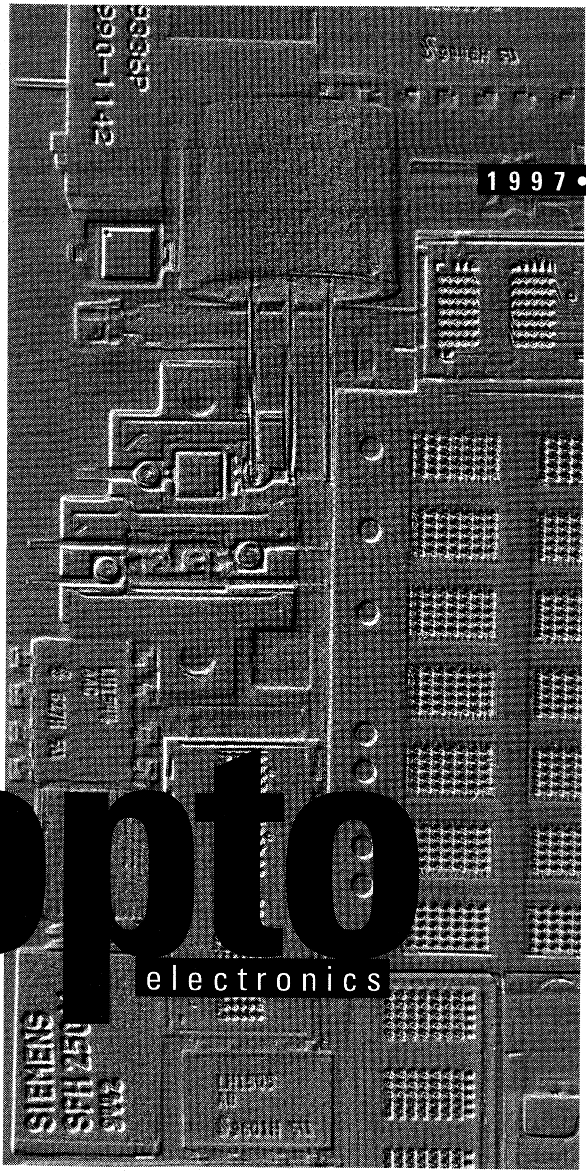
SIEMENS

opto electronics

1997 • 1998



Custom Optoelectronic Products

Intelligent Display® Devices

Numeric Displays

LED Lamps

Optocouplers

Solid State Relays (SSRs)

IR DataCOM Products

Fiber Optics
- Components
- Laser Diodes
- Photodiodes

Fiber Optic Data Links
- Transceivers
- Cable Assemblies

Infrared Emitters

Photodiodes

Phototransistors

Photovoltaic Cells

Application Notes

Siemens
Innovative Optoelectronic Products and Systems▼

Company Overview

Siemens Components is a major producer in the semiconductor industry, with facilities virtually worldwide. The U.S. Optoelectronics Division, headquartered in Cupertino, California—the heart of Silicon Valley—is teamed with the Opto-Semiconductor Group in Munich and Regensburg, Germany. Together we are world leaders in light emitting diode (LED) technology, sophisticated CMOS IC design, optics, fiber optics, and packaging.

Our combined product line is one of the most complete in the world:

- Custom Optoelectronic Products
- Intelligent Display® Devices
- Numeric Displays
- LED Lamps
- Optocouplers
- Solid State Relays
- IR DataCOM Products
- Fiber Optics: Components, Laser Diodes, and Photodiodes
- Fiber Optic Data Links: Transceivers and Cable Assemblies
- Infrared Emitters
- Infrared Photodetectors

Our materials technology includes visible and IR LEDs (GaAsP, GaP or combinations of these; GaAlAs; and Silicon Carbide) and photodetectors. Our Malaysia plant, where final product assembly is done, is a showcase of automation and efficiency, featuring the latest automated assembly and test equipment—resulting in high yields and high quality products.

Siemens USA and Worldwide

Siemens Optoelectronics is a division of Siemens Components, Inc., which is part of Siemens USA, with sales of $8.5 billion and approximately 47,050 employees. Siemens USA includes Siemens Corporation and operating companies, Siemens affiliates, and joint ventures. Among the operating companies are Siemens Automotive, Siemens Components, Siemens Energy and Automation, Siemens Industrial Automation, Siemens Medical Systems, Siemens Power Corporation, Siemens Business Communications Systems, Siemens Stromberg-Carlson, Siemens Transportation Systems, OSRAM SYLVANIA, Siemens Electromechanical Components, and Pyramid Technology, a Siemens Nixdorf Company.

Siemens USA is part of Siemens' worldwide organization, with sales of $63.6 billion, 379,000 employees, and operations in over 190 countries.

Conclusion

Siemens is strategically positioned to concentrate efforts on innovative products and systems, offering value-added, cost-effective features to our customers. All our resources and capabilities in producing LED materials (visible and infrared), R&D engineering, IC design, optics/packaging, automated assembly, and a strong focus on reliability keep Siemens at the leading edge of opto technology.

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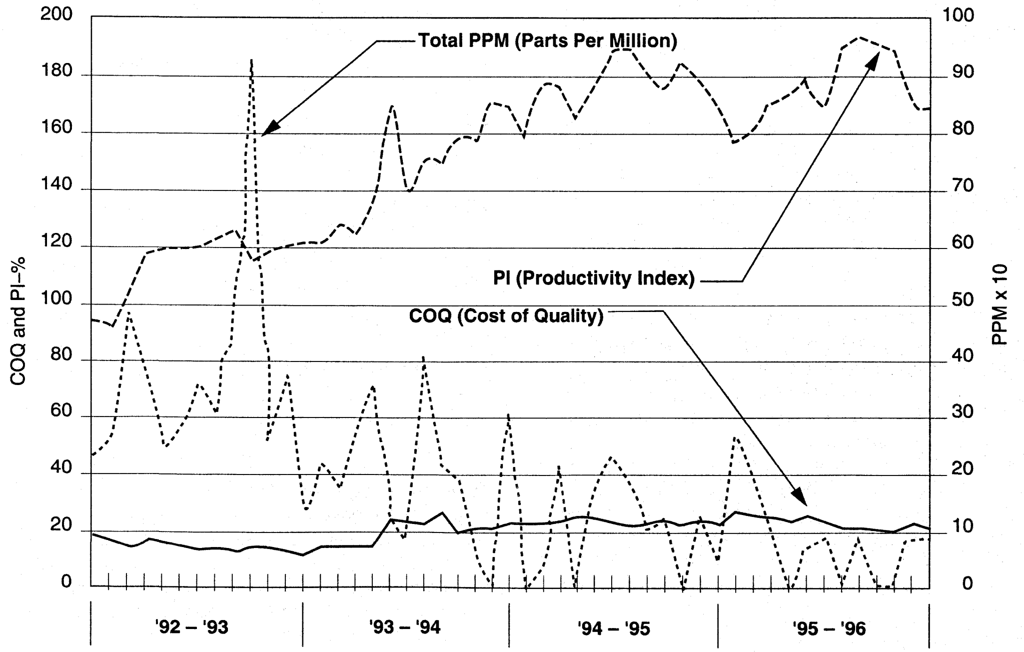
SIEMENS

Quality at Siemens Optoelectronics

At Siemens Optoelectronics, quality means more than today's satisfied customer. It means measuring up to our customer's plans for tomorrow.

It means a sophisticated process: Quality manufacturing and assurance programs, ongoing training and statistical quality control. It means continuously using customer feedback to build in improvements, ensuring just-in time delivery. And it means measurable results. During the past decade, we've continually reduced the cost of quality while increasing our productivity and reducing ppm.

In short, quality has become our way of life, permeating everything we do. It's become the art and science of exceeding our customer's expectations.



Quality Means Measurable Results at Siemens Optoelectronics

SIEMENS

Optoelectronics
Quality and Reliability

Introduction

In the technological community as a whole, the terms "quality" and "reliability" are frequently reduced to little more than advertising platitudes—heavily promised, but seldom delivered in the form of highly reliable, precision-made products. At Siemens Optoelectronics Division, however, we strive for continually increasing product excellence through increased quality and reliability reflecting a company-wide commitment of the highest priority.

Our ability to produce quality optoelectronic products offering long term reliability is directly related to intensive research and development, advanced manufacturing, a quality-oriented work force, and a company-wide philosophy attuned to the changing needs of a technologically sophisticated customer base.

Another important facet of our total commitment to manufacturing excellence is a program of quality control and reliability testing, under the Reliability and Quality Assurance (R&QA) Department. R&QA's responsibility is to interface directly with the customers, not only to determine their present satisfaction level, but to assess their future needs as well. In this way, R&QA makes certain that we will successfully meet all current and future quality/reliability requirements of our customers.

Similarly, it is also R&QA's responsibility to maintain open communication with customers, keeping them informed of our latest capabilities and achievements in the areas of product quality and reliability through detailed reports.

Although the concepts of quality and reliability are closely related, they are somewhat divergent, specialized activities. Simply put, **Quality Assurance** makes certain that products are "made right," ranging from rigid inspection and monitoring of all materials used in production processes, to monitoring the actual production processes themselves. **Reliability** on the other hand, ensures that products "work right" after assembly. At Siemens, component reliability results from an extensive program of routine monitoring and special testing activities which will be detailed later.

Parts Per Million (PPM) Program

The intensive, quality-oriented efforts of every group have enabled us to achieve one of the lowest defect percentages in the industry. Our Parts Per Million (PPM) program meets all industry expectations and is at a level sufficient to supply high-caliber OEM customers.

The annual improvement of the PPM level is vital to our ability to remain a cost-effective, on-time supplier of high quality components to the industry. Our PPM program is at the heart of the quality/reliability "revolution" that has occurred in the semiconductor industry during the last few years.

Designed to control and monitor every step of the manufacturing process, as well as assist in predictability studies, our PPM program represents the key to our long-term success in a highly competitive industry. To this end, we are heavily committed to:

- Maximum automation of processes to obtain consistent, reproducible results.
- A system of stringent process controls to ensure the achievement of expected results.
- Effective quality systems to continuously audit the PPM level actually being achieved.

Customer benefits of the PPM system are numerous:

- A low PPM defect rate enabling you to eliminate incoming QA testing.
- Dependable on-time delivery for a "just-in-time" inventory system, significantly reducing inventory costs.
- Efficient, highly automated manufacturing to keep long-term price increases as low as possible.
- Fewer production line failures; lower assembly costs; increased profit margin.
- Fewer field failures on end products; lower warranty and service costs.

The 1996/97 PPM goal for Siemens Optoelectronics is 10 PPM for critical defects.

Statistical Quality Control (SQC)

To achieve our PPM goals efficiently, we have implemented a sophisticated program of Statistical Quality Control (SQC). In effect, SQC ensures highly-reproducible, controlled manufacturing processes and "just-in-time" delivery. It enables us to meet our PPM goals without resorting to a "brute force" approach. SQC is consistent with William E. Deming's principal theory that productivity improves as a product's variability rate decreases.

We recognize the necessity of meeting our customers' ever-increasing quality requirements through a carefully developed, well-implemented program of Statistical Quality Control. After considerable research and careful planning, our SQC program was developed using the following six-point plan for Statistical

Process Control:

- Establishment of goals and objectives for company-wide implementation of Quality program
- Assessment of SQC technical capability and quantification of training aids
- Provision for training managers, engineers, supervisors, and analysts in methods and practices of SQC, as needed
- Managerial involvement in gaining statistical evidence pertaining to specific processes
- Identification of examples of successful SQC implementation to be used as models for emulation
- Monitoring progress toward established goals through a program of periodic self-audits

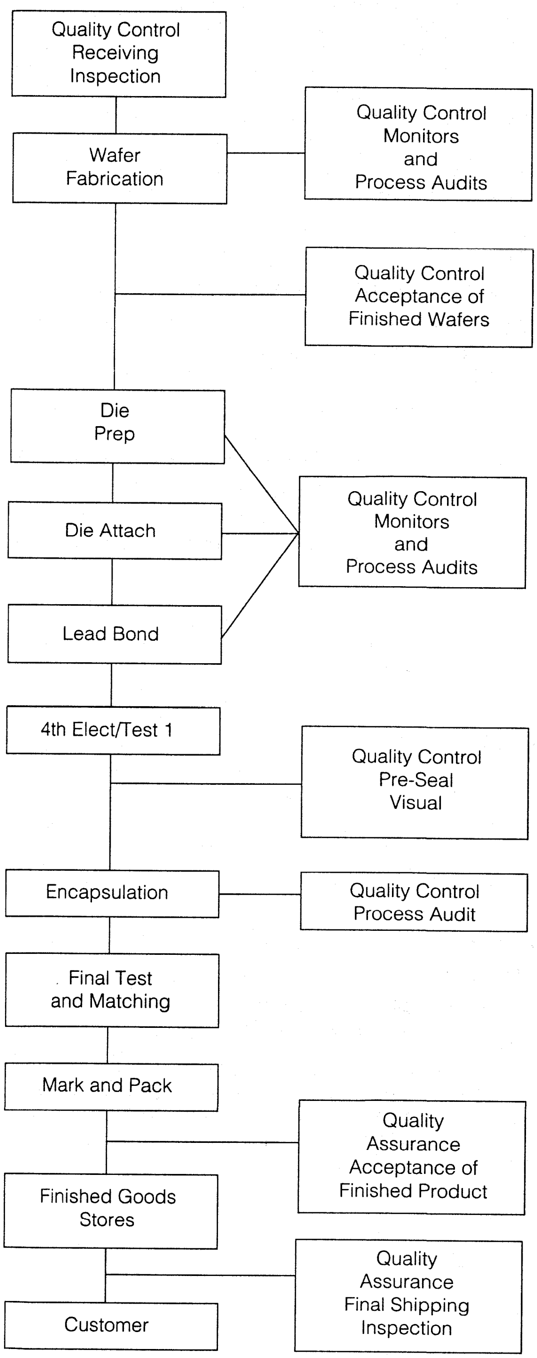
Quality Assurance

At Siemens the Quality Assurance Group serves the vital function of maintaining constant product quality standards. Quality Assurance activities begin with the careful assessment of raw materials, continues through in-process monitoring, and concludes with outgoing audits as outlined below:

- Raw Material
  - Vendor surveys
  - Vendor qualifications
  - Incoming inspections
  - Vendor rating systems
- In-process Monitors
  - Die attach monitors
  - Lead bond monitors
  - Encapsulation monitors
  - Finishing operations monitors
- Outgoing Audits
  - Outgoing audits (all lots)
  - Finished goods monitor (random)

The flowchart on the opposite page shows the basic quality control procedures employed by Siemens Opto in the production of LEDs.

LED Quality Assurance Flowchart



Reliability

The fundamental objective of our reliability program is to ensure that all our products meet or exceed, quantitatively and qualitatively, the performance requirements of our customers and our Engineering Group. To achieve this goal, the Reliability Group constantly monitors products by generic groups. This monitoring provides continuous updated measurement of product reliability in specific operating environments.

The following are typical Reliability Tests performed for the monitoring program:

- Temperature Cycle: 100 Cycles from -40¡C to 100¡C^
- Thermal Shock: 30 Cycles from 0¡C to 100¡C^
- Ambient Life Test: Max rated power for 1000 hours
- Elevated Life Test: Max rated power at 70¡C for 1000 hours
- High Temperature Storage: Max storage temperature, 1000 hours
- Low Temperature Storage: Minimum storage temperature, 1000 hours
- Temperature Humidity: 85¡C - 85% RH, 500 hours
- Solder Heat Test: 260¡C, 5 seconds

*Typical temperature cycle and thermal shock condition. Exact condition

Reliability test equipment ranges from multiple burn-in racks and table testers to a scanning electron-beam microscope. We've even designed and produced our own automatic microprocessor-based read/record tester.

Special testing covers a broad spectrum of environmental and life-stress tests. How well a sample performs under these highly accelerated conditions indicates its reliability potential under service-life conditions.

Special testing affords us vital information in many important areas:

- New product performance
- New processes
- New manufacturing techniques
- New material quality
- Special customer specifications
- Long-term reliability prediction

Reliability is also concerned with failure analysis. To determine the cause of failures, we selectively test and section products to localize and identify their failure mechanism. Selective isolation enables us to gauge the precise effects of stresses induced during reliability testing.

Continuous Improvement Program

In order to assure continuous improvement of our process and products, we are continuously evaluating and adopting new approaches and new procedures. Some of the new procedures and techniques adopted in the past ten years are:

- Taguchi Method
- Six Sigma
- TQC/TQM
- Total Productive Maintenance
- Process Capability Studies, Cp Cpk
- 8-D Team approach to problem solving
- Design + process FMEA
- ISO9000 Certification

Conclusion

Siemens is firmly committed to the design, development, and production of innovative Optoelectronics components and assemblies of the highest quality and reliability. Working to achieve this goal, every group within the Division—Management, Engineering, Reliability and Quality Assurance, Manufacturing, and Marketing—provides a vital service, enabling us to achieve and maintain the consistent product quality and the high levels of reliability required by our customers in the electronics industry.

Due in large part to the efforts of the Reliability and Quality Assurance Department and to our successful PPM and SQC efforts, we will continue to maintain our leadership position in a highly competitive future-oriented industry.

SIEMENS

Optocoupler Manufacturing and Reliability

The Concern for Optocoupler Reliability

Because of the widespread use of optocouplers as an interface device, optocoupler reliability has been a major concern to circuit designers and components engineers. Published studies of comparative tests have indicated a lack of manufacturing consistency with individual manufacturers as well as from manufacturer to manufacturer. This has resulted in user uncertainty about designing in optocouplers despite that these devices often offer the better solution in the circuit.

This report is intended to demonstrate Siemens' concern, efforts, and results in addressing these manufacturing issues to assure users of the quality (out-going) and reliability (long term) of our opto-isolated products. First, aspects of optocoupler characteristics are discussed along with the measures Siemens has taken to assure their quality and reliability. Second, the reliability tests used to approximate worst case conditions and the latest results of these tests are described.

Optocoupler Output

There are a variety of outputs available in optocouplers. A standard bipolar phototransistor is the most common. They are available with different ratings to fit most applications, including versions without access to the base of the transistor to reduce noise transmission. Darlington transistor outputs offer high gain with reduced input current requirements, but typically trade off speed. Logic optocouplers provide speed but trade off working voltage range. Logic couplers are normally only used in data transmission applications. Silicon Controlled Rectifier (SCR) devices allow control of much higher voltages and typically are applied to control AC loads. They are also offered in inverse-parallel (anti-parallel) SCR (triac) configurations that both cycles of an AC sinusoid can be switched. In Siemens manufacturing flow, all these devices are 100% monitored at a high temperature hot rail (see Figure 4) to eliminate potential failures due to marginal die attaches and lead bends, resulting in a more reliable product. Siemens offers all the above types of products.

In optocouplers, especially the transistor, the slow change over several days in the electrical parameters when voltage is applied, is termed the field effect. This process is extreme particularly at high temperatures (100°C) and with a high DC voltage (1 kV). Changes in the electrical parameters of the silicon phototransistor can occur due to the release of charge carriers. In this way, a similar effect as takes place in a MOS transistor (inversion at the surface) is caused by the strong electrical field. This may result in changes in the gain, the reverse current, and the reverse voltage. In this case, the direction of the electrical field is a decisive factor.

In Siemens' optocouplers, the pn junctions of the silicon phototransistor are protected by a TRIOS (transparent ion screen) from influences of the electrical field. In this way, changes of electrical parameters by the electrical field are limited to an extremely low value or do not occur at all.

Optocoupler Input

The area of greatest concern in optocoupler reliability has been the IR LED. The decrease in LED light output power over current flow time has been the object of considerable attention in order to reduce its effects. (Circuit designs which have not included allowances for parametric changes with temperature, input current, phototransistor bias, etc. have been attributed to LED degradation. To insure reliable system operation over time, the variation of circuit from data sheet conditions must be considered.)

Siemens has focused on the infrared LED to improve CTR degradation and consequently achieved a significant improvement in coupler reliability. The improvements have included die geometry to improve coupling efficiency metalization techniques to increase die shear strength and to increase yields while reducing user cost, and junction coating techniques to protect against mechanical stresses, thus stabilizing long term output.

Current Transfer Ratio

The Current Transfer Ratio (CRT) is the amount of output current derived from the amount of input current. CTR is normally expressed as a percent. For example, if 10 mA of input current is applied to the input (LED) and 10 mA of collector current is obtained, then the CTR is 100 or 100%. CTR is affected by a variety of influences: LED output power, Hfe of the transistor, temperature, diode current, and device geometry. If all these factors remain constant, the principle cause of CTR degradation is the degradation of the input LED.

As mentioned earlier, Siemens has made tremendous progress in manufacturing techniques to reduce CTR degradation. Siemens' manufacturing techniques maximize coupling efficiency which realize high transfer ratios and low input current requirements. Additionally this allows a large variety of standard CTR values, and the capabil-ity of special selection in production volumes.

Isolation Breakdown Voltage

Isolation voltage is the maximum voltage which may be applied across the input and output of the device without breaking down. This breakdown will not normally occur inside the package between the LED and the transistor, but rather on the boundary surfaces across which partial discharges can occur. Siemens uses a double mold manufacturing technique where the LED and transistor are encapsulated in an infrared transparent inner mold. The next step in the process is an epoxy over mold. The double mold technique lengthens the leakage path for high voltages discharges appreciably, allowing the device lo achieve very high isolation voltages. All of Siemens optocouplers are built using U.L. approved process. A standard line of V.D.E. approved optocouplers is also available.

Collector to Emitter Breakdown Voltage

Collector to emitter breakdown voltage (BV_{CEO}) can be thought of as a transistor's working voltage. When considering the application, the selection should be made to include a safety margin to insure the device is of when it is supposed to be off. Siemens transistor technology in wafer processing offers a variety of BV_{CEO} devices. Each is parametrically tested to insure proper operation (see Figure 2).

Blocking Voltage

Blocking voltage (V_{DRM}, expressed in peak value) is used when describing the working voltage for SCR or triac type devices. Siemens offers products through 600 volts of blocking capability.

DV/DT Rating

DV/DT, an important safety specification, describes a triac type device's capability to withstand a rapidly rising voltage without turning on or false firing. Siemens triac type devices have the highest available DV/DT rating offered on the market. Siemens manufacturing process yields a 10,000 V/µs DV/DT rating. This rating eliminates the need for snubber (RC) networks which negatively affect loads sensitive to leakage currents, while reducing component count for circuit implementation and cost. An example of such a load would be neon indicator lamps. Siemens' triac type devices also carry a load current rating three times the industry standard. This 300 mA current capability allows the device to drive most AC loads without the need for a follow-on triac or interposing an electromechanical relay. Siemens manufactures this device with or without zero crossing detector logic.

Figure 1. Reliability Requirements for Optocouplers
Environmental Tests

Test	MIL-STD-883 Reference	Test Condition
Pre-condition		Baking 150°C, 16 hours, RTSH

Thermal Climatic	1010 1004	TC −55°C to +150°C, 100 Cycles MC 25°C/95% RH, 12 hours 85°C/95% RH, 12 hours $V_{LED} = 0.8\ V_R$ Max. $V_{DET} = 0.8\ V_{CE}$ Max. 14 Cycles ALT Max. power at 25°C, 168 hours
Solderability	2003	260°C, 5 Seconds

Life Tests

Tests	Test Conditions			
	Temp (°C)	RH (%)	Bias	Hours
Ambient Life Test	25	≤60%	Max Rating	1000
Elevated Life Test	70	≤60%	Derated Max Rating	1000
High Temp Life Test	150	≤60%	0	1000
Low Temp Life Test	−55	≤60%	0	1000
Temp/Humidity Life	85	85%	0	1000
Intermittent Operating Life	25	≤60%	Max Rating	1000
High Temperature Reverse Bias	125	≤60%	80% of Max Voltage Rating	1000

Quality and Reliability Tests

The tests in Figure 1 were performed on Siemens optocouplers. The tests allow early detection of weak points and provide information regarding the reliability characteristics of the component.

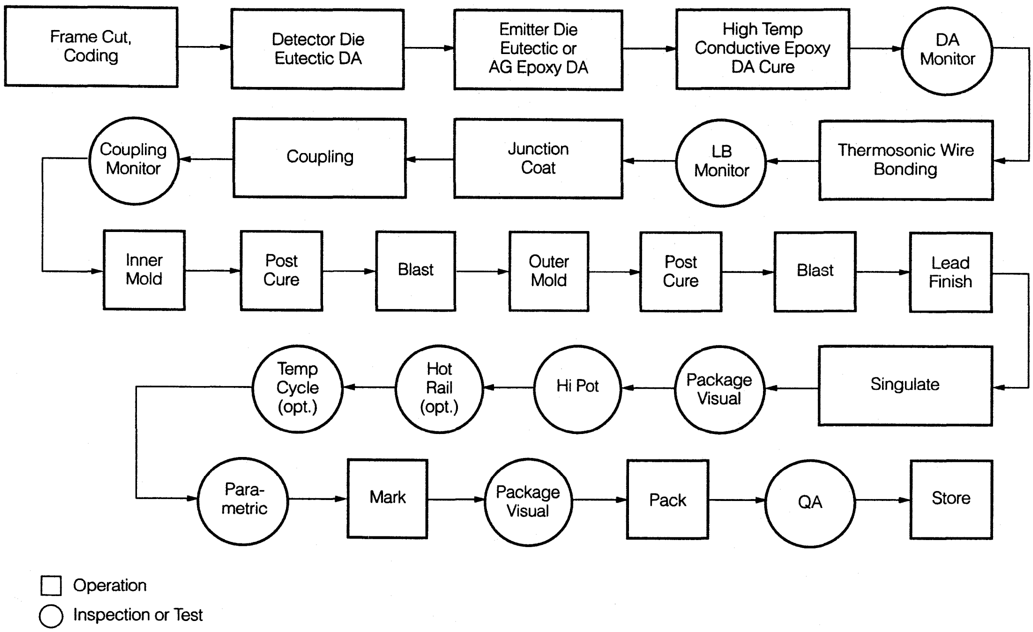
From the Life Test information assumptions of useful life expectancy can be obtained. All quality and reliability tests are performed in conditions that either exceed or are equivalent to the limits defined in our data sheets. International standards are also considered. Assuming that no new additional failure mechanisms are created by the stress conditions, the results of the stress test will correlate to conditions in the field and can be used to estimate useful lifetime. The environmental stress tests ensure Siemens manufacturing capabilities will provide package integrity in the most rigorous conditions The Life Test results highlight our ability in packaging and electrical performance to achieve MTBF hours which meet and exceed the highest expectations for the semiconductor industry.Package Integrity

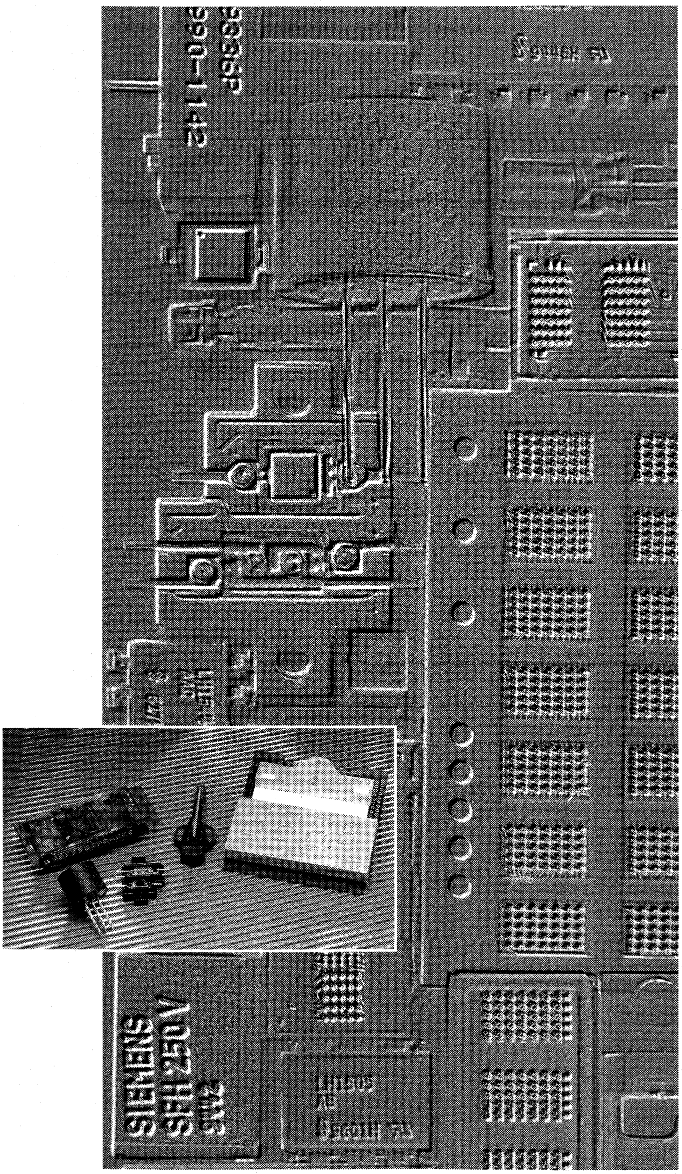
Although packaged in standard IC configurations, optocouplers have some unique package considerations. The use of two chip and internal light transfer medium require careful selection of materials to insure compatibility under a variety of operating conditions. In addition to the high isolation voltages achieved by Siemens optocouplers, our devices are tested to assure high levels of mechanical integrity and moisture resistance. For example, a ninety-six hour pressure pot test has been recently implemented to more stringently verify moisture resistance as meaningful test results are accumulated, they will be included in future reports.

Package Density

Board space has become increasingly more important in the electronic industry. Siemens uses a plate molding technique to achieve reduction in cost, allowing us to offer a wide selection of packages. These consist of single channel optocouplers in 4, 6, 8, and 16 pin DIP packages, dual channel devices in 8 pin DIP packages, and quad channel devices in 16 pin DIP packages. All of the above devices are available in two surface mount lead configurations, as well as the standard through-the-hole lead. Siemens has also a standard single and dual channel optocoupler in a SOIC-8 package. The dual SOIC-8 package has the highest packaging density of any high volume standard optocoupler available. All of these packages have been designed and tested to meet the highest quality and reliability expectations of the semiconductor industry.

Figure 2. Coupler Process Flow and Inspections





SIEMENS

Custom Optoelectronic Products

Our Mission

To provide custom solutions....product innovations in direct response to individual customer needs.

Introduction

Siemens Custom Optoelectronic Products provides innovative, cost-effective solutions for original applications for which there are no off-the-shelf alternatives. Our designs are singular creations, each individually engineered to meet the diverse needs of our worldwide customers.

Our customers, both large and small, call on us when there clearly is no other way to solve a problem or get a job done. Each of our solutions is customer specific and tailored to an individual need.

We have an enviable reputation for providing state-of-the-art custom performance products for a broad range of companies.

Benefits To You

When you work with Siemens Custom Optoelectronic Products, you obtain immediate access to superior engineering and marketing resources, world-class R&D expertise, creative ingenuity, and unrivaled manufacturing capabilities.

Here's what we guarantee: We will help you reduce system and program development costs. We will help you achieve a higher level of system performance and integration. And perhaps even more important, we will help you define and create competitive advantages through discrete product differentiation.

Working side-by-side with your key personnel, we'll develop custom solutions for applications that present technology can't support. Together, we'll advance your company's technology while creating innovative products and systems.

Our Approach

We start by working closely with your engineering and marketing personnel, working in tandem to design and develop innovative products and components from the ground up.

We're outstanding listeners. We listen hard, then we create.

And we challenge. We provide constructive comment and technical input throughout the entire discovery, design, and product development process. Together, we'll arrive at a set of system specifications that incorporates each of your marketing, quality, and reliability goals. Then we'll custom build your products — without compromise — in our state-of-the-art manufacturing facilities.

We're backed by a world-class, ISO 9001-certified R&D center with unparalleled ingenuity and renowned technical resources.

Companies and entrepreneurs the world over come to Siemens Custom Optoelectronic Products when they want true product differentiation or whenever they find that standard solutions just won't work.

At Siemens Custom Optoelectronic Products, we deliver custom solutions that improve performance and reduce system cost while giving you total design ownership.

Our Reputation

Siemens Custom Optoelectronic Products is a market leader in custom optoelectronics and a recognized technology leader in IC, LED, optical systems, and package design.

We are respected around the world for our dedication to TQM-oriented development methods. Siemens Custom Optoelectronic Products are created taking advantage of the most advanced colorimetry, indicator, and sensor technologies.

We offer highly experienced, dedicated marketing and engineering resources to complement or supplement your own internal resources. Our vertically integrated organization also includes an advanced design and measurements laboratory, as well as a broad array of other technical and engineering resources.

Strict Confidentiality

Your ideas, intellectual property, and corporate strategies are fully protected. We work with our customers under strict confidentiality agreements, employing great discretion and customer respect at all times.

Industries Served

The majority of our customers are in the communications, medical, automotive, industrial, and consumer electronics industries, but we can design solutions for virtually every OEM market.

Recent Achievements in Design

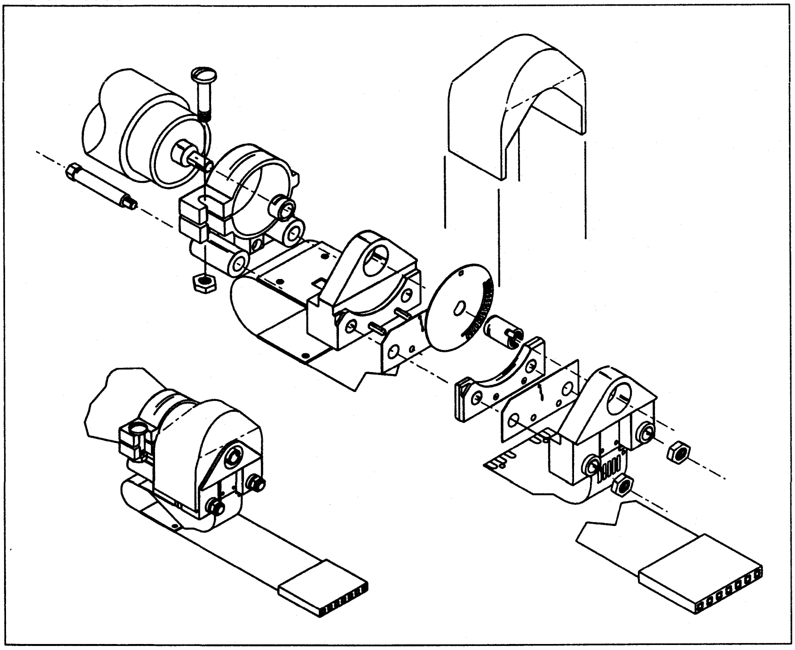
We are particularly proud of our long series of custom design innovations.

- **Consumer Market** Our Ingenuity is manifest in light curtain garage door openers, imaginative home security systems, camera displays, and breakthrough innovations for the latest generation of laptop and notebook computers.
- **Communications Industry** Our custom infrared modules are replacing bulky cables. Our advanced sensors assure precise laser tracking on floppy disc drives. Our interrupter technologies inside laser and ink jet printers monitor paper flow and position, while our colorimetry sensors assure dot pat-

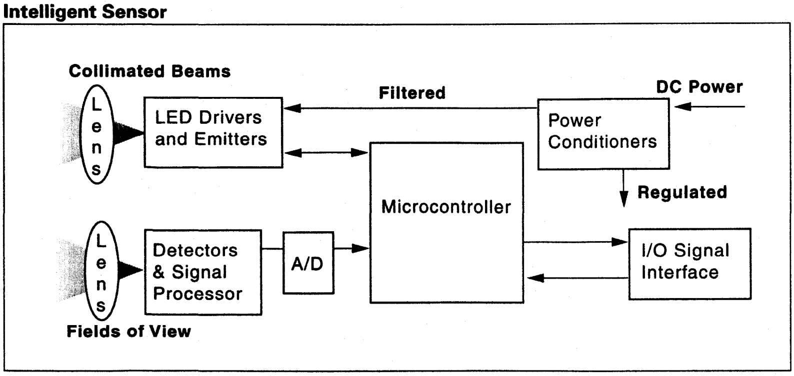
tern and color quality. In our laboratories, our engineers are creating integrated optical phone line interfaces for PC modems.

- **Medical Industry** Our custom sensors help detect the rate of blood coagulation as well as blood sugar and oxygen levels to help control the dosage of important, life-saving drugs. Other sensors identify fluids in intravenous tubing for patient safety and quality control.
- **Automotive Industry** We recently developed an infrared lane change enhancement system and provided components for a variable-rate air bag deployment system using custom infrared sensors to determine, in real time, the physical shape and position of car seat occupants.
- **Banking Industry** We developed validation sensors that recognize imbedded fibers, delicate color variations, alpha and numeric symbols, coding and other subtleties in various domestic and international currencies.

Shaft Encoder



Intelligent Sensor



The Siemens Advantage

- Preeminent custom design capabilities
- World-class technical expertise in sensors and displays
- Complete focus on response time and time to market
- Superior performance to off-the-shelf solutions
- Consistant product performance
- Improved manufacturing efficiencies and capabilities
- Lower component count and improved manufacturing yield

Why Go Anywhere Else?

When you find there is no off-the-shelf solution way to solve an engineering problem, meet a visionary marketing challenge, or just get a job done, take advantage of the special people and resources at Siemens Custom Optoelectronic Products.

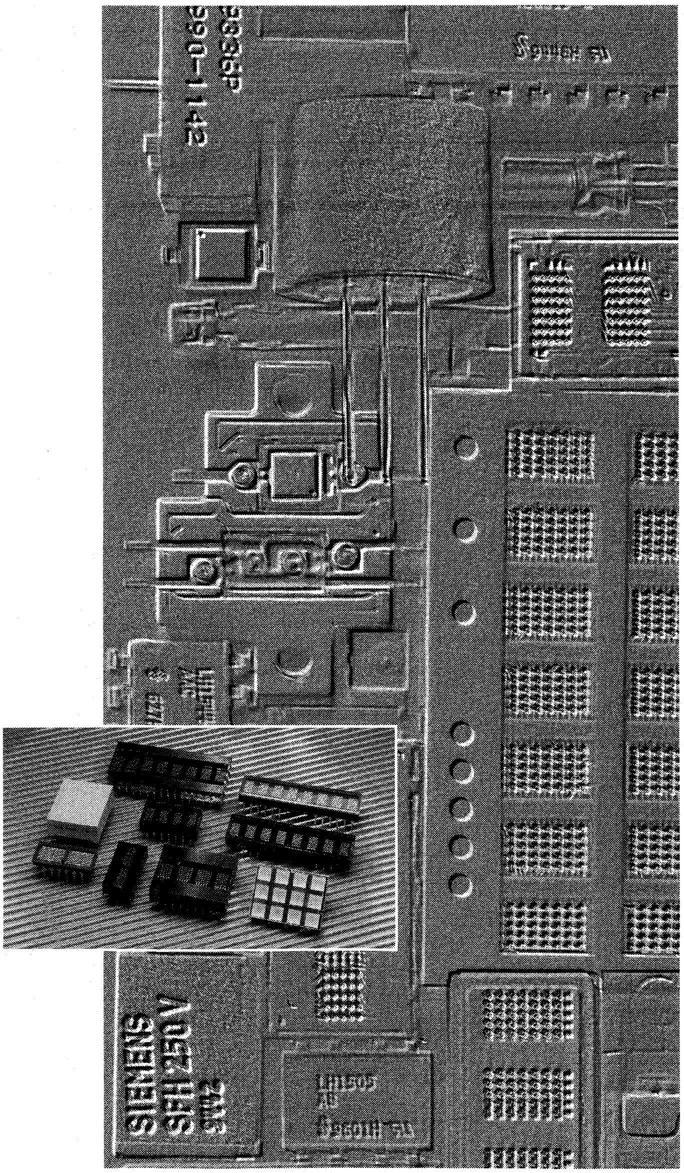
Our solutions are effective...and unique.

Sales Offices/Web Site

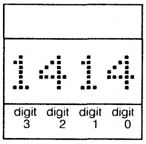
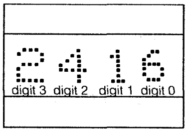
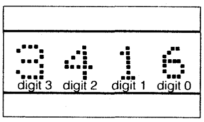
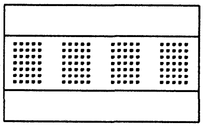
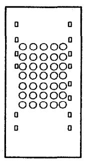
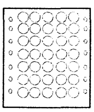
For more information, call a Siemens Components sales office nearest you (see inside back cover and last page) or visit our Web site (www.sci.siemens.com).

Siemens—The market and technology leader in custom optoelectronics.

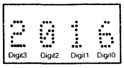
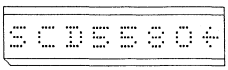
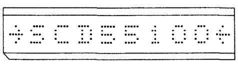
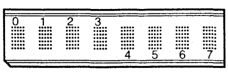
Siemens Components, Inc.
19000 Homestead Road
Cupertino, CA 95014


SIEMENS
SFH 250 V

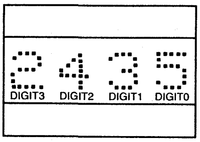
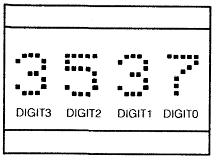
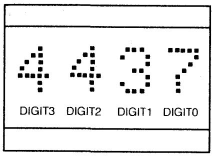
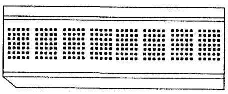
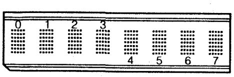
Intelligent Display® Devices

Package Outline	Part No./ Color	No. of Characters / Character Height	Viewing Angle	Description	Page
	DLR1414 Red DLO1414 HER DLG1414 Green	4 0.145"	X Axis ±50° Y Axis ±75°	Four 5x7 dot matrix characters. 128 ASCII characters (English plus 5 other languages). Access time: 110 ns. For portable applications, telecommunications equipment.	2–5
	DLR2416 Red DLO2416 HER DLG2416 Green	4 0.200"	X Axis ±50° Y Axis ±75°	Four 5x7 dot matrix characters. 128 ASCII characters (English plus 5 other languages). Access time: 110 ns. For bench equipment, instrumentation.	2–10
	DLR3416 Red DLO3416 HER DLG3416 Green	4 0.270"	X Axis ±50° Y Axis ±75°	Four 5x7 dot matrix characters. 128 ASCII characters (English plus 5 other languages). Access time: 110 ns. For bench equipment, instrumentation.	2–17
	SCF5740 Red SCF5742 HER SCF5744 HEG	4 0.270"	X Axis ±55° Y Axis ±55°	Four 5x7 dot matrix characters. Serial input dot addressable Intelligent Display devices. Built-in decoders, multiplexers, and LED drivers. Attributes: 140 bit RAM for user defined characters, eight dimming levels, power down mode, hardware/software clear functions, internal or external clock.	2–182
	DLO4135 HER DLG4137 Green	1 0.43"	±75°	Single 5x7 dot matrix character. Readable to 20 feet plus, wide viewing angle; lamp test, brightness control. One chip-enable for easy system expansion. 128 ASCII character format. Access time: 150 ns Telecommunications equipment, table top equipment, instrumentation.	2–1
	DLO7135 HER DLG7137 Green	1 0.68"	±75°	Single 5x7 dot matrix character. Readable to 30 feet plus, wide viewing angle; lamp test, brightness control. One chip-enable for easy system expansion. 96 ASCII character format. Access time: 150 ns Ideal for scales, POS terminals, instrumentation, mainframe peripherals.	

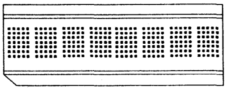
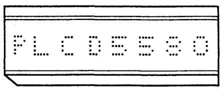
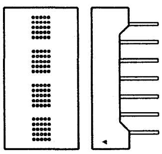
Slimline Intelligent Display® Devices

Package Outline	Part No./ Color	No. of Characters / Character Height	Viewing Angle	Description	Page
	SLR2016 Red SLO2016 HER SLG2016 Green SLY2016 Yellow	4 0.180"	X Axis ±50° Y Axis ±75°	Slimline package. Four 5x7 dot matrix characters. Very close multi-line spacing, 0.4" centers. 128 ASCII characters (English plus 5 other languages). Operating temperature: –40°C to +85°C.	2–194
	SCD5580 Red SCD5581 Yellow SCD5582 HER SCD5583 Green SCD5584 HEG	8 0.145"	X Axis ±55° Y Axis ±65°	Slimline package. Eight 5x5 dot matrix characters. Serial input dot addressable display. 200 bit RAM for user defined characters. Low power: 30% less power than 5x7 format. Operating temperature: –40°C to +85°C.	2–140
	SCD55100 Red SCD55101 Yellow SCD55102 HER SCD55103 Green SCD55104 HEG	10 0.145"	X Axis ±55° Y Axis ±65°	Slimline package. Ten 5x5 dot matrix characters. Serial input dot addressable display. 200 bit RAM for user defined characters. Low power: 30% less power than 5x7 format. Operating temperature: –40°C to +85°C.	2–125
	SCE5780 Red SCE5781 Yellow SCE5782 HER SCE5783 Green SCE5784 HEG SCE5785 Soft Orange	8 0.180"	X Axis ±55° Y Axis ±65°	Eight 5x7 dot matrix characters. Serial input dot addressable display. Built-in decoders, multiplexers, and LED drivers. Programmable features: clear function, eight dimming levels, peak current select, prescaler function, internal or external clock.	2–169

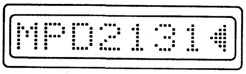
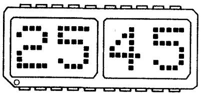
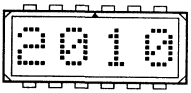
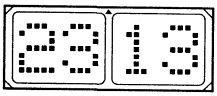
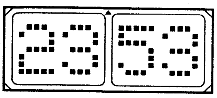
Programmable Display™ Devices

Package Outline	Part No./ Color	No. of Characters / Character Height	Viewing Angle	Description	Page
	PD2435 HER PD2436 Red PD2437 Green	4 0.200"	X Axis ±55° Y Axis ±65°	Four dot matrix characters. Built-in CMOS ASCII decoder, multiplexers memory and driver. Software driven, true microprocessor peripherals. Additional features of Programmable Display devices include: control and display memory read/ write, dimming (3 levels) and blanking, blinking cursor/character and lamp test. 128 ASCII character format. Extended operating temperature range: –40°C to +85°C.	2–79
	PD3535 HER PD3536 Red PD3537 Green	4 0.270"			
	PD4435 HER PD4436 Red PD4437 Green	4 0.45"			
	HDSP2110S Red HDSP2111S Yellow HDSP2112S HER HDSP2113S Green HDSP2114S HEG HDSP2115S Soft Orange	8 0.200"	X Axis ±55° Y Axis ±65°	Eight dot matrix characters. Built-in CMOS ASCII decoder, multiplexers memory and driver. Software driven-true microprocessor peripherals. Additional features of Programmable Display devices include: control and display memory read/ write, dimming (3 levels) and blanking, blinking cursor/character and lamp test. 128 ASCII characters format. 16 user definable characters. Access time: 110 ns. Extended operating temperature range: –40°C to +85°C.	2–34
	PDSP1880 Red PDSP1881 Yellow PDSP1882 HER PDSP1883 Green PDSP1884 HEG	8 0.180"	X Axis ±55° Y Axis ±65°	Eight dot matrix characters. Built-in CMOS ASCII decoder, multiplexers memory and driver. Software driven-true microprocessor peripherals. Additional features of Programmable Display devices include: control and display memory read/ write, dimming (3 levels) and blanking, blinking cursor/character and lamp test. 128 ASCII characters format. 16 user definable characters. Access time: 110 ns. Extended operating temperature range: –40°C to +85°C.	2–90

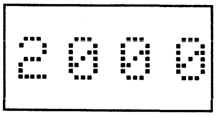
Programmable Display™ Devices

	PDSP2110 Red PDSP2111 Yellow PDSP2112 HER PDSP2113 Green PDSP2114 HEG	8 0.200"	X Axis ±55° Y Axis ±65°	Eight dot matrix characters. Built-in CMOS ASCII decoder, multiplexers memory and driver. Software driven, true microprocessor peripherals. Additional features of Programmable Display devices include: control and display memory read/write, dimming (3 levels) and blanking, blinking cursor/character and lamp test. 256 ASCII characters format. Access time: 110 ns. Extended operating temperature range: –40°C to +85°C.	2–103
	PLCD5580 Red PLCD5581 Yellow PLCD5582 HER PLCD5583 Green PLCD5584 HEG	8 0.145"	X Axis ±50° Y Axis ±65°	Eight 5x5 dot matrix characters. Built-in 2 page 256 character ROM. Built-in decoders, multiplexers, and drivers. Programmable features: individual flashing character, full display blinking, multi-level dimming and blanking, clear function, lamp test. Low power.	2–114
	SCDV5540 Red SCDV5541 Yellow SCDV5542 HER SCDV5543 Green SCDV5544 HEG	4 0.123"	X Axis ±55° Y Axis ±55°	Vertical format, four 5x5 dot matrix characters. ROMless serial input, dot addressable Intelligent Display devices. Built-in decoders, multiplexers, and LED drivers.	2–155

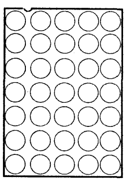
Industrial Alphanumeric Displays

Package Outline	Part No./ Color	No. of Characters / Character Height	Operating Temp. Range	Description	Page
	IPD2131 Yellow IPD2132 HER IPD2133 HEG	8 0.200"	–55°C to +100°C	**Programmable Display Devices** Eight 5x7 dot matrix characters. Built-in CMOS ASCII decoder, multiplexer, memory, and driver. 128 character ASCII character set. Rugged ceramic package, hermetically sealed flat glass lens.	2–47
	IPD2545A HER IPD2547A Green IPD2548A Yellow	4 0.252"	–55°C to +100°C	**Programmable Display Devices** Four 5x7 dot matrix characters. Built-in CMOS ASCII decoder, multiplexer, memory, and driver. 128 character ASCII character set. Rugged ceramic package, hermetically sealed flat glass lens.	2–60
	ISD2010 Red ISD2011 Yellow ISD2012 HER ISD2013 HEG	4 0.150"	–55°C to +100°C	**Small Alphanumeric Displays** Four 5x7 dot matrix characters. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power, on-board CMOS shift register and constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	
	ISD2310 Red ISD2311 Yellow ISD2312 HER ISD2313 HEG	4 0.150"	–55°C to +100°C	**Small Alphanumeric Displays** Four 5x7 dot matrix characters. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift register and constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	2–69
	ISD2351 Yellow ISD2352 HER ISD2353 HEG	4 0.200"	–55°C to +100°C	**Small Alphanumeric Displays** Sunlight viewable. Four 5x7 dot matrix characters. Rugged ceramic package, hermetically sealed flat glass lens. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift register and constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	

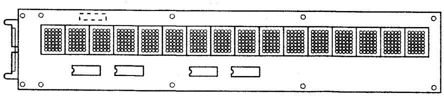
Small Alphanumeric Displays

Package Outline	Part No./ Color	No. of Characters / Character Height	Operating Temp. Range	Description	Page
	HDSP2000LP Red HDSP2001LP Yellow HDSP2002LP HER HDSP2003LP Green	4 0.150"	–40°C to +85°C	**Commercial Small Alphanumeric Displays** Four 5x7 dot matrix characters. Plastic package. Serial input/parallel output. Easily cascaded for multiple displays. Low power on-board CMOS shift register and constant current LED row drivers. External column strobing allows use of full ASCII and customized fonts.	2–27

Alphanumeric Displays

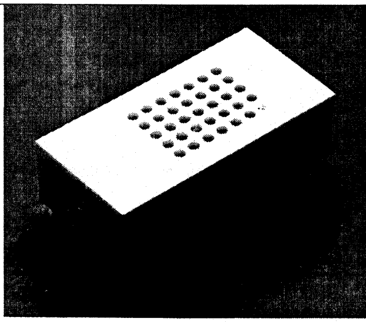
Package Outline	Part No./ Color	No. of Characters / Character Height	Polarity	Luminous Intensity per Segment Typ. (μcd)	mA	Description	Page
	DLR5735 Red DLG5735 Green	1 0.69"	Common Cathode Row	200	20	Single 5x7 dot matrix character. No built-in CMOS drive circuitry.	2–24
	DLR5736 Red DLG5736 Green	1 0.69"	Common Anode Row	650	10		

Intelligent Display® Device Assemblies

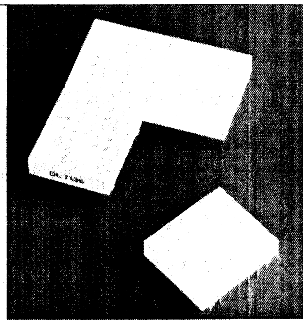
Package Outline	Part No.	Description
	IDA7135-16, example assembly: sixteen DLO7135 Intelligent Display devices mounted on a PC board.	An Intelligent Display device assembly can be made from any of our Intelligent Display devices configured to customer specifications. Contact Product Marketing.

SIEMENS

HIGH EFFICIENCY RED DLO4135/7135
GREEN DLG4137/7137
.43" Single Character DLO4135/DLG4137
.68" Single Character DLO7135/DLG7137
5x7 Dot Matrix Intelligent Display® Devices with Memory/Decoder/Driver

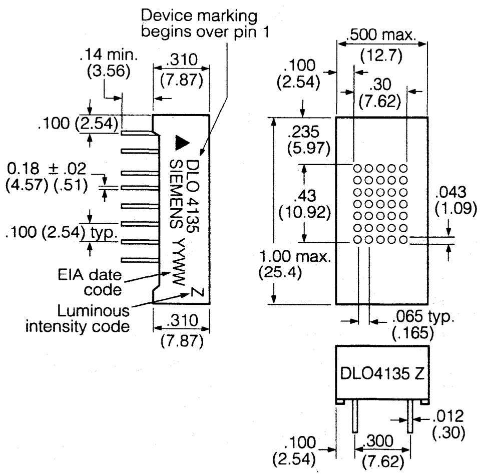


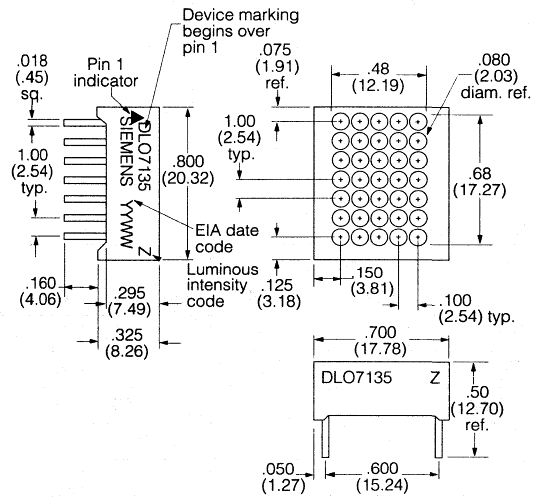
DLO4135/4137



DLO7135/7137

Package Dimensions in inches (mm)





FEATURES
- **5x7 Dot Matrix Characters**
  DLO4135/DLG4137: .43" High
  DLO7135/DLG7137: .68" High
- **Wide Viewing Angle ±75°**
- **96 Character ASCII Set**
  Upper Case and Lower Case Characters
- **Fully Encapsulated, Rugged Solid Plastic Package**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Built-in Lamp Test**
- **Intensity Control (4 levels)**
- **Microprocessor Bus Compatible**
- **Intensity Coded for Display Uniformity**
- **Single 5-Volt Power Supply**
- **X/Y Stackable**
- **Available in High Efficiency Red and Green**

DESCRIPTION

The DLX413X/DLX713X are single digit 5x7 dot matrix Intelligent Display devices. The DLX413X character is 0.43" high. The DLX713X character is 0.68" high. The built-in CMOS integrated circuit contains memory, ASCII character generator, LED multiplexing and drive circuitry; thereby eliminating the need for additional circuitry. They will display the 96 ASCII characters.

These devices are TTL and microprocessor compatible and offer the possibility of cascading the displays, allowing for multi-character messages. These displays were designed for viewing distances of up to 20 feet (DLX413X) or 30 feet (DLX713X). They require a single 5-volt power supply and parallel ASCII input.

All products are 100% tested, then subjected to out-going AQLs of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

Important: Refer to Appnote 18, "Using and Handling Intelligent Display Devices." Since this is a CMOS device, normal precautions should be taken to avoid static damage.

Timing parameters at 25°C (V_{CC}=5.0 V ±0.5 V)

Symbol	Parameter	Units (ns)
T_{CES}	Chip Enable Set-Up	10
T_{DS}	Data Set Up	100
T_W	Write Pulse	120
T_{DH}	Data Hold	20
T_{CEH}	Chip Enable Hold	20
T_{ACC}	Access Time	150

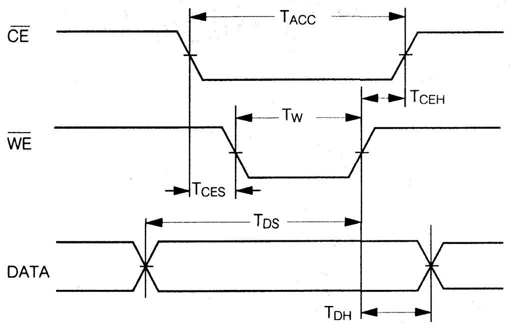
Maximum Ratings

V_{CC} Range (max.) .... –0.5 to +7.0 Vdc
Voltage, Any Pin, Respect to GND .... –0.5 to V_{CC} +0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature, .063"
below Seating Plane, t<5 sec. .... 260°C
Relative Humidity at 85°C (non condensing) 85%

Optical Characteristics (Typical) at 25°C

Time Averaged Luminous Intensity/Dot at 5 V .... 1500 mcd typ.
Character Size
DLO4135/DLG4137 .... 0.43"
DLO7135/DLG7137 .... 0.68"
Viewing Angle (1) .... ±75°
Spectral Peak Wavelength
DLO4135/7135 (High Efficiency Red) .... 635 nm typ.
DLG4137/7137 (Green) .... 565 nm typ.
Dot to Dot Intensity Ratio .... 1.8:1.0 max.

Figure 1. Timing characteristics—write cycle waveforms



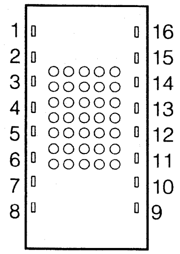
DC characteristics

Parameter	–40°C			+25°C			+85°C			Units	Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} (20 dots on)		135	180		100	140		85	115	mA	V_{CC}=5 V, $\overline{BL0}$=$\overline{BL1}$=5 V
I_{CC} Blank		2.0	5.5		1.5	4.0		0.8	3.5	mA	V_{CC}=WR=5.0 V, $\overline{BL0}$=$\overline{BL1}$=0 V
I_{IL} (all inputs)				25	50	100				µA	V_{IN}=0.8 V, V_{CC}=5 V ±0.5 V
V_{IH}	2.0			2.0			2.0			V	V_{CC}=5 V ±0.5 V
V_{IL}			0.8			0.8			0.8	V	V_{CC}=5 V ±0.5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

Notes:

1. "Off Axis Viewing Angle" definition: The minimum angle in any direction from the normal to the display surface at which any part of any dot in the display is not visible.
2. **This display contains a CMOS integrated circuit. Normal CMOS handling precautions should be taken to avoid damage due to high static voltages or electric fields. See Appnote 18.**
3. Unused inputs must be tied to an appropriate logic voltage level (either V + or GND).
4. V_{CC}=5.0 VDC ±10%.
5. Clean only in water, isopropyl alcohol, freon TF, TE (or equivalent).

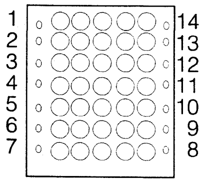
Figure 2. Top view—DLO4135/DLG4137



Pin functions—DLO4135/DLG4137

Pin	Function	Pin	Function
1	$\overline{\text{LT}}$ Lamp	9	D0 Data LSB
2	$\overline{\text{WR}}$ Write	10	D1 Data
3	$\overline{\text{BL1}}$ Brightness	11	D2 Data
4	$\overline{\text{BL0}}$ Brightness	12	D3 Data
5	No Pin	13	D4 Data
6	No Pin	14	D5 Data
7	$\overline{\text{CE}}$ Chip Enable	15	D6 Data MSB
8	GND	16	$+V_{CC}$

Figure 3. Top view—DLO7135/DLG7137



Pin functions—DLO7135/DLG7137

Pin	Function	Pin	Function
1	V_{CC}	8	D0 Data Input LSB
2	$\overline{\text{LT}}$ Lamp Test	9	D1 Data
3	$\overline{\text{CE}}$ Chip Enable	10	D2 Data
4	$\overline{\text{WR}}$ Write	11	D3 Data
5	$\overline{\text{BL1}}$ Brightness	12	D4 Data
6	$\overline{\text{BL0}}$ Brightness	13	D5 Data
7	GND	14	D6 Data Input MSB

Lamp Test

When the lamp test ($\overline{\text{LT}}$) is activated, all dots on the display are illuminated at 1/7 brightness. The lamp test function is independent of write ($\overline{\text{WR}}$) and the settings of the blanking inputs ($\overline{\text{BL0}}$, $\overline{\text{BL1}}$).

This convenient test gives a visual indication that all dots are functioning properly. Lamp test also may be used as a cursor function or pointer which does not destroy previously displayed characters.

Dimming and blanking the display

Brightness Level	$\overline{\text{BL1}}$	$\overline{\text{BL0}}$
Blank	0	0
1/7 Brightness	0	1
1/2 Brightness	1	0
Full Brightness	1	1

Loading Data

Loading data into the display is straightforward. Chip enable ($\overline{\text{CE}}$) should be present and stable during a write pulse ($\overline{\text{WR}}$). Parallel data information should be stable for the minimum time (T_W) and held for TDH after write has gone high. No synchronization is necessary and each character will continue to be displayed until it is replaced with another. Multiple displays may be stacked together with only an additional decoder IC for chip enable decoding.

Note:

Either $\overline{\text{BL0}}$ or $\overline{\text{BL1}}$ should be held high for display to light up.

Data loading example

$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{BL0}}$	$\overline{\text{BL1}}$	$\overline{\text{LT}}$	Data Input							
					D6	D5	D4	D3	D2	D1	D0	
H	X	H	X	H	X	X	X	X	X	X	X	NC
X	X	L	L	H	X	X	X	X	X	X	X	Blank
X	X	X	X	L	X	X	X	X	X	X	X	Lamp Test
L	L	H	H	H	H	L	L	L	L	L	H	A
L	L	H	H	H	H	H	H	L	L	H	L	r
L	L	H	H	H	L	H	H	L	L	H	H	3
L	L	H	H	H	L	H	L	H	L	H	H	+

X=don't care, NC=no change

Figure 4. 16 digits interconnection

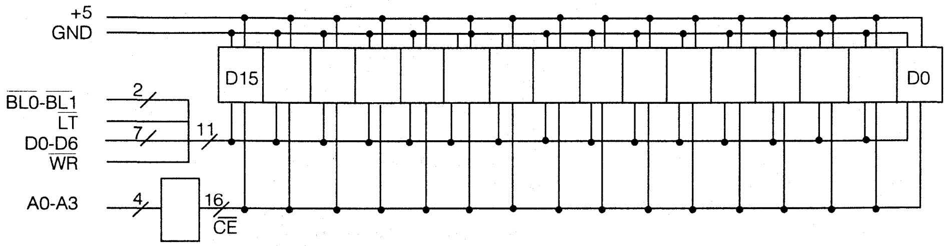
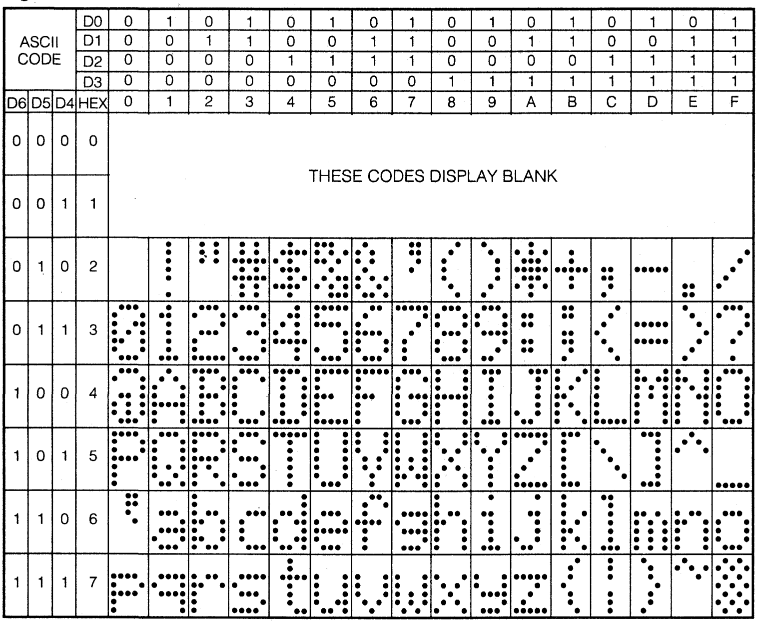


Figure 5. Character set

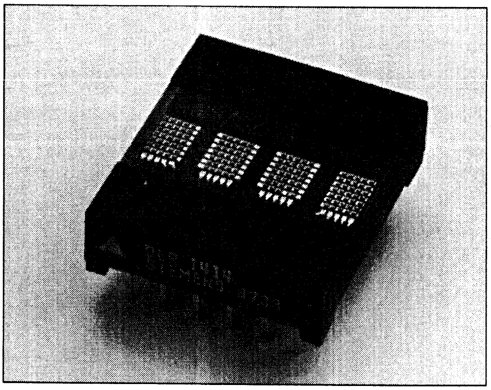


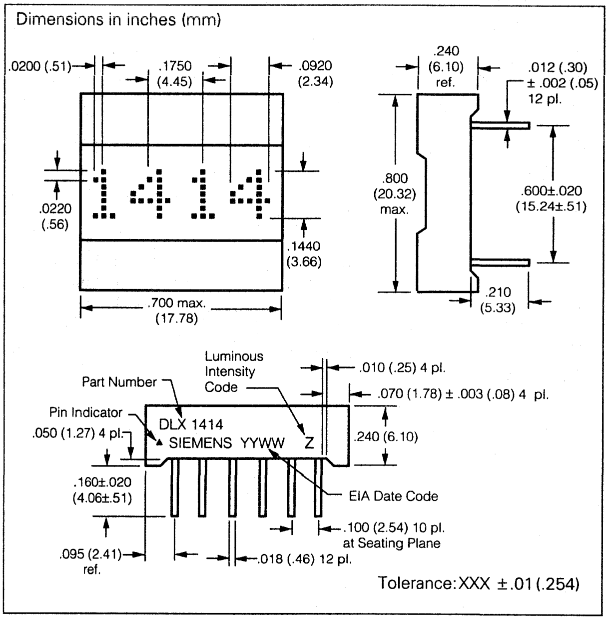
Notes:

1. High=1 level
2. Low=0 level
3. Upon power up, the device will initialize in a random state.

SIEMENS

RED DLR1414
HIGH EFFICIENCY RED DLO1414
GREEN DLG1414
0.145" 4-Character 5x7 Dot Matrix Alphanumeric Intelligent Display® Devices with Memory/Decoder/Driver





FEATURES

- **0.145" High, Dot Matrix Character**
- **128 Special ASCII Characters for English, German, Italian, Swedish, Danish, and Norwegian Languages**
- **Wide Viewing Angle: X Axis ±50°, Y Axis ±75°**
- **Close Vertical Row Spacing, 0.800" Centers**
- **Fast Access Time, 110 ns at 25°C**
- **Compact Size for Hand Held Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Direct Access to Each Digit Independently and Asynchronously**
- **TTL Compatible, 5 Volt Power**
- **Low Power Consumption, 20 mA per Character Typical**
- **Intensity Coded for Display Uniformity**
- **Extended Operating Temperature Range: –40°C to +85°C**
- **End Stackable, 4-Character Package**

See Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION

The DLR/DLO/DLG1414 is a four digit 5x7 dot matrix display module with a built-in CMOS integrated circuit.

The integrated circuit contains memory, ASCII ROM decoder, multiplex circuitry and drivers. Data entry is asynchronous and random. A display system can be built using any number of DLX1414s since each character in any DLX1414 can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is very straightforward. The least significant two address bits (A0, A1) are normally connected to the like named inputs of all displays in the system. Data lines are connected to all DLX1414s directly and in parallel as is the write line ($\overline{WR}$). The display then will behave as a write only memory.

The DLX1414 has several features superior to competitive devices. The character set consists of 128 special ASCII characters for English, German, Italian, Swedish, Danish, and Norwegian.

Maximum Ratings

DC Supply Voltage .... –0.5 to +7.0 Vdc
Input Voltage Levels Relative
to GND (all inputs) .... –0.5 to V_{CC} +0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature 063" (1.59 mm)
below Seating Plane, t<5 sec. .... 260°C
Relative Humidity at 85°C 85%

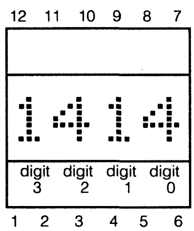
Optical Characteristics

Spectral Peak Wavelength
Red .... 660 nm typ.
High Efficiency Red (HER) .... 630 nm typ.
Green .... 565 nm typ.
Viewing Angle (off normal axis)
Horizontal .... ±50°
Vertical .... ±75°
Character Height .... 0.145"
Time Averaged Luminous Intensity [1]
(100% brightness, V_{CC}=5 V)
Red .... 50 µcd/LED typ.
HER .... 60 µcd/LED typ.
Green .... 70 µcd/LED typ.
LED to LED Intensity Matching .... 1.8:1.0 max.
LED to LED Hue Matching at V_{CC}=5 V
(Green only) .... ±2 nm max.

Note:

1) Peak luminous intensity values can be calculated by multiplying these values by 7.

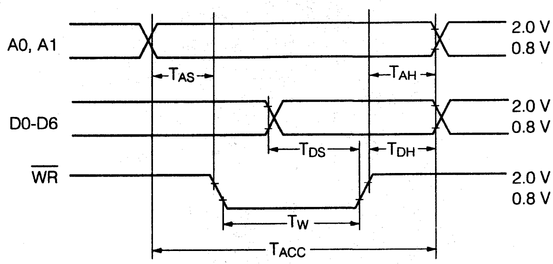
Figure 1. Top view



Pins and functions

Pin	Function	Pin	Function
1	D5 Data Input	7	GND
2	D4 Data Input	8	D0 Data Input (LSB)
3	$\overline{WR}$ Write	9	D1 Data Input
4	A1 Digit Select	10	D2 Data Input
5	A0 Digit Select	11	D3 Data Input
6	V_{CC}	12	D6 Data Input (MSB)

Figure 2. Timing characteristics (V_{CC}=4.5 V)



Note:

These waveforms are not edge triggered.

DC characteristics

Parameter	–40°C			+25°C			+85°C			Units	Condition
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} 4 Digits on 20 dots/digit		90	120		80	105		70	95	mA	V_{CC}=5 V
I_{CC} Blank		2.8	4.0		2.3	3.0		2.0	2.5	mA	V_{CC}=5 V, $\overline{WR}$=5 V V_{IN}=0 V
I_{IL} (all inputs)	30	60	120	25	50	100	20	40	80	mA	V_{IN}=0.8 V, V_{CC}=5 V
V_{IH}	2.0			2.0			2.0			V	V_{CC}=5 V ±0.5 V
V_{IL}			0.8			0.8			0.8	V	V_{CC}=5 V ±0.5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

AC characteristics (guaranteed minimum timing parameters at V_{CC}=5.0 V ±0.5 V)

Parameter	**Symbol**	**–40°C**	**+25°C**	**+85°C**	**Unit**
Address Set Up Time	T_{AS}	10	10	10	ns
Address Hold Time	T_{AH}	20	30	40	ns
Write Time	T_{W}	60	70	90	ns
Data Set Up Time	T_{DS}	20	30	50	ns
Data Hold Time	T_{DH}	20	30	40	ns
Access Time [1]	T_{ACC}	90	110	140	ns

Note:
[1] T_{ACC}=Set Up Time+Write Time+Hold Time.

Table 1. Loading data state table

$\overline{WR}$	**A1**	**A0**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**	**Display Digit**			
										3	**2**	**1**	**0**
H	previously loaded display									G	R	E	Y
L	L	L	H	L	L	L	H	L	H	G	R	E	E
L	L	H	H	L	H	L	H	L	H	G	R	U	E
L	H	L	H	L	L	H	H	L	L	G	L	U	E
L	H	H	H	L	L	L	L	H	L	B	L	U	E
L	L	H	H	L	L	H	H	L	H	B	L	E	E
L	L	L	H	L	H	L	H	H	H	B	L	E	W
L	X	X	see character code							see character set			

X=Don't care

Figure 3. Typical interconnection for 32 characters

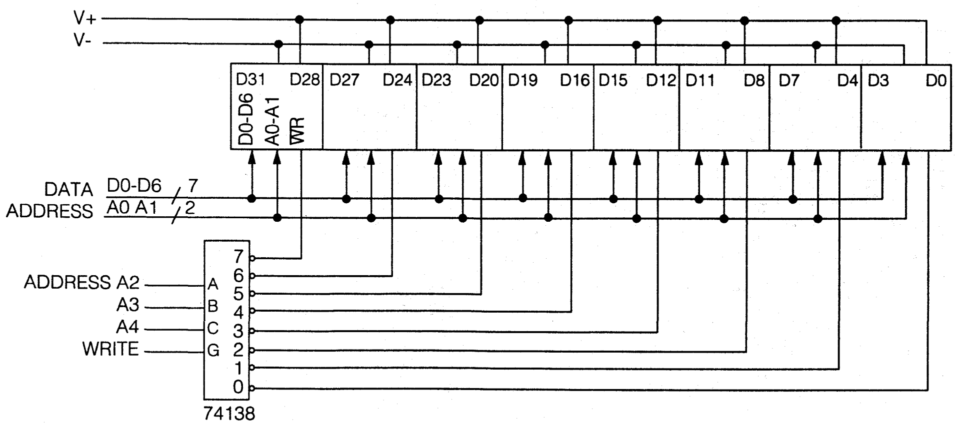


Figure 4. Block diagram

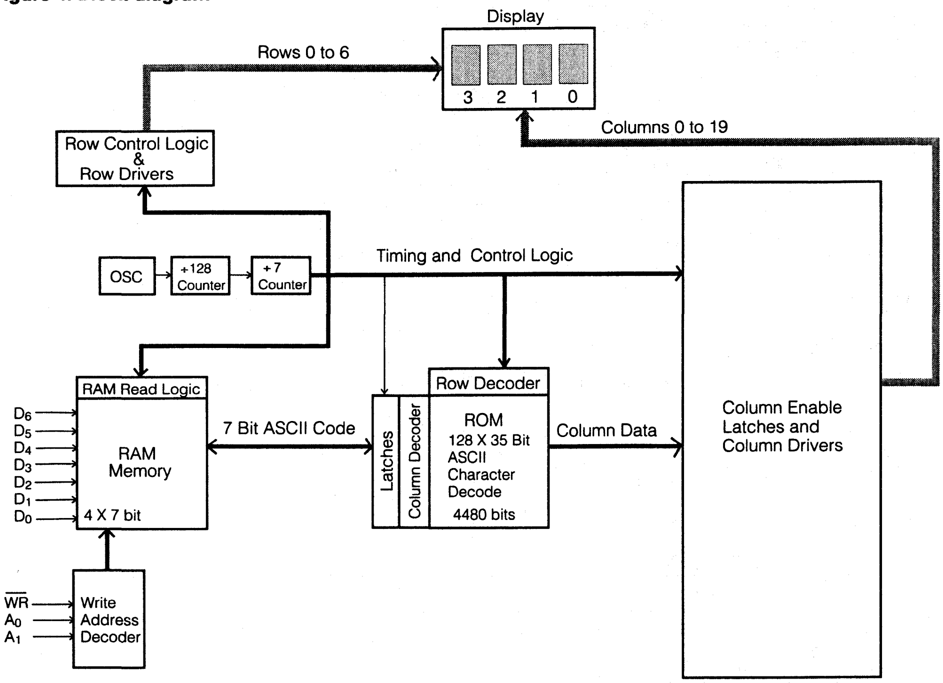
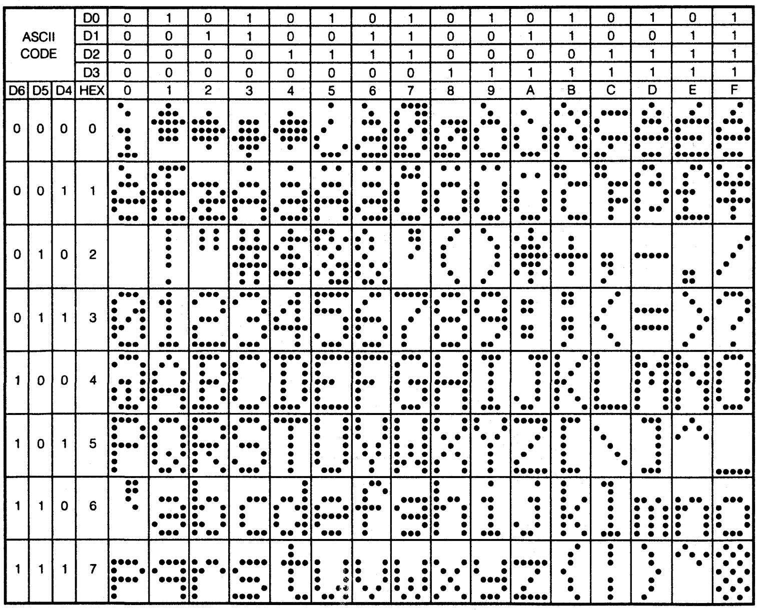


Figure 5. Character set



Notes:

1. High=1 level
2. Low=0 level
3. Upon power up, the device will initialize in a random state.

Design Considerations

For details on design and applications of the DLX1414 using standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, 8748, or 6800, refer to Appnote 15 in the current Siemens Optoelectronic Data Book.

Electrical & Mechanical Considerations

Voltage Transient Suppression

We strongly recommend that the same power supply be used for the display and the components that interface with the display to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place .01 mF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 mF capacitor for every second display.

ESD Protection

The metal gate CMOS IC of the DLX1414 is extremely immune to ESD damage. However, users of these devices are encouraged to take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. Where these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The DLX1414 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Carefully select solvents as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluorethane), TA, 111 Trichloroethane, and unheated acetone.

Note: Acceptable commercial solvents are: Basic TF, Arklone P, Genesolve D, Blaco-tron TF, Freon TA, Genesolve DA, and Blaco-tron TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Eighteen pin DIP sockets .600" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The .145" high characters of the DLX1414 gives readability up to eight feet. The user can build a display that enhances readability over this distance by proper filter selection.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Remember to take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The DLR1414 is a standard red display and should be matched with long wavelength pass filter in the 600 nm to 620 nm range. For displays of multiple colors, neutral density grey filters offer the best compromise.

The DLO1414 is a high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 range. The DLG1414 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density gray filters offer the best compromise.

Additional contrast enhancement can be gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

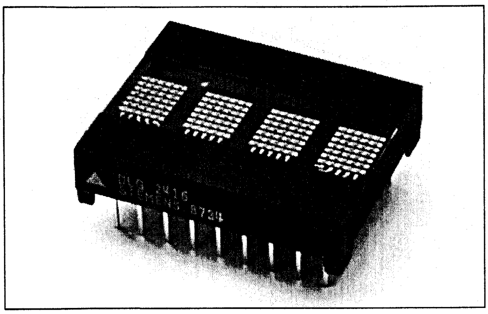
One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

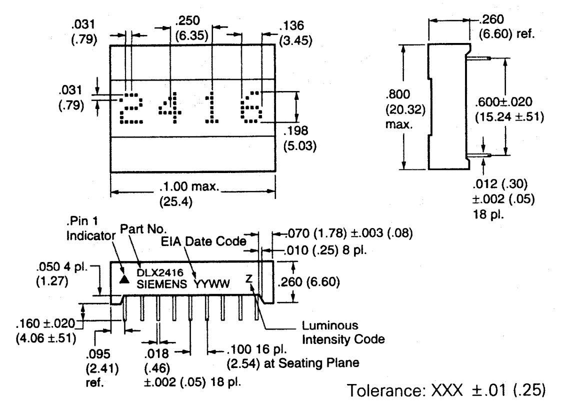
Refer to Siemens Appnote 23 for further information.

SIEMENS

RED DLR2416
HIGH EFFICIENCY RED DLO2416
GREEN DLG2416

0.200" 4-Character 5x7 Dot Matrix Alphanumeric Intelligent Display® Devices with Memory/Decoder/Driver





FEATURES

- **0.200" 5x7 Dot Matrix Characters**
- **128 Special ASCII Characters for English, German, Italian, Swedish, Danish, and Norwegian Languages**
- **Wide Viewing Angle: X Axis 50° Maximum, Y Axis ±75° Maximum**
- **Close Multi-line Spacing, 0.8" Centers**
- **Fast Access Time, 110 ns at 25°C**
- **Full Size Display for Stationary Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Direct Access to Each Digit Independently and Asynchronously**
- **Independent Cursor Function**
- **Memory Function: Clears Character and Cursor Memory Simultaneously**
- **True Blanking for Intensity Dimming Applications**
- **End-Stackable, 4-Character Package**
- **Intensity Coded for Display Uniformity**
- **Extended Operating Temperature Range: –40°C to +85°C**
- **Superior ESD Immunity**
- **Wave Solderable**
- **TTL Compatible over Operating Temperature Range**
- **Interdigit Blanking**

See Appnote 18, 19, 22, and 23 for additional information.

DESCRIPTION

The DLR/DLO/DLG2416 is a four digit 5x7 dot matrix display module with a built-in CMOS integrated circuit. This display is X/Y stackable.

The integrated circuit contains memory, ASCII ROM decoder, multiplexing circuitry and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DLX2416s since each digit can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is very straightforward. The least significant two address bits (A0, A1) are normally connected to the like-named inputs of all displays in the system. With two chip enables ($\overline{CE1}$ and $\overline{CE2}$) four displays (16 characters) can easily be interconnected without a decoder.

Data lines are connected to all DLX2416s directly and in parallel, as is the write line ($\overline{WR}$). The display will then behave as a write-only memory.

The cursor function causes all dots of a digit position to illuminate at half brightness. The cursor is not a character, and when removed the previously displayed character will reappear.

The DLX2416 has several features superior to competitive devices. True "blanking" allows the designer to dim the display for more flexibility of display presentation. Finally the $\overline{CLR}$ clear function will clear the cursor RAM and the ASCII character RAM simultaneously.

The character set consists of 128 special ASCII characters for English, German, Italian, Swedish, Danish, and Norwegian.

All products are subjected to out-going AQL's of 0.25% for brightness matching, visual alignment and dimensions, 0.065% for electrical and functional.

Maximum Ratings

DC Supply Voltage ....–0.5 V to +7.0 Vdc
Input Voltage, Respect to GND
(all inputs) ....–0.5 V to V_{CC} +0.5 Vdc
Operating Temperature ....–40°C to +85°C
Storage Temperature ....–40°C to +100°C
Relative Humidity at 85°C 85%
Maximum Solder Temperature, 0.063" (1.59 mm)
below Seating Plane, t<5 sec .... 260 °C

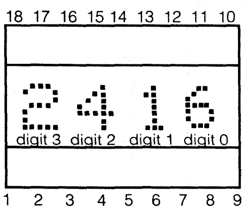
Optical Characteristics

Spectral Peak Wavelength
Red ....660 nm typ.
HER ....630 nm typ.
Green ....565 nm typ.
Character Height..0.200" (5.08 mm)
Time Averaged Luminous Intensity (1)
at V_{CC}=5 V
Red..60 µcd/LED typ.
HER..100 µcd/LED typ.
Green ....120 µcd/LED typ.
LED to LED Intensity Matching at V_{CC}=5 V .... 1.8:1.0 max.
LED to LED Hue Matching (Green only)
at V_{CC}=5 V ....±2 nm max.
Viewing Angle (off normal axis)
Horizontal ....±50° max.
Vertical ....±75° max.

Note:

1) Peak luminous intensity values can be calculated by multiplying these values by 7.

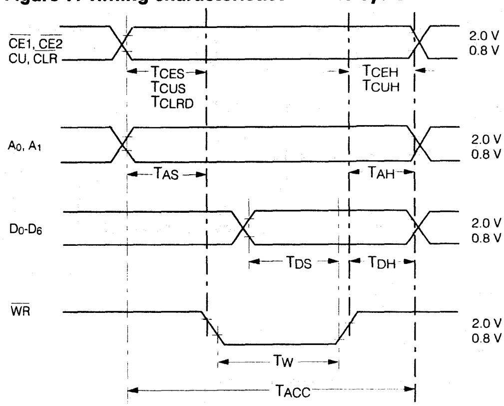
Figure 6. Top view



Pins and functions

Pin	Function	Pin	Function
1	$\overline{CE1}$ Chip Enable	10	GND
2	CE2 Chip Enable	11	D0 Data Input
3	$\overline{CLR}$ Clear	12	D1 Data Input
4	CUE Cursor Enable	13	D2 Data Input
5	$\overline{CU}$ Cursor Select	14	D3 Data Input
6	$\overline{WR}$ Write	15	D6 Data Input
7	A1 Digit Select	16	D5 Data Input
8	A0 Digit Select	17	D4 Data Input
9	V_{CC}	18	$\overline{BL}$ Display Blank

Figure 7. Timing characteristics—write cycle waveforms



Note:

These waveforms are not edge triggered.

DC characteristics

Parameter	–40°C			+25°C			+85°C			Units	Condition
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} 80 dots on		135	160		110	130		95	115	mA	V_{CC}=5 V
I_{CC} Cursor all dots at 50%			135			100			100	mA	V_{CC}=5 V
I_{CC} Blank		2.8	4.0		2.3	3.0		2.0	2.5	mA	V_{CC}=5 V, $\overline{BL}$=0.8 V
I_{IL} (all inputs)	30	60	120	25	50	100	20	40	80	µA	V_{IN}=0.8 V, V_{CC}=5 V
V_{IH} (all inputs)	2.0			2.0			2.0			V	V_{CC}=5 V ±0.5 V
V_{IL} (all inputs)			0.8			0.8			0.8	V	V_{CC}=5 V ±0.5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

AC characteristics (guaranteed minimum timing parameters at V_{CC}=5.0 V ±0.5 V)

Parameter	Symbol	-40°C	+25°C	+85°C	Unit
Chip Enable Set Up Time	T_{CES}	0	0	0	ns
Address Set Up Time	T_{AS}	10	10	10	ns
Cursor Set Up Time	T_{CUS}	10	10	10	ns
Chip Enable Hold Time	T_{CEH}	0	0	0	ns
Address Hold Time	T_{AH}	20	30	40	ns
Cursor Hold Time	T_{CUH}	20	30	40	ns
Clear Disable Time	T_{CLRD}	1	1	1	µs
Write Time	T_{W}	60	70	90	ns
Data Set Up Time	T_{DS}	20	30	50	ns
Data Hold Time	T_{DH}	20	30	40	ns
Clear Time	T_{CLR}	1	1	1	µs
Access Time	T_{ACC}	90	110	140	ns

Note:

T_{ACC}=Set Up Time+Write Time+Hold Time.

Figure 8. Internal block diagram

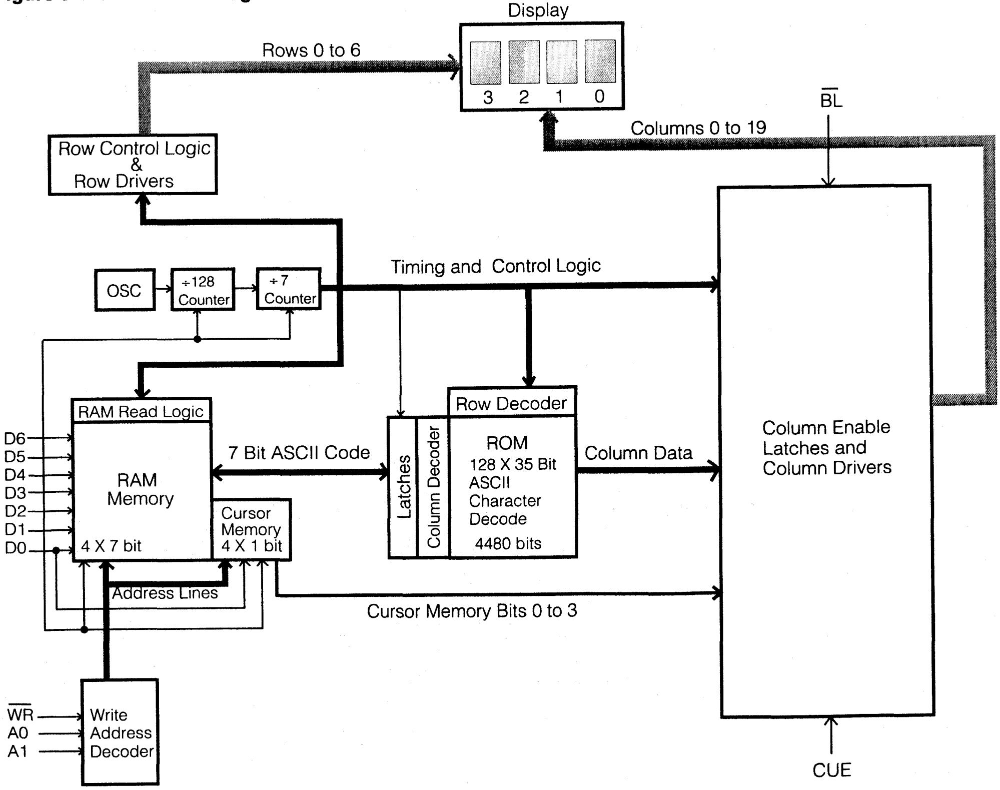


Table 2. Loading data table

Control							Address		Data							Display Digit			
$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	L	X	H	H	previously loaded display									G	R	E	Y
H	H	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	H	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	G	R	E	E
H	L	L	L	H	L	H	L	H	H	L	H	L	H	L	H	G	R	U	E
H	L	L	L	H	L	H	H	L	H	L	L	H	H	L	L	G	L	U	E
H	L	L	L	H	L	H	H	H	H	L	L	L	L	H	L	B	L	U	E
L	X	X	X	X	H	H	X	X	blank display										
H	L	L	L	H	L	H	H	H	H	L	L	L	H	H	H	G	L	U	E
H	X	X	L	X	H	L	X	X	clears character displays										
H	L	L	L	H	L	H	X	X	see character code							see character set			

X=don't care

Table 3. Loading cursor table

																	Digit				
$\overline{BL}$	CE1	CE2	$\overline{CE3}$	$\overline{CE4}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	X	X	L	X	H	H	previously loaded display									B	E	A	R
H	X	X	X	X	H	X	H	H	display previously stored cursors									B	E	A	R
H	H	H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	B	E	A	■
H	H	H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	B	E	■	■
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	B	■	■	■
H	H	H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	■	■	■	■
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	L	■	E	■	■
H	X	X	X	X	L	X	H	H	disable cursor display									B	E	A	R
H	H	H	L	L	L	L	L	H	H	H	X	X	X	X	X	X	L	B	E	A	R
H	X	X	X	X	H	H	X	H	display stored cursors									B	E	■	■

X=don't care ■= all dots on

Loading Data

Setting the chip enable ($\overline{CE1}$, $\overline{CE2}$) to their true state will enable data loading. The desired data code (D0-D6) and digit address (A0, A1) must be held stable during the write cycle for storing new data.

Data entry may be asynchronous and random. Digit 0 is defined as right hand digit with A1=A2=0.`

To clear the entire internal four-digit memory hold the clear ($\overline{CLR}$) low for 1 µs. All illuminated dots will be turned off within one complete display multiplex cycle, 1 msec minimum. The clear function will clear both the ASCII RAM and the cursor RAM.

Loading Cursor

Setting the chip enables ($\overline{CE1}$, $\overline{CE2}$) and cursor select ($\overline{CU}$) to their true state will enable cursor loading. A write ($\overline{WR}$) pulse will now store or remove a cursor into the digit location addressed by A0, A1, as defined in data entry. A cursor will be stored if D0=1 and will removed if D0=0. The cursor ($\overline{CU}$) pulse width should not be less than the write ($\overline{WR}$) pulse or erroneous data may appear in the display.

If the cursor is not required, the cursor enable signal (CUE) may be tied low to disable the cursor function. For a flashing cursor, simply pulse CUE. If the cursor has been loaded to any or all positions in the display, then CUE will control whether the cursor(s) or the characters will appear. CUE does not affect the contents of cursor memory.

Display Blanking

Blanking the display may be accomplished by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input.

Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory.

A flashing circuit can easily be constructed using a 555 astable multivibrator. Figure 4 illustrates a circuit in which varying R2 (100K~10K) will have a flash rate of 1 Hz~10 Hz.

The display can be dimmed by pulse width modulating the ($\overline{BL}$) at a frequency sufficiently fast to not interfere with the internal clock. The dimming signal frequency should be 2.5 KHz or higher. Dimming the display also reduces power consumption.

An example of a simple dimming circuit using a 556 is illustrated in Figure 5. Adjusting potentiometer R3 will dim the display by changing the blanking pulse duty cycle.

Design Considerations

For details on design and applications of the DLX2416 using standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, or 6800, refer to Appnote 15 in the current Siemens Optoelectronics Data Book.

Figure 9. DLX2416—flashing circuit using a 555 and flashing (blanking) timing

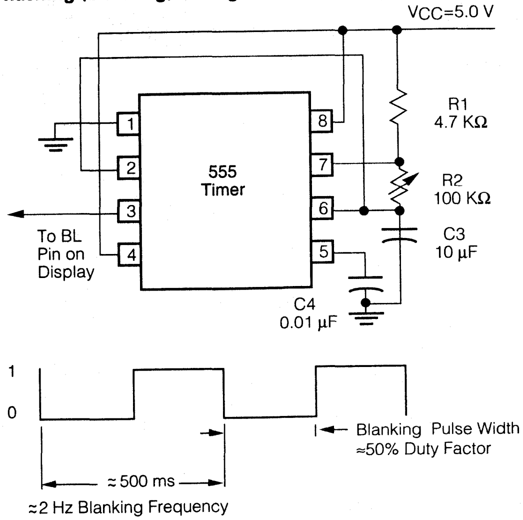


Figure 10. DLX2416—dimming circuit using a 556 and dimming (blanking) timing

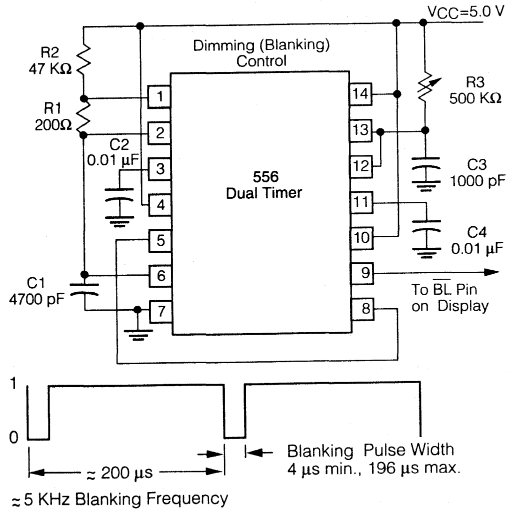
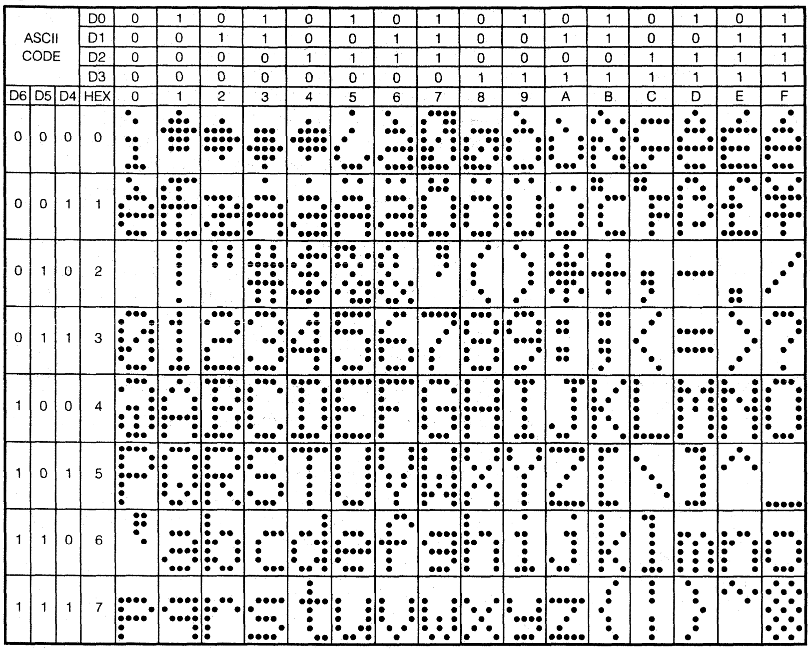


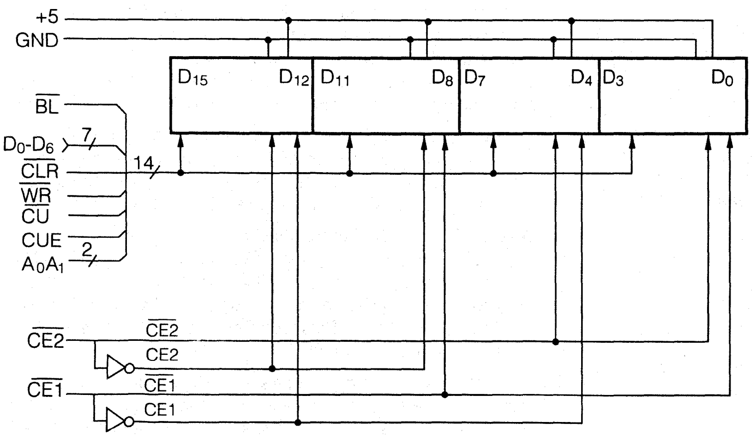
Figure 11. Character set



Notes:

1. High=1 level
2. Low=0 level
3. Upon power up, the device will initialize in a random state.

Figure 12. Typical schematic, 16-character system



Electrical and Mechanical Considerations

Voltage Transient Suppression

We recommend that the same power supply be used for the display and the components that interface with the display to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place .01 mF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 mF capacitor for every second display.

ESD Protection

The silicon gate CMOS IC of the DLX2416 is quite resistant to ESD damage and capable of withstanding discharges greater than 2 KV. However, take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The DLX2416 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Carefully select any solvent as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichorotrifluorethane), TA, 111 Trichloroethane, and unheated acetone.

Note:

Acceptable commercial solvents are: Basic TF, Arklone, P. Genesolv, D. Genesolv DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Siemens Appnotes 18 and 19.

An alternative to soldering and cleaning the display modules is to use sockets. Standard pin DIP sockets .600" wide with 0.100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswich, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Siemens Appnote 22.

Optical Considerations

The 0.200" high characters of the DLX2416 gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Filters enhance the contrast ratio between a lit LED and the character background intensifying the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios.

The DLR2416 is a standard red display and should be matched with long wavelength pass filter in the 600 nm to 620 nm range. The DLO2416 is a high efficiency red display and should be matched with a long wavelength pass filter in the 470 nm to 590 range. The DLG2416 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density gray filters offer the best compromise.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. Circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

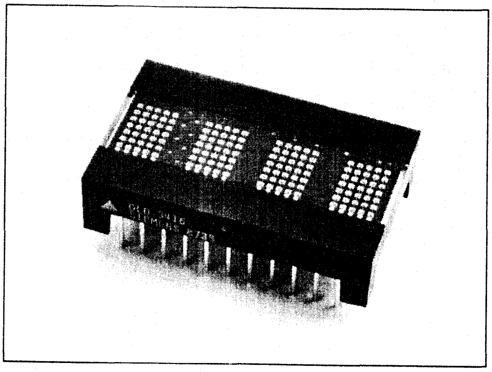
One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; .E.E.-Atlas, Van Nuys, CA.

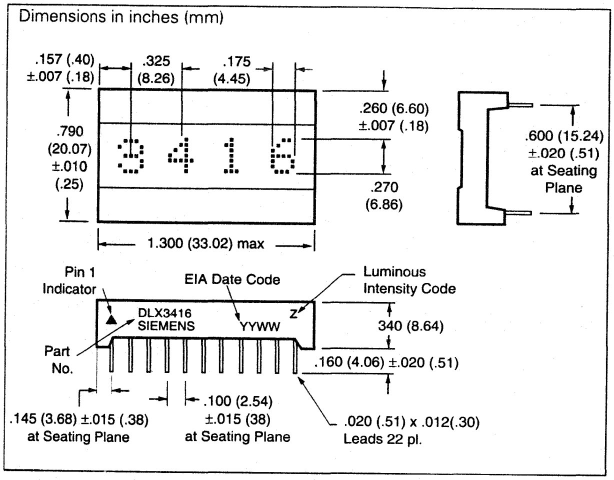
Refer to Siemens Appnote 23 for further information.

SIEMENS

RED DLR3416
HIGH EFFICIENCY RED DLO3416
GREEN DLG3416

0.270" 4-Character 5x7 Dot Matrix Alphanumeric Intelligent Display® Devices with Memory/Decoder/Driver





FEATURES

- **0.270" 5x7 Dot Matrix Characters**
- **128 Special ASCII Characters for English, German, Italian, Swedish, Danish, and Norwegian Languages**
- **Wide Viewing Angle: X Axis 50° Maximum, Y Axis ±75° Maximum**
- **Close Vertical Row Spacing, 0.800" Centers**
- **Fast Access Time, 110 ns at 25°C**
- **Full Size Display for Stationary Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Each Character Independently Accessed**
- **TTL Compatible, 5 Volt Power, V_{IH}=2.0 V, V_{IL}=0.8 V**
- **Independent Cursor Function**
- **Memory Clear Function**
- **Display Blank Function for Blinking and Dimming**
- **End-Stackable, 4-Character Package**
- **Intensity Coded for Display Uniformity**
- **Extended Operating Temperature Range: –40°C to +85°C**
- **Wave Solderable**

See Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION

The DLR/DLO/DLG3416 is a four character 5x7 dot matrix display module with a built-in CMOS integrated circuit.

The integrated circuit contains memory, ASCII ROM decoder, multiplexing circuitry and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DLX3416s since each character can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is very straightforward. The least significant two address bits (A0, A1) are normally connected to the like-named inputs of all displays in the system. With four chip enables, four displays (16 characters) can easily be interconnected without a decoder.

Data lines are connected to all DLX3416s directly and in parallel, as is the write line ($\overline{WR}$). The display will then behave as a write-only memory.

The cursor function causes all dots of a character position to illuminate at half brightness. The cursor is not a character, and when removed the previously displayed character will reappear.

The DLX3416 has several features superior to competitive devices. True "blanking" allows the designer to dim the display for more flexibility of display presentation. Finally the CLR clear function will clear the cursor RAM and the ASCII character RAM simultaneously.

The character set consists of 128 special ASCII characters for English, German, Italian, Swedish, Danish, and Norwegian.

All products are subjected to out-going AQL's of 0.25% for brightness matching, visual alignment and dimensions, 0.065% for electrical and functional.

Maximum Ratings

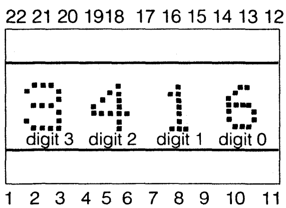
DC Supply Voltage .... –0.5 V to +7.0 Vdc
Input Voltage, Respect to GND
(all inputs) .... –0.5 V to V_{CC} +0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... 40°C to +100°C
Relative Humidity at 85°C
(non-condensing) 85%
Maximum Solder Temperature, 0.063" (1.59 mm)
below Seating Plane, t<5 sec .... 260°C

Optical Characteristics

Spectral Peak Wavelength
Red .... 660 nm typ.
HER .... 630 nm typ.
Green .... 565 nm typ.
Character Height .... 0.270" (6.86 mm)
Time Averaged Luminous Intensity [(1)]
at V_{CC}=5 V
Red .... 60 µcd/LED typ.
HER .... 120 µcd/LED typ.
Green .... 140 µcd/LED typ.
Dot to Dot Intensity Matching
at V_{CC}=5 V .... 1.8:1.0 max.
LED to LED Hue Matching
(Green only) at V_{CC}=5 V .... ±2 nm max.
Viewing Angle (off normal axis)
Horizontal .... ±50° max.
Vertical .... ±75° max.

Note:
1) Peak luminous intensity values can be calculated by multiplying these values by 7.

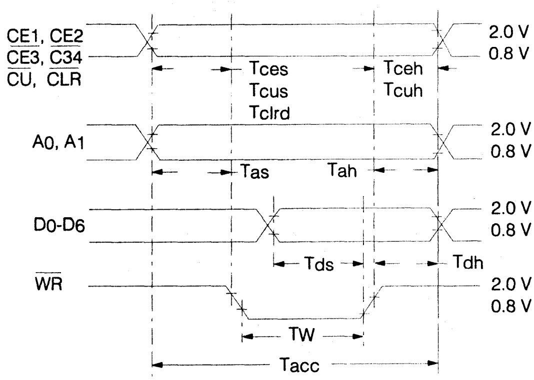
Figure 6. Top view



Pins and functions

Pin	Function	Pin	Function
1	CE1 Chip Enable	12	GND
2	CE2 Chip Enable	13	NC
3	$\overline{CE3}$ Chip Enable	14	$\overline{BL}$ Blanking
4	$\overline{CE4}$ Chip Enable	15	NC
5	$\overline{CLR}$ Clear	16	D0 Data Input
6	V_{CC}	17	D1 Data Input
7	A0 Digit Select	18	D2 Data Input
8	A1 Digit Select	19	D3 Data Input
9	$\overline{WR}$ Write	20	D4 Data Input
10	CU Cursor Select	21	D5 Data Input
11	CUE Cursor Select	22	D6 Data Input

Figure 7. Timing characteristics, write cycle waveforms



Note:
These waveforms are not edge triggered.

DC characteristics

Parameter	–40°C			+25°C			+55°C			Units	Condition
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} 80 dots on		150	190		135	165		118	150	mA	V_{CC}=5 V
I_{CC} Cursor			170			140			125	mA	V_{CC}=5 V
I_{CC} Blank		2.8	4.0		2.3	3.0		2.0	2.5	mA	V_{CC}=5 V, $\overline{BL}$=0.8 V
I_{IL} (all inputs)	30	60	120	25	50	100	20	40	80	µA	V_{IN}=0.8 V, V_{CC}=5 V
V_{IH} (all inputs)	2.0			2.0			2.0			V	V_{CC}=5 V
V_{IL} (all inputs)			0.8			0.8			0.8	V	V_{CC}=5 V
V_{CC}	4.5	5.0	5.5	4.5	5.0	5.5	4.5	5.0	5.5	V	

AC characteristics (guaranteed minimum timing parameters at V_{CC}=5.0 V ±0.5 V)

Parameter	Symbol	–40°C	+25°C	+85°C	Unit
Chip Enable Set Up Time	T_{CES}	0	0	0	ns
Address Set Up Time	T_{AS}	10	10	10	ns
Cursor Set Up Time	T_{CUS}	10	10	10	ns
Chip Enable Hold Time	T_{CEH}	0	0	0	ns
Address Hold Time	T_{AH}	20	30	40	ns
Cursor Hold Time	T_{CUH}	20	30	40	ns
Clear Disable Time	T_{CLRD}	1	1	1	µs
Write Time	T_W	60	70	90	ns
Data Set Up Time	T_{DS}	20	30	50	ns
Data Hold Time	T_{DH}	20	30	40	ns
Clear Time	T_{CLR}	1	1	1	µs
Access Time	T_{ACC}	90	110	140	ns

Note:

T_{ACC}=Set Up Time+Write Time+Hold Time.

Figure 8. Internal block diagram

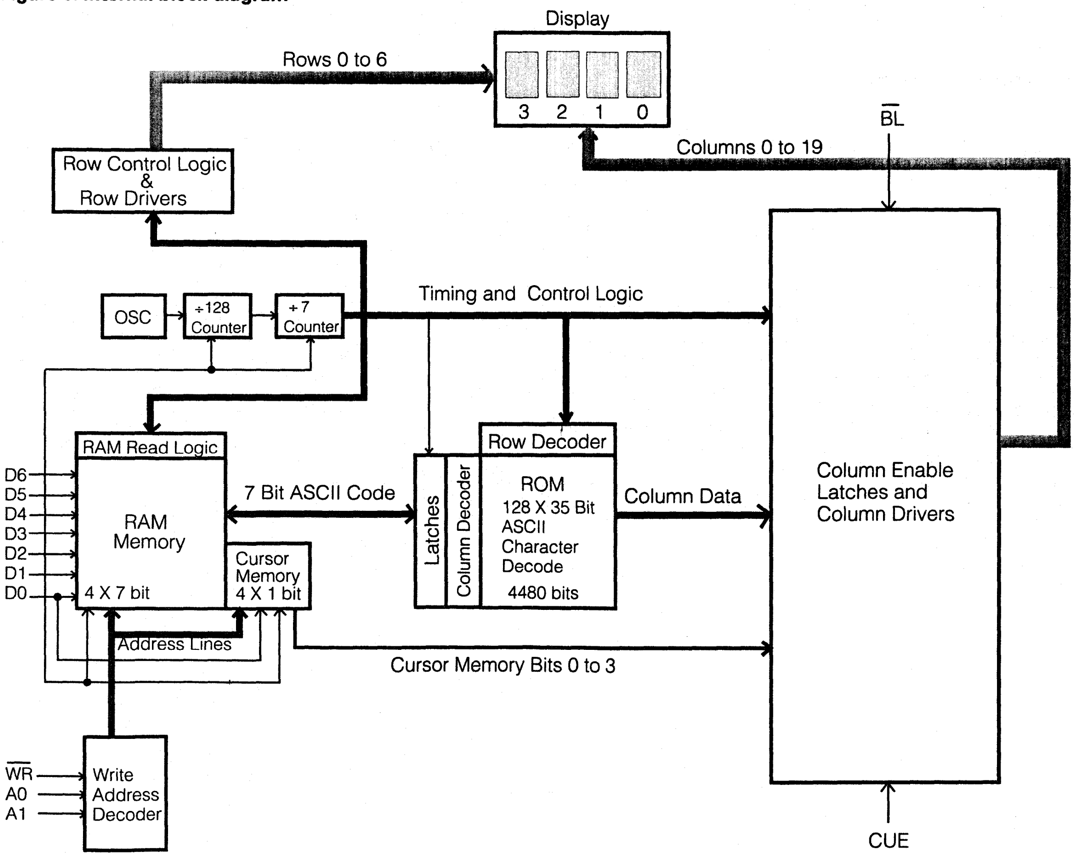


Table 2. Typical loading data state table

Control									Address		Data							Display Digit			
$\overline{\text{BL}}$	CE1	CE2	CE3	CE4	CUE	CU	$\overline{\text{WR}}$	$\overline{\text{CLR}}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	X	X	L	X	H	H	previously loaded display									G	R	E	Y
H	L	X	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	L	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	H	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	X	H	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	X	X	X	L	X	H	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	H	H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	G	R	E	E
H	H	H	L	L	L	H	L	H	L	H	H	L	H	L	H	L	H	G	R	U	E
H	H	H	L	L	L	H	L	H	H	L	H	L	L	H	H	L	L	G	L	U	E
H	H	H	L	L	L	H	L	H	H	H	L	L	L	L	L	H	L	B	L	U	E
L	X	X	X	X	X	X	H	H	X	X	L	blank display									
H	H	H	L	L	L	H	L	H	H	H	L	L	L	L	H	H	H	G	L	U	E
H	X	X	X	X	L	X	X	L		clears character display											
H	H	H	L	L	L	H	L	H	X	X		see character code						see character set			

X=don't care

Table 3. Loading cursor state table

																		Digit			
$\overline{\text{BL}}$	CE1	CE2	$\overline{\text{CE3}}$	$\overline{\text{CE4}}$	CUE	$\overline{\text{CU}}$	$\overline{\text{WR}}$	$\overline{\text{CLR}}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	X	X	L	X	H	H	previously loaded display									B	E	A	R
H	X	X	X	X	H	X	H	H	display previously stored cursors									B	E	A	R
H	H	H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	B	E	A	■
H	H	H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	B	E	■	■
H	H	H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	B	■	■	■
H	H	H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	■	■	■	■
H	H	H	L	L	H	L	L	H	H	L	H	L	L	L	H	L	L	■	E	■	■
H	X	X	X	X	L	X	H	H	disable cursor display									B	E	A	R
H	H	H	L	L	L	L	L	H	H	H	X	X	X	X	X	X	L	B	E	A	R
H	X	X	X	X	H	X	H	H	display stored cursors									B	E	■	■

X=don't care ■= all dots on

Loading Data

Setting the chip enable (CE1, CE2, $\overline{CE3}$, $\overline{CE4}$) to their true state will enable loading. The desired data code (D0-D6) and digit address (A0, A1) must be held stable during the write cycle for storing new data.

Data entry may be asynchronous and random. Digit 0 is defined as right hand digit with A1=A2=0.

To clear the entire internal four-digit memory hold the clear ($\overline{CLR}$) low for 1 µs. All illuminated dots will be turned off within one complete display multiplex cycle, 1 msec minimum. The clear function will clear both the ASCII RAM and the cursor RAM.

Loading Cursor

Setting the chip enables (CE1, CE2, $\overline{CE3}$, $\overline{CE4}$) and cursor select ($\overline{CU}$) to their true state will enable cursor loading. A write ($\overline{WR}$) pulse will now store or remove a cursor into the digit location addressed by A0, A1, as defined in data entry. A cursor will be stored if D0=1 and will removed if D0=0. The cursor ($\overline{CU}$) pulse width should not be less than the write ($\overline{WR}$) pulse or erroneous data may appear in the display.

If the cursor is not required, the cursor enable signal (CUE) may be tied low to disable the cursor function. For a flashing cursor, simply pulse CUE. If the cursor has been loaded to any or all positions in the display, then CUE will control whether the cursor(s) or the characters will appear. CUE does not affect the contents of cursor memory.

Display Blanking

Blank the display by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input.

Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory. A flashing display can be achieved by pulsing ($\overline{BL}$). A flashing circuit can be constructed using a 555 a stable multivibrator. Figure 4 illustrates a circuit in which varying R2 (100K~10K) will have a flash rate of 1 Hz~10 Hz.

The display can be dimmed by pulsing ($\overline{BL}$) line at a frequency sufficiently fast to not interfere with the internal clock. The dimming signal frequency should be 2.5 KHz or higher. Dimming the display also reduces power consumption.

An example of a simple dimming circuit using a 556 is illustrated in Figure 5. Adjusting potentiometer R3 will dim the display by changing the blanking pulse duty cycle.

Design Considerations

For details on design and applications of the DLX3416 using standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, or 6800, refer to Appnote 15 in the current Siemens Optoelectronics Data Book.

Figure 9. Flashing circuit using a 555 and flashing (blanking) timing

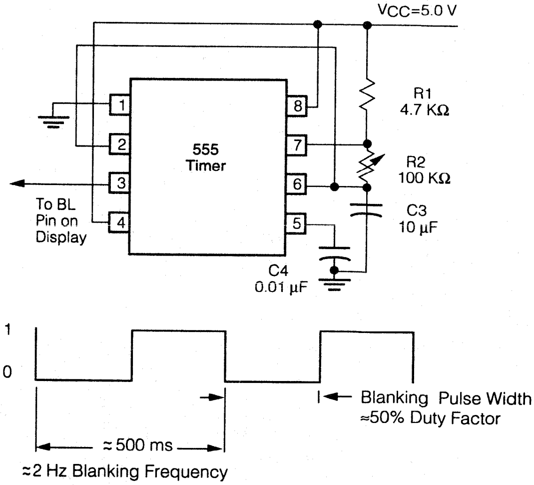


Figure 10. Dimming circuit Using a 556

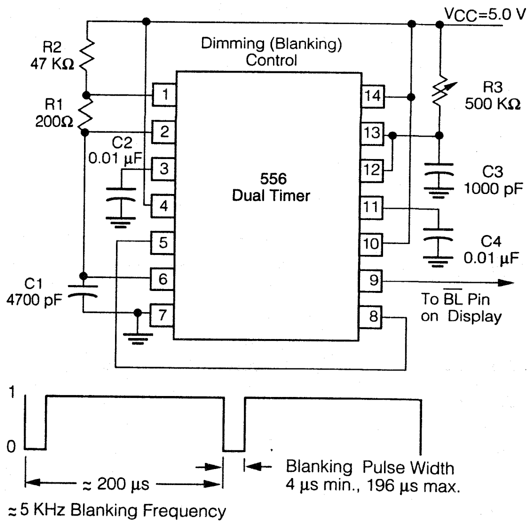
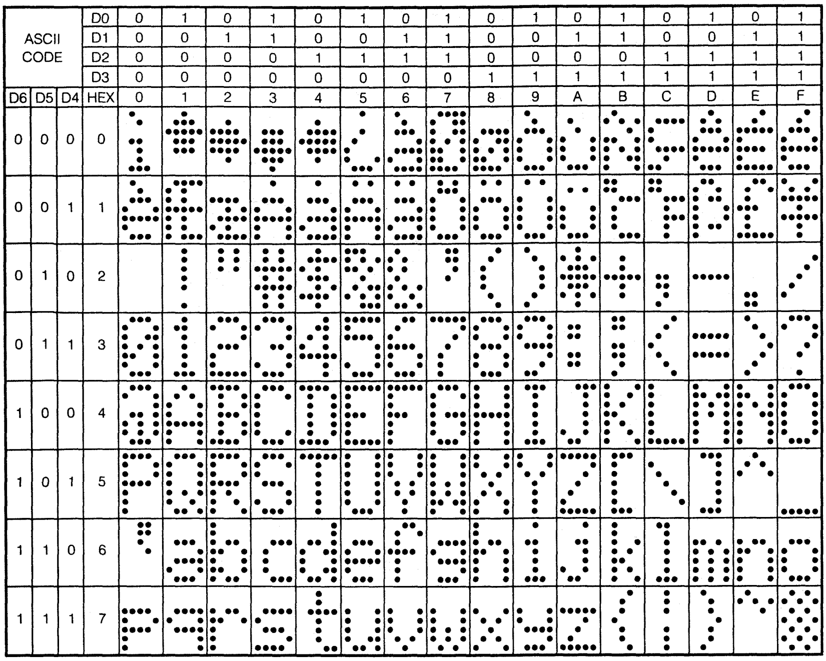


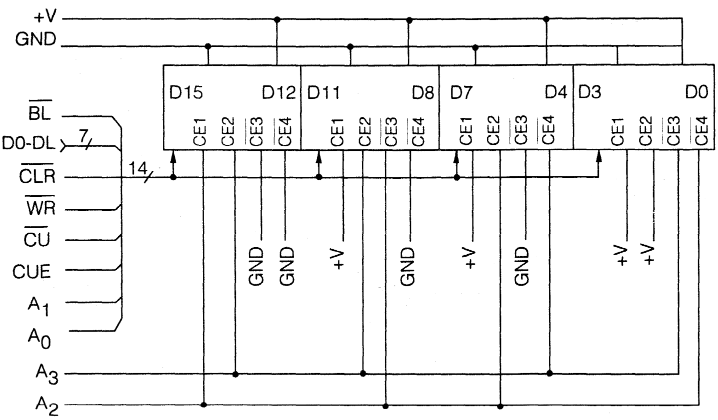
Figure 11. Character set



Notes:

1. High=1 level
2. Low=0 level
3. Upon power up, the device will initialize in a random state.

Figure 12. Typical schematic, 16-character system



Electrical and Mechanical Considerations

Voltage Transient Suppression

We recommend that the same power supply be used for the display and the components that interface with the display to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place .01 mF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 mF capacitor for every second display.

ESD Protection

The silicon gate CMOS IC of the DLX3416 is quite resistant to ESD damage and capable of withstanding discharges greater than 2 KV. However, take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The DLX3416 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Carefully select any solvent as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichorotribluorethane), TA, 111 Trichloroethane, and unheated acetone.

Note:

Acceptable commercial solvents are: Basic TF, Arklone, P. Genesolv, D. Genesolv DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Siemens Appnotes 18 and 19.

An alternative to soldering and cleaning the display modules is to use sockets. Standard pin DIP sockets .600" wide with 0.100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswich, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Siemens Appnote 22.

Optical Considerations

The 0.270" high characters of the DLX3416 gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Filters enhance the contrast ratio between a lit LED and the character background intensifying the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios.

The DLR3416 is a standard red display and should be matched with long wavelength pass filter in the 600 nm to 620 nm range. The DLO3416 is a high efficiency red display and should be matched with a long wavelength pass filter in the 470 nm to 590 range. The DLG3416 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density gray filters offer the best compromise.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. Circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

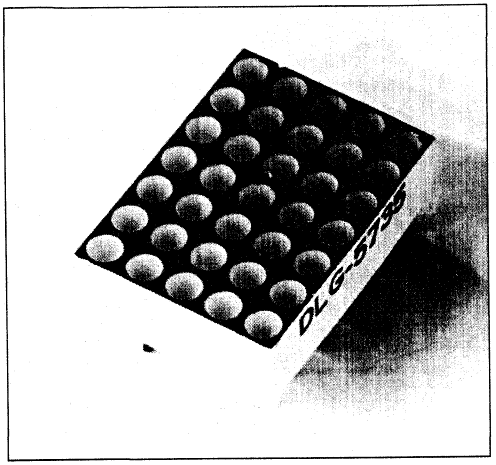
One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; .E.E.-Atlas, Van Nuys, CA.

Refer to Siemens Appnote 23 for further information.

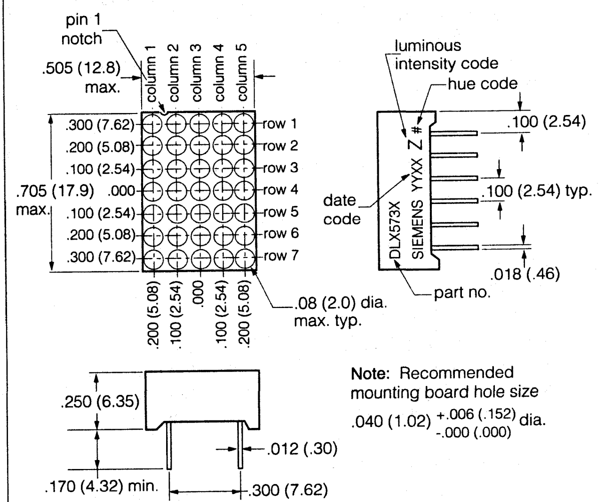
SIEMENS

RED DLR5735
RED DLR5736
GREEN DLG5735
GREEN DLG5736

0.69" (17.5 mm) Single Character 5x7 Dot Matrix Alphanumeric Display (No Built-In CMOS Drive Circuitry)



Dimensions in inches (mm)



Note: Recommended mounting board hole size .040 (1.02) +.006 (.152) -.000 (.000) dia.

FEATURES

- **DLR/DLG5735 Common Row Cathode**
- **DLR/DLG5736 Common Row Anode**
- **5x7 Matrix Array with Row-Column Select**
- **End & Side Stackable**
- **Rugged Encapsulation (Filled Reflector Construction)**
- **Compatible with ASCII and EBCDIC Format**
- **Standard 12 pin, 0.3" Pin Spacing, Dual-In-line Package**
- **Good "OFF" Segment Contrast**
- **Grey Face with Clear Segments**

DESCRIPTION

The DLR5735/5736 Series (gallium arsenide phosphide) and the DLG5735/5736 Series (gallium phosphide) are 5x7 dot matrix light emitting diode alphanumeric displays.

Compatible with ASCII and EBCDIC formats, these displays are well suited for use in keyboard verfiers, computer peripheral equipment, and other applications requiring an alphanumeric display. They are stackable both horizontally and vertically to generate large alphanumeric or even graphic displays.

Maximum Ratings

Power Dissipation (Package) .... 750 mW
Derate Linearly from 25°C .... 11.5 mW/°C
Storage/Operating Temperature .... –20°C to +70°C
Continuous Forward Current Per Segment .... 20 mA
Pulse Peak Current/Segment, 20% DutyCycle 100mA
Reverse Voltage
  DLR5735/5736 .... 3 V
  DLG5735/5736 .... 5 V
Solder Temperature, 1/16" below seating plane, 5 sec. .... 260°C

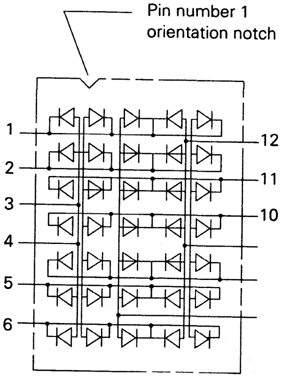
Electrical/optical characteristics (T_A=25°C)

Parameter	Min.	Typ.	Max.	Unit	Condition
Luminous Intensity Digit Average (per dot)					
DLR5735/5736	100	200		µcd	I_F=20 mA
DLG5735/5736	320	650		µcd	I_F=10 mA
Forward Voltage					
DLR5735/5736		1.7	2.0	V	I_F=20 mA
DLG5735/5736		2.3	3.0	V	I_F=20 mA
Reverse Current					
DLR5735/5736			100	µA	V_R=3 V
DLG5735/5736			100	µA	V_R=5 V
Peak Emission Wavelength					
DLR5735/5736		650		nm	
DLG5735/5736		565		nm	
Spectral Line Half-width					
DLR5735/5736		40		nm	
DLG5735/5736		30		nm	

Pin Configurations

DLR5735
DLG5735

SCHEMATIC

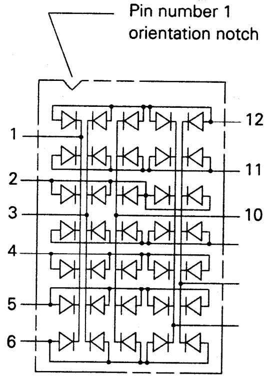


TOP VIEW

Pin	Function
1	Row 1 Cathode
2	Row 2 Cathode
3	Column 2 Anode
4	Column 1 Anode
5	Row 6 Cathode
6	Row 7 Cathode
7	Column 3 Anode
8	Row 5 Cathode
9	Column 4 Anode
10	Row 4 Cathode
11	Row 3 Cathode
12	Column 5 Anode

DLR5736
DLG5736

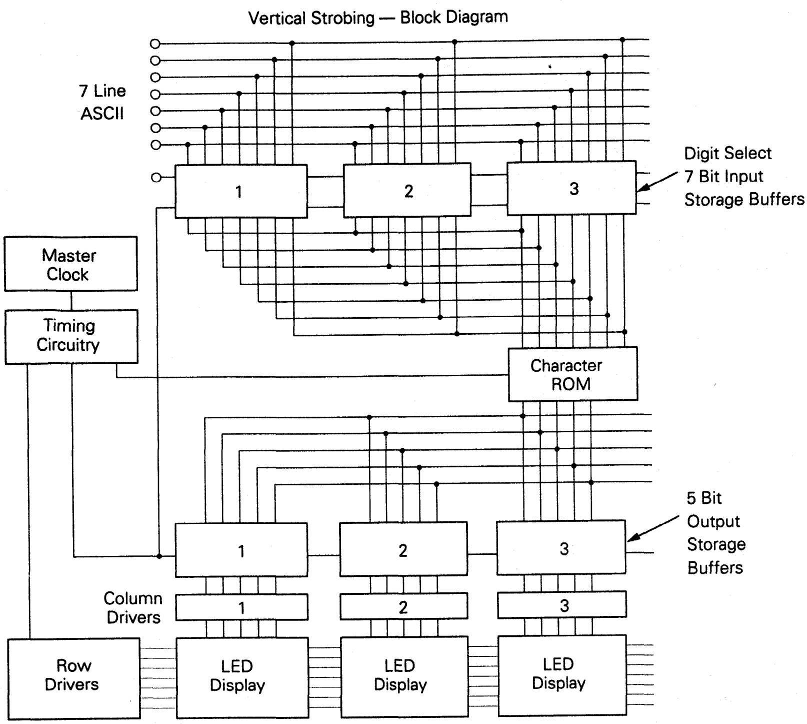
SCHEMATIC



TOP VIEW

Pin	Function
1	Column 1 Cathode
2	Row 3 Anode
3	Column 2 Cathode
4	Row 5 Anode
5	Row 6 Anode
6	Row 7 Anode
7	Column 4 Cathode
8	Column 5 Cathode
9	Row 4 Anode
10	Column 3 Cathode
11	Row 2 Anode
12	Row 1 Anode

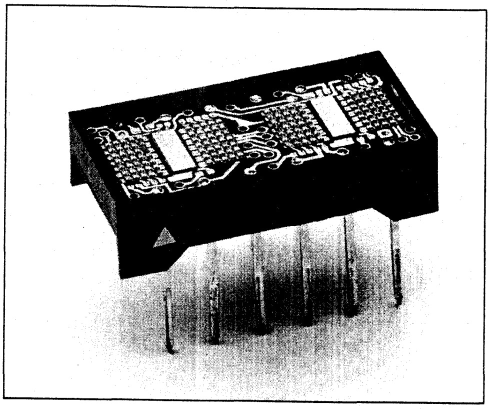
Block Diagram

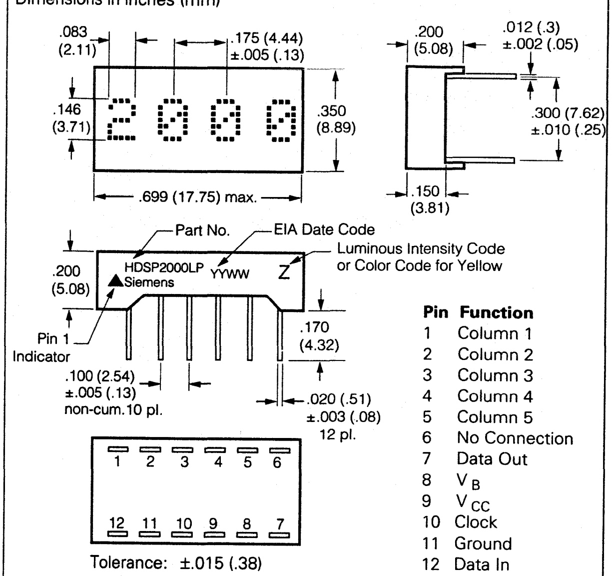


SIEMENS

RED HDSP2000LP
YELLOW HDSP2001LP
HIGH EFFICIENCY RED HDSP2002LP
GREEN HDSP2003LP

0.150" 4-Character 5x7 Dot Matrix Serial Input Alphanumeric Display





Pin	Function
1	Column 1
2	Column 2
3	Column 3
4	Column 4
5	Column 5
6	No Connection
7	Data Out
8	V_B
9	V_{CC}
10	Clock
11	Ground
12	Data In

FEATURES

- **Four 0.150" Dot Matrix Characters**
- **Four Colors: Red, Yellow, High Efficiency Red, Green**
- **Wide Viewing Angle: X Axis +50°, Y Axis +75°**
- **Built-in CMOS Shift Registers with Constant Current LED Row Drivers**
- **Custom Fonts from Shift Registers**
- **Easily Cascaded for Multiple Displays**
- **TTL Compatible**
- **End Stackable**
- **Extended Operating Temperature Range: –40°C to + 85°C**
- **Categorized for Luminous Intensity**
- **All Displays Color Matched**
- **Compact Plastic Package**
- **100% Burned-in and Tested**

See Appnote 44 for application information.

DESCRIPTION

The HDSP200XLP are four digit 5x7 dot matrix serial input alphanumeric displays. The displays are available in red, yellow, high efficiency red, or bright green. The package is a standard twelve-pin DIP with a flat plastic lens. The display can be stacked horizontally or vertically to form messages of any length.

The HDSP200XLP has two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin (see Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5x7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

—Continued

DESCRIPTION (continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations. Then column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF = \frac{T}{5(T+t)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: 1/[5x(100)] =2 msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

Maximum Ratings

Supply Voltage V_{CC} to GND .... –0.5 V to +7.0 V
Inputs, Data Out and V_B .... –0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} .... –0.5 V to +6.0 V
Operating Temperature Range .... –40°C to +85°C
Storage Temperature Range........................... –40°C to +100°C
Maximum Solder Temperature 0.063" (1.59 mm)
below Seating Plane, t<5 sec...................................... 260°C
Maximum Allowable Power Dissipation
at T_A=25°C [1] ....0.86 W

Note:

1) Maximum allowable dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V, 20 LEDs on per character, 20% DF.

Figure 1. Timing characteristics

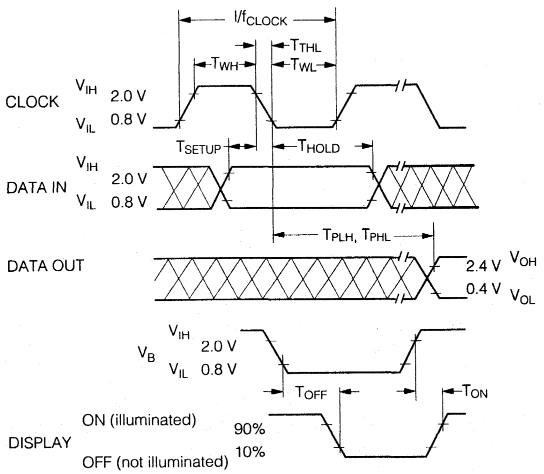
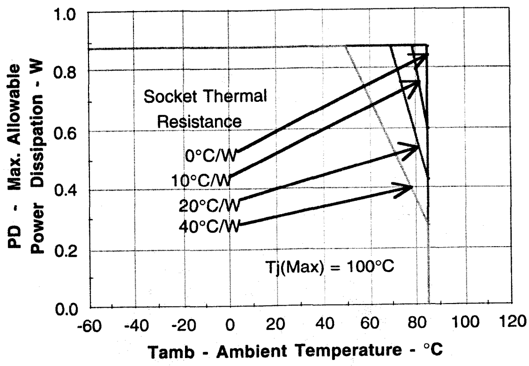


Figure 2. Maximum allowable power dissipation versus temperature



AC electrical characteristics
(V_{CC}=4.75 to 5.25 V, T_A=–40°C to 85°C)

Symbol	Description	Min.	Max.[1]	Units	Fig.
T_{SETUP}	Setup Time	50		ns	1
T_{HOLD}	Hold Time	25		ns	1
T_{WL}	Clock Width Low	75		ns	1
T_{WH}	Clock Width High	75		ns	1
$F_{(CLK)}$	Clock Frequency	0	5	MHz	1
T_{THL}, T_{TLH}	Clock Transition Time		200	ns	1
T_{PHL}, T_{PLH}	Propagation Delay Clock to Data Out		125	ns	1

Note:

1) V_B Pulse Width Modulation Frequency—50 KHz (max).

Cleaning the Displays

IMPORTANT—Do not use cleaning agents containing alcohol of any type with this display. The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For post solder cleaning use water or non-alcohol mixtures formulated for vapor cleaning processing or non-alcohol mixtures formulated for room temperature cleaning. Nonalcohol vapor cleaning processing for up to two minutes in vapors at boiling is permissible. For suggested solvents refer to Siemens Appnote 19.

Recommended operating conditions

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, High State	I_{OH}	–0.5			mA
Column Input Voltage, Column On HDSP2000LP [1]	V_{COL}	2.4		3.5	V
Column Input Voltage, Column On, HDSP2001LP/2002LP/2003LP [1]	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70			ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns

Note:
1) See Figure 3: Peak column current versus column voltage

Optical Characteristics
Red HDSP2000LP

Description	Symbol	Min.	Typ. [4]	Units	Test Conditions
Peak Luminous Intensity per LED [1,3] (Character Average)	I_{VPEAK}	105	200	µcd	V_{CC}=5.0 V, V_{COL}=3.5 V T_A=25°C, V_B=2.4 V
Peak Wavelength	λ_{VPEAK}		655	nm	
Dominant Wavelength [2]	λ_D		639	nm	

Yellow HDSP2001LP

Description	Symbol	Min.	Typ. [4]	Units	Test Conditions
Peak Luminous Intensity per LED [1,3] (Character Average)	I_{VPEAK}	400	1140	µcd	V_{CC}=5.0 V, V_{COL}=3.5 V T_A=25°C, V_B=2.4 V
Peak Wavelength	λ_{VPEAK}		583	nm	
Dominant Wavelength [2]	λ_D		585	nm	

High Efficiency Red HDSP2002LP

Description	Symbol	Min.	Typ. [4]	Units	Test Conditions
Peak Luminous Intensity per LED [1,3] (Character Average)	I_{VPEAK}	400	1430	µcd	V_{CC}=5.0 V, V_{COL}=3.5 V T_A=25°C, V_B=2.4 V
Peak Wavelength	λ_{VPEAK}		635	nm	
Dominant Wavelength [2]	λ_D		626	nm	

Green HDSP2003LP

Description	Symbol	Min.	Typ. [4]	Units	Test Conditions
Peak Luminous Intensity per LED [1,3] (Character Average)	I_{VPEAK}	650	1550	µcd	V_{CC}=5.0 V, V_{COL}=3.5 V T_A=25°C, V_B=2.4 V
Peak Wavelength	λ_{VPEAK}		565	nm	
Dominant Wavelength [2]	λ_D		569	nm	

Notes:
1) The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2) Dominant wavelength (λD) is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3) The luminous sterance of the LED may be calculated using the following relationships:
L_V (cd/m^2)=I_V (Candela)/A (Meter)^2
L_V (Footlamberts)= πI_V (Candela)/A (Foot)^2
HDSP2000LP, A=5 58x10^{-8} m^2=6x10^{-7} ft.^{2}
HDSP2001/2/3LP, A=7.8x10^{-8}m^2=8.4x10^{-7}ft.^{2}
4) All typical values specified at V_{CC}=5.0 V and T_A=25 °C unless otherwise noted.

Electrical characteristics (–40°C to +85°C, unless otherwise specified)

Description	Symbol	Min.	Typ.[1]	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}		1	5	mA	V_B=0.4 V	V_{CC}=5.25 V V_{CLK}=V_{DATA}=2.4 V All SR Stages=Loglcal 1
			1	5	mA	V_B=2.4 V	
Supply Current (operating)	I_{CC}		1.5	10.0	mA	F_{CLK}=5 MHz	
Column Current at any Column Input (2)	I_{COL} (All)			10	µA	V_B=0.4 V	V_{CC}=5.25 V V_{COL}=3.5 V All SR Stages=Logical 1
	I_{COL}		335	410	mA	V_B=2.4 V	
V_B, Clock or Data Input, Threshold Low V_B, Clock or Data Input, Threshold High	V_{IL} V_{IH}	 2.0		0.8	V V	V_{CC}= 4.75 V–5.25 V	
Data Out Voltage	V_{OH}	2.4			V	I_{OH}=–0.5 mA	V_{CC}=4.75 V I_{COL}=0 mA
	V_{OL}			0.4	V	I_{OL}=1.6 mA	
Input Current Logical 0, V_B only	I_{IL}	–30	–110	–300	µA	V_{CC}=4.75 V–5.25 V, V_{IL}=0.8 V	
Input Current Logical 0 Data, Clock	I_{IL}		–1	–10	µA		
Power Dissipation per Package (2)	P_D		0.4		W	V_{CC}=5.0, V_{COL}=3.5 V, 17.5% DF 15 LEDs on per character, V_B=2.4 V	
Thermal Resistance IC Junction-to-Ambient	$R\theta_{J\text{-}A}$		85		°C/W/ Device		

Notes:

1) All typical values specified at V_{CC}=5.0 V and T_A=25 °C unless otherwise noted.

2) See Figure 3: Peak column current versus column voltage.

Figure 3. Peak column current versus column voltage

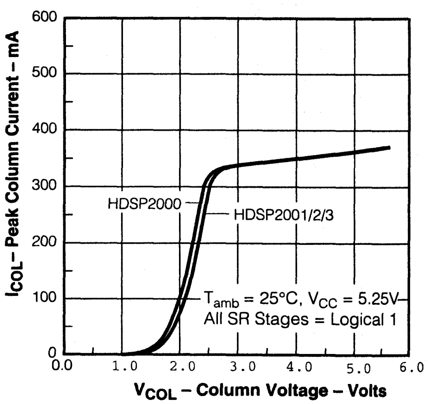
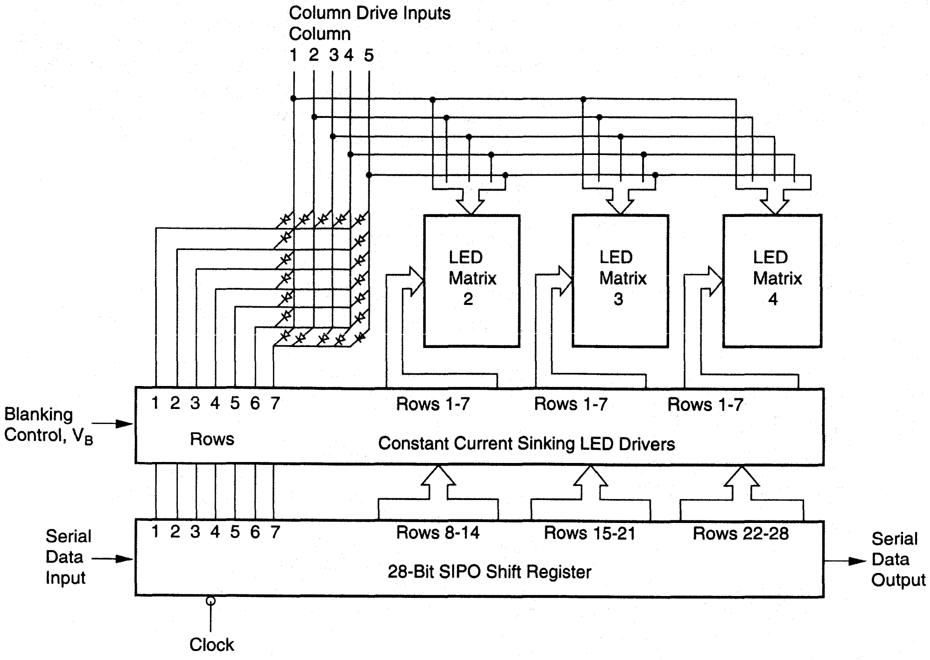


Figure 4. Block diagram



Contrast enhancement filters

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
Red HDSP2000LP	Panelgraphic Dark Red 63 Panelgraphic Ruby Red 60 Chequers Red 118 Plexiglass 2423	Polaroid HNCP37 3M Light Control Film Panelgraphic Gray 10 Chequers Gray 105	
Yellow HDSP2001LP	Panelgraphic Yellow 27		Polaroid HNCP 10-Glass* Marks Polarized MPC 30-25C**
HER HDSP2002LP	Panelgraphic Ruby Red 60 Chequers Red 112		Note 1 Polaroid HNCP 10-Glass* Marks Polarized MPC 20-15C**
Green HDSP20013P	Panelgraphic Green 48 Chequers Green 107		Polaroid HNCP 10-Glass* Marks Polarized MPC 50-12C**

Note:

1. Optically coated circular polarized filters, such as Polaroid HNCP10.

*Polaroid Corp.
1 Upland Rd., Bldg #2
Norwood, MA 02062
800/225-2770

**Marks Polarized Corp.
25-B Jefryn Blvd. W
Deer Park, NY 11729
516/242-1300
FAX 516/242-1347
Marks Polarized Corp. manufactures to MIL-1-45208 inspection system.

General Quality Assurance Levels

Generic data available.

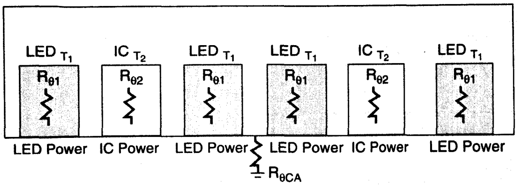
Thermal Considerations

The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial, industrial, and military environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

Thermal Modeling

HDSP200XLP displays consist of two driver ICs and four 5x7 LED matrixes. A thermal model of the display is shown in Figure 5. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

Figure 5. Thermal model



See Equation 1 below.

The junction rise within the LED is the product of the thermal impedance of an individual LED (37°C/W, DF=20%, F=200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current $I_{F(LED)}$, of 13–14.5 mA. This rise averages $T_{J(LED)}$=1°C. The table below shows the $V_{F(LED)}$ for the respective displays.

Model Number	VF		
	Min.	Typ.	Max.
HDSP2000LP	1.6	1.7	2.0
HDSP2001/2/3LP	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28°C/W results in a typical junction rise of 6°C.

See Equation 2 below.

For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5V_{COL}\, I_{COL}(n/35)\, DF + V_{CC} I_{CC}$$

For further reference see Figures 2, 7, 8, 9, 10 and 11.

Key to equation symbols

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5x7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of a LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

Optical Considerations

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 6. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

Equation 1.

$$T_{J(LED)} = P_{LED} Z_{\theta JC} + P_{CASE}(R_{\theta JC} + R_{\theta CA}) + T_A$$

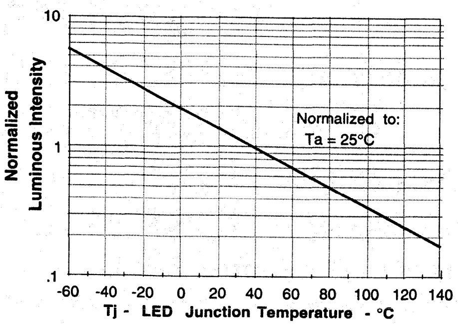
$$T_{J(LED)} = [(I_{COL}/28) V_{F(LED)} Z_{\theta JC}] + [(n/35) I_{COL}\, DF(5V_{COL}) + V_{CC} I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

Equation 2.

$$T_{J(IC)} = P_{COL}(R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5(V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35) DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

Figure 6. Normalized luminous intensity versus junction temperature



When mounted in a 10°C/W socket and operated at Absolute Maximum Electrical conditions, the HDSP200XLP will show an LED junction rise of 17°C. If T_A=40°C, then the LED's TJ will be 57°C. Under these conditions Figure 7 shows that the I_V will be 75% of its 25°C value.

Figure 7. Maximum LED junction temperature versus socket thermal resistance

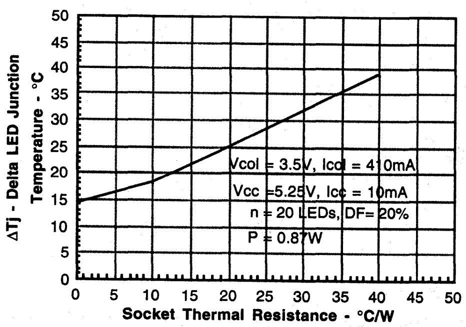


Figure 8. Maximum package power dissipation

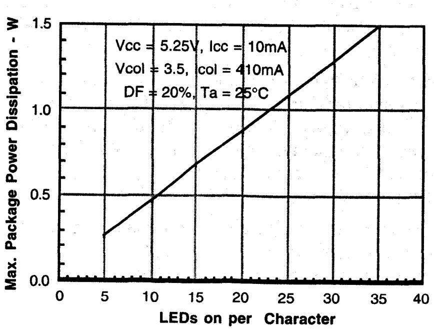


Figure 9. Package power dissipation

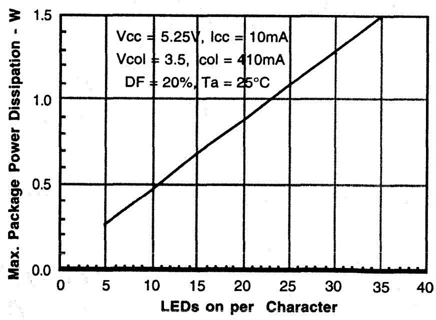


Figure 10. Maximum character power dissipation

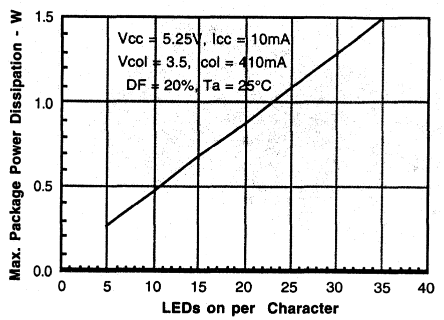
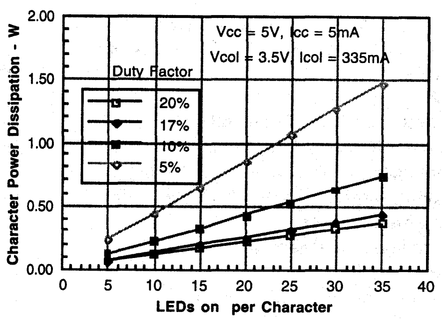


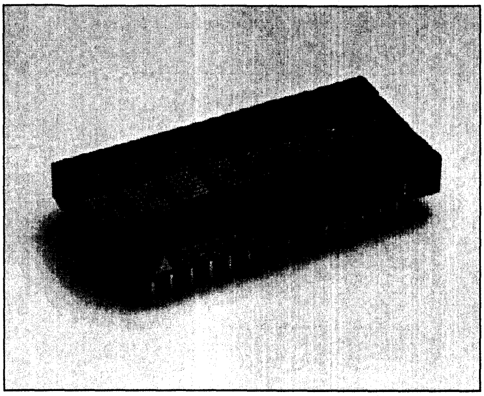
Figure 11. Character power dissipation

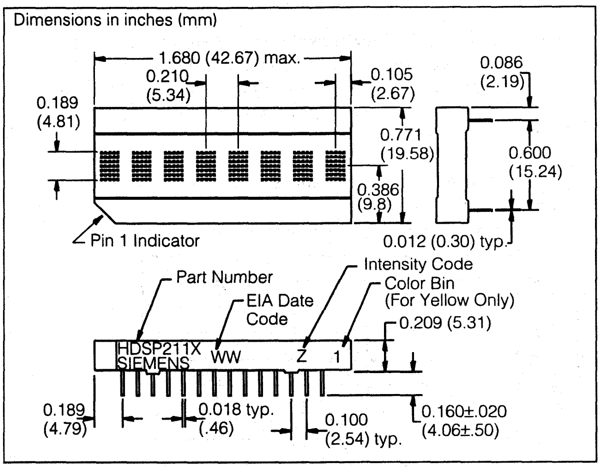


SIEMENS

RED HDSP2110S
YELLOW HDSP2111S
HIGH EFFICIENCY RED HDSP2112S
GREEN HDSP2113S
HIGH EFFICIENCY GREEN HDSP2114S
SOFT ORANGE HDSP2115S

0.200" 8-Character 5x7 Dot Matrix Parallel Input Alphanumeric Intelligent Display® Devices





FEATURES

- **Eight 0.200" Dot Matrix Characters in Red, Yellow, High Efficiency Red, Green, High Efficiency Green, or Soft Orange**
- **Built-in 128 Character ROM, Mask Programmable for Custom Fonts**
- **Readable from 8 Feet (2.5 meters)**
- **Built-in Decoders, Multiplexers and Drivers**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±65°**
- **Programmable Features:**
  - **Individual Flashing Character**
  - **Full Display Blinking**
  - **Multi-Level Dimming and Blanking**
  - **Clear Function**
  - **Self Test**
- **Internal or External Clock**
- **End Stackable Dual-In-Line Plastic Package**
- **Read/Write Capability**
- **16 User Definable Characters**

DESCRIPTION

The HDSP2110S (Red), HDSP2111S (Yellow), HDSP2112S (High Efficiency Red), HDSP2113S (Green), HDSP2114S (High Efficiency Green), and HDSP2115S (Soft Orange) are eight digit, 5x7 dot matrix, alphanumeric Intelligent Display devices. The 0.20 inch high digits are packaged in a rugged, high quality, optically transparent, 0.6 inch lead spacing, 28 pin plastic DIP.

The on-board CMOS has a built-in 128 character ROM. The HDSP211XS also has a user definable character (UDC) feature, which uses a RAM that permits storage of 16 arbitrary characters, symbols or icons that are software-definable by the user. The character ROM itself is mask programmable and easily modified by the manufacturer to provide specified custom characters.

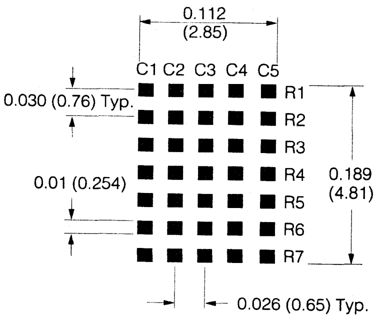
The HDSP211XS is designed for standard microprocessor interface techniques, and is fully TTL compatible. The Clock I/O and Clock Select pins allow the user to cascade multiple display modules.

ESD Warning: **Standard precautions for CMOS handling should be observed.**

Maximum Ratings (T_A=25°C)

DC Supply Voltage, V_{CC} to GND
(max. voltage with no LEDs on) .... –0.3 to +7.0 VDC
Input Voltage Levels,
All Inputs .... –0.3 to V_{CC} +0.3
Operating Temperature .... –40°C to 85°C
Storage Temperature .... –40°C to 100°C
Relative Humidity (non-condensing) 85%
Operating Voltage, V_{CC} to GND
(Max. voltage with 20 dots/digits on) .... 5.5 V
Maximum Solder Temperature
(0.063" below seating plane, t<5 sec) .... 260°C
ESD Protection at 1.5 KΩ,
100 pF .... V_Z=4 KV (each pin)

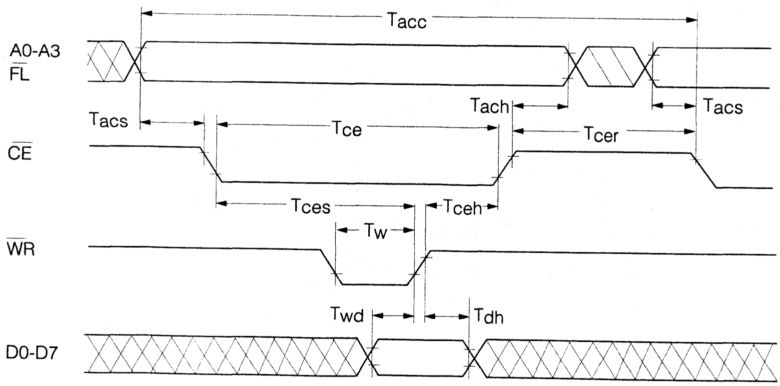
Figure 1. Enlarged character font
Dimensions in inches (mm)



Switching specifications
(over operating temperature range and V_{CC}=4.5 V)

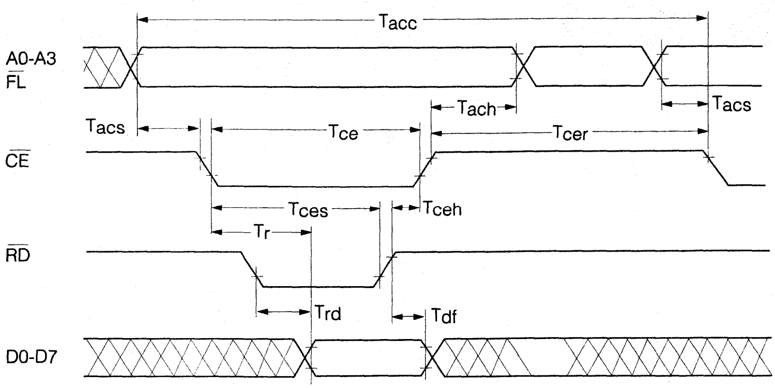
Symbol	Description	Min.	Units
Tacc	Display Access Time—Write	210	ns
Tacc	Display Access Time—Read	230	ns
Tacs	Address Setup Time to $\overline{CE}$	10	ns
Tce	Chip Enable Active Time—Write	140	ns
Tce	Chip Enable Active Time—Read	160	ns
Tach	Address Hold Time to $\overline{CE}$	20	ns
Tcer	Chip Enable Recovery Time	60	ns
Tces	Chip Enable Active Prior to Rising Edge—Write	140	ns
Tces	Chip Enable Active Prior to Rising Edge—Read	160	ns
Tceh	Chip Enable Hold to Rising Edge of Read/Write Signal	0	ns
Tw	Write Active Time	100	ns
Twd	Data Valid Prior to Rising Edge of Write Signal	50	ns
Tdh	Data Write Time	20	ns
Tr	Chip Enable Active Prior to Valid Data	160	ns
Trd	Read Active Prior to Valid Data	95	µs
Tdf	Read Data Float Delay	10	ns
Trc	Reset Active Time	300	ns

Figure 2. Write cycle timing diagram



Input pulse levels –0.6 V to 2.4 V

Figure 3. Read cycle timing diagram



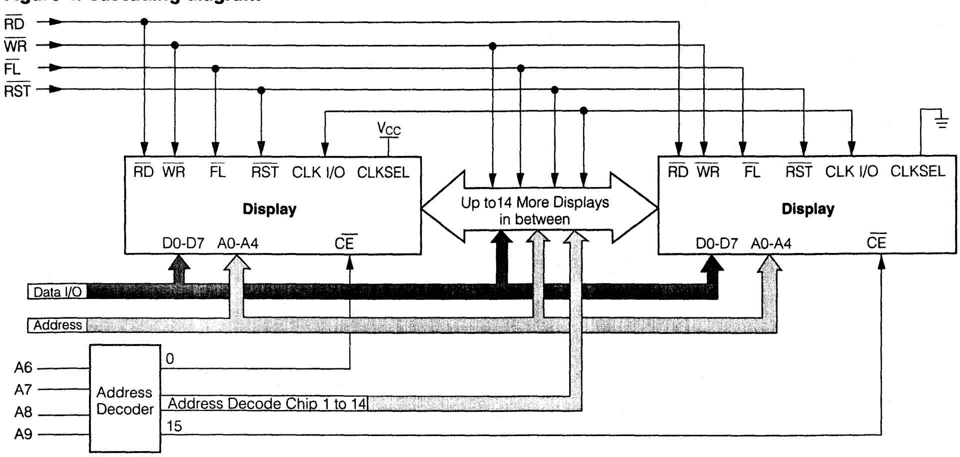
Cascading Displays

The HDSP211XS oscillator is designed to drive up to 16 other HDSP211XSs with input loading of 15 pF each.

The following are the general requirements for cascading 16 displays together:

- Determine the correct address for each display.
- Use CE from an address decoder to select the correct display.
- Select one of the Displays to provide the clock for the other displays. Connect CLKSEL to V_{CC} for this display.
- Tie CLKSEL to ground on other displays.
- Use RTS to synchronize the blinking between the displays.

Figure 4. Cascading diagram



Optical characteristics at 25°C (V_{CC}=5.0 V at full brightness)

Red HDSP2110S

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	70	90	µcd/dot
Peak Wavelength	λ(peak)		660	nm
Dominant Wavelength	λ(d)		639	nm

Yellow HDSP2111S

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	130	210	µcd/dot
Peak Wavelength	λ(peak)		583	nm
Dominant Wavelength	λ(d)		585	nm

High Efficiency Red HDSP2112S

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	150	330	µcd/dot
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		620	nm

Green HDSP2113S

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	150	260	µcd/dot
Peak Wavelength	λ(peak)		565	nm
Dominant Wavelength	λ(d)		570	nm

High Efficiency Green HDSP2114S

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	200	510	µcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		574	nm

Soft Orange HDSP2115S

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	150	270	µcd/dot
Peak Wavelength	λ(peak)		610	nm
Dominant Wavelength	λ(d)		604	nm

Note:

1) Peak luminous intensity is measured at $T_A=T_J$=25 °C. No time is allowed for the device to warm up prior to measurement.

Electrical characteristics at 25°C

Parameters	Limits				Conditions
	Min.	Typ.	Max.	Units	
V_{CC}	4.5	5.0	5.5	V	
I_{CC} Blank		0.65	1.0	mA	V_{CC}=5 V, V_{IN}=5 V
I_{CC} 12 dots/digit on (1) (2)		185	255	mA	V_{CC}=5 V, "V" in all 8 digits
I_{CC} 20 dots/digit on (1) (2)		284	370	mA	V_{CC}=5 V, "#" in all 8 digits
I_{ILP} (with pull-up) Input Leakage	–18	–11	–5	µA	V_{CC}=5 V, V_{IN}=0 V to V_{CC}, ($\overline{WR}$, $\overline{CE}$, $\overline{FL}$, $\overline{RST}$, $\overline{RD}$, $\overline{CLKSEL}$)
I_{IL} (no pull-up) Input Leakage	–1		+1	µA	V_{CC}=5 V, V_{IN}=0–5 V, (CLK, A0–A3, D0–D7)
V_{IH} Input Voltage High	2.0		V_{CC} +0.3	V	V_{CC}=4.5 V to 5.5 V
V_{IL} Input Voltage Low	GND –0.3			V	V_{CC}=4.5 V to 5.5 V
V_{OL} (D0–D7), Output Voltage Low			0.4	V	V_{CC}=4.5 V, I_{OL}=1.6 mA
V_{OL} (CLK), Output Voltage Low			0.4	V	V_{CC}=4.5 V, I_{OL}=40 µA
V_{OH} Output Voltage High	2.4			V	V_{CC}=4.5 V, I_{OH}=–40 µA
θ_{JC} Thermal Resistance, Junction to Case		25		°C/W	
Clock I/O Frequency	28	57.34	81.14	KHz	V_{CC}=4.5 to 5.5 V
FM, Digit Multiplex Frequency	125	256	362.5	Hz	V_{CC}=4.5 to 5.5 V
Blinking Rate	0.98	2.0	2.83	Hz	
Clock I/O Buss Loading			2.40	pF	
Clock Out Rise Time			500	nsec	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	nsec	V_{CC}=4.5 V, V_{OH}=0.4 V

Notes:

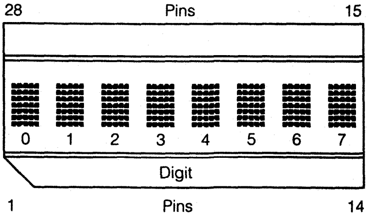
1) I_{CC} is an average value.

2) I_{CC} is measured with the display at full brightness. Peak I_{CC} = $^{28}/_{15}$ I_{CC} average (#displayed).

Recommended operating conditions (T_A=–40°C to +85°C)

Parameter	Symbol	Min.	Max.	Units
Supply Voltage	V_{CC}	4.5	5.5	V
Input Voltage Low	V_{IL}		0.8	V
Input Voltage High	V_{IH}	2.0		V
Output Voltage Low	V_{OL}		0.4	V
Output Voltage High	V_{OH}	2.4		V

Figure 5. Top view



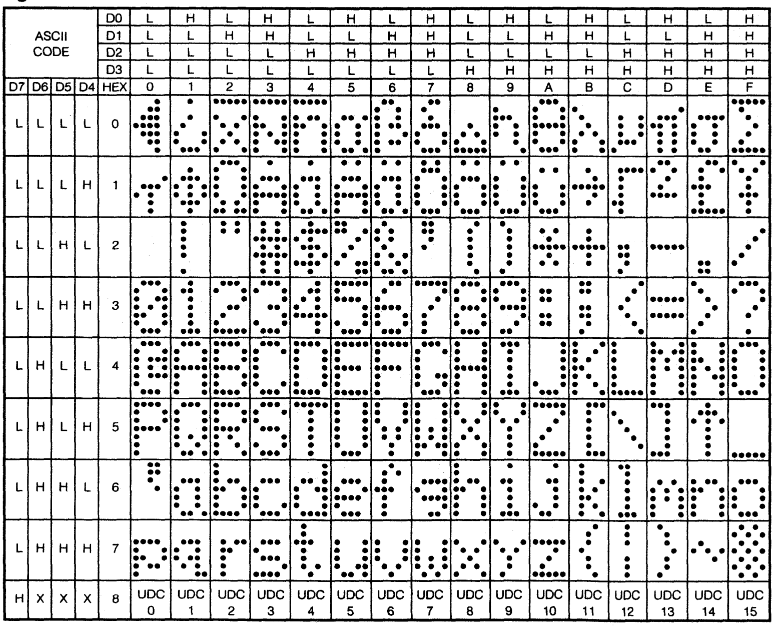
Pin assignment

Pin	Function	Definition
1	$\overline{RST}$	Used to initialize a display and sychronize blinking for multiple displays
2	$\overline{FL}$	Low input accesses the Flash RAM
3	A0	Address input LSB
4	A1	Address input
5	A2	Address input MSB
6	A3	Mode selector
7	V_{CC}	Optional connection to positive power supply input.
8	V_{CC}	
9	V_{CC}	
10	A4	Mode Selector
11	$\overline{CLKSEL}$	Selects internal/high clock source

Pin assignment (continued)

Pin	Function	Definition
12	CLK I/O	Outputs master clock or inputs external clock
13	$\overline{WR}$	A low will write data into the display if $\overline{CE}$ is low
14	V_{CC}	Positive power supply input
15	GND supply	Analog Ground for LED drivers
16	GND logic	Digital Ground for internal drivers
17	$\overline{CE}$	Enables access to the display
18	$\overline{RD}$	A low will read data from the display if $\overline{CE}$ is low. If read from display is not required, then $\overline{RD}$ can be tied to V_{CC}
19	D0	Data input LSB
20	D1	Data input
21	No pin	
22	No pin	
23	D2	Data input
24	D3	Data input
25	D4	Data input
26	D5	Data input
27	D6	Data input
28	D7	Data input MSB, selects ROM, page 1 or 2

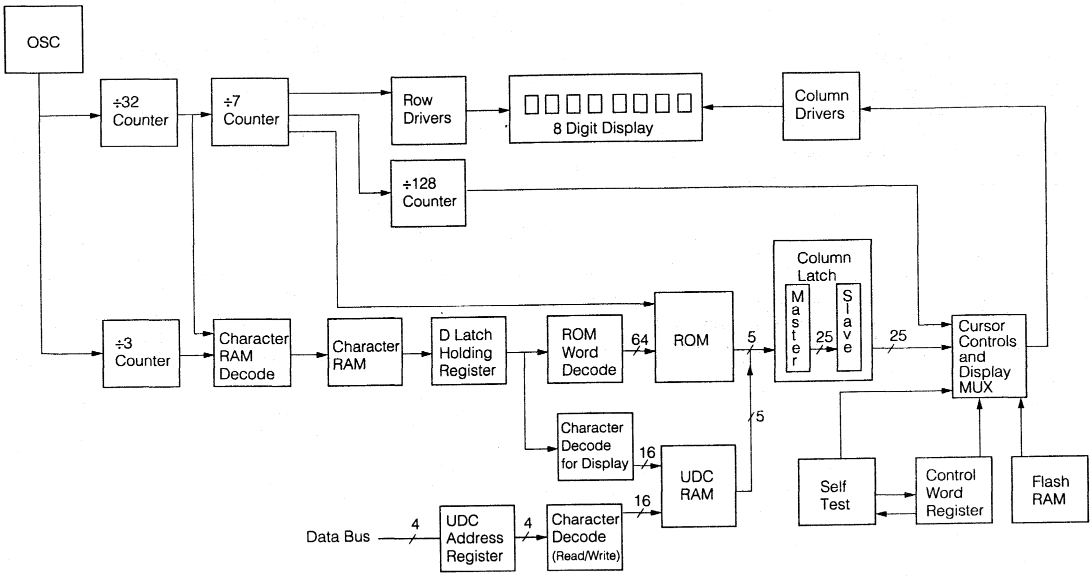
Figure 6. Character set



Notes:

1. Upon power up, the device will initialize in a random state.
2. X=don't care.

Figure 7. Block diagram



Functional Description

The display's user interface is organized into five memory areas. They are accessed using the Flash Input, $\overline{FL}$, and address lines, A3 and A4. All the listed RAMs and Registers may be read or written through the data bus. See Table 1. Each input pin is described in Pin Definitions.

Five basic memory areas

Character RAM	Stores either ASCII (Katakana) character data or an UDC RAM address
Flash RAM	1x8 RAM which stores Flash data
User-Defined Character RAM (UDC RAM)	Stores dot pattern for custom characters
User-Defined Address Register (UDC Address Register)	Provides address to UDC RAM when user is writing or reading custom character
Control Word Register	Enables adjustment of display brightness, flash individual characters, blink, self test or clearing the display

RST can be used to initialize display operation upon power up or during normal operation. When activated, $\overline{RST}$ will clear the Flash RAM and Control Word Register (00H) and reset the internal counter. All eight display memory locations will be set to 20H to show blanks in all digits.

$\overline{FL}$ pin enables access to the **Flash RAM**. The **Flash RAM** will set (D0=1) or reset (D0=0) flashing of the character addressed by A0–A2.

The 1x8 bit **Control Word Register** is loaded with attribute data if A3=0.

The **Control Word Logic** decodes attribute data for proper implementation.

Character ROM is designed for 128 ASCII characters. The ROM is Mask Programmable for custom fonts.

The **Clock Source** could either be the internal oscillator (CLKSEL=1) of the device or an external clock (CLKSEL=0) could be an input from another HDSP211X display for the synchronization of blinking for multiple displays.

The **Display Multiplexer** controls the Row Drivers so no additional logic is required for a display system.

The **Display** has eight digits. Each digit has 35 LEDs clustered into a 5x7 dot matrix.

Table 1. Memory selection

FL	A2	A3	Section of Memory	A2–A0	Data Bits Used
0	X	X	Flash RAM	Character Address	D0
1	0	0	UDC Address Register	Don't Care	D3–D0
1	0	1	UDC RAM	Row Address	D4–D0
1	1	1	Character RAM	Character Address	D7–D0
1	1	0	Control Word Register	Don't Care	D7–D0

Theory of operation

The HDSP211XS Programmable Display is designed to work with all major microprocessors. Data entry is via an eight bit parallel bus. Three bits of address route the data to the proper digit location in the RAM. Standard control signals like $\overline{WR}$ and $\overline{CE}$ allow the data to be written into the display.

D0–D7 data bits are used for both Character RAM and control word data input. A3 acts as the mode selector.

If A3=1, character RAM is selected. Then input data bit D7 will determine whether input data bits D0–D6 is ASCII coded data (D7=0) or UDC data (D7=1). See section on UDC Address Register and RAM.

For normal operation $\overline{FL}$ pin should be held high. When $\overline{FL}$ is held low, Flash RAM is accessed to set character blinking.

The seven bit ASCII code is decoded by the Character ROM to generate Column data. Twenty columns worth of data is sent out each display cycle, and it takes fourteen display cycles to write into eight digits.

The rows are multiplexed in two sets of seven rows each. The internal timing and control logic synchronizes the turning on of rows and presentation of column data to assure proper display operation.

Power Up Sequence

Upon power up display will come on at random. Thus the display should be reset on power-up. The reset will clear the Flash RAM, Control Word Register and reset the internal counter. All the digits will show blanks and display brightness level will be 100%.

The display must not be accessed until three clock pulses (110 µseconds minimum using the internal clock) after the rising edge of the reset line.

Microprocessor interface

The interface to a microprocessor is through the 8-bit data bus (D0–D7), the 4-bit address bus (A0–A3) and control lines $\overline{FL}$, $\overline{CE}$ and $\overline{WR}$.

To write data (ASCII/Control Word) into the display $\overline{CE}$ should be held low, address and data signals stable and $\overline{WR}$ should be brought low. The data is written on the low to high transition of $\overline{WR}$.

The Control Word is decoded by the Control Word Decode Logic. Each code has a different function. The code for display brightness changes the duty cycle for the column drivers. The peak LED current stays the same but the average LED current diminishes depending on the intensity level.

The character Flash Enable causes 2 Hz coming out of the counter to be ANDED with column drive signal and makes the column driver to cycle at 2 Hz. Thus the character flashes at 2 Hz.

The display Blink works the same way as the Flash Enable but causes all twenty column drivers to cycle at 2 Hz thereby making all eight digits to blink at 2 Hz.

The Self Test function of the IC consists of two internal routines which exercise major portions of the IC and illuminates all the LEDs.

Clear bit clears the character RAM and writes a blank into the display memory. It however does not clear the control word.

ASCII Data or Control Word Data can be written into the display at this point. For multiple display operation, CLK I/O must be properly selected. CLK I/O will output the internal clock if CLKSEL=1, or will allow input from an external clock if CLKSEL=0.

Character RAM

The Character RAM is selected when $\overline{FL}$, A4 and A3 are set to 1,1,1 during a read or write cycle. The Character RAM is a 8 by 8 bit RAM with each of the eight locations corresponding to a digit on the display. Digit 0 is on the left side of the display and digit 7 is on the right side of the display. Address lines, A2–A0 select the digit address with A2 being the most significant bit and A0 being the least significant bit. The two types of data stored in the Character RAM are the ASCII coded data and the UDC Address Data. The type of data stored in the Character RAM is determined by data bit, D7. If D7 is low, then ASCII coded data is stored in data bits D6–D0. If D7 is high, then UDC Address Data is stored in data bit D3–D0.

The ASCII coded data is a 7 bit code used to select one of 128 ASCII characters permanently stored in the ASCII ROM.

The UDC Address data is a 4 bit code used to select one of the UDC characters in the UDC RAM. There are up to 16 characters available. See Figure 8.

UDC Address Register and UDC RAM

The UDC Address Register and UDC RAM allows the user to generate and store up to 16 custom characters. Each custom character is defined in 5x7 dot matrix pattern. It takes 8 write cycles to define a custom character, one cycle to load the UDC Address Register and 7 cycles to define the character. The contents of the UDC Address Register will store the 4 bit address for one of the 16 UDC RAM locations. The UDC RAM is used to store the custom character.

UDC Address Register

The UDC Address Register is selected by setting $\overline{FL}$=1, A4=0, A3=0. It is a 4 bit register and uses data bits, D3–D0 to store the 4 bit address code (D7–D4 are ignored). The address code selects one of 16 UDC RAM locations for custom character generation.

UDC RAM

The UDC RAM is selected by setting $\overline{FL}$=1, A4=0, A3=1. The RAM is comprised of a 7x5 bit RAM. As shown in Figure 11, address lines, A2–A0 select one of the 7 rows of the custom character. Data bits, D4–D0 determine the 5 bits of column data in each row. Each data bit corresponds to a LED. If the data bit is high, then the LED is on. If the data bit is low, the LED is off. To create a character, each of the 7 rows of column data need to be defined. See Figures 9 and 10 for logic.

Flash RAM

The Flash RAM allows the display to flash one or more of the characters being displayed. The Flash Ram is accessed by setting $\overline{FL}$ low. A4 and A3 are ignored. The Flash RAM is a 8x1 bit RAM with each bit corresponding to a digit address. Digit 0 is on the left side of the display and digit 7 is on the right side of the display. Address lines, A2–A0 select the digit address with A2 being the most significant digit and A0 being the least significant digit. Data bit, D0, sets and resets the flash bit for each digit. When D0 is high, the flash bit is set and when D0 is low, It is reset. See Figure 11.

Control Word

The Control Word is used to set up the attributes required by the user. It is addressed by setting $\overline{FL}$=1, A4=1, A3=0. The Control Word is an 8 bit register and is accessed using data bits, D7–D0. See Figures 12 and 13 for the logic and attributed control. The Control Word has 5 functions. They are brightness control, flashing character enable, blinking character enable, self test, and clear (Flash and Character RAMS only).

Brightness Control

Control Word bits, D2–D0, control the brightness of the display with a binary code of 000 being 100% brightness and 111 being display blank. See Figure 13 for brightness level versus binary code. The average I_{CC} can be calculated by multiplying the 100% brightness level I_{CC} value by the display's brightness level. For example, a display set to 80% brightness with a 100% average I_{CC} value of 200 mA will have an average I_{CC} value of 200 mA x 80%=160 mA.

Flash Function

Control Word bit, D3, enables or disables the Flash Function. When D3 is 1, the Flash Function is enabled and any digit with its corresponding bit set in the Flash RAM will flash at approximately 2 Hz. When using an external clock, the flash rate can be determined by dividing the clock rate by 28,672. When D3 is 0, the Flash Function is disabled and the contents of the Flash RAM is ignored. For synchronized flashing on multiple displays, see the Reset Section.

Figure 8. Character RAM access logic

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7	D6 D5 D4 D3 D2 D1 D0
1	0	0	1	1	1	1	Character Address for Digits 0–7	0	7 bit ASCII code for a Write Cycle
1	0	1	0	1	1	1	Character Address for Digits 0–7	0	7 bit ASCII code read during a Read Cycle
1	0	0	1	1	0	0	Character Address for Digits 0–7	1	D3–D0=UDC address for a Write Cycle
1	0	1	0	1	0	0	Character Address for Digits 0–7	1	D3–D0=UDC address for Read Data

Figure 9. UDC address register and UDC character RAM

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0	
1	0	0	1	1	0	0	Not used for UDC Address Register	D3–D0=UDC RAM Address Code for Write Cycle	UDC Address Register
1	0	1	0	1	0	0	Not used for UDC Address Register	D3–D0=UDC RAM Address Code for Read Cycle	
1	0	0	1	1	0	1	A2–A0=Character Row Address	D4–D0=Character Column Data for Write Cycle	UDC RAM
1	0	1	0	1	0	1	A2–A0=Character Row Address	D4–D0=Character Column Data read during a Read Cycle	

Blink Function

Control Word bit, D4, enables or disables the Blink Function. When D4 is 1, the Blink Function is enabled and all characters on the display will blink at approximately 2 Hz. The Blink Function will override the Flash Function if both functions are enabled. When D4 is 0, the Blink Function is disabled. When using an external clock, the blink rate can be determined by dividing the clock rate by 28,672. For synchronized blinking on multiple displays, see the Reset Section.

Self Test

Before starting Self Test, Reset must first be activated. Control Word bits, D6 and D5, are used for the Self Test Function. When D6 is 1, the Self Test is initiated. Results of the Self Test are stored in bits D5. Control Word bit, D5, is a read only bit. When D5 is 1, Self Test passed is indicated. When D5 is 0, Self Test failed is indicated. The Self Test function of the IC consists of two internal routines which exercise major portions of the IC and illuminates all of the LEDs. The first routine cycles the ASCII decoder ROM through all states and performs a check sum on the output. If the check sum agrees with the correct value, D5 is set to a 1.

Figure 10. UDC character map

Row Data				Column Data
				C1 C2 C3 C4 C5
A2	A1	A0	Row #	D4 D3 D2 D1 D0
0	0	0	1	5x7 Dot Matrix Pattern
0	0	1	2	
0	1	0	3	
0	1	1	4	
1	0	0	5	
1	0	1	6	
1	1	0	7	

The second routine provides a visual test of the LEDs using the drive circuitry. This is accomplished by writing checkered and inverse checkered patterns to the display. Each pattern is displayed for approximately 2 seconds. During the self test function the display must not be accessed. The time needed to execute the self test function is calculated by multiplying the clock time by 262,144 (typical time ≈ 4.6 sec.). At the end of the self test function, the Character RAM is loaded with blanks; the Control Word Register is set to zeroes except D5, and the Flash RAM is cleared and the UDC Address Register is set to all 1s.

Clear Function (see Figures 13 and 14)

Control Word bit, D7 clears the character RAM to 20 hex and the flash RAM to all zeroes. The RAMs are cleared within three clock cycles (110 μs minimum, using the internal clock) when D7 is set to 1. During the clear time the display must not be accessed. When the clear function is finished, bit 7 of the Control Word RAM will be reset to a "0".

Reset Function

The display should be reset on power up of the display ($\overline{RST}$=LOW). When the display is reset, the Character RAM, Flash RAM, and Control Word Register are cleared.

The display's internal counters are reset. Reset cycle takes three clock cycles (110 μseconds minimum using the internal clock). The display must not be accessed during this time.

To synchronize the flashing and blinking of multiple displays, it is necessary for the display to use a common clock source and reset all the displays at the same time to start the internal counters at the same place.

While $\overline{RST}$ is low, the display must not be accessed by RD nor $\overline{WR}$.

Figure 11. Flash RAM access logic

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0
1	0	0	1	0	X	X	Flash RAM Address for Digits 0–7	D0=Flash Data, 0-Flash Off and 1=Flash On (Write Cycle)
1	0	1	0	0	X	X	Flash RAM Address for Digits 0–7	D0=Flash Data, 0-Flash Off and 1=Flash On (Read Cycle)

Figure 12. Control word access logic

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0
1	0	0	1	1	1	0	Not used for Control Word	Control Word data for a Write Cycle, see Figure 13
1	0	1	0	1	1	0	Not used for Control Word	Control Word data for a Read during a Read Cycle

Figure 13. Control word data definition

D7	D6	D5	D4	D3	D2	D1	D0
C	ST	ST	BL	FL	Br	Br	Br

D2	D1	D0	
0	0	0	100% Brightness
0	0	1	80% Brightness
0	1	0	53% Brightness
0	1	1	40% Brightness
1	0	0	27% Brightness
1	0	0	20% Brightness
1	1	0	13% Brightness
1	1	1	Blank Display

D3:
0 Flash Function Disabled
1 Flash Function Enabled

D4:
0 Blink Function Disabled
1 Blink Function Enabled (overrides Flash Function)

D6, D5:
0 X Normal Operation X=bit ignored
1 R Run Self Test, R=Test Result, R=1/pass, 0=fail

D7:
0 Normal Operation
1 Clear Flash RAM & Character RAM (Character RAM=20 Hex)

Key

C Clear Function
ST Self test
BL Blink function
FL Flash function
Br Brightness control

Figure 14. Clear function

$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{FL}}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	X	X	X	X	X	X	X	Clear disabled
0	0	1	0	X	X	X	1	X	X	X	X	X	X	X	Clear user RAM, page RAM, flash RAM and display

X=don't care

Figure 15. Display cycle using built-in ROM example

Display message "Showtime." Digit 0 is leftmost—closest to pin 1.
Logic levels: 0=Low, 1=High, X=Don't care.

$\overline{\text{RST}}$	$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{RD}}$	$\overline{\text{FL}}$	A4	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation	Display
0	X	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	Reset. No Read/Write Within 3 Clock Cycles	All Blank
1	0	0	1	1	1	0	X	X	X	0	0	X	0	0	0	1	1	53% Brightness Selected	All Blank
1	0	0	1	1	1	1	0	0	0	0	1	0	1	0	0	1	1	Write "S" to Digit 0	S
1	0	0	1	1	1	1	0	0	1	0	1	0	0	1	0	0	0	Write "H" to Digit 1	SH
1	0	0	1	1	1	1	0	1	0	0	1	0	0	1	1	1	1	Write "O" to Digit 2	SHO
1	0	0	1	1	1	1	0	1	1	0	1	0	1	0	1	1	1	Write "W" to Digit 3	SHOW
1	0	0	1	1	1	1	1	0	0	0	1	0	1	0	1	0	0	Write "T" to Digit 4	SHOWT
1	0	0	1	1	1	1	1	0	1	0	1	0	0	1	0	0	1	Write "I" to Digit 5	SHOWTI
1	0	0	1	1	1	1	1	1	0	0	1	0	0	1	1	0	1	Write "M" to Digit 6	SHOWTIM
1	0	0	1	1	1	1	1	1	1	0	1	0	0	0	1	0	1	Write "E" to Digit 7	SHOWTIME

Figure 16. Displaying user defined character example

Load character "A" into UDC-5 and then display it in digit 2
Logic levels: 0=Low, 1=High, X=Don't care

$\overline{\text{RST}}$	$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{RD}}$	$\overline{\text{FL}}$	A4	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation	Display
0	X	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	Reset. No Read/Write Within 3 Clock Cycles	All Blank
1	0	0	1	1	0	0	X	X	X	X	X	X	X	0	1	0	1	Select UDC-5	All Blank
1	0	0	1	1	0	1	0	0	0	X	X	X	0	1	1	1	0	Write into Row 1 of UDC-5	All Blank
1	0	0	1	1	0	1	0	0	1	X	X	X	1	0	0	0	1	Write into Row 2 of UDC-5	All Blank
1	0	0	1	1	0	1	0	1	0	X	X	X	1	0	0	0	1	Write into Row 3 of UDC-5	All Blank
1	0	0	1	1	0	1	0	1	1	X	X	X	1	1	1	1	1	Write into Row 4 of UDC-5	All Blank
1	0	0	1	1	0	1	1	0	0	X	X	X	1	0	0	0	1	Write into Row 5 of UDC-5	All Blank
1	0	0	1	1	0	1	1	0	1	X	X	X	1	0	0	0	1	Write into Row 6 of UDC-5	All Blank
1	0	0	1	1	0	1	1	1	0	X	X	X	1	0	0	0	1	Write into Row 7 of UDC-5	All Blank
1	0	0	1	1	1	1	0	1	0	1	X	X	X	0	1	0	1	Write UDC-5 into Digit 2	(Digit 2) A

Electrical and Mechanical Considerations

Voltage Transient Suppression

For best results power the display and the components that interface with the display to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place a parallel combination of a .01 µF and a 22 µF capacitor between V_{CC} and GND for all display packages.

ESD Protection

The input protection structure of the HDSP211XS provides significant protection against ESD damage. It is capable of withstanding discharges greater than 2 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in antistatic packaging.

Soldering Considerations

The HDSP211XS can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Direct contact with alcohol or alcohol vapor will cause degradation of the package.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichorotrifluorethane), TA, 111 Trichloroethane, and unheated acetone.[1]

Note:

1) Acceptable commercial solvents are: Basic TF, Arklone, P. Genesolv, D. Genesolv DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 28 pin DIP sockets .600" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The .200" high character of the HDSP211XS gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The HDSP2110/2112S are red/high efficiency red displays and should be matched with long wavelength pass filter in the 570 nm to 590 nm range. The HDSP2113S should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

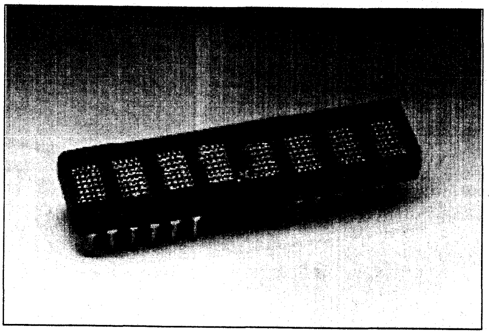
Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

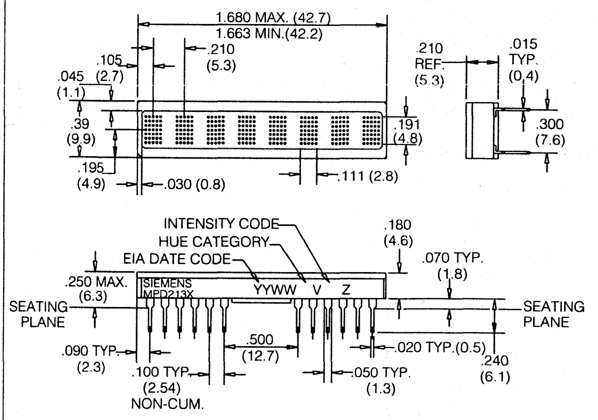
Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several bezel manufacturers are: R.M.F. Products, Baklava, IL; Nobody Components, Griffith Plastic Corp., Burningly, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

SIEMENS

YELLOW IPD2131
HIGH EFFICIENCY RED IPD2132
HIGH EFFICIENCY GREEN IPD2133
0.200" 8-Character 5x7 Dot Matrix X-Y Stackable Alphanumeric Programmable Display™





FEATURES

- **Eight .2" Dot Matrix Characters in a Ceramic Package**
- **True Hermetic Glass Flat Seal for all Colors**
- **Internal ROM with 128 ASCII Characters**
- **Internal RAM for up to 16 User Definable Characters**
- **Programmable Control Word Allows User to Select from 8 Brightness Levels, Display Blink, Character Flash, Self Test, or Clear Functions**
- **Internal or External Clock Capability**
- **8 Bit Bidirectional Data Bus Allows for Read/Write Capability**
- **Contains all Display Drive and Multiplexing Circuitry**
- **Reset Pin for Display Initialization, Multiple Display Blinking and Flashing Synchronization**
- **TTL Compatible**
- **Operating Temperature Range: –55 to +100°C Storage Temperature: –65 to +125°C**
- **Categorized for Luminous Intensity and Color**
- **X-Y Stackable**

DESCRIPTION

The IPD2131 (yellow), IPD2132 (High Efficiency Red) and IPD2133 (High Efficiency Green) are eight-digit high reliability 5x7 dot matrix Programmable Displays that are aimed at satisfying the most demanding display requirements. They are designed for use in extremely harsh environments where only the most reliable parts are acceptable. The devices are constructed in ceramic packages with eight .20 inch high 5x7 dot matrix digits. The devices incorporate the latest in CMOS technology which is the heart of the device intelligence. The CMOS IC is controlled by a user supplied eight-bit data word on a bidirectional BUS. The ASCII data and attribute data are word driven. This approach allows the displays to interface using similar techniques as a microprocessor peripheral.

Applications include: control panels, night viewing applications, cockpit monitors, portable and vehicle technology as well as industrial controllers.

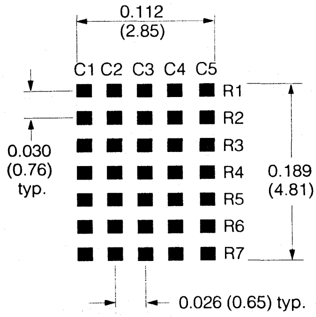
ESD Warning: Standard precautions for CMOS handling should be observed.

Maximum Ratings (T_A=25°C)

DC Supply Voltage, V_{CC} to GND
(max. voltage with no LEDs on) .... –0.3 to +7.0 VDC
Input Voltage Levels, All Inputs .... –0.3 to (V_{CC} +0.3) V
Operating Temperature .... –55°C to +100°C
Storage Temperature .... –65°C to +125°C
Relative Humidity (non-condensing) 85%
Operating Voltage, V_{CC} to GND
(Max. voltage with 20 dots/digits on) .... 5.5 V
Maximum Solder Temperature
(0.063" below Seating Plane, t<5 sec.) .... 260°C
ESD Protection at 1.5 KΩ, 100 pF .... V_Z=4 KV (each pin)

Figure 6. Enlarged character font

Dimensions in inches (mm)



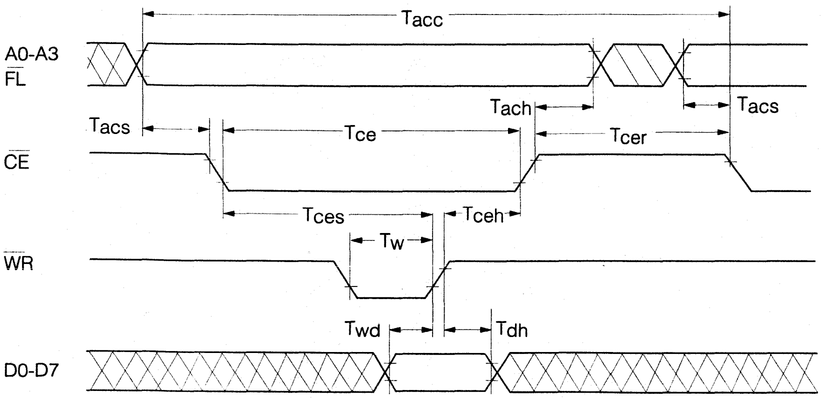
Switching specifications
(over operating temperature range and V_{CC}=4.5 V to 5.5 V)

Symbol	Description	Min.	Units
Tacc	Display Access Time—Write	210	ns
Tacc	Display Access Time—Read	230	ns
Tacs	Address Setup Time to CE	10	ns
Tce	Chip Enable Active Time—Write	140	ns
Tce	Chip Enable Active Time—Read	160	ns
Tach	Address Hold Time to CE	20	ns
Tcer	Chip Enable Recovery Time	60	ns
Tces	Chip Enable Active Prior to Rising Edge—Write	140	ns
Tces	Chip Enable Active Prior to Rising Edge—Read	160	ns
Tceh	Chip Enable Hold to Rising Edge of Read/Write Signal	0	ns
Tw	Write Active Time	100	ns
Twd	Data Valid Prior to Rising Edge of Write Signal	50	ns
Tdh	Data Write Time	20	ns
Tr	Chip Enable Active Prior to Valid Data	160	ns
Trd	Read Active Prior to Valid Data	95	ns
Tdf	Read Data Float Delay	10	ns
Trc	Reset Active Time	300	ns

Oscillator, refresh, flash and self test characteristics

Parameters	Min.	Typ.	Max.	Units	Conditions
Clock I/O Frequency	28	57.34	81.14	KHz	V_{CC}=4.5 V to 5.5 V
External Clock Frequency	25		640	KHz	V_{CC}=4.5 V to 5.5 V
FM, Digit Multiplex Frequency	125	256	362.5	Hz	V_{CC}=4.5 V to 5.5 V
Blinking Rate	0.98	2.0	2.83	Hz	
Clock I/O Bus Loading			2.40	pF	
Clock Out Rise Time			500	nsec	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	nsec	V_{CC}=4.5 V, V_{OH}=0.4 V

Figure 7. Write cycle timing diagram



Input pulse levels –0.6 V to 2.4 V

Figure 8. Read cycle timing diagram

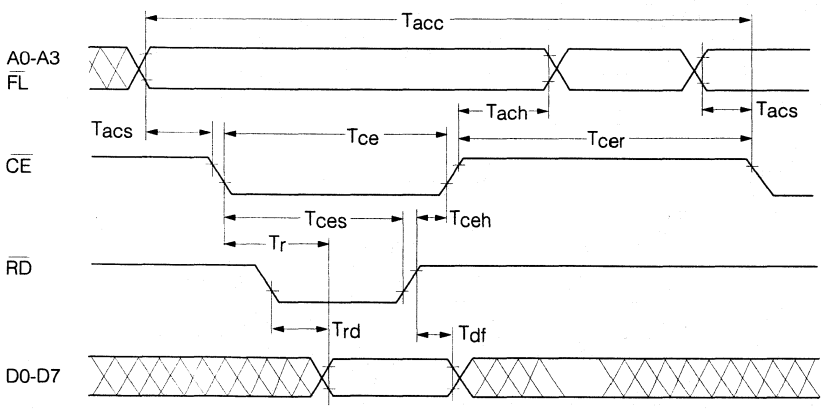
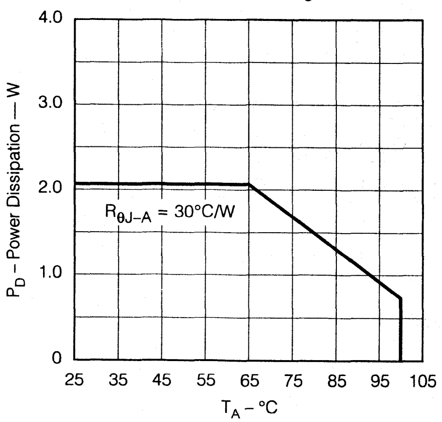


Figure 9. Maximum power dissipation vs. ambient temperature derating based on T_J max=125°C



Optical characteristics at 25°C (V_{CC}=5.0 V at full brightness)

Yellow IPD2131

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	125	205	µcd/dot
Peak Wavelength	λ(peak)		583	nm
Dominant Wavelength	λ(d)		585	nm

High Efficiency Red IPD2132

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	125	350	µcd/dot
Peak Wavelength	λ(peak)		635	nm
Dominant Wavelength	λ(d)		626	nm

High Efficiency Green IPD2133

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	150	500	µcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		574	nm

Electrical characteristics at 25°C

Parameters	Limits				Conditions
	Min.	Typ.	Max.	Units	
V_{CC}	4.5	5.0	5.5	V	
I_{CC} Blank		0.5	1.0	mA	V_{CC}=5 V, V_{IN}=5 V
I_{CC} 12 dots/digit on (1) (2)		200	255	mA	V_{CC}=5 V, "V" in all 8 digits
I_{CC} 20 dots/digit on (1) (2)		300	370	mA	V_{CC}=5 V, "#" in all 8 digits
I_{ILP} (with pull-up) Input Leakage	–1	–11	–18	µA	V_{CC}=5 V, V_{IN}=0 V to V_{CC} ($\overline{WR}$, $\overline{CE}$, $\overline{FL}$, $\overline{RST}$, $\overline{RD}$, CLKSEL)
I_{IL} (no pull-up) Input Leakage	–1		+1	µA	V_{CC}=5 V, V_{IN}=0–5 V (CLK, A0–A4, D0–D7)
V_{IH} Input Voltage High	2.0		V_{CC} +0.3	V	V_{CC}=4.5 V to 5.5 V
V_{IL} Input Voltage Low	GND –0.3		0.8	V	V_{CC}=4.5 V to 5.5 V
V_{OL} (D0–D7), Output Voltage Low			0.4	V	V_{CC}=4.5 V, I_{OL}=1.6 mA
V_{OL} (CLK), Output Voltage Low			0.4	V	V_{CC}=4.5 V, I_{OL}=40 µA
V_{OH} Output Voltage High	2.4			V	V_{CC}=4.5 V, I_{OH}=–40 µA
θ_{JC} Thermal Resistance, Junction to Case		15		°C/W	

Notes:

1) I_{CC} is an average value.

2) I_{CC} is measured with the display at full brightness. Peak I_{CC}=$^{28}/_{15}$ I_{CC} average (#displayed).

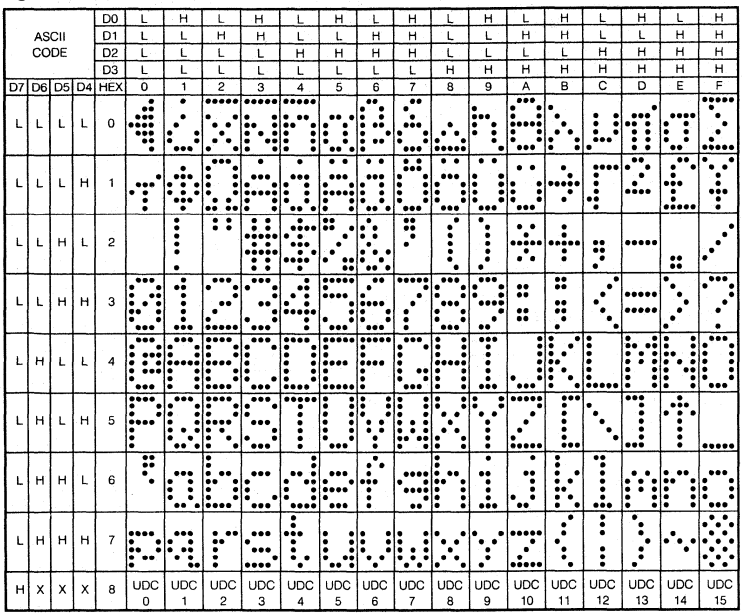
Recommended operating conditions (T_A=–55°C to +100°C)

Parameter	Symbol	Min.	Max.	Units
Supply Voltage	V_{CC}	4.5	5.5	V
Input Voltage Low	V_{IL}		0.8	V
Input Voltage High	V_{IH}	2.0		V
Output Voltage Low	V_{OL}		0.4	V
Output Voltage High	V_{OH}	2.4		V

Pin description

Pin No.	Function	Description	Explanation
1	CLS	Clock Select	Selects an internal or external clock source. CLS=1 the internal clock selected (master clock), CLS=0 then external clock selected (slave operation).
2	CLK	Clock I/O	Inputs or outputs the clock as determined by the CLS pin.
3	$\overline{WR}$	Write	Writes data into the display when $\overline{WR}$=0 and $\overline{CE}$=0.
4	$\overline{CE}$	Chip Enable	Enables the read/write access when low.
5	$\overline{RST}$	Reset	Initializes the display; clears the Character RAM (20 Hex), Flash RAM (00 Hex), Control Word (00 Hex) and resets the internal counters. UDC Address Register and UDC RAM are unaffected.
6	$\overline{RD}$	Read	Outputs data from the display when $\overline{RD}$=0 and $\overline{CE}$=0.
7	No Pin		
8			
9			
10			
11	D0	Data Bus	8 bit bidirectional data bus. Character RAM and Control Word uses D7–D0, UDC Address Register uses D3–D0, UDC RAM uses D4–D0, and Flash RAM uses D0.
12	D1		
13	D2		
14	D3		
15	NC		
16	V_{CC}		Positive power supply.
17	GND	Supply	Analog ground for the LED drivers.
18	GND	Logic	Digital ground for the logic circuitry.
19	D4	Data Bus	8 bit bidirectional data bus. Character RAM and Control Word uses D7-D0, UDC Address Register uses D3-D0, UDC RAM uses D4-D0, and Flash RAM uses D0.
20	D5		
21	D6		
22	D7		
23	No Pin		
24			
25			
26			
27	$\overline{FL}$	Flash	Accesses the Flash RAM. Address inputs, A2–A0, select the digit address while data bit D0 sets (D0=1) or resets (D0=0) the Flash bit. A4 and A3 are ignored.
28	A0	Address Inputs	A4 and A3 select a section of the display's memory. A2–A0 select specific locations in the different sections. If $\overline{FL}$ is low the Flash RAM is accessed regardless of the status of A4 and A3.
29	A1		
30	A2		
31	A3		
32	A4		

Figure 10. Character set

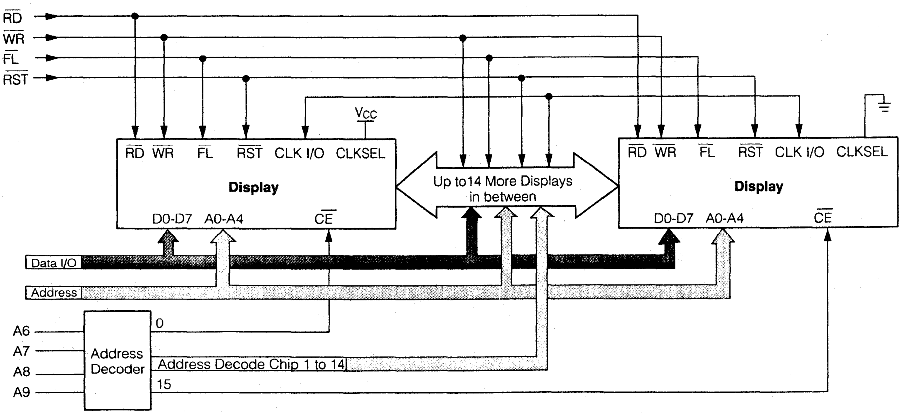


D7	D6	D5	D4	ASCII CODE D0 / D1 / D2 / D3 / HEX	L L L L 0	H L L L 1	L H L L 2	H H L L 3	L L H L 4	H L H L 5	L H H L 6	H H H L 7	L L L H 8	H L L H 9	L H L H A	H H L H B	L L H H C	H L H H D	L H H H E	H H H H F
L	L	L	L	0																
L	L	L	H	1																
L	L	H	L	2																
L	L	H	H	3																
L	H	L	L	4																
L	H	L	H	5																
L	H	H	L	6																
L	H	H	H	7																
H	X	X	X	8	UDC 0	UDC 1	UDC 2	UDC 3	UDC 4	UDC 5	UDC 6	UDC 7	UDC 8	UDC 9	UDC 10	UDC 11	UDC 12	UDC 13	UDC 14	UDC 15

Notes:

1. Upon power up, the device will initialize in a random state.
2. X=don't care.

Figure 11. Cascading diagram



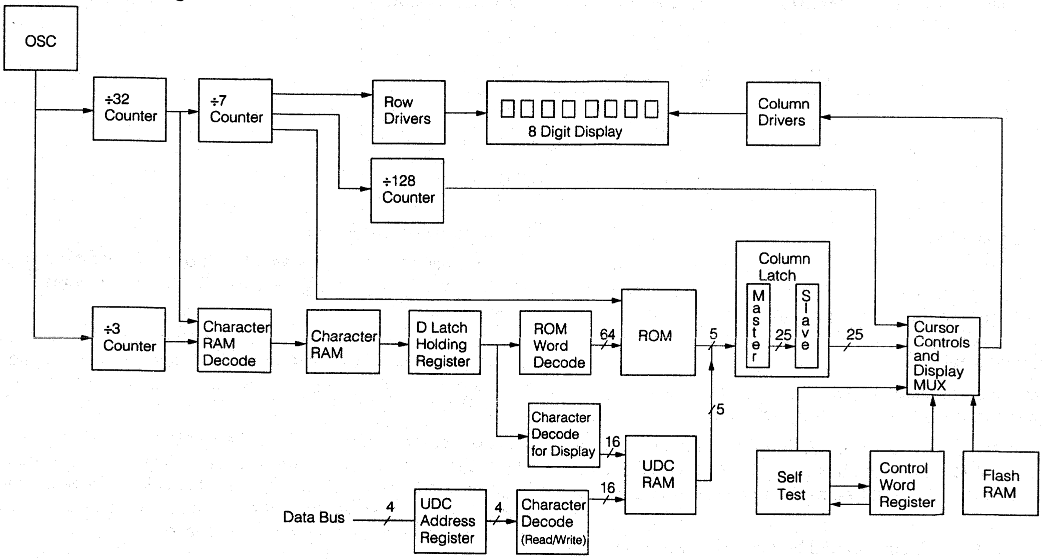
Cascading Displays

The display's oscillator is designed to drive up to 16 other display's with input loading of 15 pF each.

The following are the general requirements for cascading 16 displays together:

- Determine the correct address for each display.
- Use $\overline{CE}$ from an address decoder to select the correct display.
- Select one of the Displays to provide the Clock for the other displays. Connect CLKSEL to V_{CC} for this display.
- Tie CLKSEL to ground on other displays.
- Use $\overline{RTS}$ to synchronize the blinking between the displays.

Figure 12. Block diagram



Functional Description

The display's user interface is organized into five memory areas. They are accessed using the Flash Input, $\overline{FL}$, and address lines, A3 and A4. All the listed RAMs and Registers may be read or written through the data bus. See Table 1. Each input pin is described in Pin Definitions.

Five basic memory areas

Character RAM	Stores either ASCII (Katakana) character data or an UDC RAM address
Flash RAM	1x8 RAM which stores Flash data
User-Defined Character RAM (UDC RAM)	Stores dot pattern for custom characters
User-Defined Address Register (UDC Address Register)	Provides address to UDC RAM when user is writing or reading custom character
Control Word Register	Enables adjustment of display brightness, flash individual characters, blink, self test or clearing the display

$\overline{RST}$ can be used to initialize display operation upon power up or during normal operation. When activated, $\overline{RST}$ will clear the Flash RAM and Control Word Register (00H) and reset the internal counter. All eight display memory locations will be set to 20H to show blanks in all digits.

$\overline{FL}$ pin enables access to the **Flash RAM**. The **Flash RAM** will set (D0=1) or reset (D0=0) flashing of the character addressed by A0–A2.

The 1x8 bit **Control Word Register** is loaded with attribute data if A3=0.

The **Control Word Logic** decodes attribute data for proper implementation.

Character ROM is designed for 128 ASCII characters. The ROM is Mask Programmable for custom fonts.

The **Clock Source** could either be the internal oscillator (CLKSEL=1) of the device or an external clock (CLKSEL=0) could be an input from another IPD213X display for synchronizing blinking for multiple displays.

The **Display Multiplexer** controls the Row Drivers so no additional logic is required for a display system.

The **Display** has eight digits. Each digit has 35 LEDs.

Table 2. Memory selection

FL	A4	A3	Section of Memory	A2–A0	Data Bits Used
0	X	X	Flash RAM	Character Address	D0
1	0	0	UDC Address Register	Don't Care	D3–D0
1	0	1	UDC RAM	Row Address	D4–D0
1	1	1	Character RAM	Character Address	D7–D0
1	1	0	Control Word Register	Don't Care	D7–D0

Theory of Operation

The IPD213X Display is designed to work with all major microprocessors. Data entry is via an eight bit parallel bus. Three bits of address route the data to the proper digit location in the RAM. Standard control signals like $\overline{WR}$ and $\overline{CE}$ allow the data to be written into the display.

D0–D7 data bits are used for both Character RAM and control word data input. A3 acts as the mode selector.

If A3=1, character RAM is selected. Then input data bit D7 will determine whether input data bits D0–D6 is ASCII coded data (D7=0) or UDC data (D7=1). See section on UDC Address Register and RAM.

For normal operation $\overline{FL}$ pin should be held high. When $\overline{FL}$ is held low, Flash RAM is accessed to set character blinking.

The seven bit ASCII code is decoded by the Character ROM to generate Column data. Twenty columns worth of data is sent out each display cycle, and it takes fourteen display cycles to write into eight digits.

The rows are multiplexed in two sets of seven rows each. The internal timing and control logic synchronizes the turning on of rows and presentation of column data to assure proper display operation.

Power Up Sequence

Upon power up the display will come on at random. Thus the display should be reset on power-up. Reset will clear the Flash RAM, Control Word Register and reset the internal counter. All the digits will show blanks and display brightness level will be 100%.

The display must not be accessed until three clock pulses (110 µseconds minimum using the internal clock) after the rising edge of the reset line.

Microprocessor Interface

The interface to a microprocessor is through the 8-bit data bus (D0–D7), the 4-bit address bus (A0–A3) and control lines $\overline{FL}$, $\overline{CE}$ and $\overline{WR}$.

To write data (ASCII/Control Word) into the display $\overline{CE}$ should be held low, address and data signals stable and WR should be brought low. The data is written on the low to high transition of $\overline{WR}$.

The Control Word is decoded by the Control Word Decode Logic. Each code has a different function. The code for display brightness changes the duty cycle for the column drivers. The peak LED current stays the same but the average LED current diminishes depending on the intensity level.

The character Flash Enable causes 2 Hz coming out of the counter to be ANDED with the column drive signal to make the column driver cycle at 2 Hz. Thus the character flashes at 2 Hz.

The display Blink works the same way as the Flash Enable but causes all twenty column drivers to cycle at 2 Hz thereby making all eight digits blink at 2 Hz.

The Self Test function of the IC consists of two internal routines which exercise major portions of the IC and illuminates all the LEDs.

Clear bit clears the character RAM and writes a blank into the display memory. It however does not clear the control word.

ASCII Data or Control Word Data can be written into the display at this point. For multiple display operation, CLK I/O must be properly selected. CLK I/O will output the internal clock if CLKSEL=1, or will allow input from an external clock if CLKSEL=0.

Character RAM

The Character RAM is selected when $\overline{\text{FL}}$, A4 and A3 are set to 1,1,1 during a read or write cycle. The Character RAM is a 8 by 8 bit RAM with each of the eight locations corresponding to a digit on the display. Digit 0 is on the left side of the display and digit 7 is on the right side of the display. Address lines, A2–A0 select the digit address with A2 being the most significant bit and A0 being the least significant bit. The two types of data stored in the Character RAM are the ASCII coded data and the UDC Address Data. The type of data stored in the Character RAM is determined by data bit, D7. If D7 is low, then ASCII coded data is stored in data bits D6–D0. If D7 is high, then UDC Address Data is stored in data bit D3–D0.

The ASCII coded data is a 7 bit code used to select one of 128 ASCII characters permanently stored in the ASCII ROM.

The UDC Address data is a 4 bit code used to select one of the UDC characters in the UDC RAM. There are up to 16 characters available. See Figure 8.

UDC Address Register and UDC RAM

The UDC Address Register and UDC RAM allows the user to generate and store up to 16 custom characters. Each custom character is defined in 5x7 dot matrix pattern. It takes 8 write cycles to define a custom character, one cycle to load the UDC Address Register and 7 cycles to define the character. The contents of the UDC Address Register will store the 4 bit address for one of the 16 UDC RAM locations. The UDC RAM is used to store the custom character.

UDC Address Register

The UDC Address Register is selected by setting $\overline{\text{FL}}$=1, A4=0, A3=0. It is a 4 bit register and uses data bits, D3–D0 to store the 4 bit address code (D7–D4 are ignored). The address code selects one of 16 UDC RAM locations for custom character generation.

UDC RAM

The UDC RAM is selected by setting $\overline{\text{FL}}$=1, A4=0, A3=1. The RAM is comprised of a 7x5 bit RAM. As shown in Figure 10, address lines, A2-A0 select one of the 7 rows of the custom character. Data bits, D4-D0 determine the 5 bits of column data in each row. Each data bit corresponds to a LED. If the data bit is high, then the LED is on. If the data bit is low, the LED is off. To create a character, each of the 7 rows of column data need to be defined. See Figures 9 and 10 for logic.

Flash RAM

The Flash RAM allows the display to flash one or more of the characters being displayed. The Flash Ram is accessed by setting $\overline{\text{FL}}$ low. A4 and A3 are ignored. The Flash RAM is a 8x1 bit RAM with each bit corresponding to a digit address. Digit 0 is on the left side of the display and digit 7 is on the right side of the display. Address lines, A2–A0 select the digit address with A2 being the most significant digit and A0 being the least significant digit. Data bit, D0, sets and resets the flash bit for each digit. When D0 is high, the flash bit is set; and when D0 is low, it is reset. See Figure 11.

Figure 13. Character RAM access logic

$\overline{\text{RST}}$	$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{RD}}$	$\overline{\text{FL}}$	A4	A3	A2 A1 A0	D7	D6 D5 D4 D3 D2 D1 D0
1	0	0	1	1	1	1	Character Address for Digits 0–7	0	7 bit ASCII code for a Write Cycle
1	0	1	0	1	1	1	Character Address for Digits 0–7	0	7 bit ASCII code read during a Read Cycle
1	0	0	1	1	0	0	Character Address for Digits 0–7	1	D3–D0=UDC address for a Write Cycle
1	0	1	0	1	0	0	Character Address for Digits 0–7	1	D3–D0=UDC address for Read Data

Figure 14. UDC address register and UDC character RAM

$\overline{\text{RST}}$	$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{RD}}$	$\overline{\text{FL}}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0	
1	0	0	1	1	0	0	Not used for UDC Address Register	D3–D0=UDC RAM Address Code for Write Cycle	UDC Address Register
1	0	1	0	1	0	0	Not used for UDC Address Register	D3–D0=UDC RAM Address Code for Read Cycle	
1	0	0	1	1	0	1	A2–A0=Character Row Address	D4–D0=Character Column Data for Write Cycle	UDC RAM
1	0	1	0	1	0	1	A2–A0=Character Row Address	D4–D0=Character Column Data read during a Read Cycle	

Control Word

The Control Word is used to set up the attributes required by the user. It is addressed by setting $\overline{FL}$=1, A4=1, A3=0. The Control Word is an 8 bit register and is accessed using data bits, D7–D0. See Figures 12 and 13 for the logic and attributed control. The Control Word has 5 functions. They are brightness control, flashing character enable, blinking character enable, self test, and clear (Flash and Character RAMS only).

Brightness Control

Control Word bits, D2–D0, control the brightness of the display with a binary code of 000 being 100% brightness and 111 being display blank. See Figure 13 for brightness level versus binary code. The average I_{CC} can be calculated by multiplying the 100% brightness level I_{CC} value by the display's brightness level. For example, a display set to 80% brightness with a 100% average I_{CC} value of 200 mA will have an average I_{CC} value of 200 mA x 80%=160 mA.

Figure 15. UDC character map

Row Data				Column Data				
				C1	C2	C3	C4	C5
A2	A1	A0	Row #	D4	D3	D2	D1	D0
0	0	0	1	5x7 Dot Matrix Pattern				
0	0	1	2					
0	1	0	3					
0	1	1	4					
1	0	0	5					
1	0	1	6					
1	1	0	7					

Flash Function

Control Word bit, D3, enables or disables the Flash Function. When D3 is 1, the Flash Function is enabled and any digit with its corresponding bit set in the Flash RAM will flash at approximately 2 hertz. When using an external clock, the flash rate can be determined by dividing the clock rate by 28,672. When D3 is 0, the Flash Function is disabled and the contents of the Flash RAM is ignored. For synchronized flashing on multiple displays, see the Reset Section.

Blink Function

Control Word bit, D4, enables or disables the Blink Function. When D4 is 1, the Blink Function is enabled and all characters on the display will blink at approximately 2 hertz. The Blink Function will override the Flash Function if both functions are enabled. When D4 is 0, the Blink Function is disabled. When using an external clock, the blink rate can be determined by dividing the clock rate by 28,672. For synchronized blinking on multiple displays, see the Reset Section.

Self Test

Control Word bits, D6 and D5, are used for the Self Test Function. When D6 is 1, the Self Test is initiated. Results of the Self Test are stored in bit D5. Control Word bit, D5, is a read only bit. When D5 is 1, Self Test has passed. When D5 is 0, Self Test failed is indicated. The Self Test function of the IC consists of two internal routines which exercise major portions of the IC and illuminates all of the LEDs. The first routine cycles the ASCII decoder ROM through all states and performs a check sum on the out-put. If the check sum is correct, D5 is set to a 1 (Pass).

Figure 16. Flash RAM access logic

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0
1	0	0	1	1	X	X	Flash RAM Address for Digits 0–7	D0=Flash Data, 0=Flash Off and 1=Flash On (Write Cycle)
1	0	1	1	0	X	X	Flash RAM Address for Digits 0–7	D0=Flash Data, 0=Flash Off and 1=Flash On (Read Cycle)

Figure 17. Control word access logic

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0
1	0	0	1	1	1	0	Not used for Control Word	Control Word data for a Write Cycle, see Figure 13
1	0	1	0	1	1	0	Not used for Control Word	Control Word data for a Read during a Read Cycle

The second routine provides a visual test of the LEDs. This is accomplished by writing checkered and inversed checkered patterns to the display. Each pattern is displayed for approximately 2 seconds. During the self test function the display must not be accessed. The time needed to execute the self test function is calculated by multiplying the clock time by 262,144 (typical time ≈ 4.6 sec.). At the end of the self test, the Character RAM is loaded with blanks; the Control Word Register is set to zeroes except D5; the Flash RAM is cleared and the UDC Address Register is set to all 1s.

Clear Function (see Figures 13 and 14)

Control Word bit, D7 clears the character RAM to 20 hex and the flash RAM to all zeroes. The RAMs are cleared within three clock cycles (110 µs minimum, using the internal clock) when D7 is set to 1. During the clear time the display must not be accessed. When the clear function is finished, bit 7 of the Control Word RAM will be reset to a "0".

Reset Function

The display should be reset on power up of the display ($\overline{RST}$=LOW). When the display is reset, the Character RAM, Flash RAM, and Control Word Register are cleared.

The display's internal counters are reset. Reset cycle takes three clock cycles (110 µseconds minimum using the internal clock). The display must not be accessed during this time.

To synchronize the flashing and blinking of multiple displays, it is necessary for the display to use a common clock source and reset all the displays at the same time to start the internal counters at the same place.

While $\overline{RST}$ is low, the display must not be accessed by $\overline{RD}$ nor $\overline{WR}$.

Figure 18. Control word data definition

D7	D6	D5	D4	D3	D2	D1	D0
C	ST	ST	BL	FL	Br	Br	Br

D2	D1	D0	
0	0	0	100% Brightness
0	0	1	80% Brightness
0	1	0	53% Brightness
0	1	1	40% Brightness
1	0	0	27% Brightness
1	0	1	20% Brightness
1	1	0	13% Brightness
1	1	1	Blank Display

D3:
0 Flash Function Disabled
1 Flash Function Enabled

D4:
0 Blink Function Disabled
1 Blink Function Enabled (overrides Flash Function)

D6 D5:
0 X Normal Operation X=bit ignored
1 R Run Self Test, R=Test Result, R=1/pass, 0=fail

D7:
0 Normal Operation
1 Clear Flash RAM & Character RAM (Character RAM=20 Hex)

Key

- C Clear Function
- ST Self test
- BL Blink function
- FL Flash function
- Br Brightness control

Figure 19. Clear function

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	X	X	X	X	X	X	X	Clear disabled
0	0	1	0	X	X	X	1	X	X	X	X	X	X	X	Clear user RAM, flash RAM and display

X=don't care

Figure 20. Display cycle using built-in ROM example

Display message "Showtime." Digit 0 is leftmost—closest to pin 1.
Logic levels: 0=Low, 1=High, X=Don't care.

$\overline{\text{RST}}$	$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{RD}}$	$\overline{\text{FL}}$	A4	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation	Display
0	X	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	Reset. No Read/Write Within 3 Clock Cycles	All Blank
1	0	0	1	1	1	0	X	X	X	0	0	X	0	0	0	1	1	53% Brightness Selected	All Blank
1	0	0	1	1	1	1	0	0	0	0	1	0	1	0	0	1	1	Write "S" to Digit 0	S
1	0	0	1	1	1	1	0	0	1	0	1	0	0	1	0	0	0	Write "H" to Digit 1	SH
1	0	0	1	1	1	1	0	1	0	0	1	0	0	1	1	1	1	Write "O" to Digit 2	SHO
1	0	0	1	1	1	1	0	1	1	0	1	0	1	0	1	1	1	Write "W" to Digit 3	SHOW
1	0	0	1	1	1	1	1	0	0	0	1	0	1	0	1	0	0	Write "T" to Digit 4	SHOWT
1	0	0	1	1	1	1	1	0	1	0	1	0	0	1	0	0	1	Write "I" to Digit 5	SHOWTI
1	0	0	1	1	1	1	1	1	0	0	1	0	0	1	1	0	1	Write "M" to Digit 6	SHOWTIM
1	0	0	1	1	1	1	1	1	1	0	1	0	0	0	1	0	1	Write "E" to Digit 7	SHOWTIME

Figure 21. Displaying user defined character example

Load character "A" into UDC-5 and then display it in digit 2.
Logic levels: 0=Low, 1=High, X=Don't care

$\overline{\text{RST}}$	$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{RD}}$	$\overline{\text{FL}}$	A4	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation	Display
0	X	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	Reset. No Read/Write Within 3 Clock Cycles	All Blank
1	0	0	1	1	0	0	X	X	X	X	X	X	X	0	1	0	1	Select UDC-5	All Blank
1	0	0	1	1	0	1	0	0	0	X	X	X	0	1	1	1	0	Write into Row 1 of UDC-5	All Blank
1	0	0	1	1	0	1	0	0	1	X	X	X	1	0	0	0	1	Write into Row 2 of UDC-5	All Blank
1	0	0	1	1	0	1	0	1	0	X	X	X	1	0	0	0	1	Write into Row 3 of UDC-5	All Blank
1	0	0	1	1	0	1	0	1	1	X	X	X	1	1	1	1	1	Write into Row 4 of UDC-5	All Blank
1	0	0	1	1	0	1	1	0	0	X	X	X	1	0	0	0	1	Write into Row 5 of UDC-5	All Blank
1	0	0	1	1	0	1	1	0	1	X	X	X	1	0	0	0	1	Write into Row 6 of UDC-5	All Blank
1	0	0	1	1	0	1	1	1	0	X	X	X	1	0	0	0	1	Write into Row 7 of UDC-5	All Blank
1	0	0	1	1	1	1	0	1	0	1	X	X	X	0	1	0	1	Write UDC-5 into Digit 2	(Digit 2) A

Electrical and Mechanical Considerations

Voltage Transient Suppression

For best results power the display and the components that interface with the display to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place a parallel combination of a .01 μF and a 22 μF capacitor between V_{CC} and GND for all display packages.

ESD Protection

The input protection structure of the IPD2131X provides significant protection against ESD damage. It is capable of withstanding discharges greater than 4 KV. Take all the standard precautions normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The IPD213X can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible. Use water soluble organic acid flux or resin based RMA flux.

A wave temperature of 245°C ±5°C with a dwell between 1.5 seconds to 3.0 seconds can be used. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Suggested solvents include Freon TE, Freon TF, Genesolv DE-15, Genesolv DI-15, and Genesolv DES.

An alternative to soldering and cleaning the display modules is to use sockets. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The .200" high character of the IPD213X gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The high efficiency red displays should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The IPD2133 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

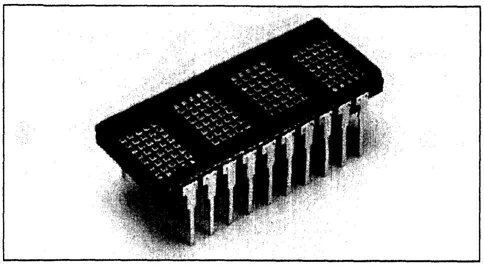
Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

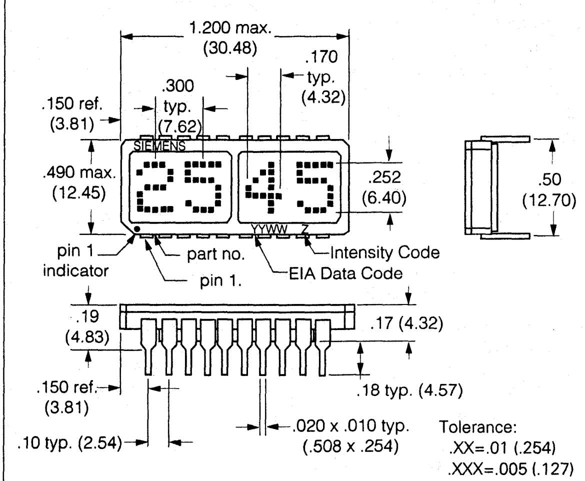
SIEMENS

HIGH EFFICIENCY RED IPD2545A
GREEN IPD2547A
YELLOW IPD2548A

0.252" 4-Character 5x7 Dot Matrix X-Y Stackable Industrial Alphanumeric Programmable Display™ with Built-in CMOS Control Functions



Dimensions in inches (mm)



FEATURES

- **Four 0.252" Dot Matrix Characters in Hermetic Package**
- **Built-in Memory, Decoders, Multiplexer and Drivers**
- **Viewing Angle, X axis ±40°, Y axis ±75°**
- **128 Character ASCII Format (Upper and Lower Case Characters)**
- **Rugged Ceramic Package, Hermetic Sealed Flat Glass Window**
- **Wide Temperature Operating Range for Industrial Use, –55°C to +100°C**
- **8-bit Bidirectional Data BUS**
- **READ/WRITE Capability**
- **Built-in Character Generator ROM**
- **TTL Compatible**
- **Easily Cascaded for Multidisplay Operation**
- **Less CPU Time Required**
- **Software Controlled Features:**
  - **Programmable Highlight Attribute (Blinking, Non-Blinking)**
  - **Asynchronous Memory Clear Function**
  - **Lamp Test**
  - **Display Blank Function**
  - **Single or Multiple Character Blinking Function**
  - **Three Programmable Brightness Levels**

DESCRIPTION

The IPD2545A (high efficiency red), IPD2547A (green), and IPD2548A (yellow) are four digit, High Reliability/Industrial, dot matrix, Programmable Displays that are aimed at satisfying the most demanding industrial display requirements.

They are designed for use in harsh environments. The devices are constructed in a hermetic package using four 0.25-inch high 5x7 dot matrix displays.

The devices incorporate the latest in CMOS technology which is the heart of the device intelligence. The CMOS controller chip is controlled by a user supplied eight bit data word on the bidirectional BUS. The ASCII data and attribute data are word driven. This approach allows the IPD254XA to interface using the same techniques as a microprocessor peripheral.

Applications include: control panels, night viewing applications (red light), cockpit monitors, night vision goggle viewable displays (green), portable and vehicle technology as well as industrial controllers.

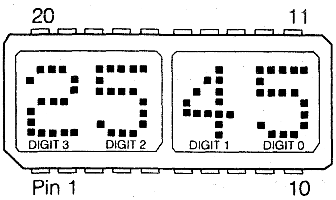
Maximum Ratings

DC Supply Voltage .... –0.5 to +6.0 Vdc
Input Voltage Relative to Ground
(all inputs) .... –0.5 to V_{CC} +0.5 Vdc
Operating Temperature .... –55°C to +100°C
Storage Temperature .... –65°C to +125°C
Thermal Resistance (θ_{JC}) .... 30°C/W

Important:

Refer to Appnote 18, "Using and Handling Intelligent Displays." Since this is a CMOS device, normal precautions should be taken to avoid static damage.

Figure 6. Top view



Pin assignments

1	$\overline{RD}$	Read	11	$\overline{WR}$	Write
2	CLK I/O	Clock I/O	12	D7	Data MSB
3	CLKSEL	Clock Select	13	D6	Data
4	$\overline{RST}$	Reset	14	D5	Data
5	CE1	Chip Enable	15	D4	Data
6	$\overline{CE0}$	Chip Enable	16	D3	Data
7	A2	Address MSB	17	D2	Data
8	A1	Address	18	D1	Data
9	A0	Address LSB	19	D0	Data LSB
10	GND		20	V_{CC}	

Figure 7. Timing characteristics—data "write" cycle

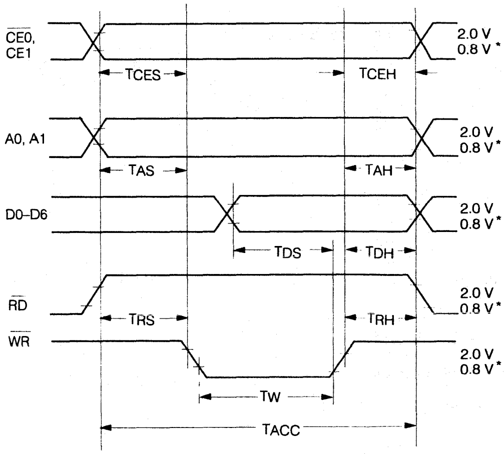
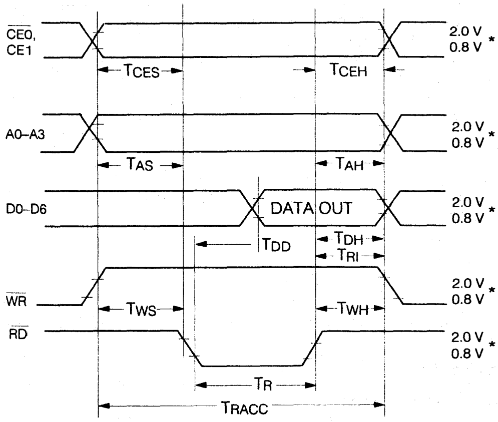


Figure 8. Timing characteristics—data "read" cycle



Notes:

1. All input voltages are V_{IL}=0.8 V, V_{IH}=2.0 V.
2. These waveforms are not edge triggered.

DC characteristics

Parameter	–55°C			+25°C			+100°C			Units	Condition
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{CC} Blank (all inputs low)		4	10		2	5		1	2.5	mA	V_{CC}=5.0 V
I_{CC} 80 dots/units (100% brightness)		220	250		160	190		125	160	mA	V_{CC}=5.0 V
I_{IL} (all inputs)		70	120		60	100		50	80	µA	V_{IH}=0.8 V, V_{CC}=5.0 V
V_{IH} (all inputs)	2.0			2.0			2.0			V	V_{CC}=5 V ±0.5 V
V_{IL} (all inputs)			0.8			0.8			0.8	V	V_{CC}=5 V ±0.5 V

Optical Characteristics

High Efficiency Red IPD2545A

Description	Symbol	Min.	Typ.[4]	Units	Test Condition
Peak Luminous Intensity per LED [1,3] (Character Average)	I_{Vave}	75	150	µcd	V_{CC}=5.0 V, # sign "ON" on all digits at full brightness, T_A=25°C
Peak Wavelength	λ_{PEAK}		635	nm	
Dominant Wavelength [2]	λ_D		626	nm	

High Efficiency Green IPD2547A

Description	Symbol	Min.	Typ.[4]	Units	Test Condition
Peak Luminous Intensity per LED [1,3] (Character Average)	I_{Vave}	75	150	µcd	V_{CC}=5.0 V, # sign "ON" on all digits at full brightness, T_A=25°C
Peak Wavelength	λ_{PEAK}		568	nm	
Dominant Wavelength [2]	λ_D		574	nm	

Yellow IPD2548A

Description	Symbol	Min.	Typ.[4]	Units	Test Condition
Peak Luminous Intensity per LED [1,3] (Character Average)	I_{Vave}	75	150	µcd	V_{CC}=5.0 V, # sign "ON" on all digits at full brightness, T_A=25°C
Peak Wavelength	λ_{PEAK}		585	nm	
Dominant Wavelength [2]	λ_D		590	nm	

Notes:

1) The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2) Dominant wavelength λ_D is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3) The luminous stearance of the LED may be calculated using the following relationships.
   LV (cd/m^2) = IV (Candela)/A (Meter)^2
   LV (Footlamberts) = πIV (Candela)/A (Foot)^2
   A=8.4 x10^{-7} ft^2, 7.8x10^{-8} m^2
4) All typical values specified at V_{CC}=5.0 V and T_A=25 °C unless otherwise noted.

Pin definitions

Pin	Function	Definition
1	$\overline{RD}$	Active low, will enable a processor to read all registers.
2	CLK I/O	If CLK SEL (pin 3) is low, then expect an external clock source into this pin. If CLK SEL is high, then this pin will be the master or source for all other devices which have CLK SEL low.
3	CLK SEL	CLocK SELect determines the action of pin 2, CLK I/O. See section on Cascading for an example.
4	$\overline{RST}$	Reset. Must be held low until V_{CC} > 4.5 V. Reset is used only to synchronize blinking and will not clear the display.
5	CE1	Chip enable (active high).
6	$\overline{CE0}$	Chip enable (active low).
7	A2	Address input (MSB).
8	A1	Address input.

Pin definitions (continued)

Pin	Function	Definition
9	A0	Address input (LSB).
10	GND	Ground.
11	$\overline{WR}$	Write. Active low. If the device is selected, a low on the write input loads the data into memory.
12	D7	Data Bus bit 7 (MSB).
13	D6	Data Bus bit 6.
14	D5	Data Bus bit 5.
15	D4	Data Bus bit 4.
16	D3	Data Bus bit 3.
17	D2	Data Bus bit 2.
18	D1	Data Bus bit 1.
19	D0	Data Bus bit 0 (LSB).
20	V_{CC}	Positive power pin.

Switching specifications (V_{CC}=4.5 V)

Write Cycle Timing					
Parameter	**Description**	**Specification Minimum**			
		–55°C	**+25°C**	**+100°C**	**Units**
T_{CLR} (1)	Clear RAM	1	1	1	µs
T_{CLRD} (1)	Clear RAM Disable	1	1	1	µs
T_{AS}	Address Setup	10	10	10	ns
T_{CES}	Chip Enable Setup	0	0	0	ns
T_{RS}	Read Enable Setup	10	10	10	ns
T_{DS}	Data Setup	20	30	50	ns
T_W	Write Pulse	60	70	90	ns
T_{AH}	Address Hold	20	30	40	ns
T_{DH}	Data Hold	20	30	40	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{RH}	Read Enable Hold	20	30	40	ns
T_{ACC}	Total Access Time = Setup Time + Write Time + Hold Time	90	110	140	ns

Switching specifications (V_{CC}=4.5 V)

Read Cycle Timing					
Parameter	**Description**	**Specification Minimum**			
		–55°C	**+25°C**	**+100°C**	**Units**
T_{AS}	Address Setup	0	0	0	ns
T_{CES}	Chip Enable	0	0	0	ns
T_{WS}	Write Enable Setup	20	30	40	ns
T_{DD}	Data Delay Time	100	150	175	ns
T_R	Read Pulse	150	175	200	ns
T_{AH}	Address Hold	0	0	0	ns
T_{DH}	Data Hold	0	0	0	ns
T_{TRI}	Time to Tristate (Max. time)	30	40	50	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{WH}	Write Enable Hold	30	40	50	ns
T_{RACC}	Total Access Time = Setup Time + Read Time + Time to Tristate	200	245	290	ns
T_{WAIT} (1)	Wait Time between Reads	0	0	0	ns

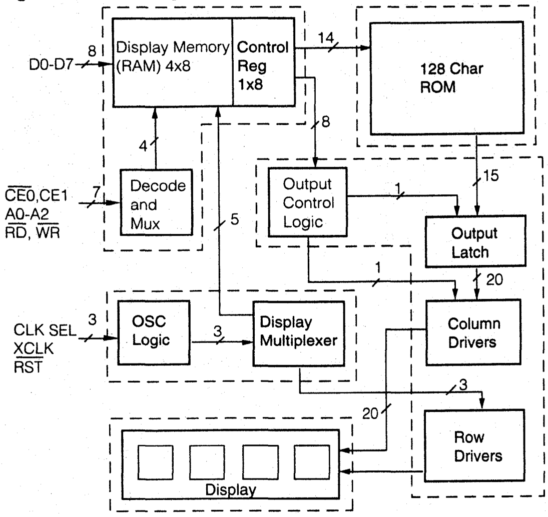
Notes:

1) Wait 1 µs between any Reads or Writes after writing a Control Word with a Clear (D7=1). Wait 1 µs between any Reads or Writes after Clearing a Control Word with a Clear (D7=0). All other Reads and Writes can be back to back.

2) All input voltages are (V_{IL}=0.8 V, V_{IH}=2.0 V)

3) Data out voltages are measured with 100pF on the data bus and the ability to source = –40 µA and sink=1.6 mA The rise and fall times are 60 ns. V_{OL}=0.4 V, V_{OH}=2.4 V.

Figure 9. Block diagram



Functional Description

The block diagram (Figure 4) includes 5 major blocks and internal registers (indicated by dotted lines).

Display Memory consists of a 5x8 bit RAM block. Each of the four 8-bit words holds the 7-bits of ASCII data (bits D0–D6) and an attribute select bit (Bit D7). The fifth 8-bit memory word is used as a control word register. A detailed description of the control register and its functions can be found under the heading Control Word. Each 8-bit word is addressable and can be read from or written to.

Mode selection

$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	Operation
0	1	0	0	None
1	X	X	X	None
X	0	X	X	None
X	X	1	1	None

0=Low logic level, 1=High logic level, X=Don't care

The **Control Logic** dictates all of the features of the display device and is discussed in the Control Word section of this data sheet.

The **Character Generator** converts the 7-bit ASCII data into the proper dot pattern for the 128 characters shown in the character set chart.

The **Clock Source** can originate either from the internal oscillator clock or from an external source–usually from the output of another IPD2545/7/8A in a multiple module display.

The **Display Multiplexer** controls all display output to the digit drivers so no additional logic is required for a display system.

The **Column Drivers** are connected directly to the display.

The **Display** has four digits. Each of the four digits is comprised of 35 LEDs in a 5x7 dot array which makes up the alphanumeric characters.

The intensity of the display can be varied by the Control Word in steps of 0% (Blank), 25%, 50%, and full brightness.

Microprocessor Interface

The interface to the microprocessor is through the address lines. (A0–A2), the data bus (D0–D7), two chip select lines ($\overline{CE0}$, CE1), and read ($\overline{RD}$) and write ($\overline{WR}$) lines.

The $\overline{CE0}$ should be held low when executing a read, or write operation. CE1 must be held high.

The read and write lines are both active low. During a valid read the data lines (D0–D7) become outputs. A valid write will enable the data lines as inputs.

Input Buffering

If a cable length of 6 inches or more is used, all inputs to the display should be buffered with a tri-state non-inverting buffer mounted as close to the display as conveniently possible. Recommended buffers are: 74LS245 for the data lines and 74LS244 for the control lines.

Data input commands

$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	No Change
0	1	0	1	1	0	0	X	X	X	X	X	X	X	X	Read Digit 0 Data to Bus
0	1	1	0	1	0	0	0	0	1	0	0	1	0	0	($) Written to Digit 0
0	1	1	0	1	0	1	0	1	0	1	0	1	1	1	(W) Written to Digit 1
0	1	1	0	1	1	0	0	1	1	0	0	1	1	0	(f) Written to Digit 2
0	1	1	0	1	1	1	0	0	1	1	0	0	1	1	(3) Written to Digit 3
0	1	1	0	1	0	0	1	X	X	X	X	X	X	X	Char. Written to Digit 0 and Cursor Enabled

Programming the IPD2545/7/8A

There are five registers within the IPD2545/7/8A display. Four of these registers are used to hold the ASCII/attribute code of the four display characters. The fifth register is the Control Word, which is used to blink, blank, clear, or dim the entire display, or to change the presentation (attributes) of individual characters.

Addressing

The addresses within the display device are shown below. Digit 0 is the rightmost digit of the display, while Digit 3 is on the left. Although there is only one Control Word, it is duplicated at the four address locations 0-3. Data can be read from any of these locations. When one of these locations is written to, all of them will change together.

Address			Contents
A2	**A1**	**A0**	
0	X	X	Control Word
1	0	0	Digit 0 (rightmost)
1	0	1	Digit 1
1	1	0	Digit 2
1	1	1	Digit 3 (leftmost)

Bit D7 of any of the display digit locations is used to allow an attribute to be assigned to that digit. The attributes are discussed in the next section. If Bit D7 is set to a one, that character will be displayed using the attribute. If bit D7 is cleared, the character will display normally.

Control Word

When address bit A2 is taken low, the Control Word is accessed. The same Control Word appears in all four of the lower address spaces of the display. Through the Control Word, the display can be cleared, the lamps can be tested, display brightness can be selected, and attributes can be set for any characters which have been loaded with their most significant bit (D7) set high.

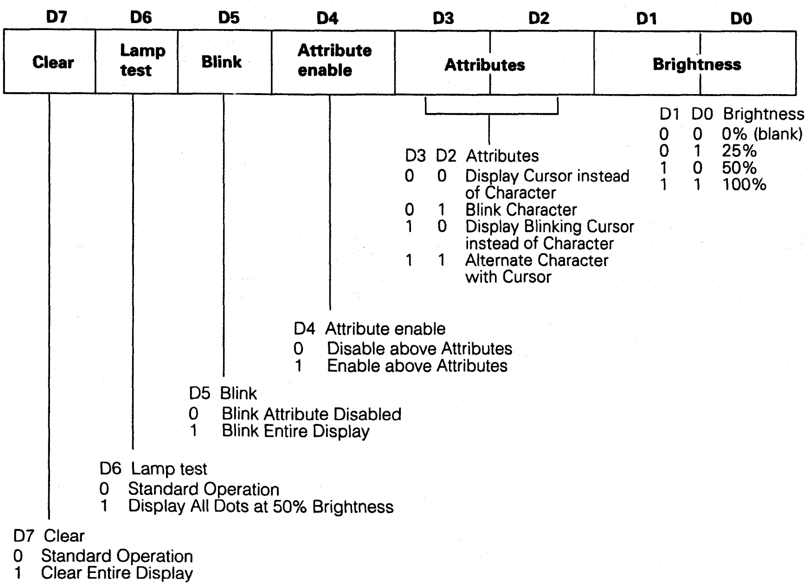
Brightness (D0, D1): The state of the lower two bits of the Control Word are used to set the brightness of the entire display, from 0% to 100%. The table below shows the correspondence of these bits to the brightness.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	X	X	X	X	0	0	Blank
0	0	X	X	X	X	0	1	25% brightness
0	0	X	X	X	X	1	0	50% brightness
0	0	X	X	X	X	1	1	Full brightness

X=don't care

Attributes (D2–D4): Bits D2, D3, and D4 control the visual attributes (i.e., blinking, alternate) of those display digits which have been written with bit D7 set high. In order to use any of the four attributes, the Cursor Enable bit (D4 in the Control Word) must be set. When the Cursor Enable bit is set, and bit D7 in a character location is set, the character will take on one of the following display attributes.

Figure 10. Control word format



D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	0	X	X	B	B	Disable highlight attribute
0	0	0	1	0	0	B	B	Display cursor* instead of character
0	0	0	1	0	1	B	B	Blink single character
0	0	0	1	1	0	B	B	Display blinking cursor* instead of character
0	0	0	1	1	1	B	B	Alternate character with cursor*

*"Cursor" = all dots in a single character space lit to half brightness
X = don't care
B = depends on the selected brightness

Attributes are non-destructive. If a character with bit D7 set is replaced by a cursor (Control Word bit D4 is set, and D3=D2=0) the character will remain in memory and can be revealed again by clearing D4 in the Control Word.

Blink (D5): The entire display can be caused to blink at a rate of approximately 2 Hz by setting bit D5 in the Control Word. This blinking is independent of the state of D7 in all character locations.

To synchronize the blink rate in a bank of these devices, it is necessary to tie all devices' clocks and resets together as described in a later section of this data sheet.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	X	X	X	B	B	Blinking display

Lamp Test (D6): When the Lamp Test bit is set, all dots in the entire display are lit at half brightness. When this bit is cleared, the display returns to the characters that were showing before the lamp test.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	1	0	0	X	X	X	X	Lamp test

Clear Data (D7): When D7 (D7=1) is set in the Control Word, all display memory bits are reset to zero. A second Control Word must be written into the chip with D7 (D7=0) reset to set up attributes and brightness levels.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	X	X	X	X	X	X	Clear

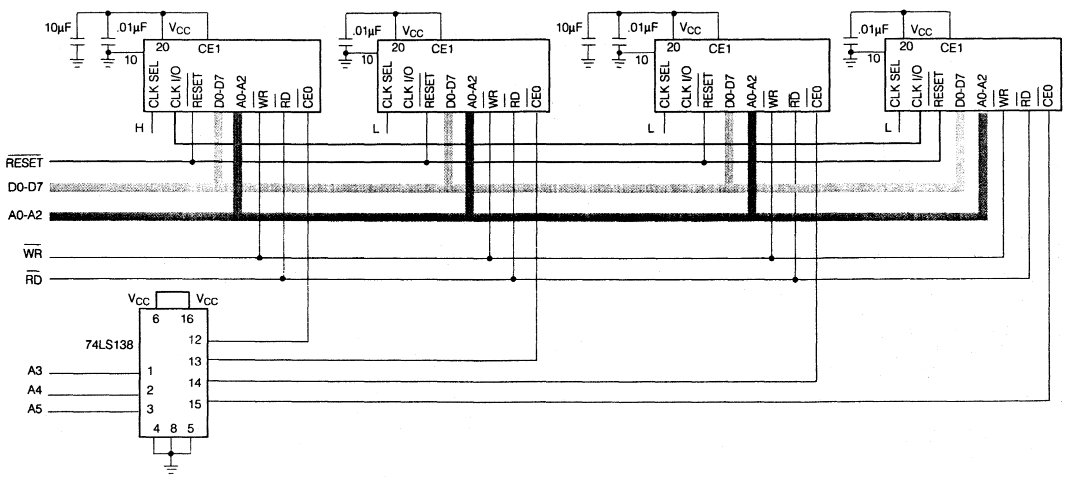
Cascading

Cascading the display (Figure 6) is a simple operation. The requirements for cascading are: 1) decoding the correct address to determine the chip select for each additional device, 2) assuring that all devices are reset simultaneously, and 3) selecting one display as the clock source and setting all others to accept clock input (the reason for cascading the clock is to synchronize the flashing of multiple displays). One display as a source is capable of driving six other displays. If more displays are required, a buffer will be necessary. The source display must have pin 3 tied high to output clock signals. All other displays must have pin 3 tied low.

Voltage Transients

It has become common practice to provide 0.01 µF bypass capacitors liberally in digital systems. Like other CMOS circuitry, the Intelligent Display controller chip has very low power consumption and the usual 0.01 µF would be adequate were it not for the LEDs. To prevent power supply transients, capacitors with low inductance and high capacitance at high frequencies are required. This suggests a solid tantalum or ceramic disc for high frequency bypass. For larger displays, distribute the bypass capacitors evenly, keeping capacitors as close to the power pins as possible. We recommend a 10 µF and 0.01 µF for every Intelligent Display to decouple the displays themselves, at the display.

Figure 11. Cascading the display



How to Load Information into the IPD25545/7/8A

Information loaded into the IPD2545/7/8A can be either ASCII data or Control Word data. The following procedure (see also Typical Loading Sequence) will demonstrate a typical loading sequence and the resulting visual display. The word STOP is used in all of the following examples.

Set Brightness

Step 1 Set the brightness level of the entire display to your preference (example: 100%).

Load Four Characters

Step 2 Load a "S" in the left hand digit.

Step 3 Load a "T" in the next digit.

Step 4 Load an "O" in the next digit.

Step 5 Load a "P" in the right hand digit. If you loaded the information correctly, the IPD2545A now should show the word "STOP."

Blink a Single Character

Step 6 Into the digit, second from the right, load the hex code "CF," which is the code for an "O" with the D7 bit added as a control bit.

Note:
The "O" is the only digit which has the control bit (D7) added to normal ASCII data.

Step 7 Load enable blinking character into the control word register. The display now should show "STOP" with a flashing "O".

Add Another Blinking Character

Step 8 Into the left hand digit, load the hex code "D3" which gives an "S" with the D7 bit added as a control bit. The display should show "STOP" with flashing "O" and a flashing "S."

Alternate Character/Cursor Enable

Step 9 Load enable alternate character/cursor into the control word register. The display now should show "STOP" with the "O" and the "S" alternating between the letter and cursor (all dots lit).

Initiate Four Character Blinking

(Regardless of Control Bit setting)

Step 10 Load enable display blinking. The display now should show the entire word "STOP" blinking.

Electrical and Mechanical Considerations

The CMOS IC of the IPD2545/7/8A are designed to provide resistance to both Electrostatic and Discharge Damage and Latch Up due to voltage or current surges. Several precautions are strongly recommended for the user, to avoid overstressing these built-in safeguards.

ESD Protection

Users of the IPD2545/7/8A should be careful to handle the devices consistent with standard ESD protection procedures. Operators should wear appropriate wrist, ankle or feet ground straps and avoid clothing that collects static charges. Work surfaces, tools and transport carriers that come into contact with unshielded devices or assemblies also should be appropriately grounded.

Latch up Protection

Latch up is condition that occurs in CMOS ICs after the input protection diodes have been broken down. These diodes can be reversed through several means.

V_{IN}<GND, V_{IN}>V_{CC} +0.5 V, or through excessive currents begin forced on the inputs. When these situations exist, the IC may develop the response of an SCR and begin conducting as much as one amp through the V_{CC} pin. This destructive condition will persist (latched) until device failure or the device is turned off.

The Voltage Transient Suppression Techniques and buffer interfaces for longer cable runs help considerably to prevent latch conditions from occurring. Additionally, the following Power Up and Power Down sequence should be observed.

Typical loading sequence

	$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Display
1.	L	H	H	L	L	X	X	0	0	0	0	0	0	1	1	
2.	L	H	H	L	H	H	H	0	1	0	1	0	0	1	1	S
3.	L	H	H	L	H	H	L	0	1	0	1	0	1	0	0	ST
4.	L	H	H	L	H	L	H	0	1	0	0	1	1	1	1	STO
5.	L	H	H	L	H	L	L	0	1	0	1	0	0	0	0	STOP
6.	L	H	H	L	H	L	H	1	1	0	0	1	1	1	1	STOP
7.	L	H	H	L	L	X	X	0	0	0	1	0	1	1	1	STO*P
8.	L	H	H	L	H	H	H	1	1	0	1	0	0	1	1	S*TO*P
9.	L	H	H	L	L	X	X	0	0	0	1	1	1	1	1	S†TO†P
10.	L	H	H	L	L	X	X	0	0	1	0	0	0	1	1	S*T*O*P*

* Blinking character, † Character alternating with cursor (all dots lit)

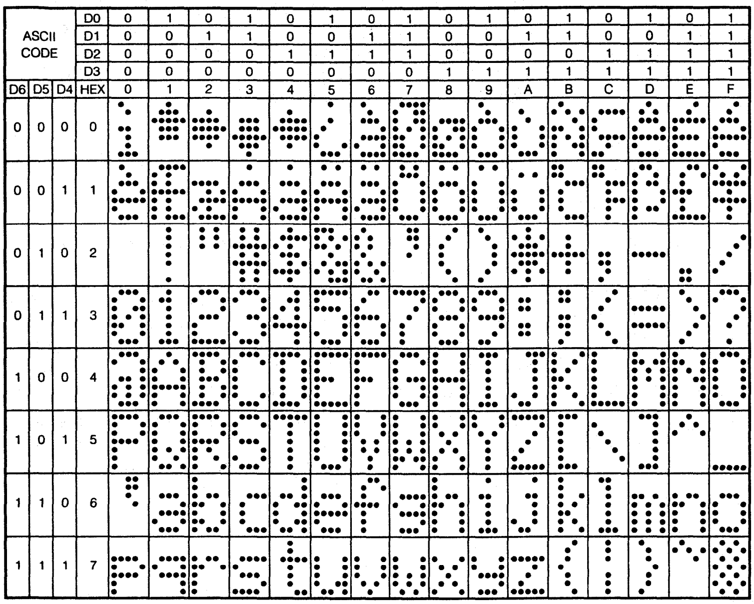
Power up Sequence

1. Float all active signals by tri-stating the inputs to the displays.
2. Apply V_{CC} and GND to the display.
3. Apply active signals to the displays by enabling all input signals per applications.

Power Down Sequence

1. Float all active signals by tri-stating the inputs to the displays.
2. Turn off the power to the display.

Figure 12. Character set



Notes:

1. High=1 level
2. Low=0 level
3. Upon power up, the device will initialize in a random state.
4. A2 must be held high for ASCII data.
5. Bit D7=1 enables attributes for the assigned digit.

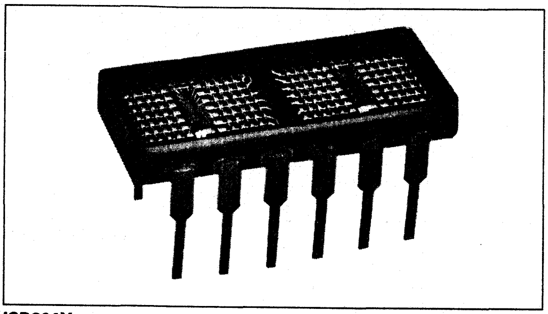
General Quality Assurance Levels

The parts are tested in conformance with Quality Level A of MIL-D-87157 for hermetically sealed LED displays with 100% screening.

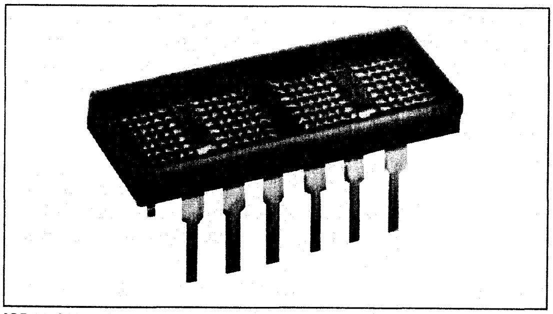
SIEMENS

RED ISD2010/2310
YELLOW ISD2011/2311/2351
HIGH EFFICIENCY RED ISD2012/2312/2352
HIGH EFFICIENCY GREEN ISD2013/2313/2353

4-Character 5x7 Dot Matrix Serial Input Alphanumeric Industrial Display Sunlight Viewable: ISD235X



ISD201X



ISD231X/235X

FEATURES

- **Four Dot Matrix Characters**
- **Character Height**
  ISD201X—0.150"
  ISD231X/235X—0.200"
- **ISD201X/231X, Four Colors: Red, Yellow, High Efficiency Red, High Efficiency Green**
- **ISD235X, Three Colors: Yellow, High Efficiency Red, High Efficiency Green**
- **Wide Viewing Angle**
- **Built-in CMOS Shift Registers with Constant Current LED Row Drivers**
- **Shift Registers Allow Custom Fonts**
- **Easily Cascaded for Multiple Displays**
- **TTL Compatible**
- **End Stackable**
- **Operating Temperature Range: –55°C to +100°C**
- **Categorized for Luminous Intensity**
- **Ceramic Package, Hermetically Sealed Flat Glass Window**

DESCRIPTION

The ISD201X/231X/235X are four digit 5x7 dot matrix serial input alphanumeric displays. The displays are available in red, yellow, high efficiency red, or high efficiency green. The package is a standard twelve-pin hermetic DIP with glass lens. The display can be stacked horizontally or vertically to form messages of any length.

These displays have two fourteen-bit CMOS shift registers with built-in row drivers. These shift registers drive twenty-eight rows and enable the design of customized fonts. Cascading multiple displays is possible because of the Data In and Data Out pins. Data In and Out are easily input with the clock signal and displayed in parallel on the row drivers. Data Out represents the output of the 7th bit of digit number four shift register. The shift register is level triggered. The like columns of each character in a display cluster are tied to a single pin (see Block Diagram). High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5x7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduce power consumption.

DESCRIPTION (continued)

In the normal mode of operation, input data for digit four, column one is loaded into the seven on-board shift register locations one through seven. Column one data for digits 3, 2, and 1 is shifted into the display shift register locations. Then column one input is enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4, and 5. If the decode time and load data time into the shift register is t, then with five columns, each column of the display is operating at a duty factor of:

$$DF = \frac{T}{5(T+1)}$$

T+t, allotted to each display column, is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time T+t of: 1/[5x(100)]=2 msec. If the device is operated at 5.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

See Appnote 44 for application information and Appnotes 18, 19, 22, 23 for additional information.

Maximum Ratings

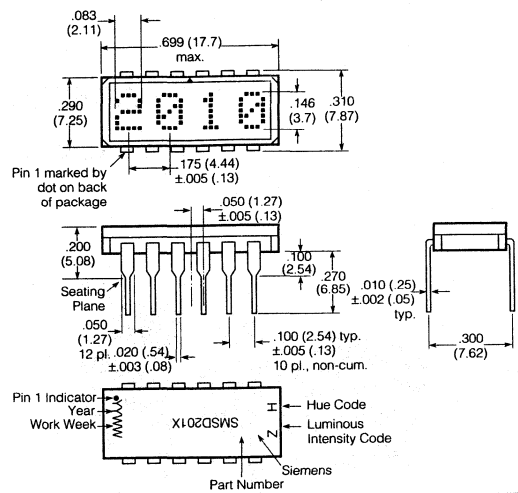
Supply Voltage V_{CC} to GND .... –0.5 V to +7.0 V
Inputs, Data Out and V_B .... –0.5 V to V_{CC} +0.5 V
Column Input Voltage, V_{COL} .... –0.5 V to +6.0 V
Operating Temperature Range .... –55°C to +100°C
Storage Temperature Range .... –65°C to +125°C
Maximum Solder Temperature, 0.063" (1.59 mm)
below Seating Plane, t<5 sec .... 260°C
Maximum Allowable Power Dissipation, T_A=25°C [(2)]
ISD2010 .... 0.91 W
ISD2011/2/3 .... 0.86 W
ISD231X .... 1.1 W
ISD235X .... 1.35 W

Notes:

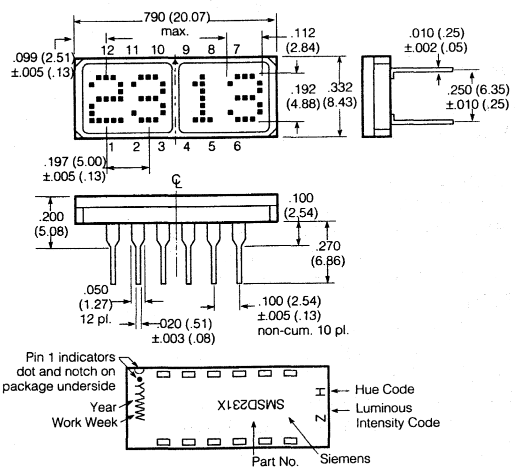
1) Operation above +100 °C ambient is possible if the following conditions are met. The junction should not exceed T_J=125 °C and the case temperature (as measured at pin 1 or the back of the display) should not exceed T_C=100 °C.

2) Maximum allowable dissipation is derived from V_{CC}=5.25 V, V_B=2.4 V, V_{COL}=3.5 V 20 LEDs on per character, 20% DF.

Dimensions in Inches (mm) **ISD210X**

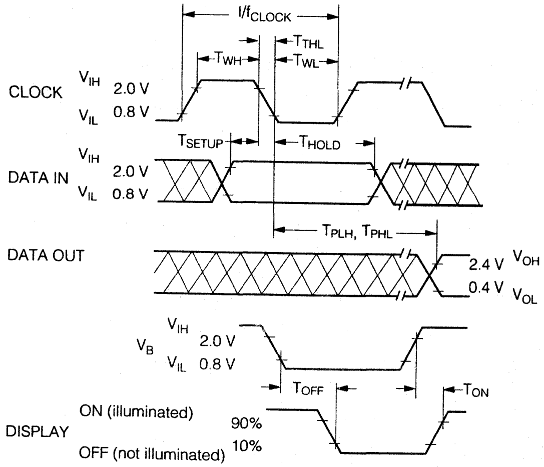


ISD231X/235X



Pin	Function	Pin	Function
1	Column 1	7	Data Out
2	Column 2	8	V_B
3	Column 3	9	V_{CC}
4	Column 4	10	Clock
5	Column 5	11	Ground
6	No connection	12	Data In

Figure 6. Timing characteristics



AC electrical characteristics

(V_{CC}=4.75 to 5.25 V, T_A=–55°C to 100°C)

Symbol	Description	Min.	Typ.	Max.[1]	Units	Fig.
T_{SETUP}	Setup Time	50	10		ns	1
T_{HOLD}	Hold Time	25	20		ns	1
T_{WL}	Clock Width Low	75	45		ns	1
T_{WH}	Clock Width High	75	45		ns	1
$F_{(CLK)}$	Clock Frequency			5	MHz	1
T_{THL} T_{TLH}	Clock Transition Time		75	200	ns	1
T_{PHL} T_{PLH}	Propagation Delay Clock to Data Out		50	125	ns	1

Notes:

1) All typical values specified at V_{CC}=5.0 V and T_A=25 °C unless otherwise noted.

2) V_B Pulse Width Frequency—50 KHz (max.)

Figure 7. Maximum allowable power dissipation vs. temperature, ISD201X

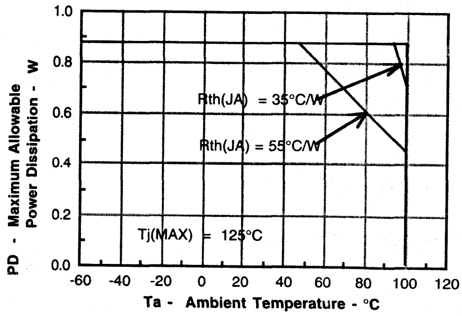


Figure 8. Maximum allowable power dissipation vs. temperature, ISD231X

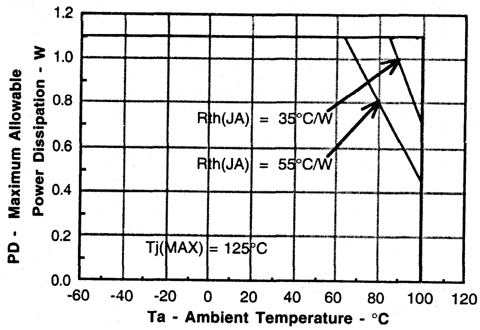
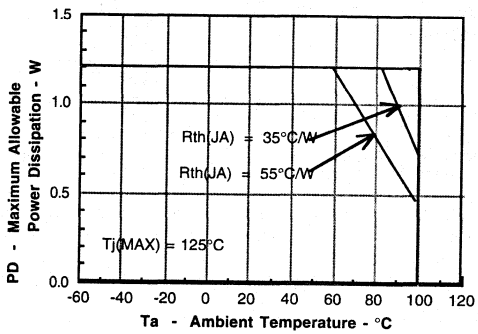


Figure 9. Maximum allowable power dissipation vs. temperature, ISD235X



Intelligent Display Devices 2

Optical Characteristics

Red ISD2010, ISD2310

Description		Symbol	Min.	Typ.(4)	Units	Test Conditions
Peak Luminous Intensity per LED (1,3) (Character Average)	ISD2010	I_{VPEAK}	105	200	μcd	V_{CC}=5.0 V, V_{COL}=3.5 V T_J=25°C(5), V_B=2.4 V
	ISD2310		220	370		
Peak Wavelength		λ_{VPEAK}		655	nm	
Dominant Wavelength(2)		λ_D		639	nm	

Yellow ISD2011, IDS2311, ISD2351

Description		Symbol	Min.	Typ.(4)	Units	Test Conditions
Peak Luminous Intensity per LED (1,3) (Character Average)	ISD2011	I_{VPEAK}	400	750	μcd	V_{CC}=5.0 V, V_{COL}=3.5 V T_J=25°C(5), V_B=2.4 V
	ISD2311		650	1140		
	ISD2351		2400	3400		
Peak Wavelength		λ_{VPEAK}		655	nm	
Dominant Wavelength(2)		λ_D		639	nm	

High Efficiency Red IDS2012, ISD2312, IDS2352

Description		Symbol	Min.	Typ.(4)	Units	Test Conditions
Peak Luminous Intensity per LED (1,3) (Character Average)	ISD2012	I_{VPEAK}	400	1430	μcd	V_{CC}=5.0 V, V_{COL}=3.5 V T_J=25°C(5), V_B=2.4 V
	ISD2312		650	1430		
	ISD2352		853	2500		
Peak Wavelength		λ_{VPEAK}		655	nm	
Dominant Wavelength(2)		λ_D		639	nm	

High Efficiency Green IDS2013, ISD2313, IDS2353

Description		Symbol	Min.	Typ.(4)	Units	Test Conditions
Peak Luminous Intensity per LED (1,3) (Character Average)	ISD2013	I_{VPEAK}	850	1550	μcd	V_{CC}=5.0 V, V_{COL}=3.5 V T_J=25°C(5), V_B=2.4 V
	ISD2313		1280	2410		
	ISD2353		2400	3000		
Peak Wavelength		λ_{VPEAK}		655	nm	
Dominant Wavelength(2)		λ_D		639	nm	

Notes:

1) The displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
2) Dominant wavelength (λ_D) is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3) The luminous sterance of the LED may be calculated using the following relationships:
L_V (cd/m ^{2}) = I_V (Candela)/A (Meter) ^{2}
L_V (Footlamberts) = πI_V (Candela)/A (Foot) ^{2}
A=5.3 x 10 $^{-8}$ m^2 = 5.8 x 10 $^{-7}$ (Foot) ^{2}
4) All typical values specified at V_{CC}=5.0 V and T_A=25 °C unless otherwise noted.
5) The luminous intensity is measured at T_A=T_J=25 °C. No time is allowed for the device to warm up prior to measurement.

Recommended operating conditions
(Guaranteed over operating temperature range)

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}				mA
Data Out Current, High State	I_{OH}				mA
Column Input Voltage, Column On (1)	V_{COL}	2.75		3.5	V
Setup Time	T_{SETUP}	70	45		ns
Hold Time	T_{HOLD}	30			ns
Width of Clock	$T_{W(CLK)}$	75			ns
Clock Frequency	T_{CLK}			5	MHz
Clock Transition Time	T_{THL}			200	ns
Free Air Operating Temperature Range	T_A	–55		+100	°C

Note:
1) SeeFigures5,6and7:Peakcolumncurrentversuscolumnvoltage

Figure 10. Peak column current vs. column voltage, ISD201X

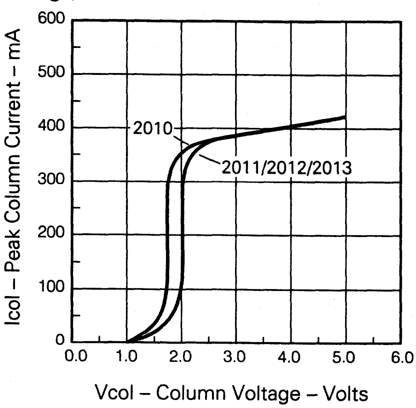


Figure 11. Peak column current vs. column voltage, ISD231X

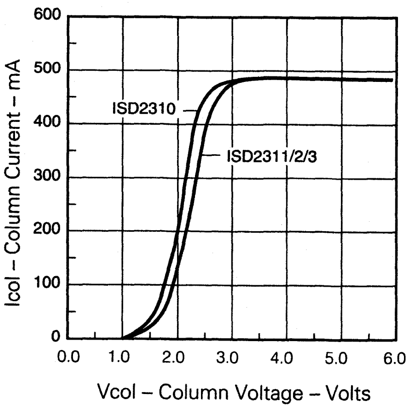
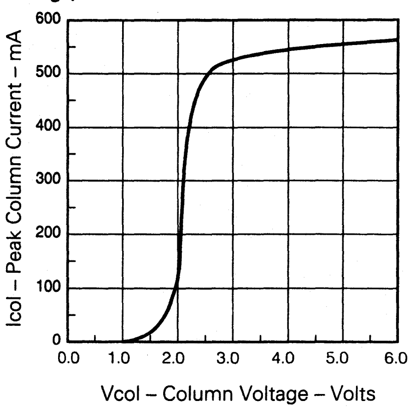


Figure 12. Peak column current vs. column voltage, ISD235X



Electrical characteristics (–55°C to +100°C, unless otherwise specified)

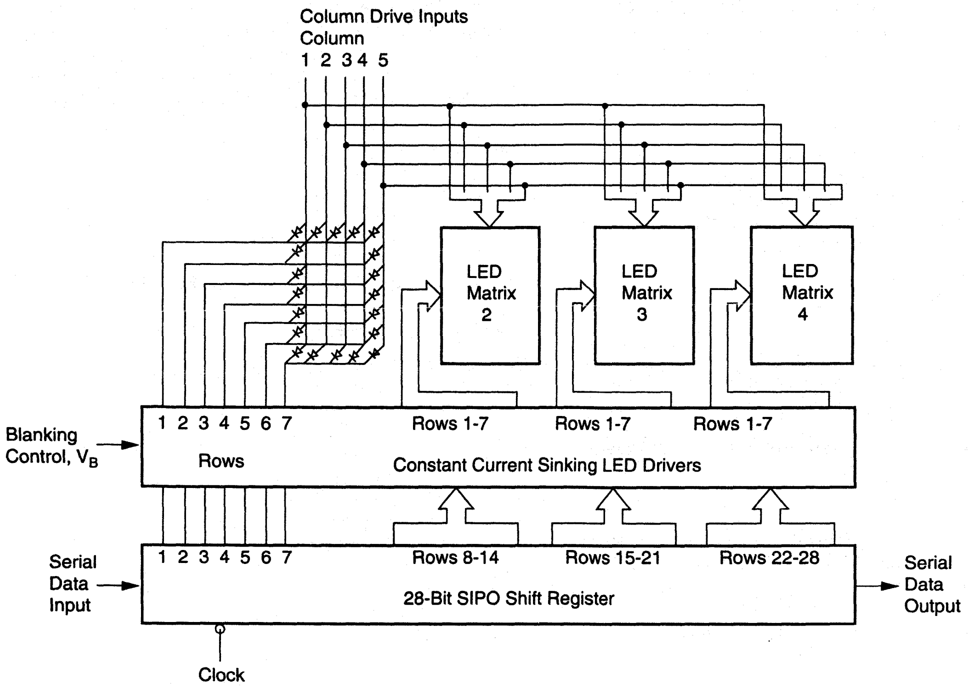
Description	Symbol	Min.	Typ.[1]	Max.	Units	Test Conditions	
Supply Current (quiescent)	I_{CC}			5.0	mA	V_B=0.4 V	V_{CC}=5.25 V V_{CLK}=V_{DATA}=2.4 V All SR Stages=Logical 1
				5.0		V_B=2.4 V	
Supply Current (operating)	I_{CC}			10	mA	F_{CLK}=5 MHz	
Column Current at Any Column Input [2]	I_{COL}			10	µA	V_B=0.4 V	V_{CC}=5.25 V V_{COL}=3.5 V All SR Stages=Logical 1
Column Current at Any Column Input [2]	I_{COL}				mA		
ISD2010 red			350	435			
ISD2011/2/3: yellow, HER, green			335	410			
ISD231X: red, yellow, HER, green			380	520			
ISD235X: yellow, HER, green			550	650			
V_B, Clock or Data Input Threshold Low	V_{IL}			0.8	V	V_{CC}=4.75 V–5.25 V	
V_B, Clock or Data Input Threshold High	V_{IH}	2.0			V		
Data Out Voltage	V_{OH}	2.4	3.6		V	I_{OH}=0.5 mA	V_{CC}=5.25 V I_{COL}=0 mA
	V_{OL}					I_{OL}=1.6 mA	
Input Current Logical 0, V_B only	I_{IL}	–30	–110	–300	µA	V_{CC}=4.75 V–5.25 V, V_{IL}=0.8 V	
Input Current Logical 0, Data, Clock	I_{IL}						
Power Dissipation per Package	PD				W	V_{CC}=5.0 V, V_{COL}=3.5 V, 17.5% DF 15 LEDs on per character, V_B=2.4 V	
ISD201X		0.44					
ISD231X		0.52					
ISD235X		0.74					
Thermal Resistance IC, Junction-to-Pin	$R\theta_{J\text{-}PIN}$				°C/W/ Device		
ISD201X			30				
ISD231X			20				
ISD235X			25				

Notes:

1) All typical values specified at V_{CC}=5.0 V and T_A=25 °C unless otherwise noted.

2) See Figures 5, 6 and 7: Peak column current versus column voltage

Figure 13. Block diagram



Contrast enhancement filters for sunlight readability

Display Color	Filter Color	Marks Polarized Corp.*	Optical Characteristics of Filter
Red, HER	Red	MPC 20-15C	25% at 635 nm, Circular Polarizer
Yellow	Amber	MPC 30-25C	25% at 583 nm, Circular Polarizer
Green	Yellow/Green	MPC 50-122C	22% at 568 nm, Circular Polarizer
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral, Circular Polarizer
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral, Circular Polarizer

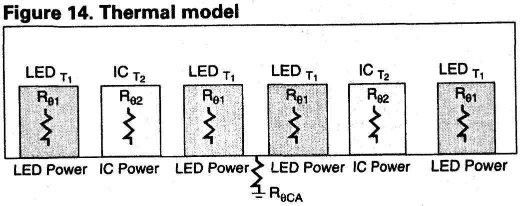
* Marks Polarized Corp.
25-B Jefryn Blvd. W.
Deer Park, NY 11729
516/242-1300
FAX 516/242-1347
Marks Polarized Corp. manufactures
to MIL-1-45208 inspection system.

The small alphanumeric displays are hybrid LED and CMOS assemblies that are designed for reliable operation in commercial and industrial environments. Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible.

Thermal Modeling

ISD displays consist of two driver ICs and four 5x7 LED matrixes. A thermal model of the display is shown in Figure 9. It illustrates that the junction temperature of the semiconductor = junction self heating + the case temperature rise + the ambient temperature. Equation 1 shows this relationship.

Figure 14. Thermal model



See Equation 1 below.

The junction rise within the LED is the product of the thermal impedance of an individual LED (37°C/W, DF=20%, F=200 Hz), times the forward voltage, $V_{F(LED)}$, and forward current $I_F(LED)$, of 13 – 14.5 mA. This rise averages $T_{J(LED)}$=1°C. The Table below shows the $V_{F(LED)}$ for the respective displays.

Model Number	VF		
	Min.	Typ.	Max.
ISD2010 ISD2310	1.6	1.7	2.0
ISD2011/2/3 ISD2311/2/3 ISD2351/2/3	1.9	2.2	3.0

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2.

A thermal resistance of 28°C/W results in a typical junction rise of 6°C.

See Equation 2 below.

For ease of calculations the maximum allowable electrical operating condition is dependent upon the aggregate thermal resistance of the LED matrixes and the two driver ICs. All of the thermal management calculations are based upon the parallel combination of these two networks which is 15°C/W. Maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5V_{COL}\, I_{COL}(n/35)\, DF + V_{CC} I_{CC}$$

For further reference see Figures 2, 3, 4 and 11 – 23.

Key to equation symbols

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5x7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of a LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

Optical Considerations

The light output of the LEDs is inversely related to the LED diode's junction temperature as shown in Figure 10. For optimum light output, keep the thermal resistance of the socket or PC board as low as possible.

Equation 1.

$$T_{J(LED)} = P_{LED} Z_{\theta JC} + P_{CASE}(R_{\theta JC} + R_{\theta CA}) + T_A$$

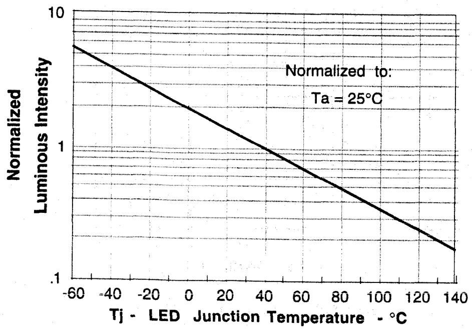
$$T_{J(LED)} = [(I_{COL}/28) V_{F(LED)} Z_{\theta JC}] + [(n/35) I_{COL} DF(5V_{COL}) + V_{CC} I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

Equation 2.

$$T_{J(IC)} = P_{COL}(R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5(V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35) DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

Figure 15. Normalized luminous intensity vs. junction temperature



When mounted in a 10°C/W socket and operated at Absolute Maximum Electrical conditions, the display will show an LED junction rise of 17°C. If T_A=40°C, then the LED's T_J will be 57°C. Under these conditions Figure 11 shows that the IV will be 75% of its 25°C value.

Figure 16. Max. LED junction temperature vs. socket thermal resistance

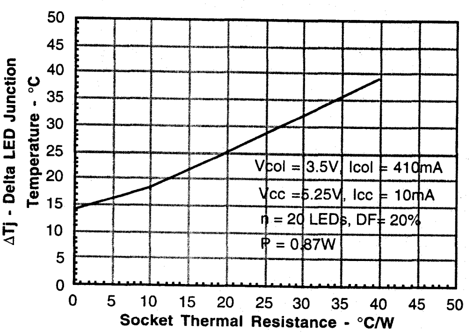


Figure 17. Max. package power dissipation, ISD201X

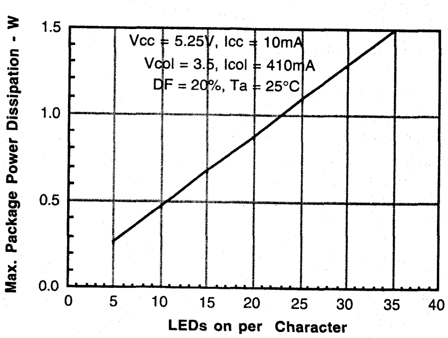


Figure 18. Max. package power dissipation, ISD231X

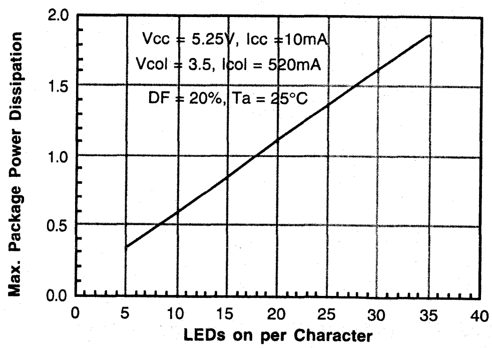


Figure 19. Max. package power dissipation, ISD235X

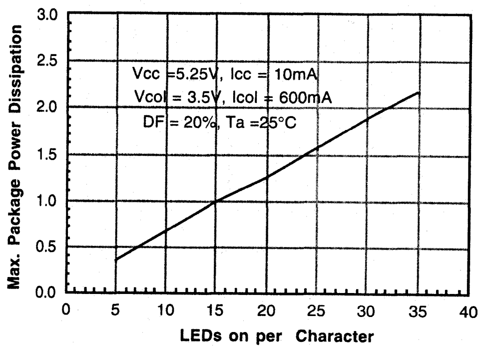


Figure 20. Package power dissipation, ISD201X

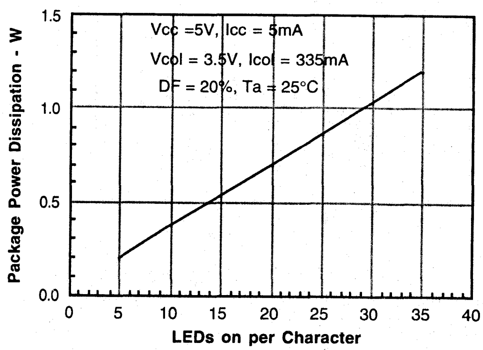


Figure 21. Max. package power dissipation, ISD231X

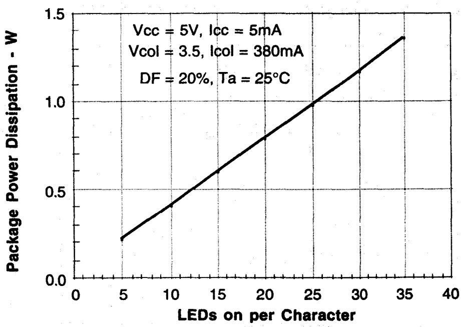


Figure 22. Max. package power dissipation, ISD235X

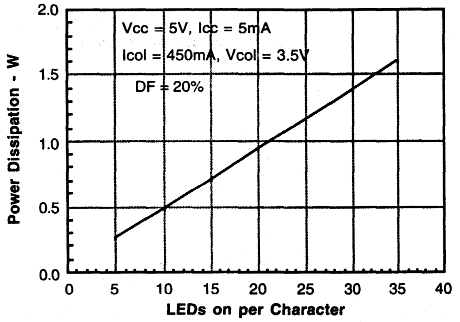


Figure 23. Max. character power dissipation, ISD201X

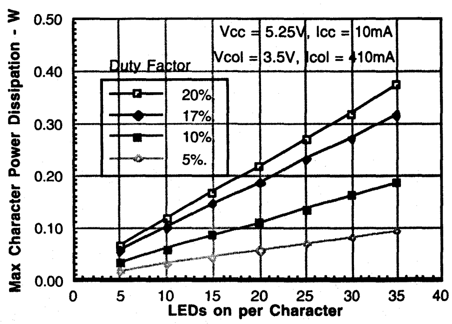


Figure 24. Max. character power dissipation, ISD231X

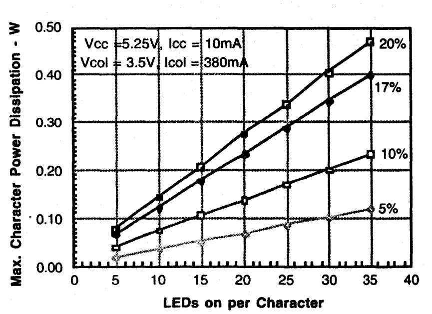


Figure 25. Max. character power dissipation, ISD235X

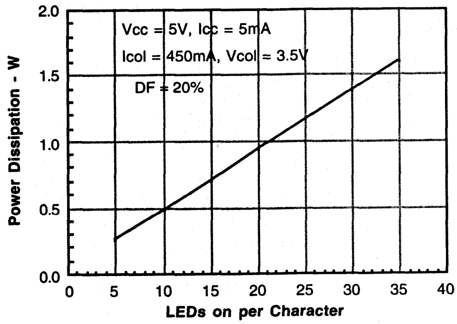


Figure 26. Character power dissipation, ISD201X

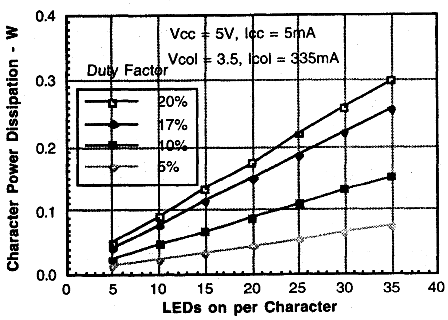


Figure 27. Character power dissipation, ISD231X

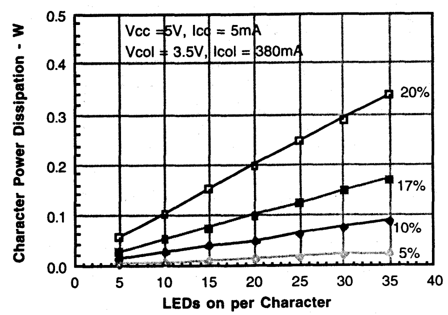
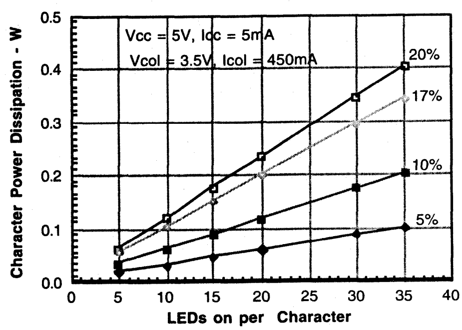


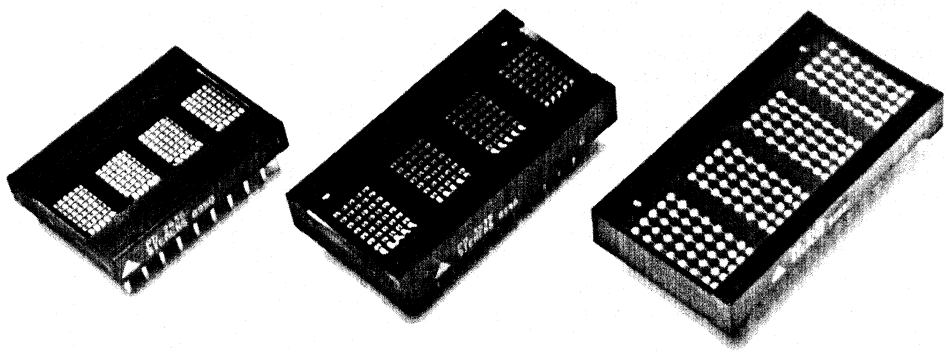
Figure 28. Character power dissipation, ISD235X



SIEMENS

HER PD2435/PD3535/PD4435
RED PD2436/PD3536/PD4436
BRIGHT GREEN PD2437/PD3537/PD4437

0.200" Character, PD2435/6/7
0.270" Character, PD3535/6/7
0.45" Character, PD4435/6/7
4-Character 5x7 Dot Matrix Alphanumeric Programmable Display™ with Built-in CMOS Control Functions



PD243X PD353X PD443X

FEATURES

- Four Dot Matrix Characters in High Efficiency Red, Red, and Bright Green
  - PD2435/6/7, 0.200" High
  - PD3535/6/7, 0.270" High
  - PD4435/6/7, 0.45" High
- Built-in Memory, Decoders, Multiplexer and Drivers
- Wide Viewing Angle, X Axis ±55°, Y Axis ±65°
- Categorized for Luminous Intensity
- 128 Character ASCII Format (Upper and Lower Case Characters)
- 8 Bit Bidirectional Data BUS
- READ/WRITE Capability
- Dual In-Line Package Configuration, 0.600" Wide, 0.100" Pin Centers
- End-Stackable Package
- Internal or External Clock
- Built-in Character Generator ROM
- TTL Compatible
- Easily Cascaded for Multidisplay Operation
- Less CPU Time Required
- Software Controlled Features:
  - Programmable Highlight Attribute (Blinking, Non-Blinking)
  - Asynchronous Memory Clear Function
  - Lamp Test
  - Display Blank Function
  - Single or Multiple Character Blinking Function
  - Programmable Intensity Three Brightness Levels
- Extended Operating Temperature Range:
  - PD243X, PD353X: –40°C to +85°C
  - PD443X: –40°C to +70°C

DESCRIPTION

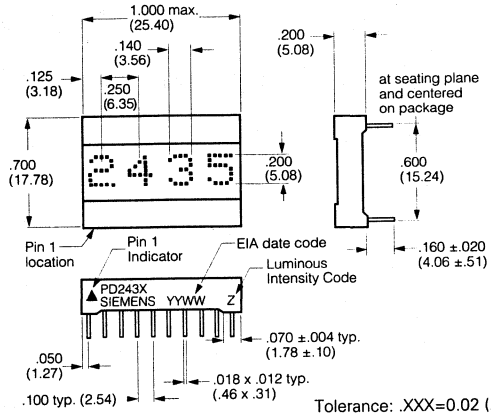
These Programmable Displays are four digit display system modules. The characters are 0.20" by 0.14" (PD243X), 0.27" by 0.20" (PD353X), and 0.45" by 0.27" (PD443X) 5x7 dot matrix arrays constructed with the latest solid state technology in light emitting diodes. Driving and controlling the LED arrays is a silicon gate CMOS integrated circuit. This integrated circuit provides all necessary LED drivers and complete multiplexing control logic.

Additionally, the IC has the necessary ROM to decode 128 ASCII alphanumeric characters and enough RAM to store the display's complete four digit ASCII message with special attributes. These attributes, all software programmable at the user's discretion, include a lamp test, brightness control, displaying cursors, alternating cursors and characters, and flashing cursors or characters.

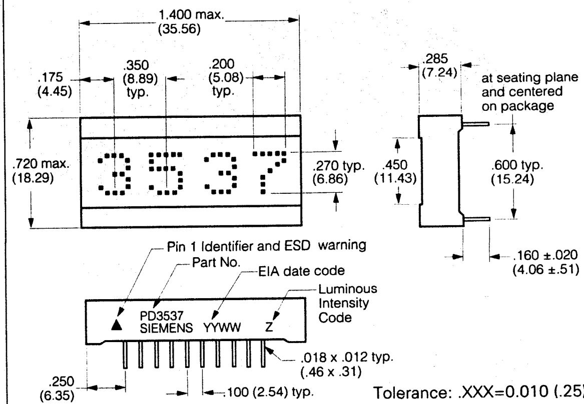
The CMOS IC also incorporates special interface control circuitry to allow the user to control the module as a fully supported microprocessor peripheral. The module, under internal or external clock control, has asynchronous read, write, and memory clear over an eight bit parallel, TTL compatible, bi-directional data bus. Each module is fully encapsulated within a package 1.0" x 0.7" x 0.2" (PD253X), 1.4" x 0.72" x 0.285" (PD353X), and 1.5" x 0.82" x 0.285" (PD443X). The standard 20 pin DIP construction with two rows spaced at 0.6" on 0.1" centers is wave solderable.

See the end of this data sheet or refer to Appnotes 18, 19, 22, and 23 for further details on handling and assembling Siemens Programmable Displays.

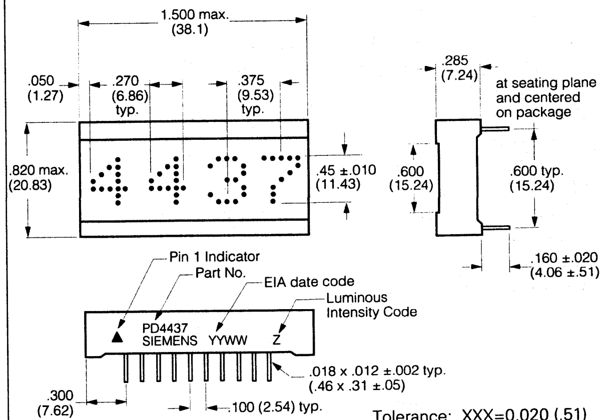
Dimensions in Inches (mm)



Tolerance: .XXX=0.02 (.51)



Tolerance: .XXX=0.010 (.25)
unless max.



Tolerance: .XXX=0.020 (.51)

Maximum Ratings

DC Supply Voltage .... –0.5 V to +7.0 Vdc
Input Voltage Relative
  to GND (all inputs) .... –0.5 V to V_{CC} +0.5 Vdc
Operating Temperature
  PD243X/353X .... –40°C to +85°C
  PD443X .... –40°C to +70°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature, .063" (1.59 mm)
  below Seating Plane, t<5 sec. .... 260°C

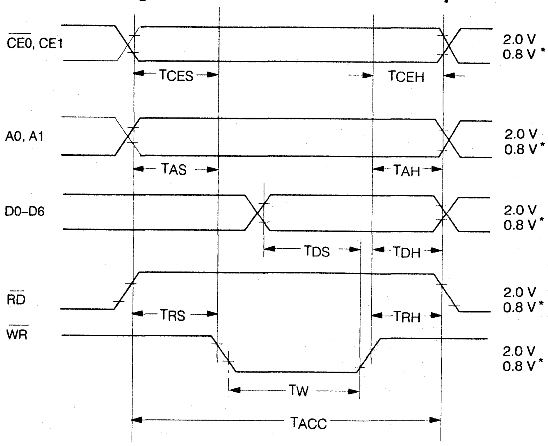
Optical Characteristics at 25°C

Spectral Peak Wavelength
  HER .... 635 nm typ.
  Red .... 660 nm typ.
  Green .... 565 nm typ.
Viewing Angle
  Horizontal
  PD243X/353X .... ±55°
  PD443X .... ±40°
  Vertical (off normal axis) .... ±65°
Digit Height
  PD243X .... 0.200" (5.08 mm)
  PD353X .... 0.270" (6.86 mm)
  PD443X .... 0.45" (11.43 mm)
Time Averaged Luminous Intensity [1]
  Red .... 30 µcd/LED min.
  HER/Green .... 90 µcd/LED min.
LED to LED Intensity Matching .... 1.8:1.0 max.
Device to Device (one bin) .... 1.5:1.0 max.
Bin to Bin (adjacent bins) .... 1.9:1.0 max.

Note:

1) Peak luminous intensity values can be calculated by multiplying these values by 7.

Figure 7. Timing characteristics—data "write" cycle



Notes:

1. All input voltages are V_{IL}=0.8 V, V_{IH}=2.0 V.
2. These waveforms are not edge triggered.

Figure 8. Timing characteristics—data "read" cycle

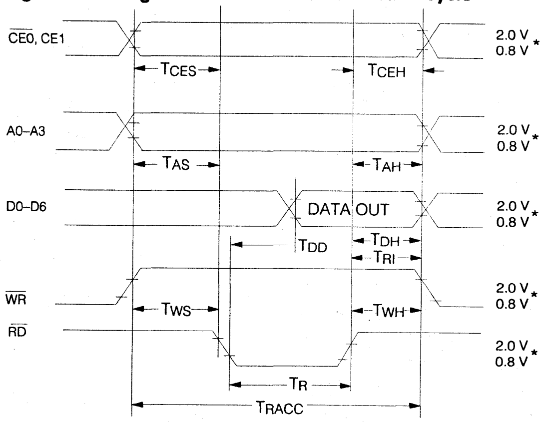
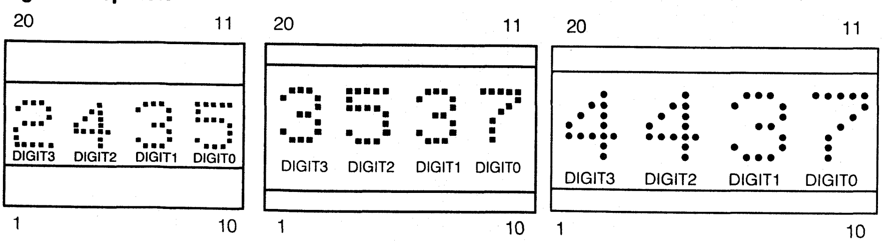


Figure 6. Top view



Switching specifications (V_{CC}=4.5 V)

Write Cycle Timing					
Parameter	**Description**	**Specification Minimum**			
		-40°C	**25°C**	**85°C**	**Units**
T_{CLR} (1)	Clear RAM	1	1	1	µs
T_{CLRD} (1)	Clear RAM Disable	1	1	1	µs
T_{AS}	Address Setup	10	10	10	ns
T_{CES}	Chip Enable Setup	0	0	0	ns
T_{RS}	Read Enable Setup	10	10	10	ns
T_{DS}	Data Setup	20	30	50	ns
T_W	Write Pulse	60	70	90	ns
T_{AH}	Address Hold	20	30	40	ns
T_{DH}	Data Hold	20	30	40	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{RH}	Read Enable Hold	20	30	40	ns
T_{ACC}	Total Access Time = Setup Time + Write Time + Hold Time	90	110	140	ns

Switching specifications (V_{CC}=4.5 V)

Read Cycle Timing					
Parameter	**Description**	**Specification Minimum**			
		-40°C	**25°C**	**85°C**	**Units**
T_{AS}	Address Setup	0	0	0	ns
T_{CES}	Chip Enable	0	0	0	ns
T_{WS}	Write Enable Setup	20	30	40	ns
T_{DD}	Data Delay Time	100	150	175	ns
T_R	Read Pulse	150	175	200	ns
T_{AH}	Address Hold	0	0	0	ns
T_{DH}	Data Hold	0	0	0	ns
T_{TRI}	Time to Tristate (Max. time)	30	40	50	ns
T_{CEH}	Chip Enable Hold	0	0	0	ns
T_{WH}	Write Enable Hold	30	40	50	ns
T_{ACC}	Total Access Time = Setup Time + Read Time + Time to Tristate	200	245	290	ns
T_{WAIT} (1)	Wait Time between Reads	0	0	0	ns

Notes:

1) Wait 1 µs between any Reads or Writes after writing a Control Word with a Clear (D7=1). Wait 1 µs between any Reads or Writes after Clearing a Control Word with a Clear (D7=0). All other Reads and Writes can be back to back.

2) All input voltages are (V_{IL}=0.8 V, V_{IH}=2.0 V)

3) Data out voltages are measured with 100 pF on the data bus and the ability to source = -40 µA and sink=1.6 mA The rise and fall times are 60 ns. V_{OL}=0.4 V, V_{OH}=2.4 V.

DC characteristics at 25°C

Parameter	Limits				Conditions
	Min.	Typ.	Max.	Units	
V_{CC}	4.5	5.0	5.5	Volts	Nominal
Blank (All Inputs Low)		2.5	3.5	mA	V_{CC}=5 V, All inputs=0.8 V
I_{CC} 80 LEDs/unit (100% Bright) PD243X PD353X PD443X		 115 145 150	 130 165 170	 mA mA mA	 V_{CC}=5 V V_{CC}=5 V V_{CC}=5 V
V_{IL}			0.8	Volts	V_{CC}=4.5 V to 5.5 V
V_{IH}	2.0			Volts	V_{CC}=4.5 V to 5.5 V
I_{IL} (except D0 to D7) [1]	25		100	µA	V_{CC}=4.5 V to 5.5 V, V_{IN}=0.8 V
V_{OL}			0.4	Volts	V_{CC}=4.5 V to 5.5 V
V_{OH}	2.4			Volts	V_{CC}=4.5 V to 5.5 V
I_{OH}	–8.9			mA	V_{CC}=4.5 V, V_{OH}=2.4 V
I_{OL}	1.6			mA	V_{CC}=4.5 V, V_{OL}=0.4 V
Data I/O Bus Loading			100	pF	
Clock I/O Bus Loading			240	pF	

Note:

1) D0 to D7 have no pull-up resistors so current is negligible.

Pin assignments and definitions

Pin	Function	Definition
1	$\overline{RD}$	Active low, will enable a processor to read all registers in the display.
2	CLK I/O	If CLK SEL (pin 3) is low, then expect an external clock source into this pin. If CLK SEL is high, then this pin will be the master or source into this pin. If CLK SEL is high, then this pin will be the master or source for all other devices which have CLK SEL low.
3	CLK SEL	CLOCK SELECT determines the action of pin 2. CLK I/O, see the section on Cascading for an example.
4	$\overline{RST}$	Reset. Must be held low until V_{CC}>4.5 V. Reset is used only to synchronize blinking and will not clear the display.
5	CE1	Chip enable (active high).
6	$\overline{CE0}$	Chip enable (active low).
7	A2	Address input (MSB).
8	A1	Address input.
9	A0	Address input (LSB).
10	GND	Ground.

Pin assignments and definitions (continued)

Pin	Function	Definition
11	$\overline{WR}$	Write. Active low. If the device is selected, a low on the write input loads the data into memory.
12	D7	Data Bus bit 7 (MSB).
13	D6	Data Bus bit 6.
14	D5	Data Bus bit 5.
15	D4	Data Bus bit 4.
16	D3	Data Bus bit 3.
17	D2	Data Bus bit 2.
18	D1	Data Bus bit 1.
19	D0	Data Bus bit 0 (LSB).
20	V_{CC}	Positive power pin.

Functional Description

The block diagram includes 5 major blocks and internal registers (indicated by dotted lines).

Display Memory consists of a 5x8 bit RAM block. Each of the four 8-bit words holds 7-bits of ASCII data (bits D0–D6) and an attribute select bit (Bit D6). The fifth 8-bit memory word is used as a control word register. A detailed description of the control register and its functions can be found in the Control Word section. Each 8-bit word is addressable and can be read from or written to.

The **Control Logic** dictates all of the features of the display device and is discussed in the Control Word section of this data sheet.

The **Character Generator** converts the 7-bit ASCII data into the proper dot pattern for the 128 characters shown in the character set chart.

The **Clock Source** can originate either from the internal oscillator clock or from an external source—usually from the output of another display in a multiple module array.

The **Display Multiplexer** controls all display output to the digit drivers so no additional logic is required for a display system.

The **Column Drivers** are connected directly to the display.

The **Display** has four digits. Each of the four digits is comprised of 35 LEDs in a 5x7 dot array which makes up the alphanumeric characters.

The intensity of the display can be varied by the Control Word in steps of 0% (Blank), 25%, 50%, and full brightness.

Microprocessor Interface

The interface to the microprocessor is through the address lines. (A0–A2), the data bus (D0–D7), two chip select lines ($\overline{\text{CE0}}$, CE1), and read ($\overline{\text{RD}}$) and write ($\overline{\text{WR}}$) lines.

The $\overline{\text{CE0}}$ should be held low when executing a read, or write operation. CE1 must be held high.

The read and write lines are both active low. During a valid read the data input lines (D0–D7) become outputs. A valid write will enable the data as input lines.

Input Buffering

If a cable length of 6 inches or more is used, all inputs to the display should be buffered with a tri-state non-inverting buffer mounted as close to the display as conveniently possible. Recommended buffers are: 74LS245 for the data lines and 74LS244 for the control lines.

Figure 9. Block diagram

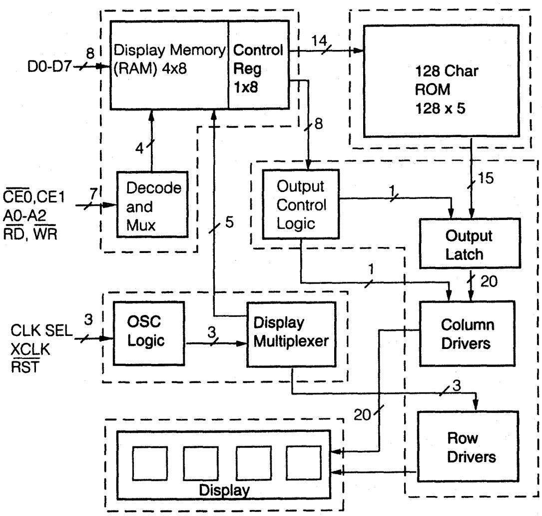


Figure 10. Mode selection

$\overline{\text{CE0}}$	CE1	$\overline{\text{RD}}$	$\overline{\text{WR}}$	Operation
0	1	0	0	None
1	X	X	X	None
X	0	X	X	None
X	X	1	1	None

0=Low logic level, 1=High logic level, X=Don't care

Data input commands

$\overline{\text{CE0}}$	CE1	$\overline{\text{RD}}$	$\overline{\text{WR}}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	No Change
0	1	0	1	1	0	0	X	X	X	X	X	X	X	X	Read Digit 0 Data to Bus
0	1	1	0	1	0	0	0	0	1	0	0	1	0	0	($) Written to Digit 0
0	1	1	0	1	0	1	0	1	0	1	0	1	1	1	(W) Written to Digit 1
0	1	1	0	1	1	0	0	1	1	0	0	1	1	0	(f) Written to Digit 2
0	1	1	0	1	1	1	0	0	1	1	0	0	1	1	(3) Written to Digit 3
0	1	1	0	1	0	0	1	X	X	X	X	X	X	X	Char. Written to Digit 0 and Cursor Enabled

There are five registers within the display. Four of these registers are used to hold the ASCII/attribute code of the four display characters. The fifth register is the Control Word, which is used to blink, blank, clear, or dim the entire display, or to change the presentation (attributes) of individual characters.

Addressing

The addresses within the display device are shown below. Digit 0 is the rightmost digit of the display, while digit 3 is on the left. Although there is only one Control Word, it is duplicated at the four address locations 0–3. Data can be read from any of these locations. When one of these locations is written to, all of them will change together.

Address			**Contents**
A2	**A1**	**A0**	
0	X	X	Control Word
1	0	0	Digit 0 (rightmost)
1	0	1	Digit 1
1	1	0	Digit 2
1	1	1	Digit 3 (leftmost)

Bit D7 of any of the display digit locations is used to allow an attribute to be assigned to that digit. The attributes are discussed in the next section. If Bit D7 is set to a one, that character will be displayed using the attribute. If bit D7 is cleared, the character will display normally.

Control Word

When address bit A2 is taken low, the Control Word is accessed. The same Control Word appears in all four of the lower address spaces of the display. Through the Control Word, the display can be cleared, the lamps can be tested, display brightness can be selected, and attributes can be set for any characters which have been loaded with their most significant bit (D7) set high.

Brightness (D0, D1): The state of the lower two bits of the Control Word are used to set the brightness of the entire display, from 0% to 100%. The table below shows the correspondence of these bits to the brightness.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	X	X	X	X	0	0	Blank
0	0	X	X	X	X	0	1	25% brightness
0	0	X	X	X	X	1	0	50% brightness
0	0	X	X	X	X	1	1	Full brightness

X=don't care

Attributes (D2–D4): Bits D2, D3, and D4 control the visual attributes (i.e., blinking) of those display digits which have been written with bit D7 set high. In order to use any of the four attributes, the Cursor Enable bit (D4 in the Control Word) must be set. When the Cursor Enable bit is set, and bit D7 in a character location is set, the character will take on one of the following display attributes.

Control word format

D7	D6	D5	D4	D3	D2	D1	D0
Clear	Lamp test	Blink	Attribute enable	Attributes		Brightness	

D1 D0 Brightness
0 0 0% (blank)
0 1 25%
1 0 50%
1 1 100%

D3 D2 Attributes
0 0 Display Cursor instead of Character
0 1 Blink Character
1 0 Display Blinking Cursor instead of Character
1 1 Alternate Character with Cursor

D4 Attribute enable
0 Disable above Attributes
1 Enable above Attributes

D5 Blink
0 Blink Attribute Disabled
1 Blink Entire Display

D6 Lamp test
0 Standard Operation
1 Display All Dots at 50% Brightness

D7 Clear
0 Standard Operation
1 Clear Entire Display

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	0	X	X	B	B	Disable highlight attribute
0	0	0	1	0	0	B	B	Display cursor* instead of character
0	0	0	1	0	1	B	B	Blink single character
0	0	0	1	1	0	B	B	Display blinking cursor* instead of character
0	0	0	1	1	1	B	B	Alternate character with cursor*

*"Cursor"= all dots in a single character space lit to half brightness
X=Don't care
B=Depends on the selected brightness.

Attributes are non-destructive. If a character with bit D7 set is replaced by a cursor (Control Word bit D4 is set, and D3=D2=0) the character will remain in memory and can be revealed again by clearing D4 in the Control Word.

Blink (D5): The entire display can be caused to blink at a rate of approximately 2 Hz by setting bit D5 in the Control Word. This blinking is independent of the state of D7 in all character locations.

To synchronize the blink rate in a bank of these devices, it is necessary to tie all devices' clocks and resets together as described in a later section of this data sheet.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	X	X	X	B	B	Blinking display

Lamp Test (D6): When the Lamp Test bit is set, all dots in the entire display are lit at half brightness. When this bit is cleared, the display returns to the characters that were showing before the lamp test.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	1	0	X	X	X	X	X	Lamp test

Clear Data (D7): When D7 is set (D7=1) in the Control Word, all (display) memory bits are reset to zero and the display goes blank.

D7	D6	D5	D4	D3	D2	D1	D0	Operation
1	0	X	X	X	X	X	X	Clear

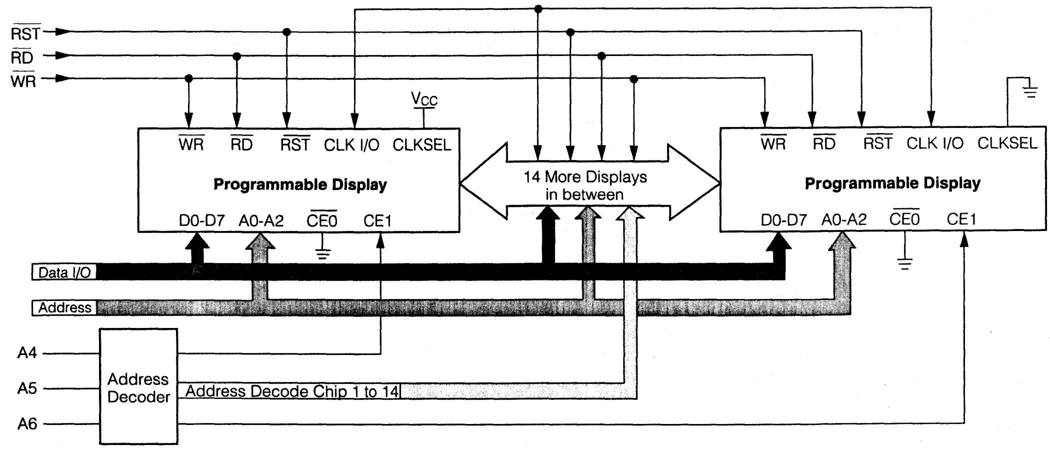
A second control word must be written into the chip with D7 reset (D7=0) to set up attributes and brightness levels.

The SMC-4740 oscillator is designed to drive up to 16 displays with input loading of 15 pF each.

The general requirements for cascading 16 displays are:

1. Determine the correct address for each display.
2. Tie $\overline{\text{CE0}}$ to ground and use CE1 from an address.
3. Select one of the displays to provide the clock for the other displays.
4. Tie $\overline{\text{CLK}}$ SEL to ground on other displays.
5. Use $\overline{\text{RST}}$ to synchronize the blinking between the displays.

Figure 11. Cascading diagram



How to Load Information Into the Display

Information loaded into the display can be either ASCII data or Control Word data. The following procedure (see also Typical Loading Sequence) will demonstrate a typical loading sequence and the resulting visual display. The word STOP is used in all of the following examples.

Set Brightness

Step 1 Set the brightness level of the entire display to your preference (example: 100%)

Load Four Characters

Step 2 Load an "S" in the left hand digit.

Step 3 Load a "T" in the next digit.

Step 4 Load an "O" in the next digit.

Step 5 Load a "P" in the right hand digit.

If you loaded the information correctly, the display now should show the word "STOP."

Blink a Single Character

Step 6 Into the digit, second from the right, load the hex code "CF," which is the code for an "O" with the D7 bit added as a control bit.

Note:
The "O" is the only digit which has the control bit (D7) added to normal ASCII data.

Step 7 Load enable blinking character into the control word register. The display should show "STOP" with a flashing "O".

Add Another Blinking Character

Step 8 Into the left hand digit, load the hex code "D3" which gives an "S" with the D7 bit added as a control bit. The display should show "STOP" with flashing "O" and a flashing "S."

Alternate Character/Cursor Enable

Step 9 Load enable alternate character/cursor into the control word register. The display now should show "STOP" with the "O" and the "S" alternating between the letter and cursor (all dots lit).

Initiate Four Character Blinking

(Regardless of Control Bit setting)

Step 10 Load enable display blinking. The display now should show the entire word "STOP" blinking.

Typical loading sequence

	$\overline{CE0}$	CE1	$\overline{RD}$	$\overline{WR}$	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Display
1.	L	H	H	L	L	X	X	0	0	0	0	0	0	1	1	
2.	L	H	H	L	H	H	H	0	1	0	1	0	0	1	1	S
3.	L	H	H	L	H	H	L	0	1	0	1	0	1	0	0	ST
4.	L	H	H	L	H	L	H	0	1	0	0	1	1	1	1	STO
5.	L	H	H	L	H	L	L	0	1	0	1	0	0	0	0	STOP
6.	L	H	H	L	H	L	H	1	1	0	0	1	1	1	1	STOP
7.	L	H	H	L	L	X	X	0	0	0	1	0	1	1	1	STO*P
8.	L	H	H	L	H	H	H	1	1	0	1	0	0	1	1	S*TO*P
9.	L	H	H	L	L	X	X	0	0	0	1	1	1	1	1	S†TO†P
10.	L	H	H	L	L	X	X	0	0	1	0	0	0	1	1	S*T*O*P*

* Blinking character
† Character alternating with cursor (all dots lit)

Electrical and Mechanical Considerations

The CMOS IC of the display is designed to provide resistance to both Electrostatic Discharge Damage and Latch Up due to voltage or current surges. Several precautions are strongly recommended to avoid overstressing these built-in safeguards.

ESD Protection

Display users should be careful to handle the devices consistent with Standard ESD protection procedures. Operators should wear appropriate wrist, ankle or feet ground straps and avoid clothing that collects static charges. Work surfaces, tools and transport carriers that come into contact with unshielded devices or assemblies should also be appropriately grounded.

Latch up Protection

Latch up is a condition that occurs in CMOS ICs after the input protection diodes have been broken down. These diodes can be reversed through several means:

V_{IN}<GND, V_{IN}>V_{CC} + 0.5 V, or through excessive currents forced on the inputs. When these situations exist, the IC may develop the response of an SCR and begin conducting as much as one amp through the V_{CC} pin. This destructive condition will persist (latched) until device failure or the device is turned off.

The Voltage Transient Suppression Techniques and buffer interfaces for longer cable runs help considerably to prevent latch conditions from occurring. Additionally, the following Power Up and Power Down sequence should be observed.

Power up Sequence

1. Float all active signals by tri-stating inputs to displays.
2. Apply V_{CC} and GND to the display.
3. Apply active signals to the displays by enabling all input signals per application.

Power Down Sequence

1. Float all active signals by tri-stating the inputs to the display.
2. Turn off the power to the display.

Soldering Considerations

These displays can be hand soldered with SN63 solder using a grounded iron set to 260°C.

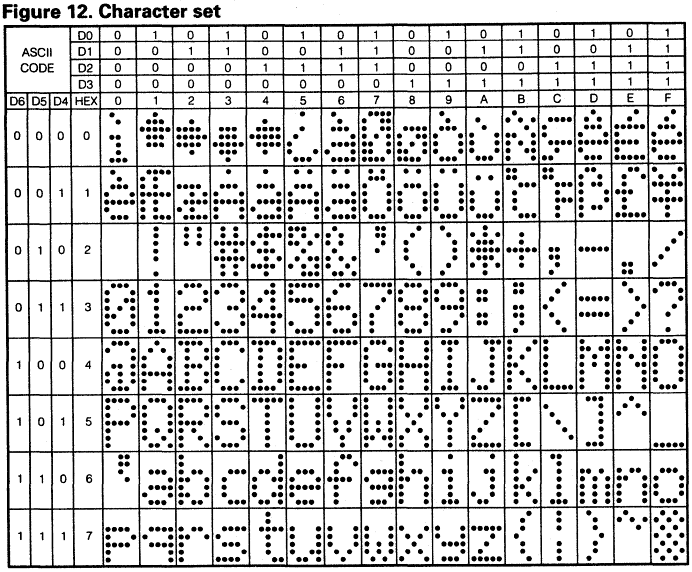
Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature is 245°C ±5°C with a dwell between 1.5 seconds to 3.0 seconds. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Voltage Transient Suppression

It has become common practice to provide 0.01 µF bypass capacitors liberally in digital systems. Like other CMOS circuitry, the Intelligent Display controller chip has very low power consumption and the usual 0.01 µF would be adequate were it not for the LEDs. To prevent power supply transients, capacitors with low inductance and high capacitance at high frequencies are required. This suggests a solid tantalum or ceramic disc for high frequency bypass. For multiple display module systems distribute the bypass capacitors evenly, keeping capacitors as close to the power pins as possible. Use a 0.01 µF capacitor for each display module and a 22 µF for every third display module.

Figure 12. Character set



Notes:

1. A2 must be held high for ASCII data.
2. Bit D7=1 enables attributes for the assigned digit.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Carefully choose the solvents as some may chemically attack the package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are: TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone. (1)

Note:

1) Acceptable commercial solvents are: Basic TF Arklone P. Genesolv D, Genesolv DA, BlacoTron TF, Blaco-Tron TA and, Freon TA.

Do not use solvents containing alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your preferred solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronics Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 20 pin DIP sockets 0.600" wide with 0.100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers include: Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronics Data Book.

Optical Considerations

The character heights of these displays allows readability up to eight feet. Proper filter selection allows the user to build a display that can be used over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. So first consider the ambient lighting environment to maximize the cost benefit ratio for using filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The PD2435/3535/4435 is high efficiency red display and should be matched with a long wavelength pass filter in the 570 nm to 590 nm range. The PD2436/3536/4436 is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. The PD2437/3537/4437 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%. Proper intensity selection of the displays will allow 10,000 foot candle sunlight viewability.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

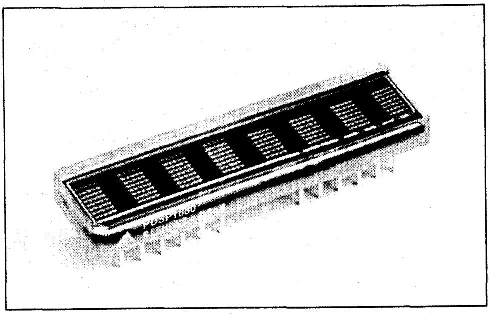
One last note on mounting filters: recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.Atlas, Van Nuys, CA.

See Siemens Appnote 23 for further information.

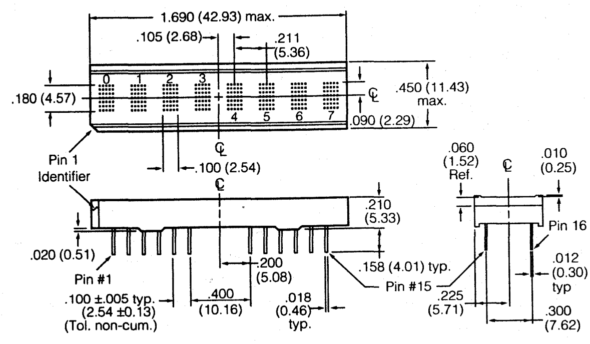
SIEMENS

RED PDSP1880
YELLOW PDSP1881
HIGH EFFICIENCY RED PDSP1882
GREEN PDSP1883
HIGH EFFICIENCY GREEN PDSP1884

0.180" 8-Character 5x7 Dot Matrix Alphanumeric Programmable Display™



Package Dimensions in inches (mm)



FEATURES

- Eight 0.180" Dot Matrix Characters in Red, Yellow, High Efficiency Red, Green, or High Efficiency Green
- Built-in 128 Character ROM, Mask Programmable for Custom Fonts
- Readable from 8 Feet (2.5 meters)
- Built-in Decoders, Multiplexers and Drivers
- Wide Viewing Angle, X Axis ± 55°, Y Axis 65°
- Programmable Features:
  - Individual Flashing Character
  - Full Display Blinking
  - Multi-Level Dimming and Blanking
  - Clear Function
  - Self Test
- Internal or External Clock
- End Stackable Dual-In-Line Plastic Package
- Read/Write Capability
- 16 User Definable Characters

DESCRIPTION

The PDSP1880 (Red), PDSP1881 (Yellow), PDSP1882 (High Efficiency Red), PDSP1883 (Green), and PDSP1884 (High Efficiency Green) are eight digit, 5x7 dot matrix, alphanumeric Programmable Displays. The 0.180 inch high digits are packaged in a rugged, high quality, optically transparent, 0.300 inch lead spacing, 30 pin plastic DIP.

The on-board CMOS has a built-in 128 character ROM. The PDSP188X also has a user definable character (UDC) feature, which uses a RAM that permits storage of 16 arbitrary characters, symbols or icons that are software-definable by the user. The character ROM itself is mask programmable and easily modified by the manufacturer to provide specified custom characters.

The PDSP188X is designed for standard microprocessor interface techniques, and is fully TTL compatible. The Clock I/O and Clock Select pins allow the user to cascade multiple display modules.

ESD Warning: Standard precautions for CMOS handling should be observed.

Maximum Ratings (T_A=25°C)

DC Supply Voltage, V_{CC} to GND
(max. voltage with no LEDs on) .... –0.3 to +7.0 VDC
Input Voltage Levels,
All Inputs .... –0.3 V to V_{CC} +0.3 V
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Relative Humidity (non-condensing) 85%
Operating Voltage, V_{CC} to GND
(Max. voltage with 20 dots/digits on) 5.5V
Maximum Solder Temperature 0.063"
below the seating plane, t<5 sec .... 260°C
ESD Protection at 1.5 KΩ,
100 pF .... V_Z=4 KV (each pin)

Figure 1. Enlarged character format
Dimensions in inches (mm)

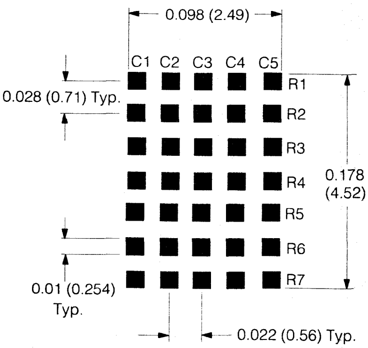
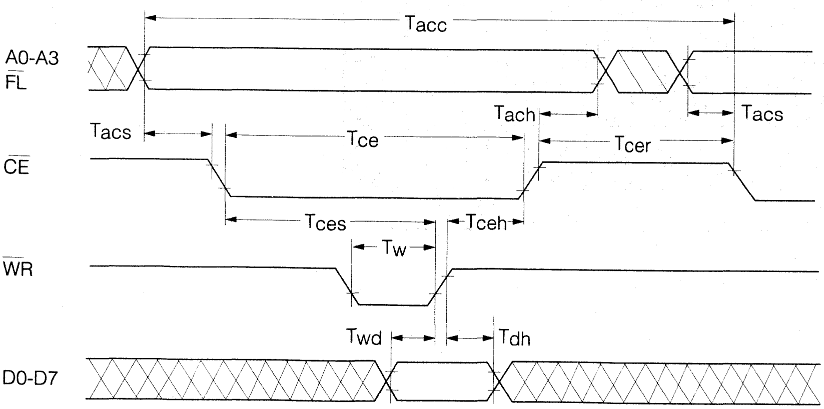


Figure 2. Write cycle timing diagram



Switching specifications
(over operating temperature range and V_{CC}=4.5 V)

Symbol	Description	Min.	Units
Tacc	Display Access Time—Write	210	ns
Tacc	Display Access Time—Read	230	ns
Tacs	Address Setup Time to CE	10	ns
Tce	Chip Enable Active Time—Write	140	ns
Tce	Chip Enable Active Time—Read	160	ns
Tach	Address Hold Time to CE	20	ns
Tcer	Chip Enable Recovery Time	60	ns
Tces	Chip Enable Active Prior to Rising Edge—Write	140	ns
Tces	Chip Enable Active Prior to Rising Edge—Read	160	ns
Tceh	Chip Enable Hold to Rising Edge of Read/Write Signal	0	ns
Tw	Write Active Time	100	ns
Twd	Data Valid Prior to Rising Edge of Write Signal	50	ns
Tdh	Data Write Time	20	ns
Tr	Chip Enable Active Prior to Valid Data	160	ns
Trd	Read Active Prior to Valid Data	95	ns
Tdf	Read Data Float Delay	10	ns
Trc	Reset Active Time	300	ns

Figure 3. Read cycle timing diagram

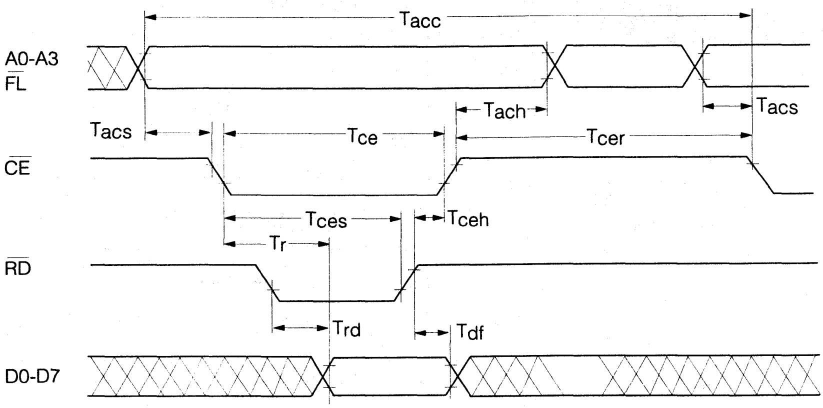
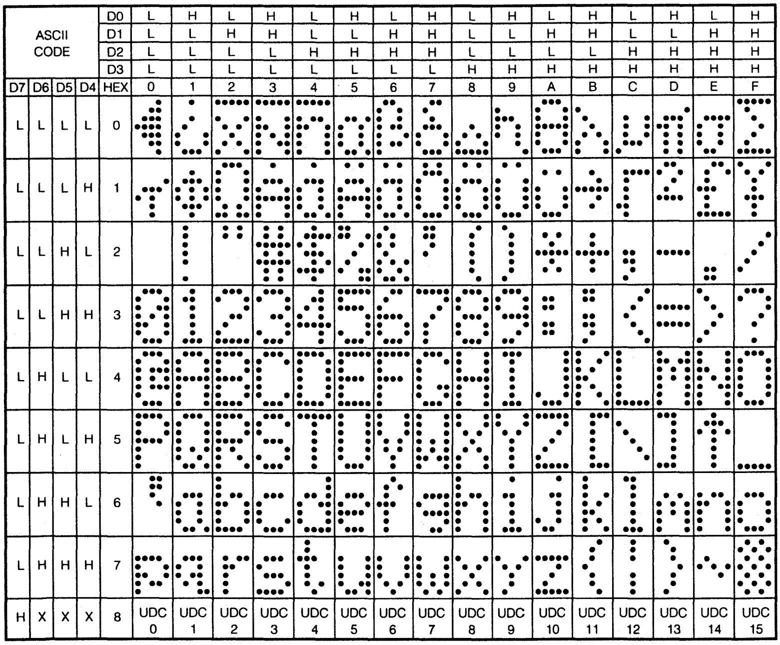


Figure 4. Character set



Notes:

1. Upon power up, the device will initialize in a random state.
2. X=don't care.

Optical characteristics at 25°C (V_{CC}=5.0 V at full brightness)

Red PDSP1880

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity	I_{Vpeak}	70	125	μcd/dot
Peak Wavelength	λ(peak)		660	nm
Dominant Wavelength	λ(d)		639	nm

Yellow PDSP1881

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity	I_{Vpeak}	125	205	μcd/dot
Peak Wavelength	λ(peak)		583	nm
Dominant Wavelength	λ(d)		585	nm

High Efficiency Red PDSP1882

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity	I_{Vpeak}	125	350	μcd/dot
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		626	nm

Green PDSP1883

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity	I_{Vpeak}	125	275	μcd/dot
Peak Wavelength	λ(peak)		565	nm
Dominant Wavelength	λ(d)		570	nm

High Efficiency Green PDSP1884

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity	I_{Vpeak}	125	500	μcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		574	nm

DC electrical characteristics at 25°C

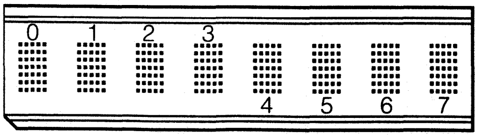
Parameters	Limits				Conditions
	Min.	Typ.	Max.	Units	
V_{CC}	4.5	5.0	5.5	V	
I_{CC} Blank		0.65	1.0	mA	V_{CC}=5 V, V_{IN}=5 V
I_{CC} 12 dots/digit on (1) (2)		200	255	mA	V_{CC}=5 V, "V" in all 8 digits
I_{CC} 20 dots/digit on (1) (2)		300	370	mA	V_{CC}=5 V, "#" in all 8 digits
I_{ILP} (with pull-up) Input Leakage	–18	–11	–5	µA	V_{CC}=5 V, V_{IN}=0 V to V_{CC} ($\overline{WR}$, $\overline{CE}$, $\overline{FL}$, $\overline{RST}$, $\overline{RD}$, CLKSEL)
I_{IL} (no pull-up) Input Leakage	–1		+1	µA	V_{CC}=5 V, V_{IN}=5 V (CLK, A0–A3, D0–D7)
V_{IH} Input Voltage High	2.0		V_{CC} +0.3	V	V_{CC}=4.5 V to 5.5 V
V_{IL} Input Voltage Low	GND –0.3			V	V_{CC}=4.5 V to 5.5 V
V_{OL} (D0–D7), Output Voltage Low			0.4	V	V_{CC}=4.5 V, I_{OL}=1.6 mA
V_{OL} (CLK), Output Voltage Low			0.4	V	V_{CC}=4.5 V, I_{OL}=40 µA
V_{OH} Output Voltage High	2.4			V	V_{CC}=4.5 V, I_{OH}=40 µA
θ_{JC} Thermal Resistance, Junction to Case		25		°C/W	
Clock I/O Frequency	28	57.34	81.14	KHz	V_{CC}=4.5 to 5.5 V
FM, Digit Multiplex Frequency	125	256	362.5	Hz	V_{CC}=4.5 to 5.5 V
Blinking Rate	0.98	2.0	2.83	Hz	
Clock I/O Buss Loading			2.40	pF	
Clock Out Rise Time			500	nsec	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	nsec	V_{CC}=4.5 V, V_{OH}=0.4 V

Notes:
1) I_{CC} is an average value.
2) I_{CC} is measured with the display at full brightness. Peak I_{CC}=$^{28}/_{15}$ I_{CC} average (#displayed).

Recommended operating conditions (T_A=–40°C to +85°C)

Parameter	Symbol	Min.	Max.	Units
Supply Voltage	V_{CC}	4.5	5.5	V
Input Voltage Low	V_{IL}		0.8	V
Input Voltage High	V_{IH}	2.0		V
Output Voltage Low	V_{OL}		0.4	V
Output Voltage High	V_{OH}	2.4		V

Figure 5. Top view



Pin assignments

Pin #	Name	Symbol	Definition
1	Reset	$\overline{RST}$	Initializes display; clears Character RAM (20H), Flash RAM (00H), control word (00H), and resets internal counters. UDC Address Register and UDC RAM unaffected.
2	Flash	$\overline{FL}$	Accesses Flash RAM. Address inputs A0–A2 select digit address while data bit D0 sets (D0=1) or resets (D0=0) Flash bit, A3 and A4 ignored.
3	Address input	A0	A0–A2 select specific digits. See Table 1.
4		A1	Same as A0
5		A2	Same as A0
6	Address input	A3	A3 and A4 access parts of memory together with Flash pin. See Table 1.
7–9	No pins		No connections
10	Address input	A4	Same as A3
11	Clock Select	CLS	Selects internal or external clock source. CLS=1 selects internal clock (master), CLS=0 selects external clock (slave operation).
12	Clock In/Out	CLK	Inputs or outputs clock as determined by CLS.
13	Write	$\overline{WR}$	Writes data into display when $\overline{WR}$=0. Note $\overline{CE}$=0 to enable write cycle.
14	Chip Enable	$\overline{CE}$	Enables display's write and read cycles when $\overline{CE}$=0.
15	Positive supply	V_{CC}	Positive power supply input.

Pin assignment (continued)

Pin #	Name	Symbol	Definition
16	Supply ground	GND_{sup}	Analog ground for LED drivers
17		NC	No connection
18	Logic ground	GND_{log}	Logic ground for digital circuitry
19	Read	$\overline{RD}$	Reads data from display when $\overline{RD}$=0. Also $\overline{CE}$=0.
20	Data bit zero	D0	Least significant data bit.
21	Data bit one	D1	Second data bit.
22–24	No pins		No connections
25	Data bit two	D2	Third data bit.
26	Data bit three	D3	Fourth data bit.
27	Data bit four	D4	Fifth data bit.
28	Data bit five	D5	Sixth data bit.
29	Data bit six	D6	Seventh data bit.
30	Data bit seven	D7	Most significant data bit.

Cascading Displays

The PDSP188X is designed to drive up to 16 other PDSP188Xs with input loading of 15 pF each.

General requirements for cascading 16 displays together:

- Determine the correct address for each display.
- Use $\overline{CE}$ from an address decoder to select the correct display.
- Use CE from an address decoder to select the correct display.
- Select one of the Displays to provide the Clock for the other displays. Connect CLKSEL to V_{CC} for this display.
- Tie CLKSEL to ground on other displays.
- Use $\overline{RST}$ to synchronize the blinking between the displays.

Figure 6. Cascading diagram

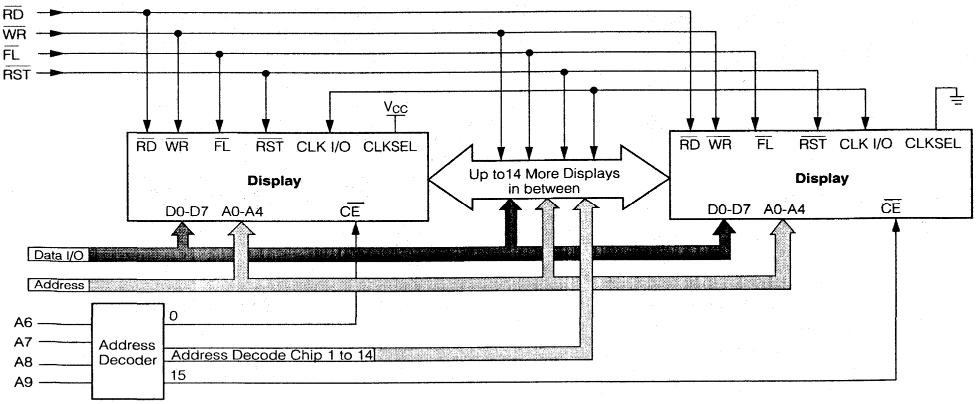
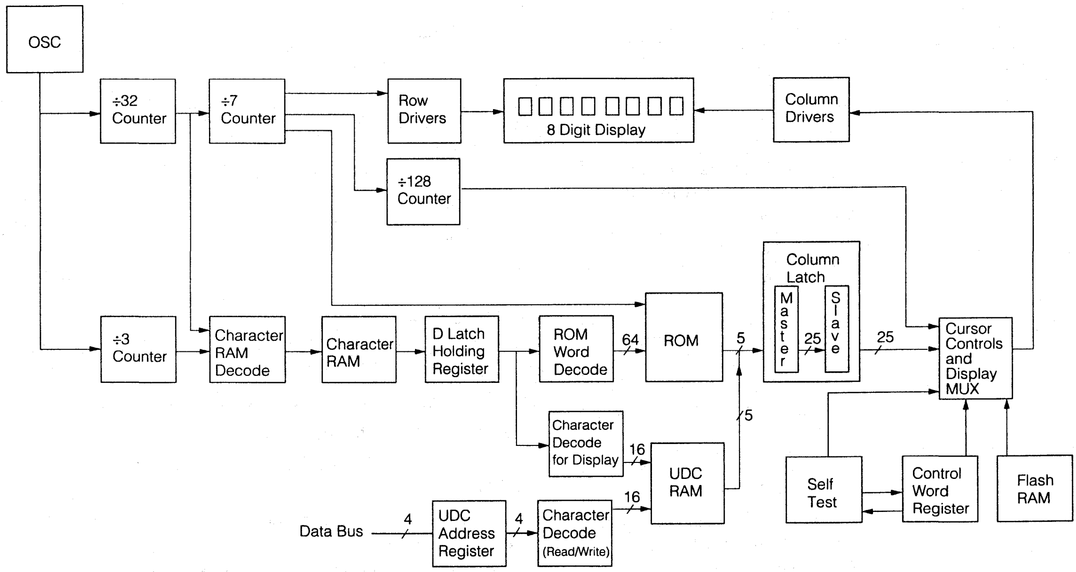


Figure 7. Block diagram



Functional Description

The display's user interface is organized into five memory areas. They are accessed using the Flash Input, $\overline{FL}$, and address lines, A3 and A4. All the listed RAMs and Registers may be read or written through the data bus. See Table 1. Each input pin is described in Pin Definitions.

Five basic memory areas

Character RAM	Stores either ASCII (Katakana) character data or an UDC RAM address
Flash RAM	1x8 RAM which stores Flash data
User-Defined Character RAM (UDC RAM)	Stores dot pattern for custom characters
User-Defined Address Register (UDC Address Register)	Provides address to UDC RAM when user is writing or reading a custom character
Control Word Register	Enables adjustment of display brightness, flash individual characters, blink, self test or clearing the display.

$\overline{RST}$ can be used to initialize display operation upon power up or during normal operation. When activated, $\overline{RST}$ will clear the Flash RAM and Control Word Register (00H) and reset the internal counter. All eight display memory locations will be set to 20H to show blanks in all digits.

$\overline{FL}$ pin enables access to the **Flash RAM**. The **Flash RAM** will set (D0=1) or reset (D0=0) flashing of the character addressed by A0-A2.

The 1x8 bit **Control Word Register** is loaded with attribute data if A3=0.

The **Control Word Logic** decodes attribute data for proper implementation.

Character ROM is designed for 128 ASCII characters. The ROM is Mask Programmable for custom fonts.

The **Clock Source** could either be the internal oscillator (CLKSEL=1) of the device or an external clock (CLKSEL=0) could be an input from another HDSP211X display for the synchronization of blinking for multiple displays.

The **Display Multiplexer** controls the Row Drivers so no additional logic is required for a display system.

The **Display** has eight digits. Each digit has 35 LEDs clustered into a 5x7 dot matrix.

Theory of Operation

The PDSP188X Programmable Display is designed to work with all major microprocessors. Data entry is via an eight bit parallel bus. Three bits of address route the data to the proper digit location in the RAM. Standard control signals like $\overline{WR}$ and $\overline{CE}$ allow the data to be written into the display.

D0-D7 data bits are used for both Character RAM and control word data input. A3 acts as the mode selector. If A3=1, character RAM is selected. Then input data bit D7 will determine whether input data bits D0-D6 is ASCII coded data (D7=0) or UDC data (D7=1). See section on UDC Address Register and RAM.

For normal operation $\overline{FL}$ pin should be held high. When $\overline{FL}$ is held low, Flash RAM is accessed to set character blinking.

The seven bit ASCII code is decoded by the Character ROM to generate Column data. Twenty columns worth of data is sent out each display cycle, and it takes fourteen display cycles to write into eight digits.

The rows are multiplexed in two sets of seven rows each. The internal timing and control logic synchronizes the turning on of rows and presentation of column data to assure proper display operation.

Power Up Sequence

Upon power up display will come on at random. Thus the display should be reset on power-up. The reset will clear the Flash RAM, Control Word Register and reset the internal counter. All the digits will show blanks and display brightness level will be 100%.

The display must not be accessed until three clock pulses (110 µseconds minimum using the internal clock) after the rising edge of the reset line.

Microprocessor Interface

The interface to a microprocessor is through the 8-bit data bus (D0-D7), the 4-bit address bus (A0-A3) and control lines $\overline{FL}$, $\overline{CE}$ and $\overline{WR}$.

To write data (ASCII/Control Word) into the display $\overline{CE}$ should be held low, address and data signals stable and $\overline{WR}$ should be brought low. The data is written on the low to high transistion of $\overline{WR}$.

The Control Word is decoded by the Control Word Decode Logic. Each code has a different function. The code for display brightness changes the duty cycle for the column drivers. The peak LED current stays the same but the average LED current diminishes depending on the intensity level.

The character Flash Enable causes 2 Hz coming out of the counter to be ANDED with column drive signal and makes the column driver to cycle at 2 Hz. Thus the character flashes at 2 Hz.

Table 1. Memory selection

$\overline{FL}$	A4	A3	Section of Memory	A2–A0	Data Bits Used
0	X	X	Flash RAM	Character Address	D0
1	0	0	UDC Address Register	Don't Care	D3–D0
1	0	1	UDC RAM	Row Address	D4–D0
1	1	1	Character RAM	Character Address	D7–D0
1	1	0	Control Word Register	Don't Care	D7–D0

The display Blink works the same way as the Flash Enable but causes all twenty column drivers to cycle at 2 Hz thereby making all eight digits to blink at 2 Hz.

The Self Test function of the IC consists of two internal routines which exercise major portions of the IC and illuminates all the LEDs.

Clear bit clears the character RAM and writes a blank into the display memory. It however does not clear the control word.

ASCII Data or Control Word Data can be written into the display at this point. For multiple display operation, CLK I/O must be properly selected. CLK I/O will output the internal clock if CLKSEL=1, or will allow input from an external clock if CLKSEL=0.

Character RAM

The Character RAM is selected when $\overline{FL}$, A4 and A3 are set to 1,1,1 during a read or write cycle. The Character RAM is a 8 by 8 bit RAM with each of the eight locations corresponding to a digit on the display. Digit 0 is on the left side of the display and digit 7 is on the right side of the display. Address lines, A2-A0 select the digit address with A2 being the most significant bit and A0 being the least significant bit. The two types of data stored in the Character RAM are the ASCII coded data and the UDC Address Data. The type of data stored in the Character RAM is determined by data bit, D7. If D7 is low, then ASCII coded data is stored in data bits D6-D0. If D7 is high, then UDC Address Data is stored in data bit D3-D0.

The ASCII coded data is a 7 bit code used to select one of 128 ASCII characters permanently stored in the ASCII ROM.

The UDC Address data is a 4 bit code used to select one of the UDC characters in the UDC RAM. There are up to 16 characters available. See Figure 8.

UDC Address Register and UDC RAM

The UDC Address Register and UDC RAM allows the user to generate and store up to 16 custom characters. Each custom character is defined in 5x7 dot matrix pattern. It takes 8 write cycles to define a custom character, one cycle to load the UDC Address Register and 7 cycles to define the character. The contents of the UDC Address Register will store the 4 bit address for one of the 16 UDC RAM locations. The UDC RAM is used to store the custom character.

UDC Address Register

The UDC Address Register is selected by setting $\overline{FL}$=1, A4=0, A3=0. It is a 4 bit register and uses data bits, D3-D0 to store the 4 bit address code (D7-D4 are ignored). The address code selects one of 16 UDC RAM locations for custom character generation.

UDC RAM

The UDC RAM is selected by setting $\overline{FL}$=1, A4=0, A3=1. The RAM is comprised of a 7x5 bit RAM. As shown in Figure 10, address lines, A2-A0 select one of the 7 rows of the custom character. Data bits, D4-D0 determine the 5 bits of column data in each row. Each data bit corresponds to a LED. If the data bit is high, then the LED is on. If the data bit is low, the LED is off. To create a character, each of the 7 rows of column data need to be defined. See Figure 9 for logic.

Figure 8. Character RAM access logic

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0
1	0	0	1	1	1	1	Character Address, Digits 0–7	0 7 bit ASCII code for a Write Cycle
1	0	1	0	1	1	1	Character Address, Digits 0–7	0 7 bit ASCII code read during a Read Cycle
1	0	0	1	1	0	0	Character Address, Digits 0–7	1 D3–D0=UDC address for a Write Cycle
1	0	1	0	1	0	0	Character Address, Digits 0–7	1 D3–D0=UDC address for Read Data

Figure 9. UDC address register and UDC character RAM

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0	
1	0	0	1	1	0	0	Not used for UDC Address Register	D3–D0=UDC RAM Address Code, Write Cycle	UDC Address Register
1	0	1	0	1	0	0	Not used for UDC Address Register	D3–D0=UDC RAM Address Code, Read Cycle	
1	0	0	1	1	0	1	A2–A0=Character Row Address	D4–D0=Character Column Data, Write Cycle	UDC RAM
1	0	1	0	1	0	1	A2–A0=Character Row Address	D4–D0=Character Column Data, Read Cycle	

Flash RAM

The Flash RAM allows the display to flash one or more of the characters being displayed. The Flash Ram is accessed by setting $\overline{FL}$ low. A4 and A3 are ignored. The Flash RAM is a 8x1 bit RAM with each bit corresponding to a digit address. Digit 0 is on the left side of the display and digit 7 is on the right side of the display. Address lines, A2-A0 select the digit address with A2 being the most significant digit and A0 being the least significant digit. Data bit, D0, sets and resets the flash bit for each digit. When D0 is high, the flash bit is set and when D0 is low, it is reset. See Figure 10.

Control Word

The Control Word is used to set up the attributes required by the user. It is addressed by setting $\overline{FL}$=1, A4=1, A3=0. The Control Word is an 8 bit register and is accessed using data bits, D7–D0. See Figures 11 and 12 for the logic and attributed control. The Control Word has 5 functions. They are brightness control, flashing character enable, blinking character enable, self test, and clear (Flash and Character RAMS only).

Brightness Control

Control Word bits, D2–D0, control the brightness of the display with a binary code of 000 being 100% brightness and 111 being display blank. See Figure 12 for brightness level versus binary code. The average I_{CC} can be calculated by multiplying the 100% brightness level I_{CC} value by the display's brightness level. For example, a display set to 80% brightness with a 100% average I_{CC} value of 200 mA will have an average I_{CC} value of 200 mA x 80%=160 mA.

Flash Function

Control Word bit, D3, enables or disables the Flash Function. When D3 is 1, the Flash Function is enabled and any digit with its corresponding bit set in the Flash RAM will flash at approximately 2 hertz. When using an external clock, the flash rate can be determined by dividing the clock rate by 28,672. When D3 is 0, the Flash Function is disabled and the contents of the Flash RAM is ignored. For synchronized flashing on multiple displays, see the Reset Section.

Blink Function

Control Word bit, D4, enables or disables the Blink Function. When D4 is 1, the Blink Function is enabled and all characters on the display will blink at approximately 2 hertz. The Blink Function will override the Flash Function if both functions are enabled. When D4 is 0, the Blink Function is disabled. When using an external clock, the blink rate can be determined by dividing the clock rate by 28,672. For synchronized blinking on multiple displays, see the Reset Section.

Row Data				**Column Data**
				C1 C2 C3 C4 C5
A2	**A1**	**A0**	**Row #**	**D4 D3 D2 D1 D0**
0	0	0	1	
0	0	1	2	
0	1	0	3	5x7 Dot Matrix Pattern
0	1	1	4	
1	0	0	5	
1	0	1	6	
1	1	0	7	

Self Test

Before starting Self Test, Reset must first be activated. Control Word bits, D6 and D5, are used for the Self Test Function. When D6 is 1, the Self Test is initiated. Results of the Self Test are stored in bits D5. Control Word bit, D5, is a read only bit. When D5 is 1, Self Test passed is indicated. When D5 is 0, Self Test failed is indicated. The Self Test function of the IC consists of two internal routines which exercise major portions of the IC and illuminates all of the LEDs. The first routine cycles the ASCII decoder ROM through all states and performs a check sum on the output. If the check sum agrees with the correct value, D5 is set to a 1.

Figure 10. Flash RAM access logic

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0
1	0	0	1	0	X	X	Flash RAM Address for Digits 0–7	D0=Flash Data, 0-Flash Off and 1=Flash On (Write Cycle)
1	0	1	0	0	X	X	Flash RAM Address for Digits 0–7	D0=Flash Data, 0-Flash Off and 1=Flash On (Read Cycle)

Figure 11. Control word access logic

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A4	A3	A2 A1 A0	D7 D6 D5 D4 D3 D2 D1 D0
1	0	0	1	1	1	0	Not used for Control Word	Control Word data for a Write Cycle, see Figure 12
1	0	1	0	1	1	0	Not used for Control Word	Control Word data for a Read during a Read Cycle

The second routine provides a visual test of the LEDs using the drive circuitry. This is accomplished by writing checkered and inversed checkered patterns to the display. Each pattern is displayed for approximately 2 seconds. During the self test function the display must not be accessed. The time needed to execute the self test function is calculated by multiplying the clock time by 262,144 (typical time≈4.6 sec.). At the end of the self test function, the Character RAM is loaded with blanks; the Control Word Register is set to zeroes except D5, and the Flash RAM is cleared and the UDC Address Register is set to all 1s.

Clear Function (see Figure 12 and Figure 13)

Control Word bit, D7 clears the character RAM to 20 hex and the flash RAM to all zeroes. The RAMs are cleared within three clock cycles (110 μs minimum, using the internal clock) when D7 is set to 1. During the clear time the display must not be accessed. When the clear function is finished, bit 7 of the Control Word RAM will be reset to a "0".

Reset Function

The display should be reset on power up of the display ($\overline{RST}$=LOW). When the display is reset, the Character RAM, Flash RAM, and Control Word Register are cleared. The display's internal counters are reset. Reset cycle takes three clock cycles (110 μseconds minimum using the internal clock). The display must not be accessed during this time.

To synchronize the flashing and blinking of multiple displays, it is necessary for the display to use a common clock source and reset all the displays at the same time to start the internal counters at the same place.

While $\overline{RST}$ is low, the display must not be accessed by RD nor $\overline{WR}$.

Figure 12. Control word data definition

D7	D6	D5	D4	D3	D2	D1	D0
C	ST	ST	BL	FL	Br	Br	Br

D2	D1	D0	
0	0	0	100% Brightness
0	0	1	80% Brightness
0	1	0	53% Brightness
0	1	1	40% Brightness
1	0	0	27% Brightness
1	0	0	20% Brightness
1	1	0	13% Brightness
1	1	1	Blank Display

D3:
0 Flash Function Disabled
1 Flash Function Enabled

D4:
0 Blink Function Disabled
1 Blink Function Enabled (overrides Flash Function)

D6, D5:
0 X Normal Operation X=bit ignored
1 R Run Self Test, R=Test Result, R=1/pass, 0=fail

D7:
0 Normal Operation
1 Clear Flash RAM & Character RAM (Character RAM=20 Hex)

Key

C Clear Function
ST Self test
BL Blink function
FL Flash function
Br Brightness control

Figure 13. Clear function

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	X	X	X	X	X	X	X	Clear Disabled
0	1	0	0	X	X	X	1	X	X	X	X	X	X	X	Clear User RAM, Flash RAM and Display

Figure 14. Display cycle using built-in ROM example

Display message "Showtime." Digit 0 is leftmost—Closest to Pin 1.
Logic levels: 0=Low, 1=High, X=Don't care.

$\overline{\text{RST}}$	$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{RD}}$	$\overline{\text{FL}}$	A4	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation	Display
0	0	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	Reset. No Read/Write within 3 Clock Cycles	All blank
1	0	0	1	1	1	0	X	X	X	0	0	X	0	0	0	1	1	53% Brightness Selected	All blank
1	0	0	1	1	1	1	0	0	0	0	1	0	1	0	0	1	1	Write "S" to Digit 0	S
1	0	0	1	1	1	1	0	0	1	0	1	0	0	1	0	0	0	Write "H" to Digit 1	SH
1	0	0	1	1	1	1	0	1	0	0	1	0	0	1	1	1	1	Write "O" to Digit 2	SHO
1	0	0	1	1	1	1	0	1	1	0	1	0	1	0	1	1	1	Write "W" to Digit 3	SHOW
1	0	0	1	1	1	1	1	0	0	0	1	0	1	0	1	0	0	Write "T" to Digit 4	SHOWT
1	0	0	1	1	1	1	1	0	1	0	1	0	0	1	0	0	1	Write "I" to Digit 5	SHOWTI
1	0	0	1	1	1	1	1	1	0	0	1	0	0	1	1	0	1	Write "M" to Digit 6	SHOWTIM
1	0	0	1	1	1	1	1	1	1	0	1	0	0	0	1	0	1	Write "E" to Digit 7	SHOWTIME

Figure 15. Displaying user defined character example

Load character "A" into UDC-5 and then display it in digit 2.
Logic levels: 0=Low, 1=High, X=Don't care.

$\overline{\text{RST}}$	$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{RD}}$	$\overline{\text{FL}}$	A4	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation	Display
0	X	1	1	1	X	X	X	X	X	X	X	X	X	X	X	X	X	Reset. No Read/Write within 3 Clock Cycles	All blank
1	0	0	1	1	0	0	X	X	X	X	X	X	X	0	1	0	1	Select UDC-5	All blank
1	0	0	1	1	0	1	0	0	0	X	X	X	0	1	1	1	0	Write into Row 1, UDC-5	All blank
1	0	0	1	1	0	1	0	0	1	X	X	X	1	0	0	0	1	Write into Row 2, UDC-5	All blank
1	0	0	1	1	0	1	0	1	0	X	X	X	1	0	0	0	1	Write into Row 3, UDC-5	All blank
1	0	0	1	1	0	1	0	1	1	X	X	X	1	1	1	1	1	Write into Row 4, UDC-5	All blank
1	0	0	1	1	0	1	1	0	0	X	X	X	1	0	0	0	1	Write into Row 5, UDC-5	All blank
1	0	0	1	1	0	1	1	0	1	X	X	X	1	0	0	0	1	Write into Row 6, UDC-5	All blank
1	0	0	1	1	0	1	1	1	0	X	X	X	1	0	0	0	1	Write into Row 7, UDC-5	All blank
1	0	0	1	1	1	1	0	1	0	1	X	X	X	0	1	0	1	Write UDC-5 into Digit 2	(Digit2) A

Electrical and Mechanical Considerations

Voltage Transient Suppression

For best results power the display and the components that interface with the display to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place a parallel combination of a .01 µF and a 22 µF capacitor between V_{CC} and GND for all display packages.

ESD Protection

The input protection structure of the PDSP188X provides significant protection against ESD damage. It is capable of withstanding discharges greater than 4 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging. Refer to Appnote 18 in the current Siemens Optoelectronics Data Book.

Soldering Considerations

The PDSP188X can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Direct contact with alcohol or alcohol vapor will cause degradation of the package.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the polycarbonate package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichorotrifluorethane), and IPA.

Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnote 19 in the current Siemens Optoelectronic Data Book (Display group 1 in Table 2 applies).

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 28 pin DIP sockets .300" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The .180" high character of the PDSP188XS gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The PDSP1880/1882 are red/high efficiency red displays and should be matched with long wavelength pass filter in the 570 nm to 590 nm range. The PDSP1883 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

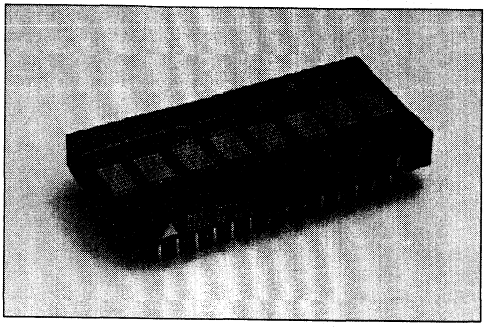
Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

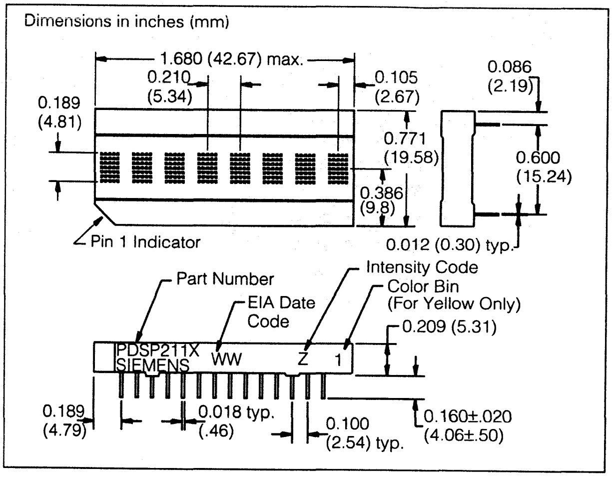
One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

SIEMENS

RED PDSP2110
YELLOW PDSP2111
HIGH EFFICIENCY RED PDSP2112
GREEN PDSP2113
HIGH EFFICIENCY GREEN PDSP2114

0.200" 8-Character 5x7 Dot Matrix Parallel Input Alphanumeric Intelligent Display® Devices





FEATURES

- **Eight 0.200" Dot Matrix Characters in Red, Yellow, High Efficiency Red, Green, High Efficiency Green**
- **Built-in 2 Page, 256 Character ROM, Both pages are Mask Programmable for Custom Fonts**
- **Readable from 8 Feet (2.5 meters)**
- **Built-in Decoders, Multiplexers and Drivers**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±65°**
- **Programmable Features:**
  - **Individual Flashing Character**
  - **Full Display Blinking**
  - **Multi-Level Dimming and Blanking**
  - **Clear Function**
  - **Lamp Test**
- **Internal or External Clock**
- **End Stackable Dual-In-Line Plastic Package**

DESCRIPTION

The PDSP2110 (Red), PDSP2111 (Yellow), PDSP2112 (High Efficiency Red), PDSP2113 (Green), PDSP2114 (High Efficiency Green), and PDSP2115 (Soft Orange) are eight digit, 5x7 dot matrix, parallel input, alphanumeric Intelligent Display devices. The 0.20 inch high digits are packaged in a rugged, high quality, optically transparent, 0.6 inch lead spacing, 28 pin plastic DIP.

The on-board CMOS has a built-in 256 character ROM. Both pages are mask programmable for 256 custom characters.The first page of ROM of a standard product contains 128 characters including ASCII, selected European and Scientific symbols. The second page contains Katakana Japanese characters, more European characters, Avionics, and other graphic symbols.

The PDSP211X is designed for standard microprocessor interface techniques, and is fully TTL compatible. The Clock I/O and Clock Select pins allow the user to cascade multiple display modules.

Maximum Ratings

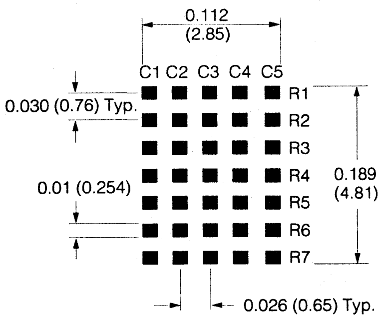
DC Supply Voltage, V_{CC} to GND .... –0.5 to +7.0 Vdc
Input Voltage Levels Relative
to Ground .... –0.5 to V_{CC} + 0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature 0.063″
below seating plane, t<5 sec .... 260°C
Relative Humidity at 85°C 85%

Note:

Maximum voltage is with no LEDs illuminated.

Figure 6. Enlarged character font

Dimensions in inches (mm)



Switching specifications

(over operating temperature range and V_{CC}=4.5 V)

Symbol	Description	Min.	Units
Tbw	Time Between Writes	30	ns
Tacc (2)	Display Access Time	130	ns
Tas	Address Setup Time	10	ns
Tces	Chip Enable Setup Time	0	ns
Tah	Address Hold Time	20	ns
Tceh	Chip Enable Hold Time	0	ns
Tw	Write Active Time	100	ns
Tds	Data Valid Prior to Rising Edge of Write	50	ns
Tdh	Data Hold Time	20	ns
Trc (1)	Reset Active Time	300	ns
Tclr (3)	Clear Cycle Time	3	µs

Notes:

1) Wait 300 ns min. after the reset function is turned off.
2) Tacc=Tas+Tw+Tah
3) The Clear Cycle Time may be shortened by writing a second Control Word with the Clear Bit disabled, 160 ns after the first control word that enabled the Clear Bit.
The Flash RAM and Character RAM may not be accessed until the Clear Cycle is complete.

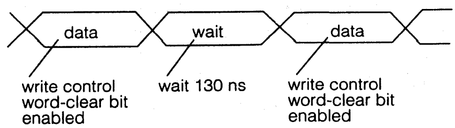
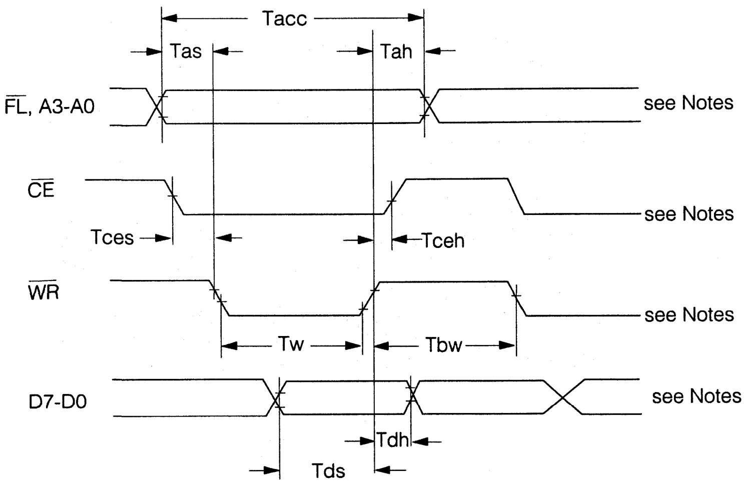


Figure 7. Write cycle timing diagram



Notes:

1. All input voltages are V_{IL}=0.8 V, V_{IH}=2.0 V.
2. These wave forms are not edge triggered.
3. Tbw=Tas+Tah

Optical characteristics at 25°C (V_{CC}=5.0 V at full brightness)

Red PDSP2110

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	70	90	µcd/dot
Peak Wavelength	λ(peak)		660	nm
Dominant Wavelength	λ(d)		639	nm

Yellow PDSP2111

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	130	210	µcd/dot
Peak Wavelength	λ(peak)		583	nm
Dominant Wavelength	λ(d)		585	nm

High Efficiency Red PDSP2112

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	150	330	µcd/dot
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		626	nm

Green PDSP2113

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	150	260	µcd/dot
Peak Wavelength	λ(peak)		565	nm
Dominant Wavelength	λ(d)		570	nm

High Efficiency Green PDSP2114

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	200	510	µcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		574	nm

Note:
1) Peak luminous intensity is measured at $T_A=T_J$=25 °C. No time is allowed for the device to warm up prior to measurement.

Electrical characteristics at 25°C

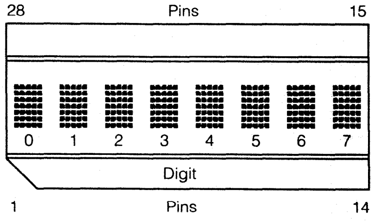
Parameters	Limits				Conditions
	Min.	Typ.	Max.	Units	
V_{CC}	4.5	5.0	5.5	V	
I_{CC} Blank		0.5	1.0	mA	V_{CC}=5 V, V_{IN}=5 V
I_{CC} 8 digits [1] 12 dots/character		200	255	mA	V_{CC}=5 V, "V" displayed in all eight digits
I_{CC} 8 digits [1] 20 dots/character		300	370	mA	V_{CC}=5 V, "#" displayed in all eight digits
I_{IP} Current (with pull-up)		11	18	µA	V_{CC}=5 V, V_{IN}=0 V to V_{CC} ($\overline{WR}$, $\overline{CE}$, $\overline{FL}$, $\overline{RST}$, $\overline{CLKSEL}$)
I, Input Leakage Current (no pull-up)			±1	µA	V_{CC}=5 V,V_{IN}=0 V to V_{CC} (Clk I/O, A0–A3, D0–D7)
V_{IH} Input Voltage High	2.0		V_{CC} +0.3	V	V_{CC}=4.5 V to 5.5 V
V_{IL} Input Voltage Low	GND –0.3		0.8	V	V_{CC}=4.5 V to 5.5 V
V_{OL} Output Voltage Low (Clock Pin)			0.4	V	V_{CC}=4.5 V to 5.5 V I_{OL}=1.6 mA
V_{OH} Output Voltage High (Clock Pin)	2.4			V	V_{CC}=4.5 V to 5.5 V I_{OH}=40 mA
I_{OH} Output Current High (Clock I/O)	–0.9			mA	V_{CC}=4.5 V, V_{OH}=–2.4 V
I_{OL} Output Current Low (Clock I/O)	1.6	2		mA	V_{CC}=4.5 V, V_{OL}=–0.4 V
θ_{JC} Thermal Resistance Junction to Case		25		°C/W	
F_{EXT} External Clock Input Frequency [2]	28		81.14	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=0
F_{OSC} Internal Clock Output Frequency [2]	28		81.14	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=1
Clock I/O Buss Loading			240	pF	
Clock Out Rise Time			500	ns	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	ns	V_{CC}=4.5 V, V_{OL}=0.4 V
FM, Digit Multiplex Frequency	125	256	362.5	Hz	
Blinking Rate	0.98	2	2.83	Hz	

Notes:

1) Average I_{CC} measured at full brightness. Peak I_{CC}=2 x I_{AVG} I_{CC} (# displayed).

2) Internal/external frequency duty factor is 50%.

Figure 6. Top view



Pin assignments

Pin	Function	Pin	Function
1	$\overline{RST}$	28	D7
2	$\overline{FL}$	27	D6
3	A0	26	D5
4	A1	25	D4
5	A2	24	D3
6	A3	23	D2
7	Substr. bias	22	No Pin
8		21	
9		20	D1
10	No Connect	19	D0
11	$\overline{CLKSEL}$	18	No Connect
12	CLK I/O	17	CE
13	$\overline{WR}$	16	GND (logic)
14	V_{CC}	15	GND (supply)

Pin definitions

Pin	Function	Definition
1	$\overline{RST}$	Used for initialization of a display and sychronization of blinking for multiple displays
2	$\overline{FL}$	Low input accesses the Flash RAM
3	A0	Address input LSB
4	A1	Address input
5	A2	Address input MSB
6	A3	Mode selector
7	Substr. bias	Used to bias IC substrate, must be connected to V_{CC}. Can't be used to supply power to display.
8		
9		
10	No connect	
11	$\overline{CLKSEL}$	Selects internal/external clock source
12	CLK I/O	Outputs master clock or inputs external clock
13	$\overline{WR}$	A low will write data into the display if $\overline{CE}$ is low
14	V_{CC}	Positive power supply input
15	GND	Analog Ground for LED drivers
16	GND	Digital Ground for internal logic
17	$\overline{CE}$	Enables access to the display
18	No Connect	
19	D0	Data input LSB
20	D1	Data input
21	No pin	
22		
23	D2	Data input
24	D3	
25	D4	
26	D5	
27	D6	
28	D7	Data input MSB, selects ROM, page 1 or 2

Figure 7. Cascading the PDSP211X displays

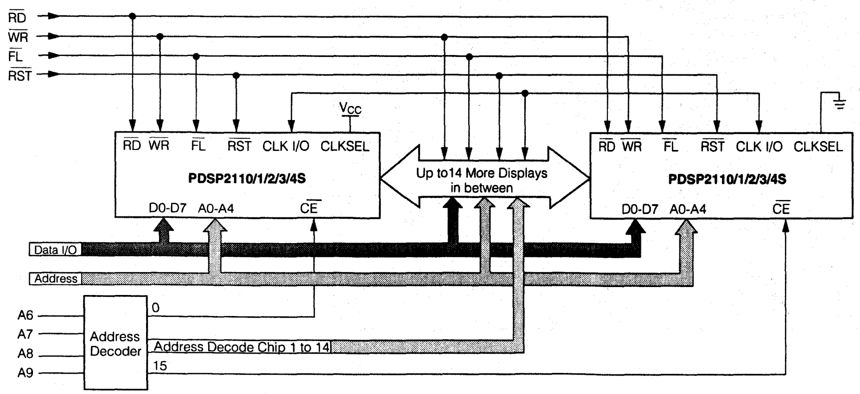
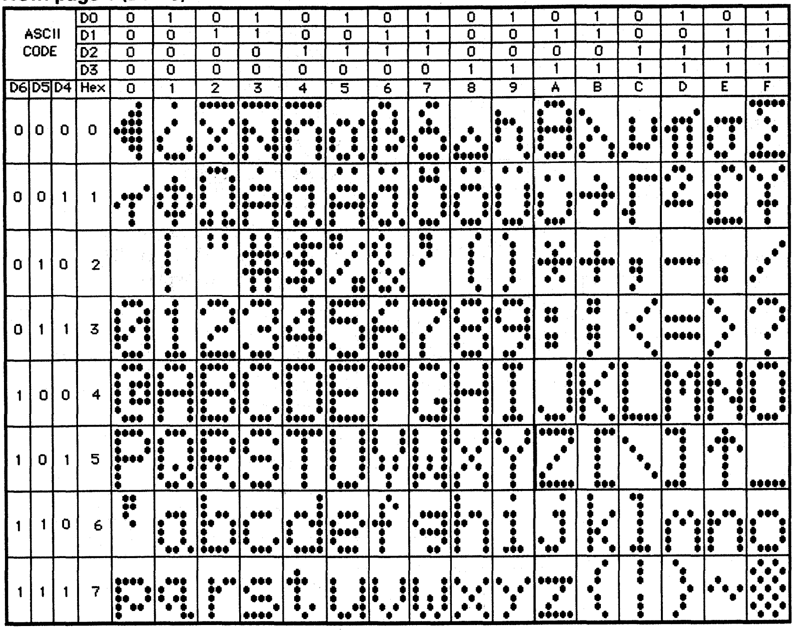


Figure 8. Character set

ROM page 1 (D7= 0)



ROM page 2 (D7=1)

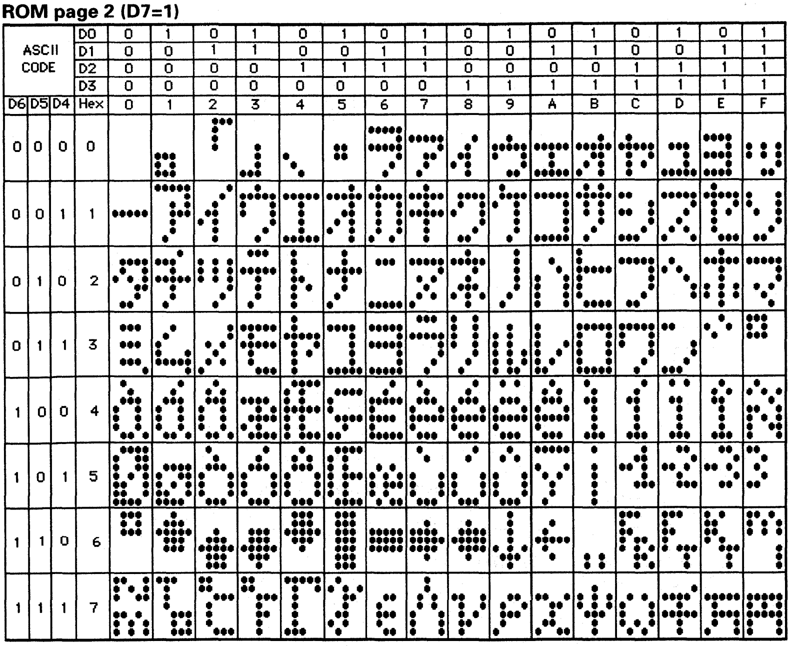
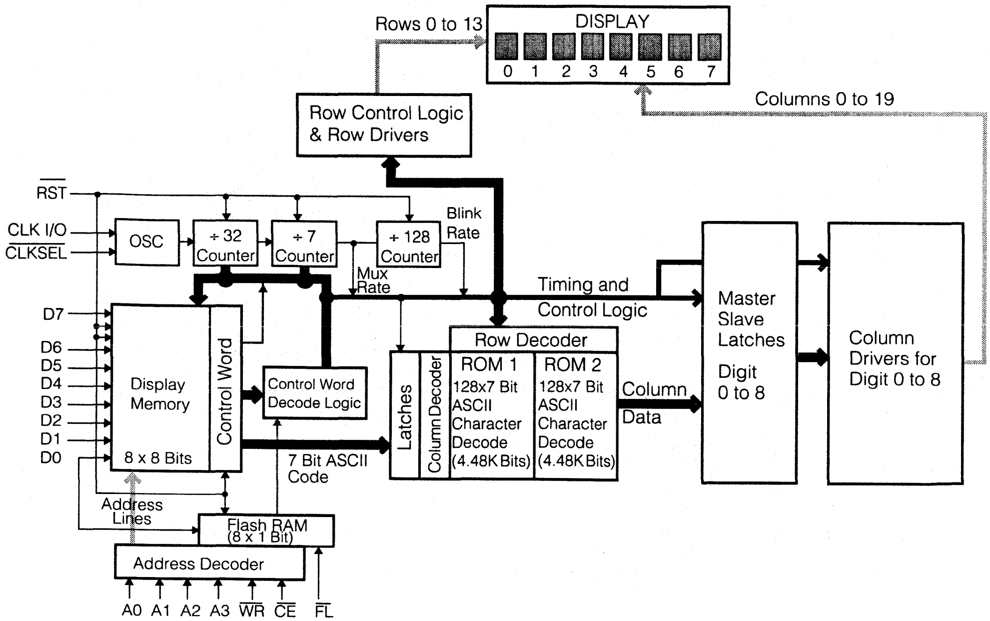


Figure 9. Block diagram



Functional Description

The PDSP211X block diagram is comprised of the following major blocks and registers.

Display Memory consists of a 8x8 bit RAM block. Each of the eight 8-bit words holds the 7-bit ASCII data (bit D0-D6). The 8th bit, D7 selects 1 of the 2 pages of character ROM. D7=0 selects Page 1 of the ROM and D7=1 selects Page 2 of the ROM. A3=1.

$\overline{RST}$ can be used to initialize display operation upon power up or during normal operation. When activated, $\overline{RST}$ will clear the Flash RAM and Control Word Register (00H) and reset the internal counter. All eight display memory locations will be set to 20H to show blanks in all digits.

$\overline{FL}$ pin enables access to the **Flash RAM**. The **Flash RAM** will set (D0=0) or reset (D0=0) flashing of the character addressed by A0-A2.

The 1x8 bit **Control Word RAM** is loaded with attribute data if A3=0.

The **Control Word Logic** decodes attribute data for proper implementation.

Character ROM is designed for two pages of 128 characters each. Both pages of the ROM are Mask Programmable for custom fonts. On the standard product page one contains standard ASCII, selected European characters and some scientific symbols. Page two contains Katakana characters, more European characters, avionics, and other graphic symbols.

The **Clock Source** could either be the internal oscillator ($\overline{CLKSEL}$=1) of the device or an external clock ($\overline{CLKSEL}$=0) could be an input from another PDSP211X display for the synchronization of blinking for multiple displays.

The **Display Multiplexer** controls the Row Drivers so no additional logic is required for a display system.

The **Display** has eight digits. Each digit has 35 LEDs clustered into a 5x7 dot matrix.

Theory of Operation

The PDSP211X Programmable display is designed to work with all major microprocessors. Data entry is via an eight bit parallel bus. Three bits of address route the data to the proper digit location in the RAM. Standard control signals like $\overline{WR}$ and $\overline{CE}$ allow the data to be written into the display.

D0- D7 data bits are used for both ASCII and control word data input. A3 acts as the mode selector. If A3=0, D0-D7 load the RAM with control word data. If A3=1, D0-D7 will load the RAM with ASCII and page select data. In the later mode, D7=0 selects Page 1 of Character ROM and D7=1 selects Page 2 of Character ROM.

For normal operation $\overline{FL}$ pin should be held high. When $\overline{FL}$ is held low, Flash RAM is accessed to set character blinking.

The seven bit ASCII code is decoded by the Character ROM to generate Column data. Twenty columns worth of data is sent out each display cycle and it takes fourteen display cycles to write into eight digits.

The rows are being multiplexed in two sets of seven rows each. The internal timing and control logic synchronizes the turning on of rows and presentation of column data to assure proper display operation.

Data input commands

Signals								
$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	Operation	
1	X	X	X	X	X	X	No operation	
X	1	X	X	X	X	X	No operation	
0	0	1	0	0	0	0	Write Control Register	
0	0	1	1	0	0	0	Digit 0 (left)	Write display data to user RAM and Page Select Register
0	0	1	1	0	0	1	Digit 1	
0	0	1	1	0	1	0	Digit 2	
0	0	1	1	0	1	1	Digit 3	
0	0	1	1	1	0	0	Digit 4	
0	0	1	1	1	0	1	Digit 5	D0–D6=ASCII Data
0	1	1	1	1	0	0	Digit 6	D7=0 Select ROM 1
0	0	1	1	1	1	1	Digit 7 (right)	D7=1 Select ROM 2
0	0	0	X	0	0	0	Digit 0 (left)	Write Flash RAM Register
0	0	0	X	0	0	1	Digit 1	
0	0	0	X	0	1	0	Digit 2	
0	0	0	X	1	1	1	Digit 3	
0	0	0	X	1	0	0	Digit 4	
0	0	0	X	1	0	1	Digit 5	D0=0 Flashing Charac. off
0	0	0	X	1	1	0	Digit 6	D0=1 Flashing Charac. on
0	0	0	X	1	1	1	Digit 7 (right)	D1–D7=X

X=Don't care

Power up Sequence

Upon power up display will come on at random. Thus the display should be reset on power-up. The reset will clear the Flash RAM, Control Word Register and reset the internal counter. All the digits will show blanks and display brightness level will be 100%.

Microprocessor Interface

The interface to a microprocessor is through the 8-bit data bus (D0-D7), the 4-bit address bus (A0-A3) and control lines $\overline{FL}$, $\overline{CE}$ and $\overline{WR}$.

To write data (ASCII/Control Word) into the display $\overline{CE}$ should be held low, address and data signals stable and $\overline{WR}$ should be brought low.

The Control Word is decoded by the Control Word Decode Logic. Each code has a different function. The code for display brightness changes the duty cycle for the column drivers. The peak LED current stays the same but the average LED current diminishes depending on the intensity level.

The character Flash Enable causes 2 Hz coming out of the counter to be ANDED with column drive signal and makes the column driver to cycle at 2 Hz. Thus the character flashes at 2 Hz.

The display Blink works the same way as the Flash Enable but causes all twenty column drivers to cycle at 2 Hz thereby making all eight digits to blink at 2 Hz.

The Lamp Test causes the column drivers to run at 1/2 duty cycle thus all the LEDs in all eight digits turn on at 50% intensity.

Clear bit clears the character RAM and writes a blank into the display memory. It however does not clear the control word.

ASCII Data or Control Word Data can be written into the display at this point. For multiple display operation, CLK I/O must be properly selected. CLK I/O will output the internal clock if $\overline{CLKSEL}$=1, or will allow input from an external clock if $\overline{CLKSEL}$=0.

Control Word Format

Display Brightness

The display can be programmed to vary between blank, 13%, 20%, 27%, 40%, 53%, 80% and full brightness. Bits D0, D1 and D2 control the display brightness.

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Display Brightness
0	0	1	0	X	X	X	0	0	X	X	X	0	0	0	100% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	0	0	1	80% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	0	1	0	53% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	0	1	1	40% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	1	0	0	27% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	1	0	1	20% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	1	1	0	13% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	1	1	1	Blank Display

X=Don't Care

Flash RAM Function

Character Flash is controlled by $\overline{FL}$ pin, bit D0 and control word bit D3. Combination of $\overline{FL}$ being low, proper digit address and D0 being high will write a flash bit into the Flash RAM Register. In the control word mode when D3 is brought high, the above mentioned character will flash.

Setting the Flash Bit

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	X	A	A	A	X	X	X	X	X	X	X	0	Flash RAM Disabled
0	0	0	X	A	A	A	X	X	X	X	X	X	X	1	Flash RAM Enabled

X=Don't Care A=Selected Address

Character Flash Control Word

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	0	X	0	0	B	B	B	Disable Flashing Character
0	0	1	0	X	X	X	0	0	X	0	1	B	B	B	Enable Flashing Character

X=Don't Care B=Selected Brightness

Display Blinking

Blinking Function is independent of Flash function. When D4 is held high, entire display blinks at 2 Hz.

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	0	X	0	0	B	B	B	Display Blinking Disabled
0	0	1	0	X	X	X	0	0	X	1	0	B	B	B	Display Blinking Enabled

X=Don't Care B=Selected Brightness

Lamp Test

Bit D6 when brought high will cause all the LEDs in all eight digits to light up at 53% brightness. Selecting or de-selecting Lamp Test bit has no effect on the display memory.

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	0	X	0	X	X	X	X	Lamp Test Disabled
0	0	1	0	X	X	X	0	1	X	0	0	X	X	X	Lamp Test Enabled

X=Don't Care

Clear Function

Clear function will clear the display. The Flash RAM will be set to all zeros. An ASCII blank code (20H) will be written into the display memory. The user must wait 3 ms or write a new control word to the display with control word bit D7 = 0 to disable clear before writing any data to the display memory, otherwise all new data to the display memory will remain cleared. See Switching Specifications for clear function timing.

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	X	X	X	X	X	X	X	Clear Disabled
0	0	1	0	X	X	X	1	X	X	X	X	X	X	X	Clear User RAM, Page RAM, Flash RAM and Display

X=Don't Care

Control Word Format

D7	D6	D5	D4	D3	D2 D1 D0
Clear Enable	Lamp Test	Not Used	Blink Enable	Flash Enable	Brightness Control

D2	D1	D0	Brightness
0	0	0	100%
0	0	1	80%
0	1	0	53%
0	1	1	40%
1	0	0	27%
1	0	1	20%
1	1	0	13%
1	1	1	0% Blank

D3 Flash Enable
0 Disable Flashing Character
1 Enable Flashing Character

D4 Blinking Display
0 Disable Blinking Display
1 Enable Blinking Display

D6 Lamp Test
0 Disable Lamp Test
1 Enable Lamp Test (all dots on at 53% brightness)

D7 Clear Enable
0 Disable Clear
1 Enable Clear (Clear Data RAM, Page RAM, Flash RAM)

Electrical and Mechanical Considerations

Voltage Transient Suppression

For best results power the display and the components that interface with the display to avoid logic inputs higher than VCC. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place a parallel combination of a .01 µF and a 22 µF capacitor between V_{CC} and GND for all display packages.

ESD Protection

The input protection structure of the PDSP2110/1/2/3/4 provides significant protection against ESD damage. It is capable of withstanding discharges greater than 2 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The PDSP2110/1/2/3/4 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichorotrifluorethane), TA, 111 Trichloroethane, and unheated acetone.[1]

Note:

1) Acceptablecommercialsolventsare:BasicTF,Arklone,P.Genesolv D. Genesolv DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 28 pin DIP sockets .600" wide with .100" centers work well for single displays.

Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The .200" high character of the PDSP211X gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The PDSP2110/2112 are red/high efficiency red displays and should be matched with long wavelength pass filter in the 570 nm to 590 nm range. The PDSP2111/2113/2114 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%. Selecting the proper intensity of the displays allows 10,000 foot candle sunlight viewability.

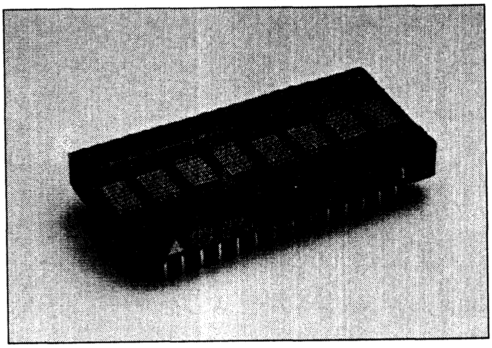
Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

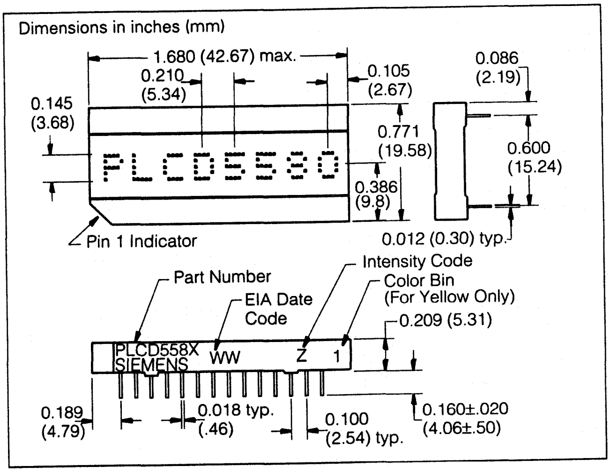
One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.–Atlas, Van Nuys, CA.

SIEMENS

RED PLCD5580
YELLOW PLCD5581
HIGH EFFICIENCY RED PLCD5582
GREEN PLCD5583
HIGH EFFICIENCY GREEN PLCD5584

Low Power 0.145" 8-Character 5x5 Dot Matrix Parallel Input Alphanumeric Intelligent Display® Devices





FEATURES

- Eight 0.145" (3.68 mm) High 5x5 Dot Matrix Characters in Red, Yellow, High Efficiency Red, Green, or High Efficiency Green
- Built-in 2 Page, 256 Character ROM. Both Pages Mask Programmable for Custom Fonts
- Built-in Decoders, Multiplexers and Drivers
- Wide Viewing Angle, X Axis ±50°, Y Axis ±65°
- Programmable Features:
  - Individual Flashing Character
  - Full Display Blinking
  - Multi-Level Dimming and Blanking
  - Clear Function
  - Lamp Test
- Internal or External Clock
- End Stackable Dual-In-Line Plastic Package
- Low Power: 20% Less Power Consumption Than 5x7 Format

DESCRIPTION

The PLCD5580 (Red), PLCD5581 (Yellow), PLCD5582 (High Efficiency Red), PLCD5583 (Green), and PLCD5584 (High Efficiency Green) are eight digit, 5x5 dot matrix, alphanumeric Intelligent Display devices. The 0.145 inch high digits are packaged in a rugged, high quality, optically transparent, standard 0.6 inch 28 pin plastic DIP.

The on-board CMOS has a built-in two page, 256 character ROM. Both pages are mask programmable for 256 custom characters. The first page of ROM of the standard product contains 128 characters including ASCII, selected European and Scientific symbols. The second page contains Katakana Japanese characters, more European characters, Avionics, and other graphic symbols.

The PLCD558X is designed for standard microprocessor interface techniques and is fully TTL compatible. The Clock I/O and Clock Select pins allow the user to synchronize multiple display modules.

Maximum Ratings

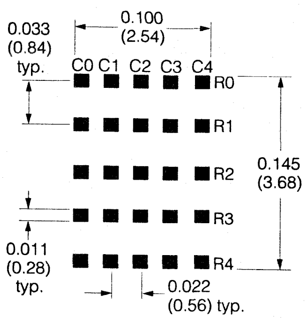
DC Supply Voltage .... –0.5 to +7.0 Vdc
Input Voltage Levels Relative
  to Ground .... –0.5 to V_{CC} +0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature 0.063"
  below Seating Plane, t<5 sec .... 260°C
Relative Humidity at 85°C 85%

Note:

Maximum voltage is with no LEDs illuminated.

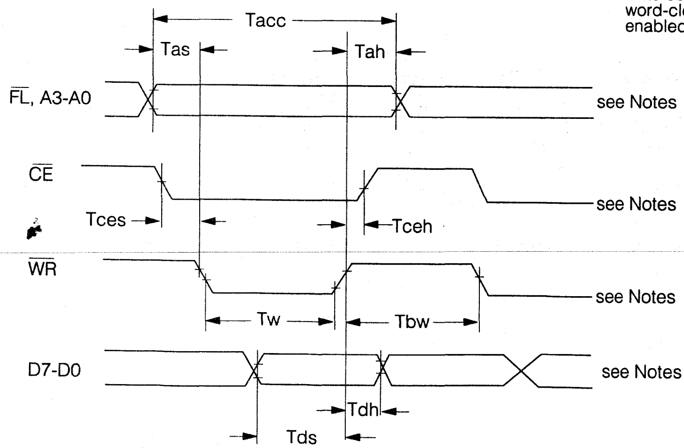
Figure 6. Enlarged character font

Dimensions in inches (mm)



Tolerance: .XXX= ±.010 (.25)

Figure 7. Write cycle timing diagram



Notes:

1. All input voltages are V_{IL}=0.8 V, V_{IH}=2.0 V.
2. These wave forms are not edge triggered.
3. Tbw=Tas+Tah

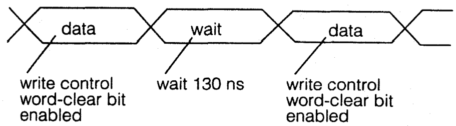
Switching specifications

(over operating temperature range and V_{CC}=4.5 V)

Symbol	Description	Min.	Units
Tbw	Time Between Writes	30	ns
Tacc (2)	Display Access Time	130	ns
Tas	Address Setup Time	10	ns
Tces	Chip Enable Setup Time	0	ns
Tah	Address Hold Time	20	ns
Tceh	Chip Enable Hold Time	0	ns
Tw	Write Active Time	100	ns
Tds	Data Valid Prior to Rising Edge of Write	50	ns
Tdh	Data Hold Time	20	ns
Trc (1)	Reset Active Time	300	ns
Tclr (3)	Clear Cycle Time	3	µs

Notes:

1) Wait 300 ns min. after the reset function is turned off.
2) Tacc=Tas+Tw+Tah
3) The Clear Cycle Time may be shortened by writing a second Control Word with the Clear Bit disabled, 160 ns after the first control word that enabled the Clear Bit.
The Flash RAM and Character RAM may not be accessed until the Clear Cycle is complete.



Optical characteristics at 25°C (V_{CC}=5.0 V at full brightness)

Red PLCD5580

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	70	90	µcd/dot
Peak Wavelength	λ(peak)		660	nm
Dominant Wavelength	λ(d)		639	nm

Yellow PLCD5581

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	130	210	µcd/dot
Peak Wavelength	λ(peak)		583	nm
Dominant Wavelength	λ(d)		585	nm

High Efficiency Red PLCD5582

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	150	330	µcd/dot
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		626	nm

Green PLCD5583

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	150	260	µcd/dot
Peak Wavelength	λ(peak)		565	nm
Dominant Wavelength	λ(d)		570	nm

High Efficiency Green PLCD5584

Description	Symbol	Min.	Typ.	Units
Peak Luminous Intensity (1)	I_{Vpeak}	200	510	µcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		574	nm

Note:

1) Peak luminous intensity is measured at T_A=T_J=25 °C. No time is allowed for the device to warm up prior to measurement.

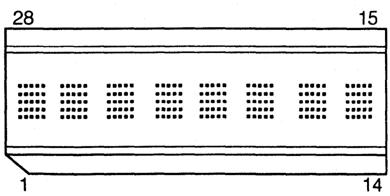
Electrical characteristics at 25°C

Parameters	Limits				Conditions
	Min.	Typ.	Max.	Units	
V_{CC}	4.5	5.0	5.5	V	
I_{CC} Blank		0.5	1.0	mA	V_{CC}=5 V, V_{IN}=5 V
I_{CC} 8 digits (1) 16 dots/character		240	290	mA	V_{CC}=5 V, "#" displayed in all eight digits
I_{IP} Current (with pull-up)		11	18	µA	V_{CC}=5 V, V_{IN}=0 V to V_{CC} ($\overline{WR}$, $\overline{CE}$, $\overline{FL}$, $\overline{RST}$, $\overline{CLKSEL}$)
I_I Input Leakage Current (no pull-up)			±1	µA	V_{CC}=5 V,V_{IN}=0 V to V_{CC} (Clk I/O, A0-A3, D0-D7)
V_{IH} Input Voltage High	2.0		V_{CC} +0.3	V	V_{CC}=4.5 V to 5.5 V
V_{IL} Input Voltage Low	GND –0.3		0.8	V	V_{CC}=4.5 V to 5.5 V
V_{OL} Output Voltage Low (Clock Pin)			0.4	V	V_{CC}=4.5 V to 5.5 V, I_{OL}=1.6 mA
V_{OH} Output Voltage High (Clock Pin)	2.4			V	V_{CC}=4.5 V to 5.5 V, I_{OH}=40 µA
I_{OH} Output Current High (Clock I/O)	–0.9			mA	V_{CC}=4.5 V, V_{OH}=2.4 V
I_{OL} Output Current Low (Clock I/O)	1.6	2		mA	V_{CC}=4.5 V, V_{OL}=0.4 V
θ_{JC} Thermal Resistance Junction to Case		25		°C/W	
F_{EXT} External Clock Input Frequency (2)	28		81.14	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=0
F_{OSC} Internal Clock Output Frequency (2)	28		81.14	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=1
Clock I/O Buss Loading			240	pF	
Clock Out Rise Time			500	ns	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	ns	V_{CC}=4.5 V, V_{OL}=0.4 V
FM, Digit Multiplex Frequency	125	256	362.5	Hz	
Blinking Rate	0.98	2	2.83	Hz	

Notes:

1) Average I_{CC} measured at full brightness. Peak I_{CC}=5/8 x I_{AVG} I_{CC} (# displayed).
2) Internal/external frequency duty factor is 50%.

Figure 8. Top View



Pin assignments

Pin	Function	Pin	Function
1	$\overline{RST}$	28	D7
2	$\overline{FL}$	27	D6
3	A0	26	D5
4	A1	25	D4
5	A2	24	D3
6	A3	23	D2
7	Substr. bias	22	No Pin
8		21	
9		20	D1
10	No Connect	19	D0
11	$\overline{CLKSEL}$	18	No Connect
12	CLK I/O	17	$\overline{CE}$
13	$\overline{WR}$	16	GND (logic)
14	V_{CC}	15	GND (supply)

Pin definitions

Pin	Function	Definition
1	$\overline{RST}$	Used for initialization of a display and sychronization of blinking for multiple displays
2	$\overline{FL}$	Low input accesses the Flash RAM
3	A0	Address input LSB
4	A1	Address input
5	A2	Address input MSB
6	A3	Mode selector
7	Substr. bias	Optional connection to V_{CC}. Can't be used to supply power to display.
8		
9		
10	No connect	
11	$\overline{CLKSEL}$	Selects internal/external clock source
12	CLK I/O	Outputs master clock or inputs external clock
13	$\overline{WR}$	A low will write data into the display if $\overline{CE}$ is low
14	V_{CC}	Positive power supply input
15	GND	Analog Ground for LED drivers
16	GND	Digital Ground for internal logic
17	$\overline{CE}$	Enables access to the display
18	No Connect	
19	D0	Data input LSB
20	D1	Data input
21	No pin	
22		
23	D2	Data input
24	D3	
25	D4	
26	D5	
27	D6	
28	D7	Data input MSB, selects ROM, page 1 or 2

Figure 9. Cascading the PLCD558X displays

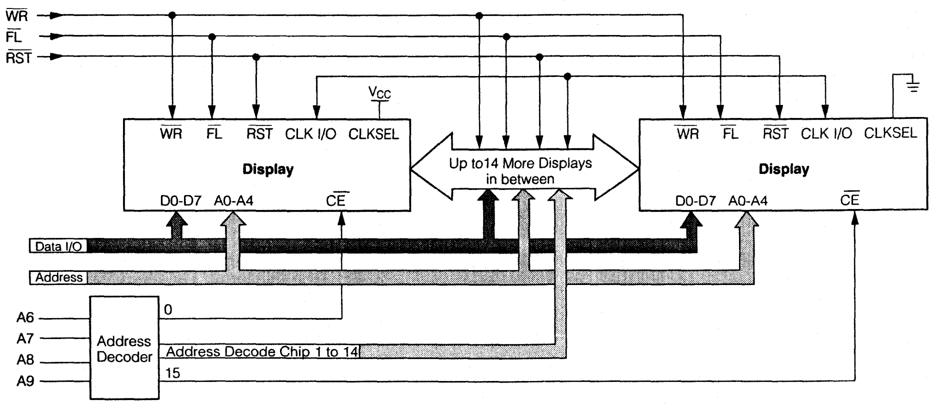
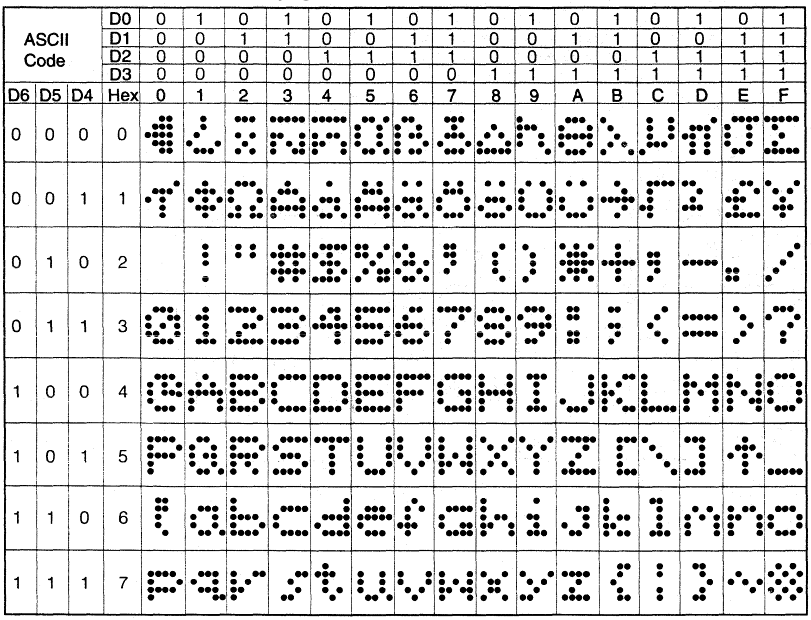


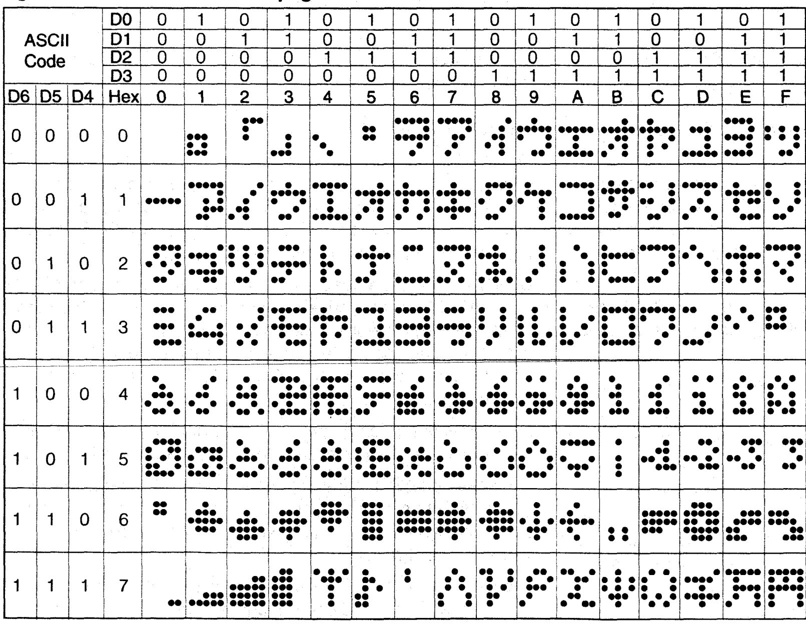
Figure 10. Character set–ROM page 1



ASCII Code			D0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
			D1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
			D2	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
			D3	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
D6	D5	D4	Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	0	0	0																
0	0	1	1																
0	1	0	2																
0	1	1	3																
1	0	0	4																
1	0	1	5																
1	1	0	6																
1	1	1	7																

Notes:
1. D7=0
2. High=1 level.
   Low=0 level.

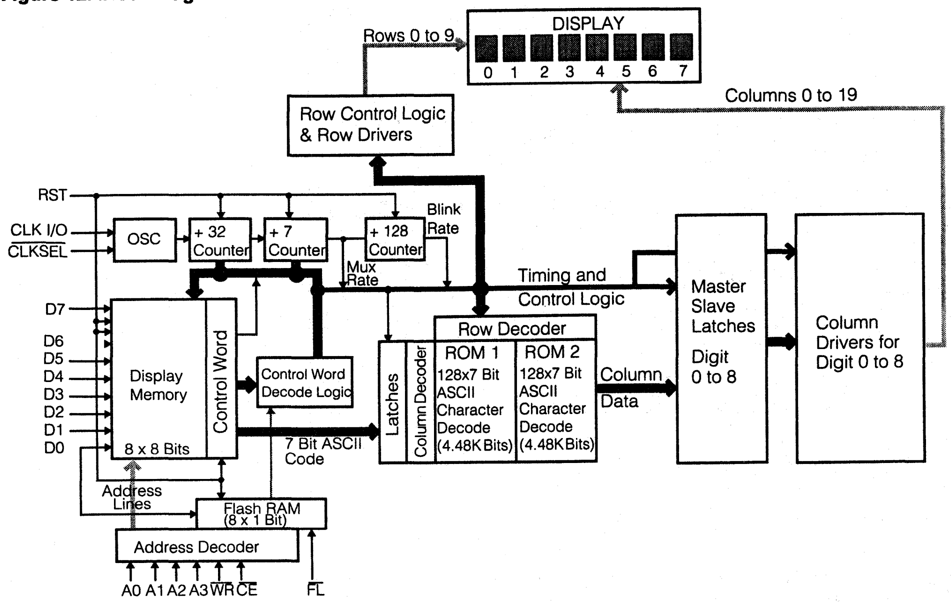
Figure 11. Character set–ROM page 2



ASCII Code			D0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
			D1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
			D2	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
			D3	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
D6	D5	D4	Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	0	0	0																
0	0	1	1																
0	1	0	2																
0	1	1	3																
1	0	0	4																
1	0	1	5																
1	1	0	6																
1	1	1	7																

Notes:
1. D7=0
2. High=1 level.
   Low=0 level.

Figure 12. Block diagram



Functional Description

The PLCD558X block diagram is comprised of the following major blocks and registers.

Display Memory consists of a 8x8 bit RAM block. Each of the eight 8-bit words holds the 7-bit ASCII data (bit D0-D6). The 8th bit, D7 selects 1 of the 2 pages of character ROM. D7=0 selects Page 1 of the ROM and D7=1 selects Page 2 of the ROM. A3=1.

RST can be used to initialize display operation upon power up or during normal operation. When activated, RST will clear the Flash RAM and Control Word Register (00H) and reset the internal counter. All eight display memory locations will be set to 20H to show blanks in all digits.

FL pin enables access to the Flash RAM. The Flash RAM will set (D0=1) or reset (D0=0) flashing of the character addressed by A0–A2.

The 1x8 bit **Control Word RAM** is loaded with attribute data if A3=0.

The **Control Word Logic** decodes attribute data for proper implementation.

Character ROM is designed for two pages of 128 characters each. Both pages of the ROM are Mask Programmable for custom fonts. On the standard product page one contains standard ASCII, selected European characters and some scientific symbols. Page two contains Katakana characters, more European characters, avionics, and other graphic symbols.

The **Clock Source** could either be the internal oscillator (CLKSEL=1) of the device or an external clock (CLKSEL=0) could be an input from another PLCD211X display for the synchronization of blinking for multiple displays.

The **Display Multiplexer** controls the Row Drivers so no additional logic is required for a display system.

The **Display** has eight digits. Each digit has 25 LEDs clustered into a 5x5 dot matrix.

Theory of Operation

The PLCD558X Programmable display is designed to work with all major microprocessors. Data entry is via an eight bit parallel bus. Three bits of address route the data to the proper digit location in the RAM. Standard control signals like WR and CE allow the data to be written into the display.

D0–D7 data bits are used for both ASCII and control word data input. A3 acts as the mode selector. If A3=0, D0–D7 load the RAM with control word data. If A3=1, D0–D7 will load the RAM with ASCII and page select data. In the later mode, D7=0 selects Page 1 of Character ROM and D7=1 selects Page 2 of Character ROM.

For normal operation FL pin should be held high. When FL is held low, Flash RAM is accessed to set character blinking.

The seven bit ASCII code is decoded by the Character ROM to generate Column data. Twenty columns worth of data is sent out each display cycle and it takes fourteen display cycles to write into eight digits.

The rows are being multiplexed in two sets of five rows each. The internal timing and control logic synchronizes the turning on of rows and presentation of column data to assure proper display operation.

Data input commands

Signals								
$\overline{\text{CE}}$	$\overline{\text{WR}}$	$\overline{\text{FL}}$	A3	A2	A1	A0	Operation	
1	X	X	X	X	X	X	No operation	
X	1	X	X	X	X	X	No operation	
0	0	1	0	0	0	0	Write Control Register	
0	0	1	1	0	0	0	Digit 0 (left)	Write display data to
0	0	1	1	0	0	1	Digit 1	user RAM and Page
0	0	1	1	0	1	0	Digit 2	Select Register
0	0	1	1	0	1	1	Digit 3	
0	0	1	1	1	0	0	Digit 4	
0	0	1	1	1	0	1	Digit 5	D0–D6=ASCII Data
0	0	1	1	1	1	0	Digit 6	D7=0 Select ROM 1
0	0	1	1	1	1	1	Digit 7 (right)	D7=1 Select ROM 2
0	0	0	X	0	0	0	Digit 0 (left)	Write Flash RAM Register
0	0	0	X	0	0	1	Digit 1	
0	0	0	X	0	1	0	Digit 2	
0	0	0	X	1	1	1	Digit 3	
0	0	0	X	1	0	0	Digit 4	
0	0	0	X	1	0	1	Digit 5	D0=0 Flashing Character off
0	0	0	X	1	1	0	Digit 6	D0=1 Flashing Character on
0	0	0	X	1	1	1	Digit 7 (right)	D1–D7=X

X=Don't care

Power up Sequence

Upon power up display will come on at random. Thus the display should be reset on power-up. The reset will clear the Flash RAM, Control Word Register and reset the internal counter. All the digits will show blanks and display brightness level will be 100%.

Microprocessor Interface

The interface to a microprocessor is through the 8-bit data bus (D0-D7), the 4-bit address bus (A0–A3) and control lines $\overline{\text{FL}}$, $\overline{\text{CE}}$ and $\overline{\text{WR}}$.

To write data (ASCII/Control Word) into the display $\overline{\text{CE}}$ should be held low, address and data signals stable and $\overline{\text{WR}}$ should be brought low.

The Control Word is decoded by the Control Word Decode Logic. Each code has a different function. The code for display brightness changes the duty cycle for the column drivers. The peak LED current stays the same but the average LED current diminishes depending on the intensity level.

The character Flash Enable causes 2 Hz coming out of the counter to be ANDED with column drive signal and makes the column driver to cycle at 2 Hz. Thus the character flashes at 2 Hz.

The display Blink works the same way as the Flash Enable but causes all twenty column drivers to cycle at 2 Hz thereby making all eight digits to blink at 2 Hz.

The Lamp Test causes the column drivers to run at 1/2 duty cycle thus all the LEDs in all eight digits turn on at 50% intensity.

Clear bit clears the character RAM and writes a blank into the display memory. It however does not clear the control word.

ASCII Data or Control Word Data can be written into the display at this point. For multiple display operation, CLK I/O must be properly selected. CLK I/O will output the internal clock if $\overline{\text{CLKSEL}}$=1, or will allow input from an external clock if $\overline{\text{CLKSEL}}$=0.

Control Word Format

Display Brightness

The display can be programmed to vary between blank, 13%, 20%, 27%, 40%, 53%, 80%, and full brightness. Bits D0, D1 and D2 control the display brightness.

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Display Brightness
0	0	1	0	X	X	X	0	0	X	X	X	0	0	0	100% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	0	0	1	80% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	0	1	0	53% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	0	1	1	40% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	1	0	0	27% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	1	0	1	20% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	1	1	0	13% Brightness
0	0	1	0	X	X	X	0	0	X	X	X	1	1	1	Blank Display

X=Don't care

Flash RAM Function

Character Flash is controlled by $\overline{FL}$ pin, bit D0 and control word bit D3. Combination of $\overline{FL}$ being low, proper digit address and D0 being high will write a flash bit into the Flash RAM Register. In the control word mode when D3 is brought high, the above mentioned character will flash.

Setting the Flash Bit

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	0	X	A	A	A	X	X	X	X	X	X	X	0	Flash RAM disabled
0	0	0	X	A	A	A	X	X	X	X	X	X	X	1	Flash RAM enabled

X=Don't care A=Selected address

Character Flash Control Word

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	0	X	0	0	B	B	B	Disable Flashing Char.
0	0	1	0	X	X	X	0	0	X	0	1	B	B	B	Enabled Flashing Char.

X=Don't care B=Selected brightness

Display Blinking

Blinking function is independent of Flash function. When D4 is held high, entire display blinks at 2 Hz.

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	0	X	0	0	B	B	B	Display Blinking disabled
0	0	1	0	X	X	X	0	0	X	1	0	B	B	B	Display Blinking enabled

X=Don't care B=Selected brightness

Lamp Test

Bit D6 when brought high will cause all the LEDs in all eight digits to light up at 53% brightness. Selecting or de-selecting Lamp Test has no effect on the display memory.

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	0	X	0	X	X	X	X	Lamp Test disabled
0	0	1	0	X	X	X	0	0	X	0	0	X	X	X	Lamp Test enabled

X=Don't care

Clear Function

Clear function will clear the display. The Flash RAM will be set to all zeros. An ASCII blank code (20H) will be written into the display memory. The user must wait 3 µs or write a new control word to the display with control word bit D7=0 to disable clear before writing any data to the display memory, otherwise all new data to the display memory will remain cleared. See Switching Specifications for clear function timing.

$\overline{CE}$	$\overline{WR}$	$\overline{FL}$	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0	Operation
0	0	1	0	X	X	X	0	X	X	X	X	X	X	X	Clear disabled
0	0	1	0	X	X	X	1	X	X	X	X	X	X	X	Clear user RAM, page RAM, flash RAM and display

X=Don't care

Control Word Format

D7	D6	D5	D4	D3	D2	D1	D0
Clear Enable	Lamp Test	Not Used	Blink Enable	Flash Enable	Brightness Control		

D2	D1	D0	Brightness
0	0	0	100%
0	0	1	80%
0	1	0	53%
0	1	1	40%
1	0	0	27%
1	0	1	20%
1	1	0	13%
1	1	1	0% Blank

D3 Flash Enable
0 Disable Flashing Character
1 Enable Flashing Character

D4 Blinking Display
0 Disable Blinking Display
1 Enable Blinking Display

D6 Lamp Test
0 Disable Lamp Test
1 Enable Lamp Test (all dots on at 53% brightness)

D7 Clear Enable
0 Disable Clear
1 Enable Clear (Clear Data RAM, Page RAM, Flash RAM)

Electrical and Mechanical Considerations

Voltage Transient Suppression

For best results power the display and the components that interface with the display to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place a parallel combination of a .01 µF and a 22 µF capacitor between V_{CC} and GND for all display packages.

ESD Protection

The input protection structure of the PLCD5580/1/2/3/4 provides significant protection against ESD damage. It is capable of withstanding discharges greater than 2 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The PLCD5580/1/2/3/4 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichorotrifluorethane), TA, 111 Trichloroethane, and unheated acetone.[1]

Note:

1) Acceptable commercial solvents are: Basic TF, Arklone, P. Genesolv, D. Genesolv DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 28 pin DIP sockets .600" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The .200" high character of the PLCD588X gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The PLCD5880/5882 are red/high efficiency red displays and should be matched with long wavelength pass filter in the 570 nm to 590 nm range. The PLCD5881/5883/5884 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%. Selecting the proper intensity of the displays allows 10,000 foot candle sunlight viewability.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

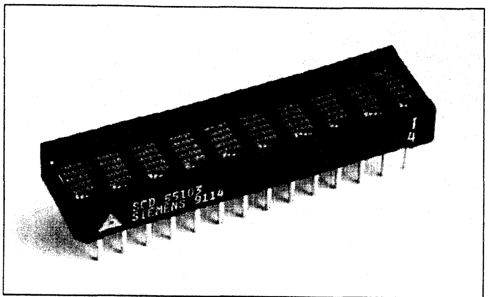
One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

SIEMENS

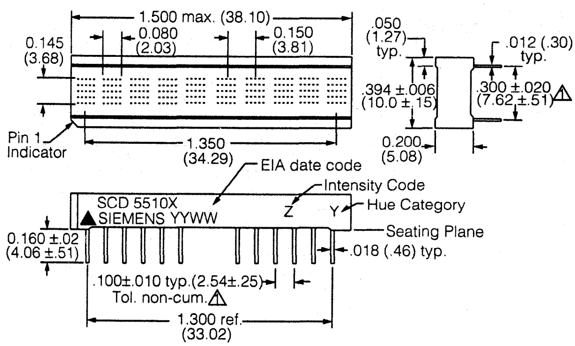
STANDARD RED SCD55100
YELLOW SCD55101
HIGH EFFICIENCY RED SCD55102
GREEN SCD55103
HIGH EFFICIENCY GREEN SCD55104

Slimline

0.145" 10-Character 5x5 Dot Matrix Serial Input Dot Addressable Intelligent Display® Devices



Dimensions in inches (mm)



1. Dimension is at Seating Plane.
2. Display matrix and pins centered on package outline.
3. Display matrix centered to pin array.
4. Tolerance: .XXX = ±.010 (.25)

FEATURES

- **Low Profile Package: 60% Smaller than Industry Standard 10-Digit Display**
- **Ten 0.145" (3.68 mm) 5x5 Dot Matrix Characters in Red, Yellow, High Efficiency Red, Green, or High Efficiency Green**
- **Optimum Display Surface Efficiency (display area to package ratio)**
- **Low Power–30% Less Power Dissipation than 5x7 Format**
- **High Speed Data Input Rate: 5 MHz**
- **ROMless Serial Input, Dot Addressable Display—Ideal for User Defined Characters**
- **Built-in Decoders, Multiplexers and LED Drivers**
- **Readable from 6 Feet (1.8 meters)**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±65°**
- **Attributes:**
  - **250 bit RAM for User Defined Characters**
  - **Eight Dimming Levels**
  - **Power Down Mode (<250 µW)**
  - **Hardware/Software Clear Function**
  - **Lamp Test**
- **Internal or External Clock**
- **End-Stackable Dual-in-line Plastic Package**
- **3.3 V Capability**

DESCRIPTION

The SCD55100 (Red), SCD55101 (Yellow), SCD55102 (HER), SCD55103 (Green) and SCD55104 (HEG) are eight digit dot addressable 5x5 matrix, Serial Input, Intelligent Display devices.

The ten 0.145" (3.68 mm) high digits are packaged in a rugged, high quality optically transparent, standard 0.3" pin spacing 28 pin plastic DIP.

The on-board CMOS has a 250 bit RAM, one bit associated with one LED, each to generate User Defined Characters. Due to the reduced LED count, power requirement and heat dissipation are reduced by 30%. Additionally in Power Down Mode quiescent current is <50 µA.

The SCD5510X is designed to work with the Serial port of most common microprocessors. The multiplex Clock I/O (CLK I/O) and multiplex Clock Select ($\overline{\text{CLK SEL}}$) pins offer the user the capability to supply a high speed external multiplex clock. This feature can minimize audio in-band interference for portable communication equipment or eliminate the visual synchronization effects found in high vibration environments such as avionics equipment.

Maximum Ratings

DC Supply Voltage .... –0.5 to +7.0 Vdc
Input Voltage Levels Relative
  to Ground .... –0.5 to V_{CC} +0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature
  0.063" below Seating Plane, t<5 sec .... 260°C
Relative Humidity at 85°C 85%
Maximum Number of LEDs on
  at 100% Brightness 160
Maximum Power Dissipation .... 1.7 Watts
IC Junction Temperature .... 125°C
ESD (100 pF, 1.5 KΩ) .... 2 KV
Maximum Input Current .... ±100 mA.

Figure 4. Top view

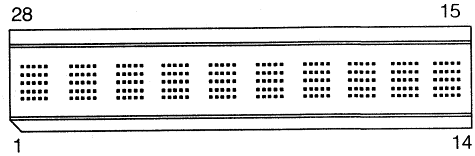


Figure 1. Data write cycle

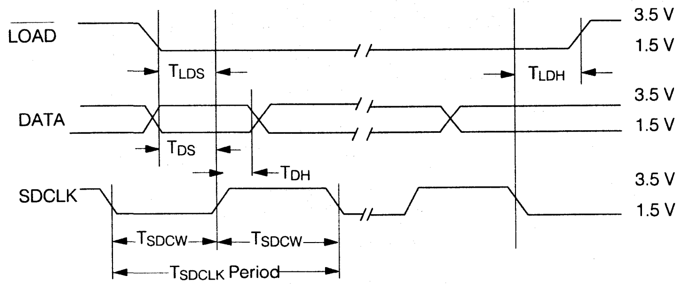


Figure 2. Instruction cycle

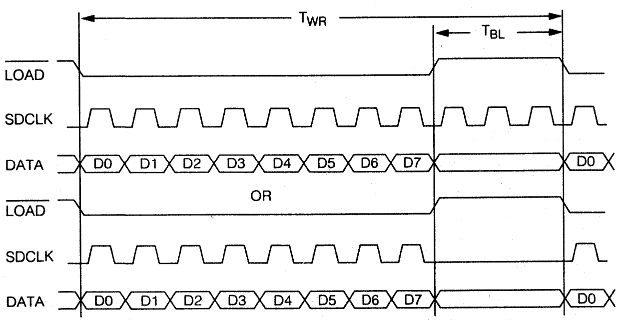
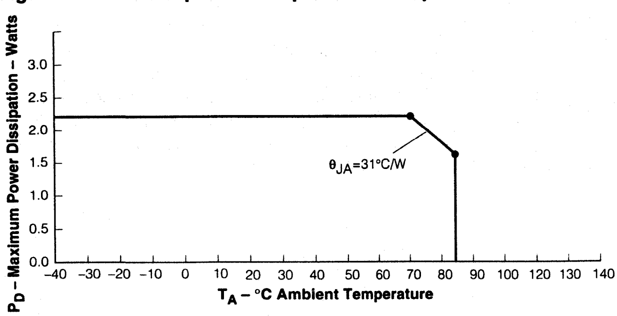


Figure 3. Maximum power dissipation vs. temperature



Electrical characteristics (over operating temperature)

Parameter	Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	V	
I_{CC} (Pwr Dwn Mode)[4]		50		µA	V_{CC}=5 V, all inputs=0 V or V_{CC}
I_{CC} 10 digits 16 dots/character		250	365	mA	V_{CC}=5 V, "#" displayed in all 10 digits at 100% brightness at 25°C
I_{IL} Input current			–10	µA	V_{CC}=5 V, V_{IN}=0 V (all inputs)
I_{IH} Input current			10	µA	V_{CC}=V_{IN}=5.0 V (all inputs)
V_{IH}	3.5			V	V_{CC}=4.5 V to 5.5 V
V_{IL}			1.5	V	V_{CC}=4.5 V to 5.5 V
I_{OH} (CLK I/O)		–8.9		mA	V_{CC}=4.5 V, V_{OH}=2.4 V
I_{OL} (CLK I/O)		1.6		mA	V_{CC}=4.5 V, V_{OL}=0.4 V
θ_{JA}			31	°C/W	
F_{ext} External Clock Input Frequency	120		347	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=0
F_{osc} Internal Clock Input Frequency	120		347	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=1
Clock I/O Bus Loading			240	pF	
Clock Out Rise Time			500	ns	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	ns	V_{CC}=4.5 V, V_{OH}=0.4 V
FM, Digit	375	768	1086	Hz	

Notes:

1) Peak current $^5/_3 \times I_{CC}$.
2) Unused inputs must be tied high.
3) Contact Siemens for 3.3 volt operation.
4) External oscillator must be stopped if being used to maintain an I_{CC}<50 µA.

Input/Output Circuits

Figures 5 and 6 show the input and output resistor/diode networks used for ESD protection and to eliminate substrate latch-up caused by input voltage over/under shoot.

Figure 5. Inputs

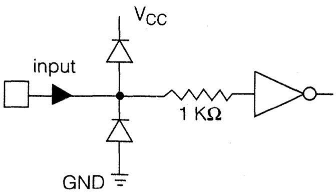
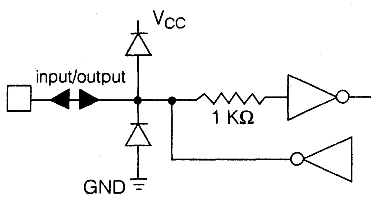


Figure 6. Clock I/O



Optical Characteristics at 25°C
(V_{CC}=5.0 V at 100% brightness level, viewing angle: X axis ±55°, Y axis ±65°)

Red SCD55100

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	36	78	μcd/dot
Peak Wavelength	λ(peak)		665	nm
Dominant Wavelength	λ(d)		639	nm

Yellow SCD55101

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	124	208	μcd/dot
Peak Wavelength	λ(peak)		583	nm
Dominant Wavelength	λ(d)		584	nm

High Efficiency Red SCD55102

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	124	237	μcd/dot
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		626	nm

Green SCD55103

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	124	238	μcd/dot
Peak Wavelength	λ(peak)		565	nm
Dominant Wavelength	λ(d)		569	nm

High Efficiency Green SCD55104

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	124	500	μcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		572	nm

Notes:
1. Dot to dot intensity matching at 100% brightness is 1.8:1.
2. Displays are binned for hue at 2 nm intervals.
3. Displays within a given intensity category have an intensity matching of 1.5:1 (max.).

Pin assignment

Pin	Function	Pin	Function
1	SDCLK	28	GND
2	$\overline{LOAD}$	27	DATA
3	NC	26	NC
4	NC	25	NC
5	NC	24	NC
6	V_{CC}	23	V_{CC}
7	NP	22	NP
8	NP	21	NP
9	V_{CC}	20	V_{CC}
10	NC	19	V_{CC}
11	NC	18	NC
12	NC	17	NC
13	$\overline{RST}$	16	$\overline{CLKSEL}$
14	GND	15	CLK I/O

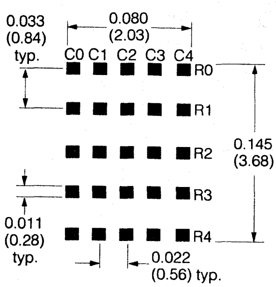
Switching specifications
(over operating temperature range and V_{CC}=4.5 V to 5.5 V)

Symbol	Description	Min.	Units
T_{RC}	Reset Active Time	600	ns
T_{LDS}	Load Setup Time	50	ns
T_{DS}	Data Setup Time	50	ns
T_{SDCLK}	Clock Period	200	ns
T_{SDCW}	Clock Width	70	ns
T_{LDH}	Load Hold Time	0	ns
T_{DH}	Data Hold Time	25	ns
T_{WR}	Total Write Time	2.2	µs
T_{BL}	Time Between Loads	600	ns

Note:

T_{SDCW} is the minimum time the SDCLK may be low or high. The SDCLK period must be a minimum of 200 ns.

Figure 7. Dot matrix format



Dimensions in inches (mm)
Tolerance:.XXX= ±.010(.25)

Pin definitions

Pin	Function	Definitions
1	SDCLK	Loads data into the 8-bit serial data register on a low to high transition.
2	$\overline{LOAD}$	Low input enables data clocking into 8-bit serial shift register. When $\overline{LOAD}$ goes high, the contents of 8-bit serial Shift Register will be decoded.
3	NC	No connection
4	NC	No connection
5	NC	No connection
6	V_{CC}	Power supply/heat sink
7	NP	No pin
8	NP	No pin
9	V_{CC}	Power supply/heat sink
10	NC	No connection
11	NC	No connection
12	NC	No connection
13	$\overline{RST}$	Asynchronous input, when low will clear the Multiplex Counter, User RAM and Data Register. Control Word Register is set to 100% brightness and the Address Register is set to select Digit 0. The display is blanked.
14	GND	Power supply ground
15	CLK I/O	Outputs master clock or inputs external clock.
16	$\overline{CLKSEL}$	H=internal clock, L=external clock
17	NC	No connection
18	NC	No connection
19	V_{CC}	Power supply/heat sink
20	V_{CC}	Power supply/heat sink
21	NP	No pin
22	NP	No pin
23	V_{CC}	Power supply/heat sink
24	NC	No connection
25	NC	No connection
26	NC	No connection
27	DATA	Serial data input
28	GND	Power supply ground

Display column and row format

	C0	C1	C2	C3	C4
Row 0	1	1	1	1	1
Row 1	0	0	1	0	0
Row 2	0	0	1	0	0
Row 3	0	0	1	0	0
Row 4	0	0	1	0	0

1=Display dot "On"
0=Display dot "Off"

Column data ranges

Row 0	00H to 1FH
Row 1	20H to 3FH
Row 2	40H to 5FH
Row 3	60H to 7FH
Row 4	80H to 9FH

Operation of the SCD5510X

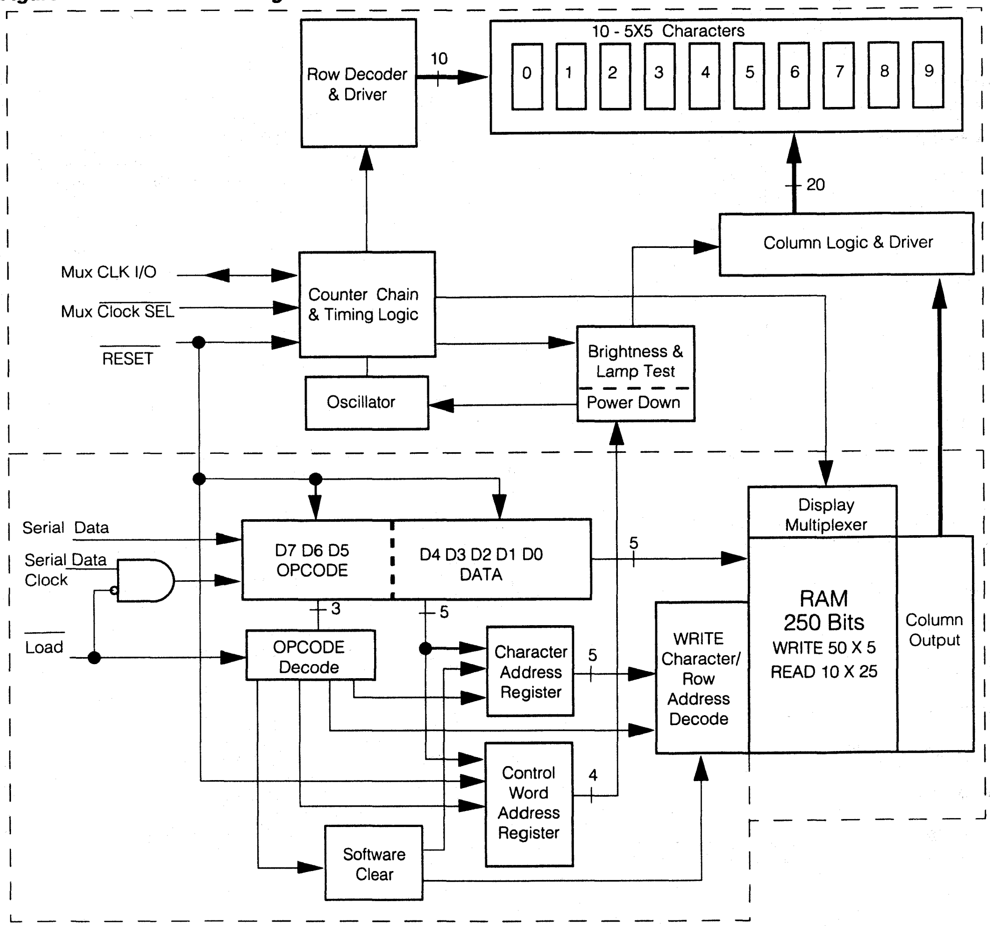
The SCD5510X display consists of a CMOS IC containing control logic and drivers for eight 5x5 characters. These components are assembled in a compact (38 mmx10 mm) plastic package.

Individual LED dot addressablity allows the user great freedom in creating special characters or mini-icons. The User Definable Character Set Examples illustrate 200 different character and symbol possibilities.

The use of a serial data interface provides a highly efficient interconnection between the display and the mother board. The SCD5510X requires only 4 lines as compared to 15 for an equivalent 8 character parallel input part.

The on-board CMOS IC is the electronic heart of the display. The IC accepts decoded serial data, which is stored in the internal RAM. Asynchronously the RAM is read by the character multiplexer at a strobe rate that results in a flicker free display. Figure 10 shows the three functional areas of the IC. These include: the input serial data register and control logic, a 250 bits two port RAM, and an internal multiplexer/display driver.

Figure 8. SCD5510X block diagram



The following explains how to format the serial data to be loaded into the display. The user supplies a string of bit mapped decoded characters. The contents of this string is shown in Figure 9a. Figure 9b shows that each character consist of six 8 bit words. The first word encodes the display character location and the succeeding five bytes are row data. The row data represents the status (On, Off) of individual column LEDs. Figure 9c shows that each 8 bit word is formatted to include a three bit Operational Code (OPCODE) defined by bits D7–D5 and five bits (D4–D0) representing Column Data, Character Address, or Control Word Data.

Figure 9d shows the sequence for loading the bytes of data. Bringing the $\overline{\text{LOAD}}$ line low enables the serial register to accept data. The shift action occurs on the low to high transition of the serial data clock (SDCLK). The least significant bit (D0) is loaded first. After eight clock pulses the $\overline{\text{LOAD}}$ line is brought high. With this transition the OPCODE is decoded. The decoded OPCODE directs D4–D0 to be latched in the Character Address register, stored in the RAM as Column data, or latched in the Control Word register. The control IC requires a minimum 600 ns delay between successive byte loads. As indicated in Figure 9a, a total of 660 clock cycles (60-8 bit words) are required to load all ten characters into the display.

The Character Address Register bits, D4–D0 (Table 2) and Row Address Register bits, D7–D5 (Table 3) direct the Column Data bits, D4–D0 (Table 3) to specific RAM location. Table 1 shows the Row Address for the example character "D." Column data is written and read asynchronously from the 250 bit RAM. Once loaded the internal oscillator and character multiplexer reads the data from the RAM. These characters are row strobed with column data as shown in Figures 10 and 11. The character strobe rate is determined by the internal or user supplied external MUX Clock and the IC's ÷320 counter.

Table 1. Character "D"

	Op code D7	D6	D5	Column Data D4 C0	D3 C1	D2 C2	D1 C3	D0 C4	Hex
Row 0	0	0	0	1	1	1	1	0	1E
Row 1	0	0	1	1	0	0	0	1	31
Row 2	0	1	0	1	0	0	0	1	51
Row 3	0	1	1	1	0	0	0	1	71
Row 4	1	0	0	1	1	1	1	0	9E

Figure 9. Loading serial character data

Example: Serial Clock = 5 MHz, Clock Period = 200 ns

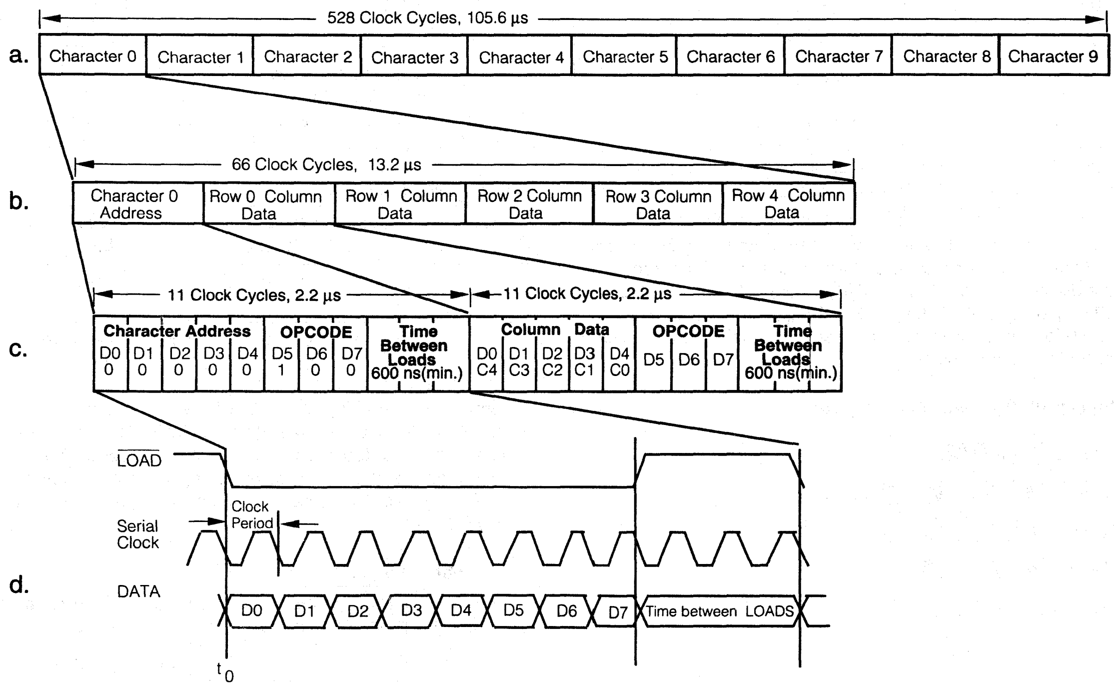


Table 2. Load character address

Op code D7	D6	D5	Character Address D4	D3	D2	D1	D0	Hex	Operation Load
1	0	1	1	0	0	0	0	B0	Character 0
1	0	1	1	0	0	0	1	B1	Character 1
1	0	1	1	0	0	1	0	B2	Character 2
1	0	1	1	0	0	1	1	B3	Character 3
1	0	1	1	0	1	0	0	B4	Character 4
1	0	1	1	0	1	0	1	B5	Character 5
1	0	1	1	0	1	1	0	B6	Character 6
1	0	1	1	0	1	1	1	B7	Character 7
1	0	1	1	1	0	0	0	B8	Character 8
1	0	1	1	1	0	0	1	B9	Character 9

Table 3. Load column data

Op code D7	D6	D5	Column Data D4	D3	D2	D1	D0	Operation Load
0	0	0	C0	C1	C2	C3	C4	Row 0
0	0	1	C0	C1	C2	C3	C4	Row 1
0	1	0	C0	C1	C2	C3	C4	Row 2
0	1	1	C0	C1	C2	C3	C4	Row 3
1	0	0	C0	C1	C2	C3	C4	Row 4

The user can activate four Control functions. These include: LED Brightness Level, Lamp Test, IC Power Down, or Display Clear. OPCODEs and five bit words are used to initiate these functions. The OPCODEs and Control Words for the Character Address and Loading Column Data are shown in Tables 2 and 3.

The user can select seven specific LED brightness levels, Table 4. These brightness levels (in percentages of full brightness of the display) include: 100% ($F0_{HEX}$), 53% ($F1_{HEX}$), 40% ($F2_{HEX}$), 27% ($F3_{HEX}$), 20% ($F4_{HEX}$), 13% ($F5_{HEX}$), and 6.6% ($F6_{HEX}$). The brightness levels are controlled by changing the duty factor of the row strobe pulse.

Figure 10. Row and column location

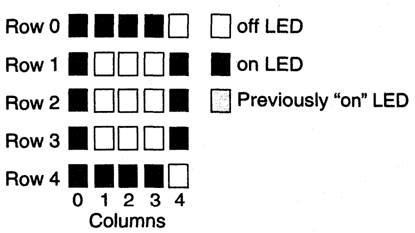


Table 4. Display brightness

Op code D7	D6	D5	Control Word D4	D3	D2	D1	D0	Hex	Operation Level
1	1	1	1	0	0	0	0	F0	100%
1	1	1	1	0	0	0	1	F1	53%
1	1	1	1	0	0	1	0	F2	40%
1	1	1	1	0	0	1	1	F3	27%
1	1	1	1	0	1	0	0	F4	20%
1	1	1	1	0	1	0	1	F5	13%
1	1	1	1	0	1	1	0	F6	6.6%

The SCD5510X offers a unique Display Power Down feature which reduces I_{CC} to less than 50 µA. When FF_{HEX} is loaded, as shown in Table 5, the display is set to 0% brightness and the internal multiplex clock is stopped. When in the Power Down mode data may still be written into the RAM. The display is reactivated by loading a new Brightness Level Control Word into the display.

Table 5. Power down

Op code D7	D6	D5	Control Word D4	D3	D2	D1	D0	Hex	Operation Level
1	1	1	1	1	1	1	1	FF	0% brightness

The Lamp Test is enabled by loading $F8_{HEX}$, Table 6, into the serial shift register. This Control Word sets all of the LEDs to a 53% brightness level. Operation of the Lamp Test has no affect on the RAM and is cleared by loading a Brightness Control Word.

Table 6. Lamp test

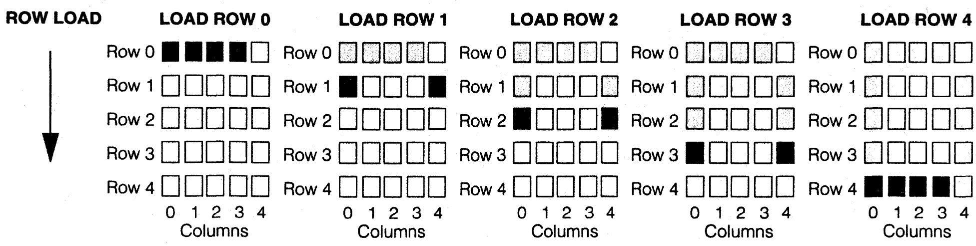
Op code D7	D6	D5	Control Word D4	D3	D2	D1	D0	Hex	Operation Level
1	1	1	1	0	B	B	B		Lamp Test (OFF)
1	1	1	1	1	0	0	0	F8	Lamp Test (ON)

The Software Clear ($C0_{HEX}$), given in Table 7, clears the Address Register and the RAM. The display is blanked and the Character Address Register will be set to Character 0. The internal counter and the Control Word Register are unaffected. The Software Clear will remain active until the next data input cycle is initiated.

Table 7. Software clear

Op code D7	D6	D5	Control Word D4	D3	D2	D1	D0	Hex	Operation Level
1	1	0	0	0	0	0	0	C0	CLEAR

Figure 11. Row strobing



Multiplexer and Display Driver

The ten characters are row multiplexed with RAM resident column data. The strobe rate is established by the internal or external MUX Clock rate. The MUX Clock frequency is divided by a 320 counter chain. This results in a typical strobe rate of 750 Hz. By pulling the Clock SEL line low, the display can be operated from an external MUX Clock. The external clock is attached to the CLK I/O connection (pin 15). The maximum external MUX Clock frequency should be limited to 1 MHz.

An asynchronous hardware Reset (pin 13) is also provided. Bringing this pin low will clear the Character Address Register, Control Word Register, RAM, and blanks the display. This action leaves the display set at Character Address 0, and the Brightness Level set at 100%.

Electrical & Mechanical Considerations Interconnect Considerations

Optimum product performance can be had when the following electrical and mechanical recommendations are adopted. The SCD5510X's IC is constructed in a high speed CMOS process, consequently high speed noise on the SERIAL DATA, SERIAL DATA CLOCK, $\overline{\text{LOAD}}$ and $\overline{\text{RESET}}$ lines may cause incorrect data to be written into the serial shift register. Adhere to transmission line termination procedures when using fast line drivers and long cables (>10 cm).

Good digital grounds (pins 14, 28) and power supply decoupling (pins 6, 9, 20, 23) will insure that I_{CC} (<400 mA peak) switching currents do not generate localized ground bounce. Therefore it is recommended that each display package use a 0.1 µF and 20 µF capacitor between V_{CC} and ground.

When the internal MUX Clock is being used connect the $\overline{\text{CLKSEL}}$ pin to V_{CC}. In those applications where $\overline{\text{RESET}}$ will not be connected to the system's reset control, it is recommended that this pin be connected to the center node of a series 0.1, µF and 100 KΩ RC network. Thus upon initial power up the $\overline{\text{RESET}}$ will be held low for 10 ms allowing adequate time for the system power supply to stabilize.

The SCD5510X allows up to 1.7 W of power dissipation at 70° and 1.29 W power dissipation at a maximum operating temperature of 85°C. Approximately 60% of this power is dissipated by the IC to the PC board via the V_{CC} connection (pins 6, 9, 20, 23). Optimum thermal reliability is obtained by connecting all of the V_{CC} pins to a common pad located on both sides of the PC board. This technique offers a low thermal resistance for IC to system ambient.

ESD Protection

The input protection structure of the SCD55100/1/2/3/4 provides significant protection against ESD damage. It is capable of withstanding discharges greater than 2 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The SCD55100/1/2/3/4 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluorethane), TA, 111 Trichloroethane, and unheated acetone.[1]

Note:

1) Acceptablecommercialsolventsare:BasicTF,Arklone,P.Genesolv, D. Genesolv DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 28 pin DIP sockets .300" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

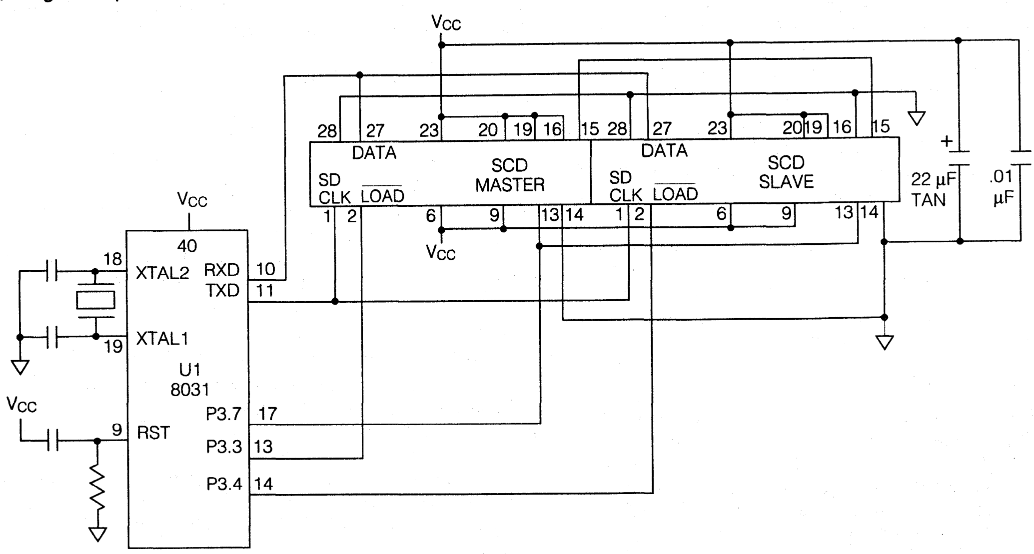
Optical Considerations

The 0.145" high character of the SCD5510X gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The SCD5510/2 are red/high efficiency red displays and should be matched with long wavelength pass filter in the 570 nm to 590 nm range. The SCD55103/4 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Figure 12. SCD interface with Siemens/Intel 8031 microprocessor (using serial port in mode 0)



Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.–Atlas, Van Nuys, CA.

Microprocessor Interface

The microprocessor interface is through the serial port, SPI port or one out of eight data bits on the eight bit parallel port and also control lines $\overline{\text{SDCLK}}$ and $\overline{\text{LOAD}}$.

Power Up Sequence

Upon power up display will come on at random. Thus the display should be reset at power-up. The reset will set the Address Register to Digit 0, User RAM is set to 0 (display blank) the Control Word is set to 0 (100% brightness with Lamp Test off) and the internal counters are reset.

Figure 13. SCD5510X interface with Siemens/Intel 8031 microprocessor

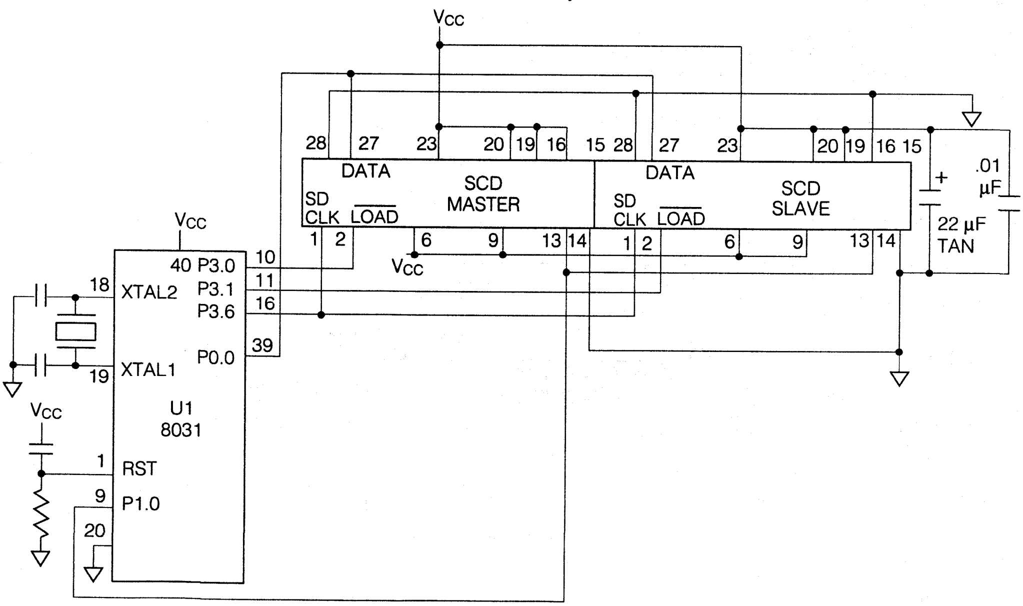
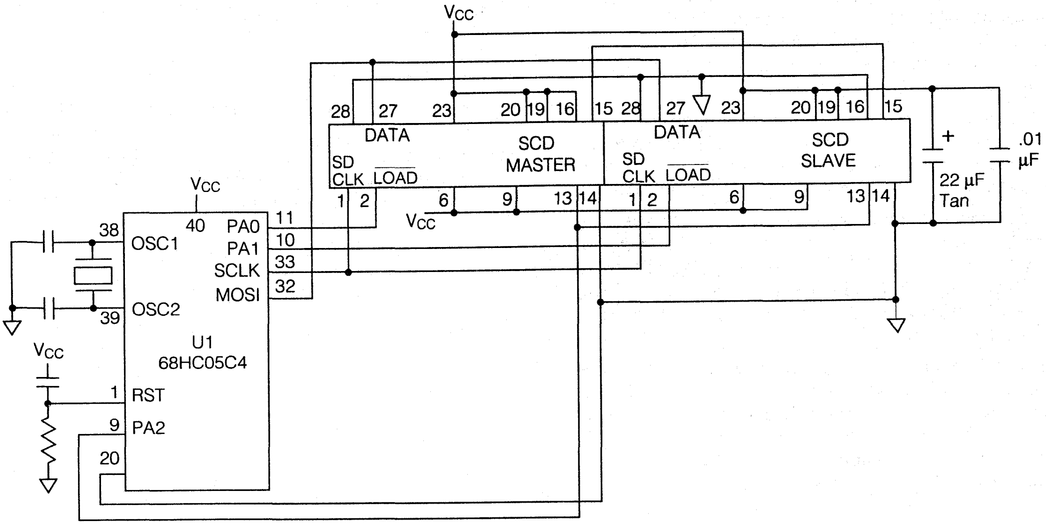


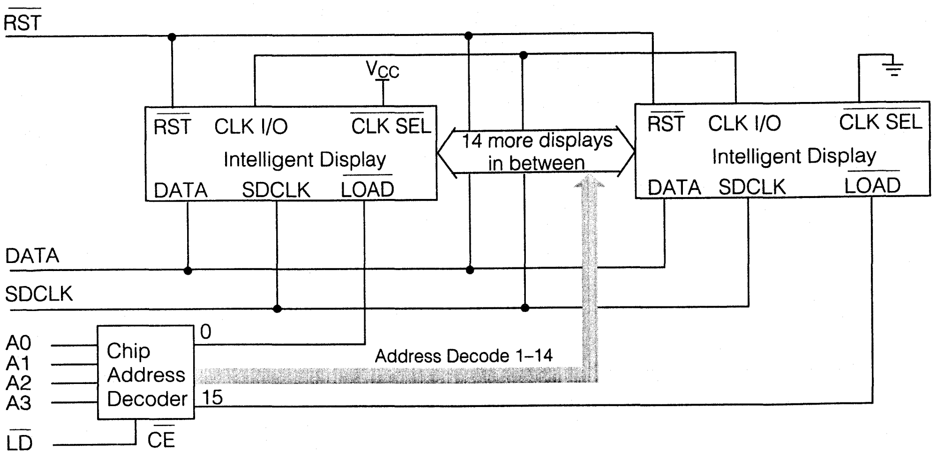
Figure 14. SCD5510X interface with Motorola 68HC05C4 microprocessor
(using SPI port)



Cascading Multiple Displays

Multiple displays can be cascaded using the CLK SEL and CLK I/O pins as shown below. The display designated as the Master Clock source should have its CLK SEL pin tied high and the slaves should have their CLK SEL pins tied low. All CLK I/O pins should be tied together. One display CLK I/O can drive 15 slave CLK I/Os. Use RST to synchronize all display counters.

Figure 15. Cascading multiple displays



Loading Data Into the Display

Use following procedure to load data into the display:

1. Power up the display.
2. Bring $\overline{RST}$ low (600 ns duration minimum) to clear the Multiplex Counter, Address Register, Control Word Register, User Ram and Data Register. The display will be blank. Display brightness is set to 100%.
3. If a different brightness is desired, load the proper brightness opcode into the Control Word Register.
4. Load the Digit Address into the display.
5. Load display row and column data for the selected digit.
6. Repeat steps 4 and 5 for all digits.

Data contents for the word "Displays"

Step	D7	D6	D5	D4	D3	D2	D1	D0	Function
A	1	1	0	0	0	0	0	0	CLEAR
B(optional)	1	1	1	1	0	B	B	B	BRIGHTNESS SELECT
1	1	0	1	1	0	0	0	0	DIGIT D0 SELECT
2	0	0	0	1	1	1	1	0	ROW 0 D0 (D)
3	0	0	1	1	0	0	0	1	ROW 1 D0 (D)
4	0	1	0	1	0	0	0	1	ROW 2 D0 (D)
5	0	1	1	1	0	0	0	1	ROW 3 D0 (D)
6	1	0	0	1	1	1	1	0	ROW 4 D0 (D)
7	1	0	1	1	0	0	0	1	DIGIT D1 SELECT
8	0	0	0	0	1	1	1	0	ROW 0 D1 (I)
9	0	0	1	0	0	1	0	0	ROW 1 D1 (I)
10	0	1	0	0	0	1	0	0	ROW 2 D1 (I)
11	0	1	1	0	0	1	0	0	ROW 3 D1 (I)
12	1	0	0	0	1	1	1	0	ROW 4 D1 (I)
13	1	0	1	1	0	0	1	0	DIGIT D2 SELECT
14	0	0	0	0	1	1	1	1	ROW 0 D2 (S)
15	0	0	1	1	0	0	0	0	ROW 1 D2 (S)
16	0	1	0	0	1	1	1	0	ROW 2 D2 (S)
17	0	1	1	0	0	0	0	1	ROW 3 D2 (S)
18	1	0	0	1	1	1	1	0	ROW 4 D2 (S)
19	1	0	1	1	0	0	1	1	DIGIT D3 SELECT
20	0	0	0	1	1	1	1	0	ROW 0 D3 (P)
21	0	0	1	1	0	0	0	1	ROW 1 D3 (P)
22	0	1	0	1	1	1	1	0	ROW 2 D3 (P)
23	0	1	1	1	0	0	0	0	ROW 3 D3 (P)
24	1	0	0	1	0	0	0	0	ROW 4 D3 (P)
25	1	0	1	1	0	1	0	0	DIGIT D4 SELECT
26	0	0	0	1	0	0	0	0	ROW 0 D4 (L)
27	0	0	1	1	0	0	0	0	ROW 1 D4 (L)
28	0	1	0	1	0	0	0	0	ROW 2 D4 (L)
29	0	1	1	1	0	0	0	0	ROW 3 D4 (L)
30	1	0	0	1	1	1	1	1	ROW 4 D4 (L)
31	1	0	1	1	0	1	0	1	DIGIT D5 SELECT
32	0	0	0	0	0	1	0	0	ROW 0 D5 (A)
33	0	0	1	0	1	0	1	0	ROW 1 D5 (A)
34	0	1	0	1	1	1	1	1	ROW 2 D5 (A)
35	0	1	1	1	0	0	0	1	ROW 3 D5 (A)
36	1	0	0	1	0	0	0	1	ROW 4 D5 (A)
37	1	0	1	1	0	1	1	0	DIGIT D6 SELECT
38	0	0	0	1	0	0	0	1	ROW 0 D6 (Y)
39	0	0	1	0	1	0	1	0	ROW 1 D6 (Y)
40	0	1	0	0	0	1	0	0	ROW 2 D6 (Y)
41	0	1	1	0	0	1	0	0	ROW 3 D6 (Y)
42	1	0	0	0	0	1	0	0	ROW 4 D6 (Y)
43	1	0	1	1	0	1	1	1	DIGIT D7 SELECT
44	0	0	0	0	1	1	1	1	ROW 0 D7 (S)
45	0	0	1	1	0	0	0	0	ROW 1 D7 (S)
46	0	1	0	0	1	1	1	0	ROW 2 D7 (S)
47	0	1	1	0	0	0	0	1	ROW 3 D7 (S)
48	1	0	0	1	1	1	1	0	ROW 4 D7 (S)

Note:

If the display is already reset at Power Up, there is no need for Software Clear.

User Definable Character Set Examples*

Upper and lower case alphabets

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
04 2A 5F 71 91		1E 29 4E 69 9E		0F 30 50 70 8F		1E 29 49 69 9E		1F 30 5E 70 9F		1F 30 5E 70 90		0F 30 53 71 8F		11 31 5F 71 91		0E 24 44 64 8E	
01 21 41 71 8E		13 34 58 74 93		10 30 50 70 9F		11 3B 55 71 91		11 39 55 73 91		0E 31 51 71 8E		1E 31 5E 70 90		0C 32 56 72 8D		1E 31 5E 74 92	
0F 30 4E 61 9E		1F 24 44 64 84		11 31 51 71 8E		11 31 51 6A 84		11 31 55 7B 91		11 2A 44 6A 91		11 2A 44 64 84		1F 22 44 68 9F			
00 2E 52 72 8D		10 30 5E 71 9E		00 2F 50 70 8F		01 21 4F 71 8F		00 2E 5F 70 8E		04 2A 48 7C 88		00 2F 50 73 8F		10 30 56 79 91		04 20 4C 64 8E	
00 26 42 72 8C		10 30 56 78 96		0C 24 44 64 8E		00 2A 55 71 91		00 36 59 71 91		00 2E 51 71 8E		00 3E 51 7E 90		00 2F 51 6F 81		00 33 54 78 90	
00 23 44 62 8C		08 3C 48 6A 84		00 32 52 72 8D		00 31 51 6A 84		00 31 55 7B 91		00 32 4C 6C 92		00 31 4A 64 98		00 3E 44 68 9E			

DOT ON = 1
DOT OFF = 0

Numerals and punctuation

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
0E 33 55 79 8E		04 2C 44 64 8E		1E 21 46 68 9F		1E 21 4E 61 9E		06 2A 5F 62 82		1F 30 5E 61 9E		06 28 5E 71 8E		1F 22 44 68 88		0E 31 4E 71 8E	
0E 31 4F 62 8C		0A 3F 4A 7F 8A		0F 34 4E 65 9E		06 29 5C 68 9F		19 3A 44 6B 93		08 34 4D 72 8D		0C 2C 44 68 80		02 24 44 64 82		08 24 44 64 88	
0C 2C 48 64 80		04 24 5F 64 84		00 2C 4C 64 88		00 20 5F 60 80		00 20 40 6C 8C		01 22 44 68 90		04 24 44 60 84		0A 2A 40 60 80		07 24 44 64 87	
10 28 44 62 81		1C 24 44 64 9C		0E 35 57 70 8E		00 20 40 60 9F		0C 2C 40 6C 8C		0C 20 4C 64 88		02 24 48 64 82		00 3F 40 7F 80		08 24 42 64 88	
0E 31 42 64 88		06 24 48 64 86		0C 24 42 64 8C		04 24 40 64 84		11 2A 44 6E 84		15 2E 5F 6E 95		04 2A 51 60 80		08 35 42 60 80			

DOT ON = 1
DOT OFF = 0

*CAUTION: No more than 128 LEDs "on" at one time at 100% brightness.

User Definable Character Set Examples* (continued)

Scientific notations, etc.

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
06 2E 5E 6E 86		04 24 48 71 8E		1F 20 59 75 93		1F 20 56 79 91		0E 20 4A 64 8A		0D 32 52 72 8D		0C 32 56 71 96		0E 24 4E 71 8E		00 24 4A 71 9F	
10 3C 52 72 81		0E 31 5F 71 8E		10 28 44 6A 91		09 29 49 6E 90		01 2E 54 64 84		04 2E 55 6E 84		0E 31 51 6A 9B		01 2E 5A 6A 8A		0F 32 52 72 8C	
1F 28 44 68 9F		18 24 48 7C 80		1C 28 44 78 80		12 36 5A 67 80		06 21 5A 67 80		07 22 59 66 80		1C 34 5C 60 80		0F 28 48 78 88		04 2E 5F 6E 80	
00 24 4E 7F 8E		00 2E 5F 6E 84		0E 3F 4E 64 80		04 3E 5F 7E 84		04 2F 5F 6F 84		0E 2E 4E 6E 8E		00 3F 5F 7F 80		04 2E 55 64 84		04 24 55 6E 84	
04 22 5F 62 84		04 28 5F 68 84		1F 31 51 71 9F		08 2C 4A 78 98		0A 35 4A 75 8A		15 2A 55 6A 95		1F 35 5F 75 9F		00 3F 5F 7C 80		0E 3F 5B 7F 8E	
00 27 4F 78 9C		00 3C 5F 63 87		00 20 40 60 83		00 20 40 67 9F		00 23 5F 7F 9F		0C 3C 5C 7C 9C		15 2E 44 64 84					

DOT ON = 1
DOT OFF = 0

Foreign characters

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
1F 21 5F 62 84		1F 21 46 64 88		01 22 46 6A 82		04 3F 51 61 86		00 3F 44 64 9F		02 3F 46 6A 92		08 3F 49 6A 88		1F 21 45 67 8C		02 3F 51 62 8C	
08 3F 49 69 92		04 3F 44 7F 84		0F 29 51 62 8C		08 2F 52 62 82		0F 21 41 61 9F		0A 3F 4A 62 8C		19 21 59 62 9C		0F 29 55 63 8C		01 3E 42 7F 86	
15 35 55 62 8C		0E 20 5F 64 98		08 28 4C 6A 88		04 3F 44 64 98		0E 20 40 60 9F		1F 21 4A 64 9A		04 3E 44 6E 95		04 24 44 68 90		04 22 51 71 91	
10 3F 50 70 8F		1F 21 41 62 8C		0E 20 4E 60 8F		04 28 51 7F 81		01 21 4A 64 8A		1F 28 5F 68 87		1E 22 42 62 9F		1F 21 5F 61 9F		0E 20 5F 61 8E	
12 32 52 64 88		04 34 54 75 96		1E 25 4F 74 8F		0F 34 5F 74 97		0F 30 4F 64 98		0F 33 55 79 9E		0F 34 57 74 8F		00 2A 5F 74 8B		08 24 4E 72 8F	
0A 2E 51 7F 91		02 24 4C 64 8E		04 2A 4E 71 8E		0A 34 52 7A 96		08 24 51 71 8E		02 24 51 71 8E		04 2A 51 71 8E					

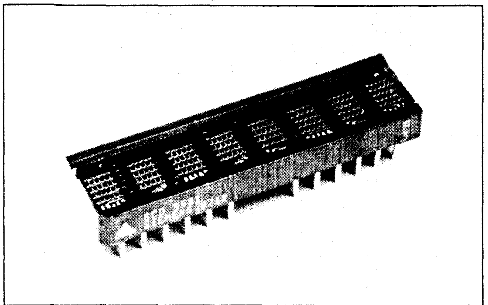
DOT ON = 1
DOT OFF = 0

*CAUTION: No more than 128 LEDs "on" at one time at 100% brightness.

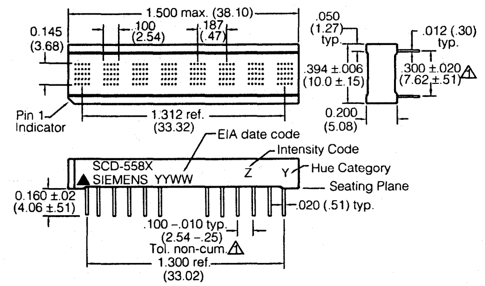
SIEMENS

STANDARD RED SCD5580
YELLOW SCD5581
HIGH EFFICIENCY RED SCD5582
GREEN SCD5583
HIGH EFFICIENCY GREEN SCD5584

Slimline 0.145" 8-Character 5x5 Dot Matrix Serial Input Dot Addressable Intelligent Display® Devices



Dimensions in inches (mm)



1. Dimension is at Seating Plane
2. Display matrix and pins centered on package outline.
3. Display matrix centered to pin array.
4. Tolerance: .XXX= ±.010 (.25)

FEATURES

- **Low Profile Package: 60% Smaller than Industry Standard 8-Digit Display**
- **Eight 0.145" (3.68 mm) 5x5 Dot Matrix Characters in Red, Yellow, High Efficiency Red, Green, or High Efficiency Green**
- **Optimum Display Surface Efficiency (display area to package ratio)**
- **Low Power—30% Less Power Dissipation than 5x7 Format**
- **High Speed Data Input Rate: 5 MHz**
- **ROMless Serial Input, Dot Addressable Display—Ideal for User Defined Characters**
- **Built-in Decoders, Multiplexers and LED Drivers**
- **Readable from 6 feet (1.8 meters)**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±65°**
- **Attributes:**
  - **200 Bit RAM for User Defined Characters**
  - **Eight Dimming Levels**
  - **Power Down Mode (<250 μW)**
  - **Hardware/Software Clear Function**
  - **Lamp Test**
- **Internal or External Clock**
- **End-Stackable Dual-In-Line Plastic Package**
- **3.3 V Capability**

DESCRIPTION

The SCD5580 (Red), SCD5581 (Yellow), SCD5582 (HER), SCD5583 (Green) and SCD5584 (HEG) are eight digit dot addressable 5x5 matrix, Serial Input, Intelligent Display devices. The eight 0.145" (3.68 mm) high digits are packaged in a rugged, high quality optically transparent, standard 0.3" pin spacing 28 pin plastic DIP.

The on-board CMOS has a 200 bit RAM, one bit associated with one LED, each to generate User Defined Characters. Due to the reduced LED count, power requirement and heat dissipation are reduced by 30%. Additionally in Power Down Mode quiescent current is <50 μA.

The SCD558X is designed to work with the Serial port of most common microprocessors. The multiplex Clock I/O (CLK I/O) and multiplex Clock Select ($\overline{\text{CLK SEL}}$) pins offer the user the capability to supply a high speed external multiplex clock. This feature can minimize audio in-band interference for portable communication equipment or eliminate the visual synchronization effects found in high vibration environments such as avionics equipment.

Maximum Ratings

DC Supply Voltage .... −0.5 to +7.0 Vdc
Input Voltage Levels Relative
to Ground .... −0.5 to V_{CC} +0.5 Vdc
Operating Temperature .... −40°C to +85°C
Storage Temperature .... −40°C to +100°C
Maximum Solder Temperature
0.063" below Seating Plane, t<5 sec .... 260°C
Relative Humidity at 85°C 85%
Maximum Number of LEDs on
at 100% Brightness 128
Maximum Power Dissipation .... 1.7 Watts
IC Junction Temperature .... 125°C
ESD (100 pF, 1.5 KΩ) .... 2 KV
Maximum Input Current .... ±100 mA

Figure 1. Data write cycle

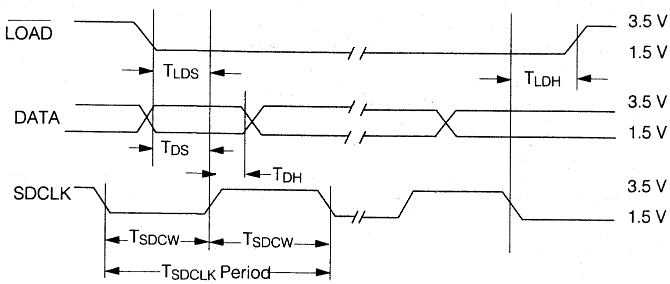


Figure 2. Instruction cycle

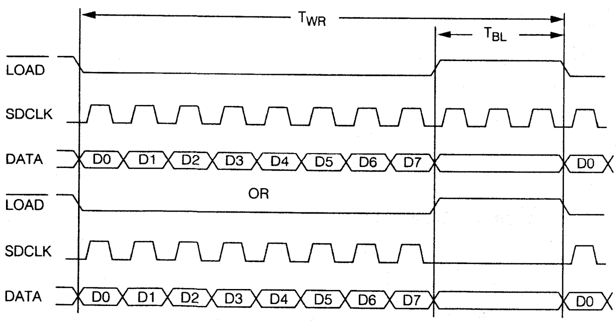


Figure 3. Maximum power dissipation vs. temperature

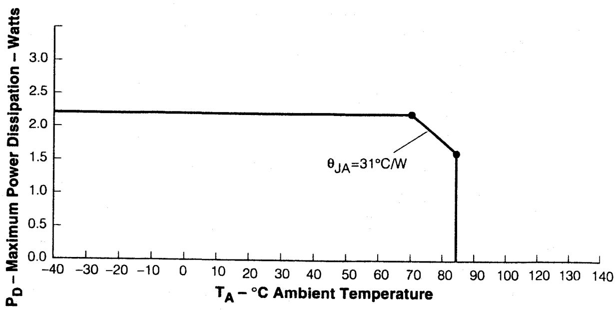
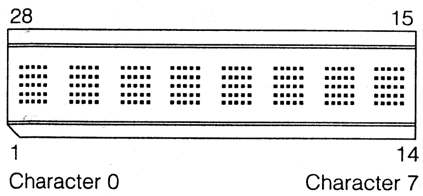


Figure 4. Top view



Electrical characteristics (over operating temperature)

Parameter	Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	V	
I_{CC} (Pwr Dwn Mode)[4]			50	µA	V_{CC}=5.0 V, all inputs=0 V or V_{CC}
I_{CC} 8 digits 16 dots/character		200	290	mA	V_{CC}=5 V, "#" displayed in all 8 digits at 100% brightness at 25°C
I_{IL} Input current			–10	µA	V_{CC}=5 V, V_{IN}=0 (all inputs)
I_{IH} Input current			10	µA	V_{CC}=V_{IN}=5.0 V (all inputs)
V_{IH}	3.5			V	V_{CC}=4.5 V to 5.5 V
V_{IL}			1.5	V	V_{CC}=4.5 V to 5.5 V
I_{OH} (CLK I/O)		–8.9		mA	V_{CC}=4.5 V, V_{OH}=2.4 V
I_{OL} (CLK I/O)		1.6		mA	V_{CC}=4.5 V, V_{OL}=0.4 V
$\theta_{JC\text{-}pin}$			31	°C/W	
F_{ext} External Clock Input Frequency	120		347	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=0
F_{osc} Internal Clock Input Frequency	120		347	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=1
Clock I/O Bus Loading			240	pF	
Clock Out Rise Time			500	ns	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	ns	V_{CC}=4.5 V, V_{OH}=0.4 V
FM, Digit	375	768	1086	Hz	

Notes:

1) Peak current $^5/_3$ x I_{CC}.
2) Unused inputs must be tied high.
3) Contact Siemens for 3.3 volt operation.
4) External oscillator must be stopped if being used to maintain an I_{CC}<50 µA.

Input/Output Circuits

Figures 5 and 6 show the input and output resistor/diode networks used for ESD protection and to eliminate substrate latch-up caused by input voltage over/under shoot.

Figure 5. Inputs

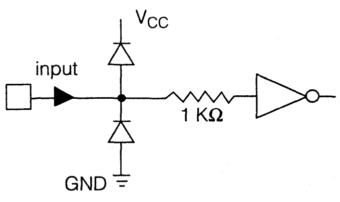
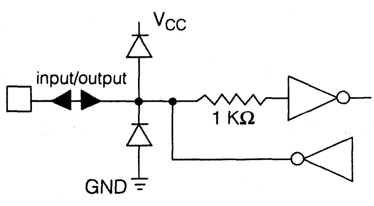


Figure 6. Clock I/O



Optical Characteristics at 25°C
(V_{CC}=5.0 V at 100% brightness level, viewing angle: X axis ±55°, Y axis ±65°)

Red SCD5580

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	36	90	µcd/dot
Peak Wavelength	λ(peak)		665	nm
Dominant Wavelength	λ(d)		639	nm

Yellow SCD5581

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	124	213	µcd/dot
Peak Wavelength	λ(peak)		583	nm
Dominant Wavelength	λ(d)		584	nm

High Efficiency Red SCD5582

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	124	265	µcd/dot
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		626	nm

Green SCD5583

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	124	221	µcd/dot
Peak Wavelength	λ(peak)		565	nm
Dominant Wavelength	λ(d)		569	nm

High Efficiency Green SCD5584

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	124	505	µcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		572	nm

Notes:

1. Dot to dot intensity matching at 100% brightness is 1.8:1.
2. Displays are binned for hue at 2 nm intervals.
3. Displays within a given intensity category have an intensity matching of 1.5:1 (max.).

Pin assignment

Pin	Function	Pin	Function
1	SDCLK	28	GND
2	$\overline{LOAD}$	27	DATA
3	NC	26	NC
4	NC	25	NC
5	NC	24	NC
6	V_{CC}	23	V_{CC}
7	NP	22	NP
8	NP	21	NP
9	V_{CC}	20	V_{CC}
10	NC	19	V_{CC}
11	NC	18	NC
12	NC	17	NC
13	$\overline{RST}$	16	$\overline{CLKSEL}$
14	GND	15	CLK I/O

Switching specifications

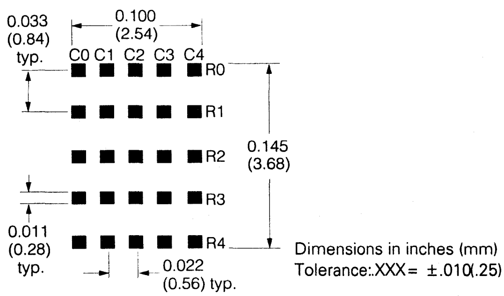
(over operating temperature range and V_{CC}=4.5 V to 5.5 V)

Symbol	Description	Min.	Units
T_{RC}	Reset Active Time	600	ns
T_{LDS}	Load Setup Time	50	ns
T_{DS}	Data Setup Time	50	ns
T_{SDCLK}	Clock Period	200	ns
T_{SDCW}	Clock Width	70	ns
T_{LDH}	Load Hold Time	0	ns
T_{DH}	Data Hold Time	25	ns
T_{WR}	Total Write Time	2.2	µs
T_{BL}	Time Between Loads	600	ns

Note:

T_{SDCW} is the minimum time the SDCLK may be low or high.
The SDCLK period must be a minimum of 200 ns.

Figure 7. Dot matrix format



Pin definitions

Pin	Function	Definitions
1	SDCLK	Loads data into the 8-bit serial data register on a low to high transition.
2	$\overline{LOAD}$	Low input enables data clocking into 8-bit serial shift register. When LOAD goes high, the contents of 8-bit serial Shift Register will be decoded.
3	NC	No connection
4	NC	No connection
5	NC	No connection
6	V_{CC}	Power supply/heat sink
7	NP	No pin
8	NP	No pin
9	V_{CC}	Power supply/heat sink
10	NC	No connection
11	NC	No connection
12	NC	No connection
13	$\overline{RST}$	Asynchronous input, when low will clear the Multiplex Counter, User RAM and Data Register. Control Word Register is set to 100% brightness and the Address Register is set to select Digit 0. The display is blanked.
14	GND	Power supply ground
15	CLK I/O	Outputs master clock or inputs external clock.
16	$\overline{CLKSEL}$	H=internal clock, L=external clock
17	NC	No connection
18	NC	No connection
19	V_{CC}	Power supply/heat sink
20	V_{CC}	Power supply/heat sink
21	NP	No pin
22	NP	No pin
23	V_{CC}	Power supply/heat sink
24	NC	No connection
25	NC	No connection
26	NC	No connection
27	DATA	Serial data input
28	GND	Power supply ground

Display column and row format

	C0	C1	C2	C3	C4
Row 0	1	1	1	1	1
Row 1	0	0	1	0	0
Row 2	0	0	1	0	0
Row 3	0	0	1	0	0
Row 4	0	0	1	0	0

1=Display dot "On"
0=Display dot "Off'

Column data ranges

Row 0	00H to 1FH
Row 1	20H to 3FH
Row 2	40H to 5FH
Row 3	60H to 7FH
Row 4	80H to 9FH

Operation of the SCD558X

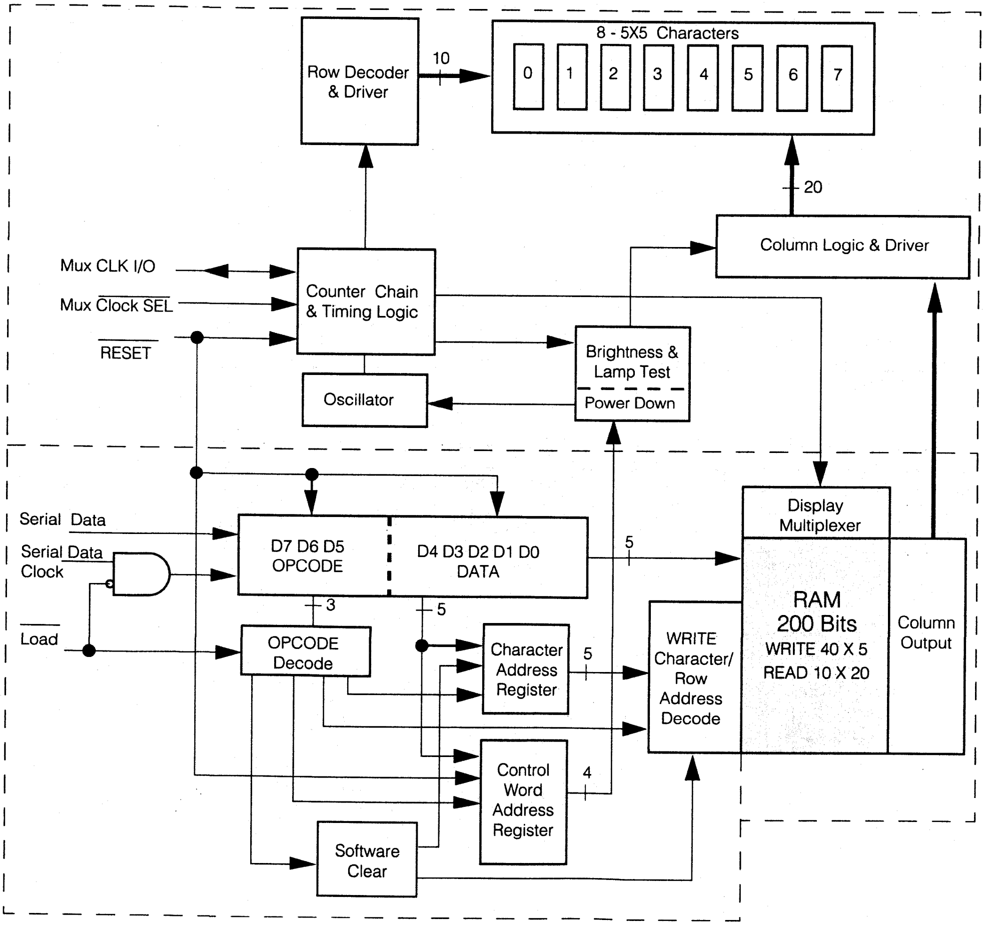
The SCD558X display consists of a CMOS IC containing control logic and drivers for eight 5x5 characters. These components are assembled in a compact (38 mm x 10 mm) plastic package.

Individual LED dot addressablity allows the user great freedom in creating special characters or mini-icons. The User Definable Character Set Examples illustrate 200 different character and symbol possibilities.

The use of a serial data interface provides a highly efficient interconnection between the display and the mother board. The SCD558X requires only 4 lines as compared to 15 for an equivalent 8 character parallel input part.

The on-board CMOS IC is the electronic heart of the display. The IC accepts decoded serial data, which is stored in the internal RAM. Asynchronously the RAM is read by the character multiplexer at a strobe rate that results in a flicker free display. Figure 8 shows the three functional areas of the IC. These include: the input serial data register and control logic, a 200 bits two port RAM, and an internal multiplexer/display driver.

Figure 8. SCD558X block diagram



The following explains how to format the serial data to be loaded into the display. The user supplies a string of bit mapped decoded characters. The contents of this string is shown in Figure 9a. Figure 9b shows that each character consist of six 8 bit words. The first word encodes the display character location and the succeeding five bytes are row data. The row data represents the status (On, Off) of individual column LEDs. Figure 9c shows that each that each 8 bit word is formatted to include a three bit Operational Code (OPCODE) defined by bits D7–D5 and five bits (D4–D0) representing Column Data, Character Address, or Control Word Data.

Figure 9d shows the sequence for loading the bytes of data. Bringing the $\overline{\text{LOAD}}$ line low enables the serial register to accept data. The shift action occurs on the low to high transition of the serial data clock (SDCLK). The least significant bit (D0) is loaded first. After eight clock pulses the $\overline{\text{LOAD}}$ line is brought high. With this transition the OPCODE is decoded. The decoded OPCODE directs D4–D0 to be latched in the Character Address register, stored in the RAM as Column data, or latched in the Control Word register. The control IC requires a minimum 600 ns delay between successive byte loads. As indicated in Figure 9a, a total of 528 bits of data are required to load all eight characters into the display.

The Character Address Register bits, D4–D0 (Table 2), and Row Address Register bits, D7–D5 (Table 3), direct the Column Data bits, D4–D0 (Table 3) to specific RAM location. Table 1 shows the Row Address for the example character "D." Column data is written and read asynchronously from the 200 bit RAM. Once loaded the internal oscillator and character multiplexer reads the data from the RAM. These characters are row strobed with column data as shown in Figures 10 and 11. The character strobe rate is determined by the internal or user supplied external MUX Clock and the IC's ÷320 counter.

Table 1. Character "D"

	Op code			Column Data					Hex
	D7	D6	D5	D4 C0	D3 C1	D2 C2	D1 C3	D0 C4	
Row 0	0	0	0	1	1	1	1	0	1E
Row 1	0	0	1	1	0	0	0	1	31
Row 2	0	1	0	1	0	0	0	1	51
Row 3	0	1	1	1	0	0	0	1	71
Row 4	1	0	0	1	1	1	1	0	9E

Figure 9. Loading serial character data

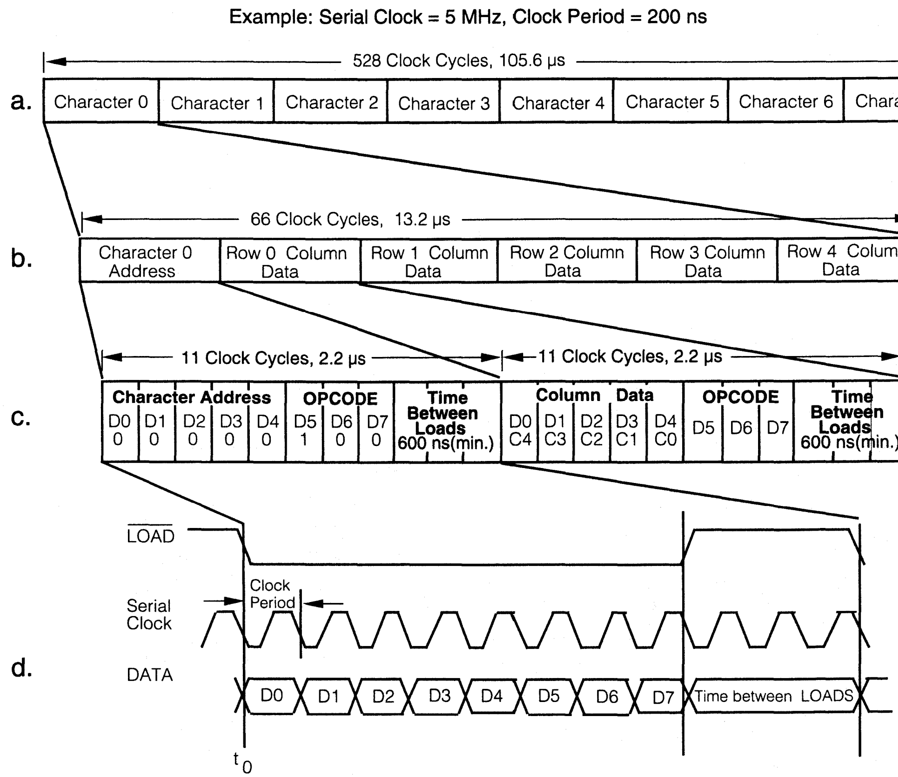


Table 2. Load character address

Op code D7 D6 D5	Character Address D4 D3 D2 D1 D0	Hex	Operation Load
1 0 1	0 0 0 0 0	A0	Character 0
1 0 1	0 0 0 0 1	A1	Character 1
1 0 1	0 0 0 1 0	A2	Character 2
1 0 1	0 0 0 1 1	A3	Character 3
1 0 1	0 0 1 0 0	A4	Character 4
1 0 1	0 0 1 0 1	A5	Character 5
1 0 1	0 0 1 1 0	A6	Character 6
1 0 1	0 0 1 1 1	A7	Character 7

Table 3. Load column data

Op code D7 D6 D5	Column Data D4 D3 D2 D1 D0	Operation Load
0 0 0	C0 C1 C2 C3 C4	Row 0
0 0 1	C0 C1 C2 C3 C4	Row 1
0 1 0	C0 C1 C2 C3 C4	Row 2
0 1 1	C0 C1 C2 C3 C4	Row 3
1 0 0	C0 C1 C2 C3 C4	Row 4

The user can activate four Control functions. These include: LED Brightness Level, Lamp Test, IC Power Down, or Display Clear. OPCODEs and five bit words are used to initiate these functions. The OPCODEs and Control Words for the Character Address and Loading Column Data are shown in Tables 2 and 3.

The user can select seven specific LED brightness levels, Table 4. These brightness levels (in percentages of full brightness of the display) include: 100% ($F0_{HEX}$), 53% ($F1_{HEX}$), 40% ($F2_{HEX}$), 27% ($F3_{HEX}$), 20% ($F4_{HEX}$), 13% ($F5_{HEX}$), and 6.6% ($F6_{HEX}$). The brightness levels are controlled by changing the duty factor of the row strobe pulse.

The SCD558X offers a unique Display Power Down feature which reduces I_{CC} to less than 50 µA. When FF_{HEX} is loaded, as shown in Table 5, the display is set to 0% brightness and the internal multiplex clock is stopped. When in the Power Down mode data may still be written into the RAM. The display is reactivated by loading a new Brightness Level Control Word into the display.

Figure 10. Row and column location

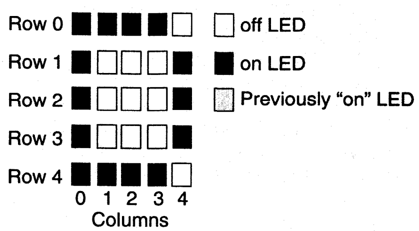


Table 4. Display brightness

Op code D7 D6 D5	Control Word D4 D3 D2 D1 D0	Hex	Operation Level
1 1 1	1 0 0 0 0	F0	100%
1 1 1	1 0 0 0 1	F1	53%
1 1 1	1 0 0 1 0	F2	40%
1 1 1	1 0 0 1 1	F3	27%
1 1 1	1 0 1 0 0	F4	20%
1 1 1	1 0 1 0 1	F5	13%
1 1 1	1 0 1 1 0	F6	6.6%

Table 5. Power down

Op code D7 D6 D5	Control Word D4 D3 D2 D1 D0	Hex	Operation Level
1 1 1	1 1 1 1 1	FF	0% brightness

The Lamp Test is enabled by loading $F8_{HEX}$, Table 6, into the serial shift register. This Control Word sets all of the LEDs to a 53% brightness level. Operation of the Lamp Test has no affect on the RAM and is cleared by loading a Brightness Control Word.

Table 6. Lamp test

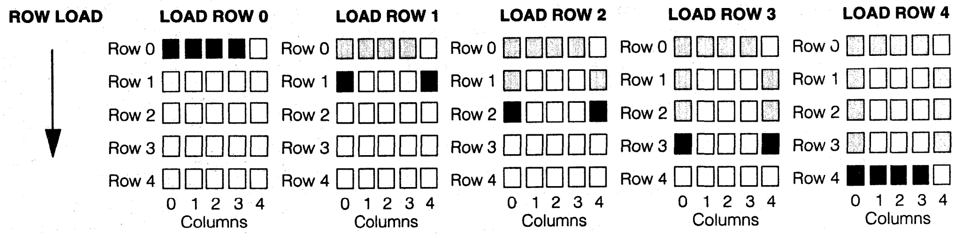
Op code D7 D6 D5	Control Word D4 D3 D2 D1 D0	Hex	Operation Level
1 1 1	1 0 B B B		Lamp Test (OFF)
1 1 1	1 1 0 0 0	F8	Lamp Test (ON)

The Software Clear ($C0_{HEX}$), given in Table 7, clears the Address Register and the RAM. The display is blanked and the Character Address Register will be set to Character 0. The internal counter and the Control Word Register are unaffected. The Software Clear will remain active until the next data input cycle is initiated.

Table 7. Software clear

Op code D7 D6 D5	Control Word D4 D3 D2 D1 D0	Hex	Operation Level
1 1 0	0 0 0 0 0	C0	CLEAR

Figure 11. Row strobing



Multiplexer and Display Driver

The eight characters are row multiplexed with RAM resident column data. The strobe rate is established by the internal or external MUX Clock rate. The MUX Clock frequency is divided by a 320 counter chain. This results in a typical strobe rate of 750Hz. By pulling the Clock SEL line low, the display can be operated from an external MUX Clock. The external clock is attached to the CLK I/O connection (pin 15). The maximum external MUX Clock frequency should be limited to 1 MHz.

An asynchronous hardware Reset (pin 13) is also provided. Bringing this pin low will clear the Character Address Register, Control Word Register, RAM, and blanks the display. This action leaves the display set at Character Address 0, and the Brightness Level set at 100%.

Electrical & Mechanical Considerations

Interconnect Considerations

Optimum product performance can be had when the following electrical and mechanical recommendations are adopted. The SCD558X's IC is constructed in a high speed CMOS process, consequently high speed noise on the SERIAL DATA, SERIAL DATA CLOCK, $\overline{\text{LOAD}}$ and $\overline{\text{RESET}}$ lines may cause incorrect data to be written into the serial shift register. Adhere to transmission line termination procedures when using fast line drivers and long cables (>10 cm).

Good digital grounds (pins 14, 28) and power supply decoupling (pins 6, 9, 20, 23) will insure that I_{CC} (<400 mA peak) switching currents do not generate localized ground bounce. Therefore it is recommended that each display package use a 0.1 µF and 20 µF capacitor between V_{CC} and ground.

When the internal MUX Clock is being used connect the $\overline{\text{CLKSEL}}$ pin to V_{CC}. In those applications where $\overline{\text{RESET}}$ will not be connected to the system's reset control, it is recommended that this pin be connected to the center node of a series 0.1 µF and 100 KΩ RC network. Thus upon initial power up the $\overline{\text{RESET}}$ will be held low for 10 ms allowing adequate time for the system power supply to stabilize.

The SCD558X allows up to 1.7 W of power dissipation at 70° and 1.29 W power dissipation at a maximum operating temperature of 85°C. Approximately 60% of this power is dissipated by the IC to the PC board via the V_{CC} connection (pins 6, 9, 20, 23). Optimum thermal reliability is obtained by connecting all of the V_{CC} pins to a common pad located on both sides of the PC board. This technique offers a low thermal resistance for IC to system ambient.

ESD Protection

The input protection structure of the SCD5580/1/2/3/4 provides significant protection against ESD damage. It is capable of withstanding discharges greater than 2 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The SCD5580/1/2/3/4 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluorethane), TA, 111 Trichloroethane, and unheated acetone. (1)

Note:

1) Acceptablecommercialsolventsare:BasicTF,Arklone,P.Genesolv, D. Genesolv DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 28 pin DIP sockets .300" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

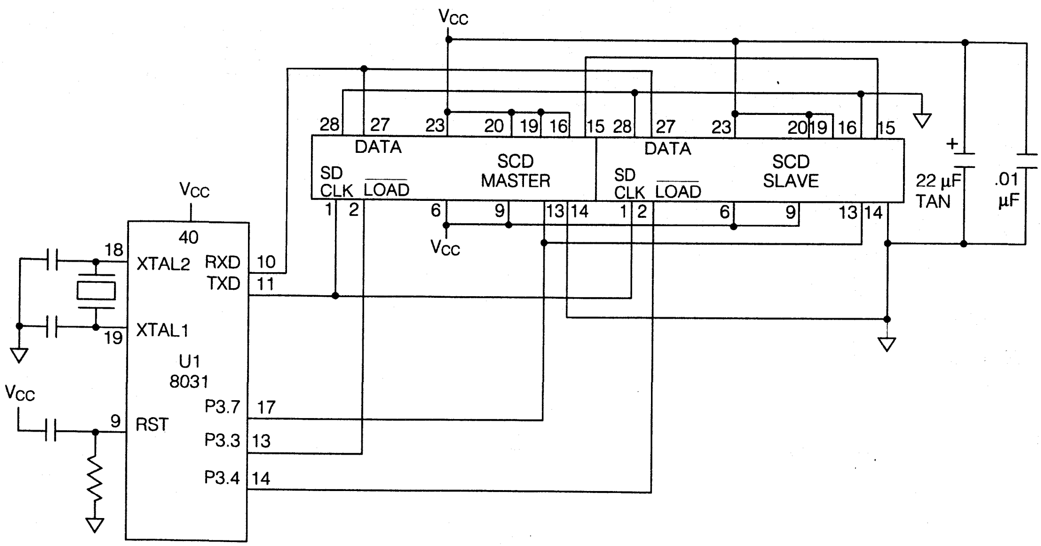
Optical Considerations

The 0.145" high character of the SCD558X gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The SCD5580/2 are red/high efficiency red displays and should be matched with long wavelength pass filter in the 570 nm to 590 nm range. The SCD5583/4 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Figure 12. SCD interface with Siemens/Intel 8031 microprocessor
(using serial port in mode 0)



Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.–Atlas, Van Nuys, CA.

Microprocessor Interface

The microprocessor interface is through the serial port, SPI port or one out of eight data bits on the eight bit parallel port and also control lines $\overline{SDCLK}$ and $\overline{LOAD}$.

Power Up Sequence

Upon power up display will come on at random. Thus the display should be reset at power-up. The reset will set the Address Register to Digit 0, User RAM is set to 0 (display blank) the Control Word is set to 0 (100% brightness with Lamp Test off) and the internal counters are reset.

Figure 13. SCD558X interface with Siemens/Intel 8031 microprocessor (using one bit of parallel port as serial input)

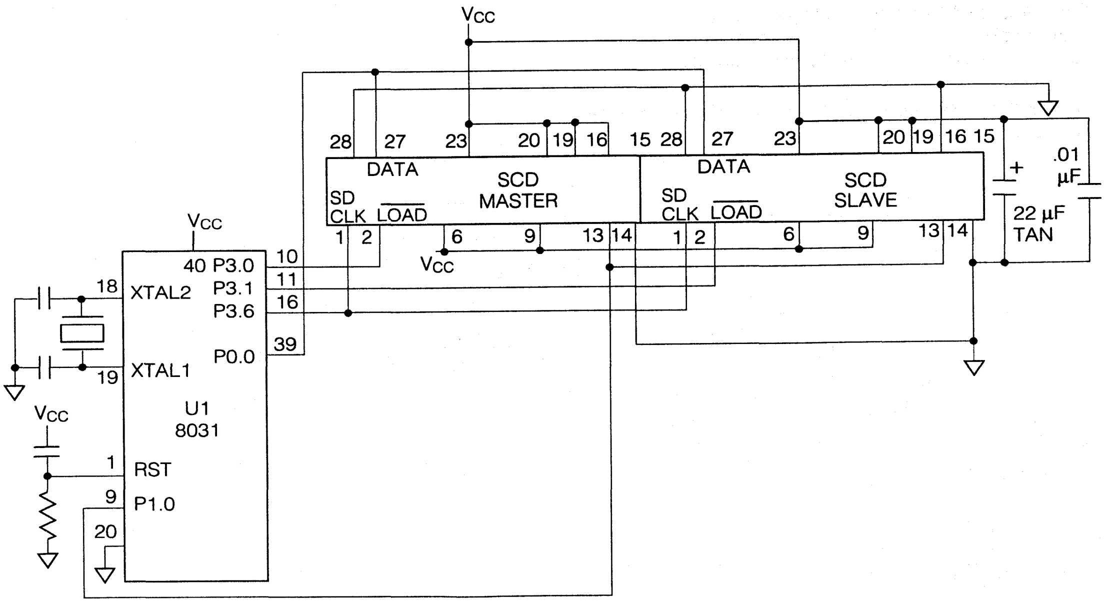
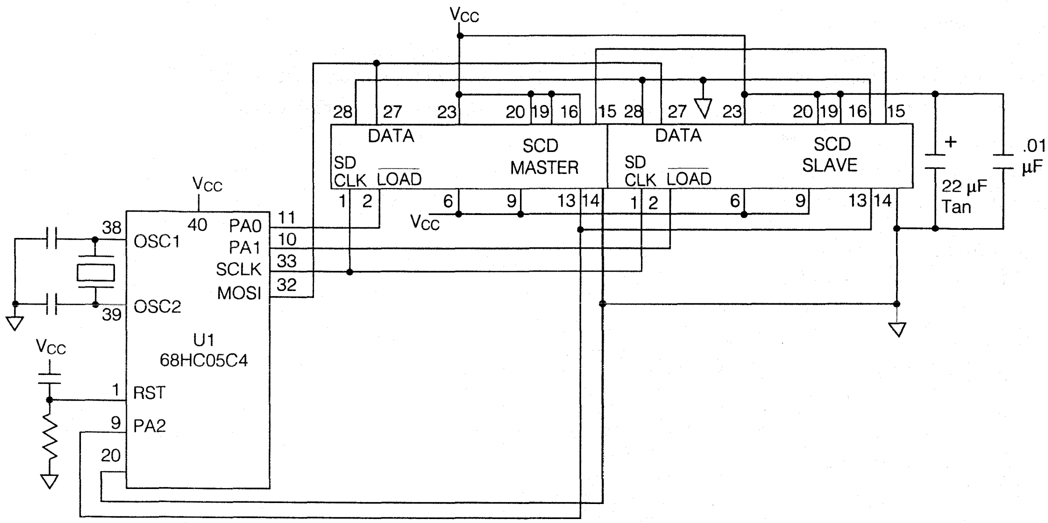


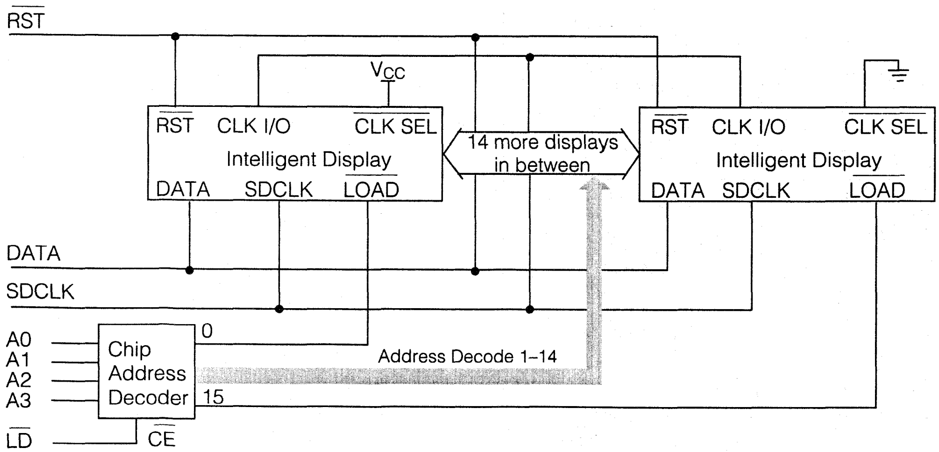
Figure 14. SCD558X interface with Motorola 68HC05C4 microprocessor
(using SPI port)



Cascading Multiple Displays

Multiple displays can be cascaded using the CLK SEL and CLK I/O pins as shown below. The display designated as the Master Clock source should have its CLK SEL pin tied high and the slaves should have their CLK SEL pins tied low. All CLK I/O pins should be tied together. One display CLK I/O can drive 15 slave CLK I/Os. Use RST to synchronize all display counters.

Figure 15. Cascading multiple displays



Loading Data Into the Display

Use following procedure to load data into the display:

1. Power up the display.
2. Bring $\overline{RST}$ low (600 ns duration minimum) to clear the Multiplex Counter, Address Register, Control Word Register, User RAM and Data Register. The display will be blank. Display brightness is set to 100%.
3. If a different brightness is desired, load the proper brightness opcode into the Control Word Register.
4. Load the Digit Address into the display.
5. Load display row and column data for the selected digit.
6. Repeat steps 4 and 5 for all digits.

Data contents for the word "Displays"

Step	D7	D6	D5	D4	D3	D2	D1	D0	Function
A	1	1	0	0	0	0	0	0	CLEAR
B (optional)	1	1	1	1	0	B	B	B	BRIGHTNESS SELECT
1	1	0	1	0	0	0	0	0	DIGIT D0 SELECT
2	0	0	0	1	1	1	1	0	ROW 0 D0 (D)
3	0	0	1	1	0	0	0	1	ROW 1 D0 (D)
4	0	1	0	1	0	0	0	1	ROW 2 D0 (D)
5	0	1	1	1	0	0	0	1	ROW 3 D0 (D)
6	1	0	0	1	1	1	1	0	ROW 4 D0 (D)
7	1	0	1	0	0	0	0	1	DIGIT D1 SELECT
8	0	0	0	0	1	1	1	0	ROW 0 D1 (I)
9	0	0	1	0	0	1	0	0	ROW 1 D1 (I)
10	0	1	0	0	0	1	0	0	ROW 2 D1 (I)
11	0	1	1	0	0	1	0	0	ROW 3 D1 (I)
12	1	0	0	0	1	1	1	0	ROW 4 D1 (I)
13	1	0	1	0	0	0	1	0	DIGIT D2 SELECT
14	0	0	0	0	1	1	1	1	ROW 0 D2 (S)
15	0	0	1	1	0	0	0	0	ROW 1 D2 (S)
16	0	1	0	0	1	1	1	0	ROW 2 D2 (S)
17	0	1	1	0	0	0	0	1	ROW 3 D2 (S)
18	1	0	0	1	1	1	1	0	ROW 4 D2 (S)
19	1	0	1	0	0	0	1	1	DIGIT D3 SELECT
20	0	0	0	1	1	1	1	0	ROW 0 D3 (P)
21	0	0	1	1	0	0	0	1	ROW 1 D3 (P)
22	0	1	0	1	1	1	1	0	ROW 2 D3 (P)
23	0	1	1	1	0	0	0	0	ROW 3 D3 (P)
24	1	0	0	1	0	0	0	0	ROW 4 D3 (P)
25	1	0	1	0	0	1	0	0	DIGIT D4 SELECT
26	0	0	0	1	0	0	0	0	ROW 0 D4 (L)
27	0	0	1	1	0	0	0	0	ROW 1 D4 (L)
28	0	1	0	1	0	0	0	0	ROW 2 D4 (L)
29	0	1	1	1	0	0	0	0	ROW 3 D4 (L)
30	1	0	0	1	1	1	1	1	ROW 4 D4 (L)
31	1	0	1	0	0	1	0	1	DIGIT D5 SELECT
32	0	0	0	0	0	1	0	0	ROW 0 D5 (A)
33	0	0	1	0	1	0	1	0	ROW 1 D5 (A)
34	0	1	0	1	1	1	1	1	ROW 2 D5 (A)
35	0	1	1	1	0	0	0	1	ROW 3 D5 (A)
36	1	0	0	1	0	0	0	1	ROW 4 D5 (A)
37	1	0	1	0	0	1	1	0	DIGIT D6 SELECT
38	0	0	0	1	0	0	0	1	ROW 0 D6 (Y)
39	0	0	1	0	1	0	1	0	ROW 1 D6 (Y)
40	0	1	0	0	0	1	0	0	ROW 2 D6 (Y)
41	0	1	1	0	0	1	0	0	ROW 3 D6 (Y)
42	1	0	0	0	0	1	0	0	ROW 4 D6 (Y)
43	1	0	1	0	0	1	1	1	DIGIT D7 SELECT
44	0	0	0	0	1	1	1	1	ROW 0 D7 (S)
45	0	0	1	1	0	0	0	0	ROW 1 D7 (S)
46	0	1	0	0	1	1	1	0	ROW 2 D7 (S)
47	0	1	1	0	0	0	0	1	ROW 3 D7 (S)
48	1	0	0	1	1	1	1	0	ROW 4 D7 (S)

Note:

If the display is already reset at Power Up, there is no need for Software Clear.

User Definable Character Set Examples*

Upper and lower case alphabets

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
04 2A 5F 71 91		1E 29 4E 69 9E		0F 30 50 70 8F		1E 29 49 69 9E		1F 30 5E 70 9F		1F 30 5E 70 90		0F 30 53 71 8F		11 31 5F 71 91		0E 24 44 64 8E	
01 21 41 71 8E		13 34 58 74 93		10 30 50 70 9F		11 3B 55 71 91		11 39 55 73 91		0E 31 51 71 8E		1E 31 5E 70 90		0C 32 56 72 8D		1E 31 5E 74 92	
0F 30 4E 61 9E		1F 24 44 64 84		11 31 51 71 8E		11 31 51 6A 84		11 31 55 7B 91		11 2A 44 6A 91		11 2A 44 64 84		1F 22 44 68 9F			
00 2E 52 72 8D		10 30 5E 71 9E		00 2F 50 70 8F		01 21 4F 71 8F		00 2E 5F 70 8E		04 2A 48 7C 88		00 2F 50 73 8F		10 30 56 79 91		04 20 4C 64 8E	
00 26 42 72 8C		10 30 56 78 96		0C 24 44 64 8E		00 2A 55 71 91		00 36 59 71 91		00 2E 51 71 8E		00 3E 51 7E 90		00 2F 51 6F 81		00 33 54 78 90	
00 23 44 62 8C		08 3C 48 6A 84		00 32 52 72 8D		00 31 51 6A 84		00 31 55 7B 91		00 32 4C 6C 92		00 31 4A 64 98		00 3E 44 68 9E			

DOT ON = 1
DOT OFF = 0

Numerals and punctuation

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
0E 33 55 79 8E		04 2C 44 64 8E		1E 21 46 68 9F		1E 21 4E 61 9E		06 2A 5F 62 82		1F 30 5E 61 9E		06 28 5E 71 8E		1F 22 44 68 88		0E 31 4E 71 8E	
0E 31 4F 62 8C		0A 3F 4A 7F 8A		0F 34 4E 65 9E		06 29 5C 68 9F		19 3A 44 6B 93		08 34 4D 72 8D		0C 2C 44 68 80		02 24 44 64 82		08 24 44 64 88	
0C 2C 48 64 80		04 24 5F 64 84		00 2C 4C 64 88		00 20 5F 60 80		00 20 40 6C 8C		01 22 44 68 90		04 24 44 60 84		0A 2A 40 60 80		07 24 44 64 87	
10 28 44 62 81		1C 24 44 64 9C		0E 35 57 70 8E		00 20 40 60 9F		0C 2C 40 6C 8C		0C 20 4C 64 88		02 24 48 64 82		00 3F 40 7F 80		08 24 42 64 88	
0E 31 42 64 88		06 24 48 64 86		0C 24 42 64 8C		04 24 40 64 84		11 2A 44 6E 84		15 2E 5F 6E 95		04 2A 51 60 80		08 35 42 60 80			

DOT ON = 1
DOT OFF = 0

*CAUTION: No more than 128 LEDs "on" at one time at 100% brightness.

User Definable Character Set Examples* (continued)

Scientific notations, etc.

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
06 2E 5E 6E 86		04 24 48 71 8E		1F 20 59 75 93		1F 20 56 79 91		0E 20 4A 64 8A		0D 32 52 72 8D		0C 32 56 71 96		0E 24 4E 71 8E		00 24 4A 71 9F	
10 3C 52 72 81		0E 31 5F 71 8E		10 28 44 6A 91		09 29 49 6E 90		01 2E 54 64 84		04 2E 55 6E 84		0E 31 51 6A 9B		01 2E 5A 6A 8A		0F 32 52 72 8C	
1F 28 44 68 9F		18 24 48 7C 80		1C 28 44 78 80		12 36 5A 67 80		06 21 5A 67 80		07 22 59 66 80		1C 34 5C 60 80		0F 28 48 78 88		04 2E 5F 6E 80	
00 24 4E 7F 8E		00 2E 5F 6E 84		0E 3F 4E 64 80		04 3E 5F 7E 84		04 2F 5F 6F 84		0E 2E 4E 6E 8E		00 3F 5F 7F 80		04 2E 55 64 84		04 24 55 6E 84	
04 22 5F 62 84		04 28 5F 68 84		1F 31 51 71 9F		08 2C 4A 78 98		0A 35 4A 75 8A		15 2A 55 6A 95		1F 35 5F 75 9F		00 3F 5F 7C 80		0E 3F 5B 7F 8E	
00 27 4F 78 9C		00 3C 5F 63 87		00 20 40 60 83		00 20 40 67 9F		00 23 5F 7F 9F		0C 3C 5C 7C 9C		15 2E 44 64 84					

DOT ON = 1
DOT OFF = 0

Foreign characters

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
1F 21 5F 62 84		1F 21 46 64 88		01 22 46 6A 82		04 3F 51 61 86		00 3F 44 64 9F		02 3F 46 6A 92		08 3F 49 6A 88		1F 21 45 67 8C		02 3F 51 62 8C	
08 3F 49 69 92		04 3F 44 7F 84		0F 29 51 62 8C		08 2F 52 62 82		0F 21 41 61 9F		0A 3F 4A 62 8C		19 21 59 62 9C		0F 29 55 63 8C		01 3E 42 7F 86	
15 35 55 62 8C		0E 20 5F 64 98		08 28 4C 6A 88		04 3F 44 64 98		0E 20 40 60 9F		1F 21 4A 64 9A		04 3E 44 6E 95		04 24 44 68 90		04 22 51 71 91	
10 3F 50 70 8F		1F 21 41 62 8C		0E 20 4E 60 8F		04 28 51 7F 81		01 21 4A 64 8A		1F 28 5F 68 87		1E 22 42 62 9F		1F 21 5F 61 9F		0E 20 5F 61 8E	
12 32 52 64 88		04 34 54 75 96		1E 25 4F 74 8F		0F 34 5F 74 97		0F 30 4F 64 98		0F 33 55 79 9E		0F 34 57 74 8F		00 2A 5F 74 8B		08 24 4E 72 8F	
0A 2E 51 7F 91		02 24 4C 64 8E		04 2A 4E 71 8E		0A 34 52 7A 96		08 24 51 71 8E		02 24 51 71 8E		04 2A 51 71 8E					

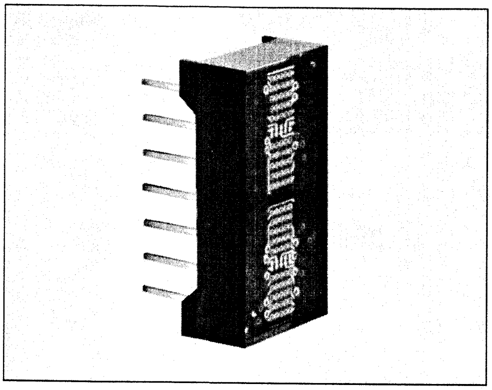
DOT ON = 1
DOT OFF = 0

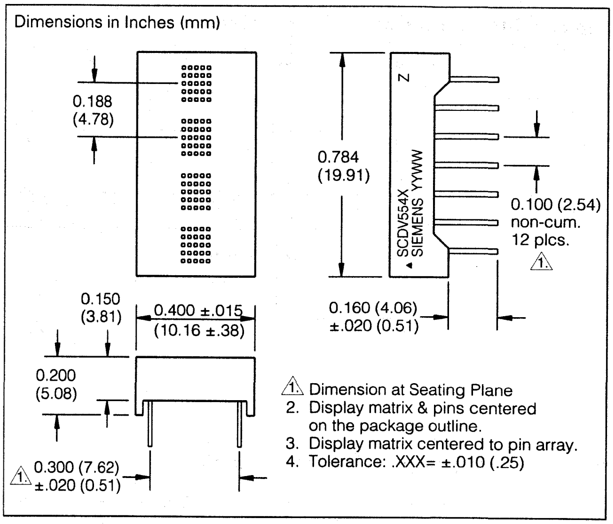
*CAUTION: No more than 128 LEDs "on" at one time at 100% brightness.

SIEMENS

STANDARD RED SCDV5540
YELLOW SCDV5541
HIGH EFFICIENCY RED SCDV5542
GREEN SCDV5543
HIGH EFFICIENCY GREEN SCDV5544

Vertical Format 0.123" 4-Character 5x5 Dot Matrix Serial Input Dot Addressable Intelligent Display® Devices





FEATURES

- **Vertical Format, Four 0.123" (3.12 mm) 5x5 Dot Matrix Characters in Red, Yellow, High Efficiency Red, Green, or High Efficiency Green**
- **Optimum Display Surface Efficiency (display area to package ratio)**
- **High Speed Data Input Rate: 5 MHz**
- **ROMless Serial Input, Dot Addressable Display Ideal for User Defined Characters**
- **Built-in Decoders, Multiplexers and LED Drivers**
- **Readable from 6 Feet (1.8 meters)**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±55°**
- **Attributes:**
  - **100 Bit RAM for User Defined Characters**
  - **Eight Dimming Levels**
  - **Power Down Model (<250 µW)**
  - **Hardware/Software Clear Functions**
  - **Lamp Test**
  - **Internal or External Clock**
- **3.3 V Capability**

DESCRIPTION

The SCDV5540 (Red), SCDV5541 (Yellow), SCDV5542 (High Efficiency Red), SCDV5543 (Green), and SCDV5544 (High Efficiency Green) are four digit, dot addressable 5x5 dot matrix, serial input, alphanumeric Intelligent Display devices in a vertical format. The four digits are packaged in a rugged, high quality, optically transparent, plastic 14 pin DIP with 0.3" pin spacing.

The on-board CMOS has a 100 bit RAM, one bit associated with one LED, each to generate User Defined Characters. In Power Down Mode, quiescent current is <50 µA.

The SCDV554X is designed for work with the serial port of most common microprocessors. Data is transferred into the display through the Serial Data Input (DATA), clocked by the Serial Data Clock (SDCLK), and enabled by the Load Input (LOAD).

The Clock I/O (CLK I/O) and Clock Select ($\overline{\text{CLK SEL}}$) pins offer the user the capability to supply a high speed external multiplex clock. This feature can minimize audio in-band interference for portable communication equipment or eliminate the visual sychronization effects found in high vibration environments such as avionic equipment.

Maximum Ratings

DC Supply Voltage .... –0.5 to +7.0 Vdc
Input Voltage Levels Relative
to Ground .... –0.5 to V_{CC} +0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature 0.063"
below Seating Plane, t<5 sec .... 260°C
Relative Humidity at 85°C 85%
Maximum Number of LEDs at 100% Brightness 64
Maximum Power Dissipation .... 0.65 W
ESD (100 pF, 1.5 KΩ) .... 2 KV
Maximum Input Current .... ±100 mA

Figure 3. Top view

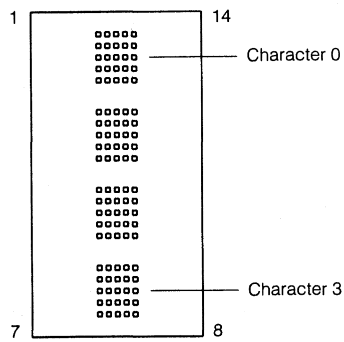


Figure 1. Timing diagram—data write cycle

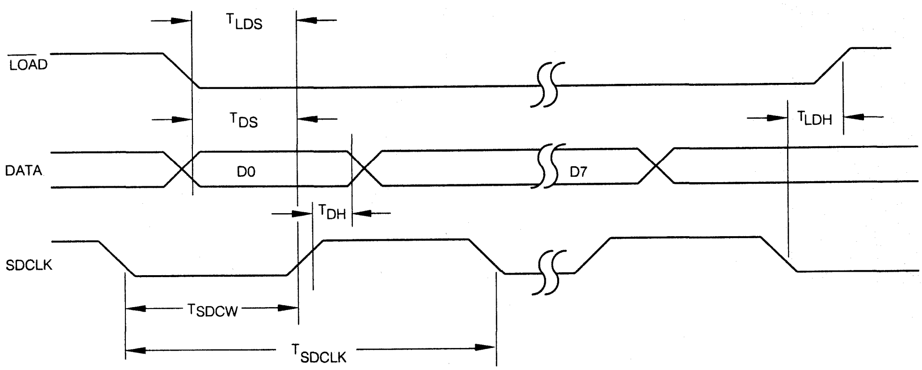
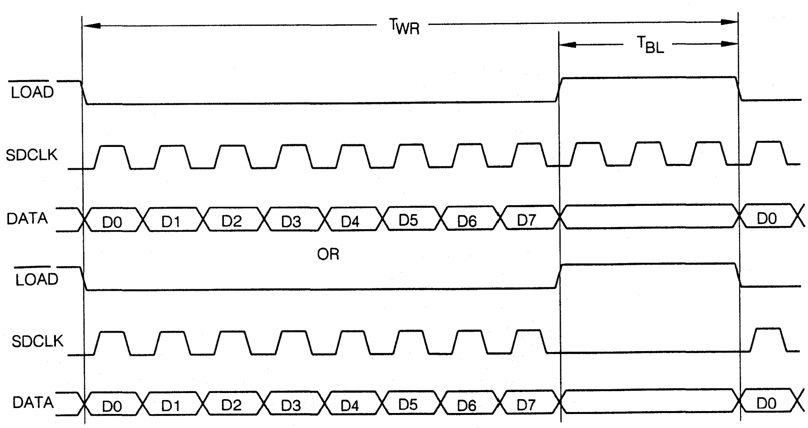


Figure 2. Timing diagram—instruction cycle



Electrical characteristics (over operating temperature)

Parameter	Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	V	
I_{CC} (Pwr Dwn Mode)[4]			50	µA	V_{CC}=5.0 V, all inputs=0 V or V_{CC}
I_{CC} 4 digits 16 dots/character		100	140	mA	V_{CC}=5 V, "#" displayed in all 4 digits at 100% brightness at 25°C
I_{IL} Input current			–10	µA	V_{CC}=5 V, V_{IN}=0 V (all inputs)
I_{IH} Input current			10	µA	V_{CC}=V_{IN}=5.0 V (all inputs)
V_{IH}	3.5			V	V_{CC}=4.5 V to 5.5 V
V_{IL}			1.5	V	V_{CC}=4.5 V to 5.5 V
I_{OH} (CLK I/O)		–8.9		mA	V_{CC}=4.5 V, V_{OH}=2.4 V
I_{OL} (CLK I/O)		1.6		mA	V_{CC}=4.5 V, V_{OL}=0.4 V
$\theta_{JC\text{-}PIN}$			64	°C/W	
F_{ext} External Clock Input Frequency	120		347	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=0
F_{osc} Internal Clock Input Frequency	120		347	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=1
Clock I/O Bus Loading			240	pF	
Clock Out Rise Time			500	ns	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	ns	V_{CC}=4.5 V, V_{OH}=0.4 V
FM, Digit	375	768	1086	Hz	

Notes:

1) Peak current $^{5}/_{3}$ x I_{CC}.
2) Unused inputs must be tied high.
3) Contact Siemens for 3.3 volt operation.
4) External oscillator must be stopped if being used to maintain an I_{CC}<50 µA.

Input/Output Circuits

Figures 4 and 5 show the input and output resistor/diode networks used for ESD protection and to eliminate substrate latch-up caused by input voltage over/under shoot.

Figure 4. Inputs

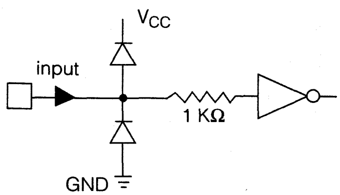
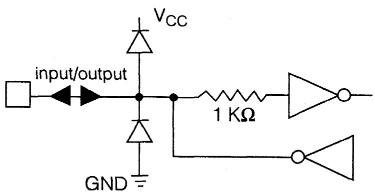


Figure 5. lock I/O



Optical Characteristics at 25°C
(V_{CC}=5.0 V at 100% brightness level, viewing angle: X axis ±55°, Y axis ±65°)

Red SCDV5540

Description	Symbol	Min.	Typ.	Units
Luminous Intensity Character Average (# displayed all digits)	I_V	0.48	1.8	mcd
Peak Wavelength	λ(peak)		665	nm
Dominant Wavelength	λ(d)		639	nm

Yellow SCDV5541

Description	Symbol	Min.	Typ.	Units
Luminous Intensity Character Average (# displayed all digits)	I_V	1.8	5.4	mcd
Peak Wavelength	λ(peak)		583	nm
Dominant Wavelength	λ(d)		585	nm

High Efficiency Red SCDV5542

Description	Symbol	Min.	Typ.	Units
Luminous Intensity Character Average (# displayed all digits)	I_V	1.8	5.4	mcd
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		620	nm

Green SCDV5543

Description	Symbol	Min.	Typ.	Units
Luminous Intensity Character Average (# displayed all digits)	I_V	1.8	5.4	mcd
Peak Wavelength	λ(peak)		565	nm
Dominant Wavelength	λ(d)		570	nm

High Efficiency Green SCDV5544

Description	Symbol	Min.	Typ.	Units
Luminous Intensity Character Average (# displayed all digits)	I_V	2.1	6.4	mcd
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		574	nm

Notes:
1. Dot to dot intensity matching at 100% brightness is 1.8:1.
2. Displays are binned for hue at 2 nm intervals.
3. Displays within a given intensity category have an intensity matching of 1.5:1 (max.).

Pin assignment

Pin	Function	Pin	Function
1	SDCLK	14	GND
2	$\overline{LOAD}$	13	DATA
3	NP	12	V_{CC}
4	NP	11	V_{CC}
5	NP	10	V_{CC}
6	$\overline{RST}$	9	CLKSEL
7	GND	8	CLK I/O

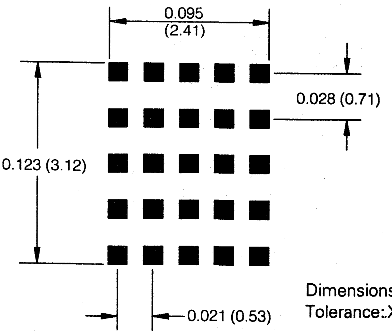
Switching specifications
(over operating temperature range and V_{CC}=4.5 V to 5.5 V)

Symbol	Description	Min.	Units
T_{RC}	Reset Active Time	600	ns
T_{LDS}	Load Setup Time	50	ns
T_{DS}	Data Setup Time	50	ns
T_{SDCLK}	Clock Period	200	ns
T_{SDCW}	Clock Width	70	ns
T_{LDH}	Load Hold Time	0	ns
T_{DH}	Data Hold Time	25	ns
T_{WR}	Total Write Time	2.2	µs
T_{BL}	Time Between Loads	600	ns

Note:

T_{SDCW} is the minimum time the SDCLK may be low or high. The SDCLK period must be a minimum of 200 ns.

Figure 6. Dot matrix format



Pin definitions

Pin	Function	Definitions
1	SDCLK	Loads data into the 8-bit serial data register on a low to high transition.
2	$\overline{LOAD}$	Low input enables data clocking into 8-bit serial shift register. When $\overline{LOAD}$ goes high, the contents of 8-bit serial Shift Register will be decoded.
3	NP	No pin
4	NP	No pin
5	NP	No pin
6	$\overline{RST}$	Asynchronous input, when low will clear the Multiplex Counter, User RAM and Data Register. Control Word Register is set to 100% brightness and the Address Register is set to select Digit 0. The display is blanked.
7	GND	Power supply ground
8	CLK I/O	Outputs master clock or inputs external clock.
9	CLK SEL	H=internal clock, L=external clock
10	V_{CC}	Power supply
11	V_{CC}	Power supply
12	V_{CC}	Power supply
13	DATA	Serial data input
14	GND	Power supply ground

Display column and row format

	C0	C1	C2	C3	C4
Row 0	1	1	1	1	1
Row 1	0	0	1	0	0
Row 2	0	0	1	0	0
Row 3	0	0	1	0	0
Row 4	0	0	1	0	0

1=Display dot "On"
0=Display dot "Off'

Column data ranges

Row 0	00H to 1FH
Row 1	20H to 3FH
Row 2	40H to 5FH
Row 3	60H to 7FH
Row 4	80H to 9FH

Operation of the SCDV554X

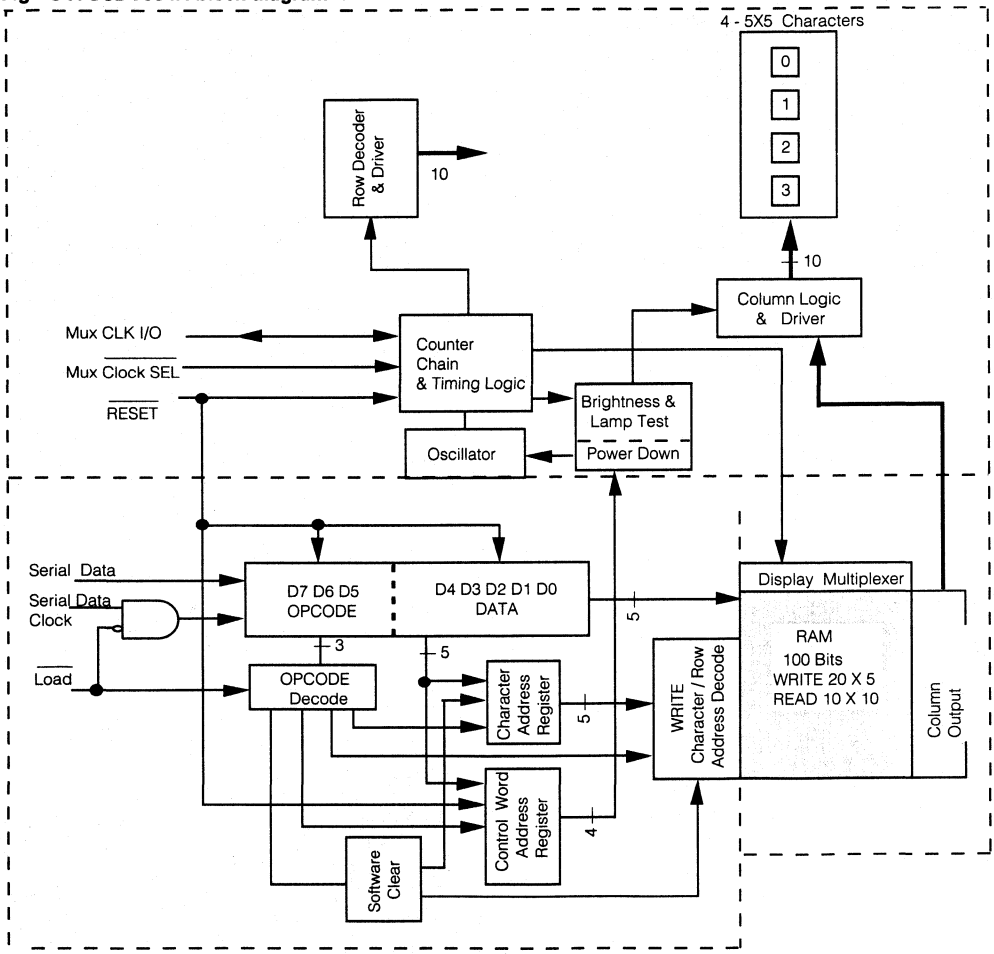
The SCDV554X display consists of a CMOS IC containing control logic and drivers for four 5x5 characters. These components are assembled in a compact plastic package.

Individual LED dot addressablity allows the user great freedom in creating special characters or mini-icons. The User Definable Character Set examples illustrate 200 different character and symbol possibilities.

The serial data interface provides a highly efficient interconnection between the display and the mother board. The SCDV554X requires only four lines as compared to 15 for an equivalent four character parallel input part.

The on-board CMOS IC is the electronic heart of the display. The IC accepts decoded serial data, which is stored in the internal RAM. Asynchronously the RAM is read by the character multiplexer at a strobe rate that results in a flicker free display. Figure 7 shows the three functional areas of the IC. These include: the input serial data register and control logic, a 100 bits two port RAM, and an internal multiplexer/display driver.

Figure 7. SCDV554X block diagram



The following explains how to format the serial data to be loaded into the display. The user supplies a string of bit mapped decoded characters. The contents of this string is shown in Figure 8a. Figure 8b shows that each character consists of six 8 bit words. The first word encodes the display character location and the succeeding five bytes are row data. The row data represents the status (On, Off) of individual column LEDs. Figure 8c shows that each that each 8 bit word is formatted to include a three bit Operational Code (OPCODE) defined by bits D7–D5 and five bits (D4–D0) representing Column Data, Character Address, or Control Word Data.

Figure 8d shows the sequence for loading the bytes of data. Bringing the LOAD line low enables the serial register to accept data. The shift action occurs on the low to high transition of the serial data clock (SDCLK). The least significant bit (D0) is loaded first. After eight clock pulses the LOAD line is brought high. With this transition the OPCODE is decoded. The decoded OPCODE directs D4–D0 to be latched in the Character Address register, stored in the RAM as Column data, or latched in the Control Word register. The control IC requires a minimum 600 ns delay between successive byte loads. As indicated in Figure 8a, a total of 264 bits of data are required to load all eight characters into the display.

The Character Address Register bits, D4–D0 (Table 2), and Row Address Register bits, D7–D5 (Table 3), direct the Column Data bits, D4–D0 (Table 3) to specific RAM location. Table 1 shows the Row Address for the example character "D." Column data is written and read asynchronously from the 200 bit RAM. Once loaded the internal oscillator and character multiplexer reads the data from the RAM. These characters are row strobed with column data as shown in Figures 9 and 10. The character strobe rate is determined by the internal or user supplied external MUX Clock and the IC's ÷ 320 counter.

Table 1. Character "D"

	Op code D7	D6	D5	Column Data D4 C0	D3 C1	D2 C2	D1 C3	D0 C4	Hex
Row 0	0	0	0	1	1	1	1	0	1E
Row 1	0	0	1	1	0	0	0	1	31
Row 2	0	1	0	1	0	0	0	1	51
Row 3	0	1	1	1	0	0	0	1	71
Row 4	1	0	0	1	1	1	1	0	9E

Figure 8. Loading serial character data

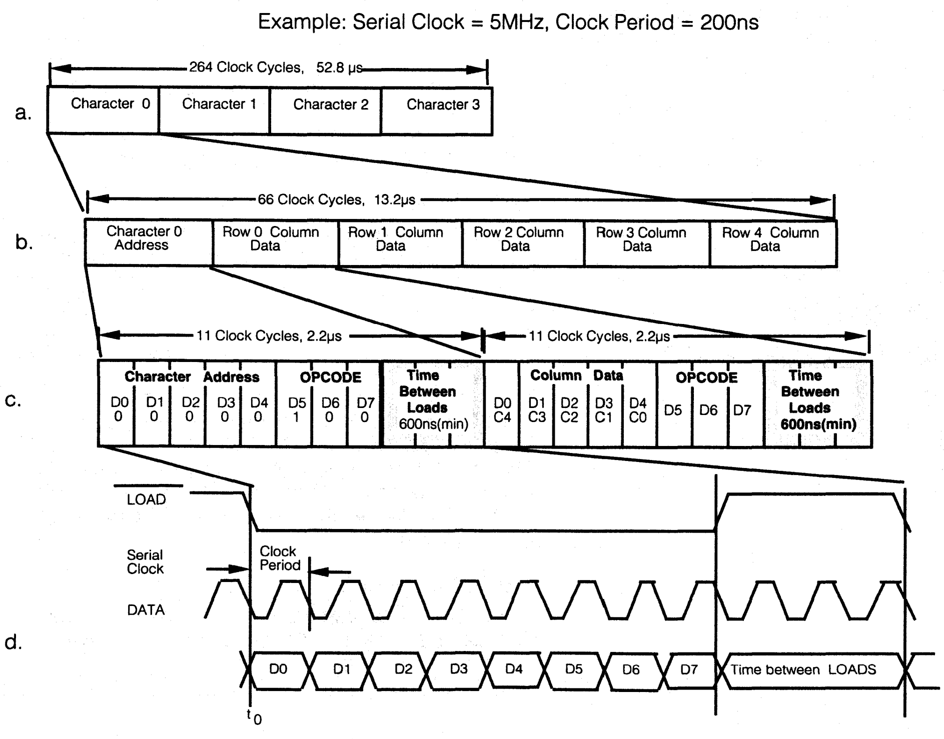


Table 2. Load character address

Op code D7 D6 D5	Character Address D4 D3 D2 D1 D0	Hex	Operation Load
1 0 1	0 0 0 0 0	A0	Character 0
1 0 1	0 0 0 0 1	A1	Character 1
1 0 1	0 0 0 1 0	A2	Character 2
1 0 1	0 0 0 1 1	A3	Character 3

Table 3. Load column data

Op code D7 D6 D5	Column Data D4 D3 D2 D1 D0	Operation Load
0 0 0	C0 C1 C2 C3 C4	Row 0
0 0 1	C0 C1 C2 C3 C4	Row 1
0 1 0	C0 C1 C2 C3 C4	Row 2
0 1 1	C0 C1 C2 C3 C4	Row 3
1 0 0	C0 C1 C2 C3 C4	Row 4

The user can activate four Control functions. These include: LED Brightness Level, Lamp Test, IC Power Down, or Display Clear. OPCODEs and five bit words are used to initiate these functions. The OPCODEs and Control Words for the Character Address and Loading Column Data are shown in Tables 2 and 3.

The user can select seven specific LED brightness levels, Table 4. These brightness levels (in percentages of full brightness of the display) include: 100% ($F0_{HEX}$), 53% ($F1_{HEX}$), 40% ($F2_{HEX}$), 27% ($F3_{HEX}$), 20% ($F4_{HEX}$), 13% ($F5_{HEX}$), and 6.6% ($F6_{HEX}$). The brightness levels are controlled by changing the duty factor of the row strobe pulse.

Figure 9. Row and column locations

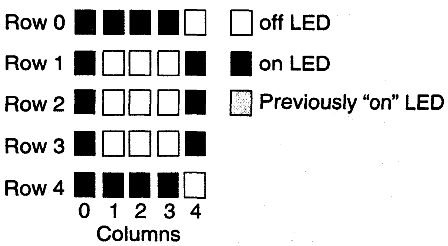


Table 4. Display brightness

Op code D7 D6 D5	Control Word D4 D3 D2 D1 D0	Hex	Operation Level
1 1 1	1 0 0 0 0	F0	100%
1 1 1	1 0 0 0 1	F1	53%
1 1 1	1 0 0 1 0	F2	40%
1 1 1	1 0 0 1 1	F3	27%
1 1 1	1 0 1 0 0	F4	20%
1 1 1	1 0 1 0 1	F5	13%
1 1 1	1 0 1 1 0	F6	6.6%

The SCDV554X offers a unique Display Power Down feature which reduces ICC to less than 50 µA. When FF_{HEX} is loaded (Table 5) the display is set to 0% brightness and the internal multiplex clock is stopped. When in the Power Down mode data may still be written into the RAM. The display is reactivated by loading a new rightness Level Control Word into the display.

Table 5. Power down

Op code D7 D6 D5	Control Word D4 D3 D2 D1 D0	Hex	Operation Level
1 1 1	1 1 1 1 1	FF	0% brightness

The Lamp Test is enabled by loading $F8_{HEX}$, Table 6, into the serial shift register. This Control Word sets all of the LEDs to a 53% brightness level. Operation of the Lamp Test has no affect on the RAM and is cleared by loading a Brightness Control Word.

Table 6. Lamp test

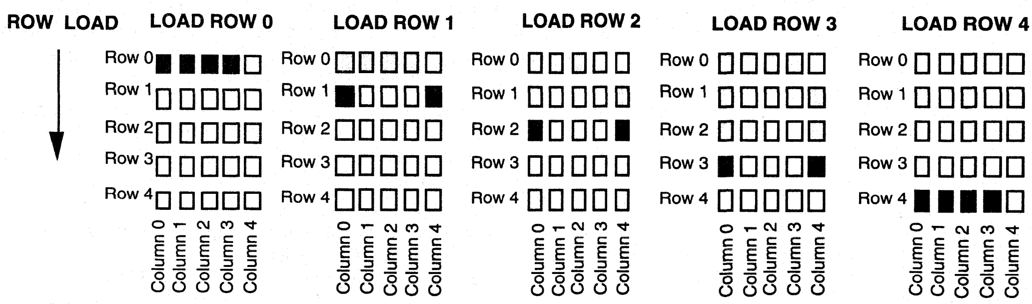
Op code D7 D6 D5	Control Word D4 D3 D2 D1 D0	Hex	Operation Level
1 1 1	1 0 B B B		Lamp Test (OFF)
1 1 1	1 1 0 0 0	F8	Lamp Test (ON)

The Software Clear ($C0_{HEX}$), given in Table 7, clears the Address Register and the RAM. The display is blanked and the Character Address Register will be set to Character 0. The internal counter and the Control Word Register are unaffected. The Software Clear will remain active until the next data input cycle is initiated.

Table 7. Software clear

Op code D7 D6 D5	Control Word D4 D3 D2 D1 D0	Hex	Operation Level
1 1 0	0 0 0 0 0	C0	CLEAR

Figure 10. Row strobing



Multiplexer and Display Driver

The four characters are row multiplexed with RAM resident column data. The strobe rate is established by the internal or external MUX Clock rate. The MUX Clock frequency is divided by a 320 counter chain. This results in a typical strobe rate of 750 Hz. By pulling the Clock SEL line low, the display can be operated from an external MUX Clock. The external clock is attached to the CLK I/O connection (pin 8). The maximum external MUX Clock frequency should be limited to 1 MHz.

An asynchronous hardware Reset (pin 9) is also provided. Bringing this pin low will clear the Character Address Register, Control Word Register, RAM, and blanks the display. This action leaves the display set at Character Address 0, and the Brightness Level set at 100%.

Electrical & Mechanical Considerations
Interconnect Considerations

Optimum product performance can be had when the following electrical and mechanical recommendations are adopted. The SCDV554X's IC is constructed in a high speed CMOS process, consequently high speed noise on the SERIAL DATA, SERIAL DATA CLOCK, $\overline{\text{LOAD}}$ and $\overline{\text{RESET}}$ lines may cause incorrect data to be written into the serial shift register. Adhere to transmission line termination procedures when using fast line drivers and long cables (>10 cm).

Good digital grounds (pins 7 and 14) and power supply decoupling (pins 11 and 12) will insure that I_{CC} (<400 mA peak) switching currents do not generate localized ground bounce. Therefore it is recommended that each display package use a 0.1 µF and 20 µF capacitor between V_{CC} and ground.

When the internal MUX Clock is being used connect the $\overline{\text{CLKSEL}}$ pin to V_{CC}. In those applications where $\overline{\text{RESET}}$ will not be connected to the system's reset control, it is recommended that this pin be connected to the center node of a series 0.1, µF and 100 KΩ RC network. Thus upon initial power up the $\overline{\text{RESET}}$ will be held low for 10 ms allowing adequate time for the system power supply to stabilize.

ESD Protection

The input protection structure of the SCDV5540/1/2/3/4 provides significant protection against ESD damage. It is capable of withstanding discharges greater than 2 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The SCDV5540/1/2/3/4 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the nylon package. For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book. See Appnote 19, Table 2, "Displays–Group 2" for the SCDV554X.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 14 pin DIP sockets .300" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The 0.123" high character of the SCDV554X gives readability up to five feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The SCDV5540/2 are red/high efficiency red displays and should be matched with long wavelength pass filter in the 570 nm to 590 nm range. The SCDV5543/4 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density grey filters offer the best compromise.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Figure 11. SCDV interface to Siemens/Intel 8031 microprocessor (using serial port in mode 0)

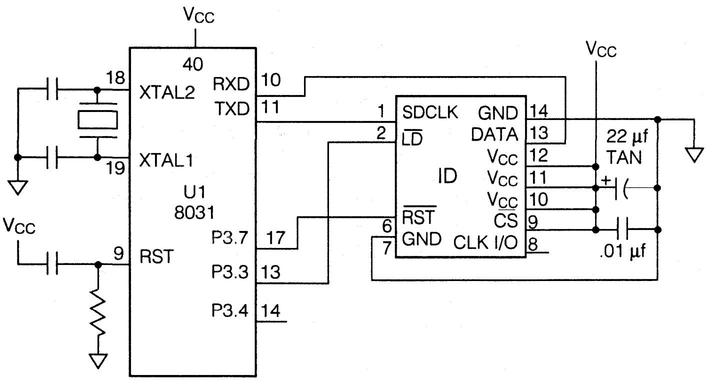
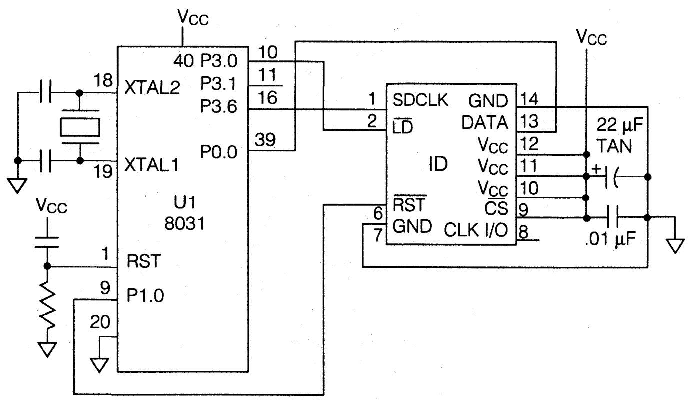


Figure 12. SCDV interface to Siemens/Intel 8031 microprocessor (using one bit of parallel port as serial input)



Microprocessor Interface

The microprocessor interface is through the serial port, SPI port or one out of eight data bits on the eight bit parallel port and also control lines SDCLK and LOAD.

Power Up Sequence

Upon power up display will come on at random. Thus the display should be reset at power-up. The reset will set the Address Register to Digit 0, User RAM is set to 0 (display blank) the Control Word is set to 0 (100% brightness with Lamp Test off) and the internal counters are reset.

Cascading Multiple Displays

Multiple displays can be cascaded using the CLK SEL and CLK I/O pins as shown below. The display designated as the Master Clock source should have its CLK SEL pin tied high and the slaves should have their CLK SEL pins tied low. All CLK I/O pins should be tied together. One display CLK I/O can drive 15 slave CLK I/Os. Use RST to synchronize all display counters.

Figure 13. SCDV554X interface with Motorola 68HC05C4 microprocessor (using SPI port)

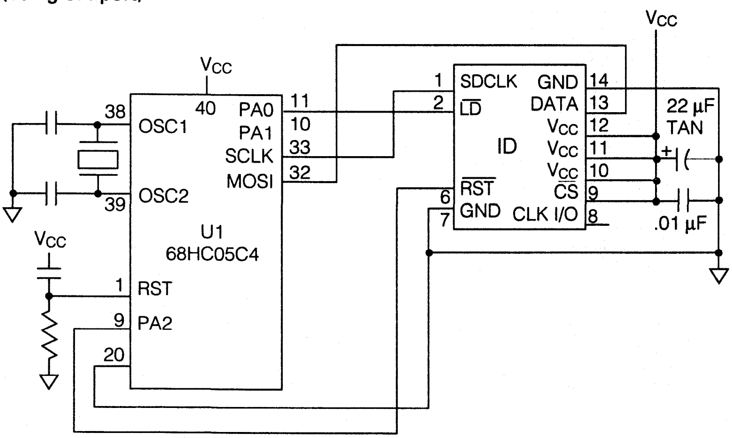
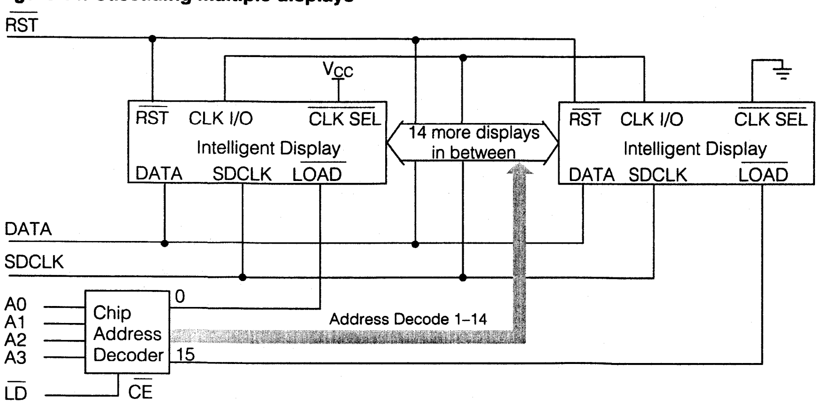


Figure 14. Cascading multiple displays



Loading Data into the Display

Use following procedure to load data into the display:

1. Power up the display.
2. Bring $\overline{RST}$ low (600 ns duration minimum) to clear the Multiplex Counter, Address Register, Control Word Register, User Ram and Data Register. The display will be blank. Display brightness is set to 100%.
3. If a different brightness is desired, load the proper brightness opcode into the Control Word Register.
4. Load the Digit Address into the display.
5. Load display row and column data for the selected digit.
6. Repeat steps 4 and 5 for all digits.

Data contents for the display in a vertical format "↑AB↓"

Step	D7	D6	D5	D4	D3	D2	D1	D0	Function
A	1	1	0	0	0	0	0	0	CLEAR
B(optional)	1	1	1	1	0	B	B	B	BRIGHTNESS SELECT
1	1	0	1	0	0	0	0	0	DIGIT D0 SELECT
2	0	0	0	0	0	1	0	0	ROW 0 D0 (↑)
3	0	0	1	0	1	1	1	0	ROW 1 D0 (↑)
4	0	1	0	1	0	1	0	1	ROW 2 D0 (↑)
5	0	1	1	0	0	1	0	0	ROW 3 D0 (↑)
6	1	0	0	0	0	1	0	0	ROW 4 D0 (↑)
7	1	0	1	0	0	0	0	1	DIGIT D1 SELECT
8	0	0	0	0	0	1	0	0	ROW 0 D1 (A)
9	0	0	1	0	1	0	1	0	ROW 1 D1 (A)
10	0	1	0	1	1	1	1	1	ROW 2 D1 (A)
11	0	1	1	1	0	0	0	1	ROW 3 D1 (A)
12	1	0	0	1	0	0	0	1	ROW 4 D1 (A)
13	1	0	1	0	0	0	1	0	DIGIT D2 SELECT
14	0	0	0	1	1	1	1	0	ROW 0 D2 (B)
15	0	0	1	0	1	0	0	1	ROW 1 D2 (B)
16	0	1	0	0	1	1	1	0	ROW 2 D2 (B)
17	0	1	1	0	1	0	0	1	ROW 3 D2 (B)
18	1	0	0	1	1	1	1	0	ROW 4 D2 (B)
19	1	0	1	0	0	0	1	1	DIGIT D3 SELECT
20	0	0	0	0	0	1	0	0	ROW 0 D3 (↓)
21	0	0	1	0	0	1	0	0	ROW 1 D3 (↓)
22	0	1	0	1	0	1	0	1	ROW 2 D3 (↓)
23	0	1	1	0	1	1	1	0	ROW 3 D3 (↓)
24	1	0	0	0	0	1	0	0	ROW 4 D3 (↓)

Note:

If the display is already reset at Power Up, there is no need for Software Clear.

User Definable Character Set Examples*

Upper and lower case alphabets

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
04 2A 5F 71 91		1E 29 4E 69 9E		0F 30 50 70 8F		1E 29 49 69 9E		1F 30 5E 70 9F		1F 30 5E 70 90		0F 30 53 71 8F		11 31 5F 71 91		0E 24 44 64 8E	
01 21 41 71 8E		13 34 58 74 93		10 30 50 70 9F		11 3B 55 71 91		11 39 55 73 91		0E 31 51 71 8E		1E 31 5E 70 90		0C 32 56 72 8D		1E 31 5E 74 92	
0F 30 4E 61 9E		1F 24 44 64 84		11 31 51 71 8E		11 31 51 6A 84		11 31 55 7B 91		11 2A 44 6A 91		11 2A 44 64 84		1F 22 44 68 9F			
00 2E 52 72 8D		10 30 5E 71 9E		00 2F 50 70 8F		01 21 4F 71 8F		00 2E 5F 70 8E		04 2A 48 7C 88		00 2F 50 73 8F		10 30 56 79 91		04 20 4C 64 8E	
00 26 42 72 8C		10 30 56 78 96		0C 24 44 64 8E		00 2A 55 71 91		00 36 59 71 91		00 2E 51 71 8E		00 3E 51 7E 90		00 2F 51 6F 81		00 33 54 78 90	
00 23 44 62 8C		08 3C 48 6A 84		00 32 52 72 8D		00 31 51 6A 84		00 31 55 7B 91		00 32 4C 6C 92		00 31 4A 64 98		00 3E 44 68 9E			

DOT ON = 1
DOT OFF = 0

Numerals and punctuation

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
0E 33 55 79 8E		04 2C 44 64 8E		1E 21 46 68 9F		1E 21 4E 61 9E		06 2A 5F 62 82		1F 30 5E 61 9E		06 28 5E 71 8E		1F 22 44 68 88		0E 31 4E 71 8E	
0E 31 4F 62 8C		0A 3F 4A 7F 8A		0F 34 4E 65 9E		06 29 5C 68 9F		19 3A 44 6B 93		08 34 4D 72 8D		0C 2C 44 68 80		02 24 44 64 82		08 24 44 64 88	
0C 2C 48 64 80		04 24 5F 64 84		00 2C 4C 64 88		00 20 5F 60 80		00 20 40 6C 8C		01 22 44 68 90		04 24 44 60 84		0A 2A 40 60 80		07 24 44 64 87	
10 28 44 62 81		1C 24 44 64 9C		0E 35 57 70 8E		00 20 40 60 9F		0C 2C 40 6C 8C		0C 20 4C 64 88		02 24 48 64 82		00 3F 40 7F 80		08 24 42 64 88	
0E 31 42 64 88		06 24 48 64 86		0C 24 42 64 8C		04 24 40 64 84		11 2A 44 6E 84		15 2E 5F 6E 95		04 2A 51 60 80		08 35 42 60 80			

DOT ON = 1
DOT OFF = 0

*CAUTION: No more than 128 LEDs "on" at one time at 100% brightness.

User Definable Character Set Examples* (continued)

Scientific notations, etc.

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
06 2E 5E 6E 86		04 24 48 71 8E		1F 20 59 75 93		1F 20 56 79 91		0E 20 4A 64 8A		0D 32 52 72 8D		0C 32 56 71 96		0E 24 4E 71 8E		00 24 4A 71 9F	
10 3C 52 72 81		0E 31 5F 71 8E		10 28 44 6A 91		09 29 49 6E 90		01 2E 54 64 84		04 2E 55 6E 84		0E 31 51 6A 9B		01 2E 5A 6A 8A		0F 32 52 72 8C	
1F 28 44 68 9F		18 24 48 7C 80		1C 28 44 78 80		12 36 5A 67 80		06 21 5A 67 80		07 22 59 66 80		1C 34 5C 60 80		0F 28 48 78 88		04 2E 5F 6E 80	
00 24 4E 7F 8E		00 2E 5F 6E 84		0E 3F 4E 64 80		04 3E 5F 7E 84		04 2F 5F 6F 84		0E 2E 4E 6E 8E		00 3F 5F 7F 80		04 2E 55 64 84		04 24 55 6E 84	
04 22 5F 62 84		04 28 5F 68 84		1F 31 51 71 9F		08 2C 4A 78 98		0A 35 4A 75 8A		15 2A 55 6A 95		1F 35 5F 75 9F		00 3F 5F 7C 80		0E 3F 5B 7F 8E	
00 27 4F 78 9C		00 3C 5F 63 87		00 20 40 60 83		00 20 40 67 9F		00 23 5F 7F 9F		0C 3C 5C 7C 9C		15 2E 44 64 84					

DOT ON = 1
DOT OFF = 0

Foreign characters

HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE		HEX CODE	
1F 21 5F 62 84		1F 21 46 64 88		01 22 46 6A 82		04 3F 51 61 86		00 3F 44 64 9F		02 3F 46 6A 92		08 3F 49 6A 88		1F 21 45 67 8C		02 3F 51 62 8C	
08 3F 49 69 92		04 3F 44 7F 84		0F 29 51 62 8C		08 2F 52 62 82		0F 21 41 61 9F		0A 3F 4A 62 8C		19 21 59 62 9C		0F 29 55 63 8C		01 3E 42 7F 86	
15 35 55 62 8C		0E 20 5F 64 98		08 28 4C 6A 88		04 3F 44 64 98		0E 20 40 60 9F		1F 21 4A 64 9A		04 3E 44 6E 95		04 24 44 68 90		04 22 51 71 91	
10 3F 50 70 8F		1F 21 41 62 8C		0E 20 4E 60 8F		04 28 51 7F 81		01 21 4A 64 8A		1F 28 5F 68 87		1E 22 42 62 9F		1F 21 5F 61 9F		0E 20 5F 61 8E	
12 32 52 64 88		04 34 54 75 96		1E 25 4F 74 8F		0F 34 5F 74 97		0F 30 4F 64 98		0F 33 55 79 9E		0F 34 57 74 8F		00 2A 5F 74 8B		08 24 4E 72 8F	
0A 2E 51 7F 91		02 24 4C 64 8E		04 2A 4E 71 8E		0A 34 52 7A 96		08 24 51 71 8E		02 24 51 71 8E		04 2A 51 71 8E					

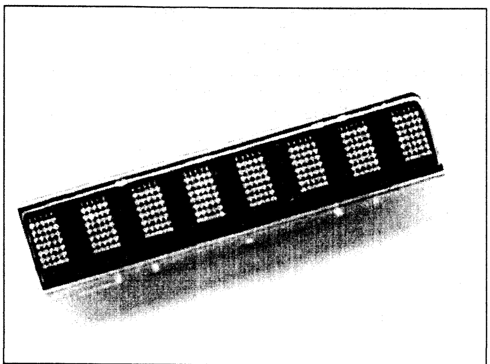
DOT ON = 1
DOT OFF = 0

*CAUTION: No more than 128 LEDs "on" at one time at 100% brightness.

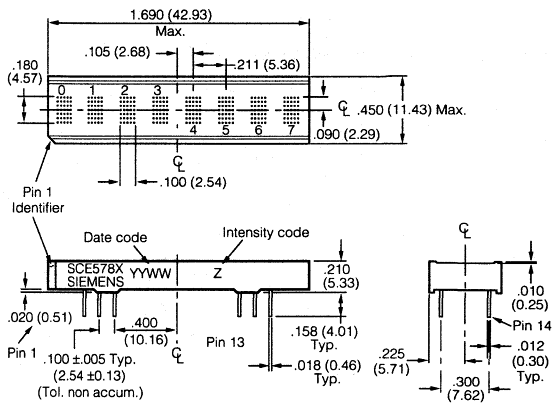
SIEMENS

RED SCE5780
YELLOW SCE5781
HIGH EFFICIENCY RED SCE5782
GREEN SCE5783
HIGH EFFICIENCY GREEN SCE5784
SOFT ORANGE SCE5785

0.180" 8-Character 5x7 Dot Matrix Serial Input Dot Addressable Intelligent Display® Devices



Dimensions in Inches (mm)



Tolerance: ±0.010 inches (0.25 mm) unless otherwise specified

FEATURES

- **Eight 0.180" (4.57 mm) 5x7 Dot Matrix Characters in Red, Yellow, High Efficiency Red, Green, High Efficiency Green, or Soft Orange**
- **ROMless Serial Input, Dot Addressable Display Ideal for User Defined Characters**
- **Built-in Decoders, Multiplexers and LED Drivers**
- **Readable from 8 Feet (2.5 meters)**
- **Programmable Features:**
  - **Clear Function**
  - **Eight Dimming Levels**
  - **Peak Current Select**
  - **(12.5% or Full Peak Current)**
  - **Prescaler Function (External Oscillator Divided by 16 or 1)**
  - **Internal or External Clock**

DESCRIPTION

The SCE5780 (red), SCE5781 (yellow), SCE5782 (HER), SCE5783 (green), SCE5784 (HEG), and SCE5785 (orange) are eight digit, dot addressable 5x7 dot matrix, serial input, Intelligent Display devices. The eight 0.180" (4.57 mm) high digits are packaged in a rugged, high quality, optically transparent, plastic 26 pin DIP with 0.3" pin spacing.

The on-board CMOS has a 280 bit RAM, one bit associated with one LED, each to generate User Defined Characters.

The SCE578X is designed to work with the serial port of most common microprocessors. Data is transferred into the display through the Serial Data Input (DATA), clocked by the Serial Data Clock (SDCLK), and enabled by the Load Input (LOAD).

The Clock I/O (CLK I/O) and Clock Select (CLK SEL) pins offer the user the capability to supply a high speed external multiplex clock. This feature can minimize audio in-band interference for portable communication equipment or eliminate the visual synchronization effects found in high vibration environments such as avionic equipment. The prescaler function allows for a higher speed external multiplex clock when set to divide by 16.

Maximum Ratings

V_{CC}, Logic Supply Voltage (non-operating) ......–0.5 to +7.0 VDC
V_{LL}, LED Supply Voltage (non-operating)...........–0.5 to 5.5 VDC
Input Voltage Levels Relative
to Ground ....–0.5 to V_{CC} +0.5 VDC
Operating Temperature [1] .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature 0.063"
below Seating Plane, t<5 sec .... 260°C
Relative Humidity at 85°C 85%
Maximum Power Dissipation
70°C ....1.7 W
85°C ....1.25 W
ESD (100 pF, 1.5 KW) ....2 KV
Maximum Input Current .... ±100 mA

Note:

1) For operation at high temperature, see Thermal Considerations.

Switching specifications
(over operating temperature range and V_{CC}=4.5 V to 5.5 V)

Symbol	Description	Min.	Units
T_{RC}	Reset Active Time	600	ns
T_{LDS}	Load Setup Time	50	ns
T_{DS}	Data Setup Time	50	ns
T_{SDCLK}	Clock Period	200	ns
T_{SDCW}	Clock Width	70	ns
T_{LDH}	Load Hold Time	0	ns
T_{DH}	Data Hold Time	25	ns
T_{WR}	Total Write Time	2.2	µs
T_{BL}	Time Between Loads	600	ns

Note:

T_{SDCW} is the minimum time the SDCLK may be low or high. The SDCLK period must be a minimum of 200 ns.

Figure 6. Timing diagram—data write cycle

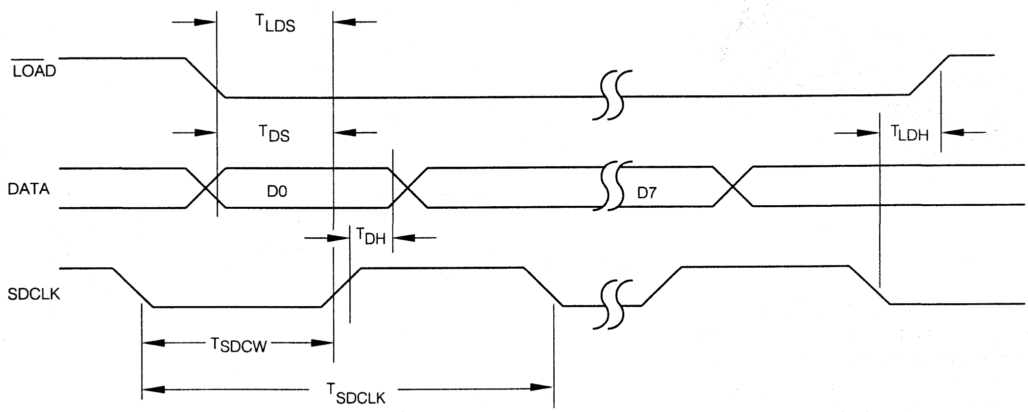
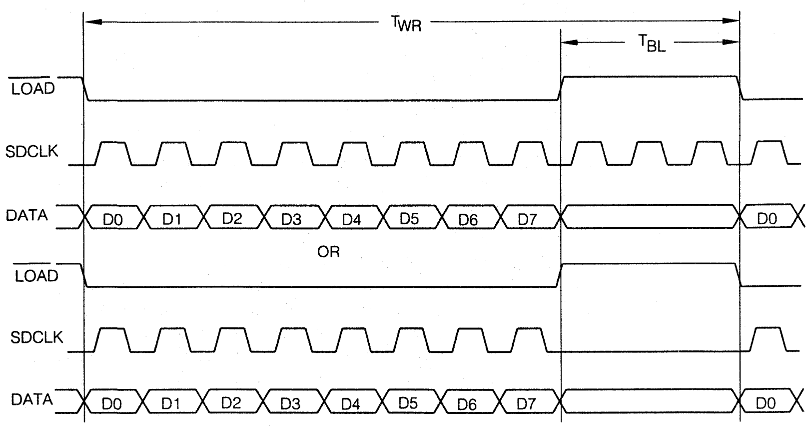


Figure 7. Timing diagram—instruction cycle



Electrical characteristics (over operating temperature)

Parameter	Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	V	
V_{LL}	3.0		5.5	V	
I_{CC} (PWR DWN)[4]			100	µA	$V_{CC}=V_{LL}$=5.0 V, all inputs=0 V or V_{CC}
I_{LL} (PWR DWN)[4]			50	µA	
I_{CC}			2	mA	V_{CC}=5.0 V
I_{LL} (20 dots/char)[1]		240	345	mA	$V_{CC}=V_{LL}$=5.0 V, "#" displayed in 8 digits, brightness=100%, I_P=100% at 25°C
I_{IL}			–10	µA	V_{CC}=5 V, all inputs=0 V
I_{IH}			10	µA	$V_{CC}=V_{IN}$=5.0 V (all inputs)
V_{IH}	3.5			V	V_{CC}=4.5 V to 5.5 V
V_{IL}			1.5	V	V_{CC}=4.5 V to 5.5 V
I_{OH} (CLK I/O)		-8.9		mA	V_{CC}=4.5 V, V_{OH}=2.4 V
I_{OL} (CLK I/O)		1.6		mA	V_{CC}=4.5 V, V_{OH}=0.4 V
$\theta_{JC\text{-}pin}$		34		°C/W	
Internal OSC Frequency	120		347	KHz	V_{CC}=5.0 V, CLKSEL=1, Prescale=÷1
External OSC Frequency	120		347	KHz	V_{CC}=5.0 V, CLKSEL=0, Prescale=÷1
External OSC Frequency with Prescale	1.92		5.55	MHz	V_{CC}=5.0 V, CLKSEL=0, Prescale=÷16
Mux Frequency[3]	375	768	1086	Hz	

Notes:

1) Peak current=1.87 x I_{LL} x I_{LL} varies with V_{LL} Normalized curve, Figure 12.
2) Unused inputs must be tied high.
3) Mux rate=[OSC Frequency/(64 x 7)].
4) Externaloscillatormustbestoppedduringpowerdownmodeforminimumcurrent.

Input/Output Circuits

Figures 3 and 4 show the input and output resistor/diode networks used for ESD protection and to eliminate substrate latch-up caused by input voltage over/under shoot.

Figure 8. Inputs

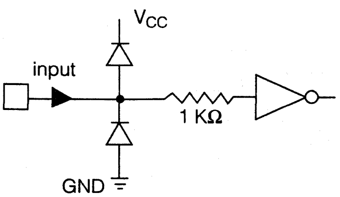
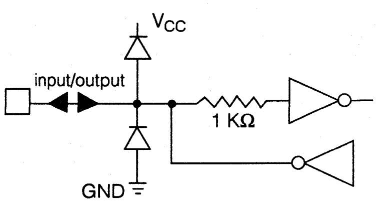


Figure 9. Clock I/O



Optical Characteristics at 25°C
(V_{LL}=V_{CC}=5.0 V at 100% brightness level, viewing angle: X axis ±55°, Y axis ±65°)

Red SCE5780

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	37.5	9.0	µcd/dot
Peak Wavelength	λ(peak)		660	nm
Dominant Wavelength	λ(d)		639	nm

Yellow SCE5781

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	75	110	µcd/dot
Peak Wavelength	λ(peak)		585	nm
Dominant Wavelength	λ(d)		583	nm

High Efficiency Red SCE5782

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	75	190	µcd/dot
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		626	nm

Green SCE5783

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	75	150	µcd/dot
Peak Wavelength	λ(peak)		565	nm
Dominant Wavelength	λ(d)		570	nm

High Efficiency Green SCE5784

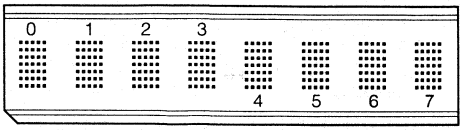
Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	120	215	µcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		574	nm

Soft Orange SCE5785

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	120	150	µcd/dot
Peak Wavelength	λ(peak)		635	nm
Dominant Wavelength	λ(d)		626	nm

Notes:
1. Dot to dot intensity matching at 100% brightness is 1.8:1.
2. Display are binned for hue at 2 nm intervals for yellow, green, and high efficiency green.
3. Displays within a given intensity category have an intensity matching of 1.5:1 (max.)

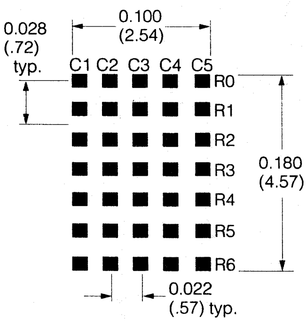
Figure 10. Top view



Pin assignment

Pin	Function	Pin	Function
1	CLKSEL	14	Serial Data
2	V_{CC} (Logic)	15	No connect
3	V_{LL} (LED)	16	Serial CLK
4	No pin	17	No pin
5	No pin	18	No pin
6	No pin	19	No pin
7	No pin	20	No pin
8	No pin	21	No pin
9	No pin	22	No pin
10	No pin	23	No pin
11	Load	24	Reset
12	GND	25	CLK I/O
13	GND	26	No connect

Figure 11. Dot matrix format



Pin definitions

Pin	Function	Definitions
1	CLKSEL	H=internal clock, L=external clock
2	V_{CC} (Logic)	Logic power supply
3	V_{LL} (LED)	LED power supply
4–10	No pin	No pins in these positions
11	Load	Low input enables data clocking into the 8-bit serial shift register. When Load goes high, the contents of the 8-bit serial shift register will be decoded.
12,13	GND	Power supply ground
14	Serial Data	Serial data input
15, 16	No connect	Pins have no function
16	Serial CLK	For loading data into the 8-bit serial register on a low to high transition
17–23	No pin	No pins in these positions
24	Reset	Asynchronous input, when low will clear the Multiplex Counter, User RAM, and Data Register. Control Word Register is set to 100% brightness, maximum peak current, and oscillator divided by 1. The display blanked.
25	CLK I/O	Outputs master clock or input external clock for display multiplexing.
26	No connect	Pins have no function

Display column and row format

	C0	C1	C2	C3	C4
Row 0	1	1	1	1	1
Row 1	0	0	1	0	0
Row 2	0	0	1	0	0
Row 3	0	0	1	0	0
Row 4	0	0	1	0	0
Row 5	0	0	1	0	0
Row 6	0	0	1	0	0

1=Display dot "On"
0=Display dot "Off'

Column data ranges

Row 0	00H to 1FH
Row 1	00H to 1FH
Row 2	00H to 1FH
Row 3	00H to 1FH
Row 4	00H to 1FH
Row 5	00H to 1FH
Row 6	00H to 1FH

Operation of the SCE578X

The SCE578X display consists of two CMOS ICs containing control logic and drivers for eight 5x7 characters. The first IC controls characters 0 through 3 and the second IC controls characters 4 through 7. These components are assembled in a compact plastic package.

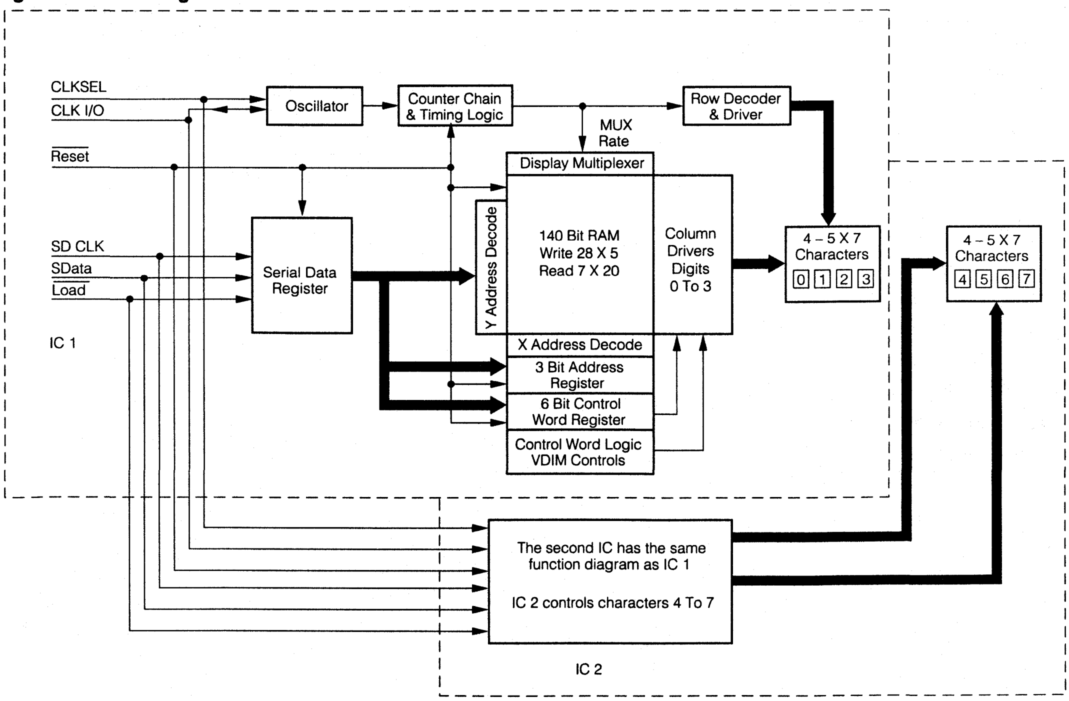
Individual LED dot addressability allows the user great freedom in creating special characters or mini-icons.

The serial data interface provides a highly efficient interconnection between the display and the mother board. The SCE578X requires a minimum three input lines as compared to fourteen for an equivalent eight character parallel input part.

The on-board CMOS IC is the electronic heart of the display. Each IC accepts serially formatted data, which is stored in the internal RAM. The IC accepts data based on the character address selected. The first IC is selected when addressing characters 0 through 3, the second IC is selected when addressing characters 4 though 7, and both ICs are selected when the Control Word is addressed.

Asynchronously the RAM is read by the character multiplexer at a strobe rate that results in a flicker free display. Figure 7 shows the three functional areas of the IC. These include: the input serial data register and control logic, a 140 bit two port RAM, and an internal multiplexer/display driver. The second IC is identical except characters 4 though 7 are driven.

Figure 12. Block diagram



The following explains how to format the serial data to be loaded into the display. The user supplies a string of bit mapped decoded characters. The contents of this string is shown in Figure 8a. Figure 8b shows that each character consist of eight 8 bit words. The first word encodes the display character location and the succeeding seven bytes are row data. The row data represents the status (On, Off) of individual column LEDs. Figure 8c shows that each 8 bit word is formatted to represent Character Address, or Column Data.

Figure 8d shows the sequence for loading the bytes of data. Bringing the $\overline{\text{LOAD}}$ line low enables the serial register to accept data. The shift action occurs on the low to high transition of the serial data clock (SDCLK). The least significant bit (D0) is loaded first. After eight clock pulses the $\overline{\text{LOAD}}$ line is brought high. With this transition the OPCODE is decoded. The decoded OPCODE directs D4–D0 to be latched in the Character Address register, stored in the RAM as Column data, or latched in the Control Word register. The control IC requires a minimum 600 ns delay between successive byte loads. As indicated in Figure 8a, a total of 512 bits of data are required to load all eight characters into the display.

The Character Address Register selects the character address that the row and column data will be written to. See Table 2 for opcode and character addressing. After loading the Character Address Register, the next seven bytes load the column data, one row at a time, starting with row 0 (top row) and ending with row 6 (bottom row). Each character address has a 7x5 bit User RAM formatted as seven rows, each containing five column data bits. The three most significant bits, D7–D5 represent the opcode for the row data and the least significant five bits, D4–D0 represent the column data. See Table 3 for the column data format. If an address is loaded before all seven rows are written, the next column data will be loaded into Row 0 of the new address. The remaining rows of the old address are not changed.

Table 1 shows the Row Address for the example character, "D." Column data is written and read asynchronously from the 280 bit RAM. Once loaded, the internal oscillator and character multiplexer reads the data from the RAM. These characters are row strobed with column data as shown in Figures 9 and 10. The character strobe rate is determined by the internal or user supplied external MUX Clock and the ICs÷ 320 counter.

Table 2. Character "D"

	Op code D7	D6	D5	Column Data D4 C0	D3 C1	D2 C2	D1 C3	D0 C4	Hex
Row 0	0	0	0	1	1	1	1	0	1E
Row 1	0	0	0	1	0	0	0	1	11
Row 2	0	0	0	1	0	0	0	1	11
Row 3	0	0	0	1	0	0	0	1	11
Row 4	0	0	0	1	0	0	0	1	11
Row 5	0	0	0	1	0	0	0	1	11
Row 6	0	0	0	1	1	1	1	0	1E

Figure 13. Loading serial character data

Example: Serial Clock = 5MHz, Clock Period = 200ns

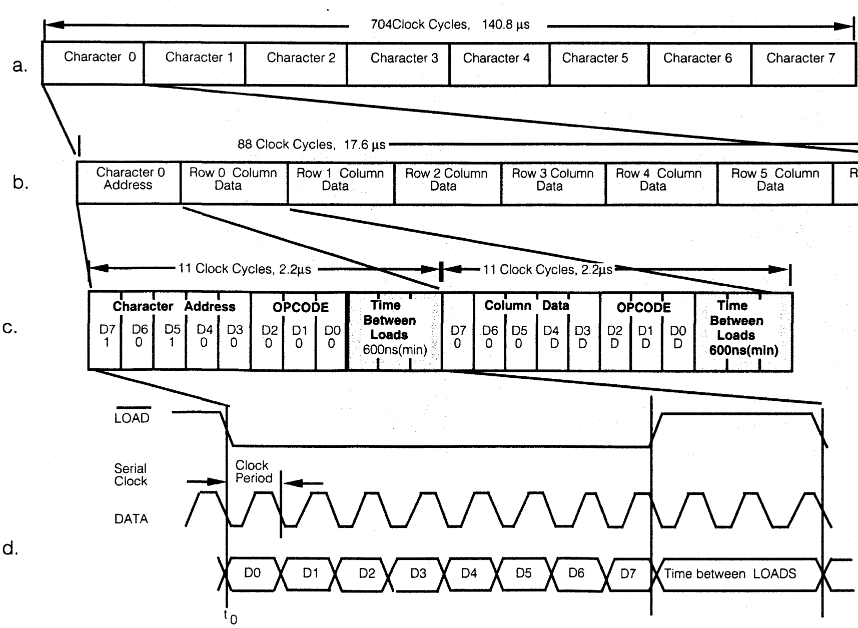


Table 3. Load character address

Op code D7 D6 D5	Character Address D4 D3 D2 D1 D0	Hex	Operation Load
1 0 1	0 0 0 0 0	A0	Character 0
1 0 1	0 0 0 0 1	A1	Character 1
1 0 1	0 0 0 1 0	A2	Character 2
1 0 1	0 0 0 1 1	A3	Character 3
1 0 1	0 0 1 0 0	A4	Character 4
1 0 1	0 0 1 0 1	A5	Character 5
1 0 1	0 0 1 1 0	A6	Character 6
1 0 1	0 0 1 1 1	A7	Character 7

Table 4. Load column data

Op code D7 D6 D5	Column Data D4 D3 D2 D1 D0	Operation Load
0 0 0	C0 C1 C2 C3 C4	Row 0
0 0 0	C0 C1 C2 C3 C4	Row 1
0 0 0	C0 C1 C2 C3 C4	Row 2
0 0 0	C0 C1 C2 C3 C4	Row 3
0 0 0	C0 C1 C2 C3 C4	Row 4
0 0 0	C0 C1 C2 C3 C4	Row 5
0 0 0	C0 C1 C2 C3 C4	Row 6

The user can activate four Control functions. These include: LED Brightness Level, IC Power Down, Prescaler, or Display Clear. OPCODEs and six bit words are used to initiate these functions. The OPCODEs and Control Words for the Character Address and Loading Column Data are shown in Tables 2 and 3.

The user can select eight specific LED brightness levels, Tables 4 and 5. Depending on how D3 is selected either one (1) for maximum peak current or zero (0) for 12.5% of maximum peak current in the control word per Table 4 and 5, the user can select 16 specific LED brightness levels. These brightness levels (in percentages of full brightness of the display) depending on how the user selects D3 can be one (1) or zero (0) are as follows: 100% ($E0_{HEX}$ or $E8_{HEX}$), 53% ($E1_{HEX}$ or $E9_{HEX}$), 40% ($E2_{HEX}$ or EA_{HEX}), 27% ($E3_{HEX}$ or EB_{HEX}), 20% ($E4_{HEX}$ or EC_{HEX}), 13% ($E5_{HEX}$ or ED_{HEX}), and 6.6% ($E6_{HEX}$ or EE_{HEX}), 0.0% ($E7_{HEX}$ or EF_{HEX}). The brightness levels are controlled by changing the duty factor of the row strobe pulse.

The SCE578X offers a unique Display Power Down feature which reduces I_{CC} to less than 150 µA total. When EF_{HEX} is loaded (Table 6) the display is set to 0% brightness. When in the Power Down mode data may still be written into the RAM. The display is reactivated by loading a new brightness Level Control Word into the display.

Table 5. Display brightness

Op code D7 D6	Control Word D5 D4 D3 D2 D1 D0	Hex	Operation Level
1 1	1 0 0 0 0 0	E0	100%
1 1	1 0 0 0 0 1	E1	53%
1 1	1 0 0 0 1 0	E2	40%
1 1	1 0 0 0 1 1	E3	27%
1 1	1 0 0 1 0 0	E4	20%
1 1	1 0 0 1 0 1	E5	13%
1 1	1 0 0 1 1 0	E6	6.6%
1 1	1 0 0 1 1 1	E7	0.0%

Table 6. Display brightness

Op code D7 D6	Control Word D5 D4 D3 D2 D1 D0	Hex	Operation Level
1 1	1 0 1 0 0 0	E8	100%
1 1	1 0 1 0 0 1	E9	53%
1 1	1 0 1 0 1 0	EA	40%
1 1	1 0 1 0 1 1	EB	27%
1 1	1 0 1 1 0 0	EC	20%
1 1	1 0 1 1 0 1	ED	13%
1 1	1 0 1 1 1 0	EE	6.6%
1 1	1 0 1 1 1 1	EF	0.0%

Table 7. Power down

Op code D7 D6	Control Word D5 D4 D3 D2 D1 D0	Hex	Operation Level
1 1	1 0 1 1 1 1	EF	0% brightness

Figure 14. Row and column locations for a character "D"

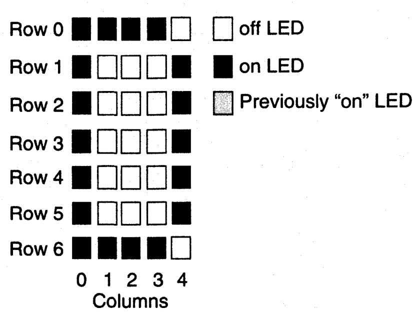
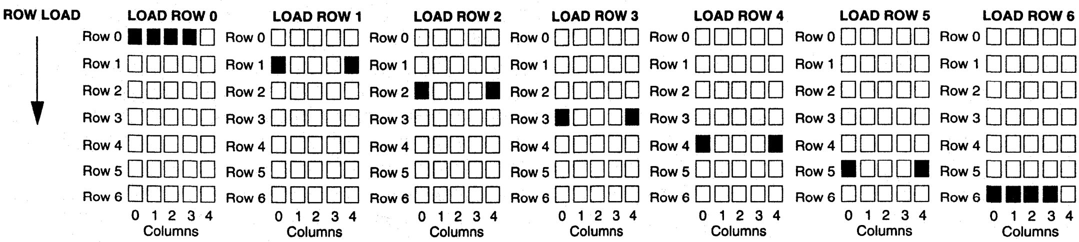


Figure 15. Row strobing



The SCE578X allows a high frequency external oscillator source to drive the display. Data bit, D4, in the control word format controls the prescaler function. The prescaler allows the oscillator source to be divided by 16 by setting D4=1. However, the prescaler should not be used, i.e., when using the internal oscillator source.

The Software Clear ($C0_{HEX}$), given in Table 7, clears the Address Register and the RAM. The display is blanked and the Character Address Register will be set to Character 0. The internal counter and the Control Word Register are unaffected. The Software Clear will remain active until the next data input cycle is initiated.

Table 8. Software clear

Op code D7	D6	Control Word D5	D4	D3	D2	D1	D0	Hex	Operation
1	1	0	0	0	0	0	0	C0	CLEAR

Multiplexer and Display Driver

The eight characters are row multiplexed with RAM resident column data. The strobe rate is established by the internal or external MUX Clock rate. The MUX Clock frequency is divided by a 320 counter chain. This results in a typical strobe rate of 768 Hz. By pulling the Clock SEL line low, the display can be operated from an external MUX Clock. The external clock is attached to the CLK I/O connection.

An asynchronous hardware Reset (pin 8) is also provided. Bringing this pin low will clear the Character Address Register, Control Word Register, RAM, and blanks the display. This action leaves the display set at Character Address 0, and the Brightness Level set at 100%, prescaler ÷1.

Electrical and Mechanical Considerations

Thermal Considerations

The display's power usage may need to be reduced to operate at high ambient temperatures. The power may be reduced by lowering the brightness level, reducing the total number of LEDs illuminated, or lowering V_{LED}. The V_{CC} supply, relative to the V_{LED} supply, has little effect on the power dissipation of the display and is not considered when determining the power dissipation.

To determine the power deration with a given ambient temperature, use the following formula:

$$T_{jmax} = T_A + P_D \cdot \theta_{ja}$$

where: T_{jmax}=maximum IC junction temperature
P_D=power dissipated by the ICs
θ_{ja}=thermal resistance, junction to ambient

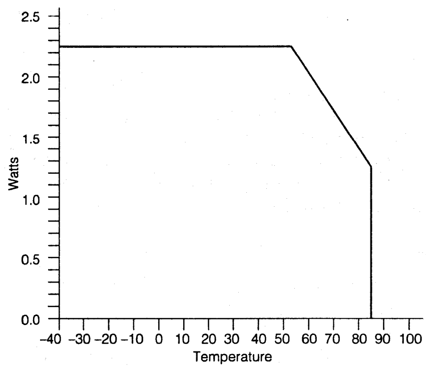
To determine the power dissipation of the display, use the following formula:

$$PD = N \cdot I_{LL} / 140 \cdot RB$$

where: N=number of LEDs on
I_{LL}/140=average current for a single LED
RB=relative brightness level

A typical thermal resistance value (θ_{ja}) for this display is 50°c/W when mounted in a socket soldered on a 0.062" thick PCB with 0.020", 1 ounce copper traces and the display covered by a plastic filter. The display's maximum IC junction temperature is 125°C. Power Deration Curve is based on these typical values.

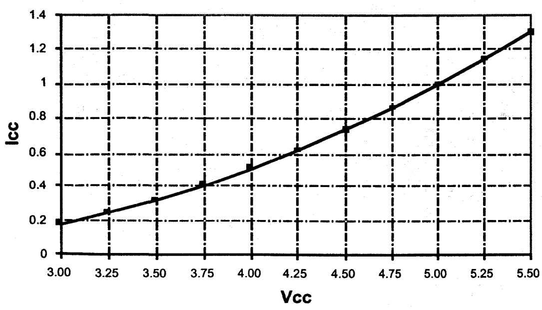
Figure 16. Power deration curve (θ_{ja}=50°C/W)



V_{CC} and V_{LL} are two separate power supplies sharing a common ground. V_{CC} supplies power for all the display logic. V_{LL} supplies the power for the LEDs. By separating the two supplies, V_{CC} and V_{LL} can be varied independently and keeps the logic supply clean.

V_{LL} can be varied between 3 volts and 5.5 volts. The LED drive current will vary with changes in V_{LL}. See Figure 12 for I_{LL} variance.

Figure 17. ILL variance



V_{CC} can vary between 3 volts and 5.5 volts. Operation below 4.5 volts will change the timing and switching levels of the inputs. Using 25% x V_{CC} for V_{IL} and 75% of V_{CC} for V_{IH} will work down to a V_{CC} level of 3 volts.

Interconnect Considerations

Optimum product performance can be had when the following electrical and mechanical recommendations are adopted. The SCE578X's IC is constructed in a high speed CMOS process; consequently high speed noise on the SERIAL DATA, SERIAL DATA CLOCK, $\overline{\text{LOAD}}$ and $\overline{\text{RESET}}$ lines may cause incorrect data to be written into the serial shift register. Adhere to transmission line termination procedures when using fast line drivers and long cables (>10 cm).

Good ground (pin 2) and power supply decoupling (pins 9 and 10) will insure that Icc (<800 mA peak) switching currents do not generate localized ground bounce. Therefore it is recommended that each display package use a 0.1 µF and 20 µF tanulum capacitor between V_{CC} and ground.

When the internal MUX Clock is being used connect the $\overline{\text{CLKSEL}}$ pin to V_{CC}. In those applications where $\overline{\text{RESET}}$ will not be connected to the system's reset control, it is recommended that this pin be connected to the center node of a series 0.1 µF and 100 KΩ RC network. Thus upon initial power up the $\overline{\text{RESET}}$ will be held low for 10 ms allowing adequate time for the system power supply to stabilize.

ESD Protection

The input protection structure of the SCE578X provides significant protection against ESD damage. It is capable of withstanding discharges greater than 2 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in antistatic packaging.

Soldering Considerations

The SCE578X can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the nylon package. For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book. See Appnote 19, Table 2, "Displays–Group 2."

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 14 pin DIP sockets .300" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The 0.180" high character of the SCE578X gives readability up to five feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The SCE5780 is a red display and should be used with long wavelength pass filter having a sharp cut-off in the 600 nm to 620 nm range. The SCE5782 is a high efficiency red display and should be used with long wavelength pass filter having a sharp cut-off in the 570 nm to 600 nm range. The SCE5784 is a high efficiency green display and should be used with long wavelength pass filter that peaks at 565 nm.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Microprocessor Interface

The microprocessor interface is through the serial port, SPI port or one out of eight data bits on the eight bit parallel port and also control lines $\overline{\text{SDCLK}}$ and $\overline{\text{LOAD}}$.

Power Up Sequence

Upon power up display will come on at random. Thus the display should be reset at power-up. The reset will set the Address Register to Digit 0, User RAM is set to 0 (display blank) the Control Word is set to 0 (100% brightness) and the internal counters are reset.

Loading Data into the Display

Use following procedure to load data into the display:

1. Power up the display.
2. Bring $\overline{\text{RST}}$ low (600 ns duration minimum) to clear the Multiplex Counter, Address Register, Control Word Register, User Ram and Data Register. The display will be blank. Display brightness is set to 100%.
3. If a different brightness is desired, load the proper brightness opcode into the Control Word Register.
4. Load the Digit Address into the display.
5. Load display row and column data for the selected digit.
6. Repeat steps 4 and 5 for all digits.

Data contents for the word "ABCDEFGH"

Step	D7	D6	D5	D4	D3	D2	D1	D0	Function
A	1	1	0	0	0	0	0	0	CLEAR
B	1	1	1	0	0	0	0	0	100% BRIGHTNESS
1	1	0	1	0	0	0	0	0	DIGIT D0 SELECT
2	0	0	0	0	0	1	0	0	ROW 0 (A)
3	0	0	0	0	1	0	1	0	ROW 1 (A)
4	0	0	0	1	0	0	0	1	ROW 2 (A)
5	0	0	0	1	1	1	1	1	ROW 3 (A)
6	0	0	0	1	0	0	0	1	ROW 4 (A)
7	0	0	0	1	0	0	0	1	ROW 5 (A)
8	0	0	0	1	0	0	0	1	ROW 6 (A)
9	1	0	1	0	0	0	0	1	DIGIT D1 SELECT
10	0	0	0	1	1	1	1	1	ROW 0 (B)
11	0	0	0	1	0	0	0	1	ROW 1 (B)
12	0	0	0	1	0	0	0	1	ROW 2 (B)
13	0	0	0	1	1	1	1	0	ROW 3 (B)
14	0	0	0	1	0	0	0	1	ROW 4 (B)
15	0	0	0	1	0	0	0	1	ROW 5 (B)
16	0	0	0	1	1	1	1	1	ROW 6 (B)
17	1	0	1	0	0	0	1	0	DIGIT D2 SELECT
18	0	0	0	0	0	1	1	1	ROW 0 (C)
19	0	0	0	0	1	0	0	0	ROW 1 (C)
20	0	0	0	1	0	0	0	0	ROW 2 (C)
21	0	0	0	1	0	0	0	0	ROW 3 (C)
22	0	0	0	1	0	0	0	0	ROW 4 (C)
23	0	0	0	0	1	0	0	0	ROW 5 (C)
24	0	0	0	0	0	1	1	1	ROW 6 (C)
25	1	0	1	0	0	0	1	1	DIGIT D3 SELECT
26	0	0	0	1	1	1	1	0	ROW 0 (D)
27	0	0	0	1	0	0	0	1	ROW 1 (D)
28	0	0	0	1	0	0	0	1	ROW 2 (D)
29	0	0	0	1	0	0	0	1	ROW 3 (D)
30	0	0	0	1	0	0	0	1	ROW 4 (D)
31	0	0	0	1	0	0	0	1	ROW 5 (D)
32	0	0	0	1	1	1	1	0	ROW 6 (D)
33	1	0	1	0	0	1	0	0	DIGIT D4 SELECT
34	0	0	0	1	1	1	1	1	ROW 0 (E)
35	0	0	0	1	0	0	0	0	ROW 1 (E)
36	0	0	0	1	0	0	0	0	ROW 2 (E)
37	0	0	0	1	1	1	1	0	ROW 3 (E)
38	0	0	0	1	0	0	0	0	ROW 4 (E)
39	0	0	0	1	0	0	0	0	ROW 5 (E)
40	0	0	0	1	1	1	1	1	ROW 6 (E)
41	1	0	1	0	0	1	0	1	DIGIT D5 SELECT
42	0	0	0	1	1	1	1	1	ROW 0 (F)
43	0	0	0	1	0	0	0	0	ROW 1 (F)
44	0	0	0	1	0	0	0	0	ROW 2 (F)
45	0	0	0	1	1	1	1	0	ROW 3 (F)
46	0	0	0	1	0	0	0	0	ROW 4 (F)
47	0	0	0	1	0	0	0	0	ROW 5 (F)
48	0	0	0	1	0	0	0	0	ROW 6 (F)
49	1	0	1	0	0	1	1	0	DIGIT D6 SELECT
50	0	0	0	0	1	1	1	0	ROW 0 (G)
51	0	0	0	1	0	0	0	1	ROW 1 (G)
52	0	0	0	1	0	0	0	0	ROW 2 (G)
53	0	0	0	1	0	0	0	0	ROW 3 (G)
54	0	0	0	1	0	0	1	1	ROW 4 (G)
55	0	0	0	1	0	0	0	1	ROW 5 (G)
56	0	0	0	0	1	1	1	0	ROW 6 (G)
57	1	0	1	0	0	1	1	1	DIGIT D7 SELECT
58	0	0	0	1	0	0	0	1	ROW 0 (H)
59	0	0	0	1	0	0	0	1	ROW 1 (H)
60	0	0	0	1	0	0	0	1	ROW 2 (H)
61	0	0	0	1	1	1	1	1	ROW 3 (H)
61	0	0	0	1	0	0	0	1	ROW 4 (H)
62	0	0	0	1	0	0	0	1	ROW 5 (H)
63	0	0	0	1	0	0	0	1	ROW 6 (H)

Figure 18. Display interface to Siemens/Intel 8031 microprocessor (using serial port in mode 0)

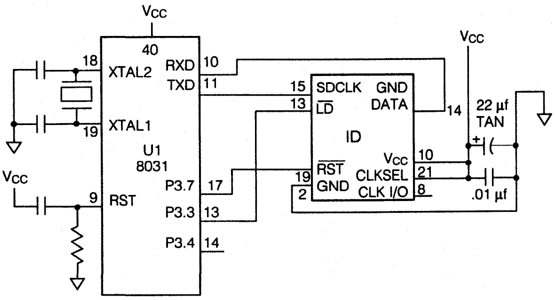


Figure 19. Display interface to Siemens/Intel 8031 microprocessor (using one bit of parallel port as serial port)

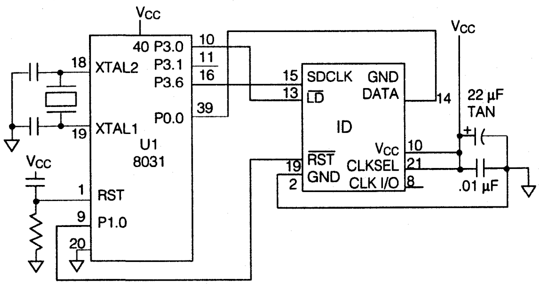


Figure 20. Display interface with Motorola 68HC05C4 microprocessor (using SPI port)

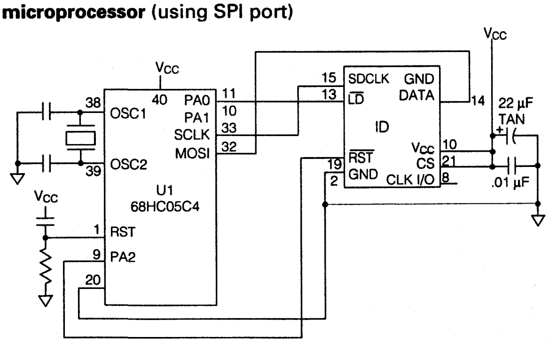
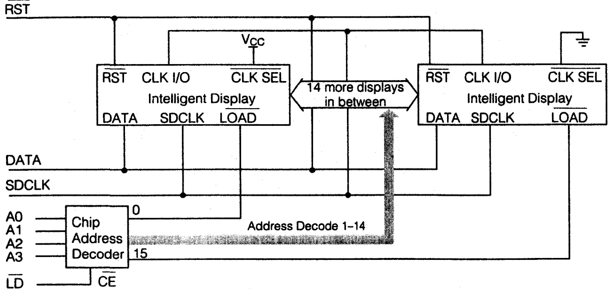
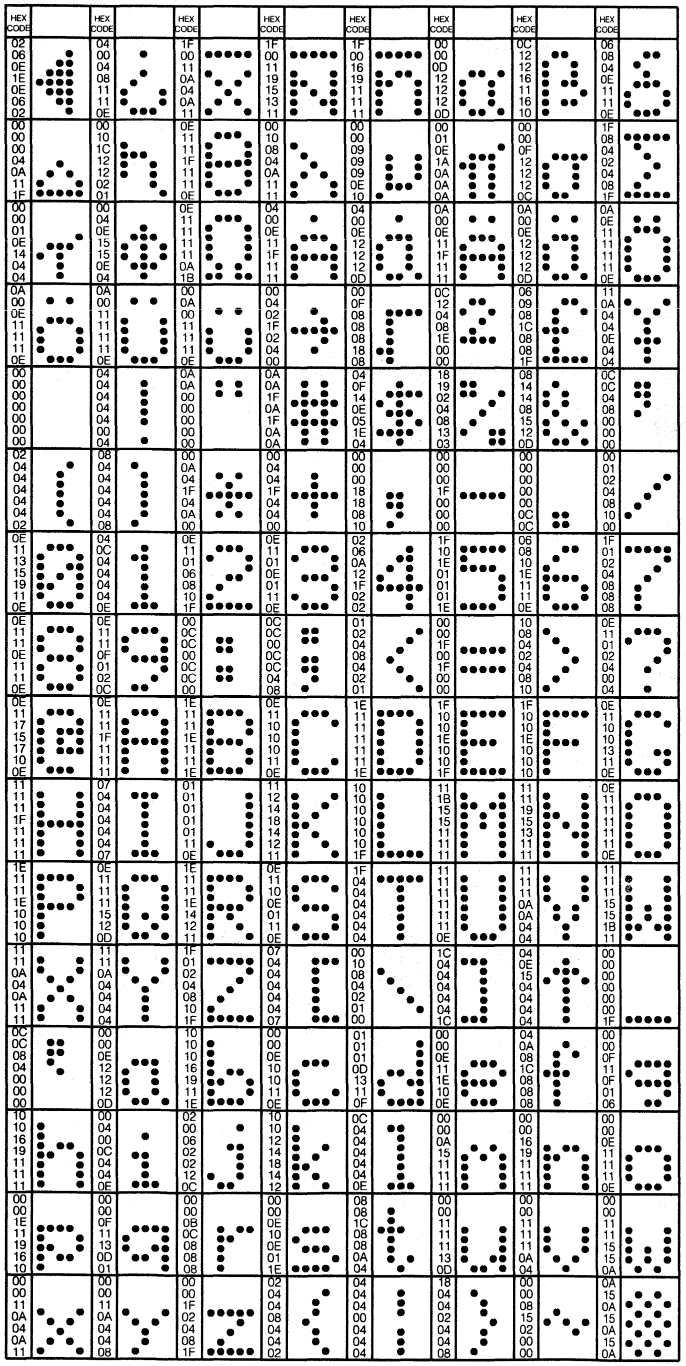


Figure 21. Cascading multiple displays



Multiple displays can be cascaded using the CLK SEL and CLK I/O pins (Figure 16). The display designated as the MasterClock source should have its CLK SEL pin tied high and the slaves should have their CLK SEL pins tied low. All CLK I/O pins should be tied together. One display CLK I/O can drive 15 slave CLK I/Os. Use RST to synchronize all display counters.

Figure 22. Character set

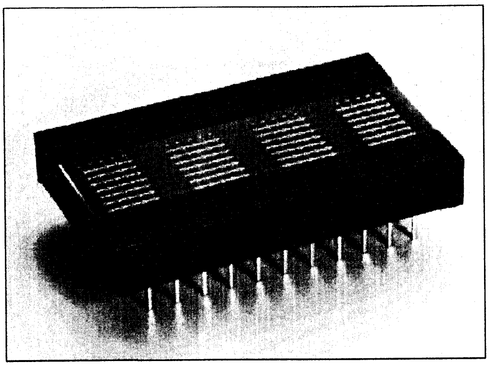


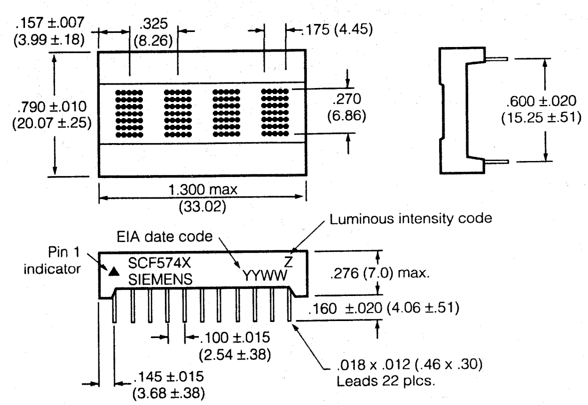
HEX CODE	HEX CODE	HEX CODE	HEX CODE	HEX CODE	HEX CODE	HEX CODE	HEX CODE
02 06 0E 1E 0E 06 02	04 00 04 08 11 11 0E	1F 00 11 0A 04 0A 11	1F 00 11 19 15 13 11	1F 00 16 19 11 11 11	00 00 0D 12 12 12 0D	0C 12 12 16 11 16 10	06 08 04 0E 11 11 0E
00 00 00 04 0A 11 1F	00 10 1C 12 12 02 01	0E 11 11 1F 11 11 0E	00 10 08 04 0A 11 11	00 00 09 09 09 0E 10	00 01 0E 1A 0A 0A 0A	00 00 0F 12 12 12 0C	1F 08 04 02 04 08 1F
00 00 01 0E 14 04 04	00 04 0E 15 15 0E 04	0E 11 11 11 11 0A 1B	04 00 0E 11 1F 11 11	04 00 0E 12 12 12 0D	0A 00 0E 11 1F 11 11	0A 00 0E 12 12 12 0D	0A 0E 11 11 11 11 0E
0A 00 0E 11 11 11 0E	0A 00 11 11 11 11 0E	00 0A 00 11 11 11 0E	00 04 02 1F 02 04 00	00 0F 08 08 08 18 08	0C 12 04 08 1E 00 00	06 09 08 1C 08 08 1F	11 0A 04 04 0E 04 04
00 00 00 00 00 00 00	04 04 04 04 04 00 04	0A 0A 00 00 00 00 00	0A 0A 1F 0A 1F 0A 0A	04 0F 14 0E 05 1E 04	18 19 02 04 08 13 03	08 14 14 08 15 12 0D	0C 0C 04 08 00 00 00
02 04 04 04 04 04 02	08 04 04 04 04 04 08	00 0A 04 1F 04 0A 00	00 04 04 1F 04 04 00	00 00 00 18 18 08 10	00 00 00 1F 00 00 00	00 00 00 00 00 0C 0C	00 01 02 04 08 10 00
0E 11 13 15 19 11 0E	04 0C 04 04 04 04 0E	0E 11 01 06 08 10 1F	0E 11 01 0E 01 11 0E	02 06 0A 12 1F 02 02	1F 10 1E 01 01 01 1E	06 08 10 1E 11 11 0E	1F 01 02 04 08 08 08
0E 11 11 0E 11 11 0E	0E 11 11 0F 01 02 0C	00 0C 0C 00 0C 0C 00	0C 0C 00 0C 0C 04 08	01 02 04 08 04 02 01	00 00 1F 00 1F 00 00	10 08 04 02 04 08 10	0E 11 01 02 04 00 04
0E 11 17 15 17 10 0E	0E 11 11 1F 11 11 11	1E 11 11 1E 11 11 1E	0E 11 10 10 10 11 0E	1E 11 11 11 11 11 1E	1F 10 10 1E 10 10 1F	1F 10 10 1E 10 10 10	0E 11 10 10 13 11 0E
11 11 11 1F 11 11 11	07 04 04 04 04 04 07	01 01 01 01 01 11 0E	11 12 14 18 14 12 11	10 10 10 10 10 10 1F	11 1B 15 15 11 11 11	11 11 19 15 13 11 11	0E 11 11 11 11 11 0E
1E 11 11 1E 10 10 10	0E 11 11 11 15 12 0D	1E 11 11 1E 14 12 11	0E 11 10 0E 01 11 0E	1F 04 04 04 04 04 04	11 11 11 11 11 11 0E	11 11 11 0A 0A 04 04	11 11 11 15 15 1B 11
11 11 0A 04 0A 11 11	11 11 0A 04 04 04 04	1F 01 02 04 08 10 1F	07 04 04 04 04 04 07	00 10 08 04 02 01 00	1C 04 04 04 04 04 1C	04 0E 15 04 04 04 04	00 00 00 00 00 00 1F
0C 0C 08 04 00 00 00	00 00 0E 12 12 12 0D	10 10 10 16 19 11 1E	00 00 0E 10 10 11 0E	01 01 01 0D 13 11 0F	00 00 0E 11 1E 10 0E	04 0A 08 1C 08 08 08	00 00 0F 11 0F 01 06
10 10 16 19 11 11 11	00 04 00 0C 04 04 0E	02 00 06 02 02 12 0C	10 10 12 14 18 14 12	0C 04 04 04 04 04 0E	00 00 0A 15 11 11 11	00 00 16 19 11 11 11	00 00 0E 11 11 11 0E
00 00 1E 11 19 16 10	00 00 0F 11 13 0D 01	00 00 0B 0C 08 08 08	00 00 0E 10 0E 01 1E	08 08 1C 08 08 0A 04	00 00 11 11 11 13 0D	00 00 11 11 11 0A 04	00 00 11 11 15 15 0A
00 00 11 0A 04 0A 11	00 00 11 0A 04 04 08	00 00 1F 02 04 08 1F	02 04 04 08 04 04 02	04 04 04 00 04 04 04	18 04 04 02 04 04 08	00 00 08 15 02 00 00	0A 15 0A 15 0A 15 0A

SIEMENS

STANDARD RED SCF5740
HIGH EFFICIENCY RED SCF5742
HIGH EFFICIENCY GREEN SCF5744

0.270" 4-Character 5x7 Dot Matrix Serial Input Dot Addressable Intelligent Display® Devices





FEATURES

- **Four 0.270" (6.85 mm) 5x7 Dot Matrix Characters in Red, High Efficiency Red, High Efficiency Green**
- **Optimum Display Surface Efficiency (display area to package ratio)**
- **High Speed Data Input Rate: 5 MHz**
- **ROMless Serial Input, Dot Addressable Display Ideal for User Defined Characters**
- **Built-in Decoders, Multiplexers and LED Drivers**
- **Readable from 6 Feet (1.8 meters)**
- **Wide Viewing Angle, X Axis ±55°, Y Axis ±55°**
- **Attributes:**
  - **140 Bit RAM for User Defined Characters**
  - **Eight Dimming Levels**
  - **Power Down Model (<250 µW)**
  - **Hardware/Software Clear Functions**
  - **Internal or External Clock**

DESCRIPTION

The SCF574X is a four digit, dot addressable 5x7 dot matrix, serial input, alphanumeric Intelligent Display device. The four digits are packaged in a rugged, high quality, optically transparent, plastic 22 pin DIP with 0.1" pin spacing.

The on-board CMOS has a 140 bit RAM, one bit associated with one LED, each to generate User Defined Characters. In Power Down Mode, quiescent current is <50 µA.

The SCF574X is designed for work with the serial port of most common microprocessors. Data is transferred into the display through the Serial Data Input (DATA), clocked by the Serial Data Clock (SDCLK), and enabled by the Load Input (LOAD).

The Clock I/O (CLK I/O) and Clock Select ($\overline{\text{CLK SEL}}$) pins offer the user the capability to supply a high speed external multiplex clock. This feature can minimize audio in-band interference for portable communication equipment or eliminate the visual sychronization effects found in high vibration environments such as avionic equipment.

Maximum Ratings

DC Supply Voltage .... –0.5 to +7.0 Vdc
Input Voltage Levels Relative
to Ground .... –0.5 to V_{CC} +0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Maximum Solder Temperature 0.063"
below Seating Plane, t<5 sec .... 260°C
Relative Humidity at 85°C 85%
Maximum Number of LEDs at 100% Brightness 64
Maximum Power Dissipation .... 0.65 W
ESD (100 pF, 1.5 KW) .... 2 KV
Maximum Input Current .... ±186 mA

Figure 1. Timing diagram—data write cycle

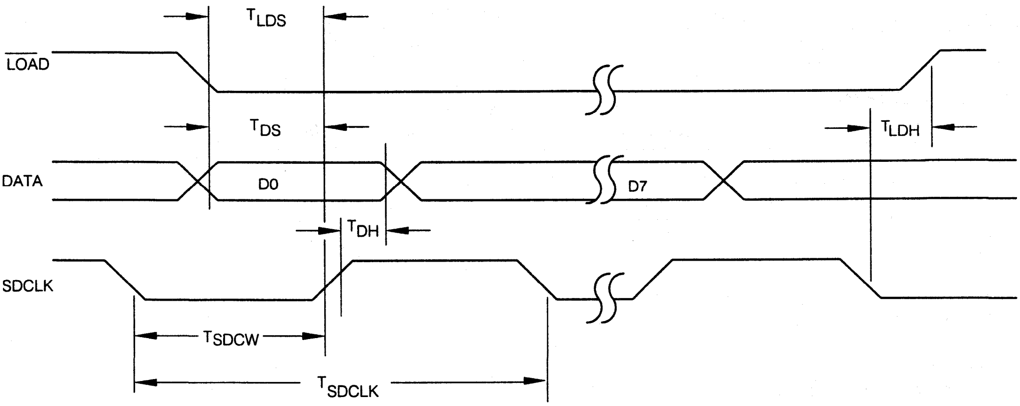
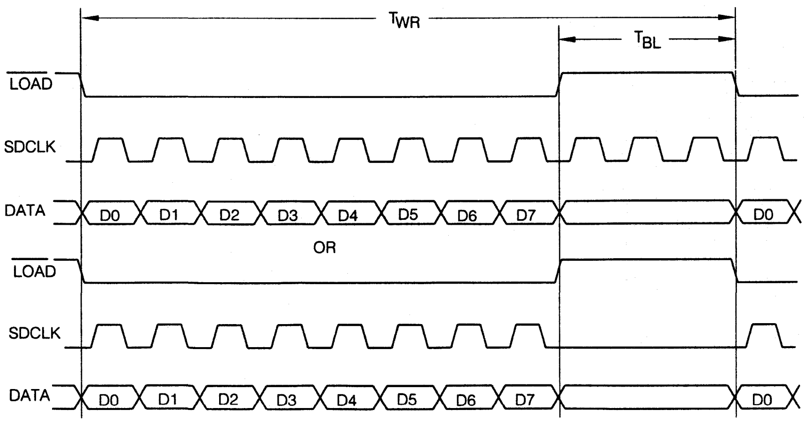


Figure 2. Timing diagram—instruction cycle



Optical Characteristics at 25°C
(V_{CC}=5.0 V at 100% brightness level, viewing angle: X axis ±55°, Y axis ±65°)

Red SCF5740

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	55		µcd/dot
Peak Wavelength	λ(peak)		655	nm
Dominant Wavelength	λ(d)		639	nm

High Efficiency Red SCF5742

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	110		µcd/dot
Peak Wavelength	λ(peak)		630	nm
Dominant Wavelength	λ(d)		626	nm

High Efficiency Green SCF5744

Description	Symbol	Min.	Typ.	Units
Luminous Intensity	I_V	110		µcd/dot
Peak Wavelength	λ(peak)		568	nm
Dominant Wavelength	λ(d)		574	nm

Notes:
1. Dot to dot intensity matching at 100% brightness is 1.8:1.
2. Displays within a given intensity category have an intensity matching of 1.5:1 (max.)

Switching specifications
(over operating temperature range and V_{CC}=4.5 V to 5.5 V)

Symbol	Description	Min.	Units
T_{RC}	Reset Active Time	600	ns
T_{LDS}	Load Setup Time	50	ns
T_{DS}	Data Setup Time	50	ns
T_{SDCLK}	Clock Period	200	ns
T_{SDCW}	Clock Width	70	ns
T_{LDH}	Load Hold Time	0	ns
T_{DH}	Data Hold Time	25	ns
T_{WR}	Total Write Time	2.2	µs
T_{BL}	Time Between Loads	600	ns

Note:
T_{SDCW} is the minimum time the SDCLK may be low or high.
The SDCLK period must be a minimum of 200 ns.

Electrical characteristics (over operating temperature)

Parameter	Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	V	
I_{CC} (PWR DWN)[4]			50	µA	V_{CC}=5.0 V, all inputs=0 V or V_{CC}
I_{CC} 4 digits 20 dots/character		150	186	mA	V_{CC}=5 V, "#" displayed in all 4 digits at 100% brightness at 25°C
I_{IL} Input current			–10	µA	V_{CC}=5 V, V_{IN}=0 (all inputs)
I_{IH} Input current			10	µA	V_{CC}=V_{IN}=5.0 V (all inputs)
V_{IH}	3.5			V	V_{CC}=4.5 V to 5.5 V
V_{IL}			1.5	V	V_{CC}=4.5 V to 5.5 V
I_{OH} (CLK I/O)		–28		mA	V_{CC}=4.5 V, V_{OH}=2.4 V
I_{OL} (CLK I/O)		23		mA	V_{CC}=4.5 V, V_{OL}=0.4 V
$\theta_{JC\text{-}pin}$			32	°C/W	
F_{ext} External Clock Input Frequency	120		347	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=0
F_{osc} Internal Clock Input Frequency	120		347	KHz	V_{CC}=5.0 V, $\overline{CLKSEL}$=1
Clock I/O Bus Loading			240	pF	
Clock Out Rise Time			500	ns	V_{CC}=4.5 V, V_{OH}=2.4 V
Clock Out Fall Time			500	ns	V_{CC}=4.5 V, V_{OH}=0.4 V
FM, Digit	375	768	1086	Hz	

Notes:

1) Peak current $^{5}/_{3}$ x I_{CC}.
2) Unused inputs must be tied high.
3) Contact Siemens for 3.3 volt operation.
4) External oscillator must be stopped if being used to maintain an I_{CC}<50 µA.

Input/Output Circuits

Figures 3 and 4 show the input and output resistor/diode networks used for ESD protection and to eliminate substrate latch-up caused by input voltage over/under shoot.

Figure 3. Inputs

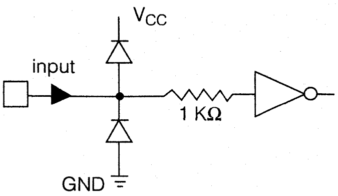


Figure 4. Clock I/O

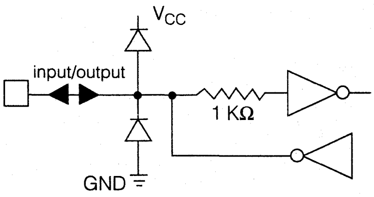
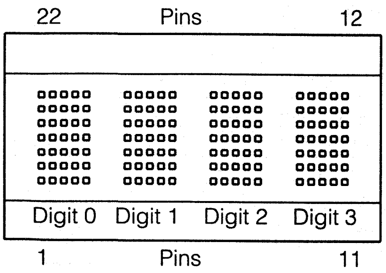


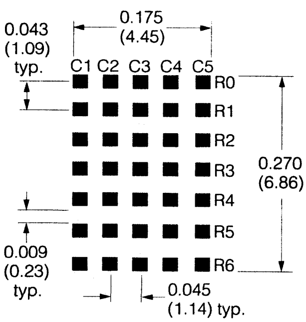
Figure 5. Top view



Pin assignment

Pin	Function	Pin	Function
1	N/C	22	N/C
2	GND	21	CLKSEL
3	N/C	20	CLK I/O
4	N/C	19	$\overline{RST}$
5	N/C	18	N/C
6	N/C	17	N/C
7	N/C	16	N/C
8	N/C	15	SCLK
9	V_{LL}	14	DATA
10	V_{CC}	13	$\overline{LOAD}$
11	N/C	12	N/C

Figure 6. Dot matrix format



Dimensions in inches (mm)
Tolerance: .XXX ±.010 (.25)

Pin definitions

Pin	Function	Definitions
1	N/C	
2	GND	Power supply ground
3	N/C	
4	N/C	
5	N/C	
6	N/C	
7	N/C	
8	N/C	
9	V_{LL}	LED supply
10	V_{CC}	Logic supply
11	N/C	
12	N/C	
13	$\overline{LOAD}$	Low input enables data clocking into 8-bit serial shift register. When load goes high, the contents of 8-bit serial shift register will be decoded.
14	DATA	Serial data input
15	SDCLK	For loading data into the 8-bit serial data register
16	N/C	
17	N/C	
18	N/C	
19	$\overline{RST}$	Asynchronous input, when low clears the multiplex counter, address register, control word register, user RAM and data register. Control word register is set to 100% brightness. The display will be blank.
20	CLK I/O	Outputs Master Clock or inputs External Clock
21	CLKSEL	High=Internal Clock (Master) Low=External Clock (Slave)
22	N/C	

Display column and row format

	C0	C1	C2	C3	C4
Row 0	1	1	1	1	1
Row 1	0	0	1	0	0
Row 2	0	0	1	0	0
Row 3	0	0	1	0	0
Row 4	0	0	1	0	0
Row 5	0	0	1	0	0
Row 6	0	0	1	0	0

1=Display dot "On"
0=Display dot "Off'

Column data ranges

Row 0	00H to 1FH
Row 1	00H to LFH
Row 2	00H to LFH
Row 3	00H to LFH
Row 4	00H to LFH
Row 5	00H to LFH
Row 6	00H to LFH

Operation of the SCF574X

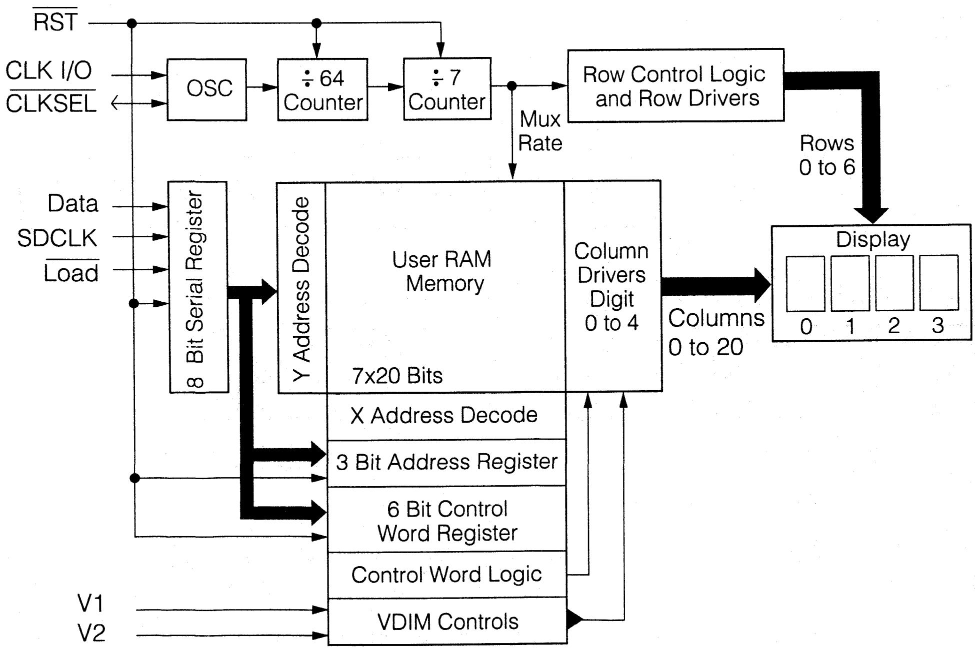
The SCF574X display consists of a CMOS IC containing control logic and drivers for four 5x7 characters. These components are assembled in a compact plastic package.

Individual LED dot addressability allows the user great freedom in creating special characters or mini-icons.

The serial data interface provides a highly efficient interconnection between the display and the mother board. The SCF574X requires only three lines as compared to 14 for an equivalent four character parallel input part.

The on-board CMOS IC is the electronic heart of the display. The IC accepts decoded serial data, which is stored in the internal RAM. Asynchronously the RAM is read by the character multiplexer at a strobe rate that results in a flicker free display. Figure 7 shows the three functional areas of the IC. These include: the input serial data register and control logic, a 140 bits two port RAM, and an internal multiplexer/display driver.

Figure 7. Block diagram



The following explains how to format the serial data to be loaded into the display. The user supplies a string of bit mapped decoded characters. The contents of this string is shown in Figure 8a. Figure 8b shows that each character consist of eight 8 bit words. The first word encodes the display character location and the succeeding seven bytes are row data. The row data represents the status (On, Off) of individual column LEDs. Figure 8c shows that each 8 bit word is formatted to represent Character Address, or Column Data.

Figure 8d shows the sequence for loading the bytes of data. Bringing the $\overline{\text{LOAD}}$ line low enables the serial register to accept data. The shift action occurs on the low to high transition of the serial data clock (SDCLK). The least significant bit (D0) is loaded first. After eight clock pulses the $\overline{\text{LOAD}}$ line is brought high. With this transition the OPCODE is decoded. The decoded OPCODE directs D4–D0 to be latched in the Character Address register, stored in the RAM as Column data, or latched in the Control Word register. The control IC requires a minimum 600 ns delay between successive byte loads. As indicated in Figure 8a, a total of 256 bits of data are required to load all four characters into the display.

The Character Address Register bits, D4–D0 (Table 2), and Row Address Register bits, D7–D5 (Table 3), direct the Column Data bits, D4–D0 (Table 3) to specific RAM location.

Table 1 shows the Row Address for the example character "D." Column data is written and read asynchronously from the 140 bit RAM. Once loaded the internal oscillator and character multiplexer reads the data from the RAM. These characters are row strobed with column data as shown in Figures 9 and 10. The character strobe rate is determined by the internal or user supplied external MUX Clock and the IC's ÷ 320 counter.

Table 1. Character "D"

	Op code D7	D6	D5	Column Data D4 C0	D3 C1	D2 C2	D1 C3	D0 C4	Hex
Row 0	0	0	0	1	1	1	1	0	1E
Row 1	0	0	0	1	0	0	0	1	11
Row 2	0	0	0	1	0	0	0	1	11
Row 3	0	0	0	1	0	0	0	1	11
Row 4	0	0	0	1	0	0	0	1	11
Row 5	0	0	0	1	0	0	0	1	11
Row 6	0	0	0	1	1	1	1	0	1E

Figure 8. Loading serial character data

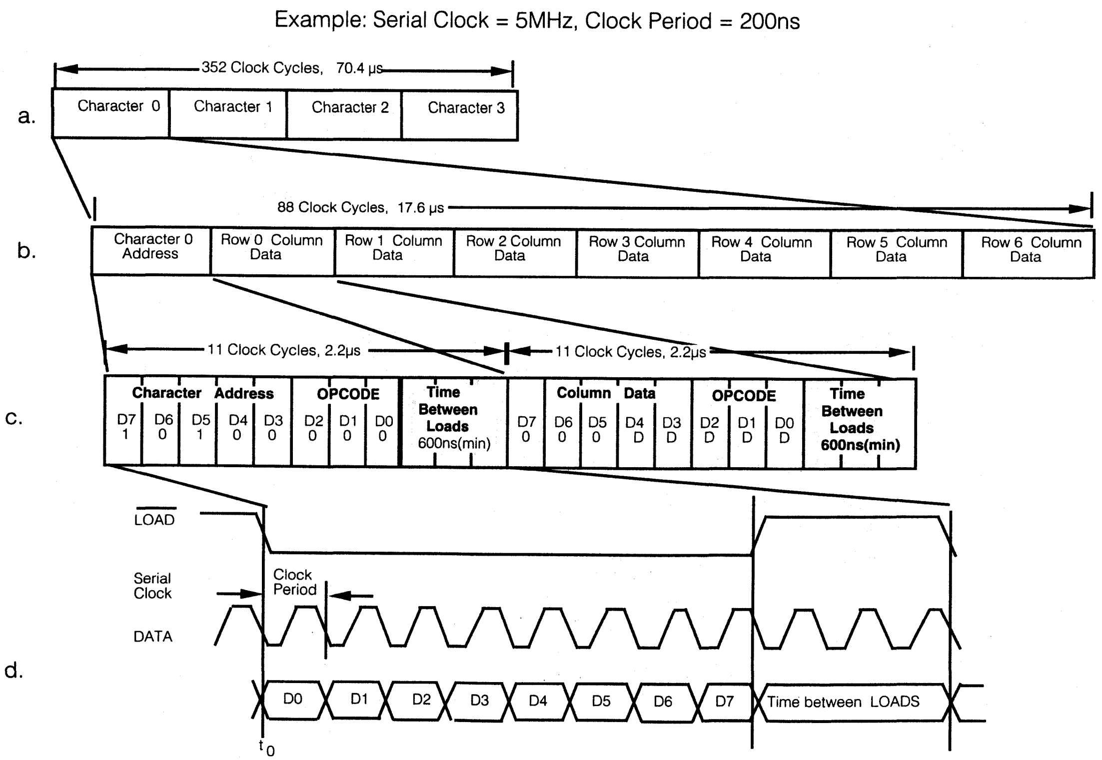


Table 2. Load character address

Op code D7 D6 D5	Character Address D4 D3 D2 D1 D0	Hex	Operation Load
1 0 1	0 0 0 0 0	A0	Character 0
1 0 1	0 0 0 0 1	A1	Character 1
1 0 1	0 0 0 1 0	A2	Character 2
1 0 1	0 0 0 1 1	A3	Character 3

Table 3. Load column data

Op code D7 D6 D5	Column Data D4 D3 D2 D1 D0	Operation Load
0 0 0	C0 C1 C2 C3 C4	Row 0
0 0 0	C0 C1 C2 C3 C4	Row 1
0 0 0	C0 C1 C2 C3 C4	Row 2
0 0 0	C0 C1 C2 C3 C4	Row 3
0 0 0	C0 C1 C2 C3 C4	Row 4
0 0 0	C0 C1 C2 C3 C4	Row 5
0 0 0	C0 C1 C2 C3 C4	Row 6

The user can activate four Control functions. These include: LED Brightness Level, IC Power Down, Prescaler, or Display Clear. OPCODEs and six bit words are used to initiate these functions. The OPCODEs and Control Words for the Character Address and Loading Column Data are shown in Tables 2 and 3.

The user can select eight specific LED brightness levels, Tables 4 and 5. Depending on how D3 is selected either one (1) for maximum peak current or zero (0) for 12.5% of maximum peak current in the control word per Tables 4 and 5, the user can select 16 specific LED brightness levels. These brightness levels (in percentages of full brightness of the display) depending on how the user selects D3 can be one (1) or zero (0) are as follows: 100% ($E0_{HEX}$ or $E8_{HEX}$), 53% ($E1_{HEX}$ or $E9_{HEX}$), 40% ($E2_{HEX}$ or EA_{HEX}), 27% ($E3_{HEX}$ or EB_{HEX}), 20% ($E4_{HEX}$ or EC_{HEX}), 13% ($E5_{HEX}$ or ED_{HEX}), and 6.6% ($E6_{HEX}$ or EE_{HEX}), 0.0% ($E7_{HEX}$ or EF_{HEX}). The brightness levels are controlled by changing the duty factor of the row strobe pulse.

The SCF574X offers a unique Display Power Down feature which reduces I_{CC} to less than 50 µA. When EF_{HEX} is loaded (Table 6) the display is set to 0% brightness. When in the Power Down mode data may still be written into the RAM. The display is reactivated by loading a new brightness Level Control Word into the display.

Table 4. Display brightness

Op code D7 D6	Control Word D5 D4 D3 D2 D1 D0	Hex	Operation Level
1 1	1 0 0 0 0 0	E0	100%
1 1	1 0 0 0 0 1	E1	53%
1 1	1 0 0 0 1 0	E2	40%
1 1	1 0 0 0 1 1	E3	27%
1 1	1 0 0 1 0 0	E4	20%
1 1	1 0 0 1 0 1	E5	13%
1 1	1 0 0 1 1 0	E6	6.6%
1 1	1 0 0 1 1 1	E7	0.0%

Table 5. Display brightness

Op code D7 D6	Control Word D5 D4 D3 D2 D1 D0	Hex	Operation Level
1 1	1 0 1 0 0 0	E8	100%
1 1	1 0 1 0 0 1	E9	53%
1 1	1 0 1 0 1 0	EA	40%
1 1	1 0 1 0 1 1	EB	27%
1 1	1 0 1 1 0 0	EC	20%
1 1	1 0 1 1 0 1	ED	13%
1 1	1 0 1 1 1 0	EE	6.6%
1 1	1 0 1 1 1 1	EF	0.0%

Table 6. Power down

Op code D7 D6	Control Word D5 D4 D3 D2 D1 D0	Hex	Operation Level
1 1	1 0 1 1 1 1	EF	0% brightness

Figure 9. Row and column locations for a character "D"

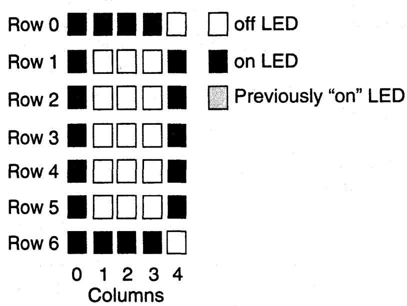
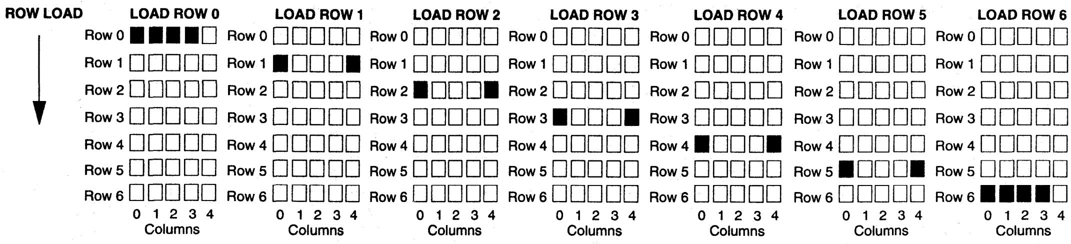


Figure 10. Row strobing



The SCF574X allows a high frequency external oscillator source to drive the display. Data bit, D4, in the control word format controls the prescaler function. The prescaler allows the oscillator source to be divided by 16 by setting D4=1. However, the prescaler should not be used, i.e., when using the internal oscillator source.

The Software Clear (CO_{HEX}), given in Table 7, clears the Address Register and the RAM. The display is blanked and the Character Address Register will be set to Character 0. The internal counter and the Control Word Register are unaffected. The Software Clear will remain active until the next data input cycle is initiated.

Table 7. Software clear

Op code D7 D6	Control Word D5 D4 D3 D2 D1 D0	Hex	Operation
1 1	0 0 0 0 0 0	C0	CLEAR

Multiplexer and Display Driver

The four characters are row multiplexed with RAM resident column data. The strobe rate is established by the internal or external MUX Clock rate. The MUX Clock frequency is divided by a 448 counter chain. This results in a typical strobe rate of 768 Hz. By pulling the Clock SEL line low, the display can be operated from an external MUX Clock. The external clock is attached to the CLK I/O connection (pin 9). The maximum external MUX Clock frequency should be limited to 1 MHz.

An asynchronous hardware Reset (pin 8) is also provided. Bringing this pin low will clear the Character Address Register, Control Word Register, RAM, and blanks the display. This action leaves the display set at Character Address 0, and the Brightness Level set at 100%.

Electrical and Mechanical Considerations
Thermal Considerations

Optimum product performance can be had when the following electrical and mechanical recommendations are adopted. The SCF574X's IC is constructed in a high speed CMOS process, consequently high speed noise on the SERIAL DATA, SERIAL DATA CLOCK, LOAD and RESET lines may cause incorrect data to be written into the serial shift register. Adhere to transmission line termination procedures when using fast line drivers and long cables (>10 cm).

Good ground (pin 2) and power supply decoupling (pins 9 and 10) will insure that I_{CC} (<400 mA peak) switching currents do not generate localized ground bounce. Therefore it is recommended that each display package use a 0.1 µF and 20 µF capacitor between V_{CC} and ground.

When the internal MUX Clock is being used connect the CLKSEL pin to V_{CC}. In those applications where RESET will not be connected to the system's reset control, it is recommended that this pin be connected to the center node of a series 0.1, µF and 100 KΩ RC network. Thus upon initial power up the RESET will be held low for 10 ms allowing adequate time for the system power supply to stabilize.

ESD Protection

The input protection structure of the SCF574X provides significant protection against ESD damage. It is capable of withstanding discharges greater than 2 KV. Take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The SCF574X can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Exercise care in choosing solvents as some may chemically attack the nylon package. For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book. See Appnote 19, Table 2, "Displays–Group 2" for the SCDV554X.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 14 pin DIP sockets .300" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardward, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

Optical Considerations

The 0.270" high character of the SCF574X gives readability up to five feet. Proper filter selection enhances readability over this distance.

Using filters emphasizes the contrast ratio between a lit LED and the character background. This will increase the discrimination of different characters. The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios. The SCF5740 is a red display and should be used with long wavelength pass filter having a sharp cut-off in the 600 nm to 620 nm range. The SCF5742 is a high efficiency red display and should be used with long wavelength pass filter having a sharp cut-off in the 570 nm to 600 nm range. The SCF5744 is a high efficiency green display and should be used with long wavelength pass filter that peaks at 565 nm.

Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Microprocessor Interface

The microprocessor interface is through the serial port, SPI port or one out of eight data bits on the eight bit parallel port and also control lines $\overline{\text{SDCLK}}$ and $\overline{\text{LOAD}}$.

Power Up Sequence

Upon power up display will come on at random. Thus the display should be reset at power-up. The reset will set the Address Register to Digit 0, User RAM is set to 0 (display blank) the Control Word is set to 0 (100% brightness) and the internal counters are reset.

Figure 11. Display interface to Siemens/Intel 8031 microprocessor (using serial port in mode 0)

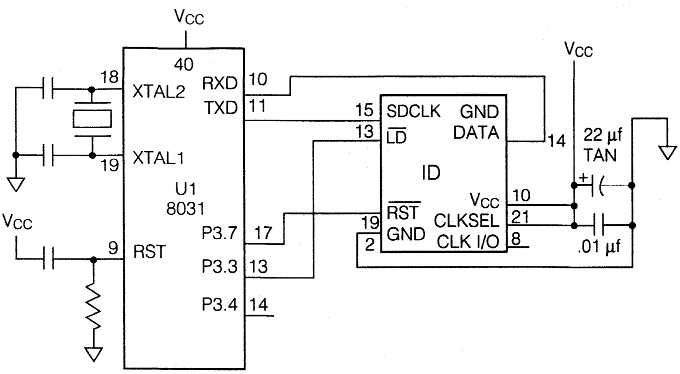


Figure 12. Display interface to Siemens/Intel 8031 microprocessor
(using one bit of parallel port as serial port)

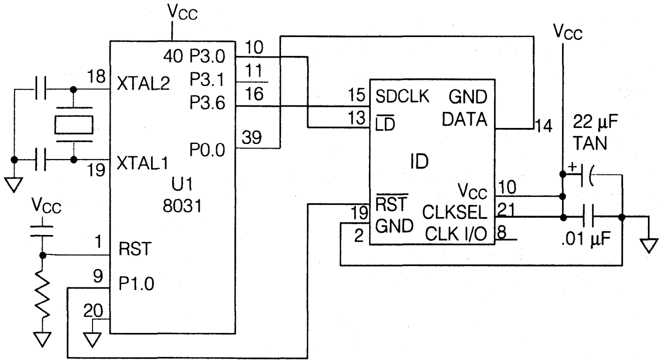


Figure 13. Display interface with Motorola 68HC05C4 microprocessor
(using SPI port)

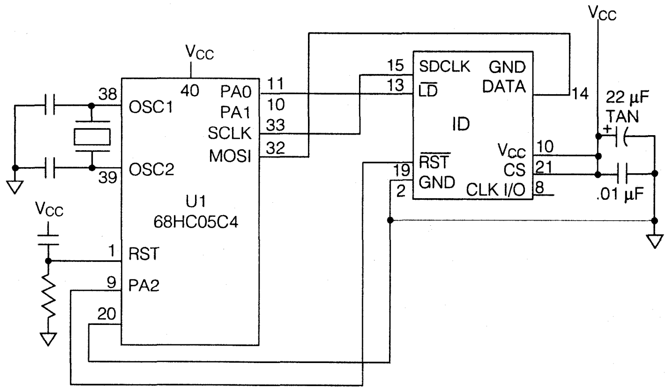
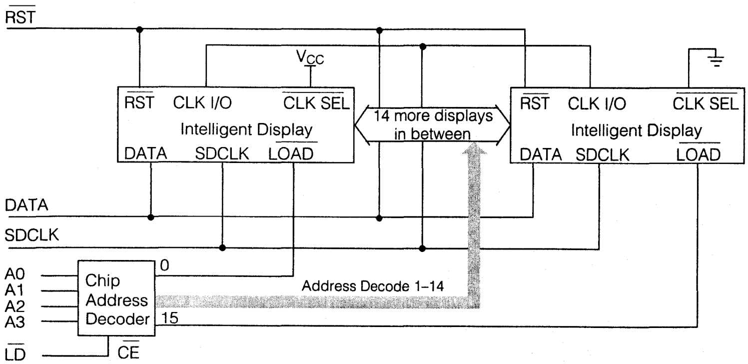


Figure 14. Cascading multiple displays



Multiple displays can be cascaded using the $\overline{\text{CLK SEL}}$ and CLK I/O pins (Figure 14). The display designated as the MasterClock source should have its $\overline{\text{CLK SEL}}$ pin tied high and the slaves should have their $\overline{\text{CLK SEL}}$ pins tied low. All CLK I/O pins should be tied together. One display CLK I/O can drive 15 slave CLK I/Os. Use $\overline{\text{RST}}$ to synchronize all display counters.

Loading Data into the Display

Use following procedure to load data into the display:

1. Power up the display.
2. Bring $\overline{\text{RST}}$ low (600 ns duration minimum) to clear the Multiplex Counter, Address Register, Control Word Register, User Ram and Data Register. The display will be blank. Display brightness is set to 100%.
3. If a different brightness is desired, load the proper brightness opcode into the Control Word Register.
4. Load the Digit Address into the display.
5. Load display row and column data for the selected digit.
6. Repeat steps 4 and 5 for all digits.

Data contents for the word "ABCD"

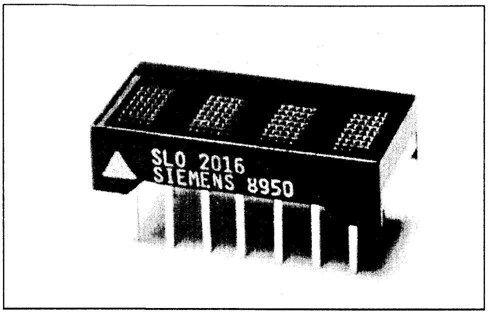
Step	D7	D6	D5	D4	D3	D2	D1	D0	Function
A	1	1	0	0	0	0	0	0	CLEAR
B (optional)	1	1	1	0	0	0	0	0	100% BRIGHTNESS
1	1	0	1	0	0	0	0	0	DIGIT D0 SELECT
2	0	0	0	0	0	1	0	0	ROW 0 (A)
3	0	0	0	0	1	0	1	0	ROW 1 (A)
4	0	0	0	1	0	0	0	1	ROW 2 (A)
5	0	0	0	1	1	1	1	1	ROW 3 (A)
6	0	0	0	1	0	0	0	1	ROW 4 (A)
7	0	0	0	1	0	0	0	1	ROW 5 (A)
8	0	0	0	1	0	0	0	1	ROW 6 (A)
9	1	0	1	0	0	0	0	1	DIGIT D1 SELECT
10	0	0	0	1	1	1	1	1	ROW 0 (B)
11	0	0	0	1	0	0	0	1	ROW 1 (B)
12	0	0	0	1	0	0	0	1	ROW 2 (B)
13	0	0	0	1	1	1	1	0	ROW 3 (B)
14	0	0	0	1	0	0	0	1	ROW 4 (B)
15	0	0	0	1	0	0	0	1	ROW 5 (B)
16	0	0	0	1	1	1	1	1	ROW 6 (B)
17	1	0	1	0	0	0	1	0	DIGIT D2 SELECT
18	0	0	0	0	0	1	1	1	ROW 0 (C)
19	0	0	0	0	1	0	0	0	ROW 1 (C)
20	0	0	0	1	0	0	0	0	ROW 2 (C)
21	0	0	0	1	0	0	0	0	ROW 3 (C)
22	0	0	0	1	0	0	0	0	ROW 4 (C)
23	0	0	0	0	1	0	0	0	ROW 5 (C)
24	0	0	0	0	0	1	1	1	ROW 6 (C)
25	1	0	1	0	0	0	1	1	DIGIT D3 SELECT
26	0	0	0	1	1	1	1	0	ROW 0 (D)
27	0	0	0	1	0	0	0	1	ROW 1 (D)
28	0	0	0	1	0	0	0	1	ROW 2 (D)
29	0	0	0	1	0	0	0	1	ROW 3 (D)
30	0	0	0	1	0	0	0	1	ROW 4 (D)
31	0	0	0	1	0	0	0	1	ROW 5 (D)
32	0	0	0	1	1	1	1	0	ROW 6 (D)

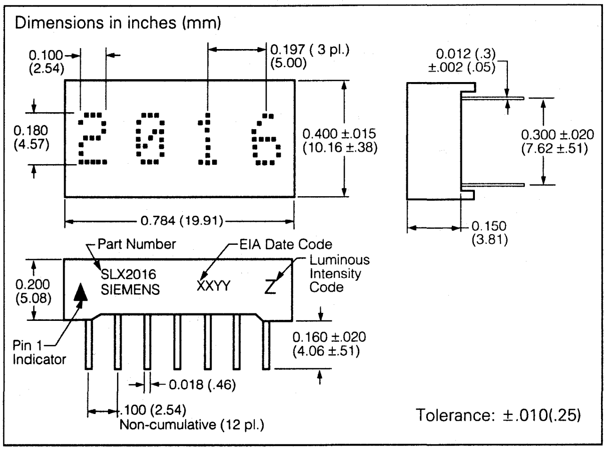
SIEMENS

RED SLR2016
HIGH EFFICIENCY RED SLO2016
GREEN SLG2016
YELLOW SLY2016

X/Y Stackable 0.180" 4-Digit 5x7 Dot Matrix Alphanumeric Intelligent Display® Devices with Memory/Decoder/Driver

Preliminary





FEATURES

- **Very Close Multi-line Spacing, 0.4" Centers**
- **0.180" 5x7 Dot Matrix Characters**
- **128 Special ASCII Characters for English, German, Italian, Swedish, Danish, and Norwegian Languages**
- **Wide Viewing Angle: X axis 50° Maximum, Y Axis ±75° Maximum**
- **Fast Access Time, 110 ns at 25°C**
- **Full Size Display for Stationary Equipment**
- **Built-in Memory**
- **Built-in Character Generator**
- **Built-in Multiplex and LED Drive Circuitry**
- **Direct Access to Each Digit Independently and Asynchronously**
- **Clear Function that Clears Character Memory**
- **True Blanking for Intensity Dimming Applications**
- **End-stackable, 4-Character Package**
- **Intensity Coded for Display Uniformity**
- **Extended Operating Temperature Range: –40°C to +85°C**
- **Superior ESD Immunity**
- **100% Burned-in and Tested**
- **Wave Solderable**
- **TTL Compatible over Operating Temperature Range**

See Appnotes 18, 19, 22, and 23 for additional information.

DESCRIPTION

The SLR/SLO/SLG/SLY2016 is a four digit 5x7 dot matrix display module with a built-in CMOS integrated circuit. This display is X/Y stackable.

The integrated circuit contains memory, a 128 ASCII ROM decoder, multiplexing circuitry and drivers. Data entry is asynchronous. A display system can be built using any number of SLR/SLO/SLG/SLY2016 since each digit can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is very straightforward. Two address bits (A0, A1) are normally connected to the like-named inputs of all displays in the system.

Data lines are connected to all SLR/SLO/SLG/SLY2016s directly and in parallel as is the write line ($\overline{WR}$). The display will then behave as a write-only memory.

The SLR/SLO/SLG/SLY2016 has several features superior to competitive devices. 100% burn-in processing insures that the SLR/SLO/SLG/SLY2016 will function in more stressful assembly and use environments. True "blanking" allows the designer to dim the display for more flexibility of display presentation. Finally the $\overline{CLR}$ clear function will clear the ASCII character RAM.

The character set consists of 128 special ASCII characters for English, German, Italian, Swedish, Danish, and Norwegian.

All products are 100% burned-in and tested, then subjected to outgoing AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

Maximum Ratings

DC Supply Voltage .... –0.5 V to +7.0 Vdc
Input Voltage, Respect to GND
(all inputs) .... –0.5 V to V_{CC} +0.5 Vdc
Operating Temperature .... –40°C to +85°C
Storage Temperature .... –40°C to +100°C
Relative Humidity at 85°C 85%
Maximum Solder Temperature, 0.063" (1.59 mm)
below Seating Plane, t<5 sec .... 260°C

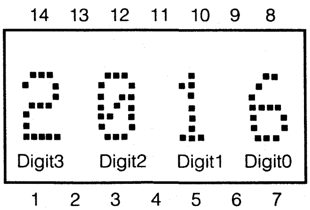
Optical Characteristics

Spectral Peak Wavelength
Red .... 660 nm typ.
HER .... 635 nm typ.
Green .... 565 nm typ.
Yellow .... 585 nm typ.
Digit Height .... 0.180" (4.57 mm)
Time Averaged Luminous Intensity [1]
at V_{CC}=5 V
Red .... 50 µcd/LED min.
HER/Yellow .... 60 µcd/LED min.
Green .... 75 µcd/LED min.
LED to LED Intensity Matching, V_{CC}=5 V .... 1.8:1.0 max.
Viewing Angle (off normal axis)
Horizontal .... ±50° max.
Vertical .... ±75° max.

Note:

1) Peak luminous intensity values can be calculated by multiplying these values by 7.

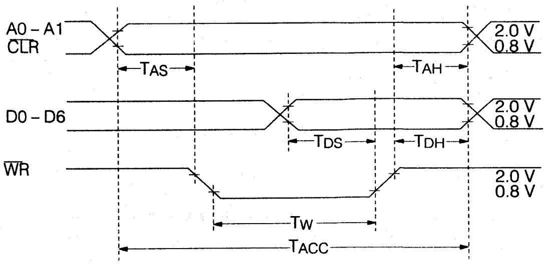
Figure 1. Top view



Pin function

Pin	Function	Pin	Function
1	$\overline{WR}$ Write	8	D3 Data
2	A1 Digit Select	9	D4 Data
3	A0 Digit Select	10	D5 Data
4	V_{CC}	11	D6 Data
5	D0 Data	12	$\overline{BL}$ Display Blank
6	D1 Data	13	$\overline{CLR}$ Clear
7	D2 Data	14	GND

Figure 2. Timing characteristics—write cycle waveforms



DC characteristics at 25°C

Parameters	Min.	Typ.	Max.	Units	Conditions
V_{CC}	4.5	5.0	5.5	V	
I_{CC} Blank		2.3	3.0	mA	V_{CC}=5.0 V
I_{CC} (80 dots on)		80	105	mA	V_{CC}=5.0 V
V_{IL} (all inputs)			0.8	V	4.5 V <V_{CC} <5.5 V
V_{IH} (all inputs)	2.0			V	4.5 V <V_{CC} <5.5 V
I_{IL} (all inputs)	25		100	µA	4.5 V <V_{CC} <5.5 V, V_{IN}=0.8 V

AC characteristics (guaranteed minimum timing parameters at V_{CC}=5.0 V ±0.5 V)

Parameter	Symbol	–40°C	+25°C	+85°C	Unit
Address Set Up Time	T_{AS}	10	10	10	ns
Write Time	T_W	60	70	90	ns
Data Set Up Time	T_{DS}	20	30	50	ns
Address Hold Time	T_{AH}	20	30	40	ns
Data Hold Time	T_{DH}	20	30	40	ns
Access Time	T_{ACC} [1]	90	110	140	ns
Clear Disable Time	T_{CLRD}	1	1	1	µs
Clear Time	T_{CLR}	1	1	1	ms

Note:

1) T_{ACC}=Set Up Time + Write Time + Hold Time

Loading Data

The desired data code (D0–D6) and digit address (A0, A1) must be held stable during the write cycle for storing new data.

Data entry may be asynchronous. Digit 0 is defined as right hand digit with A1=A2=0.`

Clearing the entire internal four-digit memory can be accomplished by holding the clear ($\overline{CLR}$) low for 1 msec minimum. The clear function will clear the ASCII RAM. Loading an illegal data code will display a blank.

Typical loading state table

WR	A1	A0	D6	D5	D4	D3	D2	D1	D0	Digit			
										3	2	1	0
H			previously loaded display							G	R	E	Y
L	L	L	H	L	L	L	H	L	H	G	R	E	E
L	L	H	H	L	H	L	H	L	H	G	R	U	E
L	H	L	H	L	L	H	H	L	L	G	L	U	E
L	H	H	H	L	L	L	L	H	L	B	L	U	E
L	L	H	H	L	L	L	H	L	H	B	L	E	E
L	L	L	H	L	H	L	H	H	H	B	L	E	W
L	X	X	see character code							see char. set			

Display Blanking

Blank the display by loading a blank or space into each digit of the display or by using the ($\overline{BL}$) display blank input. Setting the ($\overline{BL}$) input low does not affect the contents of data memory.

A flashing circuit can easily be constructed using a 555 astable multivibrator. Figure 3 illustrates a circuit in which varying R1 (100K~10K) will have a flash rate of 1 Hz~10 Hz.

The display can be dimmed by pulse width modulating the ($\overline{BL}$) at a frequency sufficiently fast to not interfere with the internal clock. The dimming signal frequency should be 2.5 KHz or higher. Dimming the display also reduces power consumption.

An example of a simple dimming circuit using a 556 is illustrated in Figure 4. Adjusting potentiometer R3 will dim the display by changing the blanking pulse duty cycle.

Figure 3. Flashing circuit using a 555 and flashing (blanking) timing

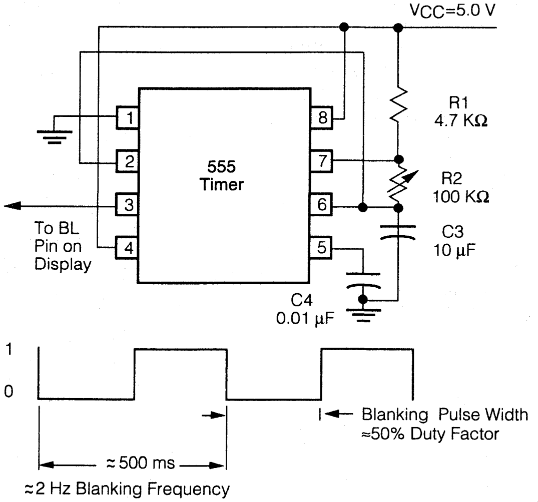


Figure 4. Dimming circuit using a 556 and dimming (blanking) timing

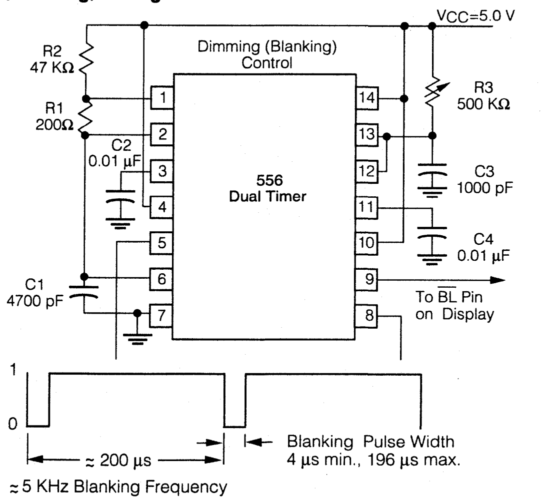
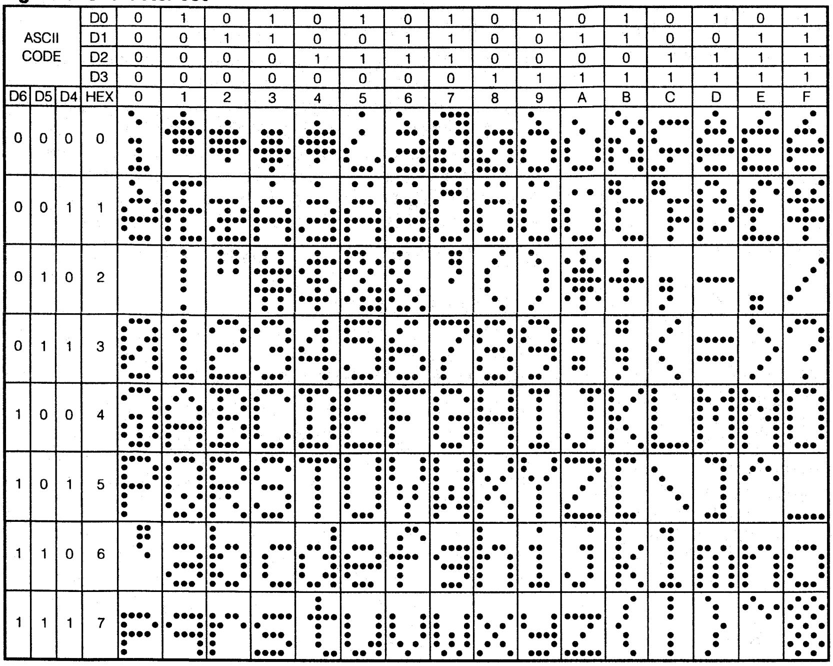
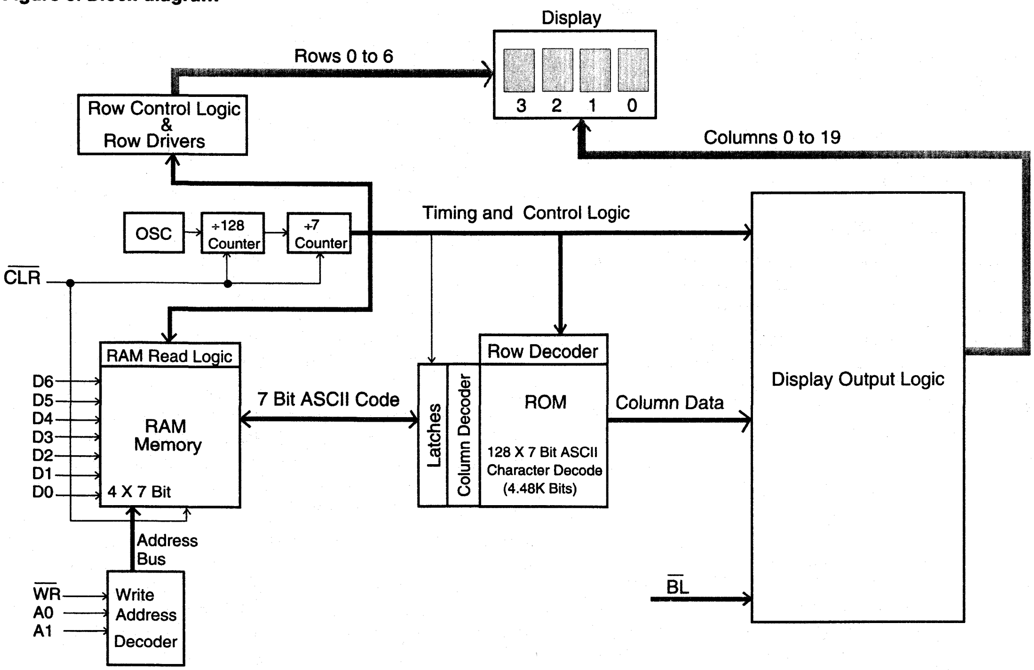


Figure 5. Character set



Notes:
1. High=1 level
2. Low=0 level
3. Upon power up, the device will initialize in a random state.

Figure 6. Block diagram



Design Considerations

For details on design and applications of the SLX2016 in multiple display systems, refer to Appnote 15 in the current Siemens Optoelectronics Data Book.

Electrical & Mechanical Considerations

Voltage Transient Suppression

We recommend that the same power supply be used for the display and the components that interface with the display to avoid logic inputs higher than V_{CC}. Additionally, the LEDs may cause transients in the power supply line while they change display states. The common practice is to place .01 mF capacitors close to the displays across V_{CC} and GND, one for each display, and one 10 µF capacitor for every second display.

ESD Protection

The CMOS IC of the SLX2016 is resistant to ESD damage and capable of withstanding discharges less than 2 KV. However, take all the standard precautions, normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. If these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

Soldering Considerations

The SLX2016 can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C ±5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C for five seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

Post Solder Cleaning Procedures

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Carefully select any solvent as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichorotrifluorethane), TA, 111 Trichloroethane, and unheated acetone.

Note:

Acceptable commercial solvents are: Basic TF, Arklone, P. Genesolv, D. Genesolv DA, Blaco-Tron TF, Blaco-Tron TA, and Freon TA.

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, or TES. Since many commercial mixtures exist, contact a solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ; Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Siemens Appnotes 18 and 19.

An alternative to soldering and cleaning the display modules is to use sockets. Standard pin DIP sockets .300" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Siemens Appnote 22.

Optical Considerations

The .180" high characters of the SLX2016 gives readability up to eight feet. Proper filter selection enhances readability over this distance.

Filters enhance the contrast ratio between a lit LED and the character background intensifying the discrimination of different characters.The only limitation is cost. Take into consideration the ambient lighting environment for the best cost/benefit ratio for filters.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are an inexpensive and effective way to strengthen contrast ratios.The SLR2016 is a standard red display and should be matched with long wavelength pass filter in the 600 nm to 620 nm range.

The SLO2016 is a high efficiency red display and should be matched with a long wavelength pass filter in the 470 nm to 590 range. The SLG/SLY2016 should be matched with a yellow-green band-pass filter that peaks at 565 nm. For displays of multiple colors, neutral density gray filters offer the best compromise.

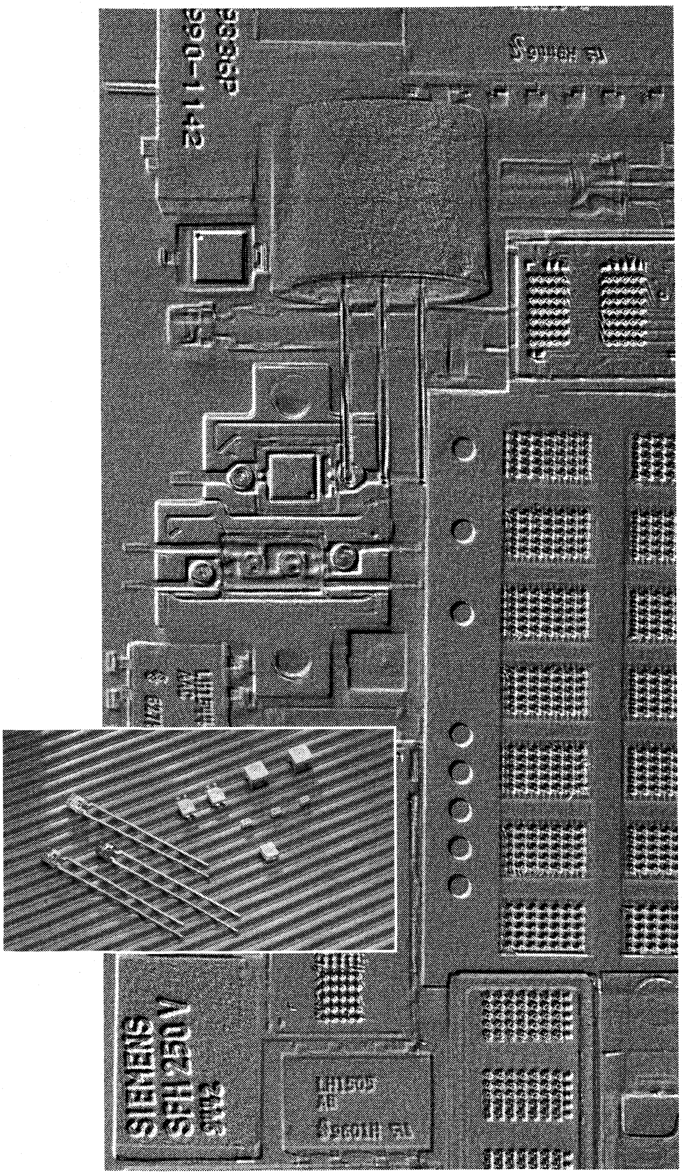
Additional contrast enhancement is gained by shading the displays. Plastic band-pass filters with built-in louvers offer the next step up in contrast improvement. Plastic filters can be improved further with anti-reflective coatings to reduce glare. The trade-off is fuzzy characters. Mounting the filters close to the display reduces this effect. Take care not to overheat the plastic filter by allowing for proper air flow.

Optimal filter enhancements are gained by using circular polarized, anti-reflective, band-pass filters. Circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY, Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters: recessing displays and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Refer to Siemens Appnote 23 for further information.



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Photodiodes

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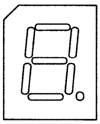
Photovoltaic Cells

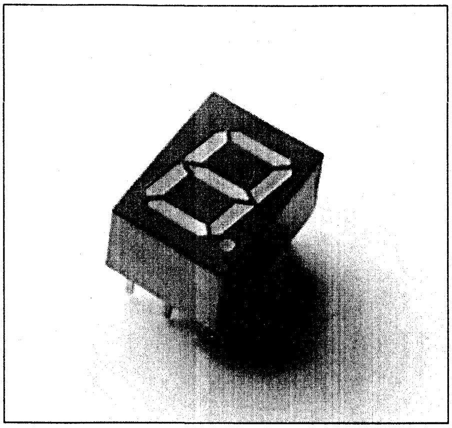
Application Notes

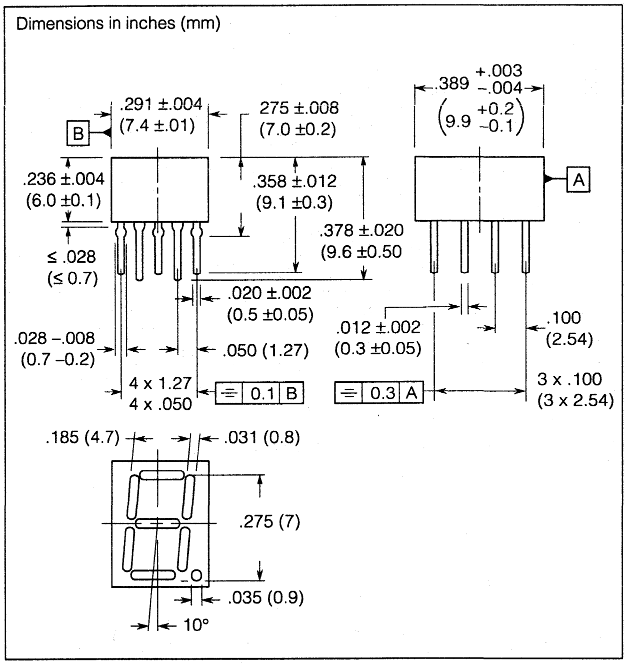
LED Numeric Displays

Package Type	Package Outline	Part Number	Character Height	Description	Polarity	Color	Luminous Intensity per Segment		Page
							µcd (typ.)	mA	
Compact single digit encapsu-lated (filled reflector)		HD1075R HD1077R	0.28" (7 mm)	7 segment, decimal point right	C.A. C.C.	Red	550	10	3–1
		HD1075O HD1077O			C.A. C.C.	Super-red	2500		
		HD1075G HD1077G			C.A. C.C.	Green	3000		
Compact single digit encapsu-lated (filled reflector)		HD1105R HD1107R	0.39" (10 mm)	7 segment, decimal point right	C.A. C.C.	Red	550	10	3–3
		HD1105O HD1107O			C.A. C.C.	Super-red	2500		
		HD1105G HD1107G			C.A. C.C.	Green	3000		
Compact single digit encapsu-lated (filled reflector)		HD1131R HD1133R	0.53" (13.5 mm)	7 segment, decimal point right	C.A. C.C.	Red	550	10	3–5
		HD1131O HD1133O			C.A. C.C.	Super-red	1100		
		HD1131G HD1133G			C.A. C.C.	Green			
Single digit encapsu-lat-ed (filled reflector), low current		HDN1075O HDN1077O	0.28" (7 mm)	7 segment, decimal point right	C.A. C.C.	Super-red	260	10	3–7
Single digit encapsu-lated (filled reflector), low current		HDN1105O HDN1107O	0.39" (10 mm)	7 segment, decimal point right	C.A. C.C.	Super-red	260	10	3–8
Single digit encapsu-lated (filled reflector), low current		HDN1131O HDN1133O	0.53" (13.5 mm)	7 segment, decimal point right	C.A. C.C.	Super-red	260	10	3–9

SIEMENS

RED HD1075R/1077R
SUPER-RED HD1075O/1077O
GREEN HD1075G/1077G
Common Anode/Common Cathode
0.28″ (7 mm) Seven Segment Numeric Display





FEATURES
- **Rugged Encapsulated Package**
- **0.28″ (7 mm) Digit Height**
- **Choice of Colors: Red, Super-Red, Green**
- **Common Anode or Common Cathode**
- **Wide Viewing**
- **Intensity Coded for Display Uniformity**

DESCRIPTION
The HD1075X/1077X are displays with 0.28 inch (7 mm) digits with either a common anode or common cathode and a right hand decimal point.

These displays have good viewing and can be used in electronic instruments, point-of-sale systems, clocks, and other general industrial and consumer applications. All displays have a light gray face.

Contrast enhancement filters are recommended for use with these displays.

Maximum Ratings
Operating Temperature (T_{OP}) .... 0°C to +85°C
Storage Temperature (T_{STG}) .... –40°C to +85°C
Lead Soldering Temperature, 2 mm from base (T_S) t=3 s .... 260°C
Peak Forward Current per Segment or DP [(1)] (I_{FM}) t_P≤10 µs
HD1075/7R .... 500 mA
HD1075/7O/G .... 150 mA
DC Forward Current per Segment or DP [(2)] (I_F)
HD1075/7R .... 25 mA
HD1075/7O/G .... 17 mA
Pulse Peak Forward Current per Segment (I_{FM})
20% Duty Cycle .... 100 mA
Reverse Voltage per Segment or DP (V_R) .... 6 V
Total Power Dissipation (P_{TOT}) T_A≤45°C .... 400 mW

Notes:
1. Do not exceed maximum average current per segment (see graph of permissible pulse handling capability).
2. Derate maximum average current above T_A=75°C at 0.5 mA/°C per segment.

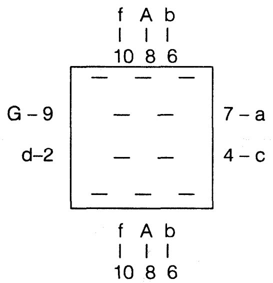
See graph numbers 1A, 2A, 3A, 5A, 6A, 7A, 8B, 9A, 11A beginning on page 3–10.

Characteristics (T_A=25°C)

Parameter		Symbol	Values Min.	Typ.	Max.	Unit	Condition
Luminous Intensity per Segment	HD1075/7R	I_V	180	550		µcd	I_F=10 mA
	HD1075/7O		700	2500			
	HD1075/7G		700	3000			
Peak Wavelength	HD1075/7R	λ_{PEAK}		660		nm	I_F=10 mA
	HD1075/7O			630			
	HD1075/7G			565			
Dominant Wavelength, Digit Average	HD1075/7R	λ_{DOM}		645		nm	
	HD1075/7O		612		625		
	HD1075/7G		562		575		
Forward Voltage per Segment (1)	HD1075/7R	V_F		1.6	2.0	V	I_F=20 mA
	HD1075/7O			2.0	3.0		
	HD1075/7G			2.4	3.0		
Breakdown Voltage per Segment(1)		V_{BR}	6	15		V	I_R=10 µA
Thermal Resistance		R_{thJA}			140	°C/W/Seg.	

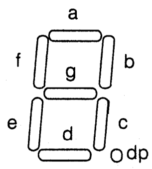
Notes:

1. AQL=0.4%.
2. Deviation of the absolute values within one digit $I_{VMAX}/I_{VMIN} \leq 2$



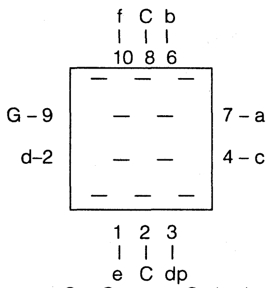
A = Common Anode

HD 1075
HDN 1075



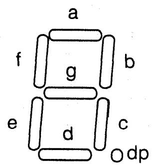
HD1075

1 Cathode E
2 Cathode D
3 Common Anode
4 Cathode C
5 Cathode DP
6 Cathode B
7 Cathode A
8 Common Anode
9 Cathode G
10 Cathode F



C = Common Cathode

HD 1077
HDN 1077

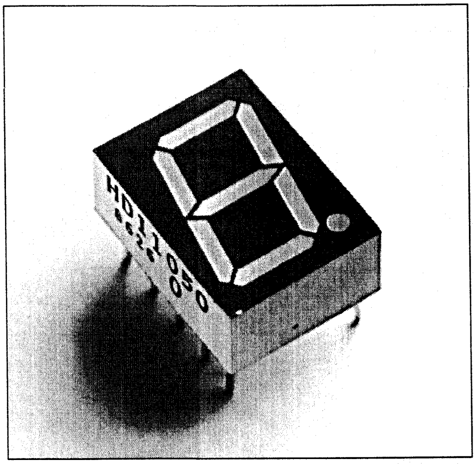


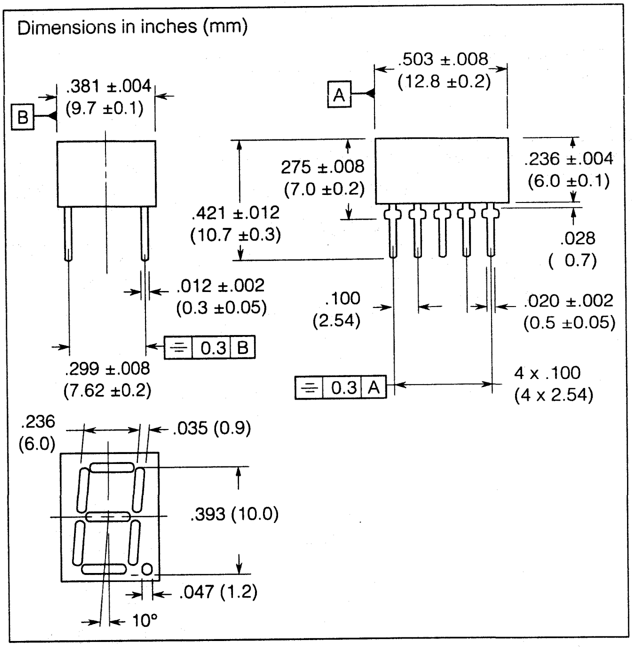
HD1077

1 Anode E
2 Anode D
3 Common Cathode
4 Anode C
5 Anode DP
6 Anode B
7 Anode A
8 Common Cathode
9 Anode G
10 Anode F

SIEMENS

RED HD1105R/1107R
SUPER-RED HD1105O/1107O
GREEN HD1105G/1107G
Common Anode/Common Cathode 0.39″ (10 mm) Seven Segment Numeric Display





FEATURES
- **Rugged Encapsulated Package**
- **0.39″ (10 mm) Digit Height**
- **Choice of Colors: Red, Super-Red, Green**
- **Common Anode or Common Cathode**
- **Wide Viewing**
- **Intensity Coded for Display Uniformity**

Description

The HD1105X/1107X are displays with 0.39 inch (10 mm) digits with either a common anode or common cathode and a right hand decimal point.

These displays were designed for viewing distances of up to 10 feet and can be used in electronic instruments, point-of-sale systems, clocks, and other general industrial and consumer applications. All displays have a light gray face.

Contrast enhancement filters are recommended for use with these displays.

Maximum Ratings

Operating Temperature (T_{OP}) .... 0°C to +85°C
Storage Temperature (T_{STG}) ....–40°C to +85°C
Lead Soldering Tempterature, 2 mm from base (T_S) t=3 s.............. 260°C
Peak Forward Current per Segment or DP [(1)] (I_{FM}) $t_P \leq 10\ \mu s$
HD1105/7R ....500 mA
HD1105/7O/G ....150 mA
DC Forward Current per Segment or DP [(2)] (I_F)
HD1105/7R ....30 mA
HD1105/7O/G ....20 mA
Reverse Voltage per Segment or DP (V_R) ....6 V
Total Power Dissipation (P_{TOT}) $T_A \leq 45°C4$ ....80 mW

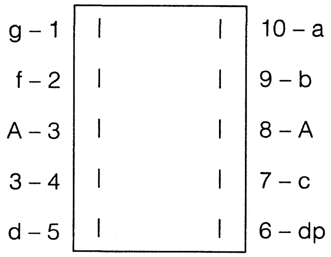
Notes:
1. Do not exceed maximum average current per segment (see graph of permissible pulse handling capability).
2. Derate maximum average current above T_A=75°C at 0.5 mA/°C per segment.

See graph numbers 1A, 2A, 3A, 5A, 6A, 8C, 8D, 9B, 11B at the end of this section.

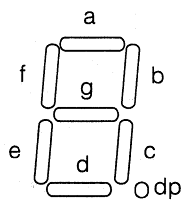
Characteristics (T_A=25°C)

Parameter		Symbol	Values			Unit	Condition
			Min.	Typ.	Max.		
Luminous Intensity per Segment	HD1105/7R	I_V	180	550		μcd	I_F=10 mA
	HD1105/7O		1100	3500			
	HD1105/7G		1100	4000			
Peak Wavelength	HD1105/7R	λ_{PEAK}		660		nm	I_F=10 mA
	HD1105/7O			630			
	HD1105/7G			565			
Dominant Wavelength, Digit Average	HD1105/7R	λ_{DOM}		645		nm	
	HD1105/7O		612		625		
	HD1105/7G		562		575		
Forward Voltage per Segment (1)	HD1105/7R	V_F		1.6	2.0	V	I_F=20 mA
	HD1105/7O			2.0	3.0		
	HD1105/7G			2.4	3.0		
Breakdown Voltage per Segment (1)		V_{BR}	6	15		V	I_R=10 μA
Thermal Resistance		R_{thJA}			120	°C/W/seg.	

Notes:
1. AQL=0.4%.
2. Deviation of the absolute values within one digit $I_{VMAX}/I_{VMIN} \leq 2$.

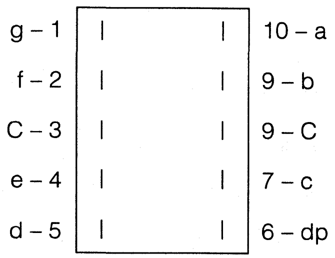


A = Common Anode

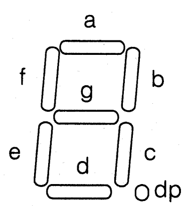


HD1105

1 Cathode G
2 Cathode F
3 Common Anode
4 Cathode E
5 Cathode D
6 Cathode DP
7 Cathode C
8 Common Anode
9 Cathode B
10 Cathode A



C = Common Cathode

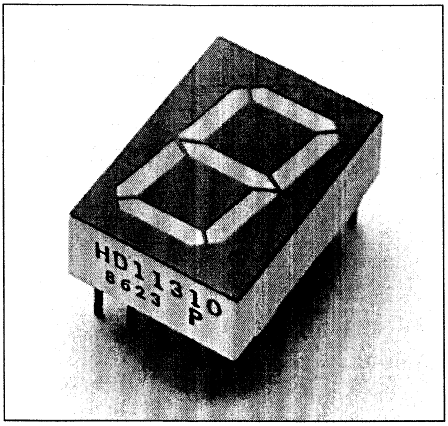


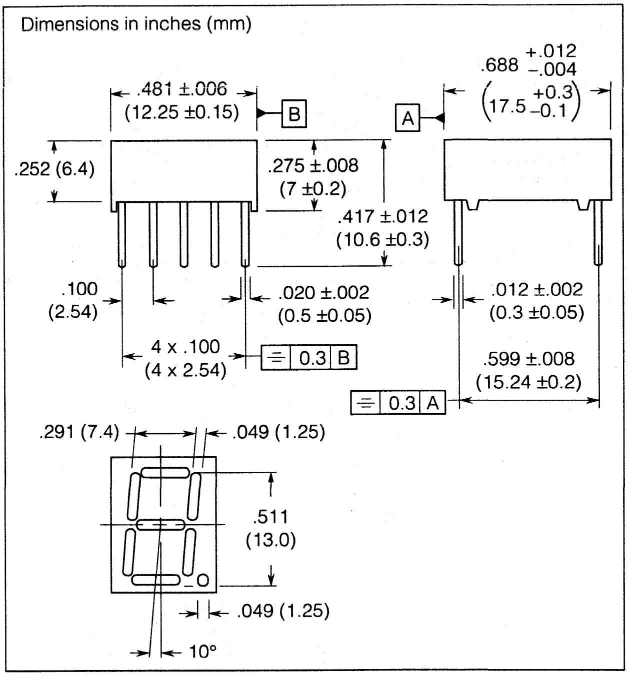
HD1107

1 Anode G
2 Anode F
3 Common Cathode
4 Anode E
5 Anode D
6 Anode DP
7 Anode C
8 Common Cathode
9 Anode B
10 Anode A

SIEMENS

RED HD1131R/1133R
SUPER-RED HD1131O/1133O
GREEN HD1131G/1133G
Common Anode/Common Cathode
0.53″ (13.5 mm) Seven Segment Numeric Display





FEATURES
- **Rugged Encapsulated Package**
- **0.53″ (13.5 mm) Digit Height**
- **Choice of Colors: Red, Super-Red, Green**
- **Common Anode or Common Cathode**
- **Wide Viewing**
- **Intensity Coded for Display Uniformity**

Description

The HD1131X/1133X are displays with 0.53 inch (13.5 mm) digits with either a common anode or common cathode and a right hand decimal point.

These displays were designed for viewing distances of up to 20 feet and can be used in electronic instruments, point-of-sale systems, clocks, and other general industrial and consumer applications. All displays have a light grey face.

Contrast enhancement filters are recommended for use with these displays.

Maximum Ratings

Operating Temperature (T_{OP}) .... 0°C to +85°C
Storage Temperature (T_{STG}) .... −40°C to +85°C
Lead Soldering Tempterature, 2 mm from base (T_S) t=3 s .... 260°C
Peak Forward Current per Segment or DP [(1)] (I_{FM}) $t_P \le 10$ µs
HD1131/3R .... 500 mA
HD1131/3O/G .... 150 mA
DC Forward Current per Segment or DP [(2)] (I_F)
HD1131/3R .... 35 mA
HD1131/3O/G .... 25 mA
Reverse Voltage per Segment or DP (V_R) .... 6 V
Total Power Dissipation (P_{TOT}) $T_A \le 45$°C .... 600 mW

Notes:
1. Do not exceed maximum average current per segment (see graph of permissible pulse handling capability).
2. Derate maximum average current above T_A=75°C at 0.5 mA/°C per segment.

See graph numbers 1A, 2A, 3A, 5A, 6A, 8E, 8F, 9C, 11C beginning on page 3–10.

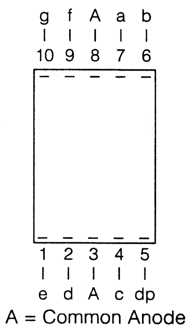
Characteristics (T_A=25°C)

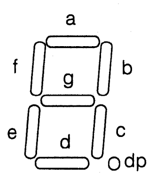
Parameter		Symbol	Values Min.	Typ.	Max.	Unit	Condition
Luminous Intensity per Segment	HD1131/3R	I_V	180	550		μcd	I_F=10 mA
	HD1131/3O		1100	4000			
	HD1131/3G		1100	4500			
Peak Wavelength,	HD1131/3R	λ_{PEAK}		660		nm	I_F=10 mA
	HD1131/3O			630			
	HD1131/3G			565			
Dominant Wavelength, Digit Average	HD1131/3R	λ_{DOM}		645		nm	
	HD1131/3O		612		625		
	HD1131/3G		562		575		
Forward Voltage per Segment (1)	HD1131/3R	V_F		1.6	2.0	V	I_F=20 mA
	HD1131/3O			2.0	3.0		
	HD1131/3G			2.4	3.0		
Breakdown Voltage per Segment (1)		V_{BR}	6	15		V	I_R=10 μA
Thermal Resistance		R_{thJA}			100	°C/W/seg.	

Notes:

1. AQL=0.4%.
2. Deviation of the absolute values within one digit $I_{VMAX}/I_{VMIN} \leq 2$.

HD 1131

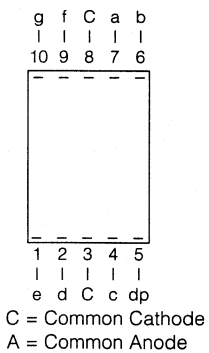


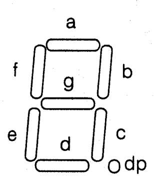


HD1131

1 Cathode E
2 Cathode D
3 Common Anode
4 Cathode C
5 Cathode DP
6 Cathode B
7 Cathode A
8 Common Anode
9 Cathode F
10 Cathode G

HD 1133





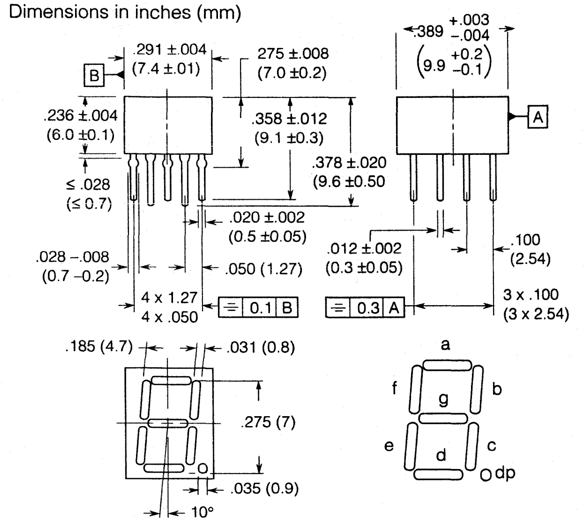
HD1133

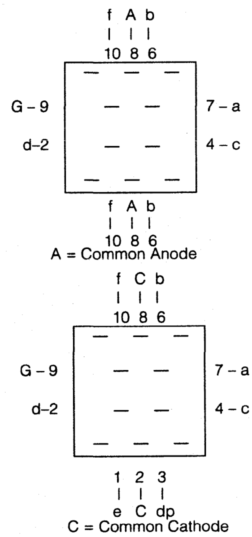
1 Anode E
2 Anode D
3 Common Cathode
4 Anode C
5 Anode DP
6 Anode B
7 Anode A
8 Common Cathode
9 Anode F
10 Anode G

SIEMENS

SUPER-RED HDN1075O/1077O

0.28" (7 mm) Seven Segment Numeric Display Low Current





HDN1075

1 Cathode E
2 Cathode D
3 Common Anode
4 Cathode C
5 Cathode DP
6 Cathode B
7 Cathode A
8 Common Anode
9 Cathode G
10 Cathode F

HDN1077

1 Anode E
2 Anode D
3 Common Cathode
4 Anode C
5 Anode DP
6 Anode B
7 Anode A
8 Common Cathode
9 Anode G
10 Anode F

FEATURES

- **Current Consumption 2 mA**
- **Direct Drive by CMOS Microprocessor, Gate and LSTTL Modules**
- **Space Saving**
- **Lower Assembly Costs**
- **No Display and LED Driver Modules**
- **Good Readability in Unfavorable Lighting Conditions**
- **Climate Proof**
- **High Packing Density**
- **Gray Package for Optimal Contrast**
- **Long Service Life**
- **Shock and Vibration Resistant**

Description

The HDN1075/1077 are one digit, seven segment, low current LED displays. The character height is 0.28″ (7 mm). The displays are available in super-red.

Applications include state-of-the-art industrial and consumer electronics, especially where low current consumption is required, i.e., portable appliances and battery-operated appliances.

See graph numbers 1A, 2A, 4A, 5B, 7A, 9D, 10A, 12A beginning on page 3–10.

Maximum Ratings

Operating Temperature (T_{OP}) .... 0°C to +85°C
Storage Temperature (T_{STG}) .... –40°C to +85°C
Lead Soldering Tempterature, 2 mm from base (T_S) .... 260°C
Peak Forward Current per Segment or DP (1) (I_{FM}) .... 100 mA
DC Forward Current per Segment or DP (2) (I_F) .... 15 mA
Reverse Voltage per Segment or DP (V_R) .... 6 V
Total Power Dissipation (P_{TOT}) .... 320 mW

Notes:

1. Do not exceed maximum average current per segment (see graph of peak forward current).
2. Derate maximum average current above T_A=75°C at 0.5 mA/°C per segment.

Characteristics (T_A=25°C)

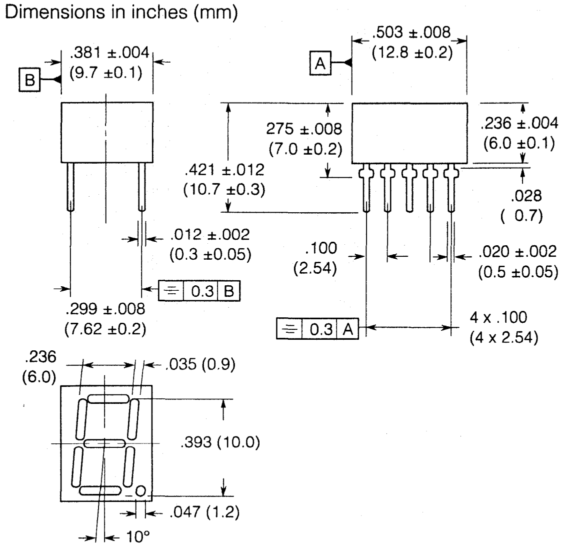
Parameter		Symbol	Values			Unit	Condition
			Min.	Typ.	Max.		
Luminous Intensity per Segment	2 mA	I_V	180	260		µcd	Digit Ave.
	5 mA			1000			
	20 mA PK: 1:4 Duty Factor			1300			
Peak Wavelength		λ_{PEAK}		635		nm	
Dominant Wavelength		λ_{DOM}	612		625	nm	Digit Ave.
Forward Voltage per Segment or DP		V_F		1.8		V	I_F=2 mA
Breakdown Voltage per Segment		V_{BR}	6	15			I_R=10 µA
Thermal Resistance LED Junction to Pin		R_{thJPIN}			180	°C/W/seg.	

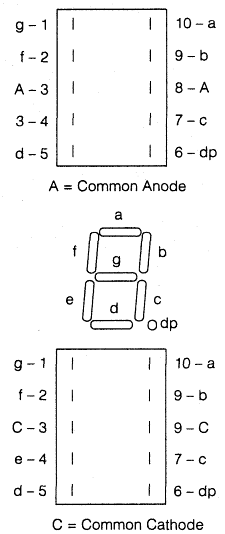
SIEMENS

SUPER-RED HDN1105O/1107O

0.39″ (10 mm) Seven Segment Numeric Display Low Current

Dimensions in inches (mm)





HDN1105

1 Cathode G
2 Cathode F
3 Common Anode
4 Cathode E
5 Cathode D
6 Cathode DP
7 Cathode C
8 Common Anode
9 Cathode B
10 Cathode A

HDN1107

1 Anode G
2 Anode F
3 Common Cathode
4 Anode E
5 Anode D
6 Anode DP
7 Anode C
8 Common Cathode
9 Anode B
10 Anode A

FEATURES

- **Current Consumption 2 mA**
- **Direct Drive by CMOS Microprocessor, Gate and LSTTL Modules**
- **Space Saving**
- **Lower Assembly Costs**
- **No Display and LED Driver Modules**
- **Good Readability in Unfavorable Lighting Conditions**
- **Climate Proof**
- **High Packing Density**
- **Gray Package for Optimal Contrast**
- **Long Service Life**
- **Shock and Vibration Resistant**

Description

The HDN1105/1107 are one digit, seven segment, low current LED displays. The character height is 0.39" (10 mm). The displays are available in super-red.

Applications include state-of-the-art industrial and consumer electronics, especially where low current consumption is required, i.e., portable appliances and battery-operated appliances.

Maximum Ratings

Operating Temperature (T_{OP}) .... 0°C to +85°C
Storage Temperature (T_{STG}) .... –40°C to +85°C
Lead Soldering Tempterature, 2 mm from base (T_S) .... 260°C
Peak Forward Current per Segment or DP [(1)] (I_{FM}) .... 100 mA
DC Forward Current per Segment or DP [(2)] (I_F) .... 15 mA
Reverse Voltage per Segment or DP (V_R) .... 6 V
Total Power Dissipation (P_{TOT}) .... 320 mW

Notes:

1. Do not exceed maximum average current per segment (see graph of peak forward current).
2. Derate maximum average current above T_A=75°C at 0.5 mA/°C per segment.

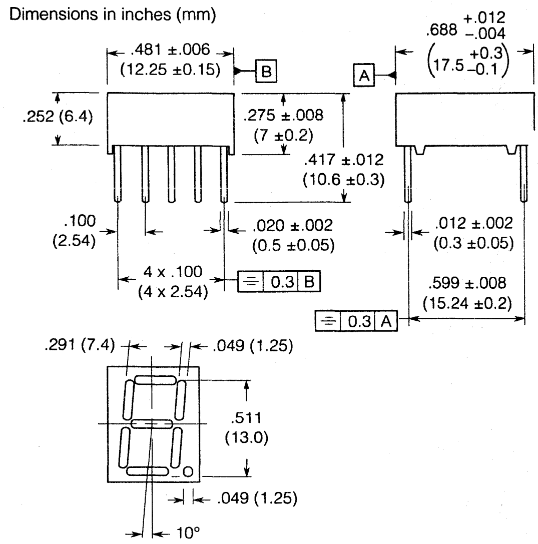
Characteristics (T_A=25°C)

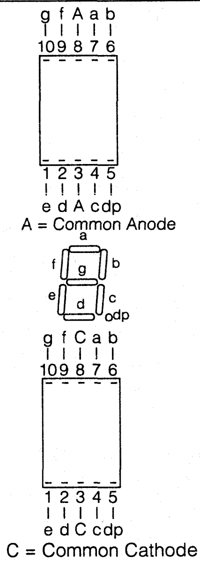
Parameter		Symbol	Values			Unit	Cond.
			Min.	Typ.	Max.		
Luminous Intensity per Segment	2 mA	I_V	180	260		µcd	Digit Ave.
	5 mA			1000			
	20 mA PK: 1:4 Duty Factor			1300			
Peak Wavelength		λ_{PEAK}		635		nm	
Dominant Wavelength		λ_{DOM}	612		625	nm	Digit Ave.
Forward Voltage per Segment or DP		V_F		1.8		V	I_F=2 mA
Breakdown Voltage per Segment		V_{BR}	6	15		V	I_R=10 µA
Thermal Resistance LED Junction to Pin		R_{thJPIN}			180	°C/W/seg.	

See graph numbers 1A, 2A, 4A, 5B, 7A, 9D, 10A, 12A beginning on page 3–10.

SIEMENS

SUPER-RED HDN1131O/1133O
0.59″ (13 mm) Seven Segment Numeric Display
Low Current





HD1131

1. Cathode E
2. Cathode D
3. Common Anode
4. Cathode C
5. Cathode DP
6. Cathode B
7. Cathode A
8. Common Anode
9. Cathode F
10. Cathode G

HD1133

1. Anode E
2. Anode D
3. Common Cathode
4. Anode C
5. Anode DP
6. Anode B
7. Anode A
8. Common Cathode
9. Anode F
10. Anode G

FEATURES
- **Current Consumption 2 mA**
- **Direct Drive by CMOS Microprocessor, Gate and LSTTL Modules**
- **Space Saving**
- **Lower Assembly Costs**
- **No Display and LED Driver Modules**
- **Good Readability in Unfavorable Lighting Conditions**
- **Climate Proof**
- **High Packing Density**
- **Gray Package for Optimal Contrast**
- **Long Service Life**
- **Shock and Vibration Resistant**

Description
The HDN1131/1133 are one digit, seven segment, low current LED displays. The character height is 0.59" (13 mm). The displays are available in super-red.

Applications include state-of-the-art industrial and consumer electronics, especially where low current consumption is required, i.e., portable applicances and battery-operated appliances.

Maximum Ratings
Operating Temperature (T_{OP})........ 0°C to +85°C
Storage Temperature (T_{STG})........ –40°C to +85°C
Lead Soldering Tempterature, 2 mm from base (T_S)........ 260°C
Peak Forward Current per Segment or DP (1) (I_{FM})........ 100 mA
DC Forward Current per Segment or DP (2) (I_F)........ 15 mA
Reverse Voltage per Segment or DP (V_R)........ 6 V
Total Power Dissipation (P_{TOT})........ 320 mW

Notes:
1. Do not exceed maximum average current per segment (see graph of peak forward current).
2. Derate maximum average current above T_A=75°C at 0.5 mA/°C per segment.

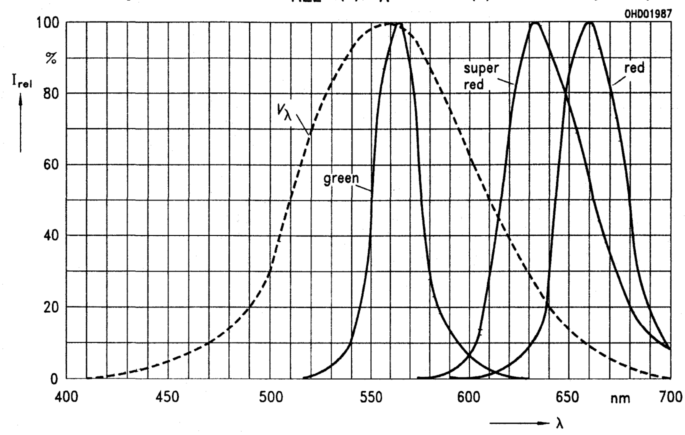
Characteristics (T_A=25°C)

Parameter		Sym.	Values			Unit	Cond.
			Min.	Typ.	Max.		
Luminous Intensity per Segment	2 mA	I_V	180	260		µcd	Digit Ave.
	5 mA			1000			
	20 mA PK: 1:4 Duty Factor			1300			
Peak Wavelength		λ_{PEAK}		635		nm	
Dominant Wavelength		λ_{DOM}	612		625	nm	Digit Ave.
Forward Voltage per Segment or DP		V_F		1.8		V	I_F=2 mA
Breakdown Voltage per Segment		V_{BR}	6	15		V	I_R=10 µA
Thermal Resistance LED Junction to Pin		R_{thJPIN}			180	°C/W/seg.	

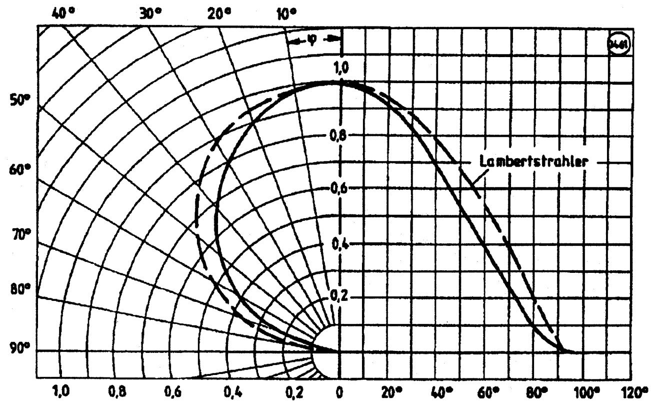
See graph numbers 1A, 2A, 4A, 5B, 7B, 9D, 10A, 12A beginning on page 3–10.

*

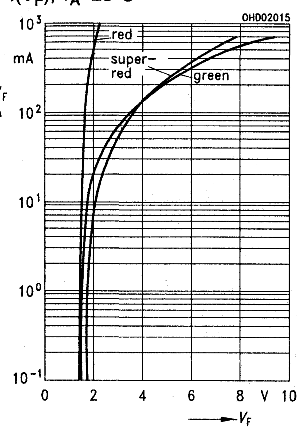
1A Relative spectral emission I_{REL}=f(λ), T_A=25° C, V(λ)=standard eye response curve



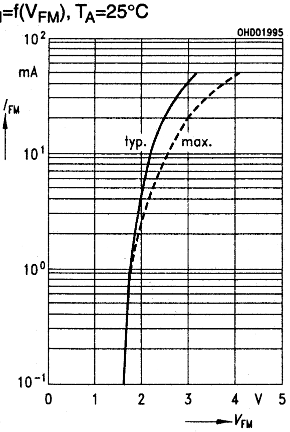
2A Relative spectral emission I_{REL}=f(λ), T_A=25° C, V(λ)=standard eye response curve



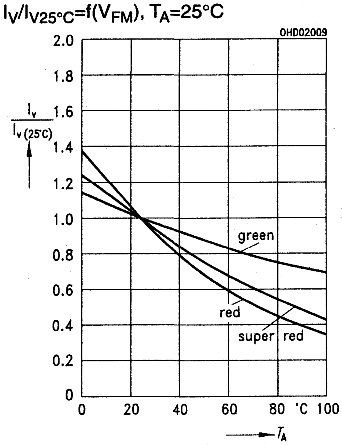
3A Forward current
I_F=f(V_F), T_A=25°C



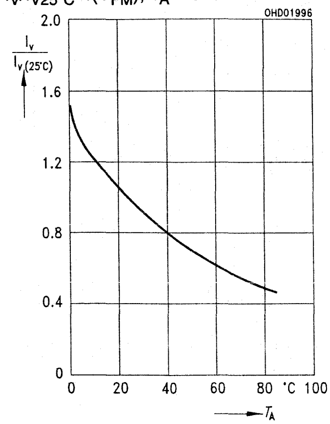
4A Peak forward current
I_{FM}=f(V_{FM}), T_A=25°C



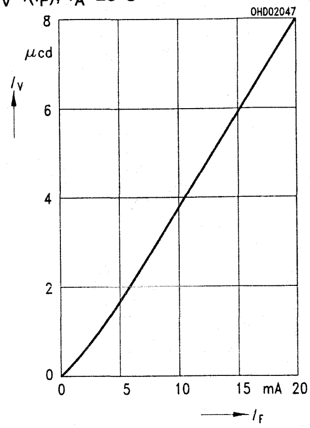
5A Relative luminous intensity
$I_V/I_{V25°C}$=f(V_{FM}), T_A=25°C



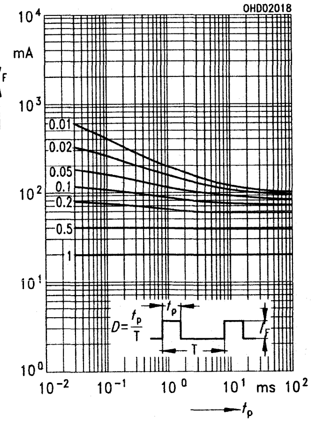
5B Relative luminous intensity
$I_V/I_{V25°C}=f(V_{FM})$, $T_A=25°C$



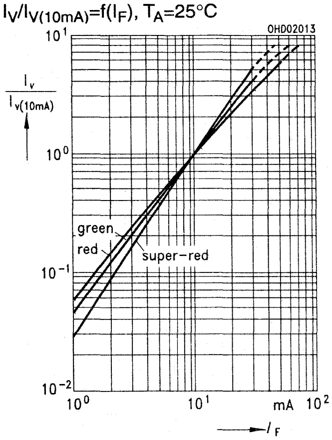
7B Luminous intensity
$I_V=f(I_F)$, $T_A=25°C$



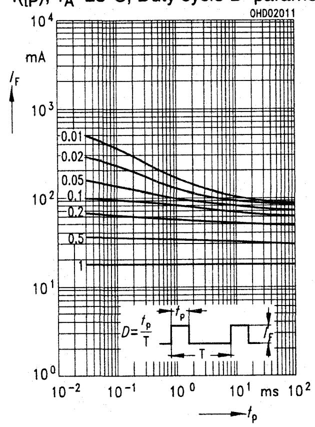
8D Permissible pulse handling capability
$I_F=f(t_P)$, $T_A=25°C$, Duty cycle D=paramete



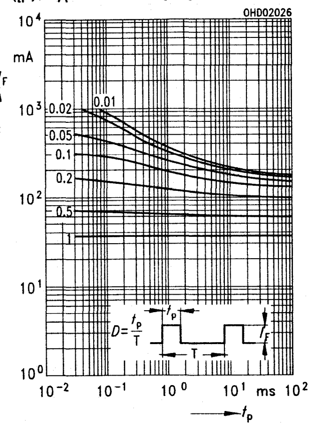
6A Relative luminous intensity
$I_V/I_{V(10mA)}=f(I_F)$, $T_A=25°C$



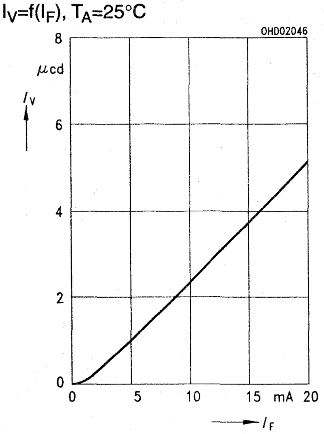
8B Permissible pulse handling capability
$I_F=f(t_P)$, $T_A=25°C$, Duty cycle D=parameter



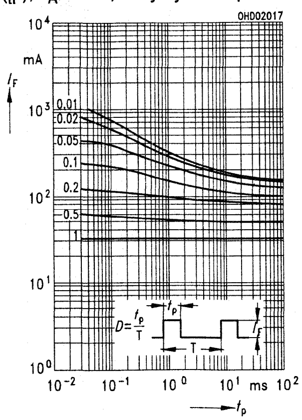
8E Permissible pulse handling capability
$I_F=f(t_P)$, $T_A=25°C$, Duty cycle D=parameter



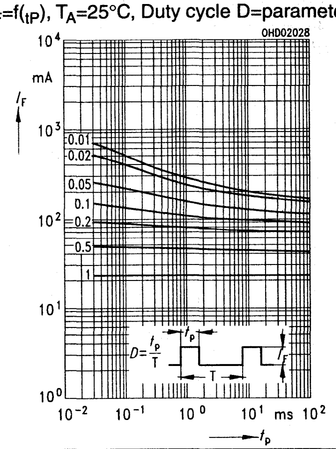
7A Luminous intensity
$I_V=f(I_F)$, $T_A=25°C$



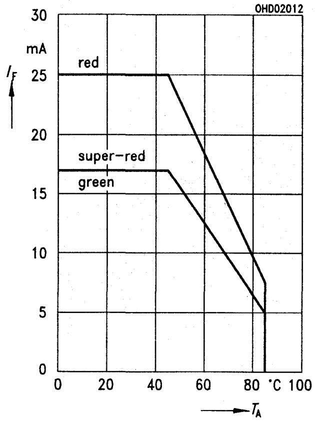
8C Permissible pulse handling capability
$I_F=f(t_P)$, $T_A=25°C$, Duty cycle D=parameter



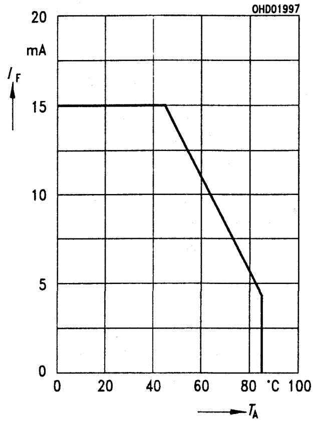
8F Permissible pulse handling capability
$I_F=f(t_P)$, $T_A=25°C$, Duty cycle D=parameter



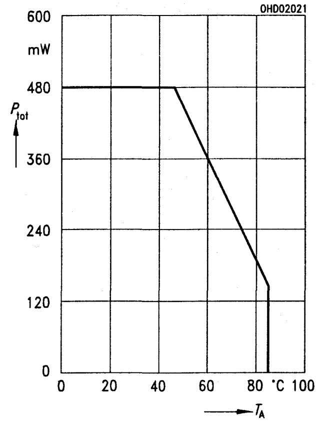
9A Maximum permissible forward current $I_F=f(T_A)$



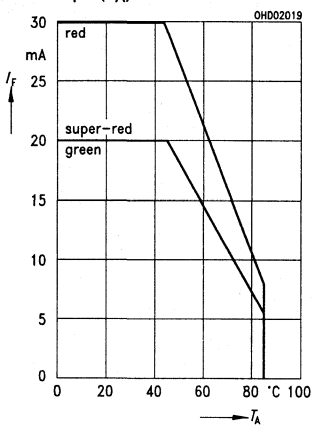
9D Maximum permissible forward current $I_F=f(T_A)$



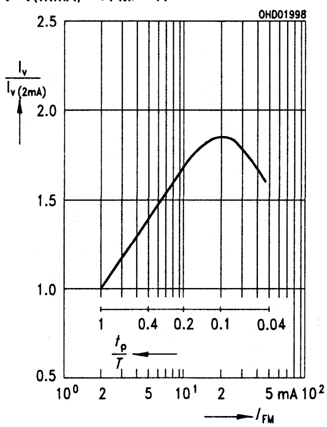
11B Total power dissipation $P_{TOT}=f(T_A)$



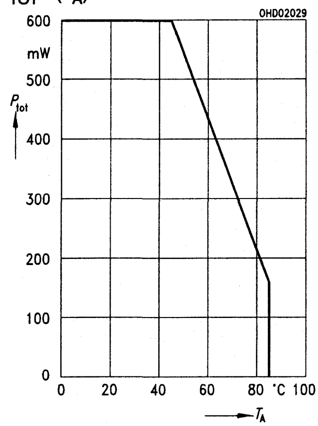
9B Maximum permissible forward current $I_F=f(T_A)$



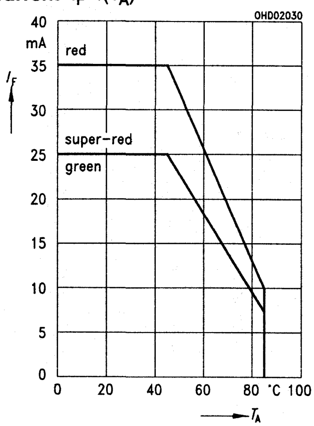
10A Relative efficiency $I_V/I_{V(\ldots mA)}=f(I_{FM})$, $T_A=25°C$



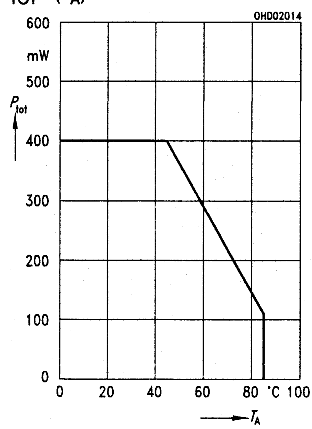
11C Total power dissipation $P_{TOT}=f(T_A)$



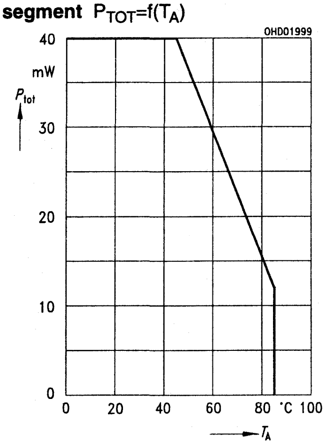
9C Maximum permissible forward current $I_F=f(T_A)$



11A Total power dissipation $P_{TOT}=f(T_A)$

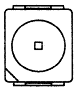
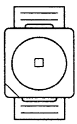
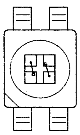
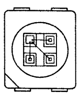
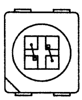


12A Total power dissipation per segment $P_{TOT}=f(T_A)$



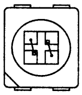
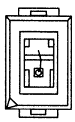
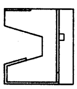
LED Lamps

Luminous intensity: see data sheets

Package & Type	Package Outline	Part Number	Color		λ Peak nm	Viewing Angle Degrees	Page
			Emission	Lens/Window			
SMT TOPLED		LB T670	Blue	Clear	467	120	4–8
		LS T670 LO T670 LY T670 LG T670 LP T670	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	4–76
		LG T671	Green	Clear	565	120	4–10
SMT TOPLED Super-Bright		LH T674	Hyper-red	Clear	660	120	4–15
SMT TOPLED Hyper-Bright		LH T676	Hyper-red	Clear	660	120	4–16
		LS T676 LA T676 LO T676 LY T676	Super-red Amber Orange Yellow	Clear	643 622 610 591	120	4–80
SMT TOPLED High Current		LS T672 LO T672 LY T672 LG T672 LP T672	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	4–78
SMT TOPLED Low Current		LS T679 LY T679 LG T679	Super-red Yellow Green	Clear	635 586 565	120	4–81
SMT TOPLED Reverse Gullwing		LB T770	Blue	Clear	467	120	4–8
		LS T770 LO T770 LY T770 LG T770 LP T770	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	4–76
SMT TOPLED Super-Bright Reverse Gullwing		LHT 774	Hyper-red	Clear	660	120	4–17
SMT TOPLED Hyper-Bright Reverse Gullwing		LS T776 LA T776 LO T776 LY T776	Super-red Amber Orange Yellow	Clear	645 622 610 591	120	4–82
Multi SMT TOPLED Reverse Gullwing		LSG T770	Super-red/Green	Clear	635/565	120	4–52
Multi TOPLED		LSPB T670	Super-red/Pure green/ Blue	Clear	635/557/ 467	120	4–65
Multi TOPLED		LOG T671 LSG T671	Orange/Green Super-red/Green	Clear	610/565 635/565	120	4–18

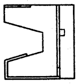
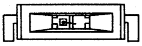
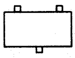
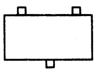
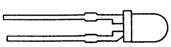
LED Lamps

Luminous intensity: see data sheets

Package & Type	Package Outline	Part Number	Color		λ Peak nm	Viewing Angle Degrees	Page
			Emission	Lens/Window			
Multi TOPLED		LSG T670 LSP T670 LSY T670 LOP T670 LOG T670 LYP T670	Super-red/Green Super-red/Pure green Super-red/Yellow Orange/Pure green Orange/Green Yellow/Pure green	Clear	635/565 635/557 635/586 610/557 610/565 586/557	120	4–49
		LSG T677	Super-red/Green	Clear	635/565	120	4–51
		LSS T670 LOO T670 LYY T670 LGG T670 LPP T670	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	4–72
Multi TOPLED Hyper-Bright		LSY T676	Super-red/Yellow	Clear	645/591	120	4–85
Super Multi TOPLED High Current		LSP T672 LOY T672 LOP T672 LSG T672 LOG T672 LYP T672	Super-red/Pure green Orange/Yellow Orange/Pure green Super-red/Green Orange/ Green Yellow/Pure green	Clear	635/557 610/586 610/557 635/565 610/565 586/557	120	4–68
Super SMT Multi TOPLED High Current		LSS T672 LOO T672 LYY T672 LGG T672 LPP T672	Super-red/Super-red Orange/Orange Yellow/Yellow Green/Green Pure green/Pure green	Clear	635 610 586 565 557	120	4–74
Mini SMT TOPLED		LB M670	Blue	Clear	467		4–7
		LS M670 LO M670 LY M670 LG M670 LP M670	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	4–59
Mini SMT TOPLED Hyper-Bright		LS M676 LA M676 LO M676 LY M676	Super-red Amber Orange Yellow	Clear	645 622 610 591	120	4–61
Mini SMT TOPLED Reverse Gullwing		LS M770 LO M770 LY M770 LG M770 LP M770	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	4–59
Mini SMT TOPLED Reverse Gullwing Hyper-Bright		LS M776 LA M776 LO M776 LY M776	Super-red Amber Orange Yellow	Clear	645 622 610 591	120	4–62
Mini SMT TOPLED Reverse Gullwing Low Current		LS M779 LY M779 LG M779	Super-red Yellow Green	Clear	635 586 565	120	4–63
SMT SIDELED		LS A670 LO A670 LY A670 LG A670 LP A670	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	4–37
SMT SIDELED High Current		LS A672 LO A672 LY A672 LG A672 LP A672	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	39

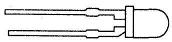
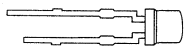
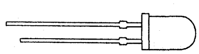
LED Lamps

Luminous intensity: see data sheets

Package & Type	Package Outline	Part Number	Color		λ Peak nm	Viewing Angle Degrees	Page
			Emission	Lens/Window			
SMT SIDELED Low Current		LS A679 LY A679 LG A679	Super-red Yellow Green	Clear	635 586 565	120	4–43
SMT Super SIDELED Super Bright		LH A674	Hyper-red	Clear	660	120	4–13
SMT SIDELED Hyper-Bright		LS A676 LA A676 LO A676 LY A676	Super-red Amber Orange Yellow	Clear	645 622 610 591	120	4–41
SMT Multi SIDELED Hyper-Bright		LSY A676	Super-red/Yellow	Clear	645/591	120	4–84
SMT Mini SIDELED		LS C870 LO C870 LY C870 LG C870 LP C870	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	120	4–44
SMT Mini SIDELED Hyper-Bright		LS C876 LA C876 LO C876 LY C876	Super-red Amber Orange Yellow	Clear	645 622 610 591	120	4–45
SMT SOT-23	Not recomended for new designs 	LS S260 LY S260 LG S260	Super-red Yellow Green	Red diffused Yellow diffused Green diffused	635 586 565	140	4–70
SMT SOT-23 Low Current		LS S269 LY S269 LG S269	Super-red Yellow Green	Red diffused Yellow diffused Green diffused	635 586 565	140	4–71
SMT SOT-23 MULTILED		LU S260 LV S260 LW S260	Super-red/Green Super-red/Super-red Green/Green	Colorless diffused Red diffused Green diffused	635/565 635/635 565/565	140	4–70
T1 (3 mm)		LR 3360 LS 3360 LO 3360 LY 3360 LG 3360 LP 3360	Red Super-red Orange Yellow Green Pure green	Red diffused Red diffused Orange diffused Yellow diffused Green diffused Green diffused	660 635 610 586 565 557	70	4–19
		LS 3340 LO 3340 LY 3340 LP 3340 LG 3330	Super-red Orange Yellow Pure green Green	Red clear Orange clear Yellow clear Clear Green clear	635 610 586 565 557	50	4–26
		LS 3341 LY 3341 LG 3341 LP 3341	Super-red Yellow Green Pure green	Red clear Yellow clear Green clear Green clear	635 586 565 557	40	4–27
T1 (3 mm) Double Hetero Junction		LH 3344 LH 3364	Hyper-red	Red clear Red diffused	660	25 45	4–11
T1 (3 mm) Low Current		LS 3369 LY 3369 LG 3369	Super-red Yellow Green	Red diffused Yellow diffused Green diffused	635 586 565	60	4–29
T1 (3 mm) Hyper-Bright		LS 3336 LA 3336 LO 3336 LY 3336	Super-red Amber Orange Yellow	Clear	645 622 610 591	50	4–25

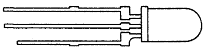
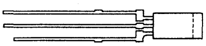
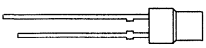
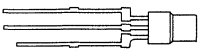
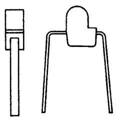
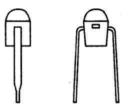
LED Lamps

Luminous intensity: see data sheets

Package & Type	Package Outline	Part Number	Color: Emission	Color: Lens/Window	λ Peak nm	Viewing Angle Degrees	Page
T1 (3 mm) Hyper-Bright		LS 3366 LA 3366 LO 3366 LY 3366	Super-red Amber Orange Yellow	Red diffused Orange diffused Orange diffused Yellow diffused	645 622 610 591	70	4–28
T1 (3 mm) Wide Angle		LS 3380 LO 3380 LY 3380	Super-red Orange Yellow	Red diffused Orange diffused Yellow diffused	635 586 565	100	4–30
T1 (3 mm) Wide Angle Hyper-Bright		LS 3386 LA 3386 LO 3386 LY 3386	Super-red Amber Orange Yellow	Red diffused Orange diffused Orange diffused Yellow diffused	645 622 610 591	100	4–31
T1 (3 mm) MULTILED		LSG 3331 LSG 3351	Super-red/Green Super-red/Green	Clear Diffused	635/565 635/565	40 50	4–46
T1 (3 mm) Plane		LS P380 LO P380 LY P380 LG P380 LP P380	Super-red Orange Yellow Green Pure green	Clear	635 610 586 565 557	—	4–64
T1 (3 mm) Plane MULTILED		LSP P370 LOP P370	Super-red/Pure green Orange/Pure green	Clear	635/557 610/557	—	4–67
T1 (3 mm) ARGUS		LS K380 LO K380 LY K380 LG K380 LP K380	Super-red Orange Yellow Green Pure green	Red clear Orange clear Yellow clear Green clear Clear	635 610 586 565 557	—	4–54
T1 (3 mm) Super ARGUS		LS K382 LO K382 LY K382 LG K382 LP K382	Super-red Orange Yellow Green Pure green	Red clear Orange clear Yellow clear Green clear Clear	635 610 586 565 557	—	4–57
T1 (3 mm) ARGUS Low Current		LS K389 LY K389 LG K389	Super-red Yellow Green	Red clear Yellow clear Green clear	635 586 565	—	4–58
T1 (3 mm) ARGUS Hyper-Bright		LH K376	Hyper-red	Clear	660	—	4–14
		LS K376 LA K376 LO K376 LY K376	Super-red Amber Orange Yellow	Clear	645 622 610 591	—	4–53
T1 (3 mm) Multi ARGUS		LSG K370 LSP K370 LOP K370 LOG K370	Super-red/Green Super-red/Pure green Orange/Pure green Orange/Green	Clear	635/565 635/557 610/557 610/565	—	4–47
T1 (3 mm) Super Multi ARGUS High Current		LSG K372 LSP K372	Super-red/Green Super-red/Pure green	Clear	635/565 635/557	—	4–48
T1 $^{3}/_{4}$ (5 mm)		LB 5410	Blue	Clear	467	50	4–6
		LH 5424 LH 5464	Hyper-red Hyper-red	Red diffused Red diffused	660	16 35	4–12
		LR 5360 LS 5360 LY 5360 LG 5360	Red Super-red Yellow Green	Red diffused Red diffused Yellow diffused Green diffused	660 635 586 565	50	4–20

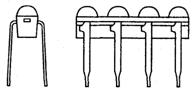
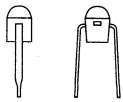
LED Lamps

Luminous intensity: see data sheets

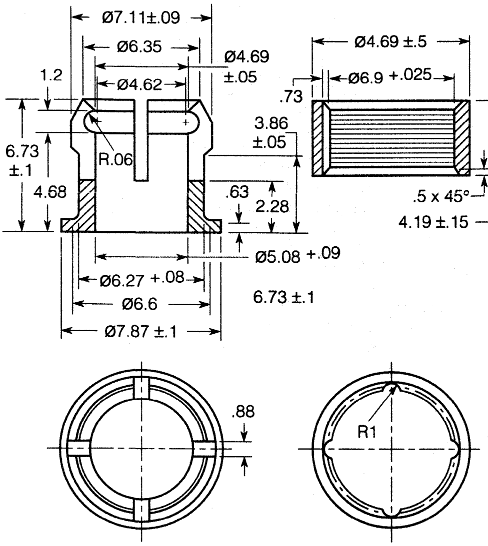
Package & Type	Package Outline	Part Number	Color		λ Peak nm	Viewing Angle Degrees	Page
			Emission	Lens/Window			
T1 $^3/_4$ (5 mm)		LR 5460 LS 5460 LY 5460 LG 5460	Red Super-red Yellow Green	Red diffused Red diffused Yellow diffused Green diffused	660 635 586 565	50	4–21
T1 $^3/_4$ (5 mm)		LR 5480 LS 5480 LY 5480 LG 5480	Red Super-red Yellow Green	Red diffused Red diffused Yellow diffused Green diffused	660 635 586 565	80	4–22
T1 $^3/_4$ (5 mm)		LS 5380 LY 5380 LG 5380	Super-red Yellow Green	Red diffused Yellow diffused Green diffused	635 586 565	140	4–32
T1 $^3/_4$ (5 mm)		LS 5420 LY 5420 LG 5410	Super-red Yellow Green	Red clear Yellow clear Green clear	635 586 565	24	4–33
T1 $^3/_4$ (5 mm) Low Current		LS 5469 LY 5469 LG 5469	Super-red Yellow Green	Red diffused Yellow diffused Green diffused	635 586 565	50	4–36
T1 $^3/_4$ (5 mm) Super Bright		LS 5421 LO 5411 LY 5421 LG 5411	Super-red Orange Yellow Green	Red diffused Clear Yellow diffused Clear	635 610 586 565	20	4–34
T1 $^3/_4$ (5 mm) Hyper-Bright		LS 5436 LA 5436 LO 5436 LY 5436	Super-red Amber Orange Yellow	Clear	645 622 610 591	30	4–35
T1 $^3/_4$ (5 mm)		LU 5351	Super-red/Green	Clear	635/565	50	4–86
Rectangular		LR B480 LS B480 LY B480 LG B480	Red Super-red Yellow Green	Red partly diffused Red partly diffused Yellow partly diffused Green partly diffused	660 635 586 565	100	4–23
Rectangular MULTILED		LU B371	Super-red/Green	Clear	635/565	100	4–86
Cylindrical		LR H380 LS H380 LY H380 LG H380 LO H380	Red Red Yellow Green Orange	Red partly diffused Red partly diffused Yellow partly diffused Green partly diffused Orange partly diffused	660 635 586 565 —	100	4–24
Cylindrical MULTILED		LU H371	Super-red/Green	Clear	635/565	100	4–86
1 mm Mini		LS U260 LY U260 LG U260	Super-red Yellow Green	Red diffused Yellow diffused Green diffused	635 586 565	60	4–83
2 mm Single		LG Z181 LR Z181 LY Z181	Green Red Yellow	Green diffused Red diffused Yellow diffused	565 660 586	100	4–9

LED Lamps

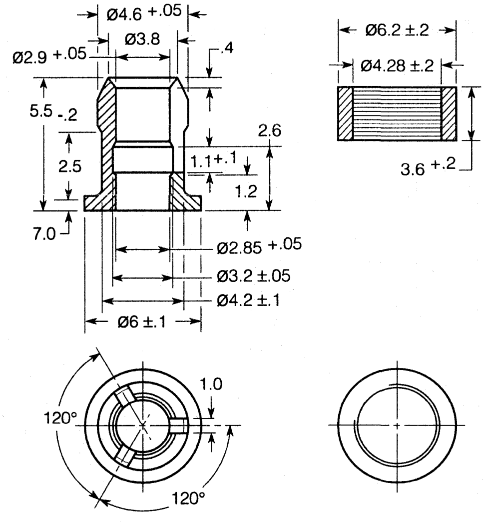
Luminous intensity: see data sheets

Package & Type	Package Outline	Part Number	Color		λ Peak nm	Viewing Angle Degrees	Page
			Emission	Lens/Window			
2 mm 2 diodes 3 diodes 4 diodes 5 diodes 6 diodes 8 diodes 10 diodes		LG Z182 LG Z183 LG Z184 LG Z185 LG Z186 LG Z188 LG Z180	Green	Green diffused	565	100	4–9
2 diodes 3 diodes 4 diodes 5 diodes 6 diodes 7 diodes 8 diodes 9 diodes 10 diodes		LR Z182 LR Z183 LR Z184 LR Z185 LR Z186 LR Z187 LR Z188 LR Z189 LR Z180	Red	Red diffused	660	100	
Miniature, axial leads		RL-50 RL-54	Red	Clear Red diffused	660	90	4–88
Miniature, axial leads highdomed lens		RL-55 YL-56 GL-56	Red Yellow Green	Red diffused Yellow diffused Green diffused	660 585 565	50 40 40	4–89
		RRL-5601 RRL-5621 RRL-5641	Red	Red diffused	650	20	4–91

Mounting Clip & Collar for T1¾ (5 mm) LED
Q 62901-B64, Clear and Q 62901-B65, Black

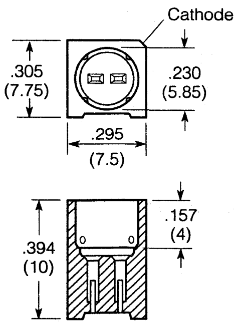


Mounting Clip & Collar for T1 (3 mm) LED
Q 62901-B61, Clear and Q 62901-B62, Black

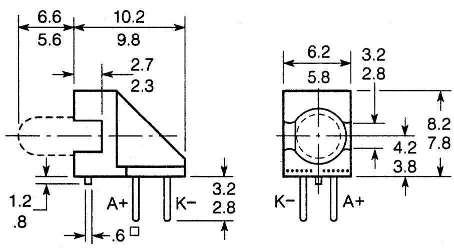


Material: Polypropylene

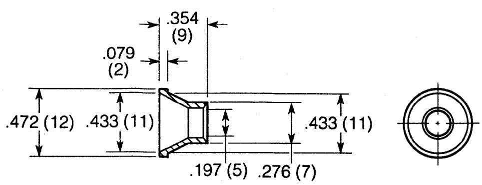
Right Angle Mount
Q 62902-B156-F222, Black



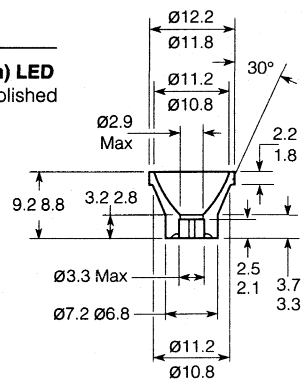
Angular Mount
Q 62902-B155-F222, Black



Reflector for T1¾ (5 mm) LED
Q 62902-B141-F222, Polished



Reflector for T1 (3 mm) LED
Q 62902-B154-F222, Polished



LED Lamp Part Numbering System

New LED type designation system

The range of Siemens light emitting diodes has received new type designations and ordering codes. The new type designation now indicates the most important characteristics of an LED.

LED type designation system

Wavelength λ peak typ. / Emission Color

	Wavelength λ peak typ.	Emission Color
M	635/557 nm	super-red/pure green
T	635/586 nm	super-red/yellow
U	635/565 nm	super-red/green
V	635 nm	super-red/super-red
W	565 nm	green/green
B	467 nm	SiC blue
P	557 nm	pure green
G	565 nm	green
Y	586 nm	yellow
O	610 nm	orange
S	635 nm	super-red
R	660 nm	GaAsP red
H	660 nm	hyper-red

Type

3	3 mm	round (standard version)
5	5 mm	round (standard version)
A:		SIDELED®
B	2.5 x 2.5 mm	rectangular (symbol LED)
C:		Mini SIDELED®
H	4 mm	round (symbol LED)
K	3 mm	ARGUS® LED/Super ARGUS® LED
M:		Mini TOPLED®
P:	3 mm	Plan LED
S	SOT-23 package	SMT LED
T:		Multi TOPLED®
T	PL-CC-2 package	SMT TOPLED®
U	1 mm	Mini LED
Z	2 mm	round (array version)

Product

L–light emitting diode

L S 3 3 6 0 - K N

Length of leads

3	<30 mm	with stand-off
4	<30 mm	without stand-off
5	gull-wing leads	
6	J-leads	
7	reverse gull wing leads	

Case / Viewing angle (typ.)

	Case	Viewing angle (typ.)
1	colorless clear	15 to 30 degrees
2	colored clear	15 to 30 degrees
3	colorless clear	30 to 70 degrees
4	colored clear	30 to 70 degrees
5	colorless diffused	40 to 80 degrees
6	colored diffused	40 to 80 degrees
7	colorless diffused	>80 degrees
8	colored diffused	>80 degrees

(SOT-23 requires no angle)

Special versions

1	aspherical lenses
2	high-current LED
3	GaAlAs single hetero LED
4	GaAlAs double hetero LED
6	Hyper bright LED
7	Multi TOPLED: cathodes on one side
8	constant current LED
9	low-current LED

Array versions: digit 4=Z
Number of lamps per array

Luminous intensity groups

A	0.1 to 0.2	P	40 to 80
B	0.16 to 0.34	Q	63 to 125
C	0.25 to 0.5	R	100 to 200
D	0.4 to 0.8	S	160 to 320
E	0.63 to 1.25	T	250 to 500
F	1 to 2	U	400 to 800
G	1.6 to 3.2	V	630 to 1250
H	2.5 to 5	W	1000 to 2000
J	4 to 8	X	1600 to 3200
K	6.3 to 12.5	Y	2500 to 5000
L	10 to 20	Z	>5000
M	16 to 32	O	open top
N	25 to 50		

Value of standard LEDs in luminous intensity I_V in mcd.

Value of ARGUS LEDs in luminous flux Φ_V in mlm.

Explanation of example:

LS 3360-KN	L	Light emitting diode
	S	Emission color: super-red, λpeak=635 nm (typ.)
	3	Standard version: 3 mm
	3	Length of leads <30 mm with stand-off
	6	Colored case, diffused; viewing angle 70 degrees (typ.)
	0	No special version
	KN	Luminous intensity of family group, minimum 6.3 mcd, maximum 50 mcd

πLuminous intensity groupings(I_V)

The different luminous intensities throughout one type family are grouped according to the following (I_F=10 mA[1]):

Group	A	B	C	D	E	F	G	H	J	K	L	M	N
I_V mcd	0.1 to 0.2	0.16 to 0.32	0.25 to 0.50	0.40 to 0.80	0.63 to 1.25	1 to 2	1.6 to 3.2	2.5 to 5	4 to 8	6.3 to 12.5	10 to 20	16 to 32	25 to 50

Group	P	O	R	S	T	U	V	W	X	Y	Z	O
I_V mcd	40 to 80	63 to 125	100 to 200	160 to 320	250 to 500	400 to 800	630 to 1250	1000 to 2000	1600 to 3200	2500 to 5000	>5000	Top open

1. For blue LED: I_F=20mA;
2. ARGUS LED: Luminous flux Φv in mlm at I_F=15 mA (at low current, I_F=2mA). Super ARGUS, I_F=50mA.

Matching factor of brightness–single-color LEDs/MULITLED

	Ivmin/Ivmax, Phivmin/Phivmax	
	Within one packing unit	Within one LED
LEDs	'1/2'	—
MULTILEDs	'1/2'	'1/3'
MULTILEDs, with pure green	'1/2'	'1/4'
LU5351-GL, LU B371-FJ, LU H371-FJ	'1/2'	'1/4'
LU5351-JM, LU B371-GK, LU H371-GK	'1/2'	'1/2'
LU S250-DO	'1/2'	'1/4'

The brightness of the darker chip in one package determines the brightness group of the LED.
The mean value of the chips determines the brightness of the LED in MULTILEDs with two chips of the same color.

Soldering conditions for LEDs

When soldering the component into position, make sure that it is not thermally overloaded.
The maximum junction temperature may only be exceeded briefly (for no more than 1 min.).

Maximum pemissible soldering temperatures and soldering times

<table>
<tr><th rowspan="2" colspan="2">Types</th><th colspan="3">Dip, wave and drag soldering</th><th colspan="3">Iron soldering
(with 1.5 mm iron tip)</th><th colspan="2">Reflow soldering</th></tr>
<tr><th>Temperature of soldering bath</th><th>Max. perm. soldering time</th><th>Distance between solder joint and case</th><th>Temperature of soldering iron</th><th>Max. perm. soldering time</th><th>Distance between solder joint and case</th><th>Temperature of soldering zone</th><th>Max. transit time</th></tr>
<tr><td colspan="2">3 mm dia.</td><td>235°C
260°C</td><td>8 s
5 s</td><td>≥2 mm</td><td rowspan="4">300 °C</td><td rowspan="4">3 s</td><td>≥2 mm</td><td rowspan="4">—</td><td rowspan="4">—</td></tr>
<tr><td rowspan="2">5 mm dia.</td><td>Symbol LED</td><td>235°C</td><td>8 s</td><td rowspan="2">≥1.5 mm</td><td rowspan="2">≥1.5 mm</td></tr>
<tr><td>Two-color LED</td><td>260°C</td><td>5 s</td></tr>
<tr><td colspan="2">LED arrays</td><td>235°C
260 °C</td><td>5 s
3 s</td><td>≥2 mm</td><td>≥2 mm</td></tr>
<tr><td colspan="2">SOT-23 LED
SMT TOPLED®</td><td>260°C</td><td>8 s</td><td colspan="4">—</td><td>260°C to 215°C
Preheating:
150°C</td><td>10 s to 30 s
Approx.
1 min.</td></tr>
</table>

Cleaning solvents for soldered-in LEDs

Organic solvents consisting of alcohols or hydrocarbonfluorides or a mixture of both groups are suitable for cleaning soldered-in LEDs. Never use solvents or solvent mixtures which contain chlorinated hydrocarbons or ketones. These types of solvents may attack or corrode the display housing or casting.

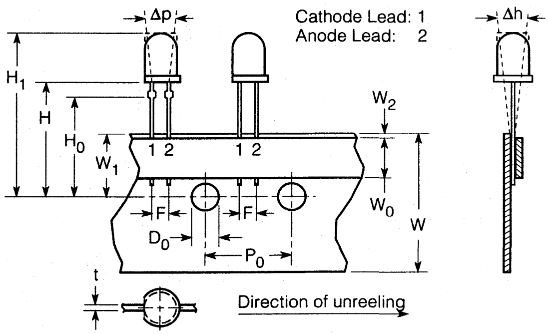
Lamp–Tape and Packaging

Light emitting diodes are available in taped form. Packaging of LEDs on continuous tapes is based on IEC standard 286.2.

The component tapes are wound on reels and supplied in boxes containing two reels each. One reel consists 1000 pieces of the 5 mm type or 2000 pieces of the 3 mm type.

For components with 2.54 mm lead spacing add "E7500" to the last position of the part number, e.g., LR 5460-DG E7500.

For components with 5.08 mm spacing add "E7501" to the last position of the part number, e.g., LG 5460-GK E7500.

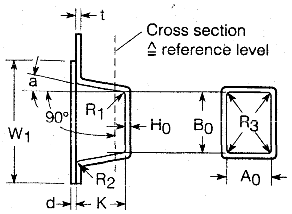


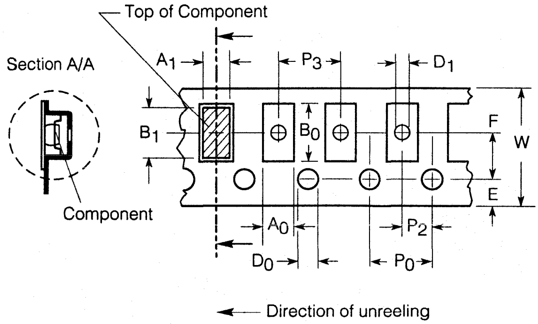
Symbol	Designation	Dimensions		Tolerance	
		inch	mm	inch	mm
W	Carrier tape width	.709	18	+.039 –.020	+1 –0.5
W_0	Hold down tape width	.236	6	±.12	±0.3
W_1	Sprocket hole position	.354	9	+.030 –.020	+0.75 –0.5
W_2	Hold down tape position	≤.118	≤3		
t	Total thickmess of carrier and hold down tape	.035 max.	0.9 max.		
D_0	Sprocket hole diameter	.157	4	±.008	±0.2
H	Sprocket hole center to bottom of component	.709	18	+.079	+2
H_0	Sprocket hole center of seating plane	.630	16	±.020	±0.5
H_1	Sprocket hole center to top of component body	1.268 max.	32.2 max.		
P_0	Sprocket hole pitch	.500	12.7	±.012	±0.3
F	Component lead pitch	.100 or .200	2.54 or 5.08	+.024 –.004	+0.6 –0.1
Δp	Maximum deviation of component in tape plane			+.040	±1
Δh	Maximum deviation of component vertical to tape plane			±.079	±2

Packaging of Surface Mount LEDs

LED in SOT-23 and TOP-LED packages are available on continuous tapes— IEC publication 40 (secretariat) 458 applies.

The 8 mm broad tape is wound on an 18 cm or 33 cm film reel. The reels have either 3000 or 10,000 components.





Blister Tape

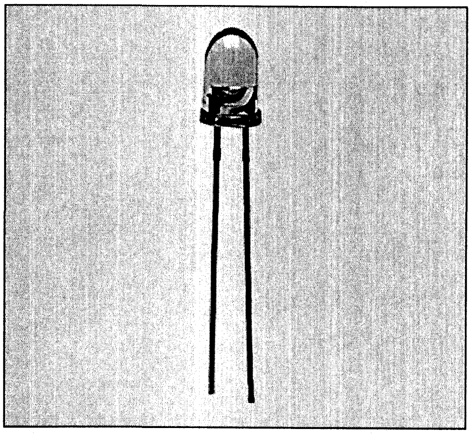
Dimensional Table for Blister Tape

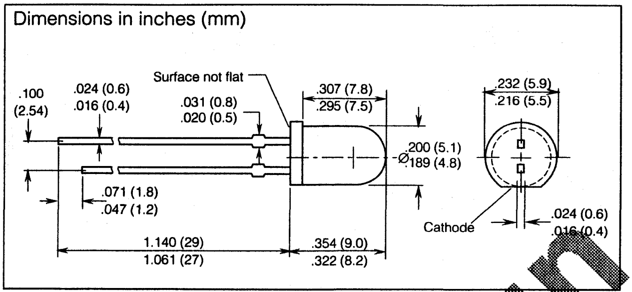
Designation	Symbol	Dimensions in inches (mm)	Notes
Tape width	W	.315 ±.012 (8 ±.3)	—
Carrier tape thickness	t	.012 max. (.3)	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±.1)	Cumulative pitch error +.2 mm/10 pitches
Diameter of sprocket holes	D_0	.039 +.008 (1 +.2)	—
Distance of sprocket holes	E	.069 ±.004 (1.75 ±.1)	
Distance of components	F	.138 ±.002 (3.5 ±.05)	Center hole to center compartment
	P_2	.079 ±.002 (2 ±.05)	
Distance compartment to compartment	P_3	.157 (4)	—
Compartment dimensions	K	.098 max. (2.5)	Exact dimensions are given with component dimensions
	a	15° max.	
	R_1, R_2	.012 max. (.3)	
	H_0	.012 +.004/ –.002 (0.3 +.1/–.05)	Between inner side of the compartment bottom and reference level for measuring A_0, B_0
Compartment	A_0 B_0	The tolerances are chosen so that the components can only move within permissible limits, yet still be easily removed from the tape.	
Hole in compartment	D_1	.039 +.008/–.002 (1 +.2/–.05)	Tolerance to the center of the sprocket hole: .1 mm
Width of fixing tape	W_1	.217 typ. (5.5)	Fixing tape shall not cover sprocket holes, nor protrude beyond carrier tape, not to exceed maximum tape width
	d	.004 max. (.1)	
Device tilt in compartment	—	15° max.	
Minimum bending radius		1.181 min. (30)	—

SIEMENS

LB 5410-GO

Blue T1¾ (5 mm) LED Lamp





FEATURES

- **Pure blue light (480 nm)**
- **Clear T1¾ (5 mm) plastic package**
- **1″ minimum lead length**
- **High brightness**
- **TTL compatible**

DESCRIPTION

The LB 5410 is a Silicon Carbide (SiC) LED, emitting a pure blue light from a clear T1¾ (5 mm) plastic package. The LB 5410 is ideal for such applications as: spectroscopy, calibration, and light sources in medical equipment.

Maximum Ratings

Operating Temperature Range (T_{OP}) .... –55°C to +100°C
Storage Temperature Range (T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 50 mA
Surge Current (I_{FM}) t_P=10 µs .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}), T_A=25°C .... 200 mW
Thermal Resistance, Junction/Air (R_{THJA}) .... 400 K/W

Characteristics T_A=25°C

Parameter		Symbol	Value	Unit	Condition
Peak Wavelength		λ_{PEAK}	467	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	480		
Spectral Bandwidth 50% I_{RELMAX}		$\Delta\lambda$	75		
Viewing Angle, 50% I_V		2φ	35	Deg.	
Forward Voltage	typ.	V_F	3.1	V	I_F=20 mA
	max.		4.5		
Switching Times, I_V 10% to 90% 90% to 10%		t_R t_F	800	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω
Luminous Intensity*		I_V	3.0 (≥1.6)	mcd	I_F=20 mA

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2

See graph numbers OHL01722, OHL01731, OHL02155, OHL02156, OHL02148, OHL02157 beginning on page 4–92.

SIEMENS

BLUE LINE™ LB M670-BO
Mini TOPLED® Lamp

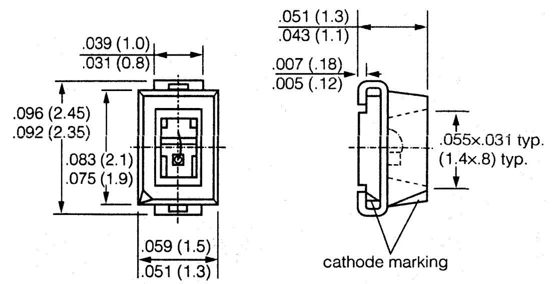
FEATURES
- **Color: blue**
- **White package, colorless clear window**
- **Cathode mark: bevelled corner**
- **Produced in SiC technology**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm)**
- **Load dump resistant per DIN 40839**

APPLICATIONS
- **Optical Indicators**
- **Backlighting, optical coupling into pipes and lenses**
- **Spectrometry**

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 30 mA
Surge Current (I_{FM}) t ≤10 µs,
D=0.005 .... 0.0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation(1) (P_{TOT})
T_A=25°C .... 130 mW
Thermal Resistance(1),
Junction to Air (R_{THJA})
mounted on PC board(2)
(pad size≥16 mm²) .... 530 K/W

Notes:
1. Preliminary
2. PC-board: FR4.

Dimensions in inches (mm)



Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	467	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	480		
Spectral Bandwidth, 50% I_{relmax}	$\Delta\lambda$	75		
Viewing Angle, 50% I_V	2φ	120	Deg.	
Forward Voltage(1)	V_F	3.1 (≤4.5)	V	I_F=20 mA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=5 V
Capacitance(1)	C_0	50	pF	V_R=0 V, f=1 MHz
Switching Time(1) Rise Time, 10% to 90% Fall Time, 90% to 10%	t_R, t_F	800	ns	I_F =100 mA, t_P=10 µs R_L=50 Ω
Luminous Intensity	I_F	0.35 (≥0.16)	mcd	I_F=20 mA
Luminous Flus	Φ_V	1.0	mlm	

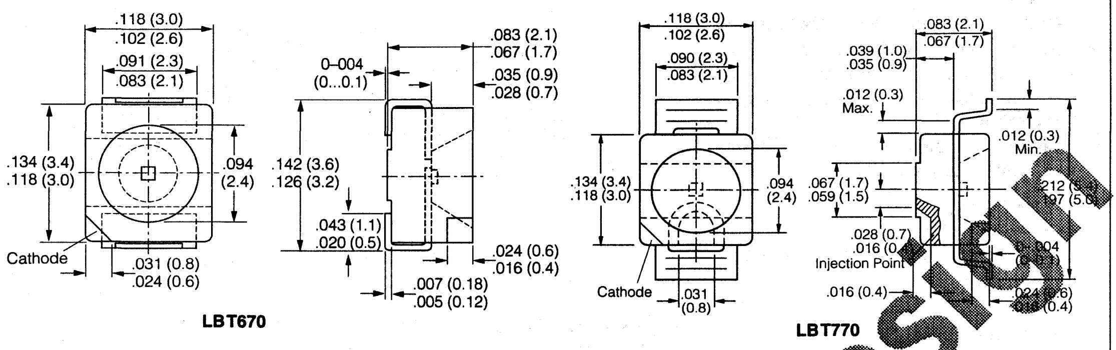
Notes
1. Preliminary
2. Luminous intensity ratio of one packaging unit I_{VMAX} / I_{VMIN} ≤ 2.0.

See graph numbers OHL01698, OHL01660, OHL02148, OHL01692, OHL02155, OHL02156 beginning on page 4–92.

SIEMENS

LB T670-BO
REVERSE GULLWING LB T770-BO
Blue Line™, Blue TOPLED® Lamp

Dimensions in Inches (mm)



FEATURES
- **LBT770: reverse gullwing**
- **PL-CC-2 package**
- **White package, colorless clear window**
- **Optical indicator**
- **Ideal for backlighting, and optical coupling into light pipes and lenses**
- **SIC chip technology**
- **Use in spectrometry**
- **Suitable for all surface mounting methods**
- **Available taped on reel**
- **Load dump resistant acc. to DIN 40839**

Maximum Ratings

Operating Temperature Range (T_{OP}) ....–55 to +100°C
Storage Temperature Range (T_{STG}) ....–55 to +100°C
Junction Temperature (T_J) ....+100°C
Forward Current (I_F) ....40 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 ....[illegible] A
Reverse Voltage (V_R)...5 V
Power Dissipation (P_{TOT}) T_A≤25°C ....160 mW
Thermal Resistance, Junction Air
Mounted on PC Board: pad size 16 mm²
(R_{THJA}) .... 400 K/W

See graph numbers OHL00670, OHL00770, OHL01698, OHL01660, OHL02155, OHL02156, OHL02148, OHL02157 beginning on page 4–92

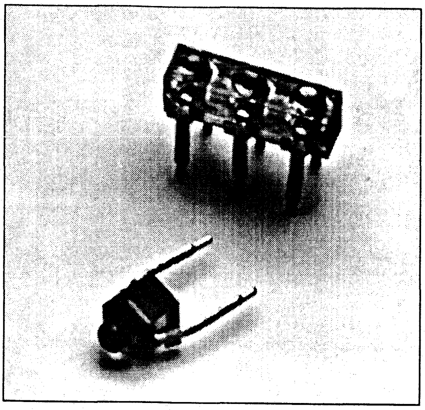
Characteristics T_A=25°C, all values typical unless otherwise noted

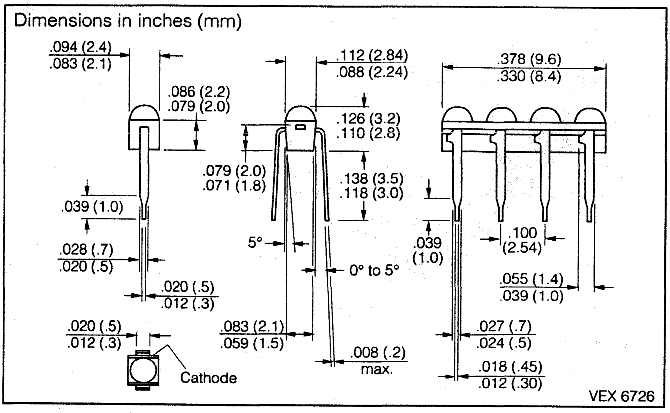
Parameter	Symbol	Values	Unit	Condition
Peak Wavelength	λ_{PEAK}	467	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	480		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	75		
Viewing Angle, 50% I_V	2φ	120	Deg.	
Forward Voltage	V_F	3.1 (≤4.5)	V	I_F=20 mA
Reverse Current	I_R	0.01 (≤ 10)	µA	V_R=5 V
Capacitance	C_0	50	pF	V_R=0 V, f=1 MHz
Luminous Intensity*	I_V	0.25 min.	mcd	I_F=20 mA

*Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≥2

SIEMENS

SINGLE LG/LR/LY Z181
2 to 6 DIODE ARRAYS LG Z182–186
8, 10 DIODE ARRAYS LG Z188, 180
2 to 10 DIODE ARRAYS LR Z182–189/180
2 mm LED Lamp





FEATURES
- **Emission color**
  - **– LR : Red**
  - **– LG : Green**
  - **– LY: Yellow**
- **Miniature Size**
- **LR: Single lamp and 2 to 10 diode arrays**
- **0.100" (2.54 mm) lead spacing**
- **End stackable to arrays of any length**
- **IC compatible**

Maximum Ratings (Individual Diode)

Operating/Storage Temperature
Range (T_{OP},T_{STG}) .... –40°C to +80°C
Junction Temperature (T_J) .... 100°C
Soldering Temperature, 2 mm from case bottom
(T_S), t≤3 sec .... 230°C
Forward Current (I_F) .... 30 mA
Surge Current (I_{FM}) t ≤10 µs .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}), T_A=25°C .... 90 mW
Thermal Resistance
Junction to Air (R_{THJA}) .... 750 K/W

Note: Mounted on PC board: pad size ≥16 mm²

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	Value	Unit	Condition
Peak Wavelength		λ_{PEAK}	660	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	645		
Spectral Bandwidth 50% I_{RELMAX}		Δλ	35		
Viewing Angle, 50% I_V		2φ	100	Deg.	
Forward Voltage		V_F	1.6 (≤2)	V	I_F=10 mA
Reverse Current		I_R	0.01 (≤10)	µA	V_R=5 V
Capacitance		C_0	25	pF	V_R=0 V f=1 MHz
Switching Time, I_V	10% to 90%, typ.	t_R	120	ns	I_F=100 mA t_P=10 µs R_L= 50 Ω
	90% to 10%, max.	t_F	50		
Luminous Intensity*		I_V	0.25	mcd	I_F=10 mA

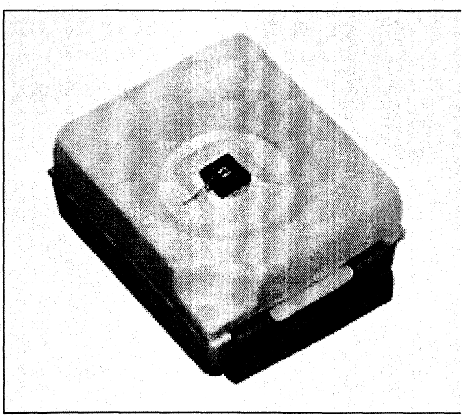
Part Number	No. of LEDs	Part Number	No. of LEDs
LG/LR/LY Z181-CO	1	LG/LR Z186-CO	6
LG/LR Z182-CO	2	LR Z187-CO	7
LG/LR Z183-CO	3	LG/LR Z188-CO	8
LG/LR Z184-CO	4	LR Z189-CO	9
LG/LR Z185-CO	5	LG/LR Z180-CO	10

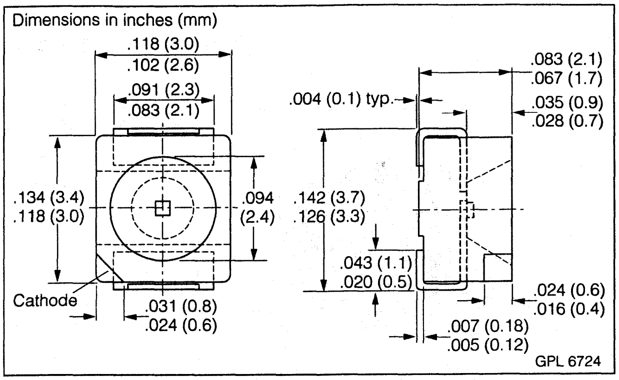
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

See graph numbers OHL02144, OHL01732, OHL01263, OHL01757, OHL01686, OHL01687, OHL01688, OHL01689, OHL01690, OHL01691 beginning on page 4–92.

SIEMENS

GREEN LG T671
Bright Green Die TOPLED® Lamp





FEATURES
- **PL-CC-2 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, Optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... +100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 30 mA
Surge Current (I_{FS}) t_p=10 µs, D = 0.005 .... 0.5 A
Power Dissipation (P_{TOT}) T_A≤25°C .... 100 mW
Thermal Resistance, Junction/Air
Mounted on PC board,(pad size ≥16 mm²)
(R_{thJA}).. 400 K/W

* PC board: FR4

Characteristics T_A=25°C, all values typical unless noted

Parameter		Symbol	Value	Units	Test Condition
Peak Wavelength		λ_{PEAK}	565	nm	I_F=10 mA
Dominant Wavelength		l_{DOM}	570		
Spectral Bandwidth 50% I_{RELMAX}		$\Delta\lambda$	25		
Viewing Angle, 50% I_V		2 φ	120	Deg.	
Forward Voltage		V_F	2 (≤ 2.6)	V	I_F=10 mA
Reverse Current		I_R	0.01(≤ 10)	µA	V_R=5 V
Capacitance		C_O	15	pF	V_R=0 V f=1 MHz
Switching Times, I_V	10%-90%	t_R	450	ns	I_F=100 mA tp=10 µs R_L=50 Ω
	90%-10%	t_F	200		

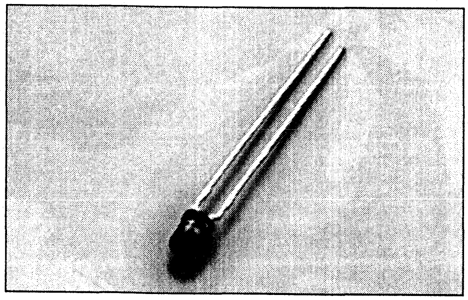
Part Number	Luminous Intensity, I_V, mcd	Luminous Flux, Φ_V, mim	Condition
LG T671-KM	6.3 to 32	—	I_F=10 mA
LG T671-L	10 to 20	45	
LG T671-M	16 to 32	75	
LG T671-LN	10 to 50	—	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

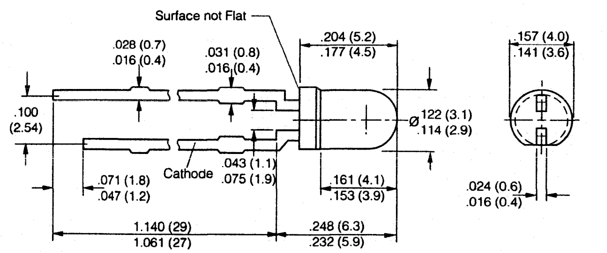
See graph numbers OHL01702, OHL01660, OHL02145, OHL02313, OHL01686, OHL01661, OHL01705, OHL01706, OHL01707, OHL01708 beginning on page 4-92.

SIEMENS

DOUBLE HETERO JUNCTION LH 3344
DOUBLE HETERO JUNCTION LH 3364
Hyper-Red GaAlAs T1 (3 mm) LED Lamp



Dimensions in inches (mm)



GEX 6717

FEATURES

- **Lens**
  - **LH3344: red, clear**
  - **LH3364: red diffused**
- **Double heterojunction in GaAlAs technology**
- **Especially high luminous intensity**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

DESCRIPTION

The T1 hyper-red GaAlAs LED lamps use double hetero junction material to produce very high luminous intensities. When operated at very low currents (1 mA) these lamps can produce luminous intensities comparable to standard and high efficiency LEDs that operate at 10 mA to 20 mA.

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to + 100°C
Junction Temperature (T_J) .... + 100°C
Forward Current (I_F) .... 40 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005.................. 0.5 A
Reverse Voltage (V_R) .... 3 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 120 mW
Thermal Resistance, Junction/Air (R_{thJA}) .... 400 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted.

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	660	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	645		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	22		
Viewing Angle, 50% I_V LH3344 LH3364	2φ	 25 45	Deg.	
Forward Voltage	V_F	1.75 (≤2.6)	V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=3 V
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Switching Time Rise time–10% to 90% Fall time–90% to 10%	 t_R t_F	 140 110	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω

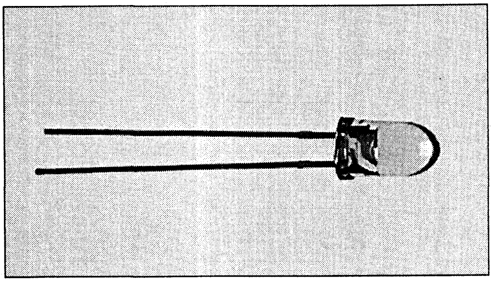
Luminous Intensity*, I_V, mcd				
Part No.	**Min. – Max.**	**Part No.**	**Min. – Max.**	**Condition**
LH 3344-QT	63 – 500	LH 3364-LP	10 – 80	I_F=10mA
LH 3344-R	100 – 200	LH 3364-M	16 – 32	
LH3344-S	160 – 320	LH3364-N	25 – 50	
LH3344-T	250 – 500	LH3364-MQ	16 – 125	
LH3344-RU	100 – 800			

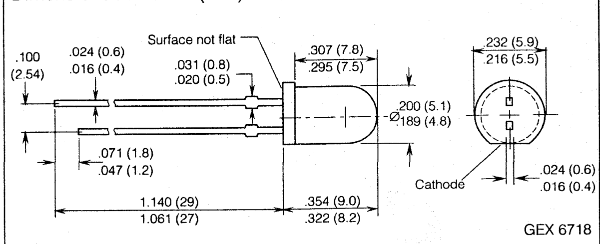
*Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

See graph numbers OHL01727, OHL01736, OHL01737, OHL01162, OHL02184, OHL01740, OHL01741, OHL01749, LH3344: OHL01729, OHL01730, LH3364: OHL01728, OHL01739 beginning on page 4–92.

SIEMENS

DOUBLE HETERO JUNCTION LH 5424
DOUBLE HETERO JUNCTION LH 5464
Hyper-Red GaAlAs T1¾ (5 mm) LED Lamp





FEATURES
- **Lens**
  - **LH 5424: red, clear**
  - **LH5464: red diffused**
- **GaAlAs, double hetero junction**
- **Especially high luminous intensity**
- **Solder leads without stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

DESCRIPTION
The T1¾ hyper red GaAlAs LED lamps use double hetero junction material to produce very high luminous intensities. When operated at very low currents (1 mA) these lamps can produce luminous intensities comparable to standard and high efficiency LEDs that operate at 10 mA to 20 mA.

Maximum Ratings
Operating/Storage Temperature Range
(T_{OP}, T_{STG}) .... –55°C to + 100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 40 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 3 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 120 mW
Thermal Resistance, Junction/Air (R_{thJA}) .... 400 K/W

See graph numbers OHL01727, OHL01736, OHL01737, OHL01162, OHL02184, OHL01739, OHL01740, OHL01741, OHL01749, LH5424: OHL01730, LH5464: OHL01731 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted.

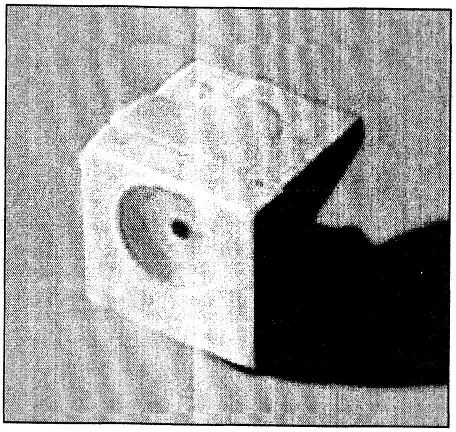
Parameter		Symbol	Value	Unit	Condition
Peak Wavelength		λ_{PEAK}	660	nm	I_F=20 V
Dominant Wavelength		λ_{DOM}	645		
Spectral Bandwidth 50% I_V		Δλ	22		I_F=20 mA
Viewing Angle, 50% I_V	LH5424	2 φ	16	Deg.	
	LH5464		35		
Forward Voltage		V_F	1.75 (≤2.6)	V	I_F=10 mA
Reverse Current		I_R	0.01 (≤10)	µA	V_R=3 V
Capacitance		C_0	25	pF	V_R=0 f=1 MHz
Switching Times, I_V	10% to 90%	t_R	140	ns	I_F=100 mA t_P=10 µs R_L=50 Ω
	90% to 10%	t_F	110		
Luminous Intensity*		I_V	see below	mcd	I_F=10mA

Part No.	Min.	Max.	Part No.	Min.	Max.
LH 5424-QT	63	500	LH 5464-MQ	16	125
LH 5424-S	160	320	LH 5464-N	25	50
LH 5424-T	250	500	LH 5464-P	40	80
LH 5424-SU	160	800	LH 5464-Q	63	125
			LH 5464-NR	25	200

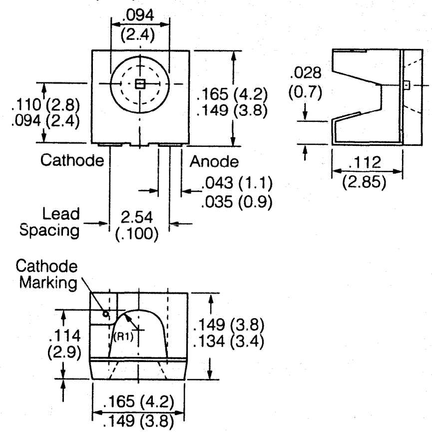
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.0.

SIEMENS

HYPER-RED LH A674
Super Bright GaAlAs SIDELED® Lamp



Dimensions in Inches (mm)



GPL 6880

FEATURES

- **SIDELED: surface mount LED lamp**
- **White package, colorless clear window**
- **GaAlAs, double hetero junction**
- **Superior luminous intensity**
- **Use as optical idicator**
- **For backlighting, optical coupling into light pipes and leness**
- **Suitable for all SMT assembly and reflow soldering methods**
- **Available taped on reel (12 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature Range
(T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 30 mA
Surge Current (I_{FM}) t≤10 µs D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 3 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 90 mW
Thermal Resistance, Junction /Air,
Mounted on PC Board*, pad size 16 mm^2
(R_{THJA}) .... 430 K/W

* PC board:FR4

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Symbol	Value	Unit	Condition
Peak Wavelength		λ_{PEAK}	660	nm	I_F=10mA
Dominant Wavelength		λ_{DOM}	645		
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	22		
Viewing Angle		2φ	120	Deg.	
Forward Voltage		V_F	1.75 (≤ 2.6)	V	I_F=10 mA
Reverse Current		I_F	0.01 (≤10)	µA	V_R=3 V
Capacitance		C_0	25	pF	V_R=0 V, f=1 MHz
Switching Times, I_V	10% to 90%	t_R	140	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω
	90% to 10%	t_F	110		

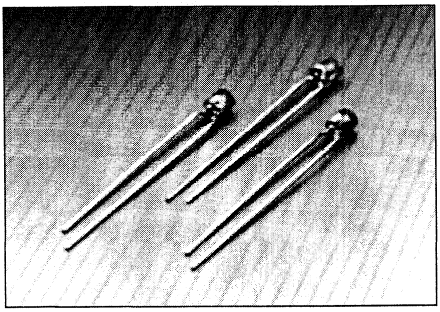
Part No.	Luminous Intensity, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LH A674-KM	6.3 to 32	—	I_F=10 mA
LH A674-L	10 to 20	45	
LH A674-M	16 to 32	75	
LH A674-LN	10 to 50	—	

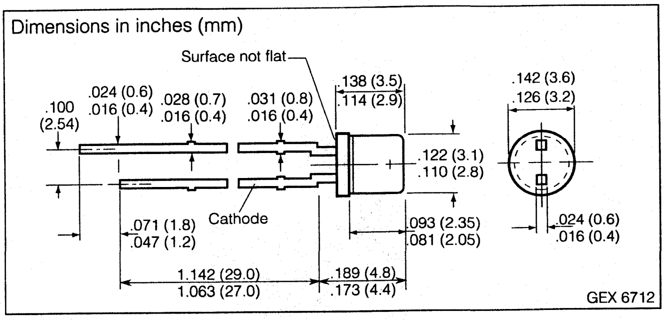
Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≥2.0.

See graph numbers OHL01698, OHL01660, OHL01736, OHL01737, OHL01686, OHL01661, OHL01739, OHL01740, OHL01741, OHL01749 beginning on page 4-92.

SIEMENS

HYPER-RED LH K376
Hyper-Bright, T1 (3 mm), TS GaAlAs ARGUS® LED Lamp





FEATURES

- **Colorless clear lens**
- **GaAlAs, double hetero junction, transparent substrate**
- **Plasic package with special design**
- **With an additional, custom built reflector suitable for backlighting display panels**
- **For optical coupling into light pipes**
- **Uniform illumination of a diffuser screen with external reflector**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Note:
If the diffuser screen is tinted, the spectral transmission must be adjusted to the wavelength emitted by the LED.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F) .... 50 mA
Surge Current (I_{FM}) t <10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 3 V
Power Dissipation (P_{TOT}) $T_A \leq 25°C$ .... 130 mW
Thermal Resistance, Junction/Air (R_{THJA}) .... 500 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	Values	Unit	Condition
Peak Wavelength		λ_{PEAK}	660	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	645		
Spectral Bandwidth 50% Φ_V		$\Delta\lambda$	22		
Forward Voltage		V_F	1.85 (≤ 2.3)	V	
Reverse Current		I_R	0.01 (≤10)	µA	V_R=3 V
Capacitance		C_O	30	pF	V_R=0 V f=1 MHz
Switching Time, I_V	10% to 90%	t_R	100	ns	I_F=100 mA t_P=10 µs R_L=50 Ω
	90% to 10%	t_F			
Temperature Coefficient	I_V or Φ_V	TC_I	–0.4	nm/K	I_F=50 mA
	V_F	TC_V	-3		
	λ_{PEAK}	TC_λ	0.16	mV/K	

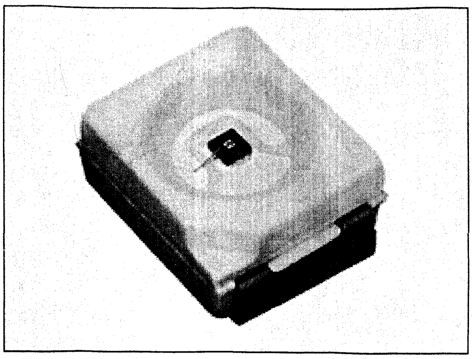
Part Number	Luminous Flux, Φ_V, mlm	Condition
LH K376-QS	63 to 200	I_F = 20 mA
LH K376-R	100 to 200	
LH K376-S	160 to 320	
LH K376-RT	100 to 500	

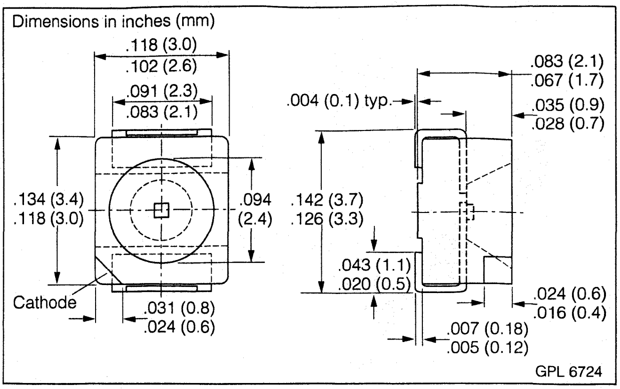
Luminous flux ratio of one packaging unit $\Phi_{VMAX} / \Phi_{VMIN} \leq 2$

See graph numbers OHLO1698, OHL01277, OHL02349, OHL00244, OHL02347, OHL00213 beginning on page 4–92.

SIEMENS

HYPER-RED LH T674
Superbright GaAlAs TOPLED® Lamp





FEATURES
- **PL-CC-2 package**
- **White package, colorless clear window**
- **Double hetero junction in GaAlAs technology**
- **Superior luminous intensity**
- **Use as optical indicator**
- **For backlighting, iptical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

DESCRIPTION

The LH T674 is a double heterojunction LED with a package that incorporates an internal reflector to optimize light coupling. This feature makes the SMT-TOPLED ideal for light pipe applications.

See graph numbers OHL01698, OHL01660, OHL01736, OHL01737, OHL01686, OHL01661, OHL01739, OHL01740, OHL01741, OHL01749 beginning on page 4–91.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) ......–55°C to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 30 mA
Surge Current (I_{FS}) t_p=10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 3 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 100 mW
Thermal Resistance, Junction/Air
Mounted on PC Board*, pad size ≥16 mm^2 (R_{thJA}) .... 400 K/W

* PC board: G30/FR4.

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	660	nm	I_F=10 mA
Dominant Wavelength	l_{DOM}	645		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	22		
Viewing Angle, 50% I_V	2 φ	120	Deg.	
Forward Voltage	V_F	1.75 (≤2.6)	V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=5 V
Capacitance	C_O	25	pF	V_R=0 V, f=1 MHz
Switching Times, I_V 10% to 90% 90% to 10%	 t_R t_F	 140 110	 ns ns	I_F=100 mA, tp=10 µs, R_L=50 Ω

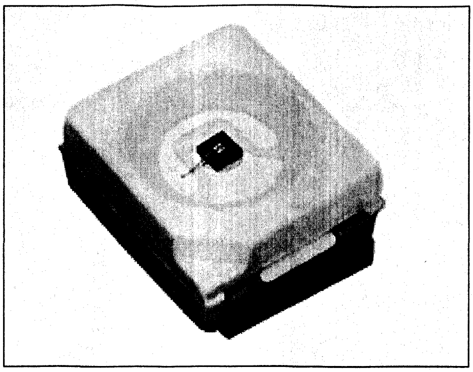
Part Number	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V (mlm)	Condition
LH T674-KM	6.3 to 32	—	10 mA
LH T674-L	10 to 20	45 (typ.)	
LH T674-M	16 to 32	75 (typ.)	
LH T674-LN	10 to 50	—	

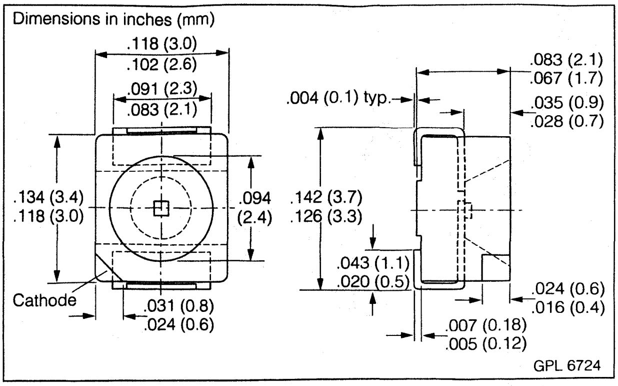
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2

LED Lamps 4

SIEMENS

HYPER-RED LH T676
Hyper-Bright TS GaAlAs TOPLED® Lamp





FEATURES
- **PL-CC-2 package**
- **White package, colorless clear window**
- **GaAlAs, double hetero junction, transparent substrate**
- **Superior luminous intensity**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating /Storage Temperature Range
(T_{OP}, T_{STG})....................................–55°C to +100°C
Junction Temperature (T_J) ....+100°C
Forward Current (I_F) ....50 mA
Surge Current (I_{FS}) t_p=10 µs, D=0.005 ....0.5 A
Reverse Voltage (V_R) ....3 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 130 mW
Thermal Resistance, Junction/Air
Mounted on PC board*, pad size ≥16 mm^2
(R_{thJA})..450 K/W

* PC board: FR4

Characteristics T_A=25°C

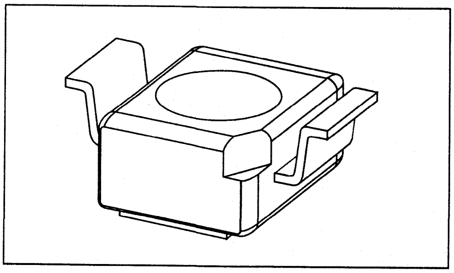
Parameter		Sym.	Value	Units	Condition
Peak Wavelength		λ_{PEAK}	660	nm	I_F=10 mA
Dominant Wavelength		l_{DOM}	645		
Spectral Bandwidth , 50% I_{RELMAX}		$\Delta\lambda$	22		
Viewing Angle, 50% I_V		2 φ	120	Deg.	
Forward Voltage		V_F	1.85 (≤ 2.3)	V	I_F=20 mA
Reverse Current		I_R	0.01 (≤ 10)	µA	V_R=3 V
Capacitance		C_O	30	pF	V_R=0 V f=1 MHz
Switching Times, I_V	10%-90%	t_R	100	ns	I_F=100 mA tp=10 µs R_L=50 Ω
	10%-90%	t_F			
Temperature Coefficient	I_V or Φ_V	TC_I	–0.4	%K	I_F=20 mA
	V_F	TC_V	-3	mV/K	
	λ_{PEAK}	TC_λ	+0.16	nm/K	

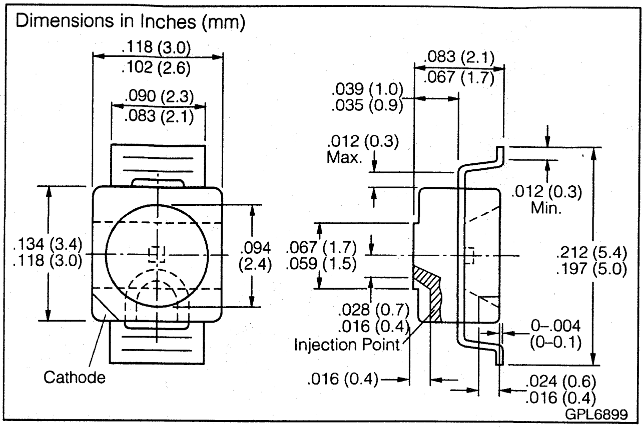
Part Number	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LH T676-NR	25 to 200	—	I_F=20 mA
LH T676-P	40 to 80	180	
LH T676-Q	63 to 125	300	
LH T676-R	100 to 200	450	
LH T676-PS	40 to 320	—	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

See graph numbers OHL01698, OHL01660, OHL02349, OHL02348, OHL02347, OHL00213 beginning on page 4–92.

HYPER-RED LH T774
Superbright GaAlAs Reverse Gullwing TOPLED® Lamp





FEATURES

- **Reverse gullwing TOPLED: surface mount LED lamp**
- **White package, colorless clear window**
- **GaAlAs, double heterojunction**
- **Superior luminous intensity**
- **Optical indicator**
- **Use as optical indicator**
- **Ideal for backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly solder processes**
- **Available taped on reel (12 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 30 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 3 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 90 mW
Thermal Resistance, Junction/Air, Mounted on PC Board(1), pad size 16 mm² (R_{THJA}) .... 400 K/W

Note: 1. PC board G30/FR4

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Symbol	Values	Unit	Condition
Peak Wavelength		λ_{PEAK}	660	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	645		I_F=10 mA
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	22		I_F=10 mA
Viewing Angle, 50%, I_V		2φ	120	Deg.	
Forward Voltage		V_F	1,75 (≤2.6)	V	I_F=10 mA
Reverse Current		I_R	0.01 (10)	µA	V_R=3 V
Capacitance		C_0	25	pF	V_R=0 V, f=1 MHz
Switching Times, I_V	10%–90%	t_R	140	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω
	90%–10%	t_F	110		

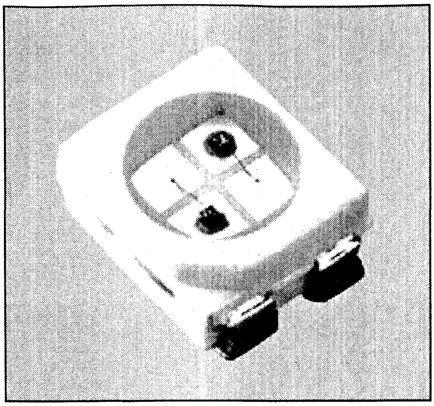
Part No.	Luminous Intensity, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LH T774-KM	6.3 to 32	—	I_F=10 mA
LH T774-L	10 to 20	45	
LH T774-M	16 to 32	75	
LH T774-LN	10 to 50	—	

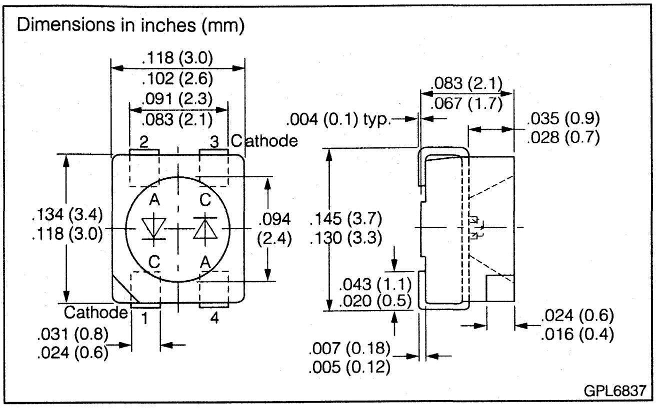
Note: Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN} ≤2.0.

See graph numbers OHL01698, OHL01660, OHL01736, OHL01737, OHL01686, OHL01661, OHL01739, OHL01740, OHL01741, OHL01749 beginning on page 4–92

SIEMENS

ORANGE/GREEN LOG T671
SUPER-RED/GREEN LSG T671
Multi TOPLED® Lamp





FEATURES
- **P-LCC-4 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) ....-55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) ....30 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005..........0.5 A
Reverse Voltage (V_R)....................5 V
Power Dissipation (P_{TOT})....................100 mW
Thermal Resistance, Junction/Air, Mounted on PC Board*, pad size 16 mm² (R_{THJA}) .... 400 K/W

Note:

1. *PC board: FR4

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength	λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% I_{RELMAX}	Δλ	45	40	45	25	22		
Viewing Angle, 50% I_V	2φ	120					Deg.	
Forward Voltage	V_F	2 (≤ 2.6)					V	I_F=10 mA
Reverse Current	I_R	0.01 (≤ 10)					µA	V_R=5 V
Capacitance	C_0	12	8	10	15		pF	V_R=0 V, f=1 MHz
Switching Times, I_V 10% to 90%	t_R	300			450		ns	I_F =100 mA, t_P=10 µs, R_L=50 Ω
Switching Times, I_V 90% to 10%	t_F	150			200			

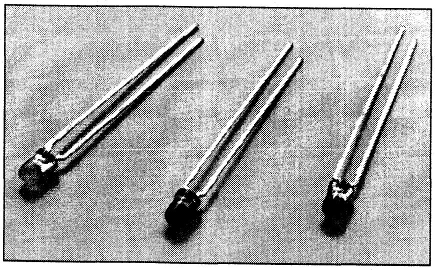
Part Number	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LOG T671-HO	8 (≥2.5)	24	I_F=10 mA
LOG T671-LO	15 (≥10)	25	
LSG T671-HK	2.5 to 12.5	—	
LSG T671-J	4 to 8	18	
LSG T671-K	6.3 to 12.5	30	
LSG T671-JL	6.3 to 20	—	

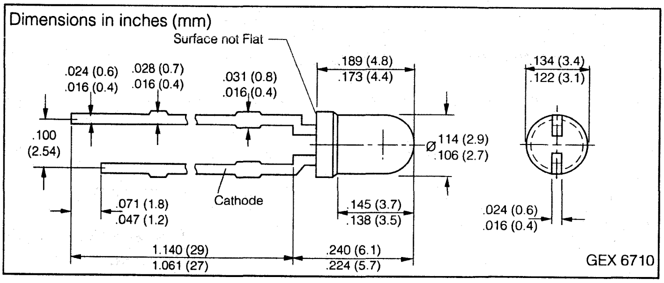
*Luminous Intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≤2.0

See graph numbers OHL01698, OHL01660, OHL02145, OHL02146, OHL01686, OHL00241, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–91.

SIEMENS

GaAsP RED LR 3360
TSN SUPER-RED LS 3360
TSN ORANGE LO 3360
TSN YELLOW LY 3360
GaP GREEN LG 3360
GaP PURE GREEN LP 3360
T1 (3 mm) LED Lamp





FEATURES

- **Color, diffused lens**
  - **LR, LS: red**
  - **LO: orange**
  - **LY: yellow**
  - **LG, LP: green**
- **Use as optical indicator**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LR .... 45 mA
LS, LO, LY, LG .... 40 mA
LP .... 30 mA
Surge Current (I_{FS}) t ≤10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C
LR, LP .... 100 mW
LS, LO, LY, LG .... 140 mW
Thermal Resistance,
Junction to Air (R_{THJA}) .... 400 K/W

See graph numbers OHL01698, OHL01165, OHL02237, OHL02146, OHL01162, OHL02142, OHL01686, OHL01170, OHL02230, OHL02234, OHL02235, OHL02236 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LR	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	660	635	610	586	565	557	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	645	628	605	590	570	560		
Spectral Bandwidth 50% I_{RELMAX}	Dl	35	45	40	45	25	22		
Viewing Angle 50%, I_V	2φ	70						Deg.	
Forward Voltage	V_F	1.6 (≤2.0)	2.0 (≤2.6)					V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)						µA	V_R=5 V
Capacitance	C_0	25	12	8	10	15		pF	V_R=0 V f=1 MHz
Swithcing Times I_V, 10% to 90%	t_R	120	300			450		ns	I_F=100 mA tp=10 µs
I_V, 90% to 10%	t_F	50	150			200			R_L=50 Ω

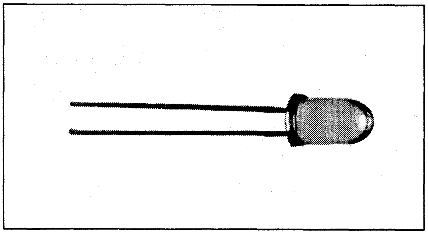
Luminous Intensity*, I_V, mcd

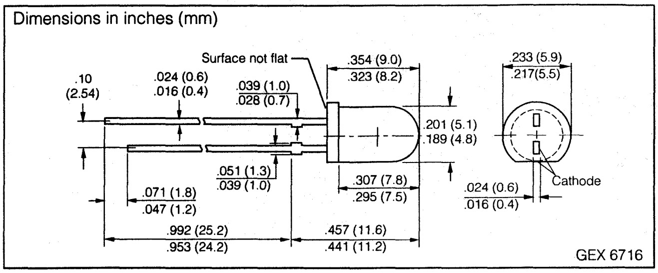
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LR 3360-DG	0.4	3.2	LY 3360-HL	2.5	20	I_F=10 mA
LR 3360-F	1	2	LY 3360-K	6.3	12.5	
LR 3360-G	1.6	3.2	LY 3360-L	10	20	
LR 3360-FJ	1	8	LY 3360-KN	6.3	50	
LS 3360-HL	2.5	20	LG 3360-HL	2.5	20	
LS 3360-K	6.3	12.5	LG 3360-J	4	8	
LS 3360-L	4	8	LG 3360-K	6.3	12.5	
LS 3360-KN	6.3	50	LG 3360-L	10	20	
LO 3360-HL	2.5	20	LG 3360-KN	6.3	50	
LO 3360-K	6.3	12.5	LP 3360-GK	1.6	12.5	
LO 3360-L	10	20	LP 3360-H	2.5	5	
LO 3360-JM	4	32	LP 3360-J	4	8	
			LP 3360-HL	2.5	20	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

SIEMENS

RED LR 5360
SUPER-RED LS 5360
YELLOW LY 5360
GREEN LG 5360
T1¾ (5 mm) LED Lamp





FEATURES

- **Colored, diffused lens**
  LR, LS: red
  LY: yellow
  LG: green
- **Use as optical indicator**
- **Solder leads withour stand-off**
- **Available taped on reel**
- **Load dump resistance per DIN 40839**

DESCRIPTION

The LR 5360 is a standard red gallium arsenide phosphide (GaAsP) LED lamp. The LS 5360 super-red and LY 5360 yellow are premium high efficiency light emitting diode lamps fabricated with TSN (transparent substrate nitrogen) technology. The LG 5360 green is a gallium phosphide (GaP) lamp. All have a diffused plastic lens which emits a full flooded intense light.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP} T_{STG})....................–55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LR..45 mA
LS, LY, LG..40 mA
Surge Current (I_{FS}) t ≤10 µs ....0.5 A
Reverse Voltage (V_R).......................................5 V
Power Dissipation (P_{TOT}) T_A≤25°C
LR.. 100 mW
LS, LY, LG.. 140 mW
Thermal Resistance,
Junction/Air (R_{THJA}) ....400 K/W

See graph numbers OHL01164, OHL01191, OHL01676, OHL01011, OHL01162, OHL02142, OHL02143, OHL01677, OHL01678, OHL01679, OHL01680 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LR	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	660	635	586	565	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	645	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	35	45		25		
Viewing Angle 50% I_V	2φ	50				Deg.	
Forward Voltage	V_F	1.6 (≤2.0)	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)				µA	V_R=5 V
Capacitance	C_0	25	12	10	15	pF	V_R=0 V f=1 MHz
Switching Times 10% to 90% 90% to 10%	t_R	120	300		450	ns	I_F=100 mA tp=10 µs R_L=50 Ω
	t_F	50	150		200		

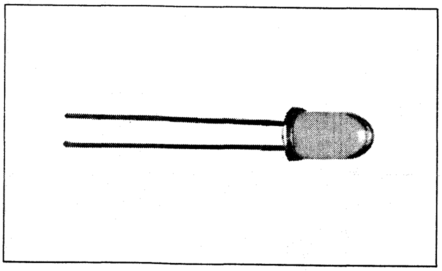
Luminous Intensity*, I_V, mcd

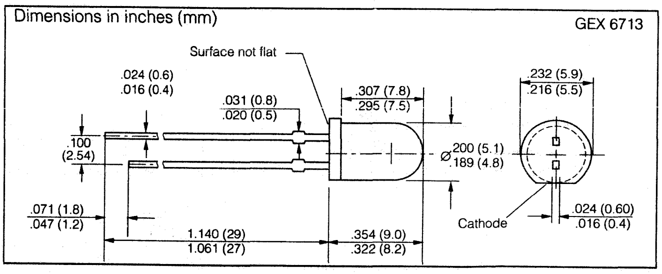
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LR 5360-DG	0.4	3.2	LY 5360-HL	2.5	20	I_F=10 mA
LR 5360-F	1	2	LY 5360-J	4	8	
LR 5360-G	1.6	3.2	LY 5360-K	6.3	12.5	
LR 5360-FJ	1	8	LY 5360-L	10	20	
LS 5360-HL	2.5	20	LY 5360-JM	4	32	
LS 5360-J	4	8	LG 5360-GK	1.6	12.5	
LS 5360-K	6.3	12.5	LG 5360-H	2.5	5	
LS 5360-L	10	20	LG 5360-J	4	8	
LS 5360-JM	4	32	LG 5360-K	6.3	12.5	
			LG 5360-HL	2.5	20	

* Luminous intensity ratio of one packaging unit $I_{VMAX}/I_{VMIN} \leq 2$

SIEMENS

RED LR 5460
SUPER-RED LS 5460
YELLOW LY 5460
GREEN LG 5460
T1¾ (5 mm) LED Lamp





FEATURES

- **Colored, diffused lens**
  LR, LS: red
  LY: yellow
  LG: green
- **Use as optical indicator**
- **Solder leads without stand-off**
- **Available taped on reel**
- **Load dump resistance per DIN 40838**

DESCRIPTION

The LR 5460 series is a standard red gallium arsenide phosphide (GaAsP) LED lamp. The LS 5460 super-red and LY 5460 yellow are premium high efficiency light emitting diode lamps fabricated with TSN (transparent substrate nitrogen) technology. The LG 5460 green is a gallium phosphide (GaP) lamp. All have a diffused plastic lens which emits a full flooded intense light.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) ....100°C
Forward Current (I_F)
LR .... 45 mA
LS, LY, LG .... 40 mA
Surge Current (I_{FS}) t ≤10 µs .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C
LR .... 100 mW
LS, LY, LG .... 140 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

See graph numbers OHL01164, OHL01191, OHL01676, OHL01011, OHL01162, OHL02142, OHL02143, OHL01677, OHL01677, OHL0 1678, OHL01679, OHL01680 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LR	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	660	635	586	565	nm	
Dominant Wavelength	λ_{DOM}	645	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	35	45		25		I_F=20 mA
Viewing Angle 50% I_V	2φ	50				Deg.	
Forward Voltage	V_F	1.6 (≤2.0)	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)				µA	V_R=5 V
Capacitance	C_0	25	12	10	15	pF	V_R=0 V, f=1 MHz
Rise Time	t_R	120	300		450	ns	
Fall Time	t_F	50	150		200		

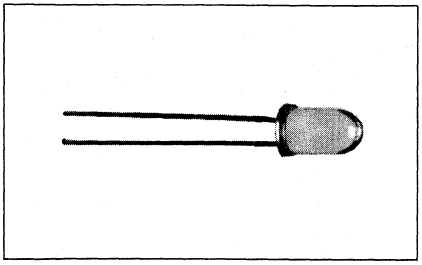
Luminous Intensity*, I_V, mcd

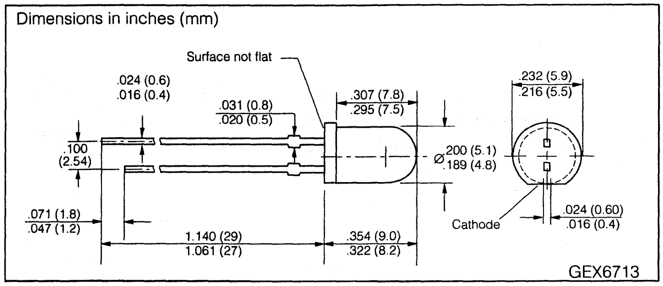
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LR 5460-DG	0.4	3.2	LY 5460-HL	2.5	20	I_F=10 mA
LR 5460-F	1	2	LY 5460-J	4	8	
LR 5460-G	1.6	3.2	LY 5460-K	6.3	12.5	
LR 5460-FJ	1	8	LY 5460-L	10	20	
LS 5460-HL	2.5	20	LY 5460-JM	4		
LS 5460-J	4	8	LG 5460-GK	1.6	12.5	
LS 5460-K	6.3	12.5	LG 5460-H	2.5	5	
LS 5460-L	10	20	LG 5460-J	4	8	
LS 5460-JM	4	32	LG 5460-K	6.3	12.5	
			LG 5460-HL	2.5	20	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

SIEMENS

GaAsP RED LR 5480
TSN SUPER-RED LS 5480
TSN YELLOW LY 5480
GaP GREEN LG 5480
T1¾ (5 mm) LED Lamp





FEATURES
- **Colored, diffused lens**
  - **LR, LS: red**
  - **LY: yellow**
  - **LG: green**
- **Use as optical Indicator**
- **Solder lead without stand-off**
- **Available taped on reel**
- **Load dump resistance per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LR .... 45 mA
LS, LY, LG .... 40 mA
Surge Current (I_{FS}) (t ≤10 µs) .... 0.5 A
Reverse Voltage (V_R) ....5 V
Power Dissipation (P_{TOT}) T_A≤25°C
LR ....100 mW
LS, LY, LG ....140 mW
Thermal Resistance,
Junction to Air (R_{THJA}) .... 400 K/W

See graph numbers OHL01164, OHL01643, OHL01676, OHL01011, OHL01162, OHL02142, OHL02143, OHL01677, OHL01678, OHL01679, OHL01680 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LR	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	660	635	586	565	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	645	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	35	45		25		
Viewing Angle 50% I_V	φ	80				Deg.	
Forward Voltage	V_F	1.6 (≤2.0)	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)				µA	V_R=5 V
Capacitance	C_0	25	12	10	15	pF	V_R=0 V, f=1 MHz
Swithcing Times I_V, 10% to 90%	t_R	120	300		450	ns	I_F=100 mA, tp=10 µs, R_L=50 Ω
I_V, 90% to 10%	t_F	50	150		200		

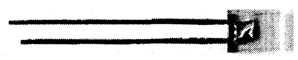
Luminous Intensity*, I_V, mcd

Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LR 5480-CF	0.25	2	LY 5480-HL	2.5	20	I_F=10 mA
LR 5480-E	0.63	1.25	LY 5480-J	4	8	
LR 5480-F	1	2	LY 5480-K	6.3	12.5	
LR 5480-DG	0.4	3.2	LY 5480-L	10	20	
LS 5480-GL	1.6	20	LY 5480-JM	4	32	
LS 5480-J	4	8	LG 5480-GK	1.6	12.5	
LS 5480-K	6.3	12.5	LG 5480-H	2.5	5	
LS 5480-L	10	20	LG 5480-J	4	8	
LS 5480-JM	4	32	LG 5480-K	6.3	12.5	
			LG 5480-HL	2.5	20	

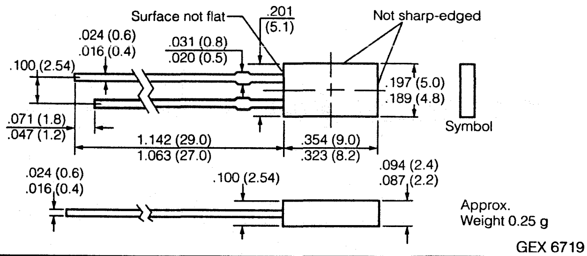
* Luminous intensity ratio of IV of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2.

SIEMENS

GaAsP RED LR B480
TSN SUPER-RED LS B480
TSN YELLOW LY B480
GaP GREEN LG B480
Rectangular LED Lamp



Dimensions in inches (mm)



FEATURES

- **Colored, partly diffused lens**
  - **LR, LS: red**
  - **LY: yellow**
  - **LG: green**
- **Use as optical indicator in frontpanel**
- **Solder leads without stand-off**
- **Bargraph displays**
- **Available taped on reel**
- **Load dump resistance per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–55°C to +100°C
Junction Temperature (T_J)........................... 100°C
Forward Current (I_F)
LR .... 45 mA
LS, LY, LG .... 40 mA
Surge Current (I_{FS}) t ≤10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R)..5 V
Power Dissipation (P_{TOT}) T_A≤25°C
LR ....100 mW
LS, LY, LG ....140 mW
Thermal Resistance,
Junction/Air (R_{THJA})............................. 400 K/W

See graph numbers OHL01164, OHL01681, OHL01676, OHL01011, OHL01162, OHL02142, OHL02143, OHL01677, OHL01678, OHL01679, OHL01680 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	**Sym.**	**LR**	**LS**	**LY**	**LG**	**Unit**	**Condition**
Peak Wavelength	λ_{PEAK}	660	635	586	565	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	645	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	35	45		25		
Viewing Angle 50% I_V	2φ	100				Deg.	
Forward Voltage	V_F	1.6 (≤2.0)	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)				µA	V_R=5 V
Capacitance	C_0	25	12	10	15	pF	V_R=0 V
Rise Time	t_R	120	300		450	ns	
Fall Time	t_F	50	150		200		

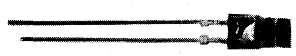
Luminous Intensity*, I_V, mcd

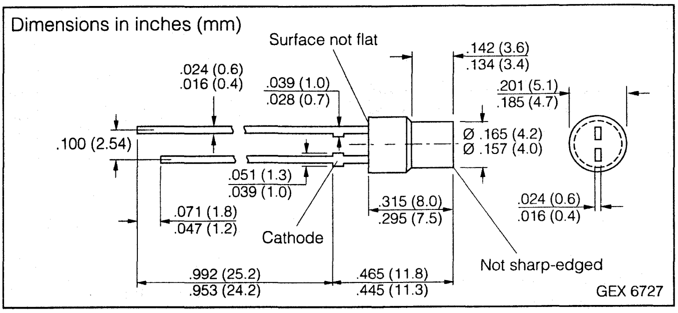
Part Number	**Min.**	**Max.**	**Part Number**	**Min.**	**Max.**	**Condition**
LR B480-BD	0.16	0.8	LY B480-EH	0.63	5	I_F=10 mA
LR B480-C	0.25	0.5	LY B480-G	1.6	3.2	
LR B480-D	0.4	0.8	LY B480-H	2.5	5	
LR B480-CE	0.25	1.25	LY B480-J	4	8	
LS B480-EH	0.63	5	LY B480-GK	1.6	12.5	
LS B480-G	1.6	3.2	LG B480-EH	0.63	5	
LS B480-H	2.5	5	LG B480-G	1.6	3.2	
LS B480-GK	1.6	12.5	LG B480-H	2.5	5	
			LG B480-GK	1.6	12.5	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

SIEMENS

GaAsP RED LR H380
TSN SUPER-RED LS H380
TSN YELLOW LY H380
GaP GREEN LG H380
ORANGE LO H380
Cylindrical LED Lamp





FEATURES
- **Colored, partly diffused lens**
  - **LR, LS: red**
  - **LO: orange**
  - **LY: yellow**
  - **LG: green**
- **Use as optical indicator in front panels**
- **Solder leads without stand-off**
- **Available taped on reel**
- **Load dump resistance per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–55°C to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 40 mA
Surge Current (I_{FS}) t ≤10 µs .... 0.5 A
Power Dissipation (P_{TOT}) T_A=25°C....... 140 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

See graph numbers OHL01164, OHL01681, OHL01676, OHL01011, OHL01162, OHL02142, OHL02143, OHL01677, OHL01678, OHL01679, OHL01680 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LR	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	660	635	586	565	nm	
Dominant Wavelength	λ_{DOM}	645	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	35	45		25		I_F=20 mA
Viewing Angle, 50% I_V	2φ	100				Deg.	
Forward Voltage	V_F	1.6 (≤2.0)	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)				µA	V_R=5 V
Capacitance	C_0	25	12	10	15	pF	V_R=0 V
Rise Time	t_R	120	300		450	ns	
Fall Time	t_F	50	150		200		

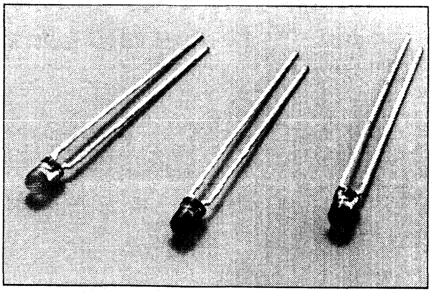
Luminous Intensity*, I_V, mcd

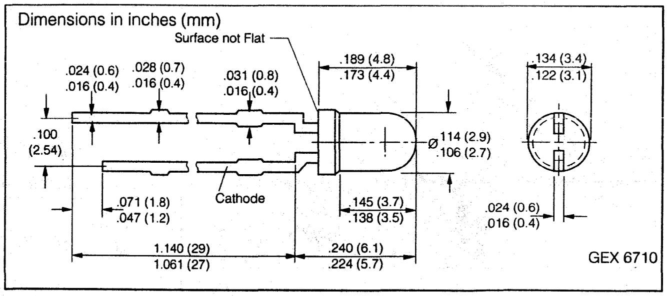
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LR H380-BD	0.16	0.8	LY H380-EH	0.63	5	I_F=10 mA
LR H380-C	0.25	0.5	LY H380-G	1.6	3.2	
LR H380-D	0.4	0.8	LY H380-H	2.5	5	
LR H380-CE	0.25	1.25	LY H380-J	4	8	
LS H380-EH	0.63	5	LY H380-GK	1.6	12.5	
LS H380-G	1.6	3.2	LG H380-EH	0.63	5	
LS H380-H	2.5	5	LG H380-G	1.6	3.2	
LS H380-J	4	8	LG H380-GK		12.5	
LS H380-GK	1.6	12.5	LG H380-J	4	8	
LO H380-GJ	≥1.6	4 typ.	LG H380-H	2.5	5	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

SIEMENS

SUPER-RED LS 3336
AMBER LA 3336
ORANGE LO 3336
YELLOW LY 3336
Hyper-Bright T1 (3 mm) LED Lamp





FEATURES

- **Colorless, clear lens**
- **Optical coupling into light pipes**
- **Use as optical indicator**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LS, LO, LA .... 30 mA
LY .... 20 mA
Surge Current (I_{FS}) t ≤10 µs, D=0.005 .... TBD
Reverse Voltage (V_R)(1) .... 3 V
Power Dissipation (P_{TOT}) T_A≤25°C
LS, LO, LA .... 80 mW
LY .... 55 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 500 K/W

1. Reverse biasing should be avoided.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	LS	LA	LO	LY	Unit	Condition
Peak Wavelength		λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	632	615	605	587		
Spectral Bandwidth 50% I_{RELMAX}		$\Delta\lambda$	16			15		
Viewing Angle 50%, I_V		2φ	50				Deg.	
Forward Voltage		V_F	2 (≤ 2.6)				V	I_F=20 mA
Reverse Current		I_R	0.01 (≤ 10)				µA	V_R=3 V
Temperature Coefficient	λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
	λ_{PEAK}		0.14	0.13				
	V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

Luminous Intensity*, I_V, mcd

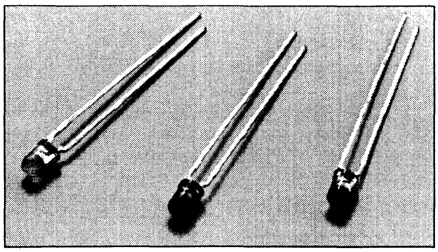
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LS 3336-QT	63	500	LA/LO/LY 3336-RU	100	800	I_F=20 mA
LS 3336-R	100	200	LA/LO/LY 3336-S	160	320	
LS 3336-S	160	320	LA/LO/LY 3336-T	250	500	
LS 3336-T	250	500	LA/LO/LY 3336-U	400	800	
LS 3336-RU	100	800	LA/LO/LY 3336-SV	160	1250	

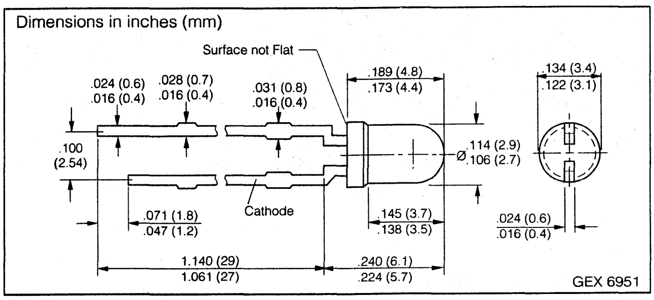
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

See graph numbers OHL00235, OHL01646, OHL00232, OHL00248, OHL00233, OHL00238, OHL00322, OHL00316 beginning on page 4-92.

SIEMENS

TSN SUPER-RED LS 3340
TSN ORANGE LO 3340
TSN YELLOW LY 3340
GaP PURE GREEN LP 3340
GaP GREEN LG 3330
T1 (3 mm) LED Lamp





FEATURES
- **Colored, clear lens**
  - **– LS: red**
  - **– LD: orange**
  - **– LY: yellow**
  - **– LG: colorless**
  - **– LP: green**
- **Optical coupling into light pipes**
- **Use as optical indicator**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J)............................100°C
Forward Current (I_F)
LS,LO, LY, LG .... 40 mA
LP .... 30 mA
Surge Current (I_{FS}) t=10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R)... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C
LS,LO, LY, LG .... 140 mW
LP .... 100 mW
Thermal Resistance,
Junction to Air (R_{THJA})........................... 400 K/W

See graph numbers OHL01698, OHL01646, OHL01263, OHL01246, OHL01162, OHL01686, OHL01170, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LY	LO	LG	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	610	565	557	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	628	590	605	570	560		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	45		40	25	22		
Viewing Angle, 50% I_V	2φ	50					Deg.	
Forward Voltage	V_F	2.0 (≤2.6)					V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance	C_0	12	10	8	15		pF	V_R=0 V, f=1 MHz
Swithcing Times I_V, 10% to 90%	t_R	300			450		ns	I_F=100 mA tp=10 µs R_L=50 Ω
I_V, 90% to 10%	t_F	150			200			

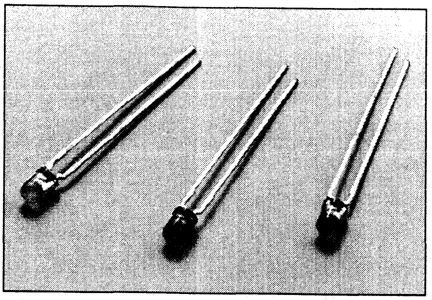
Luminous Intensity*, I_V, mcd, I_F=10 mA

Part Number	Min.	Max.	Part Number	Min.	Max.
LS 3340-KN	6.3	50	LY 3340-M	16	32
LS 3340-L	10	20	LY 3340-N	25	52
LS 3340-M	16	32	LY 3340-LP	10	80
LS 3340-N	25	50	LG 3330-KN	6.3	50
LS 3340-LP	10	80	LG 3330-L	10	20
LO 3340-KN	6.3	50	LG 3330-M	16	32
LO 3340-L	10	20	LG 3330-N	25	50
LO 3340-M	16	32	LG 3330-LP	10	80
LO 3340-N	25	50	LP 3340-JL	4.0	20
LO 3340-LP	10	80	LP 3340-K	6.3	12.5
LY 3340-JM	4	32	LP 3340-L	10	20
LY 3340-L	10	20	LP 3340-KM	6.3	32

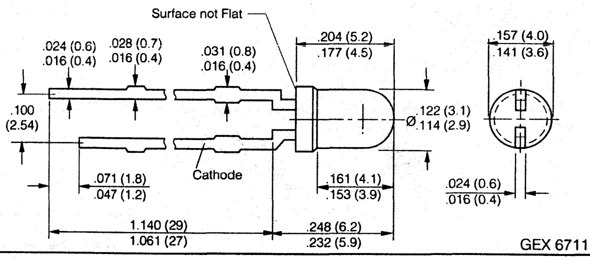
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2.0.

SIEMENS

TSN SUPER-RED LS 3341
TSN YELLOW LY 3341
GaP GREEN LG 3341
GaP PURE GREEN LP 3341
T1 (3 mm) LED Lamp



Dimensions in inches (mm)



FEATURES
- **Colored, clear package**
  - **– LS: red**
  - **– LY: yellow**
  - **– LG/LP: green**
- **High luminous intensity**
- **Optical coupling into light pipes**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LS, Ly, LG..40 mA
LP..30 mA
Surge Current (I_{FS}) t=10 µs, D=0.005 ....0.5 A
Reverse Voltage (V_R)......................................5 V
Power Dissipation (P_{TOT}) T_A≤25°C
LS, Ly, LG.. 140 mW
LP... 100 mW
Thermal Resistance,
Junction to Air (R_{THJA}).........................400 K/W

See graph numbers OHL01698, OHL01657, OHL01170, OHL02104, OHL02105, OHL02106, OHL01263 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	Super-Red	Yellow	Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	45		25		
Viewing Angle, 50% I_V	2φ	40			Deg.	
Forward Voltage	V_F	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	12	10	15	pF	V_R=0 V, f=1 MHz
Swithcing Times I_V, 10% to 90%	t_R	300		450	ns	I_F=100 mA tp=10 µs R_L=50 Ω
I_V, 90% to 10%	t_F	150		200		

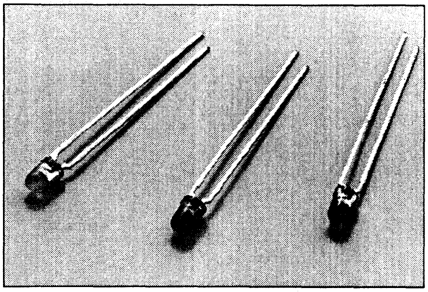
Luminous Intensity*, I_V, mcd

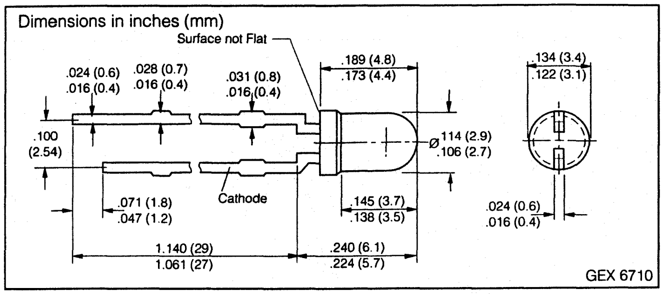
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LS 3341-LP	10	80	LG 3341-KN	6.3	50	I_F=10 mA
LS 3341-M	16	32	LG 3341-M	16	32	
LS 3341-N	25	50	LG 3341-N	25	50	
LS 3341-P	40	80	LG3341-MQ	16	125	
LS 3341-MQ	16	125	LP 3341-JM	4	32	
LY 3341-LP	10	80	LP 3341-K	6.3	12.5	
LY 3341-M	16	32	LP 3341-L	10	20	
LY 3341-N	25	50	LP 3341-M	16	32	
LY 3341-P	40	80	LP 3341-KN	6.3	50	
LY 3341-MQ	16	125				

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

SIEMENS

SUPER-RED LS 3366
AMBER LA 3366
ORANGE LO 3366
YELLOW LY 3366
Hyper-Bright T1 (3 mm) LED Lamp





FEATURES

- **Colored, diffused lens**
  - **LS: red**
  - **LA/LO: orange**
  - **LY: yellow**
- **Optical coupling into light pipes**
- **Use as optical indicator**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R)[1] .... 3 V
Forward Current (I_F), LY .... 20 mA
LS, LO, LA .... 30 mA
Surge Current (I_{FS}) t ≤10 µs .... to be defined
Power Dissipation (P_{TOT}) T_A=25°C, LY .... 55 mW
LS, LO, LA .... 80 mW
Thermal Resistance,
Junction to Air (R_{THJA}) .... 500 K/W

Note:

1. Reverse biasing should be avoided.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	LS	LA	LO	LY	Unit	Condition
Peak Wavelength		λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	632	615	605	587		
Spectral Bandwidth 50% I_{RELMAX}		$\Delta\lambda$	16			15		
Viewing Angle 50%, I_V		2φ	70				Deg.	
Forward Voltage	typ.	V_F	2				V	I_F=20 mA
	max.		2.6					
Reverse Current	typ.	I_R	0.01				µA	V_R=3 V
	max.		10					
Temperature Coefficient	λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
	λ_{PEAK}		0.14	0.13				
	V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

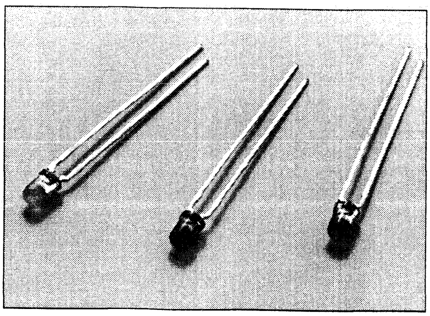
Part Number	Luminous Intensity, I_V, mcd	Part Number	Luminous Intensity, I_V, mcd	Condition
LS 3366-NR	25 to 200	LO 3366-PS	40 to 320	I_F=20 mA
LS 3366-P	40 to 80	LO 3366-Q	63 to 125	
LS 3366-Q	63 to 125	LO 3366-R	100 tp 200	
LS 3366-R	100 to 200	LO 3366-S	160 to 320	
LS 3366-PS	40 to 320	LO 3366-QT	63 to 500	
LA 3366-PS	40 to 320	LY 3366-PS	40 to 320	
LA 3366-Q	63 to 125	LY 3366-Q	63 to 125	
LA 3366-R	100 tp 200	LY 3366-R	100 tp 200	
LA 3366-S	160 to 320	LY 3366-S	160 to 320	
LA 3366-QT	63 to 500	LY 3366-QT	63 to 500	

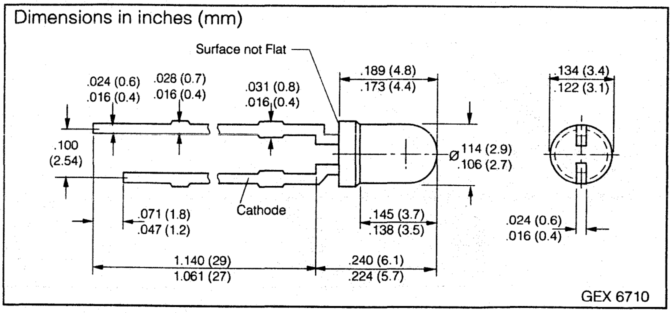
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

See graph numbers OHL00235, OHL01165, OHL00232, OHL00248, OHL00233, OHL00238, OHL00322, OHL00316 beginning on page 4–92.

SIEMENS

SUPER-RED LS 3369
YELLOW LY 3369
GREEN LG 3369
Low Current T1 (3 mm) LED Lamp





FEATURES
- **Colored, diffused lens**
  - **LS: red**
  - **LY: yellow**
  - **LG: green**
- **Use as optical indicator**
- **High luminous intensity at low currents (typ. 2 mA)**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

DESCRIPTION
The 3369 series are low current LED lamps that have been designed to optimize light output at very low currents. These parts are ideally suited for applications where power is at a premium, such as portable equipment.

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)................................. 7.5 mA
Surge Current (I_{FS}) t=10 µs, D≤0.005 .... 0.15 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 20 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 500 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	Super-Red	Yellow	Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=7.5 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	45		25		
Viewing Angle	2φ	60			Deg.	
Forward Voltage	V_F	1.8 (≤2.6)	2.0 (≤2.7)	1.9 (≤2.6)	V	I_F=2 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	3		15	pF	V_R=0 V f=1 MHz
Switching Times, I_V 10% to 90% 90% to 10%	t_R t_F	200 150		450 200	ns ns	I_F=100 mA t=10 µs R_L=50 Ω

Luminous Intensity, I_V, mcd*

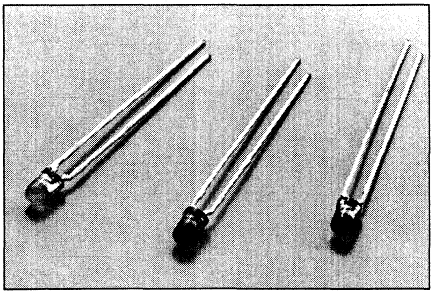
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LS 3369-EH	0.63	50	LY 3369-H	2.5	5	I_F=10 mA
LS 3369-G	1.6	3.2	LY 3369-FJ	1.0	8	
LS 3369-H	2.5	5	LG 3369-EH	0.63	5	
LS 3369-GK	1.6	12.5	LG 3369-F	1	2	
LY 3369-EH	0.63	5	LG 3369-G	1.6	3.2	
LY 3369-F	1	2	LG 3369-FJ	1	8	
LY 3369-G	1.6	3.2				

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2

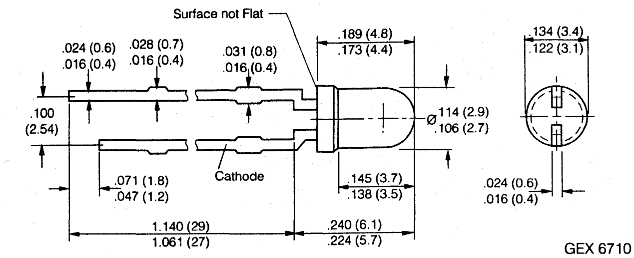
See graph numbers OHL01210, OHL01190, OHL01208, OHL01207, OHL01278, OHL01193, OHL01672, OHL01673, OHL01750, OHL01675 beginning on page 4-92

SIEMENS

SUPER-RED LS 3380
YELLOW LY 3380
GREEN LG 3380
T1 (3 mm) Wide Angle LED Lamp



Dimensions in inches (mm)



FEATURES

- **Colored, diffused lens**
  - **– LS: red**
  - **– LY: yellow**
  - **– LG: green**
- **Use as optical indicator**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–55°C to +100°C
Junction Temperature (T_J)............................ 100°C
Forward Current (I_F) .... 40 mA
Surge Current (I_{FS}) t=10 µs, D=0.005........... 0.5 A
Reverse Voltage (V_R)..5 V
Power Dissipation (P_{TOT}) T_A≤25°C............140 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	45		25		I_F=20 mA
Viewing Angle, 50% I_V	2φ	100			Deg.	
Forward Voltage	V_F	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	12	10	45	pF	V_R=0 V, f=1 MHz
Switching Times, I_V					ns	I_F=100 mA tp=10 µs R_L=50 Ω
10% to 90%	t_R	300		450		
90% to 10%	t_F	150		200		

Luminous Intensity*, I_V, mcd

Part Number	Min./Max.	Part Number	Min./Max.	Condition
LS/LY 3380-GK	1.6 to 12.5	LG 3380-GK	1.6 to 12.5	I_F=10 mA
LS/LY 3380-H	2.5 to 5	LG 3380-J	4 to 8	
LS/LY 3380-J	4 to 8	LG 3380-K	6.3 to 12.5	
LS/LY 3380-K	6.3 to 12.5	LG 3380-JL	4 to 20	
LS/LY 3380-HL	2.5 to 20			

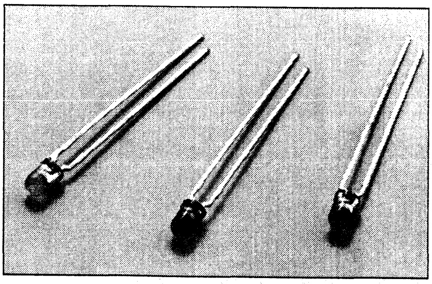
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2.0.

See graph numbers OHL01210, OHL01681, OHL01263, OHL01632, OHL01162, OHL02252, OHL01672, OHL01673, OHL01674, OHL01675 beginning on page 4–92.

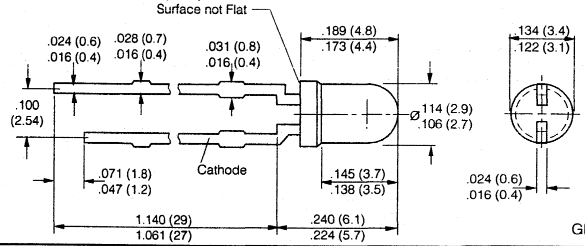
SIEMENS

SUPER-RED LS 3386
AMBER LA 3386
ORANGE LO 3386
YELLOW LY 3386

Hyper-Bright, Wide Angle T1 (3 mm) LED Lamp



Dimensions in inches (mm)



GEX 6710

FEATURES

- **Colored, diffused lens**
  - **LS: red**
  - **LA, LO: orange**
  - **LY: yellow**
- **Optical coupling into light pipes**
- **Use as optical indicator**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LS, LO, LA .... 30 mA
LY .... 20 mA
Surge Current (I_{FS}) t ≤10 µs, D=0.005 .... TBD
Reverse Voltage (V_R)(1) .... 3 V
Power Dissipation (P_{TOT}) T_A≤25°C
LS, LO, LA .... 80 mW
LY .... 55 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 500 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LA	LO	LY	Unit	Condition
Peak Wavelength	λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	632	615	605	587		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	16			15		
Viewing Angle, 50% I_V	2φ	100				Deg.	
Forward Voltage	V_F	2 (≤ 2.6)				V	I_F=20 mA
Reverse Current	I_R	0.01 (≤ 10)				µA	V_R=3 V
Temperature Coefficient λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
λ_{PEAK}		0.14	0.13				
V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

Luminous Intensity*, I_V, mcd

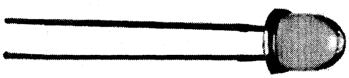
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LS 3386-LP	10	80	LA/LO/LY 3386-MQ	16	125	I_F=20 mA
LS 3386-M	16	32	LA/LO/LY 3386-N	25	50	
LS 3386-N	25	50	LA/LO/LY 3386-P	40	80	
LS 3386-P	40	80	LA/LO/LY 3386-Q	63	125	
LS 3386-MQ	16	125	LA/LO/LY 3386-NR	25	200	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

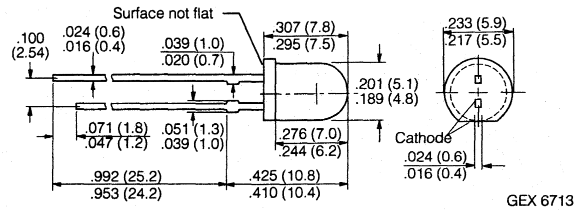
See graph numbers OHL00235, OHL01681, OHL00232, OHL00248, OHL00233, OHL00238, OHL00322, OHL00316 beginning on page 4–92.

SIEMENS

SUPER-RED LS 5380
YELLOW LY 5380
GREEN LG 5380
T1¾ (5 mm) LED Lamp



Dimensions in inches (mm)



FEATURES
- **Low profile package**
- **Colored, diffused lens**
  - **– LS:red**
  - **– LY: yellow**
  - **– LG green**
- **Use as optical indicator**
- **Solder leads without stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

DESCRIPTION

The LS 5380 super-red and LY 5380 yellow are premium high efficiency light emitting diode lamps fabricated with TSN (transparent substrate nitrogen) technology. The LG 5380 green is a gallium phosphide (GaP) lamp. All have a diffused plastic lens which emits a full flooded intense light.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F) .... 40 mA
Surge Current (I_{FS}) t = 10 µs, D0.005 .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 140 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	45		25		I_F=20 mA
Viewing Angle, 50% I_V	2φ	140			Deg.	
Forward Voltage	V_F	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	12	10	15	pF	V_R=0 V f=1 MHz
Swithcing Times, I_V 10% to 90%	t_R	300		450	ns	I_F=100 mA tp=10 µs R_L=50 Ω
90% to 10%	t_F	150		200		

Luminous Intensity*, I_V, mcd

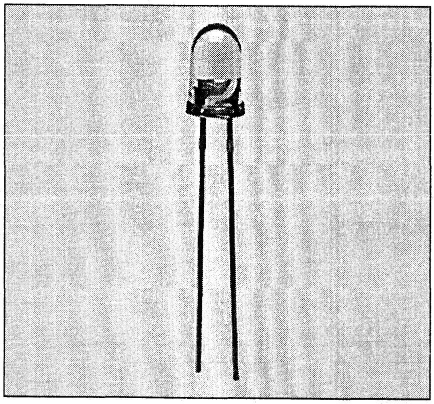
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LS 5380-FJ	1	8	LY 5380-K	6.3	12.5	I_F=10 mA
LS 5380-G	1.6	3.2	LY 5380-HL	2.5	20	
LS 5380-H	2.5	5	LG 5380-GK	1.6	12.5	
LS 5380-J	4	8	LG 5380-H	2.5	5	
LS 5380-HL	2.5	20	LG 5380-J	4	8	
LY 5380-GK	1.6	12.5	LG 5380-K	6.3	12.5	
LY 5380-H	2.5	5	LG 5380-HL	2.5	20	
LY 5380-J	4	8				

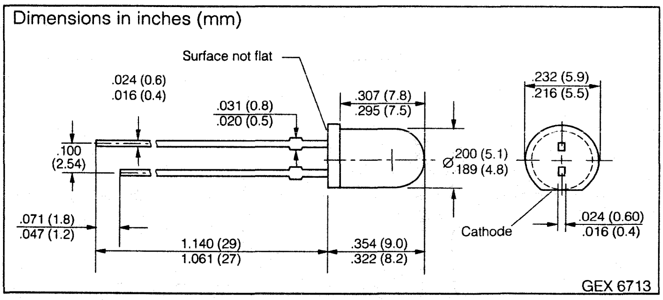
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2.0.

See graph numbers OHL01210, OHL01641, OHL01263, OHL01632, OHL01162, OHL02252, OHL01672, OHL01673, OHL01674, OHL01675 beginning on page 4–91.

SIEMENS

SUPER-RED LS 5420
YELLOW LY 5420
GREEN LG 5410
T1¾ (5 mm) LED Lamp





FEATURES

- **Colored, clear lens**
  - **LS: red**
  - **LY: yellow**
  - **LG: green**
- **Optical coupling into light pipes**
- **Use as optical indicator**
- **Solder leads without stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

DESCRIPTION

The LS 5420 super-red and LY 5420 yellow lamps are fabricated with TSN (transparent substrate nitrogen) technology. The LG 5410 is a gallium phosphide LED lamp. All three have a narrow viewing angle for the concentration of intense brightness in a head-on position. This is particularly desirable for legend back lighting applications.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F) .... 40 mA
Surge Current (I_{FS}) t=10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 140 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	45	45	25		I_F=20 mA
Viewing Angle, 50% I_V	2φ	24			Deg.	
Forward Voltage	V_F	2.0 (≤2.6)	2.0 (≤2.0)	2.0 (≤2.6)	V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	12	10	15	pF	V_R=0 V f=1 MHz
Swithcing Times, I_V 10% to 90%	t_R	300		450	ns	I_F=100 mA tp=10 µs R_L=50 Ω
90% to 10%	t_F	150		200		

Part Number	Luminous Intensity*, Iv, mcd Min.	Max.	Part Number	Luminous Intensity*, Iv, mcd Min.	Max.	Condition
LS 5420-MQ	16	125	LY 5420-R	100	200	I_F=10 mA
LS 5420-P	40	80	LY 5420-PS	40	320	
LS 5420-Q	63	125	LG 5410-MQ	16	125	
LS 5420-R	100	200	LG 5410-P	40	80	
LS 5420-PT	40	500	LG 5410-Q	63	125	
LY 5420-MQ	16	125	LG 5410-R	100	200	
LY 5420-P	40	80	LG 5410-PS	40	320	
LY 5420-Q	63	125				

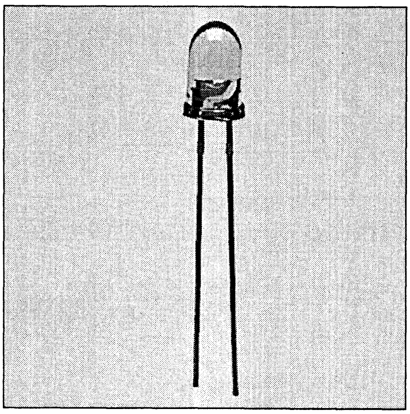
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2.

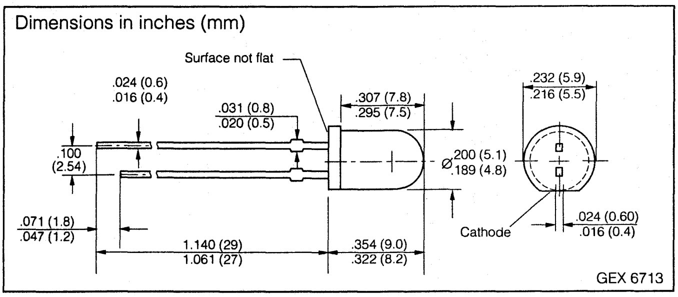
See graph numbers OHL01210, OHL01667, OHL01263, OHL01632, OHL01162, OHL02252, OHL01672, OHL01673, OHL01674, OHL01675 beginning on page 4–92

SIEMENS

SUPER-RED LS 5421
ORANGE LO 5411
YELLOW LY 5421
GREEN LG 5411

Super Bright T1¾ (5 mm) LED Lamp





FEATURES

- **Colored, clear lens**
  - **– LS: red**
  - **– LO, LG: colorless**
  - **– LY: yellow**
- **Use as optical indicator in bright ambient light**
- **Solder leads without stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

DESCRIPTION

The 5421/5411 series are superbright T1¾ (5 mm) LED lamps. Improvements in materials and optimization of lens and reflectors have resulted in a dramatic increase in luminous intensity.

Maximum Ratings

Operating/Storage Temperature
  Range (T_{OP}, T_{STG}) ....–55°C to +100°C
Junction Temperature (T_J)........................ 100°C
Forward Current (I_F) ....40 mA
Surge Current (I_{FS}) t=10 µs, D=0.005........0.5 A
Reverse Voltage (V_R)......................................5 V
Power Dissipation (P_{TOT}) T_A≤25°C........ 140 mW
Thermal Resistance,
  Junction/Air (R_{THJA}).......................... 400 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	Super-Red	Yellow	Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=10 mA
Dominant Wavelength	λ_{DOM}	628	590	570		I_F=20 mA
Spectral Bandwidth 50% I_{RELMAX}	Δλ	45		25		
Viewing Angle	2φ	20			Deg.	
Forward Voltage	V_F	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	12	10	15	pF	
Switching Time, I_V 10% to 90% 90% to 10%	t_R t_F	300 150		450 200	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω

Luminous Intensity,* I_V, mcd

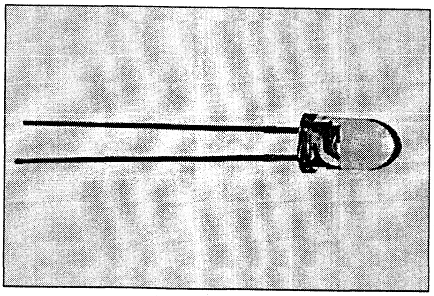
Part Number	Min.	Max.	Part Number	Min.	Max.	Condition
LS 5421-NR	25	200	LY 5421-NR	25	200	I_F=10 mA
LS 5421-Q	63	125	LY 5421-Q	63	125	
LS 5421-R	100	200	LY 5421-R	100	200	
LS 5421-S	160	320	LY5421-S	160	320	
LS 5421-QT	63	500	LY 5421-QT	63	500	
LO 5411-QT	63	500	LG 5411-NR	25	200	
LO 5411-R	100	200	LG 5411-Q	63	125	
LO 5411-S	160	320	LG 5411-R	100	200	
LO 5411-T	250	500	LG 5411-S	160	320	
LO 5411-RU	100	800	LG 5411-QT	63	500	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2.0.

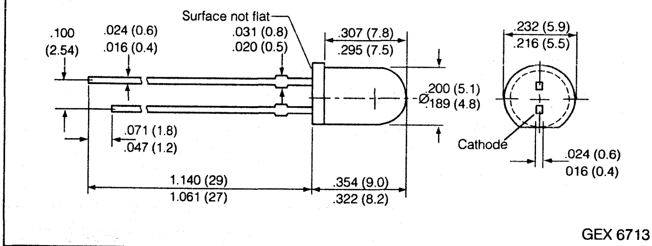
See graph numbers OHL01698. OHL01642, OHL01263, OHL02357, OHL01162, OHL02252, OHL02353, OHL02354, OHL02355, OHL02356 beginning on page 4–92.

SIEMENS

SUPER-RED LS 5436
AMBER LA 5436
ORANGE LO 5436
YELLOW LY 5436
Hyper-Bright T1¾ (5 mm) LED Lamp



Dimensions in inches (mm)



FEATURES
- **Colorless clear lens**
- **Optical coupling into light pipes**
- **Use as optical indicator**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R)[1] .... 3 V
Forward Current (I_F)
LS, LO, LA .... 30 mA
LY .... 20 mA
Surge Current (I_{FS}) t ≤10 µs, D=0.005 .... TBD
Power Dissipation (P_{TOT}) T_A≤25°C
LS, LO, LA .... 80 mW
LY .... 55 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 500 K/W

1. Reverse biasing should be avoided.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LA	LO	LY	Unit	Condition
Peak Wavelength	λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	632	615	605	587		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	16			15		
Viewing Angle 50%, I_V	2φ	30				Deg.	
Forward Voltage	V_F	2 (≤2.6)				V	I_F=20 mA
Reverse Current	I_R	0.01 (≤ 10)				µA	V_R=3 V
Temperature Coefficient λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
Temperature Coefficient λ_{PEAK}		0.14	0.13				
Temperature Coefficient V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

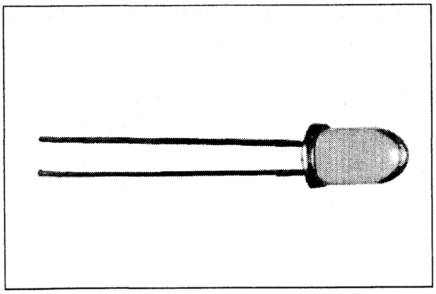
Part Number	Luminous Intensity*, I_V, mcd min. (typ.)	Condition	Part Number	Luminous Intensity*, I_V, mcd min. (typ.)	Condition
LS 5436-SO	160 (350)	I_F=20 mA	LO 5436-TO	160 (350)	I_F=20 mA
LA 5436-TO	250 (500)		LY 5436-TO	250 (500)	

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤2.

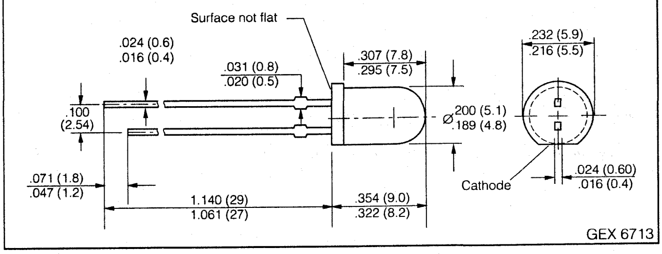
See graph numbers OHL00235, OHL00314, OHL00232, OHL00248, OHL00233, OHL00238, OHL00322, OHL00316 beginning on page 4-92.

SIEMENS

SUPER-RED LS 5469
YELLOW LY 5469
GREEN LG 5469
Low Current T1¾ (5 mm) LED Lamp



Dimensions in inches (mm)



FEATURES
- **Colored, diffused lens**
  - **– LS: red**
  - **– LY: yellow**
  - **– LG: green**
- **Use as optical indicator**
- **High luminous intensity at low currents (typ. 2 mA)**
- **Solder leads without stand-off**
- **Available taped on reel**
- **Load dump resistant per 40839**

DESCRIPTION
The 5469 series are low current LED lamps that have been designed to optimize light output at very low currents. These parts are ideally suited for applications where power is at a premium, such as portable equipment.

Both the super-red and yellow lamps utilize GaAsP on GaP semiconductor materials while the green lamps utilize GaP on GaP.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F) .... 7.5 mA
Surge Current (I_{FS}) t=10 µs/D≤0.005 .... 150 mA
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) $T_A \leq 25$°C .... 20 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 750 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=2 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	$\Delta\lambda$	45		25		I_F=7.5 mA
Viewing Angle	2φ	50			Deg.	
Forward Voltage	V_F	1.8 (≤2.5)	2.0 (≤2.7)	1.9 (≤2.6)	V	I_F=2 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	3		15	pF	V_R=0 V f=1 MHz
Switching Times, I_V 10% to 90% 90% to 10%	t_R t_F	200 150		450 200	ns ns	I_F=100 mA tp=10 µs R_L=50 Ω

Luminous Intensity*, I_V

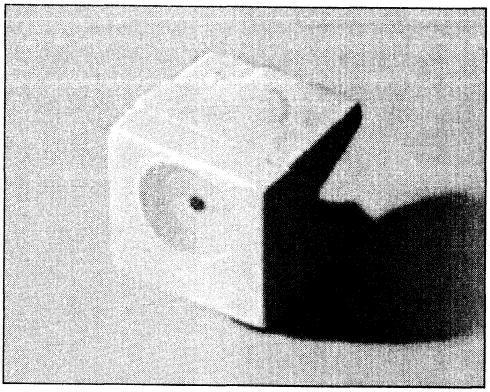
Part Number	Min.	Typ.	Unit	Condition
LS/LY/LG 5469-EH	0.63	5	mcd	I_F=2 mA
LS/LY/LG 5469-G	1.6	3.2		
LS/LY 5469-H	2.5	5		
LS 5469-GK	1.6	12.5		
LY/LG 5469-F	1	2		
LY/LG 5469-FJ	1	8		

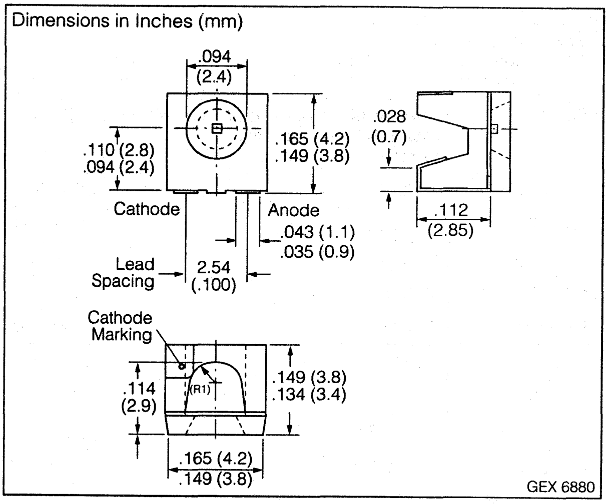
* Luminous intensity ratio of one packaging unit $I_{VMAX}/I_{VMIN} \leq 2.0$.

See graph numbers OHL01210, OHL01191, OHL01208, OHL01207, OHL01278, OHL01193, OHL01672, OHL01673, OHL01750, OHL01675 beginning on page 4-92.

SIEMENS

SUPER-RED LS A670
ORANGE LO A670
YELLOW LY A670
GREEN LG A670
PURE GREEN LP A670
SIDELED® Lamp





FEATURES

- **SIDELED: surface mount LED lamp**
- **White package, colorless clear window**
- **Use as optical indicator**
- **Backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT asembly and reflow soldering methods**
- **Available taped on reel (12 mm tape)**
- **Load dump resistant per DIN 40839**

DESCRIPTION

The LX A670 (SMT-SIDELED for surface mount applications) is available in super-red, orange, yellow, green, and pure green. The right angle package incorporates an internal reflector to optimize light coupling. This feature makes the SMT-SIDELED ideal for light pipe applications.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}).......–55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F)...30 mA
Surge Current (I_{FM}) tp≤10 µs, D=0.005 ....0.5 A
Reverse Voltage (V_R) ....5 V
Power Dissipation (P_{TOT})...100 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board, pad size 16 mm² (1) (R_{THJA})........... 430 K/W

1. PC board: FR4

See graph numbers OHL01698, OHL01660, OHL02145, OHL02146, OHL01686, OHL01661, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

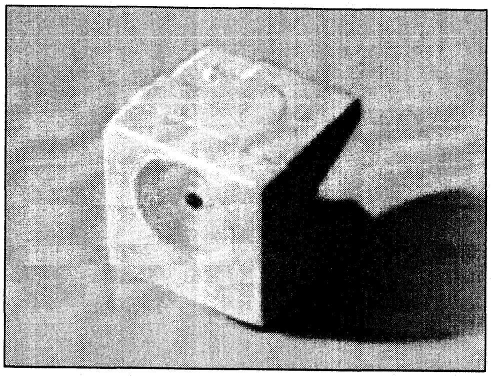
Parameter	Symbol	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength	λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% I_{RELMAX}	$\Delta\lambda$	45	40	45	25	22		
Viewing Angle	2φ	120					Deg.	–
Forward Voltage	V_F	2.0 (≤2.6)					V	I_F=10 mA
Reverse Current	I_F	0.01 (≤10)					µA	V_R=5 V
Capacitance	C_0	12	8	10	15		pF	V_R=0 V, f=1 MHz
Switching Times, I_V 10% to 90% 90% to 10%	 t_R t_F	 300 150			 450 200		ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω

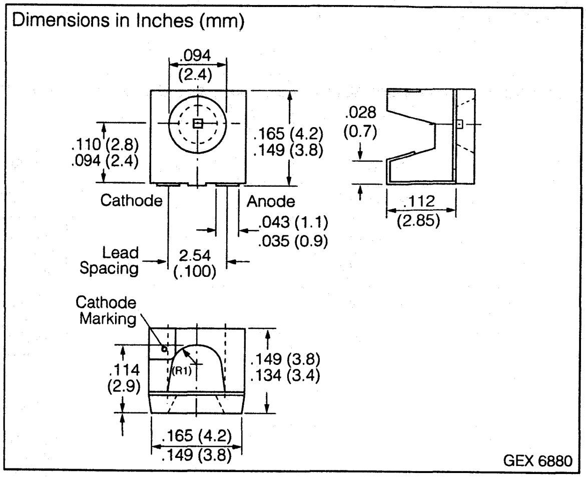
Part No.	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition	Part No.	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LS A670-HL	2.5 to 20	—	I_F=10 mA	LY A670-L	10 to 20	45	I_F=10 mA
LS A670-J	4 to 8	18		LY A670-JM	4 to 32	—	
LS A670-K	6.3 to 12.5	30		LG A670-HK	2.5 to 12.5	—	
LS A670-L	10 to 20	45		LG A670-J	4 to 8	18	
LS A670-JM	4 to 32	—		LG A670-K	6.3 to 12.5	30	
LO A670-HK	2.5 to 12.5	—		LG A670-L	10 to 20	45	
LO A670-J	4 to 8	18		LG A670-JM	4 to 32	—	
LO A670-K	6.3 to 12.5	30		LP A670-FJ	1 to 8	—	
LO A670-L	10 to 20	45		LP A670-G	1.6 to 3.2	8	
LO A670-JM	4 to 32	—		LP A670-H	2.5 to 5	12	
LY A670-HK	2.5 to 12.5	—		LP A670-J	4 to 8	18	
LY A670-J	4 to 8	18		LP A670-GK	1.6 to 12.5	—	
LY A670-K	6.3 to 12.5	30					

*Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≥2.0.

SIEMENS

SUPER-RED LS A672
ORANGE LO A672
YELLOW LY A672
GREEN LG A672
PURE GREEN LP A672
High Current Super SIDELED® Lamp





FEATURES
- **SIDELED: surface mount LED lamp**
- **White package, colorless clear window**
- **Optical indicator**
- **Appropriate for high ambient light due to higher operating current (≤50 mA DC)**
- **Ideal for backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and reflow soldering methods**
- **Available taped on reel (12 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .. –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 50 mA
Surge Current (I_{FM}) t≤10 µs D=0.005 .... 1 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 190 mW
Thermal Resistance, Junction Air,
Mounted on PC Board(1), pad size 16 mm^2 (R_{THJA}) ....330 K/W

1. PC board FR4

See graph numbers OHL01698, OHL0166O, OHL01626, OHL02152, OHL02252, OHL00221, OHL02104, OHL02105, OHL01696, OHL02154 beginning on page 4–92.

Characteristics (T_A=25°C) All values typical unless otherwise noted

Parameter		Symbol	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	628	605	590	570	560	nm	
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	45	40	45	25	22	nm	
Viewing Angle, 50% I_V		2φ	120					Deg	
Forward Voltage		V_F	2.0 (≤3.8)	2.1 (≤3.8)	2.2 (≤3.8)	2.6 (≤3.8)		V	I_F=50 mA
Reverse Current		I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance		C_0	40	35		60	80	pF	V_R=0 V, f=1 MHz
Switching Time, i_V	10% to 90%	t_R	350	500	350	500		ns	I_F =100 mA t_P=10 µs R_L=50 Ω
	90% to 10%	t_F	200	250	200	250			

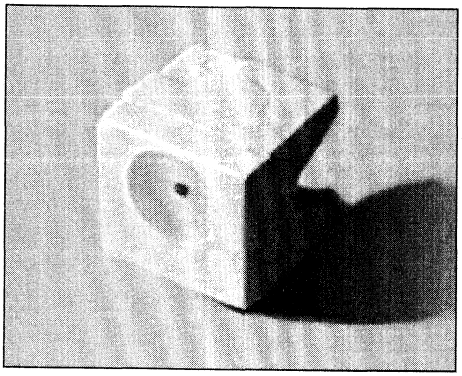
Part No.	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition	Part No.	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
*LS A672-LP	10 to 80	—	I_F=50 mA	*LY A672-P	10 to 80	180	I_F=50 mA
*LS A672-N	25 to 50	100		*LY A672-MQ	16 to 125	—	
*LS A672-P	40 to 80	180		LG A672-LP	10 to 80	—	
*LS A672-NR	25 to 200	—		LG A672-N	25 to 50	100	
*LO A672-LP	10 to 80	—		LG A672-P	40 to 80	180	
*LO A672-N	25 to 50	100		LG A672-MQ	16 to 125	—	
*LO A672-P	40 to 80	180		LP A672-KN	6.3 to 50	—	
*LO A672-NR	25 to 200	—		LP A672-L	10 to 20	45	
*LY A672-LN	10 to 50	—		LP A672-M	16 to 32	75	
*LY A672-N	25 to 50	100		LP A672-N	25 to 50	100	
				LP A672-LP	10 to 80	—	

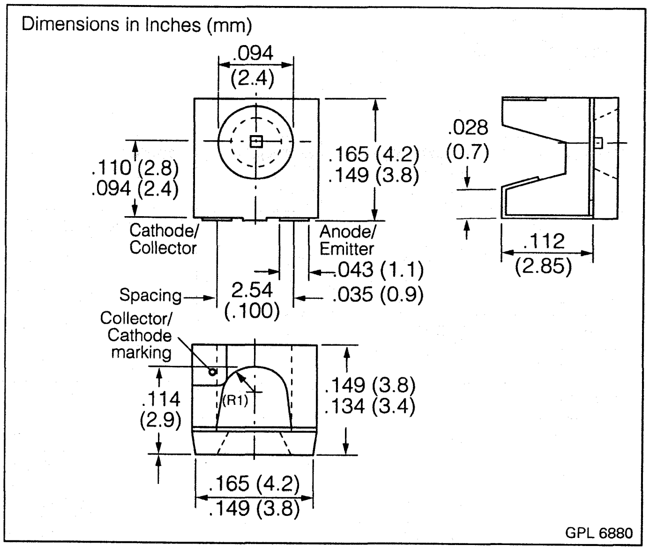
* Not for new design

1. Luminous intensity ratio in one packaging unit $I_{V\,max}/I_{V\,min} \leq 2.0$.

SIEMENS

SUPER-RED LS A676
AMBER LA A676
ORANGE LO A676
YELLOW LY A676
Hyper-Bright SIDELED® Lamp





FEATURES
- **SIDELED: surface mount LED lamp**
- **White package, colorless clear window**
- **Use as optical indicator**
- **Ideal for backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and reflow soldering methods**
- **Available taped on reel (12 mm tape)**

Maximum Ratings

Operating Temperature Range(T_{OP})........–55 to +100°C
Storage Temperature Range (T_{STG})........–55 to +100°C
Junction Temperature (T_J)........+100°C
Forward Current (I_F)
LS, LA, LO........30 mA
LY........20 mA
Surge Current (I_{FM}) $t \leq 10$ µs D=0.005........to be defined
Reverse Voltage (V_R)(1)........3 V
Power Dissipation (P_{TOT})........80 mW
Thermal Resistance, Junction Air,
Mounted on PC Board(2) (pad size 16 mm^2)
Junction/Air (R_{THJA})
LS, LA, LO........530 K/W
LY........500 K/W

Notes
1. Reverse biasing should be avoided.
2. PC board : FR4

See graph numbers OHL00235, OHL01660, OHL00232, OHL00233, OHL0248, OHL00238, OHL0321, OHL00316 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

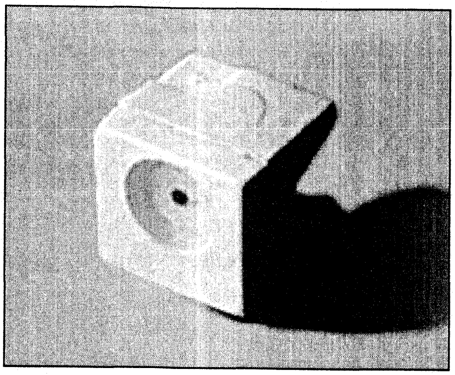
Parameter		**Symbol**	**LS**	**LA**	**LO**	**LY**	**Unit**	**Condition**
Peak Wavelength		λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	632	615	605	587		
Spectral Bandwidth (50% I_{RELMAX})		$\Delta\lambda$	16			15		
Viewing Angle, 50%, I_V		2φ	120				Deg.	
Forward Voltage		V_F	2 (≤ 2.6)				V	I_F=20 mA
Reverse Current		I_R	0.01 (≤ 10)				µA	V_R=3 V
Temperature Coefficient	λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
	λ_{PEAK}		0.14	0.13				
	V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

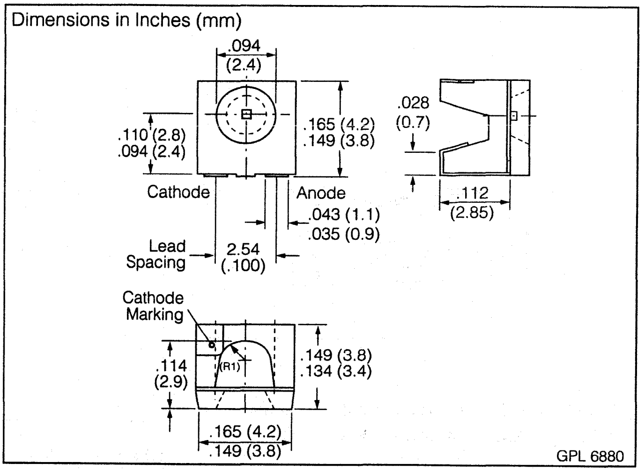
Part No.	**Luminous Intensity*, I_V, mcd**	**Luminous Flux, Φ_V, mlm**	**Condition**	**Part No.**	**Luminous Intensity*, I_V, mcd**	**Luminous Flux, Φ_V, mlm**	**Condition**
LS A676-NR	25 to 200	—	I_F = 20 mA	LO A676-PS	40 to 320	—	I_F = 20 mA
LS A676-P	40 to 80	180		LO A676-Q	63 to 125	300	
LS A676-Q	63 to 125	300		LO A676-R	100 to 200	450	
LS A676-R	100 to 200	450		LO A676-S	160 to 320	700	
LS A676-PS	40 to 320	—		LO A676-QT	63 to 500	—	
LA A676-PS	40 to 320	—		LY A676-PS	40 to 200	—	
LA A676-Q	63 to 125	300		LY A676-Q	63 to 125	300	
LA A676-R	100 to 200	450		LY A676-R	100 to 200	450	
LA A676-S	160 to 320	700		LY A676-S	160 to 320	700	
LA A676-QT	63 to 500	—		LY A676-QT	63 to 500	—	

*Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN} ≤2.0.

SIEMENS

SUPER-RED LS A679
YELLOW LY A679
GREEN LG A679
Low Current SIDELED® Lamp





FEATURES
- **SIDELED: surface mount LED lamp**
- **White package, colorless clear window**
- **Use as optical idicator**
- **For backlighting, optical coupling into light pipes and leness**
- **Suitable for all SMT assembly and reflow soldering methods**
- **Available taped on reel (12 mm tape)**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})........................... –55 to +100°C
Junction Temperature (T_J)............................. +100°C
Forward Current (I_F).. 7.5 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005............. 0.15 A
Reverse Voltage (V_R)... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C................. 20 mW
Thermal Resistance, Junction Air,
Mounted on PC Board, pad size 16 mm^2
(R_{THJA})... 500 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	Super-Red	Yellow	Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=7.5 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth, 50% I_{RELMAX}	Δλ	45		25		
Viewing Angle	2φ	120			Deg.	
Forward Voltage	V_F	1.8 (≤2.6)	2.0 (≤2.7)	1.9 (≤2.6)	V	I_F=2 mA
Reverse Current	I_F	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	3		15	pF	V_R=0 V, f=1 MHz
Switching Time, I_V					ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω
10% to 90%	t_R	200		450		
90% to 10%	t_F	150		200		

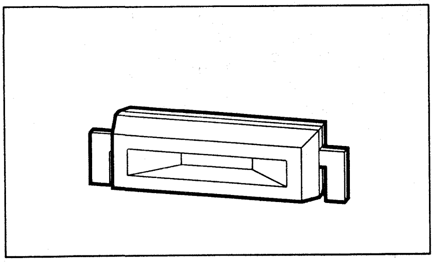
Part No.	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V (mlm)	Condition
LS A679-CO	1 (≥0.25)	3	I_F=2 mA
LY A679-CO			
LG A679-CO			

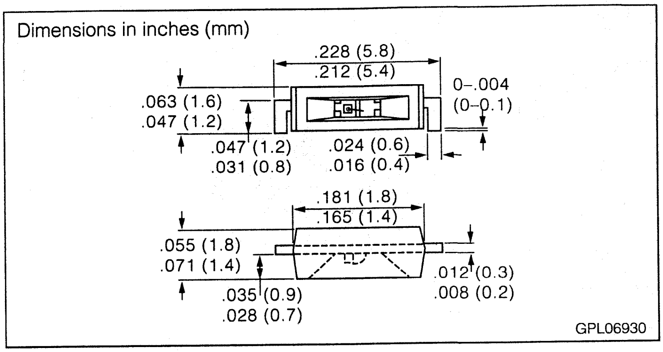
*Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≥2.0.

See graph numbers 1OHL01698, OHL01660, OHL01208, OHL01207, OHL01278, OHL01193, OHL01672, OHL01673, OHL01750, OHL01675 beginning on page 4–92.

SIEMENS

SUPER-RED LS C870
ORANGE LO C870
YELLOW LY C870
GREEN LG C870
PURE GREEN LP C870
Mini SIDELED® Lamp





FEATURES

- **Mini SIDELED: surface mount LED lamp**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (12 mm tape)**
- **Load dump resistant acc. to DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F).................................... 30 mA
Surge Current (I_{FM})
t≤10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R).......................................5 V
Power Dissipation (P_{TOT}) ....100 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board(1)
(pad size ≥16 mm^2)(R_{THJA}) .... 530 K/W

1. PC board: FR4

See graph numbers OHLO1698, OHL01660, OHL02145, OHL02146, OHL01686, OHL00231, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–92

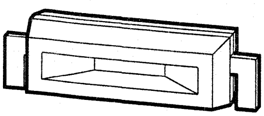
Characteristics T_A=25°C, typical unless otherwise specified

Parameter	Sym.	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength	λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% I_{RELMAX}	Δλ	45	40	45	25	22		
Viewing Angle, 50% I_V	2φ	120					Deg.	
Forward Voltage	V_F	2 (≤ 2.6)					V	I_F=10 mA
Reverse Current	I_R	0.01 (≤ 10)					µA	V_R=5 V
Capacitance	C_o	12	8	10	15		pF	V_R=0 V, f=1 MHz
Switching Times 10% to 90%	t_R	300			450		ns	I_F =100 mA, t_P=10 µs, R_L=50 Ω
Switching Times 90% to 10%	t_F	150			200			

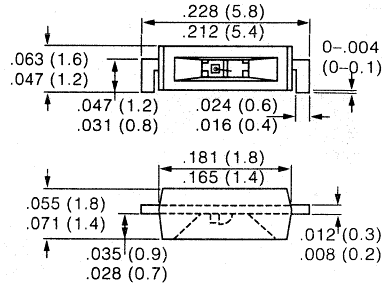
Part Number	Luminous Intensity, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LS/LO/LY/LG C870-HL	2.5 to 20	—	I_F=10 mA
LS/LO/LY/LG C870-J	4.0 to 8.0	18 (typ.)	
LS/LO/LY/LG C870-K	6.3 to 12.5	30 (typ.)	
LS/LO/LY/LG C870-L	10 to 20	45 (typ.)	
LS/LO/LY/LG C870-JM	4.0 to 32	—	
LP C870-FJ	1.0 to 8.0	—	
LP C870-G	1.6 to 3.2	8 (typ.)	
LP C870-H	2.5 to 5.0	12 (typ.)	
LP C870-GK	1.6 to 12.5	—	

SIEMENS

SUPER-RED LS C876
AMBER LA C876
ORANGE LO C876
YELLOW LY C876
Hyper-Bright Mini SIDELED® Lamp



Dimensions in inches (mm)



GPL06930

FEATURES

- **SIDELED: Surface mount LED lamp**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F)
LS, LA, LO .... 30 mA
LY .... 20 mA
Surge Current (I_{FM})
t≤10 µs D=0.005 .... to be defined
Reverse Voltage(1) (V_R) .... 3 V
Power Dissipation (P_{TOT}) $T_A \leq 25°C$
LS, LA, LO .... 80 mW
LY .... 55 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board(2) (pad size 16 mm^2)
(R_{THJA}) .... 630 K/W

Note:

1. Reverse biasing should be avoided
2. PC board: FR4

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LA	LO	LY	Unit	Condition
Peak Wavelength	λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	632	615	605	587		
Spectral Bandwidth, 50% I_{RELMAX}	$\Delta\lambda$	16			15		
Viewing Angle, 50% I_V	2φ	120				Deg.	
Forward Voltage	V_F	2 (≤ 2.6)				V	I_F=20 mA
Reverse Current	I_R	0.01 (≤ 10)				µA	V_R=3 V
Temperature coefficient λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
Temperature coefficient λ_{PEAK}		0.14	0.13				
Temperature coefficient V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

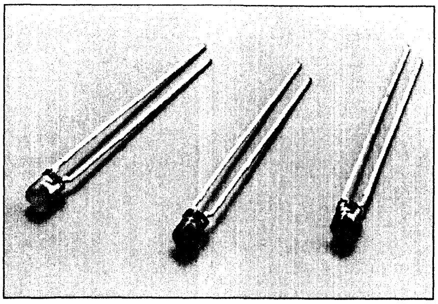
Part Number	Luminous Intensity*, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LS C876-NO	≥ 25 (60 typ.)	180	I_F=20 mA
LA/LO/LY C876-PO	≥ 40 (100 typ.)	300	

*Luminous Intensity ratio in one packaging unit $I_{VMAX}/I_{VMIN} \leq 2.0$.

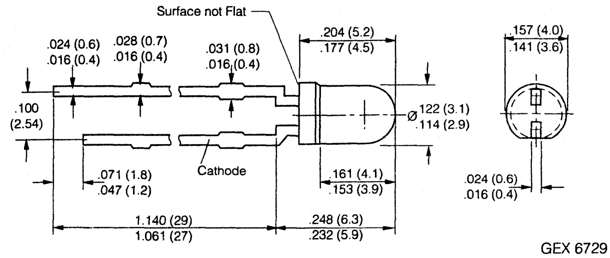
See graph numbers OHL00235, OHL01660, OHL00232, OHL00248, OHL00233, OHL00238, OHL00320, OHL00316 beginning on page 4–92.

SIEMENS

SUPER-RED/GREEN LSG 3331-JO
SUPER-RED/GREEN LSG 3351-HO
T1 (3 mm) MULTILED® Lamp



Dimensions in inches (mm)



GEX 6729

FEATURES

- **Colorless plastic lens**
  - **– LSG 3331:clear**
  - **– LSG 3351: difused**
- **Anti-parallel chips**
- **High signal efficiency by changing LED color**
- **Can change color from green to yellow, orange and super-red by using IC such as SDA 2231**
- **Both colors can be controlled separately**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

DESCRIPTION

The LSG 3331 and LSG 3351 are both super-red/green, two color LED lamps with their chips in an anti-parallel arrangement. By reversing the current the lamp can be switched from super-red to green. With the appropriate circuitry, it is also possible to produce orange and yellow.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)..................................... 40 mA
Surge Current (I_{FS}) t=10 µs, D=0.005 .... 0.5 A
Power Dissipation (P_{TOT}) T_A≤25°C .... 140 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

Note: With simultaneous operation of both diodes of two-color LEDs the sum of the currents as well as the power dissipation must not exceed the specified limits.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Symbol	Red	Green	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	565	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	628	570		
Spectral Bandwidth 50% I_{RELMAX}		$\Delta\lambda$	45	25		
Viewing Angle, 50% I_V	LSG 3331	2φ	40		Deg.	
	LSG 3351		50			
Forward Voltage		V_F	2.0 (≤2.6)		V	I_F=10 mA
Capacitance		C_0	27		pF	V_R=0 V, f=1 MHz
Swithcing Times, I_V, 10% to 90%		t_R	300	450	ns	I_F=100 mA tp=10 µs R_L=50 Ω
90% to 10%		t_F	150	200		

Luminous Intensity, Iv, mcd

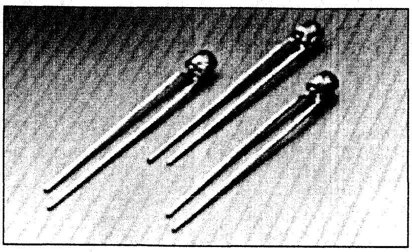
Part Number	Min. (Typ.)	Unit	Condition
LSG 3331-JO	4 (18)	mcd	I_F=10 mA
LSG 3351-HO	2.5 (10)		

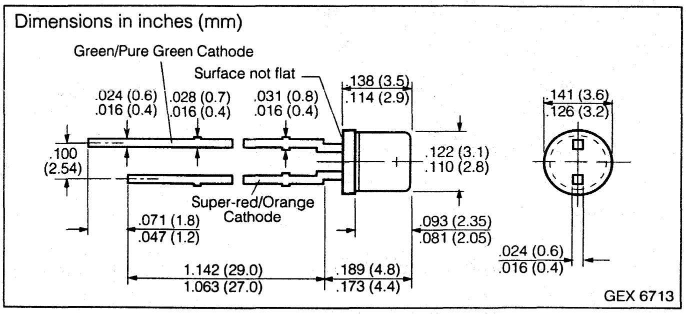
Notes:
1. Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN} ≤ 2.
2. Luminous intensity ratio in one LED I_{VMAX}/I_{VMIN} ≤ 3.
3. The brightness of the darker chip in one package determines the brightness group of the LED.

See graph numbers OHL01263, OHL01703, OHL01162, OHL02252, OHL01705, OHL01706, OHL01707, OHL01708. LSG 3331: OHL01698, OHL01646. LSG 3351: OHL01698, OHL01646 beginning on page 4–92.

SIEMENS

SUPER-RED/GREEN LSG K370
SUPER-RED/PURE GREEN LSP K370
ORANGE/PURE GREEN LOP K370
ORANGE/GREEN LOG K370
T1 (3 mm) Multi ARGUS® LED Lamp





FEATURES

- **Colorless, clear package and lens**
- **Antiparallel chip**
- **High signal efficiency by changing LED color**
- **With custom built reflector suitable for backlighting display panels**
- **For optical coupling into light pipes**
- **Uniform illumination of diffuser screen in front of custom built reflector**
- **Both colors can be controlled separately**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings refer to the specified chip regardless of the other one's operating status.

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LS, LO, LG .... 40 mA
LP .... 30 mA
Surge Current (I_{FM}) t ≤10 µS .... 0.5 A
Power Dissipation (P_{TOT}) T_A≤25°C
LS, LO, LG .... 140 mW
LP .... 100 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

DESCRIPTION

ARGUS LED lamp chips are arranged in antiparallel.

ARGUS lamps are used with an additional custom built reflector (i.e., white plastic, such as Pocan B7375). The front end of the reflector is covered by a diffuser (see package dimensions). Uniform illuminations can be enhanced by the reflector design tailored to the LED and/or by using appropriate diffuser material.

Note:
Siemens does not supply the reflector or diffuser.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	Super-Red	Orange	Green	Pure Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	610	565	557	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	628	605	570	560		
Spectral Bandwidth, 50% I_V	$\Delta\lambda$	45	40	25	22		
Forward Voltage	V_F	2.0(≤2.6)				V	I_F=10 mA
Capacitance	C_0	12	8	8	15	pF	V_R=0 V, f=1 MHz
Switching Time Rise Time, 10% to 90% Fall Time, 90% to 10%	 t_R t_F	 300 150	 300 150	 450 200	 450 200	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω

Luminous Flux (1, 2, 3), Φ_V, mlm

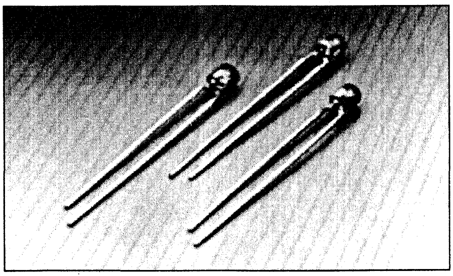
Part No.	Min–Max	Part No.	Min–Max	Condition
LSG, LOG K370-LP	10–80	LSP, LOP K370-KN	6.3–50	I_F=15 mA
LSG, LOG K370-N	25–50	LSP, LOP K370-M	16–32	
LSG, LOG K370-P	40–80	LSP, LOP K370-N	25–50	
LSG, LOG, K370-NR	25–200	LSP, LOP K370-MQ	16–125	
		LSP K370-P	40–80	

Notes:
1. Luminous flux ratio in one packaging unit Φ_{Vmax}/Φ_{Vmin} ≤2.
   Luminous flux ratio in one LED unit Φ_V max/Φ_V min. ≤4. (LSP...)
   Luminous flux ratio in one LED unit Φ_V max/Φ_V min. ≤3. (LSG...)
2. The brightness of the darker chip in one package determines the brightness group of the LED.

See graph numbers OHL01698, OHL01685, OHL02145, OHL02253, OHL01162, OHL01686, OHL01170, OHL02104, OHL02105, OHL02149, OHL02107 beginning on page 4–92.

SIEMENS

SUPER-RED/GREEN LSG K372-QO
SUPER-RED/PURE GREEN LSP K372-PO
High Current T1 (3 mm) Super ARGUS MULTILED Lamp



FEATURES

- **Colorless, clear lens**
- **Plastic package with a special design**
- **Anti-parallel chip**
- **Appropriate for high ambient light because of high operating current (typ. 50 mA)**
- **High signal efficency possible by changing LED color**
- **Suitable for backlighting of display panels with custom built reflector**
- **For optical coupling into light pipes**
- **Uniform illumination of a diffuser screen in front of a custom built reflector**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

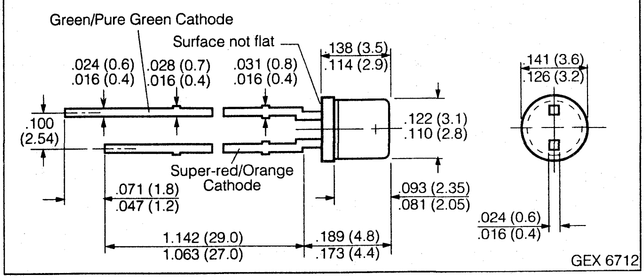
DESCRIPTION

Super ARGUS LED lamp chip are arranged anti-parallel. Super ARGUS LEDs are designed to operate at 50 mA and provide as much as 10X luminous flux as standard ARGUS LEDs.

ARGUS lamps are used with an additional custom built reflector (i.e., white plastic, such as Pocan B7375). The front end of the reflector is covered by a diffuser (see package dimensions). Uniform illuminations can be enhanced by the reflector design tailored to the LED and/or by using appropriate diffuser material.

Note: Siemens does not supply the reflector or diffuser.

Dimensions in inches (mm)



Maximum Ratings

Refer to the specified chip regardless of the other one's status.

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F) .... 75 mA
Surge Current (I_{FM}) t ≤10 µs, D=0.005 .... 1 A
Power Dissipation (P_{TOT}) T_A≤25°C .... 240 mW
Thermal Resistance, Junction to Air (R_{THJA}) .... 250 K/W

Note 1. Mounted on PC board up to stand off pad size ≥16 mm^2

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LG	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	565	557	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	628	570	560		
Spectral Bandwidth 50% I_V	$\Delta\lambda$	45	25	22		
Forward Voltage	V_F	2.0 (≤3.8)	2.6 (≤3.8)		V	I_F=50 mA
Capacitance	C_0	55		80	pF	V_R=0 V, f=1 MHz
Switching Times, I_V 10% to 90% / 90% to 10%	t_R / t_F	300 / 150	450 / 200		ns / ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω

Part Number	Luminous Flux, Φ_V, mlm	Condition
LSG K372-QO	160 (≥100)	I_F=50 mA
LSP K372-PO	100 (≥40)	

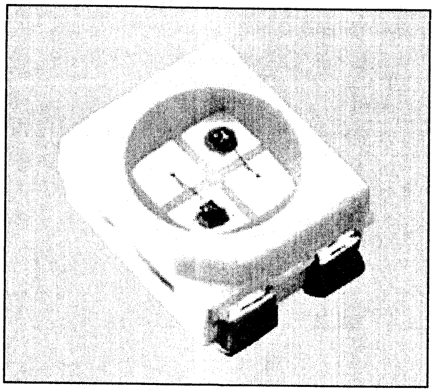
Notes:

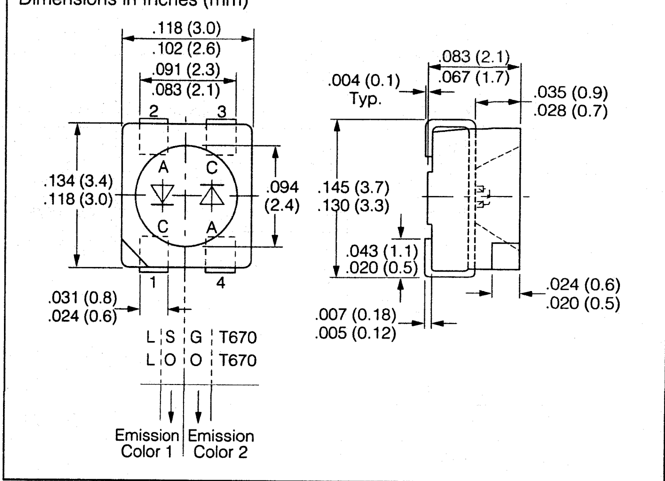
1. Total capacitance results from the sum of the capacitances.
2. Luminous flux ratio in one packaging unit Φ_{VMAX}/Φ_{VMIN} ≤2(4).
3. Luminous flux ratio of one LED $\Phi I_{VMAX}/I_{VMIN}$ ≤3.0 (LSG K372), ≤4.0 (LSP K372).
4. In MULTILEDs, the brightness of the darker chip in one package determines the brightness group of the LED.

See graph numbers OHL01698, OHL01712, OHL01626, OHLO1628, OHL01710, OHL02068, OHL02104, OHL02105, OHL01696, OHL01700 beginning on page 4–92.

SIEMENS

SUPER-RED/GREEN LSG T670
SUPER-RED/PURE GREEN LSP T670
SUPER-RED/YELLOW LSY T670
ORANGE/PURE GREEN LOP T670
ORANGE/GREEN LOG T670
Multi TOPLED® Lamp





FEATURES
- **TOPLED: surface mount LED lamp**
- **P-LCC-4 package**
- **White package, colorless clear window**
- **Optical indicator**
- **Ideal for backlighting, optical coupling into light pipes and lenses**
- **Both chips can be controlled separately**
- **High signal efficiency possible by changing LED color**
- **Suitable for all SMT assembly and solder processes**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant acc. to DIN 40839**

See graph numbers OHL01698, OHL01660, OHL02145, OHL02146, OHL01686, OHL00241, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–92

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG})	–55 to +100°C
Junction Temperature (T_J)	+100°C
Forward Current (I_F)	30 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005	0.5 A
Reverse Voltage (V_R)	5 V
Power Dissipation (P_{TOT})	100 mW
Thermal Resistance, Junction/Air, Mounted on PC Board, pad size (1) 16 mm^2	
(R_{THJA})(2)	480 K/W
(R_{THJA})(3)	650 K/W

Notes
1. PC board G30/FR4
2. One system only.
3. Both systems on simultaneously.
4. The stated maximum ratings refer to one chip.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	LR	LS	LY	LG	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength	λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% Φ_V	$\Delta\lambda$	45	40	45	25	22		
Viewing Angle, 50% I_V	2φ	120					Deg	
Forward Voltage	V_F	2.0 (≤2.6)					V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance	C_0	12	8	10	15		pF	V_R=0 V, f=1 MHz
Switching Time, i_V 10% to 90% 90% to 10%	 t_R t_F	 300 150	 450 200	 300 150	 450 200		ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω

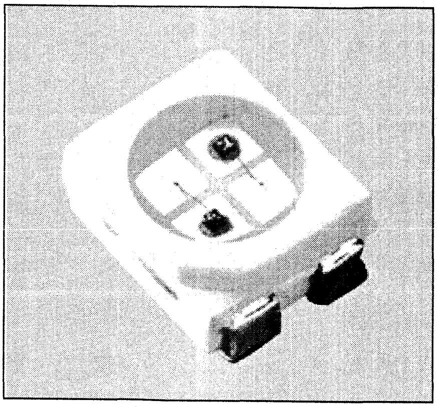
Part No.	Luminous Intensity(2), I_V, mcd	Luminous Flux, Φ_V, mlm	Condition	Part No.	Luminous Intensity(2), I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LSGT670-HK	2.5 to12.5	—	I_F=10 mA	LSY T670-K	6.3 to12.5	30	I_F=10 mA
LSGT670-J	4 to 8	18		LSY T670-JL	4 to 20	—	
LSGT670-K	6.3 to12.5	30		LOP T670-FJ	1 to 8	—	
LSGT670-JL	4 to 20	—		LOP T670-G	1.6 to 3.2	8	
LSP T670-FJ	1 to 8	—		LOP T670-H	2.5 to 5	12	
LSP T670-G	1.6 to 3.2	8		LOP T670-GK	1.6 to12.5	—	
LSP T670-H	2.5 to 5	12		LOG T670-HK	2.5 to12.5	—	
LSP T670-GK	1.6 to12.5	—		LOG T670-J	4 to 8	18	
LSP T670-J	4 to 8	18		LOG T670-K	6.3 to12.5	30	
LSY T670-HK	2.5 to12.5	—		LOG T670-JL	4 to 20	—	
LSY T670-J	4 to8	18					

Notes

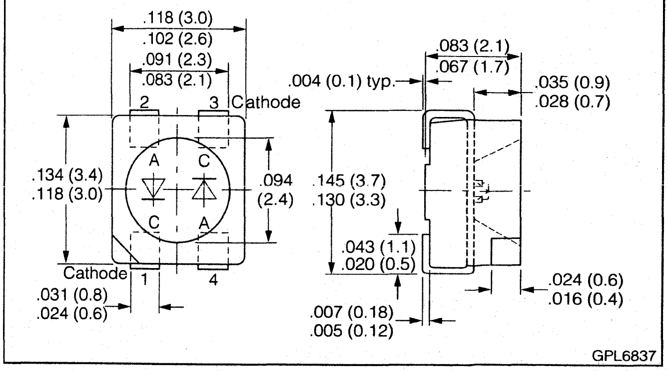
1. In MULTILEDs, the brightness of the darker chip in one package determines the brightness group of the LED.
2. Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≤2.0(1).
3. Luminous intensity ratio in one LE I_{VMAX}/I_{VMIN}≤3.0 (LSG/LOG/LSY T670), ≤4.0 (LSP/LOP/LYP T670).

SIEMENS

SUPER-RED/GREEN LSG T677
Cathodes On One Side Multi TOPLED® Lamp



Dimensions in inches (mm)



FEATURES

- **TOPLED: surface mount LED lamp**
- **P-LCC-4 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Both chips can be controlled separately**
- **High signal efficiency possible by changing LED color**
- **Can change color from green to yellow and orange to super-red with appropriate controlling**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings refer to one chip

Operating/Storage Temperature
Range (T_{OP},T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 30 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) .... 100 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board(1), pad size 16 mm²
(R_{THJA})(2) .... 480 K/W
(R_{THJA})(3) .... 650 K/W

Notes
1. PC board: FR4.
2. One system on.
3. Both systems on simultaneously.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	LS	LG	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	565	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	628	570		
Spectral Bandwidth, 50% I_{RELMAX}		Δλ	45	25		
Viewing Angle, 50% I_V		2φ	120		Deg	
Forward Voltage		V_F	2 (≤ 2.6)		V	I_F=10 mA
Reverse Current		I_R	0.01 (≤ 10)		µA	V_R=5 V
Capacitance		C_0	12	15	pF	V_R=0 V f=1 MHz
Switching Times, I_V	10% to 90%	t_R	300	450	ns	I_F=100 mA t_P=10 µs R_L=50 Ω
	90% to 10%	t_F	150	200		

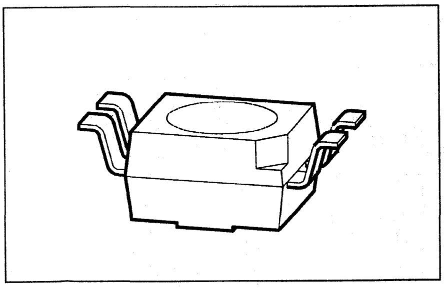
Part Number	Luminous Intensity(1), I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LSG T677-HK	2.5 to 12.5	—	I_F=10 mA
LSG T677-J	4 to 8	18	
LSG T677-K	6.3 to 12.5	30	
LSG T677-JL	4 to 20	—	

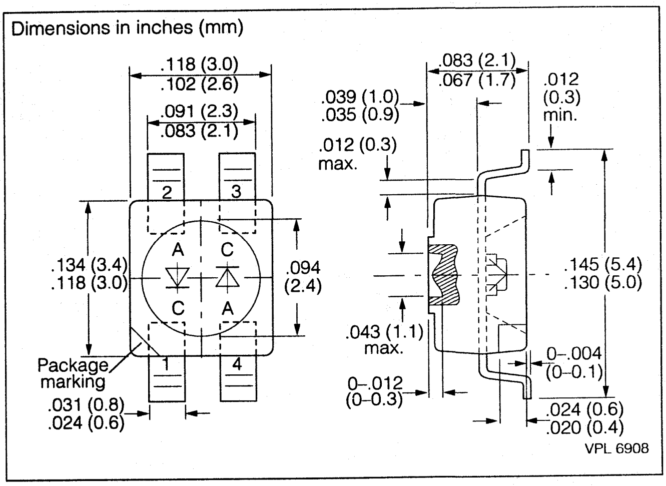
Notes
1. Luminous Intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≤2.0(3).
2. Luminous Intensity ratio in one LEDt I_{VMAX}/I_{VMIN}≤3.0.
3. In MULTILEDs, the brightness of the darker chip in one package determines the brightness group of the LED.

See graph numbers OHL01698, OHL01660, OHL02145, OHL01686, OHL00241, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–92.

SIEMENS

SUPER-RED/GREEN LSG T770
Reverse Gullwing Multi TOPLED® Lamp





FEATURES
- **TOPLED: surface mount LED lamp**
- **P-LCC-4 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Both chips can be controlled separately**
- **High signal efficiency possible by changing LED color**
- **Can change color from green to yellow and orange to super-red with appropriate controlling**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (12 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/StorageTemperature
Range (T_{OP}, T_{STG}).................... -55°C to +100°C
Junction Temperature (T_J)............................100°C
Reverse Voltage(1) (V_R) ....5 V
Forward Current (I_F)......................................30 mA
Surge Current (I_{FM}) t <10 µs, D = 0.005.........0.5 A
Power Dissipation (P_{TOT}) ....100 mW
Thermal Resistance, Junction to Air
Mounted on PC board(1) (pad size ≥ 16 mm²)
(R_{THJA})(2) .... 480 K/W
(R_{THJA})(3) .... 650 K/W

Notes
1. PC board: FR4.
2. One system only.
3. Both systems on simultaneously.
4. The stated maximum ratings refer to one chip.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	LS	LG	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	565	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	628	570		
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	45	25		
Viewing Angle, 50% I_V		2φ	120		Deg.	
Forward Voltage		V_F	2 (≤ 2.6)		V	I_F=20 mA
Reverse Current		I_R	0.01 (≤ 10)		µA	V_R=3 V
Capacitance		C_0	12	15	pF	V_R=0 V f=1 MHz
Switching Times, I_V	10% to 90%	t_R	300	450	ns	I_F =100 mA t_P=10 µs R_L=50 Ω
	90% to 10%	t_F	150	200		

Part Number	Luminous Intensity, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LSG T770-HK	2.5 to 12.5	—	I_F=10 mA
LSG T770-J	4 to 8	18	
LSG T770-K	6.3 to 12.5	30	
LSG T770-JL	4 to 20	—	

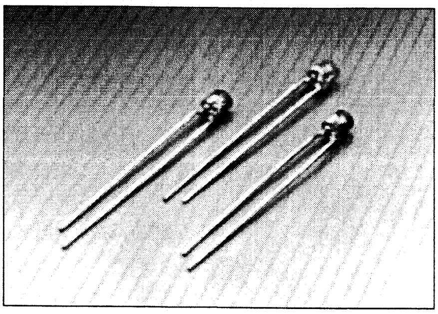
1. Luminous Intensity ratio in one packaging unit $I_{VMAX}/I_{VMIN} \leq 2$(3).
2. Luminous Intensity ratio in one LED $I_{VMAX}/I_{VMIN} \leq 3$.
3. In MULTILEDs, the brightness of the darker chip in one package detemines the brightness group of the LED.

See graph numbers OHL01698, OHL01660, OHL02145, OHL02146, OHL01686, OHL00241, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–92.

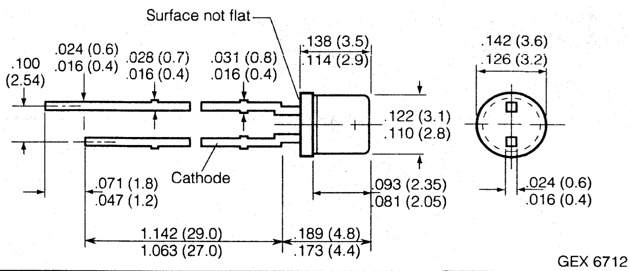
SIEMENS

SUPER-RED LS K376
AMBER LA K376
ORANGE LO K376
YELLOW LY K376

Flat Top T1 (3 mm) Hyper-Bright ARGUS® LED Lamp



Dimensions in inches (mm)



FEATURES

- **Colored, clear lens**
- **Plasic package with a special design**
- **With an additional, custom built reflector suitable for backlighting display panels**
- **For optical coupling into light pipes**
- **Uniform illumination of a diffuser screen in front of the custom built reflector**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Note:
If the diffuser screen is tinted, the spectral transmission must be adjusted to the wavelength emitted by the LED.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 3 V
Forward Current (I_F)
LS, LO, LA .... 30 mA
LY .... 20 mA
Surge Current (I_{FM}) t <10 µs,
D = 0.005 .... to be defined
Power Dissipation (P_{TOT}) $T_A \leq 25°C$
LS, LO, LA .... 80 mW
LY .... 55 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 500 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LA	LO	LY	Unit	Condition
Peak Wavelength	λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	632	615	605	587		
Spectral Bandwidth, 50% Φ_V	$\Delta\lambda$	16			15		
Forward Voltage	V_F	2.0 (≤2.6)				V	
Reverse Current	I_R	0.01 (≤10)				µA	V_R=3 V
Temperature Coefficient λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
Temperature Coefficient λ_{PEAK}		0.14	0.13				
Temperature Coefficient V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

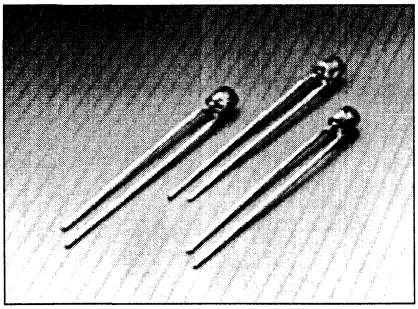
Part Number	Luminous Flux, Φ_V, mlm	Part Number	Luminous Flux, Φ_V, mlm	Condition
LS K376-QT	63 to 500	LO K376-RU	10 to 800	I_F = 20 mA
LS K376-R	100 to 200	LO K376-S	160 to 320	
LS K376-S	160 to 320	LO K376-T	250 to 500	
LS K376-T	250 to 500	LO K376-U	400 to 800	
LS K376-RU	100 to 800	LO K376-SV	160 to 1250	
LA K376-RU	10 to 800	LY K376-RU	10 to 800	
LA K376-S	160 to 320	LY K376-S	160 to 320	
LA K376-T	250 to 500	LY K376-T	250 to 500	
LA K376-U	400 to 800	LY K376-U	400 to 800	
LA K376-SV	160 to 1250	LY K376-SV	160 to 1250	

Luminous flux ratio of one packaging unit $\Phi_{VMAX} / \Phi_{VMIN} \leq 2$.

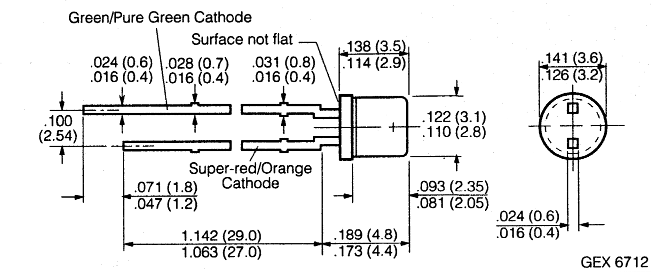
See graph numbers OHL00235, OHL01277, OHL00232, OHL00248, OHL00233, OHL00238, OHL00322, OHL00316 beginning on page 4–92.

SIEMENS

SUPER-RED LS K380
ORANGE LO K380
YELLOW LY K380
GREEN LG K380
PURE GREEN LP K380
Flat Top T1 (3 mm) ARGUS LED Lamp



Dimensions in inches (mm)



FEATURES
- **Colored, clear package**
  - **– LS: super-red**
  - **– LO: orange**
  - **– LY: yellow**
  - **– LG: green**
  - **– LP: pure gren**
- **With an additional, custom built reflector suitable for backlighting display panels**
- **For optical coupling into light pipes**
- **Uniform illumination of a diffuser screen in front of the custom built reflector**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resisant per DIN 40839**

Note

If the diffuser screen is tinted, the spectral transmission must be adjusted to the wavelength emitted by the LED.

DESCRIPTION

ARGUS lamps can be used only with an additional, customer supplied reflector (i.e., white plastic, such as Pocan B7375). The front end of the reflector is covered by a diffuser (see package dimensions). Uniform illumination can be enhanced by the reflector design tailored to the LED and/or by the use of appropriate diffuser material. If the diffuser is tinted, the spectral transmission must be adjusted to the wavelength emitted by the LED.

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG}) .... -55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LS, LO, LY, LG .... 40 mA
LP .... 30 mA
Surge Current (I_{FM}) t <10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) $T_A \leq 25°C$
LS, LO, LY, LG .... 140 mW
LP .... 100 mW
Thermal Resistance, Junction/Air (R_{THJA}) .... 400 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	**Sym.**	**LS**	**LO**	**LY**	**LG**	**LP**	**Unit**	**Condition**
Peak Wavelength	λ_{PEAK}	635	610	586	565	557	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth 50% Φ_V,	$\Delta\lambda$	45	40	45	25	22		I_F=20 mA
Forward Voltage	V_F	2.1 (≤2.6)					V	I_F=15 mA
Reverse Current	I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance	C_0	12	8	10	15		pF	V_R=0 V, f=1 MHz
Switching Times, I_V 10% to 90% 90% to 10%	t_R t_F	300 150			450 200		ns ns	I_F=100 mA tp=10 µs R_L=50 Ω

See graph numbers OHL01697, OHL01277, OHL01625, OHL02103, OHL01162, OHL01686, OHL01170, OHL02104, OHL02105, OHL02149, OHL02107 beginning on page 4–92.

Characteristics (continued)

Luminous Flux*, Φ_V, mlm, I_F =15 mA					
Part Number	**Min.**	**Max.**	**Part Number**	**Min.**	**Max.**
LS/LG K380-LP	10	80	LO/LY K380-Q	63	125
LS/LG K380-N	25	50	LO/LY K380-NR	25	200
LS/LG K380-P	40	80	LP K380-KN	6.3	50
LS/LG K380-Q	63	125	LP K380-L	10	20
LS/LG K380-NR	25	200	LP K380-M	16	32
LO/LY K380-LP	16	125	LP K380-N	25	50
LO/LY K380-N	25	50	LP K380-LP	10	80
LO/LY K380-P	40	80			

* Luminous flux ratio of one packaging unit $\Phi_{VMAX} / \Phi_{VMIN} \leq 2$

Back Lighting Using ARGUS LEDs

Siemens developed ARGUS® LEDs for applications requiring uniform light over large areas. Their light emission covers a fairly large solid angle versus conventional LEDs which concentrate their radiation in the axial direction.

Construction

ARGUS diodes are fabricated on the same production line and with the same design concepts as Siemens standard LEDs. The difference between the two is the radiation characteristic. The radiation from standard LEDs is focused in the axial direction (Fig. 1a). The chip is mounted into a reflector cup. The leadframe is placed into a mold and the body is formed with a spherical lens.

The ARGUS LED, however, is designed to produce light over an enlarged viewing angle (Fig. 1b). This is done by eliminating the reflector cup and molding a concave shaped lens into the body instead of the normal spherical type. To avoid hot spots within the illuminated area, the light emitted in the axial direction is reduced to about 20% of the maximum luminous intensity.

Applications and Benefits of ARGUS LEDs

The full benefit of ARGUS LEDs is achieved when used with an external reflector and diffuser. When properly configured, a large area of evenly distributed light is produced (1cm2/ lamp) that can be used to back light symbols, characters, and LCD displays.

- No longer will designers of systems such as dashboard instrumentation and car radios have to provide access for replacing incandescent bulbs. With extended warranties being offered by most auto makers, the labor cost to replace an incandescent bulb makes the ARGUS LED a cost effective alternative.
- With its ability to evenly illuminate a large area and its low heat generation, ARGUS LEDs provide an excellent source of light for LCD displays.
- ARGUS' compact size, large light area, low heat generation and reliability make it an ideal choice for illuminated switches instead of incandescent bulbs.
- ARGUS LEDs can be supplied on tape and reel for auto-insertion, eliminating the need to hand insert odd shaped light bars for large area back lighting applications.
- Reflectors for ARGUS LEDs can be designed to have a height from the board that equals the height of most seven-segment displays, so that panels with mechanically matched components can be built.

ARGUS LEDs as Substitutes for Lamps

In many cases incandescent lamps are easily replaced directly by ARGUS LEDs, but for best results, an appropriately shaped reflector (Figure 2) with a high diffuse reflection characteristic (above 90%) should be used. Pocan B7375 and Pocan B7376 thermoplastics have been used successfully in many applications. Requirements differ for individual applications. For optimum results, reflectors and diffusers must be matched.

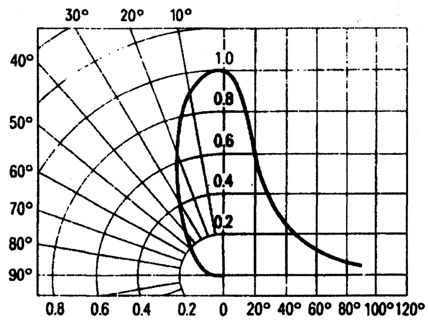
Lumens (lm) Versus Candela (cd)*

One major difference between the ARGUS LED standard LEDs is that the light output for ARGUS is measured in millilumens (mlm) while standard LEDs are measured in millicandela (mcd). The ARGUS is designed to use almost all of the light produced over a large area while standard LEDs have a focusing lens and for most applications is a point source.

See Appnote 1, "LEDs and Photometry" for detailed information.

Figure 1. ARGUS LEDs emit their light over an enlarged solid angle. Both graphs show polar coordinates on the left and rectangular coordinates on the right. a) Standard LED–viewing angle b) ARGUS LED–radiation characteristic. Relative spatial emission vs. half angle.

a



b

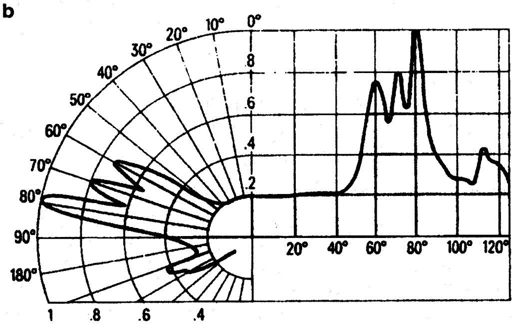
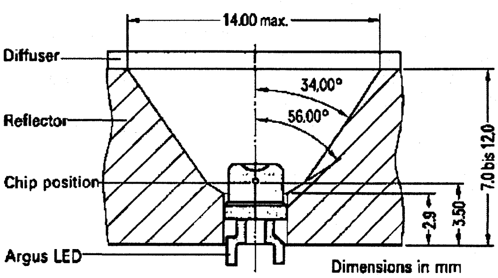
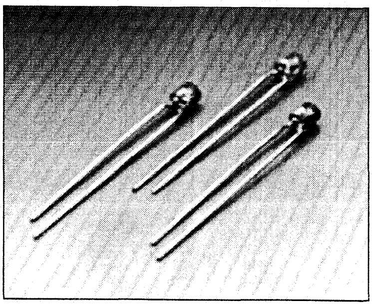


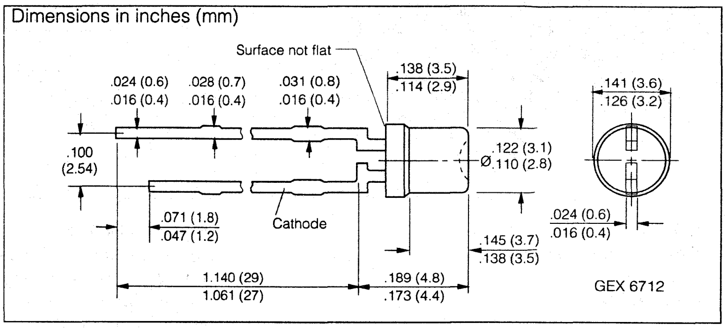
Figure 2. Section through a reflector with an ARGUS LED



SIEMENS

SUPER-RED LS K382
YELLOW LY K382
GREEN LG K382
ORANGE LO K382
PURE GREEN LP K382
Flat Top T1 (3 mm) Super ARGUS LED Lamp





FEATURES

- **Colored, clear lens**
  - **LS: red**
  - **LO: orange**
  - **LY: yellow**
  - **LG: green**
  - **LP: colorless**
- **Appropriate for high ambient light because of high operating current (typ. 50 mA)**
- **Suitable for backlighting display panels with additional, custom built reflector**
- **Uniform illumination of a diffuser screen in front of a custom built reflector**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Note: If the diffuser screen is tinted, the spectral transmission must be adjusted to the wavelengh emitted by the LED

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) . . . –55°C to +100°C
Junction Temperature (T_J). . . . . 100°C
Reverse Voltage (V_R). . . . . .5 V
Forward Current (I_f). . . . . 75 mA
Surge Current (I_{FM})
t≤10 µs, D=0.005. . . . . .1 A
Total Power Dissipation
(P_{TOT}) T_A≤25°C . . . . .300 mW
Thermal Resistance, Junction/Air (1)
(R_{THJA}). . . . . .250 K/W

1. Mounted on PC board with minimum lead length (up to stand-off, pad size ≥16 mm[2]).

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LY	LG	LO	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	610	557	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	628	590	570	605	560		
Spectral Bandwidth, 50% Φ_V	$\Delta\lambda$	45	45	25	40	22		
Forward Voltage	V_F	2.0 (≤3.8)	2.4 (≤3.8)	2.6 (≤3.8)	2.4 (≤3.8)	2.6 (≤3.2)	V	I_F=50 mA
Reverse Current	I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance	C_0	55	30	55	40	80	pF	V_R=0 V f=1 MHz
Switching Times I_V, 10% to 90% I_V, 90% to 10%		—					ns	I_F=100 mA tp=10 µs R_L=50 Ω

Part No.	Luminous Flux, Φ_V, mlm, I_F=50 mA	Part No.	Luminous Flux, Φ_V, mlm, I_F=50 mA
*LS, *LO, *LY, LG K382-QT	63 to 500	LP K382-NR	25 to 200
*LS, *LO, *LY, LG, LP K382-R	100 to 200	LP K382-P	40 to 80
*LS, *LO, *LY, LG K382-S	160 to 320	LP K382-Q	63 to 125
*LS, *LO, *LY, LG K382-RU	100 to 800	LP K382-PS	40 to 320
LG K382-T	250 to 500		

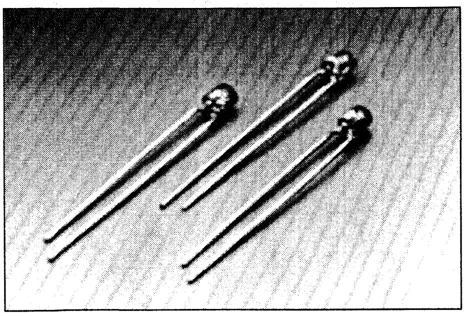
* Not for new design

Luminous flux ratio in one packaging unit $\Phi_{VMAX}/\Phi_{VMIN} \leq 2$.

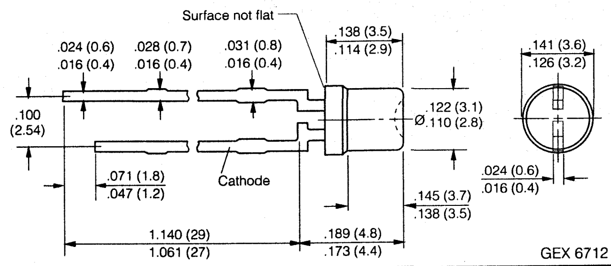
See graph numbers OHL01697, OHL01124, OHL01126, OHL01128, OHL01710, OHL02068, OHL02104, OHL02105, OHL01696, OHL01700 beginning on page 4–92.

SIEMENS

SUPER-RED LS K389-FO
YELLOW LY K389-FO
GREEN LG K389-FO
T1 (3 mm) ARGUS Low Current LED Lamp



Dimensions in inches (mm)



FEATURES

- **Colored, clear lens**
  - **LS: red**
  - **LY: yellow**
  - **LG: green**
- **Plasic package with a special design**
- **High light intensity at low currents (typ. 2 mA)**
- **Suitable for backlighting display panels with additional, custom built reflector**
- **For optical coupling into light pipes**
- **Uniform illumination of a diffuser screen in front of the custom built reflector**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant Per DIN 40839**

Note: If the diffuser screen is tinted, the spectral transmission must be adjusted to the wavelength emitted by the LED.

DESCRIPTION

The LS/LY/LG K389-FO are T1 (3 mm) ARGUS LED lamps. ARGUS lamps can be used only with an additional, customer supplied reflector (i.e., white plastic, such as Pocan B7375). The front end of the reflector is covered by a diffuser (see package dimensions). Uniform illumination can be enhanced by the reflector design tailored to the LED and/or by the use of appropriate diffuser material. If the diffuser is tinted, the spectral transmission must be adjusted to the wavelength emitted by the LED.

Applications include backlighting of display panels, e.g. front panels, graphic control and display boards, sealed keyboards, large-scale displays, dot matrix displays.

See graph numbers OHL01694, OHL01277, OHL01208, OHL01321, OHL01278, OHL01193, OHL01672, OHL01673, OHL01750, OHL01695 beginning on page 4–92.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) ..... –55°C to +100°C
Junction Temperature (T_J) ..... 100°C
Forward Current (I_F) ..... 7.5 mA
Surge Current (I_{FM}) t_P=10 µs, D=0.005 ..... 150 mA
Reverse Voltage (V_R) ..... 5 V
Total Power Dissipation (P_{TOT}) T_A≤25°C ..... 20 mW
Thermal Resistance, Junction/Air (R_{THJA}) ..... 500 K/W

Note: Soldered on PC board: pad size ≥16 mm^2.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	Super -Red	Yellow	Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=2 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth 50% Φ_V	$\Delta\lambda$	45		25		I_F=2 mA
Forward Voltage	V_F	1.8 (≤2.6)	2.0 (≤2.7)	1.9 (≤2.6)	V	
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	3		15	pF	V_R=0 V f=1 MHz
Switching Times, IV 10% to 90% 90% to 10%	t_R t_F	200 150		400 200	ns ns	I_F=100mA t_P=1 µs R_L=50 Ω

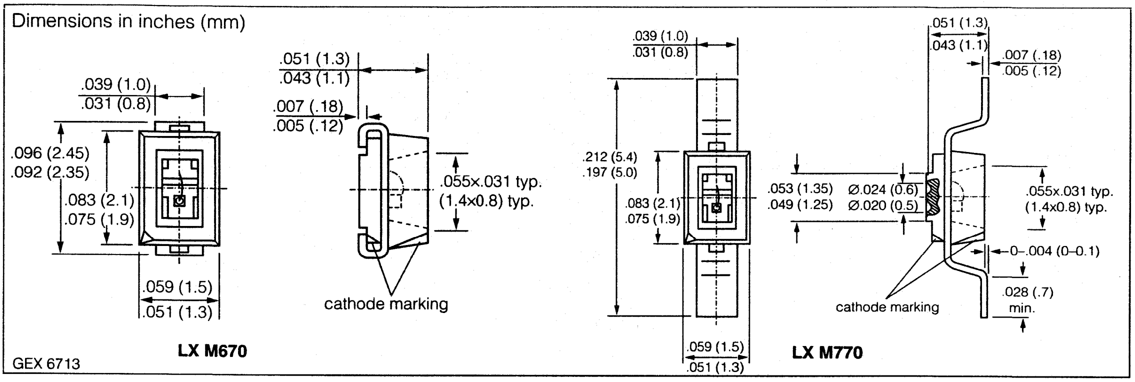
Part No.	Luminous Flux, Φ_V, min	Condition
LS K389-FO	≥1 (5.0 typ.)	I_F=2 mA
LY K389-FO	≥1 (3.2 typ.)	
LG K389-FO	≥1 (3.2 typ.)	

* Luminous flux ratio in one packaging unit Φ_{VMAX}/Φ_{VMIN} ≤ 2.

SIEMENS

SUPER-RED LS M670/M770
ORANGE LO M670/M770
YELLOW LY M670/M770
GREEN LG M670/M770
PURE GREEN LP M670/M770

LXM670, Mini TOPLED® LED Lamp
LXM770, Mini TOPLED® Reverse Gullwing LED Lamp



FEATURES

- **TOPLED: surface mount LED lamp**
- **White package**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 30 mA
Surge Current (I_{FM}) t ≤10 µs, D=0.005..... 0.5 A
Reverse Voltage (V_R)....................................5 V
Power Dissipation (P_{TOT})......................100 mW
Thermal Resistance,
Junction/Air (R_{THJA}) mounted
on PC board[1], pad size≥16 mm^2
LX M670.. 480 K/W
LX M770 .... 530 K/W

1. PC-board: FR4.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength	λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% I_{relmax}	$\Delta\lambda$	45	40	45	25	22		
Viewing Angle, 50% I_V	2φ			120			Deg	
Forward Voltage	V_F			2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R			0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	12	8	10	15		pF	V_R=0 V, f=1 MHz
Switching Times, I_V 10% to 90% 90% to 10%	t_R t_F		300 150		450 200		ns	I_F =100 mA t_P=10 µs R_L=50 Ω

See graph numbers OHL01698, OHL01660, OHL02145, OHL02146, OHL01686, OHL00231, OHL02104, OHL02105, OHL02150 beginning on page 4–92.

Luminous Intensity, I_V, I_F=10 mA and Luminous Flux, Φ_V, I_F=10 mA all values typical

Part Number Lx M670	**Luminous Intensity***	**Luminous Flux**	**Part Number Lx M770**	**Luminous Intensity***	**Luminous Flux**
LS M670-HK	2.5 to 12.5	–	LS M770-HK	2.5 to 12.5	–
LS M670-J	4 to 8	18	LS M770-J	4 to 8	18
LS M670-K	6.3 to 12.5	30	LS M770-K	6.3 to 12.5	30
LS M670-JM	4 to 32	–	LS M770-JM	4 to 32	–
LO M670-HK	2.5 to 12.5	–	LO M770-HK	2.5 to 12.5	–
LO M670-J	4 to 8	18	LO M770-J	4 to 8	18
LO M670-K	6.3 to 12.5	30	LO M770-K	6.3 to 12.5	30
LO M670-JM	4 to 32	–	LO M770-JM	4 to 32	–
LY M670-HK	2.5 to 12.5	–	LY M770-HK	2.5 to 12.5	–
LY M670-J	4 to 8	18	LY M770-H	4 to 8	18
LY M670-K	6.3 to 12.5	30	LY M770-J	6.3 to 12.5	30
LY M670-JM	4 to 32	–	LY M770-JM	4 to 32	–
LG M670-HK	2.5 to 12.5	–	LG M770-HK	2.5 to 12.5	–
LG M670-J	4 to 8	18	LG M770-J	4 to 8	18
LG M670-K	6.3 to 12.5	30	LG M770-K	6.3 to 12.5	30
LG M670-JM	4 to 32	–	LG M770-JM	4 to 32	–
LP M670-FJ	1 to 8	–	LP M770-FJ	1 to 8	–
LP M670-G	1.6 to 3.2	8	LP MM770-G	1.6 to 3.2	8
LP M670-H	2.5 to 5	12	LP M770-H	2.5 to 5	12
LP M670-GK	1.6 to 12.5	–	LP M770-GK	1.6 to 12.5	–

* Luminous intensity ratio of one packaging unit $I_{VMAX} / I_{VMIN} \leq 2.0$.

SIEMENS

SUPER-RED LS M676
AMBER LA M676
ORANGE LO M676
YELLOW LY M676
Hyper-Bright Mini TOPLED® LED Lamp

FEATURES
- **White package, colorless, clear window**
- **Use :**
  - **As optical indicator**
  - **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly soldering methods**
- **Available taped on reel (8 mm)**

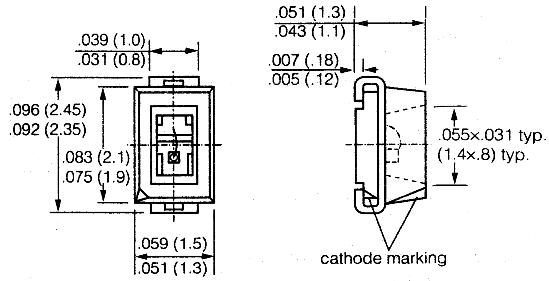
Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F)
LS, LA, LO .... 30 mA
LY .... 20 mA
Surge Current (I_{FM})
t ≤10 µs, D=0.005 .... TBD
Reverse Voltage[(1)] (V_R) .... 3 V
Power Dissipation (P_{TOT})
LS, LA, LO .... 80[(2)] mW
LY .... 55[(2)] mW
Thermal Resistance, Junction/Air
mounted on PC board[(3)]
pad size≥16 mm² (R_{THJA}) .... 550[(2)] K/W

Notes
1. Reverse biasing should be avoided.
2. Preliminary.
3. PC-board: FR4.

See graph numbers OHL00235, OHL01660, OHL00232, OHL00233, OHL00248, OHL00238, OHL00319, OHL00316 beginning on page 4–92.

Dimensions in inches (mm)



GPL 6928

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Sym.	LS	LA	LO	LY	Unit	Condition
Peak Wavelength	λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	632	615	605	587		
Spectral Bandwidth, 50% I_{RELMAX}	Δλ	16			15		
Viewing Angle, 50% I_V	2φ		120			Deg.	
Forward Voltage	V_F		2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R		0.01 (≤10)			µA	V_R=5 V
Temperature Coefficient λ_{DOM}	TC_λ	.014	.062	.067	.098	nm/K	I_F =20 mA
Temperature Coefficient λ_{PEAK}	TC_λ	.14	.13			nm/K	
Temperature Coefficient V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

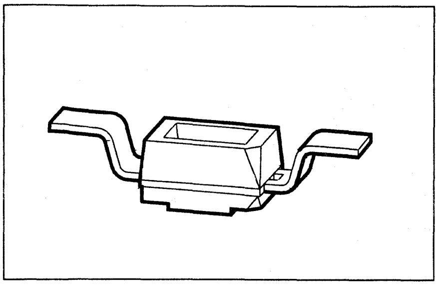
Part Number	Luminous Intensity*, I_V (mcd)	Luminous Flux, Φ_V (mlm)	Condition
LS M676-MQ	16 to 125	–	I_F=20 mA
LS M676-N	25 to 50	100	
LS M676-P	40 to 80	180	
LS M676-Q	63 to 125	300	
LS M676-NR	25 to 200	–	
LA/LO/LY M676-NR	25 to 200	–	
LA/LO/LY M676-P	40 to 80	180	
LA/LO/LY M676-Q	63 to 125	300	
LA/LO/LY M676-R	100 to 200	450	
LA/LO/LY M676-PS	40 to 320	–	

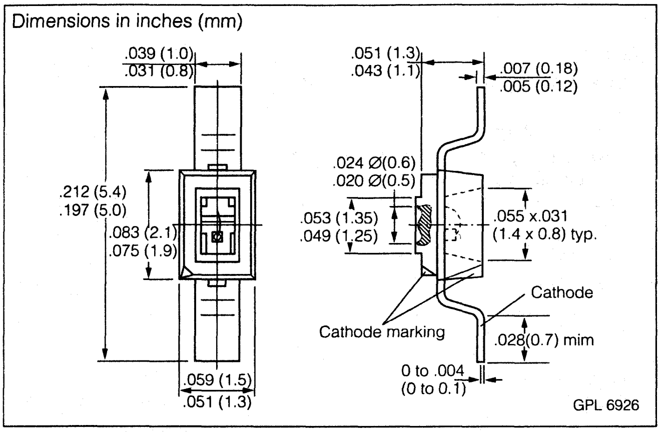
* Luminous intensity ratio of one packaging unit I_{VMAX} / I_{VMIN} ≤ 2.0.

SIEMENS

SUPPER-RED LS M776
YELLOW LA M776
GREEN LO M776
GREEN LY M776

Hyper-Bright Reverse Gullwing Mini TOPLED® Lamp





FEATURES

- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LS, LO, LA .... 30 mA
LY .... 20 mA
Surge Current (I_{FM}) t <10 µs, D=0.005 .... TBD
Reverse Voltage(1) (V_R) .... 3 V
Power Dissipation (P_{TOT})
LS, LO, LA .... 80(2) mW
LY .... 55(2) mW
Thermal Resistance, Junction/Air, Mounted on PC board(3) pad size ≥ 16 mm²
(R_{THJA}) LS, LO, LA .... 630(2) K/W
(R_{THJA}) LY .... 500 K/W

Notes
1. Reverse biasing should be avoided.
2. Preliminary.
3. PC board: FR4.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	LS	LA	LO	LY	Unit	Condition
Peak Wavelength		λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	632	615	605	587		
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	16			15		
Viewing Angle, 50% I_V		2φ	120				Deg.	
Forward Voltage		V_F	2 (≤ 2.6)				V	I_F=20 mA
Reverse Current		I_R	0.01 (≤ 10)				µA	V_R=3 V
Temperature Coefficient	λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
	λ_{PEAK}		0.14	0.13				
	V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

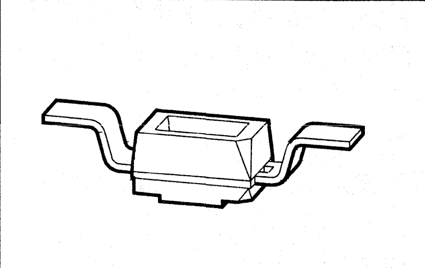
Part Number	Luminous Intensity, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LS M776-MQ	16 to 125	3	I_F=20 mA
LS M776-N	25 to 50	100	
LS/LA/LO/LY M776-P	40 to 80	180	
LS/LA/LO/LY M776-Q	63 to 125	300	
LS/LA/LO/LY M776-NR	25 to 50	100	
LA/LO/LY M776-R	100 to 200	450	
LA/LO/LY M776-PS	40 to 320	—	

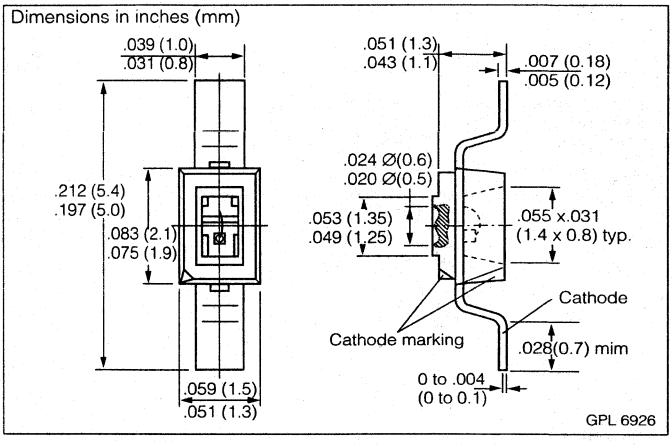
Luminous Intensity ratio in one packaging unit $I_{VMAX}/I_{VMIN} \leq 2$.

See graph numbers OHL00235, OHL01660, OHL00232, OHL00233, OHL00248, OHL00238, OHL00320, OHL00316 beginning on page 4–92.

SIEMENS

SUPER-RED LS M779
YELLOW LY M779
GREEN LG M779
Low Current Reverse Gullwing Mini TOPLED® Lamp





FEATURES

- **Mini TOPLED: surface mount LED lamp**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**

Maximum Ratings

Operating/StorageTemperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 7.5 mA
Surge Current (I_{FM}) t <10 µs, D=0.005 .... 0.15 A
Power Dissipation (P_{TOT}) .... 20 mW
Thermal Resistance, Junction/Air
Mounted on PC board*,
pad size ≥ 16 mm² (R_{THJA}) .... 530 K/W

* PC-board: FR4

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	LS	LY	LG	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	586	565	nm	I_F=7.5 mA
Dominant Wavelength		λ_{DOM}	628	590	570		
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	45		25		
Viewing Angle, 50% I_V		2φ	120			Deg.	
Forward Voltage		V_F	1.8 (≤ 2.6)	2 (≤ 2.7)	1.9 (≤ 2.6)	V	I_F=2 mA
Reverse Current		I_R	0.01 (≤ 10)			µA	V_R=5 V
Capacitance		C_0	3		15	pF	V_R=0 V f=1 MHz
Switching Times, I_V	10% to 90%	t_R	200		450	ns	I_F =100 mA t_P=10 µs R_L=50 Ω
	90% to 10%	t_F	150		200		

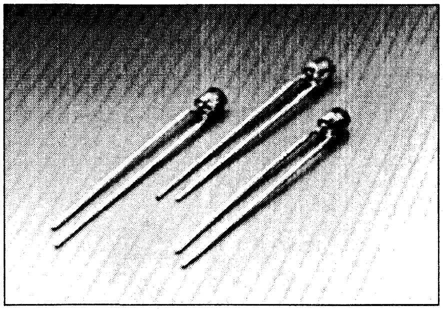
Part Number	Luminous Intensity, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LS M779-CF	0.25 to 0.5	3	I_F=2 mA
LS M779-DG	0.4 to 0.8		
LY M779-CF	0.25 to 0.5		
LY M779-DG	0.4 to 0.8		
LG M779-CO	≥ 0.25 (1.0 typ.)		

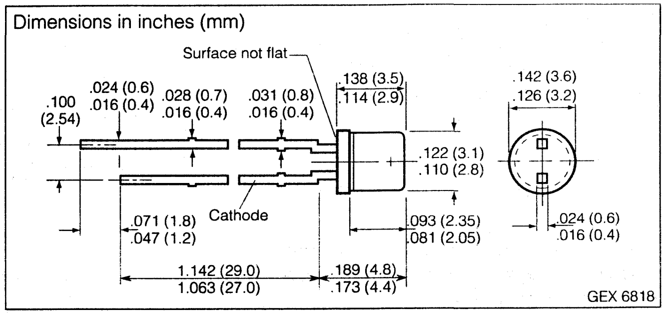
Luminous Intensity ratio in one packaging unit $I_{VMAX}/I_{VMIN} \leq 2$

See graph numbers OHL011698, OHL01660, OHL01208, OHL01207, OHL01278, OHL01193, OHL01672, OHL01673, OHL01750, OHL01675 beginning on page 4–92.

SIEMENS

SUPER-RED LS P380
ORANGE LO P380
YELLOW LY P380
GREEN LG P380
PURE GREEN LP P380
Plane Flat Top T1 (3 mm) LED Lamp





FEATURES
- **Colorless clear lens**
- **For optical coupling into light pipes**
- **Use as optical indicator**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Note:
If the diffuser screen is tinted, the spectral transmission must be adjusted to the wavelength emitted by the LED.

Maximum Ratings
Operating/StorageTemperature
Range (T_A, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LS, LO, LY, LG .... 40 mA
LP .... 30 mA
Surge Current (I_{FM}) t <10 µs, D = 0.005 .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) $T_A \leq 25$°C
LS, LO, LLY, LG .... 140 mW
LP .... 100 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	610	586	565	557	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth 50% Φ_V, I_{RELMAX}		$\Delta\lambda$	45	40	45	25	22		
Forward Voltage		V_F	2.1 (≤2.6)					V	I_F=15 mA
Reverse Current		I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance		C_O	12	8	10	15	32		V_R=0 V f=1 MHz
Switching Time, I_V	10% to 90%	t_R	300			450		ns	I_F=100 mA t_P=10 µs R_L=50 Ω
	90% to 10%	t_F	150			200			

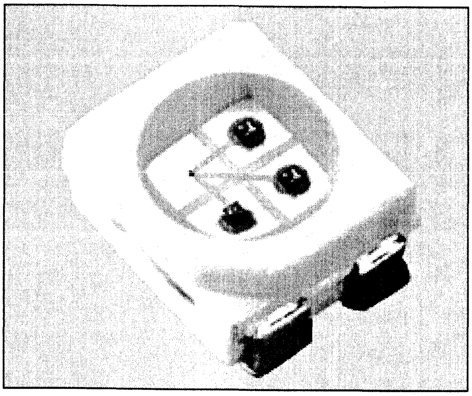
Part Number	Luminous Flux, Φ_V, mlm	Condition
LS/LO/LY/LG/LP P380-MP	16 to 80	I_F = 15 mA
LS/LO/LY/LG/LP P380-N	25 to 50	
LS/LO/LY/LG P380-P	40 to 80	
LS/LO/LY/LG P380-NQ	25 to 125	
LP P380-LN	10 to 50	
LP P380-M	16 to 32	

Luminous flux ratio of one packaging unit $\Phi_{VMAX} / \Phi_{VMIN} \leq 2$

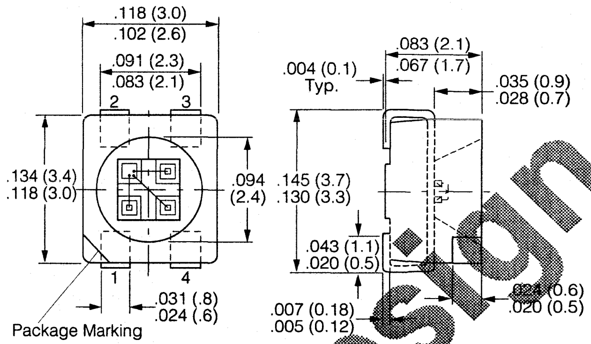
See graph numbers OHL01697, OHL02080, OHL01625, OHL02103, OHL01162, OHL01686, OHL02252, OHL01661, OHL02104, OHL02105, OHL02149, OHL02107 beginning on page 4–92.

SIEMENS

SUPER-RED/PURE GREEN/BLUE LSPB T670
Multi LED® Lamp



Dimensions in Inches (mm)



Pinning:
1. Cathode Super-red
2. Anode Super-red, Pure Green, Blue
3. Cathode Blue
4. Cathode Pure Green

FEATURES
- P-LCC-4 ackage
- White package, colorless clear window
- Complete color spectrum
- Three separate light sources (dies), blue (480 nm), pure green (557 nm), red (630 nm)
- Excellent color mixture due to small distances between dies (0.5 mm) and a common reflector, (∅ 2.4 mm)
- Suitable for matrix-displays with high packing density and high resolution (pixel graphic), respectively
- High signal efficiency and ratio possible by changing LED color
- Suitable for all SMT placement and solder processes
- Available taped on reel (8 mm tape)
- Load dump resistant acc. to DIN 40839

APPLICATIONS
- Ideal for backlighting, optical coupling into light pipes and lenses
- Colorimeter
- Medical analysis

Note: Due to rapid technological development of blue chips, data are preliminary.

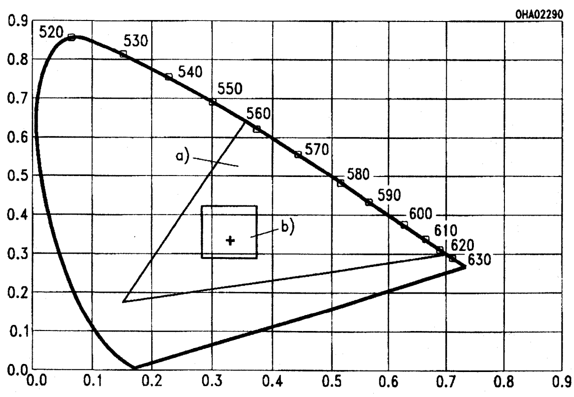
Maximum Ratings

Operating Temperature Range (T_{OP})	–55 to +100°C
Storage Temperature Range (T_{STG})	–55 to +100°C
Junction Temperature (T_J)	+100°C
Forward Current(1) (I_F)	30 mA
Forward Current(2) (I_F)	
Super-Red	7.5 mA
Pure Green	15 mA
Blue	30 mA
Reverse Voltage (V_R)	5 V
Power Dissipation (P_{TOT})	
Super-Red, LP Pure Green	100 mW
Blue	130 mW
Thermal Resistance, Junction Air	
Super-Red (R_{THJA})(1)	480 K/W
Super-Red (R_{THJA})(2)	630 K/W
Pure Green (R_{THJA})(1)	370 K/W
Pure Green (R_{THJA})(2)	450 K/W
Blue (R_{THJA})(1)	450 K/W
Blue (R_{THJA})(2)	530 K/W

Notes:
1. The stated maximum ratings refer to one die with the others turned off.
2. The stated maximum ratings refer to all dies turned on.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Symbol	LS	LP	LB	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	557	467	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	628	560	480	nm	
Spectral Bandwidth, 50% I_{relmax}		$\Delta\lambda$	45	22	75	nm	
Visual Efficiency	Super-Red	η_V	130			lm/W	I_F=2 mA
	Pure Green	η_V		625		lm/W	I_F=10 mA
	Blue	η_V			165	lm/W	I_F=30 mA
Viewing Angle, 50% I_V		2φ	120			Deg	
Forward Voltage	Super-Red, Pure Green	V_F	2.0 (≤2.6)			V	I_F=10 mA
	Blue	V_F			3.1 (≤4.5)	V	I_F=20 mA
Reverse Current		I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance		C_0	12	15	50	pF	V_R=0 V, f=1 MHz
Switching Times, i_V	Rise Time, 10% to 90%	t_R	300	450	800	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω
	Fall Time, 90% to 10%	t_F	150	200	800		
Forward Current		I_F	2	10	30	mA	
Radiant Intensity		I_E	5.5 (≥2.5)	4.0 (≥2.0)		µW/sr	
Total Flux		Φ_E	16.5	12		µW	
Luminous Intensity		I_V	0.7	2.5	0.6	mcd	



Additive mixture of color stimuli by independent driving of each chip.

The color coordinates of the mixed light are within area "a)"of the color triangle.

The Achromatic point (x=0.33) is marked "+".

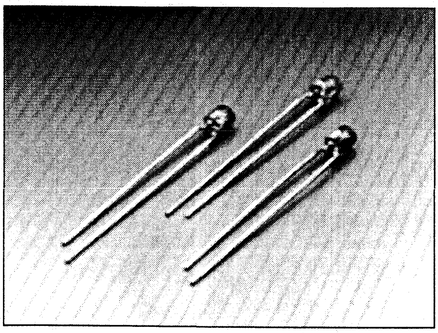
With LED operating currents of:

Super-red	2 mA
Pure Green	10 mA
Blue	30 mA

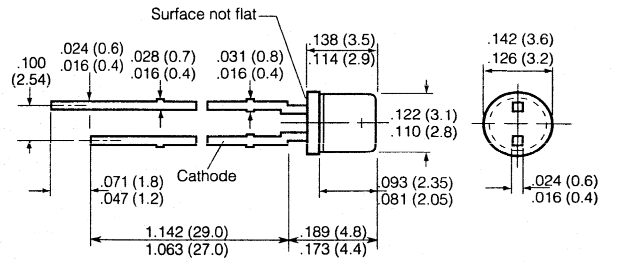
the color coordinates of the emitted light are in area "b)" of the color triangle (s=0.275–0.37; y=0.295–0.42).

SIEMENS

SUPER-RED/PURE GREEN LSP P370
ORANGE/PURE GREEN LOP P370
3 mm (T1) Plane MULTILED® Lamp



Dimensions in inches (mm)



GEX 6816

LED Lamps 4

FEATURES
- **Colorless, clear package**
- **For optical coupling into light pipes**
- **Use as optical indicator**
- **Antiparallel chips**
- **High signal efficiency possible by changing LED color**
- **Can change color from green to yellow and orange (resp. to super-red) with appropriate controlling by IC such as SDA 2231**
- **Solder leads with stand-off**
- **Available taped on reel**
- **Load dump resistant per DIN 40839**

Maximum Ratings The stated maximum ratings refer to the specified chip, regardless of the other one's operating staus.

Operating/StorageTemperature
Range (T_{OP}, T_{STG}) .... –55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F)
LS, LO 40*mA
LP 30*mA
Surge Current (I_{FM}) t <10 µs, D=0.005 .... 0.5 A
Power Dissipation (P_{TOT}) T_A≤25°C
LS, LO .... 140 mW
LP .... 100 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 400 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		**Sym.**	**LS**	**LO**	**LY**	**Unit**	**Condition**
Peak Wavelength		λ_{PEAK}	635	610	557	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	628	605	560		
Spectral Bandwidth, 50% Φ_V		$\Delta\lambda$	45	40	22		
Forward Voltage		V_F	2.1 (≤2.6)			V	
Capacitance(4)		C_O	12	8	15	pF	I_F=20 mA
Switching Times, I_V	10% to 90%	T_R	300		450	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω
	90% to10%	T_F	150		200		

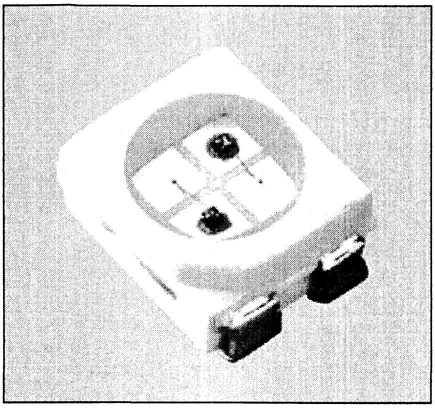
Part Number	**Luminous Flux, Φ_V, mlm**	**Part Number**	**Luminous Flux, Φ_V, mlm**	**Condition**
LSP P370-KN	6.3 to 50	LOP P370-KN	6.3 to 50	I_F = 15 mA
LSP P370-M	16 to 32	LOP P370-M	16 to 32	
LSP P370-N	25 to 50	LOP P370-N	25 to 50	
LSP P370-P	40 to 80	LOP P370-MQ	16 to 125	
LSP P370-MQ	16 to 125			

Notes
1. Luminous flux ratio of one packaging unit $\Phi_{VMAX} / \Phi_{VMIN} \leq 2^{(3)}$.
2. Luminous flux ratio of one LED $\Phi_{VMAX} / \Phi_{VMIN} \leq 4$.
3. In MULTILEDs, the brightness of the darker chip in one packaging unit deter mines the brightness group of the LED.
4. The total capacitance results from the sum of the single capacitances.

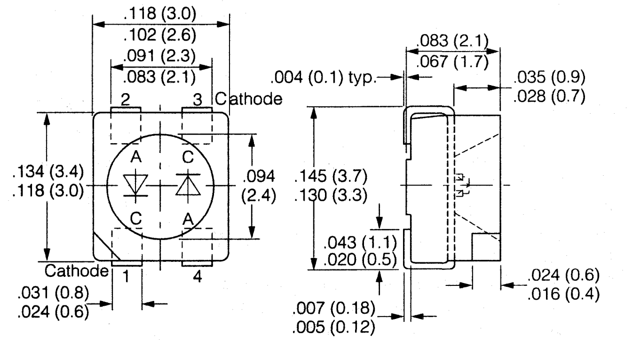
See graph numbers OHL01698, OHL02066, OHL02145, OHL02253, OHL01162, OHL01686, OHL02252, OHL01661, OHL02104, OHL02149, OHL02107 beginning on page 4–92.

SIEMENS

SUPER-RED/PURE GREEN LSP T672
ORANGE/YELLOW LOY T672
ORANGE/PURE GREEN LOP T672
SUPER-RED/GREEN LSG T672
ORANGE/GREEN LOG T672
YELLOW/PURE GREEN LYP T672
High Current Super Multi TOPLED® Lamp



Dimensions in inches (mm)



GPL6837

FEATURES
- **TOPLED: surface mount LED lamp**
- **P-LCC-4 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **Appropriate for high ambient light because of high operating current (≤ 50 mA DC)**
- **For backlighting, optical coupling into light pipes and lenses**
- **Both chips can be controlled separately**
- **High signal efficiency possible by changing LED color**
- **Can change color from green to yellow and orange to super-red with appropriate con-trolling**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 50 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 .... 1 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) .... 140 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board(1), pad size 16 mm^2
(R_{THJA}) .... 380 K/W
(R_{THJA})(2) .... 530 K/W

Note:
1. PC board: FR4
2. One system only
3. Both systems on simultaneously
4. The stated maximum ratings refer to one chip.

See graph numbers OHL01698, OHL01660, OHL01626, OHL02152, OHL02254, OHL00240, OHL02104, OHL02105, OHL01696, OHL02154 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Symbol	Value					Unit	Condition
			LS	**LO**	**LT**	**LG**	**LP**		
Peak Wavelength		λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% I_{relmax}		$\Delta\lambda$	45	40	45	25	22		
Viewing Angle, 50% I_V		2φ	120					Deg	
Forward Voltage	typ.	V_F	2	2.1	2.2	2.6		V	I_F=10 mA
	max.		3.8				3.2		
Reverse Current	typ.	I_R	0.01					µA	V_R=5 V
	max.		10						
Capacitance		C_0	40	35		60	80	pF	V_R=0 V, f=1 MHz
Switching Times, I_V	10% to 90%	t_R	350	500	350	500		ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω
	90% to 10%	t_F	200	250	200	250			

Part Number	Luminous Intensity[1], I_V, mcd	Luminous Flux, Φ_V, mlm	Condition	Part Number	Luminous Intensity[1], I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LSG T672-MO	30 (≥16)	90	I_F=50 mA	LOG T672-MO	50 (≥16)	150	I_F=50 mA
LSP T672-KN	6.3 to 50	—		LOP T672-KN	6.3 to 50	—	
LSP T672-L	10 to 20	45		LOP T672-L	10 to 20	45	
LSP T672-M	16 to 32	75		LOP T672-M	16 to 32	75	
LSP T672-N	25 to 50	100		LOP T672-N	25 to 50	100	
LSP T672-LP	10 to 80	—		LOP T672-LP	10 to 80	—	
*LOY T672-MO	50 (≥16)	150		LYP T672-LO	20 (≥10)	60	

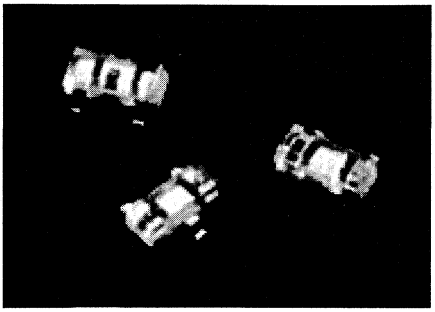
*Not for new design

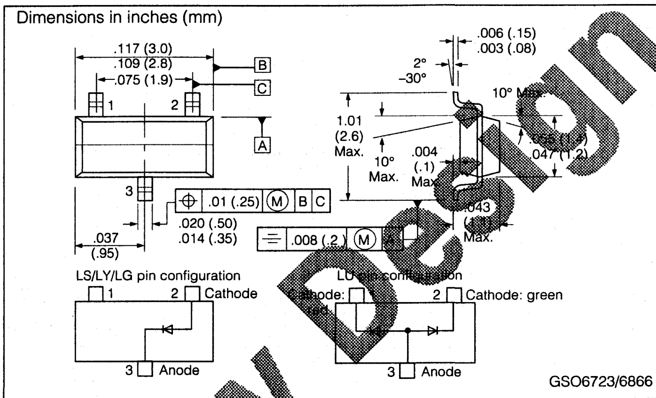
Notes

1. Luminous Intensity ratio in one packaging unit $I_{VMAX}/I_{VMIN} \leq 2.0$[3].
2. Luminous Intensity ratio in one LED $I_{VMAX}/I_{VMIN} \leq 3.0$ (LOY, LSG, LOG), ≤4.0 (LSP, LOP, LYP).
3. In MULTILEDs, the brightness of the darker chip in one package determines the brightness group of the LED.

SIEMENS

SUPER-RED LS S260-DO
YELLOW LY S260-DO
GREEN LG S260-DO
SUPER-RED/GREEN LU S250-DO
SUPER-RED/SUPER-RED LV S260-DO
GREEN/GREEN LW S260-DO
SOT23 Surface Mount MULTILED® LED Lamp





FEATURES
- **Colored, diffused package**
  - **– LU: colorless**
  - **– LV/LS: red**
  - **– LW/LG: green**
  - **– LY: yellow**
- **Extreme wide-angle LED**
- **For use as optical jindicator**
- **Suitable for all SMT assembly and soldering methods**
- **Both colors can be controlled separately**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

DESCRIPTION
The SOT23 LED is available in super-red, green, and yellow package. Supplied on 8 mm wide reels with 3,000 components per reel, the packaging conforms to IEC standards and can be used on all commercial automatic surface mount insertion equipment. Standard reels are 18 cm in diameter, however, special 38 cm reels with 10,000 components per reel are available.

For 3,000 pieces per reel option add suffix E7502 to the part number. For 10,000 pieces per reel option, add E7503 to the part number.

See graph numbers OHL01698, OHL01693, OHL01263, OHL01632, OHL01686, OHL01692, OHL01672, OHL01673, OHL01674,OHL01675 beginning on page 4-92.

Maximum Ratings refer to one chip

Operating/Storage Temperature Range (T_{OP}, T_{STG}) ....–55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F) ....30 mA
Surge Current (I_{FS}) t=10 µs, D=0.005 ....0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) T_A≤25°C .... 100 mW
Thermal Resistance, Junction/Air T_A (R_{THJA}) (1) ....750 K/W

(1) Soldered on PC board: pad size ≥16 mm².

Characteristics T_A=25°C, all values typical unless otherwise noted

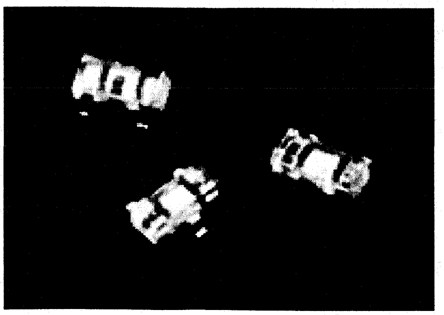
Parameter		Symbol	Super-Red	Yellow	Green	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	586	565	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}		$\Delta\lambda$	45		25		
Viewing Angle, 50% I_V		2φ	140			Deg.	
Forward Voltage		V_F	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current		I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance		C_0	12	10	15	pF	V_R=0 V, f=1 MHz
Switching Time, I_V	10% to 90%	t_R	300		450	µs	
	90% to 10%	t_F	150		200		
Luminous Intensity*		I_V	≥ 0.4			mcd	I_F=10 mA

* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2

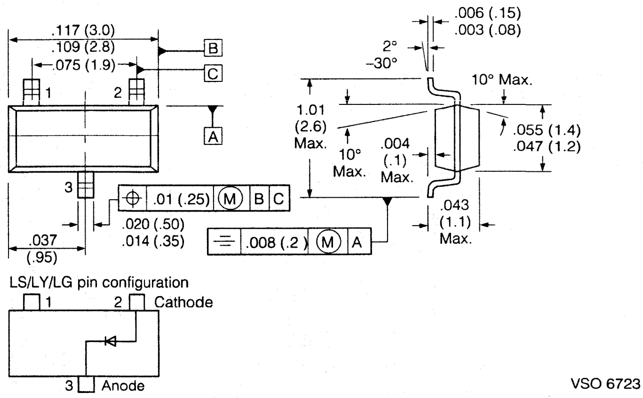
SIEMENS

SUPER-RED LS S269-BO
YELLOW LY S269-BO
GREEN LG S269-BO

SOT23 Low Current Surface Mount LED Lamp



Dimensions in inches (mm)



FEATURES

- **Colored, diffused package**
  - **LS: red**
  - **LY: yellow**
  - **LG: green**
- **Extrem wide-angle LED**
- **For use as optical indicator**
- **High luminous intensity at very low currents (typ. 2 mA)**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**

DESCRIPTION

The LS/LY/LG S269-BO are low current, plastic SOT23 surface mountable LED lamps. They are available in three colors: LS S269-BO: super-red, LY S269-BO: yellow, LG S269-BO: green.

These SOT23 LEDs are supplied only on tape and reel. Standard reels are 18 cm in diameter with tape width of 8 mm and 3,000 pieces per reel. Special 38 cm reels with 10,000 pieces per reel are also available.

To order reels with 3,000 pieces, add suffix E7502 to the part number. To order reels with 10,000 pieces, add suffix E7503 to the part number.

See graph numbers OHL01698, OHL01693, OHL01208, OHL01207, OHL01278, OHL01193, OHL01672, OHL01673, OHL01750, OHL01675 beginning on page 4–91.

Maximum Ratings

Operating and Storage Temperature (T_{OP}, T_{STG}) ....–55°C to +100°C
Junction Temperature (T_J) .... 100°C
Forward Current (I_F) .... 7.5 mA
Surge Current (I_{FS}) t ≤10 µs, D≤0.005 .... 150 mA
Power Dissipation (P_{TOT}) T_A≤25°C .... 20 mW
Reverse Voltage (V_R) .... 5 V
Thermal Resistance: Junction/Air(1) (R_{THJA}) .... 750 K/W

1. Soldered on PC board: pad size ≥16 mm².

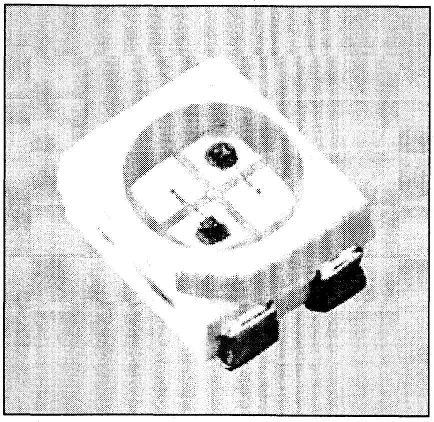
Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	Super-Red	Yellow	Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=7.5 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth 50% I_{RELMAX}	Δλ	45		25		
Viewing Angle, 50% I_V	2φ	140			Deg.	
Forward Voltage	V_F	1.8 (2.6)	2.0 (2.7)	1.9 (2.6)	V	I_F=2 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance,	C_0	3		15	pF	V_R=0 V, f=1 MHz
Switching Times, I_V 10% to 90% 90% to 10%	t_R t_F	200 150		450 200	ns ns	I_F=100mA, t_P=10 µs, R_L=50 Ω
Luminous Intensity*,	I_V	≥0.16			mcd	I_F=2 mA

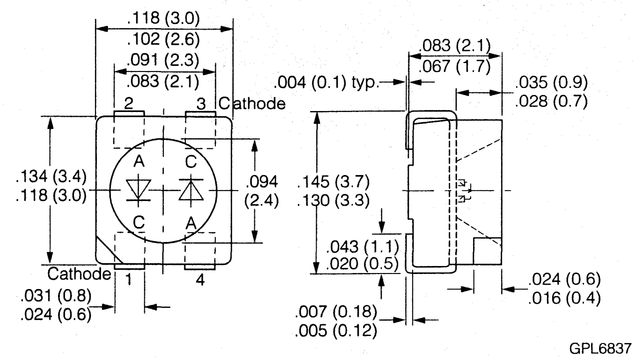
* Luminous intensity ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2

SIEMENS

SUPER-RED/SUPER-RED LSS T670
ORANGE/ORANGE LOO T670
YELLOW/YELLOW LYY T670
GREEN/GREEN LGG T670
PURE GREEN/PURE GREEN LPP T670
Multi TOPLED® Lamp



Dimensions in inches (mm)



FEATURES
- **P-LCC-4 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **Both chips can be controlled separately**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available on tape and reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 30 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 .... 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) .... 100 mW
Thermal Resistance, Junction/Air, mounted on
PC Board[(1)], pad size 16 mm^2
(R_{THJA})[(2)] .... 480 K/W
(R_{THJA})[(3)] .... 650 K/W

Notes
1. PC board G30/FR4
2. One system on.
3. Both systems on simultaneously.
4. The stated maximum ratings refer to one chip.

See graph numbers OHL01698, OHL01660, OHL02145, OHL01686, OHL02146, OHL00241, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Symbol	Super-Red	Orange	Yellow	Green	Pure Green	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% I_{relmax}		$\Delta\lambda$	45	40	45	25	22		
Viewing Angle, 50% I_V		2φ	120					Deg	
Forward Voltage		V_F	2.0 (≤2.6)					V	I_F=10 mA
Reverse Current		I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance		C_0	12	8	10	15		pF	V_R=0 V f=1 MHz
Switching Times, i_V	10% to 90%	t_R	300			450		ns	I_F =100 mA t_P=10 µs R_L=50 Ω
	90% to 10%	t_F	150			200			

Part Number	Luminous Intensity(1), I_V, mcd	Luminous Flux, Φ_V, mlm	Condition	Part Number	Luminous Intensity(1), I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
*LSS T670-JO	8 (≥4)	24	I_F=10 mA	LGG T670-JO	10 (≥4)	30	I_F=10 mA
*LOO T670-JO				LPP T670-HO	5 (≥2.5)	15	
*LYY T670-JO							

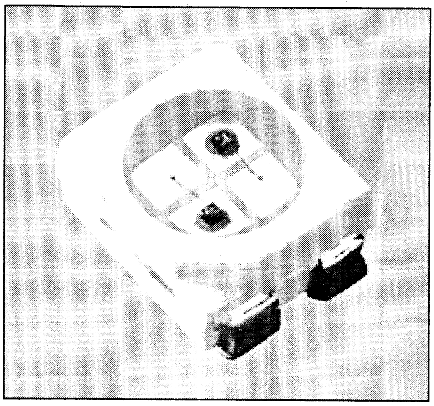
* Not for new design

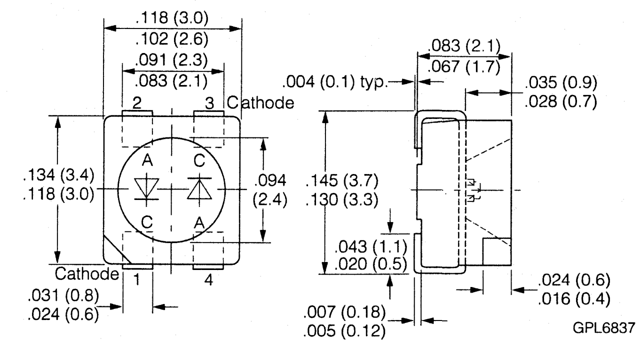
Notes

1. In MULTILEDs with two chips of the same color in one package, the mean of the brightness determines the brightness group of the LED.
2. Luminous Intensity ratio in one packaging unit $I_{VMAX}/I_{VMIN} \geq 2.0^{(1)}$.
3. Luminous Intensity ratio in one LED $I_{VMAX}/I_{VMIN} \geq 2.0$.

SIEMENS

SUPER-RED/SUPER-RED LSST672
ORANGE/ORANGE LOOT672
YELLOW/YELLOW LYYT672
GREEN/GREEN LGGT672
PURE GREEN/PURE GREEN LPPT672
High Current Super Multi TOPLED® Lamp





FEATURES

- **TOPLED: surface mount LED lamp**
- **P-LCC-4 Package**
- **White Package, colorless clear window**
- **Use as optical indicator**
- **Appropriate for high ambient light because of high operating current (≤50 mA DC)**
- **For backlighting, optical coupling into light pipes and lenses**
- **Both chips can be controlled separately**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings refer to one chip

Operating/Storage Temperature Range (T_{OP}, T_{STG})................. –55 to +100°C
Forward Current (I_F).. 50 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005........................ 1 A
Reverse Voltage (V_R).. 5 V
Power Dissipation (P_{TOT})...................................... 160 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board(1), pad size 16 mm^2
(R_{THJA})(2)... 350 K/W
(R_{THJS})(3)... 300 K/W

Notes

1. PC board G30/FR4
2. One system on.
3. Both systems on simultaneously.

See graph numbers OHL01698, OHL01660, OHL01626, OHL02152, OHL02254, OHL00240, OHL02104, OHL02105, OHL01696, OHL02154 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Symbol	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% I_{relmax}		$\Delta\lambda$	45	40	45	25	22		
Viewing Angle, 50% I_V		2φ	120					Deg	
Forward Voltage		V_F	2.0 (≤3.8)	2.1 (≤3.8)	2.2 (≤3.8)	2.6(≤3.8)		V	I_F=50 mA
Reverse Current		I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance		C_0	40	35	35	60	80	pF	V_R=0 V f=1 MHz
Switching Times, i_V	Rise Time, 10% to 90%	t_R	350	500	350	500		ns	I_F =100 mA t_P=10 µs R_L=50 Ω
	Fall Time, 90% to 10%	t_F	200	250	200	250			

Part No.	Luminous Intensity[2], I_V, mcd	Luminous Flux, Φ_V, mlm	Condition	Part No.	Luminous Intensity[2], I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
*LSS T672-NO	100 (≥25)	300	I_F=50 mA	LGG T672-NO	100 (≥25)	300	I_F=50 mA
*LOO T672-MO	100 (≥16)			LPP T672-MO	50 (≥16)	150	
*LYY T672-NO	100 (≥25)						

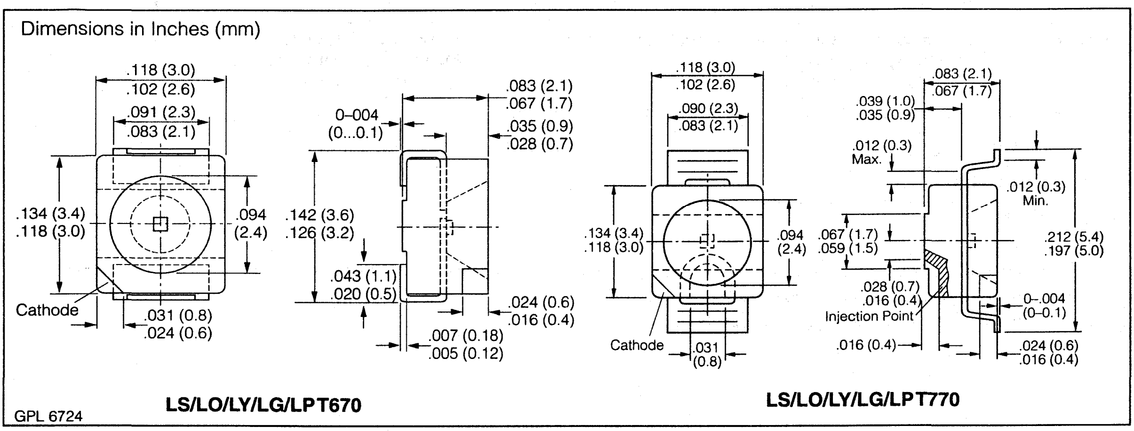
*Not for new design

Notes

1. In MULTILEDs with two chips of the same color in one package, the mean of the brightness determines the brightness group of the LED.
2. Luminous Intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≥2.0[1].
3. Luminous Intensity ratio in one LED I_{VMAX}/I_{VMIN}≥2.0.

SIEMENS

SUPER-RED LS T670/770
ORANGE LO T670/770
YELLOW LY T670/770
GREEN LG T670/770
PURE GREEN LP T670/770
LxT 670, TOPLED® Lamp
LxT 770, Reverse GullwingTOPLED® Lamp



FEATURES
- **P-LCC-2 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and solder methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

See graph numbers OHL01698, OHL01660, OHL02145, OHL02146, OHL01686, OHL01661, OHL02104, OHL02105, OHL02106, OHL02150 beginning on page 4–92.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}).......–55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F)........ 30 mA
Surge Current (I_{FS}) t≤10 µs, D=0.005........ 0.5 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT})........ 100 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board(1), pad size 16 mm^2 (R_{THJA}) .... 400 K/W

1. PC board G30/FR4

Characteristics T_A=25°C, all values typical unless otherwise noted

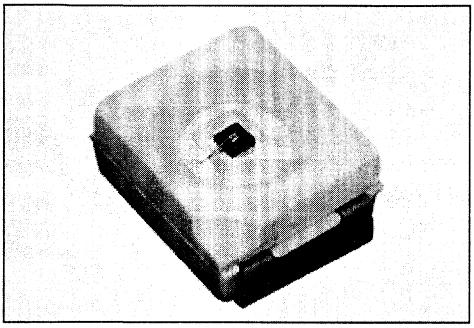
Parameter		Symbol	LS	LO	LY	LG	LP	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth (50% I_{RELMAX})		$\Delta\lambda$	45	40	45	25	22		
Viewing Angle, 50%, I_V		2φ	120					Deg.	
Forward Voltage		V_F	2.0 (≤ 2.6)					V	I_F=10 mA
Reverse Current		I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance		C_0	12	8	10	15	15	pF	V_R=0 V f=1 MHz
Switching Times, I_V	10%–90%	t_R	300	300	300	450	450	ns	I_F=100 mA t_P=10 µs R_L=50 Ω
	90%–10%	t_F	150	150	150	200	200		

Part Number	Luminous Intensity*, I_V	Luminous Flux, Φ_V	Condition	Part Number	Luminous Intensity*, I_V	Luminous Flux, Φ_V	Condition
LS T670-HK	2.5 to 12.5	—	I_F=10 mA	LY T670-L	10 to 20	18	I_F=10 mA
LS T670-J	4 to 8	18		LYT670-JM	4 to 32	—	
LS T670-K	6.3 to 12.5	30		LGT670-HK	2.5 to 12.5	—	
LS T670-L	10 to 20	45		LG T670-J	4 to 8	18	
LS T670-JM	4 to 32	—		LG T670-K	6.3 to 12.5	30	
LOT670-HK	2.5 to 12.5	—		LG T670-L	10 to 20	45	
LO T670-J	4 to 8	8		LG T670-JM	4 to 32	—	
LO T670-K	6.3 to 12.5	12		LPT670-FJ	1 to 2	—	
LO T670-L	10 to 20	18		LPT670-G	1.6 to 3.2	8	
LO T670-JM	4 to 32	—		LPT670-H	2.5 to 5	12	
LY T670-HK	2.5 to 12.5	—		LPT670-J	4 to 8	18	
LY T670-J	4 to 8	18		LPT670-GK	1.6 to 12.5	—	
LY T670-K	6.3 to 12.5	30					
LS T770-HK	2.5 to 12.5	—	I_F=10 mA	LY T770-L	10 to 20	18	I_F=10 mA
LS T770-J	4 to 8	18		LYT770-JM	4 to 32	—	
LS T770-K	6.3 to 12.5	30		LGT770-HL	2.5 to 12.5	—	
LS T770-L	10 to 20	45		LG T770-J	4 to 8	18	
LS T770-JM	4 to 32	—		LG T770-K	6.3 to 12.5	30	
LOT770-HK	2.5 to 12.5	—		LG T770-L	10 to 20	45	
LO T770-J	4 to 8	8		LG T770-JM	4 to 32	—	
LO T770-K	6.3 to 12.5	30		LPT770-FJ	1 to 2	—	
LO T770-L	10 to 20	45		LPT770-G	1.6 to 3.2	8	
LO T770-JM	4 to 32	—		LPT770-H	2.5 to 5	12	
LY T6770-HK	2.5 to 12.5	—		LPT770-J	4 to 8	18	
LY T770-J	4 to 8	8		LPT770-GK	1.6 to 12.5	—	
LY T770-K	10 to 20	12					

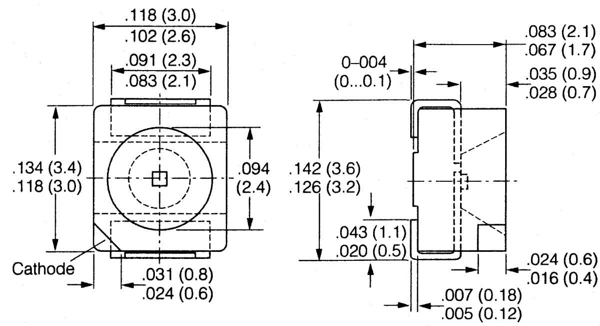
*Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≥2.0

SIEMENS

SUPER-RED LS T672
ORANGE LO T672
YELLOW LY T672
GREEN LG T672
PURE GREEN LP T672
High Current Super TOPLED® Lamp



Dimensions in Inches (mm)



GPL 6724

FEATURES

- **TOPLED: surface mount LED lamp**
- **PL-CC-2 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **Appropriate for high ambient light due to high operating current (≤50 mA DC)**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant acc. to DIN 40839**

DESCRIPTION

The LX T672 (Super TOPLED for surface mount applications) is available in super-red, orange, yellow, green, and pure green. The package incorporates an internal reflector to optimize light coupling. This feature makes the TOPLED ideal for light pipe applications.

The large LED chip allows the part to be driven at a current of 50 mA for increased luminous intensity.

Maximum Ratings

Operating/StorageTemperature Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 50 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 .... 1 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation (P_{TOT}) .... 190 mW
Thermal Resistance, Junction Air,
Mounted on PC Board[1], pad size 16 mm^2 (R_{THJA}) .... 300 K/W

1. PC board FR4

See graph numbers OHL01698, OHL01660, OHL01626, OHL02152, OHL02254, OHL00243, OHL02104, OHL02105, OHL01696, OHL02154 beginning on page 4-92.

Characteristics (T_A=25°C) All values typical unless otherwise noted

Parameter	Symbol	Super-Red	Orange	Yellow	Green	Pure Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	610	586	565	557	nm	I_F=10 mA
Dominant Wavelength	λ_{DOM}	628	605	590	570	560		
Spectral Bandwidth, 50% I_{RELMAX}	$\Delta\lambda$	45	40	45	25	22		
Viewing Angle, 50% I_V	2φ	120					Deg.	
Forward Voltage	V_F	2.0 (≤3.8)	2.1 (≤3.8)	2.2 (≤3.8)	2.6(≤3.8)	2.6(≤3.2)	V	I_F=50 mA
Reverse Current	I_R	0.01 (≤10)					µA	V_R=5 V
Capacitance	C_0	40	35		60	80	pF	V_R=0 V f=1 MHz
Switching Time, i_V 10% to 90% 90% to 10%	 t_R t_F	 350 200	 500 250	 350 200	 500 250		ns	I_F=100 mA t_P=10 µs R_L=50 Ω

Part No.	Luminous Intensity(1), I_V, mcd	Luminous Flux, Φ_V, mlm	Condition	Part No.	Luminous Intensity(1), I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
*LS T672-LP	10 to 80	—	I_F=50 mA	LG T672-MQ	16 to 125	—	I_F=50 mA
*LS T672-N	25 to 50	100		LG T672-N	25 to 50	100	
*LS T672-P	40 to 80	180		LG T672-P	40 to 80	180	
*LS T672-NR	25 to 200	—		LG T672-Q	63 to 125	300	
*LO T672-MQ	16 to 125	—		LG T672-NR	25 to 200	—	
*LO T672-N	25 to 50	100		LP T672-KN	6.3 to 50	—	
*LO T672-P	4 to 80	180		LP T672-L	10 to 20	45	
*LO T672-NR	25 to 200	—		LP T672-M	16 to 32	75	
*LY T672-LN	10 to 80	—		LP T672-N	25 to 50	100	
*LY T672-N	25 to 50	100		LP T672-LP	10 to 80	—	
*LY T672-P	40 to 80	180					
*LY T672-NR	25 to 200	—					

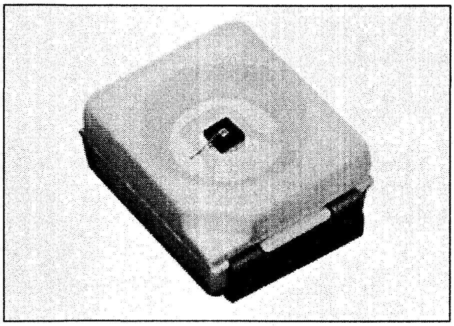
*Not for new design

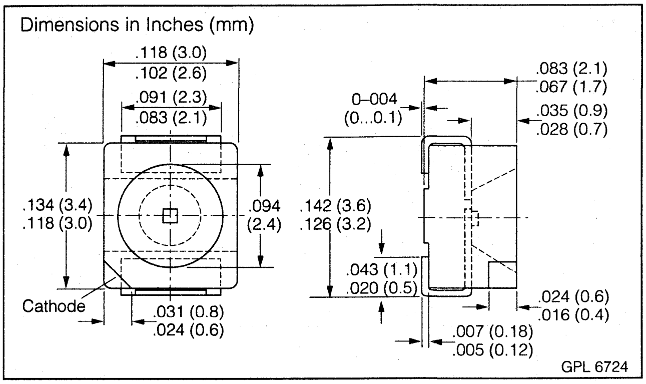
Note

1. Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≤2.0.

SIEMENS

SUPER-RED LS T676
AMBER LA T676
ORANGE LO T676
YELLOW LY T676
Hyper-Bright TOPLED® Lamp





FEATURES
- **TOPLED: surface mount LED lamp**
- **P-LCC-2 package**
- **White package; colorless, clear window**
- **For use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**

Maximum Ratings
Operating/Storage Temperature Range
(T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F)
LS/LA/LO .... 30 mA
LY .... 20 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005
LS/LA/LO .... 1 A
LY .... 0.2 A
Reverse Voltage (V_R)(1) .... 3 V
Power Dissipation (P_{TOT}) T_A≤25°C
LS/LA/LO .... 80 mW
LY .... 55 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board(2), pad size ≥16 mm²
(R_{THJA}) .... 500 K/W

Notes
1. Avoid reverse biasing
2. PC board FR4

Characteristics T_A=25°C, all values typical unless noted

Parameter	Symbol	LS	LA	LO	LY	Unit	Condition
Peak Wavelength	λ_{PEAK}	643	622	610	591	nm	I_F=10 mA
Dominant Wavelength	λ_{DOM}	632	615	605	587		
Spectral Bandwidth (50% I_{RELMAX})	Δλ	16			15		
Viewing Angle, 50%, I_V	2φ	120				Deg.	
Forward Voltage	V_F	2.0 (≤ 2.6)				V	I_F=50 mA
Reverse Current	I_R	0.01 (≤ 10)				µA	V_R=5 V

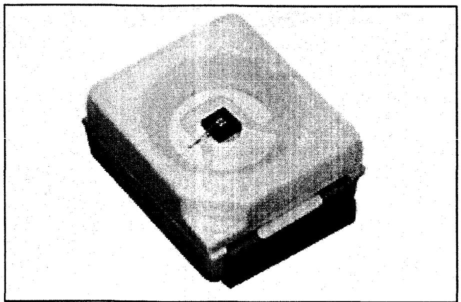
Type	Luminous Intensity, I_V, mcd	Luminous Flux, Φ_V, mlm	Condition
LST676-NR	25 to 200	—	I_F=20 mA
LST676-P	40 to 80	180	
LST676-Q	63 to 125	300	
LST676-R	100 to 200	450	
LST676-PS	40 to 320	—	
LO/LA/LY T676-PS	40 to 320	—	
LO/LA/LYT676-Q	63 to 125	300	
LO/LA/LYT676-R	100 to 200	450	
LO/LA/LYT676-S	160 to 320	700	
LO/LA/LYT676-QT	63 to 500	—	

Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≥2.0

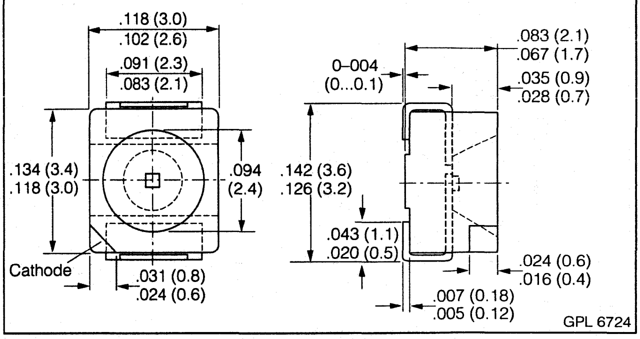
See graph numbers OHL00235, OHL01660, OHL00232, OHL00233, OHL00248, OHL00238, OHL00318, OHL00316 beginning on page 4–92.

SIEMENS

SUPER-RED LS T679
YELLOW LY T679
GREEN LG T679
Low Current TOPLED® Lamp



Dimensions in Inches (mm)



FEATURES

- **TOPLED: surface mount LED lamp**
- **PL-CC-2 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**

DESCRIPTION

The LX T679-CO TOPLED for surface mount applications) is available in super-red, yellow, and green. The package incorporates an internal reflector to optimize light coupling. This feature makes the TOPLED ideal for light pipe applications.

The low current requirement makes this part ideal for portable equipment or any other application where power is at a premium.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F) .... 7.5 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 .... 0.15 A
Reverse Voltage (V_R) .... 5 V
Power Dissipation .... 20 mW
Thermal Resistance, Junction/Ambient, mounted on PC board, pad size≥16mm^2 .... 500 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter	Symbol	LS	LY	LG	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=7.5 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth, 50% I_{RELMAX}	$\Delta\lambda$	45		25		
Viewing Angle, 50% I_V	2φ	120			Deg.	—
Forward Voltage	V_F	1.8 (≤2.6)	2.0 (≤2.7)	1.9 (≤2.6)	V	I_F=2 mA
Reverse Current	I_F	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	3		15	pF	V_R=0 V, f=1 MHz
Switching Time, I_V 10% to 90% 90% to 10%	t_R t_F	200 150		450 200	ns	I_F=100 mA, t_P=10 µs, R_L=50 Ω

Part No.	Luminous Intensity*, I_V	Unit	Luminous Flux, Φ_V	Unit	Condition
LS T679-CO	1 (≥0.25)	mcd	3	mlm	I_F=2 mA
LY T679-CO					
LG T679-CO					

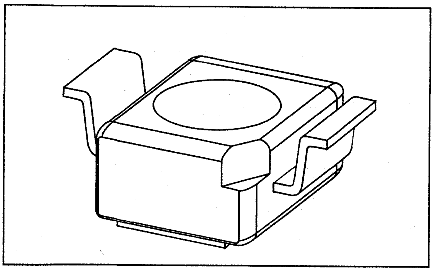
*Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN}≥2.0.

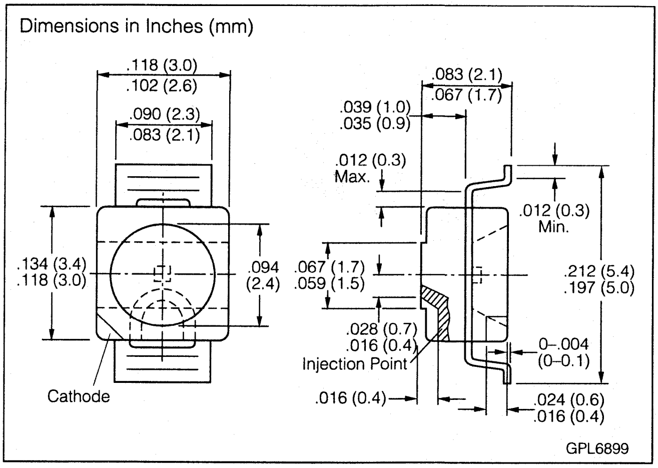
See graph numbers OHL01698, OHL01660, OHL01208, OHL01207, OHL01278, OHL01193, OHL01672, OHL01673, OHL01750, OHL01675 beginning on page 4-92.

SIEMENS

SUPER-RED LS T776
AMBER LA T776
ORANGE LO T776
YELLOW LY T776

Hyper-Bright Reverse Gullwing TOPLED® Lamp





FEATURES

- **Reverse gullwing TOPLED: surface mount LED lamp**
- **White package, colorless clear window**
- **Use as optical indicator**
- **Ideal for backlighting, optical coupling into light pipes and lenses**
- **Suitable for all SMT assembly solder processes**
- **Available taped on reel (12 mm tape)**

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F)
LS, LO, LA .... 30 mALY20 mA
LY .... 20 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005
LS, LO, LA .... 1 A
LY .... 0.2 A
Reverse Voltage (V_R) ....3 V
Power Dissipation (P_{TOT})
LS, LO, LA ....80 mW
LY ....55 mW
Thermal Resistance, Junction/Air, mounted on PC Board(1), pad size 16 mm² (R_{THJA}) .... 500 K/W

Note: 1. PC board FR4

See graph numbers OHL01698, OHL01660, OHL01736, OHL01737, OHL01686, OHL01661, OHL01739, OHL01740, OHL01741, OHL01749 beginning on page 4–92.

Characteristics T_A=25°C, all values typical unless otherwise noted

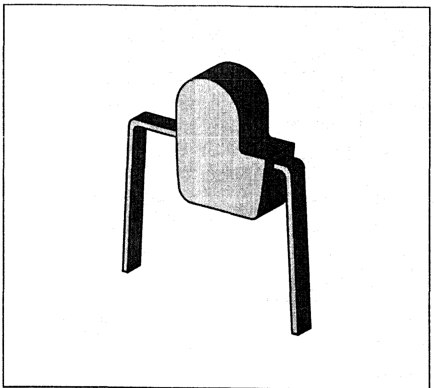
Parameter		Sym.	LS	LA	LO	LY	Unit	Condition.
Peak Wavelength		λ_{PEAK}	645	622	610	591	nm	I_F=20 mA
Dominant Wavelength		λ_{DOM}	632	615	605	587		
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	16			15		
Viewing Angle, 50% I_V		2φ	120				Deg.	
Forward Voltage		V_F	2 (≤ 2.6)				V	I_F=20 mA
Reverse Current		I_R	0.01 (≤ 10)				µA	V_R=3 V
Temperature Coefficient	λ_{DOM}	TC_λ	0.014	0.062	0.067	0.096	nm/K	I_F=20 mA
	λ_{PEAK}		0.14	0.13				
	V_F	TC_V	–1.95	–1.78	–1.67	–2.51	mV/K	

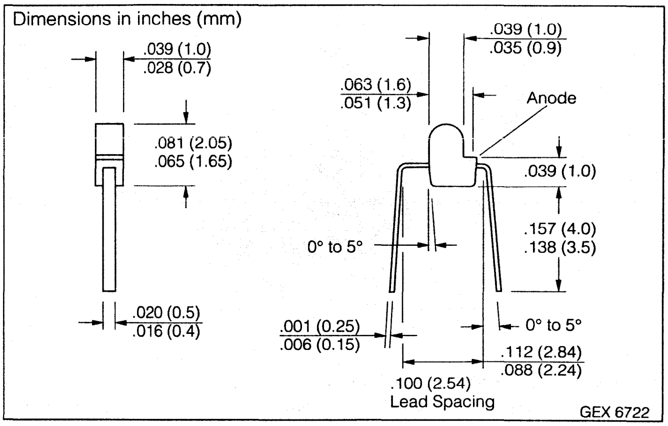
Part No.	Luminous Intensity, I_v, mcd	Luminous Flux, Φ_V, mim	Condition
LS T776-NR	25 to 200	—	I_F=20 mA
LS T776-P	40 to 80	180	
LS/LA/LO/LY T776-Q	63 to 125	300	
LS/LA/LO/LY T776-R	100 to 200	450	
LS/LA/LO/LY T776-PS	40 to 320	—	
LA/LO/LY T776-S	160 to 320	700	
LA/LO/LY T776-QT	63 to 500	—	

Note: Luminous intensity ratio in one packaging unit I_{VMAX}/I_{VMIN} ≤2.0.

SIEMENS

SUPER-RED LS U260-EO
YELLOW LY U260-EO
GREEN LG U260-EO
1 mm Mini LED Lamp





FEATURES

- **Colored, diffused lens**
  LS: red
  LY: yellow
  LG: colorless
- **For use as optical indicator**
- **Miniature package**
- **Load dump resistant per DIN 40839**

DESCRIPTION

The LS U260 super-red and LY U260 yellow are high efficiency lamps fabricated with TSN (transparent substrate nitrogen) technology. The LG U260 is a gallium phosphide (GaP) lamp.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –40°C to +80°C
Junction Temperature (T_J) .... 80°C
Forward Current (I_F) .... 15 mA
Surge Current (I_{FS}) t=10 µs, D=0.005 ....0.35 A
Reverse Voltage (V_R) .... 5 V
Total Power Dissipation (P_{TOT}) T_A≤25°C ..... 50 mW
Thermal Resistance,
Junction/Air (R_{THJA}) .... 1100 K/W

Characteristics T_A=25°C, all values typical unless otherwise noted

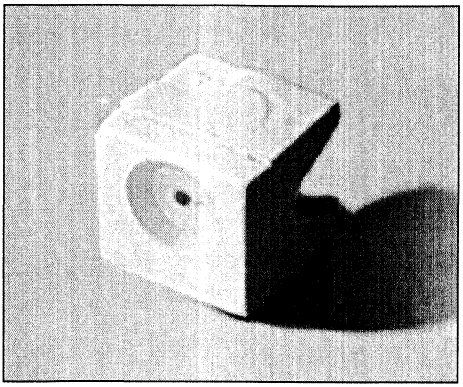
Parameter	Symbol	Super -Red	Yellow	Green	Unit	Condition
Peak Wavelength	λ_{PEAK}	635	586	565	nm	I_F=20 mA
Dominant Wavelength	λ_{DOM}	628	590	570		
Spectral Bandwidth, 50% I_{RELMAX}	$\Delta\lambda$	45		25		
Viewing Angle, 50% I_V	2φ	60			Deg.	
Forward Voltage	V_F	2.0 (≤2.6)			V	I_F=10 mA
Reverse Current	I_R	0.01 (≤10)			µA	V_R=5 V
Capacitance	C_0	12	10	15	pF	V_R=0 V f=1 MHz
Switching Times, I_V 10% to 90%	t_R	300		450	ns	I_F=10 mA t_P=10 µs R_L=50 Ω
90% to 10%	t_F	150		200		
Luminous Intensity*	I_V	≥0.63			mcd	I_F=10 mA

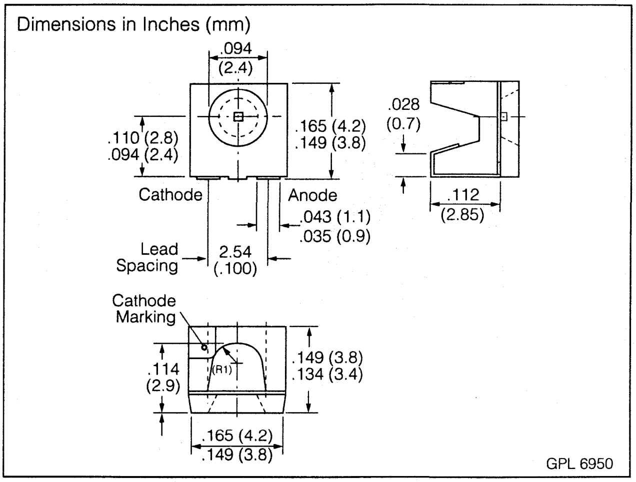
* Luminous flux ratio of one packaging unit I_{VMAX}/I_{VMIN} ≤ 2

See graph numbers OHL01210, OHL01682, OHL01263, OHL01632, OHL01753, OHL02196, OHL01672, OHL01673, OHL01674, OHL01675 beginning on page 4–91.

SIEMENS

SUPER-RED/YELLOW LSY A676
Hyper-Bright Multi SIDELED® Lamp





FEATURES
- **SIDELED: surface mount LED lamp**
- **White package, colorless clear window**
- **Use as optical idicator**
- **For backlighting, optical coupling into light pipes and leness**
- **High signal efficiency possible by changing LED color**
- **Can change color from green to yellow and orange to super-red with appropriate controlling**
- **Suitable for all SMT assembly and reflow soldering methods**
- **Available taped on reel (12 mm tape)**

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C
Forward Current (I_F)
Super-Red .... 30 mA
Yellow .... 20 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005 .... TBD
Power Dissipation (P_{TOT})
Super-Red .... 80 mW
Yellow .... 55 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board(1), pad size 16 mm^2
(R_{THJA}) .... 530 K/W

Notes:
1. PC board: FR4
2. The stated maximum ratings refer to the specified chip, regardless of the other one's operating status.

Characteristics T_A=25°C, all values typical unless otherwise noted

Parameter		Sym.	S	Y	Unit	Condition
Peak Wavelength		λ_{PEAK}	645	591	nm	I_F=10mA
Dominant Wavelength		λ_{DOM}	632	587		
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	16	15		
Viewing Angle		2φ	120		Deg.	–
Forward Voltage		V_F	2.0 (≤2.6)		V	I_F=20 mA
Temperature Coefficient	λ_{DOM}	TC_λ	0.014	0.096	nm/K	
	λ_{PEAK}		0.14	0.13		
	λ_F	TC_V	–1.95	–2.51	mV/K	

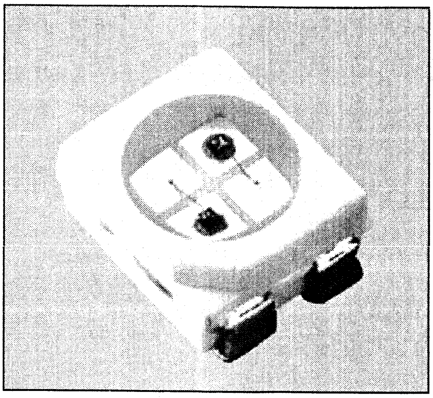
Part No.	Luminous Intensity, I_V		Unit	Condition
	Super-Red	Yellow		
LSY A676	≥ 40	3	mcd	I_F=20 mA
LSY A676-P+P	40 to 80	40 to 80		
LSY A676-P+Q		63 to 125		
LSY A676-P+R		100 to 200		
LSY A676-Q+Q	63 to 125	63 to 125		
LSY A676-Q+R		100 to 200		

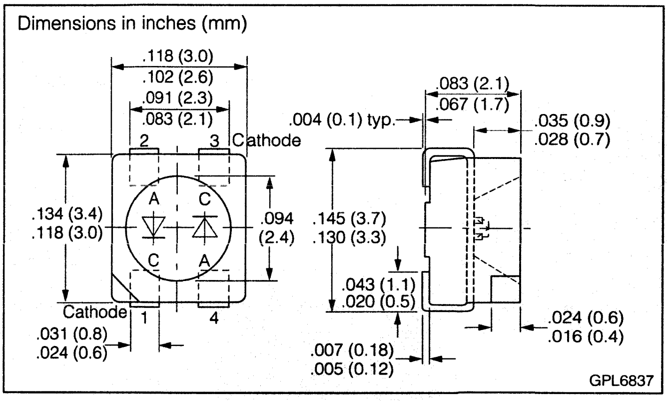
See graph numbers OHL00235, OHL01660, OHL00248, OHL00233, OHL00238 beginning on page 4-92.

SIEMENS

SUPER-RED/YELLOW LSY T676

Hyper-Bright Multi TOPLED® Lamp





FEATURES

- **TOPLED: surface mount LED**
- **P-LCC-4 package**
- **White package, colorless clear window**
- **Use as optical indicator**
- **For backlighting, optical coupling into light pipes and lenses**
- **Both chips can be controlled separately**
- **High signal efficiency possible by changing LED color**
- **Can change color from green to yellow and orange to super-red with appropriate controlling**
- **Suitable for all SMT assembly and soldering methods**
- **Available taped on reel (8 mm tape)**
- **Load dump resistant per DIN 40839**

Maximum Ratings

Operating and Storage Temperature Range
(T_{OP}, T_{STG})....................................–55 to +100°C
Junction Temperature (T_J)........................ +100°C
Forward Current (I_F)
LS...30 mA
LY...20 mA
Surge Current (I_{FM}) t≤10 µs, D=0.005............TBD
Reverse Voltage (V_R).......................................3 V
Power Dissipation (P_{TOT})
LS...80 mW
LY...55 mW
Thermal Resistance, Junction/Air,
Mounted on PC Board[1], pad size 16 mm²
(R_{THJA})[2]...500 K/W
(R_{THJA})[3]...600 K/W

Notes
1. PC board: FR4
2. One system only
3. Both systems on simultaneously
4. The stated maximum ratings refer to one chip.

Characteristics T_A=25°C, all values typical unless otherwise noted

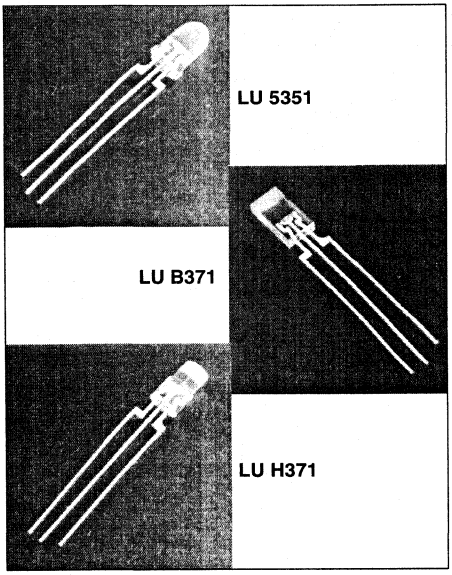
Parameter		Sym.	LS	LY	Unit	Condition
Peak Wavelength		λ_{PEAK}	645	591	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	630	587		
Spectral Bandwidth, 50% I_{RELMAX}		$\Delta\lambda$	16	15		
Viewing Angle, 50% I_V		2φ	120		Deg	
Forward Voltage		V_F	2 (≤ 2.6)		V	I_F=10 mA
Reverse Current		I_R	0.01 (≤ 10)		µA	V_R=5 V
Capacitance		C_0	12	15	pF	V_R=0 V, f=1 MHz
Temperature Coefficient	λ_{DOM}	TC_λ	0.014	0.096	nm/K	I_F =20 mA
	λ_{PEAK}		0.14	0.13		
	λ_F	TC_V	–1.95	–2.51	mV/K	

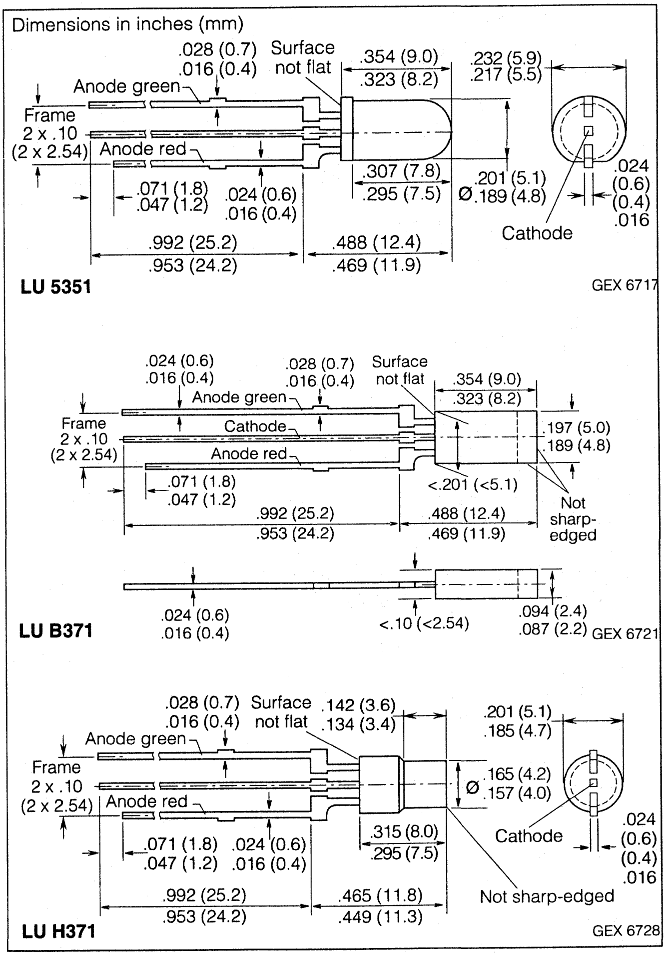
Part Number	Luminous Intensity, I_V	Unit	Luminous Flux, Φ_V	Unit	Condition
LSY T676	≥ 40	mcd	≥ 40	mlm	I_F=20 mA
LSY T676-P+P	40 to 80		40 to 80		
LSY T676-P+Q			63 to 125		
LSY T676-P+R			100 to 200		
LSY T676-Q+Q	63 to 125		63 to 125		
LSY T676-Q+R			100 to 200		

See graph numbers OHL00235, OHL01660, OHL00232, OHL00248, OHL00233, OHL00308, OHL00238 beginning on page 4–92.

SIEMENS

T1¾ (5 mm) LU 5351
RECTANGULAR LU B371
CYLINDRICAL LU H371
Super-Red and Green MULTILED® Lamp





FEATURES

- Colorless lens
- 2.54 mm lead spacing
- High signal efficiency possible by changing LED color
- Can indicate different operation modes by changing colorfrom:
  Green to yellow, orange and super-red (LU 5351)
  Red to green (LU B371)
- Ideal for multiplexed or pulsed operations (LU H371)
- Both colors can be controlled separately
- Solder leads with stand-off
- Available taped on reel
- Load dump resistant per DIN 40839

DESCRIPTION

These LED lamps have a colorless lens with a diffused surface. Two chips (green and super red) allow for use as an optical indicator with multiple functions.

See graph numbers OHL01702, OHL01263, OHL01703, OHL01162, OHL01705, OHL01706, OHL01707, OHL01708. LU 5351: OHL01191; LUB 371: OHL001170; LU B371, LU H371: OHL001681; LU 535: LU H371: OHL02252 beginning on page 4-92.

Maximum Ratings

Forward Current* (I_F) .... 40 mA
Surge Current* (I_{FM}) t_P <10 ms .... 0.5 A
Operating Temperature Range (T_{OP}) ....–55°C to + 100°C
Storage Temperature Range (T_{STG}) ....–55°C to +100°C
Junction Temperature (T_J) .... + 100°C
Reverse Voltage (V_R) ....5 V
Total Power Dissipation* (P_{TOT}) T_A=25°C ....140 mW
Thermal Resistance, Junction to Air (R_{THJA}) .... 400 K/W

* The ratings indicated for the forward current I_F, the surge current I_{FS} or power dissipation P_{TOT}, respectively, are maximum ratings of the component. If both chips are operated simultaneously, the sum of the forward current ratings is not allowed to exceed the indicated maximum.

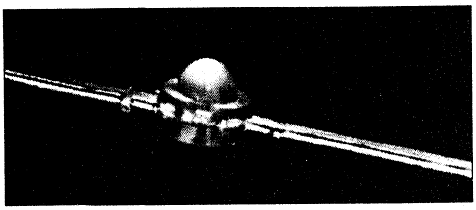
Characteristics T_A=25°C, all values typical unless otherwise noted.

Parameter		**Symbol**	**Super-Red**	**Green**	**Unit**	**Condition**
Peak Wavelength		λ_{PEAK}	635	565	nm	
Dominant Wavelength		λ_{DOM}	628	570		
Spectral Bandwidth 50% I_{RELMAX}		$\Delta\lambda$	45	25		I_F=20 mA
Viewing Angle, 50% I_V	LU5351	φ	50	50	Deg.	
	LUB371, LUH371		100	100		
Forward Voltage		V_F	2.0 (≤2.6)	2.0 (≤2.6)	V	I_F=10 mA
Capacitance		C_0	12	15	pF	V_R=0 V, f=1 MHz
Rise Time		t_R	300	450	ns	
Fall Time		t_F	150	200		
Luminous Intensity		**Min.**	**Max.**	**Unit**		**Condition**
LU5351-GL		1.6	20	mcd		I_F=10 mA
LU5351-JM		4	32			
LUB371-FJ, LUH371-FJ		1	8			
LUB371-GK, LUH371-GK		1.6	12.5			

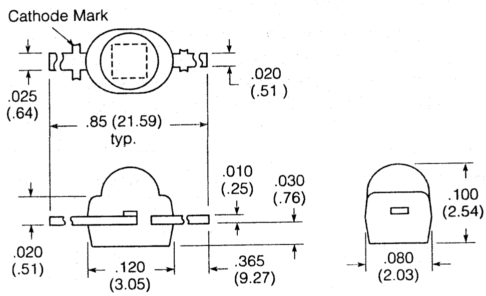
Notes
1. Luminous intensity ratio of one packaging unit: $I_{VMAX}/I_{VMIN} \leq 2^{(3)}$
2. Luminous intensity ratio of one LED:
   LU 5351-GL, LU B371-FJ, LU H371-FJ: $I_{VMAX}/I_{VMIN} \leq 4$
   LU 5351-JM, LU B371-GK, LU H371-GK: $I_{VMAX}/I_{VMIN} \leq 2$
3. The brightness of the darker chip in one package determines the brightness of the entire LED.

SIEMENS

WATER CLEAR DIFFUSED LENS RL-50
RED DIFFUSED LENS RL-54
Red Miniature Axial Lead LED Lamp



Dimensions in inches (mm)



FEATURES
- **Lens**
  - **RL-50: Water clear**
  - **RL-54: Red diffused**
- **High luminance–1.0 mcd at 20 mA, typical**
- **Optimum packaging design for maximum strength at minimum linear spacing**
- **Operates from 5 volt IC logic supply**
- **High reliability**
- **Small size, long life, low cost**
- **Use in arrays and as indicator lights**

Maximum Ratings

Operating/Storage Temperature
Range .... –55°C to +100°C
Lead Solder Time, 260°C (.063″ from case) ....5 sec.
Peak Reverse Voltage .... 3 V
Continuous Forward Current .... 40 mA
Power Dissipation (T_A=25 °C) .... 80 mW
Derate Linearly from 25°C .... –1.1 mW/°C

Electrical/Optical Characteristics T_A=25°C

Parameter		Min.	Typ.	Max.	Unit	Condition
Peak Wavelength			660		nm	
Viewing Angle			90		Deg.	
Forward Voltage			1.6	2.0	V	I_F=20 mA
Reverse Current				100	µA	V_R=3 V
Luminous Intensity	RL-50	0.5	1.0		mcd	I_F=20 mA
	RL-54	0.4	0.6			

Figure 1. Luminous intensity vs. forward current RL-50

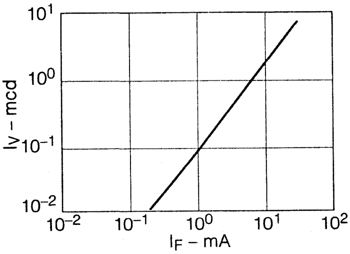


Figure 2. Luminous intensity vs. forward current RL-54

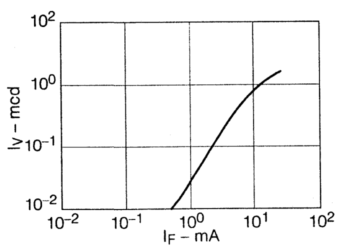


Figure 3. Radiation characteristicsRelative

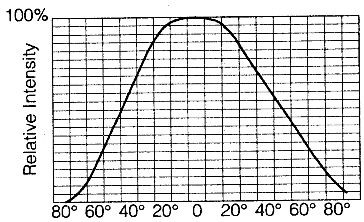


Figure 4. Relative spectral emission

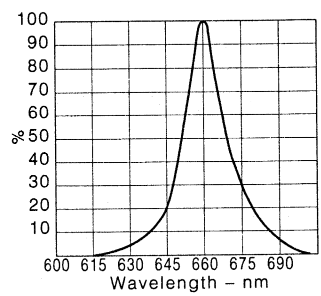
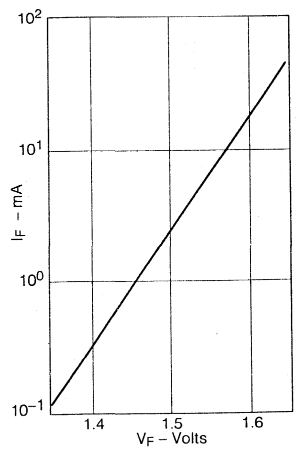
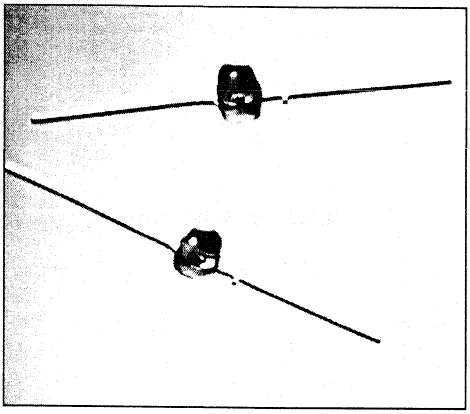


Figure 5. Foward current vs. forward voltage

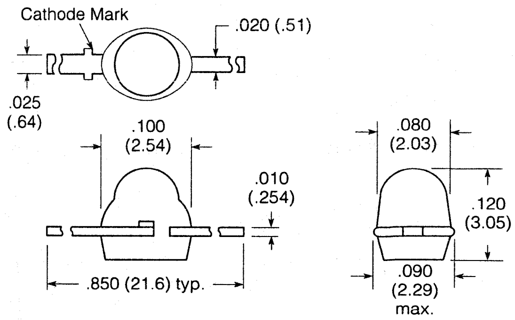


SIEMENS

RED RL-55
YELLOW YL-56
GREEN GL-56
Miniature Axial Lead LED Lamp



Dimensions in inches (mm)



FEATURES

- **High on axis intensity**
- **Optimum packaging design for maximum strength at minimum linear spacing**
- **Operates from 5 volt IC logic supply**
- **Miniature axial lead**
- **High reliability**
- **Low cost version (red), RL-55-5**

DESCRIPTION

The RL-55 is a gallium arsenide phosphide lamp and the GL-56/YL-56 are gallium phosphide lamps that have on-axis intensity, long life and low cost. They have diffused lenses and provide a full 0.080" flooded light with good constrast.

Applications include mounting on PC boards at low current as diagnostic and circuit status indicators.

Maximum Ratings

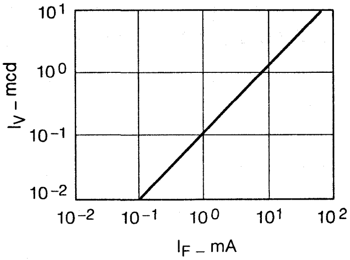
Operating and Storage Temperature Range .... –55°C to +100°C
Lead Solder Time, 260°C (.063″ from case) .... 5 sec.
Peak Inverse Voltage .... 3 V
Continuous Forward Current
RL-55 .... 40 mA
GL-56, YL-56 .... 25 mA
Peak Forward Current (1 µs pulse, 0.1% duty cycle) .... 250 mA
Power Dissipation (T_A=25°C) .... 80 mW
Derate Linearly from 25°C .... –1.1 mW/°C

Electrical/Optical Characteristics T_A=25°C

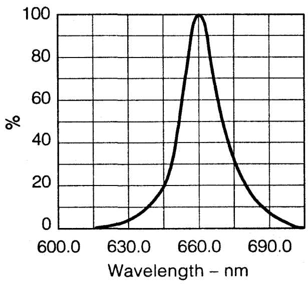
Parameter	Min.	Typ.	Max.	Unit	Test Condition
Peak Wavelength RL-55 GL-56 YL-56		 660 565 585		nm	
Spectral Line Half Width		40		nm	
Viewing Angle RL-55 GL-56, YL-56		 50 40		Deg.	
Forward Voltage RL-55 GL-56		 1.6 2.2	 2.0 3.5	V	I_F=20 mA
Reverse Current		0.15	10	µA	V_R=3 V
Luminous Intensity RL-55 GL-56 YL-56	 2.0 1.0 2.0	 2.2 1.3 2.2		mcd	I_F=10 mA

Red, RL-55

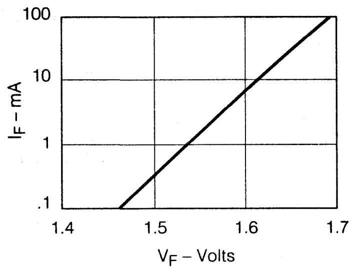
Luminous intensity versus forward current



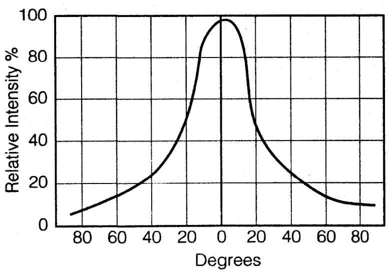
Relative spectral emission



Forward current vs. forward voltage)

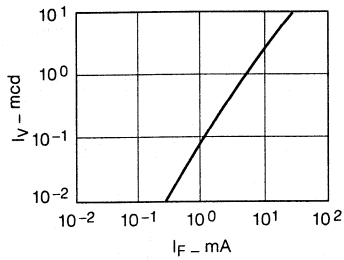


Radiation characteristics

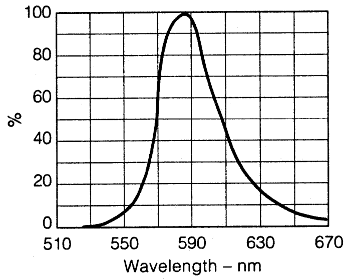


Yellow, YL-56

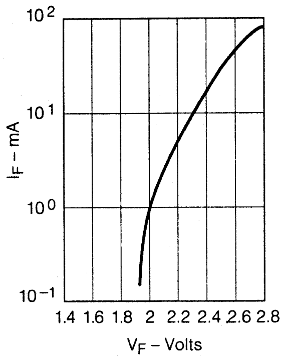
Luminous intensity versus forward current



Relative spectral emission

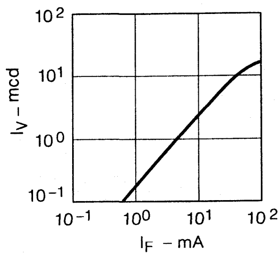


Forward current vs. forward voltage

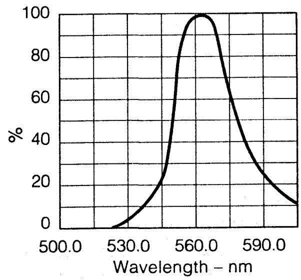


Green, GL-56

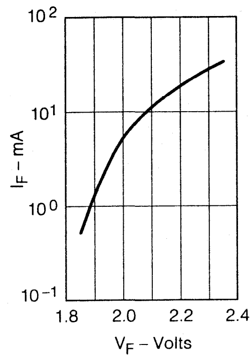
Luminous intensity versus forward current



Relative spectral emission



Forward current vs. forward voltage



SIEMENS

RRL-5601
RRL-5621
RRL-5641

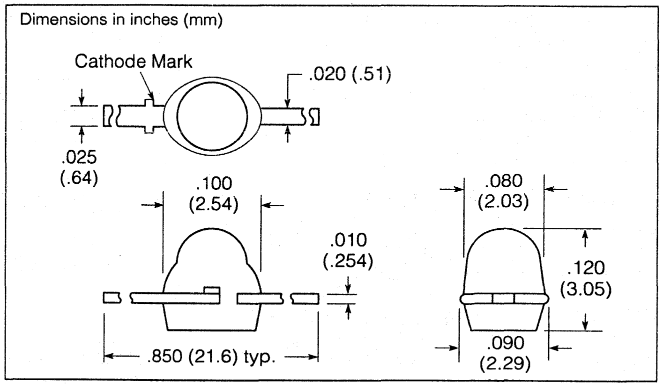
Red, Resistor, Miniature Axial Lead LED Lamp

FEATURES
- **Integral current limiting resistor**
- **No external resistor required with 5 volt supply**
- **Miniature axial lead package**
- **Red diffused lens**
- **Three light intensity ranges**
- **High reliability**

DESCRIPTION
The RRL-5601/-5621/-5641are gallium arsenide phosphide LED red lamps with integral resistor chips in series with the LED. This construction allows operation from a 5 volt source without an external current limiting resistor.

Applications include mounting on PC boards as diagnostic and circuit status indicators.

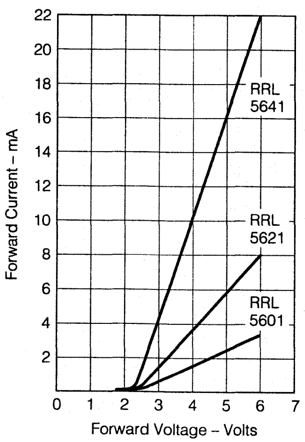
Maximum Ratings
Operating Temperature Range .... –55°C to +100°C
Storage Temperature Range .... –55°C to +100°C
Soldering Time, 260°C (.063" from case)...... 5 sec.
Reverse Voltage .... 6 V
DC Forward Voltage .... 6 V



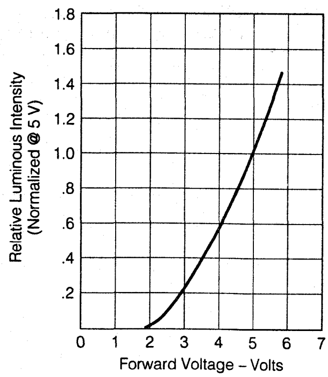
Optoelectronic Characteristics T_A=25°C

Parameter	Min.	Typ.	Max.	Unit	Test Condition
Peak Wavelength		650		nm	
Half Angle		20		Deg.	
Forward Current				mA	5 V
RRL-5601	2.0	3.0	4.0		
RRL-5621	4.0	6.0	8.0		
RRL-5641	13.0	16.0	21.0		
Reverse Current		0.1	10	µA	6 V
Luminous Intensity				mcd	5 V
RRL-5601	0.3				
RRL-5621	0.6	1.2			
RRL-5641	1.0	2.0			

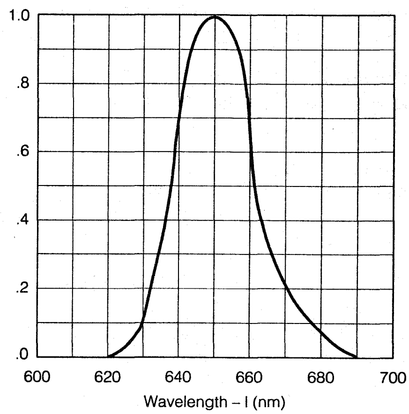
Forward current vs. forward voltage



Relative luminous intensity



Spectral distribution



Relative spectral emission $I_{rel}=f(\lambda)$, $T_A=25°C$
V(λ)=standard eye response curve
Graphs: OHL00235, OHL01164, OHL01210, OHL01694, OHL01698, OHL01702, OHL01727

Radiation characteristic $I_{rel}=f(\rho)$
Graphs: OHL00314, OHL01165, OHL01190, OHL01191, OHL01277, OHL01624,OHL01641, OHL01642, OHL01646, OHL01657, OHL01660, OHL01667, OHL01682, OHL01685, OHL01693, OHL01712, OHL01728, OHL01729, OHL01730, OHL01731, OHL02066, OHL02080

Forward current $I_F=f(V_F)$, $T_A=25°C$
Graphs: OHL00232, OHL01208, OHL01263, OHL01625, OHL01626, OHL01676, OHL01736, OHL02145, OHL02237, OHL02349

Rel. luminous intensity $I_V/I_{V(25°C)}=f(I_F)$, $T_A=25°C$
Graphs: OHL00238, OHL01675, OHL01680, OHL01708, OHL01749, OHL02150, OHL02355

Rel. luminous flux $\Phi_V/\Phi_{V(25°C)}=f(I_F)$, $T_A=25°C$
Graphs: OHL01695, OHL01700, OHL02107

Permissible pulse handling capability
$I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter
Graphs: OHL0308, OHL00316, OHL00318, OHL00319, OHL00321, OHL0322, OHL01162, OHL01278, OHL01686, OHL01753, OHL02068, OHL02142, OHL02254, OHL02347

Max. permissible forward current $I_F=f(T_A)$
Graphs: OHL00213, OHL00221, OHL00231, OHL00240, OHL00241, OHL00243, OHL00248, OHL01170, OHL01193, OHL01661, OHL01692, OHL01710, OHL02143, OHL02184, OHL02196, OHL02252

Peak wavelength $\lambda_{PEAK}=f(T_A)$
Graphs: OHL1672, OHL01677, OHL1705, OHL01739, OHL02104, OHL02233, OHL02354, OHL02355

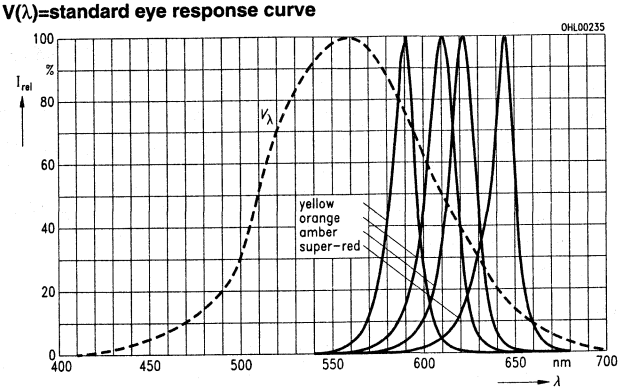
Dominant wavelength $\lambda_{DOM}=f(T_A)$
Graphs: OHL1673, OHL01678, OHL1706, OHL01740, OHL02105, OHL02234, OHL02356

Forward voltage $V_F=f(V_F)$
Graphs: OHL1674, OHL01679, OHL01696, OHL01707, OHL01741, OHL01750, OHL02106, OHL02149, OHL02353

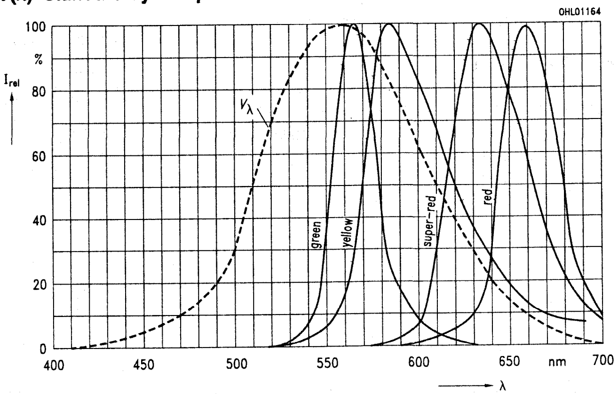
Rel. luminous intensity $I_V/I_{V(mA)}=f(T_A)$
Graphs: OHL00233, OHL01011, OHL01207, OHL01632, OHL01703, OHL01737, OHL02146, OHL02150, OHL02152, OHL02313, OHL02348, OHL02357

Rel. luminous flux $\Phi_V/\Phi I_{V(mA}=f(T_A)$
Graphs: OHL0244, OHL01321, OHL01628, OHL02103, OHL02253

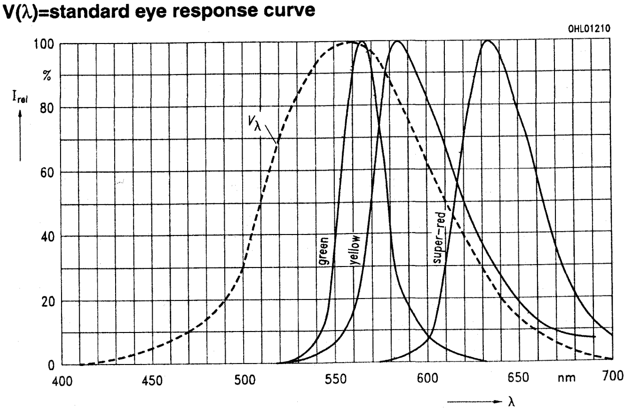
OHL00235. Relative spectral emission $I_{rel}=f(\lambda)$, $T_A=25°C$
V(λ)=standard eye response curve



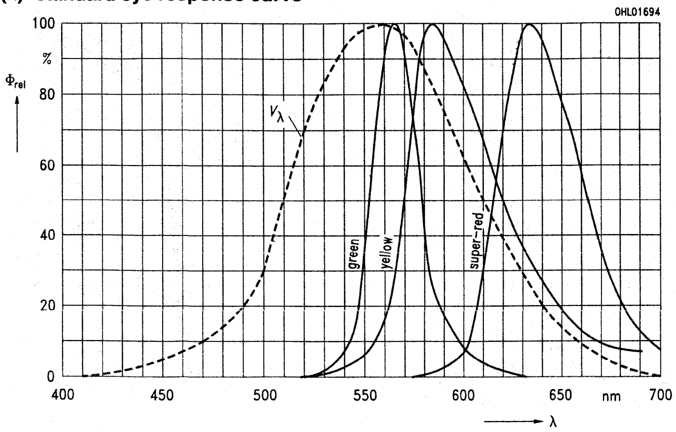
OHL01164. Relative spectral emission $I_{rel}=f(\lambda)$, $T_A=25°C$
V(λ)=standard eye response curveOHL01164.



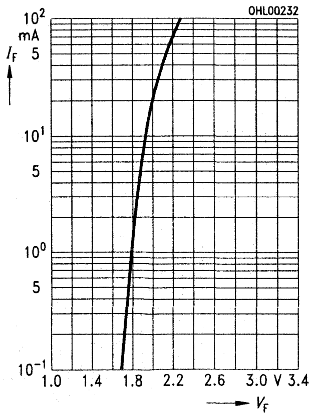
OHL01210. Relative spectral emission $I_{rel}=f(\lambda)$, $T_A=25°C$
V(λ)=standard eye response curve



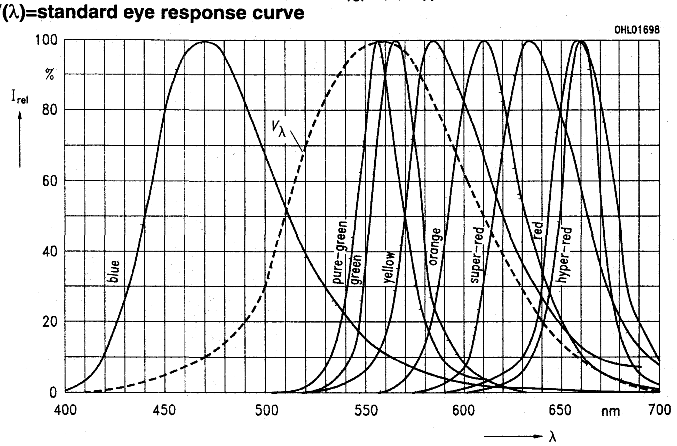
OHL01694. Relative spectral emission $I_{rel}=f(\lambda)$, $T_A=25°C$
V(λ)=standard eye response curve



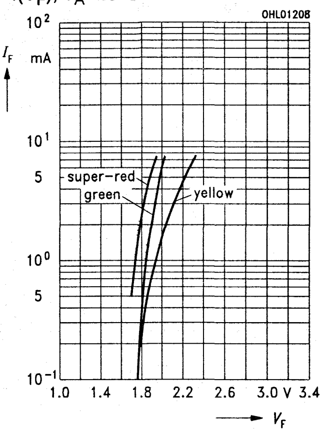
OHL00232. Forward current
$I_F=f(V_F)$, $T_A=25°C$



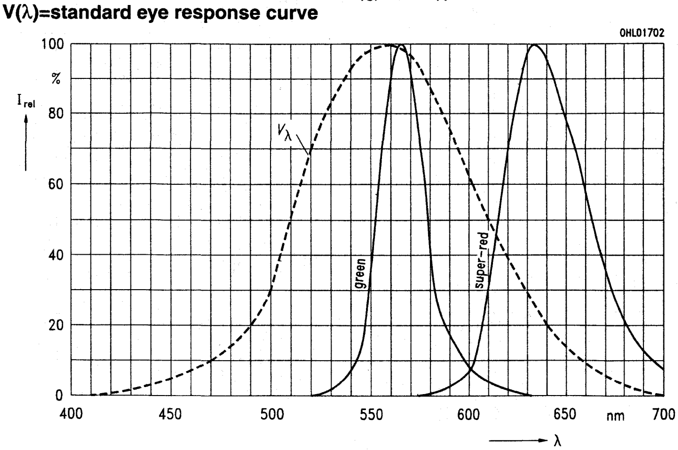
OHL01698. Relative spectral emission $I_{rel}=f(\lambda)$, $T_A=25°C$
V(λ)=standard eye response curve



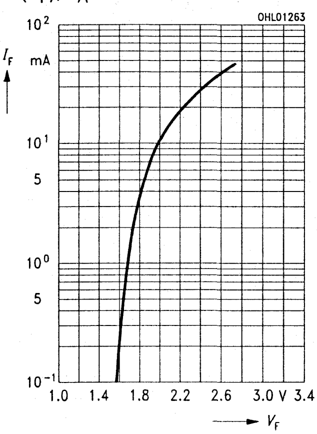
OHL01208. Forward current
$I_F=f(V_F)$, $T_A=25°C$



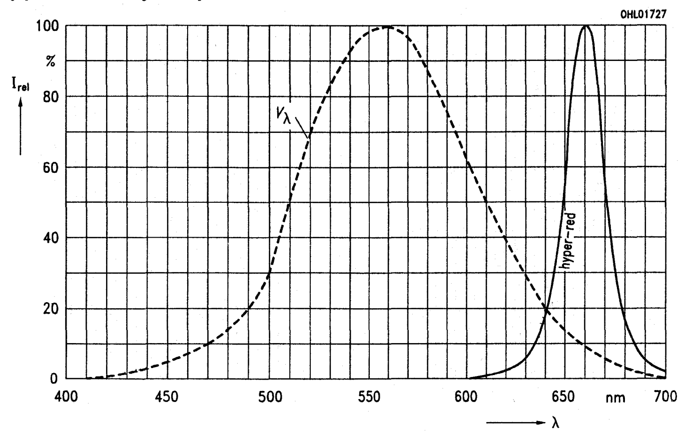
OHL01702. Relative spectral emission $I_{rel}=f(\lambda)$, $T_A=25°C$
V(λ)=standard eye response curve



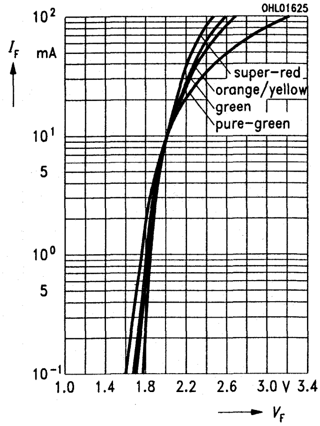
OHL01263. Forward current
$I_F=f(V_F)$, $T_A=25°C$



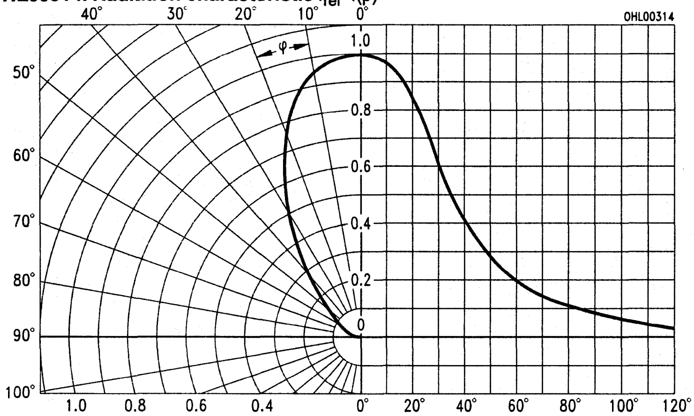
OHL01727. Relative spectral emission $I_{rel}=f(\lambda)$, $T_A=25°C$
$V(\lambda)$=standard eye response curve



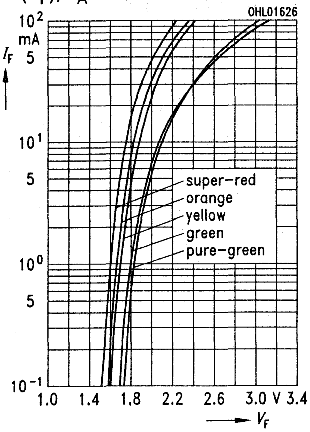
OHL01625. Forward current
$I_F=f(V_F)$, $T_A=25°C$



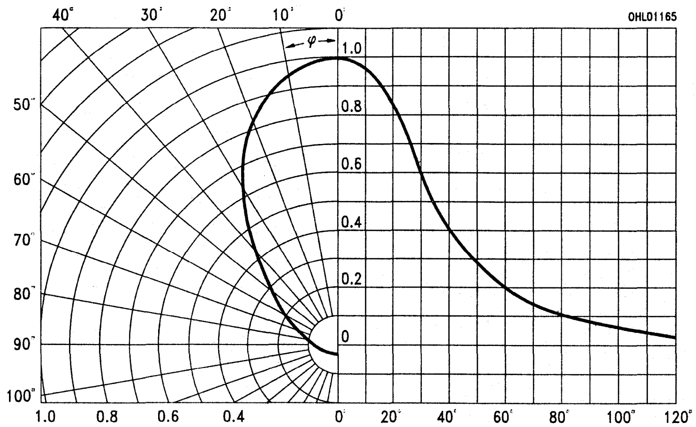
OHL00314. Radiation characteristic $I_{rel}=f(\rho)$



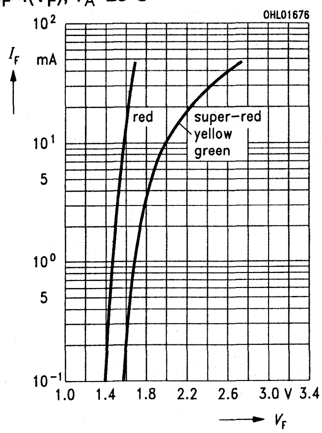
OHL01626. Forward current
$I_F=f(V_F)$, $T_A=25°C$



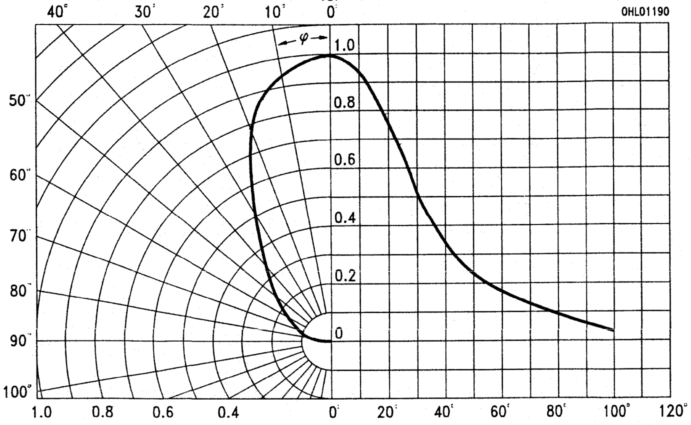
OHL01165. Radiation characteristic $I_{rel}=f(\rho)$



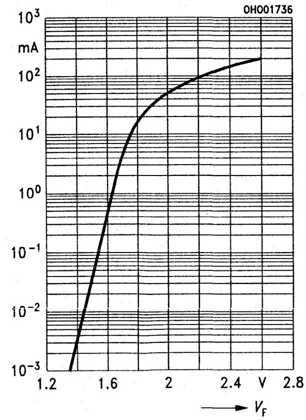
OHL01676. Forward current
$I_F=f(V_F)$, $T_A=25°C$



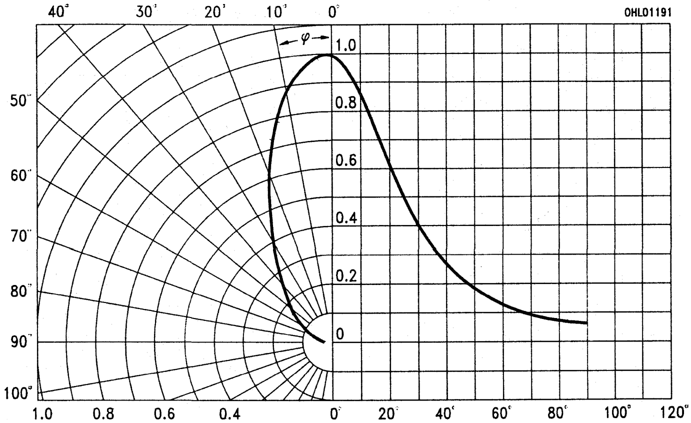
OHL01190. Radiation characteristic $I_{rel}=f(\rho)$



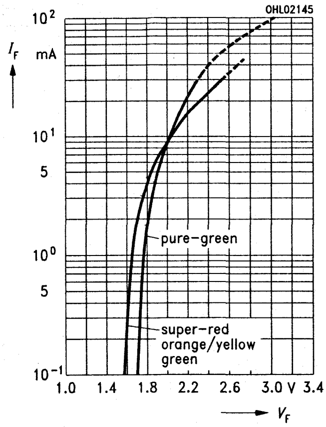
OHL01736. Forward current
$I_F=f(V_F)$, $T_A=25°C$



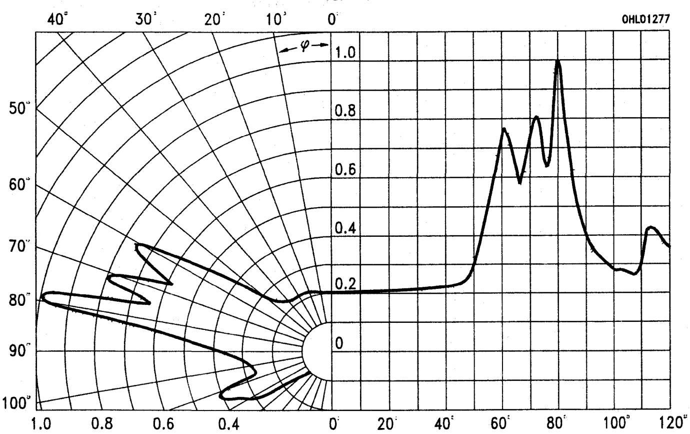
OHL01191. Radiation characteristic $I_{rel}=f(\rho)$



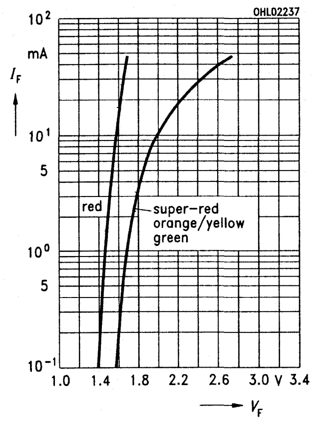
OHL02145. Forward current
$I_F=f(V_F)$, $T_A=25°C$



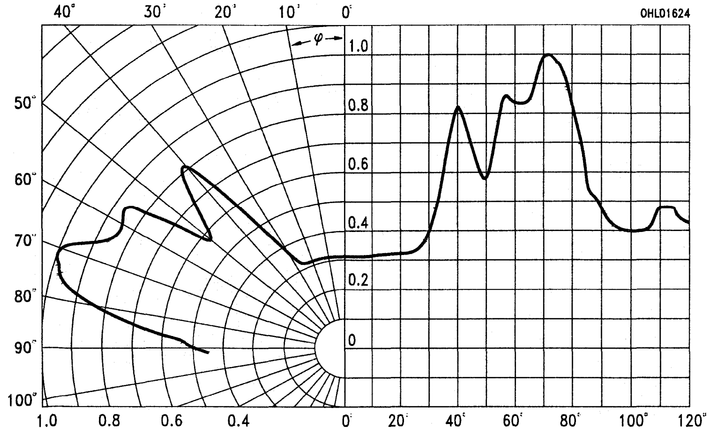
OHL01277. Radiation characteristic $I_{rel}=f(\rho)$



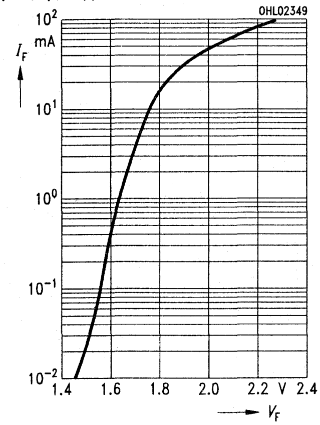
OHL02237. Forward current
$I_F=f(V_F)$, $T_A=25°C$



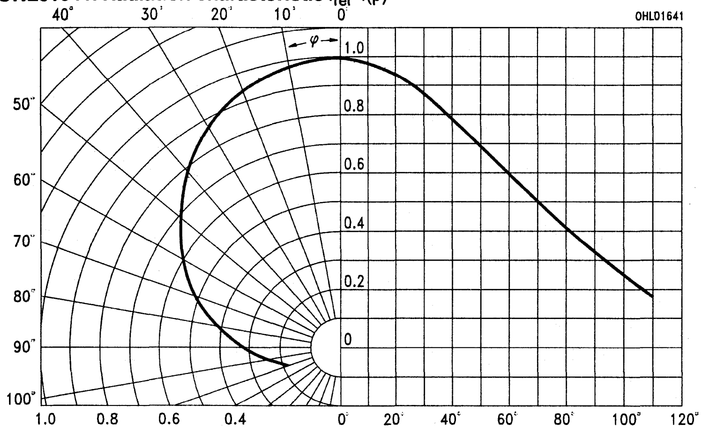
OHL01624. Radiation characteristic $I_{rel}=f(\varphi)$



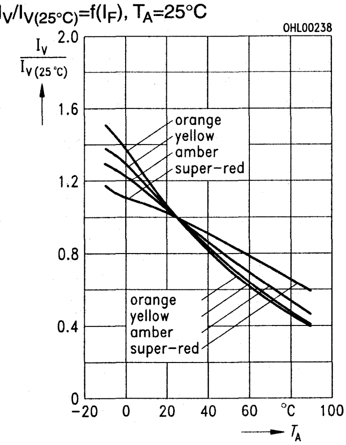
OHL02349. Forward current
$I_F=f(V_F)$, $T_A=25°C$



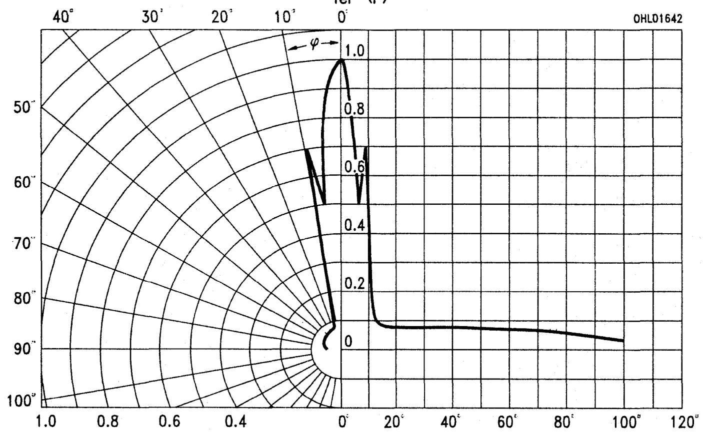
OHL01641. Radiation characteristic $I_{rel}=f(\varphi)$



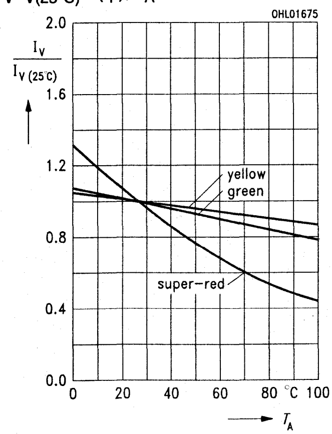
OHL00238. Rel. luminous intensity
$I_V/I_{V(25°C)}=f(I_F)$, $T_A=25°C$



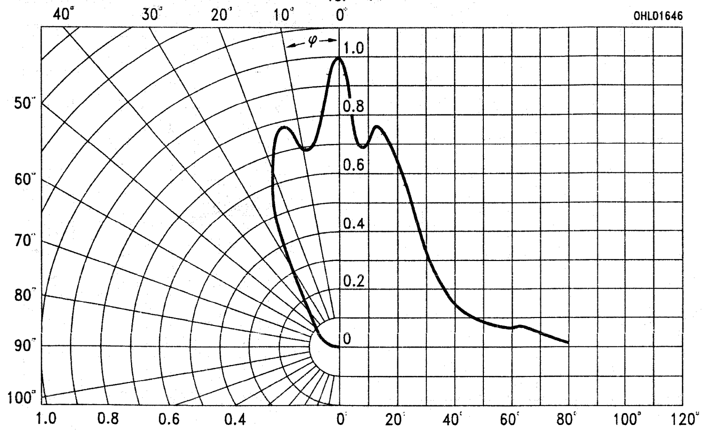
OHL01642. Radiation characteristic $I_{rel}=f(\varphi)$



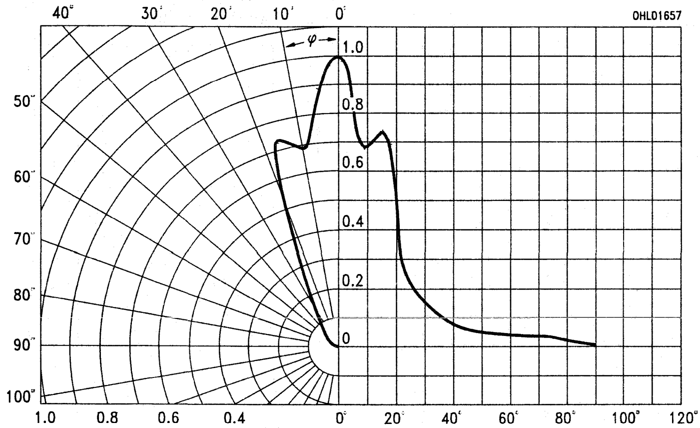
OHL01675. Rel. luminous intensity
$I_V/I_{V(25°C)}=f(I_F)$, $T_A=25°C$



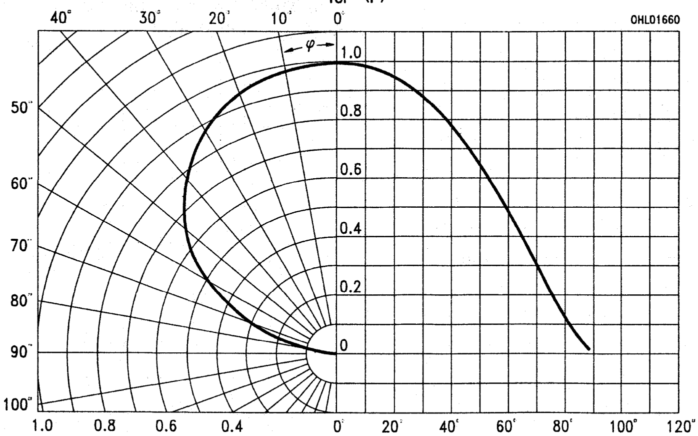
OHL01646. Radiation characteristic $I_{rel}=f(\rho)$



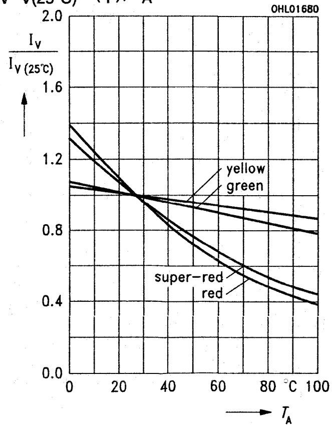
OHL01657. Radiation characteristic $I_{rel}=f(\rho)$



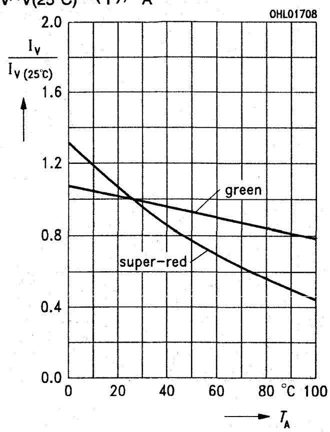
OHL01660. Radiation characteristic $I_{rel}=f(\rho)$



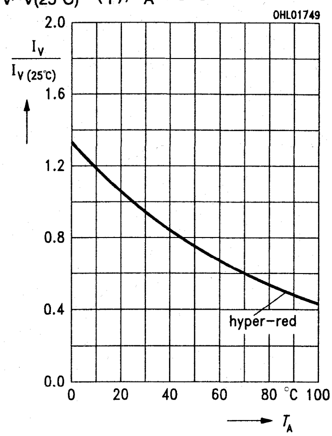
OHL01680. Rel. luminous intensity
$I_V/I_{V(25°C)}=f(I_F)$, $T_A=25°C$



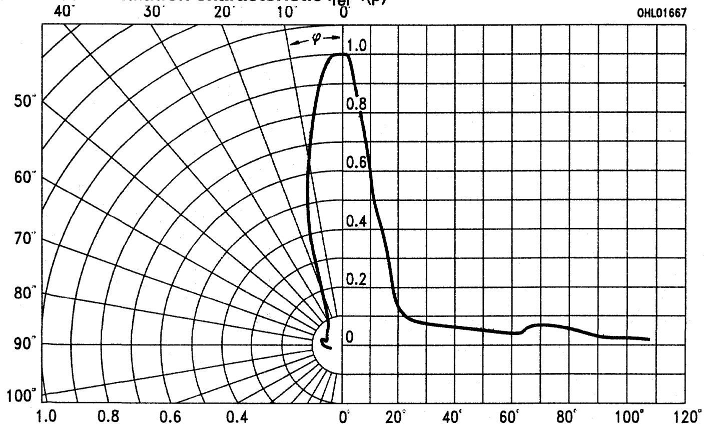
OHL01708. Rel. luminous intensity
$I_V/I_{V(25°C)}=f(I_F)$, $T_A=25°C$



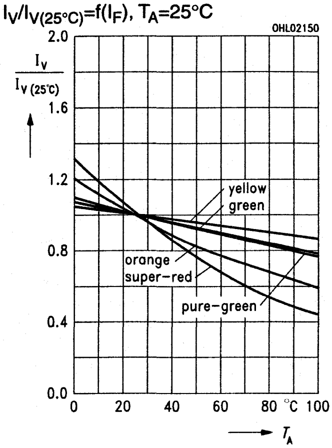
OHL01749. Rel. luminous intensity
$I_V/I_{V(25°C)}=f(I_F)$, $T_A=25°C$



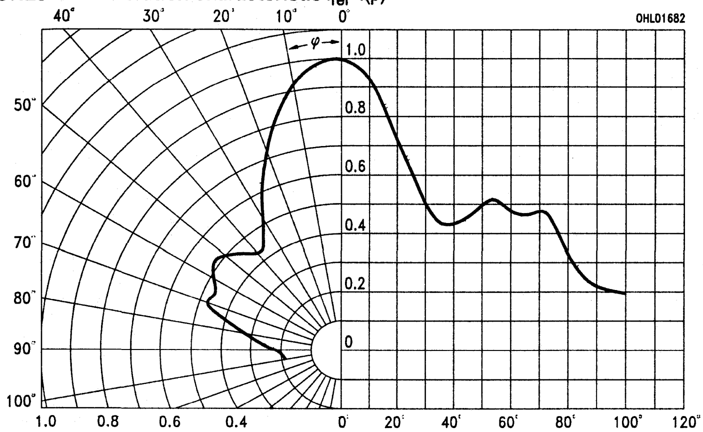
OHL01667. Radiation characteristic $I_{rel}=f(\rho)$



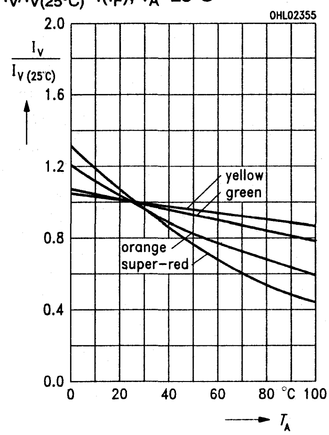
OHL02150. Rel. luminous intensity
$I_V/I_{V(25°C)}=f(I_F)$, T_A=25°C



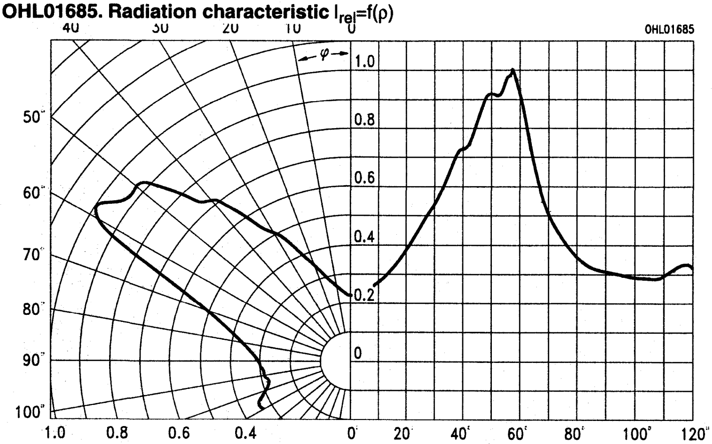
OHL01682. Radiation characteristic $I_{rel}=f(\rho)$



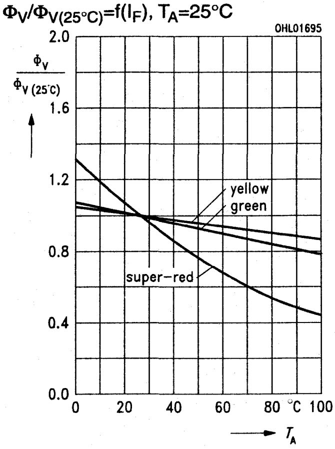
OHL02355. Rel. luminous intensity
$I_V/I_{V(25°C)}=f(I_F)$, T_A=25°C



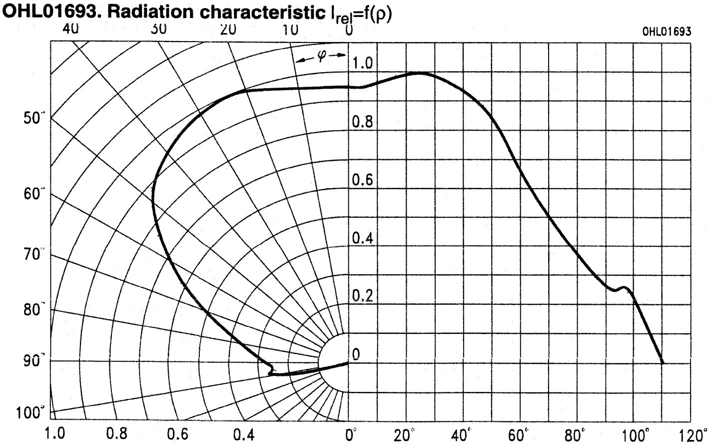
OHL01685. Radiation characteristic $I_{rel}=f(\rho)$



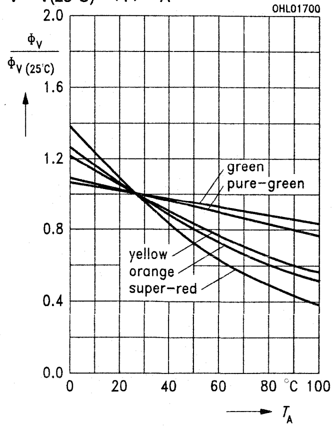
OHL01695. Rel. luminous flux
$\Phi_V/\Phi_{V(25°C)}=f(I_F)$, T_A=25°C



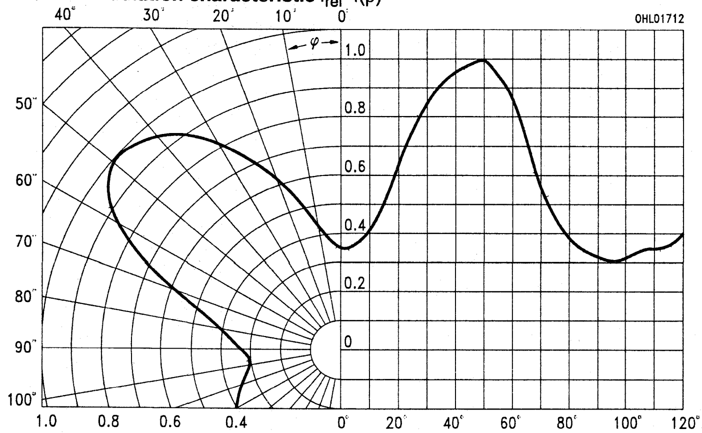
OHL01693. Radiation characteristic $I_{rel}=f(\rho)$



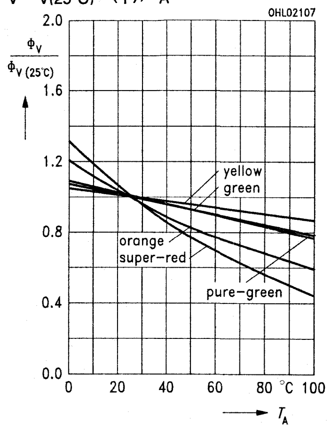
OHL01700. Rel. luminous flux
$\Phi_V/\Phi_{V(25°C)}=f(I_F)$, $T_A=25°C$



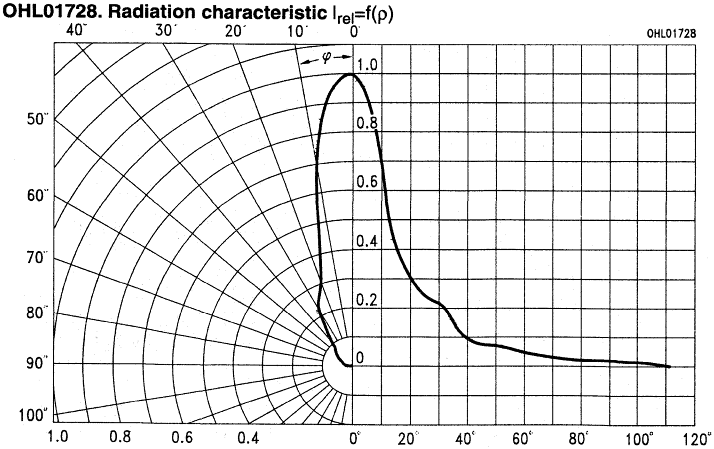
OHL01712. Radiation characteristic $I_{rel}=f(\rho)$



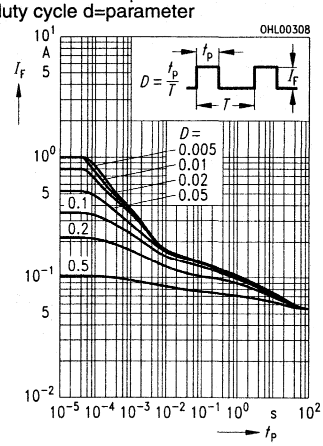
OHL02107. Rel. luminous flux
$\Phi_V/\Phi_{V(25°C)}=f(I_F)$, $T_A=25°C$



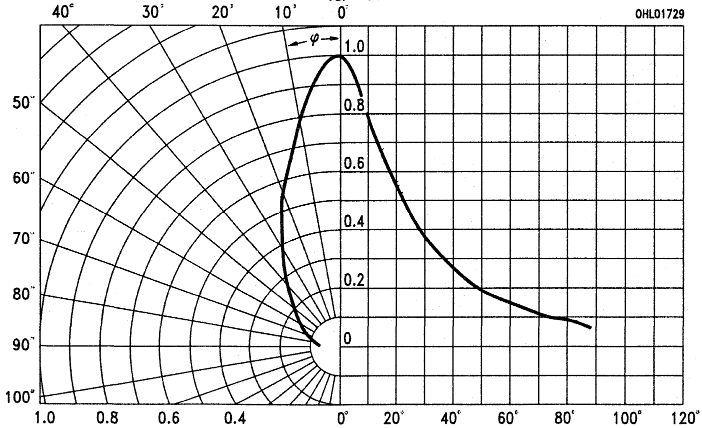
OHL01728. Radiation characteristic $I_{rel}=f(\rho)$



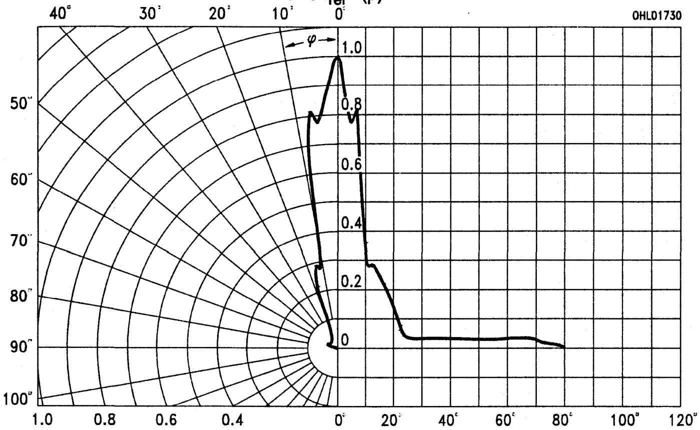
OHL00308. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$,
duty cycle d=parameter



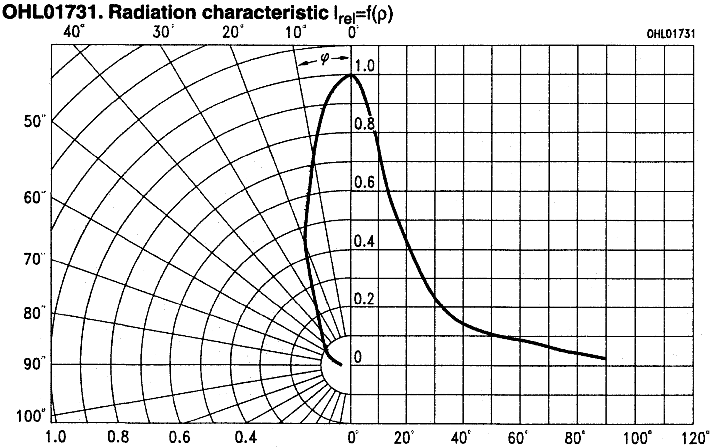
OHL01729. Radiation characteristic $I_{rel}=f(\rho)$



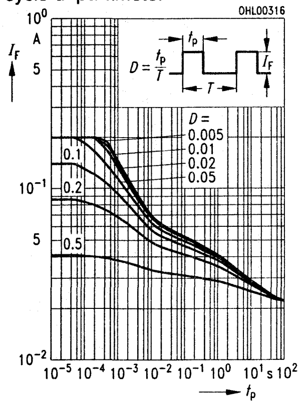
OHL01730. Radiation characteristic $I_{rel}=f(\rho)$



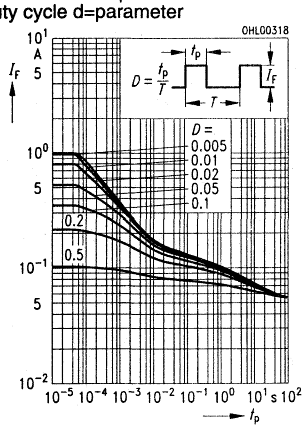
OHL01731. Radiation characteristic $I_{rel}=f(\rho)$



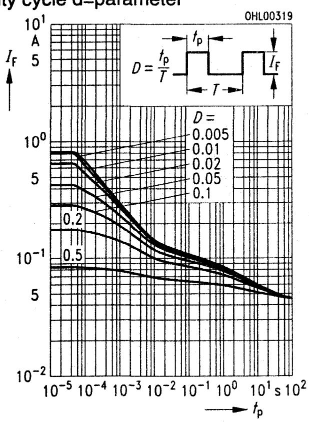
OHL00316. Permissible pulse handling capability $I_F=f(t_p)$, T_A=25°C, duty cycle d=parameter



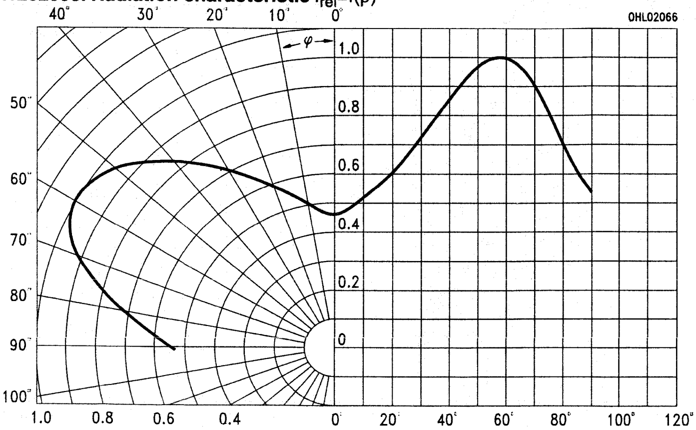
OHL00318. Permissible pulse handling capability $I_F=f(t_p)$, T_A=25°C, duty cycle d=parameter



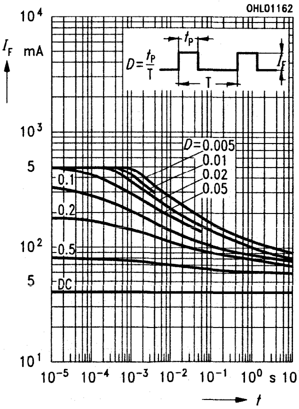
OHL00319. Permissible pulse handling capability $I_F=f(t_p)$, T_A=25°C, duty cycle d=parameter



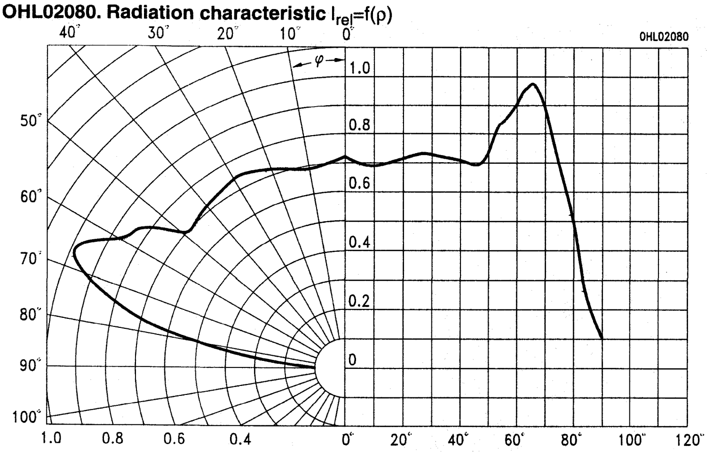
OHL02066. Radiation characteristic $I_{rel}=f(\rho)$



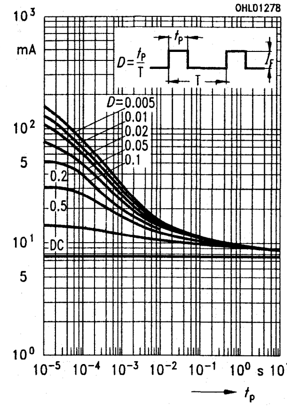
OHL01162. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



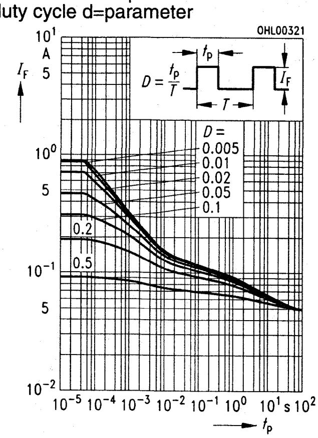
OHL02080. Radiation characteristic $I_{rel}=f(\rho)$



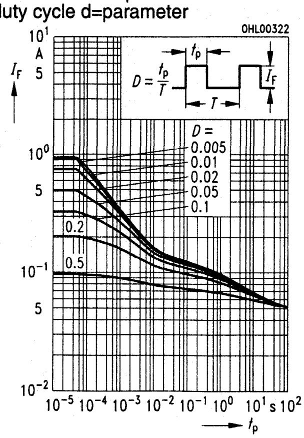
OHL01278. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



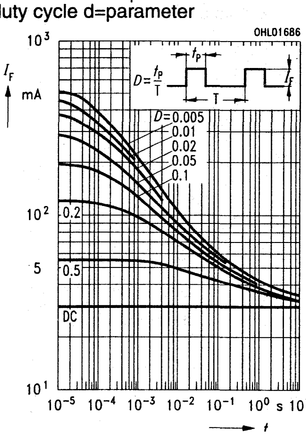
OHL00321. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



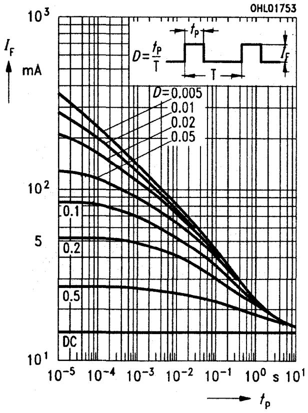
OHL00322. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



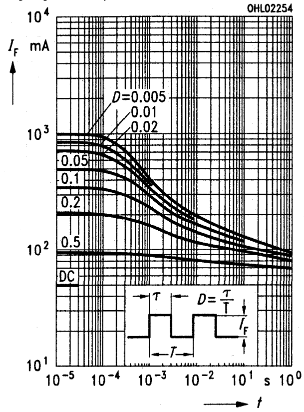
OHL01686. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



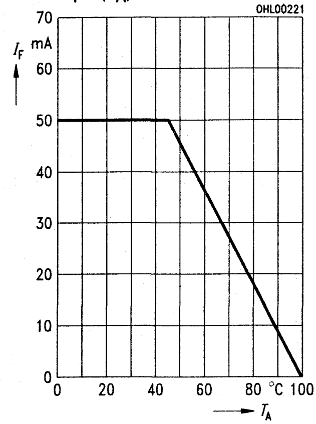
OHL01753. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



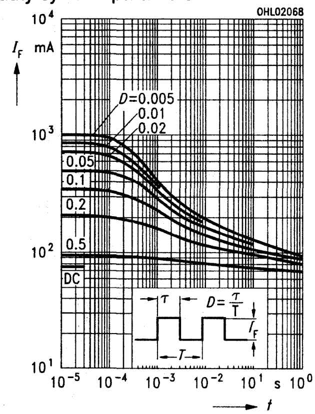
OHL02254. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



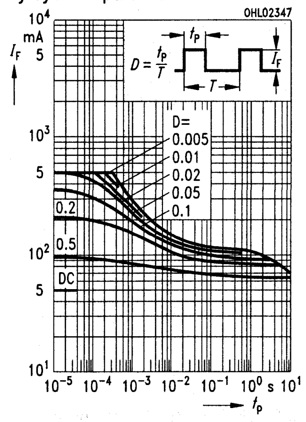
OHL00221. Max. permissible forward current $I_F=f(T_A)$



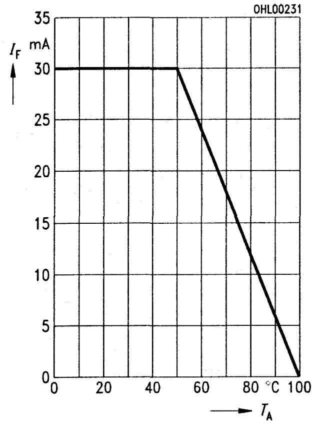
OHL02068. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



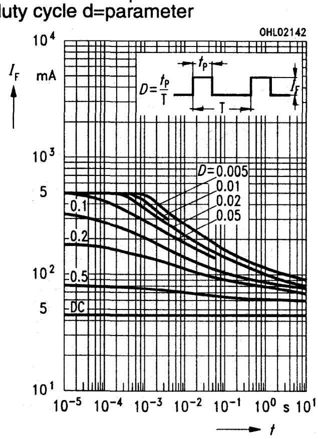
OHL02347. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



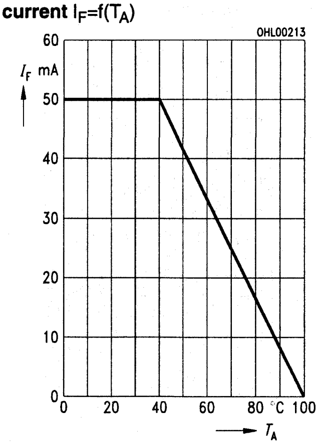
OHL00231. Max. permissible forward current $I_F=f(T_A)$



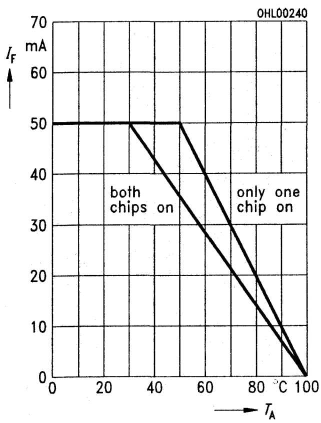
OHL02142. Permissible pulse handling capability $I_F=f(t_p)$, $T_A=25°C$, duty cycle d=parameter



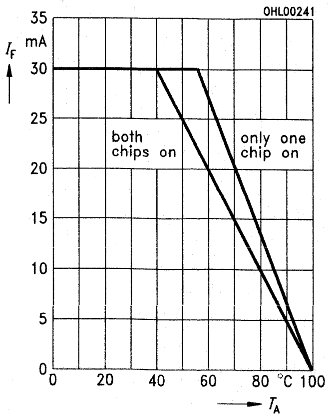
OHL00213. Max. permissible forward current $I_F=f(T_A)$



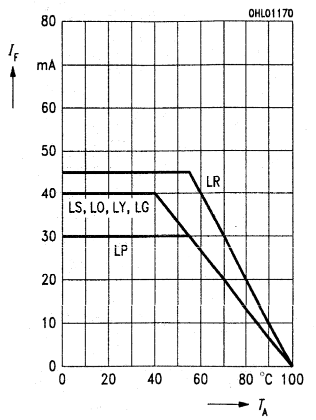
OHL00240. Max. permissible forward current $I_F=f(T_A)$



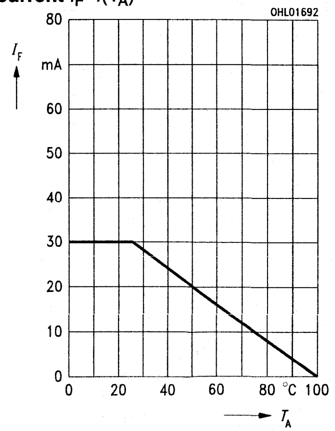
OHL00241. Max. permissible forward current $I_F=f(T_A)$



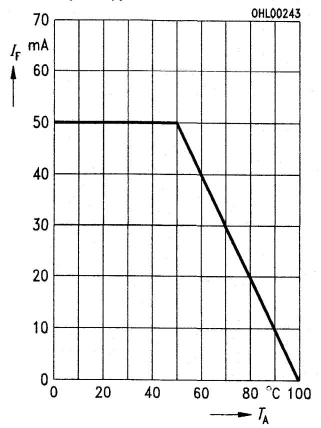
OHL01170. Max. permissible forward current $I_F=f(T_A)$



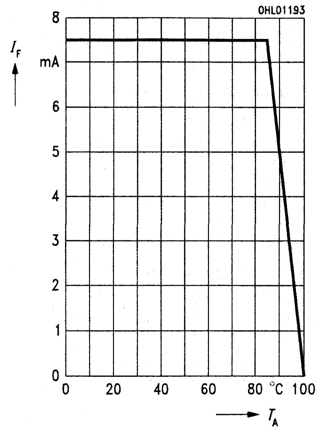
OHL01692. Max. permissible forward current $I_F=f(T_A)$



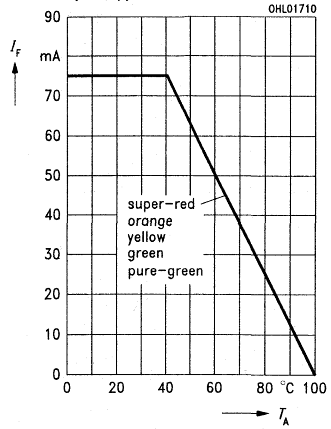
OHL00243. Max. permissible forward current $I_F=f(T_A)$



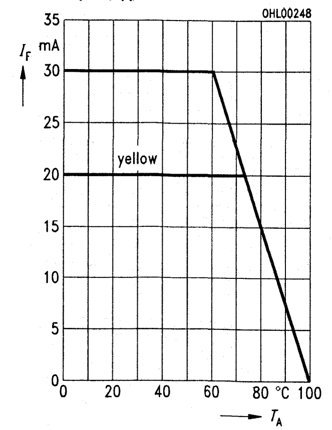
OHL01193. Max. permissible forward current $I_F=f(T_A)$



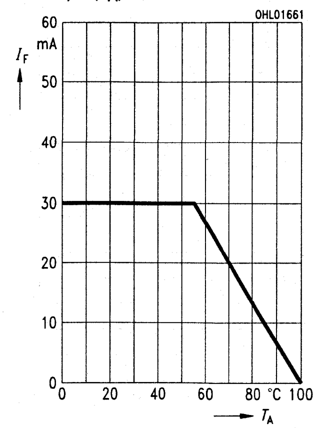
OHL01710. Max. permissible forward current $I_F=f(T_A)$



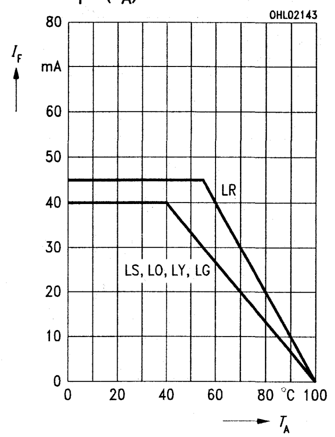
OHL00248. Max. permissible forward current $I_F=f(T_A)$



OHL01661. Max. permissible forward current $I_F=f(T_A)$

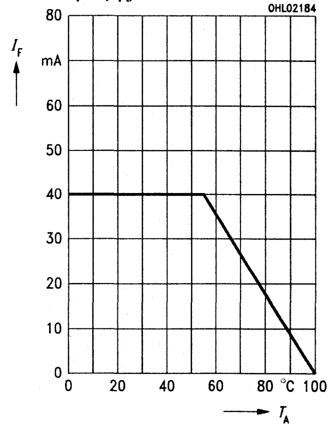


OHL02143. Max. permissible forward current $I_F=f(T_A)$

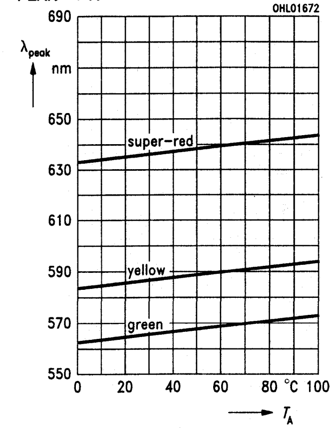


4

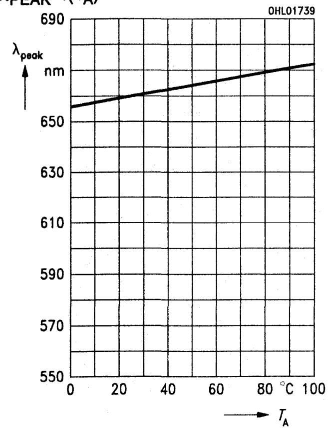
OHL02184. Max. permissible forward current $I_F = f(T_A)$



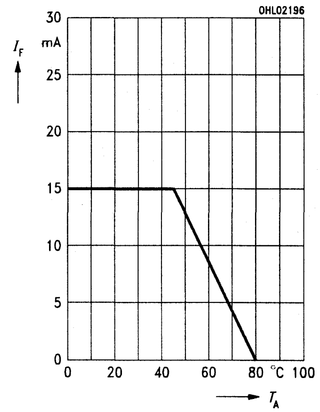
OHL01672. Peak wavelength $\lambda_{PEAK} = f(T_A)$



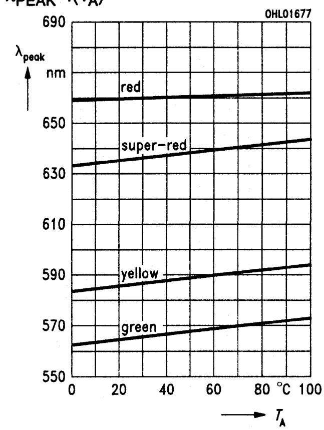
OHL01739. Peak wavelength $\lambda_{PEAK} = f(T_A)$



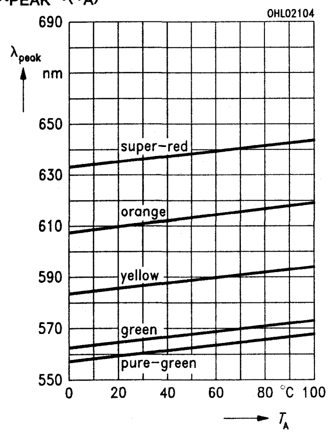
OHL02196. Max. permissible forward current $I_F = f(T_A)$



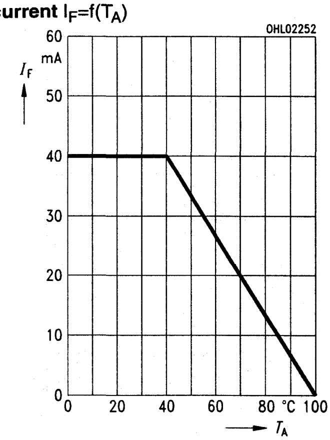
OHL01677. Peak wavelength $\lambda_{PEAK} = f(T_A)$



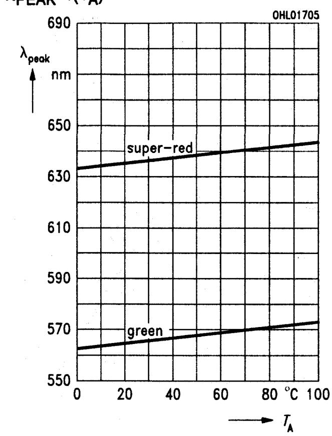
OHL02104. Peak wavelength $\lambda_{PEAK} = f(T_A)$



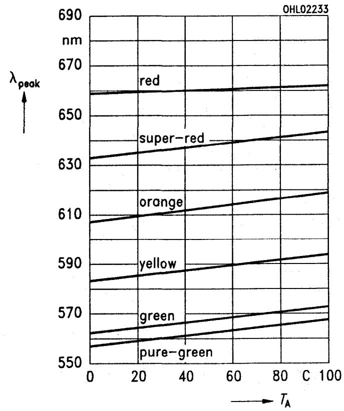
OHL02252. Max. permissible forward current $I_F = f(T_A)$



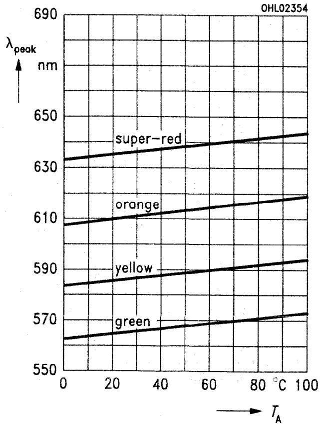
OHL01705. Peak wavelength $\lambda_{PEAK} = f(T_A)$



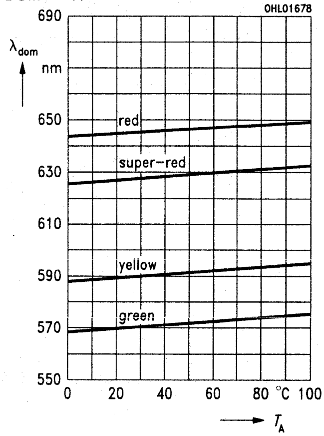
OHL02233. Peak wavelength $\lambda_{PEAK} = f(T_A)$



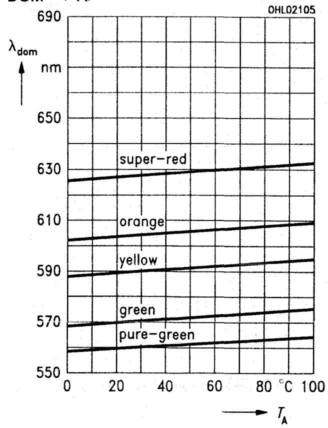
OHL02354. Peak wavelength
$\lambda_{PEAK}=f(T_A)$



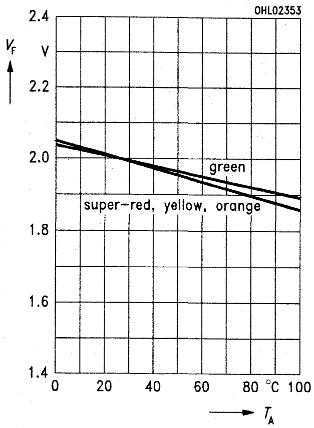
OHL01678. Dominant wavelength
$\lambda_{DOM}=f(T_A)$



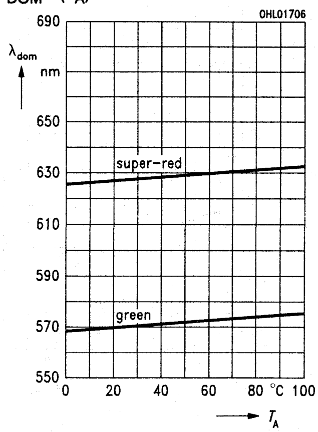
OHL02105. Dominant wavelength
$\lambda_{DOM}=f(T_A)$



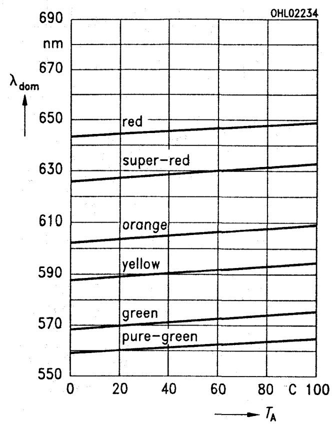
OHL02355. Peak wavelength
$\lambda_{PEAK}=f(T_A)$



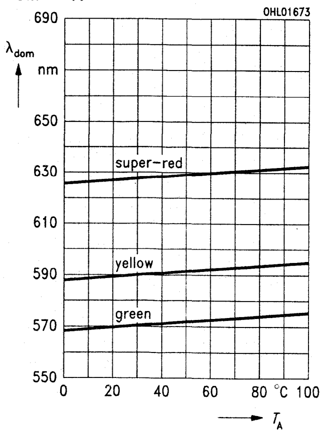
OHL01706. Dominant wavelength
$\lambda_{DOM}=f(T_A)$



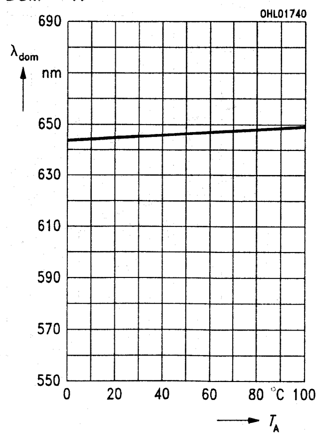
OHL02234. Dominant wavelength
$\lambda_{DOM}=f(T_A)$



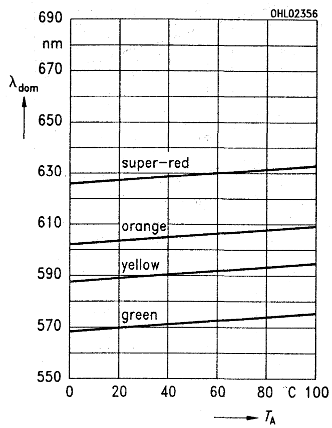
OHL01673. Dominant wavelength
$\lambda_{DOM}=f(T_A)$



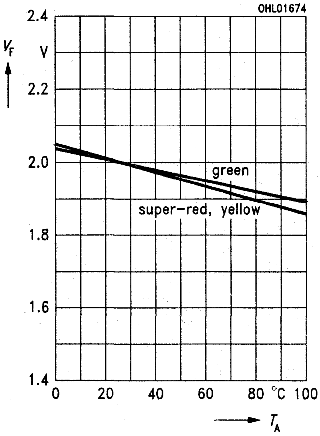
OHL01740. Dominant wavelength
$\lambda_{DOM}=f(T_A)$



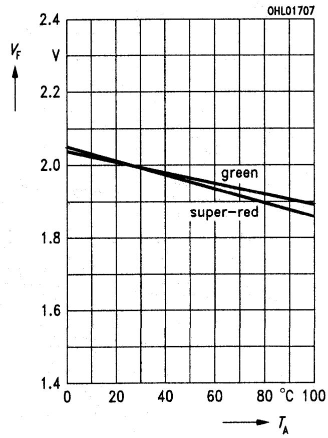
OHL02356. Dominant wavelength
$\lambda_{DOM}=f(T_A)$



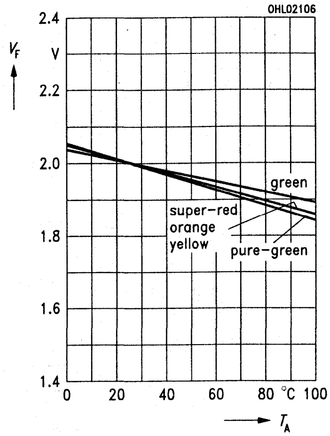
OHL01674. Forward voltage V_F=f(V_F)



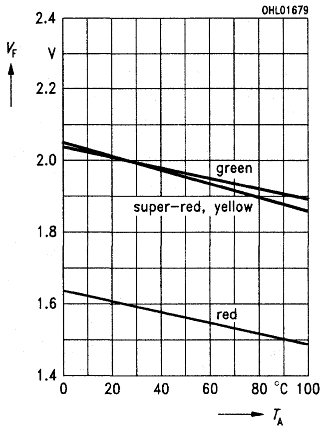
OHL01707. Forward voltage V_F=f(V_F)



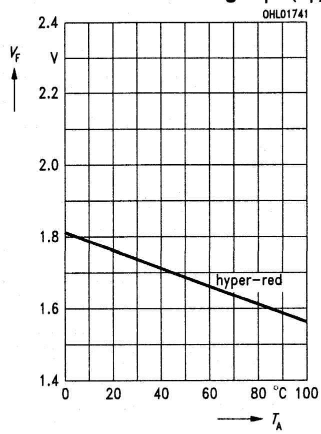
OHL02106. Forward voltage V_F=f(V_F)



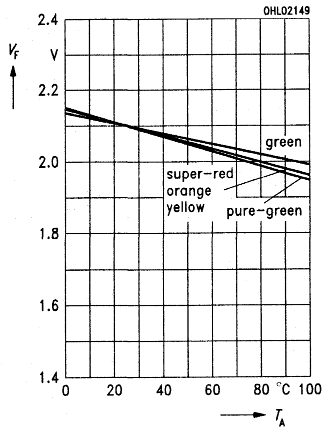
OHL01679. Forward voltage V_F=f(V_F)



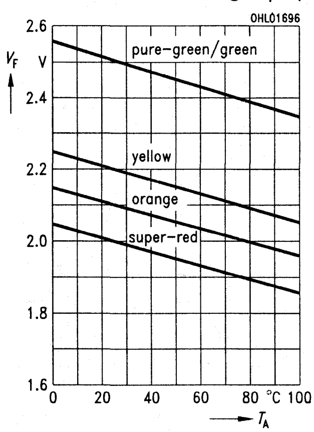
OHL01741. Forward voltage V_F=f(V_F)



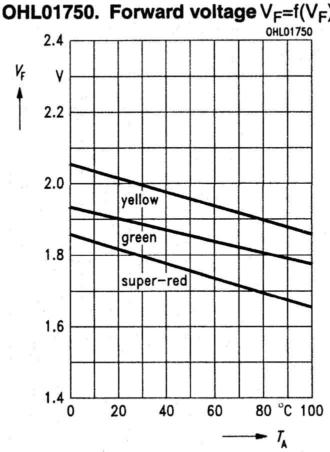
OHL02149. Forward voltage V_F=f(V_F)



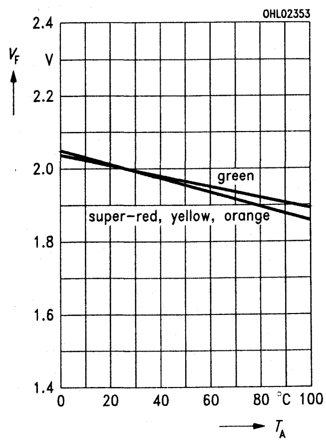
OHL01696. Forward voltage V_F=f(V_F)



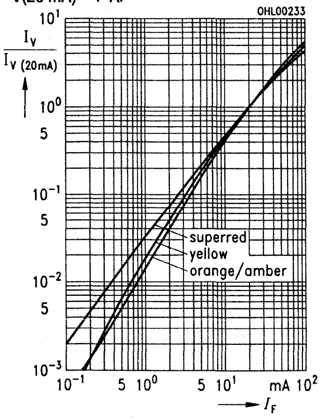
OHL01750. Forward voltage V_F=f(V_F)



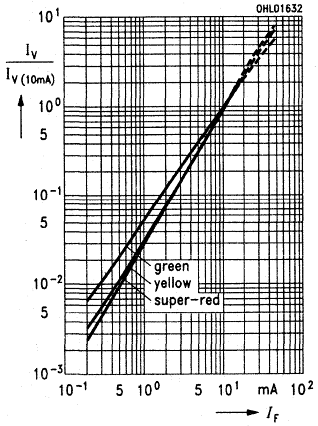
OHL02353. Forward voltage V_F=f(V_F)



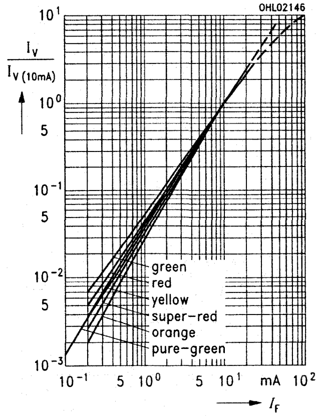
OHL00233. Rel. luminous intensity
$I_V/I_{V(20\,mA)}=f(T_A)$



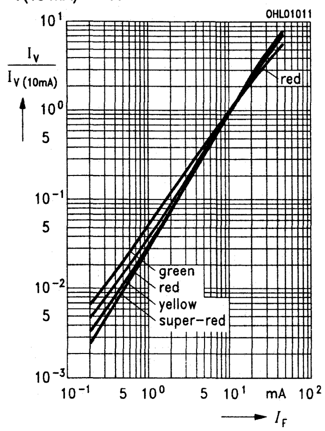
OHL01632. Rel. luminous intensity
$I_V/I_{V(10\,mA)}=f(T_A)$



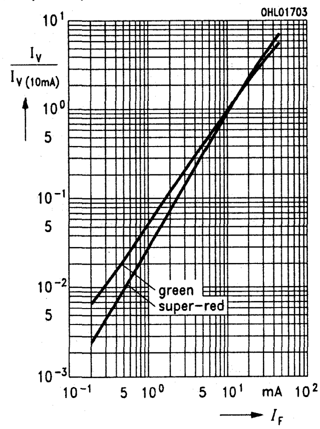
OHL02146. Rel. luminous intensity
$I_V/I_{V(10\,mA)}=f(T_A)$



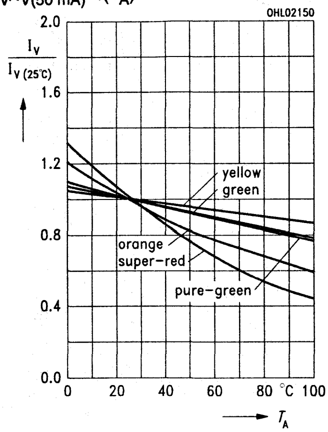
OHL01011. Rel. luminous intensity
$I_V/I_{V(10\,mA)}=f(T_A)$



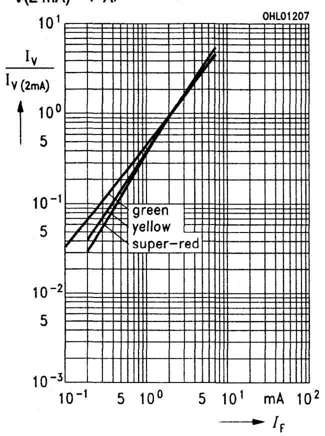
OHL01703. Rel. luminous intensity
$I_V/I_{V(10\,mA)}=f(T_A)$



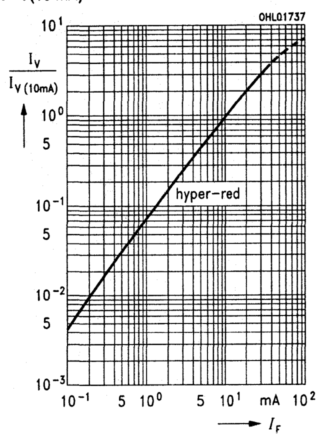
OHL02150. Rel. luminous intensity
$I_V/I_{V(50\,mA)}=f(T_A)$



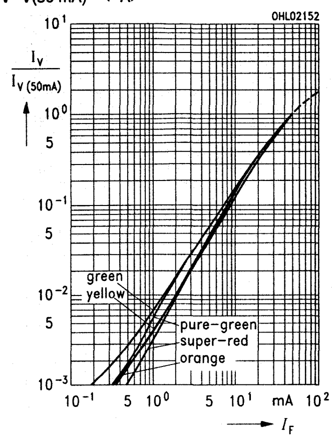
OHL01207. Rel. luminous intensity
$I_V/I_{V(2\,mA)}=f(T_A)$



OHL01737. Rel. luminous intensity
$I_V/I_{V(10\,mA)}=f(T_A)$

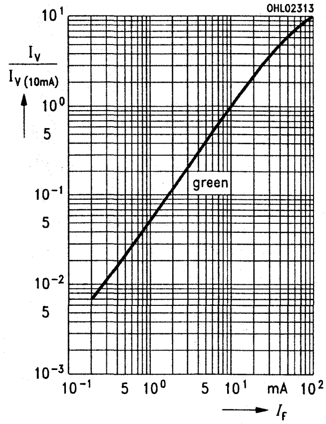


OHL02152. Rel. luminous intensity
$I_V/I_{V(50\,mA)}=f(T_A)$

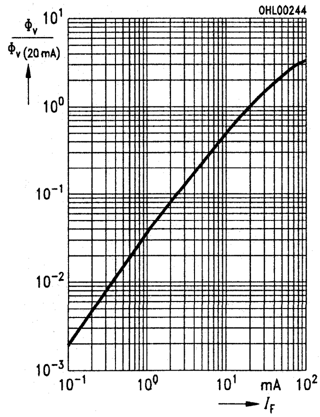


LED Lamps 4

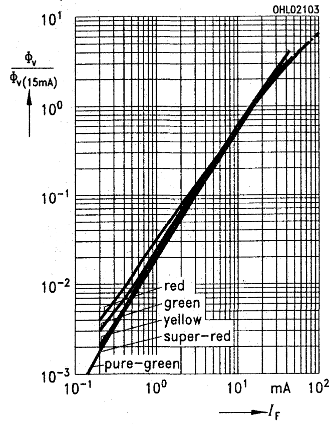
OHL02313. Rel. luminous intensity
$I_V/I_{V(10\ mA)}=f(T_A)$



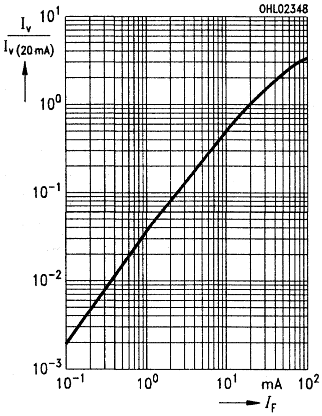
HL00244. Rel. luminous flux
$\Phi_V/\Phi I_{V(20\ mA}=f(T_A)$



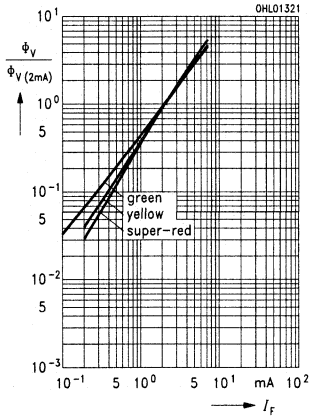
OHL02103. Rel. luminous flux
$\Phi_V/\Phi I_{V(15\ mA}=f(T_A)$



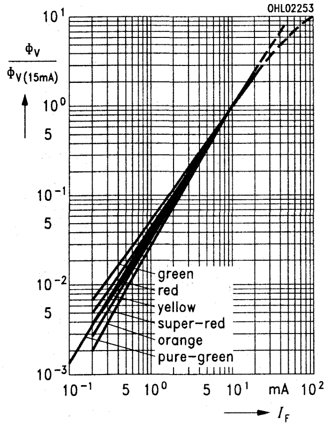
OHL02348. Rel. luminous intensity
$I_V/I_{V(20\ mA)}=f(T_A)$



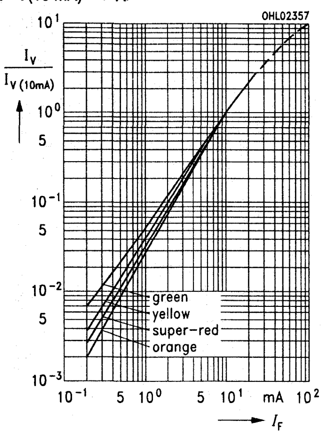
OHL01321. Rel. luminous flux
$\Phi_V/\Phi I_{V(2\ mA}=f(T_A)$



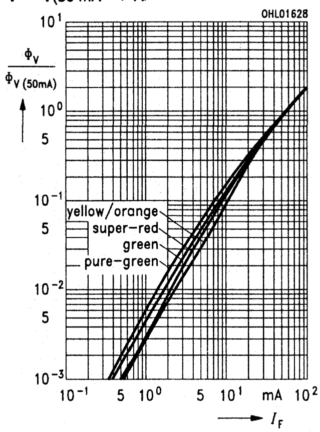
OHL02253. Rel. luminous flux
$\Phi_V/\Phi I_{V(15\ mA}=f(T_A)$

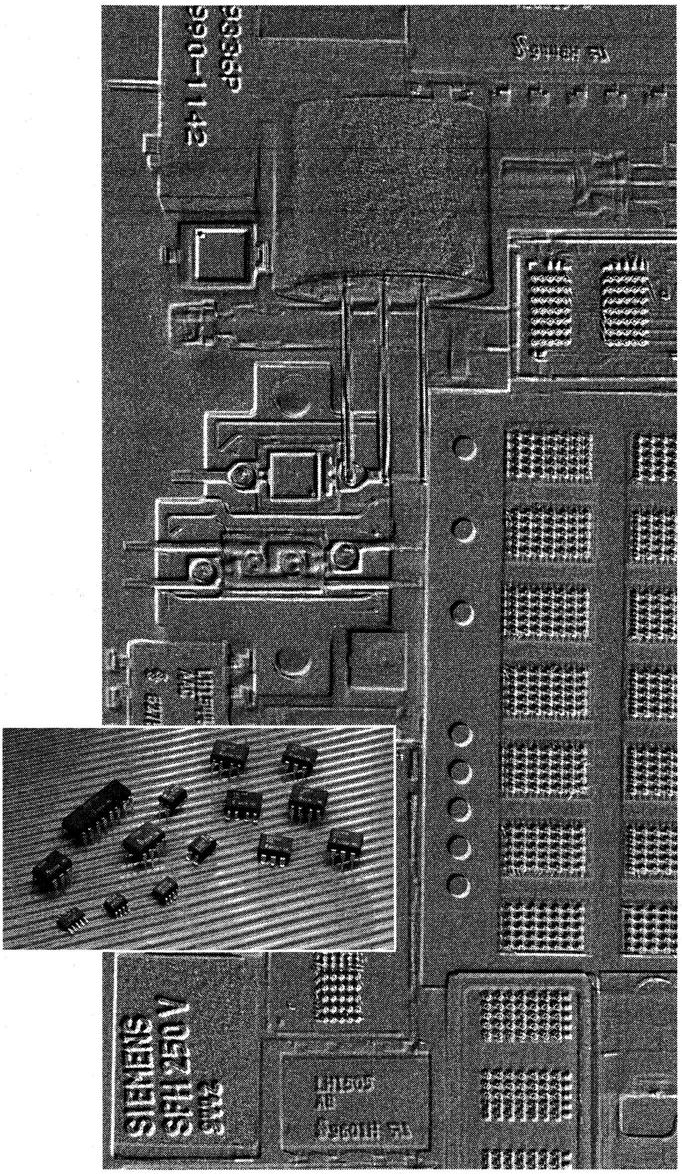


OOHL02357. Rel. luminous intensity
$I_V/I_{V(10\ mA)}=f(T_A)$



OHL01628. Rel. luminous flux
$\Phi_V/\Phi I_{V(50\ mA}=f(T_A)$





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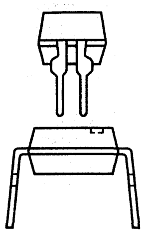
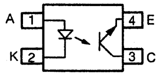
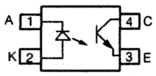
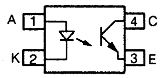
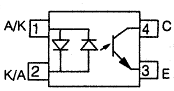
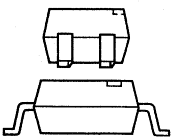
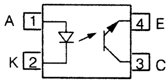
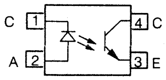
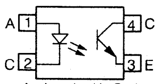
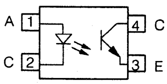
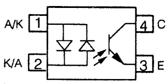
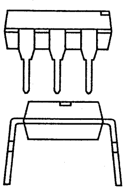
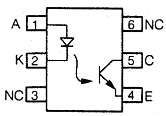
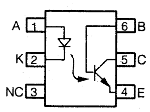
Application Notes

Optocouplers

Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA		Isolation Test Voltage	BV_{CEO}	Features	Page
4 Pin DIP 	Phototransistor/Single	 A=Anode K=Cathode	SFH610A-1	40–80		5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	5–220
			SFH610A-2	63–125					
			SFH610A-3	100–200					
			SFH610A-4	160–320					
		 A=Anode K=Cathode	SFH611A-1	40–80					
			SFH611A-2	63–125					
			SFH611A-3	100–200					
			SFH611A-4	160–320					
		 A=Anode K=Cathode	SFH615A-1	40–80					
			SFH615A-2	63–125					
			SFH615A-3	100–200					
			SFH615A-4	160–320					
			SFH615AA	50–600	I_F=5 mA	5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	5–223
			SFH615AGB	100–600					
			SFH615AGR	100–300					
			SFH617A-1	40–80		5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	5–220
			SFH617A-2	63–125					
			SFH617A-3	100–200					
			SFH617A-4	160–320					
			SFH618A-2	63–125	I_F=1 mA	5300 V_{RMS}	55	Low current input. TRIOS (TRansparent IOn Shield).	5–226
			SFH618A-3	100–200					
			SFH618A-4	160–320					
			SFH618A-5	250–500					
	AC/bidirectional	 A=Anode K=Cathode	SFH620A-1	40–125		5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	5–230
			SFH620A-2	63–200					
			SFH620A-3	100–320					
			SFH620AA	50–600	I_F=5 mA	5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	5–233
			SFH620AGB	100–600					
			SFH628A-2	63–200	I_F=1 mA	5300 V_{RMS}	55	TRIOS (TRansparent IOn Shield).	5–226
			SFH628A-3	100–320					
			SFH628A-4	160–500					

Optocouplers

Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA	Isolation Test Voltage	BV_{CEO}	Features	Page
4 Pin DIP SMD Leads 	Phototransistor/SMT	 A=Anode K=Cathode	SFH6106-1	40–80	5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	5–243
			SFH6106-2	63–125				
			SFH6106-3	100–200				
			SFH6106-4	160–320				
		 A=Anode K=Cathode	SFH6116-1	40–80	5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	
			SFH6116-2	63–125				
			SFH6116-3	100–200				
			SFH6116-4	160–320				
	Phototransistor/SMT	 A=Anode K=Cathode	SFH6156-1	40–80	5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	
			SFH6156-2	63–125				
			SFH6156-3	100–200				
			SFH6156-4	160–320				
		 A=Anode K=Cathode	SFH6186-2	63–125	5300 V_{RMS}	55	TRIOS (TRansparent IOn Shield).	
			SFH6186-3	100–200				
			SFH6186-4	160–320				
			SFH6186-5	250–500				
	AC/bidirectional/SMT	 A=Anode K=Cathode	SFH6206-1	40–125	5300 V_{RMS}	70	TRIOS (TRansparent IOn Shield).	
			SFH6206-2	63–200				
			SFH6206-3	100–320				
			SFH6286-2	63–200 (I_F=1 mA)	5300 V_{RMS}	55	TRIOS (TRansparent IOn Shield).	
			SFH6286-3	100–320 (I_F=1 mA)				
			SFH6286-4	160–500 (I_F=1 mA)				
6 Pin DIP 	Phototransistor/Single	 A=Anode K=Cathode	CNY17F-1	40–80	5300 V_{RMS}	70	No base pin connection. CTR groupings.	5–45
			CNY17F-2	63–125				
			CNY17F-3	100–200				
			CNY17F-4	160–320				
			MOC8111	20 Min.	5300 V_{RMS}	30	No base connection	5–207
		 A=Anode K=Cathode	CNY17-1	40–80	5300 V_{RMS}	70	CTR groupings.	5–41
			CNY17-2	63–125				
			CNY17-3	100–200				
			CNY17-4	160–320				

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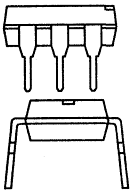
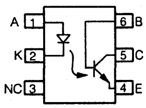
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA	Isolation Test Voltage	BV_{CEO}	Features	Page
6 Pin DIP 	Phototransistor/Single	 A=Anode K=Cathode	SFH600-0	40–80	5300 V_{RMS}	70	CTR groupings.	5–210
			SFH600-1	63–125				
			SFH600-2	100–200				
			SFH600-3	160–320				
			SFH601-1	40–80	5300 V_{RMS}	100	CTR groupings.	5–214
			SFH601-2	63–125				
			SFH601-3	100–200				
			SFH601-4	160–320				
			SFH608-2	63–125 (I_F=1 mA)	5300 V_{RMS}	55	Low current. TRIOS (TRansparent IOn Shield).	5–218
			SFH608-3	100–200 (I_F=1 mA)				
			SFH608-4	160–320 (I_F=1 mA)				
			SFH608-5	250–500 (I_F=1 mA)				
			SFH640-1	40–80	5300 V_{RMS}	300	High BV_{CER} voltage. TRIOS (TRansparent IOn Shield).	5–240
			SFH640-2	63–125				
			SFH640-3	100–200				
			4N25	20 Min.	5300 V_{RMS}	30	Low cost industry standard.	5–27
			4N26					
			4N27	10 Min.				
			4N28					
			4N35	100 Min.	5300 V_{RMS}	30	Low cost industry standard.	
			4N36					
			4N37					
			4N38	10 Min.				
			H11A1	50 Min.	5300 V_{RMS}	30	Low cost industry standard.	
			H11A2	20 Min.				
			H11A3	20 Min.				
			H11A4	10 Min.				
			H11A5	30 Min.				
			H11D1	20 Min.	5300 V_{RMS}	300	High BV_{CER} voltage. TRIOS (TRansparent IOn Shield).	5–55
			H11D2					
			H11D3			200		
			H11D4					

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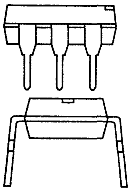
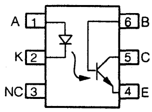
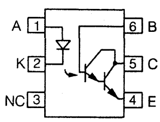
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA	Isolation Test Voltage	BV_{CEO}	Features	Page
6 Pin DIP 	Phototransistor/Single	 A=Anode K=Cathode	IL1	20–300	5300 V_{RMS}	30	TRIOS (TRansparent IOn Shield).	5–58
			IL2	100–500		70		
			IL5	50–400				
			IL74	12.5 Min.		20		5–73
			MCT2	20 Min.	5300 V_{RMS}	30	Low cost industry standard.	5–27
			MCT2E	20 Min.				
			MCT270	50 Min.	5300 V_{RMS}	30	Low cost industry standard.	
			MCT271	45–90				
			MCT272	75–150				
			MCT273	125–250				
			MCT274	225–400				
			MCT275	70–210				
			MCT276	15–60				
			MCT277	100 Min.				
			MCT5210	7 Min., I_F=3.0 mA	5300 V_{RMS}	70	Low input forward current.	5–202
			MCT5211	110 Min., I_F=1 mA				
			IL201	10 Min. (I_F=1 mA)	5300 V_{RMS}	70	Low input forward current.	5–77
			IL202	30 Min.				
			IL203	50 Min.				
	Photodarlington/Single	 A=Anode K=Cathode	IL30	100 Min.	5300 V_{RMS}	30	High gain.	5–63
			IL31	200 Min.				
			IL55	100 Min.		55		
			4N32	500 Min.	5300 V_{RMS}	30	High gain.	5–33
			4N33					
			H11B1	500 Min. (I_F=1 mA)	5300 V_{RMS}	30	High gain. Low cost industry standard.	5–52
			H11B2	200 Min.				
			H11B3	100 Min.				
			MCA230	100 Min.	5300 V_{RMS}	30	High gain. Low cost industry standard.	5–197
			MCA231	200 Min.				
			MCA255	100 Min.		55		

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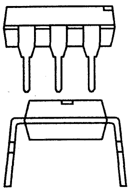
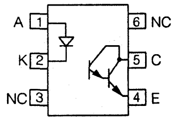
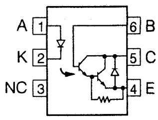
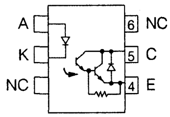
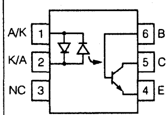
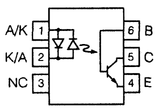
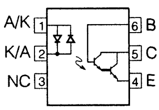
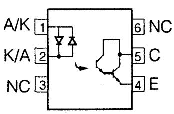
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA	Isolation Test Voltage	BV_{CEO}	Features	Page
6 Pin DIP 	Darlington/Single	 A=Anode K=Cathode	MOC8050	500 Min.	5300 V_{RMS}	80	High BV_{CEO}. No base lead.	5–205
			IL55B	500 Min.	5300 V_{RMS}	80	High BV_{CEO}.	5–66
			IL66-1	100 Min. (I_F=2 mA)	5300 V_{RMS}	60	Internal R_{BE} for high stability.	5–68
			IL66-2	300 Min. (I_F=2 mA)				
			IL66-3	400 Min. I_F=0.7 mA				
			IL66-4	500 Min. I_F=2 mA				
			IL66B-1	200 Min. (I_F=2 mA)	5300 V_{RMS}	60	Internal R_{BE} for high stability. No base lead.	5–71
			IL66B-2	750 Min. (I_F=2 mA)				
	AC/bidirectional		H11AA1	20 Min.	5300 V_{RMS}	70	3:1 CTR matching.	5–49
			IL250	50 Min.			2:1 CTR matching.	5–92
			IL251	20 Min.				
			IL252	100 Min.				
			IL255	20 Min.	5300 V_{RMS}	30	Improved CTR symmetry	5–95
			L255-1	20 Min., I_F=100 mA				
			IL255-2	50 Min.				
	AC/bidirectional/photodarlington	 A=Anode K= Cathode	IL755-1	750 Min., I_F=2 mA	5300 V_{RMS}	60	High CTR.	5–131
			IL755-2	1000 Min., I_F=1 mA				
		 A=Anode K= Cathode	IL755B-1	750 Min., I_F=2 mA	5300 V_{RMS}	70	No base pin connection.	5–134
			IL755B-2	1000 Min., I_F=1 mA				

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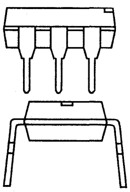
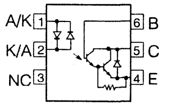
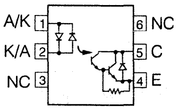
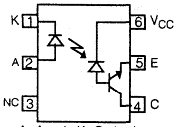
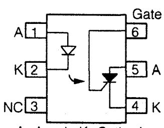
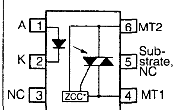
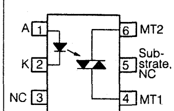
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA		Isolation Test Voltage	BV_{CEO}	Features	Page
6 Pin DIP 	AC/bidirectional/photodarlington	 A=Anode K= Cathode	IL766-1	500 Min., I_F=2 mA		5300 V_{RMS}	60	Internal R_{BE} for better stability.	5–136
		 A=Anode K=Cathode	IL766-2	500 Min., I_F=1 mA					
			IL766B-1	400 Min., I_F=1 mA		5300 V_{RMS}	60	No base pin connection.	5–139
			IL766B-2	900 Min., I_F=0.5 mA					
	Split collector transistor	 A=Anode K=Cathode	SFH636	19 Min., I_F=16 mA		5300 V_{RMS}	NA	No base lead. High CMR. High speed.	5–236
	SCR output	 A=Anode K=Cathode	H11C4	11 mA	LED trigger current	5300 V_{RMS}	Fwd. blocking voltage V_{DRM}=600 V	Optically coupled SCR	5–54
			H11C5	11 mA					
			H11C6	14 mA					
			IL400	10 mA					5–118
			4N39	14 mA					5–35
	Triac output	 A=Anode K=Cathode	IL410	2 mA	LED trigger current	5300 V_{RMS}	600 V	Optically coupled triac driver. Zero crossing detector. High dv/dt.	5–119
			IL4108	2 mA		5300 V_{RMS}	800 V		5–140
			IL4116	1.3 mA max.		5300 V_{RMS}	600 V	Optically coupled triac driver. Zero crossing detector. AlGaAs LED. Very low input LED current.	5–142
			IL4117				700 V		
			IL4118				800 V		
		 A=Anode K=Cathode	IL420	2 mA max.		5300 V_{RMS}	600 V	Optically coupled triac driver. High dv/dt. Low input required.	5–125
			IL440–1	15 mA max.		3750V_{RMS}	600 V		5–129
			IL440–2	10 mA max.					
			IL440–3	5 mA max.					
			IL440–4	15 mA max.			400 V		
			IL440–5	10 mA max.					
			IL440–6	5 mA max.					
			IL4208	2 mA max.		5300 V_{RMS}	800 V		5–145

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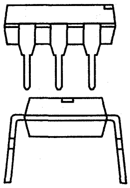
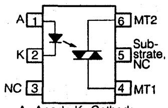
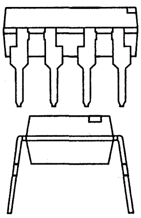
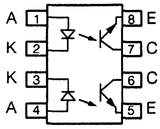
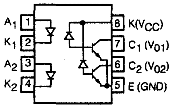
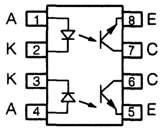
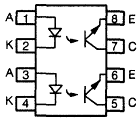
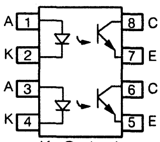
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA	Isolation Test Voltage	BV_{CEO}	Features	Page
6 Pin DIP 	Triac output	 A=Anode K=Cathode	IL4216	1.3 mA max.	5300 V_{RMS}	600 V	Optically coupled triac driver. AlGaAs LED. Very low input LED current.	5–147
			IL4217			700 V		
			IL4218			800 V		
8 Pin DIP 	Phototransistor/Dual	 A=Anode K=Cathode	ILCT6	20 Min.	5300V_{RMS}	30	TRIOS (TRansparent IOn Shield).	5–150
			ILD1	20–300	5300V_{RMS}	50		5–153
			ILD2	100–500				
			ILD5	50–400		70		
			SFH6325	16, I_F=16 mA	2500V_{RMS}	—	TRIOS (TRansparent IOn Shield).	5–256
			SFH6326	35, I_F=16 mA				
		 A=Anode K=Cathode	ILD3	300, I_F=1.6 mA	5300V_{RMS}	50	High CTR at low current.	5–157
			ILD74	12.5	5300V_{RMS}	20	TRIOS (TRansparent IOn Shield).	5–73
			MCT6	20 Min.	5300 V_{RMS}	30	Low cost industry standard.	5–199
		 K=Cathode	ILD610-1	40–80	5300V_{RMS}	70	Repetitive pinout–emitter and detector. CTR groupings.	5–170
			ILD610-2	63–125				
			ILD610-3	100–200				
			ILD610-4	160–320				
		 K=Cathode	ILD615-1	160–320	5300V_{RMS}	70	Repetitive pinout—emitter and detector. CTR groupings.	5–173
			ILD615-2	63–125				
			ILD615-3	100–200				
			ILD615-4	160–320				
			ILD621	50–600 (I_F=5 mA)	5300V_{RMS}	70	Repetitive pinout—emitter and detector. CTR groupings.	5–182
			ILD621GB	100–600 (I_F=5 mA)				

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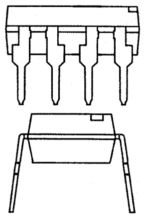
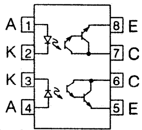
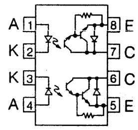
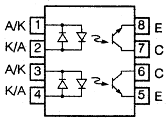
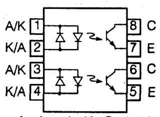
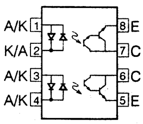
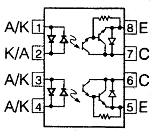
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA	Isolation Test Voltage	BV_{CEO}	Features	Page
8 Pin DIP 	Photodarlington/Dual	 A=Anode K=Cathode	ILD30	100 Min.	$5300V_{RMS}$	30	High gain.	5–63
			ILD31	200 Min.				
			ILD55	100 Min.		55		
			ILD32	500 Min.	$5300V_{RMS}$	30	High gain.	5–160
		 A=Anode K=Cathode	ILD66-1	100 Min., I_F=2 mA	$5300V_{RMS}$	60	Internal R_{BE} for high stability.	5–68
			ILD66-2	300 Min., I_F=2 mA				
			ILD66-3	400 Min., I_F=0.7 mA				
			ILD66-4	500 Min., I_F=2 mA				
	AC/bidirectional/Dual	 A=Anode K= Cathode	ILD250	50 Min.	$5300V_{RMS}$	70	2:1 CTR matching.	5–92
			ILD251	20 Min.				
			ILD252	100 Min.				
			ILD255	50 Min.	$5300V_{RMS}$	70	Bidirectional input.	5–165
		 A=Anode K=Cathode	ILD620	50–600 (I_F=5 mA)	$5300V_{RMS}$	70	Repetitive pinout—emitter and detector.	5–178
			ILD620GB	100–600 (I_F=5 mA)				
	AC/bidirectional/Darlington	 A=Anode K=Cathode	ILD755-1	750 Min., I_F=2 mA	$5300V_{RMS}$	60	High CTR. AC/bidirect/Darling-ton	5–131
			ILD755-2	1000 Min., I_F=1 mA				
		 A=Anode K=Cathod	ILD766-1	500 Min., I_F=2 mA	5300 V_{RMS}	60	Internal R_{BE} for better stability.	5–136
			ILD766-2	500 Min., I_F=1 mA				

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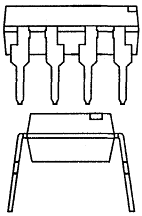
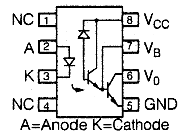
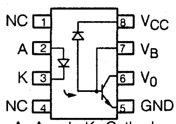
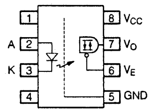
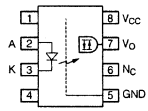
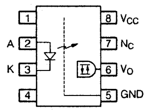
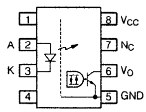
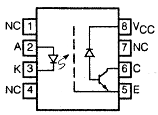
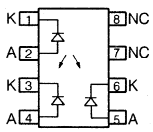
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA		Isolation Test Voltage	BV_{CEO}	Features	Page
8 Pin DIP 	Photo IC Output/Single	 A=Anode K=Cathode	6N138	300 Min.	I_F=1.6 mA	2500 V_{RMS}	NA	High gain. Low input forward current.	5–39
			6N139	500 Min.					
			SFH6138	300 Min.		5300 V_{RMS}	NA	High gain. Low input forward current.	5–247
			SFH6139	500 Min.					
		 A=Anode K=Cathode	6N135	16 (≥7)	I_F=16 mA	2500 V_{RMS}	NA	High speed, high bit rates—1 Mbits.	5–36
			6N136	35 (≥19)					
			SFH6135	16 (≥7)		5300 V_{RMS}	NA	High speed, high bit rates—1 Mbits.	5–244
			SFH6136	35 (≥19)					
	High Speed/Logic Gate		SFH6700	Low input current.		2500 V_{RMS}	V_{CC}=15 V Max.	5 Mb/s CMR=1000 V/µs @ V_{CM}=50V	5–263
			SFH6719					5 Mb/s CMR=2500 V/µs @ V_{CM}=400V	
			SFH6701	Low input current.		2500 V_{RMS}	V_{CC}=15 V Max.	5 Mb/s CMR=1000 V/µs @ V_{CM}=50V	
			SFH6711					5 Mb/s CMR=2500 V/µs @ V_{CM}=400V	
			SFH6702	Low input current.		2500 V_{RMS}	V_{CC}=15 V Max.	5 Mb/s CMR=1000 V/µs @ V_{CM}=50V	
			SFH6712					5 Mb/s CMR=2500 V/µs @ V_{CM}=400V	
			SFH6705	Low input current.		2500 V_{RMS}	V_{CC}=15 V Max.	5 Mb/s CMR=1000 V/µs @ V_{CM}=50V	
	Photo IC Output/Single	 A=anode K=Cathode	SFH6345	30 (≥19)	I_F=16 mA	5300 V_{RMS}	NA	15 KV/µs common mode immunity.	5–259
	Linear		IL300	Gain ratio categories: A,B,C,D,E,F,G,H,I,J		5300 V_{RMS}	15	0.05% servo linearity.	5–100

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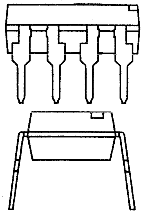
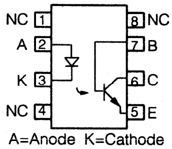
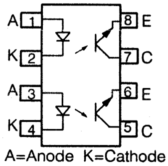
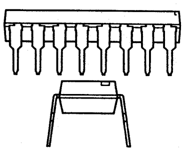
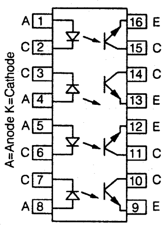
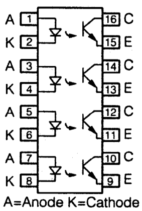
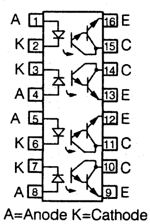
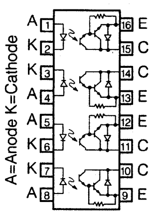
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA	Isolation Test Voltage	BV_{CEO}	Features	Page
8 Pin DIP 	Hermetic		ILH100	100 Min.	3000 V_{RMS}	70	Single channel. hermetically sealed, ceramic package. High CTR at low input current.	5–186
			ILH200	100 Min.	3000 V_{RMS}	70	Dual channel. hermetically sealed, ceramic package. High CTR at low input current.	5–193
16 Pin DIP 	Phototransistor/Quad		ILQ1	20–300	5300 V_{RMS}	50	TRIOS (TRansparent IOn Shield).	5–153
			ILQ2	100–500		70		
			ILQ5	50–400		50		
			ILQ3	300 Min. I_F=1.6 mA	5300 V_{RMS}	70	High CTR at low current.	5–157
			ILQ74	12.5 Min.	5300 V_{RMS}	20	TRIOS (TRansparent IOn Shield).	5–73
			ILQ615-1	40–80	5300 V_{RMS}	70	Repetitive pinout—emitter and detector.	5–173
			ILQ615-2	63–125				
			ILQ615-3	100–200				
			ILQ615-4	160–320				
			ILQ621	50–600 I_F=5 mA	5300 V_{RMS}	70	Repetitive pinout—emitter and detector.	5–182
			ILQ621GB	100–600 I_F=5 mA				
			ILQ30	100 Min.	5300 V_{RMS}	30	High gain.	5–63
			ILQ31	200 Min.				
			ILQ55	100 Min.		55		
			ILQ32	500 Min.	5300 V_{RMS}	30	High gain.	5–159
			ILQ66-1	100 Min., I_F=2 mA	5300 V_{RMS}	60	Internal R_{BE} for high stability.	5–68
			ILQ66-2	300 Min., I_F=2 mA				
			ILQ66-3	400 Min., I_F=0.7 mA				
			ILQ66-4	500 Min., I_F=2 mA				

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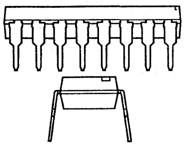
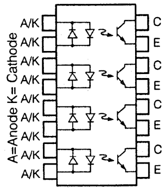
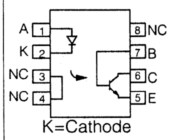
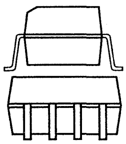
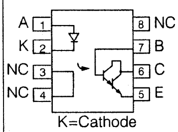
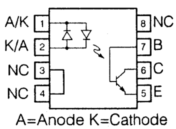
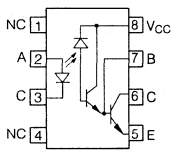
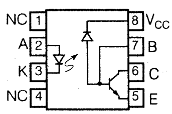
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA		Isolation Test Voltage	BV_{CEO}	Features	Page
16 Pin DIP 	AC/bidirectional		ILQ620	50–600	I_F=5 mA	5300 V_{RMS}	70	Repetitive pinout—emitter and detector.	5–178
			ILQ620GB	100–600					
	Phototransistor/Single		IL205A	40–80		2500 V_{RMS}	70	Double molded package. Small outline surface mount. 0.05” standard lead spacing. Available on tape and reel, add “T” suffix to part number.	5–80
			IL206A	63–125					
			IL207A	100–200					
			IL208A	160–320					
			IL211A	20 Min.		2500 V_{RMS}	30		5–83
			IL212A	50 Min.					
			IL213A	100 Min.					
			IL215A	20 Min.	I_F=1mA	2500 V_{RMS}	30		5–86
			IL216A	50 Min.					
			IL217A	100 Min.					
SOIC-8 	Photodarlington		IL221A	100 Min.	I_F=1mA	2500 V_{RMS}	30	Double molded package. Small outline surface mount. 0.05” standard lead spacing. Available on tape and reel, add “T” suffix to part number.	5–89
			IL222A	200 Min.					
			IL223A	500 Min.					
	Bidirectional		IL256A	20 Min.		2500 V_{RMS}	30		5–97
	Photo IC		SFH6318	300-2000	I_F=1.6 mA	2500 V_{RMS}	NA	High gain, low input forward current.	5–253
			SFH6319	500–3500					
			SFH6315	7–50	I_F=1.6 mA	2500 V_{RMS}	NA	High speed 1 Mbit.	5–249
			SFH6316	19–50					
			SFH6343	36 (≥15)			NA	High speed 1 Mbit. High CMR, 15 kV/µsec.	

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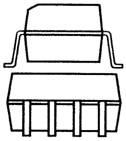
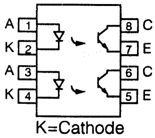
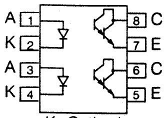
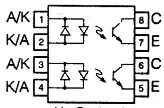
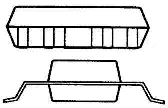
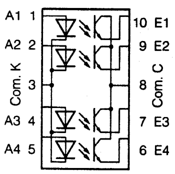
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA	Isolation Test Voltage	BV_{CEO}	Features	Page
SOIC-8 	Phototransistor/Dual	 K=Cathode	ILD205	40–80	2500 V_{RMS}	70	Small outline surface mount SOIC-8 footprint. 0.05" standard lead spacing. Available on tape and reel.	5–161
			ILD206	63–125				
			ILD207	100–200				
			ILD211	20 Min.	2500 V_{RMS}	70		
			ILD213	100 Min.				
			ILD217	100 Min.				
	Photodarlington/Dual	 K=Cathode	ILD223	500 Min., I_F=1 mA	2500 V_{RMS}	30		5–163
	AC/Bidirectional/Dual	 K=Cathode	ILD256	20 Min.	2500 V_{RMS}	30		5–167
SOT223/10 	Low current input		SFH6943-2	63–200 (I_F=1 mA)	2500 VDC		Ultra compact package, common cathode, common collector configuration.	5–272
			SFH6943-3	100–320 (I_F=1 mA)				
			SFH6943-4	160–500 (I_F=1 mA)				

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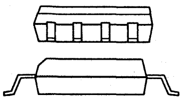
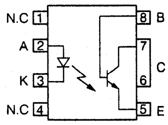
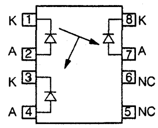
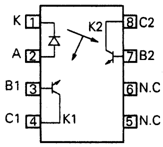
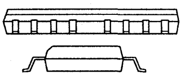
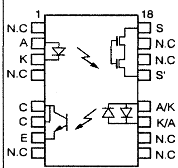
Package Outline	Type	Schematic	Part Number	Current Transfer Ratio (%) I_F=10 mA		Isolation Test Voltage	BV_{CEO}	Features	Page
PCMCIA package 2 mm high, 8 pin 	Phototransistor		IL352	100	I_F=1 mA	2500 V_{RMS}	30	Application: PCMCIA fax/ modem.	5–113
	Linear		IL350	0.003	A–J	2500 V_{RMS}	0.01% servo linear-ity	Application: PCMCIA fax/ modem.	5–111
			IL351	0.005	D,E, F,G				
			IL358	0.008	D,E, F,G				
			IL359	0.008	E,F				
			IL388	0.007 I_F=2 mA	C,D, E,F, G,H	2500 VDC	0.01% servo linear-ity	Application: PCMCIA fax/ modem.	5–116
PCMCIA package 2 mm high, 16 pin 	Telecom switch		IL329	33–165, I_{FT}=0.5 mA		2500 V_{RMS}	NA	Application: PCMCIA fax/ modem.	5–108

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Part Numbers	UL E52744 System Code	CSA LRD93751	DIN VDE 0884	BSI IEC 65	BSI IEC950 EN60950	FIMKO IEC 65	FIMKO IEC950 EN60950	DEMKO	SEMKO	CECC
4N25/4N26/4N27/4N28	H or J	X	X	X	X	X	X			
4N32/4N33	H or J	X	X	X	X	X	X			
4N35/4N36/4N37	H or J	X	X	X	X	X	X			
4N38	H or J	X		X	X	X	X			
4N39	H or J	X		X	X	X	X			
6N135/6N136	H		X					X		
6N138/6N139	H		X							
CNY17/CNY17F	H or J	a	X	X	X	X	X	X		
H11A1/H11A2/H11A3/H11A4/H11A5	H or J	X	X	X	X	X	X			
H11AA1	H	X	X	X	X	X	X			
H11B1/H11B2/H11B3	H or J	X	X	X	X	X	X			
H11C4/H11C5/H11C6	H or J	a	X	X	X	X	X			
H11D1/H11D2/H11D3	H or J	a	X	X	X	X	X			
IL1/IL2/IL5	H or J	X	X	X	X	X	X			
IL30/IL31	H or J	X	X	X	X	X	X			
IL55	H or J	a	X	X	X	X	X			
IL55B	H or J	a	a	X	X	X	X			
IL66	H or J	X	X	X	X	X	X			
IL66B	H or J	a	X	X	X	X	X			
IL74	H or J	X	X	X	X	X	X			
IL201/IL202/IL203	H or J	X	X	X	X	X	X			
IL205A/IL206A/IL207A/IL208A	Y									
IL211A/IL212A/IL213A	Y									
IL215A/IL216A/IL217A	Y									
IL221A/IL222A/IL223A	Y									
IL250/IL251/IL252	H	X	X	X	X	X	X			
IL256A	Y									
IL300	H		X	X	X	X	X			
IL350/351/352/356/358/359										
IL400	H	X	X	X	X	X	X			
IL410	H	X	X							
IL420	H	X	X							
IL440				X	X	X	X			
IL485	J	X								
IL755	H	X	X	X	X	X	X			
IL755B	H	a	X	X	X	X	X			
IL766	H	a	X	X	X	X	X			
IL766B	H	a	X	X	X	X	X			
IL4108/ IL4208	H	X		X	X	X	X			
IL255				X	X					
IL4116/IL4117/IL4118	H	a	X	X	X	X	X			
IL4216/IL4217/IL4218	H	a	X	X	X	X	X			
ILCT6	H	X	X	X	X	X	X			
ILD1/ILD2/ILD5	H	X	X	X	X	X	X			
ILD3	H	X	a	X	X	X	X			
ILD30/ILD31/ILD32	H	X	X	X	X	X	X			
ILD55	H	X	X	X	X	X	X			
ILD66	H	X	X	X	X	X	X			
ILD74	H	X	X	X	X	X	X			
ILD205/ILD206/ILD207	Y									
ILD211/ILD213	Y									
ILD217	Y									
ILD223	Y									
ILD250/ILD251/ILD252	H	a	X	X	X	X	X			
ILD255	H	a	X	X	X	X	X			

X=available, a= pending approval

Optocoupler Agency Table

Part Numbers	UL E52744 System Code	CSA LRD93751	DIN VDE 0884	BSI IEC 65	BSI IEC950 EN60950	FIMKO IEC 65	FIMKO IEC950 EN60950	DEMKO	SEMKO	CECC
ILD256	Y									
ILD610	H	X	X	X	X	X	X			
ILD615	H	a	X	X	X	X	X			
ILD620/ILD620GB	H	a	X	X	X	X	X			
ILD621/ILD621GB	H	a	X	X	X	X	X			
ILD755	H	a	X	X	X	X	X			
ILD766	H	a	X	X	X	X	X			
ILH100										
ILH200										
ILQ1/ILQ2/ILQ5	H	X	X	X	X	X	X			
ILQ3	H		a	X	X	X	X			
ILQ30/ILQ31/ILQ32	H	X	X	X	X	X	X			
ILQ55	H	X	X	X	X	X	X			
ILQ66	H	X	X	X	X	X	X			
ILQ74	H	X	X	X	X	X	X			
ILQ615	H	a	X	X	X	X	X			
ILQ620/ILQ620GB	H	a	X	X	X	X	X			
ILQ621/ILQ621GB	H	a	X	X	X	X	X			
LH1056	H	a		X	X	X	X			
LH1298	H	a		X	X	X	X			
LH1529	H	a		X	X	X	X			
LH1540	H	a								
LH1550	H	X								
MCA230/MCA231/MCA255	H or J	X	X	X	X	X	X			
MCT2	H or J	X	X							
MCT2E	H or J	X	X	X	X	X	X			
MCT6	H	X	X	X	X	X	X			
MCT270 - MCT275	H or J	X	X	X	X	X	X			
MCT276/277	H or J	X	X	X	X	X	X			
MCT5210/MCT5211	H or J	a	X	X	X	X	X			
MOC8050	H or J	X		X	X	X	X			
MOC8111	H or J	X		X	X	X	X			
SFH600	J	a	X	X	X	X	X	X		
SFH601	J	a	X	X	X	X	X	X		X
SFH608	J	a	X	X	X	X	X			
SFH610A/611A	H or J	X	X	X	X	X	X			X
SFH615A/SFH617A	H or J	X	X	X	X	X	X			
SFH615AA/SFH615AGB	H or J	X	X	X	X	X	X			
SFH618A/628A	H or J	X	X	X	X	X	X			
SFH620A	H or J	X	X	X	X	X	X			
SFH620AA/SFH620AGB	H or J	X	X	X	X	X	X			
SFH636	J	a	a							
SFH640	J	a	X	X	X	X	X			
SFH6106	H or J	a	X	X	X	X	X			
SFH6116	H or J	a	X	X	X	X	X			
SFH6135/SFH6136	H		X							
SFH6138/SFH6139	H or J		X							
SFH6156	H or J	a	X	X	X	X	X			
SFH6186	H or J	a	X	X	X	X	X			
SFH6206	H or J	a	X	X	X	X	X			
SFH6286	H or J	a	X	X	X	X	X			
SFH6315/16/18/19	Y									
SFH6343	Y									
SFH6345	H		a							
SFH6941										

X=available, a= pending approval

Optocoupler Options

Siemens offers couplers in single, dual, quad, and small outline surface mount packages. The coupler types offered are high reliability, high voltage, triacs and linear, and high current transfer ratio. In addition to our true surface mount couplers, most of the standard couplers can be ordered with optional gull wing, surface mount lead bends. All surface mount lead couplers are available on tape and reel.

All couplers are recognized under the Component Program of Underwriters Laboratories, File #E52744.

Options:

1. Safe electrical isolation per VDE #0884.
2. Very high long-term stability of coupling factor (CTR).
3. Specified characteristics from 0°C to 70°C.
4. Faster switching times.
6. Wide lead spacing: 0.4" (10.16).
7. Surface mount leads (SMD).
9. Surface mount leads (SMD).

Examples of ordering optocouplers with options:

1. IL420 with option 1: IL420-X001
2. IL420 with option 1 and option 6: IL420-X016

The following optocouplers have been replaced by options:

Old Part No.	**New Part No.**
4N25-004	4N25-X009
4N25-009	4N25-X009
CNY17GF	CNY17F-X006
SFH601G	SFH601-X006
SFH6016	SFH601-X007
SFH6011	SFH601-X003
SFH606	SFH600-1X004

Device	Option 1	Option 2	Option 3	Option 4	Option 6	Option 7	Option 9
4N25/26/27/28	X				X	X	X
4N32/33	X				X	X	X
4N35/36/37	X				X	X	X
4N38					X	X	X
4N39					X	X	X
6N135/136	X				X	X	X
6N138/139	X				X	X	X
CNY17/CNY17F	X	X			X	X	X
H11A1/2/3/4/5	X				X	X	X
H11AA1	X				X	X	X
H11B1/2/3	X				X	X	X
H11C4/5/6	X				X	X	X
H11D1/2/3	X				X	X	X
IL1/2/5	X				X	X	X
IL30/31/55	X				X	X	X
IL55B	X				X	X	X
IL66	X				X	X	X
IL66B	X				X	X	X
IL74	X				X	X	X

Device	Option 1	Option 2	Option 3	Option 4	Option 6	Option 7	Option 9
IL201/2/3	X				X	X	X
IL205/6/7/8A							
IL211/2/3A							
IL215/6/7A							
IL221/2/3A							
IL250/1/2	X				X	X	X
IL256A							
IL300	X				X	X	X
IL329							
IL350/1/8/9							
IL352							
IL356							
IL400	X				X	X	X
IL410	X				X	X	X
IL420	X				X	X	X
IL440					X	X	X
IL485					X	X	X
IL755	X				X	X	X
IL755B	X				X	X	X
IL766	X				X	X	X
IL766B	X				X	X	X
IL4108					X	X	X
IL4116/7/8	X				X	X	X
IL4208					X	X	X
IL4216/7/8	X				X	X	X
ILCT6	X				X	X	X
ILD1/2/5	X				X	X	X
ILD3	X				X	X	X
ILD30/31/55	X				X	X	X
ILD32	X				X	X	X
ILD66	X				X	X	X
ILD74	X				X	X	X
ILD205/6/7/11/13/17							
ILD223							
ILD250/1/2	X				X	X	X
ILD255	X				X	X	X
ILD256							
ILD610	X				X	X	X
ILD615	X				X	X	X
ILD620/ILD620GB	X				X	X	X
ILD621/ILD621GB	X				X	X	X
ILD755	X				X	X	X
ILD766	X				X	X	X
ILH100							
ILH200							
ILQ1/2/5	X				X	X	X
ILQ3	X				X	X	X
ILQ30/31/55	X				X	X	X
ILQ32	X				X	X	X

Device	Option 1	Option 2	Option 3	Option 4	Option 6	Option 7	Option 9
ILQ66	X				X	X	X
ILQ74	X				X	X	X
ILQ615	X				X	X	X
ILQ620/ILQ620GB	X				X	X	X
ILQ621/ILQ621GB	X				X	X	X
MCA230/231/255	X				X	X	X
MCT2/MCT2E	X				X	X	X
MCT6	X				X	X	X
MCT270–MCT277	X				X	X	X
MCT5210/5211	X				X	X	X
MOC8050					X	X	X
MOC8111					X	X	X
SFH600	X	X	X	X	X	X	X
SFH601	X	X	X		X	X	X
SFH608	X				X	X	X
SFH610A/611A/615A/617A	X	X	X		X	X	X
SFH615AA/AGB	X	X			X	X	X
SFH618A/628A	X				X	X	X
SFH620A	X				X	X	X
SFH620AA/AGB	X				X	X	X
SFH636	X				X	X	X
SFH640	X				X	X	X
SFH6106	X						
SFH6116	X						
SFH6135/6136	X				X	X	X
SFH6138/6139	X				X	X	X
SFH6156	X						
SFH6206	X						
SFH6186	X						
SFH6286	X						
SFH6315/6316/6343							
SFH6318/6319							
SFH6345	X				X	X	X
SFH6941							

Option 1
Optocouplers for Safe Electrical Insulation per DIN VDE 0884*

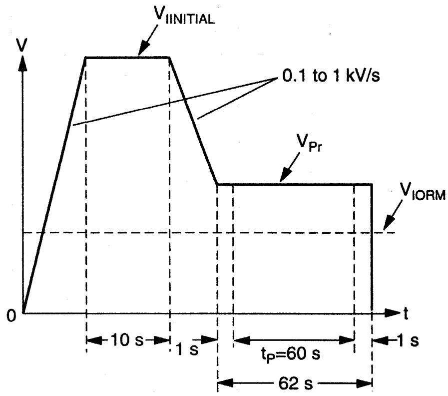
These optocouplers are suitable for safe electrical insulation only within the safety maximum ratings. Compliance with the safety maximum ratings must be ensured by protective circuits.

The partial discharge measurement ensures that no partial discharge occurs during operation at maximum permissible operating insulation voltage (V_{IORM}). Permanent partial discharge affects the insulating materials and can result in a high-voltage breakdown.

It is recommended that tests with the insulation test voltage (V_{ISOL}) should not be made, otherwise partial discharge may occur impairing the insulation characteris-tics. Thus partial discharges also may occur at the maximum permissible operating insulation voltage.

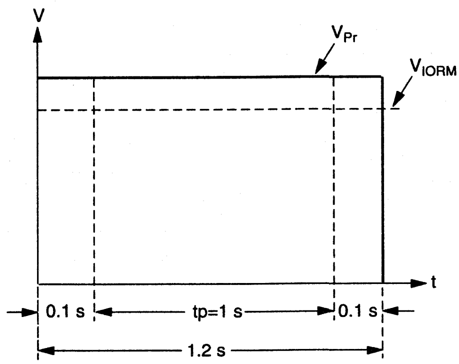
The insulation test per DIN VDE 0884 is carried out after all the other high voltage tests.

Time-Test Voltage Diagram per DIN VDE 0884*



tp-measuring time for partial discharge

Procedure a. Type & sampling tests, destructive tests



tp-measuring time for partial discharge

Procedure b. Routine tests, non-destructive tests

* DIN VDE 0884, edition June 1992

Optocouplers for safe electrical insulation per DIN VDE 0884*

Option 1: Insulation Characteristics

Description	Sym.	System 1	System 2	System 3 **	System 4 **	System 5 **	System 1	Unit
		DIP 4 SFH610A-.. SFH611A-.. SFH615A-.. SFH615AA-.. SFH615AGB-.. SFH617A-.. SFH618A-.. SFH620A-.. SFH620AA-.. SFH620AGB-.. SFH628A-.. SFH6106-.. SFH6116-.. SFH6156-.. SFH6186-.. SFH6206-.. SFH6286-.. **DIP 8** ILCT6 ILD1/2/5/74 ILD3 ILD30/31/55 ILD32 ILD66-.. ILD250/1/2 ILD255 ILD610-.. ILD615-.. ILD620-.. ILD621-.. ILD755-.. ILD766-.. MCT6 **DIP 16** ILQ1/2/5/74 ILQ3 ILQ30/31/55 ILQ32 ILQ66-.. ILQ615-.. ILQ620-.. ILQ621-..	4N25/26/27/28 4N35/36/37 4N32/33 CNY17-.. CNY17F-.. H11A-.. H11AA1 H11B1-.. H11C-.. H11D-.. IL1/2/5/74 IL2B-.. IL30/31/55 IL66-.. IL66B-.. IL201/202/203 IL250/251/252 IL400 IL755-.. IL755B-.. IL766-.. IL766B-.. MCA230/231 MCA255 MCT2/2E MCT270/271/272 MCT273/274/275 MCT276/277 MCT5210/5211 SFH600-.. SFH601-.. SFH608-.. SFH640-..		IL410 IL420	IL300	6N135 6N136 SFH6135 SFH6136 6N138 SFH6138 SFH6139 6N139	
Installation Category (DIN VDE 0110) for rated line voltages ≤300 V_{RMS} for rated line voltages ≤600 V_{RMS} for rated line voltages ≤1000 V_{RMS}		 I–IV I–III –	 I–IV I–III –	 I–IV I–III –	 I–IV I–III –	 I–IV I–III –	 I–IV I–III –	
IEC climatic category (DIN IEC 68 part 1/9.80)		55/100/21	55/100/21	55/100/21	55/100/21	55/100/21	55/100/21	

Description	Sym.	System 1	System 2	System 3 **	System 4 **	System 5 **	System 1	Unit
Pollution degree (DIN VDE 0110 part 1/ 1.89)		2	2	2	2	2	2	
Maximum Operation Insulation Voltage (1)	V_{IORM}	890	890	890	850	850	630	V
Test voltage input/output, procedure b (1) V_{Pr}=1.875 x V_{IORM}, Routine 100% test, t_P=1 s Partial Discharge <5 pC	V_{Pr}	1669	1669	1669	1594	1594	1181	V
Test voltage input/output, procedure b (1) V_{Pr}=1.5 x V_{IORM}, Type and sampling test, t_P=60 s Partial Discharge <5 pC	V_{Pr}	1335	1335	1335	1275	1275	945	V
Maximum permissible overvoltage (Transient overvoltage)	V_{IOTM}	8000	8000	6000	6000	6000	6000	V
Partial Discharge Test Voltage(1)	$V_{INITIAL}$	8000	8000	6000	6000	6000	6000	V
Safety maximum ratings (maximum permissible ratings in case of a fault, also refer to diagram)								
Package temperature	T_{si}	175	175	175	165	165	175	°C
Current (input current I_F, P_{Si}=0, T_A=25°C)	I_{si}	400	400	400	250	235	300	mA
Derating with higher ambient temperature	ΔI_{si}	–2.67	–2.67	–2.67	–1.79	–1.68	–2	mA/K
Power (Output or total power dissipation, T_A=25°C)	P_{si}	700	700	700	500	465	500	mW
Derating with higher ambient temperature	ΔP_{si}	–4.67	–4.67	–4.67	–3.57	–3.32	–3.33	mW/K
Insulation resistance at T_{si} $V_{I/O}$=500 V	R_{IS}	$\geq 10^9$	$\geq 10^9$	$\geq 10^9$	$\geq 10^9$	$\geq 10^9$	$\geq 10^9$	Ω

All voltages referred to are peak values except otherwise specified.

1. See time-test voltage diagram

*DIN VDE 0884, edition June 1992

**Approved per DIN VDE edition August 1987

Testing input/output voltage requires all input pins and all output pins to be shorted.

Option1: Tested per DIN VDE 0884

Option 6: Wide lead spacing
(10.16 mm, creepage/clearance distances >8 mm)
Option 7: Surface mount leads
(creepage/clearance distances >8 mm)
Option 9: Surface mount leads

See CECC 00802, edition 1, for soldering conditions for SMT devices
(option 7 and 9).
Systems 1 (4 pin coupler) and 2 are approved for class A

"-.." means dash selections.

Option 2
High-Rel Optocoupler With Very High Long-Term Stability of Coupling Factor (CTR)

Each optocoupler is tested for its degradation characteristics (change of current transfer ratio). The degradation behavior of the optocouplers tested during a short burn-in provides information on the long-term stability. Only optocouplers showing a minimum change in the current transfer ratio during burn-in are supplied. These optocouplers feature excellent long-term stability.

Test procedure:

- **First data logging**

The coupling factor (CTR_I) at I_F=1 mA, V_{CE}=5 V is logged.

- **Load**

Short-time burn-in: The emitter is loaded with a forward current of I_F=150 mA at room temperature (25°C) for 30 minutes.

- **Second data logging**

The coupling factor (CTR_2) at I_F=1 mA, V_{CE}=5 V is logged.

- **Evaluation**

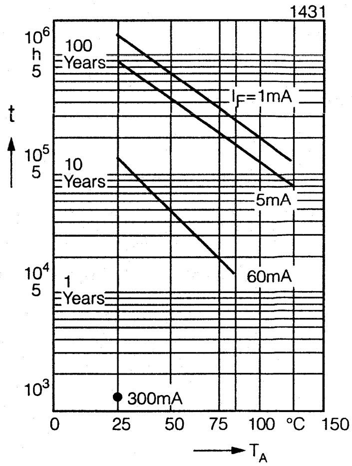
Determination of the relative change of the coupling factor:
DCTR (%)=100 x (1-CTR_2/CTR_I)

The change of the coupling factor DCTR caused by the burn-in may not be greater than a defined range. Thus the high long-term stability of the coupling factor shown in the graph can be specified. All couplers show a similar degradation behavior meaning that even after a longer operating time the coupling factor spread is not very wide.

- **Evaluation**

Determination of the relative change of the coupling factor:
DCTR (%)=100 x (1-CTR_2/CTR_I)

The change of the coupling factor DCTR caused by the burn-in may not be greater than a defined range. Thus the high long-term stability of the coupling factor shown in the graph can be specified. All couplers show a similar degradation behavior meaning that even after a longer operating time the coupling factor spread is not very wide.



Service life relative to temperature and current-load

Average expected service life extrapolated from laboratory tests. The end of the service life is defined as the time when the CTR falls to 50% of the initial value. Confidence level is 90%.

Option 3
Optocouplers with Specified Characteristics From 0°C to 70°C

Parameter	Symbol	Values	Unit	Condition
Emitter (IR GaAs LED)				
Forward voltage	V_F	1.25 (≤1.65)	V	I_F=60 mA
Breakdown voltage	V_{BR}	≥6		I_R=10 µA
Reverse current	I_R	0.01 (≤10)	µA	V_R=6V
Detector (Si phototransistor)				
Collector-emitter breakdown voltage	V_{CEO}	≥70	V	I_{CE} =10 µA
Emitter-base breakdown voltage	V_{EBO}	≥7		I_{EBO}=10 µA
Optocoupler				
Collector-emitter saturation voltage	V_{CEsat}	0.25 (≤0.4)	V	I_F =10 mA, I_C=2.5 mA,

These optocouplers are grouped according to their current transfer ratio I_C/I_F at V_{CE}=5V and are marked by dash numbers.

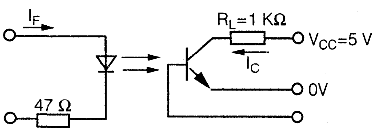
Parameter	Symbol	Values				Unit	Condition
Dash Numbers		**–1**	**–2**	**–3**	**–4**		
Dash Numbers for SFH600 only		**–0**	**–1**	**–2**	**–3**		
Current transfer ratio	I_C/I_F	35–85	55–135	80–210	140–340	%	I_F=10 mA
		30(>10)	45(>17)	70(>28)	90(>45)		I_F=1 mA
Collector-emitter leakage current	I_{CEO}	≤500	≤500	≤1000	≤1000	nA	V_{CE}=10V

Option 4
Selection of Optocouplers with Fast Switching Time (For SFH 600 Only)

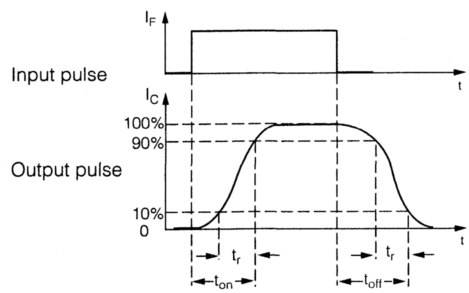
These optocouplers comply with the switching times listed in the table below. In addition, the devices are 100% tested to ensure the values.

Parameter	Sym.	Values			Unit
		–0 I_F = 20 mA	–1 I_F = 10 mA	–2 I_F = 10 mA	
Turn-on time	t_{on}	≤4.5			µs
Rise time	t_r	≤3			
Turn-off time	t_{off}	≤12	≤14	≤20	
Fall time	t_f	≤7	≤10	≤12	

Test circuit (saturated, V_{CEsat} ≤0.4 V)



Pulse Definition



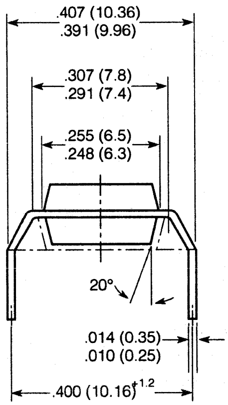
Option 6
DIP Optocouplers with 0.4" (10.16 mm) Lead Spread.

The leads of the optocouplers are bent according to a spacing of 0.4" (10.16 mm). Dimensions deviating from the standard type are:

Lead spacing	10.16 mm (0.4")
Creepage distance	>8.0 mm
Clearance	>8.0 mm

This version additionally complies with the following standards:

- IEC 950 DIN VDE 0805/05 90 (System 2 and 3 only) Reinforced insulation up to an operating voltage of 400 V_{RMS} or DC



Clearance-creepage distance=8.0 min
See standard version for pin configuration

Option 7
Lead Bends for Surface Mount Optocouplers

These optocouplers are suitable for surface mounting. Dimensions deviating from the standard type are:

Creepage distance	>8.0 mm
Clearance	>8.0 mm

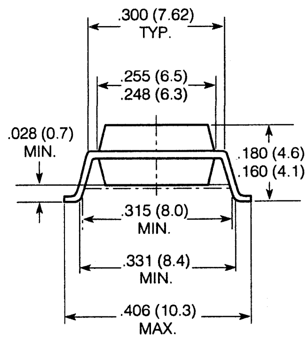
This version additionally complies with the following standards:

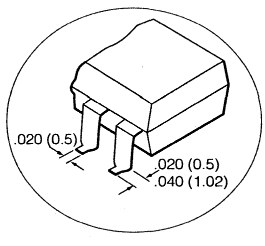
- IEC 950 DIN VDE 0805/05 90 (System 2 and 3 only) Reinforced insulation up to an operating voltage of 400 VRMS or DC

During the soldering process, the package should not be wetted with tin-lead solder to prevent the impairment of the isolation features. Apart from iron soldering, only reflow soldering methods (vapor phase, infrared and hot gas) are permissible.

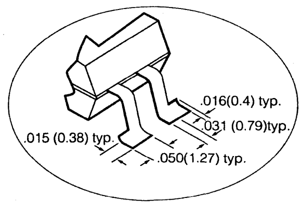
Permissible soldering conditions:
260°C at 10 seconds to 215°C at 30 seconds

The soldering process may be repeated two times at the most. Attention must be paid to the cooling down of the device to 25°C between the soldering processes.





DIP 6



DIP 4/8/16

Clearance and creepage distances must be considered for the solder pad design.

Clearance-creepage distance=8.0 min.
See standard version for pin configuration.

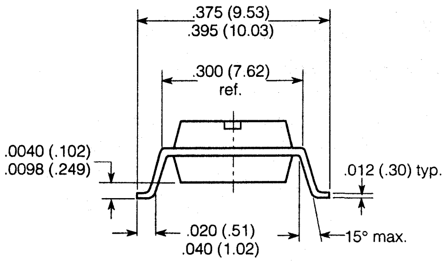
Option 9
Lead Bends for Surface Mount Optocouplers

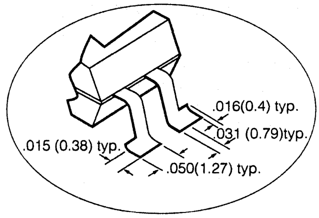
During the soldering process, the package should not be wetted with tin-lead solder to prevent the impairment of the isolation features. Apart from iron soldering, only reflow soldering methods (vapor phase, infrared and hot gas) are permissible.

Permissible soldering conditions:

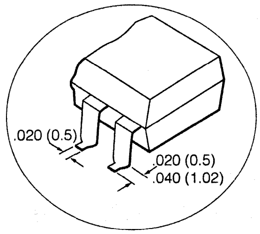
260°C at 10 seconds to 215°C at 30 seconds

The soldering process may be repeated two times at the most. Attention must be paid to the cooling down of the device to 25°C between the soldering processes.





DIP 4/8/16

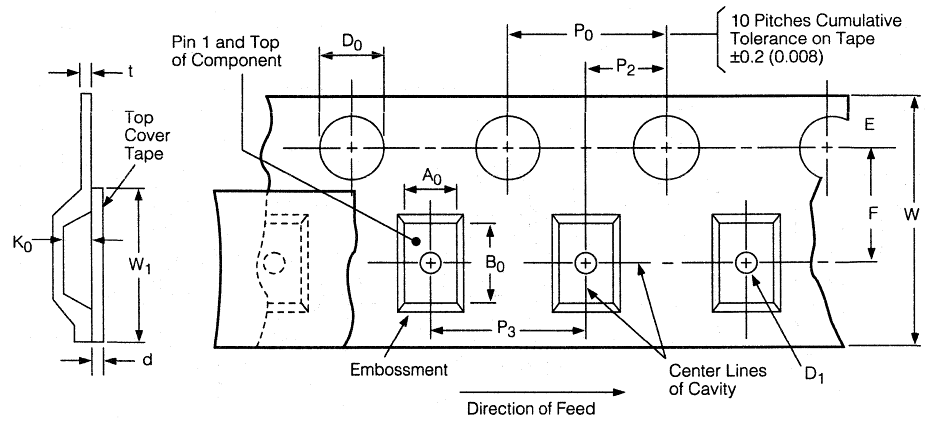


DIP 6

Tape and Reel Packaging for Single Channel SOIC8 Optocouplers

All SOIC8 optocouplers are available in tape and reel format. To order any surface mount IL2XXA optocoupler on tape and reel, add a suffix "T" after the part number, i.e., IL207AT.

The tape is 12 mm wide for single channel and 16mm for dual channel. Both tape widths have 2000 parts on a 33 cm reel. Taped and reeled SOIC8-A optocouplers conform to EIA-481-2.

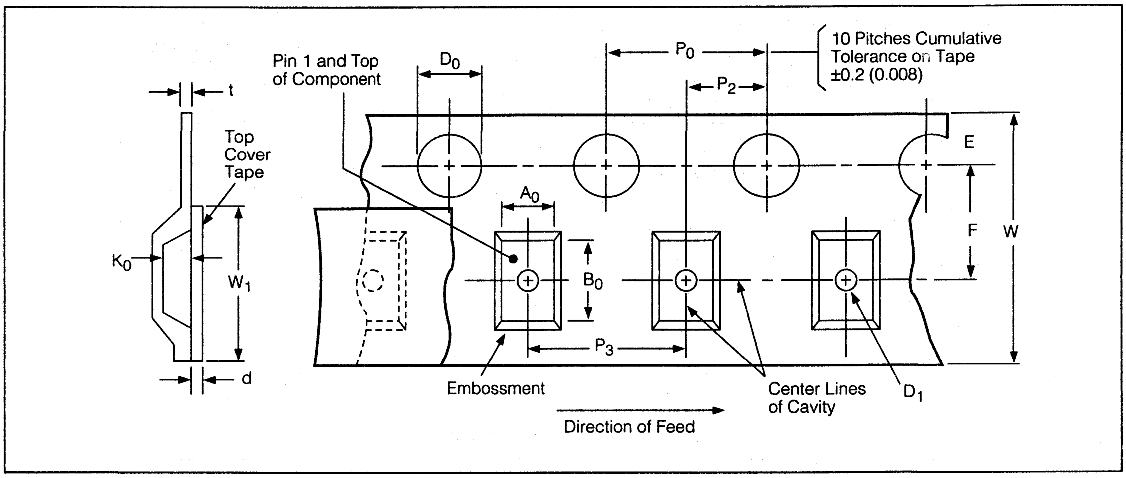


Description	Symbol	Dimensions in Inches (mm) SOIC8-A	Notes
Tape width	W	.472 ±.012 (12.0 ±.3)	Single channel
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.004 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.315 ±.004 (8.0 ±0.1)	
Compartment	K_0 A_0 B_0	.142 (3.6) .256 (6.5) .252 (6.4)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Tape and Reel Packaging for Dual Channel SOIC8 Optocouplers

All dual SOIC8 optocouplers are available in tape and reel format. To order any surface mount ILD2XX optocoupler on tape and reel, add a suffix "T" after the part number, i.e., ILD207T.

The tape is 16 mm and is wound on a 33 cm reel. There are 2000 parts per reel. Taped and reeled dual SOIC8 optocouplers conform to EIA-481-2.

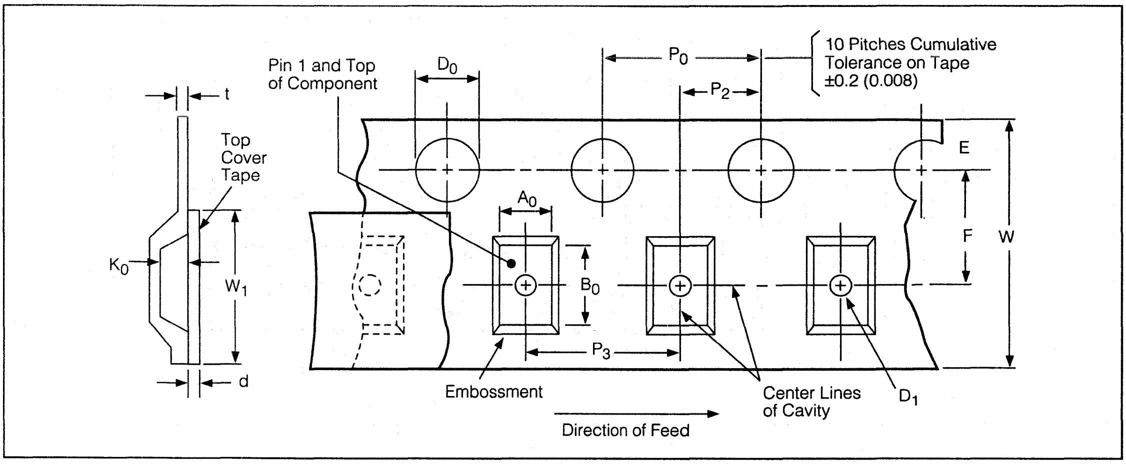


Description	Symbol	Dimensions in Inches (mm) Dual SOIC8	Notes
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.300 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.480 ±.004 (12.0 ±0.1)	
Compartment	K_0 A_0 B_0	.155 (3.95) .266 (6.75) .256 (6.4)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Tape and Reel Packaging for 4-Pin Optocouplers

All 4-pin optocouplers are available in tape and reel format. To order any 4-pin optocoupler on tape and reel, add a suffix "T" after the part number, i.e., SFH6156-3T, SFH615A-3X009T or SFH615A-3X007T.

The tape is 16 mm wide and is wound on a 33 cm reel. There are 1000 parts per reel. Taped and reeled 4-pin optocouplers conform to EIA-481-2.

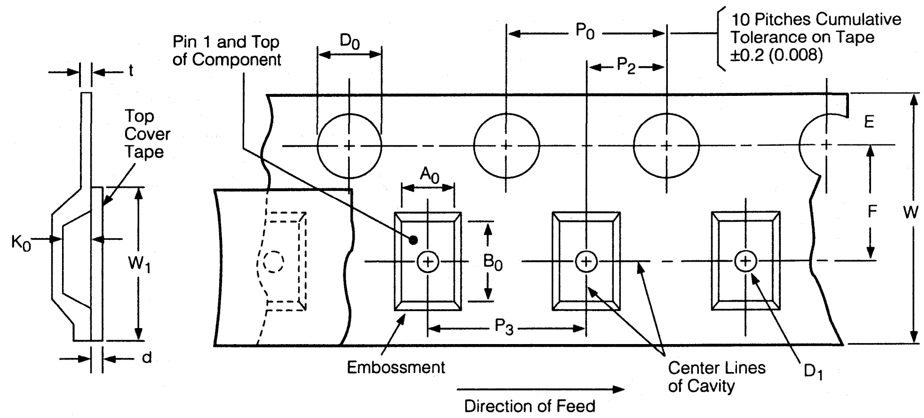


Description	Symbol	Dimensions in Inches (mm) 4-Pin	Notes
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 (12.0)	
Compartment: Option 9 or SFH6xx6	K_0 A_0 B_0	.158 (4.01) .402 (10.21) .198 (5.03)	
Compartment: Option 7	K_0 A_0 B_0	.194 (4.93) .421 (10.7) .209 (5.3)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width

Tape and Reel Packaging for 6-Pin Optocouplers with Option 7

All 6-pin optocouplers with Option 7 are available in tape and reel format. To order any 6-pin optocoupler with Option 7 on tape and reel, add a suffix "T" after the option, i.e., CNY17-3X007T.

The tape is 16 mm and is wound on a 33 cm reel. There are 1000 parts per reel. Taped and reeled 6-pin optocouplers conform to EIA-481-2.

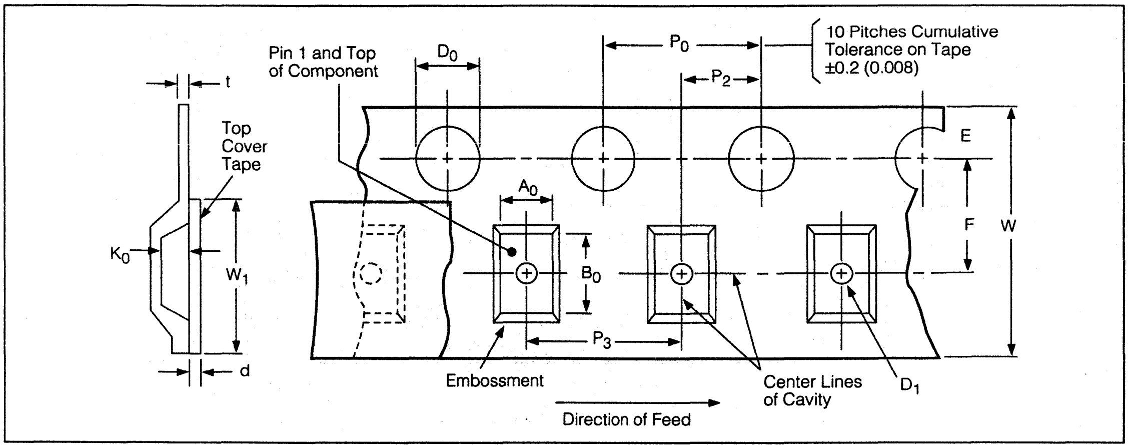


Description	**Symbol**	**Dimensions in Inches (mm) 6-Pin with Option 7**	**Notes**
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 (12.0)	
Compartment	K_0 A_0 B_0	.180 (4.57) .410 (10.4) .362 (9.2)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Tape and Reel Packaging for 6-Pin Optocouplers with Option 9

All 6-pin optocouplers with Option 9 are available in tape and reel format. To order any 6-pin optocoupler with Option 9 on tape and reel, add a suffix "T" after the option, i.e., CNY17-3X009T.

The tape is 16 mm and is wound on a 33 cm reel. There are 1000 parts per reel. Taped and reeled 6-pin optocouplers conform to EIA-481-2.

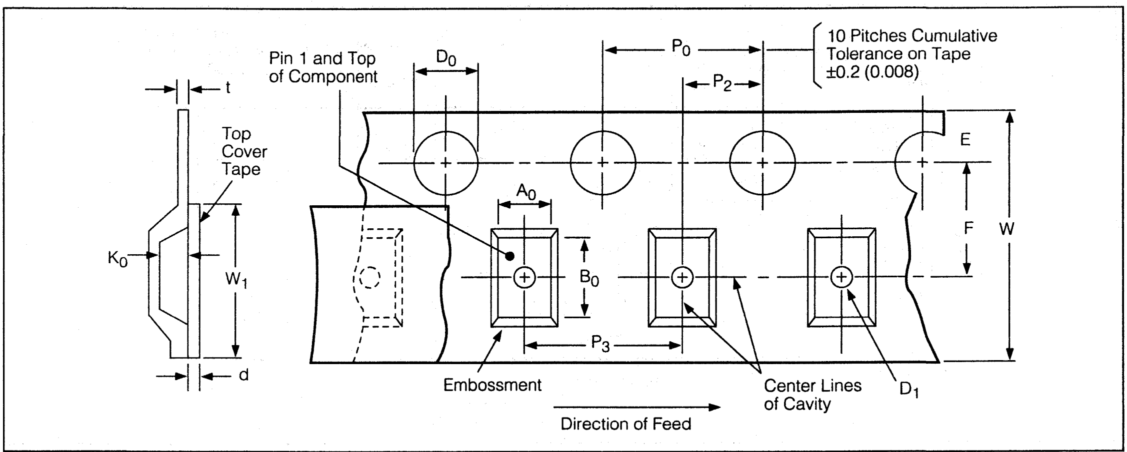


Description	Symbol	Dimensions in Inches (mm) 6-Pin with Option 9	Notes
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 (12.0)	
Compartment	K_0 A_0 B_0	.158 (4.01) .402 (10.21) .362 (9.2)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Tape and Reel Packaging for 8-Pin Optocouplers with Option 7

All 8-pin optocouplers with Option 9 are available in tape and reel format. To order any 8-pin optocoupler with Option 7 on tape and reel, add a suffix "T" after the option, i.e., ILCT6-X007T.

The tape is 16 mm and is wound on a 33 cm reel. There are 1000 parts per reel. Taped and reeled 8-pin optocouplers conform to EIA-481-2.

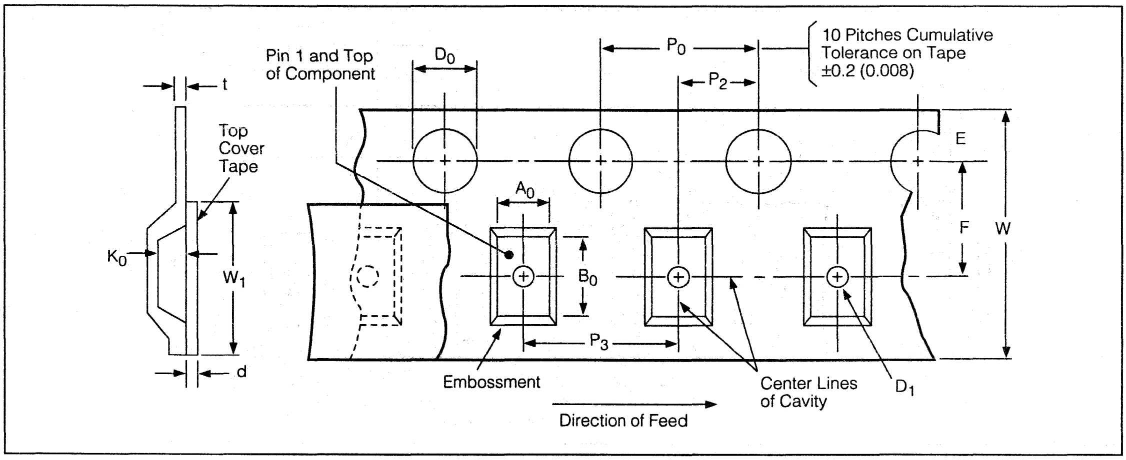


Description	Symbol	Dimensions in Inches (mm) 8-Pin with Option 7	Notes
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 (12.0)	
Compartment	K_0 A_0 B_0	.180 (4.57) .410 (10.41) .406 (10.3)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Tape and Reel Packaging for 8-Pin Optocouplers with Option 9

All 8-pin optocouplers with Option 9 are available in tape and reel format. To order any 8-pin optocoupler with Option 9 on tape and reel, add a suffix "T" after the option, i.e., ILCT6-X009T.

The tape is 16 mm and is wound on a 33 cm reel. There are 1000 parts per reel. Taped and reeled 8-pin optocouplers conform to EIA-481-2.



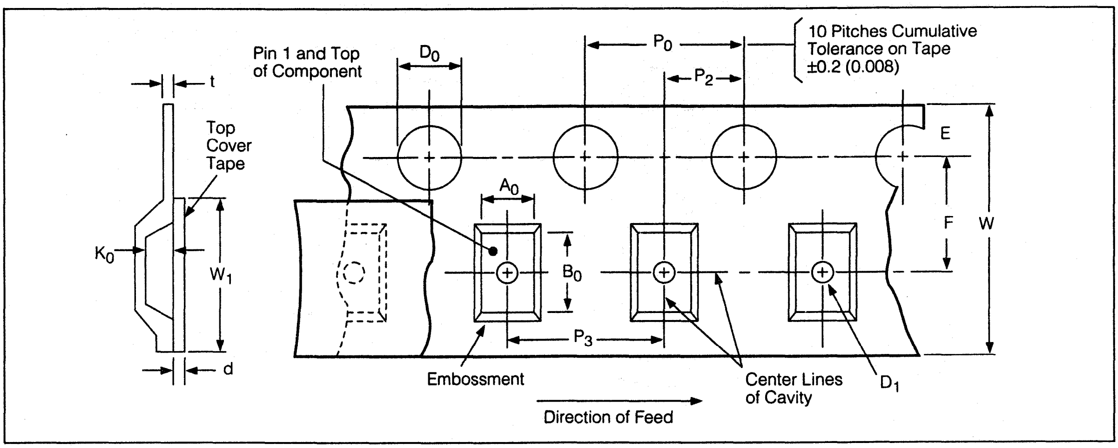
Description	Symbol	Dimensions in Inches (mm) 8-Pin with Option 9	Notes
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 (12.0)	
Compartment	K_0 A_0 B_0	.167 (4.24) .402 (10.2) .406 (10.3)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Optocouplers (Optoisolators) 5

Tape and Reel Packaging for 16-Pin Optocouplers with Option 7

All 16-pin optocouplers with Option 7 are available in tape and reel format. To order any 16-pin optocoupler with Option 7 on tape and reel, add a suffix "T" after the option, i.e., ILQ-X007T.

The tape is 32 mm and is wound on a 33 cm reel. There are 750 parts per reel. Taped and reeled 16-pin optocouplers conform to EIA-481.

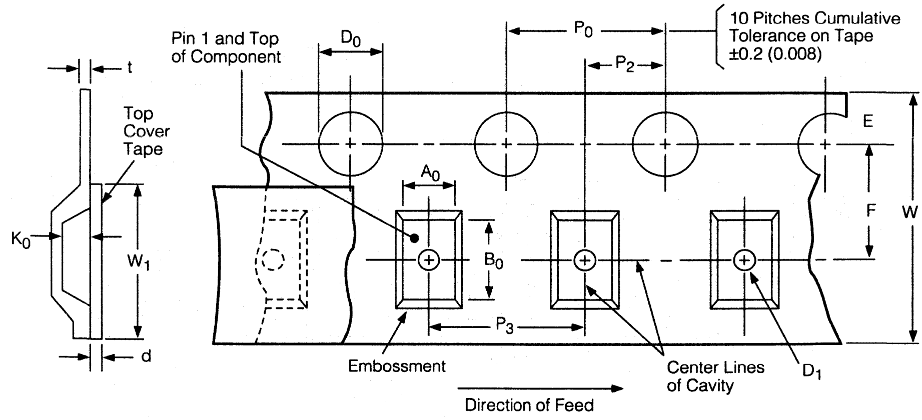


Description	Symbol	Dimensions in Inches (mm) 16-Pin with Option 7	Notes
Tape width	W	1.260 (32)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.559 ±.002 (14.2 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.630 (16.0)	
Compartment	K_0 A_0 B_0	.180 (4.57) .410 (10.41) .805 (20.45)	
Hole in compartment	D_1	.079 (2.0)	
Width of fixing tape	W_1 d	1.116 (28.4) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Tape and Reel Packaging for 16-Pin Optocouplers with Option 9

All 16-pin optocouplers with Option 9 are available in tape and reel format. To order any 16-pin optocoupler with Option 9 on tape and reel, add a suffix "T" after the option, i.e., ILQ1-X009T.

The tape is 32 mm and is wound on a 33 cm reel. There are 750 parts per reel. Taped and reeled 16-pin optocouplers conform to EIA-481.

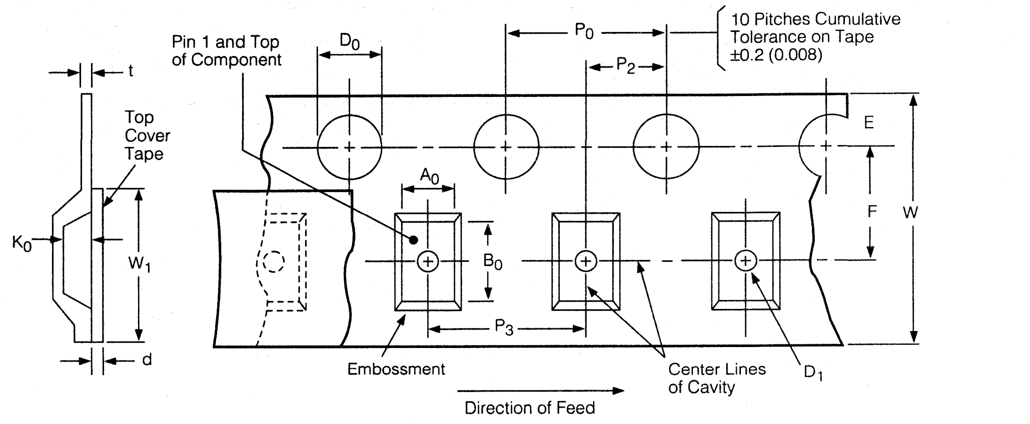


Description	Symbol	Dimensions in Inches (mm) 16-Pin with Option 9	Notes
Tape width	W	1.260 (32)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.559 ±.002 (14.2 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.630 (16.0)	
Compartment	K_0 A_0 B_0	.167 (4.25) .408 (10.35) .813 (20.65)	
Hole in compartment	D_1	.079 (2.0)	
Width of fixing tape	W_1 d	1.116 (28.4) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Tape and Reel Packaging for 8-Pin 2 mm Optocouplers

All 8-pin 2 mm optocouplers are available in tape and reel format. To order any 8-pin 2 mm optocoupler on tape and reel, add a suffix "T" after the part number.

The tape is 16 mm and is wound on a 33 cm reel. There are 2000 parts per reel. Taped and reeled 8-pin 2mm optocouplers conform to EIA-481.

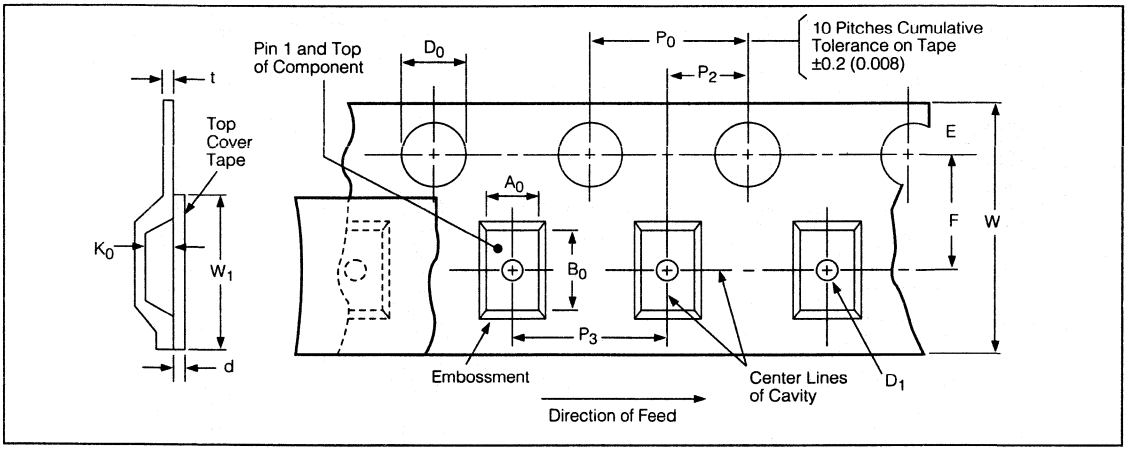


Description	Symbol	Dimensions in Inches (mm) 2 mm Package	Notes
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004(1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 ±.004 (12.0 ±0.1)	
Compartment	K_0 A_0 B_0	.104 (2.65) .361 (9.17) .251 (6.38)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Tape and Reel Packaging for 10-Pin Mini-couplers

All 10-pin mini-couplers are available in tape and reel format. To order any surface mount optocoupler on tape and reel, add a suffix "T" after the part number.

The tape is 16 mm and is wound on a 33 cm reel. There are 2000 parts per reel. Taped and reeled 10-pin mini-couplers conform to EIA-481.



Description	Symbol	Dimensions in Inches (mm) 10-Pin Mini-coupler	Notes
Tape width	W	.630 (16.0)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cummulative pitch error+0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 ±.004 (12.0 ±0.1)	
Compartment	K_0 A_0 B_0	.079 (2.0) .295 (7.5) .276 (7.0)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Figure 1. 4-pin SMD option 7

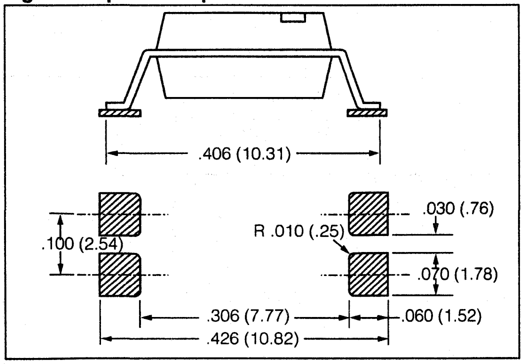


Figure 2. 6-pin SMD option 7

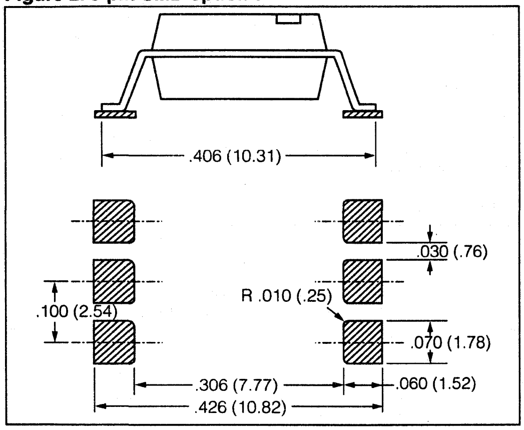


Figure 3. 8-pin SMD option 7

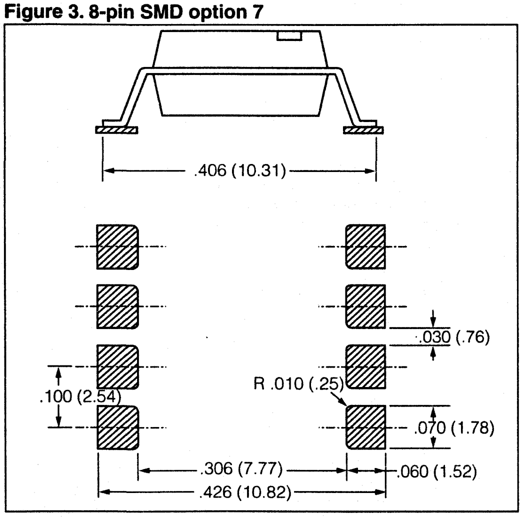


Figure 4. 18-pin SMD option 7

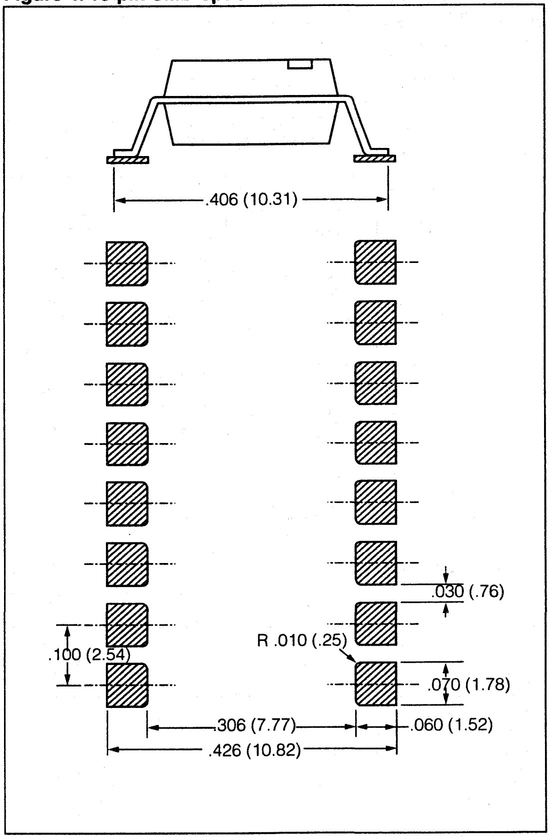


Figure 5. 4-pin SMD option 9

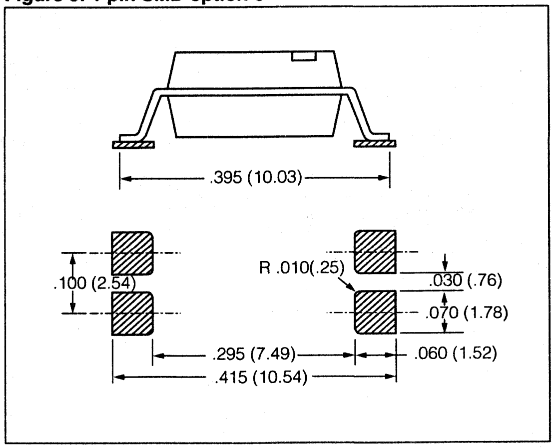


Figure 6. 6-pin SMD option 9

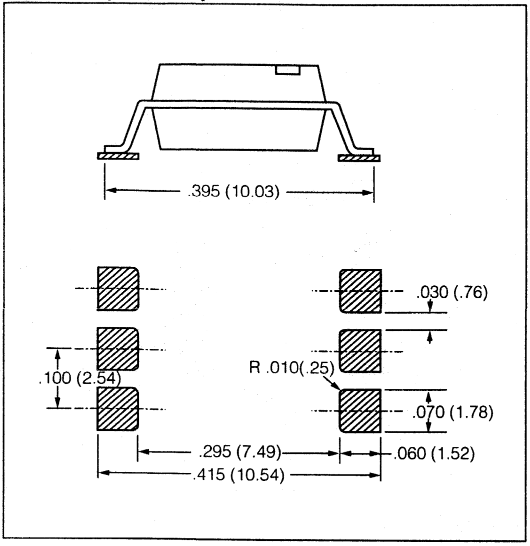


Figure 7. 8-pin SMD option 9

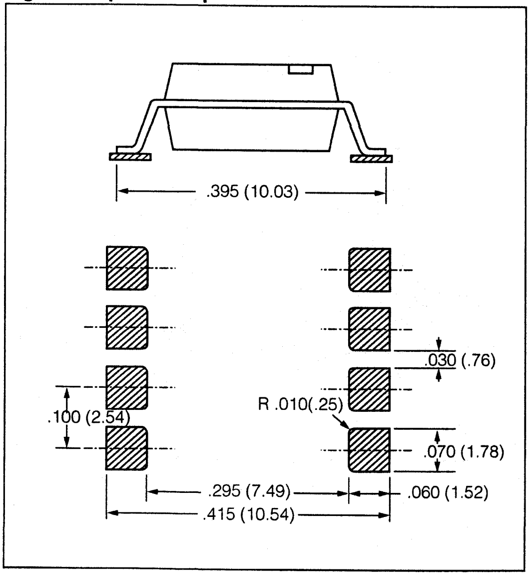


Figure 8. 16-pin SMD option 9

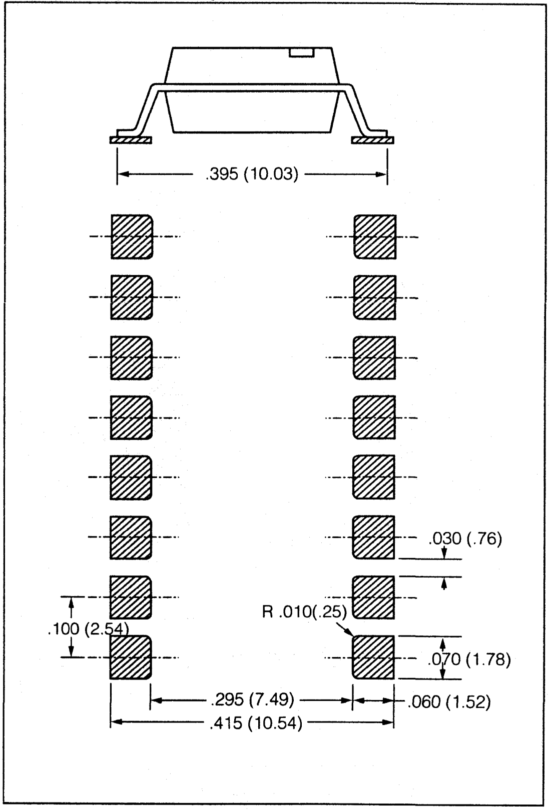


Figure 9. 8-pin PCMCIA

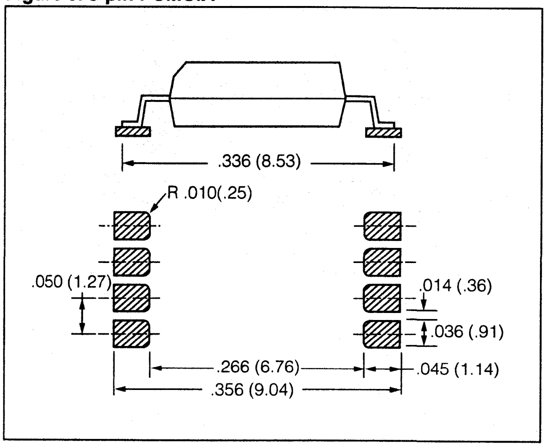


Figure 10. 16-pin PCMCIA

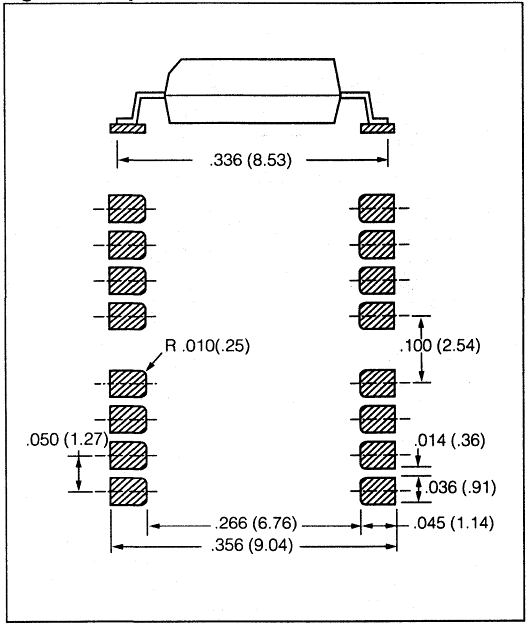


Figure 11. 8-pin PCMCIA, heatsink

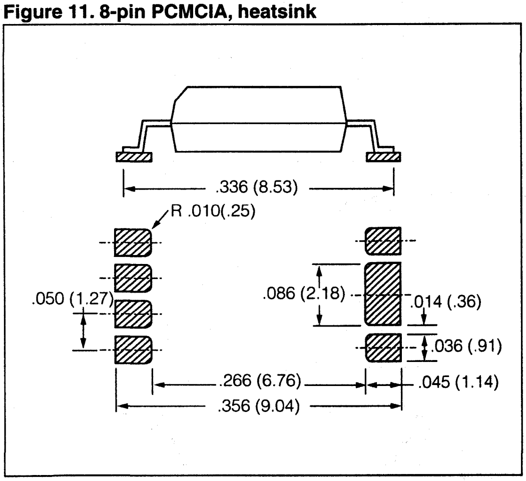


Figure 12. SO8A and DSO8A SMD

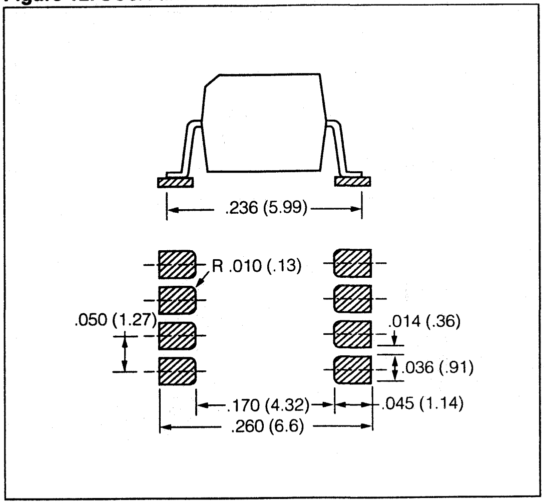
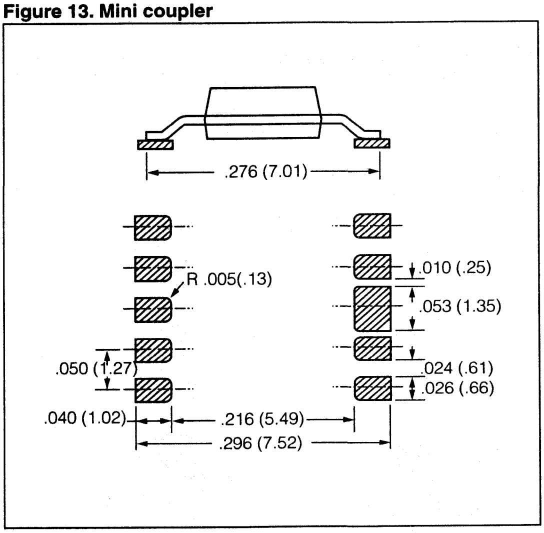


Figure 13. Mini coupler



SIEMENS

PHOTOTRANSISTOR
Industry Standard Single Channel 6 Pin DIP Optocoupler

DEVICE TYPES

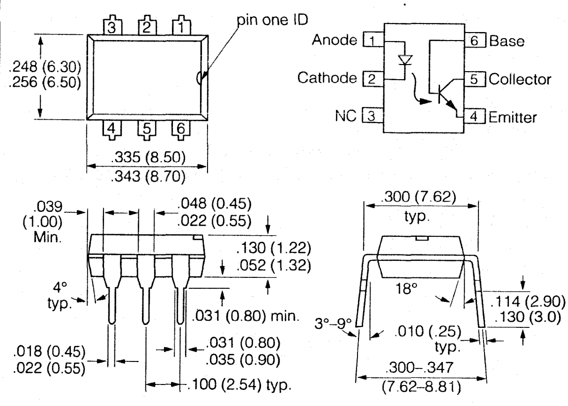
Part No.	CTR, % Min.	Part No.	CTR % Min.
4N25	20	MCT2	20
4N26	20	MCT2E	20
4N27	10	MCT270	50
4N28	10	MCT271	45–90
4N35	100	MCT272	75–150
4N36	100	MCT273	125–250
4N37	100	MCT274	225–400
4N38	10	MCT275	70–90
H11A1	50	MCT276	15–60
H11A2	20	MCT277	100
H11A3	20		
H11A4	10		
H11A5	30		

FEATURES
- **Interfaces with Common Logic Families**
- **Input-output Coupling Capacitance < 0.5 pF**
- **Industry Standard Dual-in-line 6-pin Package**
- **Field Effect Stable by TRIOS**
- **5300 VAC_{RMS} Isolation Test Voltage**
- **Recognized under Underwriters Laboratory File #E52744**
- **VDE #0884 Approval Available with Option -001**

APPLICATIONS
- **AC Mains Detection**
- **Reed Relay Driving**
- **Switch Mode Power Supply Feedback**
- **Telephone Ring Detection**
- **Logic Ground Isolation**
- **Logic Coupling with High Frequency Noise Rejection**

Notes:
1. TRIOS=TRansparent IOn Shield
2. Designing with data sheet is covered in Application Note 45, Application Notes section of Data Book.

Dimensions in Inches (mm)



DESCRIPTION

This data sheet presents five families of Siemens Industry Standard Single Channel Phototransistor Couplers. These families include the 4N25/26/27/28 types, the 4N35/36/37/38 couplers, the H11A1/A2/A3/A4/A5, the MCT2/2E, and MCT270/271/272/273/274/275/276/277 devices.Each optocoupler consists of Gallium Arsenide infrared LED and a silicon NPN phototransistor.

All couplers are Underwriters Laboratories (UL) listed to comply with a 7500 $V_{AC(PK)}$ Isolation Test Voltage. This isolation performance is accomplished through Siemens double molding isolation manufacturing process. Compliance to VDE 0884 partial discharge isolation specification is available for these families by ordering option -001. Phototransistor gain stability, in the presence of high isolation voltages, is insured by incorporating a TRansparent IOn Shield (TRIOS) on the phototransistor substrate. These isolation processes and the Siemens IS09001 Quality program results in the highest isolation performance available for a commercial plastic phototransistor optocoupler.

The devices are available in lead formed configuration suitable for surface mounting and are available either on tape and reel, or in standard tube shipping containers.

Maximum Ratings T_A=25°C

Emitter

Reverse Voltage .... 6 V
Forward Current .... 60 mA
Surge Current (t≤10 µs) .... 2.5 A
Power Dissipation .... 100 mW

Detector

Collector-Emitter Breakdown Voltage .... 70 V
Emitter-Base Breakdown Voltage .... 7 V
Collector Current .... 50 mA
Collector Current (t <1 ms) .... 100 mA
Power Dissipation .... 150 mW

Package

Isolation Test Voltage .... 5300 VAC_{RMS}
Creepage .... ≥7 mm
Clearance .... ≥7 mm
Isolation Thickness between Emitter and Detector .... ≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE0303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... 10^{12} Ω
V_{IO}=500 V, T_A=100°C .... 10^{11} Ω
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature (max. 10 s, dip soldering:
distance to seating plane ≥1.5 mm) .... 260°C

4N25/26/27/28—Characteristics T_A=25°C

Emitter		**Symbol**	**Min.**	**Typ.**	**Max.**	**Unit**	**Condition**
Forward Voltage*		V_F		1.3	1.5	V	I_F=50 mA
Reverse Current*		I_R		0.1	100	µA	V_R=3.0 V
Capacitance		C_O		25		pF	V_R=0
Detector							
Breakdown Voltage*	Collector-Emitter	BV_{CEO}	30			V	I_C=1 mA
	Emitter-Collector	BV_{ECO}	7				I_E=100 µA
	Collector-Base	BV_{CBO}	70				I_C=100 µA
I_{CEO}(dark)*	4N25/26/27 4N28			5 10	50 100	nA	V_{CE}=10 V, (base open)
I_{CBO}(dark)*				2	20	nA	V_{CB}=10 V, (emitter open)
Capacitance, Collector-Emitter		C_{CE}		6		pF	V_{CE}=0
Package							
DC Current Transfer Ratio*	4N25/26	CTR	20	50		%	V_{CE}=10 V, I_F=10 mA
	4N27/28		10	30			
Isolation Voltage*	4N25	V_{IO}	2500			V	Peak, 60 Hz
	4N26/27		1500				
	4N28		500				
Saturation Voltage, Collector-Emitter		$V_{CE(sat)}$			0.5	V	I_{CE}=2.0 mA, I_F=50 mA
Resistance, Input to Output*		R_{IO}	100			GΩ	V_{IO}=500 V
Coupling Capacitance		C_{IO}		0.5		pF	f=1 MHz
Rise and Fall Times		t_R, t_F		2		µs	I_F=10 mA V_{CE}=10 V, R_E=100 Ω

* Indicates JEDEC registered values

4N35/36/37/38—Characteristics T_A=25°C

Emitter		Symbol	Min.	Typ.	Max.	Unit	Condition
Forward Voltage*		V_F		1.3	1.5	V	I_F=10 mA
			0.9		1.7		I_F=10 mA, T_A=–55°C
Reverse Current*		I_R		0.1	10	µA	V_R=6.0 V
Capacitance		C_O		25		pF	V_R=0, f=1 MHz
Detector							
Breakdown Voltage, Collector-Emitter*	4N35/36/37	BV_{CEO}	30			V	I_C=1 mA
	4N38		80				
Breakdown Voltage, Emitter-Collector*		BV_{ECO}	7			V	I_E=100 µA
Breakdown Voltage, Collector-Base*	4N35/36/37	BV_{CBO}	70			V	I_C=100 µA, I_B=1 µA
	4N38		80				
Leakage Current, Collector-Emitter*	4N35/36/37	I_{CEO}		5	50	nA	V_{CE}=10 V, I_F=0
	4N38				50		V_{CE}=60 V, I_F=0
Leakage Current,Collector-Emitter*	4N35/36/37	I_{CEO}			500	µA	V_{CE}=30 V, I_F=0, T_A=100°C
	4N38			6			V_{CE}=60 V, I_F=0, T_A=100°C
Capacitance, Collector-Emitter		C_{CE}		6		pF	V_{CE}=0
Package							
DC Current Transfer Ratio*	4N35/36/37	CTR	100			%	V_{CE}=10 V, I_F=10 mA,
	4N38		20				V_{CE}=1 V, I_F=20 mA
DC Current Transfer Ratio*	4N35/36/37	CTR	40	50		%	V_{CE}=10 V, I_F=10 mA, T_A=–55 to 100°C
	4N38			30			
Resistance, Input to Output*		R_{IO}	10^{11}			W	V_{IO}=500 V
Coupling Capacitance*		C_{IO}		0.5		pF	f=1 MHz
Switching Time*		t_{ON}, t_{OFF}		10		µs	I_C=2 mA, R_E=100 Ω, V_{CC}=10 V

* Indicates JEDEC registered value

H11A1 through H11A5—Characteristics T_A=25°C

Emitter		Symbol	Min.	Typ.	Max.	Unit	Condition
Forward Voltage	H11A1–H11A4	V_F		1.1	1.5	V	I_F=10 mA
	H11A5			1.1	1.7		
Reverse Current		I_R			10	µA	V_R=3 V
Capacitance		C_0		50		pF	V_R=0, f=1 MHz
Detector							
Breakdown Voltage, Collector-Emitter		BV_{CEO}	30			V	I_C=1 mA, I_F=0 mA
Breakdown Voltage, Emitter-Collector		BV_{ECO}	7			V	I_E=100 µA, I_F=0 mA
Breakdown Voltage, Collector-Base		BV_{CBO}	70			V	I_C=10 µA, I_F=0 mA
Leakage Current, Collector-Emitter		I_{CEO}		5	50	nA	V_{CE}=10 V, I_F=0 mA
Capacitance, Collector-Emitter		C_{CE}		6		pF	V_{CE}=0
Package							
DC Current Transfer Ratio	H11A1	CTR	50			%	V_{CE}=10 V, I_F=10 mA
	H11A2/3		20				
	H11A4		10				
	H11A5		30				
Saturation Voltage, Collector-Emitter		V_{CEsat}			0.4	V	I_{CE}=0.5 mA, I_F=10 mA
Capacitance, Input to Output		C_{IO}		0.5		pF	
Switching Time		t_{ON}, t_{OFF}		3.0		µs	I_C=2 mA, R_E=100 Ω, V_{CE}=10 V

MCT2/MCT2E—Characteristics T_A=25°C

Emitter		Symbol	Min.	Typ.	Max.	Unit	Condition
Forward Voltage		V_F		1.1	1.5	V	I_F=20 mA
Reverse Current		I_R			10	µA	V_R=3 V
Capacitance		C_O		25		pF	V_R=0, f=1 MHz
Detector							
Breakdown Voltage	Collector-Emitter	BV_{CEO}	30			V	I_C=1 mA, I_F=0 mA
	Emitter-Collector	BV_{ECO}	7				I_E=100 µA, I_F=0 mA
	Collector-Base	BV_{CBO}	70				I_C=10 µA, I_F=0 mA
Leakage Current	Collector-Emitter	I_{CBO}		5	50	nA	V_{CE}=10 V, I_F=0
	Collector-Base	I_{CBO}			20		
Capacitance, Collector-Emitter		C_{CE}		10		pF	V_{CE}=0
Package							
DC Current Transfer Ratio		CTR	20	60		%	V_{CE}=10 V, I_F=10 mA
Capacitance, Input to Output		C_{IO}		0.5		pF	
Resistance, Input to Output		R_{IO}		100		GΩ	
Switching Time		t_{ON}, t_{OFF}		3.0		µs	I_C=2 mA, R_E=100 Ω, V_{CE}=10 V

MCT270 through MCT277—Characteristics T_A=25°C

Emitter		Symbol	Min.	Typ.	Max.	Unit	Condition
Forward Voltage		V_F			1.5	V	I_F=20 mA
Reverse Current		I_R			10	µA	V_R=3 V
Capacitance		C_O		25		pF	V_R=0, f=1 MHz
Detector							
Breakdown Voltage	Collector-Em"itter	BV_{CEO}	30			V	I_C=10 µA, I_F=0 mA
	Emitter-Collector	BV_{ECO}	7				I_E=10 µA, I_F=0 mA
	Collector-Base	BV_{CBO}	70				I_C=10 µA, I_F=0 mA
Leakage Current, Collector-Emitter		I_{CEO}			50	nA	V_{CE}=10 V, I_F=0 mA
Package							
DC Current Transfer Ratio	MCT270	CTR	50			%	V_{CE}=10 V, I_F=10 mA
	MCT271		45		90		
	MCT272		75		150		
	MCT273		125		250		
	MCT274		225		400		
	MCT275		70		210		
	MCT276		15		60		
	MCT277		100				
Current Transfer Ratio, Collector–Emitter	MCT271–276	CTR_{CE}	12.5			%	V_{CE}=0.4 V, I_F=16 mA
	MCT277		40				
Collector–Emitter Saturation Voltage		V_{CEsat}			0.4	V	I_{CE}=2 mA, I_F=16 mA
Capacitance, Input to Output		C_{IO}		0.5		pF	
Resistance, Input to Output		R_{IO}		10^{12}		W	V_{IO}=500 VDC
Switching Time	MCT270/272	t_{ON}, t_{OFF}			10	µs	I_C=2 mA, R_E=100 Ω, V_{CE}=5 V
	MCT271				7		
	MCT273				20		
	MCT274				25		
	MCT275/277				15		
	MCT276				3.5		

Figure 1. Forward voltage vs. forward current

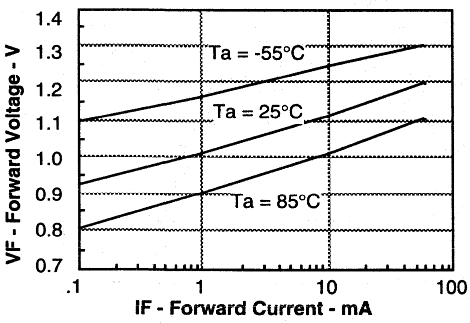


Figure 2. Normalized non-saturated and saturated CTR, T_A=25°C vs. LED current

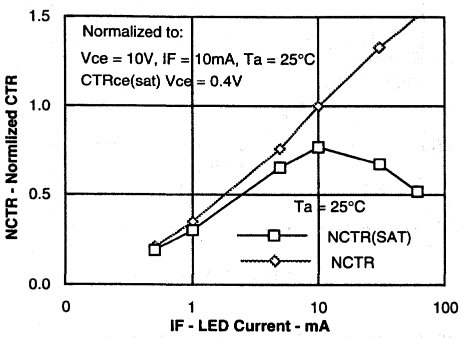


Figure 3. Normalized non-saturated and saturated CTR, T_A=50°C vs. LED current

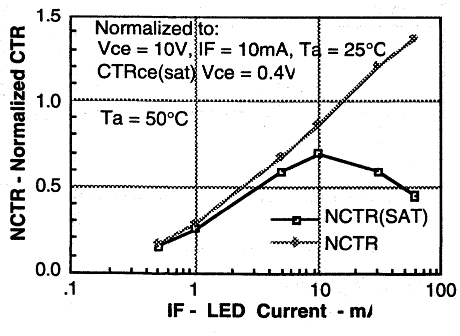


Figure 4. Normalized non-saturated and saturated CTR, T_A=70°C vs. LED current

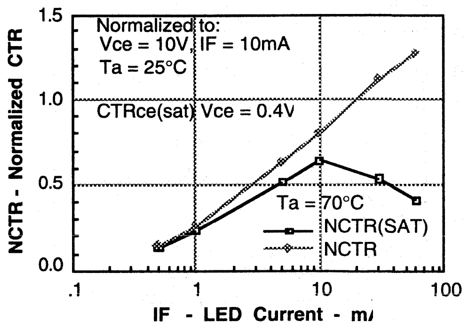


Figure 5. Normalized non-saturated and saturated CTR, T_A=85°C vs. LED current

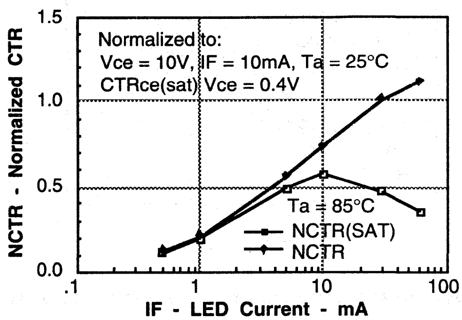


Figure 6. Collector-emitter current vs. temperature and LED current

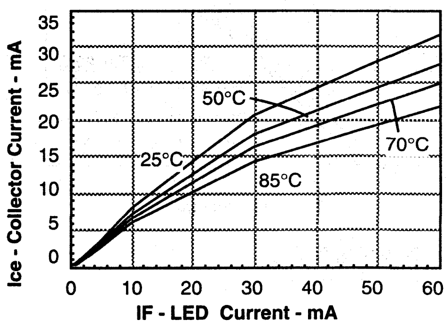


Figure 7. Collector-emitter leakage current vs. temp.

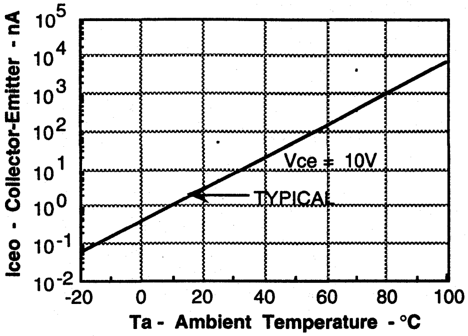


Figure 8. Normalized CTRcb vs. LED current and temp.

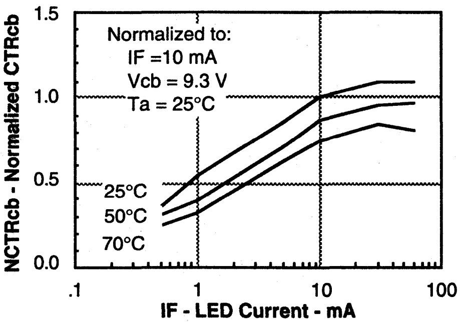


Figure 9. Normalized photocurrent vs. If and temperature

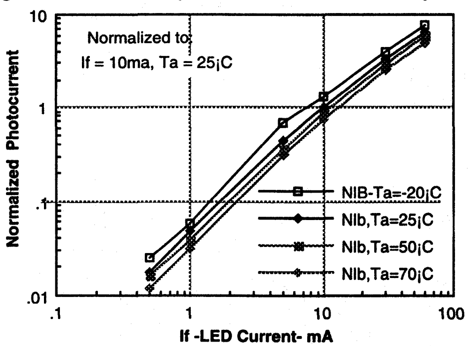


Figure 10. Normalized non-saturated HFE vs. base current and temperature

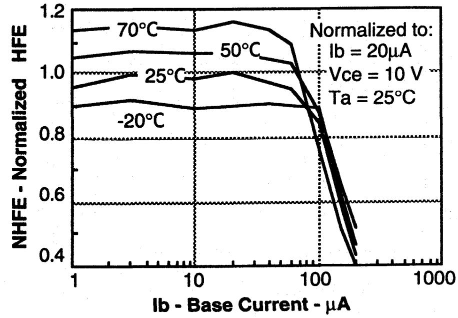


Figure 11. Normalized HFE vs. base current and temp.

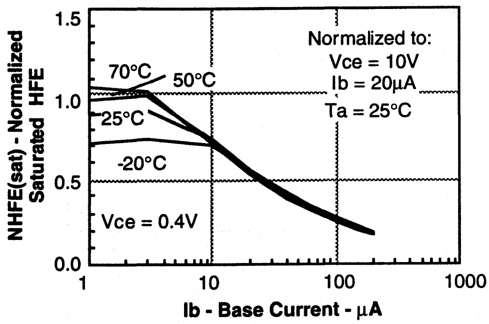


Figure 12. Propagation delay vs. collector load resistor

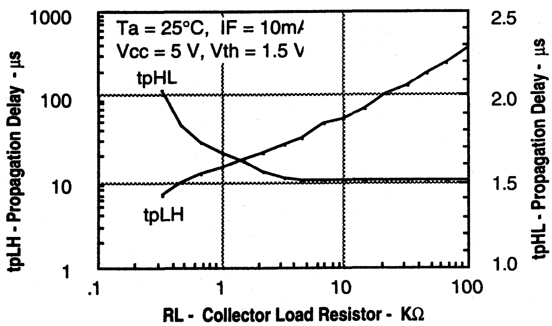


Figure 13. Switching timing

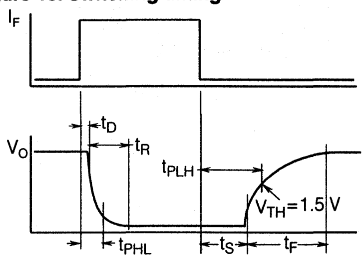
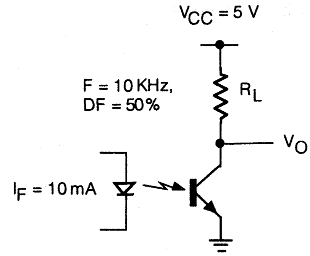
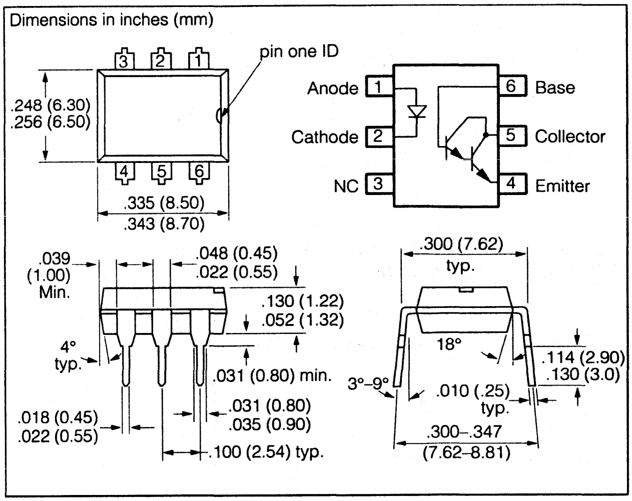


Figure 14. Switching schematic



SIEMENS

4N32/4N33
Photodarlington Optocoupler



FEATURES
- **Very High Current Transfer Ratio, 500% Min.**
- **High Isolation Resistance, 1011 W Typical**
- **Standard Plastic DIP Package**
- **Underwriters Lab File #E52744**
- **VDE Approvals #0884 (Available with Option 1)**

DESCRIPTION
The 4N32 and 4N33 are optically coupled isolators with a Gallium Arsenide infrared LED and a silicon photodarlington sensor. Switching can be achieved while maintaining a high degree of isolation between driving and load circuits. These optocouplers can be used to replace reed and mercury relays with advantages of long life, high speed switching and elimination of magnetic fields.

Maximum Ratings
Emitter

Peak Reverse Voltage .... 3 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 100 mW
Derate Linearly from 55°C .... 1.33 mW/°C

Detector

Collector-Emitter Breakdown Voltage, BV_{CEO} .... 30 V
Emitter-Base Breakdown Voltage, BV_{EBO} 8V
Collector-Base Breakdown Voltage, BV_{CBO} .... 50 V
Emitter-Collector Breakdown Voltage, BV_{ECO} .... 5 V
Collector (load) Current .... 125 mA
Power Dissipation at 25°C Ambient .... 150 mW
Derate Linearly from 25°C .... 2.0 mW/°C

Package

Total Dissipation at 25°C Ambient .... 250 mW
Derate Linearly from 25°C .... 3.3 mW/°C
Isolation Test Voltage .... 5300 VAC_{RMS}
(between emitter and detector, Standard Climate: 23°C/50%RH, DIN 50014)
Leakage Path .... 7 mm min.
Air Path .... 7 mm min.
Isolation Resistance
V_{IO}=500 V/25°C .... $\geq 10^{12}\ \Omega$
V_{IO}=500 V/100°C .... $\geq 10^{11}\ \Omega$
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

Electrical Characteristics T_A=25°

Parameter	Min.	Typ.	Max.	Unit	Condition
Emitter					
Forward Voltage		1.25	1.5	V	I_F=50 mA
Reverse Current		0.1	100	µA	V_R=3.0 V
Capacitance		25		pF	V_R=0 V
Detector					
BV_{CEO}*	30			V	I_C=100 µA, I_F=0
BV_{CBO}*	50				
BV_{EBO}*	8				
BV_{ECO}*	5	10			I_E=100 µA, I_F=0
I_{CEO}		1.0	100	nA	V_{CE}=10 V, I_F=0
H_{FE}		13K			I_C=0.5 mA, V_{CE}=5 V
Package					
Current Transfer Ratio	500			%	I_F=10 mA, V_{CE}=10 V
V_{CEsat}		1.0		V	I_C=2 mA, I_F=8 mA
Coupling Capacitance		1.5		pF	
Turn On Time			5	µs	V_{CC}=10 V, I_C=50 mA
Turn Off Time			100		I_F=200mA, R_L=180 Ω

*Indicates JEDEC registered values

Figure 1. Forward voltage versus forward current

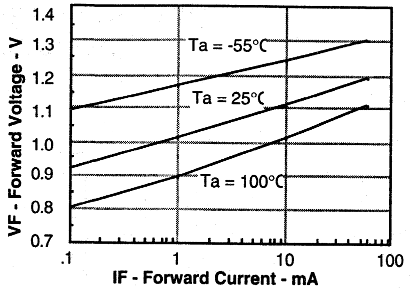


Figure 5. Non-saturated and saturated HFE versus base current

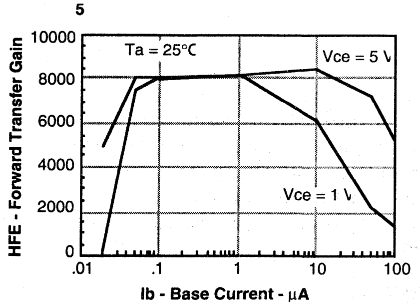


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

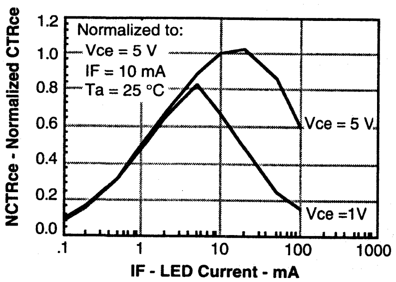


Figure 6. Low to high propagation delay versus collector load resistance and LED current

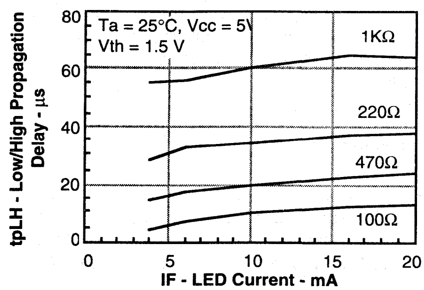


Figure 3. Normalized non-saturated and saturated collector-emitter current versus LED current

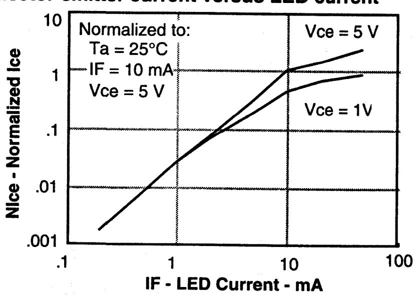


Figure 7. High to low propagation delay versus collector load resistance and LED current

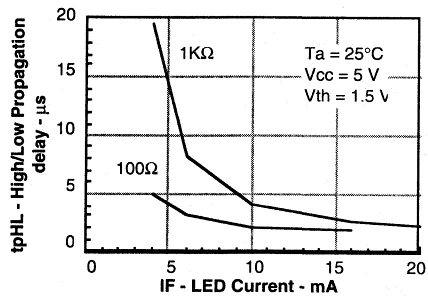


Figure 4. Normalized collector-base photocurrent versus LED current

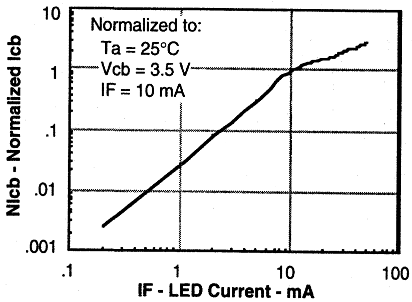
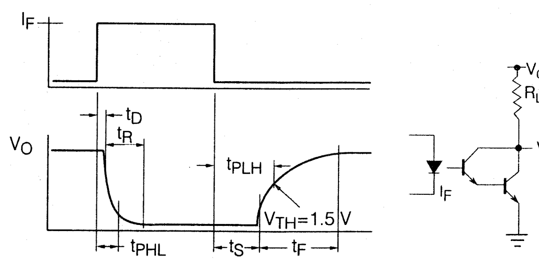


Figure 8. Switching waveform and switching schematic



SIEMENS

4N39
Photo SCR Optocoupler

FEATURES
- **Turn On Current (I_{FT}), 5.0 mA Typical**
- **Gate Trigger Current (I_{GT}), 20 mA**
- **Surge Anode Current, 10 Amp**
- **Blocking Voltage, 200 VAC_{PK}**
- **Gate Trigger Voltage (V_{GT}), 0.6 Volt**
- **Isolation Voltage, 5300 VAC_{RMS}**
- **Solid State Reliability**
- **Standard DIP Package**
- **Underwriters Lab File #E52744**

DESCRIPTION
The 4N39 is an optically coupled SCR with a Gallium Arsenide infrared emitter and a silicon photo SCR sensor. Switching can be achieved while maintaining a high degree of isolation between triggering and load circuits. The 4N39 can be used in SCR triac and solid state relay applications where high blocking voltages and low input current sensitivity are required.

Maximum Ratings
Emitter

Peak Reverse Voltage ....6.0 V
Peak Forward Current
(100 µs, 1% Duty Cycle)..............................1.0 A
Continuous Forward Current.........................60 mA
Power Dissipation at 25°C..........................100 mW
Derate Linearly from 50°C.........................2 mW/°C

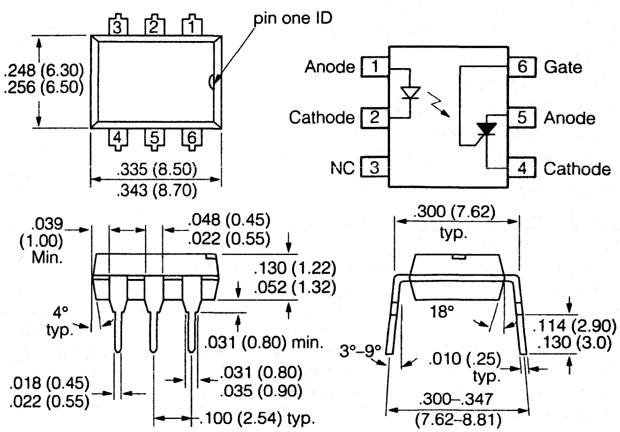
Detector

Reverse Gate Voltage ....6.0 V
Anode Peak Blocking Voltage ....200 V
Peak Reverse Gate Voltage ....6 V
Anode Current...300 mA
Surge Anode Current (100 µs duration)...........10 A
Surge Gate Current (5 ms duration)............100 mA
Power Dissipation, 25°C ambient ....400 mW
Derate Linearly from 25°C.........................8 mW/°C

Package

Isolation Test Voltage (1 sec.) ....5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C ....$\geq 10^{12}$ Ω
V_{IO}=500 V, T_A=100°C ....$\geq 10^{11}$ Ω
Total Package Dissipation..........................450 mW
Derate Linearly from 50°C.........................9 mW/°C
Operating Temperature................–55°C to +100°C
Storage Temperature....................–55°C to +150°C
Soldering Temperature (10 s.).......................260°C

Dimensions in Inches (mm)



Characteristics T_A=25°C

	Sym.	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.2	1.5	V	I_F=20 mA
Reverse Current	I_R			10	µA	V_R=5 V
Detector						
Forward Blocking Voltage	V_{DM}	200			V	R_{GK}=10 KΩ T_A=100°C I_d=150 µA
Reverse Blocking Voltage	V_{RM}	200			V	
On-state Voltage	V_{TM}			1.2	V	I_{TM}=300 mA
Holding Current	I_H			200	µA	R_{GK}=27 KΩ V_{FX}=50 V
Gate Trigger Voltage	V_{GT}		0.6	1.0	V	V_{FX}=100 V R_{GK}=27 KΩ R_L=10 KΩ
Forward Leakage Current	I_{DM}			50	µA	R_{GK}=10 KΩ V_{RX}=200 V I_F=0, T_A=100°C
Reverse Leakage Current	I_{RM}			50	µA	R_{GK}=27 KΩ V_{RX}=200 V I_F=0, T_A=100°C
Package						
Turn-On Current	I_{FT}		15	30	mA	V_{FX}=50 V R_{GK}=10 KΩ
			8	14		V_{FX}=100 V R_{GK}=27 KΩ
Isolation Capacitance			2		pF	f=1 MHz

SIEMENS

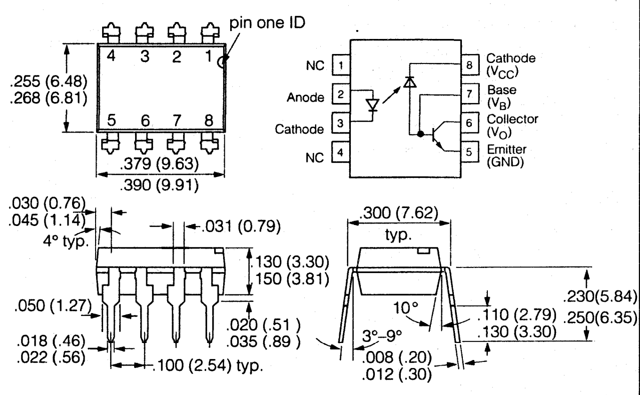
6N135
6N136
High-Speed 2.5 kV TRIOS®
Optocoupler

FEATURES
- **Isolation Test Voltage: 2500 VAC_{RMS}**
- **TTL Compatible**
- **High Bit Rates: 1 Mbit/s**
- **High Common-Mode Interference Immunity**
- **Bandwidth 2 MHz**
- **Open-Collector Output**
- **External Base Wiring Possible**
- **Field-Effect Stable by TRIOS***
- **Underwriters Lab File #E52744**

Description
The 6N135 and 6N136 are optocouplers with a GaAlAs infrared emitting diode, optically coupled with an integrated photodetector which consists of a photodiode and a high-speed transistor in a DIP-8 plastic package.

Signals can be transmitted between two electrically separated circuits up to frequencies of 2 MHz. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible reference voltages.

Dimensions in inches (mm)



Maximum Ratings
Emitter

Reverse Voltage .... 5 V
Forward Current... 25 mA
Peak Forward Current
(t =1 ms, duty cycle 50%) .... 50 mA
Maximum Surge Forward Current
($t \leq 1$ µs, 300 pulses/s) .... 1 A
Thermal Resistance.................................... 700 K/W
Total Power Dissipation ($T_A \leq 70$°C) .... 45 mW

Detector

Supply Voltage .... –0.5 to 15 V
Output Voltage.................................... –0.5 to 15 V
Emitter-Base Voltage .... 5 V
Output Current.. 8 mA
Maximum Output Current .... 16 mA
Base Current .... 5 mA
Thermal Resistance.................................... 300 K/W
Total Power Dissipation ($T_A \leq 70$°C) .... 100 mW

Package

Isolation Test Voltage (between emitter and detector climate per DIN 50014, part 2, Nov. 74 (t=1min.) .... 2500 VAC_{RMS}
Pollution Degree (DIN VDE 0109) 2
Creepage... ≥7 mm
Clearance .... ≥7 mm
Comparative Tracking Index per DIN IEC112/VDE 0303 part 1, Group IIIa per DIN VDE 6110 175
Isolation Resistance
V_{IO}=500 V, T_A = 25°C .... ≥10^{12} Ω
V_{IO}=500 V, T_A = 100°C .... ≥10^{11} Ω
Storage Temperature Range .... –55°C to +125°C
Ambient Temperature Range ...... –55°C to +100°C
Soldering Temperature (max. ≤10 sec., dip soldering ≥0.5 mm from case bottom)....... 260°C

Characteristics T_A=0 to 70°C unless otherwise specified, T_A=25°C typ.

Emitter	Symbol	Value	Unit	Condition
Forward Voltage	V_F	1.6 (≤1.9)	V	I_F=16 mA
Breakdown Voltage	V_{BR}	≥5		I_R=10 µA
Reverse Current	I_R	0.5 (≤10)	µA	V_R=5 V
Capacitance	C_O	125	pF	V_R=0 V, f=1 MHz
Temperature Coefficient, Forward Voltage	$\Delta V_F / \Delta T_A$	–1.7	mV/°C	I_F=16 mA
Detector				
Supply Current Logic Low	I_{CCL}	150	µA	I_F=16 mA, V_O open, V_{CC}=15 V
Supply Current Logic High	I_{CCH}	0.01 (≤1)		I_F=0 mA, V_O open, V_{CC}=15 V
Output Voltage, Output Low 6N135 6N136	V_{OL}	0.1 (≤0.4)	V	I_F=16 mA, V_{CC}=4.5 V I_O=1.1 mA I_O=2.4 mA
Output Current, Output High	I_{OH}	3 (≤500)	nA	I_F=0 mA, V_O=V_{CC}=5.5 V
Output Current, Output High		0.01 (≤1)	µA	I_F=0 mA, V_O=V_{CC}=15 V
Current Gain	H_{FE}	150		V_O=5 V, I_O=3 mA
Package				
Coupling Capacitance, Input-Output	C_{IO}	0.6	pF	f=1 MHz
Current Transfer Ratio				
6N135 6N136	CTR CTR	16 (≥7) 35 (≥19)	%	I_F=16 mA, V_O=0.4 V, V_{CC}=4.5 V, T_A=25°C
6N135 6N136	CTR CTR	≥5 ≥15		I_F=16 mA, V_O=0.5 V, V_{CC}=4.5 V

***TRIOS—TR**ansparent **IO**n **S**hield

Figure 1. Switching times

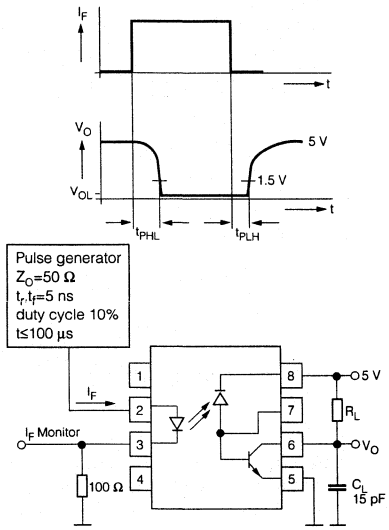
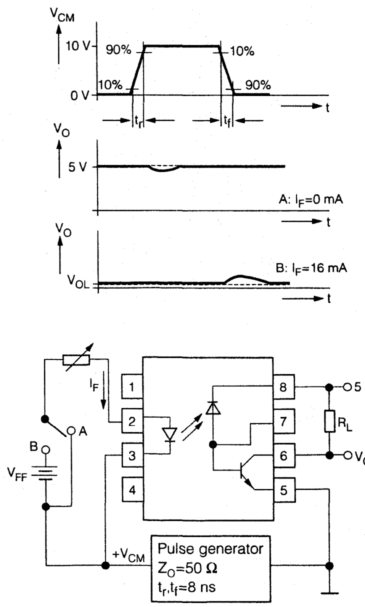


Figure 2. Common-mode interference immunity



Delay Time I_F=16 mA, V_{CC}=5 V, T_A=25°C

Parameter		**Symbol**	**Value**	**Unit**	**Condition**
High–Low	6N135	t_{PHL}	0.3 (≤1.5)	μs	R_L=4.1 kΩ
	6N136		0.2 (≤0.8)		R_L=1.9 kΩ
Low–High	6N135	t_{PLH}	0.3 (≤1.5)	μs	R_L=4.1 kΩ
	6N136		0.2 (≤0.8)		R_L=1.9 kΩ

Common Mode Interference Immunity
"V_{CM}=10 V_{P-P} V_{CC}=5 V, T_A=25°C

Parameter		**Symbol**	**Value**	**Unit**	**Condition**
High, I_F=0 mA	6N135	CMH	1000	V/μs	R_L=4.1 kW
	6N136				R_L=1.9 kW
Low, I_F=16 mA	6N135	CML			R_L=4.1 kW
	6N136				R_L=1.9 kW

Figure 3. Output characteristics-6N135
Output current versus output voltage
(T_A=25°C, V_{CC}=5 V)

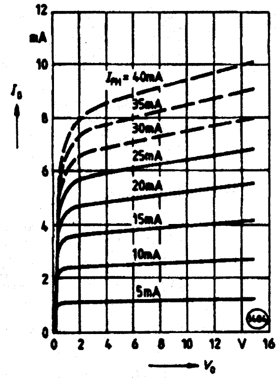
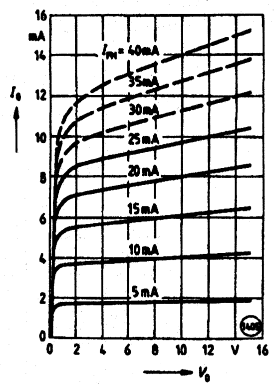


Figure 4. Output characteristics-6N136
Output current versus output voltage
(T_A=25°C, V_{CC}=5 V)



5 Optocouplers (Optoisolators)

Figure 5. Permissible forward current of emitting diode versus ambient temperature

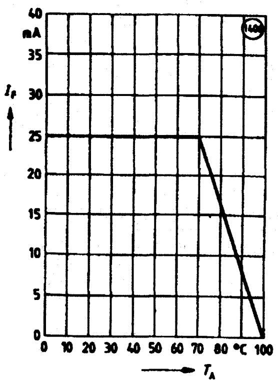


Figure 8. Small signal transfer ratio versus forward current (V_{CC}=5 V, T_A=25°C)

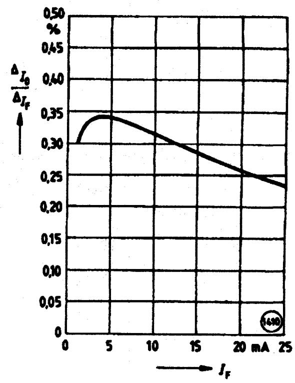


Figure 11. Delay times versus ambient temperature (I_F=16 mA, V_{CC}=5 V, 6N135: R_L=4.1 kΩ, 6N136: R_L=1.9 kΩ)

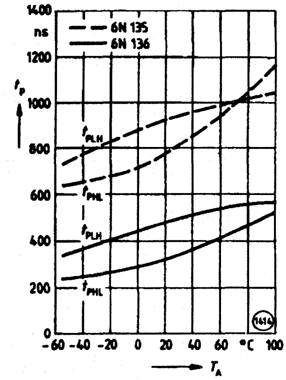


Figure 6. Permissible total power dissipation versus ambient temperature

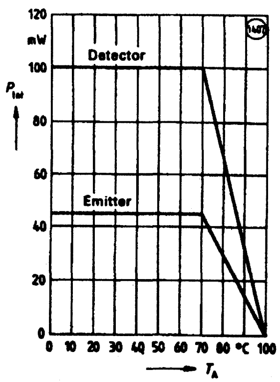


Figure 9. Current transfer ratio (normalized) versus ambient temperature (normalized to I_F=16 mA, V_O=0.4 V, V_{CC}=5 V, T_A=25°C)

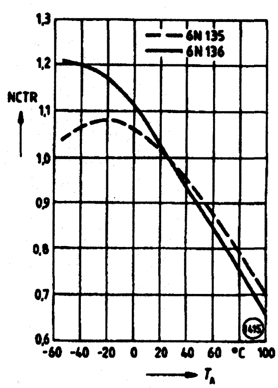


Figure 12. Current transfer ratio (normalized) versus forward current (I_F=16 mA, V_O=0.4 V, V_{CC}=5 V, T_A=25°C)

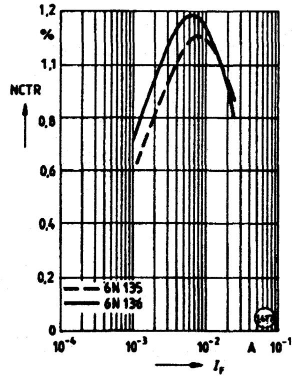


Figure 7. Forward current of emitting diode versus forward voltage (T_A=25°C)

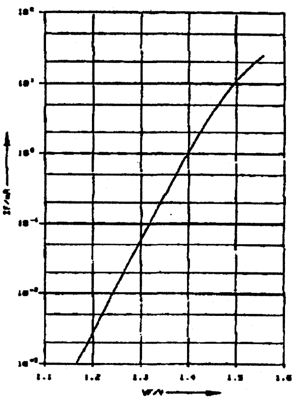
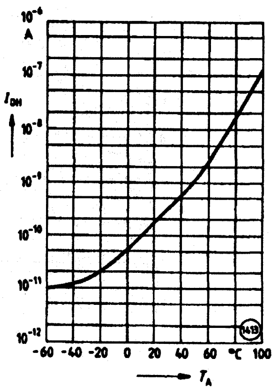


Figure 10. Output current (high)versus ambient temperature (V_O=V_{CC}=5 V, I_F=0)



SIEMENS

6N138
6N139

Low Input Current, High Gain Optocoupler

FEATURES
- **High Current Transfer Ratio, 800%**
- **Low Input Current, 0.5mA**
- **High Output Current, 60mA**
- **Isolation Test Voltage, 2500 VAC_{RMS}**
- **TTL Compatible Output, V_{OL}=0.1 V**
- **High Common Mode Rejection, 500V/µsec.**
- **Adjustable Bandwidth–Access to Base**
- **Standard Molded Dip Plastic Package**
- **Underwriters Lab File #E52744**

APPLICATIONS
- **Logic Ground Isolation–TTL/TTL, TTL/CMOS, CMOS/CMOS, CMOS/TTL**
- **EIA RS 232C Line Receiver**
- **Low Input Current Line Receiver–Long Lines, Party Lines**
- **Telephone Ring Detector**
- **117 VAC Line Voltage Status Indication–Low Input Power Dissipation**
- **Low Power Systems–Ground Isolation**

DESCRIPTION
High common mode transient immunity and very high current ratio together with 2500 VAC insulation are achieved by coupling an LED with an integrated high gain photo detector in an eight pin dual-in-line package. Separate pins for the photodiode and output stage enable TTL compatible saturation voltages with high speed operation. Photodarlington operation is achieved by tying the V_{CC} and V_O terminals together. Access to the base terminal allows adjustment to the gain bandwidth.

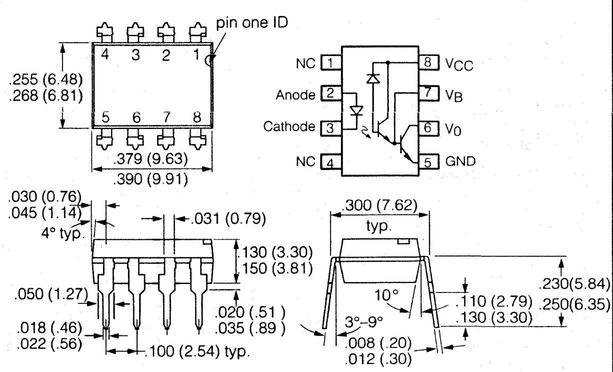
The 6N138 is ideal for TTL applications since the 300% minimum current transfer ratio with an LED current of 1.6 mA enables operation with one unit load-in and one unit load-out with a 2.2 KΩ pull-up resistor.

The 6N139 is best suited for low power logic applications involving CMOS and low power TTL. A 400% current transfer ratio with only 0.5 mA of LED current is guaranteed from 0°C to 70°C.

Caution:

Due to the small geometries of this device, it should be handled with Electrostatic Discharge (ESD) precautions. Proper grounding would prevent damage further and/or degradation which may be induced by ESD.

Dimensions in inches (mm)



Maximum Ratings

Reverse Input Voltage	5 V
Supply and Output Voltage, V_{CC} (pin 8-5), V_O (pin 6-5)	
6N138	–0.5 to 7 V
6N139	–0.5 to 18 V
Emitter-Base Reverse Voltage (pin 5-7)	0.5 V
Average Input Current	20 mA
Peak Input Current (50% Duty Cycle–1 ms pulse width)	40 mA
Peak Transient Input Current (tp≤1 µsec, 300 pps	1.0 A
Output Current I_O (pin 6)	60 mA
Derate linearly above 25°C, free air temperature at 0.7 mA/°C	
Input Power Dissipation	35 mW
Derate linearly above 50%, free air temperature at 0.7 mW/°C	
Output Power Dissipation	100 mW
Derate linearly above 25°C, free air temperature at 0.2 mA/°C	
Isolation Test Voltage	2500 VAC_{RMS}
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	$\geq 10^{12}$ Ω
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}$ Ω
Storage Temperature	–55°C to +125°C
Operating Temperature	–55°C to +100°C
Lead Soldering Temperature (t=10 sec.)	260°C

Electro-Optical Characteristics T_A=0°C to 70°C, T_A=25°C) (Typical, unless otherwise specified

Parameter	Symbol	Device	Min.	Typ.	Max.	Units	Test Conditions	Note
Current Transfer Ratio	CTR	6N138	300	1600		%	I_F=1.6 mA, V_O=0.4 V, V_{CC}=4.5 V	5.6
		6N139	400 500	1600 2000			I_F=0.5 mA, V_O=0.4 V, V_{CC}=4.5 V I_F=1.6 mA, V_O=0.4 V, V_{CC}=4.5 V	
Logic Low, Output Voltage	V_{OL}	6N138		0.1	0.4	V	I_F=1.6 mA, I_O=4.8 mA, V_{CC}=4.5 V	6
		6N139		0.1 0.15 0.25	0.4		I_F=1.6 mA, I_O=8 mA, V_{CC}=4.5 V I_F=5 mA, I_O=15 mA, V_{CC}=4.5 V I_F=12 mA, I_O=24 mA, V_{CC}=4.5 V	
Logic High, Output Current	I_{OH}	6N138		0.1	250	µA	I_F=0 mA, V_O=V_{CC}=7 V	
		6N139		0.05	100		I_F=0 mA, V_O=V_{CC}=18 V	
Logic Low Supply Current	I_{CCL}			0.2	1.5	mA	I_F=1.6 mA, V_O=OPEN, V_{CC}=18 V	
Logic High Supply Current	I_{CCH}			0.001	10	µA	I_F=0 mA, V_O=OPEN, V_{CC}=18 V	
Input Forward Voltage	V_F			1.4	1.7	V	I_F=1.6 mA, T_A=25°C	
Input Reverse Breakdown Voltage	BV_R		5				I_R=10 µA	
Temperature Coefficient of Forward Voltage				-1.8		mV/°C	I_F=1.6 mA	
Input Capacitance	C_{IN}			25		pF	f=1 MHz, V_F=0	
Input-Output Insulation Leakage Current	I-0				1.0	µA	45% Relative Humidity, T_A=25°C t=5_S, V_{1-0}=3000 VDC	7
Resistance (Input-Output)	R_{I-O}			10^{12}		W	V_{IO}=500 VDC	
Capacitance (Input-Output)	C_{I-O}			0.6		pF	f=1 MHz	

Switching Specifications T_A=25°C

Parameter	Symbol	Device	Min.	Typ.	Max.	Units	Test Conditions	Note
Propagation Delay Time, To Logic Low at Output	t_{PHL}	6N138		2	10	µS	I_F=1.6 mA, R_L=2.2 KΩ	
		6N139		6 0.6	25 1		I_F=0.5 mA, R_L=4.7 KΩ I_F=12 mA, R_L=270 Ω	6, 8
Propagation Delay Time, To Logic High at Output	t_{PLH}	6N138		2	35	µS	I_F=1.6 mA, R_L=2.2 KΩ	
		6N139		4 1.5	60 7		I_F=0.5 mA, R_L=4.7 KΩ I_F=12 mA, R_L=270 Ω	6, 8
Common Mode Transient Immunity, Logic High Level Output	CM_H			500		V/µS	I_F=0 mA, R_L=2.2 KΩ R_{CC}=0/V_{CM}/=10 V_{p-p}	9,10
Common Mode Transient Immunity, Logic Low Level Output	CM_L			–500			I_F=1.6 mA, R_L=2.2 KΩ R_{CC}=0/V_{CM}/=10 V_{p-p}	9,10

Notes

1. Derate linearly above 50°C free-air temperature at a rate of 0.4 mA/°C.
2. Derate linearly above 50°C free-air temperature at a rate of 0.7 mW/°C.
3. Derate linearly above 25°C free-air temperature at a rate of 0.7 mA/°C.
4. Derate linearly above 25°C free-air temperature at a rate of 2.0 mW/°C.
5. DC current transfer ratio is defined as the ratio of output collector current, IO, to the forward LED input current, IF times 100%.
6. Pin 7 open.
7. Device considered a two-terminal device: pins 1, 2, 3 and 4 shorted together and pins 5, 6, 7, and 8 shorted together.
8. Using a resistor between pin 5 and 7 will decrease gain and delay time.
9. Common mode transient immunity in logic high level is the maximum tolerable (positive) dVcm/dt on the leading edge of the common mode pulse, V_{CM}, to assure that the output will remain in a logic high state (i.e. V_O>2.0 V) common mode transient immunity in logic low level is the maximum tolerable (negative) dVcm/dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a logic low state (i.e. V_O<0.8 V).
10. In applications where dv/dt may exceed 50,000 V/µs (such as state discharge) a series resistor, R_{CC} should be included to protect I_C from destructively high surge currents. The recommended value is $R_{CC} \cong \frac{IV}{0.15 I_F(mA)} k\Omega$

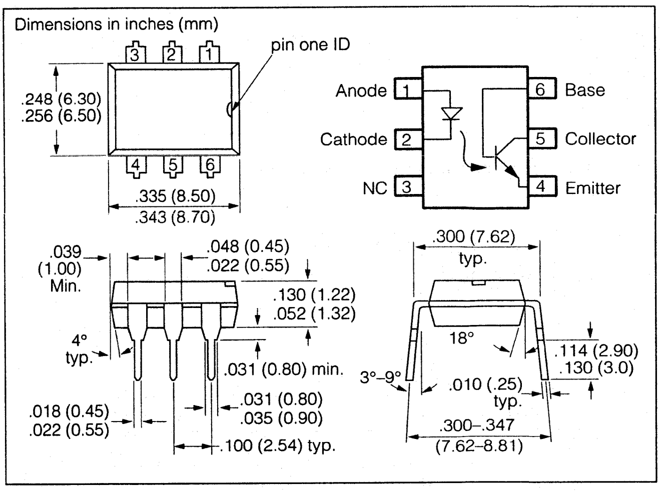
SIEMENS

CNY17

TRIOS® Phototransistor Optocoupler

FEATURES

- **High Current Transfer Ratio**
  CNY17-1, 40 to 80%
  CNY17-2, 63 to 125%
  CNY17-3, 100 to 200%
  CNY17-4, 160 to 320%
- **Breakdown Voltage, 5300 VAC_{RMS}**
- **Field-Effect Stable by TRIOS***
- **Long Term Stability**
- **Industry Standard Dual-in-Line Package**
- **Underwriters Lab File #E52744**
- **VDE #0884, Available with Option 1**



DESCRIPTION

The CNY17 is an optically coupled pair consisting of a Gallium Arsenide infrared emitting diode optically coupled to a silicon NPN phototransistor.

Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output.

The CNY17 can be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation.

Maximum Ratings (T_A=25°C)

Emitter

Reverse Voltage .... 6 V
Forward Current .... 60 mA
Surge Current (t≤10µs) .... 2.5 A
Power Dissipation .... 100 mW

Detector

Collector-Emitter Breakdown Voltage .... 70 V
Emitter-Base Breakdown Voltage .... 7 V
Collector Current .... 50 mA
Collector Current (t <1 ms) .... 100 mA
Power Dissipation .... 150 mW

Package

Isolation Test Voltage (between emitter & detector referred to climate DIN 50014, part 2, Nov. 74) .... 5300 VAC_{RMS}
Creepage Distance .... ≥7 mm
Clearance Distance .... ≥7 mm
Isolation Thickness between Emitter and Detector .... ≥0.4 mm
Comparative Tracking Index per DIN IEC 112/ VDE0303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... ≥10^{12} Ω
V_{IO}=500 V, T_A=100°C .... ≥10^{11} Ω
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature (max. 10 s, dip soldering: distance to seating plane ≥1.5 mm) .... 260°C

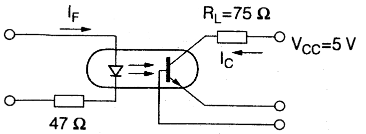
Characteristics (T_A=25°C)

Parameter	Symbol	Values	Unit	Condition
Emitter				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F = 60 mA
Breakdown Voltage	V_{BR}	≥6		I_R = 10 mA
Reverse Current	I_R	0.01 (≤10)	µA	V_R = 6 V
Capacitance		25	pF	V_R = 0 V, f =1 MHz
Thermal Resistance	R_{thjamb}	750	K/W	
Detector				
Capacitance	C_{CE} C_{CB} C_{EB}	5.2 6.5 7.5	pF	V_{CE} =5 V, f =1 MHz V_{CB} =5 V, f =1 MHz V_{EB} =5 V, f =1 MHz
Thermal Resistance	R_{thjamb}	500	K/W	
Package				
Collector-Emitter Saturation Voltage	V_{CEsat}	0.25 (≤0.4)	V	I_F =10 mA, I_C=2.5 mA
Coupling Capacitance	C_C	0.6	pF	

Current Transfer Ratio and Collector-Emitter Leakage Current by dash number (T_A=25°C)

	-1	-2	-3	-4	Unit
I_C/I_F at V_{CE}=5 V (I_F=10 mA)	40-80	63-125	100-200	160-320	%
I_C/I_F at V_{CE}=5 V (I_F=1 mA)	30 (>13)	45 (>22)	70 (>34)	90 (>56)	%
Collector-Emitter Leakage Current (V_{CE}=10 V) (I_{CEO})	2 (≤ 50)	2 (≤ 50)	5 (≤ 100)	5 (≤ 100)	nA

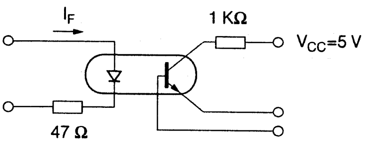
Figure 1. Linear Operation (without saturation)



I_F=10 mA, V_{CC}=5 V, T_A=25 °C

Load Resistance	R_L	75	W
Turn-On Time	t_{ON}	3.0	µs
Rise Time	t_R	2.0	µs
Turn-Off Time	t_{OFF}	2.3	µs
Fall Time	t_f	2.0	µs
Cut-off Frequency	f_{CO}	250	kHz

Figure 2. Switching Operation (with saturation)



		-1 (I_F=20 mA)	-2 and -3 (I_F=10 mA)	-4 (I_F=5 mA)	
Turn-On Time	t_{ON}	3.0	4.2	6.0	µs
Rise Time	t_R	2.0	3.0	4.6	µs
Turn-Off Time	t_{OFF}	18	23	25	µs
Fall Time	t_F	11	14	15	µs

Figure 3. Current transfer ratio versus diode current (T_A=–25°C, V_{CE}=5 V) I_C/I_F=f (I_F)

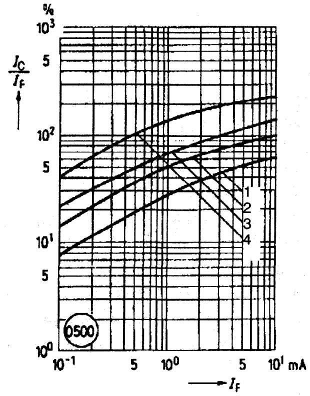


Figure 4. Current transfer ratio versus diode current (T_A=0°C, V_{CE}=5 V) I_C/I_F=f (I_F)

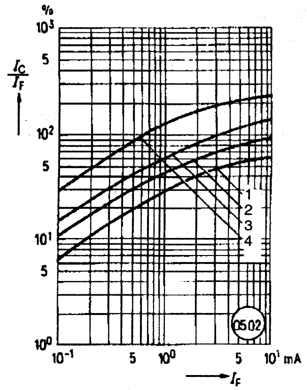


Figure 5. Current transfer ratio versus diode current (T_A=25°C, V_{CE}=5 V) I_C/I_F=f (I_F)

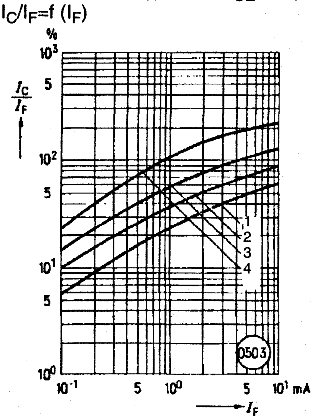


Figure 6. Current transfer ratio versus diode current (T_A=50°C) V_{CE}=5 V, I_C/I_F=f (I_F)

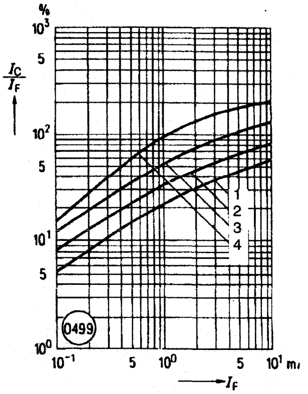


Figure 9. Transistor characteristics (B=550) **CNY17-3**, -4 I_C=f(V_{CE}) (T_A=25°C, I_F=0)

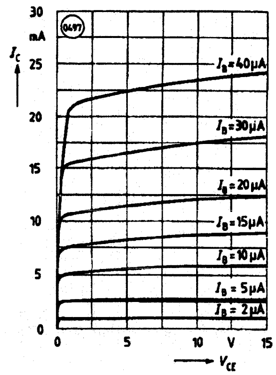


Figure 12. Collector emitter off-state current I_{CEO}=f (V, T) (T_A=25°C, I_F=0)

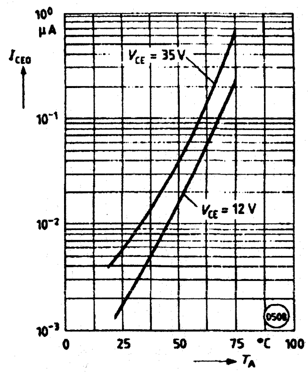


Figure 7. Current transfer ratio versus diode current (T_A=75°C) V_{CE}=5 V

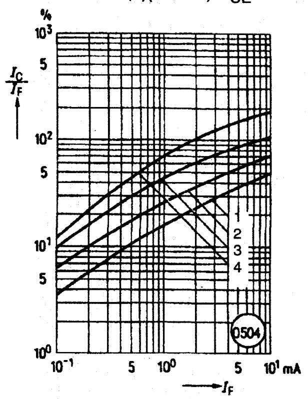


Figure 10. Output characteristics CNY17-3, -4 (T_A=25°C) I_C=f(V_{CE})

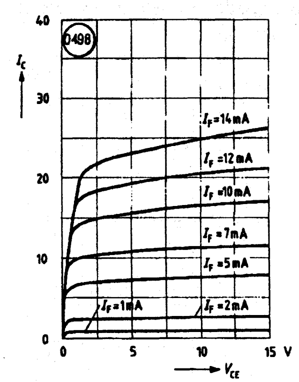


Figure 13. Saturation voltage versus collector current and modulation depth CNY17-1 V_{CEsat}=f (I_C) (T_A=25°C)

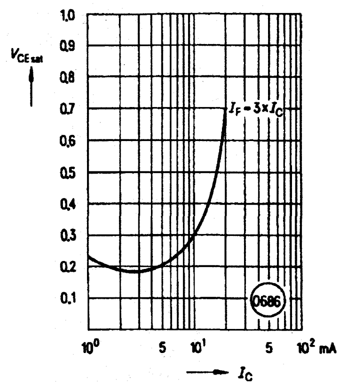


Figure 8. Current transfer ratio versus temperature (I_F=10 mA, V_{CE}=5 V) I_C/I_F=f (T)

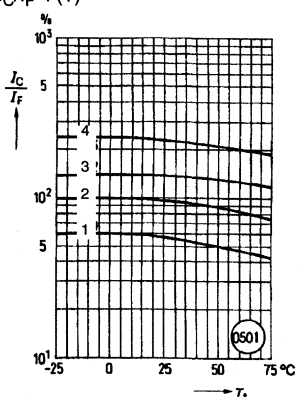


Figure 11. Forward voltage V_F=f (I_F)

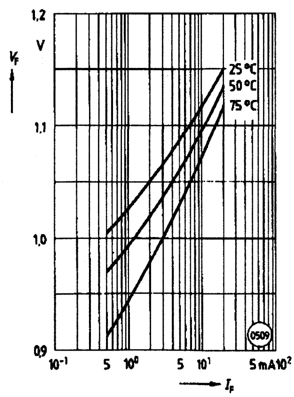


Figure 14. Saturation voltage versus collector current and modulation depth CNY17-2 V_{CEsat}=f (I_C) (T_A=25°C)

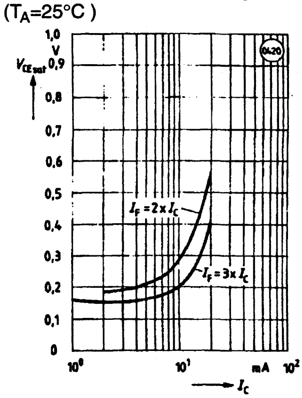


Figure 15. Saturation voltage versus collector current and modulation depth CNY17-3 V_{CEsat}=f (I_C) (T_A=25°C)

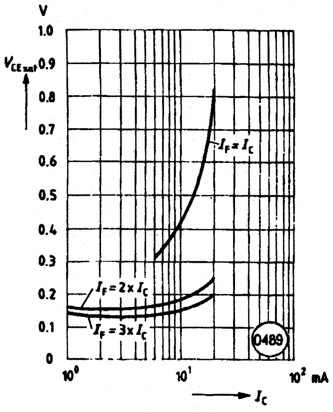


Figure 16. Saturation voltage versus collector current and modulation depth CNY17-4 V_{CEsat}=f (I_C) (T_A=25°C)

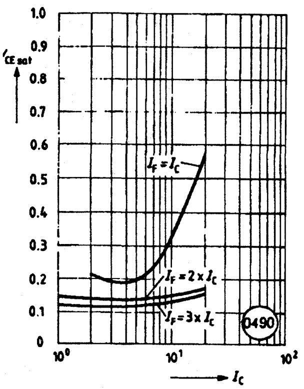


Figure 17. Permissible pulse load
D=parameter, T_A=25°C, I_F=f (t_p)

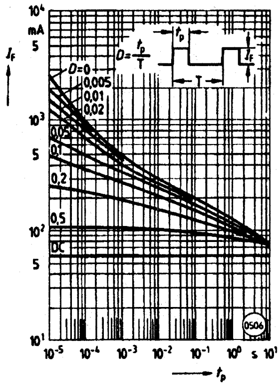


Figure 18. Permissible power dissipation transistor and diode
P_{tot}=f (T_A)

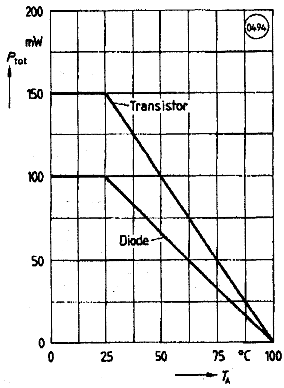


Figure 19. Permissible forward current P_{tot}=f (T_A)

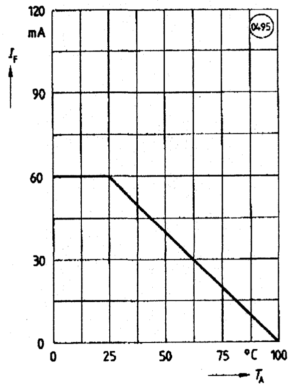
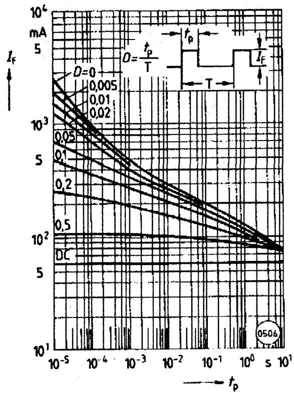


Figure 20. Transistor capacitance
C=f(V_O) (T_A=25°C, f=1 MHz)



SIEMENS

CNY17F

No Base Connection Phototransistor Optocoupler

- **FEATURES**
- **High Current Transfer Ratio**
  CNY17F-1, 40-80%
  CNY17F-2, 63-125%
  CNY17F-3, 100-200%
  CNY17F-4, 160-320%
- **Breakdown Voltage, 5300 VAC_{RMS}**
- **High Collector-Emitter Voltage**
- **V_{CEO}=70 V**
- **No Base Terminal Connection for Improved Common Mode Interface Immunity**
- **Field-Effect Stable by TRIOS***
- **Long Term Stability**
- **Industry Standard Dual-in-Line Package**
- **Underwriters Lab File #E52744**
- **VDE #0884, Available with Option 1**

Maximum Ratings T_A=25°C

Emitter

Reverse Voltage .... 6 V
DC Forward Current .... 60 mA
Surge Forward Current (t ≤10 μs) .... 2.5 A
Total Power Dissipation .... 100 mW

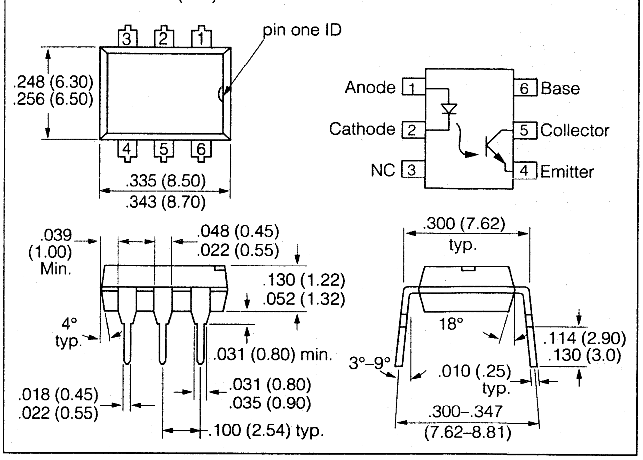
Detector

Collector-Emitter Breakdown Voltage .... 70 V
Collector Current .... 50 mA
Collector Current (t≤1 ms)........................... 100 mA
Total Power Dissipation .... 150 mW

Package

Isolation Test Voltage (between emitter and detector referred to standard climate 23/50 DIN 50014)................5300 VAC_{RMS}
Creepage .... >7 mm
Clearance.. >7 mm
Isolation Thickness between Emitter and Detector.. ≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303, part 1 175
Isolation Resistance (V_{IO}=500 V).................. $\geq 10^{11}\ \Omega$
Storage Temperature Range .... –55 to +150°C
Ambient Temperature Range .... –55 to +100°C
Junction Temperature ....100°C
Soldering Temperature (max. 10 s, dip soldering: distance to seating plane ≥1.5 mm)............260°C

***TRIOS—TR**ansparent **IO**n **S**hield



DESCRIPTION

The CNY17F is an optocoupler consisting of a Gallium Arsenide infrared emitting diode optically coupled to a silicon planar phototransistor detector in a plastic plug-in DIP-6 package.

The coupling device is suitable for signal transmission between two electrically separated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible reference voltages.

In contrast to the CNY17 Series, the base terminal of the F type is not connected, resulting in a substantially improved common-mode interference immunity.

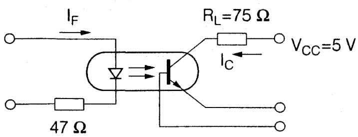
Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Emitter				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=60mA
Breakdown Voltage	V_{BR}	≥6		I_R=10μA
Reverse Current	I_R	0.01 (≤10)	μA	V_R=6 V
Capacitance	C_O	25	pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}	750	K/W	
Detector				
Capacitance	C_{CE}	5.2	pF	V_{CE}=5 V, f=1 MHz
	C_{BC}	6.5		
	C_{EB}	7.5		
Thermal Resistance	R_{thJA}	500	K/W	
Package				
Saturation Voltage, Collector-Emitter	V_{CEsat}	0.25 (≤0.4)	V	I_F=10 mA I_C=2.5 mA
Coupling Capacitance	C_C	0.6	pF	

Current Transfer Ratio I_C/I_F at V_{CE}=5 V, 25°C
and Collector-Emitter Leakage Current by dash number

	-1	-2	-3	-4	Unit
I_C/I_F at V_{CE}=5 V (I_F=10 mA)	40–80	63-125	100–200	160–320	%
I_C/I_F at V_{CE}=5 V (I_F=1 mA)	30 (>13)	45 (>22)	70 (>34)	90 (>56)	
Collector-Emitter Leakage Current (V_{CE}=10 V) (I_{CEO})	2 (≤ 50)	2 (≤ 50)	5 (≤ 100)		nA

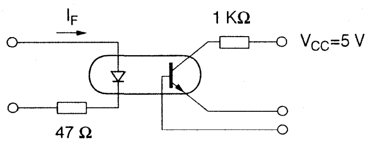
Figure 1. Linear operation (without saturation)



I_F=10 mA, V_{CC}=5 V, T_A=25°C

Load Resistance	R_L	75	W
Turn-On Time	t_{ON}	3.0	µs
Rise Time	t_R	2.0	
Turn-Off Time	t_{OFF}	2.3	
Fall Time	t_f	2.0	
Cut-Off Frequency	f_{CO}	250	kHz

Figure 2. Switching operation (with saturation)



		-1 (I_F=20 mA)	-2 and -3 (I_F=10 mA)	-4 (I_F=5 mA)	
Turn-On Time	t_{ON}	3.0	4.2	6.0	µs
Rise Time	t_R	2.0	3.0	4.6	
Turn-Off Time	t_{OFF}	18	23	25	
Fall Time	t_F	11	14	15	

Figure 3. Current transfer ratio versus diode current (T_A=–25°C, V_{CE}=5 V) I_C/I_F=f (I_F)

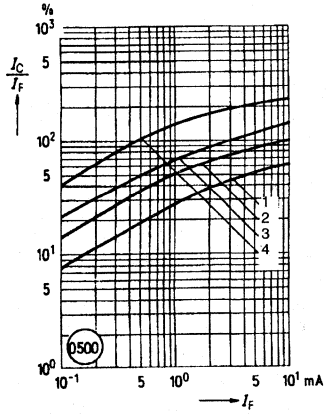


Figure 4. Current transfer ratio versus diode current (T_A=0°C, V_{CE}=5 V) I_C/I_F=f (I_F)

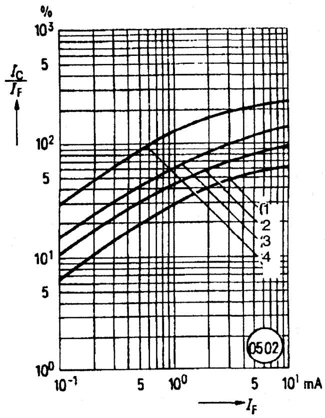


Figure 5. Current transfer ratio versus diode current (T_A=25°C, V_{CE}=5 V) I_C/I_F=f (I_F)

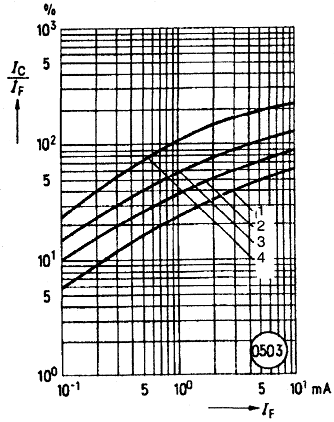


Figure 6. Current transfer ratio versus diode current (T_A=50°C) V_{CE}=5 V

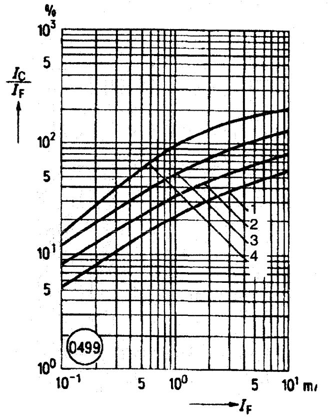


Figure 9. Output characteristics CNY17F-2, -3 (T_A=25°C) IC=f(V_{CE})

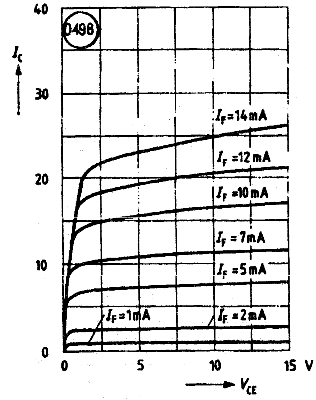


Figure 12. Saturation voltage current and modulation CNY17F-1
V_{CEsat}=f (I_C) (T_A=25°C)

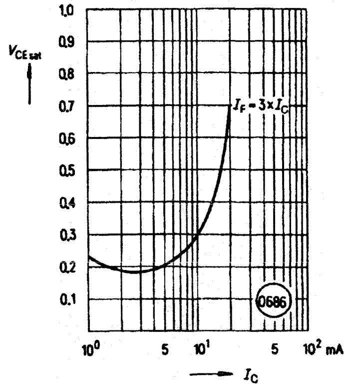


Figure 7. Current transfer ratio versus diode current (T_A=75°C) V_{CE}=5 V

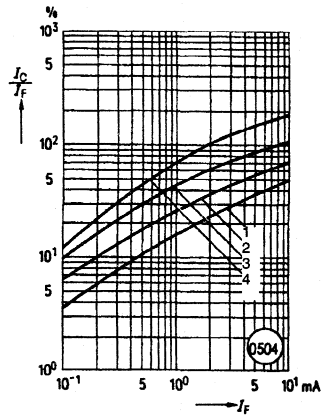


Figure 10. Forward voltage V_F=f(I_F)

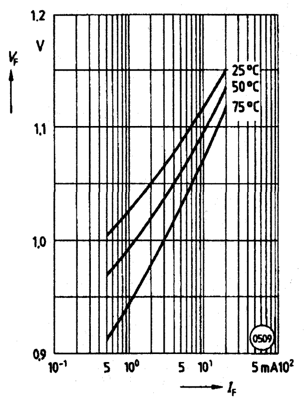


Figure 13. Saturation voltage versus collector current and modulation depth CNY17F-2 V_{CEsat}=f (I_C) (T_A=25°C)

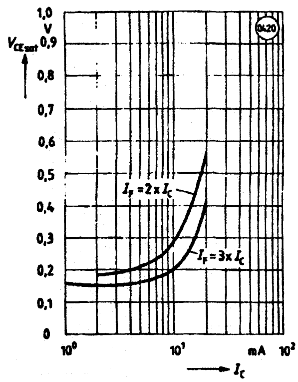


Figure 8. Current transfer ratio versus temperature (I_F=10 mA, V_{CE}=5 V)
I_C/I_F=f (T)

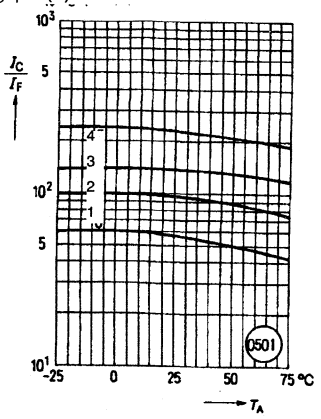


Figure 11. Collector emitter off-state current I_{CEO}=f(V,T) (T_A=75°C, I_F=0)

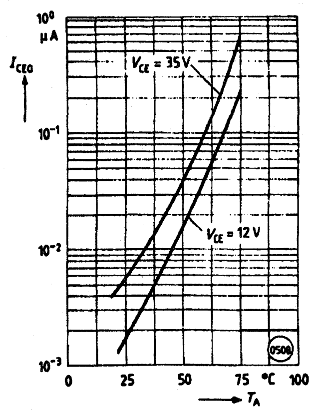
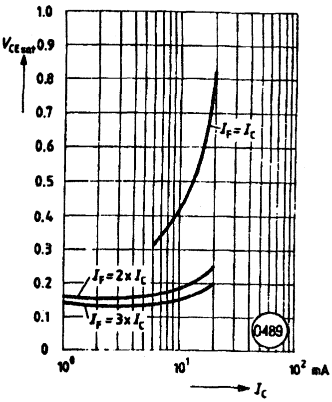


Figure 14. Saturation voltage versus collector current and modulation depth CNY17F-3 V_{CEsat}=f (I_C) (T_A=25°C)



Optocouplers (Optoisolators)

5

Figure 15. Saturation voltage versus collector current and modulation depth CNY17F-4 V_{CEsat}=f (I_C) (T_A=25°C)

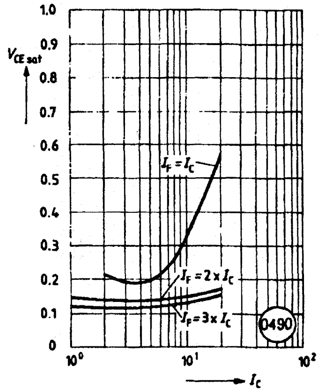


Figure 17. Permissible power dissipation transistor and diode P_{tot}=f(T_A)

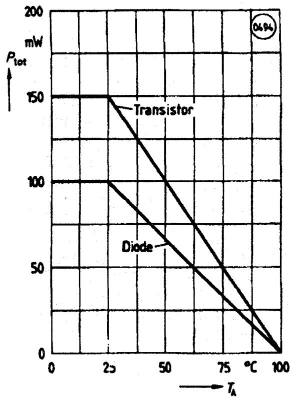


Figure 19. Transistor capacitance C=f(V_O)(T_A=25°C, f=1 MHz)

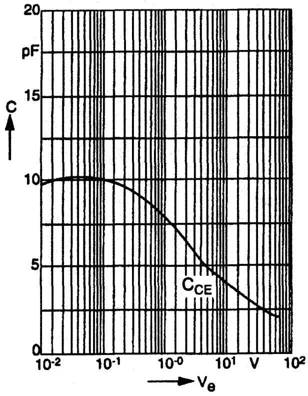


Figure 16. Permissible pulse load D=parameter, T_A=25°C, I_F=f(t_p)

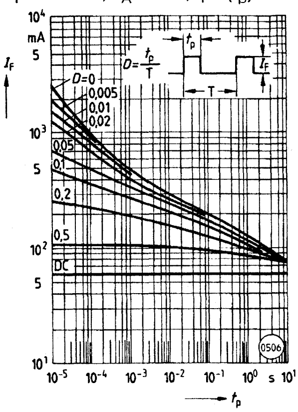
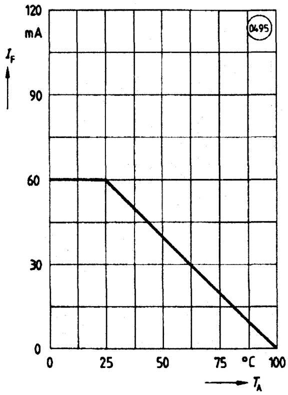


Figure 18. Permissible forward current diode I_F=f(T_A)



SIEMENS

H11AA1

Bidirectional Input Optocoupler

FEATURES

- **Current Transfer Ratio, 20% Min.**
- **AC or Polarity Insensitive Input**
- **Built-in Reverse Polarity Input Protection**
- **I/O Compatible with Integrated Circuits**
- **Industry Standard DIP Package**
- **Underwriters Lab File #E52744**
- **VDE Approval #0884 (Available with Option 1)**

DESCRIPTION

The H11AA1 is a bi-directional input optically coupled isolator consisting of two Gallium Arsenide infrared LEDs coupled to a silicon NPN phototransistor in a 6-pin DIP package. The H11AA1 has a minimum CTR of 20% and a CTR symmetry of 1:3 and is designed for applications requiring detection or monitoring of AC signals.

Maximum Ratings

Emitter

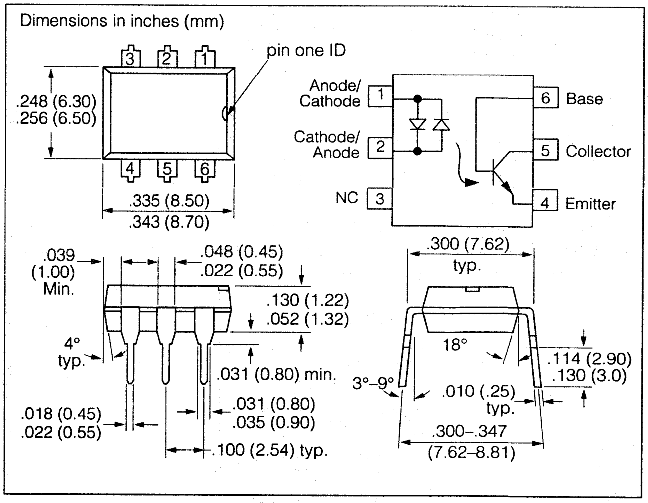
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C.......................... 100 mW
Derate Linearly from 25°C...................... 1.3 mW/°C

Detector

Power Dissipation at 25°C Ambient .... 200 mW
Derate Linearly from 25°C...................... 2.6 mW/°C
Collector-Emitter Breakdown Voltage, BV_{CEO} .. 30 V
Emitter-Base Breakdown Voltage, BV_{EBO} .... 5 V
Collector-Base Breakdown Voltage, BV_{CBO}..... 70 V

Package

Isolation Test Voltage (between emitter and detector referred to standard climate 23°C/50%RH, DIN 50014) ....5300 VAC_{RMS}
Creepage ....min. 7 mm
Clearance..min. 7 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C....................................≥10^{12} Ω
V_{IO}=500 V, T_A=100°C ....≥10^{11} Ω
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C...................... 10 sec.



Electrical Characteristics T_A=25°C

Parameter	Min.	Typ.	Max.	Unit	Condition
Emitter					
Forward Voltage, V_F		1.2	1.5	V	I_F=±10 mA
Detector					
Breakdown Voltage					
BV_{CEO}	30			V	I_C=1 m A
BV_{EBO}	7				I_E=100 µA
BV_{CBO}	70				I_C=100 µA
I_{CEO}		5	100	nA	V_{CE}=10 V
Package					
V_{CEsat}			0.4	V	I_F=±10 mA, I_C=0.5 mA
DC Current Transfer Ratio	20			%	I_F=±10 mA, V_{CE}=10 V
Symmetry CTR at + 10 mA / CTR at - 10 mA	0.33	1.0	3.0		

Figure 1. LED forward current versus forward voltage

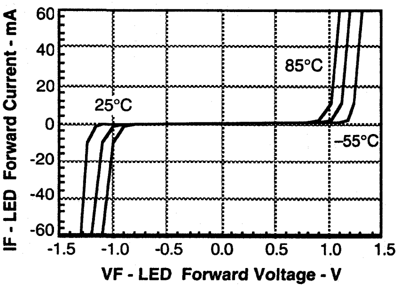


Figure 2. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

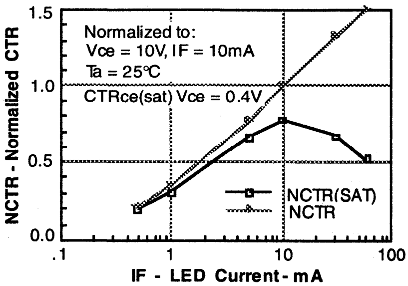


Figure 3. Normalized non-saturated and saturated CTR at T_A=50°C versus LED current

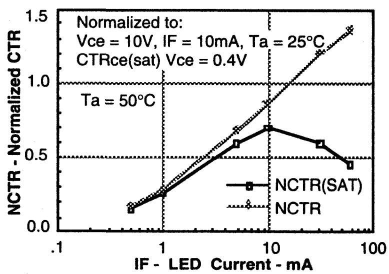


Figure 4. Normalized non-saturated and saturated CTR at T_A=70°C versus LED current

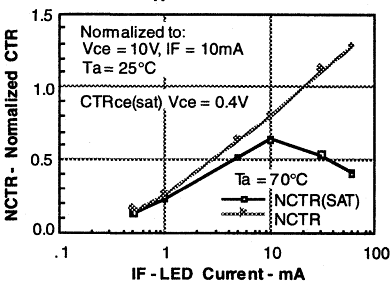


Figure 5. Normalized non-saturated and saturated CTR at T_A=85°C versus LED current

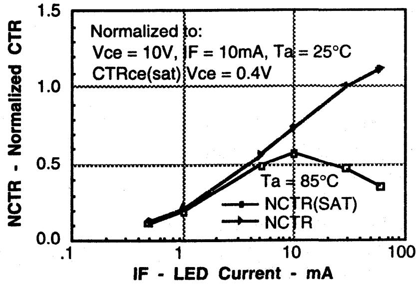


Figure 6. Collector-emitter current versus temperature and LED current

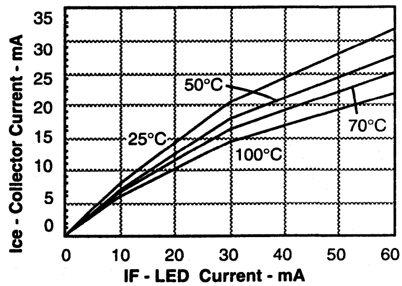


Figure 7. Collector-emitter leakage current versus temperature

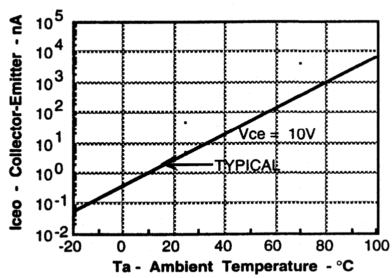


Figure 8. Normalized CTRcb versus LED current and temperature

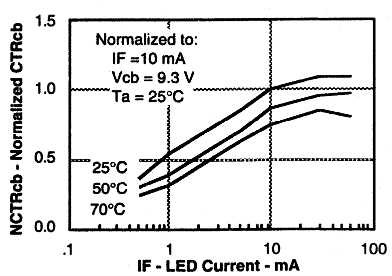


Figure 9. Collector base photocurrent versus LED current

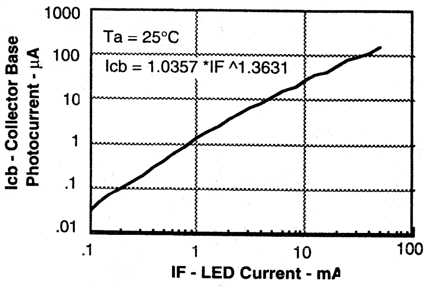


Figure 10. Normalized photocurrent versus LED current

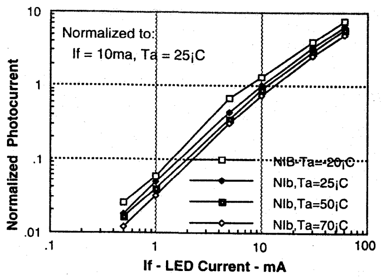


Figure 11. Normalized saturated HFE versus base current and temperature

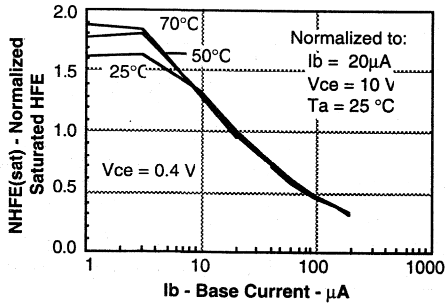


Figure 12. Normalized saturated HFE versus base current and temperature

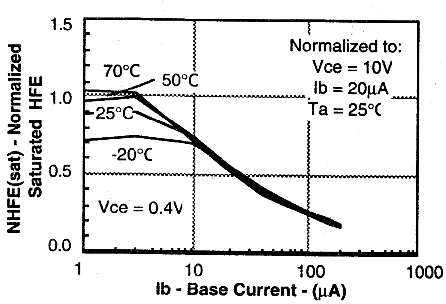


Figure 13. Propagation delay versus collector load resistor

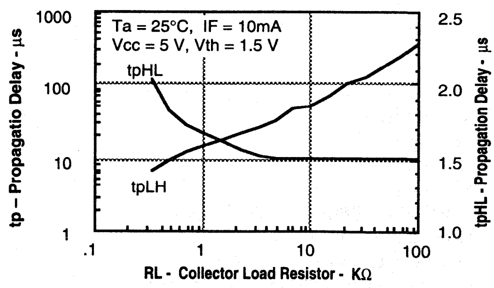


Figure 14. Switching waveform

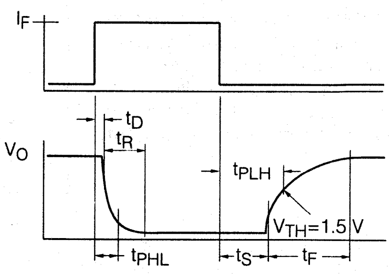
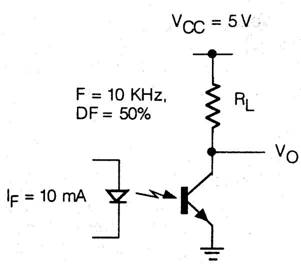


Figure 15. Switching schematic



SIEMENS

H11B1/H11B2/H11B3

Photodarlington Optocoupler

FEATURES

- **CTR Minimum at I_F = 1 mA**
  H11B1, 500%
  H11B2, 200%
  H11B3, 100%
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **Coupling Capacitance, 0.5 pF**
- **Underwriters Lab File #E52744**
- **VDE Approval #0884 (Available with Option 1)**

DESCRIPTION

The H11B1/H11B2/H11B3 are industry standard optocouplers, consisting of a Gallium Arsenide infrared LED and a silicon phototdarlington. These optocouplers are constructed with a high voltage insulation, double molded packaging process which offers 7.5 KV withstand test capability.

Maximum Ratings

Emitter

Reverse Voltage ... 3 V
Continuous Forward Current ... 60 mA
Power Dissipation at 25°C ... 100 mW
Derate Linearly from 25°C ... 1.33 mW/°C

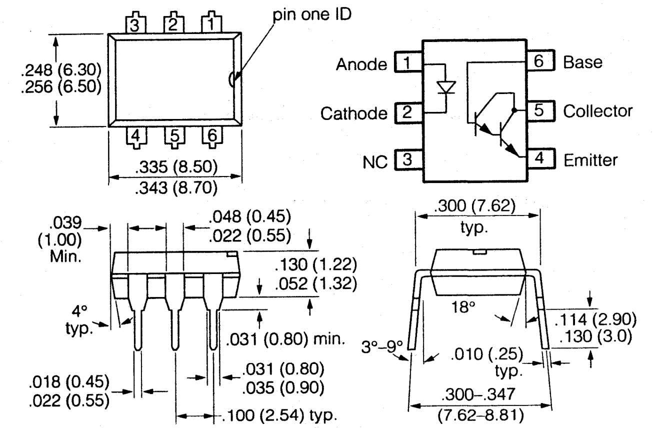
Detector

Collector-Emitter Breakdown Voltage, BV_{CEO} 25 V
Emitter-Collector Breakdown Voltage BV_{ECO} ... 7 V
Collector-Base Breakdown Voltage, BV_{CBO} ... 30 V
Collector-Current (Continuous) ... 100 mA
Power Dissipation at 25°C ... 150 mW
Derate Linearly from 25°C ... 2.0 mW/°C

Package

Isolation Test Voltage (between emitter and detector, refer to standard climate 23°C/50%RH, DIN 50014) ... 5300 VAC_{RMS}
Creepage ... min. 7 mm
Clearance ... min. 7 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303, part 1 ... 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C ... $\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C ... $\geq 10^{11}\ \Omega$
Total Package Dissipation at 25°C (LED plus Detector) ... 260 mW
Derate Linearly from 25°C ... 3.5 mW/°C
Storage Temperature ... -55°C to +150°C
Operating Temperature ... –55°C to +100°C
Lead Soldering Time at 260°C ... 10 sec.

Dimensions in inches (mm)



Characteristics T_A=25°C

Parameter	Sym.	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage H11B1, B2 H11B3	V_F		1.1	1.5	V	I_F=10 mA I_F=50 mA
Reverse Current	I_R			10	µA	V_R=3V
Junction Capacitance	C_J		50		pF	V_F=0 V, f=1 mHz
Detector						
BV_{CEO}		30			V	I_C=1.0 mA, I_F=0 mA
BV_{ECO}		7				I_E=100 µA, I_F=0 mA
BV_{CBO}		30				I_C=100 µA, I_F=0 mA
I_{CEO}				100	nA	V_{CE}=10 V, I_F=0 mA
Package						
V_{CEsat}				1.0		I_C=1 mA, I_C=1 mA
DC Current Transfer Ratio H11B1 H11B2 H11B3	CTR	 500 200 100			%	V_{CE}=5 V, I_F=1 mA
Capacitance Input to Output	C_{IO}		0.5		pF	
Switching Times	t_{on}		5		µs	I_F=5 mA V_{CE}=10 V R_L=100 Ω
	t_{off}		30			

Figure 1. Forward voltage versus forward current

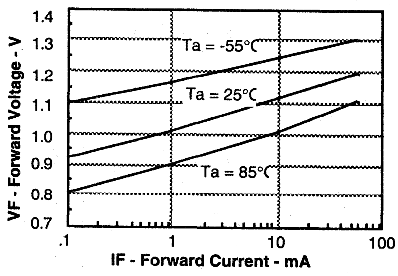


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

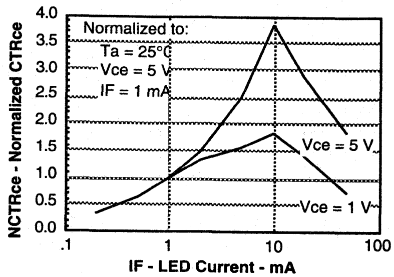


Figure 3. Normalized non-saturated and saturated Ice versus LED current

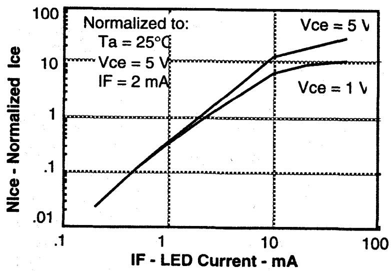


Figure 4. Normalized non-saturated and saturated collector-emitter current versus LED current

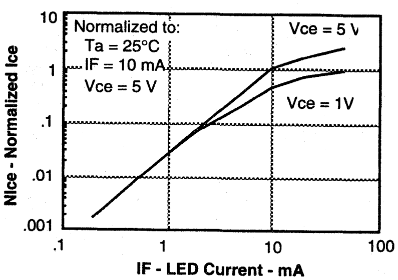


Figure 5. Non-saturated and saturated HFE versus base current

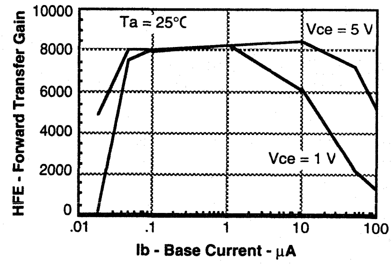


Figure 6. Low to high propagation delay versus collector load resistance and LED current

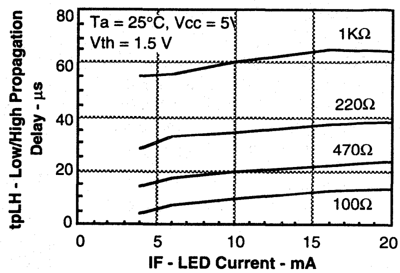


Figure 7. High to low propagation delay versus collector load resistance and LED current

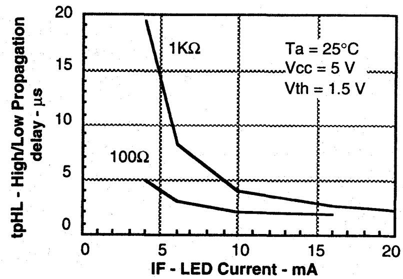
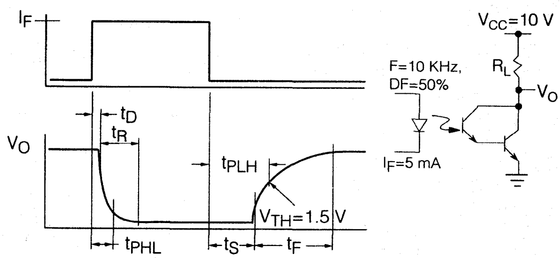


Figure 8. Switching waveform and schematic



SIEMENS

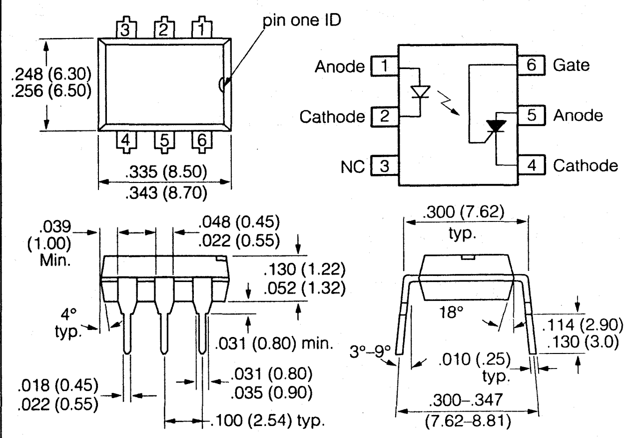
H11C4/H11C5/H11C6

Photo SCR Optocoupler

FEATURES

- **Turn On Current (IFT), 5.0 mA Typical**
- **Gate Trigger Current (IGT), 20 mA Typical**
- **Surge Anode Current, 5.0 A**
- **Blocking Voltage, 400 V Gate Trigger Voltage (VGT), 0.6 V Typical**
- **Isolation Voltage, 5300 VAC_{RMS}**
- **Solid State Reliability**
- **Standard DIP Package**
- **Underwriters Lab File #E52744**

Dimensions in Inches (mm)



DESCRIPTION

The H11C4/H11C5/H11C6 are optically coupled SCRs with a Gallium Arsenide infrared emitter and a silicon photo SCR sensor. Switching can be achieved while maintaining a high degree of isolation between triggering and load circuits. These optocouplers can be used in SCR triac and solid state relay applications where high blocking voltages and low input current sensitivity are required.

The H11C4 and H11C5 has a maximum turn-on-current of 11 mA. The H11C6 has a maximum of 14 mA.

Maximum Ratings

Emitter

Peak Reverse Voltage .... 6.0 V
Continuous Forward Current .... 60 mA
Peak Forward Current
 (1 ms, 1% Duty Cycle)................................ 3.0 A
Power Dissipation at 25°C.......................... 100 mW
Derate Linearly from 25°C..................... 1.33 mW/°C

Detector

Reverse Gate Voltage .... 6.0 V
Anode Voltage (DC or AC Peak)..................... 400 V
RMS Forward Current................................. 300 mA
Surge Anode Current (10 ms duration)............ 5.0 A
Peak Forward Current
 (100 µs, 1% Duty Cycle)............................... 10 A
Surge Gate Current (5 ms duration)............. 200 mA
Power Dissipation, 25°C case .... 1000 mW
Derate Linearly from 25°C..................... 13.3 mW/°C

Package

Isolation Test Voltage........................ 5300 VACRMS
 (between emitter and detector
 referred to Standard Climate
 23°C/50%RH, DIN 50014)
Creepage ....min.7 mm
Clearance..min. 7 mm
Comparative Tracking Index per
 DIN IEC 112/VDE 0303, part 1 175
Isolation Resistance
 VIO=500 V, TA=25°C ....≥1012 Ω
 VIO=500 V, TA=100°C ....≥1011 Ω
Total Package Dissipation .... 400 mW
Derate Linearly from 25°C....................... 5.3 mW/°C
Operating Temperature Range...... –55°C to +100°C
Storage Temperature Range......... –55°C to +150°C
Lead Soldering Time at 260°C...................... 10 sec.

Characteristics T_A=25°C

	Sym	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.2	1.5	V	I_F=10 mA
Reverse Current	I_R			10	µA	V_R=3 V
Capacitance	C_O		50		pF	V_R=0, f=1 MHz
Detector						
Forward Blocking Voltage	V_{DM}	400			V	R_{GK}=10 KΩ T_A=100°C I_d=150 µA
Reverse Blocking Voltage	V_{DM}	400			V	
On-state Voltage	V_t		1.1	1.3	V	I_T=300 mA
Holding Current	I_H			500	µA	R_{GK}=27 KΩ V_{FX}=50 V
Gate Trigger Voltage	V_{GT}		0.6	1.0	V	V_{FX}=100 V R_{GK}=27 KΩ R_L=10 KΩ
Forward Leakage Current	I_R		150		µA	R_{GK}=10 KΩ V_{RM}=400 V I_F=0, T_A=100°C
Reverse Leakage Current	I_R		150		µA	R_{GK}=10 KΩ V_{RX}=400 V I_F=0, T_A=100°C
Gate Trigger Current	I_{GT}		20	50	µA	V_{FX}=100 V R_{GK}=27 KΩ, R_L=10 KΩ
Capacitance Anode to Gate Gate to Cathode			 20 350		 pF pF	V=0, f=1 MHz
Package						
Turn-On Current H11C4/H11C5 H11C6	I_{FT}			 20 30	 mA mA	V_{DM}=50 V R_{GK}=10 KΩ
Turn-On Current H11C4/H11C5 H11C6	I_{FT}		 5 7	 11 14	 mA mA	V_{DM}=100 V R_{GK}=27 KΩ

SIEMENS

H11D1/H11D2/H11D3/H11D4

Phototransistor, 5.3 KV, TRIOS®
High BV_{CER} Voltage
Optocoupler

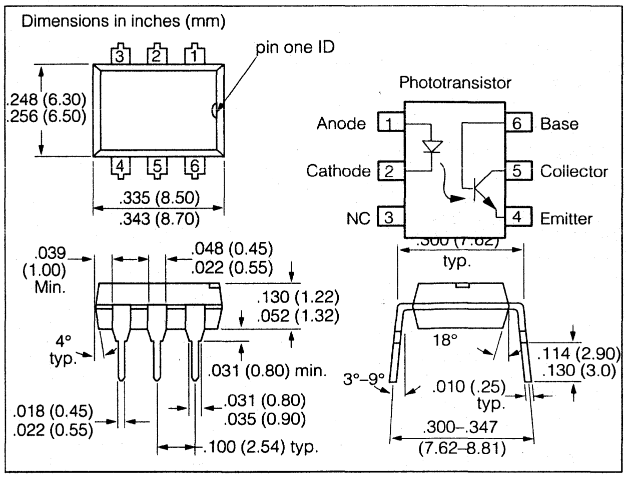
FEATURES
- **CTR at I_F=10 mA, BV_{CER}=10 V: ≥20%**
- **Good CTR Linearity with Forward Current**
- **Low CTR Degradation**
- **Very High Collector-Emitter Breakdown Voltage**
  - **H11D1/H11D2, BV_{CER}=300 V**
  - **H11D3/H11D4, BV_{CER}=200 V**
- **Isolation Test Voltage: 5300 VAC_{RMS}**
- **Low Coupling Capacitance**
- **High Common Mode Transient Immunity**
- **Phototransistor Optocoupler in 6 Pin DIP Package with Base Connection**
- **Field Effect Stable: TRIOS***
- **VDE 0884 Available with Option 1**
- **Underwriters Lab File #E52744**

APPLICATIONS
- **Telecommunications**
- **Replace Relays**

DESCRIPTION

The H11D1/2/3 are optocouplers with very high BV_{CER}. They are intended for telecommunications applications or any DC application requiring a high blocking voltage.

***TRIOS**—**TR**ansparent **IO**n **S**hield



Maximum Ratings T_A=25°C

Emitter

Reverse Voltage	6 V
DC Forward Current	60 mA
Surge Forward Current (tp ≤ 10 µs)	2.5 A
Total Power Dissipation	100 mW

Detector

Collector-Emitter Voltage	
H11D1/2	300 V
H11D3 /4	200 V
Collector-Base Voltage	
H11D1/2	300 V
H11D3 /4	200 V
Emitter-Base Voltage	7 V
Collector Current	100 mA
Total Power Dissipation	300 mW

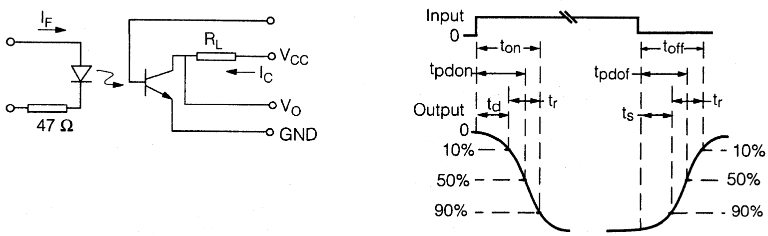
Package

Isolation Test Voltage (between emitter and detector, refer to climate DIN 50014, part 2, Nov. 74)	5300 VAC_{RMS}
Insulation Thickness between Emitter and Detector	≥0.4 mm
Creepage Distance	≥7 mm
Clearance Distance	≥7 mm
Comparative Tracking Index (per DIN IEC 112/VDE 0303, part 1)	175
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	$\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}\ \Omega$
Storage Temperature Range	–55°C to +150°C
Operating Temperature Range	–55°C to +100°C
Junction Temperature	100°C
Soldering Temperature (max. 10 sec., dip soldering: distance to seating plane ≥ 1.5 mm)	260°C

Characteristics T_A=25°C, unless otherwise specified)

Parameter		Symbol	Min	Typ	Max	Unit	Condition
Emitter							
Forward Voltage		V_F		1.1	1.5	V	I_F=10 mA
Reverse Voltage		V_R	6				I_R=10 µA
Reverse Current		I_R		0.01	10	µA	V_R=6 V
Capacitance		C_O		25		pF	V_R=0 V, f=1 MHz
Thermal Resistance		R_{thJA}		750		K/W	
Detector							
Voltage, Collector-Emitter	H11D1/H11D2	BV_{CER}	300			V	I_{CE}=1 mA, R_{BE}=1 MΩ
	H11D3/H11D4		200				
Voltage, Emitter-Base		BV_{EBO}	7				I_{EB}=100 µA
Capacitance		C_{CE}		7		pF	V_{CE}=10 V, f=1 MHz
		C_{CB}		8		pF	V_{CB}=10 V, f=1 MHz
		C_{EB}		38		pF	V_{EB}=5 V, f=1 MHz
Thermal Resistance		R_{thJA}		250		K/W	
Package							
Coupling Capacitance		C_C		0.6		pF	
Coupling Transfer Ratio		I_C/I_F	20			%	I_F=10 mA, V_{CE}=10 V, R_{BE}=1 MΩ
Collector-Emitter, Saturation Voltage		V_{CEsat}		0.25	0.4	V	I_F=10 mA, I_C=0.5 mA, R_{BE}=1 MΩ
Leakage Current, Collector-Emitter	H11D1/H11D2	I_{CER}			100	nA	V_{CE}=200 V, R_{BE}=1 MΩ
	H11D3/H11D4						V_{CE}=100 V, R_{BE}=1 MΩ
	H11D1/H11D2				250	µA	V_{CE}=300 V, R_{BE}=1 MΩ, T_A=100°C
	H11D3/H11D4						V_{CE}=100 V, R_{BE}=1 MΩ, T_A=100°C

Figure 1. Switching times measurement-test circuit and waveforms



Switching Times (typ.)

I_C=2 mA (to be adjusted by varying I_F), R_L=100Ω, T_A=25°C, V_{CC}=10 V

Description	Symbol	Values	Unit
Turn-On Time	t_{ON}	5	µs
Rise Time	t_R	2.5	
Turn-Off Time	t_{OFF}	6	
Fall Time	t_F	5.5	

Figure 2. Current transfer ratio (typ.) V_{CE}=10 V, T_A=25°C, normalized to I_F=10 mA, NCTR=f(I_F)

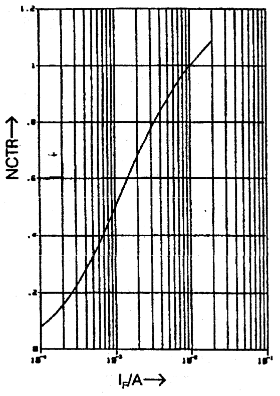


Figure 3. Diode forward voltage (typ.) V_F=f(I_F, T_A)

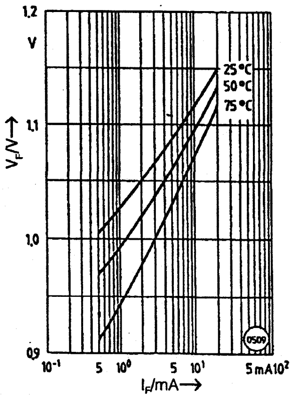


Figure 4. Output characteristics (typ.) T_A=25°C, I_{CE}=f(V_{CE}, I_B)

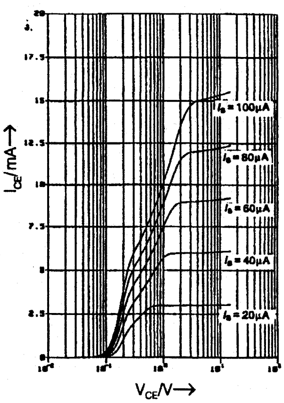


Figure 5. Output characteristics (typ.) T_A=25°C, I_{CE}=f(V_{CE}, I_F)

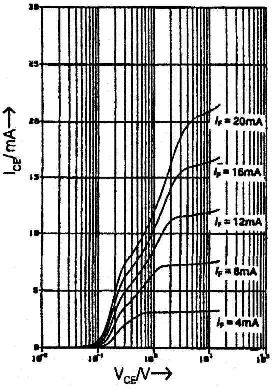


Figure 6. Transistor capacitances (typ.) T_A=25°C, f=1 MHz, C_{CE}=f(V_{CE}) C_{CB}=f (V_{CB}), C_{EB}=f (V_{EB})

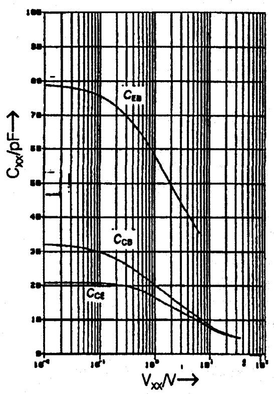


Figure 7. Collector-emitter leakage current (typ.) I_F=0, R_{BE}=1 MΩ, I_{CER}=f(V_{CE})

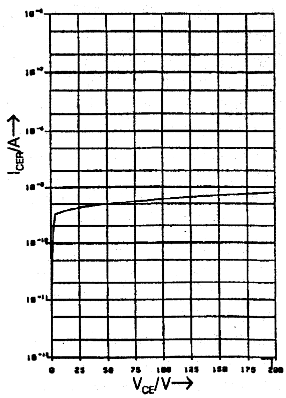


Figure 8. Permissible loss diode I_F= f(T_A)

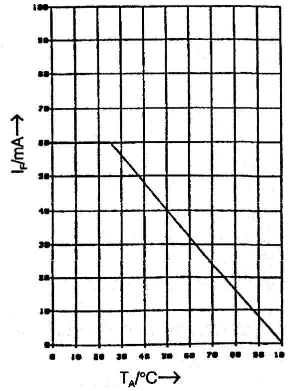
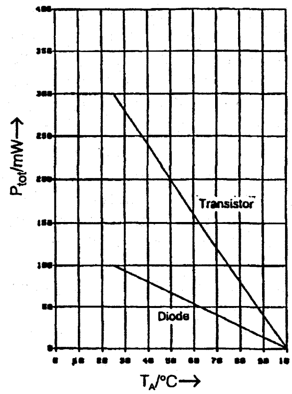


Figure 9. Permissible power dissipation P_{IOT}=f(T_A)



SIEMENS

IL1/2/5

Phototransistor Optocoupler

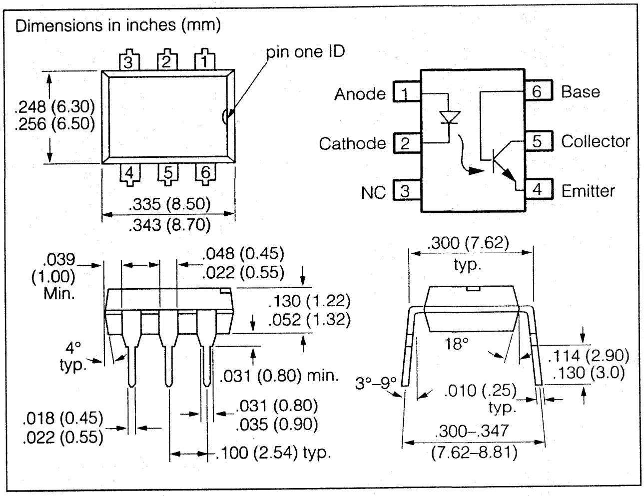
FEATURES

- **Current Transfer Ratio at I_F=10 mA**
  IL1, 20% Min.
  IL2, 100% Min.
  IL5, 50% Min.
- **High Collector-Emitter Voltage**
  IL1 – BV_{CEO}=50 V
  IL2, IL5 – BV_{CEO}=70 V
- **Field-Effect Stable by TRansparent IOn Shield (TRIOS)**
- **Double Molded Package Offers Isolation Test Voltage 5300 VAC_{RMS}**
- **Underwriters Lab File #E52744**
- **VDE Approval #0884 (Available with Option 1)**

DESCRIPTION

The IL1/2/5 are optically coupled isolated pairs employing GaAs infrared LEDs and silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the drive while maintaining a high degree of electrical isolation between input and output. The IL1/2/5 are especially designed for driving medium-speed logic and can be used to eliminate troublesome ground loop and noise problems. These couplers can be used also to replace relays and transformers in many digital interface applications such as CRT modulation.

See Appnote 45, "How to Use Optocoupler Normalized Curves."



Maximum Ratings

Emitter

Reverse Voltage	6 V
Forward Current	60 mA
Surge Current	2.5 A
Power Dissipation	100 mW
Derate Linearly from 25°C	1.33 mW/°C

Detector

Collector-Emitter Reverse Voltage	
IL1	50 V
IL2, IL5	70 V
Emitter-Base Reverse Voltage	7 V
Collector-Base Reverse Voltage	70 V
Collector Current	50 mA
Collector Current (t<1 ms)	400 mA
Power Dissipation	200 mW
Derate Linearly from 25°C	2.6 mW/°C

Package

Package Power Dissipation	250 mW
Derate Linearly from 25°C	3.3 mW/°C
Isolation Test Voltage (between emitter and detector referred to standard climate 23°C/50%RH, DIN 50014)	5300 VAC_{RMS}
Creepage	min. 7 mm
Clearance	min. 7 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303, part 1	175
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	$\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}\ \Omega$
Storage Temperature	–40°C to +150°C
Operating Temperature	–40°C to +100°C
Junction Temperature	100°C
Soldering Temperature (2 mm from case bottom)	260°C

Characteristics

	Symbol	Min	Typ	Max	Unit	Condition
Emitter						
Forward Voltage	V_F		1.25	1.65	V	I_F=60 mA
Breakdown Voltage	V_{BR}	6	30			I_R=10 µA
Reverse Current	I_R		0.01	10	µA	V_R=6 V
Capacitance	C_O		40		pF	V_R=0 V, f=1 MHz
Thermal Resistance Junction to Lead	R_{THJL}		750		°C/W	
Detector						
Capacitance	C_{CE} C_{CB} C_{EB}		6.8 8.5 11		pF	V_{CE}=5 V, f=1 MHz V_{CB}=5 V, f=1 MHz V_{EB}=5 V, f=1 MHz
Collector-Emitter Leakage Current	I_{CEO}		5	50	nA	V_{CE}=10 V
Collector-Emitter Saturation Voltage	V_{CESAT}		0.25			I_{CE}=1 mA, I_B=20 µA
Base-Emitter Voltage	V_{BE}		0.65		V	V_{CE}=10 V, I_B=20 µA
DC Forward Current Gain	HFE	200	650	1800		V_{CE}=10 V, I_B=20 µA
Saturated DC Forward Current Gain	HFE_{SAT}	120	400	600		V_{CE}=0.4 V, I_B=20 µA
Thermal Resistance Junction to Lead	R_{THJL}		500		°C/W	
Package Transfer Characteristics						
IL1						
Saturated Current Transfer Ratio (Collector-Emitter)	CTR_{CESAT}		75		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio (Collector-Emitter)	CTR_{CE}	20	80	300		I_F=10 mA, V_{CE}=10 V
Current Transfer Ratio (Collector-Base)	CTR_{CB}		0.25			I_F=10 mA, V_{CB}=9.3 V
IL2						
Saturated Current Transfer Ratio (Collector-Emitter)	CTR_{CESAT}		170		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio (Collector-Emitter)	CTR_{CE}	100	200	500		I_F=10 mA, V_{CE}=10 V
Current Transfer Ratio	CTR_{CB}		0.25			I_F=10 mA, V_{CB}=9.3 V
IL5						
Saturated Current Transfer Ratio (Collector-Emitter)	CTR_{CESAT}		100		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio (Collector-Emitter)	CTR_{CE}	50	130	400		I_F=10 mA, V_{CE}=10 V
Current Transfer Ratio	CTR_{CB}		0.25			I_F=10 mA, V_{CB}=9.3 V
Isolation and Insulation						
Common Mode Rejection Output High	CMH		5000		V/µs	V_{CM}=50 $V_{P\text{-}P}$, R_L=1 kΩ, I_F=10 mA
Common Mode Rejection Output Low	CML					
Common Mode Coupling Capacitance	C_{CM}		0.01		pF	
Package Capacitance	$C_{I\text{-}O}$		0.6			$V_{I\text{-}O}$=0 V, f=1 MHz
Insulation Resistance	R_S		10^{+14}		Ω	$V_{I\text{-}O}$=500 V

Optocouplers (Optoisolators) 5

Switching Times

Figure 1. Non-saturated switching timing

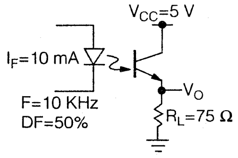


Figure 2. Saturated switching timing

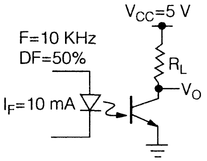


Figure 3. Non-saturated switching timing

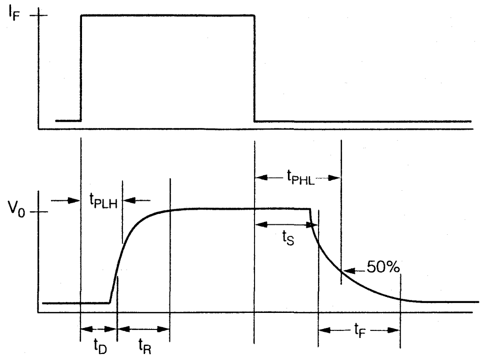
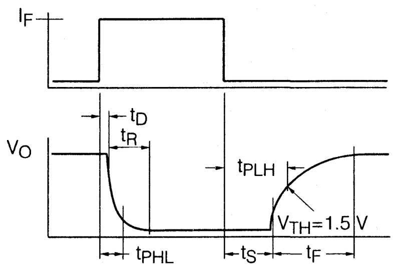


Figure 4. Saturated switching timing



Non-Saturated Switching Time Table—Typical

Characteristic	**Sym**	**IL1** I_F=20 mA	**IL2** I_F=5 mA	**IL5** I_F=10 mA	**Unit**	**Test Condition**
Delay	T_D	0.8	1.7	1.7	µs	
Rise Time	t_R	1.9	2.6	2.6		V_{CC}=5 V
Storage	t_S	0.2	0.4	0.4		R_L=75 Ω
Fall Time	t_F	1.4	2.2	2.2		
Propagation H-L	t_{PHL}	0.7	1.2	1.1		t_p measured at 50% of output
PropagationL-H	t_{PLH}	1.4	2.3	2.5		

Saturated Switching Time Table—Typical

Characteristic	**Sym**	**IL1** I_F=20 mA	**IL2** I_F=5 mA	**IL5** I_F=10 mA	**Unit**	**Test Condition**
Delay	T_D	0.8	1	1.7	µs	
Rise Time	t_R	1.2	2	7		V_{CL}=5.0 V
Storage	t_S	7.4	5.4	4.6		V_{CE}=0.4
Fall Time	t_F	7.6	13.5	20		R_L=1 K
Propagation H-L	t_{PHL}	1.6	5.4	2.6		V_{TH}=1.5 V
Propagation L-H	t_{PLH}	8.6	7.4	7.2		

Figure 5. Forward voltage versus forward current

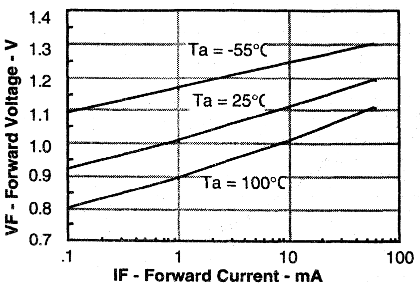


Figure 6. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

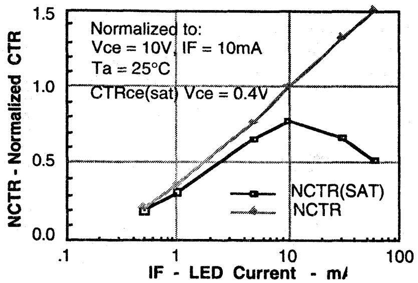


Figure 7. Normalized non-saturated and saturated CTR at T_A=50°C versus LED current

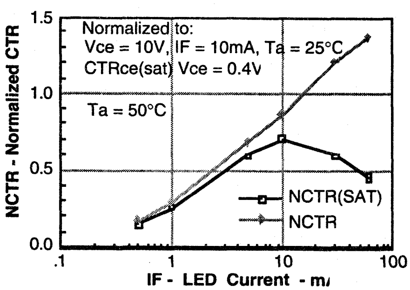


Figure 8. Normalized non-saturated and saturated CTR at T_A=70°C versus LED current

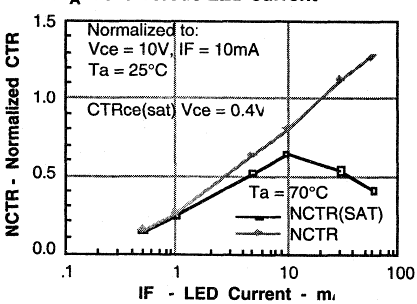


Figure 9. Normalized non-saturated and saturated CTR at T_A=100°C versus LED current

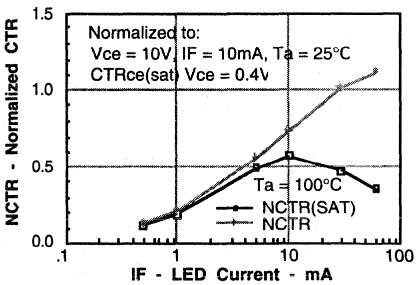


Figure 10. Collector-emitter current versus temperature and LED current

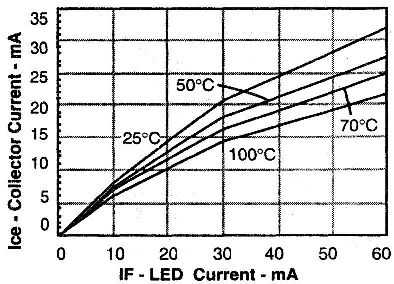


Figure 11. Collector-emitter leakage current versus temperature

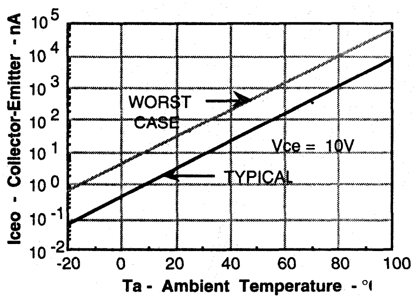


Figure 12. Normalized CTRcb versus LED current and temperature

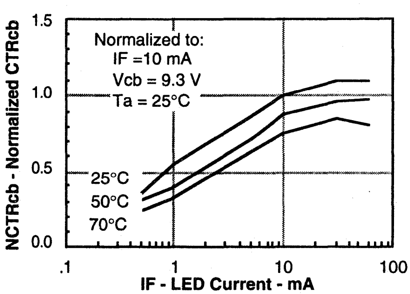


Figure 13. Collector base photocurrent versus LED current

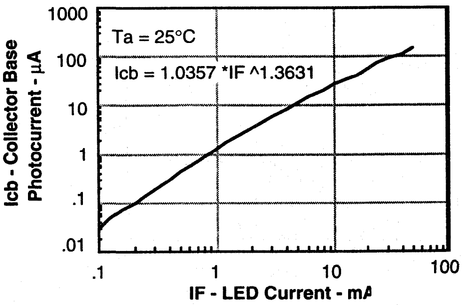


Figure 14. Normalized photocurrent versus If and temperature

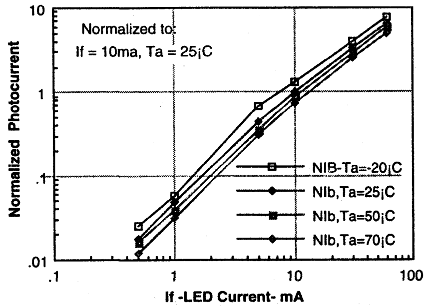


Figure 15. Normalized non-saturated HFE versus base current and temperature

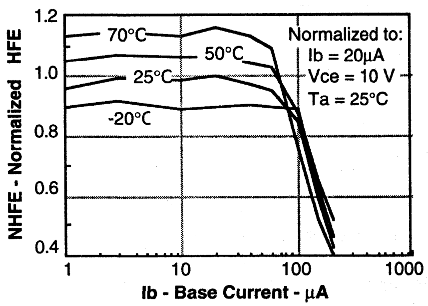


Figure 16. Normalized saturated HFE versus base current and temperature

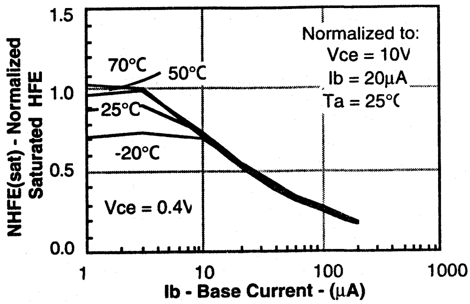
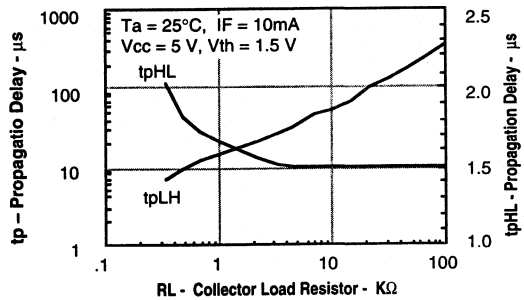


Figure 17. Propagation delay versus collector load resistor



SIEMENS

SINGLE CHANNEL IL30/31/55
DUAL CHANNEL ILD30/31/55
QUAD CHANNEL ILQ30/31/55
Photodarlington Optocoupler

FEATURES
- **Current Transfer Ratio IL/ILD/ILQ30/55, 100% min. IL/ILD/ILQ31, 200% min.**
- **125 mA Load Current Rating**
- **Fast Rise Time, 10 µS**
- **Fast Fall Time, 35 µS**
- **Single, Dual and Quad Channel**
- **Solid State Reliability**
- **Standard DIP Packages**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

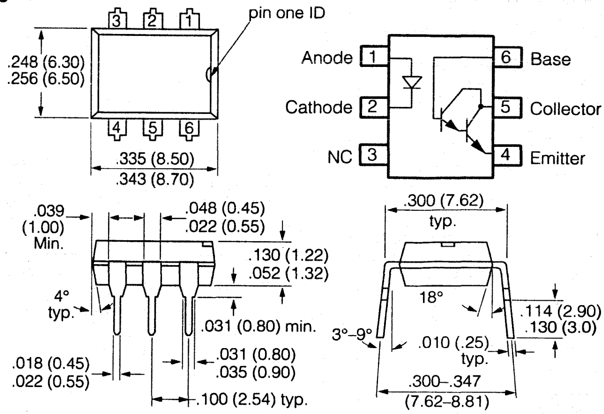
DESCRIPTION
The IL30/31/55, ILD30/31/55, and ILQ30/31/55 are optically coupled isolators wih Gallium Arsenide infrared emitters and silicon photodarlington sensors. Switching can be achieved while maintaining a high degree of isolation between driving and load circuits, with no crosstalk between channels. These optocouplers can be used to replace reed and mercury relays with advantages of long life, high speed switching and elimination of magnetic fields.

The Il30/31/55 are equivalent to MCA230/MCA231/MCA255. The ILD30/31/55 re designed to reduce board space requirements in high density applications.

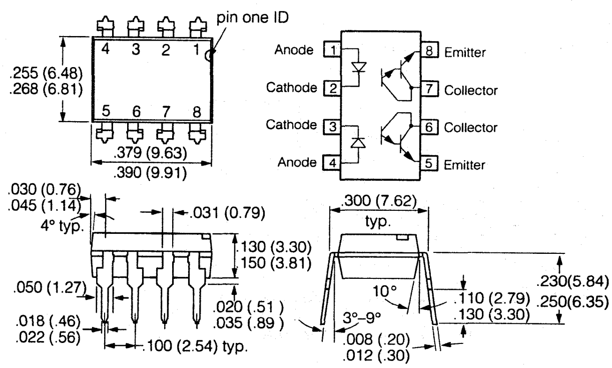
Maximum Ratings
Emitter (each channel)
Peak Reverse Voltage....................................3 V
Continuous Forward Current.......................60 mA
Power Dissipation at 25°C.......................100 mW
Derate Linearly from 25°C..................1.33 mW/°C
Detector (each channel)
Collector-Emitter Breakdown Voltage
IL/D/Q30..30 V
IL/D/Q55..55 V
Collector (Load) Current..........................125 mA
Power Dissipation at 25°C Ambient...........150 mW
Derate Linearly from 25°C.....................2.0 mW/°C
Package
Total Package Power Dissipation at 25°C
IL30/31/55..250 mW
ILD30/31/55..400 mW
ILQ30/31/55..500 mW
Derate Linearly from 25°C
IL30/31/55...3.3 mW/°C
ILD30/31/55...5.33 mW/°C
ILQ30/31/55...6.67 mW/°C
Isolation Test Voltage.......................5300 VAC_{RMS}
Creepage...7 mm min.
Clearance..7 mm min.
Comparative Tracking Index............................175
Storage Temperature..................–55°C to +125°C
Operating Temperature................–55°C to +100°C
Lead Soldering Time at 260°C.................. 10 sec.

Dimensions in inches (mm)

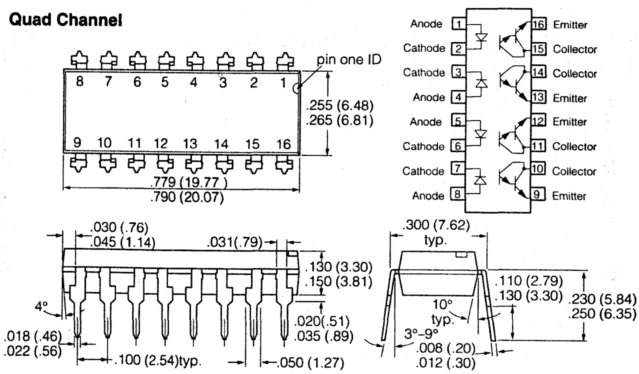
Single Channel



Dual Channel



Quad Channel



Electrical Characteristics T_A=25°C

Parameter		Symbol	Min.	Typ.	Max..	Unit	Condition
GaAs Emitter (per channel)							
Forward Voltage		V_F		1.25	1.5	V	I_F=20 mA
Reverse Current		I_R		0.1	10	µA	V_R=3.0 V
Capacitance		C_O		25		pF	V_R=0 V
Detector (per channel)							
Collector-Emitter Breakdown Voltage		BV_{CEO}	30/55			V	I_C=100 µA
Collector-Emitter Leakage Current		I_{CEO}		1.0	100	nA	V_{CE}=10 V, I_F=0
Collector-Emitter Capacitance		C_{CE}		3.4		pF	V_{CE}=10 V, f=1 MHz
Package							
Current Transfer Ratio	IL/D/Q30/55	CTR	100	400		%	I_F=10 mA,V_{CE}=5 V
	IL/D/Q31		200	400			
Collector-Emitter Saturation Voltage		V_{CEsat}		0.9	1.0	V	I_C=50 mA, I_F=50 mA
Isolation Test Voltage			5300			VAC_{RMS}	
Isolation Resistance		R_{ISOL}		10^{12}		Ω	
Coupling Capacitance		C_{ISOL}		0.5		pF	
Rise Time		t_R		10		µs	V_{CC}=13.5 V, I_F=50 mA, R_C=100 Ω
Fall Time		t_F		35		µs	

Figure 1. Forward voltage versus forward current

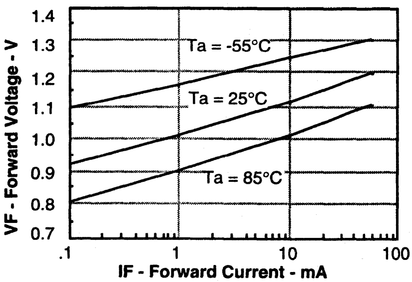


Figure 3. Normalized non-saturated and saturated collector-emitter current versus LED current

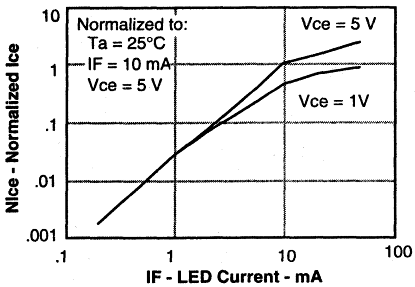


Figure 2. Normalized non-saturated and saturated CTRce at T_A=25°C versus LED current

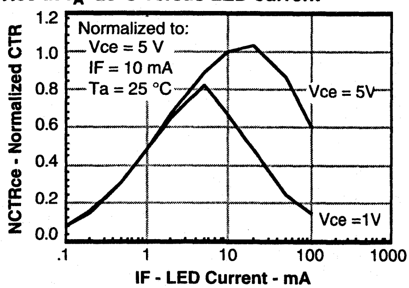


Figure 4. Normalized collector-base photocurrent versus LED current

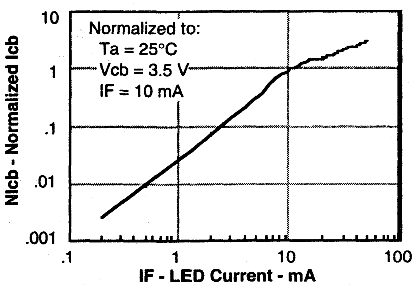


Figure 5. Hfe current gain versus base current

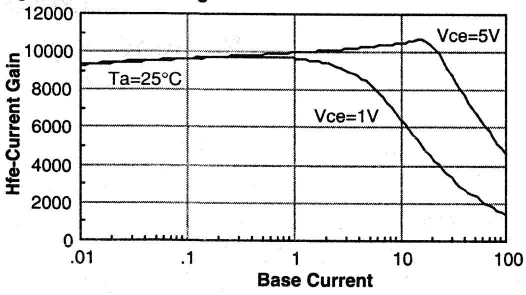


Figure 6. Low to high propagation delay versus collector load resistance and LED current

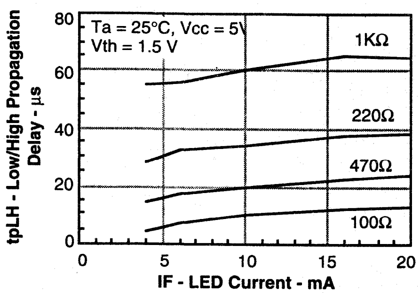


Figure 7. High to low propagation delay versus collector load resistance and LED current

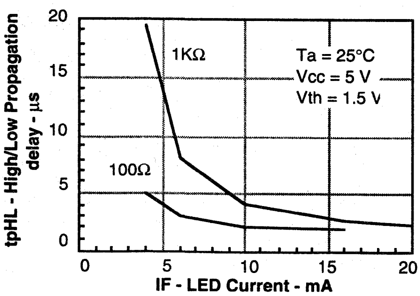


Figure 8. Switching waveforms

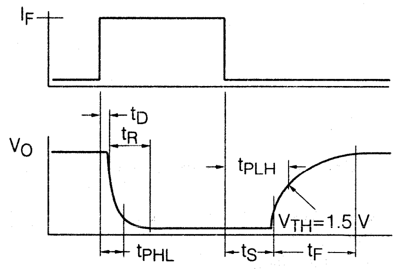
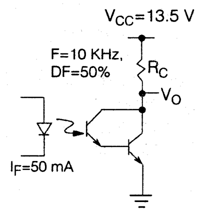


Figure 9. Switching schematic



Optocouplers (Optoisolators) 5

SIEMENS

IL55B

Photodarlington Optocoupler

FEATURES
- **High Collector-Emitter Breakdown Voltage, 80 V minimum**
- **High Isolation Resistance, 1011 W Typical**
- **Standard Plastic DIP Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

DESCRIPTION
The IL55B is an optically coupled isolator with a Gallium Arsenide infrared LED and a silicon photodarlington sensor. Switching can be achieved while maintaining a high degree of isolation between driving and load circuits. These optocouplers can be used to replace reed and mercury relays with advantages of long life, high speed switching and elimination of magnetic fields.

Maximum Ratings
Emitter

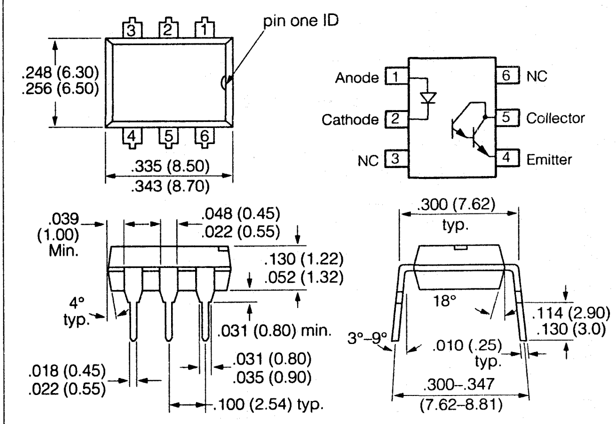
Peak Reverse Voltage .... 3 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C.............................. 100 mW
Derate Linearly from 55°C......................... 1.33 mW/°C

Detector

Collector-Emitter Breakdown Voltage, BV_{CEO}....... 80 V
Emitter-Collector Breakdown Voltage BV_{ECO}.......... 5 V
Collector (load) Current.................................... 125 mA
Power Dissipation at 25°C Ambient .... 150 mW
Derate Linearly from 25°C........................... 2.0 mW/°C

Package

Total Dissipation at 25°C Ambient .... 250 mW
Derate Linearly from 25°C........................... 3.3 mW/°C
Isolation Test Voltage (between emitter and detector refered to standard climate 23°C/50%RH, DIN 50014) .... 5300 VAC_{RMS}
Creepage .... 7 mm min.
Clearance.. 7 mm min.
Tracking Resitance, Group III (KC>600 per VDE 110 § 6,Table 3 and DIN 53480/VDE 0330, Part 1
Isolation Resistance
V_{IO}=500 V, T_A=25°C ....10^{12} Ω
V_{IO}=500 V, T_A=100°C ....10^{11} Ω
Storage Temperature ....–55°C to +150°C
Operating Temperature ....–55°C to +100°C
Lead Soldering Time at 260°C......................... 10 sec.



Electrical Characteristics T_A=25°C

Parameter	Min.	Typ.	Max.	Unit	Condition
Emitter					
Forward Voltage*		1.25	1.5	V	I_F=50 mA
Reverse Current*		0.1	10	µA	V_R=3.0 V
Capacitance		25		pF	V_R=0 V
Detector					
BV_{CEO}	80			V	I_C=1 mA, I_F=0
BV_{ECO}	5	10		V	I_E=100 µA, I_F=0
I_{CEO}			1	µA	V_{CE}=60 V, I_F=0
Package					
Current Transfer Ratio	500			%	I_F=10 mA V_{CE} =1.5 V
Coupling Capacitance		1.5		pF	
Turn-On Time		5		µs	V_{CC}=10 V
Turn-Off Time		100		µs	I_F=5 mA R_L=100 Ω

Figure 1. Forward voltage versus forward current

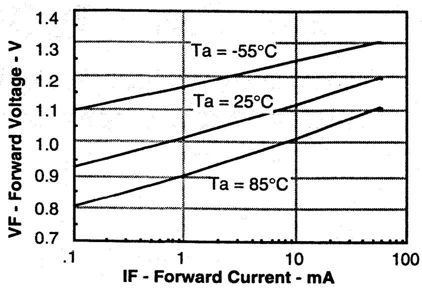


Figure 2. Normalized non-saturated and saturated CTRce at T_A=25°C versus LED current

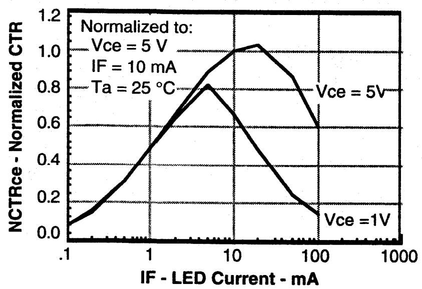


Figure 3. Normalized non-saturated and saturated collector-emitter current versus LED current

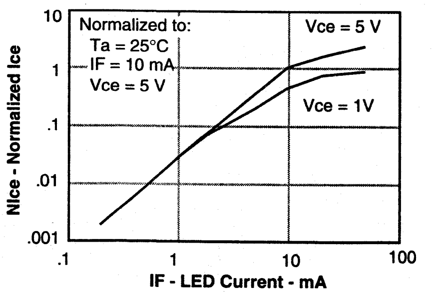


Figure 4. Low to high propagation delay versus collector load resistance and LED current

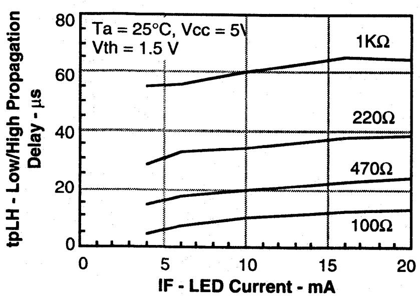


Figure 5. High to low propagation delay verus collector load resistance and LED current

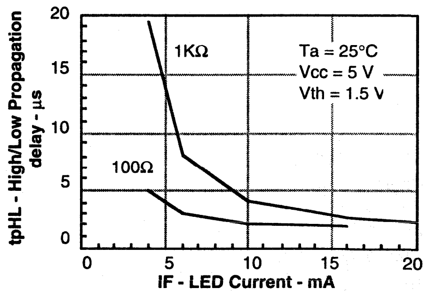


Figure 6. Switching waveforms

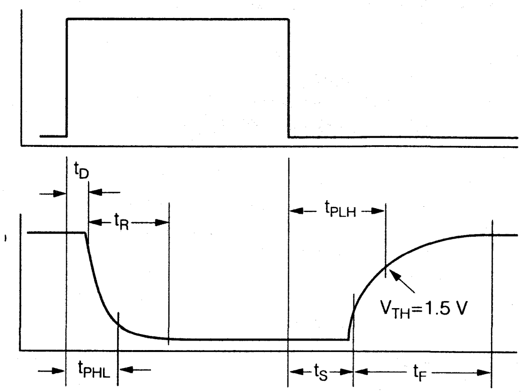
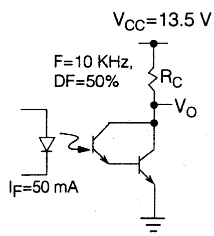


Figure 7. Switching schematic

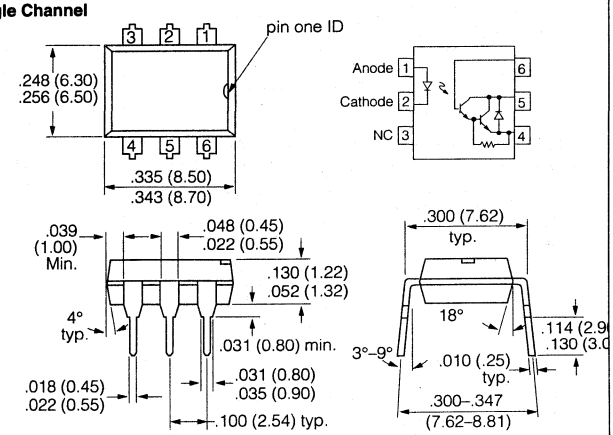


SIEMENS

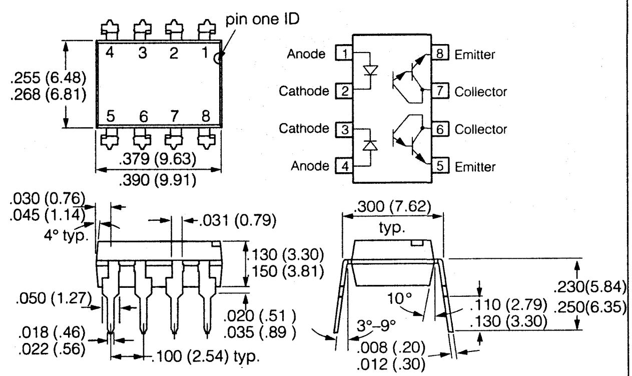
SINGLE CHANNEL IL66
DUAL CHANNEL ILD66
QUAD CHANNEL ILQ66
Photodarlington Optocoupler

Dimensions in inches (mm)

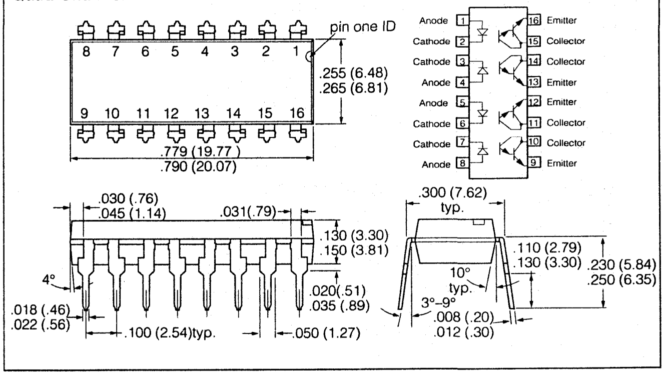
Single Channel



Dual Channel



Quad Channel



FEATURES

- **Internal RBE for High Stability**
- **Current Transfer Ratio is Tested at 2.0 mA and 0.7 mA Input IL/ILD/ILQ66 Series:**
  –1, 100% min. at I_F=2 mA, V_{CE}=10 V
  –2, 300% min. at I_F=2 mA, V_{CE}=10 V
  –3, 400% min. at I_F=0.7 mA, V_{CE}=10 V
  –4, 500% min. at I_F=2 mA, V_{CE}=5 V
- **Four Available CTR Categories per Package Type**
- **BV_{CEO}>60 V**
- **Standard DIP Packages**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

DESCRIPTION

IL66, ILD66, and ILQ66 are optically coupled isolators employing Gallium Arsenide infrared emitters and silicon photodarlington detectors. Switching can be accomplished while maintaining a high degree of isolation between driving and load circuits, with no crosstalk between channels.

Maximum Ratings

Emitter Each Channel

Peak Reverse Voltage	6 V
Continuous Forward Current	60 mA
Power Dissipation at 25°C	100 mW
Derate Linearly from 25°C	1.33 mW/°C

Detector (Each Channel)

Power Dissipation at 25°C Ambient	150 mW
Derate Linearly from 25°C	2.0 mW/°C

Package

Isolation Test Voltage (t=1 sec.)	5300 VAC_{RMS}
Total Package Power Dissipation at 25°C	
IL66	250 mW
ILD66	400 mW
ILQ66	500 mW
Derate Linearly from 25°C	
IL66	3.3 mW/°C
ILD66	5.33 mW/°C
ILQ66	6.67 mW/°C
Creepage	7 min mm
Clearance	7 min mm
Comparative Tracking Index	175
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	$\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}\ \Omega$
Storage Temperature	–55°C to +125°C
Operating Temperature	–55°C to +100°C
Lead Soldering Time at 260°C	10 sec.

Electrical Characteristics T_A=25C

Parameter		Symbol	Min.	Typ.	Max.	Unit	Condition
GaAs Emitter							
Forward Voltage		V_F		1.25	1.5	V	I_F=20 mA
Reverse Current		I_R		0.1	10	µA	V_R=6.0 V
Capacitance		C_O		25		pF	V_R=0 V
Photodarlington							
Breakdown Voltage	Collector-Emitter	BV_{CEO}	60			V	I_C=1 mA, I_F=0
	Collector-Base (IL66)	BV_{CBO}	60				I_C=10 µA
Leakage Current, Collector-Emitter		I_{CEO}		1.0	100	nA	V_{CE}=50 V, I_F=0
Capacitance, Collector-Emitter				3.4		pF	V_{CE}=10 V
Coupled Characteristics							
Current Transfer Ratio	IL/ILD/ILQ66-1	CTR	100	400		%	I_F=2 mA, V_{CE}=10 V
	IL/ILD/ILQ66-2		300	500			I_F=2 mA, V_{CE}=10 V
	IL/ILD/ILQ66-3		400	500			I_F=0.7 mA, V_{CE}=10 V
	IL/ILD/ILQ66-4		500	750			I_F=2 mA, V_{CE}=5 V
Saturation Voltage, Collector-Emitter		V_{CEsat}		0.9	1.0	V	I_C=10 mA, I_F=10 mA
Rise Time -1, -2, -4		t_R			200	µs	V_{CC}=10 V
Fall Time -1, -2, -4		t_F			200		I_F=2 mA, R_C=100 Ω
Rise Time -3		t_R			200		I_F=0.7 mA
Fall Time -3		t_F			200		V_{CC}=10 V, R_L=100 Ω

Figure 1. Forward voltage versus forward current

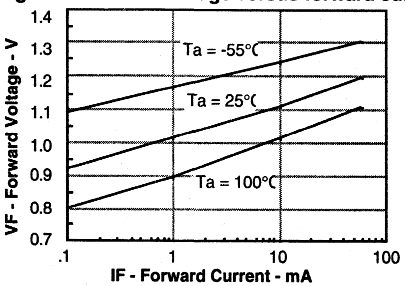


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

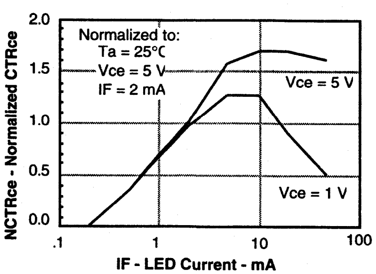


Figure 3. Normalized non-saturated and saturated CTRce versus LED current

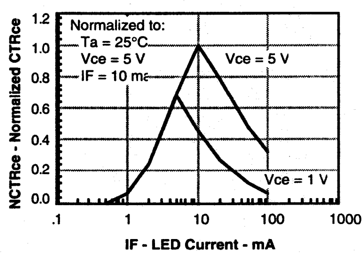


Figure 4. Non-saturated and saturated collector emitter current versus LED current

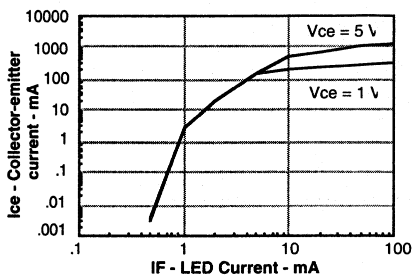


Figure 5. Collector-base photocurrent versus LED current

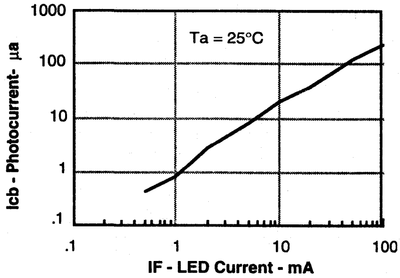


Figure 6. Collector-emitter current versus LED current

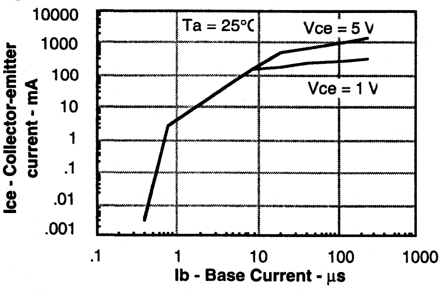


Figure 7. Non-saturated and saturated HFE versus LED current

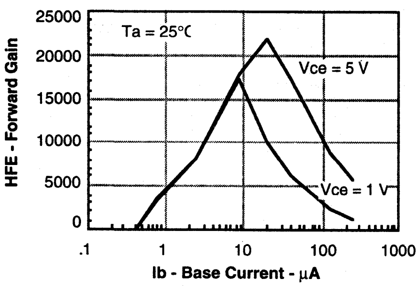


Figure 8. High/low propagation delay versus collector load resistance and LED current

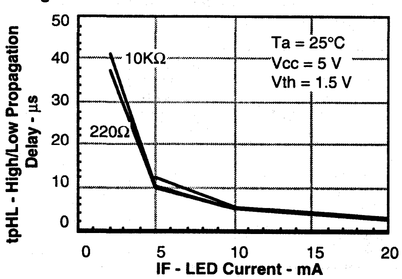


Figure 9. Low/high propagation delay versus collector load resistance and LED current

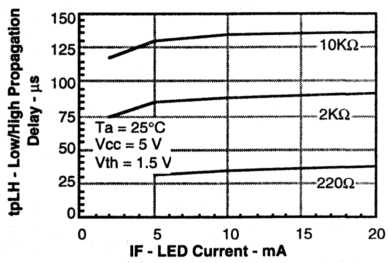


Figure 10. Switching waveform

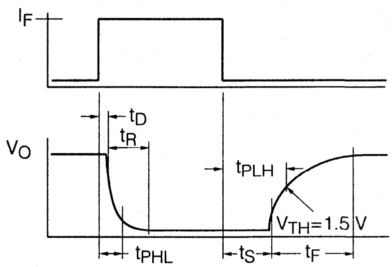
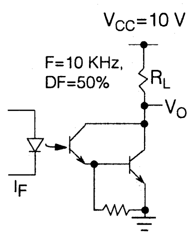


Figure 11. Switching schematic



SIEMENS

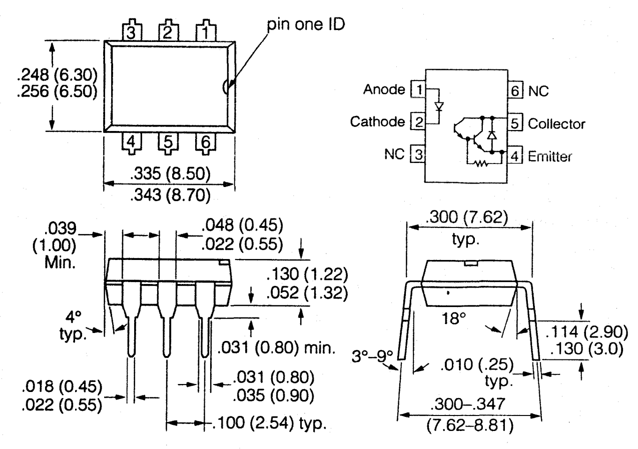
IL66B

Photodarlington Optocoupler

FEATURES

- **Internal RBE for High Stability**
- **High Current Transfer Ratio at I_F=2 mA, V_{CE}=5 V IL66B-1, 200% min. IL66B-2, 750% min.**
- **Withstand Test Voltage, 5300 VAC_{RMS}**
- **No Base Connection**
- **High Isolation Resistance**
- **Standard Plastic DIP Package**
- **Underwriters Lab Approval #E52744**
- **VDE 0884 Available with Option 1**

Dimensions in inches (mm)



DESCRIPTION

The IL66B is an optically coupled isolator employing a Gallium Arsenide infrared emitter and a silicon photodarlington detector. Switching can be accomplished while maintaining a high degree of isolation between driving and load circuits. They can be used to replace reed and mercury relays with advantages of long life, high speed switching and elimination of magnetic fields.

Maximum Ratings (at 25°C)

Emitter

Peak Reverse Voltage .... 6 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 100 mW
Derate Linearly from 55°C .... 1.33 mW/°C

Detector

Collector-Emitter Breakdown Voltage .... 60 V
Emitter-Collector Breakdown Voltage .... 5 V
Power Dissipation at 25°C Ambient .... 200 mW
Derate Linearly from 25°C .... 2.6 mW/°C

Package

Isolation Test Voltage (t=1 sec.) ...... 5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... ≥10^{12} Ω
V_{IO}=500 V, T_A=100°C .... ≥10^{11} Ω
Total Dissipation at 25°C .... 250 mW
Derate Linearly from 25°C .... 3.3 mW/°C
Creepage Path .... 7 min mm
Clearance Path .... 7 min mm
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

Electrical Characteristics (T_A=25°C)

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.25	1.5	V	I_F=10 mA
Reverse Current	I_R		0.01	100	µA	V_R=3.0 V
Capacitance	C_O		25		pF	V_R=0 V
Detector						
Breakdown Voltage Collector-Emitter	BV_{CEO}	60			V	I_C=100 µA, I_F=0
Leakage Current Collector-Emitter	I_{CEO}		1.0	100	nA	V_{CE}=50 V, I_F=0
Package						
Current Transfer Ratio IL66B-1 IL66B-2	CTR	 200 750	 1000		%	I_F=2 mA, V_CE=5 V
Saturation Voltage Collector-Emitter	V_{CEsat}			1.0	V	I_C=10 mA, I_F=10 mA
Turn-On, Turn-Off Time	t_{on}, t_{off}			200	µs	V_{CC}=10 V I_F=2 mA, R_L=100 Ω

Figure 1. Forward voltage versus forward current

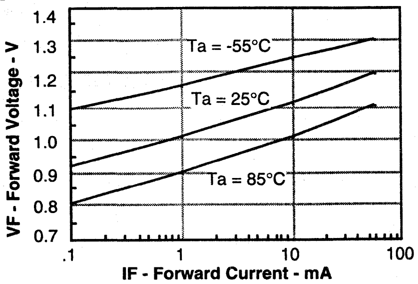


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

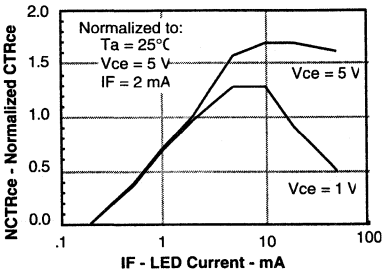


Figure 3. Normalized non-saturated and saturated CTRce versus LED current

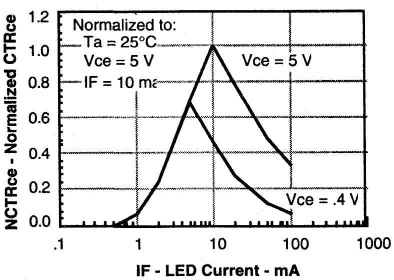


Figure 4. Non-saturated and saturated collector emitter current versus LED current

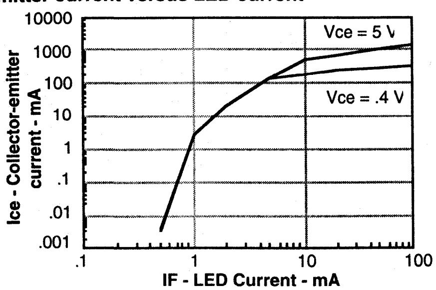


Figure 5. High/low propagation delay versus collector load resistance and LED current

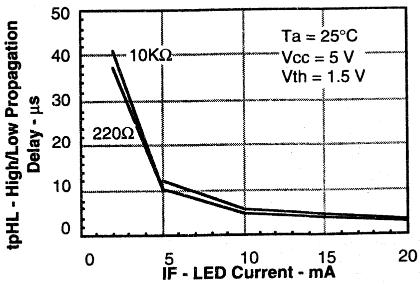
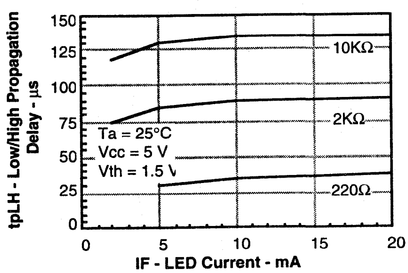


Figure 6. Low/high propagation delay versus collector load resistance and LED current



SIEMENS

SINGLE CHANNEL IL74
DUAL CHANNEL ILD74
QUAD CHANNEL ILQ74
Phototransistor Optocouper

Optocouplers (Optoisolators) 5

FEATURES

- **7400 Series T²L Compatible**
- **Transfer Ratio, 35% Typical**
- **Coupling Capacitance, 0.5 pF**
- **Single, Dual, & Quad Channel**
- **Industry Standard DIP Package**
- **Underwriters Lab File #E52744**
- **VDE Approvals #0884 (Optional with Option 1, Add -X001 Suffix)**

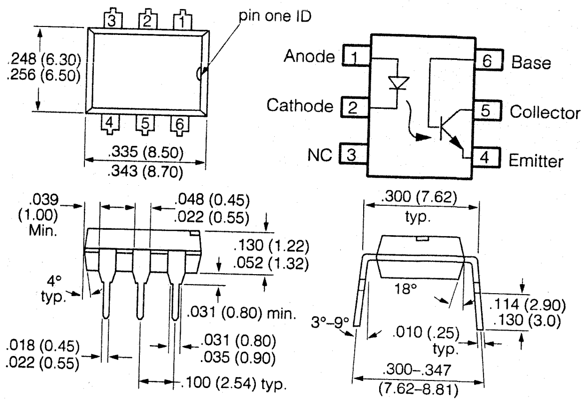
DESCRIPTION

The IL74 is an optically coupled pair with a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL74 is especially designed for driving medium-speed logic, where it may be used to eliminate troublesome gound loop and noise problems. Also it can be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation.

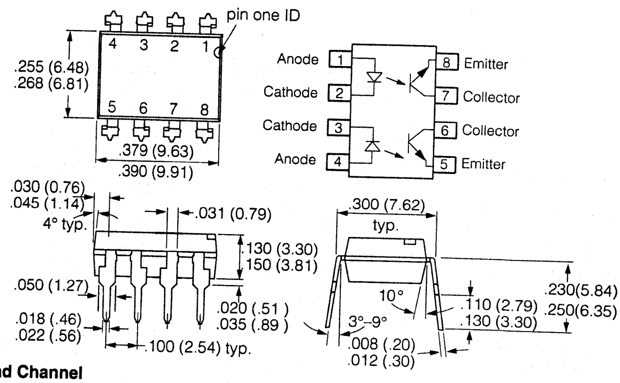
The ILD74 has two isolated channels in a single DIP package; the ILQ74 has four isolated channels per package.

Dimensions in inches (mm)

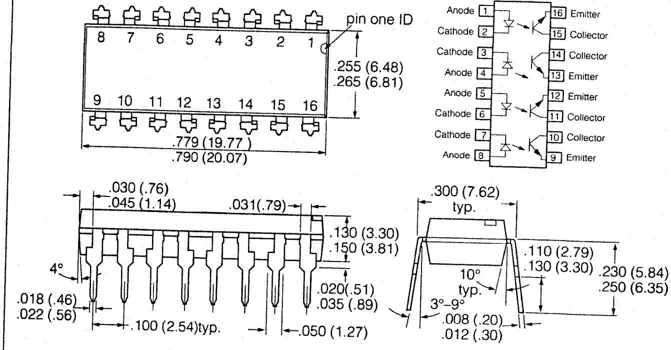
Single Channel



Dual Channel



Quad Channel



Maximum Ratings

Emitter (each channel)

Peak Reverse Voltage .... 3.0 V
Continuous Forward Current .... 60 mA
Power Dissipationat 25°C .... 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C

Detector **(each channel)**

Collector-Emitter Breakdown Voltage .... 20 V
Emitter-Base Breakdown Voltage .... 5 V
Collector-Base Breakdown Voltage .... 70 V
Power Dissipation at 25°C .... 150 mW
Derate Linearly from 25°C .... 2.0 mW/°C

Package

Isolation Test Voltage (t=1 sec.) .... 5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... ≥10^{12} Ω
V_{IO}=500 V, T_A=100°C .... ≥10^{11} Ω
Total Package Dissipation
at 25°C Ambient (LED Plus Detector)
IL74 .... 200 mW
ILD74 .... 400 mW
IL74Q .... 500 mW
Derate Linearly from 25°C
IL74 .... 2.7 mW/°C
ILD74 .... 5.33 mW/°C
ILQ74 .... 6.67 mW/°C
Creepage .... 7 mm min.
Clearance .... 7 mm min.
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

Electrical Characteristics T_A=25°C

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.3	1.5	V	I_F=20 mA
Reverse Current	I_R		0.1	100	µA	V_R=3.0 V
Capacitance	C_O		25		pF	V_R=0
Detector						
Breakdown Voltage, Collector-Emitter	BV_{CEO}	20	50		V	I_C=1 mA
Leakage Current, Collector-Emitter	I_{CEO}		5.0	500	nA	V_{CE}=5 V, I_F=0
Capacitance, Collector-Emitter	C_{CE}		10.0		pF	V_{CE}=0, F=1 MHz
Package						
DC Current Transfer Ratio	CTR_{DC}	12.5	35		%	I_F=16 mA, V_{CE}=5 V
Saturation Voltage, Collector-Emitter	V_{CEsat}		0.3	0.5	V	I_C=2 mA, I_F=16 mA
Resistance, Input to Output	R_{IO}		100		GΩ	
Capacitance, Input to Output	C_{IO}		0.5		pF	
Switching Times	t_{ON}, t_{OFF}		3.0		µs	R_E=100 Ω, V_{CE}=10 V, I_C=2 mA

Figure 1. Forward voltage versus forward current

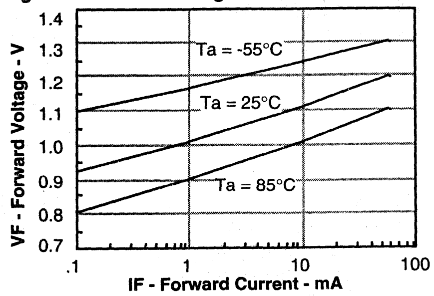


Figure 2. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

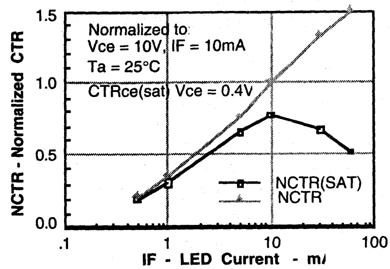


Figure 3. Normalized non-saturated and saturated CTR at T_A=50°C versus LED current

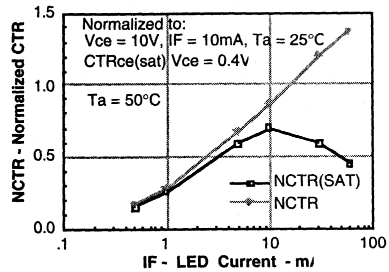


Figure 4. Normalized non-saturated and saturated CTR at T_A=70°C versus LED current

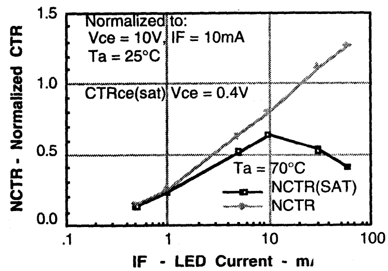


Figure 5. Normalized non-saturated and saturated CTR at T_A=85°C versus LED current

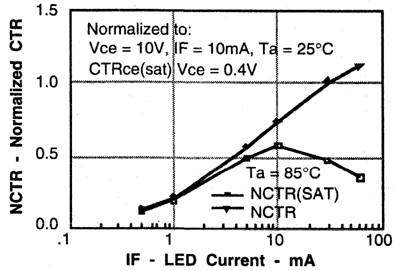


Figure 6. Collector-emitter current versus temperature and LED current

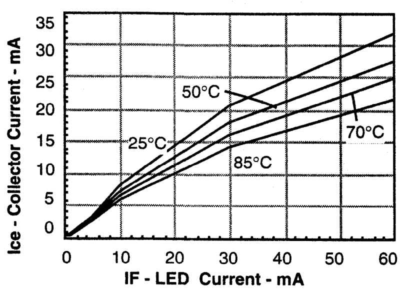


Figure 7. Collector-emitter leakage current versus temperature

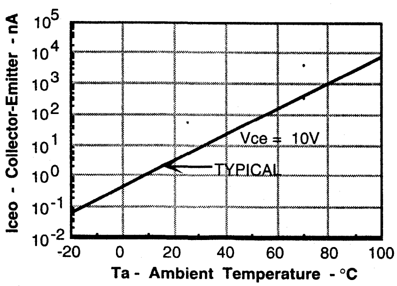


Figure 8. Normalized CTRcb versus LED current and temperature

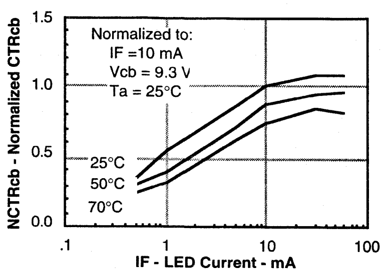


Figure 9. Collector base photocurrent versus LED current

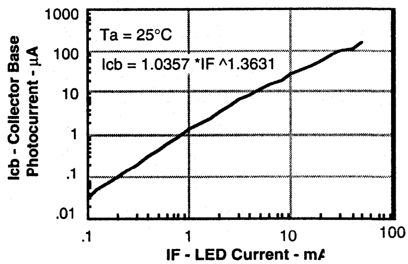


Figure 10. Normalized photocurrent versus If and temperature

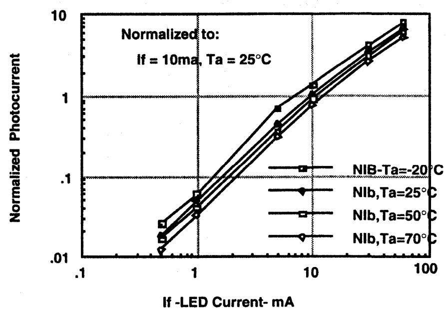


Figure 11. Normalized non-saturated HFE versus base current and temperature

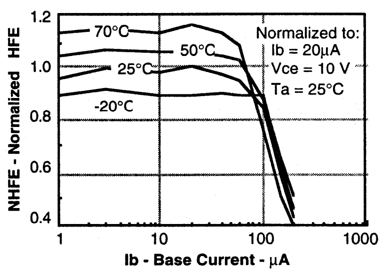


Figure 12. Normalized saturated HFE versus base current and temperature

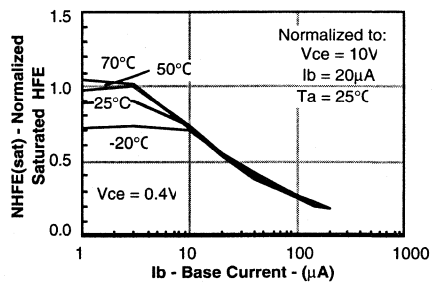


Figure 13. Propagation delay versus collector load resistor

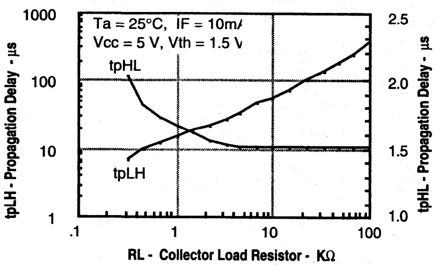
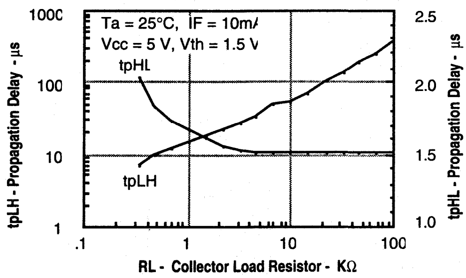


Figure 14. Propagation delay versus collector load resistor



SIEMENS

IL201/IL202/IL203

Phototransistor Optocoupler

FEATURES

- **High Current Transfer Ratio, 75% to 450%**
- **Minimum Current Transfer Ratio, 10%**
- **Guaranteed at I_F=1mA**
- **High Collector-Emitter Voltage, BV_{CEO}=70V**
- **Long Term Stability**
- **Industry Standard DIP Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

DESCRIPTION

The IL201/202/203 are optically coupled pairs employing a Gallium Arsenide infrared LED and a Silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL201/202/203 can be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation.

Maximum Ratings

Emitter

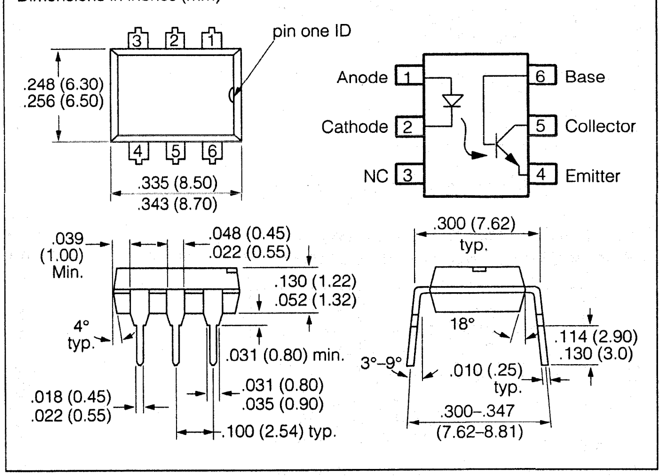
Peak Reverse Voltage .... 6 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C

Detector

Collector-Emitter Breakdown Voltage,
BV_{CEO} .... 70 V
Emitter-Collector Breakdown Voltage,
BV_{ECO} .... 7 V
Collector-Base Breakdown Voltage,
BV_{CBO} .... 70 V
Power Dissipation .... 200 mW
Derate Linearly from 25°C .... 2.6 mW/°C

Package

Isolation Test Voltage (t=1 sec.) ..... 5300 VAC_{RMS}
Total Package Dissipation at 25°C A
(LED + Detector) .... 250 mW
Derate Linearly from 25°C .... 3.3 mW/°C
Creepage .... 7 min mm
Clearance .... 7 min mm
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.



Characteristics 0°C to 70°C unless otherwise specified

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.2	1.5	V	I_F=20 mA
Forward Voltage			1.0	1.2		I_F=1 mA
Breakdown Voltage		6	20			I_R=10 µA
Reverse Current	I_R		0.1	10	µA	V_R=6 V T_A=25°C
Detector						
	HFE	100	200			V_{CE}=5 V I_C=100 µA
	BV_{CEO}	70			V	I_C=100 µA
	BV_{ECO}	7	10			I_E=100 µA
	BV_{CBO}	70	90			I_C=10 µA
	I_{CEO}		5	50	nA	V_{CE}=10 V, T_A=25°C
Package						
Base Current Transfer Ratio	CTRCB	0.15			%	I_F=10 mA V_{CB}=10 V
	V_{CEsat}			0.4	V	I_F=10 mA I_C=2 mA
DC Current Transfer Ratio IL201 IL202 IL203	CTR	 75 125 225	 100 200 300	 150 250 450	%	I_F=10 mA, V_{CE}=10 V
DC Current Transfer Ratio IL201 IL202 IL203	CTR	 10 30 50			%	I_F=1 mA, V_{CE}=10 V

Figure 1. Forward voltage versus forward current

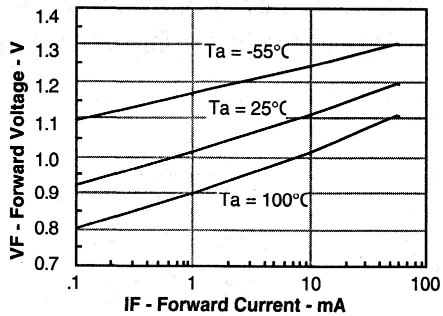


Figure 2. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

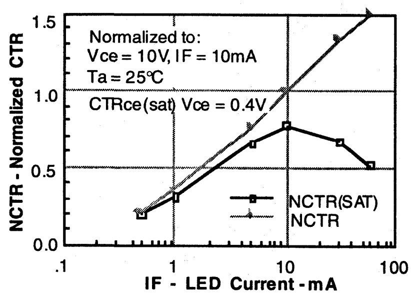


Figure 3. Normalized non-saturated and saturated CTR at T_A=50°C versus LED current

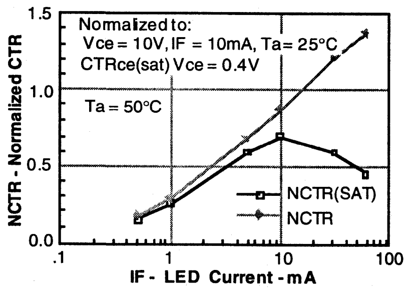


Figure 4. Normalized non-saturated and saturated CTR at T_A=70°C versus LED current

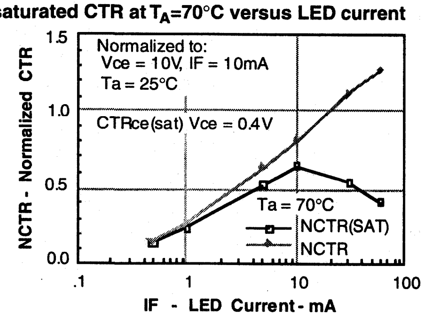


Figure 5. Normalized non-saturated and saturated CTR at T_A=85°C versus LED current

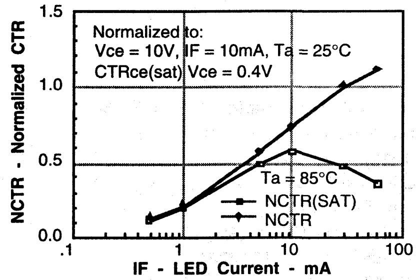


Figure 6. Collector-emitter current versus temperature and LED current

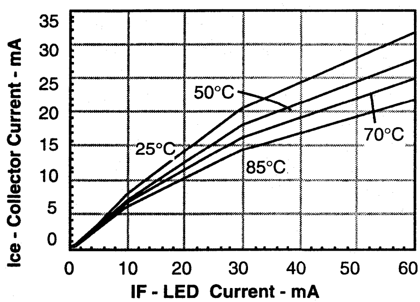


Figure 7. Collector-emitter leakage current versus temperature

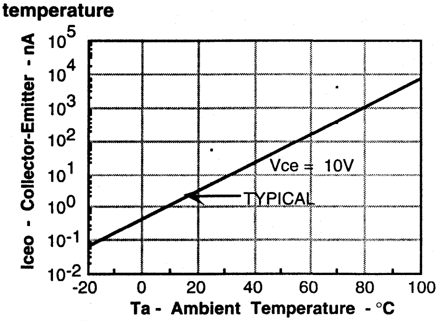


Figure 8. Normalized CTRcb versus LED current and temperature

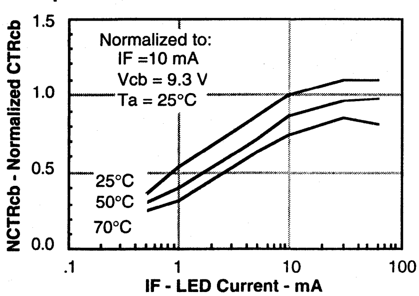


Figure 9. Collector base photocurrent versus LED current

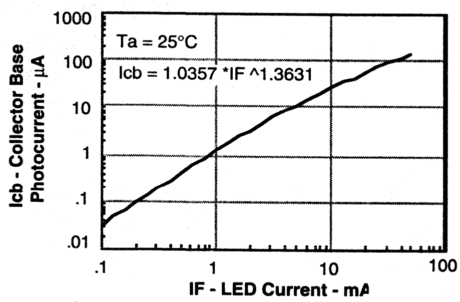


Figure 12. Propagation delay versus collector load resistor

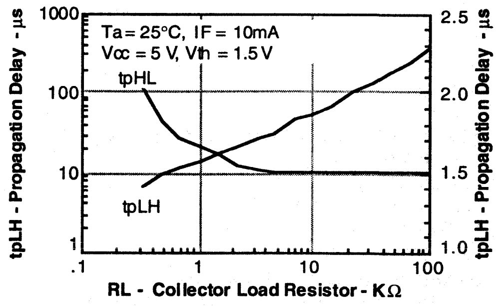


Figure 10. Normalized photocurrent versus If and temperature

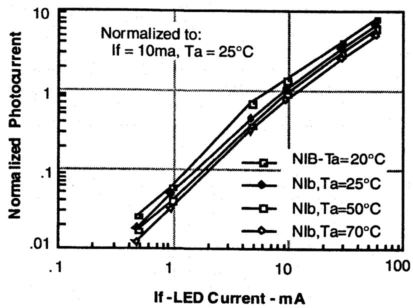


Figure 13. Normalized non-saturated and saturated CTRce versus LED current

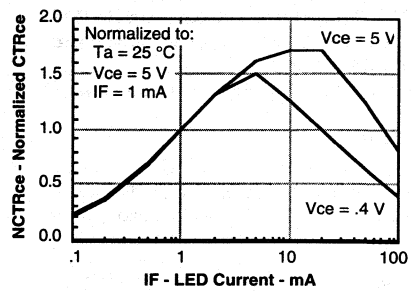


Figure 11. Normalized saturated HFE versus base current and temperature

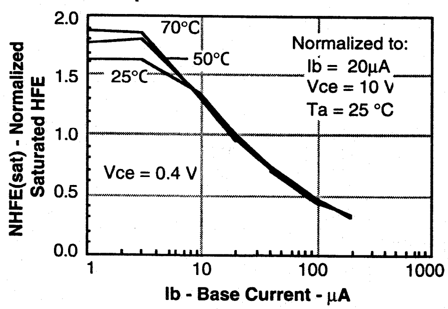
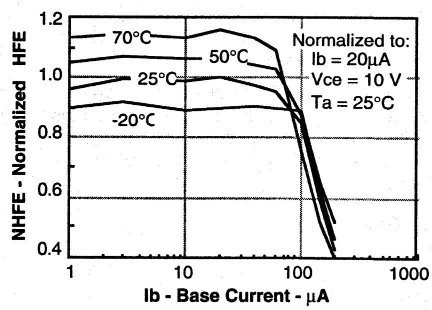


Figure 14. Normalized non-saturated HFE versus base current and temperature



SIEMENS

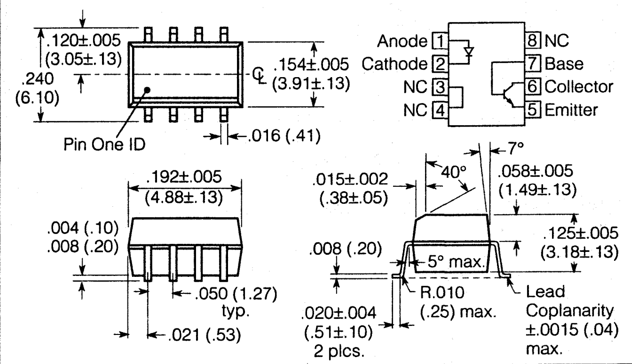
IL205A/206A/207A/208A

Phototransistor Small Outline Surface Mount Optocoupler

FEATURES

- **High Current Transfer Ratio, I_F=10 mA, V_{CE}=5 V**
  IL205A, 40–80%
  IL206A, 63–125%
  IL207A, 100–200%
  IL208A, 160–320%
- **High BV_{CEO}, 70 V**
- **Isolation Test Voltage, 2500 VAC_{RMS}**
- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing, .05"**
- **Available only on Tape and Reel Option—Suffix "T" (Conforms to EIA Standard RS481A)**
- **Compatible with Dual Wave, Fapor Phase and IR Reflow Soldering**
- **Underwriters Lab File #E52744 (Code Letter P)**

Dimensions in inches (mm)



DESCRIPTION

The IL205A/206A/207A/208A are optically coupled pairs with a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL205/6/7/8 come in a standard SOIC-8 small outline package for surface mounting which makes them ideally suited for high density applications with limited space. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

A specified minimum and maximum CTR allows a narrow tolerance in the electrical design of the adjacent circuits. The high BV_{CEO} of 70 volts gives a higher safety margin compared to the industry standard 30 volts.

Maximum Ratings

Emitter

Peak Reverse Voltage .... 6.0 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 90 mW
Derate Linearly from 25°C...................... 1.2 mW/°C

Detector

Collector-Emitter Breakdown Voltage.............. 70 V
Emitter-Collector Breakdown Voltage................ 7 V
Collector-Base Breakdown Voltage.................. 70 V
$I_{CMAX\ DC}$ .... 50 mA
I_{CMAX} (t<1 ms) .... 100 mA
Power Dissipation .... 150 mW
Derate Linearly from 25°C...................... 2.0 mW/°C

Package

Total Package Dissipation at 25°C Ambient
(LED + Detector) .... 240 mW
Derate Linearly from 25°C...................... 3.3 mW/°C
Storage/Operating Temperature .. –55°C to +150°C
Soldering Time at 260°C .... 10 sec.

Characteristics T_A=25°C

Parameter		Sym.	Min.	Typ.	Max.	Unit	Condition
Emitter							
Forward Voltage		V_F		1.3	1.5	V	I_F=±10 mA
Reverse Current		I_R		0.1	100	µA	V_R=6.0 V
Capacitance		C_O		25		pF	V_R=0
Detector							
Breakdown Voltage		BV_{CEO}	70			V	I_C=100 mA
		BV_{ECO}	7	10			I_E=100 µA
Leakage Current, Collector-Emitter		I_{CEO}		5	50	nA	V_{CE}=10 V
Package							
DC Current Transfer	IL205A	CTR_{DC}	40		80	%	I_F=±10 mA, V_{CE}=5 V
	IL206A		63		125		
	IL207A		100		200		
	IL208A		100		320		
DC Current Transfer	IL205A	CTR_{DC}	13	25		%	I_F=±1 mA, V_{CE}=5 V
	IL206A		22	40			
	IL207A		34	60			
	IL208A		56	95			
Saturation Voltage, Collector-Emitter		V_{CEsat}			0.4		I_C=2.0 mA, I_F=10 mA,
Isolation Test Voltage		V_{IO}	2500			VAC_{RMS}	
Equivalent DC Isolation Voltage			3535			VDC	
Capacitance, Input to Output		C_{IO}		0.5		pF	
Resistance, Input to Output		R_{IO}		100		GΩ	
Switching Time		t_{ON}, t_{OFF}		3.0		µs	I_C=2.0 mA, R_E=100 Ω, V_{CE}=10 V

Optocouplers (Optoisolators)
5

Figure 1. Forward voltage versus forward current

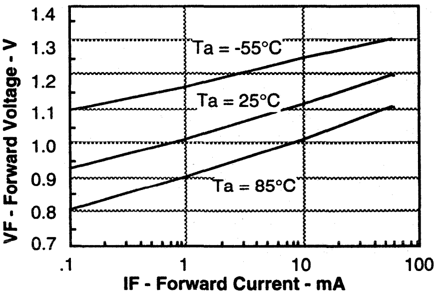


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

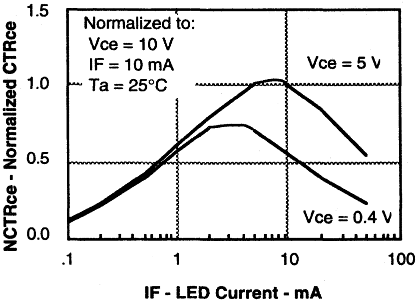


Figure 3. Collector-emitter current versus LED current

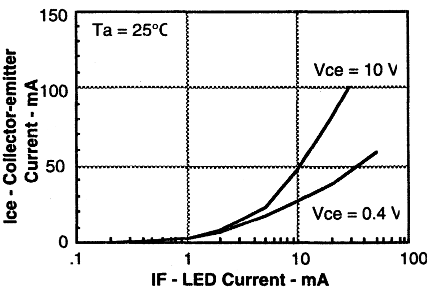


Figure 4. Normalized collector-base photocurrent versus LED current

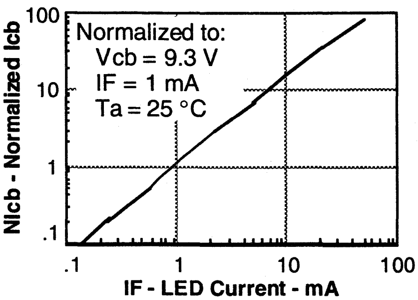


Figure 5. Normalized collector-base photocurrent versus LED current

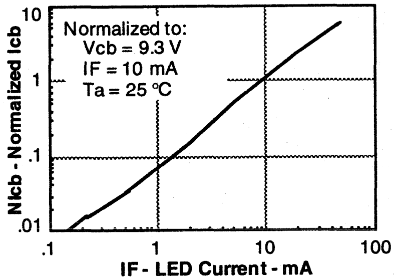


Figure 6. Collector-emitter photocurrent versus LED current

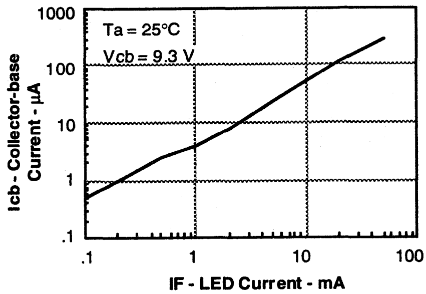


Figure 7. Collector-emitter photocurrent versus LED current

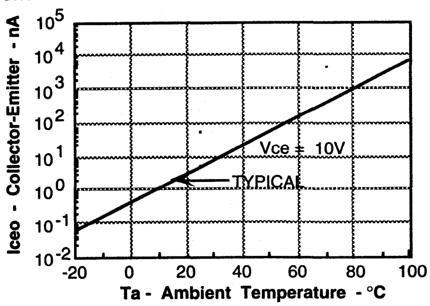


Figure 8. Base current versus If and HFE

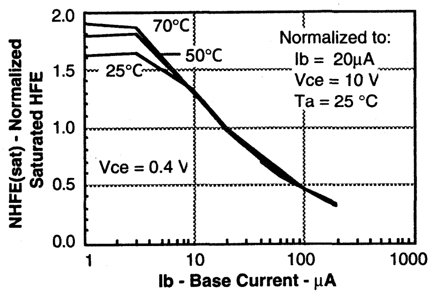


Figure 9. Typical switching characteristics versus base resistance (saturated operation)

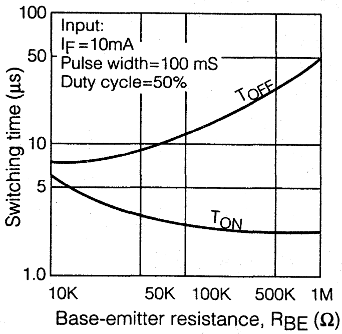
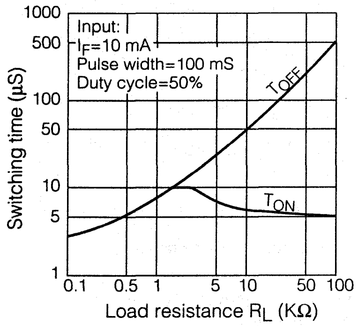


Figure 10. Typical switching times versus load resistance



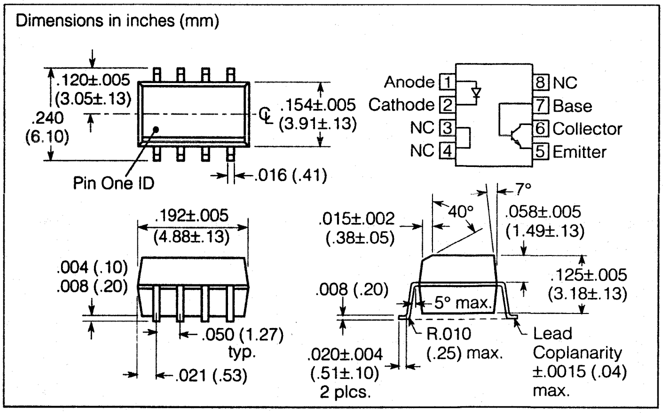
SIEMENS

IL211A/212A/213A

Phototransistor Small Outline Surface Mount Optocoupler

FEATURES

- **High Current Transfer Ratio**
  IL211A, 20% Minimum
  IL212A, 50% Minimum
  IL213A, 100% Minimum
- **Isolation Voltage, 2500 VAC_{RMS}**
- **Electrical Specifications Similar to Standard 6 Pin Coupler**
- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing, .05"**
- **Available only on Tape and Reel Option (Conforms to EIA Standard RS481A)**
- **Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering**
- **Underwriters Lab File #E52744 (Code Letter P)**



DESCRIPTION

The IL211A/212A/213A are optically coupled pairs with a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL211A//212A/213A comes in a standard SOIC-8 small outline package for surface mounting which makes it ideally suited for high density applications with limited space. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

A choice of 20, 50, and 100% minimum CTR at I_F=10 mA makes these optocouplers suitable for a variety of different applications.

Maximum Ratings

Emitter

Peak Reverse Voltage .... 6.0 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C.......................... 90 mW
Derate Linearly from 25°C.................... 1.2 mW/°C

Detector

Collector-Emitter Breakdown Voltage............. 30 V
Emitter-Collector Breakdown Voltage............... 7 V
Collector-Base Breakdown Voltage................ 70 V
$I_{CMAX\ DC}$ .... 50 mA
I_{CMAX} (t<1 ms)... 100 mA
Power Dissipation .... 150 mW
Derate Linearly from 25°C2.0 mW/°C

Package

Total Package Dissipation at 25°C Ambient (LED + Detector) .... 280 mW
Derate Linearly from 25°C.................... 3.3 mW/°C
Storage/Operating Temperature .–55°C to +150°C
Soldering Time at 260°C .... 10 sec.

Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.3	1.5	V	I_F=10 mA
Reverse Current	I_R		0.1	100	µA	V_R=6.0 V
Capacitance	C_O		25		pF	V_R=0
Detector						
Breakdown Voltage	B_{VCEO}		30		V	I_C=10 µA
	B_{VECO}		7			I_E=10 µA
Dark Current, Collector-Emitter	$I_{CEOdark}$		5	50	nA	V_{CE}=10 V I_F=0
Capacitance, Collector-Emitter	C_{CE}		10		pF	V_{CE}=0
Package						
DC Current Transfer Ratio IL211A	CTR_{DC}	20	50		%	I_F=10 mA, V_{CE}=5 V
IL212A		50	80			
IL213A		100	130			
Saturation Voltage, Collector-Emitter	V_{CEsat}			0.4		I_F=10 mA, I_C=2.0 mA
Isolation Test Voltage	V_{IO}	2500			VAC_{RMS}	
Capacitance, Input to Output	C_{IO}		0.5		pF	
Resistance, Input to Output	R_{IO}		100		GΩ	
Switching Time	t_{on}, t_{off}		3.0		µs	I_C=2 mA, R_E=100 Ω, V_{CE}=10 V

Figure 1. Forward voltage versus forward current

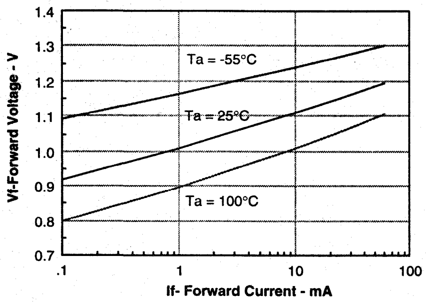


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

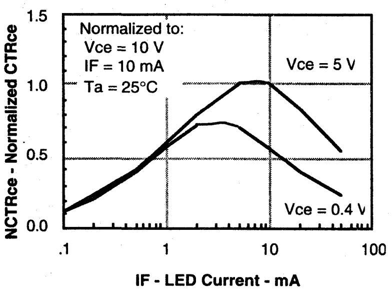


Figure 3. Collector-emitter current versus LED current

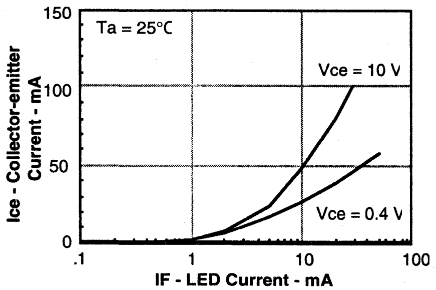


Figure 4. Normalized collector-base photocurrent versus LED current

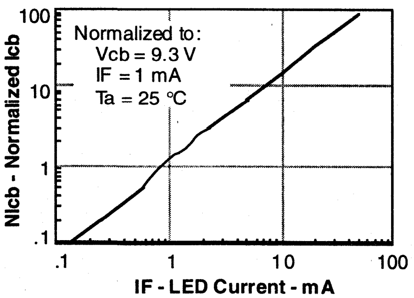


Figure 5. Normalized collector-base photocurrent versus LED current

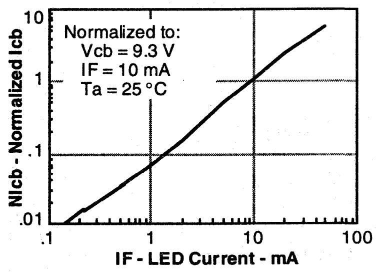


Figure 6. Collector-base photocurrent versus LED current

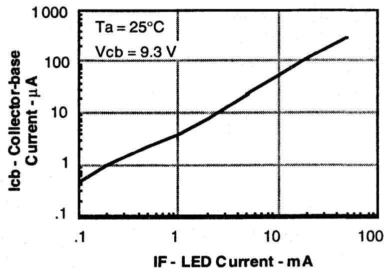


Figure 7. Collector-emitter leakage current versus temperature

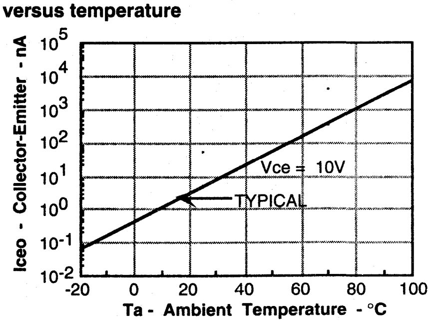


Figure 8. Normalized saturated HFE versus base current and temperature

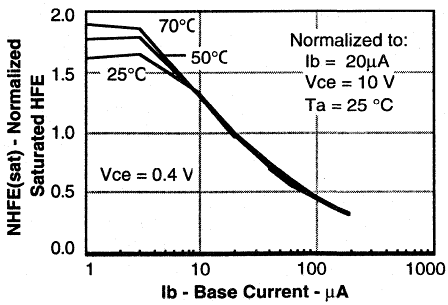


Figure 9. Typical switching characteristics versus base resistance (saturated operation)

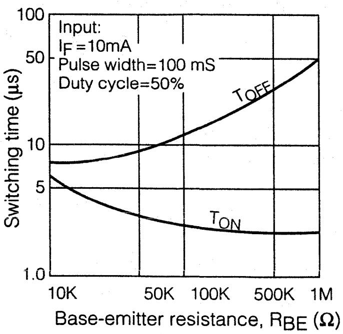
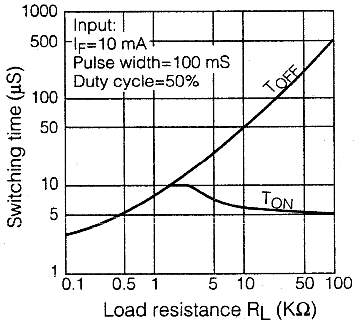


Figure 10. Typical switching times versus load resistance



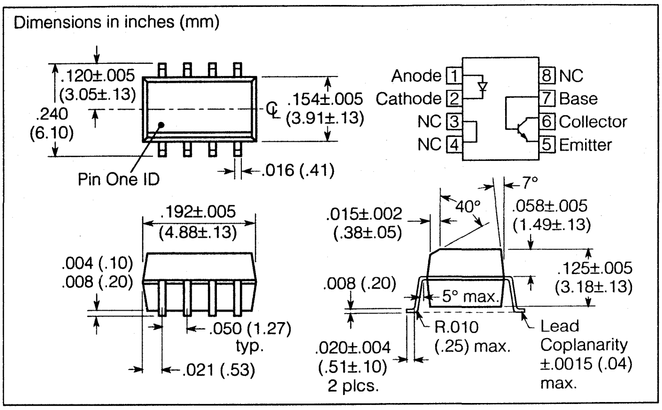
SIEMENS

IL215A/216A/217A

Phototransistor Small Outline Surface Mount Optocoupler

FEATURES

- **High Current Transfer Ratio, I_F=1 mA**
  IL215A—20% Minimum
  IL216A—50% Minimum
  IL217A—100% Minimum
- **Isolation Voltage, 2500 VAC_{RMS}**
- **Electrical Specifications Similar to Standard 6 Pin Coupler**
- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing, .05"**
- **Available only on Tape and Reel Option (Conforms to EIA Standard RS481A)**
- **Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering**
- **Underwriters Lab File #E52744 (Code Letter P)**



DESCRIPTION

The IL215A/216A/217A are optically coupled pairs with a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The IL215A//216A/217A comes in a standard SOIC-8 small outline package for surface mounting which makes it ideally suited for high density applications with limited space. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

The high CTR at low input current is designed for low power consumption requirements such as CMOS microprocessor interfaces.

Maximum Ratings

Emitter

Peak Reverse Voltage ....6.0 V
Continuous Forward Current ....60 mA
Power Dissipation at 25°C...........................90 mW
Derate Linearly from 25°C ....1.2mW/°C

Detector

Collector-Emitter Breakdown Voltage............30 V
Emitter-Collector Breakdown Voltage..............7 V
Collector-Base Breakdown Voltage...............70 V
$I_{CMAX\ DC}$ ....50 mA
I_{CMAX} (t<1 ms)..100 mA
Power Dissipation ....150 mW
Derate Linearly from 25°C ....2.0mW/°C

Package

Total Package Dissipation at 25°C Ambient (LED + Detector)..................................280 mW
Derate Linearly from 25°C ....3.3mW/°C
Storage/Operating Temp. ....–55°C to +150°C
Soldering Time at 260°C .... 10 sec.

Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.0	1.5	V	I_F=1 mA
Reverse Current	I_R		0.1	100	µA	V_R=6.0 V
Capacitance	C_O		25		pF	V_R=0
Detector						
Breakdown Voltage	B_{VCEO}	30			V	I_C=10 µA
	B_{VECO}	7				I_E=10 µA
Dark Current, Collector-Emitter	$I_{CEOdark}$		5	50	nA	V_{CE}=10 V I_F=0
Capacitance, Collector-Emitter	C_{CE}		10		pF	V_{CE}=0
Package						
DC Current Transfer Ratio IL215A	CTR_{DC}	20	50		%	I_F=10 mA, V_{CE}=5 V
IL216A		50	80			
IL217A		100	130			
Saturation Voltage, Collector-Emitter	V_{CEsat}			0.5		I_F=1 mA, I_C=0.1 mA
Isolation Test Voltage	V_{IO}	2500			VAC_{RMS}	
Capacitance, Input to Output	C_{IO}		0.5		pF	
Resistance, Input to Output	R_{IO}		100		GΩ	
Switching Time	t_{on},t_{off}		3.0		µs	I_C=2 mA, R_E=100 Ω, V_{CE}=10 V

Figure 1. Forward voltage versus forward current

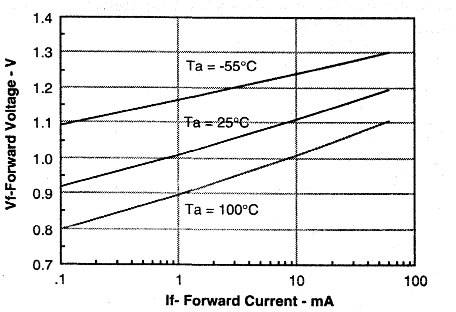


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

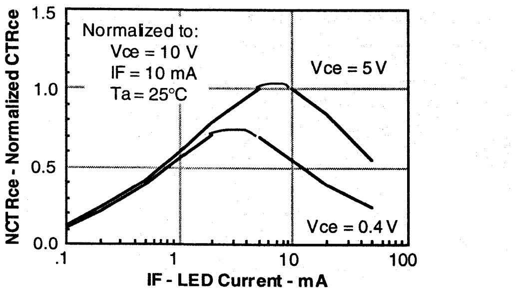


Figure 3. Collector-emitter current versus LED current

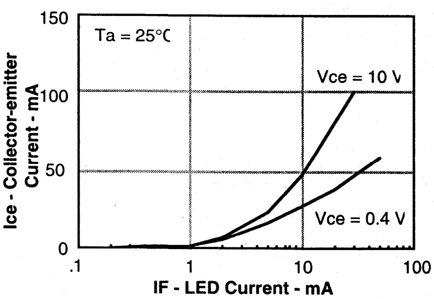


Figure 4. Normalized collector-base photocurrent versus LED current

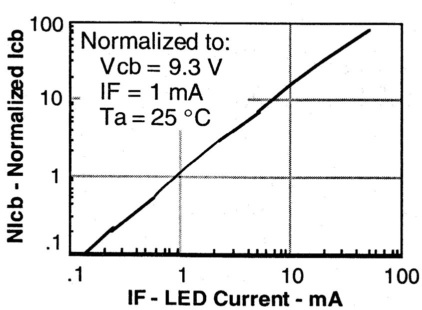


Figure 5. Collector-base photocurrent versus LED current

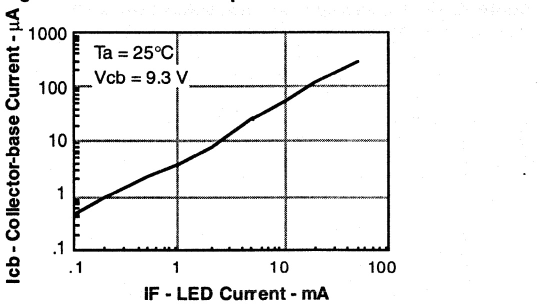


Figure 6. Collector-emitter leakage current versus temperature

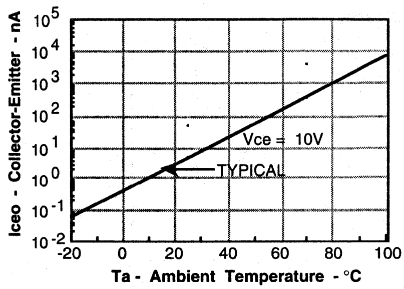


Figure 7. Normalized saturated HFE versus base current and temperature

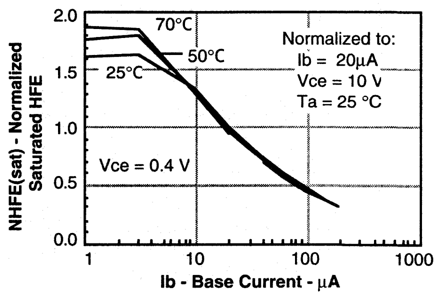


Figure 8. Normalized non-saturated and saturated CTRce versus LED current

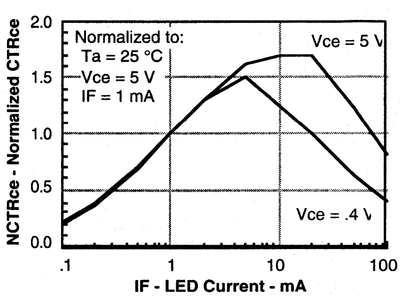


Figure 9. Normalized non-saturated and saturated collector-emitter current versus LED current

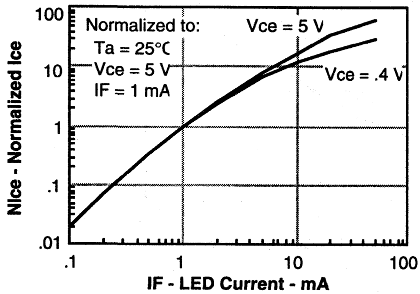


Figure 13. Low to high propagation delay versus LED current and load resistor

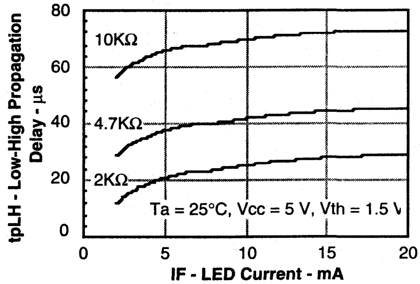


Figure 10. Normalized collector-base photocurrent versus LED current

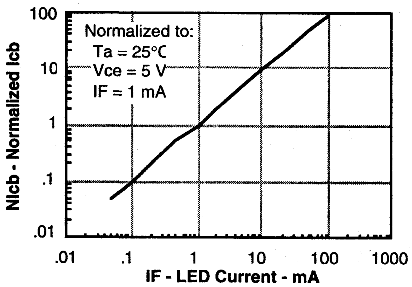


Figure 14. Normalized non-saturated HFE versus base current and temperature

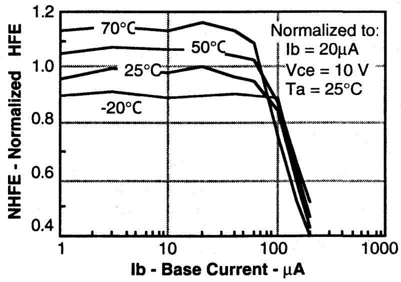


Figure 11. Collector-base photocurrent versus LED current

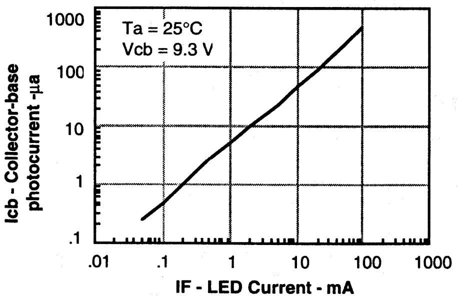


Figure 15. Typical switching characteristics versus base resistance (saturated operation)

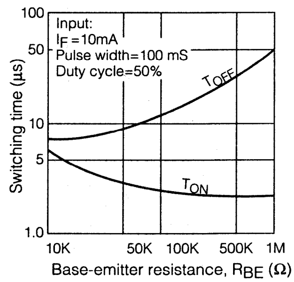


Figure 12. High to low propagation delay versus LED current and load resistor

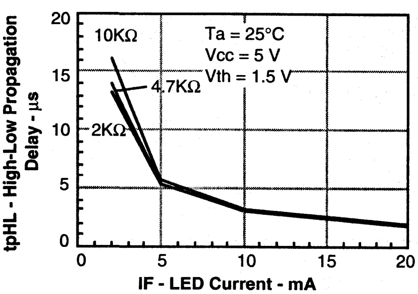
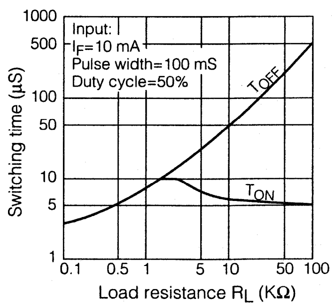


Figure 16. Typical switching times versus load resistance



SIEMENS

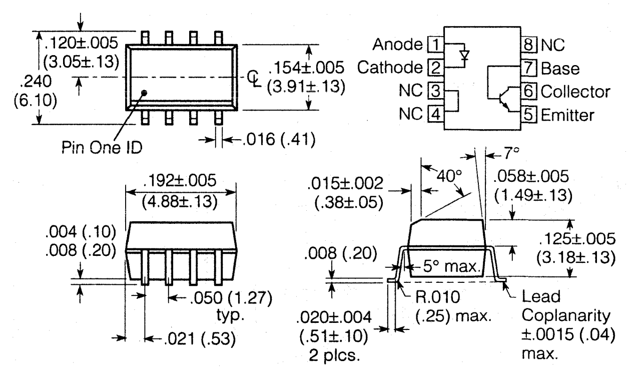
IL221A/IL222A/IL223A

Phototransistor Small Outline Surface Mount Optocoupler

FEATURES

- **High Current Transfer Ratio, I_F=1 mA,**
  IL221A, 100% Minimum
  IL222A, 200% Minimum
  IL223A, 500% Minimum
- **Withstand Test Voltage, 2500 VAC_{RMS}**
- **Electrical Specifications Similar to Standard 6 Pin Coupler**
- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing, .05"**
- **Available only on Tape and Reel Option (Conforms to EIA Standard RS481A)**
- **Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering**
- **Underwriters Lab File #E52744 (Code Letter P)**

Dimensions in inches (mm)



DESCRIPTION

The IL221A/IL222A/IL223A is a high current transfer ratio (CTR) optocoupler with a Gallium Arsenide infrared LED emitter and a silicon NPN photodarlington transistor detector.

This device has a CTR tested at an 1 mA LED current. This low drive current permits easy interfacing from CMOS to LSTTL or TTL.

This optocoupler is constructed in a standard SOIC-8 foot print which makes it ideally suited for high density applications. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

Maximum Ratings

Emitter

Peak Reverse Voltage .... 6.0 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 90 mW
Derate Linearly from 25°C .... 1.2 mW/°C

Detector

Collector-Emitter Breakdown Voltage .... 30 V
Emitter-Collector Breakdown Voltage .... 5 V
Collector-Base Breakdown Voltage .... 70 V
$I_{CMAX\ DC}$ .... 50 mA
I_{CMAX} (t<1 ms) .... 100 mA
Power Dissipation .... 150 mW
Derate Linearly from 25°C .... 2.0 mW/°C

Package

Total Package Dissipation at 25°C Ambient
(LED + Detector) .... 240 mW
Derate Linearly from 25°C .... 3.3 mW/°C
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Soldering Time at 260°C .... 10 sec.

Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.0	1.5	V	I_F=1 mA
Reverse Current	I_R		0.1	100	µA	V_R=6.0 V
Capacitance	C_O		25		pF	V_R=0 V, F=1 MHz
Detector						
Breakdown Voltage	B_{VCEO}	30			V	I_C=100 µA
	B_{VECO}	5				I_E=100 µA
Voltage, Collector-Base	BV_{CBO}	70			V	I_C=10 µA
Capacitance, Collector-Emitter	C_{CE}		3.4		pF	V_{CE}=10 V
Package						
DC Current Transfer Ratio IL221A	CTR_{DC}	100				I_F=1 mA, V_{CE}=5 V
DC Current Transfer Ratio IL222A		200				
DC Current Transfer Ratio IL223A		300				
Saturation Voltage, Collector-Emitter	V_{CEsat}			1	V	I_{CE}=0.5 mA, I_F=1 mA
Isolation Test Voltage	V_{IO}	2500			VAC_{RMS}	t=1 sec.
Capacitance, Input to Output	C_{IO}		0.5		pF	
Resistance, Input to Output	R_{IO}		100		GΩ	

Optocouplers (Optoisolators) 5

Figure 1. Forward voltage versus forward current

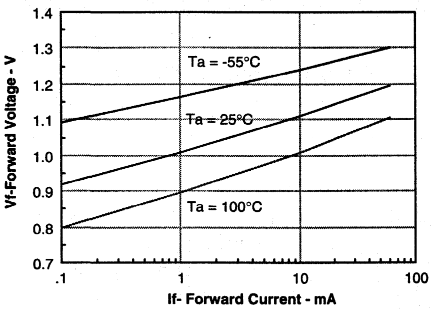


Figure 5. CTR_{CB} versus LED current

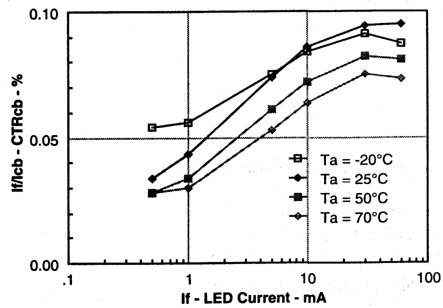


Figure 2. Peak LED current versus duty factor, Tau

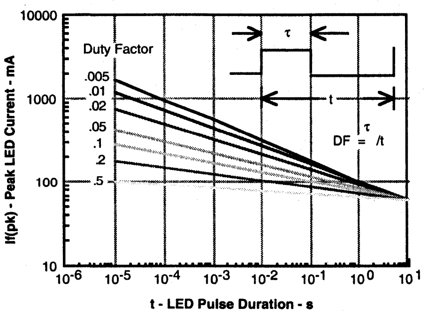


Figure 6. CTR versus LED current

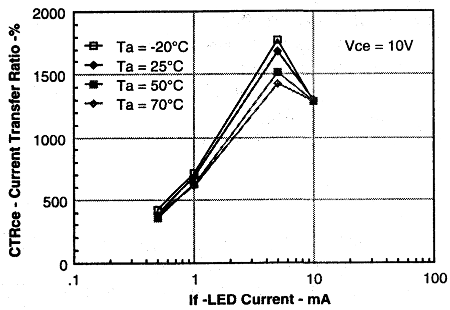


Figure 3. Normalized CTR_{CB} versus I_F

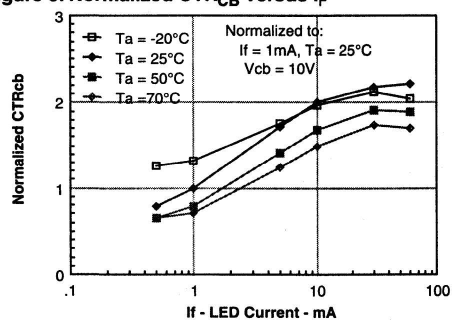


Figure 7. Collector current versus LED current

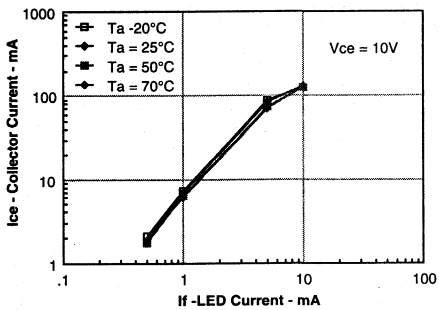


Figure 4. Normalized CTR_{CE} versus LED current

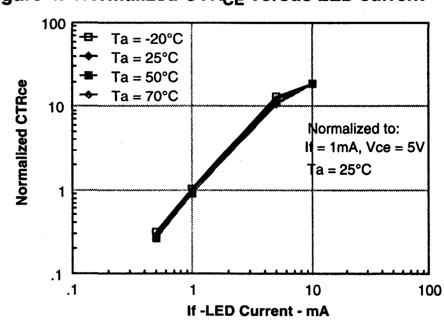


Figure 8. Photocurrent versus LED current

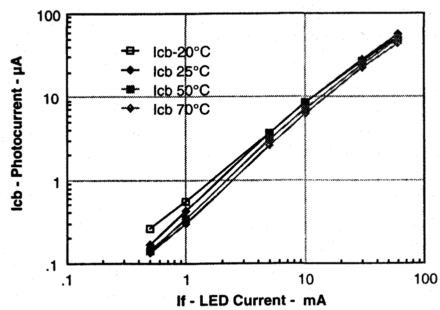


Figure 9. Normalized I_{CB} versus I_F

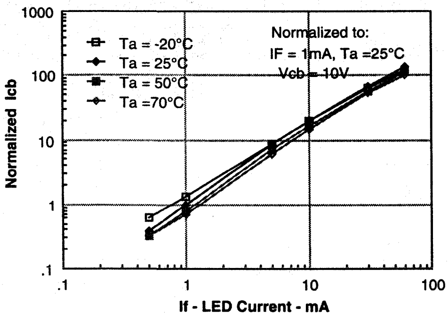


Figure 10. Switching timing

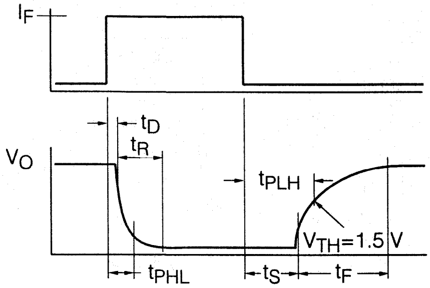
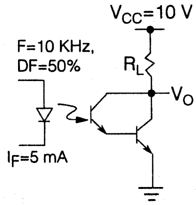


Figure 11. Switching schematic



Optocouplers (Optoisolators)

5

SIEMENS

SINGLE CHANNEL IL250/251/252
DUAL CHANNEL ILD250/251/252
Bidirectional Input Optocoupler

FEATURES
- **Selected Current Transfer Ratios 20%, 50%, 100% Minimum**
- **AC or Polarity Insensitive Input**
- **Built-in Reverse Polarity Input Protection**
- **Improved CTR Symmetry**
- **Industry Standard DIP Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

Maximum Ratings (Per Channel)

Emitter

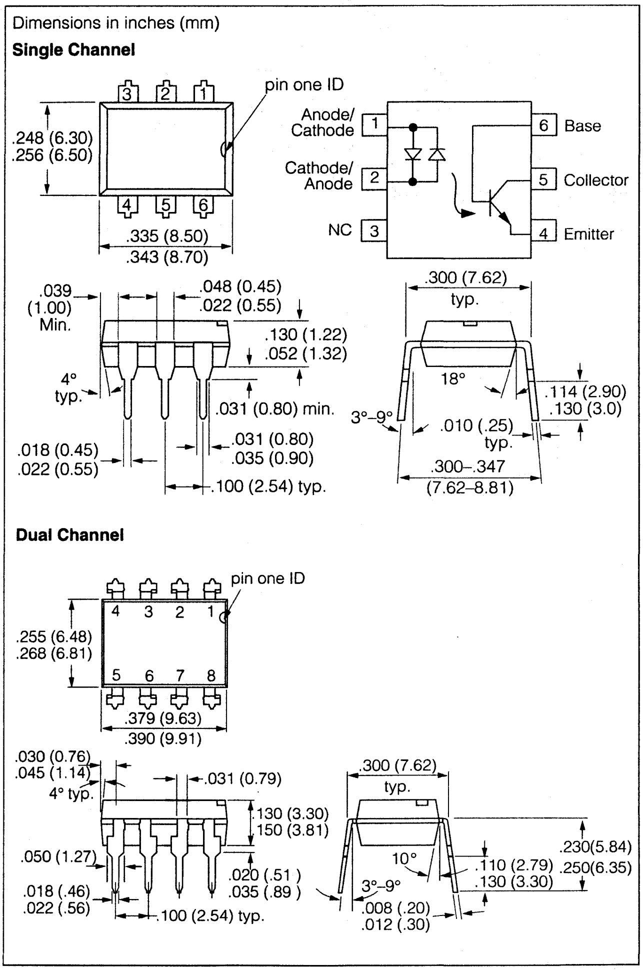
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C

Detector

Collector-Emitter Breakdown Voltage .... 30 V
Emitter-Base Breakdown Voltage .... 5 V
Collector-Base Breakdown Voltage .... 70 V
Power Dissipation at 25°C
  Single Channel .... 200 mW
  Dual Channel .... 150 mW
Derate Linearly from 25°C
  Single Channel .... 2.6 mW/°C
  Dual Channel .... 2.0 mW/°C

Package

Isolation Test Voltage (between emitter and detector referred to standard climate 23°C/50%RH, DIN 50014) .... 5300 VAC_{RMS}
Creepage .... 7 mm min.
Clearance .... 7 mm min.
Isolation Resistance
  V_{IO}=500V, T_A=25°C .... 10^{12} Ω
  V_{IO}=500V, T_A=100°C .... 10^{11} Ω
Total Dissipation at 25°C
  Single Channel .... 250 mW
  Dual Channel .... 400 mW
Derate Linearly from 25°C
  Single Channel .... 3.3 mW/°C
  Dual Channel .... 5.3 mW/°C
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.



DESCRIPTION

The IL/ILD250/251/252 are bidirectional input optically coupled isolators consisting of two Gallium Arsenide infrared LEDs coupled to a silicon NPN phototransistor per channel.

The IL/ILD250 has a minimum CTR of 50%, the IL/ILD251 has a minimum CTR of 20%, and the IL/ILD252 has a minimum CTR of 100%.

The IL/IL250/1/2 are single channel optocouplers. The ILD250/1/2 has two isolated channels in a single DIP package.

These optocouplers are ideal for applications requiring AC signal detection and monitoring.

Electrical Characteristics T_A=25 C

Parameter	Min.	Typ.	Max.	Unit	Condition
Emitter					
Forward Voltage V_F		1.2	1.5	V	I_F=±10 mA
Detector					
BV_{CEO}	30	50		V	I_C=1 mA
BV_{EBO}	7	10		V	I_E=100 µA
BV_{CBO}	70	90		V	I_C=10 µA
I_{CEO}		5	50	nA	V_{CE}=10 V
Package					
V_{CEsat}			0.4	V	I_F=±16 mA, I_C=2 mA
DC Current Transfer Ratio IL/D250 IL/D251 IL/D252	 50 20 100			%	I_F=±10 mA, V_{CE}=10 V
Symmetry CTR @ +10 mA / CTR @ - 10 mA	0.50	1.0	2.0		

Figure 1. LED forward current versus forward voltage

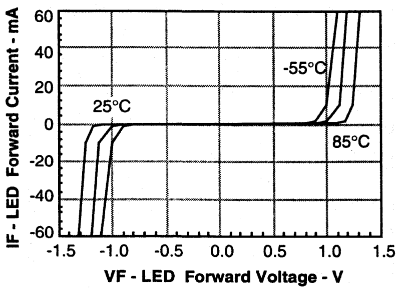


Figure 2. Normalized non-saturated and saturated CTR at T_A = 25°C versus LED current

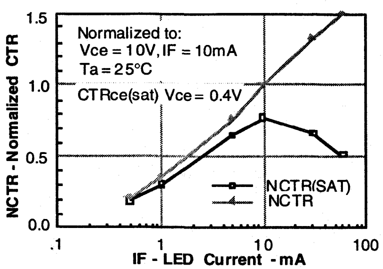


Figure 3. Normalized non-saturated and saturated CTR at T_A = 50°C versus LED current

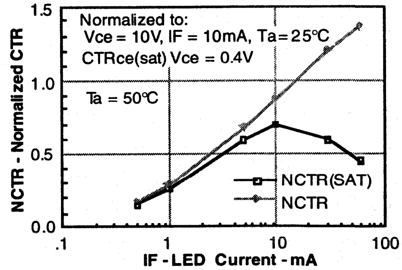


Figure 4. Normalized non-saturated and saturated CTR at T_A = 70°C versus LED current

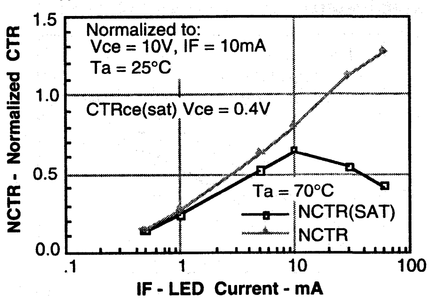


Figure 5. Normalized non-saturated and saturated CTR at T_A = 85°C versus LED current

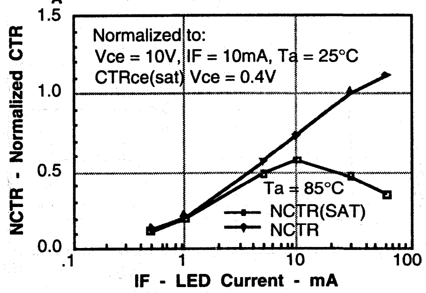


Figure 6. Collector-emitter current versus temperature and LED current

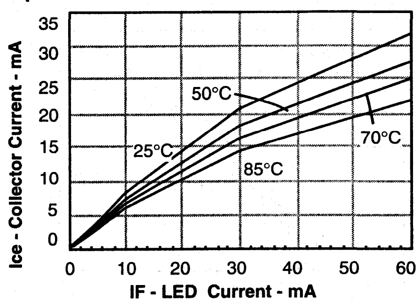


Figure 7. Collector-emitter leakage current versus temperature

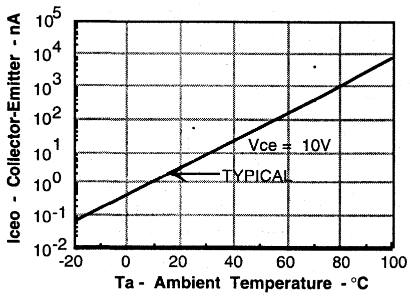


Figure 8. Normalized CTRcb versus LED current and temperature

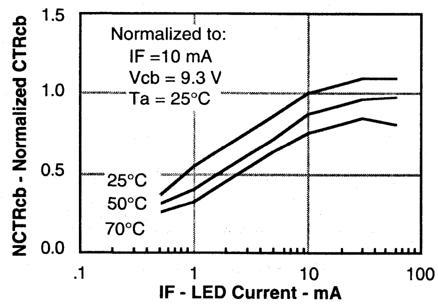


Figure 9. Collector base photocurrent versus LED current

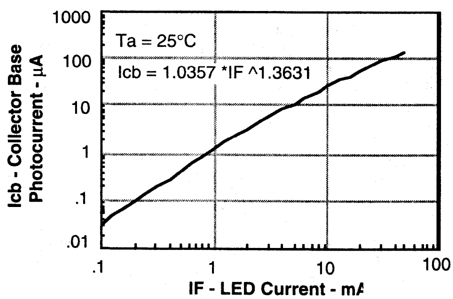


Figure 10. Normalized photocurrent versus If and temperature

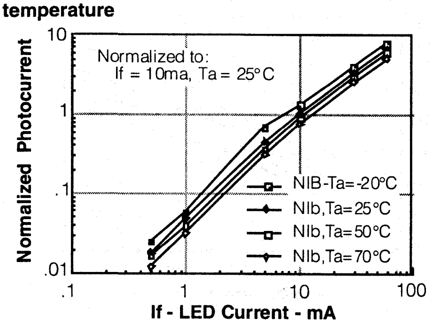


Figure 11. Normalized non-saturated HFE versus base current and temperature

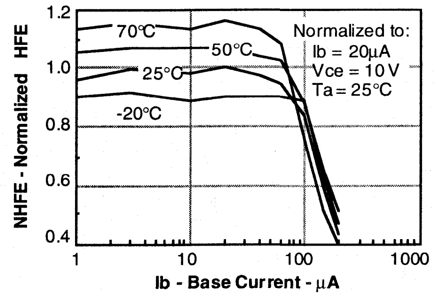


Figure 12. Normalized saturated HFE versus base current and temperature

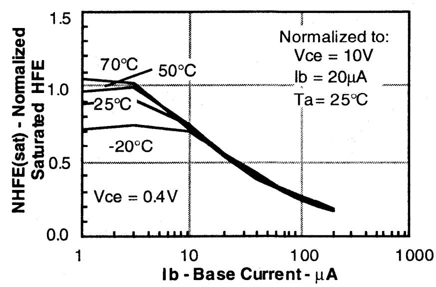


Figure 13. Propagation delay versus collector load resistor

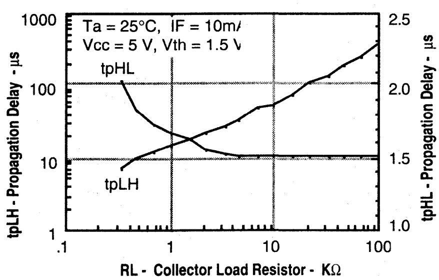
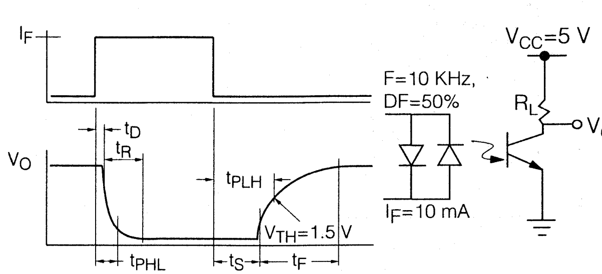


Figure 14. Switching timing and schematic



SIEMENS

SINGLE CHANNEL IL255
Bidirectional Input Optocoupler

FEATURES
- **AC or Polarity Insensitive Inputs**
- **Continuous Forward Current, 130 mA**
- **Applications—Telecommunications**
  - **Ring Detection**
  - **Loop Current Detector**
- **Built-in Reverse Polarity Input Protection**
- **Improved CTR Symmetry**
- **Industry Standard DIP Package**
- **Underwriters Lab File #E52744**
- **VDE Approval #0884 Applied For**

DESCRIPTION
The IL255 is a bidirectional input optically coupled isolator consisting of two high current Gallium Arsenide infrared LEDs coupled to a silicon NPN phototransistor. The IL255 has a minimum CTR of 20%.

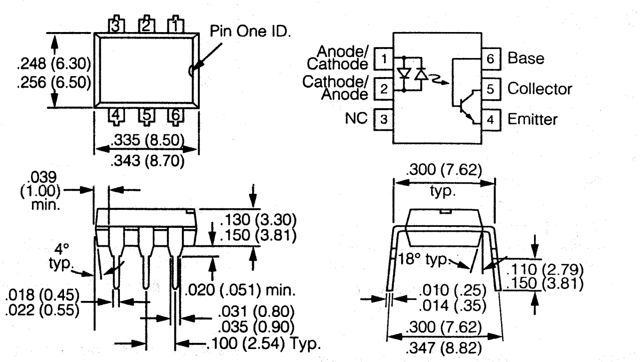
This optocoupler is ideal for applications requiring AC signal detection and monitoring.

Maximum Ratings
Emitter
Peak Pulsed Current (1 µs, 300 pps) ....3 A
Continuous Forward Current .... 130 mA
Power Dissipation at 25°C................... 175 mW
Derate Linearly from 25°C.............. 2.3 mW/°C

Detector
Collector-Emitter Breakdown Voltage ....30 V
Emitter-Base Breakdown Voltage ....5 V
Collector-Base Breakdown Voltage............70 V
Power Dissipation at 25°C................... 200 mW
Derate Linearly from 25°C............... 2.6 mW/°C

Package
Isolation Test Voltage................... 5300 VAC_{RMS}
(between emitter and detector, refer to standard climate 23°C/50%RH, DIN 50014)
Creepage ....min. 7 mm
Clearance...min. 7 mm
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}$ Ω
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}$ Ω
Total Dissipation at 25°C...................... 250 mW
Derate Linearly from 25°C.............. 3.3 mW/°C
Storage Temperature ....–55°C to +150°C
Operating Temperature ....–55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

Package Dimensions in Inches (mm)



Electrical Characteristics T_A=25°C

Parameter	Min.	Typ.	Max.	Unit	Test Condition
Emitter					
Forward Voltage		1.4	1.7	V	I_F=±100 mA
Detector					
BV_{CEO}	30	50		V	I_C=10 mA
BV_{ECO}	7	10		V	I_E=10 µA
BV_{CBO}	70			V	I_C=100 µA
BV_{EBO}	7			V	I_E=100 µA
I_{CEO}		5	50	nA	V_{CE}=10 V

Package

Parameter	Device	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Current Transfer Ratio	IL255	CTR	20			%	I_F=±10 mA, V_{CE}=10 V
	IL255-1		20		80	%	I_F=±100 mA, V_{CE}=2 V
	IL255-2		50			%	I_F=±10 mA, V_{CE}=10 V
Current Transfer Ratio Symmetry	IL255		0.33		3.0		I_F=±10 mA, V_{CE}=10 V
	IL255-1						
	IL255-2		0.5	1.0	2.0		I_F=±10 mA, V_{CE}=10 V
Collector-emitter Saturation Voltage	IL255	$V_{CE(sat)}$			0.4	V	I_F=±10 mA, I_C=0.5 mA
	IL255-1			0.1	0.2	V	I_F=±100 mA, I_C=1 mA
	IL255-2				0.4	V	I_F=±16 mA, I_C=2 mA

Figure 1. LED forward current versus forward voltage

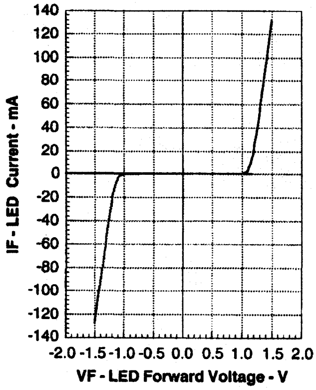


Figure 2. Maximum LED current versus ambient temperature

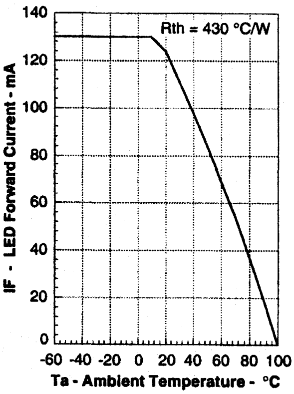


Figure 3. Maximum LED power dissipation

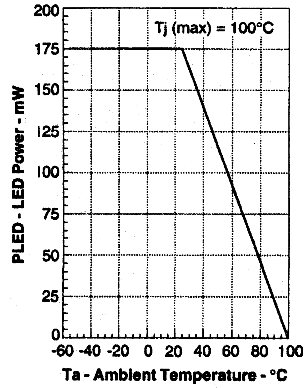


Figure 4. Current transfer ratio versus LED current and collector-emitter voltage

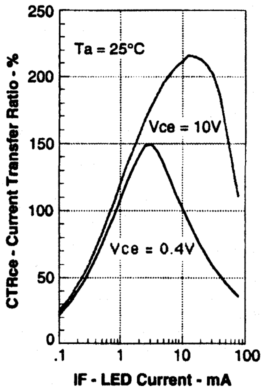


Figure 5. Saturated and non-saturated collector-emitter current versus LED current

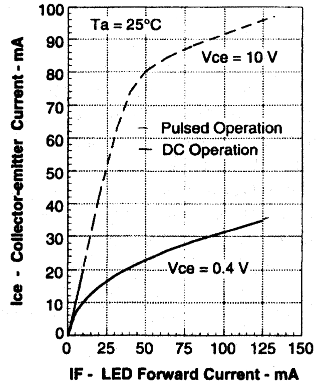


Figure 6. Saturated and non-saturated collector-emitter current versus LED current

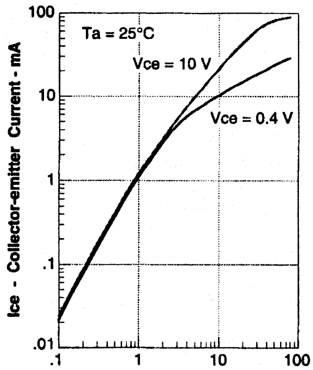
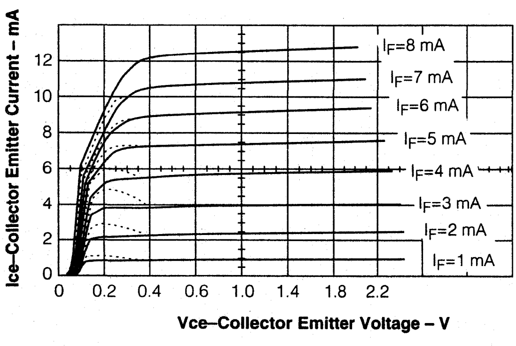


Figure 7. Collector-emitter current versus LED collector-emitter voltage



SIEMENS

IL256A

AC Input Phototransistor Small Outline Surface Mount Optocoupler

FEATURES

- **Guaranteed CTR Symmetry, 2:1 Maximum**
- **Bidirectional AC Input Industry Standard SOIC-8 Surface**
- **Mountable Package**
- **Standard Lead Spacing, .05"**
- **Available only on Tape and Reel Option (Conforms to EIA Standard RS481A)**

DESCRIPTION

The IL256A is an AC input phototransistor optocoupler. The device consists of two infrared emitters connected in anti-parallel and coupled to a silicon NPN phototransistor detector.

These circuit elements are constructed with a standard SOIC-8 foot print.

The product is well suited for telecom applications such as ring detection or off/on hook status, given its bidirectional LED input and guaranteed current transfer ratio (CTR) minimum of 20% at I_F=10 mA.

Maximum Ratings

Emitter

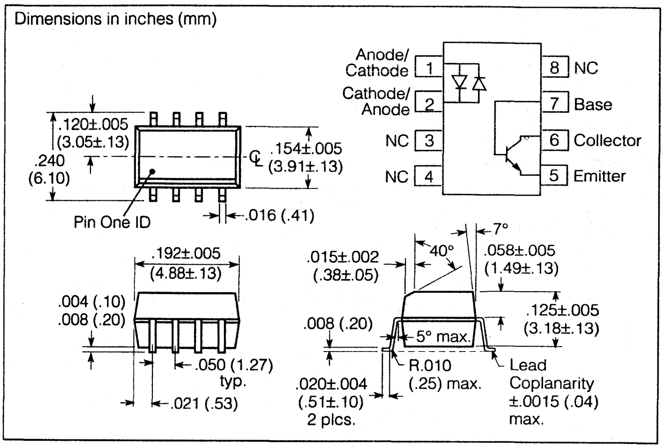
Continuous Forward Current........................60 mA
Power Dissipation at 25°C..........................90 mW
Derate Linearly from 25°C....................0.8 mW/°C

Detector

Collector-Emitter Breakdown Voltage.............30 V
Emitter-Collector Breakdown Voltage...............5 V
Collector-Base Breakdown Voltage................70 V
Power Dissipation....................................150 mW
Derate Linearly from 25°C....................2.0 mW/°C

Package

Total Package Dissipation at 25°C Ambient (LED + Detector)..................................240 mW
Derate Linearly from 25°C....................3.1 mW/°C
Storage Temperature ....–55°C to +150°C
Operating Temperature ....–55°C to +100°C
Soldering Time at 260°C........................... 10 sec.



Characteristics T_A=25°C

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.2	1.5	V	I_F=±10 mA
Detector						
Breakdown Voltage	BV_{CEO}	30	50		V	I_C=1 mA
	BV_{ECO}	5	10			I_E=100 μA
	BV_{CBO}	70	90			I_C=100 μA
Leakage Current, Collector-Emitter	I_{CEO}		5	50	nA	V_{CE}=10 V
Package						
DC Current Transfer Ratio	CTR	20			%	I_F=±10 mA, V_{CE}=5 V
Symmetry CTR at +10mA / CTR at –10 mA		0.5	1.0	2.0		
Saturation Voltage, Collector-Emitter	V_{CEsat}			0.4		I_F=±16 mA, I_C=2 mA
Isolation Voltage, Input to Output	V_{IO}	2500			VAC_{RMS}	

Figure 1. LED forward current versus forward voltage

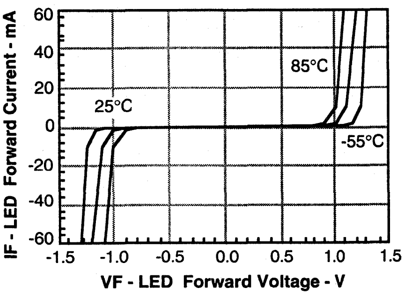


Figure 2. Forward voltage versus forward current

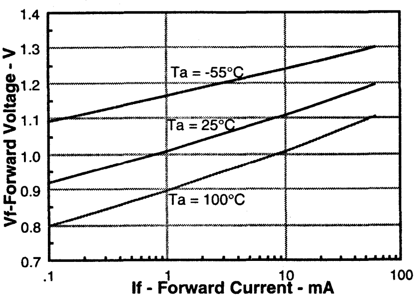


Figure 3. Peak LED current versus duty factor, Tau

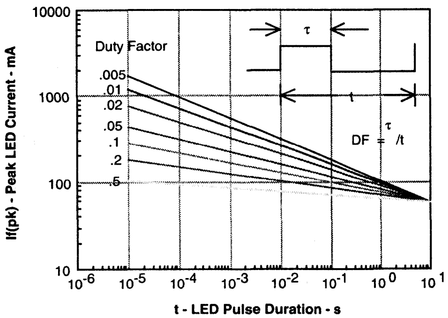


Figure 4. Normalized CTR versus If and Ta

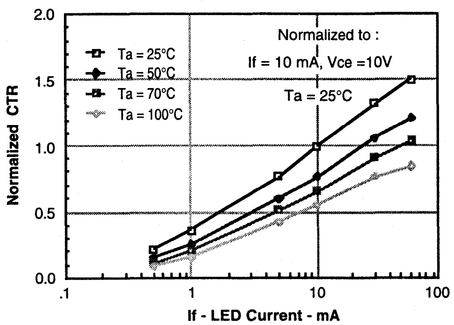


Figure 5. Normalized saturated CTR

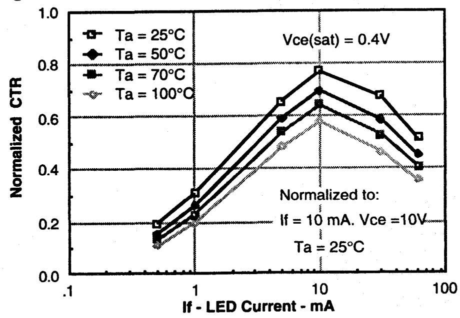


Figure 6. Normalized CTRcb

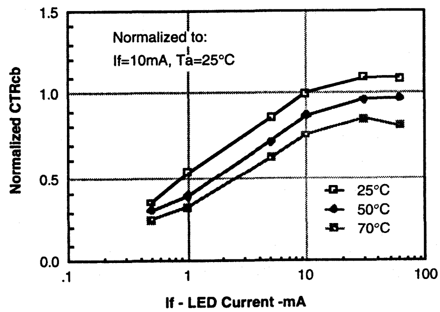


Figure 7. Photocurrent versus LED current

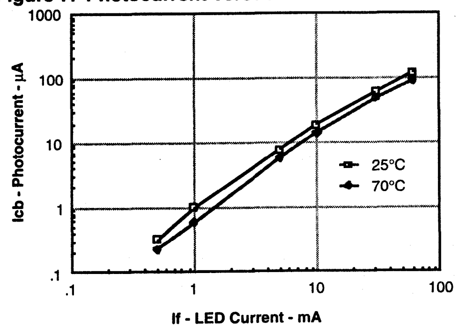


Figure 8. Base current versus If and HFE

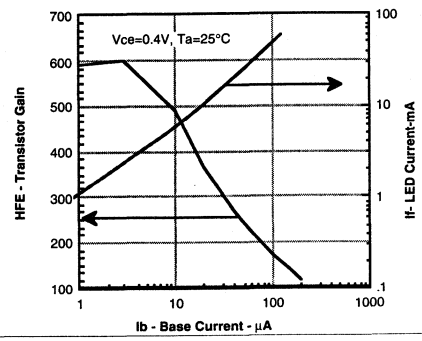


Figure 9. Normalized HFE versus Ib, Ta

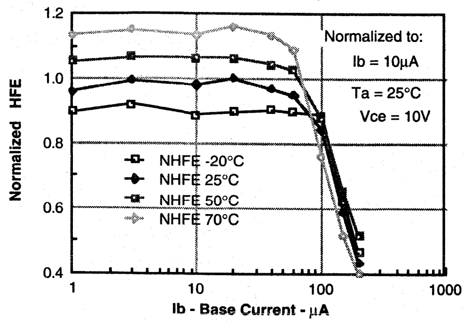


Figure 10. Normalized saturated HFE versus Ib

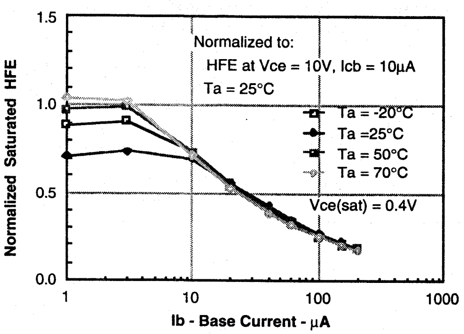


Figure 11. Base emitter voltage versus base current

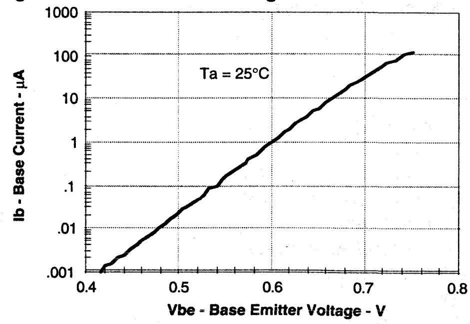
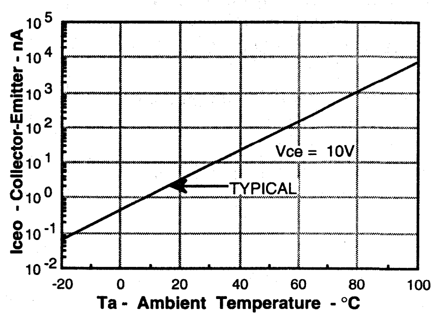


Figure 12. Collector-emitter leakage current versus temperature



Optocouplers (Optoisolators)

5

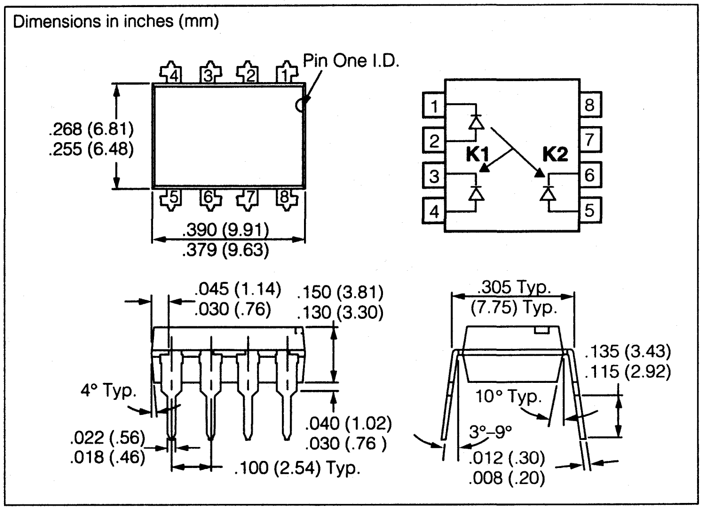
SIEMENS

IL300

Linear Optocoupler

FEATURES

- **Couples AC and DC signals**
- **0.01% Servo Linearity**
- **Wide Bandwidth, >200 KHz**
- **High Gain Stability, ±0.05%/C**
- **Low Input-Output Capacitance**
- **Low Power Consumption, < 15mw**
- **Isolation Test Voltage, 5300 VAC_{RMS}, 1 sec.**
- **Internal Insulation Distance, >0.4 mm for VDE**
- **Underwriters Lab File #E52744**
- **VDE Approval #0884 (Optional with Option 1, Add -X001 Suffix)**
- **IL300G Replaced by IL300-X006**
- **APPLICATIONS**
- **Power Supply Feedback Voltage/Current**
- **Medical Sensor Isolation**
- **Audio Signal Interfacing**
- **Isolate Process Control Transducers**
- **Digital Telephone Isolation**



DESCRIPTION

The IL300 Linear Optocoupler consists of an AlGaAs IRLED irradiating an isolated feedback and an output PIN photodiode in a bifurcated arrangement. The feedback photodiode captures a percentage of the LED's flux and generates a control signal (IP_1) that can be used to servo the LED drive current. This technique compensates for the LED's non-linear, time, and temperature characteristics. The output PIN photodiode produces an output signal (IP_2) that is linearly related to the servo optical flux created by the LED.

The time and temperature stability of the input-output coupler gain (K3) is insured by using matched PIN photodiodes that accurately track the output flux of the LED.

A typical application circuit (Figure 1) uses an operational amplifier at the circuit input to drive the LED. The feedback photodiode sources current to R1 connected to the inverting input of U1. The photocurrent, IP1, will be of a magnitude to satisfy the relationship of ($IP1=V_{IN}/R1$).

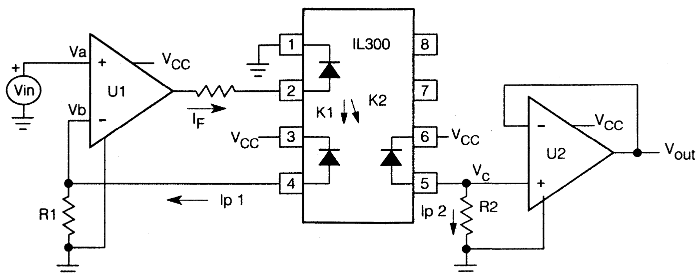
DESCRIPTION (continued)

The magnitude of this current is directly proportional to the feedback transfer gain (K1) times the LED drive current ($V_{IN}/R1=K1 \Sigma I_F$). The op-amp will supply LED current to force sufficient photocurrent to keep the node voltage (Vb) equal to Va

The output photodiode is connected to a non-inverting voltage follower amplifier. The photodiode load resistor, R2, performs the current to voltage conversion. The output amplifier voltage is the product of the output forward gain (K2) times the LED current and photodiode load, R2 ($V_O=I_F \Sigma K2 \Sigma R2$).

Therefore, the overall transfer gain (V_O/V_{IN}) becomes the ratio of the product of the output forward gain (K2) times the photodiode load resistor (R2) to the product of the feedback transfer gain (K1) times the input resistor (R1). This reduces to $V_O/V_{IN}=(K2 \Sigma R2)/(K1 \Sigma R1)$. The overall transfer gain is completely independent of the LED forward current. The IL300 transfer gain (K3) is expressed as the ratio of the output gain (K2) to the feedback gain (K1). This shows that the circuit gain becomes the product of the IL300 transfer gain times the ratio of the output to input resistors [$V_O/V_{IN}=K3\ (R2/R1)$].

Figure 1. Typical application circuit



IL300 Terms

KI—Servo Gain

The ratio of the input photodiode current (I_{P1}) to the LED current (I_F). i.e., $K1 = I_{P1}/ I_F$

K2—Forward Gain

The ratio of the output photodiode current (I_{P2}) to the LED current (I_F), i.e., $K2 = I_{P2}/ I_F$

K3—Transfer Gain

The Transfer Gain is the ratio of the Forward Gain to the Servo gain, i.e., K3 = K2/K1.

ΔK3—Transfer Gain Linearity

The percent deviation of the Transfer Gain, as a function of LED or temperature from a specific Transfer Gain at a fixed LED current and temperature.

Photodiode

A silicon diode operating as a current source. The output current is proportional to the incident optical flux supplied by the LED emitter. The diode is operated in the photovoltaic or photoconductive mode. In the photovoltaic mode the diode functions as a current source in parallel with a forward biased silicon diode.

The magnitude of the output current and voltage is dependent upon the load resistor and the incident LED optical flux. When operated in the photoconductive mode the diode is connected to a bias supply which reverse biases the silicon diode. The magnitude of the output current is directly proportional to the LED incident optical flux.

LED (Light Emitting Diode)

An infrared emitter constructed of AlGaAs that emits at 890 nm operates efficiently with drive current from 500 µA to 40 mA. Best linearity can be obtained at drive currents between 5 mA to 20 mA. Its output flux typically changes by –0.5%/°C over the above operational current range.

Absolute Maximum Ratings

	Symbol	Min.	Max.	Unit
Emitter				
Power Dissipation (T_A=25°C)	P_{LED}		160	mW
Derate Linearly from 25°C			2.13	mW/°C
Forward Current	I_F		60	mA
Surge Current (Pulse width <10µs)	I_{pk}		250	mA
Reverse Voltage	V_R		5	V
Thermal Resistance	R_{th}		470	°C/W
Junction Temperature	T_J		100	°C
Detector				
Power Dissipation	P_{DET}		50	mA
Derate linearly from 25°C			0.65	mW/°C
Reverse Voltage	V_R		50	V
Junction Temperature	T_J		100	°C
Thermal Resistance	R_{th}		1500	°C/W
Coupler				
Total Package Dissipation at 25°C	P_T		210	mW
Derate linearly from 25°C			2.8	mW/°C
Storage Temperature	T_S	–55	150	°C
Operating Temperature	T_{OP}	–55	100	°C
Isolation Test Voltage		5300		VAC_{RMS}
Isolation Resistance V_{IO}=500 V, T_A=25°C V_{IO}=500 V, T_A=100°C		 10^{12} 10^{11}		 Ω Ω

Characteristics T_A=25°C

	Symbol	Min.	Typ.	Max.	Unit	Test Condition
LED Emitter						
Forward Voltage	V_F		1.25	1.50	V	I_F=10 mA
V_F Temperature Coefficient	$\Delta V_F/\Delta$°C		–2.2		mV/°C	
Reverse Current	I_R		1	10	µA	V_R=5 V
Junction Capacitance	C_J		15		pF	V_F=0 V, f=1 MHz
Dynamic Resistance	$\Delta V_F/\Delta I_F$		6		Ω	I_F=10 mA
Switching Time	t_R t_F		1 1		µs µs	ΔI_F=2 mA, I_{Fq}=10 mA ΔI_F=2 mA, I_{Fq}=10 mA
Detector						
Dark Current	I_D		1	25	nA	V_{det}=-15 V, I_F=0 µA
Open Circuit Voltage	V_D		500		mV	I_F=10 mA
Short Circuit Current	I_{SC}		70		µA	I_F=10 mA
Junction Capacitance	C_J		12		pF	V_F=0 V, f=1 MHz
Noise Equivalent Power	NEP		4×10^{14}		W/√Hz	V_{det}=15 V
Coupled Characteristics						
K1, Servo Gain (I_{P1}/I_F)	K1	0.0050	0.007	0.011		I_F=10 mA, V_{det}=-15 V
Servo Current, see Note 1, 2	I_P1		70		µA	I_F=10 mA, V_{det}=-15 V
K2, Forward Gain (I_{P2}/I_F)	K2	0.0036	0.007	0.011		I_F=10 mA, V_{det}=-15 V
Forward Current	I_P2		70		µA	I_F=10 mA, V_{det}=-15 V
K3, Transfer Gain (K2/K1) See Note 1, 2	K3	0.56	1.00	1.65	K2/K1	I_F=10 mA, V_{det}=-15 V
Transfer Gain Linearity	ΔK3		±0.25		%	I_F=1 to 10 mA
Transfer Gain Linearity	ΔK3		±0.5		%	I_F=1 to 10 mA, T_A=0°C to 75°C
Photoconductive Operation						
Frequency Response	BW (–3 db)		200		KHz	I_{Fq}=10 mA, MOD=±4 mA, R_L=50 Ω,
Phase Response at 200 KHz			–45		Deg.	V_{det}=–15 V
Rise Time	t_R		1.75		µs	
Fall Time	t_F		1.75		µs	
Package						
Input-Output Capacitance	C_{IO}		1		pF	V_F=0 V, f=1 MHz
Common Mode Capacitance	C_{cm}		0.5		pF	V_F=0 V, f=1 MHz
Common Mode Rejection Ratio	CMRR		130		dB	f=60 Hz, R_L=2.2 KΩ

Notes

1. Bin Sorting:
   K3 (transfer gain) is sorted into bins that are ±6%, as follows:
   Bin A=0.557–0.626
   Bin B=0.620–0.696
   Bin C=0.690–0.773
   Bin D=0.765–0.859
   Bin E=0.851–0.955
   Bin F=0.945–1.061
   Bin G=1.051–1.181
   Bin H=1.169–1.311
   Bin I=1.297–1.456
   Bin J=1.442–1.618
   K3=K2/K1. K3 is tested at I_F=10 mA, V_{det}=–15 V.
2. Bin Categories: All IL300s are sorted into a K3 bin, indicated by an alpha character that is marked on the part. The bins range from "A" through "J".
   The IL300 is shipped in tubes of 50 each. Each tube contains only one category of K3. The category of the parts in the tube is marked on the tube label as well as on each individual part.
3. Category Options: Standard IL300 orders will be shipped from the categories that are available at the time of the order. Any of the ten categories may be shipped. For customers requiring a narrower selection of bins, four different bin option parts are offered.
   IL300-DEFG: Order this part number to receive categories D,E,F,G only.
   IL300-EF: Order this part number to receive categories E, F only.
   IL300-E: Order this part number to receive category E only.
   IL300-F: Order this part number to receive category F only.

Figure 2. LED forward current vs. forward voltage

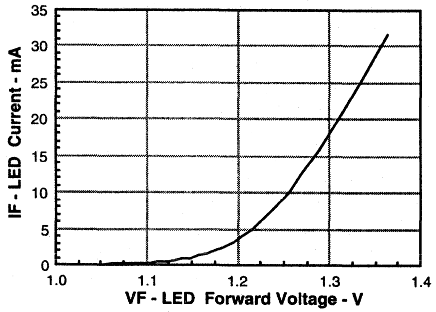


Figure 3. LED forward current vs. forward voltage

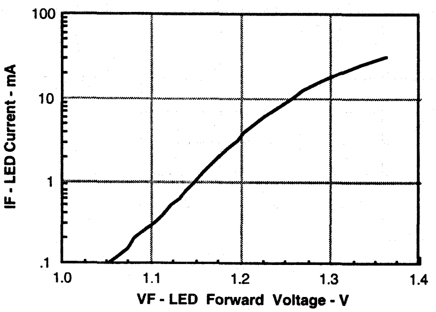


Figure 4. Servo photocurrent vs. LED current and temperature

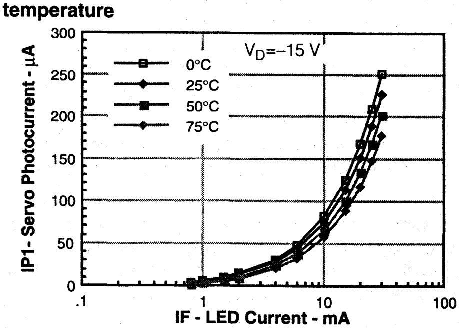


Figure 5. Servo photocurrent vs. LED current and temperature

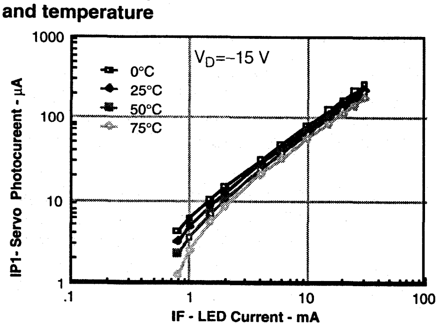


Figure 6. Normalized servo photocurrent vs. LED current and temperature

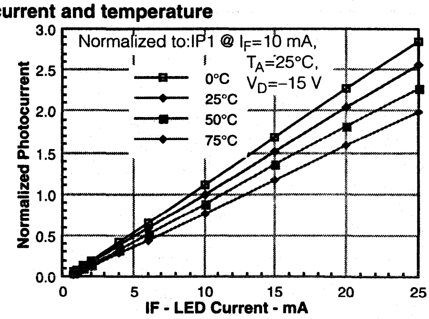


Figure 7. Normalized servo photocurrent vs. LED current and temperature

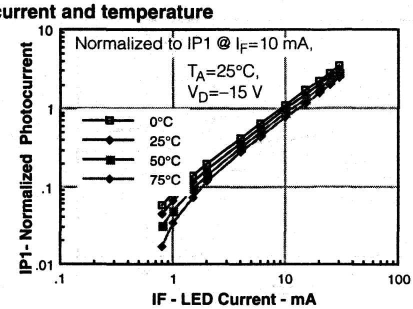


Figure 8. Servo gain vs. LED current and temperature

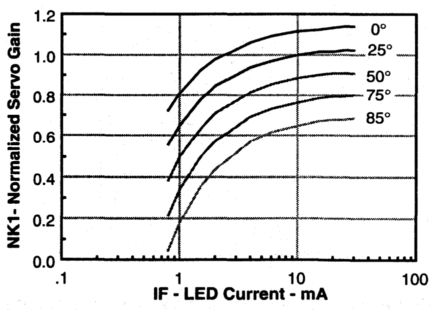


Figure 9. Normalized servo gain vs. LED current and temperature

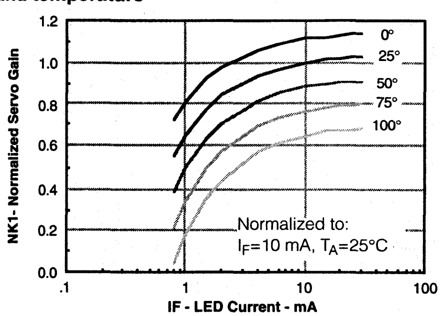


Figure 10. Transfer gain vs. LED current and temperature

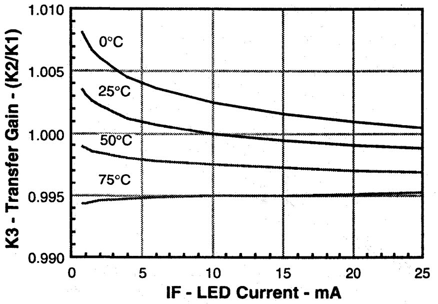


Figure 11. Normalized transfer gain vs. LED current and temperature

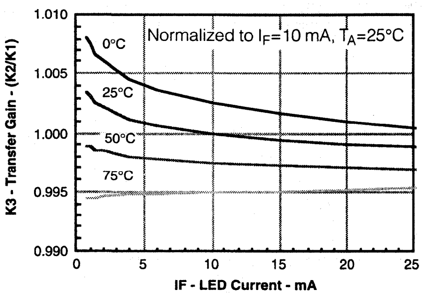


Figure 12. Amplitude response vs. frequency

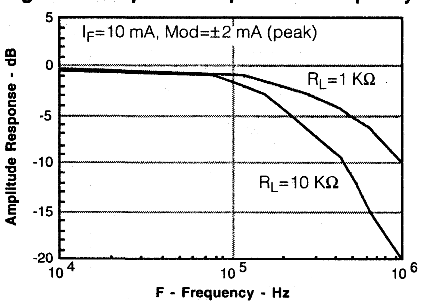


Figure 13. Amplitude and phase response vs. frequency

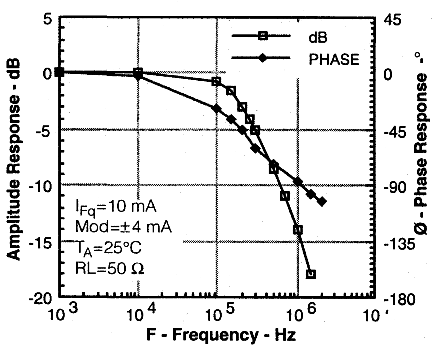


Figure 14. Common mode rejection

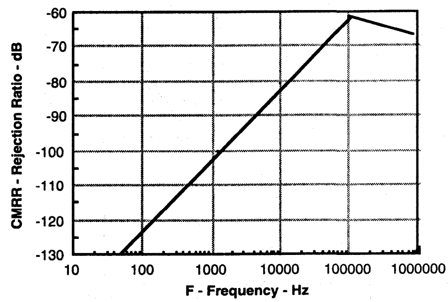
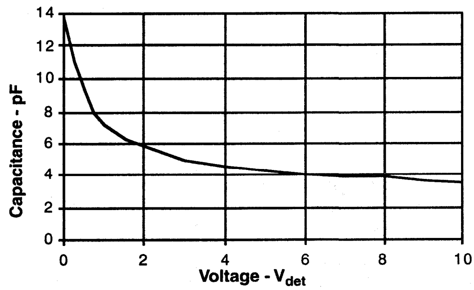


Figure 15. Photodiode junction capacitance vs. reverse voltage



Application Considerations

In applications such as monitoring the output voltage from a line powered switch mode power supply, measuring bioelectric signals, interfacing to industrial transducers, or making floating current measurements, a galvanically isolated, DC coupled interface is often essential. The IL300 can be used to construct an amplifier that will meet these needs.

The IL300 eliminates the problems of gain nonlinearity and drift induced by time and temperature, by monitoring LED output flux.

A PIN photodiode on the input side is optically coupled to the LED and produces a current directly proportional to flux falling on it. This photocurrent, when coupled to an amplifier, provides the servo signal that controls the LED drive current.

The LED flux is also coupled to an output PIN photodiode. The output photodiode current can be directly or amplified to satisfy the needs of succeeding circuits.

Isolated Feedback Amplifier

The IL300 was designed to be the central element of DC coupled isolation amplifiers. Designing the IL300 into an amplifier that provides a feedback control signal for a line powered switch mode power is quite simple, as the following example will illustrate.

See Figure 17 for the basic structure of the switch mode supply using the Siemens TDA4918 Push-Pull Switched Power Supply Control Chip. Line isolation and insulation is provided by the high frequency transformer. The voltage monitor isolation will be provided by the IL300.

The isolated amplifier provides the PWM control signal which is derived from the output supply voltage. Figure 16 more closely shows the basic function of the amplifier.

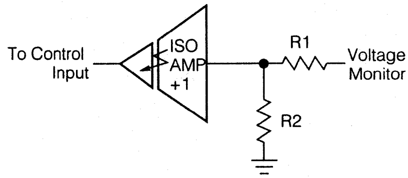
The control amplifier consists of a voltage divider and a non-inverting unity gain stage. The TDA4918 data sheet indicates that an input to the control amplifier is a high quality operational amplifier that typically requires a +3V signal. Given this information, the amplifier circuit topology shown in Figure 18 is selected.

The power supply voltage is scaled by R1 and R2 so that there is +3 V at the non-inverting input (Va) of U1. This voltage is offset by the voltage developed by photocurrent flowing through R3. This photocurrent is developed by the optical flux created by current flowing through the LED. Thus as the scaled monitor voltage (Va) varies it will cause a change in the LED current necessary to satisfy the differential voltage needed across R3 at the inverting input.

The first step in the design procedure is to select the value of R3 given the LED quiescent current (I_{Fq}) and the servo gain (K1). For this design, I_{Fq}=12 mA. Figure 4 shows the servo photocurrent at I_{Fq} is found to be 100 μA. With this data R3 can be calculated.

$$R3 = \frac{V_b}{I_{PI}} = \frac{3V}{100\mu A} = 30K\Omega$$

Figure 16. Isolated control amplifier



For best input offset compensation at U1, R2 will equal R3. The value of R1 can easily be calculated from the following.

$$R1 = R2\left(\frac{V_{MONITOR}}{V_a} - 1\right)$$

The value of R5 depends upon the IL300 Transfer Gain (K3). K3 is targeted to be a unit gain device, however to minimize the part to part Transfer Gain variation, Siemens offers K3 graded into ±5 % bins. R5 can determined using the following equation,

$$R5 = \frac{V_{OUT}}{V_{MONITOR}} \bullet \frac{R3(R1 + R2)}{R2K3}$$

Or if a unity gain amplifier is being designed (V*MONITOR*=V*OUT*, R1=0), the equation simplifies to:

$$R5 = \frac{R3}{K3}$$

Figure 17. Switch mode power supply

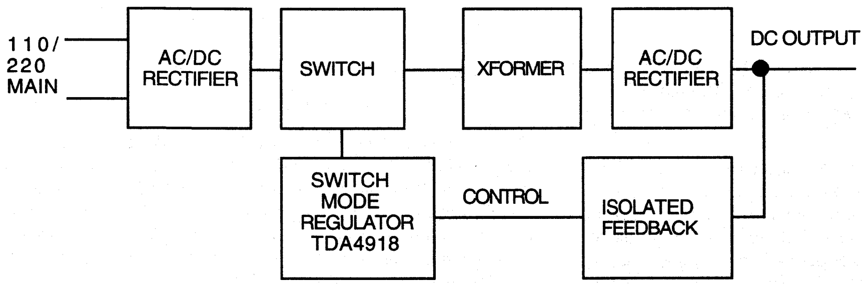


Figure 18. DC coupled power supply feedback amplifier

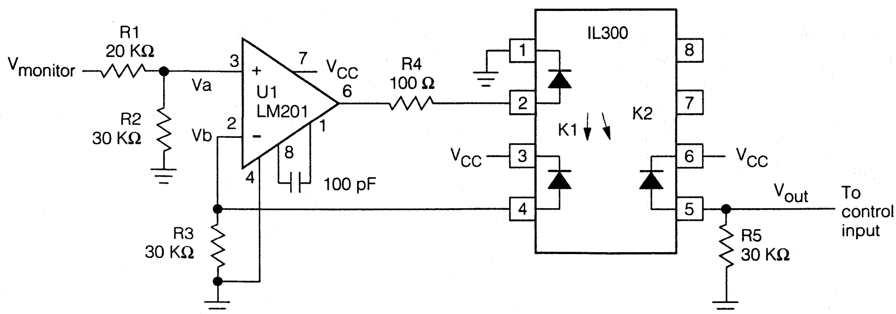


Table 1 gives the value of R5 given the production K3 bins.

Table 1. R5 selection

Bins	Min.	Max.	K3 Typ.	R5 Resistor KΩ	1% KΩ
A	0.560	0.623	0.59	50.85	51.1
B	0.623	0.693	0.66	45.45	45.3
C	0.693	0.769	0.73	41.1	41.2
D	0.769	0.855	0.81	37.04	37.4
E	0.855	0.950	0.93	32.26	32.4
F	0.950	1.056	1.00	30.00	30.0
G	1.056	1.175	1.11	27.03	27.0
H	1.175	1.304	1.24	24.19	24.0
I	1.304	1.449	1.37	21.90	22.0
J	1.449	1.610	1.53	19.61	19.4

The last step in the design is selecting the LED current limiting resistor (R4). The output of the operational amplifier is targeted to be 50% of the V_{CC}, or 2.5 V. With an LED quiescent current of 12 mA the typical LED (V_F) is 1.3 V. Given this and the operational output voltage, R4 can be calculated.

$$R4 = \frac{V_{opamp} - V_F}{I_{Fq}} = \frac{2.5V - 1.3V}{12mA} = 100\Omega$$

The circuit was constructed with an LM201 differential operational amplifier using the resistors selected. The amplifier was compensated with a 100 pF capacitor connected between pins 1 and 8.

The DC transfer characteristics are shown in Figure 19. The amplifier was designed to have a gain of 0.6 and was measured to be 0.6036. Greater accuracy can be achieved by adding a balancing circuit, and potentiometer in the input divider, or at R5. The circuit shows exceptionally good gain linearity with an RMS error of only 0.0133% over the input voltage range of 4 V–6 V in a servo mode; see Figure 20.

Figure 19. Transfer gain

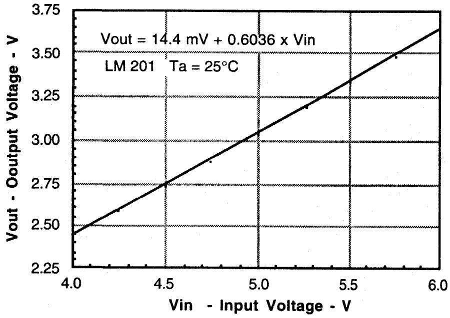
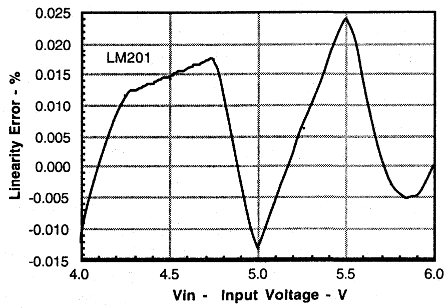
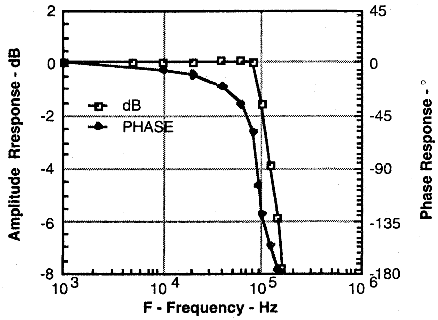


Figure 20. Linearity error vs. input voltage



The AC characteristics are also quite impressive offering a -3 dB bandwidth of 100 KHz, with a -45° phase shift at 80 KHz as shown in Figure 21.

Figure 21. Amplitude and phase power supply control



The same procedure can be used to design isolation amplifiers that accept bipolar signals referenced to ground. These amplifiers circuit configurations are shown in Figure 22. In order for the amplifier to respond to a signal that swings above and below ground, the LED must be prebiased from a separate source by using a voltage reference source (Vref1). In these designs, R3 can be determined by the following equation.

$$R3 = \frac{V_{ref1}}{I_{P1}} = \frac{V_{ref1}}{K1 I_{Fq}}$$

Figure 22. Non-inverting and inverting amplifiers

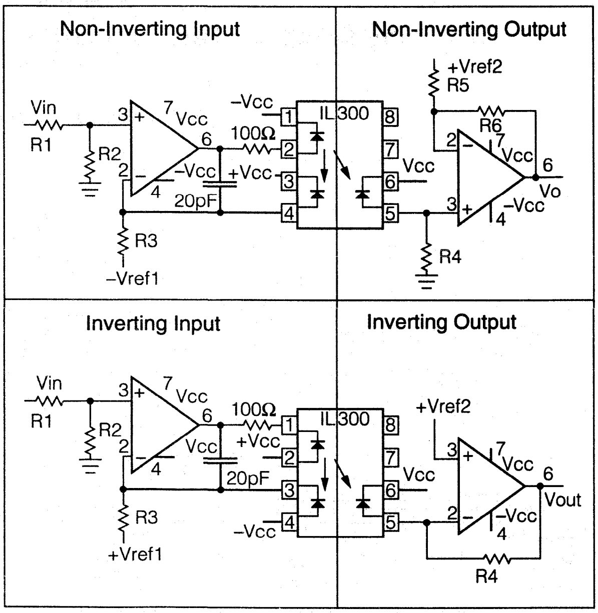


Table 2. Optolinear amplifiers

Amplifier	**Input**	**Output**	**Gain**	**Offset**
Non-Inverting	Inverting	Inverting	$\frac{V_{OUT}}{V_{IN}} = \frac{K3\ R4\ R2}{R3\ (R1+R2)}$	$V_{ref2} = \frac{V_{ref1}\ R4\ K3}{R3}$
	Non-Inverting	Non-Inverting	$\frac{V_{OUT}}{V_{IN}} = \frac{K3\ R4\ R2\ (R5+R6)}{R3\ R5\ (R1+R2)}$	$V_{ref2} = \frac{-V_{ref1}\ R4\ (R5+R6)\ K3}{R3\ R6}$
Inverting	Inverting	Non-Inverting	$\frac{V_{OUT}}{V_{IN}} = \frac{-K3\ R4\ R2\ (R5+R6)}{R3\ R5\ (R1+R2)}$	$V_{ref2} = \frac{V_{ref1}\ R4\ (R5+R6)\ K3}{R3\ R6}$
	Non-Inverting	Inverting	$\frac{V_{OUT}}{V_{IN}} = \frac{-K3\ R4\ R2}{R3\ (R1+R2)}$	$V_{ref2} = \frac{-V_{ref1}\ R4\ K3}{R3}$

These amplifiers provide either an inverting or non-inverting transfer gain based upon the type of input and output amplifier. Table 2 shows the various configurations along with the specific transfer gain equations. The offset column refers to the calculation of the output offset or Vref2 necessary to provide a zero voltage output for a zero voltage input. The non-inverting input amplifier requires the use of a bipolar supply, while the inverting input stage can be implemented with single supply operational amplifiers that permit operation close to ground.

For best results, place a buffer transistor between the LED and output of the operational amplifier when a CMOS opamp is used or the LED I_{Fq} drive is targeted to operate beyond 15 mA. Finally the bandwidth is influenced by the magnitude of the closed loop gain of the input and output amplifiers. Best bandwidths result when the amplifier gain is designed for unity.

SIEMENS

IL329

Optically Coupled Telecom Switch

Preliminary Data Sheet

FEATURES
- **Solid state relay and AC input**
- **Optocoupler Package—Single 18 Pin**
- **I/O Isolation, 2500 V_{RMS}**
- **Surface Mountable**
- **Optocoupler**
  - **Bidirectional Current Detection**
- **Solid-state Relay**
  - **Typical RON 25 W**
  - **Load Voltage 400 V**
  - **Load Current 100 mA**
  - **Current Limit Protection**
  - **High Surge Capability**
  - **Linear, AC/DC Operation**
  - **Clean Bounce Free Switching**
  - **Low Power Consumption**
  - **High Reliability Monolithic Receptor**

Applications—General Telecom Switching
- **On/off Hook Control**
- **Dial Pulse**
- **Ring Current Detection**
- **Loop Current Sensing**

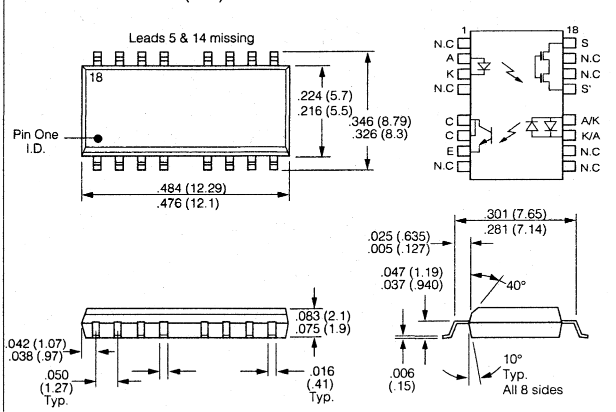
DESCRIPTION

The IL329 Telecom switch consists of an optically coupled solid state relay (SSR) and a bidirectional input optocoupler. The SSR is ideal for performing switchhook and dial-pulse switching while the optocoupler performs ring detection and loop current sensing functions. Both the SSR and opto coupler provide 2500 VRMS of input to ouput isolation.

The SSR is integrated on a monolithic receptor die using high voltage BCDMOS technology. The SSR features low ON-resistance, high breakdown voltage and current-limit circuitry that protects the relay from telephone line induced lightning surges.

The optocoupler provides bidirectional current sensing via two antiparallel GaAs infrared emitting diodes. The opto channel provides a minimum CTR of 33% at 6 mA.

The IL329 comes in a 18 pin, plastic surface mount package.



Absolute Maximum Ratings

Package

Ambient Temperature Range .... –40 to +85°C
Storage Temperature Range .... –40 to +150°C
Soldering Temperature (t=10 sec. max.) .... 260°C
Input/Output Isolation Voltage (t=60 sec. min.) .... 2500 V_{RMS}
Total Power Dissipation .... 500 mW
Isolation Test Voltage (between emitter and detector) .... 2500 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}\ \Omega$
Storage Temperature Range .... –55°C to +125°C
Ambient Temperature Range .... –55°C to +100°C
Soldering Temperature (max. ≤10 sec.,
dip soldering ≥0.5 mm from case bottom) .... 260°C

SSR

LED Continuous Forward Current .... 50 mA
LED Reverse Voltage (I_R≤10 µA) .... 5 V
DC or Peak AC Load Voltage (I_L≤50 µA) .... ±400 V
Continous DC Load Current .... 100 mA
Total Power Dissipation .... 350 mW

Optocoupler

LED Continuous Forward Current .... ±50 mA
Collector to Emitter Breakdown Voltage .... 30 V
Phototransistor Power Dissipation .... 150 mW

Electrical Characteristics T_A=25°

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
SSR						
LED Forward Current for Switch Turn-on	I_{Fon}		0.2	0.5	mA	I_L=100 mA, t=10 ms
LED Forward Current for Switch Turn-off	I_{Foff}	0.001			mA	V_L=±350 V
LED Forward Voltage	V_F	0.8	1.20	1.45	V	I_F=1.5 mA
ON-Resistance	R_{ON}	17	2.5	33	W	I_F=1.5 mA,I_L=±50 mA
OFF-Resistance	R_{OFF}		5000		GΩ	I_F=0 mA, V_L=±100 V
Current Limit	I_{limit}	170	210	270	mA	I_F=1.5 mA, t=5 ms
Output Off-state Leakage Current			0.1	200 1	nA µA	I_F=0 mA, V_L=±100 V I_F=0 mA, V_L=±400 V
Output Capacitance Pins 15 to 18			55 10		pF pF	I_F=0 mA, V_L=1 V I_F=0 mA, V_L=50 V
Turn-on Time	T_{on}		1.0		ms	I_F=1.5 mA, I_L=50 mA
				0.8	ms	I_F=5.0 mA, I_L=50 mA
Turn-off Time	T_{off}		0.1		ms	I_F=1.5 mA, I_L=50 V
				0.2	ms	I_F=5.0 mA, I_L=50 mA
Optocoupler						
LED Forward Voltage	V_F	0.9	1.25	1.5	V	I_F=10 mA
DC Current Transfer Ratio	CTR	33	165		%	I_F=6.0 mA, V_{CE}=0.5 V
Saturation Voltage	V_{CEsat}		.07	0.5	V	I_F=16.0 mA, I_C=2 mA
Dark Current Leakage	I_{CEO}			500	nA	I_F=0 mA, V_{CE}=5 V
Trickle Current Leakage	I_{CEO}			1	µA	I_F=5 µA, V_{CE}=5 V

SSR Characteristic Curves

Figure 1. SSR recommended operating conditions

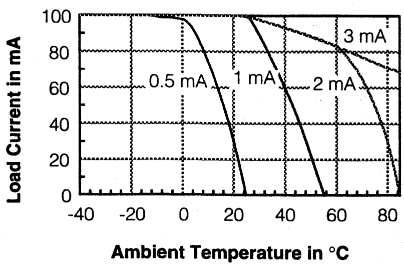


Figure 3. SSR turn-on current vs. temperature

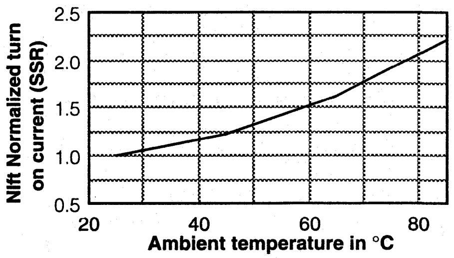


Figure 2. I_F **vs.** V_F**, typical**

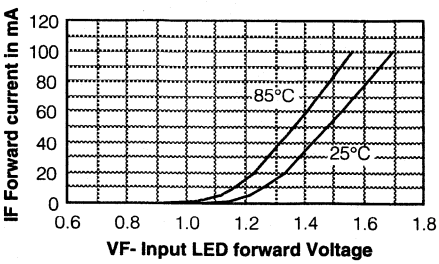


Figure 4. SSR current vs. voltage, typical

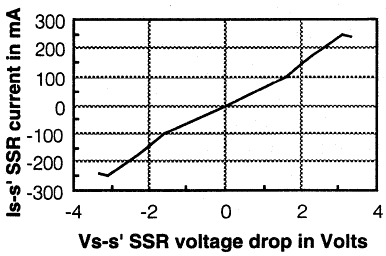


Figure 5. SSR turn on time vs. resistive load

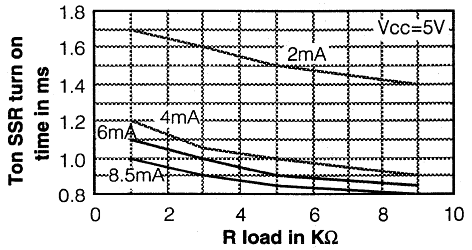


Figure 9. Saturated current transfer ratio, typical

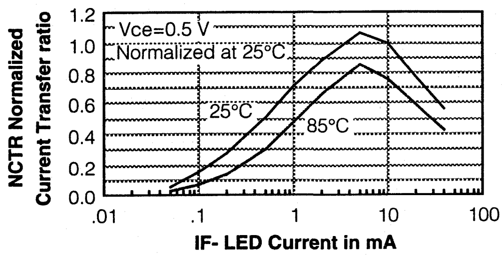


Figure 6. SSR current limit vs. temperature

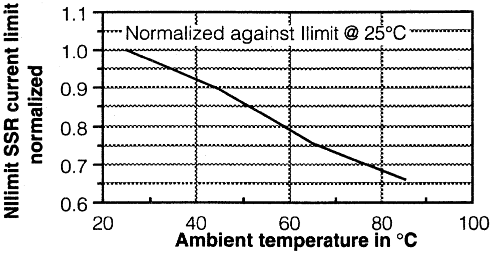
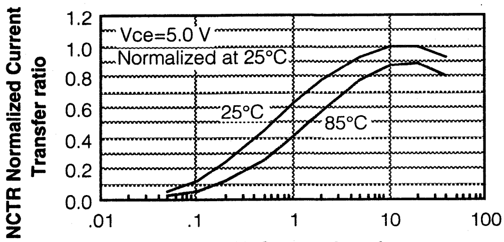


Figure 10. Non-saturated current transfer ratio, typical



Typical Opto Channel Characteristic Curves

Figure 11. Switching test circuit for SSR channel

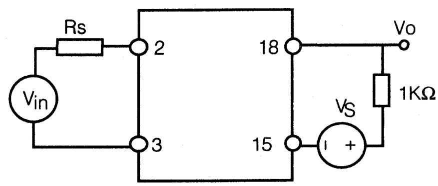


Figure 7. I_C vs. V_{CE}, typical

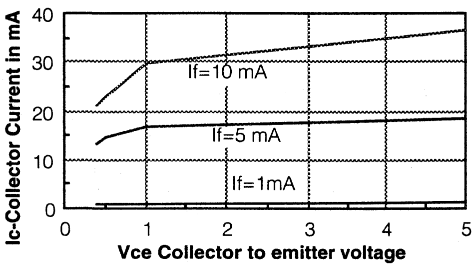


Figure 12. Switching waveform

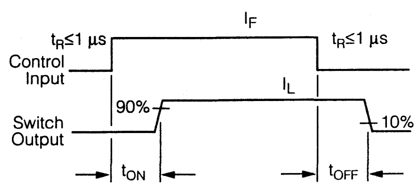
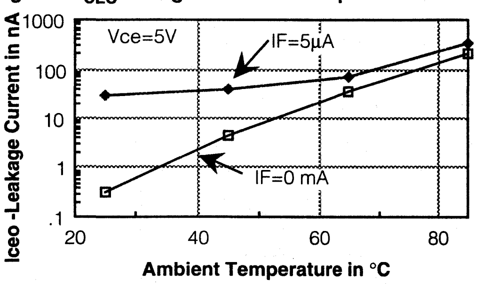


Figure 8. I_{CEO} leakage current vs. temp.



SIEMENS

IL350/351/358/359

High Performance Linear Optocoupler for Optical DAA in Telecommunications

Preliminary Data Sheet

FEATURES
- **2 mm High SMT Package**
- **High Sensitivity (K1) at Low Operating LED Current**
- **Couples AC and DC Signals**
- **Low Input-Output Capacitance**
- **Isolation Voltage, 2500 V_{RMS}**
- **Low Distortion**

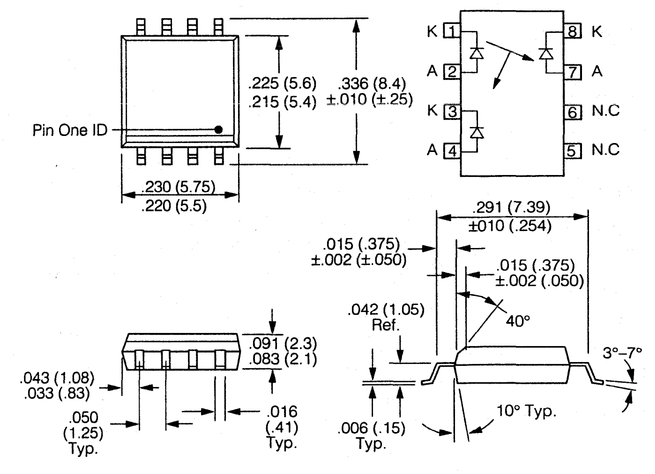
APPLICATIONS
- **Optical DAA for V.34 FAX/Modem PCMCIA Cards**
- **Digital Telephone Line Isolation**

DESCRIPTION

The IL350/1/8/9 family of Linear Optocoupler consist of an IRLED optically coupled to two photodiodes. The emitter mechanically faces both diodes enabling them to receive approximately an equal amount of infrared light. The diodes produce a proportional amount of photocurrents. The ratio of the photocurrents stays constant with high accuracy when either the LED current changes or the ambient temperature changes. Thus one can control the output diode current optically by controlling the input photodiode current.

The IL350/1/8/9 optocouplers can be used with the aid of operational amplifiers in closed loop conditions to achieve highly linear and electrically isolated AC and or DC signal amplifiers.

Dimensions in Inches (mm)



Absolute Maximum Ratings

Maximum Ratings

Emitter

Reverse Voltage	3 V
Forward Current	30 mA
SurgeCurrent , Pulse Width <10 µs	150 mA
Power Dissipation, T_A=25°C	150 mW
Derate Linearly from 25°C	2 mW/°C

Detector

Reverse Voltage	15 V
Power Dissipation	50 mW
Derate Linearly from 25°C	0.65 mW/°C
Junction Temperature	100°C

Coupler

Isolation Test Voltage	2500 V_{RMS}
Total Package Power Dissipation	250 mW
Derate Linearly from 25°C	2.8 mW/°C
Storage Temperature Range	–40°C to +150°C
Operating Temperature	75°C
Lead Soldering Time at 260°C	10 sec.
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	≥10^{12} Ω
V_{IO}=500 V, T_A=100°C	≥10^{11} Ω

Electrical Characteristics T_A=25°C

LED Emitter		Symbol	Min.	Typ.	Max.	Units	Test Conditions
Forward Voltage		V_F		1.8	2.1	V	I_F=10 mA
Reverse Current		I_R		.01	10	µA	V_R=3 V
V_F Temperature Coefficient		$\Delta V_F/\Delta °C$		–2.2		mV/°C	
Junction Capacitance		C_J		TBD		pF	V_F=0 V, f=1 MHz
Dynamic Resistance		$\Delta V_F/\Delta I_F$		6		W	I_F=2.5 mA ΔI_F=1 mA
Switching Time IL358/9		t_F		40		ns	
		t_R		40		ns	
Detector							
Junction Capacitance		C_J		12		pF	V_F=0 V, f=1 MHz
NEP				$<4^{-14}$		W/√Hz	V_{DET}=0 V
AC Characteristics Photovoltaic Mode							
Frequency Response	IL358/9	BW(–3dB)		1.0		MHz	I_{P1}=25 µA Modulation current ΔIP1=±6 µA
Phase Response				45		Deg.	
Rise Time				350		ns	
Package							
Input-Output Capacitance		C_{IO}		1		pF	V_F=0 V, f=1 MHz
Common Mode Capacitance		C_{cm}		0.5		pF	V_F=0 V, f=1 MHz

Coupled Characteristics

	K1 at I_F=2 mA, V_D=0 V			K3 Bins
	Min.	**Typ.**	**Max.**	
IL350	0.003			A–J
IL351	0.005			D, E, F, G
IL358	0.008			C,D, E, F, G, H
IL359	0.008			E, F

Bin Table

Bin	Min.	Max.
A	0.557	0.626
B	0.620	0.696
C	0.690	0.773
D	0.765	0.859
E	0.851	0.955
F	0.945	1.061
G	1.051	1.181
H	1.169	1.311
I	1.297	1.456
J	1.442	1.618

SIEMENS

IL352

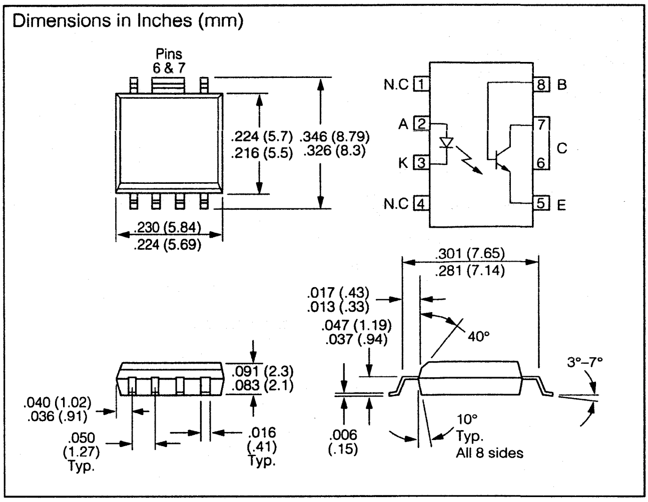
Phototransistor Optocoupler

Preliminary Data Sheet

FEATURES
- **Good CTR Linearity Depending on Forward Current**
- **Isolation Test Voltage, 2500 V_{RMS}**
- **High Collector-Emitter Voltage, V_{CEO}=30 V**
- **Low Saturation Voltage**
- **Fast Switching Times**
- **Field-Effect Stable by TRIOS***

DESCRIPTION
The IL352 is an optically coupled isolator that features a high current transfer ratio, low coupling capacitance and high isolation voltage. It has a GaAs infrared emitting diode emitter, which is optically coupled to a silicon planar phototransistor detector. The component is housed in a thin line package.

The coupling device is designed for signal transmission between two electrically separated circuits. The potential difference between the circuits to be coupled must not exceed the maximum permissible reference voltages.



Maximum Ratings
Emitter

Reverse Voltage .... 6 V
DC Forward Current .... 60 mA
Total Power Dissipation .... 50 mW
Derate Linearly from 25°C .... 0.66 mW/°C

Detector

Collector-Emitter Voltage .... 70 V
Emitter-Base Voltage .... 7 V
Collector Current .... 50 mA
Collector Current (t ≤1 ms) .... 100 mA
Total Power Dissipation .... 150 mW
Derate Linearly from 25°C .... 2.5 mW/°C

Package

Isolation Test Voltage (between emitter and detector referred to climate DIN 40046, part 2, Nov. 74) .... 2500 V_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... ≥10^{12} Ω
V_{IO}=500 V, T_A=100°C .... ≥10^{11} Ω
Storage Temperature Range .... –40°C to +150°C
Ambient Temperature Range .... –40°C to +85°C
Junction Temperature .... 100°C
Soldering Temperature (max 10 s, Dip Soldering Distance to Seating Plane ≥1.5 mm) .... 260°C

***TR**ansparent **IO**n **S**hield

Characteristics T_A=25°C

Emitter	Sym.	Min.	Typ.	Max.	Units	Condition
Forward Voltage	V_F		1.3	1.5	V	I_F=10 mA
Reverse Current	I_R		0.1	10	µA	V_R=6.0 V
Capacitance	C_O		25		pF	V_R=0 f=1 MHz
Detector						
Breakdown Voltage Collector-Emitter Emitter-Collector	 BV_{CEO} BV_{ECO}	 30 7			V	 I_C=1 mA I_E=100 µA
Collector-Emitter Leakage	I_{CEO}		5	50	nA	V_{CE}=10 V I_F=0 T_A=25°C
				500	µA	V_{CE}=30 V I_F=0 T_A=85°C
Collector to Base	BV_{CBO}	70			V	I_C=100 µA
Capacitance Collector-Emitter	C_{CE}		6		pF	V_{CE}=0

Characteristics T_A=25°C (continued)

Package	Symbol	Min.	Typ.	Max.	Units	Condition
DC Current Transfer Ratio	CTR	100			%	I_F=10 mA V_{CE}=10 V
DC Current Transfer Ratio	CTR	34			%	I_F=1 mA V_{CE}=10 V
Saturation Voltage Collector-Emitter	V_{CEsat}			0.3	V	I_F=10 mA, I_C=0.5 mA
Coupling Capacitance	C_{IO}		0.5		pF	f=1.0 MHz
Switching Time, Non-Saturated	T_{on}, T_{off}		10		µs	I_C=2 mA R_E=100 Ω V_{CC}=10 V RH≤50%

Figure 1. Switching waveform

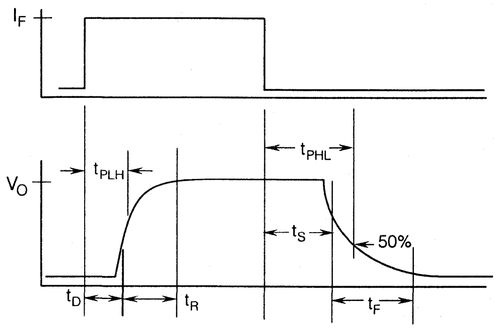


Figure 2. Switching schematic

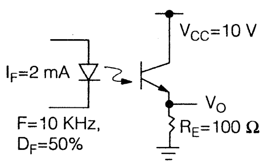


Figure 3. Forward voltage versus forward current

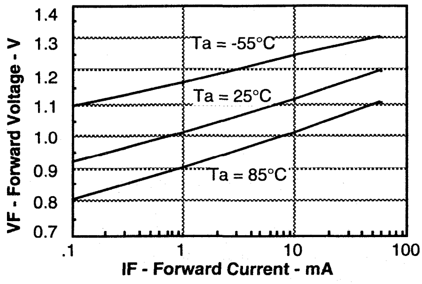


Figure 4. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

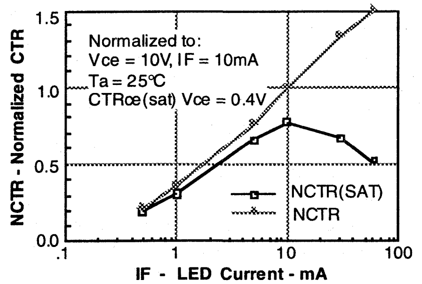


Figure 5. Normalized non-saturated and saturated CTR at T_A=50°C versus LED current

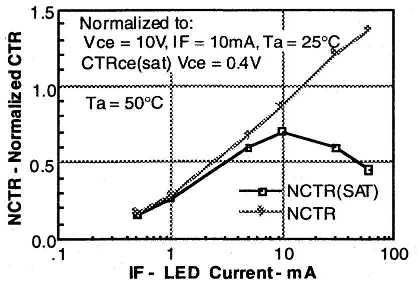


Figure 6. Normalized non-saturated and saturatedCTR at T_A=70°C versus LED current

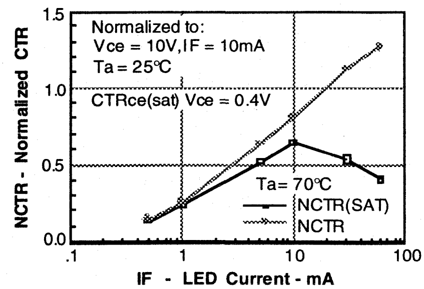


Figure 7. Normalized non-saturated and saturated CTR at T_A=85°C versus LED current

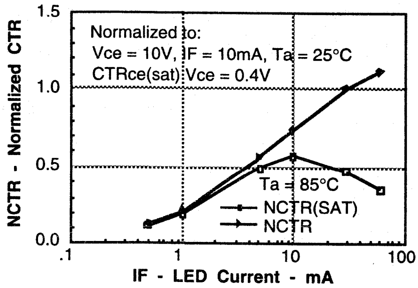


Figure 11. Collector base photocurrent versus LED current

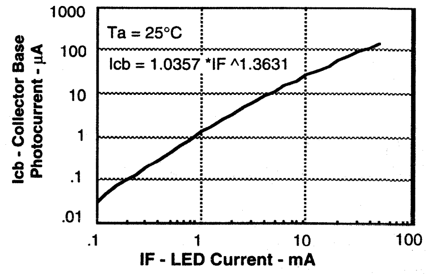


Figure 8. Collector-emitter current versus temperature and LED current

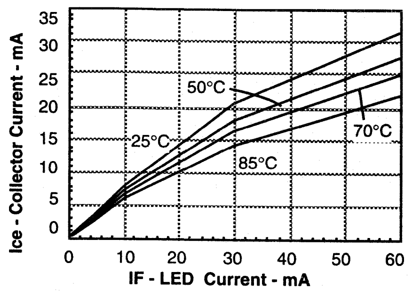


Figure 12. Normalized photocurrent versus I_F and temperature

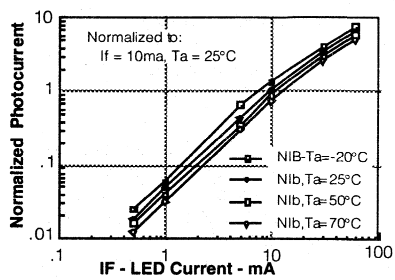


Figure 9. Collector-emitter leakage current versus temperature

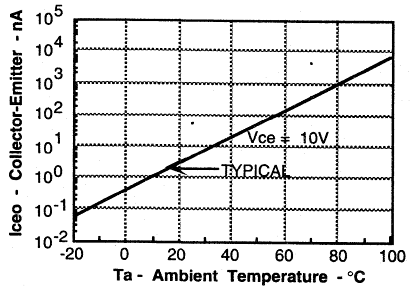


Figure 13. Propagation delay versus collector load resistor

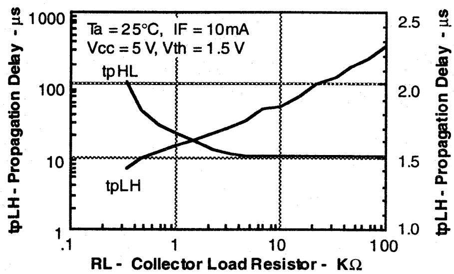
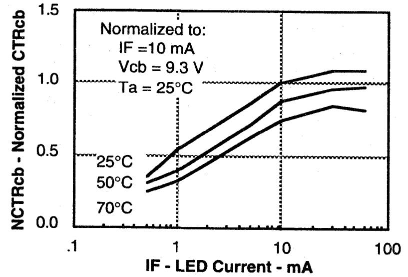


Figure 10. Normalized CTRcb versus LED current and temperature



SIEMENS

IL388

High Peformance Linear Optocoupler for Optical DAA in Telecommunications

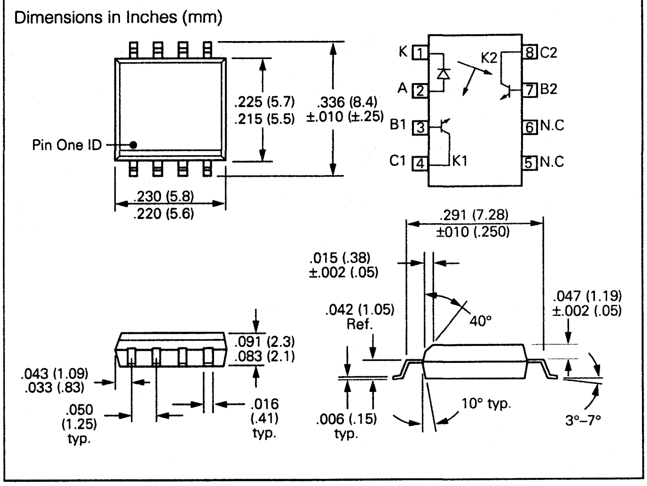
Preliminary Data Sheet

FEATURES
- **2.3 mm High SMT Package**
- **High Sensitivity (K1) at Low Operating LED Current**
- **Couples AC and DC Signals**
- **Low Input-Output Capacitance**
- **Isolation Voltage, 2500 VDC**
- **Low Distortion, below –80 db**
- **0.4 mm Internal Insulation Thickness**

APPLICATIONS
- **Optical DAA for V.34 FAX/Modem PCMCIA Cards**
- **Digital Telephone Line Isolation**

DESCRIPTION
The IL388 family of Linear Optocoupler consist of an IRLED optically coupled to two photodiodes. The emitter is located such that both photodiodes receive approximately an equal amount of infrared light. The diodes produce a proportional amount of photocurrents. The ratio of the photocurrents stays constant with high accuracy when either the LED current changes or the ambient temperature changes. Thus one can control the output diode current optically by controlling the input photodiode current.

The IL388 optocouplers can be used with the aid of operational amplifiers in closed loop conditions to achieve highly linear and electrically isolated AC and or DC signal amplifiers.



Absolute Maximum Ratings

Emitter	Sym	Min.	Max.	Units
Reverse Voltage	V_R		3	V
Forward Current	I_F		30	mA
Surge Current Pulse Width <10 µs	I_{PK}		150	mA
Power Dissipation, T_A=25°C	P_{LED}		150	mW
Dearate Linearly from 25°C			2	mW/°C
Junction Temperature	T_J		100	°C
Detector (each)				
Reverse Voltage	V_R		15	V
Power Dissipation	P		50	mW
Derate Linearly from 25°C			0.65	mW/°C
Junction Temperature	T_J		100	°C
Coupler				
Isolation Test Voltage	V_{ISOL}	2500		V_{DC}
Total Package Power Dissipation	Pt		250	mW
Derate Linearly from 25°C			2.8	mW/°C
Storage Temperature	T_S	–40	150	°C
Operating Temperature	T_{OP}	0	75	°C
Lead Soldering Time at 260°C			10	sec.
Isolation Resistance V_{IO}=500 V, T_A=25°C V_{IO}=500 V, T_A=100°C		 10^{12} Ω 10^{11} Ω		

Electrical Characteristics T_A=25°C)

LED Emitter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Forward Voltage	V_F		1.8	2.1	V	I_F=10 mA
Reverse Current	I_R		.01	10	µA	V_R=3 V
V_F Temperature Coefficient	$\Delta V_F/\Delta°C$		–2.2		mV/°C	
Junction Capacitance	C_J		TBD		pF	V_F=0 V, f=1 MHz
Dynamic Resistance	$\Delta V_F/\Delta I_F$		6		W	
Detector						
Junction Capacitance	C_J		12		pF	V_F=0 V, f=1 MHz
AC Characteristics Photovoltaic Mode						
Frequency Response	BW(–3dB)		1.0		MHz	I_{P1}=25 µA Modulation current ΔIP1=±6 µA
Phase Response			45		Deg.	
Rise Time			350		ns	
Package						
Input-Output Capacitance	C_{IO}		1		pF	V_F=0 V, f=1 MHz
Common Mode Capacitance	C_{cm}		0.5		pF	V_F=0 V, f=1 MHz
Coupled Characteristics			**Min.**	**Typ.**	**Max.**	**Units**
K_1 at I_F=2 mA, V_D=0 V			0.007			
THD at f_0=316, I_{PI}=35 µA, V_D=0 V			–83			db
$K_3=K_2/K_1$, I_F=2 mA, V_D=0 V			0.690		1.311	

Bin table for K_3

Bin	Min.	Max.
C	0.690	0.773
D	0.765	0.859
E	0.851	0.955
F	0.945	1.061
G	1.051	1.181
H	1.169	1.311

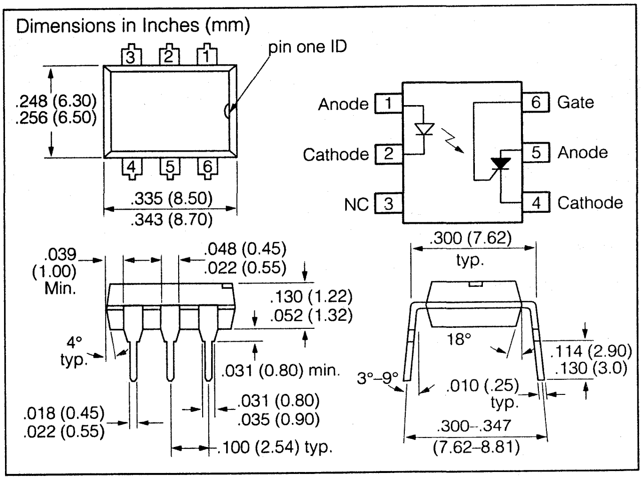
SIEMENS

IL400

Photo SCR Optocoupler

FEATURES

- **Turn On Current (IFT), 5.0 mA Typical**
- **Gate Trigger Current (IGT), 20 μA**
- **Surge Anode Current, 1.0 Amp**
- **Blocking Voltage, 400 V**
- **Gate Trigger Voltage (VGT), 0.6 Volt**
- **Isolation Voltage, 5300 VAC_{RMS}**
- **Solid State Reliability**
- **Standard DIP Package**
- **Underwriters Lab File #E52744**



DESCRIPTION

The IL400 is an optically coupled SCR with a Gallium Arsenide infrared emitter and a silicon photo SCR sensor. Switching can be achieved while maintaining a high degree of isolation between triggering and load circuits. The IL400 can be used in SCR triac and solid state relay applications where high blocking voltages and low input current sensitivity are required.

Maximum Ratings

Emitter

Peak Reverse Voltage .... 6.0 V
Peak Forward Current
(100 μs, 1% Duty Cycle) .... 1.0 A
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 100 mW
Derate Linearly from 25°C .... 1.3 mW/°C

Detector

Reverse Gate Voltage .... 6.0 V
Anode Voltage (DC or AC Peak) .... 400 V
Anode Current .... 100 mA
Surge Anode Current (10 ms duration) .... 1.0 A
Surge Gate Current (5 ms duration) .... 200 mA
Power Dissipation, 25°C ambient .... 200 mW
Derate Linearly from 25°C .... 2.11 mW/°C

Package

Isolation Voltage .... 5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... min. 10^{12} Ω
V_{IO}=500 V, T_A=100°C .... min. 10^{11} Ω
Total Package Dissipation .... 250 mW
Derate Linearly from 25°C .... 2.63 mW/°C
Operating Temperature .... –55°C to +100°C
Storage Temperature .... –55°C to +150°C

Characteristics T_A=25°C

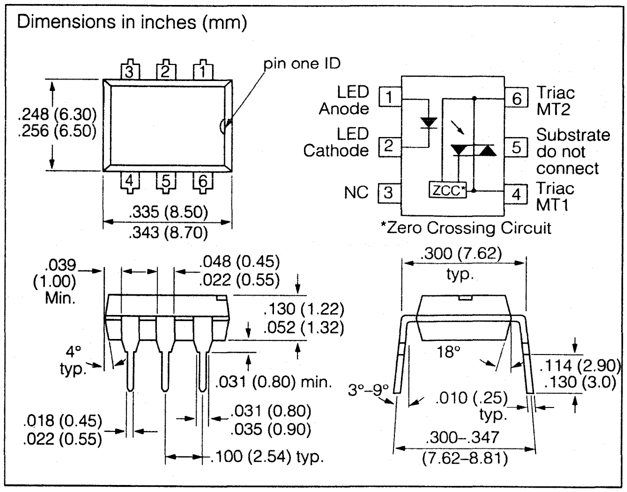
	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.2	1.5	V	I_F=20 mA
Reverse Voltage	V_R	5.0			V	I_R=10 μA
Reverse Current	I_R			10	μA	V_R=5 V
Detector						
Forward Blocking Voltage	V_{DRM}	400			V	R_{GK}=10 KΩ, T_A=100°C, I_d=150 μA
Reverse Blocking Voltage	V_{DRRM}	400			V	R_{GK}=10 KΩ, T_A=100°C, I_d=150 μA
On-state Voltage	V_t			1.2	V	I_T=100 mA
Holding Current	I_H			500	μA	R_{GK}=27 KΩ, V_{FX}=50 V
Gate Trigger Voltage	V_{GT}		0.6	1.0	V	V_{FX}=100 V, R_{GK}=27 KΩ, R_L=10 KΩ
Forward Leakage Current	I_D		0.2	2.0	μA	R_{GK}=27 KΩ, V_{RX}=400 V, I_F=0, T_A=25°C
Reverse Leakage Current	I_R		0.2	2.0	μA	R_{GK}=27 KΩ, V_{RX}=400 V, I_F=0, T_A=25°C
Gate Trigger Current	I_{GT}		20	50	μA	V_{FX}=100 V, R_{GK}=27 KΩ, R_L=10 KΩ
Package						
Turn-On Current	I_{FT}	0.5	5.0	10.0	mA	V_{FX}=100 V, R_{GK}=27 KΩ
Isolation Capacitance				2	pF	f=1 MHz

SIEMENS

IL410

Zero Voltage Crossing
600 V Triac Driver Optocoupler

FEATURES
- **On-State Current, 300 mA**
- **Zero Voltage Crossing**
- **Blocking Voltage, 600 V**
- **Isolation Test Voltage from Double Molded Package, 5300 VACRMS**
- **High Input Sensitivity**
  I_{FT}=2 mA, PF=1.0
  I_{FT}=5 mA, PF£1.0
- **High Static dv/dt 10K V/µs**
- **Inverse Parallel SCRs Provide Commutating dv/dt >10K V/µs**
- **Very Low Leakage <10 µA**
- **Small 6-Pin DIP Package**
- **Underwriters Lab File #E52744**
- **VDE Approval #0884 (Optional with Option 1, Add -X001 Suffix)**



Maximum Ratings
Emitter

Reverse Voltage	6 V
Forward Current	60 mA
Surge Current	2.5 A
Power Dissipation	100 mW
Thermal Resistance	750 °C/W
Derate from 25°C	1.33 mW/°C

Detector

Peak Off-State Voltage	600 V
Peak Reverse Voltage	600 V
RMS On-State Current	300 mA
Single Cycle Surge	3 A
Total Power Dissipation	500 mW
Thermal Resistance	150°C/W
Derate from 25°C	6.6 mW/°C

Package

Isolation Test Voltage	5300 VAC_{RMS}
Storage Temperature	–55°C to +150°C
Operating Temperature	–55°C to +100°C
Lead Soldering Temperature	260°C/5 sec.

DESCRIPTION

The IL410 consists of a GaAs IRLED optically coupled to a photosensitive zero crossing TRIAC network. The TRIAC consists of two inverse parallel connected monolithic SCRs. These three semiconductors are assembled in a six pin 0.3 inch dual in-line package, using high insulation double molded, over/under leadframe construction.

High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR predriver resulting in an LED trigger current of less than 2 mA (DC).

The IL410 uses two discrete SCRs resulting in a commutating dV/dt greater than 10KV/µs. The use of a proprietary dv/dt clamp results in a static dV/dt of greater than 10KV/µs. This clamp circuit has a MOSFET that is enhanced when high dV/dt spikes occur between MT1 and MT2 of the TRIAC. When conducting, the FET clamps the base of the phototransistor, disabling the first stage SCR predriver.

The zero cross line voltage detection circuit consists of two enhancement MOSFETS and a photodiode. The inhibit voltage of the network is determined by the enhancement voltage of the N-channel FET. The P-channel FET is enabled by a photocurrent source that permits the FET to conduct the main voltage to gate on the N-channel FET. Once the main voltage can enable the N-channel, it clamps the base of the phototransistor, disabling the first stage SCR predriver.

The 600V blocking voltage permits control of off-line voltages up to 240VAC, with a safety factor of more than two, and is sufficient for as much as 380VAC.

The IL410 isolates low-voltage logic from 120, 240, and 380 VAC lines to control resistive, inductive, or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.

Characteristics

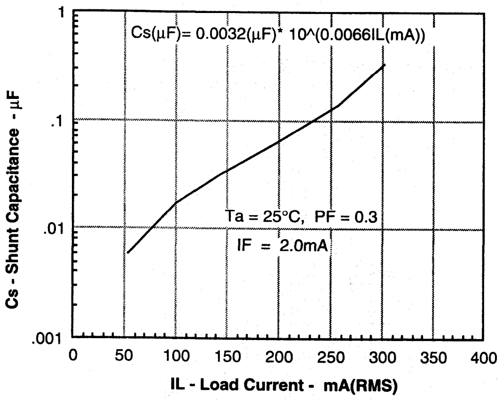
	Symbol	Min	Typ	Max	Unit	Condition
Emitter						
Forward Voltage	V_F		1.16	1.35	V	I_F=10 mA
Reverse Current	I_R		0.1	10	µA	V_R=6 V
Capacitance	C_0		25		pF	V_F=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJA}		750		°C/W	
Output Detector						
Off-State Voltage	$V_{D(RMS)}$	424	460		V	$I_{D(RMS)}$=70 mA
Off-State Current	$I_{D(RMS)1}$		10	100	µA	V_D=600 V, T_A=100°C, I_F=0 mA
Off State Current	$I_{D(RMS)2}$			200		V_D=600 V, I_F=Rated I_{FT}
On-State Voltage	V_{TM}		1.7	3	V	I_T=300 mA
On State Current	I_{TM}			300	mA	PF=1.0, $V_{T(RMS)}$=1.7 V
Surge (Non-Repetitive), On-State Current	I_{TSM}			3	A	f=50 Hz
Trigger Current 1	I_{FT1}			2.0	mA	V_D=5 V
Trigger Current 2	I_{FT2}			6.0		V_{OP}=220 V, f=50 Hz, T_j=100°C, t_{pF}>10 ms
Trigger Current Temp. Gradient	$\Delta I_{FT1}/\Delta T_j$ $\Delta I_{FT2}/\Delta T_j$		7 7	14 14	µA/K	
Inhibit Voltage Temp. Gradient	$\Delta V_{DINH}/\Delta T_j$		–20		mV/K	
Off-State Current in Inhibit State	I_{DINH}		50	200	µA	I_F=I_{FT1}, V_{DRM}
Capacitance Between Input and Output Circuit	C_{IO}		2.0		pF	V_D=0, f=1 kHz
Holding Current	I_H		65	500	µA	
Latching Current	I_L		5		mA	V_T=2.2 V
Zero Cross Inhibit Voltage	V_{IH}		15	25	V	I_F=Rated I_{FT}
Turn-On Time	t_{ON}		35		µs	V_{RM}=V_{DM}=424 VAC
Turn-Off Time	t_{OFF}		50		µs	PF=1.0, I_T=300 mA
Critical Rate of Rise of Off-State Voltage	dv/dt_{cr}	10000 5000			V/µs	V_D=0.67 V_{DRM}, T_j=25°C T_j=80°C
Critical Rate of Rise of Voltage at Current Commutation	dv/dt_{crq} dv/dt_{crq}	10000 5000			V/µs	V_D=0.67 V_{DRM}, di/dt_{crq} ≤ 15 A/ms T_j=25°C T_j=80°C
Critical Rate of Rise of On-State Current	di/dt_{cr}			8	A/µs	
Thermal Resistance, Junction to Lead	R_{THJA}		150		°C/W	
Insulation and Isolation						
Critical Rate of Rise of Coupled Input/Output Voltage	$dv_{(IO)}/dt$		10000		V/µs	I_T=0 A, V_{RM}=V_{DM}=424 VAC
Common Mode Coupling Capacitor	C_{CM}		0.01		pF	
Packing Capacitance	C_{IO}		0.8		pF	f=1 MHz, V_{IO}=0 V
Isolation Test Voltage, Input-Output	V_{ISO}	5300			VAC_{RMS}	Relative Humidity ≤ 50%
Creepage		≥7			mm	
Clearance		≥7				
Creepage Tracking Resistance per DIN IEC 112/VDE 0303, Part 1 Group III a per DIN VDE 10110	CTI		175			
Isolation Resistance	R_{is} R_{is}		$\geq 10^{12}$ $\geq 10^{11}$		Ω	V_{IO}=500 V T_A=25°C T_A+100°C

Power Factor Considerations

A snubber isn't needed to eliminate false operation of the TRIAC driver because of the IL410's high static and commutating dv/dt with loads between 1 and 0.8 power factors. When inductive loads with power factors less than 0.8 are being driven, include a RC snubber or a single capacitor directly across the device to damp the peak commutating dv/dt spike. Normally a commutating dv/dt causes a turning-off device to stay on due to the stored energy remaining in the turning-off device.

But in the case of a zero voltage crossing optotriac, the commutating dv/dt spikes can inhibit one half of the TRIAC from turning on. If the spike potential exceeds the inhibit voltage of the zero cross detection circuit, half of the TRIAC will be held-off and not turn-on. This hold-off condition can be eliminated by using a snubber or capacitor placed directly across the optotriac as shown in Figure 1. Note that the value of the capacitor increases as a function of the load current.

Figure 1. Shunt capacitance versus load current



The hold-off condition also can be eliminated by providing a higher level of LED drive current. The higher LED drive provides a larger photocurrent which causes the phototransistor to turn-on before the commutating spike has activated the zero cross network. Figure 2 shows the relationship of the LED drive for power factors of less than 1.0. The curve shows that if a device requires 1.5 mA for a resistive load, then 1.8 times (2.7 mA) that amount would be required to control an inductive load whose power factor is less than 0.3.

Figure 2. Normalized LED trigger current versus power factor

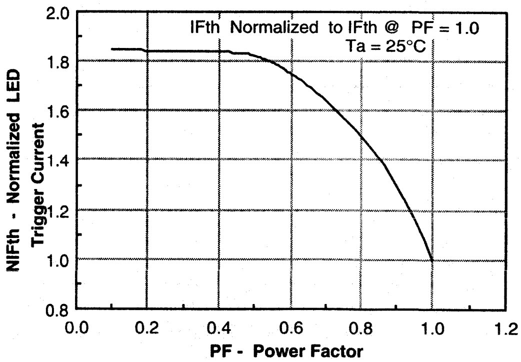


Figure 3. Forward voltage versus forward current

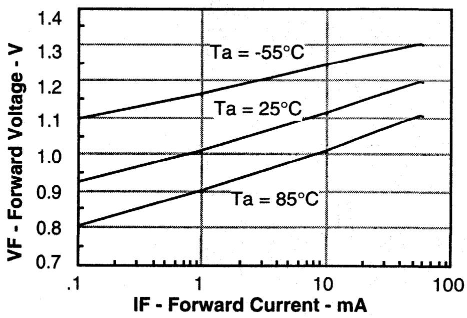


Figure 4. Peak LED current versus duty factor, Tau

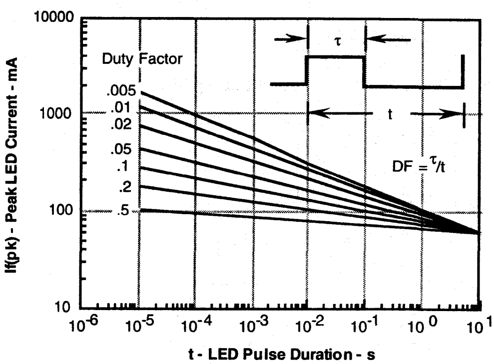


Figure 5. Maximum LED power dissipation

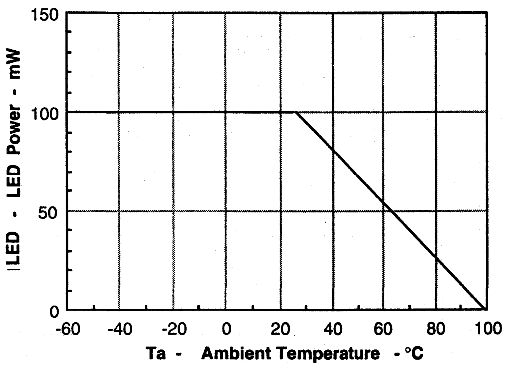


Figure 6. Typical output characteristics

$I_T = f(V_T)$, parameter: T_j

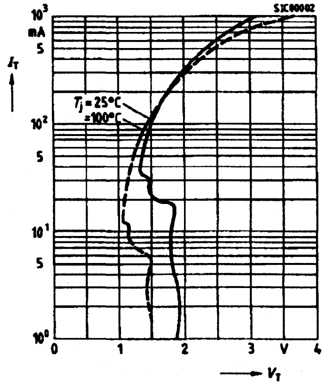


Figure 7. Current reduction

$I_{TRMS}=f(T_A)$, R_{thJA}=125 K/W

Device switch soldered in pcb or base plate.

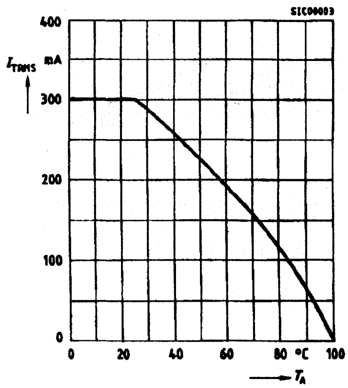


Figure 8. Current reduction

$I_{TRMS}=f(T_{PIN5})$, $R_{thJ-PIN5}$=16.5 K/W

Thermocouple measurement must be performed potentially separated to A1 and A2. Measuring junction as near as possible at the case.

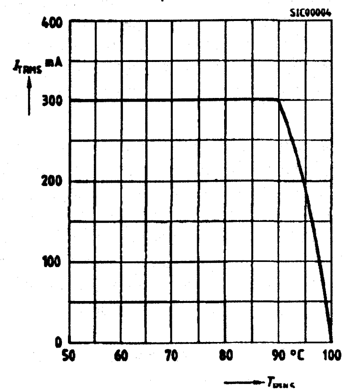


Figure 9. Typical trigger delay time

t_{gd}=f ($I_F I_{FT25°C}$), V_D=200 V, f=40 to 60 Hz, parameter: T_j

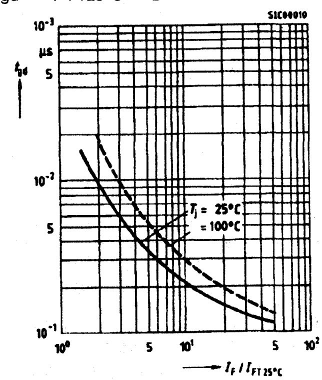


Figure 10. Typical inhibit current

I_{DINH} =f($I_F/I_{FT25°C}$)

V_D=600 V, parameter: T_j

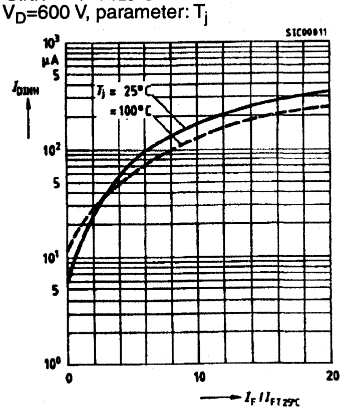


Figure 11. Power dissipation40 to 60 Hz line operation, P_{TOT}=f(I_{TRMS})

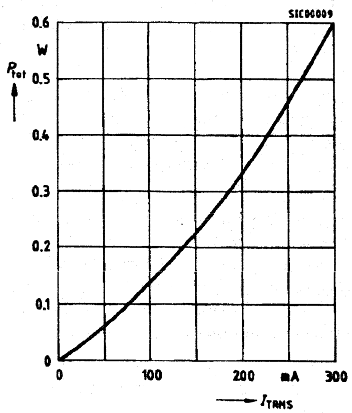
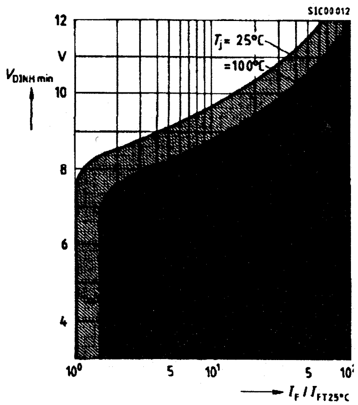


Figure 12. Typical static inhibit voltage limit $V_{DINHmin}$= f(I_F/I_{FT}25°C), parameter: T_j
Device zero voltage switch can be triggered only in hatched area below T_j curves.



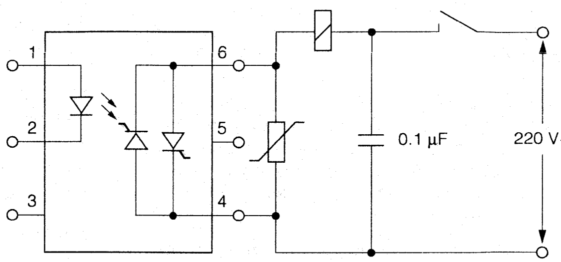
Current commutation:

The values 100 A/ms with following peak reverse recovery current >80 mA should not be exceeded.

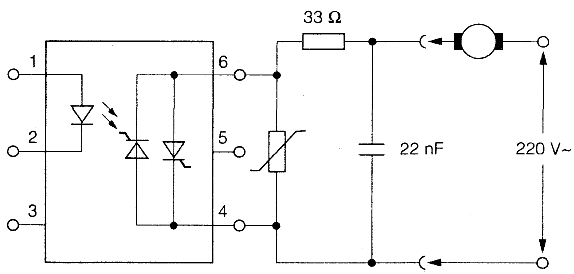
Avoiding high-frequency turn-off current oscillations:

This effect can occur when switching a circuit. Current oscillations which appear essentially with inductive loads of a higher winding capacity result in current commutation and can generate a relatively high peak reverse recovery current. The following alternating protective measures are recommended for the individual operating states:

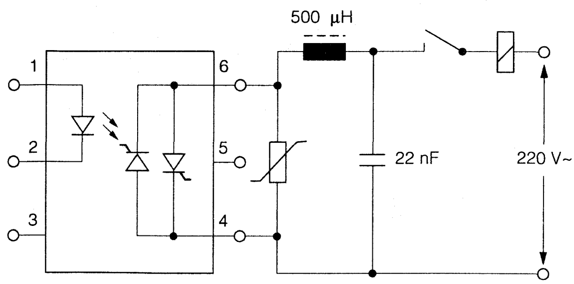
1—Apply a capacitor to the supply pins at the load-side.



2— Connect a series resistor to the IL410 output and bridge both by a capacitor.



3—Connect a choke of low winding capacity in series, e.g., a ringcore choke, with higher load currents.



Note:

Measures 2 to 3 are especially required for the load separated from the IL410 during operation. The above mentioned effects do not occur with IL410 circuits which are connected to the line by transformers and which are not mechanically interrupted. In such cases as well as in applications with a resistive load the corresponding protective circuits can be neglected.

Technical Information

Commutating Behavior

The use of a triac at the output creates difficulties in commutation due to both the built-in coupled thyristor systems. The triac can remain conducting by parasitic triggering after turning off the control current. However, if the IL410 is equipped with two separate thyristor chips featuring high dv/dt strength, no *RC* circuit is needed in case of commutation.

Control And Turn-On Behavior

The trigger current of the IL410 has a positive temperature gradient. The time which expires from applying the control current to the turn-on of the load current is defined as the trigger delay time (tgd). On the whole this is a function of the overdrive meaning the ratio of the applied control current versus the trigger current (I_F/I_{FT}). If the value of the control current corresponds to that of the individual trigger current of IL410 turn-on delay times amounts to a few milliseconds only. The shortest times of 5 to 10 µs can be achieved for an overdrive greater or equal than 10. The trigger delay time rises with an increase in temperature.

For very short control current pulses (t_{pIF} <500 µs) a correspondingly higher control current must be used. Only the IL410 without zero voltage switch is suitable for this operating mode.

Zero Voltage Switch

The IL410 with zero voltage switch can only be triggered during the zero crossing the sine AC voltage. This prevents current spikes, e. g. when turning-on cold lamps or capacitive loads.

Applications

Direct switching operation: The IL410 switch is mainly suited to control synchronous motors, valves, relays and solenoids in Grätz circuits. Due to the low latching current (500 µA) and the lack of an *RC* circuit at the output, very low load currents can easily be switched.

Indirect switching operation: The IL410 switch acts here as a driver and thus enables the driving of thyristors and triacs of higher performance by microprocessors. The driving current pulse should not exceed the maximum permissible surge current of the IL410. For this reason, the IL410 without zero voltage switch often requires current limiting by a series resistor.

The favorably low latching current in this operating mode results in AC current switches which can handle load currents from some milliamperes up to high currents.

Application Note

• Over voltage protection: A voltage-limiting varistor (e.g. SIO VS05K250) which directly connected to the IL410 can protect the component against overvoltage.

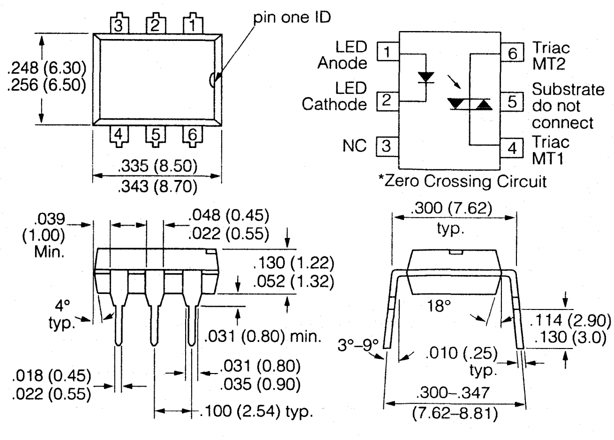
SIEMENS

IL420

600 V Triac Driver Optocoupler

FEATURES
- High Input Sensitivity I_{FT}=2 mA
- Blocking Voltage, 600 V
- 300 mA On-State Current
- High Static dv/dt 10 KV/µs
- Inverse Parallel SCRs Provide Commutating dv/dt >10 KV/µs
- Very Low Leakage <10 µA
- Isolation Test Voltage from Double Molded Package 5300 VAC_{RMS}
- Small 6-Pin DIP Package
- Underwriters Lab File #E52744
- VDE 0884 Available with Option 1

Dimensions in inches (mm)



Maximum Ratings

Emitter

Reverse Voltage	6 V
Forward Current	60 mA
Surge Current	2.5 A
Power Dissipation	100 mW
Derate from 25°C	1.33 mW/°C
Thermal Resistance	750 °C/W

Detector

Peak Off-State Voltage	600 V
Peak Reverse Voltage	600 V
RMS On-State Current	300 mA
Single Cycle Surge	3 A
Total Power Dissipation	500 mW
Derate from 25°C	6.6 mW/°C
Thermal Resistance	150°C/W

Package

Isolation Test Voltage	5300 VAC_{RMS}
Storage Temperature	–55°C to +150°C
Operating Temperature	–55°C to +100°C
Lead Soldering Temperature	260°C/5 sec.

DESCRIPTION

The IL420 consists of a GaAs IRLED optically coupled to a photosensitive non-zero crossing TRIAC network. The TRIAC consists of two inverse parallel connected monolithic SCRs. These three semiconductors are assembled in a six pin 0.3 inch dual in-line package, using high insulation double molded, over/under leadframe construction.

High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR predriver resulting in an LED trigger current of less than 2 mA (DC).

The IL420 uses two discrete SCRs resulting in a commutating dV/dt of greater than 10KV/ms. The use of a proprietary ***dv/dt clamp*** results in a static dV/dt of greater than 10KV/ms. This clamp circuit has a MOSFET that is enhanced when high dV/dt spikes occur between MT1 and MT2 of the TRIAC. When conducting, the FET clamps the base of the phototransistor, disabling the first stage SCR predriver.

The 600 V blocking voltage permits control of off-line voltages up to 240 VAC, with a safety factor of more than two, and is sufficient for as much as 380 VAC.

The IL420 isolates low-voltage logic from 120, 240, and 380 VAC lines to control resistive, inductive, or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.

Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.16	1.35	V	I_F=10 mA
Reverse Current	I_R		0.1	10	µA	V_R=6 V
Capacitance	C_O		40		pF	V_F=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJA}		750		°C/W	
Output Detector						
Off-State Voltage	$V_{D\,(RMS)}$	424	460		V	$I_{D(RMS)}$=70 µA
Reverse Voltage	V_R		460			
Off-State Current	$I_{D\,(RMS)}$		10	100	µA	V_D=600 V, T_A=100°C
Reverse Current	$I_{R\,(RMS)}$		10	100		V_R=600 V, T_A=100°C
On-State Voltage	V_{TM}		1.7	3	V	I_T=300 mA
On-State Current	I_{TM}			300	mA	PF=1.0, $V_{T(RMS)}$=1.7 V
Surge (Non-Repetitive) On-State Current	I_{TSM}			3	A	f=50 Hz
Holding Current	I_H		65	500	µA	
Latching Current	I_L		5		mA	V_T=2.2 V
LED Trigger Current	I_{FT}		1	2		V_{AK}=5 V
Turn-On Time	t_{ON}		35		µs	V_{RM}=V_{DM}=424 VAC
Turn-Off Time	t_{OFF}		50			PF=1.0, I_T=300 mA
Critical State of Rise of Off-State Voltage	dv/dt_{cr}	10000			V/µs	V_D=0.67 V_{DRM}, T_j=25°C
		5000				V_D=0.67 V_{DRM}, T_j=80°C
Critical Rate of Rise of Voltage at Current Commutation	dv/dt_{crq}	10000				V_D=0.67 V_{DRM}, di/dt_{crq}≤15 A/ms T_j=25°C
		5000				V_D=0.67 V_{DRM}, di/dt_{crq}≤15 A/ms T_j=80°C
Critical State of Rise of On-State Current	di/dt_{cr}			8	A/µs	
Thermal Resistance, Junction to Lead	R_{THJA}		150		°C/W	
Insulation and Isolation						
Critical Rate of Rise of Coupled Input/Output Voltage	$dv_{(IO)}/dt$		5000		V/µs	I_T=0 A, V_{RM}=V_{DM}=424 VAC
Common Mode Coupling Capacitor	C_{CM}		0.01		pF	
Package Capacitance	C_{IO}		0.8			f=1 MHz, V_{IO}=0 V
Isolation Test Voltage, Input-Output	V_{ISO}	5300			VAC_{RMS}	Relative Humidity ≤50%
Creepage		≥7			mm	
Clearance						
Creepage Tracking Resistance per DIN IEC 112/ VDE 0303, Part 1 group IIIa per DIN VDE 0110		CTI		175		
Isolation Resistance	R_{is}		$\geq 10^{12}$		Ω	V_{IO}=500, T_A=25°C
			$\geq 10^{11}$			V_{IO}=500, T_A=100°C
Trigger Current Temperature Gradient	$\Delta I_{FT}/\Delta T_j$		7	14	µA/K	
Capacitance Between Input and Output Circuit	C_{IO}			2	pF	V_R=0, f=1 kHz

Figure 1. Forward voltage versus forward current

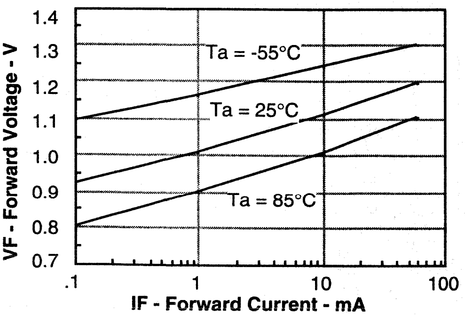


Figure 2. Peak LED current versus duty factor, Tau

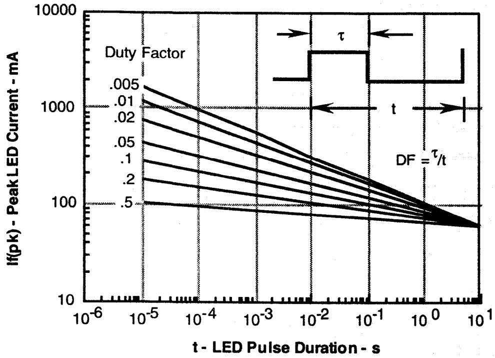


Figure 3. Maximum LED power dissipation

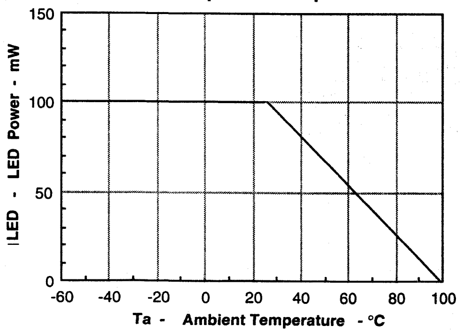


Figure 4. Typical output characteristics

I_T=f(V_t), parameter: T_j

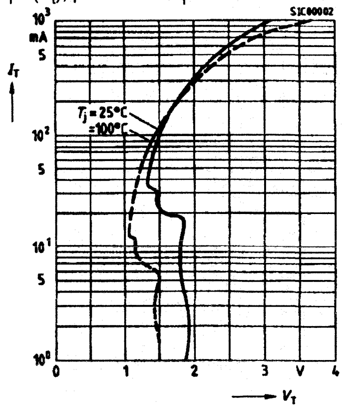


Figure 5. Current reduction

I_{TRMS}=f(T_A) R_{thJA}=125 K/W

Device switch is soldered in PCB or base plate

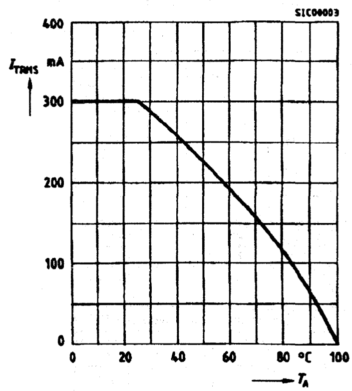


Figure 6. Current reduction

I_{TRMS}=f(T_{PIN5}), R_{thJ}=16.5 K/W

Thermocouple measurement must be performed potentially separated to A1 and A2. Measuring junction to be as near as possible at case.

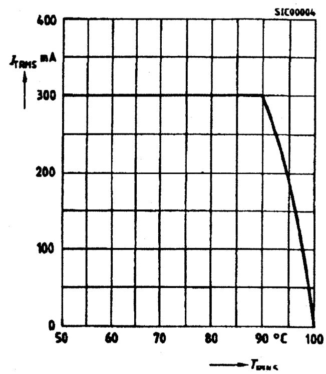


Figure 7. Typical trigger delay time
tgd=f(I_F/$I_{FT25°C}$), V_D=200 V, parameter: T_j

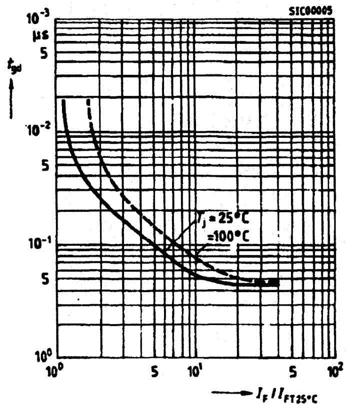


Figure 9. Power dissipation
for 40 to 60 Hz line operation, P_{TOT}=f(I_{TRMS})

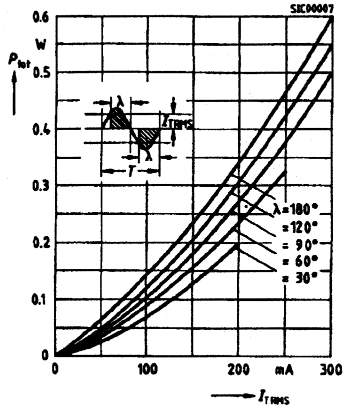


Figure 8. Typical off-state current
I_D=f(T_j), V_D=800 V, parameter: T_j

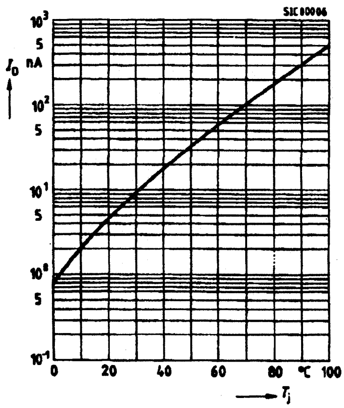
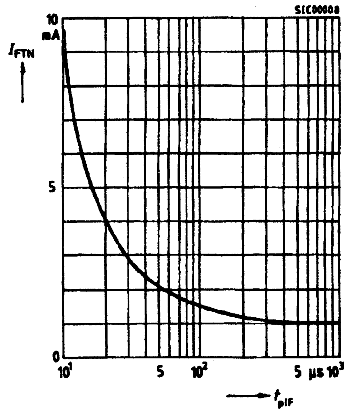


Figure 10. Pulse trigger current
I_{FTN}=f(t_{pIF})I_{FTN} normalized to I_{FT}, referring to t_{pIF}≥1ms, V_{OP}=200 V, f=40 to 60 Hz typ.



SIEMENS

IL440

Triac Predriver Non-Zero Crossing Optocoupler

FEATURES

- **400 and 600 V Blocking Voltage**
- **5 mA Maximum Trigger Current**
- **Isolation Voltage, 5300 VAC$_{RMS}$, t=1 sec.**
- **Isolation Materials per UL94**
- **Pin Compatible with Motorola Optocouplers**

IL440–1	**MOC 3051**
IL440–2	**MOC 3052**
IL440–3	**—**
IL440–4	**MOC 3021**
IL440–5	**MOC 3022**
IL440–6	**MOC 3023**

APPLICATIONS

- **High Current Triac Driver**
- **Solid State Relays**
- **Switch Small AC Loads**

Maximum Ratings

Emitter

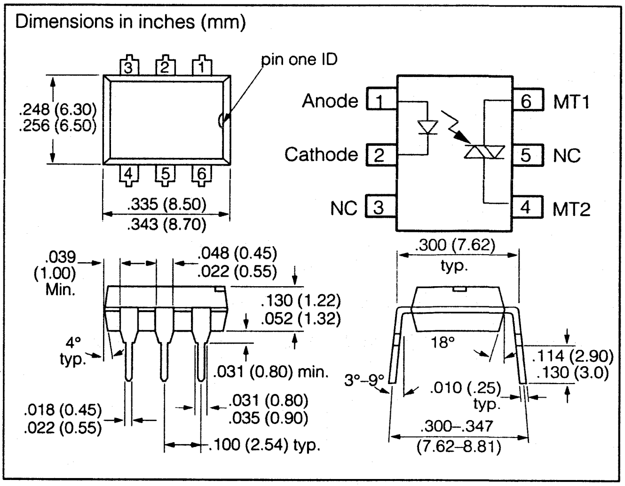
Reverse Voltage .... 5 V
Forward Current .... 60 mA
Surge Current (P.W.<10 µs) .... 3 A
Power Dissipation .... 100 mW
Junction Temperature .... 100 °C

Detector

Peak Off-state Voltage
IL440–1, 2, 3 .... 600 V
IL440–4, 5, 6 .... 400 V
On-state RMS Current .... 100 mA
Peak Surge Current (t_p≤10 ms) .... 1.2 A
Peak On-state Current (t_p/T=0.01≤100 µs) .... 2 A
Power Dissipation .... 300 mW
Junction Temperature .... 125 °C

Package

Isolation Voltage, 1 sec. .... 5300 VAC
per Standard Climate 23°C/50% RH, DIN 50014
Creepage .... ≥7 mm
Clearance .... ≥7 mm
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}$ Ω
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}$ Ω
Total Power Dissipation, T_A=25°C .... 330 mW
Storage Temperature Range .... –55°C to +125°C
Operating Temperature Range .... –40°C to +100°C
Junction Temperature .... 100°C
Lead Soldering Temperature
(2 mm from case, t<10 s.) .... 260°C



DESCRIPTION

The IL440–X consists of a GaAs infrared emitter optically coupled to a silicon planar triac chip with a non-zero crossing network. The two semiconductors are assembled in a 6 pin dual-in-line plastic package. The output detector IL440–1, 2, 3 is capable of blocking up to 600 volts which permits control of off-line voltages up to 240 VAC. The IL440 can handle currents up to 100 mA$_{RMS}$.

Maximum Safety Ratings

This device is used for protective separation against electrical shock within the maximum safety ratings. This must be ensured by protective circuits in the applications.

Parameter	Symbol	Max.	Unit	Test Condition
Emitter				
Forward Current	I_{SI}	130	mA	
Detector				
Power Dissipation	P_{SI}	300	mW	T_A≤25°C

Electrical Characteristics, T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Emitter						
Forward Voltage	V_F		1.25	1.6	V	I_F=50 mA
Breakdown Voltage	V_{BR}	5			V	I_R=10 µA
Junction Capacitance	C_J		50		pF	V_R=0 V, f=1 MHz
Detector						
Off-state Output Terminal Voltage (see Table 1.)						
Peak On-state Voltage	V_{TM}		1.5	3	V	I_{TM}=100 mA, I_{FT}=30 mA
Critical Rate of Rise of Off-state Voltage	$(dv/dt)_{cr}$		50		V/µs	I_F=0, V_S=240 V_{RMS}
	$(dv/dt)_{crq}$	0.13	0.25		V/µs	I_F=30 mA, V_S=60 V_{RMS}
Coupled Device						
Holding Current	I_H		1		mA	I_F≥10 mA, V_S≥3 V

Table 1. I_{FT} and Blocking Voltage Selection(1)

Bin number	BV (Volts) Max @ I_{DRM} =500 nA	I_{FT}. Max @ V_T=6 V, R_L=150 Ω
IL440–1	600	15
IL440–2	600	10
IL440–3	600	5
IL440–4	400	15
IL440–5	400	10
IL440–6	400	5

1. Test voltage must be applied within dV/dt rating of 0.13 V/µsec.

SIEMENS

SINGLE CHANNEL IL755
DUAL CHANNEL ILD755
Bidirectional Input Darlington Optocoupler

FEATURES
- **High Current Transfer Ratios, V_{CE}=5 V IL/ILD755-1: 750% at I_F=2 mA**
- **IL/ILD755-2: 1000% at I_F=1 mA BV_{CEO} >60 V**
- **AC or Polarity Insensitive Inputs**
- **Built-In Reverse Polarity Input Protection**
- **Industry Standard DIP Package**
- **Underwriters Lab File #E52744**
- **VDE #0884 Available with Option 1**

DESCRIPTION
The IL/ILD755 are bidirectional input optically coupled isolators. They consist of two Gallium Arsenide infrared emitting diodes coupled to a silicon NPN photodarlington per channel.

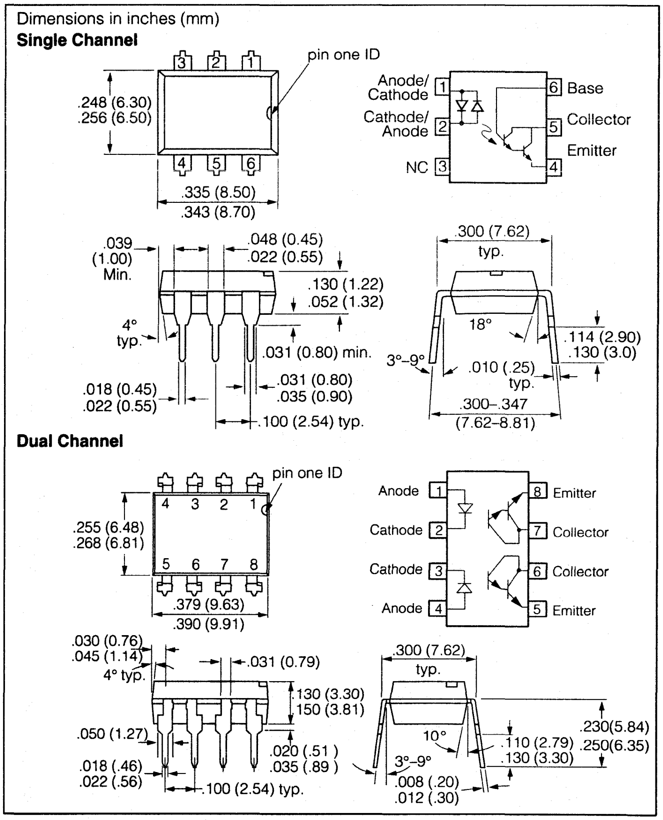
The IL755 are single channel Darlington optocouplers. The ILD755 has two isolated channels in a single DIP package.

They are designed for applications requiring detection or monitoring of AC signals.

Maximum Ratings
Emitter (Each Channel)
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C

Detector (Each Channel)
Collector-Emitter Breakdown Voltage .... 60 V
Collector-Base Breakdown Voltage .... 60 V
Power Dissipation at 25°C
IL755 .... 200 mW
ILD755 .... 150 mW
Derate Linearly from 25°C
ILD7552.6 mW/°C .... ILD7552.0 mW/°C

Package
Isolation Test Voltage (PK)
(t=1 sec.) .... 7500 VAC_{PK}/5300 VAC_{RMS}
Total Power Dissipation at 25°C Ambient
(LED Plus Detector)
IL755 .... 250 mW
ILD755400 .... mW
Derate Linearly from 25°C
IL7553 .... 3 mW/°C
ILD7555. .... 3 mW/°C
Creepage .... 7 mm min.
Clearance .... 7 mm min.
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.



Electrical Characteristics T_A=25°C

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.2	1.5	V	I_F=±10 mA
Detector						
	BV_{CEO}	60	75		V	I_C=1 mA
	BV_{CBO}	60	90			I_C=10 µA
	I_{CEO}		10	100	nA	V_{CE}=10 V
Package						
	V_{CEsat}			1.0		I_F=±10 mA, I_C=10 mA
DC Current Transfer Ratio IL755/ILD755-1 IL755/ILD755-2	CTR	 750 1000			 % %	V_{CE}=5 V I_F=±2 mA, I_F=±1 mA,
Rise Time/Fall Time IL/ILD755-1 IL/ILD755-2			 50 70		 µs µs	V_{CC}=10 V, R_L=100 Ω, I_F=2 mA I_F=1mA

Figure 1. LED forward current versus forward voltage

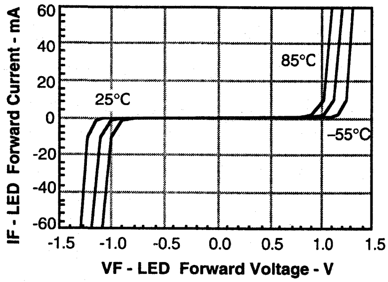


Figure 5. Normalized non-saturated and saturated collector-emitter current versus LED current

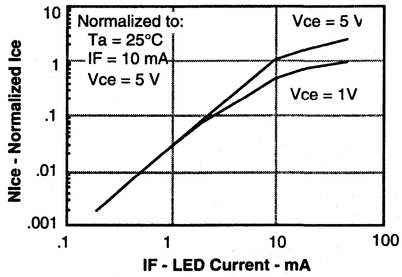


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

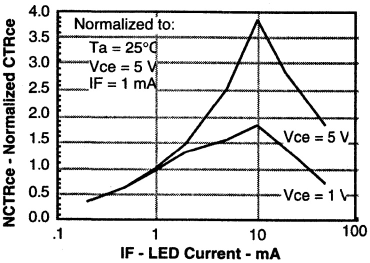


Figure 6. Non-saturated and saturated HFE versus base current

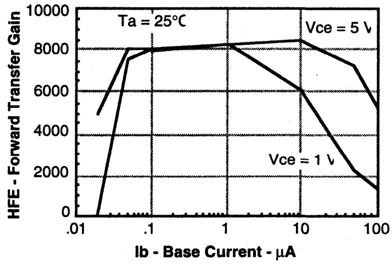


Figure 3. Normalized non-saturated and saturated CTRce versus LED current

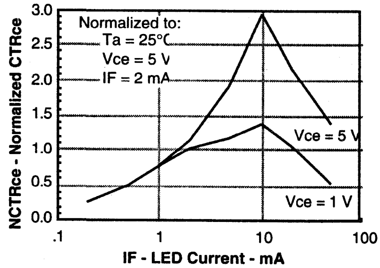


Figure 7. Low to high propagation delay versus collector load resistance and LED current

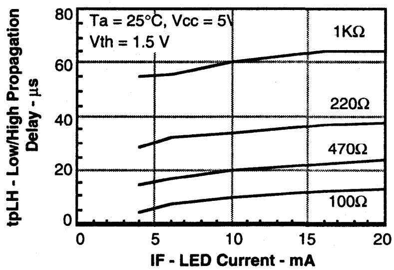


Figure 4. Normalized non-saturated and saturated Ice versus LED current

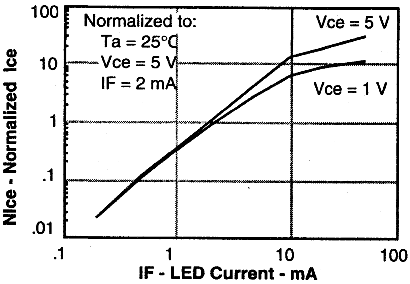


Figure 8. High to low propagation delay versus collector load resistance and LED current

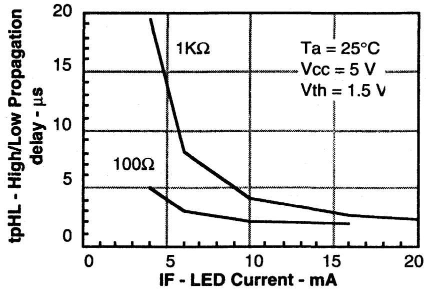


Figure 9. Switching waveform

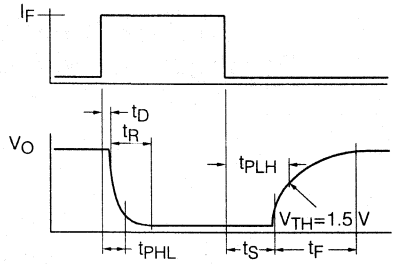
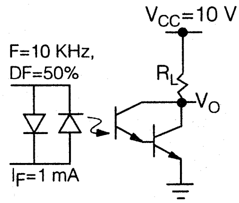


Figure 10. Normalized non-saturated and saturated CTRce versus LED current



Optocouplers (Optoisolators) 5

SIEMENS

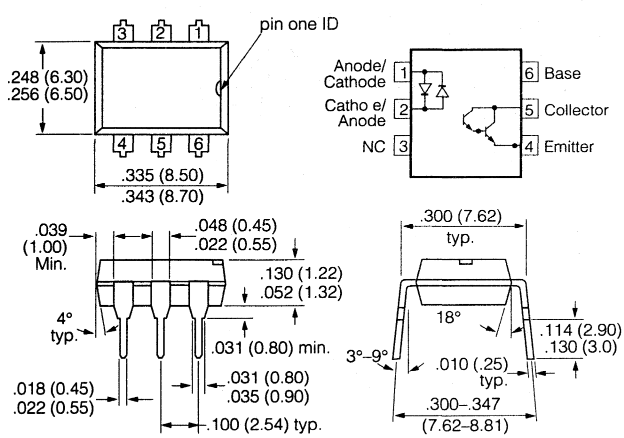
IL755B

Bidirectional Input Darlington Optocoupler

FEATURES

- **Very High Current Transfer Ratio (500% min.)**
  IL755B-1: 750% at I_F=2 mA, V_{CE}=5 V
  IL755B-2: 1000% at I_F=1 mA, V_{CE}=5 V
- **BV_{CEO} >60 V**
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **AC or Polarity Insensitive Inputs**
- **No Base Connection**
- **High Isolation Resistance, 10^{12} Ω**
- **Low Coupling Capacitance**
- **Standard Plastic DIP Package**
- **Underwriters Lab Approval #E52744**
- **VDE #0884 Available with Option 1**

Dimensions in inches (mm)



DESCRIPTION

The IL755B is a bidirectional input, optically coupled isolator consisting of two Gallium Arsenide infrared emitters and a silicon photodarlington sensor.

Maximum Ratings (at 25°C)

Emitter (Drive Circuit)

Continuous Forward Current .... 60 mA
Power Dissipation at 25°C........................... 100 mW
Derate Linearly from 55°C..................... 1.33 mW/°C

Detector

Collector-Emitter Breakdown Voltage .... 60 V
Emitter-Collector Breakdown Voltage .... 12 V
Power Dissipation at 25°C Ambient .... 200 mW
Derate Linearly from 25°C....................... 2.6 mW/°C

Package

Isolation Test Voltage
(PK), t=1 sec.5300 VAC_{RMS}
Dissipation at 25°C....................................... 250 mW
Derate Linearly from 25°C....................... 3.3 mW/°C
Creepage .... 7 min mm
Clearance... 7 min mm
Isolation Resistance
T_A=25°C≥10^{12} Ω
T_A=100°C≥10^{11} Ω
Storage Temperature ....–55°C to +150°C
Operating Temperature ....–55°C to +100°C
Lead Soldering Time at 260°C..................... 10 sec.

Electrical Characteristics T_A=25°C

	Sym.	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage(1)	V_F		1.25	1.5	V	I_F=10 mA
Detector						
Breakdown Voltage, Collector-Emitter	BV_{CEO}	60	75		V	I_C=1 mA, I_F=0
Leakage Current, Collector-Emitter	I_{CEO}		1.0	100	nA	V_{CE}=10 V, I_F=0
Package						
Current Transfer Ratio IL755B-1 IL755B-2	CTR	 750 1000			%	V_{CE}=5 V I_F=±2 mA, I_F=±1 mA,
Saturation Voltage, Collector-Emitter	V_{CEsat}			1.0	V	I_C=10 mA, I_F=±10 mA
Turn-On Time Turn-Off Time	t_{on} t_{off}			200	µs	V_{CC}=10 V I_F=±2 mA, R_L=100 Ω

Notes:

1. Indicates JEDEC registered data.

Figure 1. LED forward current versus forward voltage

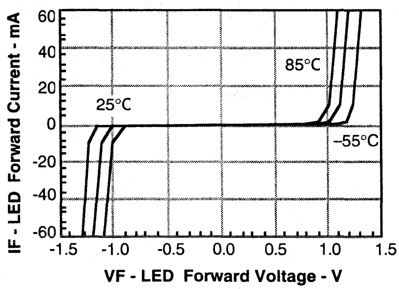


Figure 2. Normalized non-saturated and saturated CTRce versus LED current

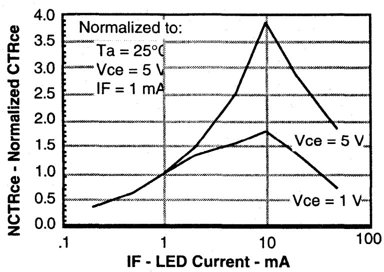


Figure 3. Normalized non-saturated and saturated CTRce versus LED current

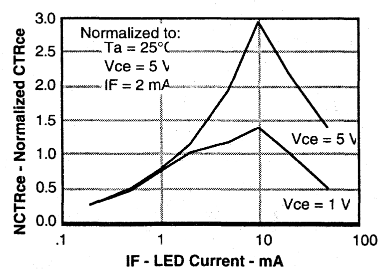


Figure 4. Normalized non-saturated and saturated Ice versus LED current

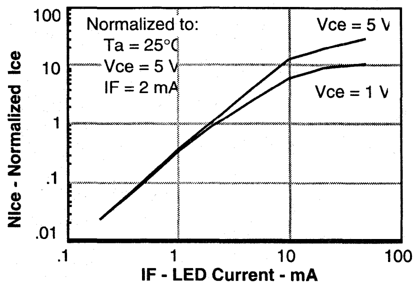


Figure 5. Normalized non-saturated and saturated collector-emitter current versus LED current

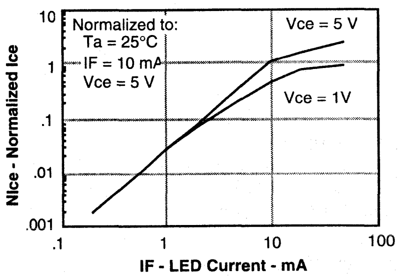


Figure 6. Low to high propagation delay versus collector load resistance and LED current

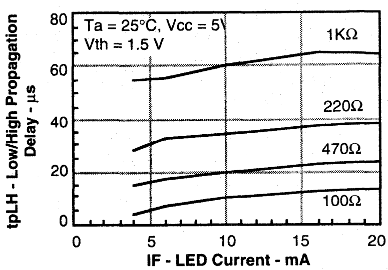


Figure 7. High to low propagation delay versus collector load resistance and LED current

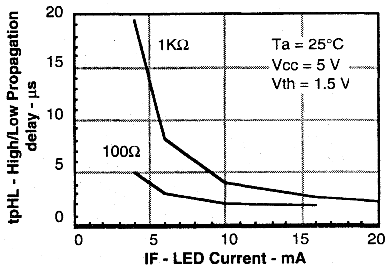


Figure 8. Switching waveform

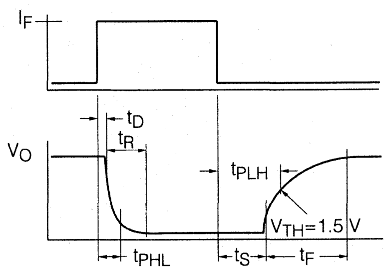
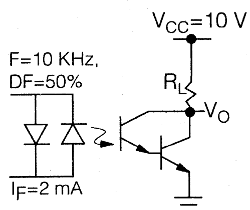


Figure 9. Normalized non-saturated and saturated CTRce versus LED current



SIEMENS

SINGLE CHANNEL IL766
DUAL CHANNEL ILD766
Bidirectional Input Darlington Optocoupler

FEATURES

- **Internal R_{BE} for Better Stability**
- **High Current Transfer Ratios, V_{CE}=5 V**
  IL/ILD766-1: 500% at I_F=2 mA
  IL/ILD766-2: 500% at I_F=1.0 mA
- **BV_{CEO} >60 V**
- **AC or Polarity Insensitive Inputs**
- **Built-In Reverse Polarity Input Protection**
- **Industry Standard DIP Package**
- **Underwriters Lab File #E52744**

DESCRIPTION

The IL/ILD766 are bidirectional input optically coupled isolators. They consist of two Gallium Arsenide infrared emitting diodes coupled to a silicon NPN photodarlington per channel.

The IL766 are single channel optocouplers. The ILD766 has two isolated channels in a single DIP package. They are designed for applications requiring detection or monitoring of AC signals.

Maximum Ratings

Emitter (Each Channel)

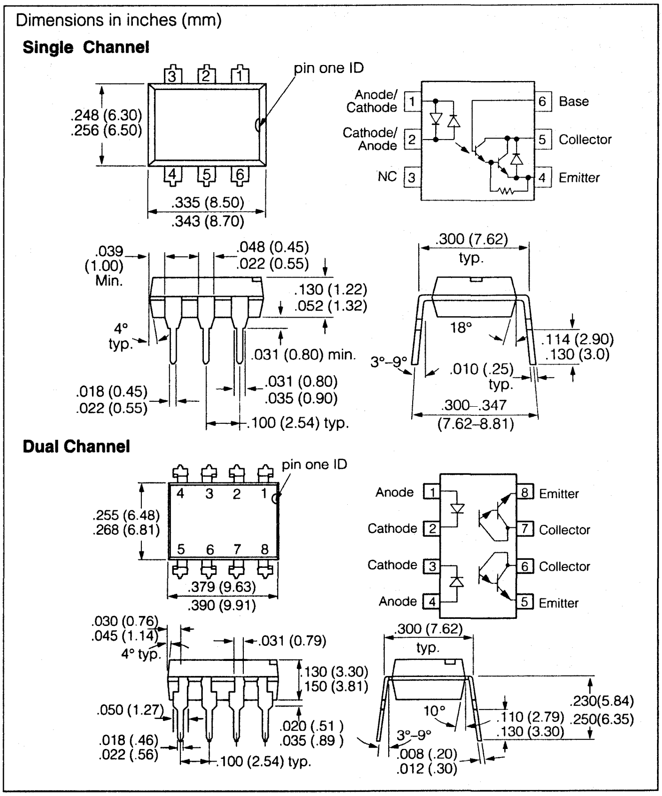
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C
  Single Channel .... 200 mW
  Dual Channel.. 90 mW
Derate Linearly from 25°C
  Single Channel .... 2.6 mW/°C
  Dual Channel.................................... 1.2 mW/°C

Detector (Each Channel)

Collector-Emitter Breakdown Voltage .... 60 V
Collector-Base Breakdown Voltage .... 70 V
Power Dissipation at 25°C .... 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C

Package

Isolation Test Voltage
  (t= 1 sec.) .... 7500 VAC_{PK}/5300 VAC_{RMS}
Isolation Resistance
  T_A=25°C .... $\geq 10^{12}\ \Omega$
  T_A=100°C .... $\geq 10^{11}\ \Omega$
Total Power Dissipation at T_A=25°C
(LED Plus Detector)
  Single Channel .... 250 mW
  Dual Channel.. 400 mW
Derate Linearly from 25°C
  Single Channel .... 3.3 mW/°C
  Dual Channel .... 5.3 mW/°C
Creepage...7 mm min.
Clearance ....7 mm min.
Comparative Tracking Index per
  DIN IEC 112/VDE303, part 1 175
Storage Temperature .... –55°C to +150°C
Operating Temperature................ –55°C to +100°C
Lead Soldering Time at 260°C..................... 10 sec.



Electrical Characteristics T_A=25°C

	Sym	Min	Typ	Max	Unit	Condition
Emitter						
Forward Voltage	V_F		1.2	1.5	V	I_F=±10 mA
Detector						
Breakdown Voltage, Collector-Emitter	BV_{CEO}	60	75		V	I_C=1 mA
Collector-Base	BV_{CBO}	60	90		V	I_C=10 μA
Leakage Current, Collector-Emitter	I_{CEO}		10	100	nA	V_{CE}=10 V
Package						
Saturation Voltage, Collector-Emitter	V_{CEsat}			1.0	V	I_F=±10 mA, I_C=10 mA
DC Current Transfer Ratio	CTR					V_{CE}=5 V
IL766/ILD766-1		500			%	I_F=±2 mA,
IL766-2		500			%	I_F=±1.0 mA,
Rise Time, Fall Time			100		μs	V_{CC}=10 V, I_F=±2 mA, R_L=100 Ω

Figure 1. Input characteristics

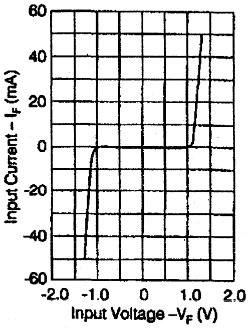


Figure 2. Transistor current versus voltage

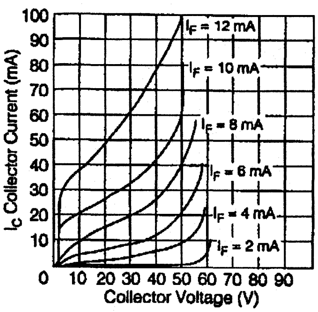


Figure 3. Transistor output current versus voltage

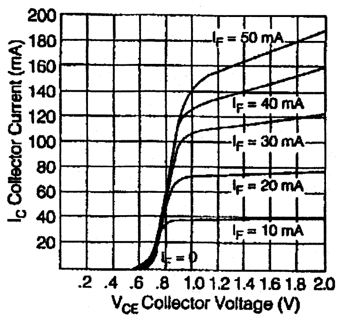


Figure 4. I_{CEO} at V_{CE}=10 V versus temperature

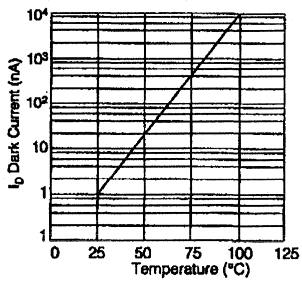


Figure 5. Normalized CTR versus forward current

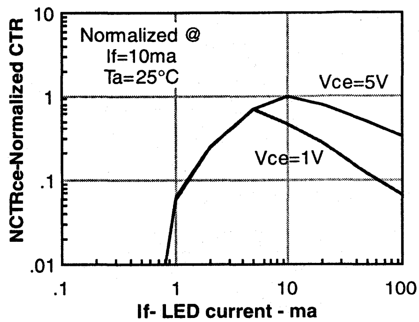


Figure 6. Tr versus forward current

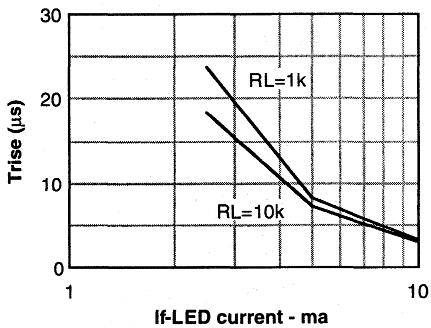


Figure 7. Saturated switching characteristics measurements—schematic and waveform

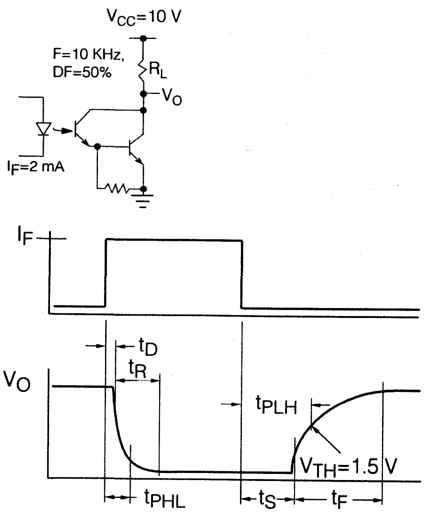


Figure 8. T_{fall} versus forward current

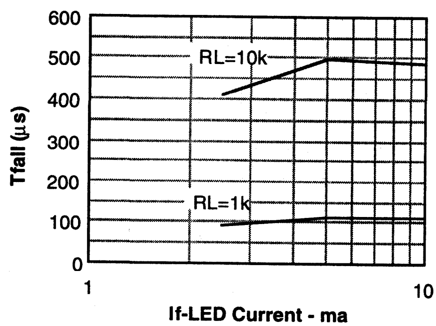


Figure 9. T_{on} versus forward current

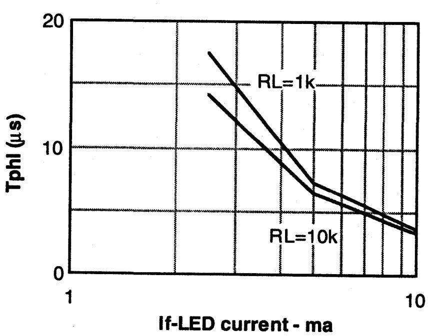


Figure 10. T_{off} versus forward current

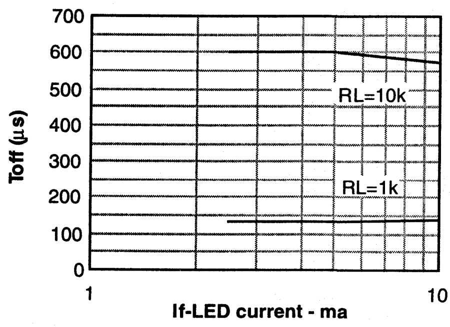


Figure 11. T_{phl} versus forward current

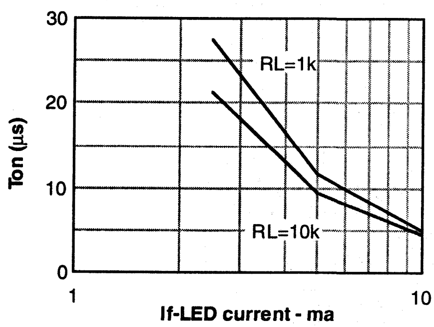
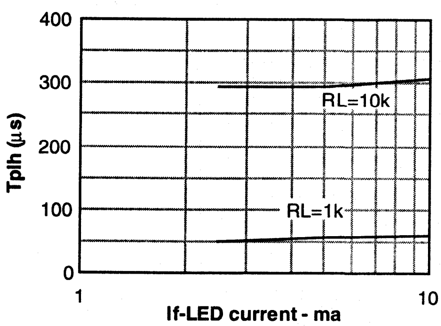


Figure 12. T_{plh} versus forward current



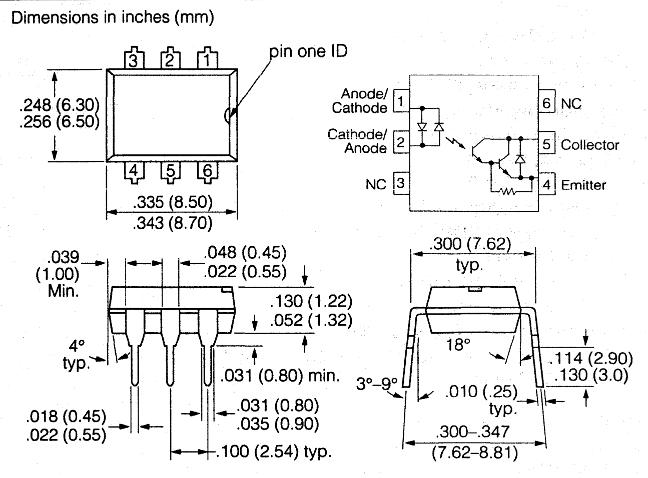
SIEMENS

IL766B

Bidirectional Input Optocoupler

FEATURES

- **Very High Current Transfer Ratio IL766B-1: 400% at I_F=1 mA, V_{CE}=5 V IL766B-2: 900% at I_F=0.5 mA, V_{CE}=5 V**
- **Internal R_{BE} for Better Stability**
- **BV_{CEO} >60 V**
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **AC or Polarity Insensitive Inputs**
- **No Base Connection**
- **High Insulation Resistance, $10^{11}\Omega$ Typical**
- **Standard Plastic DIP Package**
- **Underwriters Lab File #E52744**



DESCRIPTION

The IL766B is a bidirectional input, optically coupled isolator consisting of two Gallium Arsenide infrared emitters and a silicon photodarlington sensor.

Maximum Ratings at 25°C

Emitter (Drive Circuit)

Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 200 mW
Derate Linearly from 55°C .... 2.6 mW/°C

Detector (Load Circuit)

Collector-Emitter Breakdown Voltage .... 60 V
Collector-Base Breakdown Voltage .... 70 V
Power Dissipation at 25°C Ambient .... 200 mW
Derate Linearly from 25°C .... 2.6 mW/°C

Package

UL Isolation Test Voltage
(t=1 sec.) .... 5300 VAC_{RMS}
Dissipation at 25°C .... 250 mW
Derate Linearly from 25°C .... 3.3 mW/°C
Creepage .... 7 min mm
Clearance .... 7 min mm
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $10^{11}\ \Omega$
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.25	1.5	V	I_F=±10 mA
Detector						
Breakdown Voltage, Collector-Emitter	BV_{CEO}	60			V	I_C=1 mA, I_F=0
Leakage Current						
Collector-Emitter	I_{CEO}		1.0	100	nA	V_{CE}=10 V, I_F=0
Package						
Current Transfer Ratio IL766B-1	CTR	400			%	I_F=±1 mA, V_{CE}=5 V
Current Transfer Ratio IL766B-2		900				I_F=±0.5 mA, V_{CE}=5 V
Saturation Voltage, Collector-Emitter	V_{CEsat}			1.0	V	I_C=10 mA, I_F=±10 mA
Turn-On, Turn-Off Time	t_{on}, t_{off}		200		µs	V_{CC}=5 V, I_F=±2 mA, R_L=100 Ω

SIEMENS

IL4108

Zero Voltage Crossing 800 V Triac Driver Optocoupler

FEATURES

- **On-State Current, 300 mA**
- **Zero Voltage Crossing**
- **Blocking Voltage, 800 V**
- **Isolation Test Voltage 5300 VACRMS**
- **High Input Sensitivity**
  IFT=2 mA, PF=1.0
  IFT=5 mA, PF≤1.0
- **High Static dv/dt 10,000 V/µs**
- **Inverse Parallel SCRs Provide Commutating dv/dt >10K V/µs**
- **Very Low Leakage <10 µA**
- **Small 6-Pin DIP Package**
- **Underwriters Lab File #E52744**
- **VDE Approval #0884 (Optional with Option 1, Add -X001 Suffix)**

Maximum Ratings

Emitter

Reverse Voltage .... 6 V
Forward Current .... 60 mA
Surge Current .... 2.5 A
Thermal Resistance .... 750 °C/W
Derate from 25°C .... 1.33 mW/°C

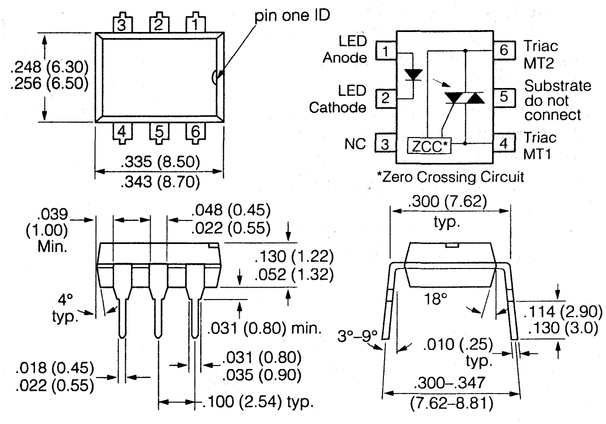
Detector

Peak Off-state Voltage .... 800 V
Peak Reverse Voltage .... 800 V
RMS On-state Current .... 300 mA
Single Cycle Surge .... 3 A
Thermal Resistance .... 125 °C/W
Total Power Dissipation .... 500 mW
Derate from 25°C .... 6.6 mW/°C

Package

Isolation Test Voltage (between emitter and detector, climate per DIN 500414, part 2, Nov. 74, t=1 min.) .... 5300 VAC_{RMS}
Pollution Degree (DIN VDE 0109) 2
Creepage Distance .... ≥7 mm
Clearance .... ≥7 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303 part 1, Group IIIa per DIN VDE 6110 .... ≥175
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}\ \Omega$
Storage Temperature Range .... –55°C to +125°C
Ambient Temperature Range .... –55°C to +100°C
Soldering Temperature (max. ≤10 sec. dip soldering ≥0.5 mm from case bottom) .... 260°C

Dimensions in inches (mm)



DESCRIPTION

The IL4108 consists of a GaAs IRLED optically coupled to a photosensitive zero crossing TRIAC network. The TRIAC consists of two inverse parallel connected monolithic SCRs. These three semiconductors are assembled in a six pin 0.3 inch dual in-line package, using high insulation double molded, over/under leadframe construction.

High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR predriver resulting in an LED trigger current of less than 2 mA (DC).

The IL4108 uses two discrete SCRs resulting in a commutating dV/dt greater than 10 KV/µs. The use of a proprietary dv/dt clamp results in a static dV/dt of greater than 10 KV/µs. This clamp circuit has a MOSFET that is enhanced when high dV/dt spikes occur between MT1 and MT2 of the TRIAC. When conducting, the FET clamps the base of the phototransistor, disabling the first stage SCR predriver.

The zero cross line voltage detection circuit consists of two enhancement MOSFETS and a photodiode. The inhibit voltage of the network is determined by the enhancement voltage of the N-channel FET. The P-channel FET is enabled by a photocurrent source that permits the FET to conduct the main voltage to gate on the N-channel FET. Once the main voltage can enable the N-channel, it clamps the base of the phototransistor, disabling the first stage SCR predriver.

The 800 V blocking voltage permits control of off-line voltages up to 240VAC, with a safety factor of more than two, and is sufficient for as much as 380 VAC.

The IL4108 isolates low-voltage logic from 120, 240, and 380 VAC lines to control resistive, inductive, or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.

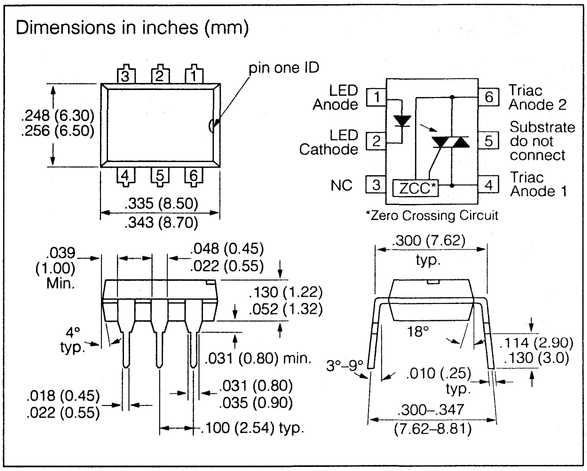
Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.16	1.35	V	I_F=10 mA
Breakdown Voltage	V_{BR}	6	30		V	I_R=10 µA
Reverse Current	I_R		0.1	10	µA	V_R=6 V
Capacitance	C_O		25		pF	V_F=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		750		°C/W	
Output Detector						
Repetitive Peak Off-state Voltage	V_{DRM}	800			V	I_{DRM}=100 µA
Off-state Voltage	$V_{D(RMS)}$	565			V	$I_{D(RMS)}$=70 µA
Off-state Current	$I_{D(RMS)1}$		10	100	µA	V_D=800 V, T_A100°C, I_F=0 mA
Off-state Current	$I_{D(RMS)2}$			200	µA	V_D=800 V, I_F=Rated I_{FT}
On-state Voltage	V_{TM}		1.7	3	V	I_T=300 mA
On-state Current	I_{TM}			300	mA	PF=1.0, $V_{T(RMS)}$=1.7 V
Surge (Non-repetitive On-state Current)	I_{TSM}			3	A	f=50 Hz
Trigger Current 1	I_{FT1}			2.0	mA	V_D=5 V
Trigger Current 2	I_{FT2}			6.0	mA	V_{op}=220 V, f=50 Hz, T_j=100°C, t_{pF}>10 ms
Trigger Current Termperature Gradient	$\Delta I_{FT1}/\Delta T_j$ $\Delta I_{FT2}/\Delta T_j$		7 7	14 14	µA/K µA/K	
Inhibit Voltage Temperature Gradient	$\Delta V_{DINH}/\Delta T_j$		-20		mV/K	
Off-state Current in Inhibit State	I_{DINH}		50	200	µA	I_F=I_{FT1}, V_{DRM}
Capacitance between Input and Output Circuit	C_{IO}		2.0		pF	V_D=0, f=1 kHz
Holding Current	I_H		65	500	µA	
Latching Current	I_L		5		mA	V_T=2.2 V
Zero Cross Inhibit Voltage	V_{IH}		15	25	V	I_F=Rated I_{FT}
Turn-on Time	t_{ON}		35		µs	V_{RM}=V_{DM}=565 VAC
Turn-off Time	t_{OFF}		50		µs	PF=1.0, I_T=300 mA
Critical Rate of Rise of Off-State Voltage	dv/dt_{cr} dv/dt_{cr}	10000 5000			V/µs V/µs	V_D=0.67 V_{DRM}, T_j=25°C T_j=80°C
Critical Rate of Rise of Voltage at Current Commutation	dv/dt_{crq} dv/dt_{crq}	10000 5000			V/µs V/µs	V_D=0.67 V_{DRM}, di/dt_{crq}<15 A/ms T_j=25°C T_j=80°C
Critical Rate of Rise of On-state Current	$di/dt/_{cr}$			8	A/µs	
Thermal Resistance, Junction to Lead	R_{THJL}		150		°C/W	
Package						
Critical Rate of Rise of Coupled Input/Output Voltage	$dv_{(IO)}/dt$		1000 0		V/µs	I_T=0 A, V_{RM}=V_{DM}=565 VAC
Common Mode Coupling Capacitor	C_{CM}		0.01		pF	
Package Capacitance	C_{IO}		0.8		pF	f=1 MHz, V_{IO}=0 V

SIEMENS

600 V IL4116
700 V IL4117
800 V IL4118

Zero Voltage Crossing Triac Driver Optocoupler



FEATURES

- **High Input Sensitivity: I_{FT}=1.3 mA, PF=1.0; I_{FT}=3.5 mA, Typical PF < 1.0**
- **Zero Voltage Crossing**
- **600/700/800 V Blocking Voltage**
- **300 mA On-State Current**
- **High Static dv/dt 10,000 V/µsec., typical**
- **Inverse Parallel SCRs Provide Commutating dv/dt >10 KV/msec.**
- **Very Low Leakage <10 µA**
- **Isolation Test Voltage from Double Molded Package 5300 VACRMS**
- **Package, 6-Pin DIP**
- **Underwriters Lab File #E52744**

DESCRIPTION

The IL411x consists of an AlGaAs IRLED optically coupled to a photosensitive zero crossing TRIAC network. The TRIAC consists of two inverse parallel connected monolithic SCRs. These three semiconductors are assembled in a six pin 0.3 inch dual in-line package, using high insulation double molded, over/under leadframe construction.

High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR predriver resulting in an LED trigger current of less than 1.3 mA(DC).

The IL411x uses two discrete SCRs resulting in a commutating dV/dt greater than 10 KV/ms The use of a proprietary dv/dt clamp results in a static dv/dt of greater than 10 KV/µs. This clamp circuit has a MOSFET that is enhanced when high dv/dt spikes occur between MT1 and MT2 of the TRIAC. When conducting, the FET clamps the base of the phototransistor, disabling the first stage SCR predriver.

The zero cross line voltage detection circuit consists of two enhancement MOSFETS and a photodiode. The inhibit voltage of the network is determined by the enhancement voltage of the N-channel FET. The P-channel FET is enabled by a photocurrent source that permits the FET to conduct the main voltage to gate on the N-channel FET. Once the main voltage can enable the N-channel, it clamps the base of the phototransistor, disabling the first stage SCR predriver.

The blocking voltage of up to 800 V permits control of off-line voltages up to 240 VAC, with a safety factor of more than two, and is sufficient for as much as 380 VAC. Current handling capability is up to 300 mA RMS continuous at 25°C.

The IL411x isolates low-voltage logic from 120, 240, and 380 VAC lines to control resistive, inductive, or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.

Maximum Ratings

Emitter

Reverse Voltage .... 6 V
Forward Current .... 60 mA
Surge Current .... 2.5 A
Power Dissipation .... 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C
Thermal Resistance .... 750 °C/W

Detector

Peak Off-State Voltage
IL4116 .... 600 V
IL4117 .... 700 V
IL4118 .... 800 V
RMS On-State Current .... 300 mA
Single Cycle Surge .... 3 A
Total Power Dissipation .... 500 mW
Derate Linearly from 25°C .... 6.6 mW/°C
Thermal Resistance .... 150°C/W

Package

Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Temperature .... 260°C/5 sec.
Isolation Test Voltage .... 5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}$ Ω
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}$ Ω

Characteristics T_A=25°C

Parameter		Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter							
Forward Voltage		V_F		1.3	1.5	V	I_F-20 mA
Breakdown Voltage		V_{BR}	6	30		V	I_R=10 µA
Reverse Current		I_R		0.1	10	µA	V_R=6 V
Capacitance		C_O		40		pF	V_F=0 V, f=1 MHz
Thermal Resistance, Junction to Lead		R_{THJL}		750		°C/W	
Output Detector							
Repetitive Peak Off-State Voltage	IL4116	V_{DRM}	600	650		V	I_{DRM}=100 µA
	IL4117		700	750			
	IL4118		800	850			
Off-State Voltage	IL4116	$V_{D(RMS)}$	424	460		V	$I_{D(RMS)}$=70 µA
	IL4117		494	536			
	IL4118		565	613			
Off-State Current		$I_{D(RMS)}$		10	100	µA	V_D=600 V, T_A=100°C
On-State Voltage		V_{TM}		1.7	3	V	I_T=300 mA
On-State Current		I_{TM}			300	mA	PF=1.0, $V_{T(RMS)}$=1.7 V
Surge (Non-Repetitive, On-State Current)		I_{TSM}			3	A	f=50 Hz
Holding Current		I_H		65	200	µA	V_T=3 V
Latchiing Current		I_L		5		mA	V_T=2.2 V
LED Trigger Current		I_{FT}		0.7	1.3	mA	V_{AK}=5 V
Zero Cross Inhibit Voltage		V_{IH}		15	25	V	I_F=Rated I_{FT}
Turn-On Time		t_{ON}		35		µs	V_{RM}=V_{DM}=424 VAC
Turn-Off Time		t_{OFF}		50		µs	PF=1.0, I_T=300 mA
Critical State of Rise: Off-State Voltage		$dv_{(MT)}/dt$	10,000			V/µs	V_{RM}, V_{DM}=400 VAC, T_A=25°C
				2000			V_{RM}, V_{DM}=400 VAC, T_A=80°C
Commutating Voltage		$dv_{(COM)}/dt$	10,000			V/µs	V_{RM}, V_{DM}=400 VAC, T_A=25°C
				2000			V_{RM}, V_{DM}=400 VAC, T_A=80°C
Commutating Current		di/dt		100		A/ms	I_T=300 mA
Thermal Resistance, Junction to Lead		R_{THJL}		150		°C/W	
Package							
Critical State of Rise of Couplrd Input-Output Voltage		$dv_{(IO)}/dt$	10,000			V/µs	I_T=0 A, V_{RM}=V_{DM}=424 VAC
Common Mode Coupling Capacitor		C_{CM}		0.01		pF	
Package Capacitance		C_{IO}		0.8		pF	f=1 MHz, V_{IO}=0 V

Figure 1. LED forward current vs. forward voltage

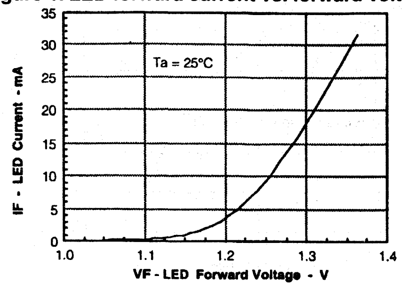


Figure 2. Forward voltage versus forward current

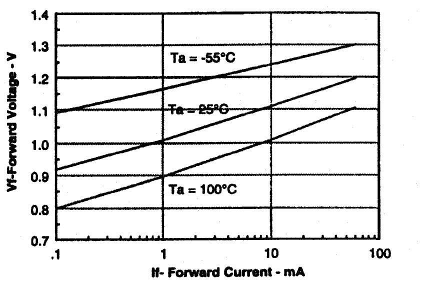


Figure 3. Peak LED current vs. duty factor, Tau

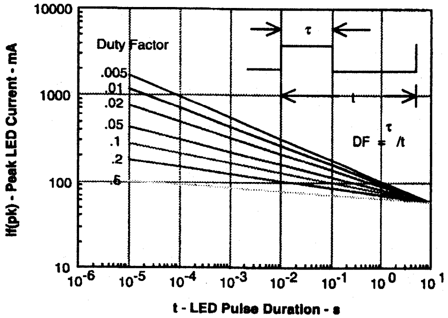


Figure 4. Maximum LED power dissipation

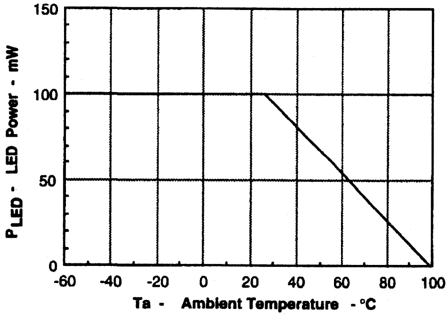


Figure 5. On-state terminal voltage vs. terminal current

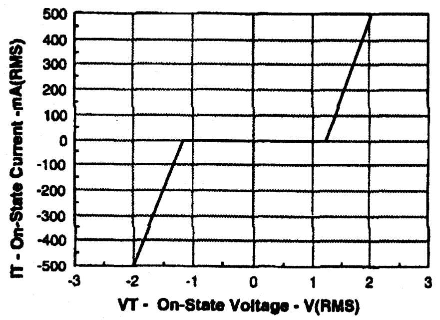
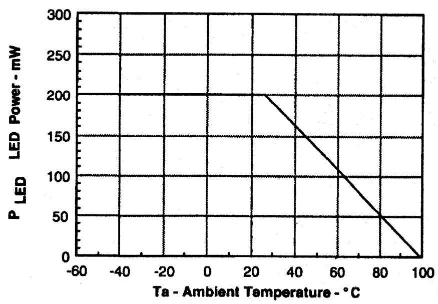


Figure 6. Maximum output power dissipation



Power Factor Considerations

A snubber isn't needed to eliminate false operation of the TRIAC driver because of the IL411's high static and commutating dv/dt with loads between 1 and 0.8 power factors. When inductive loads with power factors less than 0.8 are being driven, include a RC snubber or a single capacitor directly across the device to damp the peak commutating dv/dt spike. Normally a commutating dv/dt causes a turning-off device to stay on due to the stored energy remaining in the turning-off device.

But in the case of a zero voltage crossing optotriac, the commutating dv/dt spikes can inhibit one half of the TRIAC from turning on. If the spike potential exceeds the inhibit voltage of the zero cross detection circuit, half of the TRIAC will be held-off and not turn-on. This hold-off condition can be eliminated by using a snubber or capacitor placed directly across the optotriac as shown in Figure 7. Note that the value of the capacitor increases as a function of the load current.

The hold-off condition also can be eliminated by providing a higher level of LED drive current. The higher LED drive provides a larger photocurrent which causer. the phototransistor to turn-on before the commutating spike has activated the zero cross network. Figure 8 shows the relationship of the LED drive for power factors of less than 1.0. The curve shows that if a device requires 1.5 mA for a resistive load, then 1.8 times (2.7 mA) that amount would be required to control an inductive load whose power factor is less than 0.3.

Figure 7. Shunt capacitance versus load current versus power factor

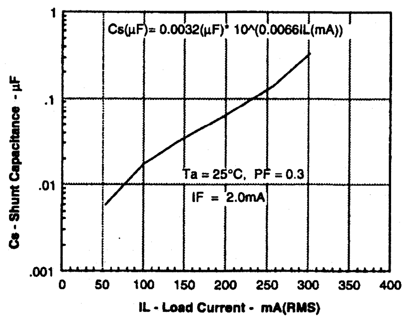
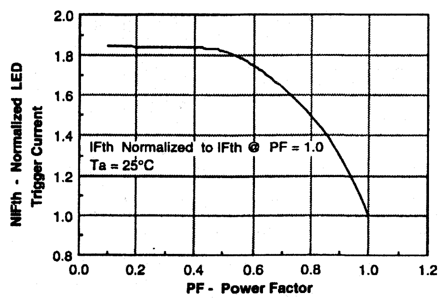


Figure 8. Normalized LED trigger current



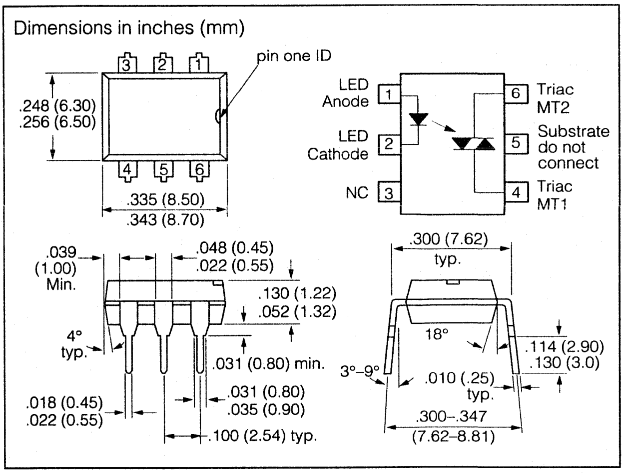
SIEMENS

IL4208

800 V Triac Driver Optocoupler

FEATURES

- High Input Sensitivity, I_{FT}=2 mA
- Blocking Voltage, 800 V
- Isolation Test Voltage 5300 VAC_{RMS}
- 300 mA On-state Current
- High Static dv/dt 10,000 V/Ms
- Inverse Parallel SCRs Provide
- Commutating dv/dt >2K V/μs
- Very Low Leakage <10 μA
- Small 6-Pin DIP Package
- Underwriters Lab File #E52744
- VDE 0884 Available with Option 1



Maximum Ratings

Emitter

Reverse Voltage	6 V
Forward Current	60 mA
Surge Current	2.5 A
Thermal Resistance	750 °C/W
Derate from 25°C	1.33 mW/°C

Detector

Peak Off-state Voltage	800 V
Peak Reverse Voltage	800 V
RMS On-state Current	300 mA
Single Cycle Surge	3 A
Thermal Resistance	125 °C/W
Total Power Dissipation	500 mW
Derate from 25°C	6.6 mW/°C

Package

Isolation Test Voltage (between emitter and detector, climate per DIN 50014, part 2, Nov. 74, t=1 sec.)	5300 VAC_{RMS}
Pollution Degree (DIN VDE 0109)	2
Creepage Distance	≥7 mm
Clearance	≥7 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303 part 1, Group IIIa per DIN VDE 6110	175
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	≥10^{12} Ω
V_{IO}=500 V, T_A=100°C	≥10^{11} Ω
Storage Temperature Range	–55°C to +125°C
Ambient Temperature Range	–55°C to +100°C
Soldering Temperature (max. ≤10 sec.dip soldering ≥0.5 mm from case bottom)	260°C

DESCRIPTION

The IL4208 consists of a GaAs IRLED optically coupled to a photosensitive non-zero crossing TRIAC network. The TRIAC consists of two inverse parallel connected monolithic SCRs. These three semiconductors are assembled in a six pin 0.3 inch dual in-line package, using high insulation double molded, over/under leadframe construction.

High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR predriver resulting in an LED trigger current of less than 2 mA (DC).

The IL4208 uses two discrete SCRs resulting in a commutating dV/dt greater than 10 KV/μs. The use of a proprietary dv/dt clamp results in a static dV/dt of greater than 10KV/μs. This clamp circuit has a MOSFET that is enhanced when high dV/dt spikes occur between MT1 and MT2 of the TRIAC. When conducting, the FET clamps the base of the phototransistor, disabling the first stage SCR predriver.

The 800 V blocking voltage permits control of off-line voltages up to 240 VAC, with a safety factor of more than two, and is sufficient for as much as 380 VAC.

The IL4208 isolates low-voltage logic from 120, 240, and 380 VAC lines to control resistive, inductive, or capacitive loads including motors, solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.

Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.16	1.35	V	I_F=10 mA
Reverse Current	I_R		0.1	10	µA	V_R=6 V
Capacitance	C_0		40		pF	V_F=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		750		°C/W	
Output Detector						
Repetitive Peak Off-state Voltage	V_{DRM}	800			V	I_{DRM}=100 µA
Repetitive Peak Reverse Voltage	V_{RRM}	800			V	I_{RM}=100 µA
Off-state Voltage	$V_{D(RMS)}$	565			V	$I_{D(RMS)}$=70 µA
Reverse Voltage	V_R	565			V	$I_{R(RMS)}$=70 µA
Off-state Current	$I_{D(RMS)}$		10	100	µA	V_D=800 V, T_A100°C
Reverse Current	$I_{R(RMS)}$		10	100	µA	V_R=800 V, T_A=100°C
On-state Voltage	V_{TM}		1.7	3	V	I_T=300 mA
On-state Current	I_{TM}			300	mA	PF=1.0, $V_{T(RMS)}$=1.7 V
Surge (Non-repetitive On-state Current)	I_{TSM}			3	A	f=50 Hz
Holding Current	I_H		65	500	µA	
Latching Current	I_L		5		mA	V_T=2.2 V
LED Trigger Current	I_{FT}		1	2	mA	V_{AK}=5 V
Turn-on Time Turn-off Time	t_{ON} t_{OFF}		35 50		µs µs	V_{RM}=V_{DM}=565 VAC, PF=1.0, I_T=300 mA
Critical Rate of Rise of Off-State Voltage	dv/dt_{cr} dv/dt_{cr}	10000 5000			V/µ V/µss	V_D=0.67 V_{DRM}, T_j=25°C V_D=0.67 V_{DRM}, T_j=80°C
Critical Rate of Rise of Voltage at Current Commutation	 dv/dt_{crq} dv/dt_{crq}	 10000 5000			V/µs	V_D=0.67 V_{DRM}, di/dt_{crq}<15 A/ms T_j=25°C T_j=80°C
Critical Rate of Rise of On-state Current	$di/dt/_{cr}$			8	A/µs	
Thermal Resistance, Junction to Lead	R_{THJL}		150		°C/W	
Package						
Critical Rate of Rise of Coupled Input/Output Voltage	$dv_{(IO)}/dt$		5000		V/µs	I_T=0 A, V_{RM}=V_{DM}=565 VAC
Common Mode Coupling Capacitor	C_{CM}		0.01		pF	
Package Capacitance	C_{IO}		0.8		pF	f=1 MHz, V_{IO}=0 V
Trigger Current Temperature Gradient	$\Delta I_{FT}/\Delta T_j$		7	14	µA/K	

SIEMENS

600 V IL4216
700 V IL4217
800 V IL4218

Triac Driver Optocoupler

FEATURES

- **High Input Sensitivity I_{FT}=1.3 mA**
- **600/700/800 V Blocking Voltage**
- **300 mA On-State Current**
- **High Static dv/dt 10,000 V/µsec., typical**
- **Inverse Parallel SCRs Provide Commutating dv/dt >10 KV/µsec**
- **Very Low Leakage <10 µA**
- **Isolation Test Voltage from Double Molded Package 5300 VAC_{RMS}**
- **Package, 6-Pin DIP**
- **Underwriters Lab File #E52744**

DESCRIPTION

The IL421x consists of an AlGaAs IRLED optically coupled to a pair of photosensitive non-zero crossing SCR chips and are connected inversely parallel to form a TRIAC. These three semiconductors are assembled in a six pin 0.3 inch dual in-line package, using high insulation double molded, over/under lead-frame construction.

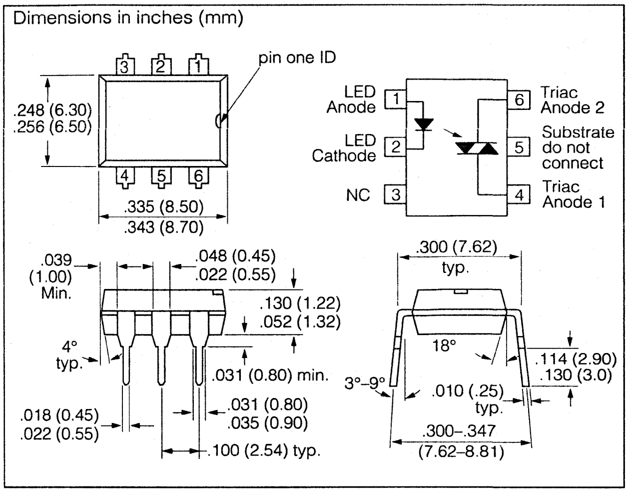
High input sensitivity is achieved by using an emitter follower phototransistor and a cascaded SCR pre-driver resulting in an LED trigger current of less than 1.3 mA (DC).

The IL421x uses two discrete SCRs resulting in a commutating dv/dt of greater than 10KV/µs. The use of a proprietary *dv/dt clamp* results in a static dv/dt of greater than 10KV/µs. This clamp circuit has a MOS-FET that is enhanced when high dv/dt spikes occur between MT1 and MT2 of the TRIAC. The FET clamps the base of the phototransistor when conducting, disabling the internal SCR predriver.

The blocking voltage of up to 800 V permits control of off-line voltages up to 240 VAC, with a safety factor of more than two, and is sufficient for as much as 380 VAC. Current handling capability is up to 300 mA RMS, continuous at 25°C.

The IL421x isolates low-voltage logic from 120, 240, and 380 VAC lines to control resistive inductive, or capacitive loads including motors solenoids, high current thyristors or TRIAC and relays.

Applications include solid-state relays, industrial controls, office equipment, and consumer appliances.



Maximum Ratings

Emitter

Reverse Voltage	6 V
Forward Current	60 mA
Surge Current	2.5 A
Power Dissipation	100 mW
Derate Linearly from 25°C	1.33 mW/°C
Thermal Resistance	750 °C/W

Detector

Peak Off-State Voltage	
IL4216	600 V
IL4217	700 V
IL4218	800 V
RMS On-State Current	300 mA
Single Cycle Surge	3 A
Total Power Dissipation	500 mW
Derate Linearly from 25°C	6.6 mW/°C
Thermal Resistance	150°C/W

Package

Isolation Test Voltage	5300 VAC_{RMS}
Storage Temperature	–55°C to +150°C
Operating Temperature	–55°C to +100°C
Lead Soldering Temperature	260°C/5 sec.
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	$\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}\ \Omega$

Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.3	1.5	V	I_F=20 mA
Breakdown Voltage	V_{BR}	6	30		V	I_R=10 mA
Reverse Current	I_R		0.1	10	µA	V_R=6 V
Capacitance	C_O		40		pF	V_F=o V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		750		°C/W	
Output Detector						
Repetitive Peak Off-State Voltage IL4216 IL4217 IL4218	 V_{DRM} V_{DRM} V_{DRM}	 600 700 800	 650 750 850		 V V V	 I_{DRM}=100 µA I_{DRM}=100 µA I_{DRM}=100 µA
Off-State Voltage IL4216 IL4217 IL4218	 $V_{D(RMS)}$ $V_{D(RMS)}$ $V_{D(RMS)}$	 424 484 565	 460 536 613		 V V V	 $I_{D(RMS)}$=70 µA $I_{D(RMS)}$=70 µA $I_{D(RMS)}$=70 µA
Off-State Current	$I_{D(RMS)}$		10	100	µA	V_D=600 V, T_A=100°C
Reverse Current	$I_{R(RMS)}$		10	100	µA	V_R=600 V, T_A=100°C
On-State Voltage	V_{TM}		1.7	3	V	I_T=300 mA
On-State Current	I_{TM}			300	mA	PF=1.0, $V_{T(RMS)}$=1.7 V
Surge (Non-Repetitive) On-State Current	I_{TSM}			3	A	f=50 Hz
Holding Current	I_H		65	200	µA	V_T=3 V
Latching Current	I_L		5		mA	V_T=2.2 V
LED Trigger Current	I_{FT}		0.7	1.3	mA	V_{AK}=5 V
Turn-On Time	t_{ON}		35		µs	V_{RM}=V_{DM}=424 VAC
Turn-Off Time	t_{OFF}		50		µs	PF=1.0, I_T=300 mA
Critical State of Rise: Off-State Voltage	$dv_{(MT)}/dt$	10,000	 2000		V/µs V/µs	V_{RM}, V_{DM}=400 VAC, T_A=25°C V_{RM}, V_{DM}=400 VAC, T_A=25°C
Commutating Voltage	$dv_{(COM)}/dt$	10,000	 2000		V/µs V/µs	V_{RM}, V_{DM}=400 VAC, T_A=25°C V_{RM}, V_{DM}=400 VAC, T_A=25°C
Off-State Current	di/dt		100		A/ms	I_T=300 mA
Thermal Resistance, Junction to Lead	R_{THJL}		150		°C/W	
Package						
Critical Rate of Rise of Coupled Input-Output Voltage	$dv_{(IO)}/dt$	5000			V/µs	I_T=0 A, V_{RM}=V_{DM}=300 VAC
Common Mode Coupling Capacitor	C_{CM}		0.01		pF	
Package Capacitance	C_{IO}		0.8		pF	f=1 MHz, V_{IO}=0 V

Figure 1. LED forward current vs. forward voltage

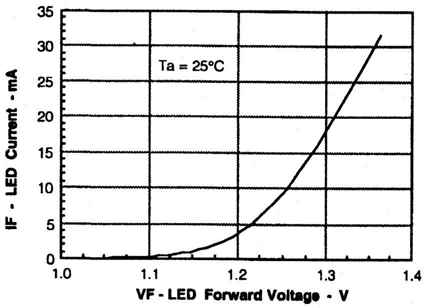
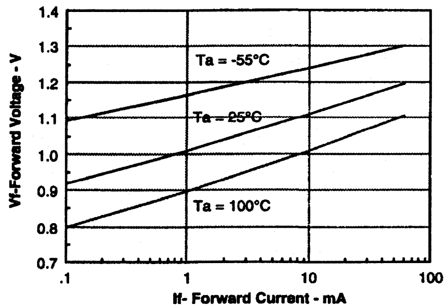


Figure 2. Forward voltage versus forward current



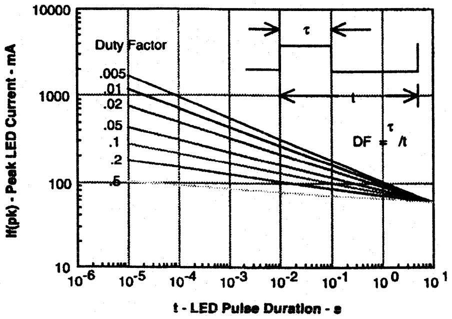


Figure 3. Peak LED current vs. duty factor, Tau

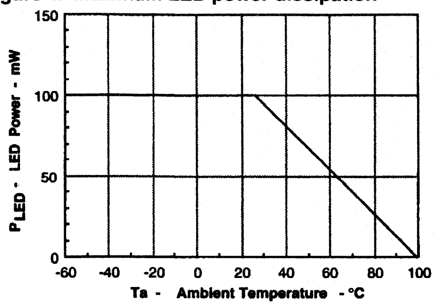


Figure 4. Maximum LED power dissipation

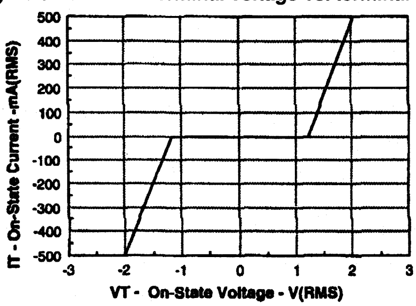


Figure 5. On-state terminal voltage vs. terminal current

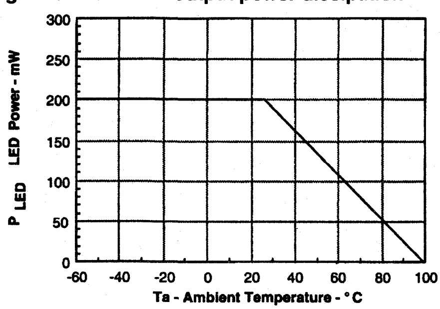


Figure 6. Maximum output power dissipation

Power Factor Considerations

A snubber isn't needed to eliminate false operation of the TRIAC driver because of the IL411's high static and commutating dv/dt with loads between 1 and 0.8 power factors. When inductive loads with power factors less than 0.8 are being driven, include a RC snubber or a single capacitor directly across the device to damp the peak commutating dv/dt spike. Normally a commutating dv/dt causes a turning-off device to stay on due to the stored energy remaining in the turning-off device.

But in the case of a zero voltage crossing optotriac, the commutating dv/dt spikes can inhibit one half of the TRIAC from turning on. If the spike potential exceeds the inhibit voltage of the zero cross detection circuit, half of the TRIAC will be held-off and not turn-on. This hold-off condition can be eliminated by using a snubber or capacitor placed directly across the optotriac as shown in Figure 7. Note that the value of the capacitor increases as a function of the load current.

The hold-off condition also can be eliminated by providing a higher level of LED drive current. The higher LED drive provides a larger photocurrent which causer. the phototransistor to turn-on before the commutating spike has activated the zero cross network. Figure 8 shows the relationship of the LED drive for power factors of less than 1.0. The curve shows that if a device requires 1.5 mA for a resistive load, then 1.8 times (2.7 mA) that amount would be required to control an inductive load whose power factor is less than 0.3.

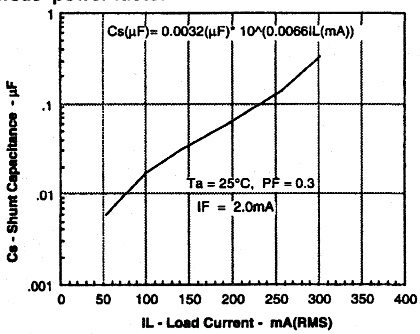


Figure 7. Shunt capacitance versus load current versus power factor

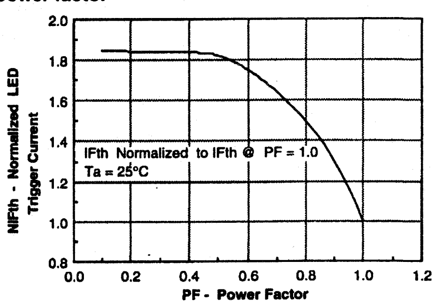


Figure 8. Normalized LED trigger current versus power factor

SIEMENS

ILCT6

Dual Phototransistor Optocoupler

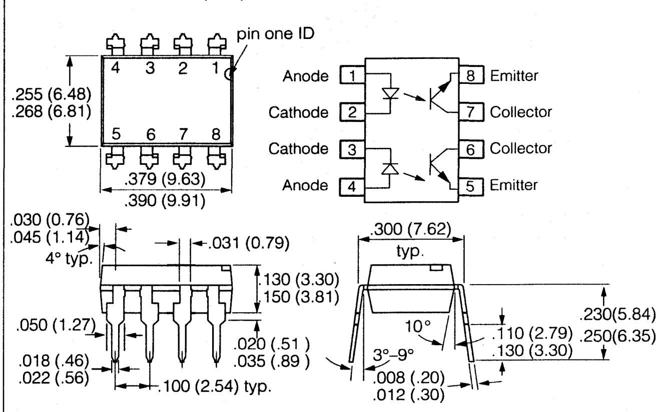
FEATURES
- **Current Transfer Ratio, 50% Typical**
- **Leakage Current, 1 nA Typ.**
- **Two Isolated Channels Per Package**
- **Direct Replacement for MCT6**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option1**

DESCRIPTION
The ILCT6 is a two channel opto coupler for high density applications. Each channel consists of an optically coupled pair with a gallium arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output.

The ILCT6 is especially designed for driving medium-speed logic, where it may be used to eliminate troublesome ground loop and noise problems. It can also be used to replace relays and transformers in many digital interface applications, as well as analog applications such as CRT modulation.

Maximum Ratings
Emitter (each channel)
Rated Forward Current, DC .... 60 mA
Peak Forward Current, DC
(1 µs pulse, 300 pps) .... 3 A
Power Dissipation at 25°C Ambient .... 100 mW
Derate Linearly from 25°C .... 1.3 mW/°C
Detector (each channel)
Collector Current .... 30 mA
Collector-Emitter Breakdown Voltage .... 30 V
Power Dissipation at 25°C Ambient .... 150 mW
Derate Linearly from 25°C .... 2 mW/°C
Package
Isolation Test Voltage .... 5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}\ \Omega$
Creepage .... 7 mm min.
Clearance .... 7 mm min.
Total Package Dissipation
at 25°C Ambient. .... 400 mW
Derate Linearly from 25°C .... 5.33 mW/°C
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

Dimensions in inches (mm)



Electrical Characteristics T_A=25°C

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.25	1.50	V	I_F=20 mA
Reverse Current	I_R		0.1	10	µA	V_R=3.0 V
Junction Capacitance	C_J		25		pF	V_F=0 V
Detector						
Breakdown Voltage	BV_{CEO}	30	65		V	I_C=10 µA
	BV_{ECO}	7.0	10			I_E=10 µA
Leakage Current, Collector-Emitter	I_{CEO}		1.0	100	nA	V_{CE}=10 V
Capacitance, Collector-Emitter	C_{CE}		8.0		pF	V_{CE}=0 V
Package						
DC Current Transfer Ratio	CTR	20	50		%	I_F=10 mA, V_{CE}=10 V
Saturation Voltage, Collector-Emitter	V_{CEsat}			0.40	V	I_C=2.0 mA, I_F=16 mA
Isolation Capacitance	C_{ISOL}		0.5		pF	f=1.0 MHz
Capacitance between Channels			0.4		pF	f=1.0 MHz
Bandwidth			150		KHz	I_C=2.0 mA, V_{CC}=10 V, R_L= 100 Ω
Switching Times, Output Transistor	t_{on}, t_{off}		3.0		µs	I_C=2 mA, R_E=100 Ω, V_{CE}=10 V

Figure 1. Forward voltage versus forward current

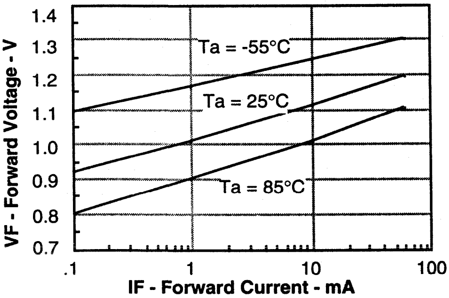


Figure 5. Normalized non-saturated and saturated CTR at T_A=85°C versus LED current

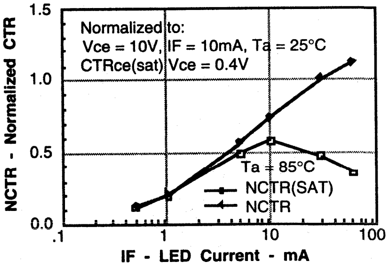


Figure 2. Normalized non-saturated and saturatedCTR at T_A=25°C versus LED current

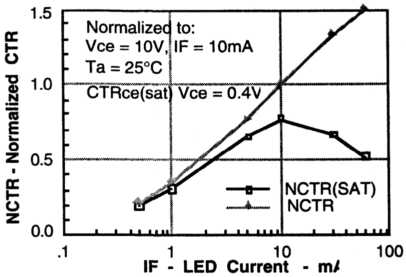


Figure 6. Collector-emitter current versus temperature and LED current

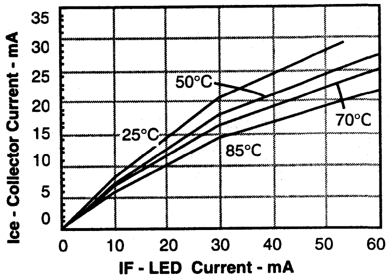


Figure 3. Normalized non-saturated and saturated CTR at T_A=50°C versus LED current

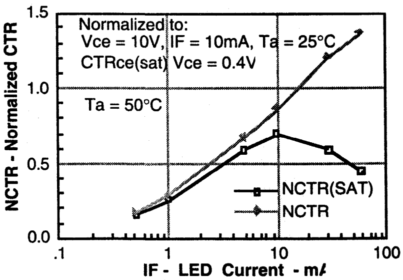


Figure 7. Collector-emitter leakage current versus temperature

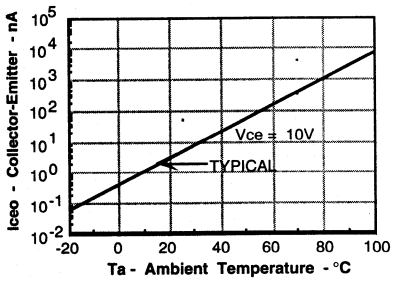


Figure 4. Normalized non-saturated and saturated CTR at T_A=70°C versus LED current

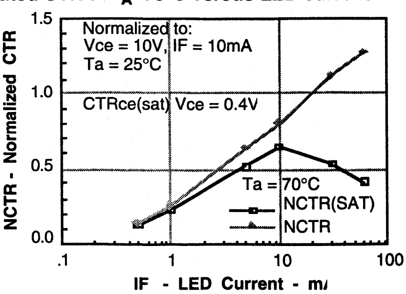


Figure 8. Propagation delay versus collector load resistor

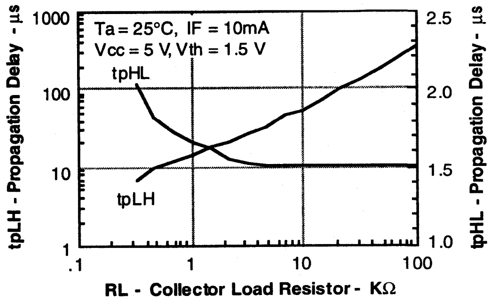


Figure 9. Switching Timing

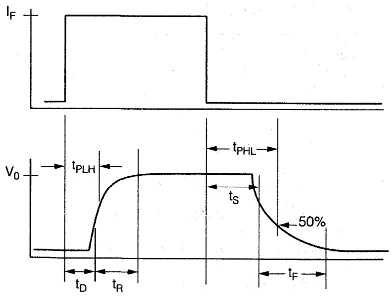
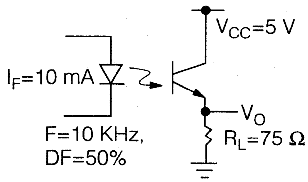


Figure 10. Switching schematic



SIEMENS

DUAL CHANNEL ILD1/2/5
QUAD CHANNEL ILQ1/2/5
Phototransistor Optocoupler

FEATURES

- **Current Transfer Ratio at I_F=10 mA**
  ILD/Q1, 20% Min.
  ILD/Q2, 100% Min.
  ILD/Q5, 50% Min.
- **High Collector-Emitter Voltage**
  ILD/Q1: BV_{CEO}=50 V
  ILD/Q2, ILD/Q5: BV_{CEO}=70 V
- **Field-Effect Stable by TRansparent IOn Shield (TRIOS) Isolation Test Voltage, 5300 VAC_{RMS}**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

Maximum Ratings (Each Channel)

Emitter

Reverse Voltage .... 6 V
Forward Current .... 60 mA
Surge Current .... 2.5 A
Power Dissipation .... 100 mW
Derate Linearly from 25°C .... 1.3 mW/°C

Detector

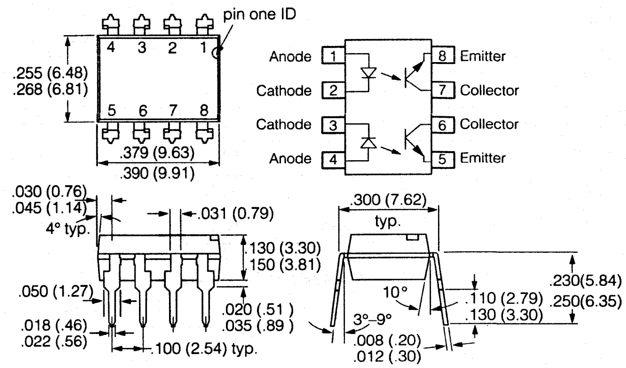
Collector-Emitter Reverse Voltage
ILD/Q1 .... 50 V
ILD/Q2, ILD/Q5 .... 70 V
Collector Current .... 50 mA
Collector Current (t<1 ms) .... 400 mA
Power Dissipation .... 200 mW
Derate Linearly from 25°C .... 2.6 mW/°C

Package

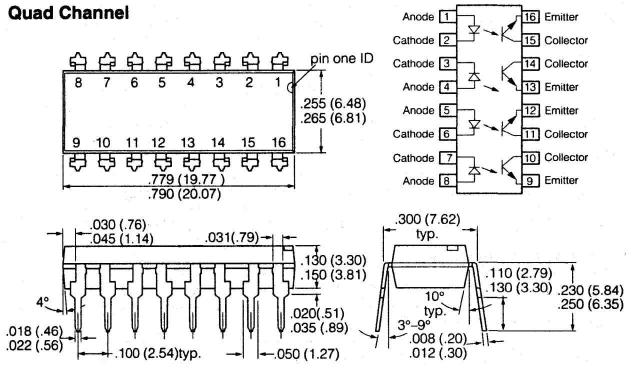
Isolation Test Voltage (between emitter and detector referred to standard climate 23°C/50%RH, DIN 50014) .... 5300 VAC_{RMS}
Creepage .... min. 7 mm
Clearance .... min. 7 mm
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $R_{IO}=10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $R_{IO}=10^{11}\Omega$
Package Power Dissipation .... 250 mW
Derate Linearly from 25°C .... 3.3 mW/°C
Storage Temperature .... –40°C to +150°C
Operating Temperature .... –40°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature
(2 mm from case bottom) .... 260°C

Dimensions in inches (mm)

Dual Channel



Quad Channel



DESCRIPTION

The ILD/Q1/2/5 are optically coupled isolated pairs employing GaAs infrared LEDs and silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the drive while maintaining a high degree of electrical isolation between input and output. The ILD/Q1/2/5 are especially designed for driving medium-speed logic and can be used to eliminate troublesome ground loop and noise problems. Also these couplers can be used to replace relays and transformers in many digital interface applications such as CRT modulation. The ILD1/2/5 has two isolated channels in a single DIP package and the ILQ1/2/5 has four isolated channels per package.

See Appnote 45, "How to Use Optocoupler Normalized Curves."

Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.25	1.65	V	I_F=60 mA
Reverse Current	I_R		0.01	10	μA	V_R=6 V
Capacitance	C_0		25		pF	V_R=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		750		°C/W	
Detector						
Capacitance	C_{CE}		6.8		pF	V_{CE}=5 V, f=1 MHz
Leakage Current, Collector-Emitter	I_{CEO}		5	50	nA	V_{CE}=10 V
Saturation Voltage, Collector-Emitter	V_{CESAT}		0.25	0.4		I_{CE}=1 mA, I_B=20 μA
DC Forward Current Gain	HFE	200	650	1800		V_{CE}= 10 V, I_B=20 μA
Saturated DC Forward Current Gain	HFE_{SAT}	120	400	600		V_{CE}= 0.4 V, I_B=20 μA
Thermal Resistance, Junction to Lead	R_{THJL}		500		°C/W	

Package Transfer Characteristics (Each Channel)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
ILD/Q1						
Saturated Current Transfer Ratio (Collector-Emitter)	CTR_{CESAT}		75		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio (Collector-Emitter)	CTR_{CE}	20	80	300	%	I_F=10 mA, V_{CE}=10 V
ILD/Q2						
Saturated Current Transfer Ratio (Collector-Emitter)	CTR_{CESAT}		170		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio (Collector-Emitter)	CTR_{CE}	100	200	500	%	I_F=10 mA, V_{CE}=10 V
ILD/Q5						
Saturated Current Transfer Ratio (Collector-Emitter)	CTR_{CESAT}		100		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio (Collector-Emitter)	CTR_{CE}	50	130	400	%	I_F=10 mA, V_{CE} =10 V
Isolation and Insulation						
Common Mode Rejection, Output High	C_{MH}		5000		V/μs	V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=0 mA
Common Mode Rejection, Output Low	C_{ML}		5000		V/μs	V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=10 mA
Common Mode Coupling Capacitance	C_{CM}		0.01		pF	
Package Capacitance	C_{IO}		0.8		pF	V_{IO}=0 V, f=1 MHz

Typical Switching Times

Figure 1. Non-saturated switching timing

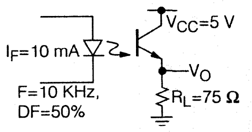


Figure 2. Non-saturated switching timing

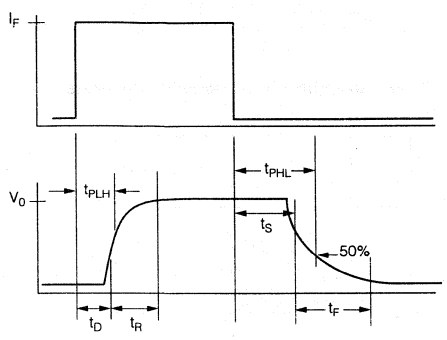


Figure 3. Saturated switching timing

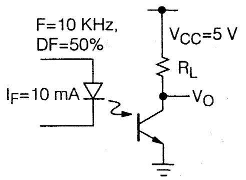
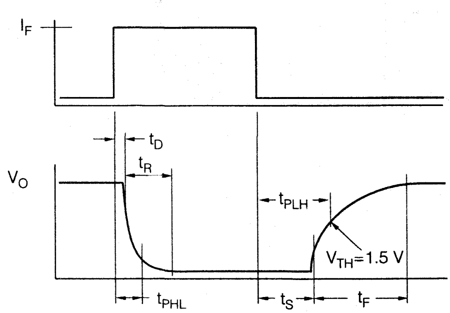


Figure 4. Saturated switching timing



Non-saturated

Characteristic	ILD/Q1 I_F=20 mA	ILD/Q2 I_F=5 mA	ILD/Q5 I_F=10 mA	Unit	Condition
Delay, t_D	0.8	1.7	1.7	µs	V_{CE}=5 V R_L=75 Ω 50% of V_{PP}
Rise time, t_R	1.9	2.6	2.6	µs	
Storage, t_S	0.2	0.4	0.4	µs	
Fall Time, t_F	1.4	2.2	2.2	µs	
Propagation H-L, t_{PHL}	0.7	1.2	1.1	µs	
Propagation L-H, t_{PLH}	1.4	2.3	2.5	µs	

Saturated

Characteristic	ILD/Q1 I_F=20 mA	ILD/Q2 I_F=5 mA	ILD/Q5 I_F=10 mA	Unit	Condition
Delay, t_D	0.8	1	1.7	µs	V_{CE}=0.4 V R_L=1 kΩ V_{CC}=5 V V_{TH}=1.5 V
Rise time, t_R	1.2	2	7	µs	
Storage, t_S	7.4	5.4	4.6	µs	
Fall Time, t_F	7.6	13.5	20	µs	
Propagation H-L, t_{PHL}	1.6	5.4	2.6	µs	
Propagation L-H, t_{PLH}	8.6	7.4	7.2	µs	

Figure 5. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

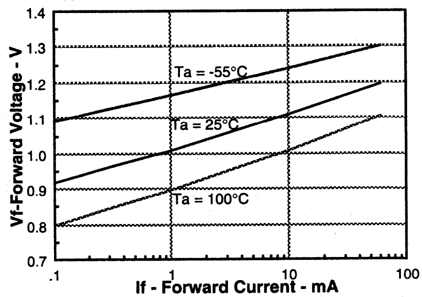


Figure 6. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

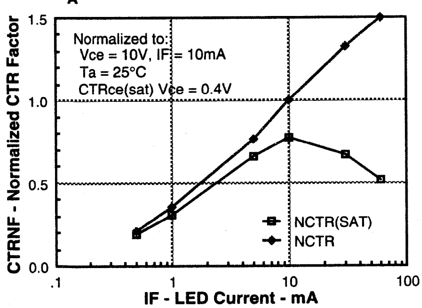


Figure 7. Normalized non-saturated and saturated CTR at T_A=50°C versus LED current

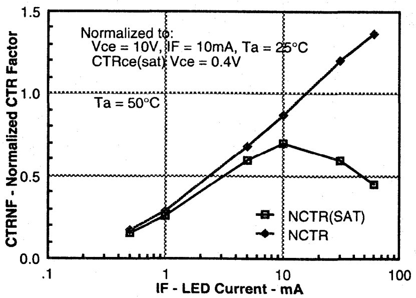


Figure 10. Collector-emitter current versus temperature and LED current

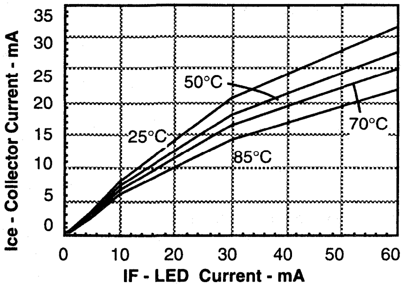


Figure 8. Normalized non-saturated and saturated CTR at T_A=70°C versus LED current

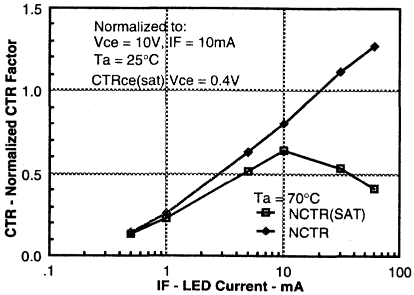


Figure 11. Collector-emitter leakage current versus temperature

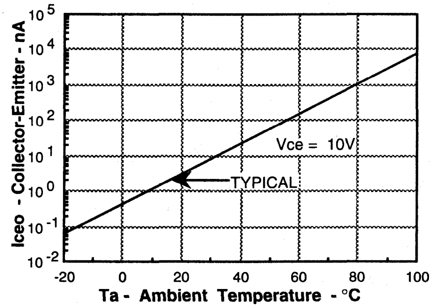


Figure 9. Normalized non-saturated and saturated CTR at T_A=85°C versus LED current

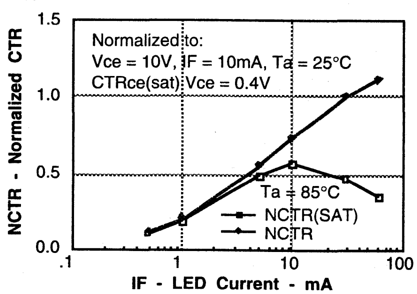
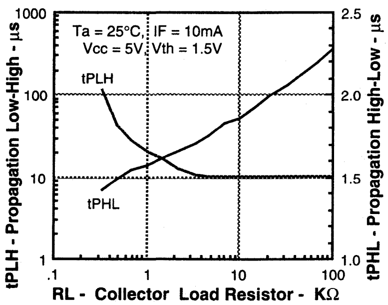
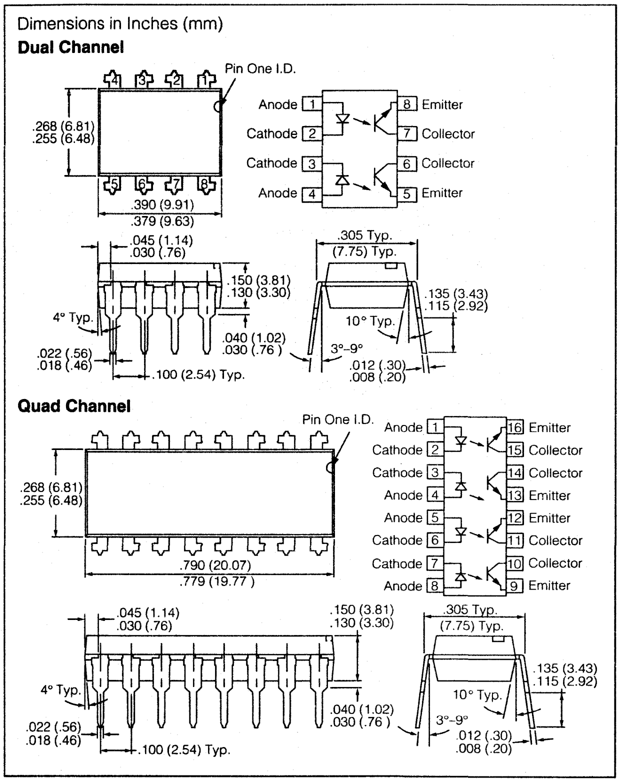


Figure 12. Propagation delay versus collector load resistor



SIEMENS

DUAL CHANNEL ILD3
QUAD CHANNEL ILQ3
Phototransistor Optocoupler



FEATURES
- **Current Transfer Ratio at IF=1.6 mA, 300% Min.**
- **High Collector-Emitter Voltage**
- **BV_{CEO}=50 V**
- **Field-Effect Stable by TRansparent IOn Shield (TRIOS)**
- **Double Molded Package Offers Isolation Test Voltage 5300 VAC_{RMS}, 1 sec.**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

Maximum Ratings (Each Channel)

Emitter	
Reverse Voltage	6 V
Continuous Forward Current	60 mA
Surge Current	2.5 A
Power Dissipation	100 mW
Derate Linearly from 25°C	1.3 mW/°C
Detector	
Collector-Emitter Reverse Voltage	50 V
Collector Current	50 mA
Collector Current (t<1 ms)	400 mA
Total Power Dissipation	200 mW
Derate Linearly from 25°C	2.6 mW/°C
Package	
Isolation Test Voltage (between emitter and detector, refer to standard climate 23°C/50% RH, DIN50014)	V_{IO}=5300 VAC_{RMS}
Creepage	min. 7 mm
Clearance	min. 7 mm
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	$R_{IO}=10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C	$R_{IO}=10^{11}\ \Omega$
Power Dissipation	250 mW
Derate Linearly from 25°C	3.3 mW/°C
Storage Temperature Range	–40 to +150°C
Operating Temperature Range	–40 to +100°C
Junction Temperature	100°C
Soldering Temperature, 2 mm from case bottom	260°C

DESCRIPTION
The ILD/Q3 are optically coupled isolated pairs employing GaAs infrared LEDs and silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the drive while maintaining a high degree of electrical isolation between input and output. The ILD/Q3 are especially designed for driving medium-speed logic and can be used to eliminate ground loop and noise problems. Also these couplers can be used to replace relays and transformers in many digital interface applications such as CRT modulation. The ILD3 has two isolated channels in a single DIP package and the ILQ3 has four isolated channels per package.

See Appnote 45, *"How to Use Optocoupler Normalized Curves."*

Characteristics

Emitter (IR GaAs)	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Forward Voltage	V_F		1.25	1.65	V	I_F=60 mA
Reverse Current	I_R		0.01	10	µA	V_R=6 V
Capacitance	C_0		25		pF	V_R=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		750		°C/W	
Detector						
Collector-Emitter Leakage Current	I_{CEO}		5	70	nA	V_{CE}=15 V
Capacitance	C_{CE}		6.8		pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		500		°C/W	
Package Transfer Characteristics (Each Channel)						
Saturated Current Transfer Ratio, ILD/Q3-1	CTR_{SAT}	300			%	I_F=1.6 mA, V_{CE}=0.4 V
Saturated Current Transfer Ratio, ILD/Q3-2	CTR_{SAT}	100			%	I_F=1.0 mA, V_{CE}=0.4 V
Common Mode Rejection Output High	CMH		5000		V/µs	V_{CM}=50 V_{P-P}, R_L=10 kΩ, I_F=0 mA
Common Mode Rejection Output Low	CML		5000		V/µs	V_{CM}=50 V_{P-P}, R_L=10 kΩ, I_F=0 mA
Common Mode Coupling Capacitance	C_{CM}		0.01		pF	
Package Capacitance	C_{IO}		0.8		pF	V_{IO}=0 V, f=1 MHz

SIEMENS

DUAL/QUADCHANNEL ILD32/ILQ32
Photodarlington Optocoupler

FEATURES
- **Very High Current Transfer Ratio, 500% Min.**
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **High Isolation Resistance, 10^{11} Ω Typical**
- **Low Coupling Capacitance**
- **Standard Plastic DIP Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

Maximum Ratings (Each Channel)
Emitter

Peak Reverse Voltage .... 3 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C .... 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C

Detector

Collector-Emitter Breakdown Voltage .... 30 V
Collector (Load) Current .... 125 mA
Power Dissipation at 25°C Ambient .... 150 mW
Derate Linearly from 25°C .... 2.0 mW/°C

Package

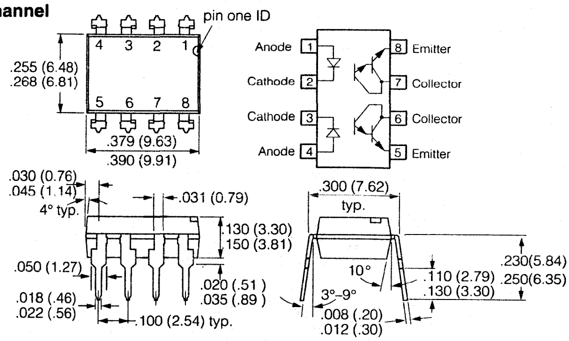
Isolation Test Voltage (between emitter and detector refer to standard climate 23°C/50%RH, DIN 50014)
t=1 sec. ....5300 VAC_{RMS}
Creepage ....7 mm min.
Clearance ....7 mm min.
Comparative Tracking Index per DIN IEC 112/VDE303, part 1 ....≥175
Isolation Resistance
V_{IO}=500V, T_A=25°C .... $R_{IO}=10^{12}$ Ω
V_{IO}=500V, T_A=100°C .... $R_{IO}=10^{11}$ Ω
Total Dissipation at 25°C Ambient
ILD32 .... 400 mW
ILQ32 .... 500 mW
Derate Linearly from 25°C
ILD32 .... 5.33 mW/°C
ILQ32 .... 6.67 mW/°C
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

DESCRIPTION
The ILD32/ILQ32 are optically coupled isolators with a Gallium Arsenide infrared LED and a silicon photodarlington sensor. Switching can be achieved while maintaining a high degree of isolation between driving and load circuits. These optocouplers can be used to replace reed and mercury relays with advantages of long life, high speed switching and elimination of magnetic fields.

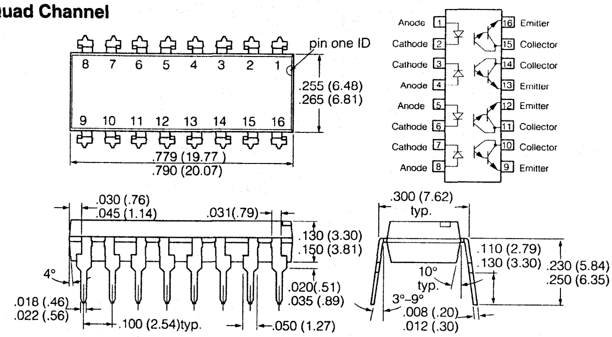
The ILD32 has two isolated channels in a DIP package, and the ILQ32 has four channels. These devices can be used to replace 4N32s or 4N33s in applications calling for several single channel optocouplers on a board.

Dimensions in inches (mm)

Dual Channel



Quad Channel



Electrical Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.25	1.5	V	I_F=10 mA
Reverse Current	I_R		0.1	100	µA	V_R=3.0 V
Capacitance	C_O		25		pF	V_R=0 V
Detector						
Breakdown Voltage Collector-Emitter	BV_{CEO}	30			V	I_C=100 µA, I_F=0
Breakdown Voltage Emitter-Collector	BV_{ECO}	5	10		V	I_E=100 µA
Collector-Emitter Leakage Current	I_{CEO}		1.0	100	nA	V_{CE}=10V, I_F=0
Package						
Current Transfer Ratio	CTR	500			%	I_F=10 mA, V_{CE}=10V
Collector Emitter Saturation Voltage	V_{CEsat}			1.0	V	I_C=2 mA, I_F=8 mA
Isolation Capacitance	C_{ISOL}		0.5		pF	
Turn-On Time	t_{on}		15		µs	V_{CC}=10 V I_F=5 mA, R_L=100 Ω
Turn-Off Time	t_{off}		30		µs	

Figure 1. Forward voltage versus forward current

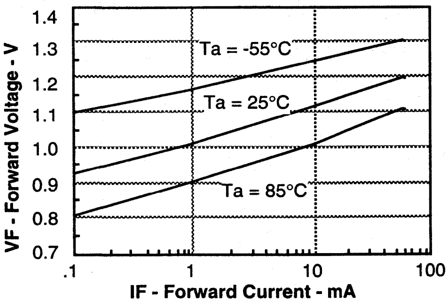


Figure 2. Normalized non-saturated and saturated CTRce at TA=25°C versus LED current

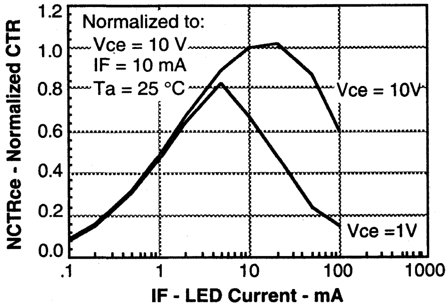


Figure 3. Normalized non-saturated and saturated collector-emitter current versus LED current

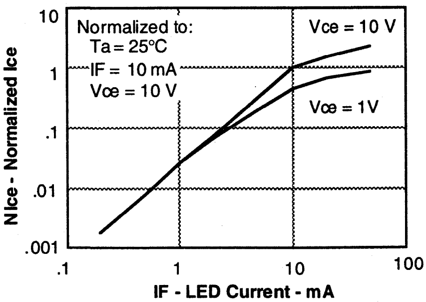


Figure 4. Low to high propagation delay versus collector load resistance and LED current

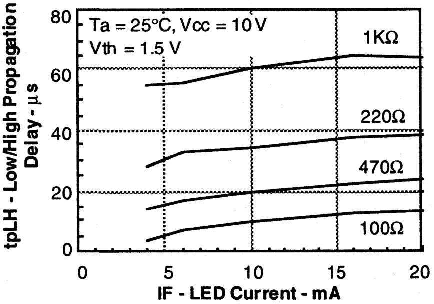


Figure 5. High to low propagation delay versus collector load resistamce and LED current

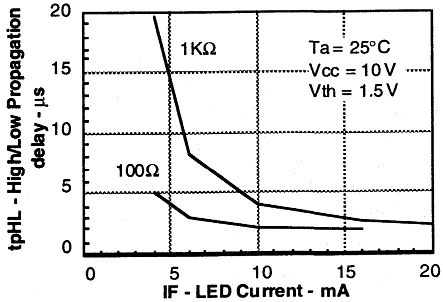


Figure 6. Switching timing

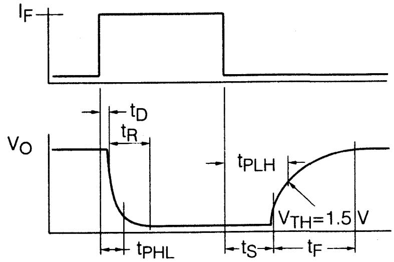
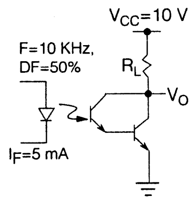


Figure 7. Switching schematic



SIEMENS

ILD205/206/207/211/213/217

Dual Phototransistor
Small Outline Surface Mount Optocoupler

FEATURES

- **Two Channel Coupler**
- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing of .05"**
- **Available only on Tape and Reel Option (Conforms to EIA Standard 481-2)**
- **Isolation Test Voltage, 2500 V_{RMS}**
- **High Current Transfer Ratios**
  ILD205, 40 – 80%
  ILD206, 63 –125%
  ILD207, 100 – 200%
  ILD211, 20% Minimum
  ILD213, 100% Minimum
  ILD217, 100% Minimum at 1 mA
- **High BV_{CEO}, 70 V**
- **Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering**

DESCRIPTION

The ILD205/206/207/211/213/217 are optically coupled pairs with a gallium arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The ILD205/6/7/11/13/17 come in a standard SOIC-8 small outline package for surface mounting which makes it ideally suited for high density applications with limited space. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

A specified minimum and maximum CTR allows a narrow tolerance in the electrical design of the adjacent circuits. The high BV_{CEO} of 70 volts gives a higher safety margin compared to the industry standard of 30 volts.

Maximum Ratings (Each Channel)

Emitter

Peak Reverse Voltage .... 6.0 V
Peak Pulsed Current (1 µs, 300 pps) .... 1 A
Continuous Forward Current per Channel .... 30 mA
Power Dissipation at 25°C .... 45 mW
Derate Linearly from 25°C .... 0.5 mW/°C

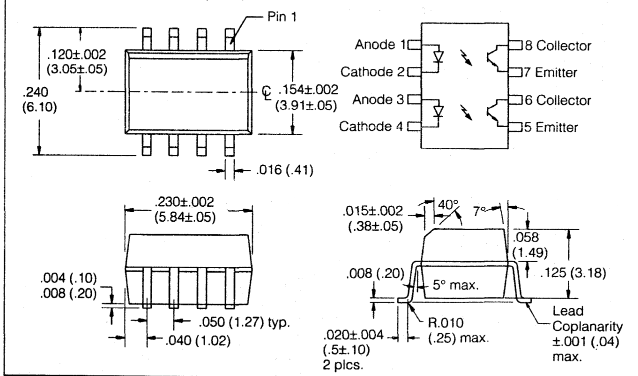
Detector

Collector-Emitter Breakdown Voltage .... 70 V
Emitter-Collector Breakdown Voltage .... 7 V
Power Dissipation per Channel .... 55 mW
Derate Linearly from 25°C .... 0.55 mW/°C

Package

Total Package Dissipation at 25°C Ambient
(2 LEDs + 2 Detectors, 2 Channels)....... 200 mW
Derate Linearly from 25°C .... 2.0 mW/°C
Storage Temperature –55°C .... to +150°C
Operating Temperature –55°C .... to +100°C
Soldering Time at 260°C .... 10 sec.

Dimensions in inches (mm)



Characteristics T_A=25°C

Parameter		Min.	Typ	Max.	Unit	Condition
Emitter						
Forward Voltage			1.2	1.55	V	I_F=10 mA
Reverse Current			0.1	100	mA	V_R=6.0 V
Capacitance			25		pF	V_R=0
Detector						
Brealdowm Voltage	BV_{CEO}	70			V	I_C=10 mA
	BV_{ECO}	7			V	I_E=10 mA
	I_{CEO}		5	50	nA	V_{CE}=10 V I_F=0
Collector-Emitter Capacitance			10		pF	V_{CE}=0
Package						
DC Current Transfer, V_{CE}=5 V	ILD205	40		80	%	I_F=10 mA
	ILD206	63		125		
	ILD207	100		200		
	ILD211	20				
	ILD213	100				
	ILD205	13	30			I_F=1 mA
	ILD206	22	45			
	ILD207	34	70			
	ILD217	100	120			
Collector-Emitter Saturation Voltage $V_{CE\ (sat)}$				0.4	V	I_F=10 mA I_F=2.5 mA
Capacitance, Input to Output			0.5		pF	
Isolation Test Voltage		2500			VAC_{RMS}	t=1 min.
Resistance, Input to Output			100		GΩ	
Turn-on Time			5.0		µs	I_C=2 mA, R_E= 100 Ω V_{CE}=5 V
Turn-off Time			4.0		µs	

Figure 1. Forward current versus forward voltage

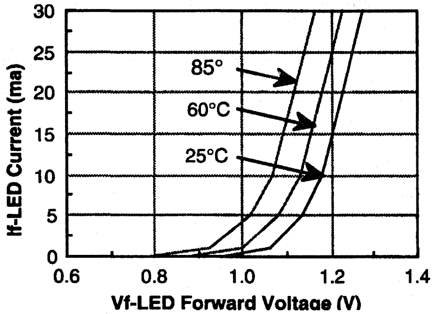


Figure 2. Collector-emitter current versus temperature

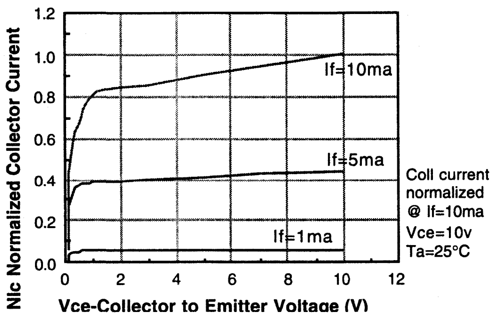


Figure 3. Normalized CTRce versus forward current

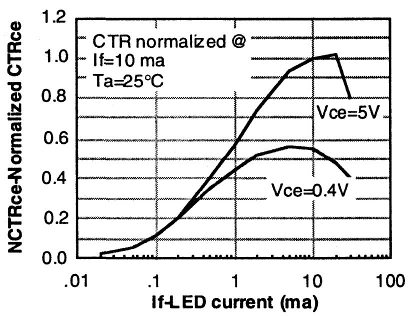


Figure 4. CTR (normalized) versus temperature

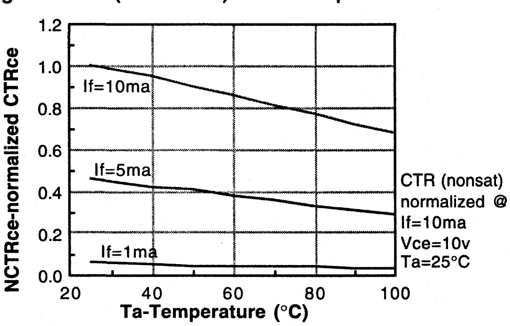


Figure 5. Switching speed versus load resistor

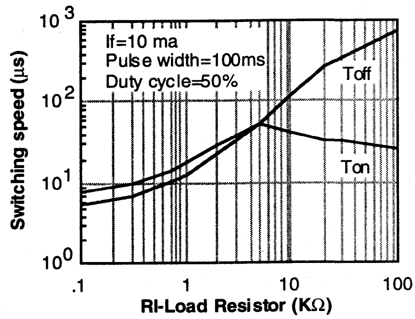


Figure 6. Collector current versus temperature

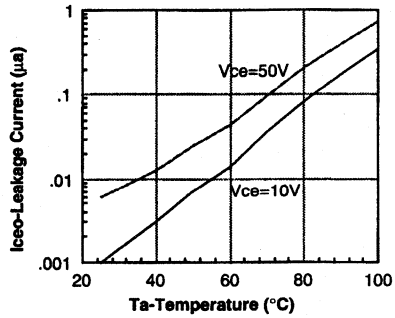


Figure 7. Power dissipation versus ambient temperature

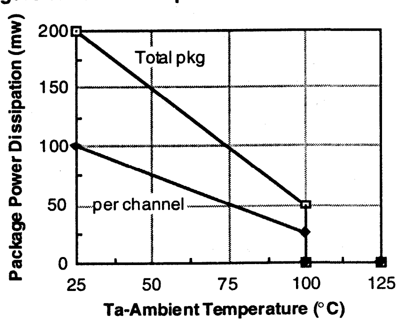
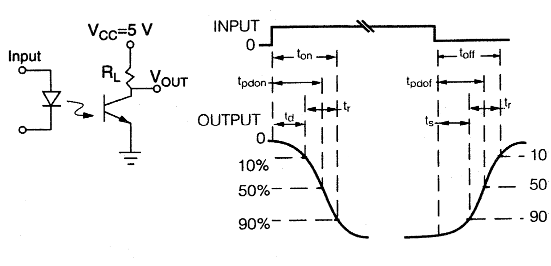


Figure 8. Switching time test schematic and waveform



SIEMENS

ILD223

Dual Photodarlington
Small Outline Surface Mount Optocoupler

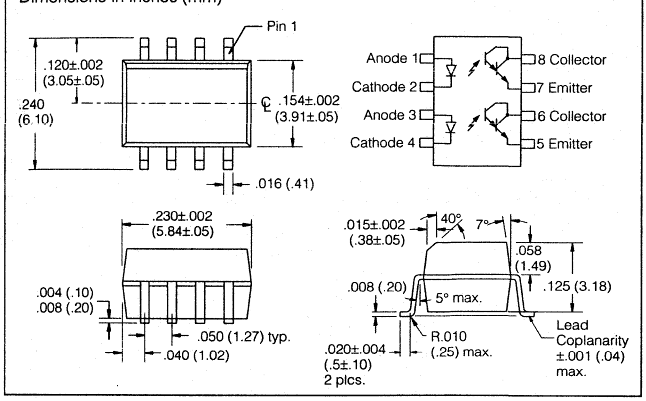
FEATURES
- **Two Channel Optocoupler**
- **High Current Transfer Ratio at I_F=1 mA, 500% Min.**
- **Isolation Test Voltage, 2500 VRMS**
- **Electrical Specifications Similar to Standard 6-pin Coupler**
- **Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering**
- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing, .05"**
- **Available only on Tape and Reel Option (Conforms to EIA Standard 481-2)**
- **Underwriters Lab File #E52744**

DESCRIPTION
The ILD223 is a high current transfer ratio (CTR) optocoupler. It has a Gallium Arsenide infrared LED emitter and a silicon NPN photodarlington transistor detector.

This device has CTRs tested at an LED current of 1 mA. This low drive current permits easy interfacing from CMOS to LSTTL or TTL.

The ILD223 is constructed in a standard SOIC-8 foot print which makes it ideally suited for high density applications. In addition to eliminating through-holes requirements, this package conforms to standards for surface mounted devices.

Maximum Ratings (Each Channel)
Emitter
Peak Reverse Voltage ....6.0 V
Peak Pulsed Current (1 µs, 300 pps) .... 3 A
Continuous Forward Current per Channel .... 30 mA
Power Dissipation at 25°C............................45 mW
Derate Linearly from 25°C......................0.4 mW/°C
Detector
Collector-Emitter Breakdown Voltage................30 V
Emitter-Collector Breakdown Voltage.................5 V
Power Dissipation per Channel.................... 75 mW
Derate Linearly from 25°C......................3.1 mW/°C
Package
Total Package Dissipation at 25°C Ambient
(2 LEDs + 2 Detectors, 2 Channels)........240 mW
Derate Linearly from 25°C.........................2 mW/°C
Storage Temperature ....–55°C to +150°C
Operating Temperature .... –55°C to +100°C
Soldering Time at 260°C .... 10 sec.



Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F			1.3	V	I_F=1 mA
Reverse Current	I_R		0.1	100	µA	V_R=6.0 V
Capacitance	C_O		25		pF	V_F=0 V, F=1 MHz
Detector						
Breakdown Voltage	BV_{CEO}	30			V	I_C=10 µA
	BV_{ECO}	5				I_E=10 µA
Current, Collector-Emitter	I_{CEO}			50	nA	V_{CE}=5 V, I_F=0
Capacitance, Collector-Emitter	C_{CE}		3.4		pF	V_{CE}=5 V
Package						
DC Current Transfer Ratio	CTR_{DC}	500			%	I_F=1 mA, V_{CE}=5 V
Saturation Voltage, Collector-Emitter	V_{CEsat}			1	V	I_F=1 mA, I_{CE}=0.5 mA
Capacitance, Input to Output	C_{IO}	0.5		pF		
Resistance, Input to Output	R_{IO}	100		GΩ		
Turn-On Time	t_{ON}	15		µs		V_{CC}=10 V, R_L=100 Ω, I_F=5 mA
Turn-Off Time	t_{OFF}	30		µs		
Isolation Test Voltage	V_{IO}					t=1 min., 2500 VAC_{RMS}

Figure 1. Forward voltage versus forward current

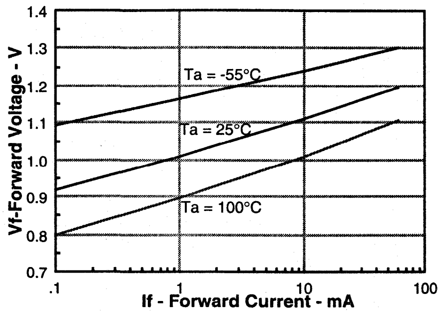


Figure 2. Peak LED current versus duty factor, Tau

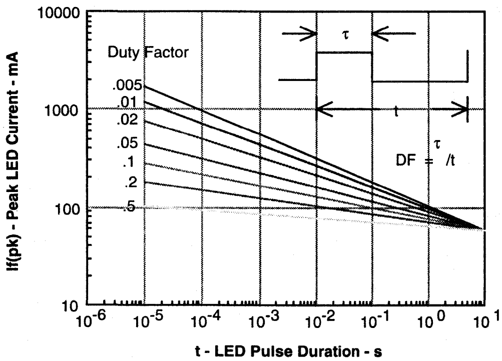


Figure 3. Normalized CTR_{CE} versus LED current

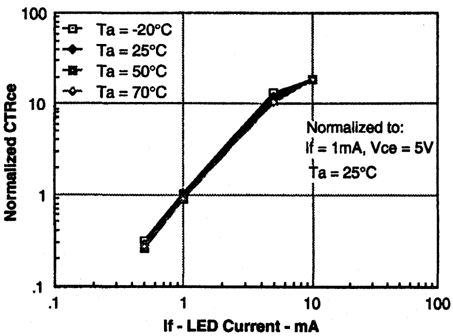


Figure 4. CTR versus LED current

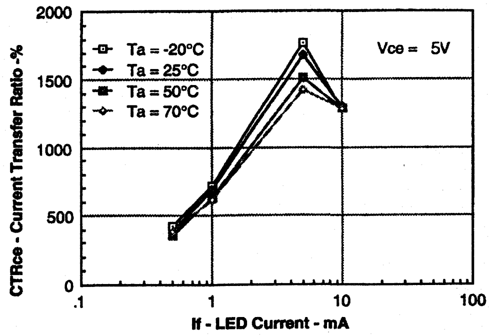


Figure 5. Collector current versus LED current

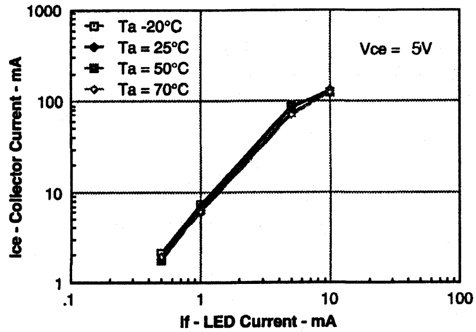
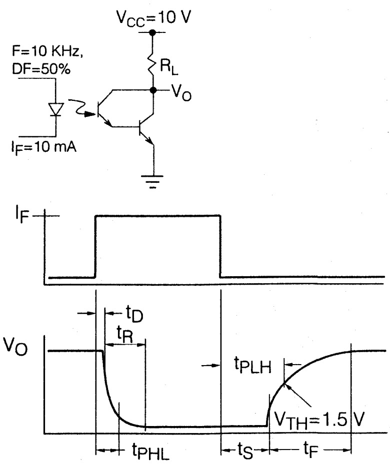


Figure 6. Switching schematic and switching timing



SIEMENS

DUAL CHANNEL ILD255

Bidirectional Input Optocoupler

FEATURES

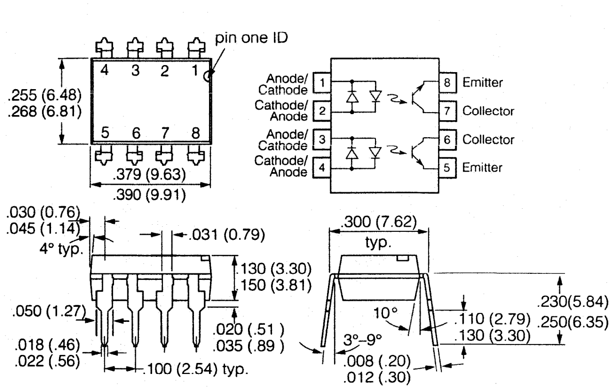
- **AC or Polarity Insensitive Inputs**
- **Continuous Forward Current, 130 mA**
- **Applications—Telecommunications**
  - **Ring Detection**
  - **Loop Current Detector**
- **Built-in Reverse Polarity Input Protection**
- **Improved CTR Symmetry**
- **Industry Standard DIP Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

DESCRIPTION

The ILD255 is a bidirectional input optically coupled isolator consisting of two high current Gallium Arsenide infrared LEDs coupled to a silicon NPN phototransistor per channel. The ILD255 has a minimum CTR of 50%

These optocouplers are ideal for applications requiring AC signal detection and monitoring.

Dimensions in inches (mm)



Maximum Ratings (Each Channel)

Emitter

Peak Pulsed Current (1 μs, 300 pps) .... 3 A
Continuous Forward Current .... 130 mA RMS
Power Dissipation at 25°C .... 175 mW
Derate Linearly from 25°C .... 2.3 mW/°C

Detector

Collector-Emitter Breakdown Voltage .... 30 V
Emitter-Base Breakdown Voltage .... 5 V
Power Dissipation at 25°C .... 200 mW
Derate Linearly from 25°C .... 2.6 mW/°C

Package

Isolation Test Voltage (between emitter and detector referred to standard climate 23°C/50%RH, DIN 50014) .... 5300 VAC_{RMS}
Creepage .... min. 7 mm
Clearance .... min. 7 mm
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $R_{IO} \geq 10^{12}$ Ω
V_{IO}=500 V, T_A=100°C .... $R_{IO} \geq 10^{11}$ Ω
Total Dissipation at 25°C .... 400 mW
Derate Linearly from 25°C .... 5.3 mW/°C
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

Electrical Characteristics T_A=25°C

Parameter	Min.	Typ.	Max.	Unit	Condition
Emitter					
Forward Voltage V_F		1.2	1.5	V	I_F=±10 mA
Detector					
BV_{CEO}	30	50		V	I_C=10 mA
BV_{ECO}	7	10		V	I_E=10 μA
I_{CEO}		5	50	nA	V_{CE}=10 V
Package					
V_{CEsat}			0.4	V	I_F=±16 mA, I_C=2 mA
DC Current Transfer Ratio	50			%	I_F=±10mA, V_{CE}=10 V
Symmetry $\frac{\text{CTR at +10 mA}}{\text{CTR at −10 mA}}$	0.50	1.0	2.0		

Figure 1. LED forward current versus forward voltage

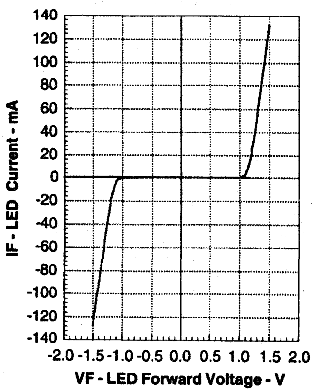


Figure 2. Maximum LED current versus ambient temperature

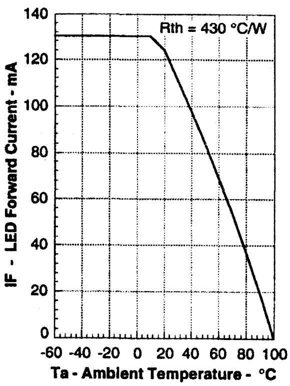


Figure 3. Maximum LED power dissipation

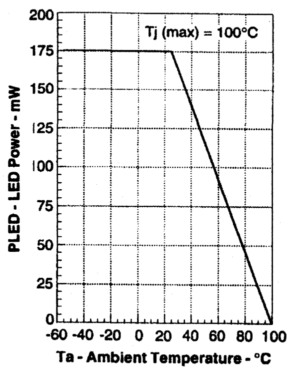


Figure 4. Current transfer ratio versus LED current and collector-emitter voltage

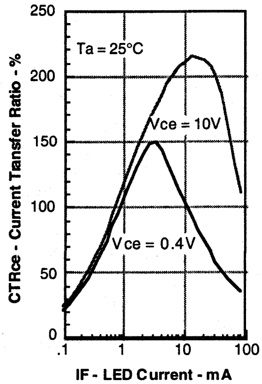


Figure 5. Saturated and nonsaturated collector-emitter current versus LED current

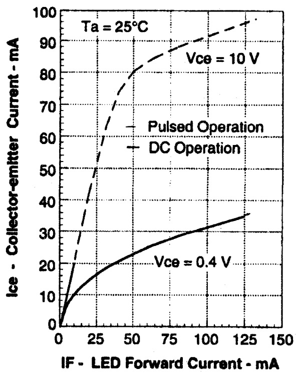


Figure 6. Saturated and nonsaturated collector-emitter current versus LED current

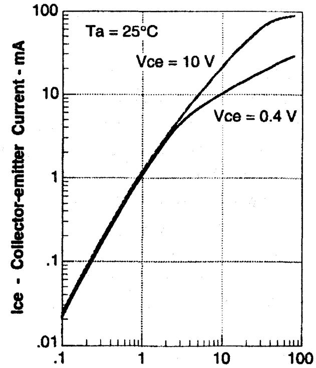
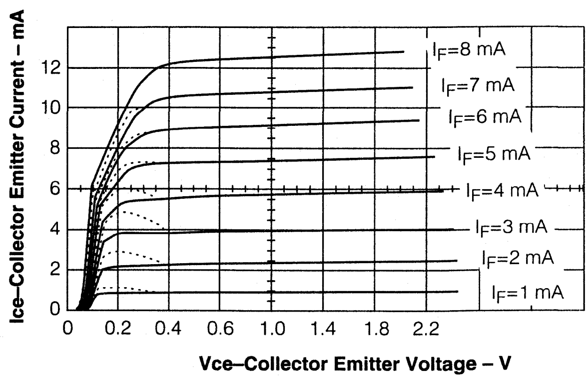


Figure 7. Collector emitter current versus collector emitter voltage



ILD256

Dual AC Input Phototransistor Small Outline Surface Mount Optocoupler

FEATURES

- **Each Channel: Guaranteed CTR Symmetry, 2:1 Maximum**
- **Bidirectional AC Input**
- **Industry Standard SOIC-8 Surface Mountable Package**
- **Standard Lead Spacing, .05"**
- **Available only on Tape and Reel Option (Conforms to EIA Standard 481-2)**

DESCRIPTION

The ILD256 is a dual channel optocoupler. Each channel consists of two infrared emitters connected in anti-parallel and coupled to a silicon NPN phototransistor detector.

These circuit elements are constructed with a standard SOIC-8 footprint.

The product is well suited for telecom applications such as ring detection or off/on hook status, given its bidirectional LED input and guaranteed current transfer ratio (CTR) of 20% at I_F= 10 mA.

Maximum Ratings

Emitter (Each Channel)

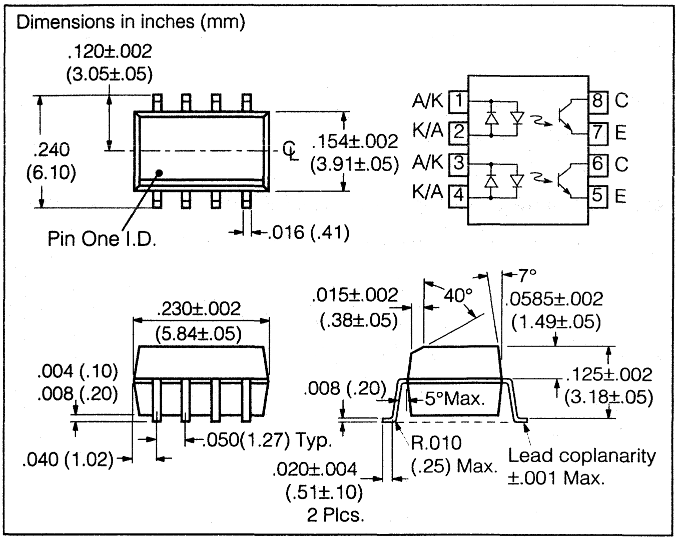
Continuous Forward Current .... 30 mA
Power Dissipation at 25°C .... 45 mW
Derate Linearly from 25°C .... 0.5 mW/°C

Detector (Each Channel)

Collector-Emitter Breakdown Voltage .... 70 V
Emitter-Collector Breakdown Voltage .... 7 V
Power Dissipation .... 55 mW
Derate Linearly from 25°C .... 0.55 mW/°C

Package

Total Package Dissipation at 25°C Ambient (LED + Detector) .... 200 mW
Derate Linearly from 25°C .... 2.0 mW/°C
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Soldering Time at 260°C .... 10 sec.



Characteristics T_A=25°C

	Sym	Min.	Typ.	Max.	Unit	Condition
Emitter (Each Channel)						
Forward Voltage	V_F		1.2	1.55	V	I_F=±10 mA
Reverse Current	I_R		0.1	100	mA	V_R=6.0 V
Detector (Each Channel)						
Breakdown Voltage	BV_{CEO}	70			V	I_C=10 µA
	BV_{ECO}	7				I_E=10 µA
Leakage Current, Collector-Emitter	I_{CEO}		5	50	nA	V_{CE}=10 V
Package						
DC Current Transfer	CTR	20			%	I_F=±10 mA, V_{CE}=5 V
Symmetry CTR at + 10 mA / CTR at -10 mA		0.5	1.0	2.0		
Saturation Voltage, Collector-Emitter	V_{CEsat}			0.4		I_F=±16 mA, I_C=2 mA
Isolation Voltage, Input to Output	V_{IO}	2500			VAC_{RMS}	t=1 min.

Figure 1. LED forward current versus forward voltage

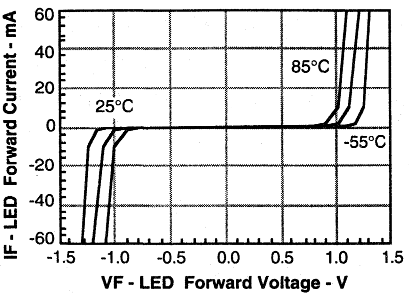


Figure 2. Forward voltage versus forward current

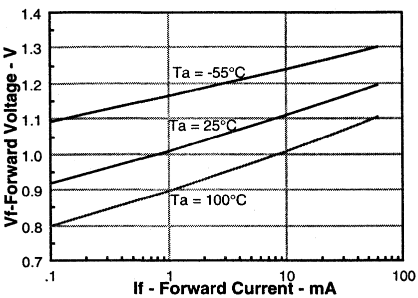


Figure 3. Peak LED current versus duty factor, Tau

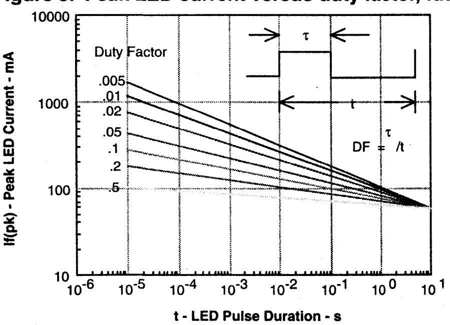


Figure 4. Normalized CTR versus If and Ta

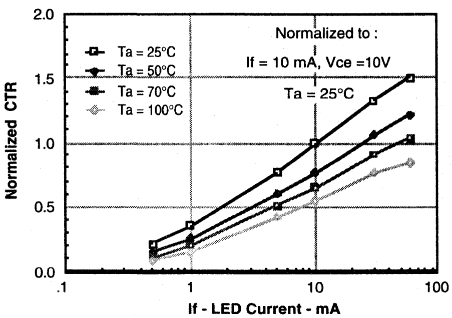


Figure 5. Normalized saturated CTR

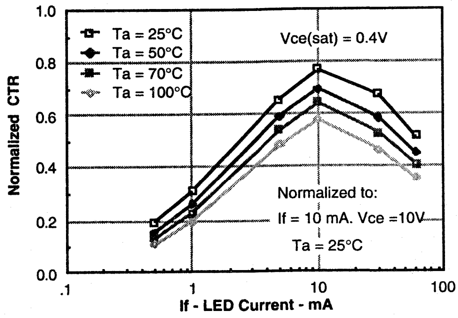


Figure 6. Normalized CTRcb

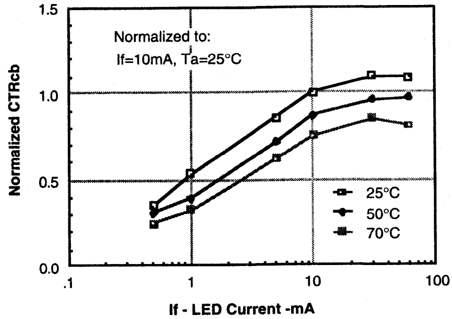


Figure 7. Photocurrent versus LED current

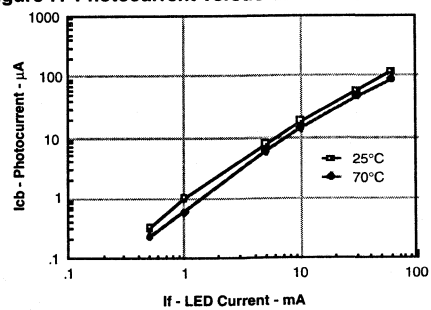


Figure 8. Base current versus If and HFE

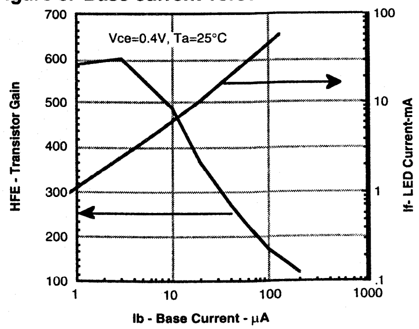


Figure 9. Normalized HFE versus I_b, T_a

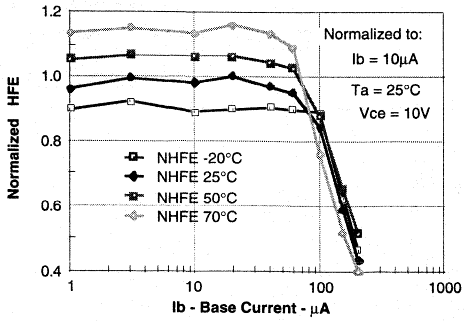


Figure 11. Base emitter voltage versus base

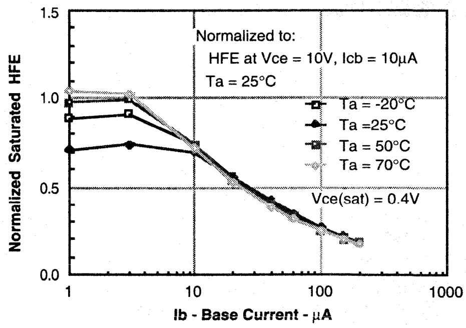


Figure 10. Normalized saturated HFE versus I_b

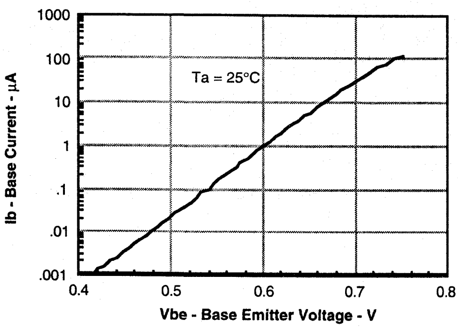
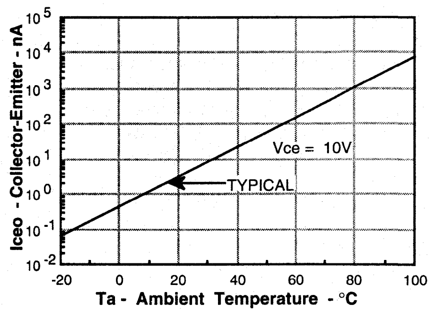


Figure 12. Collector-emitter leakage current versus temperature



Optocouplers (Optoisolators) 5

SIEMENS

ILD610

Dual Phototransistor Optocoupler

FEATURES

- **Dual Version of SFH610 Series**
- **High Current Transfer Ratios**
  ILD610-1, 40-80%
  ILD610-2, 63-125%
  ILD610-3, 100-200%
  ILD610-4, 160-320%
- **Isolation Test Voltage, 5300 V_{RMS}**
- **V_{CEsat} 0.25 (≤0.4) V at I_F=10 mA, I_C=2.5 mA**
- **V_{CEO}=70 V**
- **Underwriters Lab File #E52744**
- **VDE #0884 Available with Option 11**

DESCRIPTION

The ILD610 Series is a dual channel optocoupler series for high density applications. Each channel consists of an optically coupled pair with a Gallium Arsenide infrared LED and a silicon NPN phototransistor. Signal information, including a DC level, can be transmitted by the device while maintaining a high degree of electrical isolation between input and output. The ILD610 Series is the dual version of SFH610 Series and uses a repetitive pin-out configuration instead of the more common alternating pin-out used in most dual couplers.

Maximum Ratings (Each Channel)

Emitter

Reverse Voltage .... 6 V
Surge Forward Current (t £10 ms) .... 1.5 A
Total Power Dissipation .... 100 mW
Derate Linearly from 25°C .... 1.3 mW/°C
DC Forward Current .... 60 mA

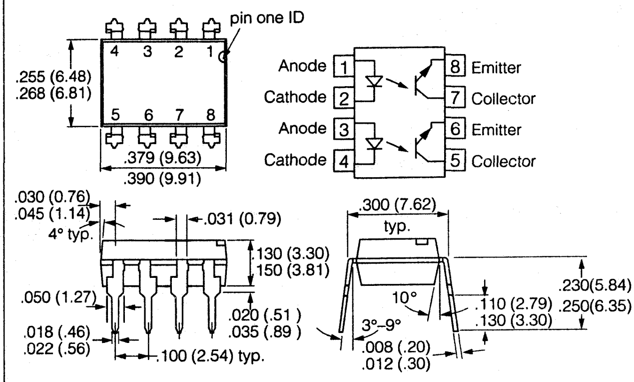
Detector

Collector-Emitter Voltage .... 70 V
Collector Current .... 50 mA
Collector Current (t ≤1 ms) .... 100 mA
Total Power Dissipation .... 150 mW
Derate Linearly from 25°C .... 2.0 mW/°C

Package

Isolation Test Voltage (t=1 sec.) .... 5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}\ \Omega$
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Junction Temperature .... 100°C
Lead Soldering Time at 260°C .... 10 sec.

Dimensions in inches (mm)



Electrical Characteristics T_A=25°C

	Symbol	Typ.	Unit	Condition
Emitter				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=60mA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=6V
Capacitance	C_O	25	pF	V_R=0 V, f=1 MHz
Detector				
Breakdown Voltage	BV_{CEO}	90 (≥70)	V	I_C=10 µA
	BV_{CEO}	7.0 (≥6.0)		I_E=10 µA
Collector-Emitter Dark Current	I_{CEO}	2 (≤50)	nA	V_{CE}=10 V
Capacitance	C_{CE}	7	pF	V_{CE}=5 V, f=1 MHz
Package				
Collector-Emitter Saturation Voltage	V_{CEsat}	0.25 (≤0.40)	V	I_F=10 mA, I_C=2.5 mA
Coupling Capacitance	C_C	0.35	pF	

	-1	-2	-3	-4	
CTR[1], I_F =10 mA, V_{CE}=5 V	40-80	63-125	100-200	160-320	%
CTR[1], I_F =1 mA, V_{CE}=5 V	13 min.	22 min.	34 min.	56 min.	%
I_{CEO} (V_{CE}=10 V)	2 (≤50)	2 (≤50)	5 (≤100)	5 (≤100)	nA

CTR will match within a ratio of 1.7:1

Switching Characteristics

Linear Operation (without saturation) I_F=10 mA, V_{CC}=5 V, R_C=75 Ω, Typical

		-1	-2	-3	-4	
Turn on time	t_{on}	3.0	3.2	3.6	4.1	µs
Rise time	t_r	2.0	2.5	2.9	3.3	µs
Turn off time	t_{off}	2.3	2.9	3.4	3.7	µs
Fall time	t_f	2.0	2.6	3.1	3.5	µs

Switching Operation (with saturation) V_{CC}=5 V, R_C=1 Ω, Typical

		-1 I_F = 20 mA	-2 I_F = 10 mA	-3 I_F = 10 mA	-4 I_F = 5 mA	
Turn on time	t_{on}	3.0	4.3	4.6	6.0	µs
Rise time	t_r	2.0	2.8	3.3	4.6	µs
Turn off time	t_{off}	18	2.9	3.4	25	µs
Fall time	t_f	11	2.6	3.1	15	µs

Figure 1. Forward voltage versus forward current

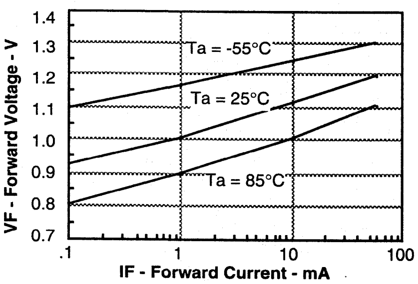


Figure 2. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

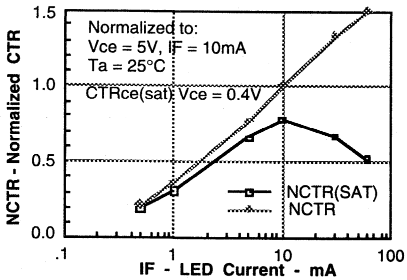


Figure 3. Normalized non-saturated and saturated CTR at T_A=50°C versus LED current

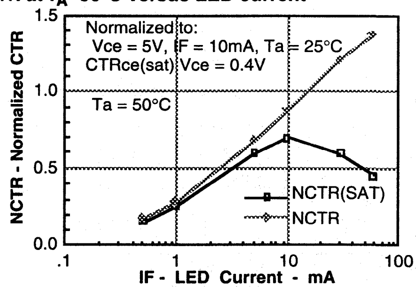


Figure 4. Normalized non-saturated and saturated CTR at T_A=70°C versus LED curent

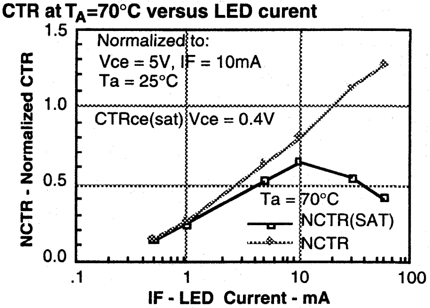


Figure 5. Normalized non-saturated and saturated CTR at T_A=85°C versus LED current

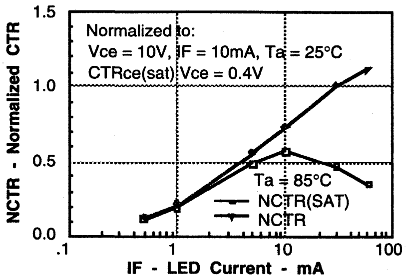


Figure 6. Collector-emitter current versus temperature and LED current

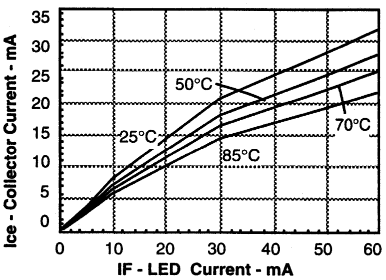


Figure 7. Collector-emitter leakage current versus temperature

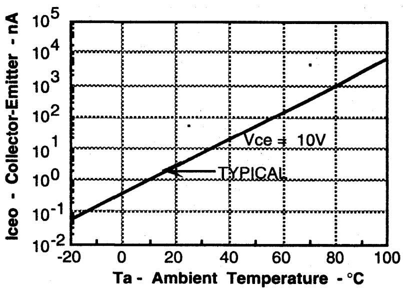


Figure 8. Propagation delay versus collector load resistor

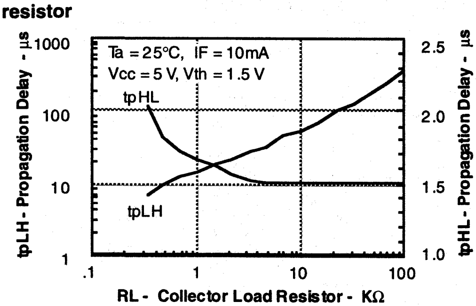


Figure 9. Switching timing

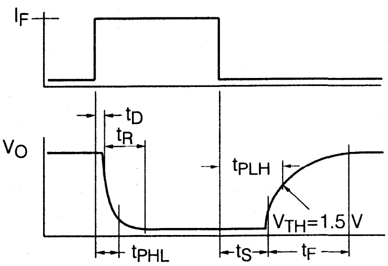


Figure 10. Non-saturated switching schematic

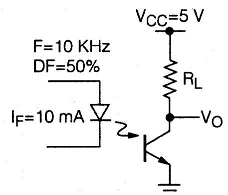
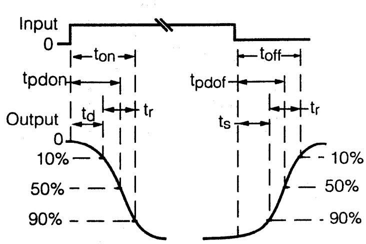


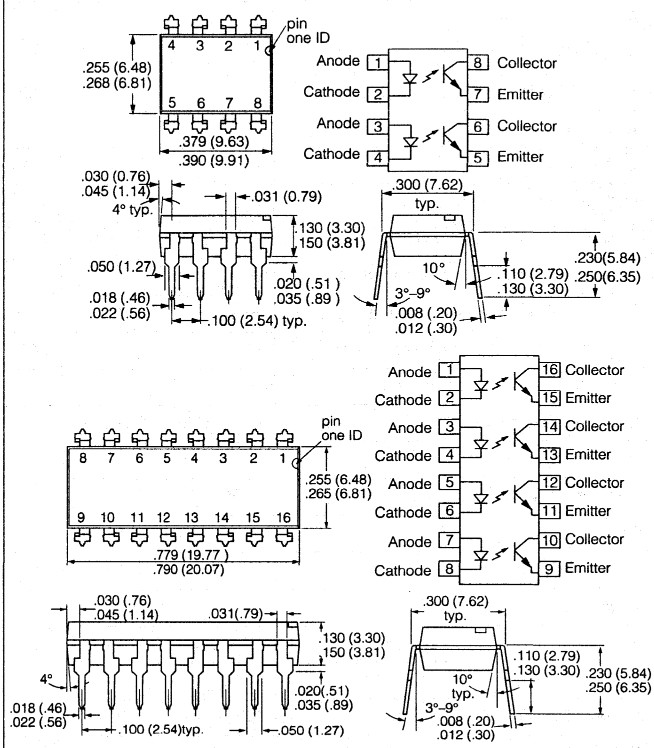
Figure 11. Saturated switching time test waveform



SIEMENS

DUAL CHANNEL ILD615
QUAD CHANNEL ILQ615
Phototransistor Optocoupler

Dimensions in inches (mm)



FEATURES

- **Identical Channel to Channel Footprint**
- **Current Transfer Ratio (CTR) Range at I_F=10 mA**
  ILD/Q615-1: 40 – 80% Min.
  ILD/Q615-2: 63 – 125% Min.
  ILD/Q615-3: 100 – 200% Min.
  ILD/Q615-4: 160 – 320% Min.
- **Guaranteed CTR at I_F=1 mA**
  ILD/Q615-1: 13% Min.
  ILD/Q615-2: 22% Min.
  ILD/Q615-3: 34% Min.
  ILD/Q615-4: 56% Min.
- **High Collector-Emitter Voltage BV_{CEO}=70 V**
- **Dual and Quad Packages Feature:**
  - **Reduced Board Space**
  - **Lower Pin and Parts Count**
  - **Better Channel to Channel CTR Match**
  - **Improved Common Mode Rejection**
- **Field-Effect Stable by TRIOS (TRansparent IOn Shield)**
- **Isolation Test Voltage from Double Molded Package, 5300 VAC_{RMS}**
- **UL Approval #E52744**
- **VDE #0884 Available with Option 1**

Maximum Ratings (Each Channel)

Emitter

Reverse Voltage .... 6 V
Forward Current .... 60 mA
Surge Current .... 1.5 A
Power Dissipation .... 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C

Detector

Collector-Emitter Reverse Voltage .... 70 V
Emitter-Collector Reverse Voltage .... 7 V
Collector Current .... 50 mA
Collector Current (t <1 ms) .... 100 mA
Power Dissipation .... 150 mW
Derate Linearly from 25°C .... 2 mW/°C

Package

Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature
(2 mm distance from case bottom) .... 260°C
Package Power Dissipation, ILD615 .... 400 mW
Derate Linearly from 25°C .... 5.33 mW/°C
Package Power Dissipation, ILQ615 .... 500 mW
Derate Linearly from 25°C .... 6.67 mW/°C
Isolation Test Voltage (t=1 sec.) .... 5300 VAC_{RMS}
Creepage .... 7 mm min.
Clearance .... 7 mm min.
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}\ \Omega$

DESCRIPTION

The ILD/Q615 are multi-channel phototransistor optocouplers that use GaAs IRLED emitters and high gain NPN phototransistors. These devices are constructed using over/under leadframe optical coupling and double molded insulation technology resulting a Withstand Test Voltage of 7500 VAC_{PEAK} and a Working Voltage of 1700 VAC_{RMS}.

The binned min./max. and linear CTR characteristics combined with the TRIOS (TRansparent IOn Shield) field-effect process make these devices well suited for DC or AC voltage detection. Eliminating the phototransistor base connection provides added electrical noise immunity from the transients found in many industrial control environments.

Because of guaranteed maximum non-saturated and saturated switching characteristics, the ILD/Q615 can be used in medium speed data I/O and control systems. The binned min./max. CTR specification allow easy worst case interface calculations for both level detection and switching applications. Interfacing with a CMOS logic is enhanced by the guaranteed CTR at an I_F=1 mA.

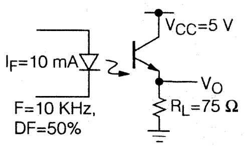
See Appnote 45, "How to Use Optocoupler Normalized Curves."

Characteristics T_A=25°C

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F	1	1.15	1.3	V	I_F=10 mA
Breakdown Voltage	V_{BR}	6	30		V	I_R=10 µA
Reverse Current	I_F		0.01	10	µA	V_R=6 V
Capacitance	C_O		25		pF	V_R=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		750		°C/W	
Detector						
Capacitance	C_{CE}		6.8		pF	V_{CE}=5 V, f=1 MHz
Collector-Emitter Leakage Current, -1, -2	I_{CEO}		2	50	nA	V_{CE}=10 V
Collector-Emitter Leakage Current, -3, -4	I_{CEO}		5	100	nA	V_{CE}=10 V
Collector-Emitter Breakdown Voltage	BV_{CEO}	70			V	I_{CE}=0.5 mA
Emitter-Collector Breakdown Voltage	BV_{ECO}	7			V	I_E=0.1 mA
Thermal Resistance, Junction to Lead	R_{THJL}		500		°C/W	
Package Transfer Characteristics						
Channel/Channel CTR Match	CTRX/CTRY	1 to 1		2 to 1		I_F=10 mA, V_{CE}=5 V
ILD/Q615-1						
Saturated Current Transfer Ratio	CTR_{CEsat}		25		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio	CTR_{CE}	40	60	80	%	I_F=10 mA, V_{CE}=5 V
Current Transfer Ratio	CTR_{CE}	13	30		%	I_F=1 mA, V_{CE}=5 V
ILD/Q615-2						
Saturated Current Transfer Ratio	CTR_{CEsat}		40		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio	CTR_{CE}	63	80	125	%	I_F=10 mA, V_{CE}=5 V
Current Transfer Ratio	CTR_{CE}	22	45		%	I_F=1 mA, V_{CE}=5 V
ILD/Q615-3						
Saturated Current Transfer Ratio	CTR_{CEsat}		60		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio	CTR_{CE}	100	150	200	%	I_F=10 mA, V_{CE}=5 V
Current Transfer Ratio	CTR_{CE}	34	70		%	I_F=1 mA, V_{CE}=5 V
ILD/Q615-4						
Saturated Current Transfer Ratio	CTR_{CEsat}		100		%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio	CTR_{CE}	160	200	320	%	I_F=10 mA, V_{CE}=5 V
Current Transfer Ratio	CTR_{CE}	56	90		%	I_F=1 mA, V_{CE}=5 V
Isolation and Insulation						
Common Mode Rejection, Output High	CMH		5000		V/µs	V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=0 mA
Common Mode Rejection, Output Low	CML		5000		V/µs	V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=10 mA
Common Mode Coupling Capacitance	C_{CM}		0.01		pF	
Package Capacitance	CI-O	0.8			pF	V_{IO}=0 V, f=1 MHz
Insulation Resistance	R_S		10^{14}		W	V_{IO}=500 V, T_A=25°C
Channel to Channel Isolation		500			VAC	

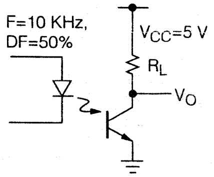
SWITCHING TIMES

Figure 1. Non-saturated switching timing



Parameter	Typ.	Unit	Test Condition
t_{ON}	3.0	μs	R_L=75 Ω I_F=10 mA V_{CC}=5 V
t_R	2.0	μs	
t_{OFF}	2.3	μs	
t_F	2.0	μs	
t_{PHL} Propagation H-L (50% of V_{PP})	1.1	μs	
t_{PHL} Propagation L-H	2.5	μs	

Figure 2. Saturated switching timing



Parameter	-1 I_F=20 mA Typ.	-1,-3 I_F=10 mA Typ.	-4 I_F=5mA Typ.	Unit	Test Condition
t_{ON}	3.0	4.3	6.0	μs	R_L=1 Ω V_{CC}=5 V V_{TH}=1.5 V
t_R	2.0	2.8	4.6	μs	
t_{OFF}	18	25	25	μs	
t_F	11	14	15	μs	
t_{PHL} Propagation H-L	1.6	2.6	5.4	μs	
t_{PLH} Propagation L-H	8.6	7.2	7.4	μs	

Figure 3. Non-saturated switching timing

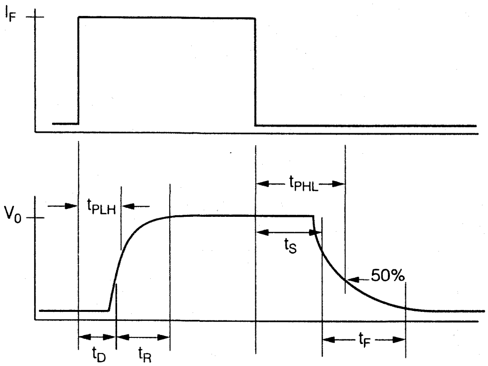


Figure 4. Saturated switching timing

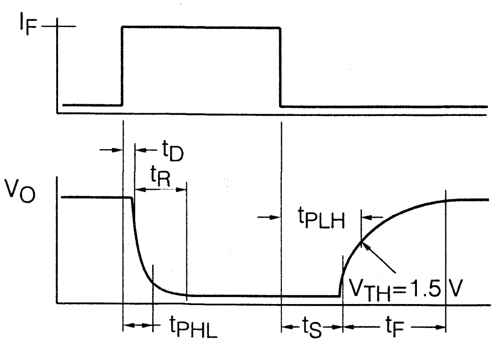


Figure 5. Maximum LED current versus ambient temperature

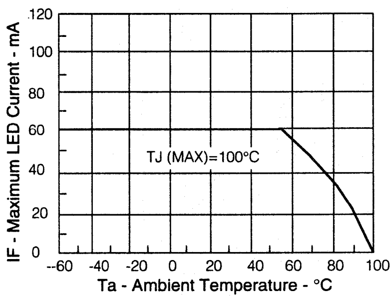


Figure 6. Maximum LED power dissipation

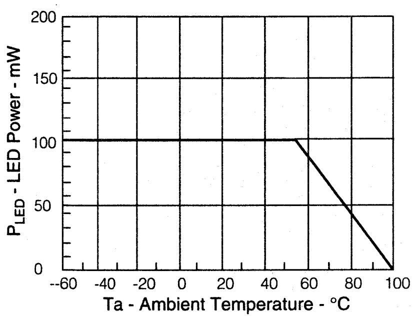


Figure 7. Forward voltage versus forward current

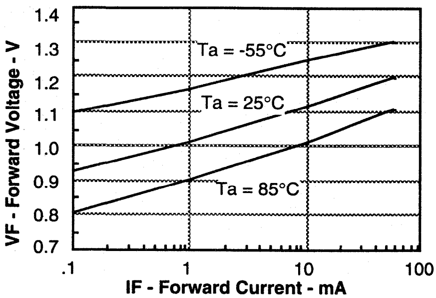


Figure 8. Peak LED current versus pulse detection, Tau

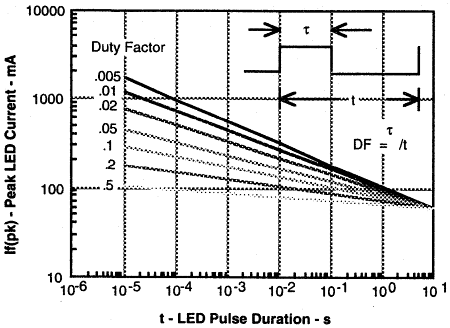


Figure 9. Maximum detector power dissipation

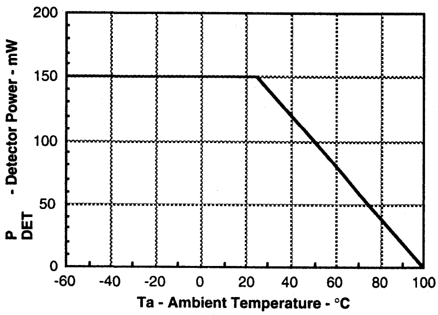


Figure 10. Maximum collector current versus collector voltage

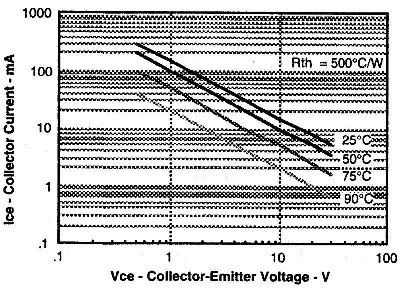


Figure 11. Normalization factor for non-saturated and saturated CTR T_A=25°C versus if

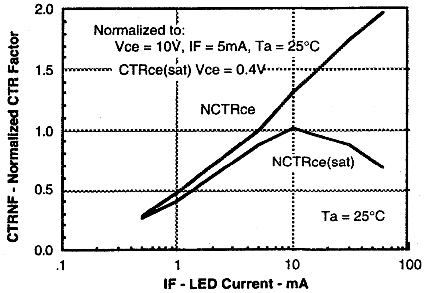


Figure 12. Normalization factor for non-saturated and saturated CTR T_A=50°C versus if

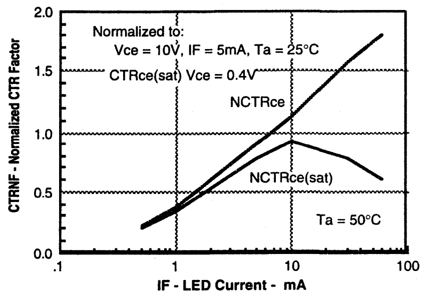


Figure 13. Normalization factor for non-saturated and saturated CTR T_A=70°C versus if

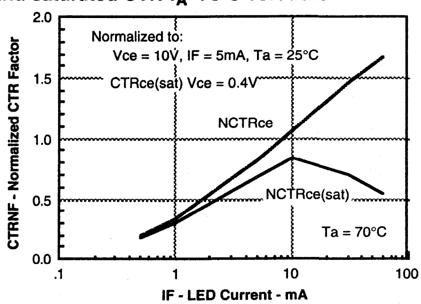


Figure 14. Normalization factor for non-saturated and saturated CTR T_A=85°C versus if

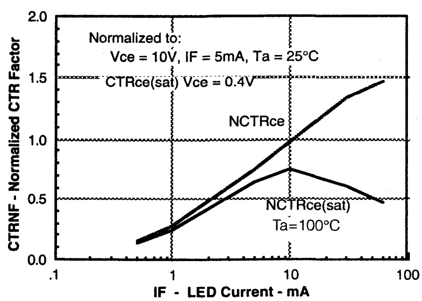


Figure 15. Collector-emitter current versus temperature and LED current

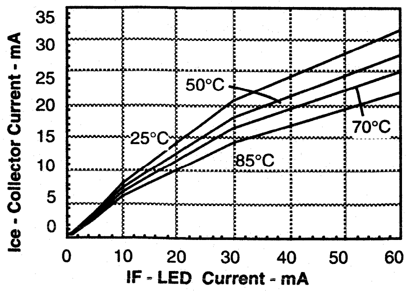


Figure 16. Collector-emitter leakage versus temperature

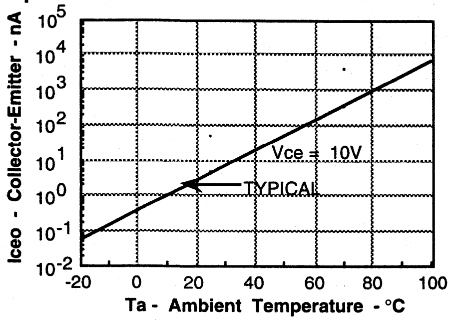


Figure 17. -1 Propagation delay versus collector load resistor

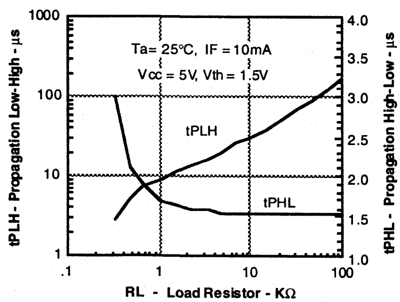


Figure 18. -2, -3 Propagation delay versus collector load resistor

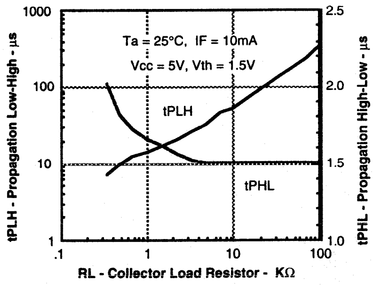
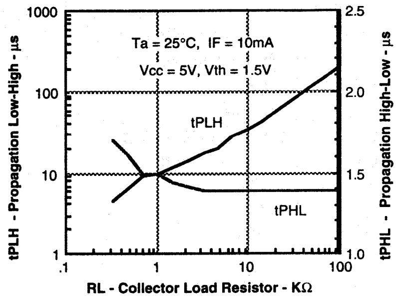


Figure 19. -4 Propagation delay versus collector load resistor



SIEMENS

DUAL CHANNEL ILD620/620GB
QUAD CHANNEL ILQ620/620GB
AC Input Phototransistor Optocoupler

FEATURES

- **Identical Channel to Channel Footprint**
  ILD620 Crosses to TLP620-2
  ILQ620 Crosses to TLP620-4
- **Current Transfer Ratio (CTR) at $I_F = \pm 5$ mA**
  ILD/Q620: 50% Min.
  ILD/Q620GB: 100% Min.
- **Saturated Current Transfer Ratio (CTR_{SAT}) at $I_F = \pm 1$ mA**
  ILD/Q620: 60% Typ.
  ILD/Q620GB: 30% Min.
- **High Collector-Emitter Voltage, BV_{CEO}=70 V**
- **Dual and Quad Packages Feature:**
  - **Reduced Board Space**
  - **Lower Pin and Parts Count**
  - **Better Channel to Channel CTR Match**
  - **Improved Common Mode Rejection**
- **Field-Effect Stable by TRIOS (TRansparent IOn Shield)**
- **Isolation Test Voltage from Double Molded Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

Maximum Ratings (Each Channel)

Emitter

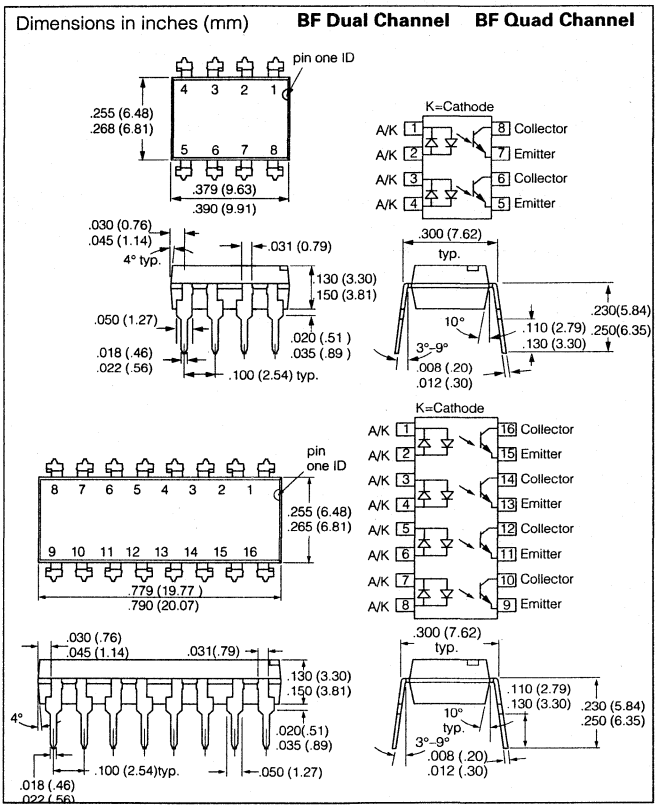
Forward Current ....±60 mA
Surge Current .... ±1.5 A
Power Dissipation ....100 mW
Derate from 25°C ....1.3 mW/°C

Detector

Collector-Emitter Breakdown Voltage ....70 V
Collector Current .... 50 mA
Collector Current (t <1 ms)..........................100 mA
Power Dissipation ....150 mW
Derate from 25°C...................................... 2 mW/°C

Package

Isolation Test Voltage(t=1 sec.) ....5300 VAC_{RMS}
Package Dissipation, ILD620/GB.............. 400 mW
Derate from 25°C...............................5.33 mW/°C
Package Dissipation, ILQ620/GB.............. 500 mW
Derate from 25°C...............................6.67 mW/°C
Creepage... 7 mm min.
Clearance .... 7 mm min.
Isolation Resistance
V_{IO}=500 V, T_A=25°C..............................$\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C...........................$\geq 10^{11}\ \Omega$
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature
(2 mm from case bottom) ....260°C



DESCRIPTION

The ILD/Q620 and ILD/Q620GB are multi-channel input phototran-sistor optocouplers that use inverse parallel GaAs IRLED emitters and high gain NPN silicon phototransistors per channel. These devices are constructed using over/under leadframe optical coupling and double molded insulation resulting in a Withstand Test Voltage of 7500 VAC_{PEAK}.

The LED parameters and the linear CTR characteristics combined with the TRIOS field-effect process make these devices well suited for AC voltage detection. The ILD/Q620GB with its low IF guaranteed CTR_{CEsat} minimizes power dissipation of the AC voltage detection network that is placed in series with the LEDs. Eliminating the phototransistor base connection provides added electrical noise immunity from the transients found in many industrial control environments.

Characteristics

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F	1	1.15	1.3	V	I_F=±10 mA
Forward Current	I_F		2.5	20	µA	V_R=±0.7 V
Capacitance	C_O		25		pF	V_F=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		750		°C/W	
Detector						
Capacitance	C_{CE}		6.8		pF	V_{CE}=5 V, f=1 MHz
Collector-Emitter Leakage Current	I_{CEO}		10	100	nA	V_{CE}=24 V
Collector-Emitter Leakage Current	I_{CEO}		2	50	µA	T_A=85°C, V_{CE}=24 V
Thermal Resistance, Junction to Lead	R_{THJL}		500		°C/W	
Package Transfer Characteristics						
Channel/Channel CTR Match	CTRX/CTRY	1 to 1		3 to 1		I_F=±5 mA, V_{CE}=5 V
CTR Symmetry	$I_{CE(RATIO)}$	0.5		2		$I_{CE}(I_F$=–5 mA)/$I_{CE}(I_F$=+5 mA)
Off-State Collector Current	$I_{CE(OFF)}$		1	10	µA	V_F=±0.7 V, V_{CE}=24 V
ILD/Q620						
Saturated Current Transfer Ratio	CTR_{CEsat}		60		%	I_F=±1 mA, V_{CE}=0.4 V
Current Transfer Ratio	CTR_{CE}	50	80	600	%	I_F=±5 mA, V_{CE}=5 V
Collector-Emitter Saturation Voltage	V_{CEsat}			0.4	V	I_F=±8 mA, I_{CE}=2.4 mA
ILD/Q620GB						
Saturated Current Transfer Ratio	CTR_{CEsat}	30			%	I_F=±1 mA, V_{CE}=0.4 V
Current Transfer Ratio (Collector-Emitter)	CTR_{CE}	100	200	600	%	I_F=±5 mA, V_{CE}=5 V
Collector-Emitter Saturation Voltage	V_{CEsat}			0.4	V	I_F=±1 mA, I_{CE}=0.2 mA
Isolation and Insulation						
Common Mode Rejection, Output High	CMH		5000		V/µs	V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=0 mA
Common Mode Rejection, Output Low	CML		5000		V/µs	V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=10 mA
Common Mode Coupling Capacitance	C_{CM}		0.01		pF	
Package Capacitance	CI-O	0.8			pF	V_{I-O}=0 V, f=1 MHz
Insulation Resistance	R_S		10^{12}		W	V_{I-O}=500 V
Channel to Channel Insulation		500			VAC	

Switching Times

Figure 1. Non-saturated switching timing

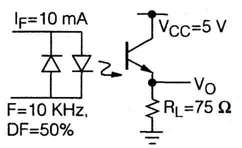


Figure 2. Saturated switching timing

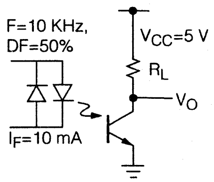


Figure 3. Non-saturated switching timing

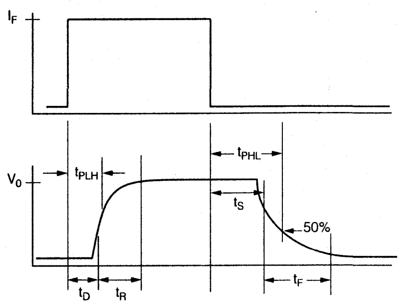
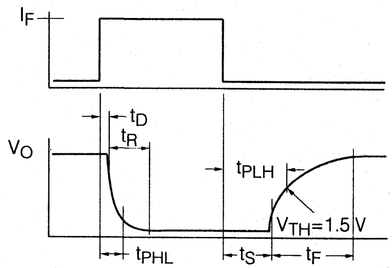


Figure 4. Saturated switching timing



Non-saturated

Characteristic	Symbol	Typ.	Unit	Test Condition
On Time	T_{ON}	3.0	µs	I_F=±10 mA
Rise Time	t_R	20	µs	V_{CC}=5 V
Off Time	t_{OFF}	2.3	µs	R_L=75 Ω
Fall Time	t_F	2.0	µs	50% of V_{PP}
Propagation H-L	t_{PHL}	1.1	µs	
Propagation L-H	t_{PLH}	2.5	µs	

Saturated

Characteristic	Symbol	Typ.	Unit	Test Condition
On Time	T_{ON}	4.3	µs	I_F=±10 mA
Rise Time	t_R	2.8	µs	V_{CC}=5 V
Off Time	t_{OFF}	2.5	µs	R_L=1 Ω
Fall Time	t_F	11	µs	V_{TH}=1.5 V
Propagation H-L	t_{PHL}	2.6	µs	
Propagation L-H	t_{PLH}	7.2	µs	

Figure 5. LED forward current versus forward voltage

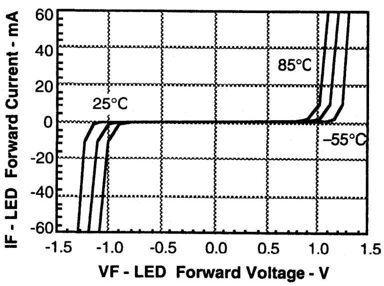


Figure 6. Collector-emitter leakage versus temperature

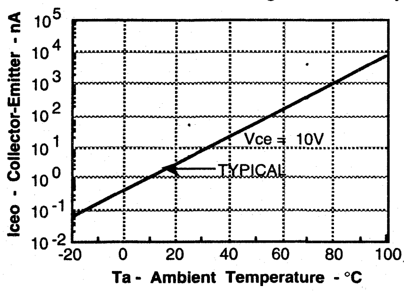


Figure 7. Maximum LED current versus ambient temperature

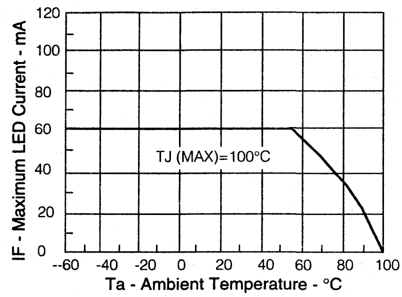


Figure 8. Maximum LED power dissipation

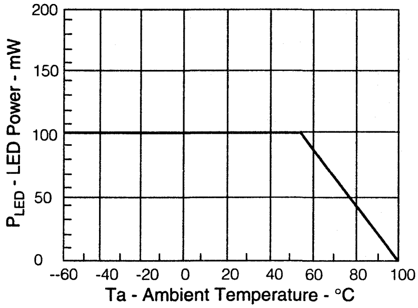


Figure 9. Collector current versus diode forward current

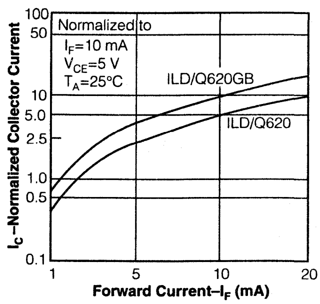


Figure 10. Normalization factor for non-saturated and saturated CTR T_A=50°C versus if

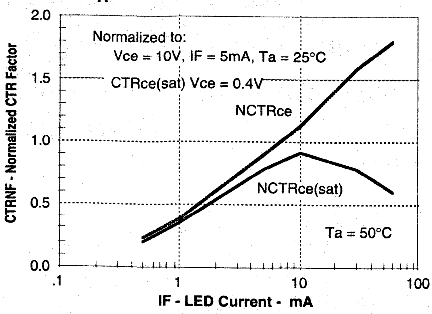


Figure 11. Normalization factor for non-saturated and saturated CTR T_A=70°C versus if

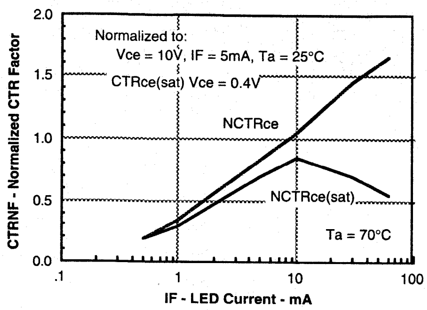


Figure 12. Normalization factor for non-saturated and saturated CTR T_A=100°C versus if

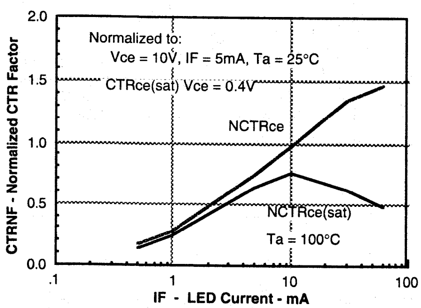


Figure 13. Peak LED current versus peak duration, Tau

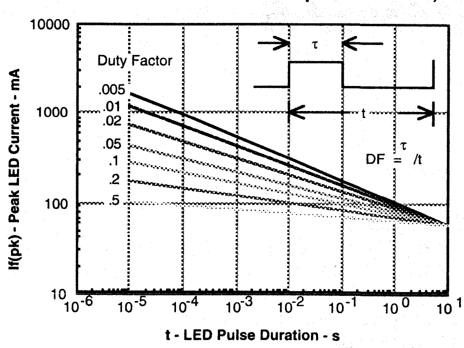


Figure 14. Maximum detector power dissipation

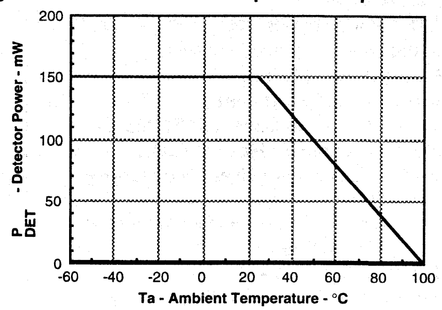
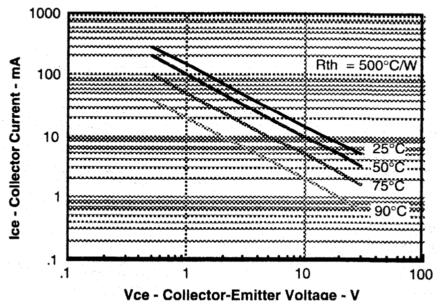


Figure 15. Maximum collector current versus collector voltage



Optocouplers (Optoisolators) 5

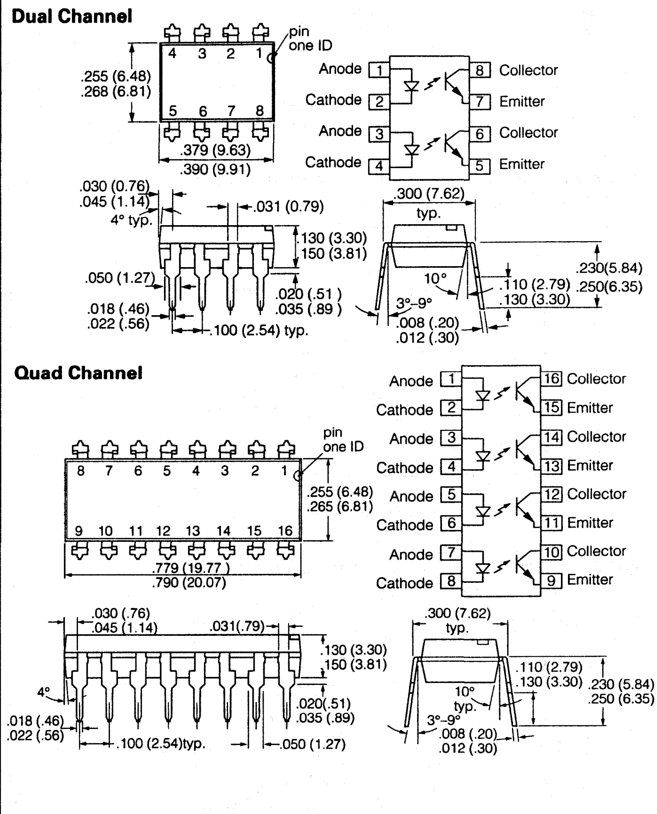
SIEMENS

DUAL CHANNEL ILD621/621GB
QUAD CHANNEL ILQ621/621GB
Multi-Channel Phototransistor Optocoupler

FEATURES

- **Alternate Source to TLP621-2/-4 and TLP621GB-2/-4**
- **Current Transfer Ratio (CTR) at I_F= 5 mA**
  ILD/Q621: 50% Min.
  ILD/Q621GB: 100% Min.
- **Saturated Current Transfer Ratio (CTR_{SAT}) at I_F=1 mA**
  ILD/Q621: 60% Typ.
  ILD/Q621GB: 30% Min.
- **High Collector-Emitter Voltage, BV_{CEO}=70 V**
- **Dual and Quad Packages Feature:**
  - **Reduced Board Space**
  - **Lower Pin and Parts Count**
  - **Better Channel to Channel CTR Match**
  - **Improved Common Mode Rejection**
- **Field-Effect Stable by TRIOS (TRansparent IOn Shield)**
- **Isolation Test Voltage from Double Molded Package, 5300 VAC_{RMS}**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

Dimensions in inches (mm)



Maximum Ratings (Each Channel)

Emitter

Reverse Voltage	6 V
Forward Current	60 mA
Surge Current	1.5 A
Power Dissipation	100 mW
Derate from 25°C	1.33 mW/°C

Detector

Collector-Emitter Reverse Voltage	70 V
Collector Current	50 mA
Collector Current (t <1 ms)	100 mA
Power Dissipation	150 mW
Derate from 25°C	–2 mW/°C

Package

Isolation Test Voltage	
(t=1 sec.)	7500 VAC_{PK}
(t=1 min.)	5300 VAC_{RMS}
Package Dissipation ILD620/GB	400 mW
Derate from 25°C	5.33 mW/°C
Package Dissipation ILQ620/GB	500 mW
Derate from 25°C	6.67 mW/°C
Creepage	7 mm min.
Clearance	7 min min.
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	$\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}\ \Omega$
Storage Temperature	–55°C to +150°C
Operating Temperature	–55°C to +100°C
Junction Temperature	100°C
Soldering Temperature	
(2 mm from case bottom)	260°C

DESCRIPTION

The ILD/Q621 and ILD/Q621GB are multi-channel phototransistor optocouplers that use GaAs IRLED emitters and high gain NPN silicon phototransistors. These devices are constructed using over/under leadframe optical coupling and double molded insulation technology. This assembly process offers a withstand test voltage of 7500 VDC.

The ILD/Q621GB is well suited for CMOS interfacing given the CTR_{CEsat} of 30% minimum at I_F of 1 mA. High gain linear operation is guaranteed by a minimum CTR_{CE} of 100% at 5 mA. The ILD/Q621 has a guaranteed CTR_{CE} of 50% minimum at 5 mA. The TRansparent IOn Shield insures stable DC gain in applications such as power supply feedback circuits, where constant DC V_{IO} voltages are present.

Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F	1	1.15	1.3	V	I_F=10 mA
Reverse Current	I_R		0.01	10	µA	V_R=6 V
Capacitance	C_O		40		pF	V_F=0 V, f=1 MHz
Thermal Resistance, Junction to Lead	R_{THJL}		750		°C/W	
Detector						
Capacitance	C_{CE}		6.8		pF	V_{CE}=5 V, f=1 MHz
Collector-Emitter Leakage Current	I_{CEO}		10	100	nA	V_{CE}=24 V
Collector-Emitter Leakage Current	I_{CEO}		2	50	µA	T_A=85°C, V_{CE}=24 V
Thermal Resistance, Junction to Lead	R_{THJL}		500		°C/W	
Package Transfer Characteristics						
Channel/Channel CTR Match	CTRX/CTRY	1 to 1		3 to 1		I_F=5 mA, V_{CE}=5 V
ILD/Q621						
Saturated Current Transfer Ratio	CTR_{CEsat}		60		%	I_F=1 mA, V_{CE}=0.4 V
Current Transfer Ratio	CTR_{CE}	50	80	600	%	I_F=5 mA, V_{CE}=5 V
Collector-Emitter Saturation Voltage	V_{CEsat}			0.4	V	I_F=8 mA, I_{CE}=2.4 mA
ILD/Q621GB						
Saturated Current Transfer Ratio	CTR_{CEsat}	30			%	I_F=1 mA, V_{CE}=0.4 V
Current Transfer Ratio (Collector-Emitter)	CTR_{CE}	100	200	600	%	I_F=5 mA, V_{CE}=5 V
Collector-Emitter Saturation Voltage	V_{CEsat}			0.4	V	I_F=1 mA, I_{CE}=0.2 mA
Isolation and Insulation						
Common Mode Rejection, Output High	CMH		5000		V/µs	V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=0 mA
Common Mode Rejection, Output Low	CML		5000		V/µs	V_{CM}=50 V_{P-P}, R_L=1 kΩ, I_F=10 mA
Common Mode Coupling Capacitance	C_{CM}		0.01		pF	
Package Capacitance	CI-O	0.8			pF	V_{IO}=0 V, f=1 MHz
Insulation Resistance	R_S	10^{12}			W	V_{IO}=500 V, T_A=25°C
Channel to Channel Insulation		500			VAC	

Switching Times

Figure 1. Non-saturated switching timing

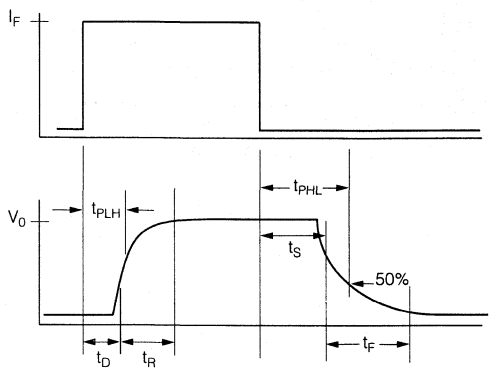
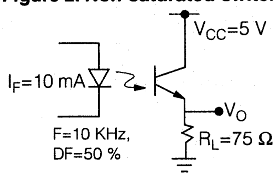


Figure 2. Non-saturated switching timing



Characteristic	Symbol	Typ.	Unit	Test Condition
On Time	T_{ON}	3.0	µs	I_F=±10 mA
Rise Time	t_R	2.0		V_{CC}=5 V
Off Time	t_{OFF}	2.3		R_L=75 Ω
Fall Time	t_F	2.0		50% of V_{PP}
Propagation H-L	t_{PHL}	1.1		
Propagation L-H	t_{PLH}	2.5		

Figure 3. Saturated switching timing

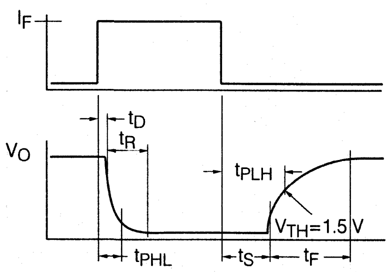
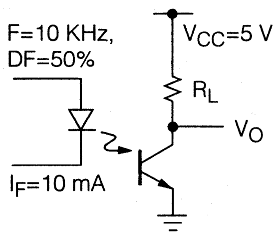


Figure 4. Saturated switching timing



Characteristic	Symbol	Typ.	Unit	Test Condition
On Time	T_{ON}	4.3	µs	I_F=±10 mA
Rise Time	t_R	2.8		V_{CC}=5 V
Off Time	t_{OFF}	2.5		R_L=1 Ω
Fall Time	t_F	11		V_{TH}=1.5 V
Propagation H-L	t_{PHL}	2.6		
Propagation L-H	t_{PLH}	7.2		

Figure 5. Maximum LED current versus ambient temperature

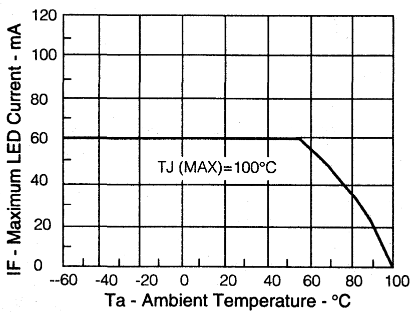


Figure 6. Maximum LED power dissipation

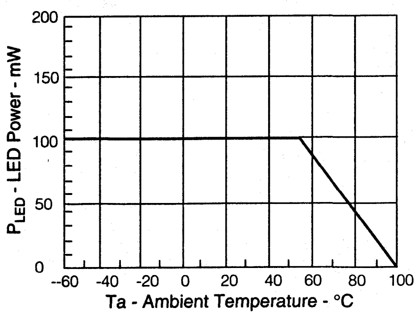


Figure 7. Forward voltage versus forward current

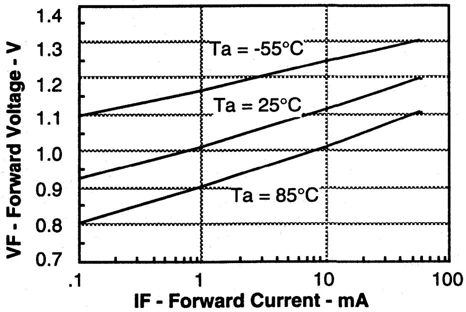


Figure 8. Collector-emitter current versus temperature and LED current

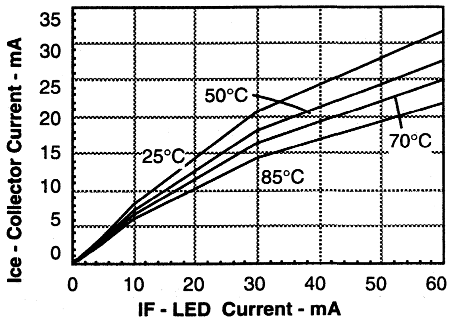


Figure 9. Collector-emitter leakage versus temperature

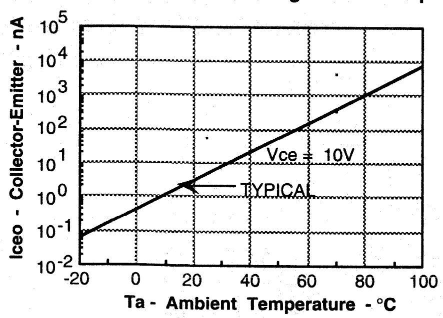


Figure 10. Propagation delay versus collector load resistor

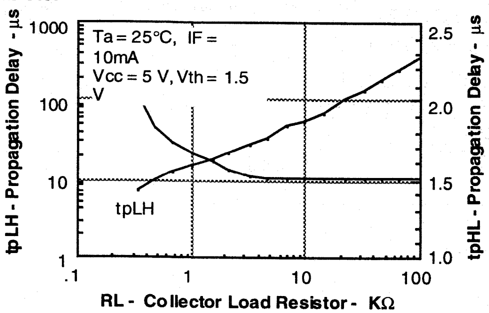


Figure 11. Maximum detector power dissipation

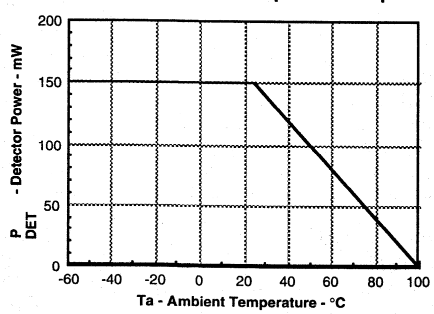


Figure 12. Maximum collector current versus collector voltage

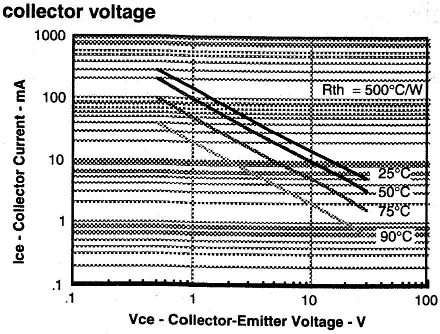


Figure 13. Normalization factor for non-saturated and saturated CTR T_A=50°C versus If

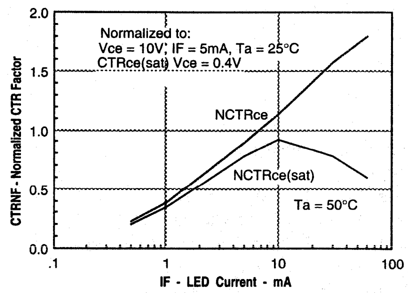


Figure 14. Normalization factor for non-saturated and saturated CTR T_A=70°C versus If

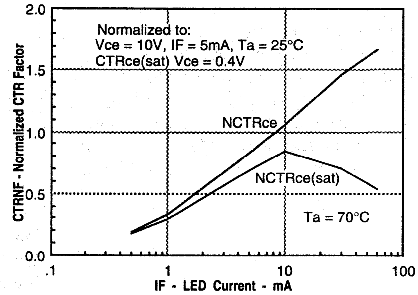


Figure 15. Normalization factor for non-saturated and saturated CTR T_A=100°C versus If

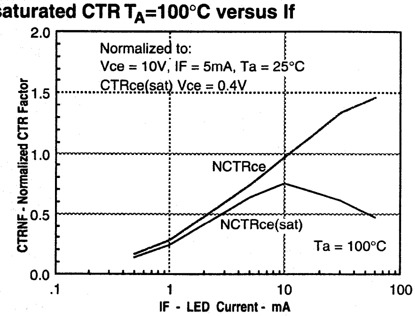
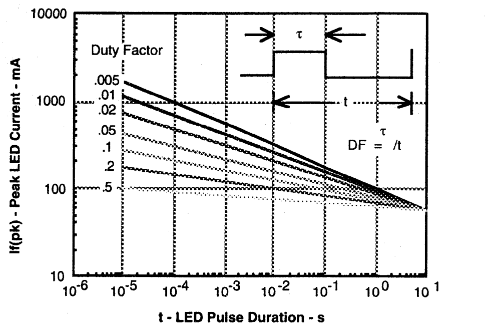


Figure 16. Peak LED current versus pulse duration, Tau



Optocouplers (Optoisolators) 5

SIEMENS

ILH100

Hermetic Phototransistor Optocoupler

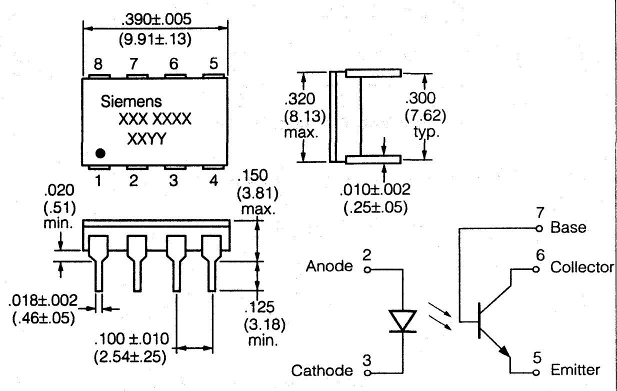
FEATURES

- **Operating Temperature Range, –55°C to +125°C**
- **Current Transfer Ratio Guaranteed from –55°C to +100°C Ambient Temperature Range**
- **High Current Transfer Ratio at Low Input Current**
- **Isolation Test Voltage, 3000 V_{DC}**
- **Base Lead Available for Transistor Biasing**
- **Standard 8 Pin DIP Package**

DESCRIPTION

The ILH100 is designed especially for hi-rel applications requiring optical isolation with high current transfer ratio and low saturation V_{CE}. Each optocoupler consists of a light emitting diode and a NPN silicon phototransistor mounted and coupled in an 8 pin hermetically sealed DIP package. The ILH100's low input current makes it well suited for direct CMOS to LSTTL/TTL interfaces.

Dimensions in inches (mm)



Maximum Ratings

Emitter

Reverse Voltage .... 6.0 V
Forward Current .... 60 mA
Peak Forward Current(1) .... 1 A
Power Dissipation .... 150 mW
Derate Linearly from 25°C .... 1.5 mW/°C

Detector

Collector–Emitter Voltage .... 70 V
Emitter–Base Voltage .... 7 V
Collector–Base Voltage .... 70 V
Continuous Collector Current .... 50 mA
Power Dissipation .... 300 mW
Derate Linearly from 25°C .... 3.0 mW/°C

Package

Input–Output Isolation Test Voltage(2) .... 3000 VDC
Storage Temperature Range .... –65°C to +150°C
Operating Temperature Range .... –55 to +125°C
Junction Temperature .... 150°C
Soldering Time at 240°C, 1.6 mm from case .... 10 sec.
Power Dissipation .... 350 mW
Derate Linearly from 25°C .... 3.5 mW/°C

Notes:

1. Values applies for $P_W \leq 1$ ms, PRR≤300 pps.
2. Measured between pins 1,2,3 and 4 shorted together and pins 5,6,7 and 8 shorted together. T_A=25°C and duration=1 second, RH=45%.

Characteristics T_A=25°C, unless otherwise specified

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.45	1.7	V	I_F=60 mA
Reverse Breakdown Voltage	V_{BR}	6				I_R=10 µA
Reverse Current	I_R		0.01	10	µA	V_R=6 V
Capacitance	C_J		20		pF	V_F=0 V, f=1 MHz
Thermal Resistance	R_{TH}		220		°C/W	Junction to Lead
Detector						
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$		0.25	0.4	V	I_B=20µA, I_{CE}=1 mA
Base-Emitter Voltage	V_{BE}		0.65			I_B=20µA
Collector-Emitter Leakage Current	I_{CEO}		5	50	nA	V_{CE}=10 V
DC Forward Current Gain	HFE	250	400	750		V_{CE}=10 V, I_B=20µA
Saturated DC Forward Gain	$HFE_{(sat)}$	125	200	325		V_{CE}=0.4 V, I_B=20µA
Capacitance	C_{CE}		6.8		pF	V_{CE}=5 V, f=1 MHz
	C_{CB}		8.5			
	C_{EB}		11			
Thermal Resistance	R_{TH}		220		°C/W	Junction to Lead
Coupled Characteristics (-55°C to 100° C)						
Saturated Current Transfer Ratio	$CTR_{(sat)}$	70	210	250	%	I_F=10 mA V_{CE}=0.4 V
Current Transfer Ratio, Collector-Emitter	CTE_{ce}	100	300	450	%	I_F=10 mA, V_{CE}=10 V
Current Transfer Ratio, Collector-Base	CTR_{cb}	0.4	0.7	0.9		I_F=10 mA, V_{CB}=9.3 V
Isolation and Insulation						
Common Mode Rejection Output High	CM_H	1000	2000		V/µs	V_{CM}=500 $V_{p\text{-}p}$, V_{CC}=5 V, R_L=1 KΩ, I_F=0 mA
Common Mode Rejection Output Low	CM_L	1000	2000		V/µs	V_{CM}=500 $V_{p\text{-}p}$, V_{CC}=5 V, R_L=1 KΩ, I_F=10 mA
Package Capacitance	C_{IO}		1.5		pF	V_{IO}=0 V, 1 MHz
Insulation Resistance	R_{IO}	10^{11}	10^{14}		W	V_{IO}=500 VDC
Leakage Current, Input-Output	I_{IO}			10	µA	Relative Humidity ≤50%, V_{IO} 3000 VDC, 5 sec.

Typical Switching Speeds T_A=25°C

Non-Saturated Switching	Symbol	Typ.	Max.	Unit	Test Condition
Delay	td	0.8	2	µs	
Rise	tr	2	5		V_{CC}=5 V
Storage	ts	0.4	1.5		R_L=75 Ω
Fall	tf	2	5		I_F=10 mA
Propagation-High to Low	tpHL	1	3		50% of V_{PP}
Propagation-Low to High	tpLH	1.5	4		R_{BE}=open
Saturated Switching(1)	**Symbol**	**Typ.**	**Max.**		**Test Condition**
Delay	td	0.7	2		V_{CE}=0.4 V
Rise	tr	1	3		V_{CE}=0.4 V
Storage	ts	13.5	30		R_L=1 KΩ
Fall	tf	12			I_F=10 mA
Propagation-High to Low	tpHL	1.4	5		V_{CC}=5 V, V_{TH}=1.5 V
Propagation-Low to High	tpLH	15	40		R_{BE}=open

Figure 1. Switching time waveform and test schematic— non-saturated test condition

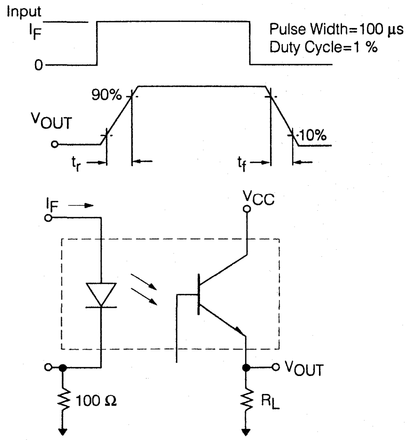


Figure 2. Forward current versus forward voltage and temperature

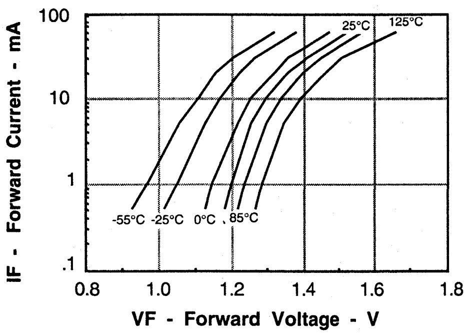


Figure 3. Peak LED current versus duty factor refresh rate and temperature

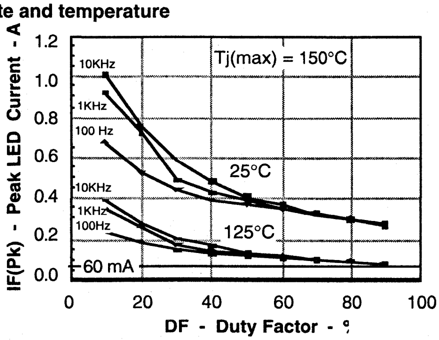


Figure 4. Normalized non-saturated current transfer ratio versus temperature and LED current

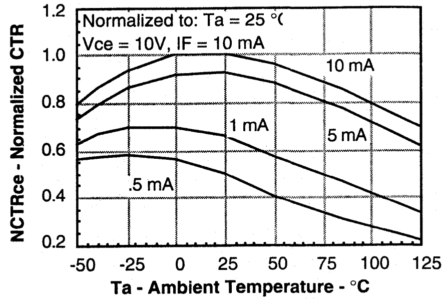


Figure 5. Normalized saturated current transfer ratio versus temperature and LED current

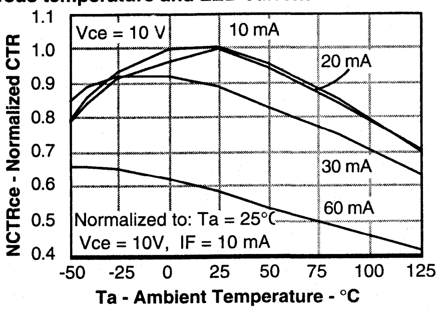


Figure 6. Normalized saturated current transfer ratio versus temperature and LED current

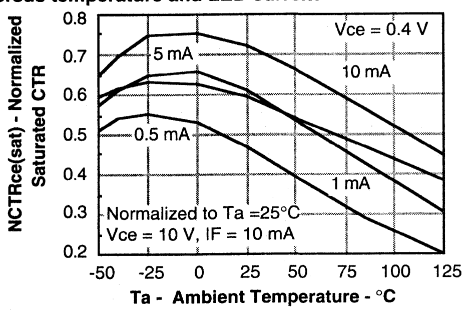


Figure 7. Collector-emitter current versus temperature and LED current

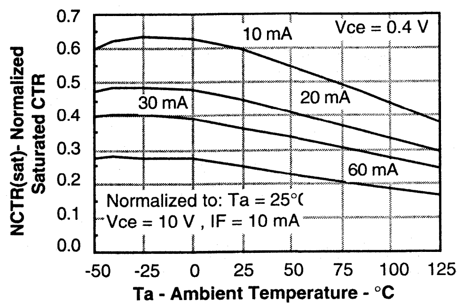


Figure 8. Collector-emitter current versus temperature and LED current

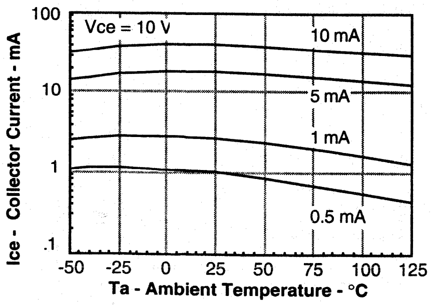


Figure 9. Collector-emitter current versus temperature and LED current

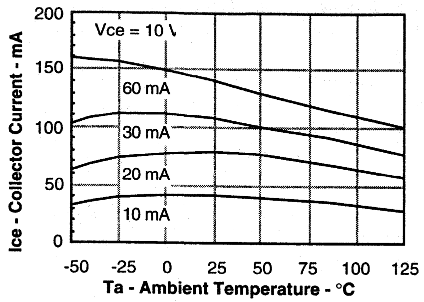


Figure 10. Saturated collector-emitter current versus temperature and LED current

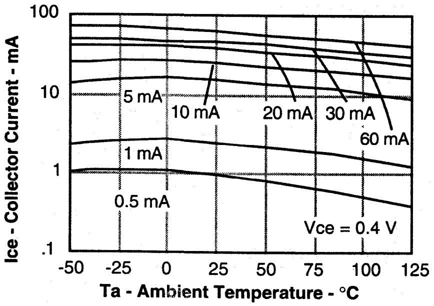


Figure 11. Saturated collector-emitter current versus temperature and LED current

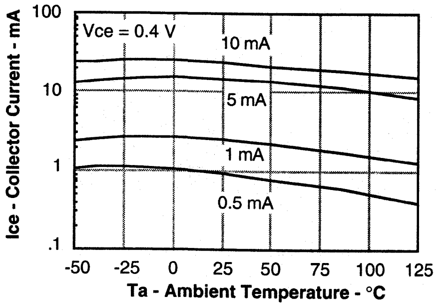


Figure 12. Normalized collector base CRT versus temperature and LED current

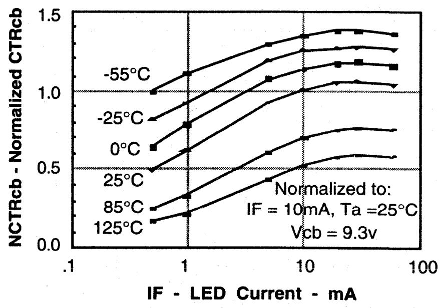


Figure 13. Normalizied Icb photocurrent versus temperature and LED current

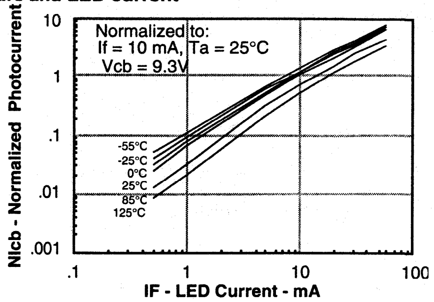


Figure 14. Normalized non-saturated and saturated HFE at T_A=25°C versus base current

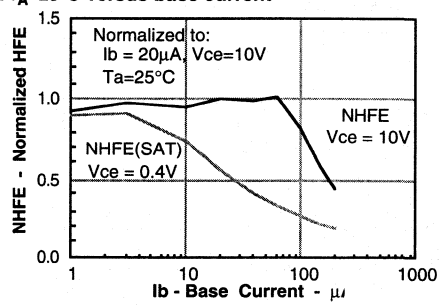


Figure 15. Normalizied non-saturated and saturated HFE at T_A=50°C versus base current

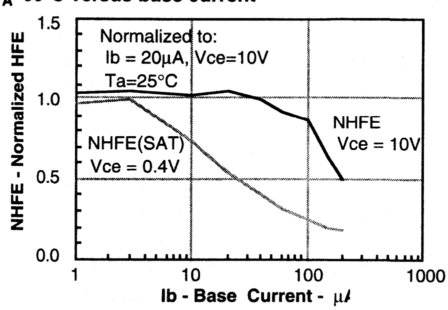


Figure 16. Normalized non-saturated and saturated HFE at T_A=70°C versus base current

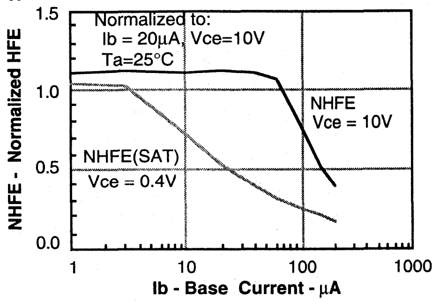


Figure 17. Collector-emitter leakage current versus temperature

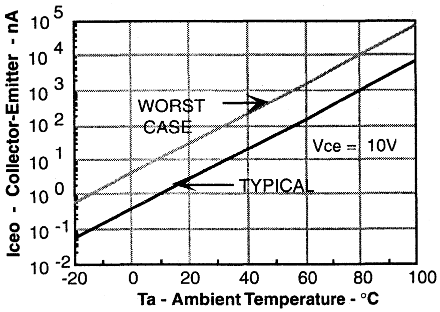


Figure 18. Base emitter voltage versus base current

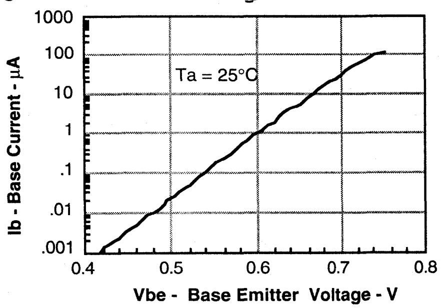


Figure 19. Base emitter capacitance versus base emitter voltage

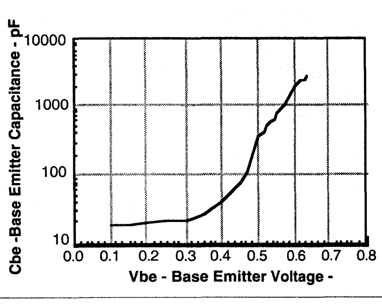


Figure 20. Propagation delay versus temperature and collector load resistance for I_F=5 mA

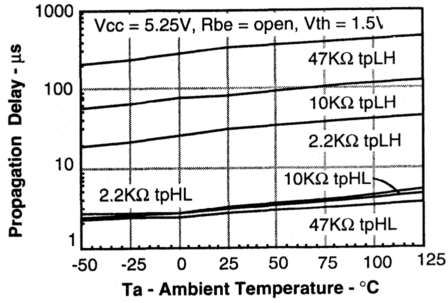


Figure 21. Propagation delay versus temperature and collector load resistance for I_F=10 mA

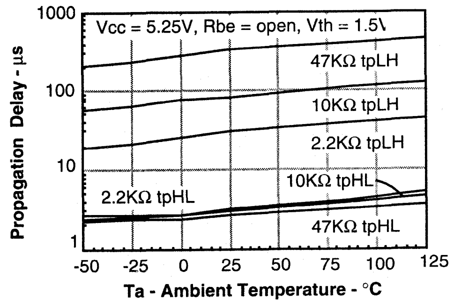


Figure 22. Propagation delay versus temperature and collector load resistance for I_F=20 mA

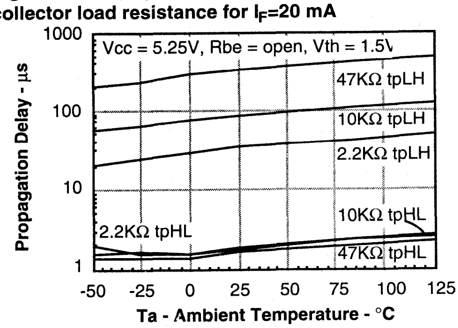


Figure 23. Propagation delay versus temperature and collector load resistance for I_F=5 mA

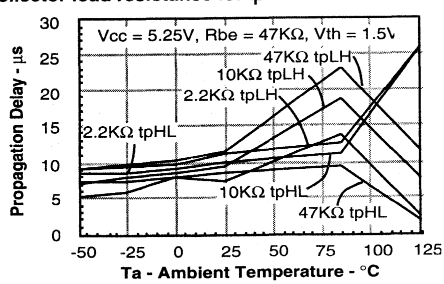


Figure 1. Switching time waveform and test schematic—saturated test condition

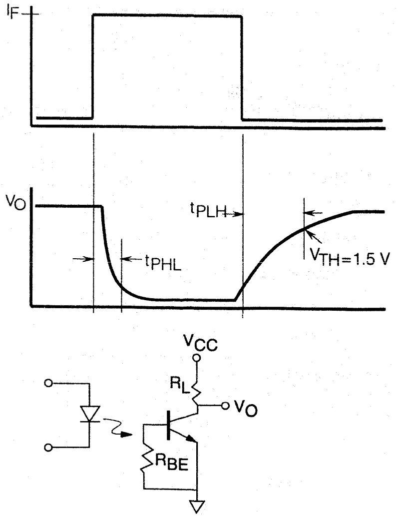


Figure 2. Propagation delay versus temperature and collector load resistance for I_F=10 mA

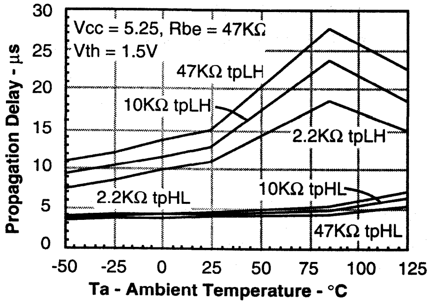


Figure 3. Propagation delay versus temperature and collector load resistance for I_F=20 mA

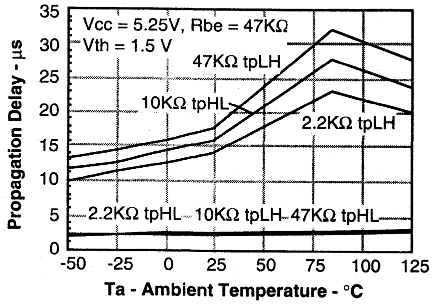


Figure 4. Propagation delay versus collector load and base-emitter resistance for I_F=5 mA

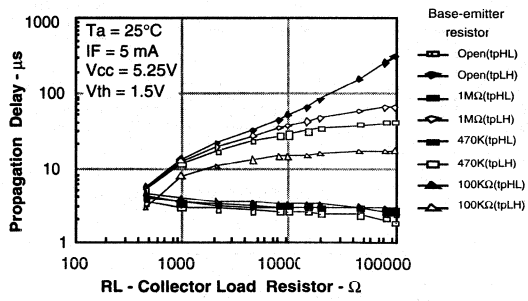


Figure 5. Propagation delay versus collector load and base-emitter resistance for I_F=5 mA

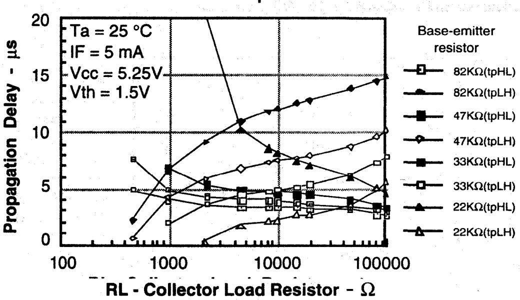


Figure 6. Propagation delay versus collector load and base-emitter resistance for I_F=10 mA

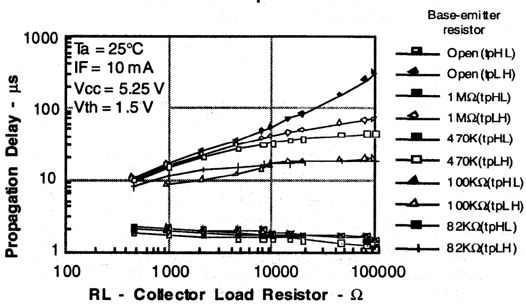


Figure 7. Propagation delay versus collector load and base-emitter resistance for I_F=10 mA

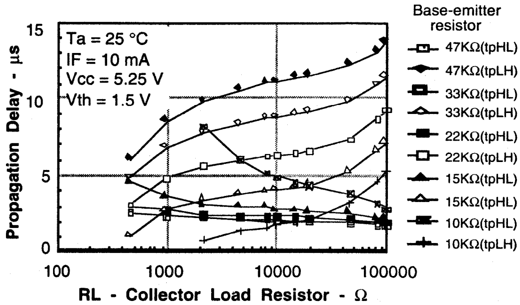


Figure 8. Propagation delay versus collector load and base-emitter resistance for I_F=15 mA

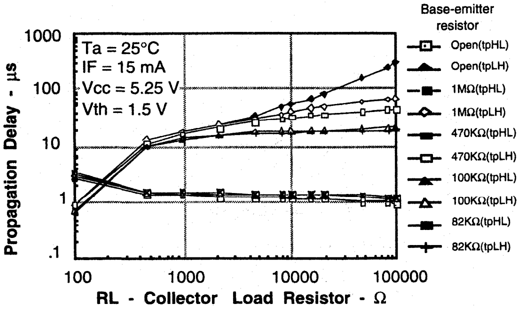


Figure 9. Propagation delay versus collector load and base-emitter resistance for I_F=15 mA

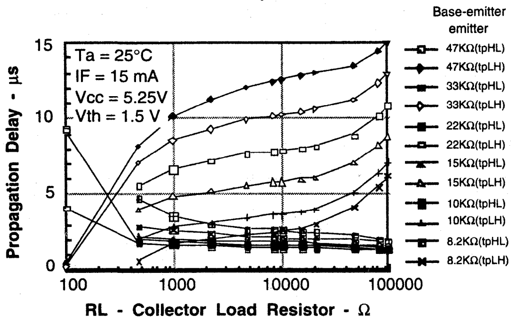


Figure 10. Propagation delay versus collector load and base-emitter resistance for I_F=15 mA

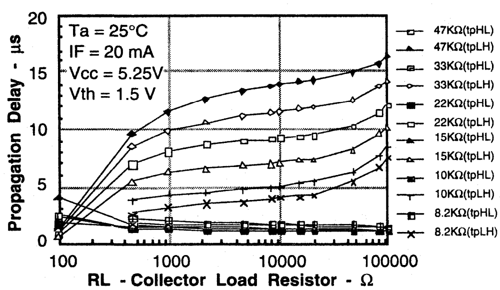


Figure 11. Propagation delay versus collector load and base-emitter resistance for I_F=15 mA

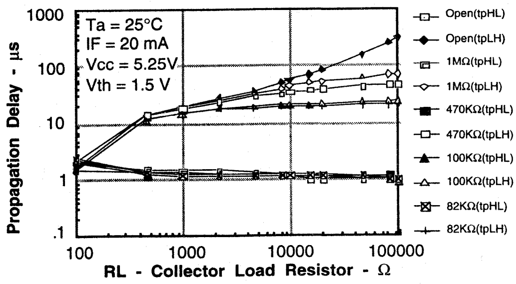
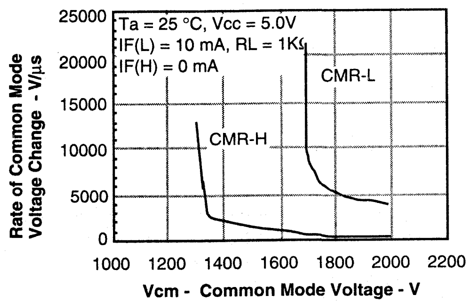


Figure 12. Common mode transient rejection



SIEMENS

ILH200

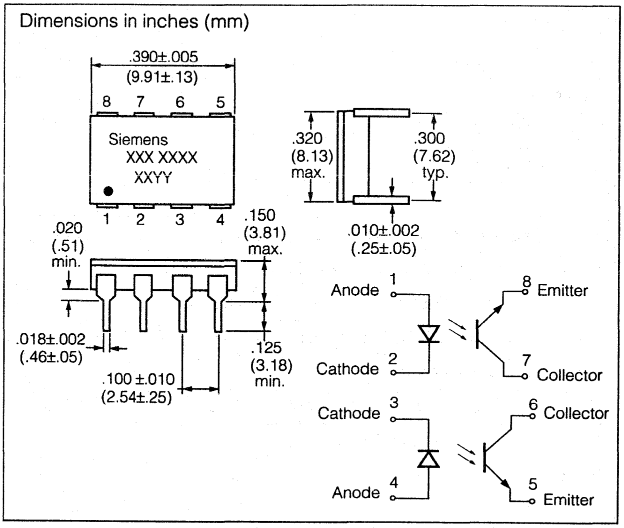
Hermetic Phototransistor Dual Channel Optocoupler

FEATURES

- **Operating Temperature Range, –55°C to +125°C**
- **Current Transfer Ratio Guaranteed from –55°C to +100°C Ambient Temperature Range**
- **High Current Transfer Ratio at Low Input Current**
- **Isolation Test Voltage, 3000 V_{DC}**
- **Two Isolated Channels per Package**
- **Standard 8 Pin DIP Package**

DESCRIPTION

The ILH200 is designed especially for hi-rel applications requiring optical isolation with high current transfer ratio and low saturation V_{CE}. Each channel of the optocoupler consists of a light emitting diode and a NPN silicon phototransistor mounted and coupled in an 8 pin hermetically sealed DIP package. The low input current makes the ILH200 well suited for direct CMOS to LSTTL/TTL interfaces.



Maximum Ratings

Emitter (per channel)

Reverse Voltage	6.0 V
Forward Current	60 mA
Peak Forward Current(1)	1 A
Power Dissipation	75 mW
Derate Linearly from 25°C	0.75 mW/°C

Detector (per channel)

Collector-Emitter Voltage	70 V
Emitter-Collector Voltage	7 V
Continuous Collector Current	50 mA
Power Dissipation	100 mW
Derate Linearly from 25°C	1.0 mW/°C

Package

Input to Output Isolation Test Voltage(2)	3000 VDC
Storage Temperature Range	–65°C to +150°C
Operating Temperature Range	–55°C to +125°C
Junction Temperature	150°C
Soldering Time at 240°C, 1.6 mm from case	10 sec.
Power Dissipation	350 mW
Derate Linearly from 25°C	3.5 mW/°C

Notes:

1. Values applies for $P_W \le 1$ ms, PRR≤300 pps.
2. Measured between pins 1,2,3 and 4 shorted together and pins 5,6,7 and 8 shorted together. T_A=25°C and duration=1 second, RH=45%.

Characteristics (Each Channel) T_A=25°C, unless otherwise specified

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.46	1.7	V	I_F=60 mA
Reverse Breakdown Voltage	V_{BR}	6			V	I_R=10 µA
Reverse Current	I_R		0.01	10	µA	V_R=6 V
Capacitance	C_J		20		pF	V_F=0 V, f=1 MHz
Thermal Resistance	R_{TH}		220		°C/W	Junction to Lead
Detector						
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$		0.25	0.4	V	I_B=20 µA, I_{CE}=1 mA
Collector-Emitter Leakage Current	I_{CEO}		5	50	nA	V_{CE}=10 V
Capacitance	C_{CE}		6.8		pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance	R_{TH}		220		°C/W	Junction to Lead
Coupled Characteristic –55°C to 100°C						
Saturated Current Transfer Ratio	$CTR_{(sat)}$	70	210	250	%	I_F=10 mA, V_{CE}=0.4 V
Current Transfer Ratio Collector-Emitter	CTR_{ce}	100	300	450	%	I_F=10 mA, V_{CE}=10 V
Isolation and Insulation						
Common Mode Rejection, Output High	CM_H	1000	2000		V/µs	V_{CM}=500 V_{p-p}, V_{CC}=5 V, R_L=1 KΩ, I_F=0 mA
Common Mode Rejection, Output Low	CM_L	1000	2000		V/µs	V_{CM}=500 V_{p-p}, V_{CC}=5 V, R_L=1 KΩ, I_F=10 mA
Package Capacitance	C_{IO}		1.5		pF	V_{IO}=0 V, 1 MHz
Insulation Resistance	R_{IO}	10^{11}	10^{14}		W	V_{IO}=500 VDC
Leakage Current, Input–Output	I_{IO}			10	µA	Relative Humidity ≤50%, V_{IO} 3000 VDC, 5 sec.

Typical Switching Speeds T_A=25°C

Non-Saturated Switching	Symbol	Typ.	Max.	Unit	Test Condition
Delay	td	0.8	2	µs	
Rise	tr	2	5	µs	V_{CC}=5 V
Storage	ts	0.4	1.5	µs	R_L=75 Ω
Fall	tf	2	5	µs	I_F=10 mA
Propagation–High to Low	tpHL	1	3	µs	50% of V_{pp}
Propagation–Low to High	tpLH	1.5	4	µs	
Saturated Switching(1)	**Symbol**	**Typ.**	**Max.**	**Unit**	**Test Condition**
Delay	td	0.7	2	µs	
Rise	tr	1	3	µs	V_{CE}=0.4 V
Storage	ts	13.5	30	µs	R_L=1 KΩ
Fall	tf	12	30	µs	I_F=10 mA
Propagation–High to Low	tpHL	1.4	5	µs	V_{CC}=5 V, V_{TH}=1.5 V
Propagation–Low to High	tpLH	15	40	µs	

Figure 1. Forward current versus forward voltage and temperature

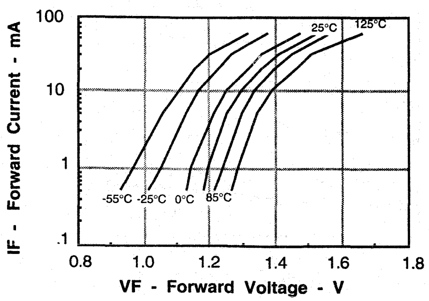


Figure 2. Peak LED current versus duty factor refresh rate and temperature

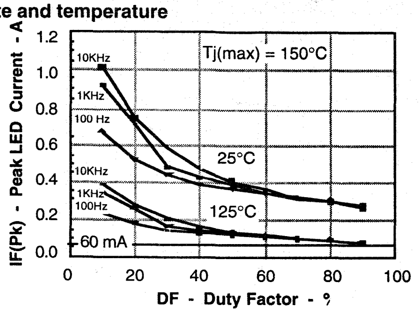


Figure 3. Normalized non-saturated current transfer ratio versus temperature and LED current

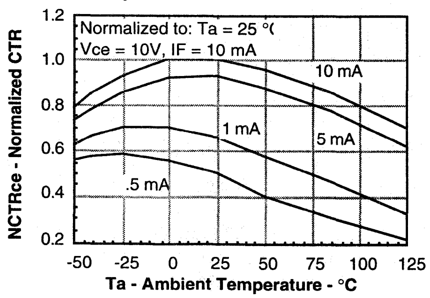


Figure 4. Normalized non-saturated current transfer ratio versus temperature and LED current

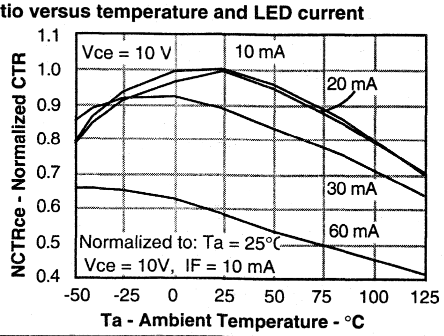


Figure 5. Normalized saturated current transfer ratio versus temperature and LED current

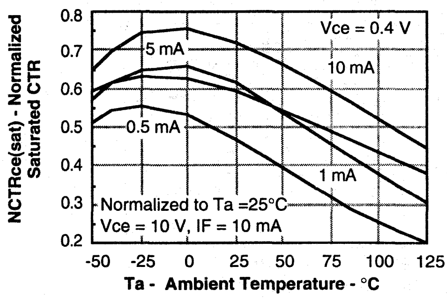


Figure 6. Normalized saturated current transfer ratio versus temperature and LED current

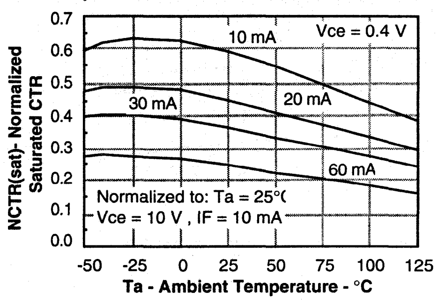


Figure 7. Collector-emitter current versus temperature and LED current

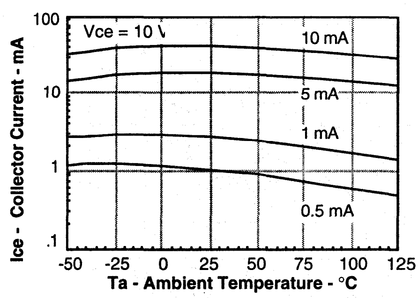


Figure 8. Collector-emitter current versus temperature and LED current

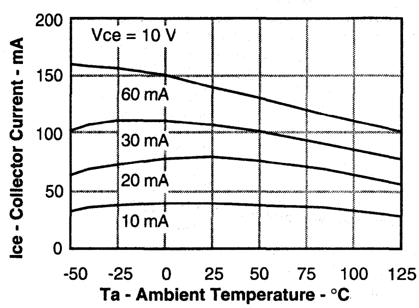


Figure 9. Saturated collector-emitter current versus temperature and LED current

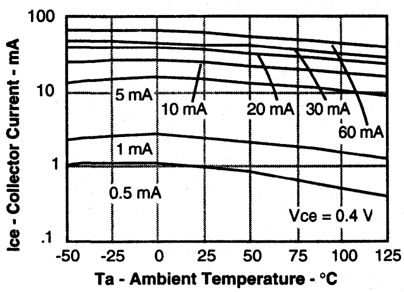


Figure 13. Propagation delay versus temperature and collector load resistance for I_F=10 mA

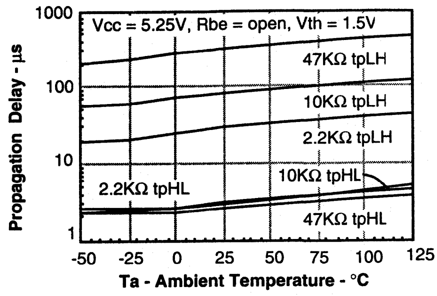


Figure 10. Saturated collector-emitter current versus temperature and LED current

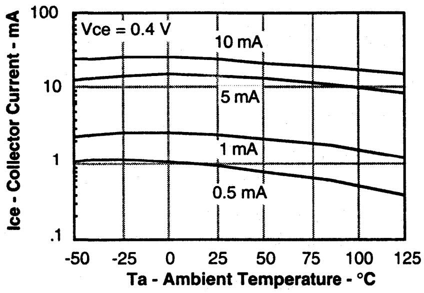


Figure 14. Propagation delay versus temperature and collector load resistance for I_F=20 mA

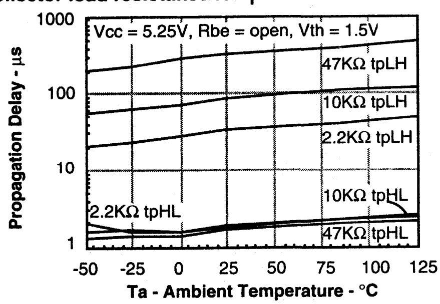


Figure 11. Collector-emitter leakage current versus temperature

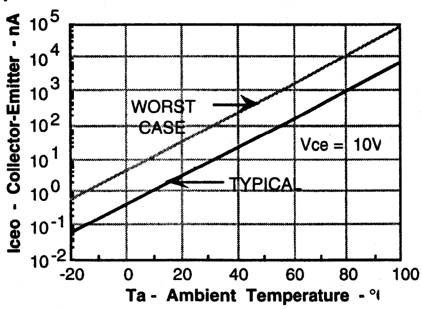


Figure 15. Common mode transient rejection

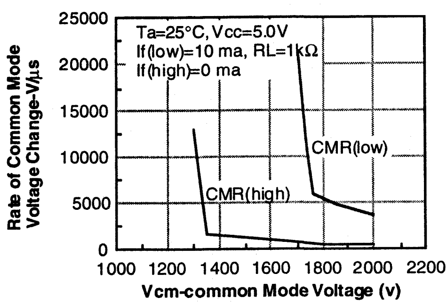


Figure 12. Propagation delay versus temperature and collector load resistance for I_F=5 mA

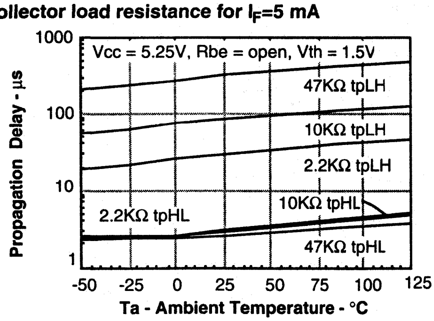
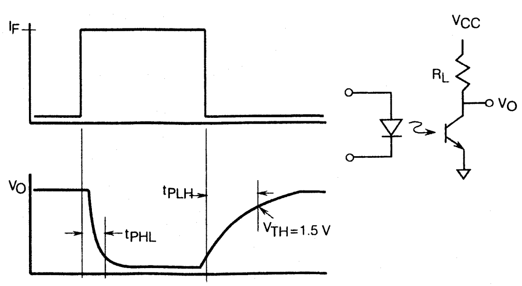


Figure 16. Saturated switching



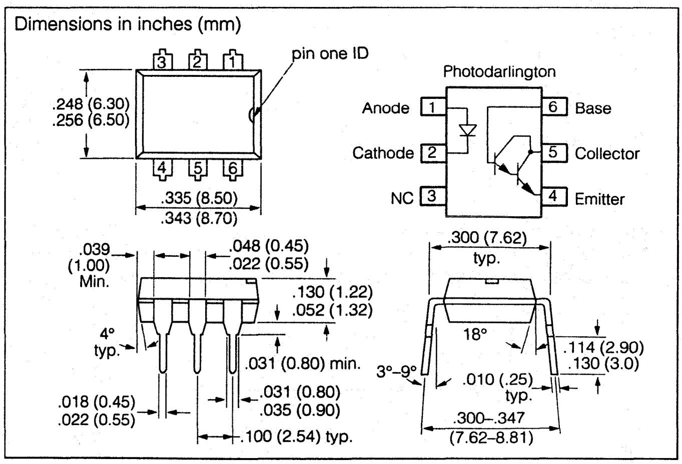
SIEMENS

MCA230/231/255

Photodarlington Optocoupler

FEATURES

- **CTR Minimum**
  MCA230/255, 100%
  MCA231, 200%
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **Coupling Capacitance, 0.5 pF**
- **Fast Rise Time, 10 μs**
- **Fast Fall Time, 35 μs**
- **Underwriters Lab File #E52744**
- **VDE #0884 Available with Option 1**



DESCRIPTION

The MCA230/231/255 are industry standard optocouplers, consisting of a Gallium Arsenide infrared LED and a silicon phototdarlington. These optocouplers are constructed with a high voltage insulation, double molded packaging process which offers 7.5 KV withstand test capability.

Maximum Ratings

Emitter

Reverse Voltage .... 6 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C.................... 135 mW
Derate Linearly from 25°C .... 1.8 mW/°C

Detector

Collector-Emitter Breakdown Voltage
  MCA230/231 .... 30 V
  MCA255 .... 55 V
Emitter-Collector Breakdown Voltage .... 7 V
Collector-Base Breakdown Voltage
  MCA230/231 .... 30 V
  MCA255 .... 55 V
Power Dissipation at 25°C..................... 210 mW
Derate Linearly from 25°C .... 2.8 mW/°C

Package

Total Package Dissipation at 25°C
  (LED plus Detector) .... 260 mW
Derate Linearly from 25°C .... 3.5 mW/°C
Storage Temperature ....–55°C to +150°C
Operating Temperature ....–55°C to +100°C
Lead Soldering Time at 260°C ....10 sec.
Isolation Test Voltage .... 5300 VAC_{RMS}
Isolation Resistance
  V_{IO}=500 V, T_A=25°C............................ 10^{12} Ω
  V_{IO}=500 V, T_A=100°C........................... 10^{11} Ω

Characteristics (T_A=25°C)

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.1	1.5	V	I_F=50 mA
Reverse Current	I_R			10	μA	V_R=3 V
Junction Capacitance	C_J		50		pF	V_R=3 V
Detector						
BV_{CEO} MCA230/231 MCA255		30 30			V V	I_C=100 μA, I_F=0 mA I_C=100 μA, I_F=0 mA
BV_{ECO}		7			V	I_E=10 μA, I_F=0 mA
BV_{CBO} MCA230/231 MCA55		30 55			V V	I_C=10 μA, I_F=0 mA I_C=10 μA, I_F=0 mA
I_{CEO}				100	nA	V_{CE}=10 V, I_F=0 mA
Package						
V_{CEsat}				0.8 1.0 1.0 1.0 1.2	V V V V V	I_{CE}=2 mA, I_F=16 mA I_C=I_F=50 mA I_C=2 mA, I_F=1 mA I_C=10 mA, I_F=5 mA I_C=50 mA, I_F=10 mA
DC Current Transfer Ratio MCA230/255 MCA231	 CTR CTR	 100 200			 % %	 V_{CE}=5 V, I_F=10 mA V_{CE}=5 V, I_F=1 mA
Capacitance Input to Output	C_{IO}		0.5		pF	
Switching Times	t_{on} t_{off}		10 35		μs μs	R_L=100 Ω V_{CE}=10 V

Figure 1. Forward voltage versus forward current

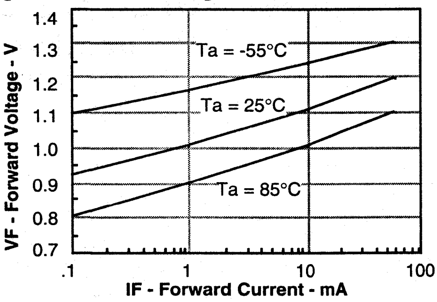


Figure 5. Non-saturated and saturated HFE versus base current

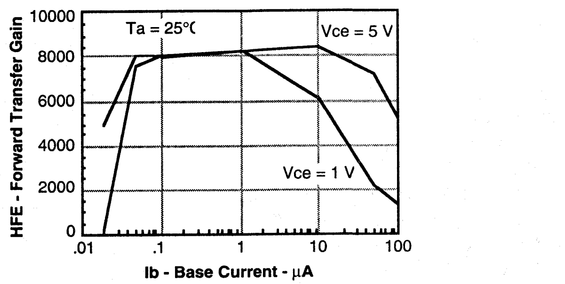


Figure 2. Normalized non-saturated and saturated CTRce at T_A=25°C versus LED current

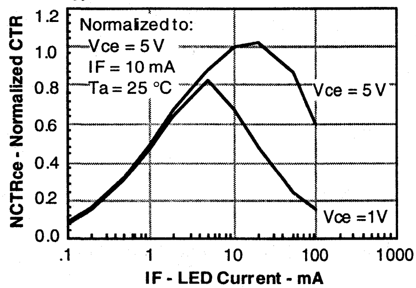


Figure 6. Low to high propagation delay versus collector load resistance and LED current

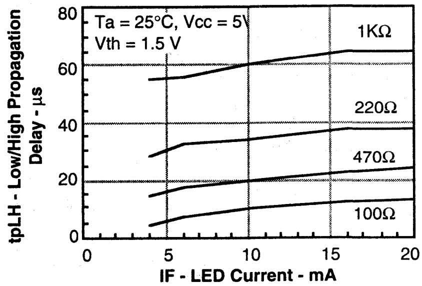


Figure 3. Normalized non-saturated and saturated collector-emitter current versus LED current

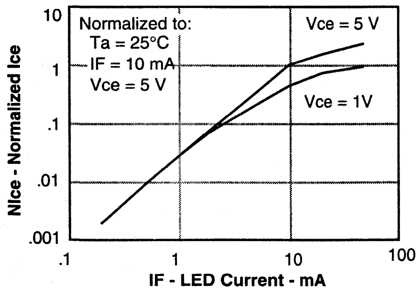


Figure 7. High to low propagation delay versus collector load resistance and LED current

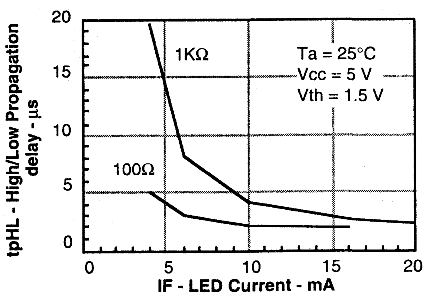


Figure 4. Normalized collector-base photocurrent versus LED current

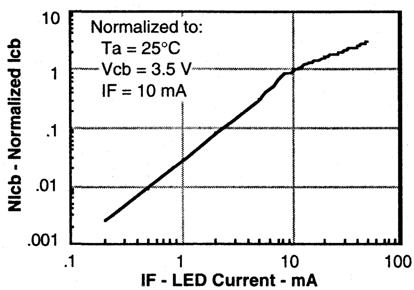
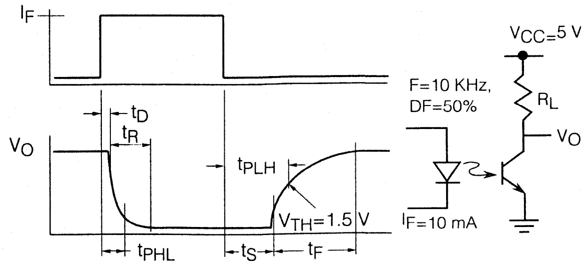


Figure 8. Switching timing waveform and schematic



SIEMENS

MCT6

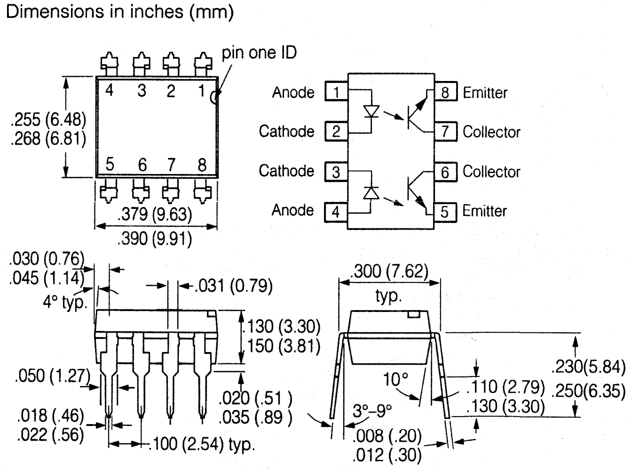
Dual Phototransistor Optocoupler

FEATURES

- **Current Transfer Ratio, 20% Minimum**
- **Two Isolated Channels Per Package**
- **Isolation Text Voltage, 5300 VAC_{RMS}**
- **Underwriters Lab File #E52744**
- **VDE #0884 Available with Option 1**

DESCRIPTION

The MCT6 is an industry standard dual optocoupler consisting of a Gallium Arsenide infrared LED and a silicon phototransistor. The MCT6 is constructed with a high voltage insulation, double molded packaging process which offers 5300 VAC_{RMS} isolation test capability.



Maximum Ratings

Emitter (each channel)

Reverse Voltage .... 3 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C Ambient .... 100 mW
Derate Linearly from 25°C .... 1.3 mW/°C

Detector (each channel)

Collector-Emitter Breakdown Voltage 30V
Emitter-Collector Breakdown Voltage 6V
Power Dissipation at 25°C Ambient .... 150 mW
Derate Linearly from 25°C .... 2 mW/°C

Package

Total Package Dissipation
at 25°C (LED + Detector). .... 400 mW
Derate Linearly from 25°C .... 5.33 mW/°C
Storage Temperature .... –55°C to +150°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.
Isolation Test Voltage .... 5300 VAC_{RMS}
Pollution Degree (DIN VDE 0110) 2
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $R_{IO}=10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $R_{IO}=10^{11}\Omega$

Electrical Characteristics (T_A=25°C)

	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.1	1.5	V	I_F=20 mA
Reverse Current	I_R			10	µA	V_R=3 V
Junction Capacitance	C_J		25		pF	V_F=0 V, f=1 MHz
Detector						
Breakdown Voltage						
Collector-Emitter	BV_{CEO}	30			V	I_C=10 µA, I_F=0 mA
Emitter-Collector	BV_{ECO}	6			V	I_E=10 µA, I_F=0 mA
Package						
DC Current Transfer Ratio	CTR_{DC}	20	50		%	V_{CE}=10 V, I_F=10 mA
Saturation Voltage, Collector-Emitter	V_{CEsat}			0.4	V	I_{CE}=2 mA, I_F=16 mA
Switching Times	t_{on}		3		µs	R_E=100 Ω, V_{CE}=10 V, I_C=2 mA
	t_{off}		15		µs	

Figure 1. Forward voltage versus forward current

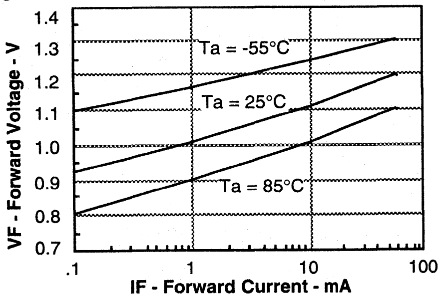


Figure 2. Normalized non-saturated and saturated CTR at T_A=25°C versus LED current

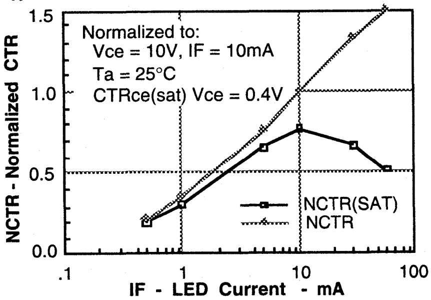


Figure 3. Normalized non-saturated and saturated CTRat T_A=50°C versus LED current

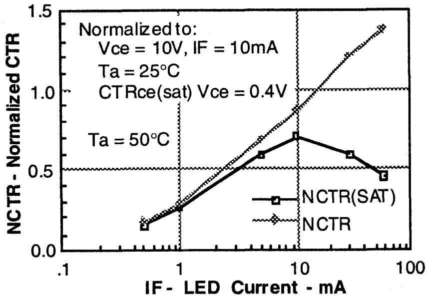


Figure 4. Normalized non-saturated and saturated CTR at T_A=70°C versus LED current

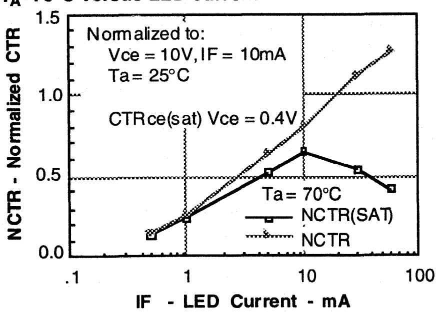


Figure 5. Normalized non-saturated and saturated CTR at T_A=85°C versus LED current

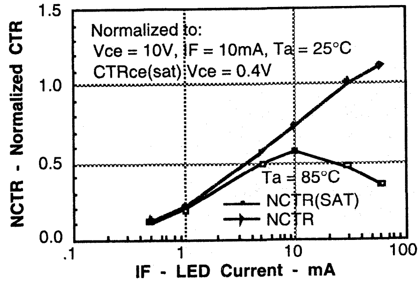


Figure 6. Collector-emitter leakage current versus temperature and LED current

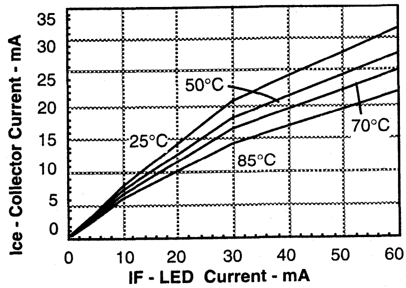


Figure 7. Collector-emitter leakage current versus temperature

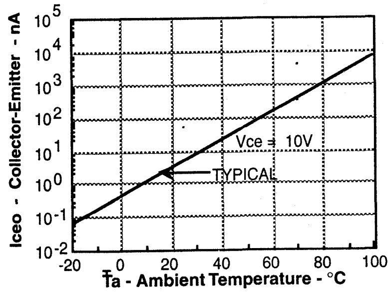


Figure 8. Propagation delay versus collector load resistor

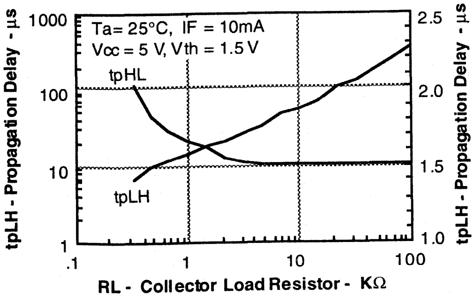


Figure 9. Non-saturated switching timing

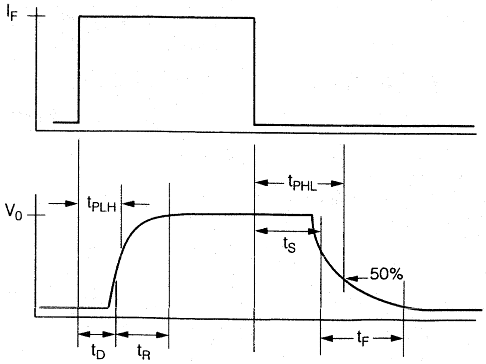
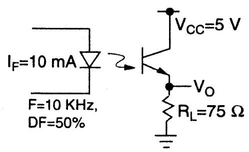


Figure 10. Switching schematic

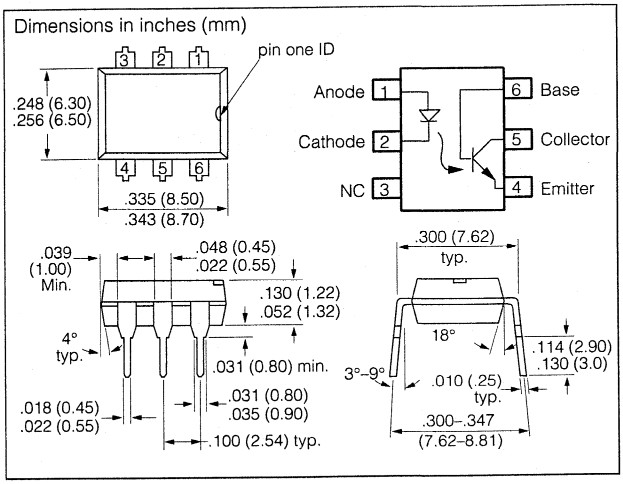


Optocouplers (Optoisolators) 5

SIEMENS

MCT5210
MCT5211

AlGaAs LED/ Phototransistor Optocoupler



FEATURES

- **Current Transfer Ratio**
  MCT5210, >70% at I_F=3.0 mA
  MCT5211, >110% at I_F=1.0 mA
- **Saturation CTR–MCT5211, >100% at I_F=1.6 mA**
- **High Isolation Voltage, 5300 VAC_{RMS}**
- **Underwriters Lab File #E52744**
- **VDE #0884 Available with Option 1**

DESCRIPTION

The MCT5210/5211 are optocouplers with a high efficiency AlGaAs LED optically coupled to a NPN phototransistor. The high performance LED makes operation at low input currents practical. The coupler is housed in a double molded, six pin DIP package. Isolation test voltage is 5300 VAC_{RMS}.

Because these parts have guaranteed CTRs at one and three mA, they are ideally suitable for interfacing from CMOS to TTL or LSTTL to TTL. They are also ideal for telecommunications applications such as ring or off-hook detection.

Maximum Ratings

Emitter

Peak Reverse Voltage .... 6 V
Continuous Forward Current .... 40 mA
Power Dissipation at 25°C .... 75 mW
Derate Linearly from 25°C .... 1.0 mW/°C

Detector

Collector-Emitter Breakdown Voltage .... 30 V
Emitter-Collector Breakdown Voltage .... 7 V
Collector-Base Breakdown Voltage .... 70 V
Power Dissipation .... 200 mW
Derate Linearly from 25°C .... 2.6 mW/°C

Package

Isolation Test Voltage .... 5300 VAC_{RMS}
Total Package Dissipation
at 25°C Ambient (LED + Detector) .... 260 mW
Derate Linearly from 25°C .... 3.5 mW/°C
Leakage Path .... 7 mm min.
Clearance Path .... 7 mm min.
Comparative Tracking Index per
DIN IEC 112/VDE 0303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... ≥10^{12} Ω
V_{IO}=500 V, T_A=100°C .... ≥10^{11} Ω
Operating Temperature .... –55°C to +100°C
Storage Temperature .... –55°C to +150°C

Electrical Characteristics (25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.2	1.5	V	I_F=5 mA
Reverse Voltage	V_R	6			V	I_R=10 µA
Detector						
	HFE	100	200			V_{CE}=5 V I_C=100 µA
	BV_{CEO}	30			V	I_C=100 µA
	BV_{ECO}	7			V	I_E=100 µA
	BV_{CBO}	70			V	I_E=10 µA
	I_{CEO}		5	100	nA	V_{CE}=10 V
Package (0–70°C)						
Saturated Current Transfer Ratio						V_{CE}=0.4 V
MCT5210 MCT5211 MCT5211	CTR_{CEsat} CTR_{CEsat} CTR_{CEsat}	60 100 75	120 200 150		% % %	I_F=3.0 mA I_F=1.6 mA I_F=1.0 mA
Current Transfer Ratio						V_{CE}=5.0 V
MCT5210 MCT5211 MCT5211	CTR CTR CTR	70 150 110	150 300 225		% % %	I_F=3.0 mA I_F=1.6 mA I_F=1.0 mA
Collector-Base Current Transfer Ratio						V_{CE}=4.3 V
MCT5210 MCT5211 MCT5211	CTR_{CB} CTR_{CB} CTR_{CB}	0.2 0.3 0.25	0.4 0.6 0.5		% % %	I_F=3.0 mA I_F=1.6 mA I_F=1.0 mA
Saturation Voltage						
MCT5210	V_{CEsat}		0.25	0.4	V	I_F=3.0 mA I_C=1.8 mA
MCT5211	V_{CEsat}		0.25	0.4	V	I_F=1.6 mA I_C=1.6 mA

Characteristics — *continued*

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Switching Characteristics (25°C)						
Propagation Delay —High to Low						
MCT5210	tPHL		10		µs	R_L=330 Ω, I_F=3.0 mA, V_{CC}=5.0 V
MCT5211	tPHL		20		µs	R_L=750 Ω, I_F=1.6 mA, V_{CC}=5.0 V
MCT5211	tPHL		40		µs	R_L=1.5 Ω, I_F=1.0 mA, V_{CC}=5.0 V
Propagation Delay —Low to High						
MCT5210	tPLH		10		µs	R_L=330 Ω, I_F=3.0 mA, V_{CC}=5.0 V
MCT5211	tPLH		20		µs	R_L=750 Ω, I_F=1.6 mA, V_{CC}=5.0 V
MCT5211	tPLH		40		µs	R_L=1.5 Ω, I_F=1.0 mA, V_{CC}=5.0 V

Figure 13. Forward current vs. forward voltage

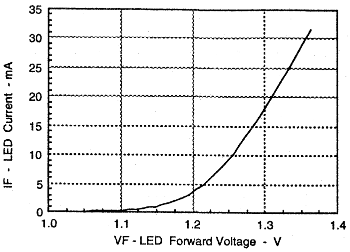


Figure 16. Collector base photocurrent vs. LED current

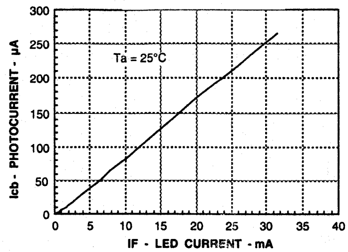


Figure 19. Collector base current transfer ratio vs. LED current

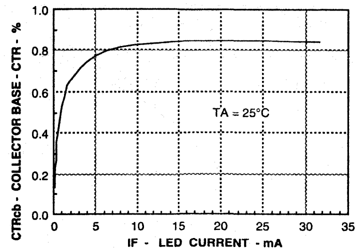


Figure 14. LED forward current vs. forward voltage

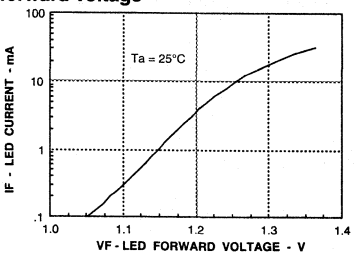


Figure 17. Photocurrent vs. LED current

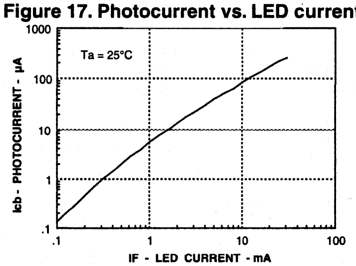


Figure 20. Collector base current transfer ratio vs. LED current

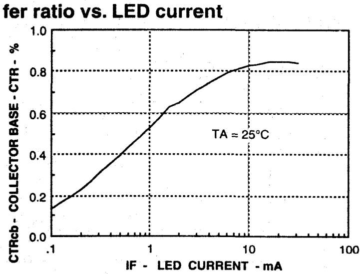


Figure 15. Switching waveform

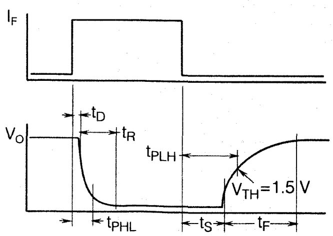


Figure 18. Switching schematic

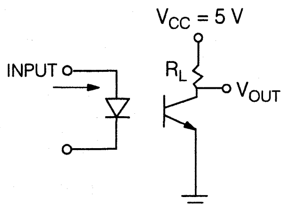


Figure 21. Current transfer ratio ratio vs. LED current

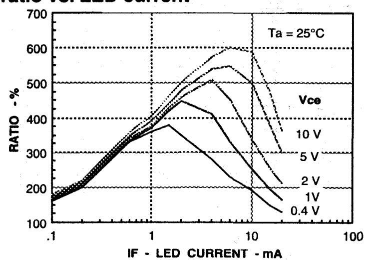


Figure 22. Collector current vs. LED current

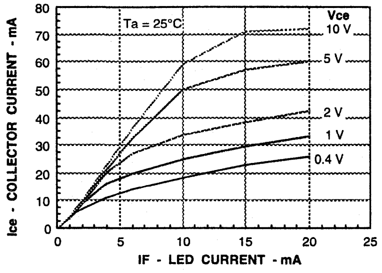


Figure 23. Collector current vs. LED current

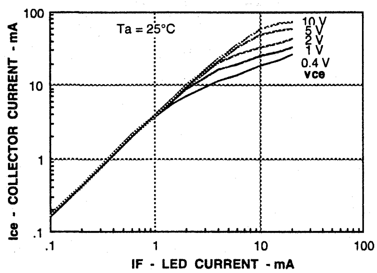


Figure 24. Transistor current gain vs. base current

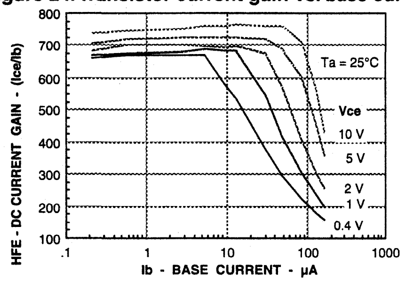


Figure 25. Transfer curve

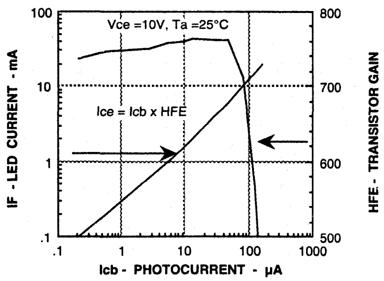


Figure 26. Transfer curve

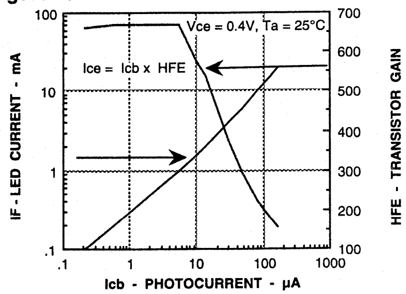


Figure 27. Propagation delay vs. base emitter resistor

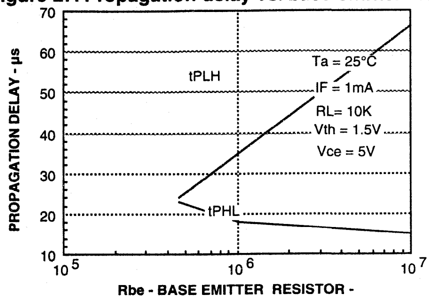


Figure 28. Propagation delay vs. base emitter resistor

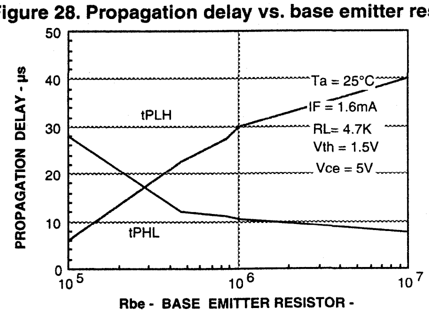
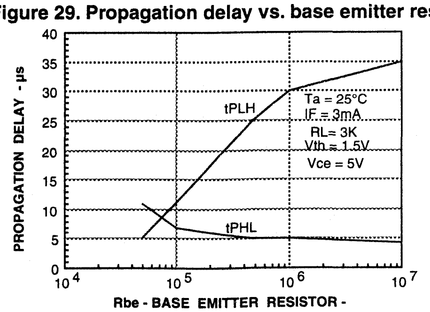


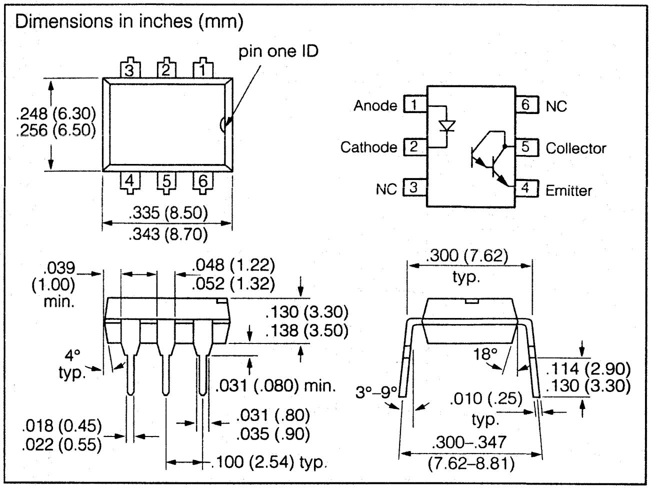
Figure 29. Propagation delay vs. base emitter resistor



SIEMENS

MOC8050
Photodarlington Optocoupler

FEATURES
- **High Current Transfer Ratio 500% at 50 mA Output**
- **High Collector to Emitter Breakdown Voltage: 80 V Min.**
- **High Isolation Voltage V_{ISO}=5300 VAC_{RMS}**
- **Base Lead Not Connected**
- **Solid State Reliability**
- **Standard DIP Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Availablle with Option 1**



DESCRIPTION
The MOC8050 is an optically coupled isolator with a Gallium Arsenide infrared emitter and a silicon photodarlington sensor. Switching can be achieved while maintaining a high degree of isolation between driving and load circuits, with no cross talk between channels. These optocouplers can be used to replace reed and mercury relays with advantages of long life, high speed switching and elimination of magnetic fields.

Maximum Ratings
Emitter
Peak Reverse Voltage .... 3 V
Continuous Forward Current .... 60 mA
Power Dissipation at 25°C............................ 100 mW
Derate Linearly from 25°C .... 1.33 mW/°C
Detector
Collector-Emitter Reverse Voltage..................... 80 V
Collector Load Current .... 125 mA
Power Dissipation at 25°C Ambient .... 150 mW
Derate Linearly from 25°C .... 2.0 mW/°C
Package
Total Package Dissipation at 25°C.............. 250 mW
Derate Linearly from 25°C .... 3.3 mW/°C
Isolation Test Voltage.......................... 5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... 10^{12} Ω
V_{IO}=500 V, T_A=100°C .... 10^{11} Ω
Creepage Path .... 8 mm min.
Clearance Path..7 mm min.
Comparative Tracking Index 175
Storage Temperature Range .... –55°C to +125°C
Operating Temperature Range...... –55°C to +100°C
Lead Soldering Time at 260°C .... 10 sec.

Electrical Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.25	1.5	V	I_F=20 mA
Reverse Current	I_R		0.1	10	µA	V_R=3.0 V
Capacitance	C_O		25		pF	V_R=0
Detector						
Collector-Emitter Breakdown Voltage	BV_{CEO}	80			V	I_C=10 µA
Collector-Emitter Leakage Current	I_{CEO}		25	1000	nA	V_{CE}=60 V I_F=0
Emitter-Collector Breakdown Voltage	V_{ECO}	5.0	8.0		V	I_C=10 µA
Package						
Current Transfer Ratio	CTR	500			%	I_F=10 mA V_{CE}=1.5 V
Collector-Emitter Saturation Voltage	V_{CEsat}		0.9	1.0	V	I_C=50 mA I_F=50 mA
Isolation Test Voltage	VISO	5300			VAC_{RMS}	1 sec., 60 Hz
Coupling Capacitance	C_{ISOL}		0.5		pF	
Rise Time	T_R		10		µs	V_{CC}=13.5 V I_F=50 mA R_L=100 Ω
Fall Time	T_F		35			

Figure 13. Forward voltage vs. forward current

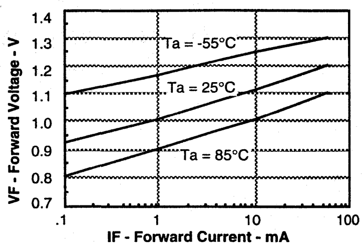


Figure 14. Typical Ic vs. Vce

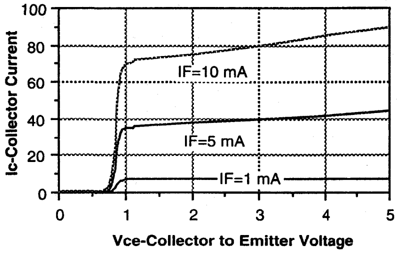


Figure 15. Typical Ic vs. Vce vs. temperature

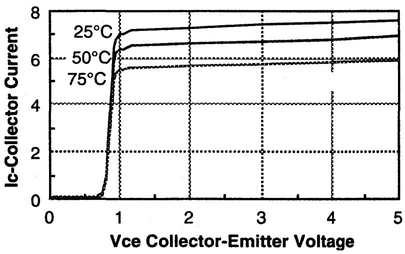


Figure 16. Typical NCTR vs. LED current

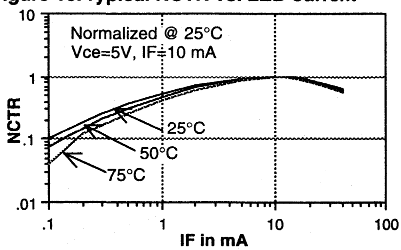


Figure 21. Switching waveform

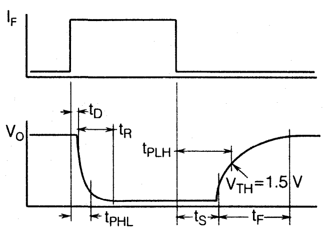


Figure 17. Typical Ic vs. Vce (sat. region)

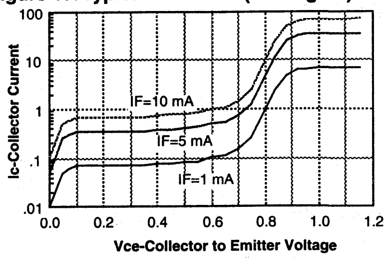


Figure 18. Typical Iceo vs. temperature

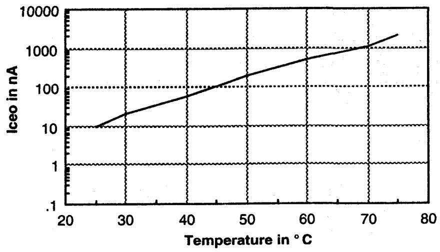


Figure 19. Low to high propagation delay vs. collector load resistance and LED current

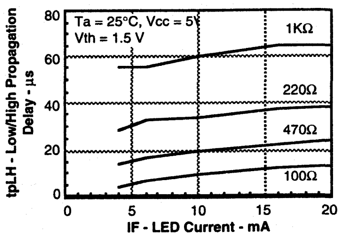


Figure 20. High to low propagation delay vs. collector load resistance and LED current

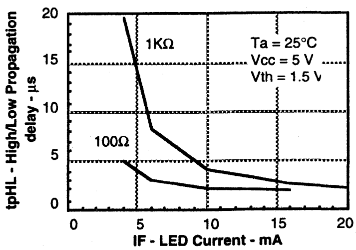
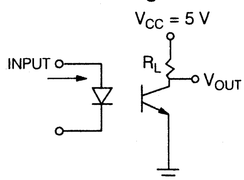


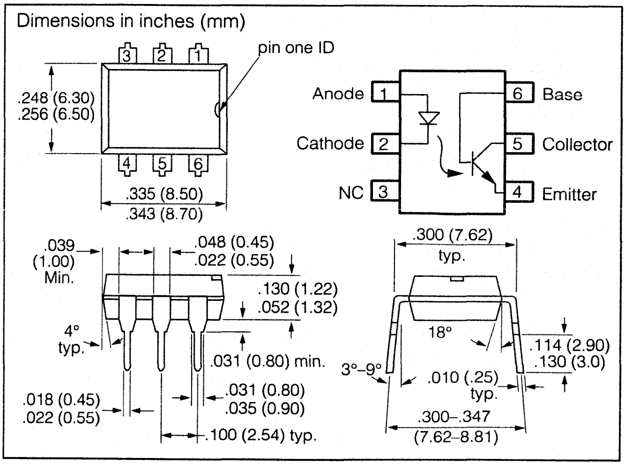
Figure 22. Switching schematic



SIEMENS

MOC8111

No Base Connection Phototransistor Optocoupler



FEATURES
- **Current Transfer Ratio 20% Min.**
- **No Base Terminal Connection for Improved Common Mode Interface Immunity**
- **Field-Effect Stable by TRIOS®** **(TRansparent IOn Shield)**
- **Long Term Stability**
- **Industry Standard Dual-in-Line Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

DESCRIPTION

The MOC8111 is an optocoupler consisting of a Gallium Arsenide infrared emitting diode optically coupled to a silicon planar phototransistor detector in a plastic plug-in DIP 6 pin package.

The coupling device is suitable for signal transmission between two electrically separated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible reference voltages.

In contrast to the IL1, the base terminal is not connected, resulting in a substantially improved common-mode interference immunity.

Maximum Ratings (T_A=25°C)

Emitter

Reverse Voltage ....6 V
DC Forward Current .... 60 mA
Surge Forward Current (t≤10 µs)......................... 2.5 A
Total Power Dissipation ....100 mW

Detector

Collector-Emitter Breakdown Voltage....................30 V
Collector Current .... 50 mA
Collector Current (t≤1 ms)............................... 150 mA
Total Power Dissipation ....150 mW

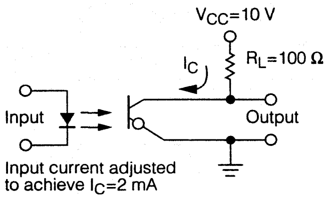
Package

Isolation Test Voltage between Emitter and Detector, Refer to Standard Climate 23/50 DIN 50014..5300 VAC_{RMS}
Creepage ....≥7 mm
Clearance...≥7 mm
Isolation Thickness between Emitter and Detector..................................≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C....................................... $10^{12}\Omega$
V_{IO}=500 V, T_A=100°C..................................... $10^{11}\Omega$
Storage Temperature Range ....–55°C to +150°C
Ambient Temperature Range ....–55°C to +100°C
Soldering Temperature (max. 10 s, dip soldering distance to seating plane ≥1.5 mm).............................260°C

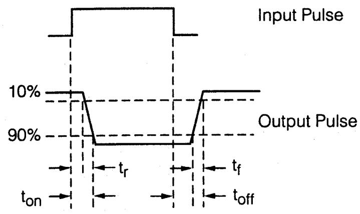
Electrical Characteristics T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter						
Forward Voltage	V_F		1.15	1.5	V	I_F=10 mA
Reverse Leakage Current	I_R		0.05	10	µA	V_R=6 V
Capacitance	C_J		25		pF	V=0, f=1 MHz
Detector						
Collector-Emitter Breakdown Voltage	BV_{CEO}	30			V	I_C=1 µA
Collector-Emitter Leakage Current	I_{CEO}		1	50	nA	V_{CE}=10 V
Emitter-Collector Breakdown Voltage	V_{ECO}	7			V	I_E=10 µA
Collector-Emitter Capacitance	C_{CE}		7		pF	V_{CE}=0 V, f=1 MHz
Package						
Collector Saturation Voltage	V_{CESAT}		0.15	0.4	V	I_C=500 µA I_F=10 mA
Output Collector Current	I_C	2	5		mA	I_F=10 mA V_{CE}=10 V
Turn On Time	T_{ON}		7.5	20	µs	V_{CC}=10 V R_L=100 Ω,
Turn Off Time	T_{OFF}		5.7	20	µs	I_C=2 mA, see Figure 1

Figure 13. Switching times



Test Circuit



Waveforms

SIEMENS

SFH600

TRIOS®* PhototransistorOptocoupler

FEATURES

- **High Current Transfer Ratios**
  SFH600-0, 40 to 80%
  SFH600-1, 63 to 125%
  SFH600-2, 100 to 200%
  SFH600-3, 160 to 320%
- **Isolation Test Voltage (1 Sec.), 5300 VAC_{RMS}**
- **V_{CEsat} 0.25 (≤0.4) V, I_F=10 mA, I_C=2.5 mA**
- **High Quality Premium Device**
- **Long Term Stability**
- **Storage Temperature, –55° to +150°C**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

DESCRIPTION

The SFH600 is an optocoupler with a GaAs LED emitter which is optically coupled with a silicon planar phototransistor detector. The component is packaged in a plastic plug-in case, 20 AB DIN 41866.

The coupler transmits signals between two electrically isolated circuits. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible insulating voltage.

Maximum Ratings

Emitter

Reverse Voltage .... 6 V
DC Forward Current .... 60 mA
Surge Forward Current (t_p=10 µs) .... 2.5 A
Total Power Dissipation .... 100 mW

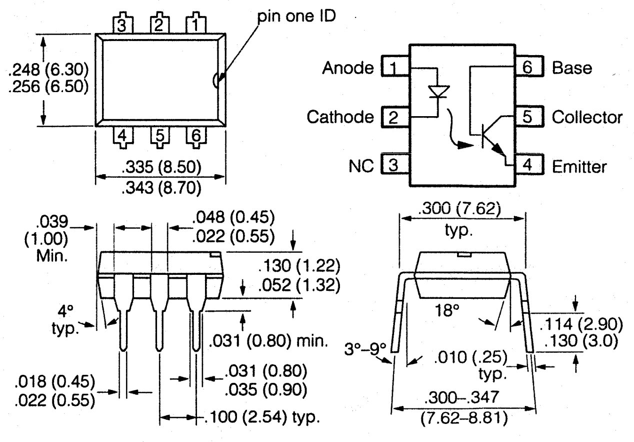
Detector

Collector-Emitter Voltage .... 70 V
Emitter-Base Voltage .... 7 V
Collector Current .... 50 mA
Collector Current (t=1 ms) .... 100 mA
Power Dissipation .... 150 mW

Package

Isolation Test Voltage (between emitter and detector referred to climate DIN 40046, part 2, Nov. 74) (t=1 sec.) .... 5300 VAC_{RMS}
Creepage .... ≥7 mm
Clearance .... ≥7 mm
Isolation Thickness between Emitter & Detector .... ≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE0303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}\ \Omega$
Storage Temperature Range ...... –55°C to +150°C
Ambient Temperature Range ..... –55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature (max. 10 s, dip soldering: distance to seating plane ≥1.5 mm) .... 260°C

Dimensions in inches (mm)



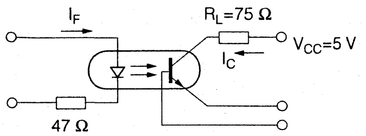
Characteristics (T_A=25°C)

	Symbol		Unit	Condition
Emitter				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=60 mA
Breakdown Voltage	V_{BR}	≥6		I_R=10 µA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=6 V
Capacitance	C_O	25	pF	V_F=0 V, f=1 MHz
Thermal Resistance	R_{THJamb}	750	°C/W	
Detector				
Capacitance Collector-Emitter Collector-Base Emitter-Base	 C_{CE} C_{CB} C_{EB}	 5.2 6.5 9.5	pF	f=1 MHz V_{CE}=5 V V_{CB}=5 V V_{EB}=5 V
Thermal Resistance	R_{THJamb}	500	°C/W	
Package				
Saturation Voltage, Collector-Emitter	V_{CEsat}	0.25 (≤0.4)	V	I_F=10 mA, I_C=2.5 mA
Coupling Capacitance	C_{IO}	0.6	pF	V_{IO}=0, f=1 MHz

Current Transfer Ratio and Collector-Emitter Leakage Current by dash number

Parameter	Dash No.				Unit	Condition
	-0	-1	-2	-3		
I_C/I_F at V_{CE}=5 V	40-80	63-125	100-200	160-320	%	I_F=10 mA
I_C/I_F at V_{CE}=5 V	30 (>13)	45 (>22)	70 (>34)	90 (>56)		I_F=1 mA
Collector-Emitter Leakage Current (I_{CEO})	2 (≤ 35)	2 (≤ 35)	2 (≤ 35)	5 (≤ 70)	nA	V_{CE}=10 V

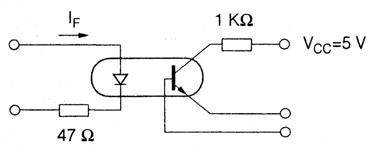
Figure 1. Linear operation (without saturation)



I_F=10 mA, V_{CC}=5 V, T_A=25 °C, Typical

Load Resistance	R_L	75	Ω
Turn-On Time	t_{ON}	3.2	µs
Rise Time	t_R	2.0	
Turn-Off Time	t_{OFF}	3.0	
Fall Time	t_f	2.5	
Cut-off Frequency	F_{CO}	250	kHz

Figure 2. Switching operation (with saturation)



Typical

Parameter		Dash No.			Unit
		-0 (I_F=20 mA)	-1 and -2 (I_F=10 mA)	-3 (I_F=5 mA)	
Turn-On Time	t_{ON}	3.7	4.5	5.8	µs
Rise Time	t_R	2.5	3.0	4.0	
Turn-Off Time	t_{OFF}	19	21	24	
Fall Time	t_F	11	12	14	
	V_{CESAT}	0.25 (≤0.4)			V

Figure 3. Current transfer ratio versus diode current (T_A=–25°C, V_{CE}=5 V) I_C/I_F=f (I_F)

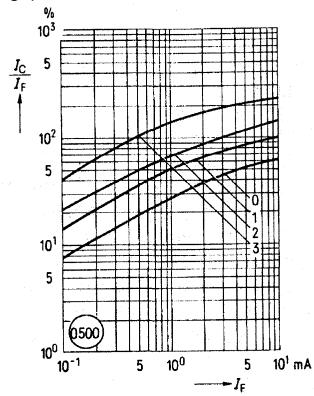


Figure 4. Current transfer ratio versus diode current (T_A=0°C, V_{CE}=5 V) I_C/I_F=f (I_F)

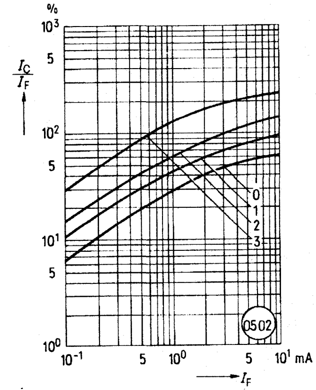


Figure 5. Current transfer ratio versus diode current (T_A=25°C, V_{CE}=5 V) I_C/I_F=f (I_F)

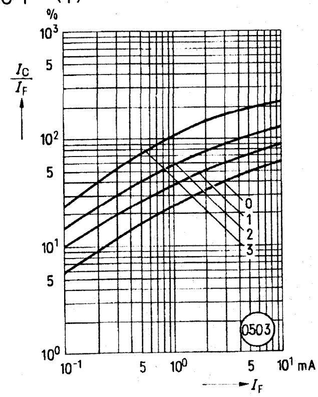


Figure 6. Current transfer ratio versus diode current (T_A=50°C) V_{CE}=5 V I_C/I_F=f (I_F)

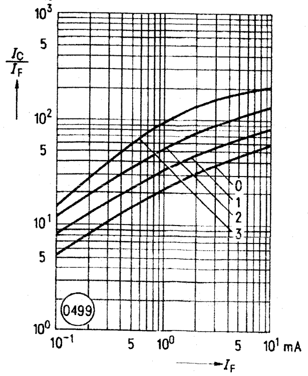


Figure 9. Transistor characteristics (HFE =550) SFH600-2, -3 I_C=f(V_{CE}) (T_A=25°C, I_F=0)

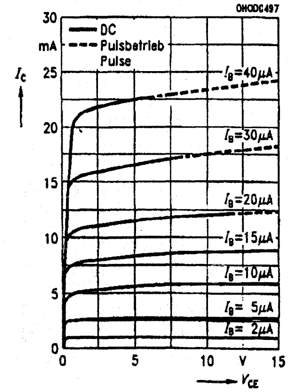


Figure 12. Collector emitter off-state current I_{CEO}=f (V, T) (T_A=25°C, I_F=0)

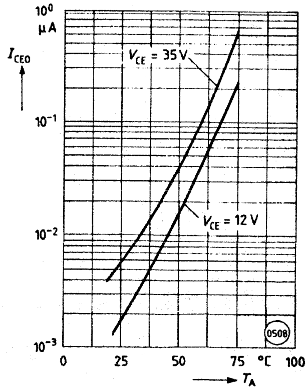


Figure 7. Current transfer ratio versus diode current (T_A=75°C) V_{CE}=5V I_C/I_F=f (I_F)

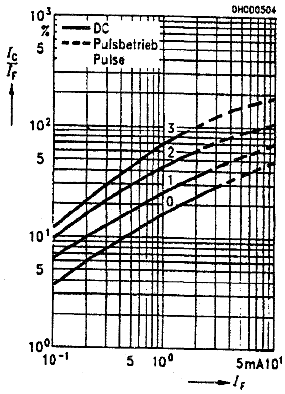


Figure 10. Output characteristics SFH600-2, -3 (T_A=25°C) I_C=f(V_{CE})

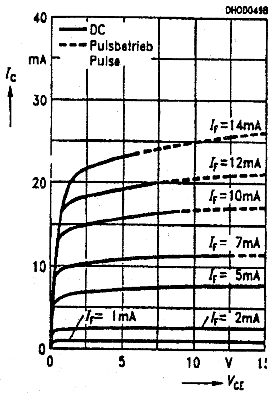


Figure 13. Saturation voltage versus collector current and modulation depth SFH600-0 V_{CEsat}=f (I_C) (T_A=25°C)

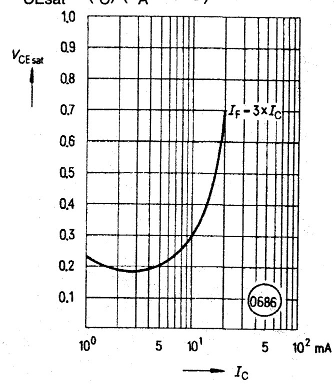


Figure 8. Current transfer ratio versus temperature (I_F=10 mA, V_{CE}=5 V) I_C/I_F=f(T)

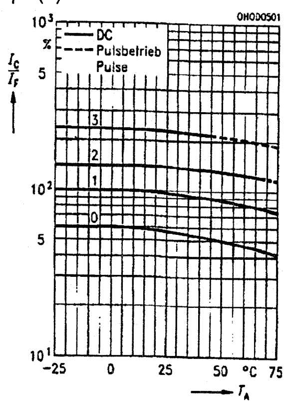


Figure 11. Forward voltage V_F=f (I_F)

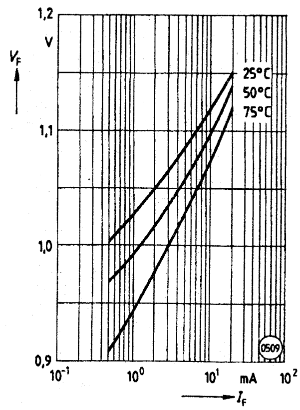


Figure 14. Saturation voltage versus collector current and modulation depth SFH600-1 V_{CEsa}t=f (I_C) (T_A=25°C

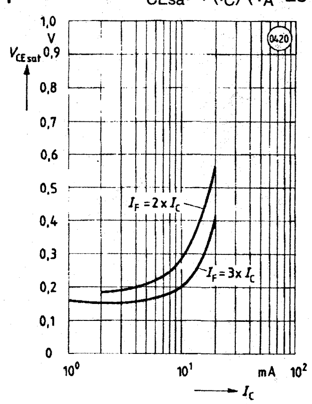


Figure 15. Saturation voltage versus collectorcurrent and modulation depth SFH600-2 V_{CEsat}=f (I_C) (T_A=25°C)

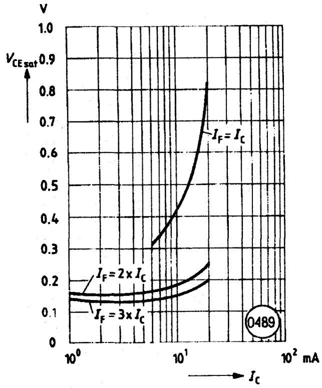


Figure 18. Permissible power dissipation for transistor and diode P_{tot}=f (T_A)

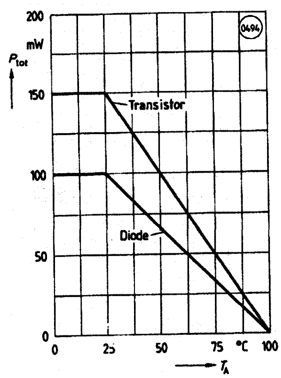


Figure 16. Saturation voltage versus collectorcurrent and modulation depth SFH600-3 V_{CEsat}=f (I_C) (T_A=25°C)

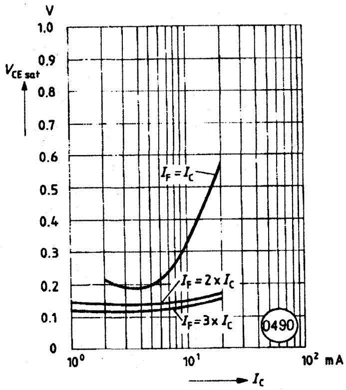


Figure 19. Permissible forward current diode P_{tot}=f (T_A)

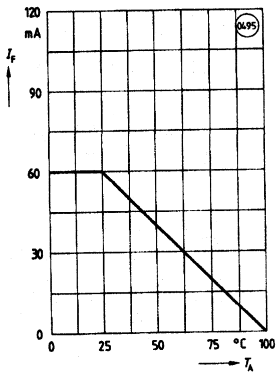


Figure 17. Permissible pulse load
D=parameter, T_A=25°C, I_F=f (t_p)

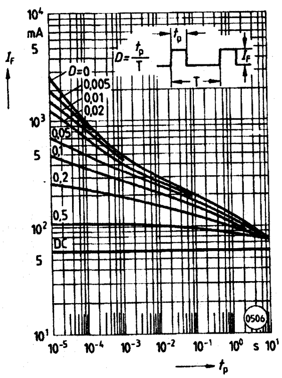
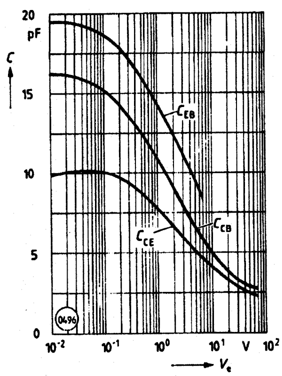


Figure 20. Transistor capacitance
C=f(V_O) (T_A=25°C, f=1 MHz)



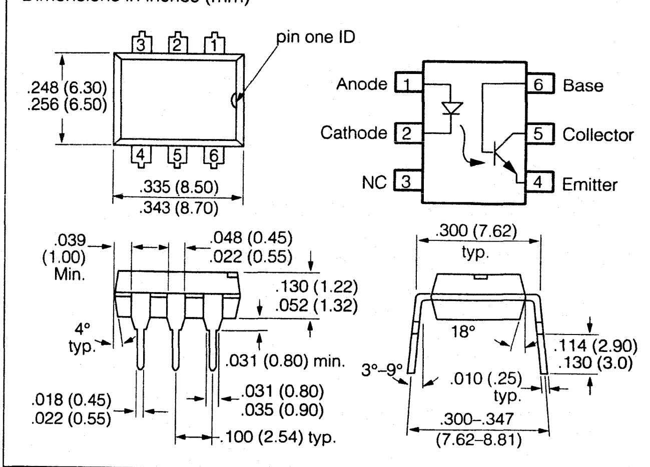
SIEMENS

SFH601

TRIOS®* Phototransistor Optocoupler

FEATURES

- **High Current Transfer Ratios**
  SFH601-1, 40 to 80%
  SFH601-2, 63 to 125%
  SFH601-3 ,100 to 200%
  SFH601-4, 160 to 320%
- **Isolation Test Voltage (1 Sec.), 5300 VAC_{RMS}**
- **V_{CEsat} 0.25 (≤0.4) V, I_F=10 mA, I_C=2.5 mA**
- **Built to conform to VDE Requirements**
- **Highest Quality Premium Device**
- **Long Term Stability**
- **Storage Temperature, –55° to +150°C**
- **Underwriters Lab File #E52744**
- **CECC Approved**
- **VDE 0884 Available with Option 1**



DESCRIPTION

The SFH601 is an optocoupler with a Gallium Arsenide LED emitter which is optically coupled with a silicon planar phototransistor detector. The component is packeged in a plastic plug-in case 20 AB DIN 41866.

The coupler transmits signals between two electrically isolated circuits.

Maximum Ratings

Emitter

Reverse Voltage .... 6 V
DC Forward Current .... 60 mA
Surge Forward Current (t_p=10 µs) .... 2.5 A
Total Power Dissipation .... 100 mW

Detector

Collector-Emitter Voltage .... 100 V
Emitter-Base Voltage .... 7 V
Collector Current .... 50 mA
Collector Current (t=1 ms) .... 100 mA
Power Dissipation...................................... 150 mW

Package

Isolation Test Voltage (between emitter and detector referred to climate DIN 40046, part 2, Nov. 74) (t=1 sec.) ....5300 VAC_{RMS}
Creepage ....≥7 mm
Clearance...≥7 mm
Isolation Thickness between Emitter and Detector ....≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE0303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C................................$\geq 10^{12}\,\Omega$
V_{IO}=500 V, T_A=100°C..............................$\geq 10^{11}\,\Omega$
Storage Temperature Range ...... –55°C to +150°C
Ambient Temperature Range ..... –55°C to +100°C
Junction Temperature................................. 100°C
Soldering Temperature (max. 10 s, dip soldering: distance to seating plane ≥1.5 mm)........ 260°C

***TRIOS—TR**ansparent **IO**n **S**hield

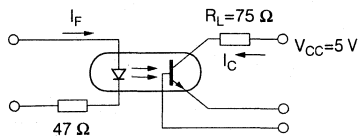
Characteristics (T_A=25°C)

	Symbol		Unit	Condition
Emitter				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=60 mA
Breakdown Voltage	V_{BR}	≥6	V	I_R=10 µA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=6 V
Capacitance	C_O	25	pF	V_F=0 V, f=1 MHz
Thermal Resistance	R_{THJamb}	750	°C/W	
Detector				
Capacitance Collector-Emitter Collector-Base Emitter-Base	 C_{CE} C_{CB} C_{EB}	 6.8 8.5 11	pF	f=1 MHz V_{CE}=5 V V_{CB}=5 V V_{EB}=5 V
Thermal Resistance	R_{THJamb}	500	°C/W	
Package				
Saturation Voltage, Collector-Emitter	V_{CEsat}	0.25 (≤0.4)	V	I_F=10 mA, I_C=2.5 mA
Coupling Capacitance	C_{IO}	0.6	pF	V_{I-O}=0, f=1 MHz

***TRIOS—TR**ansparent **IO**n **S**hield
Current Transfer Ratio and Collector-Emitter Leakage Current by dash number

Parameter	Dash No.				Unit	Condition
	-0	-1	-2	-3		
I_C/I_F at V_{CE}=5 V	40-80	63-125	100-200	160-320	%	I_F=10 mA
I_C/I_F at V_{CE}=5 V	30 (>13)	45 (>22)	70 (>34)	90 (>56)	%	I_F=1 mA
Collector-Emitter Leakage Current (I_{CEO})	2 (≤ 50)	2 (≤ 50)	5 (≤ 100)	5 (≤ 100)	nA	V_{CE}=10 V

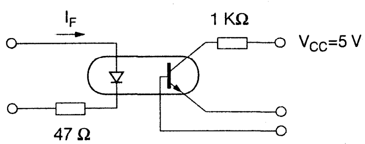
Figure 1. Linear operation (without saturation)



I_F=10 mA, V_{CC}=5 V, T_A=25 °C, Typical

Load Resistance	R_L	75	Ω
Turn-On Time	t_{ON}	3.0	µs
Rise Time	t_R	2.0	µs
Turn-Off Time	t_{OFF}	2.3	µs
Fall Time	t_f	2.0	µs
Cut-off Frequency	F_{CO}	250	kHz

Figure 2. Switching operation (with saturation)



Typical

Parameter		Dash No.			Unit
		-1 (I_F=20 mA)	-2 and -3 (I_F=10 mA)	-4 (I_F=5 mA)	
Turn-On Time	t_{ON}	3.0	4.2	6.0	µs
Rise Time	t_R	2.0	3.0	4.6	µs
Turn-Off Time	t_{OFF}	18	23	25	µs
Fall Time	t_F	11	14	15	µs
	V_{CESAT}	0.25 (≤0.4)			V

Figure 3. Current transfer ratio versus diode current (T_A=–25°C, V_{CE}=5 V)
I_C/I_F=f (I_F)

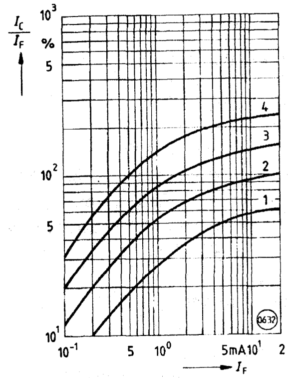


Figure 4. Current transfer ratio versus diode current (T_A=0°C, V_{CE}=5 V)
I_C/I_F=f (I_F)

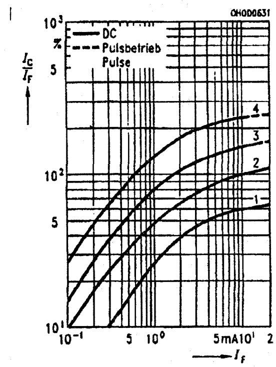


Figure 5. Current transfer ratio versus diode current (T_A=25°C, V_{CE}=5 V)
I_C/I_F=f (I_F)

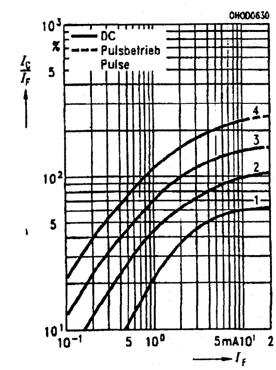


Figure 6. Current transfer ratio versus diode current (T_A=50°C) V_{CE}=5 V, I_C/I_F=f (I_F)

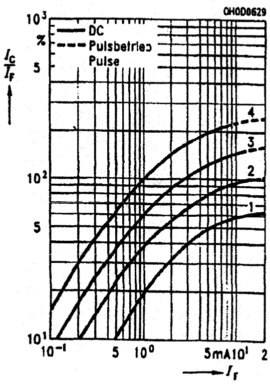


Figure 9. Transistor characteristics (HFE =550) I_C=f(V_{CE}) (T_A=25°C, I_F=0)

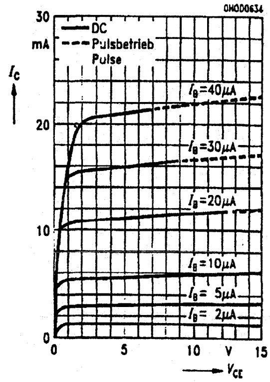


Figure 12. Collector emitter off-state current I_{CEO}=f (V, T) (T_A=25°C, I_F=0)

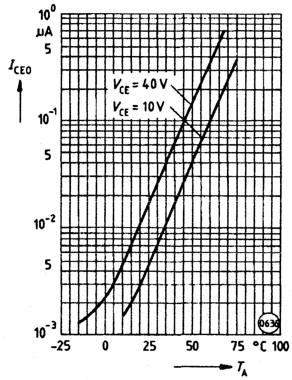


Figure 7. Current transfer ratio versus diode current (T_A=75°C, V_{CE}=5 V) I_C/I_F=f (I_F)

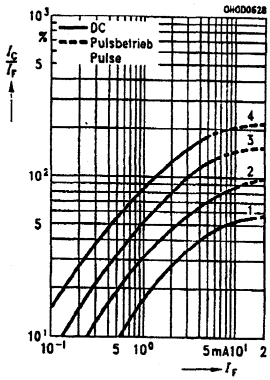


Figure 10. Output characteristics I_C=f(V_{CE})(T_A=25°C)

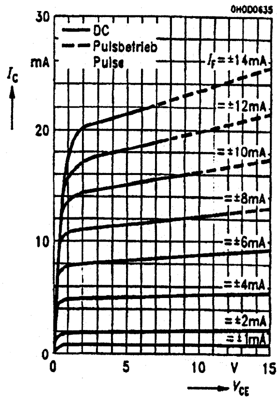


Figure 13. Saturation voltage versus collector current and modulation depthSFH601-1 V_{CEsat}=f (I_C) (T_A=25°C)

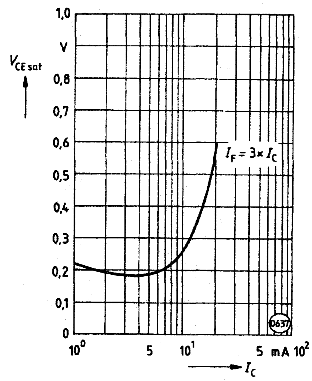


Figure 8. Current transfer ratio versus temperature (I_F=10 mA, V_{CE}=5 V) I_C/I_F=f(T)

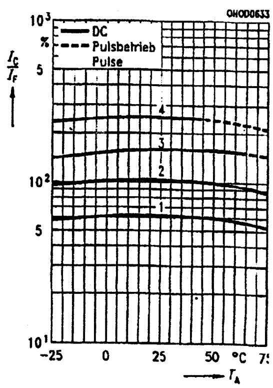


Figure 11. Forward voltage V_F=f (I_F)

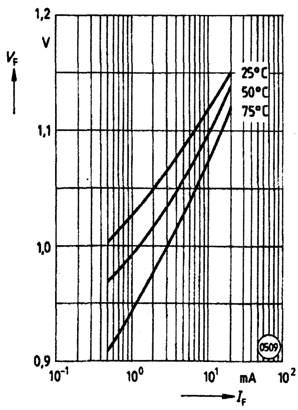


Figure 14. Saturation voltage versus collector current and modulation depthSFH601-2 V_{CEsat}=f (I_C) (T_A=25°C)

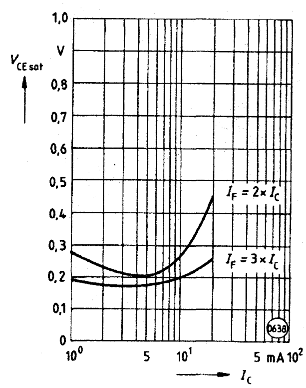


Figure 15. Saturation voltage versus collector current and modulation depth SFH601-3 V_{CEsat}=f (I_C) (T_A=25°C)

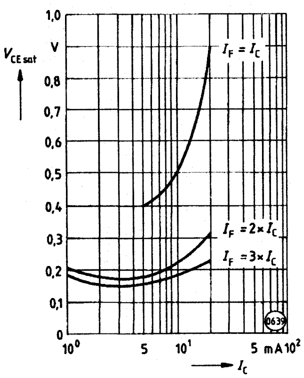


Figure 16. Saturation voltage versus collector current and modulation depth SFH601-4 V_{CEsat}=f (I_C) (T_A=25°C)

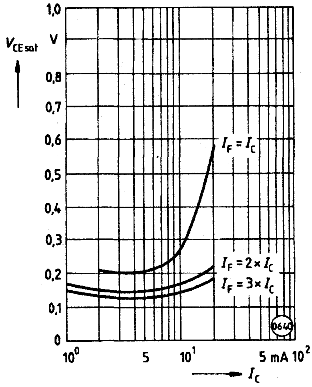


Figure 17. Permissible pulse load
D=parameter, T_A=25°C, I_F=f (t_p)

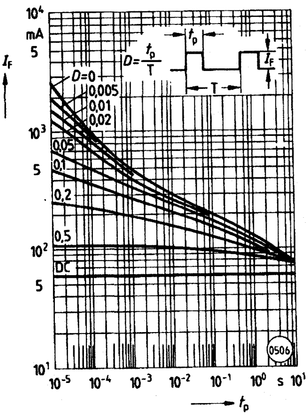


Figure 18. Permissible power dissipation for transistor and diode P_{tot}=f (T_A)

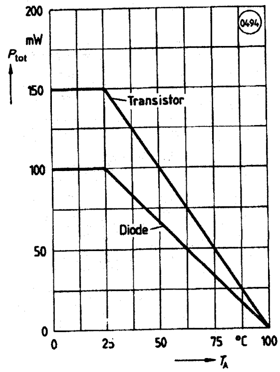


Figure 19. Permissible forward current diode P_{tot}=f (T_A)

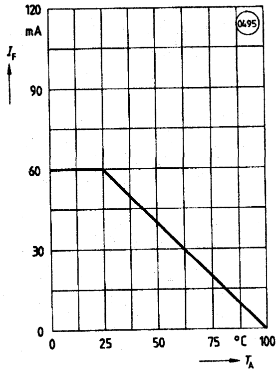
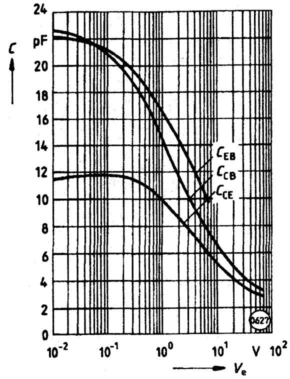


Figure 20. Transistor capacitance C=f(V_O) (T_A=25°C, f=1 MHz)



SIEMENS

SFH608

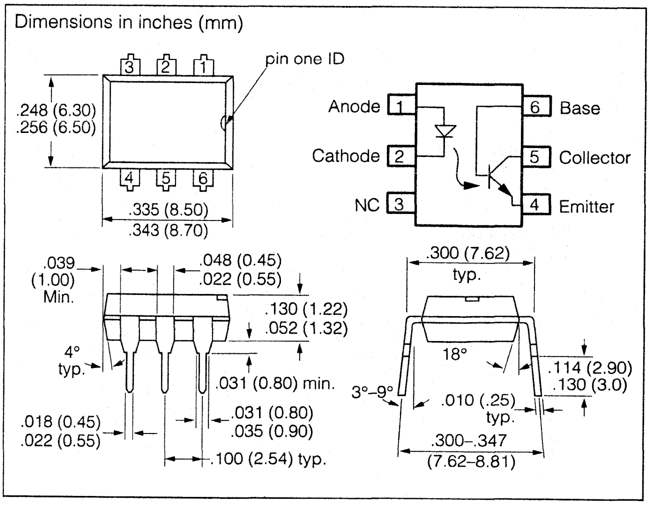
5.3 KV, TRIOS®, Low Current Phototransistor Optocoupler

FEATURES
- Very High CTR at IF=1 mA, V_{CE}=0.5 V
  - SFH608-2, 63-125%
  - SFH608-3, 100-200%
  - SFH608-4, 160-320%
  - SFH608-5, 250-500%
- Specified Minimum CTR at I_F=0.5 mA, V_{CE}=1.5 V: ≥ 32% (typ. 120%)
- Good CTR Linearity with Forward Current
- Low CTR Degradation
- High Collector-Emitter Voltage V_{CEO}=55 V
- Isolation Test Voltage: 5300 VAC_{RMS}
- Low Current Input
- Low Coupling Capacitance
- High Common Mode Transient Immunity
- Phototransistor Optocoupler in 6 Pin DIP Package
- Field Effect Stable: TRIOS*
- VDE 0884 Available with Option 1
- Underwriters Lab File #E52744

APPLICATIONS
- Telecommunications
- Industrial Controls
- Office Machines
- Microprocessor System Interfaces

DESCRIPTION
The SFH 608 is an optocoupler designed for high current transfer ratio at low input currents with the output transistor saturated. This makes the device ideal for low current switching applications. The SFH608 is packaged in a six pin plastic DIP.

***TRIOS**—**TR**ansparent **IO**n **S**hield



Maximum Ratings (T_A=25°C)

Emitter

Reverse Voltage	6 V
DC Forward Current	50 mA
Surge Forward Current (tp≤10 µs)	2.5 A
Total Power Dissipation	70 mW

Detector

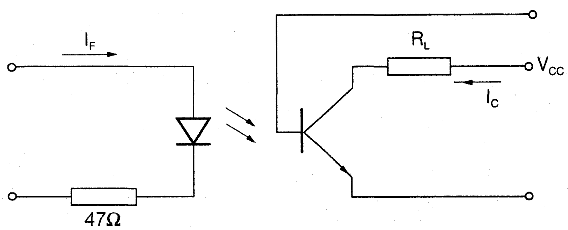
Collector-Emitter Voltage	55 V
Collector-Base Voltage	55 V
Emitter-Base Voltage	7 V
Collector Current	50 mA
Surge Collector Current (tp≤1 ms)	100 mA
Total Power Dissipation	150 mW
Isolation Test Voltage (between emitter and detector, refer to climate DIN 40046 part 2 Nov. 74) (t=1 sec.)	5300 VAC_{RMS}
Creepage	≥7 mm
Clearance	≥7 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303, part1	175
Isolation Resistance V_{IO}=500 V, T_A=25°C	$\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}\ \Omega$
Storage Temperature Range	-55°C to +150°C
Operating Temperature Range	-55°C to +100°C
Junction Temperature	100°C
Soldering Temperature (max. 10 sec., dip soldering: distance to seating plane≥1.5 mm)	260°C

Optocouplers (Optoisolators) 5

Characteristics (T_A=25°C, unless otherwise specified)

	Symbol	Typ	Unit	Condition
Emitter				
Forward Voltage	V_F	1.1 (≤ 1.5)	V	I_F=5 mA
Reverse Voltage	V_R	(≥ 6)	V	I_R= 10 µA
Reverse Current	I_R	0.01 (≤ 10)	µA	V_R=6 V
Capacitance	C_O	25	pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}	1070	K/W	
Detector				
Voltage, Collector-Emitter	V_{CEO}	≥ 55	V	I_{CE}=10 µA
Voltage, Emitter-Base	V_{EBO}	≥ 7	V	I_{EB}=10 µA
Capacitance	C_{CE}	10	pF	V_{CE}=5 V, f=1 MHz
Capacitance	C_{CB}	16	pF	V_{CE}=5 V, f=1 MHz
Capacitance	C_{EB}	10	pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance	R_{thJA}	500	K/W	
Package				
Coupling Capacitance	C_C	0.60	pF	
Coupling Transfer Ratio SFH 608-2 SFH 608-3 SFH 608-4 SFH 608-5	 I_C/I_F I_C/I_F I_C/I_F I_C/I_F	 63-125 75 (≥ 32) 100-200 120 (≥ 50) 160-320 200 (≥ 80) 250-500 300 (≥ 125)	 % % % % % % % %	 I_F=1 mA, V_{CE}=0.5 V I_F=0.5 mA, V_{CE}=1.5 V I_F=1 mA, V_{CE}=0.5 V I_F=0.5 mA, V_{CE}=1.5 V I_F=1 mA, V_{CE}=0.5 V I_F=0.5 mA, V_{CE}=1.5 V I_F=1 mA, V_{CE}=0.5 V I_F=0.5 mA, V_{CE}=1.5 V
Saturation Voltage, Collector-Emitter SFH 608-2 SFH 608-3 SFH 608-4 SFH 608-5	 V_{CEsat} V_{CEsat} V_{CEsat} V_{CEsat}	 0.25 (≤ 0.4) 0.25 (≤ 0.4) 0.25 (≤ 0.4) 0.25 (≤ 0.4)	 V V V V	 I_C=0.32 mA, I_F=1 mA I_C= 0.5 mA, I_F=1 mA I_C= 0.8 mA, I_F=1 mA I_C=1.25 mA, I_F=1 mA
Leakage Current, Collector-Emitter	I_{CEO}	10 (≤ 200)	nA	V_{CE}=10 V

Figure 1. Schematic



I_C=2 mA (to adjust by I_F), R_L=100 Ω, T_A=25°C, V_{CC}=5 V

Description	Symbol	Values	Unit
Turn-On Time	t_{ON}	8	µs
Rise Time	t_R	5	µs
Turn-Off Time	t_{OFF}	7.5	µs
Fall Time	t_F	7	µs

Figure 2. Switching times T_A=25°C, I_F=1 mA, V_{CC}=5 V, t_{ON}, t_R, t_{OFF}, t_F =f(R_L)

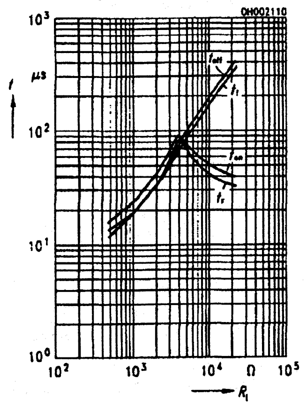


Figure 3. Current transfer ratio (typ.) V_{CE}=0.5 V, C_{TR}=f(T_A, I_F)

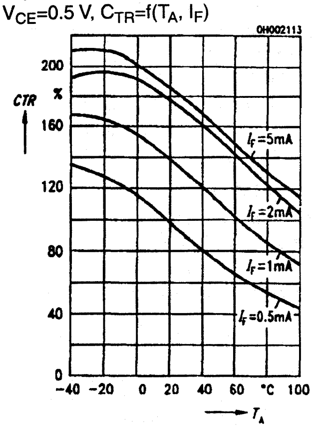


Figure 4. Current transfer ratio (typ.) V_{CE}=1.5 V, C_{TR}=f(T_A, I_F)

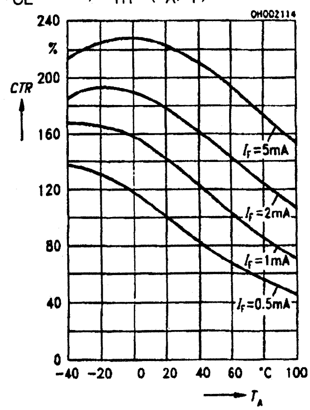


Figure 5. Diode forward voltage (typ.) T_A=25°C, V_F=f(I_F)

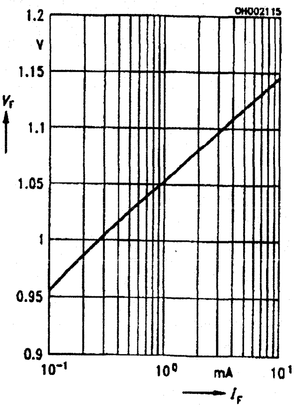


Figure 6. Diode forward voltage (typ.) I_F =1 mA, V_F=f(T_A)

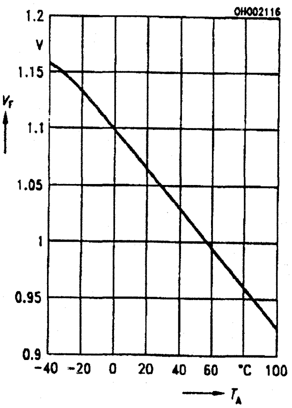


Figure 7. Output characteristics (typ.) T_A=25°C, I_{CE}=f(V_{CE}, I_B)

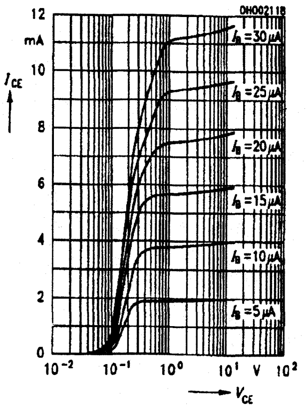


Figure 8. Output characteristics (typ.) T_A=25°C, I_{CE}=f(V_{CE}, I_F)

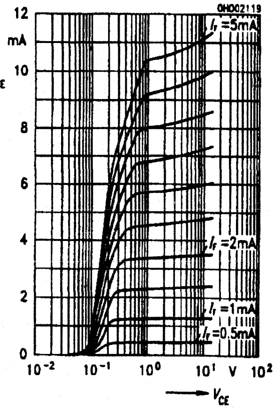


Figure 9. Permissible forward current diode I_F=f(T_A)

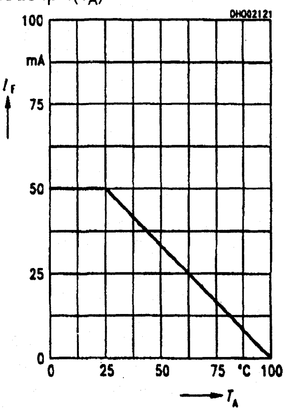


Figure 10. Permissible power dissipation P_{TOT}=f(T_A)

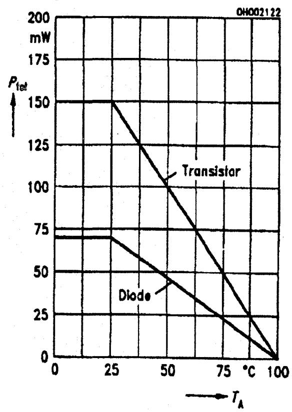


Figure 11. Transistor capacitance (typ.) T_A=25°C, f=1 MHz, C_{CE}=f(V_{CE}) C_{CB}=f (V_{CB}), C_{EB}=f (V_{EB})

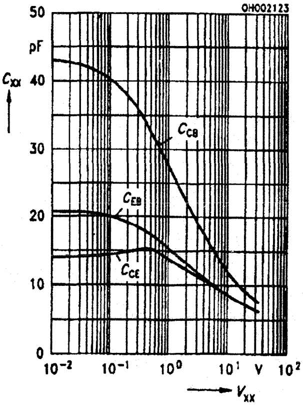
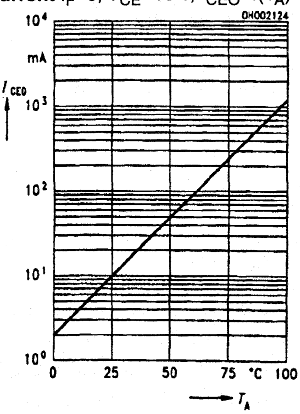


Figure 12. Collector-emitter leakage current I_F=0, V_{CE}=10 V, I_{CEO}=f(T_A)



SIEMENS

SFH610A/611A/615A/617A

5.3 kV TRIOS® Optocoupler High Reliability

FEATURES

- **High Current Transfer Ratios at 10 mA: 40–320% at 1 mA: 60% typical (>13)**
- **Low CTR Degradation**
- **Good CTR Linearity Depending on Forward Current**
- **Withstand Test Voltage, 5300 VAC_{RMS}**
- **High Collector-Emitter Voltage, V_{CEO}=70 V**
- **Low Saturation Voltage**
- **Fast Switching Times**
- **Field-Effect Stable by TRIOS (TRansparent IOn Shield)**
- **Temperature Stable**
- **Low Coupling Capacitance**
- **End-Stackable, .100"(2.54 mm) Spacing**
- **High Common-Mode Interference Immunity (Unconnected Base)**
- **Underwriters Lab File #52744**
- **VDE 0884 Available with Option 1**
- **SMD Option – See SFH6106/16/56 Data Sheet**

DESCRIPTION

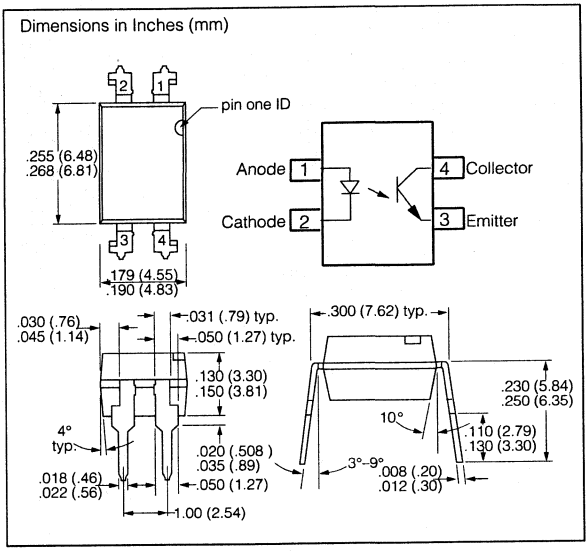
The SFH61XA features a high current transfer ratio, low coupling capacitance and high isolation voltage. These couplers have a GaAs infrared emitting diode emitter, which is optically coupled to a silicon planar phototransistor detector, and is incorporated in a plastic DIP-4 package.

The coupling devices are designed for signal transmission between two electrically separated circuits.

The couplers are end-stackable with 2.54 mm spacing.

Creepage and clearance distances of >8 mm are achieved with option 6. This version complies with IEC 950 (DIN VDE 0805) for reinforced insulation up to an operation voltage of 400 V_{RMS} or DC.

Specifications subject to change.



Maximum Ratings

Emitter

Reverse Voltage	6 V
DC Forward Current	60 mA
Surge Forward Current (tP≤10 µs)	2.5 A
Total Power Dissipation	100 mW

Detector

Collector-Emitter Voltage	70 V
Emitter-Collector Voltage	7 V
Collector Current	50 mA
Collector Current (tP≤1 ms)	100 mA
Total Power Dissipation	150 mW

Package

Isolation Test Voltage between Emitter and Detector, refer to Climate DIN 40046, part 2, Nov. 74	5300 VAC_{RMS}
Creepage	≥7 mm
Clearance	≥7 mm
Insulation Thickness between Emitter and Detector	≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE0 303, part 1	≥175
Isolation Resistance V_{IO}=500 V, T_A=25°C	$\geq 10^{12}$ Ω
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}$ Ω
Storage Temperature Range	–55 to +150°C
Ambient Temperature Range	–55 to +100°C
Junction Temperature	100°C
Soldering Temperature (max. 10 s. Dip Soldering Distance to Seating Plane ≥1.5 mm)	260°C

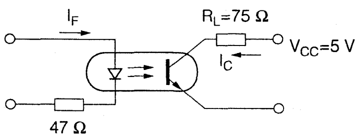
Characteristics (T_A=25°C)

Description	Symbol		Unit	Condition
Emitter (IR GaAs)				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=60 mA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=6 V
Capacitance	C_O	13	pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}	750	K/W	
Detector (Si Phototransistor)				
Capacitance	C_{CE}	5.2	pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance	R_{thJA}	500	K/W	
Package				
Collector-Emitter Saturation Voltage	V_{CESAT}	0.25 (≤0.4)	V	I_F=10 mA, I_C=2.5 mA
Coupling Capacitance	C_C	0.4	pF	

Current Transfer Ratio (I_C/I_F at V_{CE}=5 V) and Collector-Emitter Leakage Current by Dash Number

Description	-1	-2	-3	-4	
I_C/I_F (I_F=10 mA)	40–80	63–125	100–200	160–320	%
I_C/I_F (I_F=1 mA)	30 (>13)	45 (>22)	70 (>34)	90 (>56)	
Collector-Emitter Leakage Current, I_{CEO} V_{CE}=10 V	2 (≤50)	2 (≤50)	5 (≤100)	5 (≤100)	nA

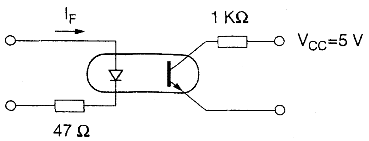
Switching Times (Typical)
Linear Operation (without saturation)



I_F=10 mA, V_{CC}=5 V, T_A=25°C

Load Resistance	R_L	75	Ω
Turn-on Time	t_{ON}	3.0	µs
Rise Time	t_R	2.0	
Turn-off Time	t_{OFF}	2.3	
Fall Time	t_F	2.0	
Cut-off Frequency	F_{CO}	250	kHz

Switching Operation (with saturation)



Parameter	Sym.	Dash No.			Unit
		-1 I_F=20 mA	**-2 and -3** I_F=10 mA	**-4** I_F=5 mA	
Turn-on Time	t_{ON}	3.0	4.2	6.0	µs
Rise Time	t_R	2.0	3.0	4.6	
Turn-off Time	t_{OFF}	18	23	25	
Fall Time	t_F	11	14	15	

Figure 1. Current transfer ratio (typ.) vs. temperature I_F=10 mA, V_{CE}=5 V

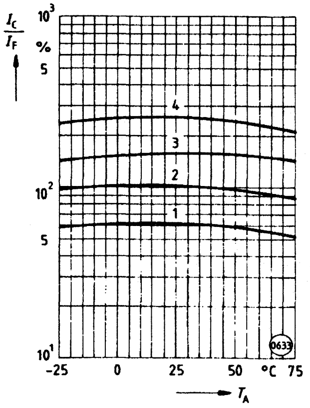


Figure 2. Output characteristics (typ.) Collector current vs. collector-emitter voltage T_A=25°C

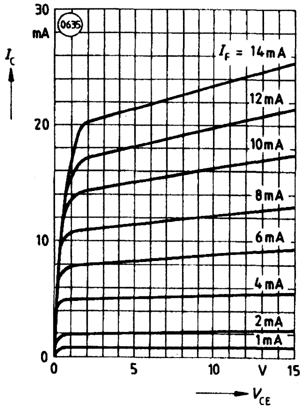


Figure 3. Diode forward voltage (typ.) vs. forward current

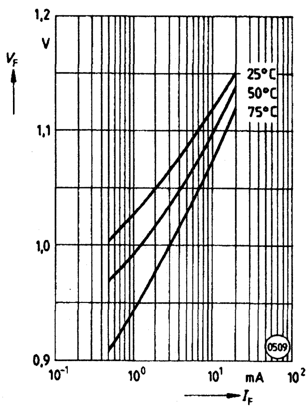


Figure 4. Transistor capacitance (typ.) vs. collector-emitter voltage T_A=25°C, f=1 MHz

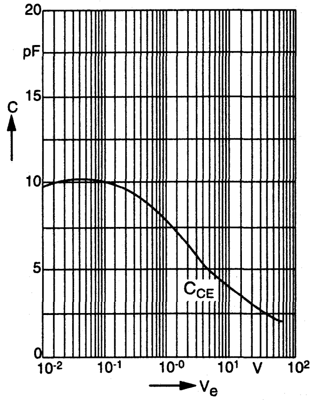


Figure 5. Permissible pulse handling capability. Forward current vs. pulse width Pulse cycle D=parameter, T_A=25°C

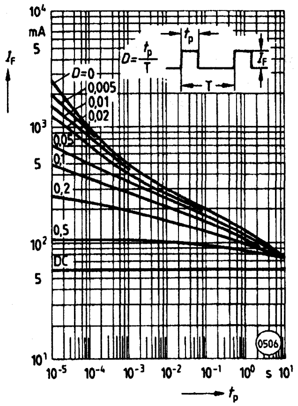


Figure 6. Permissible power dissipation vs. ambient temperature

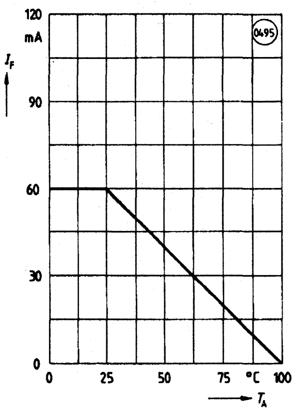
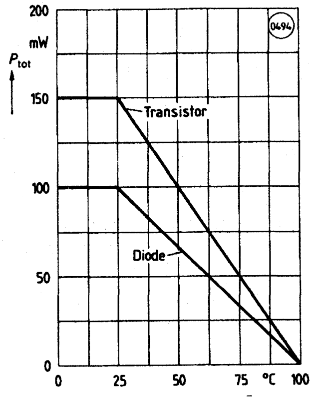


Figure 7. Permissable diode forward current vs. ambient temp.



SIEMENS

SFH615AA/AGB/AGR

5.3 kV TRIOS® Optocoupler High Reliability

FEATURES

- **High Current Transfer Ratios**
  - **– at 5 mA: 50–600%**
  - **– at 1 mA: 60% typical (>13)**
- **Low CTR Degradation**
- **Good CTR Linearity Depending on Forward Current**
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **High Collector-Emitter Voltage, V_{CEO}=70 V**
- **Low Saturation Voltage**
- **Fast Switching Times**
- **Field-Effect Stable by TRIOS (TRansparent IOn Shield)**
- **Temperature Stable**
- **Low Coupling Capacitance**
- **End-Stackable, .100"(2.54 mm) Spacing**
- **High Common-Mode Interference Immunity (Unconnected Base)**
- **Underwriters Lab File #52744**
- **VDE 0884 Available with Option 1**
- **SMD Option – See SFH6106/16/56 Data Sheet**

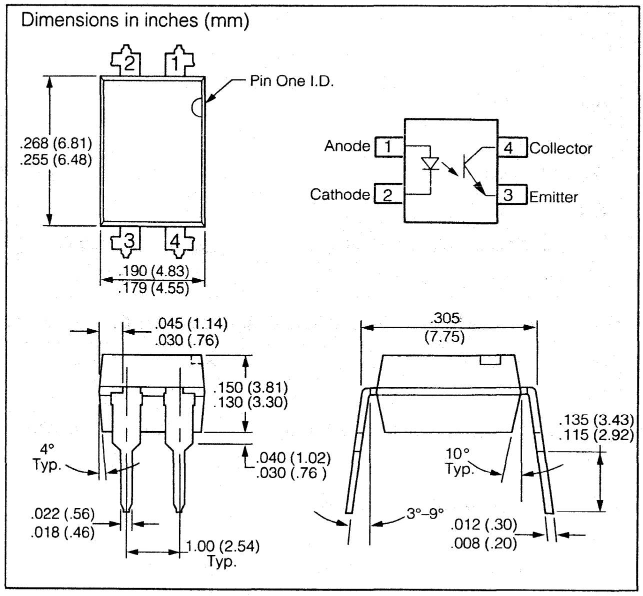
DESCRIPTION

The SFH615AA/AGB/AGR features a high current transfer ratio, low coupling capacitance and high isolation voltage. These couplers have a GaAs infrared emitting diode emitter, which is optically coupled to a silicon planar phototransistor detector, and is incorporated in a plastic DIP-4 package.

The coupling devices are designed for signal transmission between two electrically separated circuits.

The couplers are end-stackable with 2.54 mm spacing.

Creepage and clearance distances of >8 mm are achieved with option 6. This version complies with IEC 950 (DIN VDE 0805) for reinforced insulation up to an operation voltage of 400 V_{RMS} or DC.



Maximum Ratings

Emitter

Reverse Voltage	6 V
DC Forward Current	60 mA
Surge Forward Current (t_P≤10 µs)	2.5 A
Total Power Dissipation	100 mW

Detector

Collector-Emitter Voltage	70 V
Emitter-Collector Voltage	7 V
Collector Current	50 mA
Collector Current (t_P≤1 ms)	100 mA
Total Power Dissipation	150 mW

Package

Isolation Test Voltage between Emitter and Detector, refer to Climate DIN 40046, part 2, Nov. 74	5300 VAC_{RMS}
Creepage	≥7 mm
Clearance	≥7 mm
Insulation Thickness between Emitter and Detector	≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE0 303, part 1	≥175
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	≥10^{12} Ω
V_{IO}=500 V, T_A=100°C	≥10^{11} Ω
Storage Temperature Range	–55 to +150°C
Ambient Temperature Range	–55 to +100°C
Junction Temperature	100°C
Soldering Temperature (max. 10 s. Dip Soldering Distance to Seating Plane ≥1.5 mm)	260°C

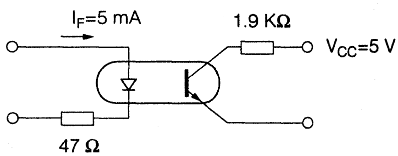
Characteristics (T_A=25°C)

Description	Symbol		Unit	Condition
Emitter (IR GaAs)				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=60 mA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=6 V
Capacitance	C_0	13	pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}	750	K/W	
Detector (Si Phototransistor)				
Capacitance	C_{CE}	5.2	pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance	R_{thJA}	500	K/W	
Package				
Collector-Emitter Saturation Voltage	V_{CESAT}	0.25 (≤0.4)	V	I_F=10 mA, I_C=2.5 mA
Coupling Capacitance	C_C	0.4	pF	

Current Transfer Ratio (I_C/I_F at V_{CE}=5 V) **and Collector-Emitter Leakage Current**

Description	AA	AGB	AGR	
I_C/ I_F (I_F=5 mA)	50–600	100–600	100–300	%
Collector-Emitter Leakage Current, I_{CEO} V_{CE}=10 V	10 (≤100)	10 (≤100)	10 (≤100)	nA

Switching Operation (with saturation)



		I_F=5 mA	
Turn-on Time	t_{ON}	2.0	µs
Turn-off Time	t_{OFF}	25	µs

Figure 1. Current transfer ratio (typ.) vs. temperature
I_F=10 mA, V_{CE}=0.5 V

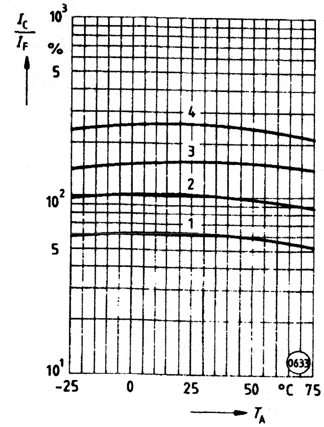


Figure 4. Output characteristics (typ.) Collector current vs. collector-emitter voltage T_A=25°C

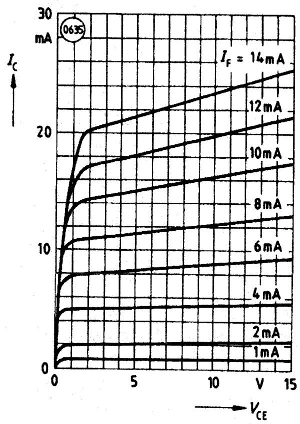


Figure 6. Diode forward voltage (typ.) vs. forward current

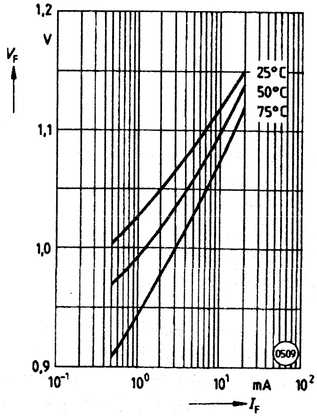


Figure 2. Transistor capacitance (typ.) vs. collector-emitter voltage
T_A=25°C, f=1 MHz

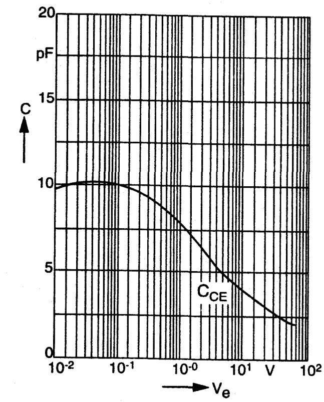


Figure 5. Permissiable pulse handling capability. Fwd. current vs. pulse width Pulse cycle D=parameter, T_A=25°C

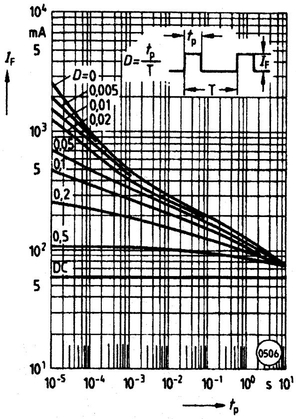


Figure 7. Permissible power dissipation vs. ambient temp.

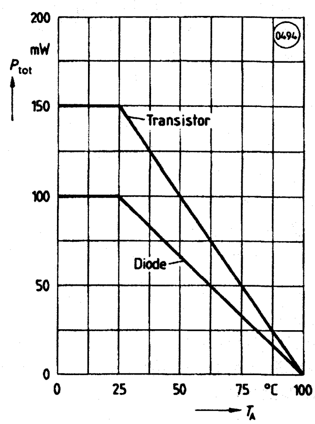
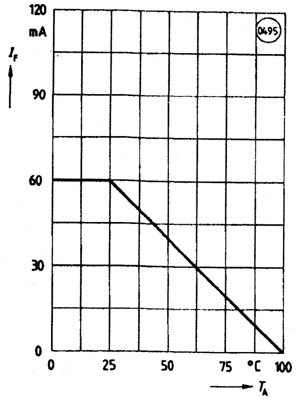


Figure 3. Permissible diode forward current vs. ambient temp.



SIEMENS

SFH618A/628A

Phototransistor, 5.3 kV TRIOS®
Low Current Input
Optocoupler

FEATURES
- Very High CTR at I_F=1 mA, V_{CE}=0.5 V
  - SFH618A-2, 63–125%
  - SFH618A-3, 100–200%
  - SFH618A-4, 160–320%
  - SFH618A-5, 250–500%
  - SFH628A-2, 63–200%
  - SFH628A-3, 100–320%
  - SFH628A-4, 160–500%
- Specified Minimum CTR at I_F=-0.5 mA
  - SFH618A, V_{CE}=1.5 V: ≥32% (typical 120%)
  - SFH628A, V_{CE}=1.5 V: ≥50% (typical 160%)
- Good CTR Linearity Depending on Forward Current
- Low CTR Degradation
- High Collector-Emitter Voltage, V_{CEO}=55 V
- Isolation Test Voltage, 5300 VAC_{RMS}
- Low Coupling Capacitance
- Field-Effect Stable by TRIOS (TRansparent IOn Shield)
- End-Stackable, 0.100" (2.54 mm) Spacing
- High Common-Mode Interference Immunity (Unconnected Base)
- Underwriters Lab File #52744
- VDE 0884 Available with Option 1
- SMD Option — See SFH6186/6286 Data Sheet

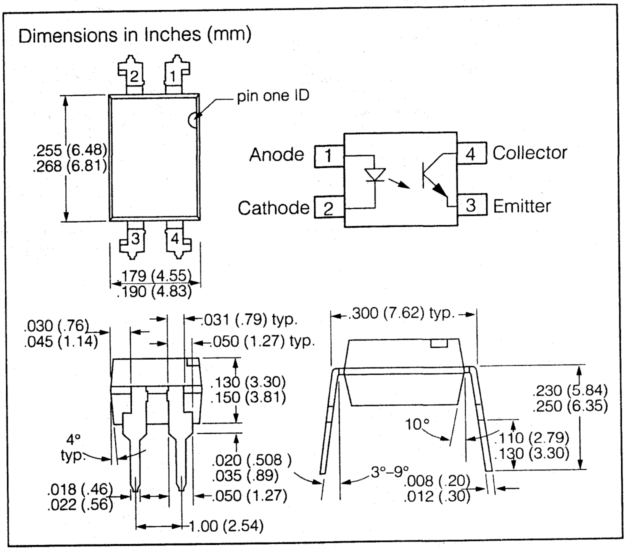
APPLICATIONS
- Telecom
- Industrial Controls
- Battery Powered Equipment
- Office Machines

DESCRIPTION
The SFH618A/628A feature a high current transfer ratio, low coupling capacitance and high isolation voltage. These couplers have a GaAs infrared emitting diode emitter, which is optically coupled to a silicon planar phototransistor detector, and is incorporated in a plastic DIP-4 package.

The coupling devices are designed for signal transmission between two electrically separated circuits.

The couplers are end-stackable with 2.54 mm spacing. Therefore multicouplers can easily be implemented and conventional multicouplers can be replaced.

Creepage and clearance distances of >8 mm are achieved with option 6. This version complies with IEC 950 (DIN VDE 0805) for reinforced insulation up to an operation voltage of 400 V_{RMS} or DC.



Maximum Ratings

Emitter

Reverse Voltage (SFH618A) .... 6 V
DC Forward Current (SFH628A) .... 50 mA
Surge Forward Current (t_p≤10 µs) (SFH628A) .... 2.5 A
Total Power Dissipation .... 70 mW

Detector

Collector-Emitter Voltage .... 55 V
Emitter-Collector Voltage .... 7 V
Collector Current .... 50 mA
Collector Current (t_p≤1 ms) .... 100 mA
Total Power Dissipation .... 150 mW

Package

Isolation Test Voltage between Emitter and Detector, refer to Climate DIN 40046, part 2, Nov. 74 .... 5300 VAC_{RMS}
Creepage .... ≥7 mm
Insulation Thickness between Emitter and Detector .... ≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE0 303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... ≥10^{12} Ω
V_{IO}=500 V, T_A=100°C .... ≥10^{11} Ω
Storage Temperature Range .... –55 to +150°C
Ambient Temperature Range .... –55 to +100°C
Junction Temperature .... 100°C
Soldering Temperature (max. 10 s. Dip Soldering Distance to Seating Plane ≥1.5 mm) .... 260°C

Characteristics (T_A=25°C)

Description		Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter							
Forward Voltage		V_F		1.1	1.5	V	I_F=5 mA
Reverse Current	SFH618A	I_R		.01	10		V_R=6 V
Capacitance	SFH618A SFH628A	C_0		25 45		pF	V_R=0 V, f=1 MHz
Thermal Resistance		R_{thJA}		1070		K/W	
Detector							
Collector-Emitter Leakage Current		I_{CEO}		10	200	nA	V_{CE}=10 V
Capacitance		C_{CE}		7		pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance		R_{thJA}		500		K/W	
Package							
Collector-Emitter Saturation Voltage	SFH618A-2	V_{CESAT}		0.25	0.4	V	I_C=0.32 mA, I_F=1 mA
	SFH618A-3			0.25	0.4		I_C=0.5 mA, I_F=1 mA
	SFH618A-4			0.25	0.4		I_C=0.8 mA, I_F=1 mA
	SFH618A-5			0.25	0.4		I_C=1.25 mA, I_F=1 mA
Collector-Emitter Saturation Voltage	SFH628A-2	V_{CESAT}		0.25	0.4	V	I_C=0.5 mA, I_F=±1 mA
	SFH628A-3			0.25	0.4		I_C=0.8 mA, I_F=±1 mA
	SFH628A-4			0.25	0.4		I_C=1.25 mA, I_F=±1 mA
Coupling Capacitance		C_C		0.25		pF	
Coupling Transfer Ratio	SFH618A-2	I_C/I_F	63		125	%	I_F=1 mA, V_{CE}=0.5 V
	SFH618A-2		32	75			I_F=0.5 mA, V_{CE}=1.5 V
	SFH618A-3	I_C/I_F	100		200	%	I_F=1 mA, V_{CE}=0.5 V
	SFH618A-3		50	120			I_F=0.5 mA, V_{CE}=1.5 V
	SFH618A-4	I_C/I_F	160		320	%	I_F=1 mA, V_{CE}=0.5 V
	SFH618A-4		80	200			I_F=0.5 mA, V_{CE}=1.5 V
	SFH618A-5	I_C/I_F	250		500	%	I_F=1 mA, V_{CE}=0.5 V
	SFH618A-5		125	300			I_F=0.5 mA, V_{CE}=1.5 V
Coupling Transfer Ratio	SFH628A-2	I_C/I_F	63		200	%	I_F=±1 mA, V_{CE}=0.5 V
	SFH628A-2		32	100			I_F=±0.5 mA, V_{CE}=1.5 V
	SFH628A-3	I_C/I_F	100		320	%	I_F=±1 mA, V_{CE}=0.5 V
	SFH628A-3		50	160			I_F=±0.5 mA, V_{CE}=1.5 V
	SFH628A-4	I_C/I_F	160		500	%	I_F=±1 mA, V_{CE}=0.5 V
	SFH628A-4		80	250			I_F=±0.5 mA, V_{CE}=1.5 V

Figure 1. Current transfer ratio (typ.)
V_{CE}=0.5 V, C_{TR}=f(T_A)

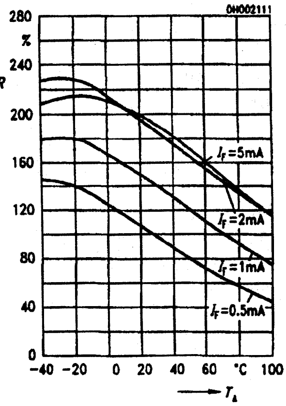


Figure 2. Current transfer ratio (typ.)
V_{CE}=1.5 V, C_{TR}=f(T_A)

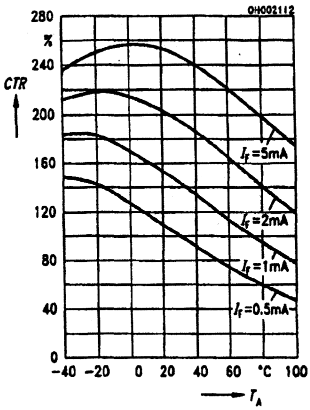


Figure 3. Diode forward voltage
T_A=25°C, V_F=f(I_F)

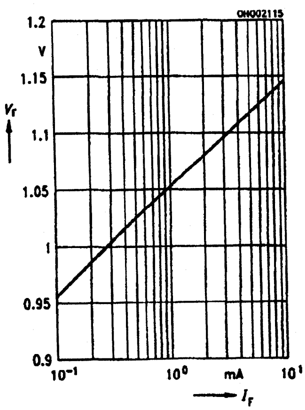


Figure 4. Diode forward voltage
I_F=1 mA, V_F=f(T_A)

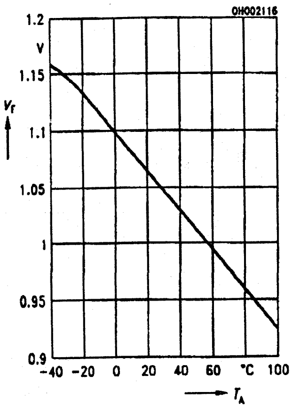


Figure 5. Transistor capacitance
T_A=25°C, f=1 MHz, C_{CE}=f(V_{CE})

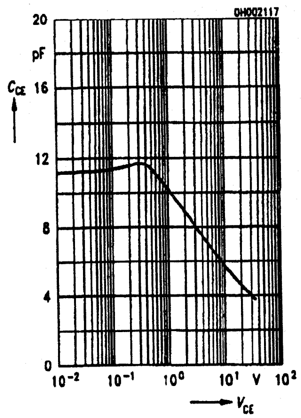


Figure 6. Output characteristics
T_A=25°C, C_E=f(V_{CE}, I_F)

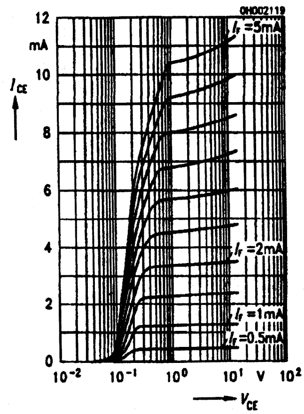


Figure 7. Permissible forward current diode I_F=f(T_A)

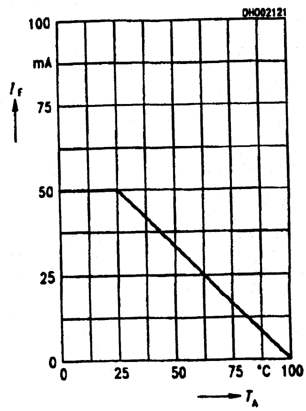


Figure 8. Permissible power dissipation P_{TOT}=f(T_A)

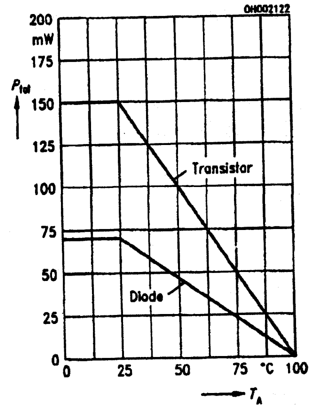
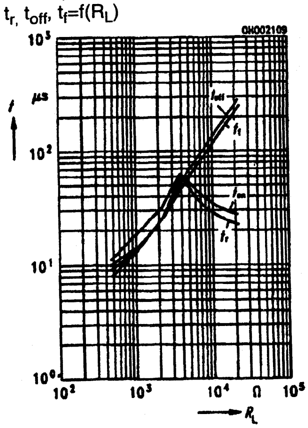


Figure 9. Switching times (typ.)
T_A=25°C, I_F=1 mA, V_{CC}=5 V
t_{on}, t_r, t_{off}, t_f=f(R_L)



Switching times, typical

V_{CC}=5 V, I_C=2 mA, R_L=100W, T_A=25°C

Turn-on Time	t_{ON}	6.0	µs
Rise Time	t_R	3.5	
Turn-off Time	t_{OFF}	5.5	
Fall Time	t_F	5.0	

Figure 22. Test circuit—SFH618A

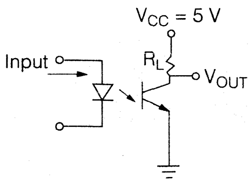


Figure 23. Test circuit—SFH628A

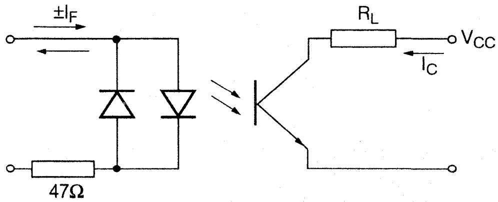
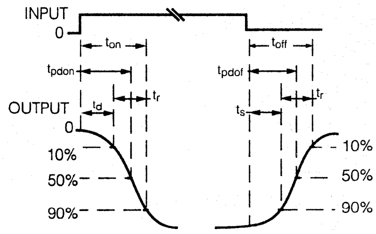


Figure 24. Test circuit and waveforms



SIEMENS

SFH620A

5.3 kV TRIOS® Optocoupler AC Voltage Input

FEATURES

- **High Current Transfer Ratios**
  - **at 10 mA: 40–320%**
  - **at 1 mA: 45% typical (>13)**
- **Low CTR Degradation**
- **Good CTR Linearity Depending on Forward Current**
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **High Collector-Emitter Voltage, V_{CEO}=70 V**
- **Low Saturation Voltage**
- **Fast Switching Times**
- **Field-Effect Stable by TRIOS (TRansparent IOn Shield)**
- **Temperature Stable**
- **Low Coupling Capacitance**
- **End-Stackable, .100" (2.54 mm) Spacing**
- **High Common-Mode Interference Immunity (Unconnected Base)**
- **Underwriters Lab File #52744**
- **VDE 0884 Available with Option 1**
- **SMD Option, See SFH6206 Data Sheet**

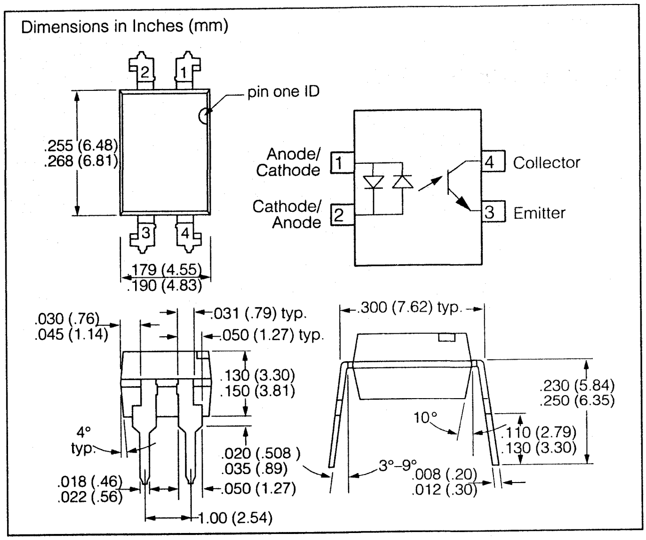
DESCRIPTION

The SFH620A features a high current transfer ratio, low coupling capacitance and high isolation voltage. These couplers have a GaAs infrared emitting diode emitter, which is optically coupled to a silicon planar phototransistor detector, and is incorporated in a plastic DIP-4
package.

The coupling devices are designed for signal transmission between two electrically separated circuits.

The couplers are end-stackable with 2.54 mm spacing.

Creepage and clearance distances of >8 mm are achieved with option 6. This version complies with IEC 950 (DIN VDE 0805) for reinforced insulation up to an operation voltage of 400 V_{RMS} or DC.



Maximum Ratings

Emitter

Reverse Voltage	6 V
DC Forward Current	±60 mA
Surge Forward Current (t_P≤10 µs)	±2.5 A
Total Power Dissipation	100 mW

Detector

Collector-Emitter Voltage	70 V
Emitter-Collector Voltage	7 V
Collector Current	50 mA
Collector Current (t_P≤1 ms)	100 mA
Total Power Dissipation	150 mW

Package

Isolation Test Voltage between Emitter and Detector, refer to Climate DIN 40046, part 2, Nov. 74	5300 VAC_{RMS}
Creepage	≥7 mm
Clearance	≥7 mm
Insulation Thickness between Emitter and Detector	≥0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE0 303, part 1	175
Isolation Resistance V_{IO}=500 V, T_A=25°C	$≥10^{12}$ Ω
V_{IO}=500 V, T_A=100°C	$≥10^{11}$ Ω
Storage Temperature Range	–55 to +150°C
Ambient Temperature Range	–55 to +100°C
Junction Temperature	100°C
Soldering Temperature (max. 10 s. Dip Soldering Distance to Seating Plane ≥1.5 mm)	260°C

Characteristics (T_A=25°C)

Description	Symbol		Unit	Condition
Emitter				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=±60 mA
Capacitance	C_0	50	pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}	750	K/W	
Detector				
Capacitance	C_{CE}	6.8	pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance	R_{thJA}	500	K/W	
Package				
Collector-Emitter Saturation Voltage	V_{CESAT}	0.25 (≤0.4)	V	I_F=10 mA, I_C=2.5 mA
Coupling Capacitance	C_C	0.2	pF	

Note: Still air, coupler soldered to PCB or base.

Current Transfer Ratio (I_C/I_F at V_{CE}=5 V) **and Collector-Emitter Leakage Current by Dash Number**

Description	-1	-2	-3	
I_C/ I_F (I_F=±10 mA)	40–125	63–200	100–320	%
I_C/ I_F (I_F=±1 mA)	30 (>13)	45 (>22)	70 (>34)	%
Collector-Emitter Leakage Current, I_{CEO} V_{CE}=10 V	2 (≤50)	2 (≤50)	5 (≤100)	nA

Figure 1. Current transfer ratio (typ.) vs. temperature
I_F=10 mA, V_{CE}=5 V

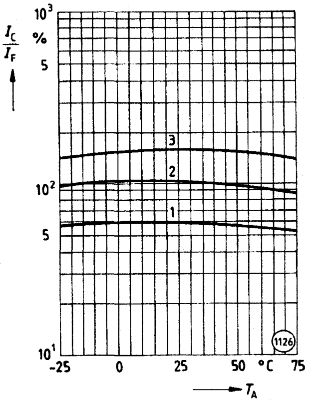


Figure 2. Output characteristics (typ.) Collector current vs. collector-emitter voltage T_A=25°C

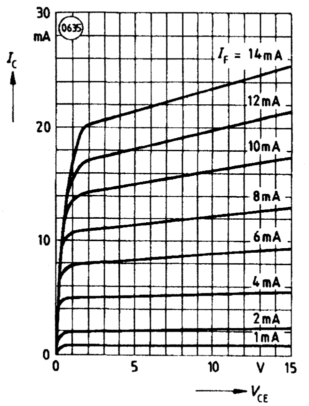


Figure 3. Diode forward voltage (typ.) vs. forward current

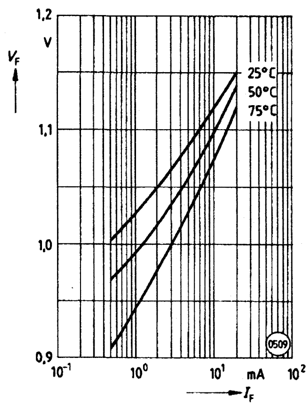


Figure 4. Transistor capacitance (typ.) vs. collector-emitter voltage
T_A=25°C, f=1 MHz

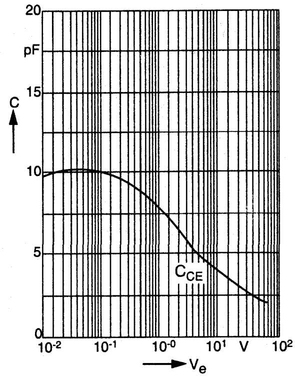


Figure 5. Permissiable pulse handling capability. Fwd. current vs. pulse width
Pulse cycle D=parameter, T_A=25°C

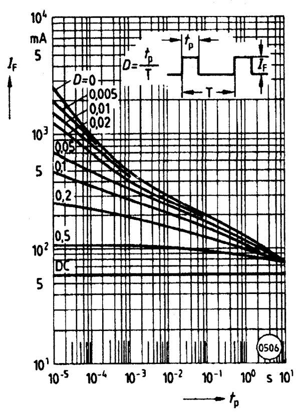


Figure 6. Permissible power dissipation vs. ambient temp.

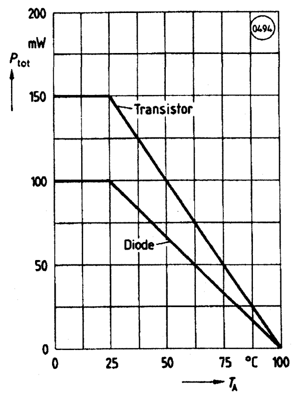


Figure 7. Permissible diode forward current vs. ambient temp.

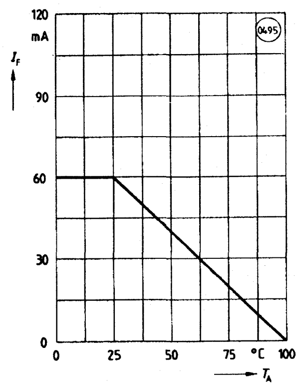
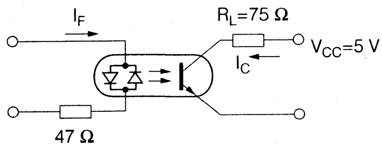


Figure 8. Switching Times Linear Operation (without saturation)



I_F=10 mA, V_{CC}=5 V, T_A=25°C

Load Resistance	R_L	75	Ω
Turn-on Time	t_{ON}	3.0	µs
Rise Time	t_r	2.0	µs
Turn-off Time	t_{OFF}	2.3	µs
Fall Time	t_r	2.0	µs
Cut-off Frequency	F_{CO}	250	kHz

SIEMENS

SFH620AA/AGB

5.3 kV TRIOS® Optocoupler
AC Voltage Input

FEATURES
- **High Current Transfer Ratios**
  at 5 mA: 50–600%
  at 1 mA: 45% typical (>13)
- **Low CTR Degradation**
- **Good CTR Linearity Depending on Forward Current**
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **High Collector-Emitter Voltage, V_{CEO}=70 V**
- **Low Saturation Voltage**
- **Fast Switching Times**
- **Field-Effect Stable by TRIOS (TRansparent IOn Shield)**
- **Temperature Stable**
- **Low Coupling Capacitance**
- **End-Stackable, .100"(2.54 mm) Spacing**
- **High Common-Mode Interference Immunity (Unconnected Base)**
- **Underwriters Lab File #52744**
- **VDE 0884 Available with Option 1**
- **SMD Option, See SFH6206 Data Sheet**

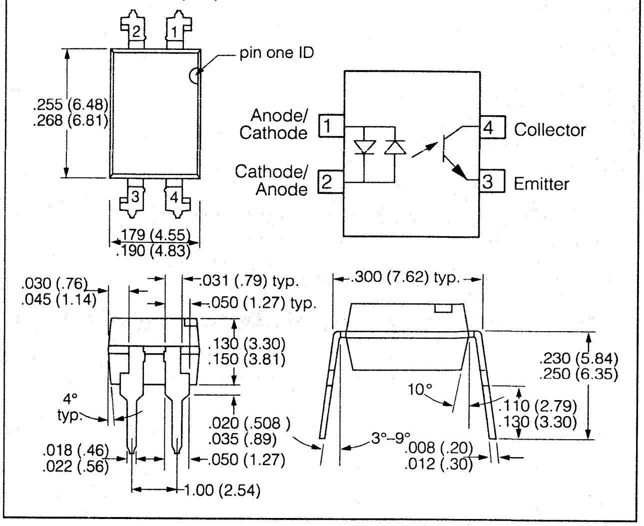
DESCRIPTION

The SFH620AA/AGB features a high current transfer ratio, low coupling capacitance and high isolation voltage. These couplers have a GaAs infrared emitting diode emitter, which is optically coupled to a silicon planar phototransistor detector, and is incorporated in a plastic DIP-4 package.

The coupling devices are designed for signal transmission between two electrically separated circuits.

The couplers are end-stackable with 2.54 mm spacing.

Creepage and clearance distances of >8 mm are achieved with option 6. This version complies with IEC 950 (DIN VDE 0805) for reinforced insulation up to an operation voltage of 400 V_{RMS} or DC.



Maximum Ratings

Emitter

Reverse Voltage	±60 mA
Surge Forward Current (t_P≤10 µs)	±2.5 A
Total Power Dissipation	100 mW

Detector

Collector-Emitter Voltage	70 V
Emitter-Collector Voltage	7 V
Collector Current	50 mA
Collector Current (t_P≤1 ms)	100 mA
Total Power Dissipation	150 mW

Package

Isolation Test Voltage between Emitter and Detector, refer to Climate DIN 40046, part 2, Nov. 74	5300 VAC_{RMS}
Creepage	≥7 mm
Clearance	≥7 mm
Insulation Thickness between Emitter and Detector	0.4 mm
Comparative Tracking Index per DIN IEC 112/VDE0 303, part 1	175
Isolation Resistance	
V_{IO}=500 V, T_A=25°C	$\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C	$\geq 10^{11}\ \Omega$
Storage Temperature Range	–55 to +150°C
Ambient Temperature Range	–55 to +100°C
Junction Temperature	100°C
Soldering Temperature (max. 10 s. Dip Soldering Distance to Seating Plane ≥1.5 mm)	260°C

Characteristics (T_A=25°C)

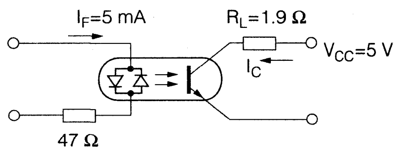
Description	Symbol		Unit	Condition
Emitter				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=±60 mA
Capacitance	C_0	50	pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}	750	K/W	
Detector				
Capacitance	C_{CE}	6.8	pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance	R_{thJA}	500	K/W	
Package				
Collector-Emitter Saturation Voltage	V_{CESAT}	0.25 (≤0.4)	V	I_F=10 mA, I_C=2.5 mA
Coupling Capacitance	C_C	0.2	pF	

Note: 1. Still air, coupler soldered to PCB or base.

Current Transfer Ratio (I_C/I_F at V_{CE}=5 V) **and Collector-Emitter Leakage Current**

Description	AA	AGB	Unit
I_C/I_F (I_F=±5 mA)	50–600	100–600	%
Collector-Emitter Leakage Current, I_{CEO} V_{CE}=10 V	10 (≤100)	10 (≤100)	nA

Switching Times (Typical Values)
Linear Operation (saturated)



Turn-on Time	t_{ON}	2.0	µs
Turn-off Time	t_{OFF}	25	µs

Figure 1. Current transfer ratio (typ.) vs. temperature
I_F=10 mA, V_{CE}=5 V

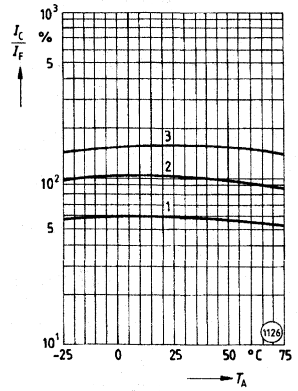


Figure 2. Output characteristics (typ.) Collector current vs. collector-emitter voltage T_A=25°C

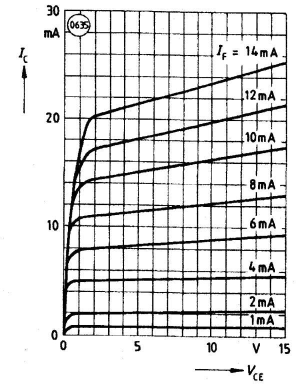


Figure 3. Diode forward voltage (typ.) vs. forward current

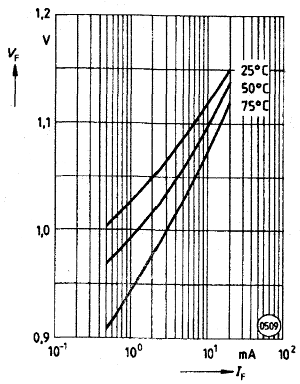


Figure 4. Transistor capacitance (typ.) vs. collector-emitter voltage
T_A=25°C, f=1 MHz

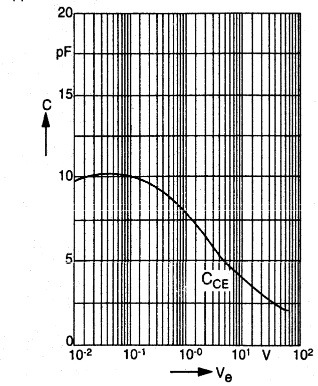


Figure 5. Permissiable pulse handling capability. Fwd. current vs. pulse width
Pulse cycle D=parameter, T_A=25°C

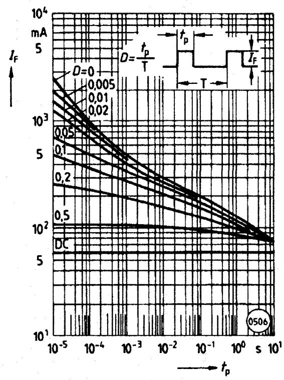


Figure 6. Permissible power dissipation vs. ambient temp.

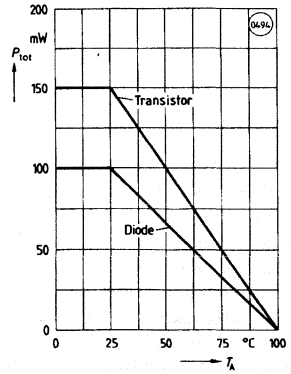
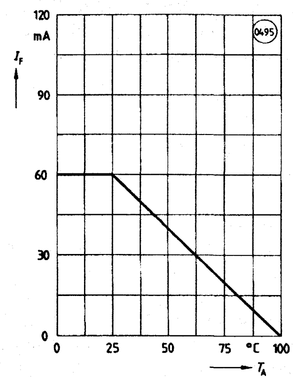


Figure 7. Permissible diode forward current vs. ambient temp.

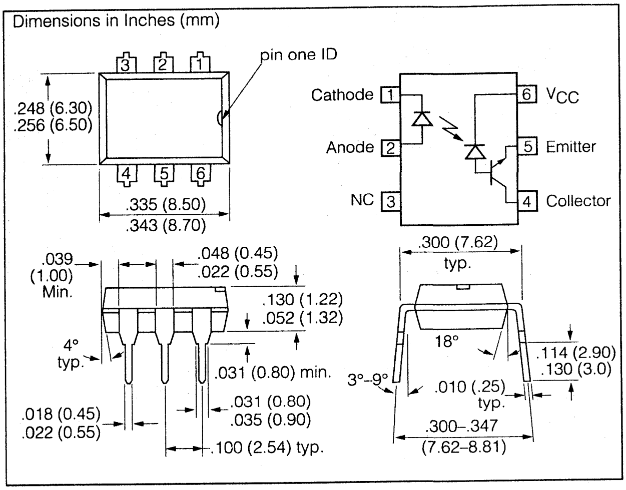


SIEMENS

SFH636

High Speed 5.3 kV Optocoupler

Preliminary Data Sheet



FEATURES

- **High Speed Optocoupler without Base Connection**
- **GaAlAs Emitter**
- **Integrated Detector with Photodiode and Transistor**
- **High Data Transmission Rate: 1 MBit/s**
- **TTL Compatible**
- **Open Collector Output**
- **CTR at I_F=16 mA, V_O=0.4 V, V_{CC}=4.5 V, T_A=25°C: ≥19%**
- **Good CTR Linearity Relative to Forward Current**
- **Field Effect Stable by TRIOS®**
- **(TRansparent IOn Shield)**
- **Low Coupling Capacitance**
- **dV/dt: typ. 10 kV/µs**
- **Isolation Test Voltage: 5300 VAC_{RMS}**
- **VDE 0884 Available with Option 1**
- **UL Approval, File #E52744**

APPLICATIONS

- **IGBT Drivers**
- **Data Communications**
- **Programmable Controllers**

DESCRIPTION

The SFH636 is an optocoupler with a GaAlAs infrared emitting diode, optically coupled to an integrated photodetector consisting of a photodiode and a high speed transistor in a DIP-6 plastic package. The device is functionally similar to 6N136 except there is no base connection, and the electrical foot print is different. Noise and
dv/dt performance is enhanced by not bringing out the base connection.

Signals can be transmitted between two electrically separated circuits up to frequencies of 2 MHz. The potential difference between the circuits to be coupled should not exceed the maximum permissible reference voltages.

Absolute Maximum Ratings

Emitter (GaAlAs)

Reverse Voltage .... 3 V
DC Forward Current .... 25 mA
Surge Forward Current .... 1 A
  t_p≤1 µs, 300 pulses/sec.
Total Power Dissipation .... 45 mW

Detector (Si Photodiode + Transistor)

Supply Voltage .... –0.5 to 30 V
Output Voltage .... –0.5 to 20 V
Output Current .... 8 mA
Total Power Dissipation .... 100 mW

Package Insulation

Isolation Test Voltage
  between emitter and detector
  (refer to climate DIN 40046, part 2, Nov. 74) .... 5300 VAC_{RMS}
Creepage .... 7 mm min.
Clearance .... 7 mm min.
Comparative Tracking Index
  per DIN IEC 112/VDE0303, part 1 175
Isolation Resistance
  V_{IO}=500 V, T_A=25°C .... ≥10^{12} Ω
  V_{IO}=500 V, T_A=100°C .... ≥10^{11} Ω
Storage Temperature Range .... –55 to +150°C
Ambient Temperature Range .... –55 to +100°C
Junction Temperature .... 100°C
Soldering Temperature (t=10 sec. max.) .... 260°C
  Dip soldering: distance to seating plane ≥1.5 mm

Characteristics (T_A=0° to 70°C, unless otherwise specified, typical values T_A=25°C)

Description	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter (IR GaAlAs)						
Forward Voltage	V_F		1.5	1.8	V	I_F=16 mA
Reverse Current	I_R		0.5	10	µA	V_R=3 V
Capacitance	C_0		125		pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}		700		°K/W	
Detector (Si Photodiode + Transistor)						
Supply Current, Logic High	I_{CCH}		0.01	1	µA	I_F=0, V_O (open), V_{CC}=15 V, T_A=25°C
			0.01	2		I_F=0, V_O (open), V_{CC}=15 V
Output Current, Output High	I_{OH}		.003	0.5	µA	I_F=0, V_O (open), V_{CC}=5.5 V, T_A=25°C
			.01	1		I_F=0, V_O (open), V_{CC}=15 V, T_A=25°C
			—	50		I_F=0, V_O (open), V_{CC}=15 V
Capacitance	C_{CE}		3		pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance	R_{thJA}		300		°K/W	
Package						
Coupling Capacitance	C_C		0.6		pF	
Coupling Transfer Ratio	I_C/I_F	19	30		%	I_F=16 mA, V_O=0.4 V, V_{CC}=4.5 V, T_A=25°C
		15	—			I_F=16 mA, V_O=0.5 V, V_{CC}=4.5 V
Collector Emitter Saturation Voltage	V_{OL}		0.1	0.4	V	I_F=16 mA, I_O=2.4 mA, V_{CC}=4.5 V, T_A=25°C
Supply Current, Logic Low	I_{CCL}		80		µA	I_F=16 mA, V_O open, V_{CC}=15 V

Figure 1. Test set-up

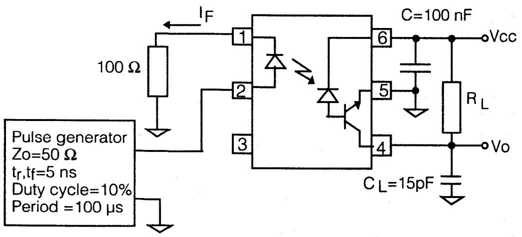
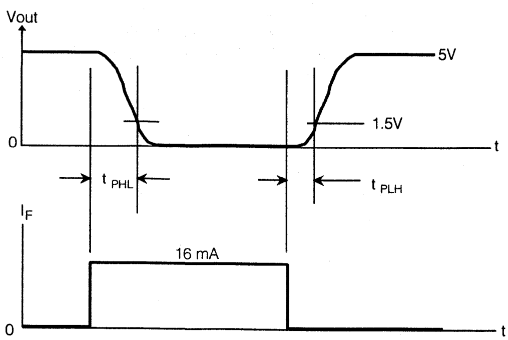


Figure 2. Switching time measurement



Description	Symbol	Min.	Typ.	Max.	Unit	Condition
Propagation Delay Time (High-Low)	t_{PHL}		0.3	0.8	µs	I_F=16 mA, V_{CC}=5 V R_L=1.9 kΩ, T_A=25°C
Propagation Delay Time (Low-Low)	t_{PLH}					

Figure 3. Common mode transient test

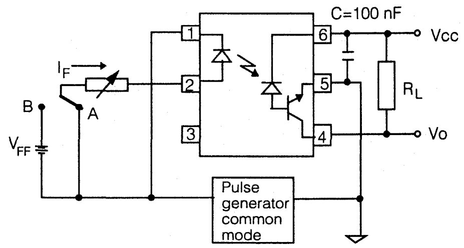
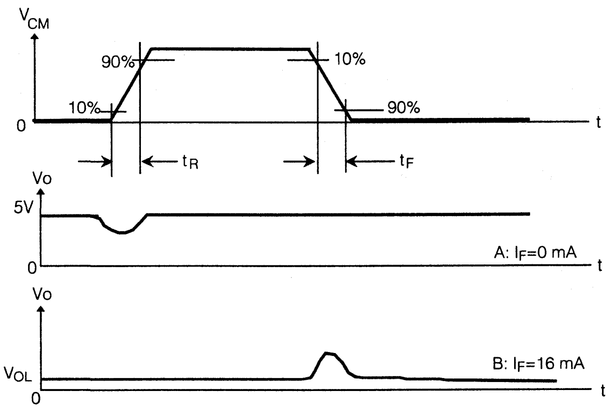


Figure 4. Measurement waveform of CMR



Description	Symbol	Min.	Typ.	Max.	Unit	Condition
Common Mode Transient Immunity (High)	CM_H		10		kV/µs	I_F=0, V_{CM}=1500 V_{P-P}, R_L=1.9 kΩ, V_{CC}=5 V, T_A=25°C
Common Mode Transient Immunity (Low)	CM_L		10		kV/µs	I_F=16 mA, V_{CM}=1500 V_{P-P}, R_L=1.9 kΩ, V_{CC}=5 V, T_A=25°C

Figure 5. Output characteristics– Output current vs. output voltage T_A=25°C, V_{CC}=5 V

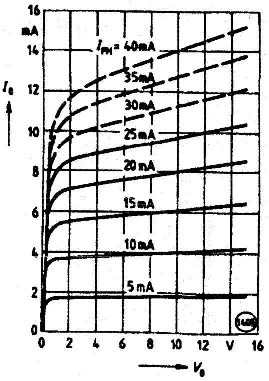


Figure 8. Forward current of emitting diode vs. forward voltage T_A=25°C

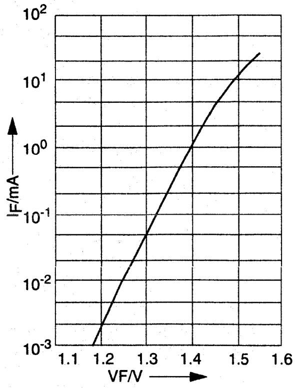


Figure 11. Output current (high) vs. ambient temperature V_O=V_{CC}=5 V, I_F=0

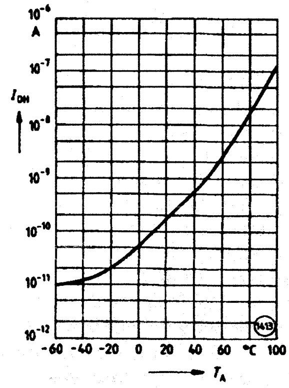


Figure 6. Permissible forward current of emitting diode vs. ambient temperature

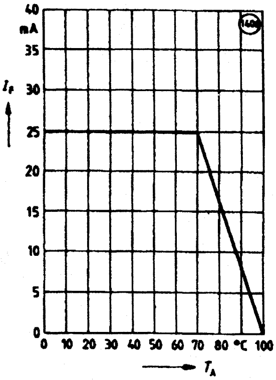


Figure 9. Small signal transfer ratio vs. forward current V_{CC}=5 V, T_A=25°C

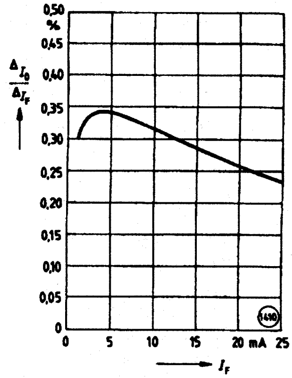


Figure 12. Delay times vs. ambient temperature I_F=16 mA, V_{CC}=5 V, R_L=4.1 kΩ, SFH6136: R_L=1.9kΩ

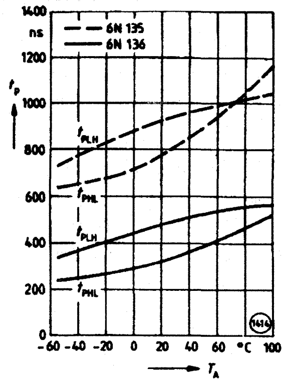


Figure 7. Permissible total power dissipation vs. ambient temperature

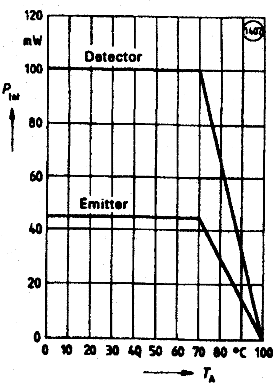


Figure 10. Current transfer ratio (normalized) vs. ambient temp. I_F=16 mA, V_O=0.4 V, V_{CC}=5 V, T_A=25°C

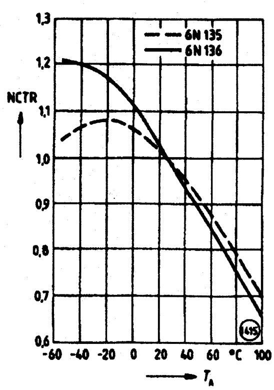
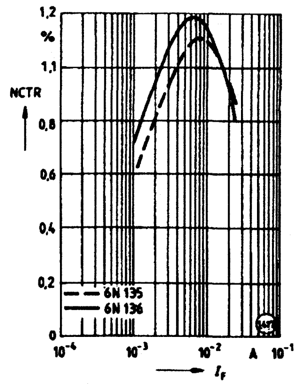


Figure 13. Current transfer ratio (normalized) vs. forward current I_F=16 mA, V_O=0.4 V, V_{CC}=5 V, T_A=25°C)



SIEMENS

SFH640

5.3 KV TRIOS® High BV_{CER} Voltage Phototransistor Optocoupler

FEATURES

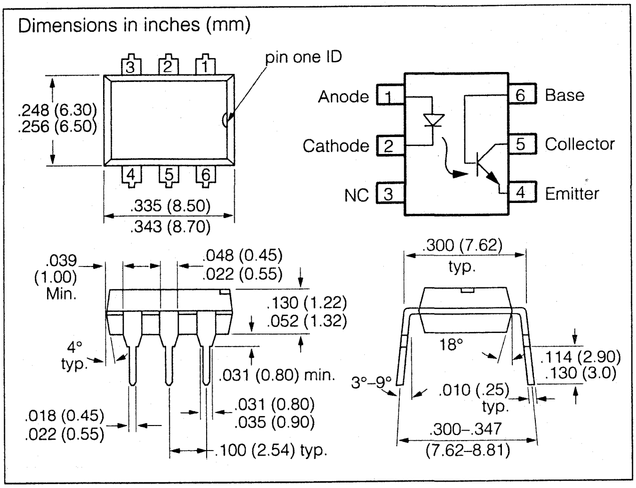
- CTR at I_F=10 mA, V_{CE}=10 V
  SFH640-1, 40-80%
  SFH640-2, 63-125%
  SFH640-3*, 100-200%
- **Good CTR Linearity with Forward Current**
- **Low CTR Degradation**
- **Very High Collector-Emitter Breakdown Voltage, BV_{CER}=300 V**
- **Isolation Test Voltage: 5300 VAC_{RMS}**
- **Low Coupling Capacitance**
- **High Common Mode Transient Immunity**
- **Phototransistor Optocoupler**
  6 Pin DIP Package with Base Connection
- **Field Effect Stable: TRIOS+**
- **VDE 0884 Available with Option 1**
- **Underwriters Lab File #E52744**

DESCRIPTION

The SFH 640 is an optocoupler with very high BVCER, a minimum of 300 volts. It is intended for telecommunications applications or any DC application requiring a high blocking voltage. The SFH640 is a "better than" replacement for H11D1.

*Supplies from this group can't always be guranteed due to unforseeable yield spread.

+**TRIOS**–**TR**ansparent **IO**n **S**hield



Maximum Ratings (T_A=25°C)

Emitter

Reverse Voltage .... 6 V
DC Forward Current .... 60 mA
Surge Forward Current (tp≤10 µs) .... 2.5 A
Total Power Dissipation .... 100 mW

Detector

Collector-Emitter Voltage .... 300 V
Collector-Base Voltage .... 300 V
Emitter-Base Voltage .... 7 V
Collector Current .... 50 mA
Surge Collector Current (tp≤1 ms) .... 100 mA
Total Power Dissipation .... 300 mW

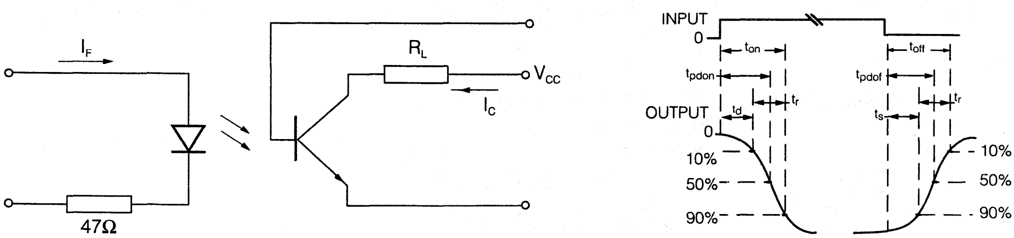
Package

Isolation Test Voltage (between emitter and detector, refer to climate DIN 40046 part 2 Nov. 74) .... 5300 VAC_{RMS}/7500 VAC_{PK}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}\ \Omega$
V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}\ \Omega$
Insulation Thickness between Emitter and Detector .... ≥0.4 mm
Creepage .... ≥7 mm
Clearance .... ≥7 mm
Comparative Tracking Index per DIN IEC 112/VDE 0303, part1 175
Storage Temperature Range .... -55°C to +150°C
Operating Temperature Range .... -55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature (max. 10 sec., dip soldering: distance to seating plane≥1.5 mm) .... 260°C

Characteristics (T_A=25°C, unless otherwise specified)

	Symbol	Min	Typ	Max	Unit	Condition
Emitter						
Forward Voltage	V_F		1.1	1.5	V	I_F=10 mA
Reverse Voltage	V_R	6			V	I_R= 10 µA
Reverse Current	I_R		0.01	10	µA	V_R=6 V
Capacitance	C_O		25		pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}		750		K/W	
Detector						
Voltage Collector-Emitter Emitter-Base	 BV_{CER} BV_{BEO}	 300 7			 V V	 I_{CE}=1 mA, R_{BE}=1 MΩ I_{EB}=10 µA
Capacitance	C_{CE} C_{CB} C_{EB}		7 8 38		pF pF pF	V_{CE}=10 V, f=1 MHz V_{CB}=10 V, f=1 MHz V_{EB}=5 V, f=1 MHz
Thermal Resistance	R_{thJA}		250		K/W	
Package						
Coupling Capacitance	C_C		0.6		pF	
Coupling Transfer Ratio SFH 640-1 SFH 640-2 SFH 640-3	 I_C/I_F I_C/I_F I_C/I_F	 40 13 63 22 100 34	 30 45 70	 80 125 200	 % % %	 I_F=10 mA, V_{CE}=10 V I_F=1 mA, V_{CE}=10 V I_F=10 mA, V_{CE}=10 V I_F=1 mA, V_{CE}=10 V I_F=10 mA, V_{CE}=10 V I_F=1 mA, V_{CE}=10 V
Saturation Voltage, Collector-Emitter SFH 640-1 SFH 640-2 SFH 640-3	 V_{CEsat} V_{CEsat} V_{CEsat}		 0.25 0.25 0.25	 0.4 0.4 0.4	 V V V	 I_F= 10 mA, I_C=2 mA I_F= 10 mA, I_C=3.2 mA I_F=10 mA, I_C=5 mA
Leakage Current, Collector-Emitter	I_{CER}		1	100	nA	V_{CE}=200 V, R_{BE}=1 MΩ

Figure 1. Switching times measurement-test circuit and waveform



Switching Times (Typical)

I_C=2 mA (to adjust by I_F), R_L=100 Ω, T_A=25°C, V_{CC}=10 V

Description	Symbol	Values	Unit
Turn-On Time	t_{ON}	5	µs
Rise Time	t_R	2.5	µs
Turn-Off Time	t_{OFF}	6	µs
Fall Time	t_F	5.5	µs

Figure 2. Current transfer ratio (typ.) V_{CE}=10 V, T_A=25°C, normalized to I_F=10 mA, NCTR=f(I_F)

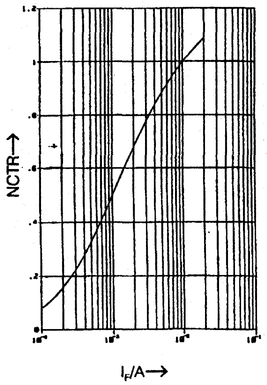


Figure 3. Diode forward voltage (typ.) V_F=f(I_F, T_A)

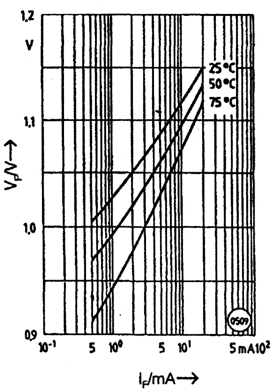


Figure 4. Output characteristics (typ.) T_A=25°C, I_{CE}=f(V_{CE}, I_B)

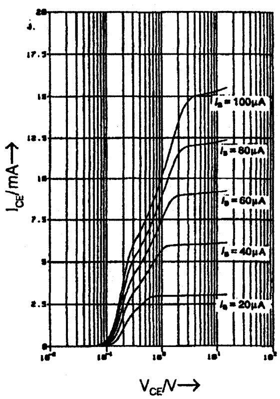


Figure 5. Output characteristics (typ.) T_A=25°C, I_{CE}=f(V_{CE}, I_F)

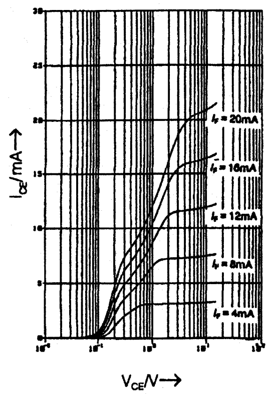


Figure 6. Transistor capacitances (typ.) T_A=25°C, f=1 MHz, C_{CE}=f(V_{CE}) C_{CB}=f (V_{CB}), C_{EB}=f (V_{EB})

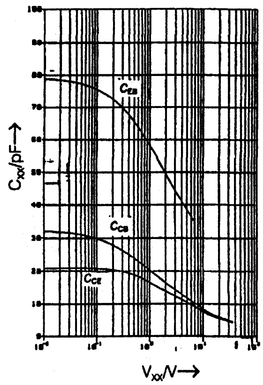


Figure 7. Collector-emitter leakage current (typ.) I_F=0, R_{BE}=1 MW, I_{CER}=f(V_{CE})

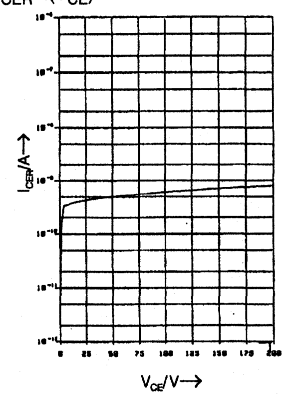


Figure 8. Permissible loss diode I_F= f(T_A)

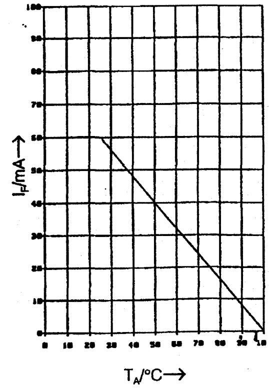
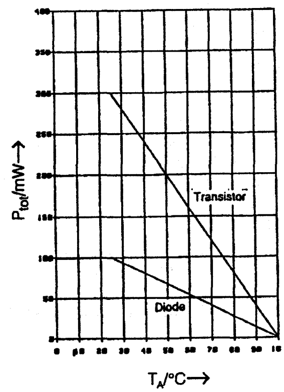


Figure 9. Permissible power dissipation P_{IOT}=f(T_A)



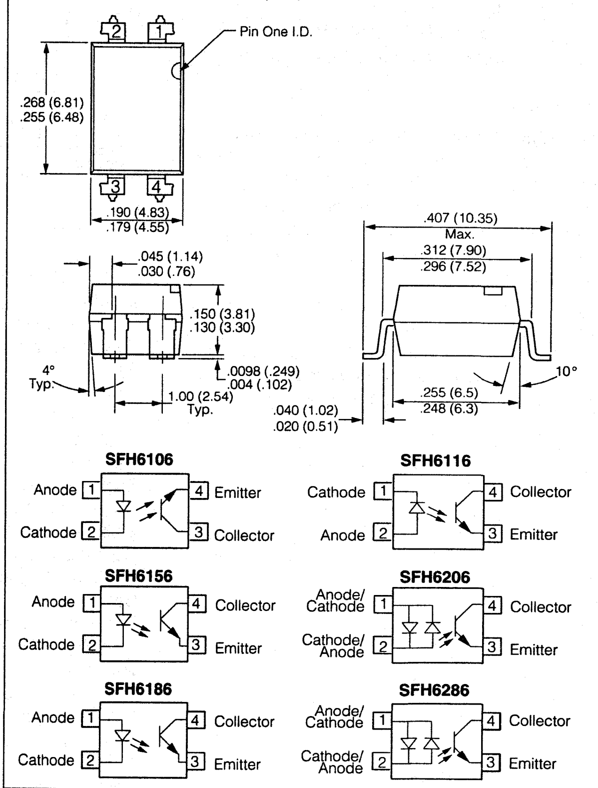
SIEMENS

SFH6106
SFH6116
SFH6156
SFH6186
SFH6206
SFH6286

5.3 kV TRIOS® High Reliability Optocouplers

FEATURES
- **SMD Versions of SFH610, 611, 615, 618, 620, 628**
- **Available on Tape and Reel —To Order Use Suffix "T"**
- **TRIOS —Transparent IOn Shield**

Package Dimensions in Inches (mm)



DESCRIPTION
The SFH6106, 6116, 6156, 6186, 6206, 6286 families of optocouplers are lead bent for SMD applications. They are electrically equilvalent to the SFH610, 611, 615, 618, 620, and 628 families of optocouplers.

CROSS REFERENCE

SMD	Thru-hole	
	New Designs	Not for New Design
SFH6106-1 SFH6106-2 SFH6106-3 SFH6106-4	SFH610A-1 SFH610A-2 SFH610A-3 SFH610A-4	SFH610-1 SFH610-2 SFH610-3 SFH610-4
SFH6116-1 SFH6116-2 SFH6116-3 SFH6116-4	SFH611A-1 SFH611A-2 SFH611A-3 SFH611A-4	SFH611-1 SFH611-2 SFH611-3 SFH611-4
SFH6156-1 SFH6156-2 SFH6156-3 SFH6156-4	SFH615A-1 SFH615A-2 SFH615A-3 SFH615A-4	SFH615-1 SFH615-2 SFH615-3 SFH615-4
SFH6186-2 SFH6186-3 SFH6186-4 SFH6186-5	SFH618A-2 SFH618A-3 SFH618A-4 SFH618A-5	SFH618-2 SFH618-3 SFH618-4 SFH618-5
SFH6206-1 SFH6206-2 SFH6206-3	SFH620A-1 SFH620A-2 SFH620A-3	SFH620-1 SFH620-2 SFH620-3
SFH6286-2 SFH6286-3 SFH6286-4	SFH628A-2 SFH628A-3 SFH628A-4	SFH628-2 SFH628-3 SFH628-4

SIEMENS

SFH6135
SFH6136

High-Speed 5.3 kV TRIOS® Optocoupler

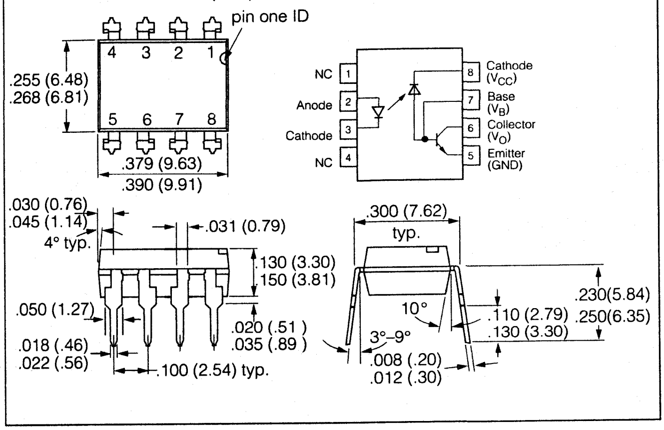
FEATURES
- **Isolation Test Voltage: 5300 VAC_{RMS}**
- **TTL Compatible**
- **High Bit Rates: 1 Mbit/s**
- **High Common-Mode Interference Immunity**
- **Bandwidth 2 MHz**
- **Open-Collector Output**
- **External Base Wiring Possible**
- **Field-Effect Stable by TRIOS (TRansparent IOn Shield)**
- **Underwriters Lab File #52744**
- **VDE 0884 Available with Option 1**

Description

The SFH6135 and SFH6136 optocouplers feature a high signal transmission rate and a high isolation resistance. They have a GaAIAs infrared emitting diode, optically coupled with an integrated photodetector which consists of a photodiode and a high-speed transistor in a DIP-8 plastic package.

Signals can be transmitted between two electrically separated circuits up to frequencies of 2 MHz. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible reference voltages.

Dimensions in inches (mm)



Maximum Ratings

Emitter

Reverse Voltage	3 V
Forward Current	25 mA
Peak Forward Current (t =1 ms, duty cycle 50%)	50 mA
Maximum Surge Forward Current (t ≤1 µs, 300 pulses/s)	1 A
Thermal Resistance	700 K/W
Total Power Dissipation (T_A≤70°C)	45 mW

Detector

Supply Voltage	-0.5 to 15 V
Output Voltage	-0.5 to 15 V
Emitter-Base Voltage	5 V
Output Current	8 mA
Maximum Output Current	16 mA
Base Current	5 mA
Thermal Resistance	300 K/W
Total Power Dissipation (T_A≤70°C)	100 mW

Package

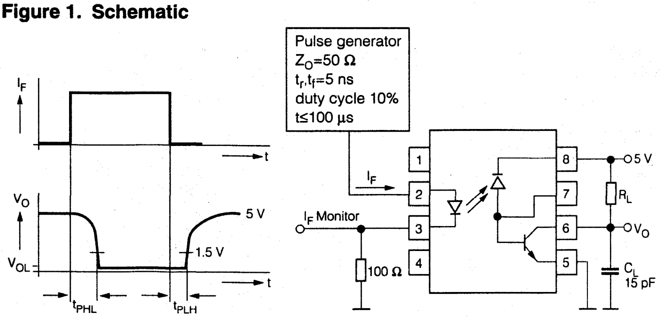
Isolation Test Voltage	5300 VAC_{RMS}
Pollution Degree (DIN VDE 0110)	2
Creepage	≥7 mm
Clearance	≥7 mm
Comparative Tracking Index per DIN IEC112/VDE 0303 part 1	175
Isolation Resistance	
V_{IO}=500 V, T_A = 25°C	≥10^{12} Ω
V_{IO}=500 V, T_A = 100°C	≥10^{11} Ω
Storage Temperature Range	–55°C to +125°C
Ambient Temperature Range	–55°C to +100°C
Soldering Temperature (max. ≤10 s. dip soldering ≥0.5 mm distance from case bottom)	260°C

Characteristics (T_A=25°C, unless otherwise specified)

	Symbol		Unit	Condition
Emitter				
Forward Voltage	V_F	1.6 (≤1.9)	V	I_F=16 mA
Breakdown Voltage	V_{BR}	≥3	V	I_R=10 µA
Reverse Current	I_R	0.5 (≤10)	µA	V_R=3 V
Capacitance	C_O	125	pF	V_R=0 V, f=1 MHz
Temperature Coefficient of Forward Voltage	$\Delta V_F / \Delta T_A$	1.7	mV/°C	I_F=16 mA
Detector				
Supply Current, Logic Low	I_{CCL}	150	µA	I_F=16 mA, V_O open, V_{CC}=15 V
Supply Current, Logic High	I_{CCH}	0.01 (≤1)	µA	I_F=0 mA, V_O open, V_{CC}=15 V
Output Voltage, Output Low SFH6135 SFH6136	V_{OL} V_{OL}	0.1 (≤0.4) 0.1 (≤0.4)	V V	I_F=16 mA, V_{CC}=4.5 V I_O=1.1 mA I_O=2.4 mA
Output Current, Output High	I_{CH}	3 (≤500)	nA	I_F=0 mA, V_O=V_{CC}=5.5 V
Output Current, Output High	I_{CH}	0.01 (≤1)	µA	I_F=0 mA V_O=V_{CC}=15 V
Current Gain	H_{FE}	150		V_O=5 V, I_O=3 mA
Package				
Coupling Capacitance-Input-Output	C_{IO}	0.6	pF	f=1 MHz
Current Transfer Ratio SFH6135 SFH6136	CTR CTR	16 (≥7) 35 (≥19)	% %	I_F=16 mA, V_O=0.4 V, V_{CC}=4.5 V, T_A=25°C
Current Transfer Ratio SFH6135 SFH6136	CTR CTR	≥5 ≥15	% %	I_F=16 mA, V_O=0.5 V, V_{CC}=4.5 V

SWITCHIMG TIMES

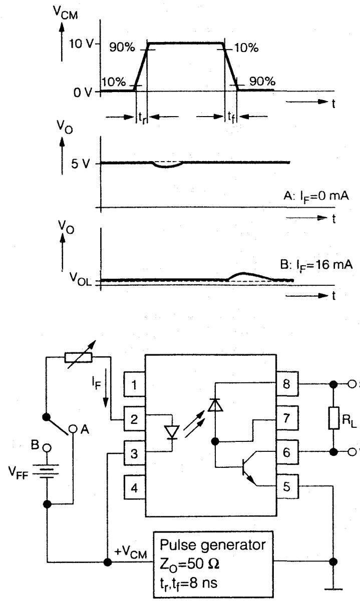
Figure 1. Schematic



Delay Time (I_F=16 mA, V_{CC}=5 V, T_A=25°C)

High - Low SFH6135 (R_L=4.1 kΩ) SFH6136 (R_L=1.9 kΩ)	t_{PHL} t_{PHL}	0.3 (≤1.5) 0.2 (≤0.8)	µs µs
Low - High SFH6135 (R_L=4.1 kΩ) SFH6136 (R_L=1.9 kΩ)	t_{PLH} t_{PLH}	0.3 (≤1.5) 0.2 (≤0.8)	µs µs

Figure 2. Common-mode interference immunity



Common Mode Interference Immunity
V_{CM}=10 VP-P, V_{CC}=5 V, T_A=25°C

High (I_F=0 mA) SFH6135 (R_L=4.1 kΩ) SFH6136 (R_L=1.9 kΩ)	CM_H CM_H	1000 1000	V/µs V/µs
Low (I_F=16 mA) SFH6135 (R_L=4.1 kΩ) SFH6136 (R_L=1.9 kΩ)	CM_L CM_L	1000 1000	V/µs V/µs

Figure 3. Output characteristics–SFH6135 Output current versus output voltage
T_A=25°C, V_{CC}=5 V

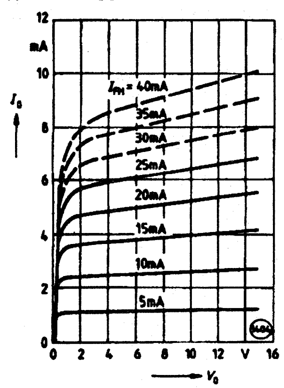


Figure 4. Output characteristics–SFH6136 Output current versus output voltage T_A=25°C, V_{CC}=5 V

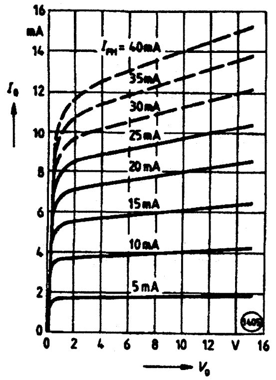


Figure 7. Forward current of emitting diode versus forward voltage
T_A=25°C

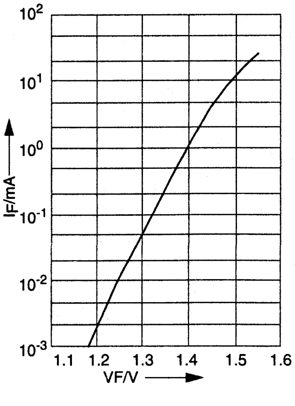


Figure 10. Output current (high) versus ambient temperature
V_O=V_{CC}=5 V, I_F=0

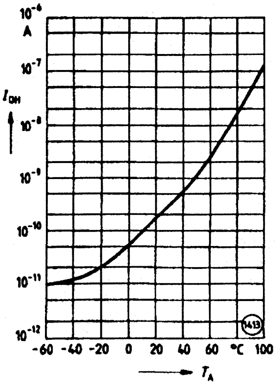


Figure 5. Permissible forward current of emitting diode versus ambient temperature

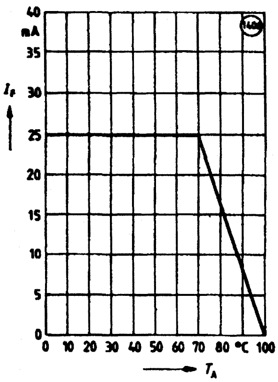


Figure 8. Small signal transfer ratio versus forward current
V_{CC}=5 V, T_A=25°C

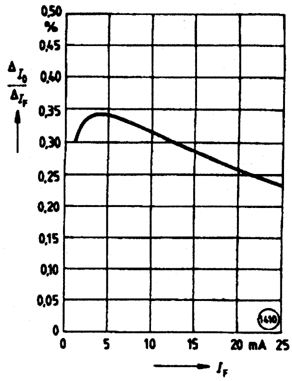


Figure 11. Delay times versus ambient temperature I_F=16 mA, V_{CC}=5 V, SFH6135: R_L=4.1 kΩ, SFH6136: R_L=1.9kΩ

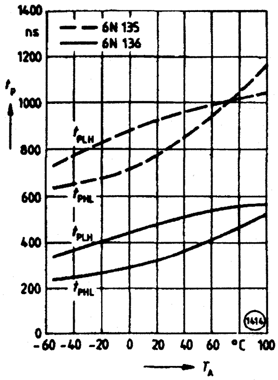


Figure 6. Permissible total power dissipation versus ambient temperature

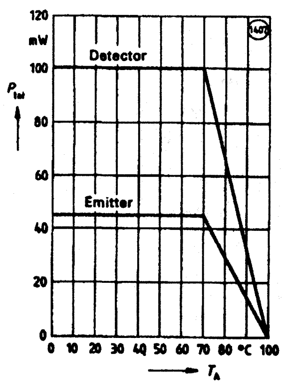


Figure 9. Current transfer ratio (normalized) versus ambient temp. I_F=16 mA, V_O=0.4 V, V_{CC}=5 V, T_A=25°C

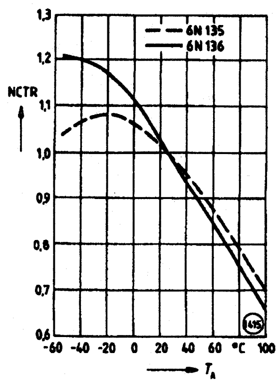
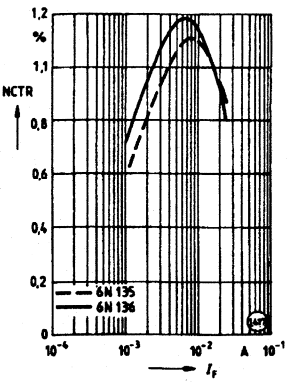


Figure 12. Current transfer ratio (normalized) versus forward current
I_F=16 mA, V_O=0.4 V, V_{CC}=5 V, T_A=25°C)



SIEMENS

SFH6138
SFH6139

Low Input Current, High Gain TRIOS® Optocoupler

FEATURES

- **High Current Transfer Ratio, 800%**
- **Low Input Current Requirement, 0.5 mA**
- **High Output Current, 60 mA**
- **Isolation Test Voltage, 5300 VAC_{RMS}**
- **TTL Compatible Output, 0.1V V_{OL}**
- **High Common Mode Rejection, 500V/µsec.**
- **DC to 0.1 Megabit/Sec. Operation**
- **Adjustable Bandwidth—Access to Base**
- **TRIOS (TRansparent IOn Shield)**
- **Standard Molded Dip Plastic Package**
- **Underwriters Lab File #E52744**
- **VDE 0884 Available with Option 1**

APPLICATIONS

- **Logic Ground Isolation—TTL/TTL, TTL/CMOS, CMOS/CMOS, CMOS/TTL**
- **EIA RS 232C Line Receiver**
- **Low Input Current Line Receiver—Long Lines, Party Lines**
- **Telephone Ring Detector**
- **117 VAC Line Voltage Status Indication—Low Input Power Dissipation**
- **Low Power Systems—Ground Isolation**

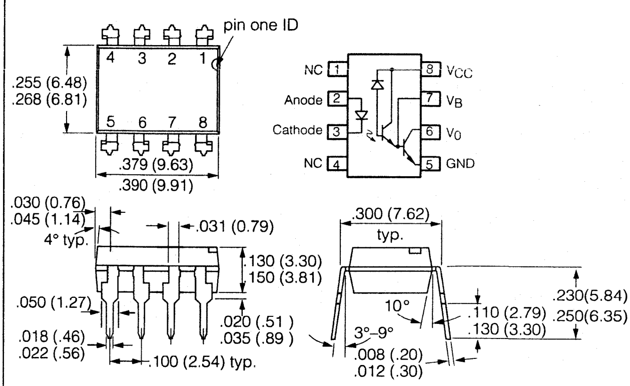
DESCRIPTION

High common mode transient immunity and very high current ratio together with 5300 VAC_{RMS} insulation are achieved by coupling an LED with an integrated high gain photon detector in an eight pin dual-in-line package. Separate pins for the photodiode and output stage enable TTL compatible saturation voltages with high speed operation. Photodarlington operation is achieved by tying the V_{CC} and V_O terminals together. Access to the base terminal allows adjustment to the gain bandwidth.

The SFH6138 is ideal for TTL applications since the 300% minimum current transfer ratio with an LED current of 1.6 mA enables operation with one unit load-in and one unit load-out with a 2.2 KΩ pull-up resistor.

The SFH6139 is best suited for low power logic applications involving CMOS and low power TTL. A 400% current transfer ratio with only 0.5 mA of LED current is guaranteed from 0°C to 70°C.

Dimensions in Inches (mm)



Maximum Ratings

Reverse Input Voltage .... 5 V
Supply and Output Voltage, V_{CC} (pin 8-5), V_O (pin 6-5)
SFH6138 .... –0.5 to 7 V
SFH6139 .... –0.5 to 18 V
Emitter-Base Reverse Voltage (pin 5-7) .... 0.5 V
Average Input Current .... 20 mA
Peak Input Current .... 40 mA
(50% Duty Cycle—1 ms pulse width)
Peak Transient Input Current (t_p≤1 µsec, 300 pps) .... 1.0 A
Output Current IO (pin 6) .... 60 mA
Derate linearly above 25°C, free air temperature at 0.7 mA/°C
Input Power Dissipation .... 35 mW
Derate linearly above 50%, free air temperature at 0.7 mW/°C
Output Power Dissipation .... 100 mW
Derate linearly above 25°C, free air temperature at 0.2 mA/°C
Storage Temperature .... –55°C to +125°C
Operating Temperature .... –55°C to +100°C
Lead Soldering Temperature (t=10 sec.) .... 260°C
Isolation Test Voltage (t=1 sec.) .... 5300 VAC_{RMS}
Isolation Resistance
V_{IO}=500 V, T_A=25°C .... ≥10^{12} Ω
V_{IO}=500 V, T_A=100°C .... ≥10^{11} Ω

Optocouplers (Optoisolators) 5

Electro-Optical Characteristics T_A=0° to 70°C, unless otherwise specified

Parameter	Device	Min.	Typ.	Max.	Units	Test Condition
Current Transfer Ratio (CTR)	SFH6138[1,2]	300	1600		%	I_F=1.6 mA, V_O=0.4 V, V_{CC}=4.5 V
	SFH6139[1,2]	400	1600			I_F=0.5 mA, V_O=0.4 V, V_{CC}=4.5 V
	SFH6139	500	2000			I_F=1.6 mA, V_O=0.4 V, V_{CC}=4.5 V
Logic Low—Output Voltage (V_{OL})	SFH6138[2]		0.1	0.4	V	I_F=1.6 mA, I_O=4.8 mA, V_{CC}=4.5 V
	SFH6139[2]		0.1	0.4		I_F=1.6 mA, I_O=8 mA, V_{CC}=4.5 V
	SFH6139		0.15	0.4		I_F=5 mA, I_O=15 mA, V_{CC}=4.5 V
	SFH6139		0.25	0.4		I_F=12 mA, I_O=24 mA, V_{CC}=4.5 V
Logic High—Output Current (I_{OH})	SFH6138[2]		0.1	250	µA	I_F=0 mA, V_O=V_{CC}=7 V
	SFH6139[2]		0.05	100		I_F=0 mA, V_O=V_{CC}=18 V
Logic Low Supply Current (I_{CCL})[2]			0.2	1.5	mA	I_F=1.6 mA, V_O=OPEN, V_{CC}=18 V
Logic High Supply Current (I_{CCH})			0.001	10	µA	I_F=0 mA, V_O=OPEN, V_{CC}=18 V
Input Forward Voltage (V_F)			1.4	1.7	V	I_F=1.6 mA, T_A=25°C
Input Reverse Breakdown Voltage (BV_R)		5			V	I_R=10 µA
Temperature Coefficient of Forward Voltage			–1.8		mV/°C	I_F=1.6 mA
Input Capacitance (C_{IN})			25		pF	f=1 MHz, V_F=0
Capacitance (Input-Output)[3]			0.6		pF	f=1 MHz

Switching Specifications T_A=0° to 70°C, unless otherwise specified

Parameter	Device	Min.	Typ.	Max.	Units	Test Condition
Propagation Delay Time	SFH6138		2	10	µs	I_F=1.6 mA, R_L=2.2 KΩ
To Logic Low at Output t_{PHL}	SFH6139[2,4]		6 0.6	25 1	µs	I_F=0.5 mA, R_L=4.7 KΩ I_F=12 mA, R_L=270 KΩ
Propagation Delay Time	SFH6138		4	35	µs	I_F=1.6 mA, R_L=2.2 KΩ
To Logic High at Output t_{PLH}[2,4]	SFH6139		5 1	60 7	µs	I_F=0.5 mA, R_L=4.7 KΩ I_F=12 mA, R_L=270 KΩ
Common Mode Transient Immunity at Logic High Level (CM_H) Output[5,6]			500		V/µs	I_F=0 mA, R_L=2.2 KΩ R_{CC}=0/V_{CM}=10 $V_{p\text{-}p}$
Common Mode Transient Immunity at Logic Low Level (CM_L) Output[5,6]			–500		V/µs	I_F=1.6 mA, R_L=2.2 KΩ R_{CC}=0/V_{CM}=10 $V_{p\text{-}p}$

Notes

1. DC current transfer ratio is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F times 100%.
2. Pin 7 open.
3. Device considered a two-terminal device: pins 1, 2, 3 and 4 shorted together and pins 5, 6, 7, and 8 shorted together.
4. Using a resistor between pin 5 and 7 will decrease gain and delay time.
5. Common mode transient immunity in logic high level is the maximum tolerable (positive) dV_{cm}/dt on the leading edge of the common mode pulse, V_{CM}, to assure that the output will remain in a logic high state (i.e. V_O>2.0 V) common mode transient immunity in logic low level is the maximum tolerable (negative) dV_{cm}/dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a logic low state (i.e. V_O<0.8 V).
6. In applications where dv/dt may exceed 50,000 V/µs (such as state discharge) a series resistor, R_{CC} should be included to protect I_C from destructively high surge currents. The recommended value is $R_{CC} \cong \frac{1V}{0.15\, I_F(mA)}$ kΩ

SIEMENS

SFH6315
SFH6316
SFH6343

High Speed Optocoupler

FEATURES

- **Surface Mountable**
- **Industry Standard SOIC-8 Footprint**
- **Compatible with Infrared Vapor Phase Reflow and Wave Soldering Processes**
- **Isolation Voltage, 2500 V_{RMS}**
- **Very High Common Mode Transient Immunity: 15000 V/µs at V_{CM}=1500 V Guaranteed (SFH6343)**
- **High Speed: 1 Mb/s**
- **TTL Compatible**
- **Guaranteed AC and DC Performance Over Temperature: 0°C to 70°C**
- **Open Collector Output**
- **Pin Compatible with HP Optocouplers**
  SFH6315—HCPL0500
  SFH6316—HCPL0501
  SFH6343—HCPL0453

APPLICATIONS

- **Line Receivers**
- **Logic Ground Isolation**
- **Analog Signal Ground Isolation**
- **Replace Pulse Transformers**

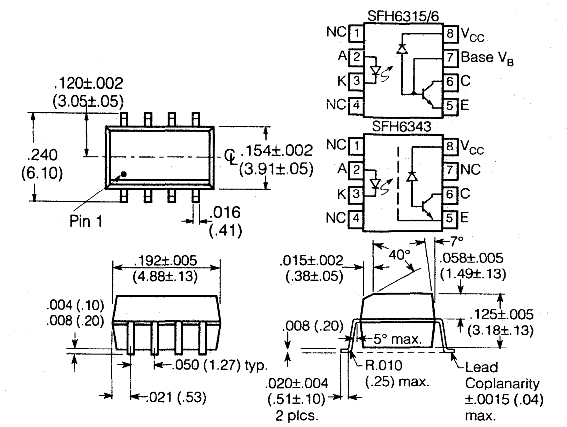
DESCRIPTION

The SFH6315/16/43, high speed optocouplers, each consists of a GaAlAs infrared emitting diode, optically coupled with an integrated photodetector and a high speed transistor. The photodetector is junction isolated from the transistor to reduce miller capacitance effects. The open collector output function allows circuit designers to adjust the load conditions when interfacing with different logic systems such as TTL, CMOS, etc.

Because the SFH6343 has a Faraday shield on the detector chip, it can also reject and minimize high input to output common mode transient voltages. There is no base connection, further reducing the potential electrical noise entering the package.

The SFH6315/16/43 are packaged in industry standard SOIC-8 packages and are suitable for surface mounting.

Package Dimensions in Inches (mm)



Absolute Maximum Ratings

Emitter (GaAlAs)

Reverse Voltage .... 3 V
DC Forward Current .... 25 mA
Surge Forward Current (t_p≤1 µs, 300 pulses/sec.) .... 1 A
Total Power Dissipation (T_A≤70°C) .... 45 mW

Detector (Si Photodiode + Transistor)

Supply Voltage .... –0.5 to 30 V
Output Voltage .... –0.5V to 20 V
Output Current .... 8 mA
Total Power Dissipation (T_A≤70°C) .... 100 mW

Package

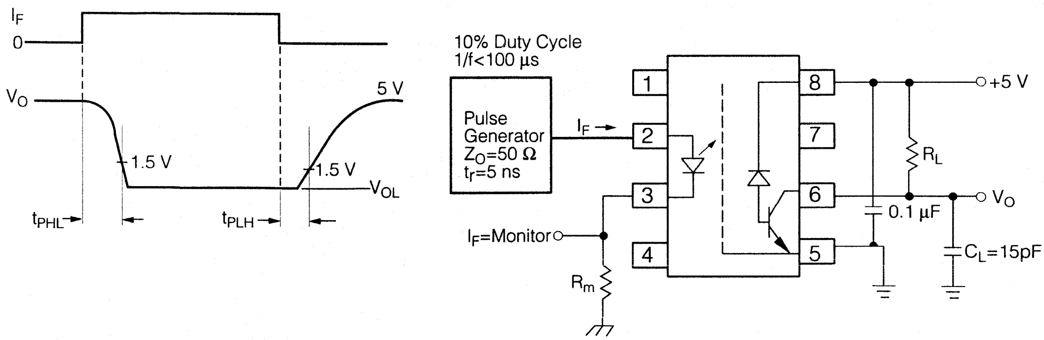
Isolation Test Voltage
between emitter and detector .... 2500 VAC_{RMS}
(refer to climate DIN 40046, part 2, Nov. 74)
Pollution Degree (DIN VDE 0110) 2
Creepage .... ≥4 mm
Clearance .... ≥4 mm
Comparative Tracking Index
per DIN IEC 112/VDE 0303, part 1 175
Isolation Resistance
V_{IO}=500 V, T_A=25°C, R_{ISOL} (Note 2) .... ≥1012 W
V_{IO}=500 V, T_A=100°C, R_{ISOL}(Note 2) .... ≥1011 W
Storage Temperature Range .... –55°C to +150°C
Ambient Temperature Range .... –55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature (t=10 sec. max.) .... 260°C
Dip soldering: distance to seating plane ≥1.5 mm

Electrical Characteristics

Over recommended temperature (T_A=0°C to 70°C) unless otherwise specified. See note 6. *All typical values at T_A=25°C.

Parameter	Symbol	Device	Min.	Typ.*	Max.	Units	Test Conditions	Note
Input Forward Voltage	V_F			1.6	1.8	V	T_A=25°C, I_F=16 mA	
					1.9		I_F=16 mA	
Input Reverse Current	I_R			0.5	10	µA	V_R=3 V	
Input Capacitance	C_{IN}			75		pF	f=1 MHz, V_F=0 V	
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$			–1.7		mV/°C	I_F=16 mA	
Logic Low Supply Current	I_{CCL}			100		µA	I_F=16 mA, V_O=Open, V_{CC}=15 V	
Logic High Supply Current	I_{CCH}			0.001	1	µA	T_A=25°C, I_F=0 mA, V_O=Open, V_{CC}=15 V	
					2		I_F=0 mA, V_O=Open, V_{CC}=15 V	
Logic Low Output Voltage	V_{OL}	SFH6315		0.15	0.4	V	T_A=25°C, I_O=1.1 mA, I_F=16 mA, V_{CC}=4.5 V	
					0.5		I_O=0.8 mA, I_F=16 mA, V_{CC}=4.5 V	
		SFH6316 SFH6343		0.15	0.4	V	T_A=25°C, I_O=3.0 mA, I_F=16 mA, V_{CC}=4.5 V	
					0.5		I_O=2.4 mA, I_F=16 mA, V_{CC}=4.5 V	
Logic High Output Current	I_{OH}			0.003	0.5	µA	T_A=25°C, V_O=V_{CC}=5.5 V, I_F=0 mA	
				0.01	1		T_A=25°C, V_O=V_{CC}=15.0 V, I_F=0 mA	
					50		T_A=0–70°C, V_O=V_{CC}=15.0 V, I_F=0 mA	
Transistor DC Current Gain	h_{FE}			150			V_O=5 V, I_O=3 mA	
Capacitance (Input-Output)	C_{I-O}			0.4		pF	f=1 MHz	6
Current Transfer Ratio	CTR	SFH6315	7	16	50	%	T_A=25°C, V_O=0.4 V, I_F=16 mA, V_{CC}=4.5 V	1, 6
			5	17			V_O=0.5 V, I_F=16 mA, V_{CC}=4.5 V	
		SFH6316 SFH6343	19	35	50	%	T_A=25°C, V_O=0.4 V, I_F=16 mA, V_{CC}=4.5 V	
			15	36			V_O=0.5 V, I_F=16 mA, V_{CC}=4.5 V	

Figure 1. Test circuit for switching times



Switching Specifications

Over recommended temperature (T_A=0°C to 70°C), V_{CC}=5 V, I_F=16 mA unless otherwise specified. *All typical values, T_A=25°C

Parameter	Symbol	Device	Min.	Typ.*	Max.	Units	Test Conditions		Fig.	Note
Propagation Delay Time to Logic Low at Output	t_{PHL}	SFH6315		0.5	1.5	µs	T_A=25°C	R_L=4.1 KΩ	1	4, 5
					2.0					
		SFH6316 SFH6343		0.25	0.8		T_A=25°C	R_L=1.9 KΩ		
					1.0					
Propagation Delay Time to Logic High at Output	t_{PLH}	SFH6315		0.5	1.5	µs	T_A=25°C	R_L=4.1 KΩ	1	4, 5
					2.0					
		SFH6316 SFH6343		0.5	0.8		T_A=25°C	R_L=1.9 KΩ		
					1.0					
Common Mode Transient Immunity at Logic High Level Output	$\|CM_H\|$	SFH6315		1		kV/µs	R_L=4.1 KΩ	I_F=0 mA, T_A=25°C, V_{CM}=10 V_{P-P}	2	3, 4, 5
		SFH6316		1			R_L=1.9 KΩ			
		SFH6343	15	30			R_L=1.9 KΩ	I_F=0 mA, T_A=25°C, V_{CM}=1500 V_{P-P}		
Common Mode Transient Immunity at Logic Low Level Output	$\|CM_L\|$	SFH6315		1		kV/µs	R_L=4.1 KΩ	I_F=16 mA, T_A=25°C, V_{CM}=10 V_{P-P}	2	3, 4, 5
		SFH6316		1			R_L=1.9 KΩ			
		SFH6343	15	30			R_L=1.9 KΩ	I_F=16 mA, T_A=25°C, V_{CM}=1500 V_{P-P}		

Notes

1. Current transfer ratio in percent equals the ratio of output collector current (I_O) to the forward LED input current (I_F) times 100.
2. Device considered a two-terminal device: pins 1, 2, 3, and 4 shorted together and pins 5, 6, 7, and 8 shorted together.
3. Common mode transient immunity in a Logic High level is the maximum tolerable (positive) dV_{cm}/dt on the leading edge of the common mode pulse (V_{CM}) to assure that the output will remain in a Logic High state (i.e., V_O>2.0 V). Common mode transient immunity in a Logic Low level is the maximum tolerable (negative) dVcm/dt on the trailing edge of the common mode pulse signal (V_{CM} to assure that the output will remain in a Logic Low state, i.e., V_O<0.8 V).
4. The 1.9 KΩ load represents 1 TTL unit load of 1.6 mA and the 5.6 kΩ pull-up resistor.
5. The 4.1 KΩ load represents 1 LSTTL unit load of 0.36 mA and the 6.1 kΩ pull-up resistor.
6. A 0.1 µf bypass capacitor connected between pins 5 and 8 is recommended.

Figure 2. Test circuit for transient immunity and typical waveforms

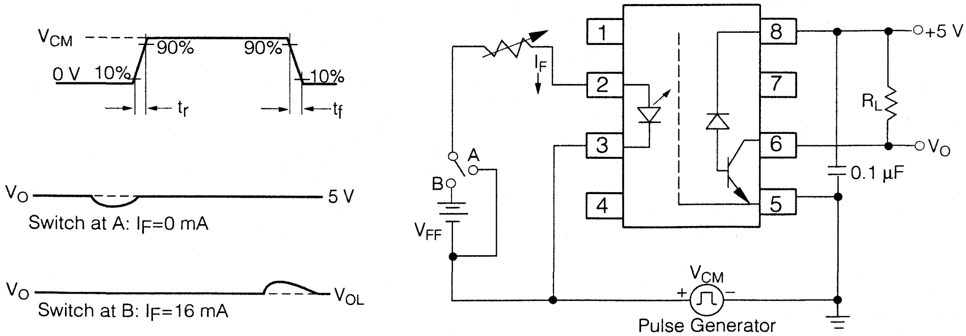


Figure 3. LED forward current vs. forward voltage

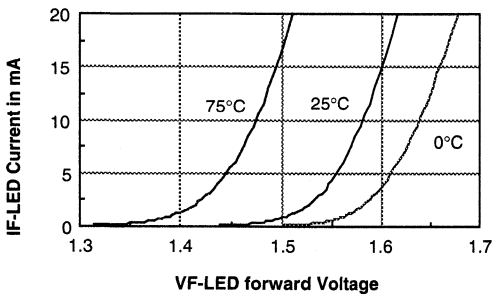


Figure 4. Permissible forward LED current vs. temperature

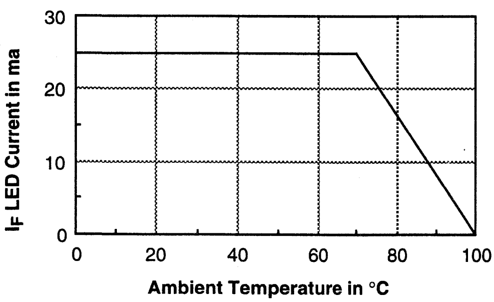


Figure 5. Permissible power dissipation vs. temp.

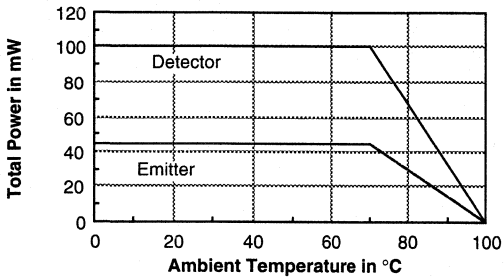


Figure 6. Output current vs. output voltage

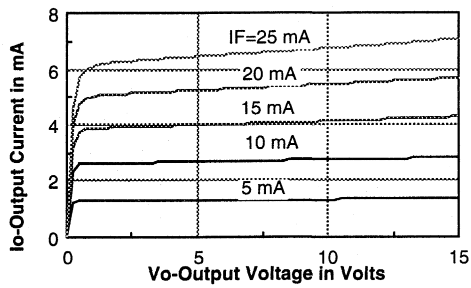


Figure 7. Output current (high) vs. temperature

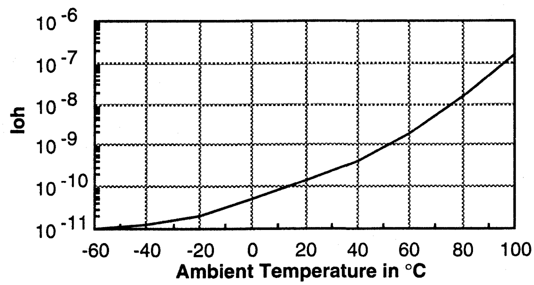
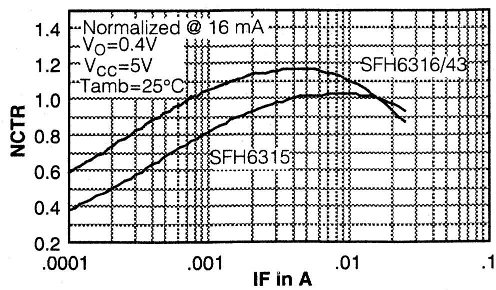


Figure 8. NCTR vs. IF



SIEMENS

SFH6318
SFH6319

Low Current, High Gain Optocoupler

FEATURES

- **Industry Standard SOIC-8 Surface Mountable Package**
- **High Current Transfer Ratio, 800%**
- **Low Input Current, 0.5 mA**
- **High Output Current, 60 mA**
- **Isolation Test Voltage, 2500 VAC_{RMS}**
- **TTL Compatible Output, V_{OL}=0.1 V**
- **Adjustable Bandwidth—Access to Base**
- **Underwriters Lab File #E52744**

APPLICATIONS

- **Logic Ground Isolation—TTL/TTL, TTL/CMOS, CMOS/CMOS, CMOS/TTL**
- **EIA RS 232C Line Receiver**
- **Low Input Current Line Receiver—Long Lines, Party Lines**
- **Telephone Ring Detector**
- **117 VAC Line Voltage Status Indication—Low Input Power Dissipation**
- **Low Power Systems—Ground Isolation**

DESCRIPTION

Very high current ratio together with 2500 VAC isolation are achieved by coupling an LED with an integrated high gain photodetector in a SOIC-8 package. Separate pins for the photodiode and output stage enable TTL compatible saturation voltages with high speed operation. Photodarlington operation is achieved by tying the V_{CC} and V_O terminals together. Access to the base terminal allows adjustment to the gain bandwidth.

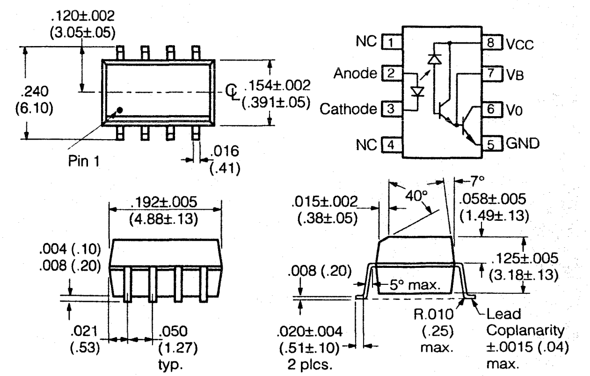
The SFH6318 is ideal for TTL applications since the 300% minimum current transfer ratio with an LED current of 1.6 mA enables operation with one unit load-in and one unit load-out with a 2.2 KΩ pull-up resistor.

The SFH6319 is best suited for low power logic applications involving CMOS and low power TTL. A 400% current transfer ratio with only 0.5 mA of LED current is guaranteed from 0°C to 70°C.

Caution:

Due to the small geometries of this device, it should be handled with Electrostatic Discharge (ESD) precautions. Proper grounding would prevent damage further and/or degradation which may be induced by ESD.

Package Dimensions in Inches (mm)



TOLERANCE: ±.005 (unless otherwise noted)

Maximum Ratings (25°)

Emitter

Reverse Input Voltage .... 3 V
Supply and Output Voltage, V_{CC} (pin 8-5), V_O (pin 6-5)
  SFH6318 .... –0.5 to 7 V
  SFH6319 .... –0.5 to 18 V
Input Power Dissipation .... 35 mW
  Derate Linearly above .... 50°C
  Free Air Temperature .... 0.7 mW/°C
Average Input Current .... 20 mA
Peak Input Current .... 40 mA
  (50% Duty Cycle-1 ms pulse width)
Peak Transient Input Current
  (t_p≤1 µsec, 300 pps) .... 1.0 A

Detector (Si Photodiode + Photodarlington)

Output Current I_O (pin 6) .... 60 mA
Emitter-Base Reverse Voltage (pin 5-7) .... 0.5 V
Output Power Dissipation .... 150 mW
  Derate Linearly from 25°C .... 2 mW/°C

Package

Storage Temperature .... –55°C to +125°C
Operating Temperature .... –40°C to +85°C
Lead Soldering Temperature (t=10 sec.) .... 260°C
Junction Temperature .... 100°C
Ambient Temperature Range .... –55°C to +100°C
Isolation Test Voltage between
  Emitter and Detector .... 2500 VAC_{RMS}
  (refer to climate DIN 40046, part 2, Nov. 74)
Pollution Degree (DIN VDE 0110) 2
Creepage Distance .... ≥4 mm
Clearance .... ≥4 mm
Comparative Tracking Index
  per DIN IEC 112/VDE 0303, part 1 175
Isolation Resistance
  V_{IO}=500 V, T_A=25°C R_{ISOL} .... ≥10^{12}Ω
  V_{IO}=500 V, T_A=100°C R_{ISOL} .... ≥10^{11}Ω

Electro-Optical Characteristics (T_A=0°C to 70°C, T_A=25°C—Typical, unless otherwise specified)

Parameter	Symbol	Device	Min	Typ	Max	Units	Test Conditions	Note
Current Transfer Ratio	CTR	SFH6318	300	1600	2600	%	I_F=1.6 mA, V_O=0.4 V, V_{CC}=4.5 V	1,2
		SFH6319	400 500	2000 1600	3500 2600		I_F=0.5 mA, V_O=0.4 V, V_{CC}=4.5 V I_F=1.6 mA, V_O=0.4 V, V_{CC}=4.5 V	
Logic Low Output Voltage	V_{OL}	SFH6318		0.1	0.4	V	I_F=1.6 mA, I_O=4.8 mA, V_{CC}=4.5 V	2
		SFH6319		0.1 0.15 0.25	0.4 0.4 0.4		I_F=1.6 mA, I_O=8 mA, V_{CC}=4.5 V I_F=5 mA, I_O=15 mA, V_{CC}=4.5 V I_F=12 mA, I_O=24 mA, V_{CC}=4.5 V	
Logic High Output Current	I_{OH}	SFH6318		0.1	250	µA	I_F=0 mA, V_O=V_{CC}=7 V	
		SFH6319		0.05	100		I_F=0 mA, V_O=V_{CC}=18 V	
Logic Low Supply Current	I_{CCL}			0.2	1.5	mA	I_F=1.6 mA, V_O=OPEN, V_{CC}=18 V	
Logic High Supply Current	I_{CCH}			0.01	10	µA	I_F=0 mA, V_O=OPEN, V_{CC}=18 V	
Input Forward Voltage	V_F			1.4	1.7	V	I_F=1.6 mA, T_A=25°C	
Temperature Coefficient, Forward Voltage	$\Delta V_F/\Delta T_A$			–1.8		mV/°C	I_F=1.6 mA	
Input Capacitance	C_{IN}			25		pF	f=1 MHz, V_F=0	
Resistance (Input-Output)	R_{I-O}			10^{12} 10^{11}		Ω	V_{IO}=500 VDC, T_A=25°C V_{IO}=500 VDC, T_A=100°C	3
Capacitance (Input-Output)	C_{I-O}			0.6		pF	f=1 MHz	3

Switching Specifications (T_A=25°C)

Parameter	Symbol	Device	Min	Typ	Max	Units	Test Conditions	Note
Propagation Delay Time To Logic Low at Output	t_{PHL}	SFH6318		2	10	µs	I_F=1.6 mA, R_L=2.2 KΩ	
		SFH6319		6 0.6	25 1		I_F=0.5 mA, R_L=4.7 KΩ I_F=12 mA, R_L=270 Ω	2,4
Propagation Delay Time To Logic High at Output	t_{PLH}	SFH6318		2	35		I_F=1.6 mA, R_L=2.2 KΩ	
		SFH6319		4 1.5	60 7		I_F=0.5 mA, R_L=4.7 KΩ I_F=12 mA, R_L=270 Ω	2,4
Common Mode Transient Immunity at Logic High Level Output	$\vert CM_H \vert$			1 K		V/µs	I_F=0 mA, R_L=2.2 KΩ V_{CM}=10 V_{p-p}	5,6
Common Mode Transient Immunity at Logic Low Level Output	$\vert CM_L \vert$						I_F=1.6 mA, R_L=2.2 KΩ V_{CM}=10 V_{p-p}	

Notes

1. DC current transfer ratio is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F times 100%.
2. Pin 7 open.
3. Device considered a two-terminal device: pins 1, 2, 3 and 4 shorted together and pins 5, 6, 7 and 8 shorted together.
4. Using a resistor between pin 5 and 7 will decrease gain and delay time.
5. Common mode transient immunity in logic high level is the maximum tolerable (positive) dV_{cm}/dt on the leading edge of the common mode pulse, V_{CM}, to assure that the output will remain in a logic high state (i.e. V_O>2.0 V) common mode transient immunity in logic low level is the maximum tolerable (negative) dV_{cm}/dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a logic low state (i.e. V_O<0.8 V).
6. In applications where dv/dt may exceed 50,000 V/µs (such as state discharge) a series resistor, R_{CC} should be included to protect IC from destructively high surge currents. The recommended value is $R_{CC} \cong \frac{IV}{0.15\ I_F(mA)}$ kΩ. Refer to Figure 2.

Figure 1. Switching test circuit

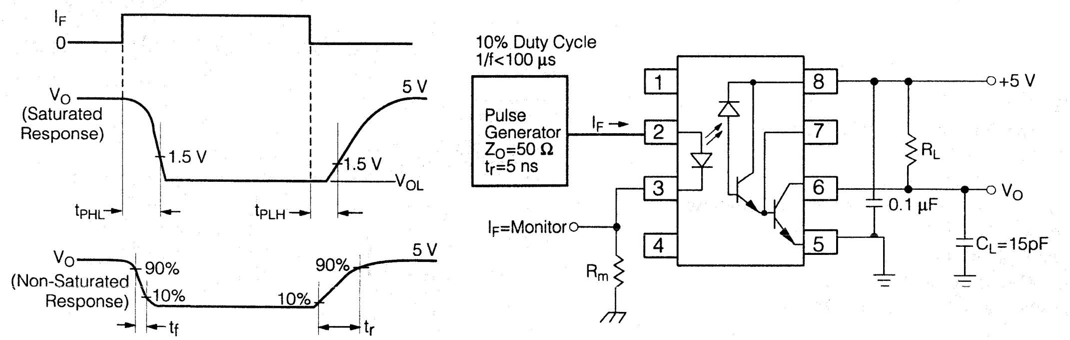
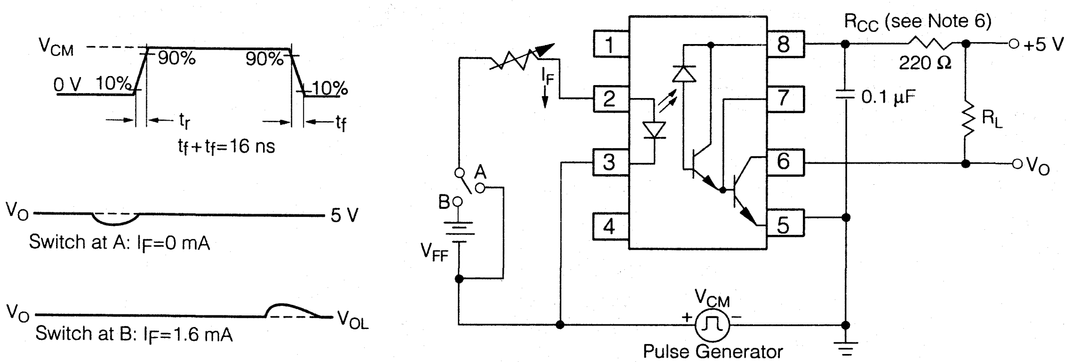


Figure 2. Test circuit for transient immunity and typical waveforms



SIEMENS

SFH6325
SFH6326

High-Speed Dual Optocoupler

Preliminary Data Sheet

FEATURES

- **Isolation Test Voltage: 2500 VAC_{RMS}**
- **TTL Compatible**
- **High Bit Rates: 1 Mbit/s**
- **High Common-Mode Interference Immunity**
- **Bandwidth 2 MHz**
- **Open-Collector Output**
- **Field-Effect Stable by TRIOS***
- **Underwriters Lab File #E52744**

Description

The SFH6325/6326 are dual channel optocouplers with a GaAlAs infrared emitting diode, optically coupled with an integrated photodetector which consists of a photodiode and a high-speed transistor in a DIP-8 plastic package.

Signals can be transmitted between two electrically separated circuits up to frequencies of 2 MHz. The potential difference between the circuits to be coupled is not allowed to exceed the maximum permissible reference voltages.

Maximum Ratings

Emitter (each channel)

Reverse Voltage .... 5 V
Forward Current .... 25 mA
Peak Forward Current
  (t =1 ms, duty cycle 50%) .... 50 mA
Maximum Surge Forward Current
  (t ≤1 µs, 300 pulses/s) .... 1 A
Total Power Dissipation (T_A≤70°C) .... 100 mW

Detector (each channel)

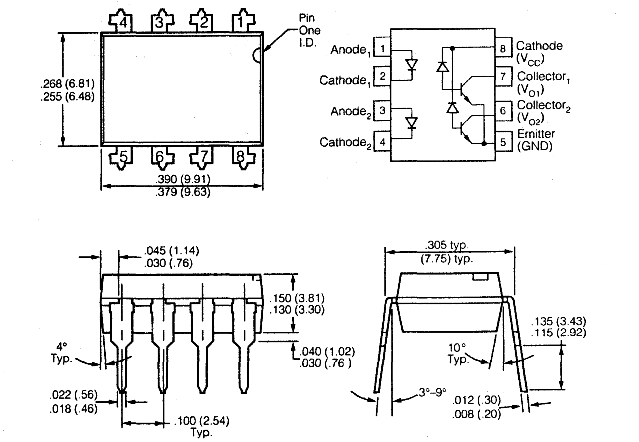
Supply Voltage .... –0.5 to 15 V
Output Voltage .... –0.5 to 15 V
Collector Output Current .... 16 mA
Total Power Dissipation (T_A≤70°C) .... 150 mW

Package

Isolation Test Voltage (between emitter and detector climate per DIN 40046, part 2, Nov. 74 (t=1min.) .... 2500 VAC_{RMS}
Pollution Degree (DIN VDE 0109) 2
Creepage .... ≥7 mm
Clearance .... ≥7 mm
Total Package Dissipation at 25°C T_A ...... 400 mW
Derate Linearly from 25°C .... 5.33 mW/°C
Comparative Tracking Index per DIN IEC112/VDE 0303 part 1, Group IIIa per DIN VDE 6110 175
Isolation Resistance
  V_{IO}=500 V, T_A = 25°C .... ≥10^{12} Ω
  V_{IO}=500 V, T_A = 100°C .... ≥10^{11} Ω
Storage Temperature Range ..... –55°C to +125°C
Ambient Temperature Range .... –55°C to +100°C
Soldering Temperature (max. ≤10 sec., dip soldering ≥0.5 mm from case bottom) ..... 260°C

***TRIOS—TRansparent IOn Shield**

Dimensions in inches (mm)



Characteristics T_A=0 to 70°C unless otherwise specified, T_A=25°C typ.

Emitter		Symbol	Value	Unit	Condition
Forward Voltage		V_F	1.6 (≤1.9)	V	I_F=16 mA
Breakdown Voltage		V_{BR}	≥5	V	I_R=10 µA
Reverse Current		I_R	0.5 (≤10)	µA	V_R=5 V
Capacitance		C_O	125	pF	V_R=0 V, f=1 MHz
Temperature Coefficient, Forward Voltage		$\Delta V_F / \Delta T_A$	-1.7	mV/°C	I_F=16 mA
Detector					
Supply Current, Logic Low		I_{CCL}	150	µA	I_F=16 mA, V_O open, V_{CC}=15 V
Supply Current Logic High		I_{CCH}	0.01 (≤1)	µA	I_F=0 mA, V_O open, V_{CC}=15 V
Output Voltage, Output Low	SFH6325	V_{OL}	0.1 (≤0.4)	V	I_F=16 mA, V_{CC}=4.5 V I_O=1.1 mA
	SFH6326				I_F=16 mA, V_{CC}=4.5 V I_O=2.4 mA
Output Current, Output High		I_{OH}	3 (≤500)	nA	I_F=0 mA, V_O=V_{CC}=5.5 V
			0.01 (≤1)	µA	I_F=0 mA V_O=V_{CC}=15 V
Cross Talk		I_{OH-XT}	≤900	nA	I_F=0 mA V_O=V_{CC}=5.5 V
Current Gain		H_{FE}	150		V_O=5 V, I_O=3 mA
Package					
Coupling Capacitance Input-Output		C_{IO}	0.6	pF	f=1 MHz
Current Transfer Ratio	SFH6325	CTR	16 (≥7)	%	I_F=16 mA, V_O=0.4 V,
	SFH6326	CTR	35 (≥19)	%	V_{CC}=4.5 V, T_A=25°C
	SFH6325	CTR	≥5	%	I_F=16 mA, V_O=0.5 V,
	SFH6326	CTR	≥15	%	V_{CC}=4.5 V

Figure 1. Switching times

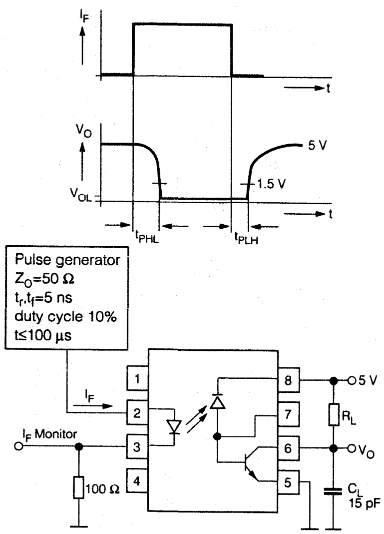
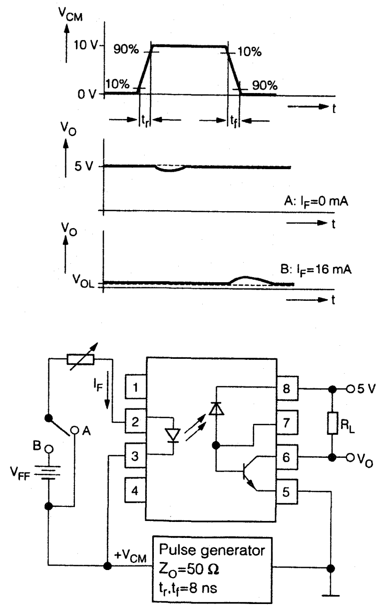


Figure 2. Common-mode interference immunity



Delay Time I_F=16 mA, V_{CC}=5 V, T_A=25°C

Parameter		Sym.	Value	Unit	Condition
High–Low	SFH6325	t_{PHL}	0.3 (≤1.5)	µs	R_L=4.1 kΩ
	SFH6326		0.2 (≤0.8)		R_L=1.9 kΩ
Low–High	SFH6325	t_{PLH}	0.3 (≤1.5)	µs	R_L=4.1 kΩ
	SFH6326		0.2 (≤0.8)		R_L=1.9 kΩ

Common Mode Interference Immunity
V_{CM}=10 V_{P-P} V_{CC}=5 V, T_A=25°C

Parameter		Sym.	Value	Unit	Condition
High I_F=0 mA	SFH6325	CM_H	1000	V/µs	I_F=0 mA, R_L=4.1 kΩ
	SFH6326				I_F=0 mA, R_L=1.9 kΩ
Low I_F=16 mA	SFH6325	CM_L	1000	V/µs	I_F=16 mA, R_L=4.1 kΩ
	SFH6326				I_F=16 mA, R_L=1.9 kΩ

Figure 3. Output characteristics—SFH6325
Output current vs. output voltage
(T_A=25°C, V_{CC}=5 V)

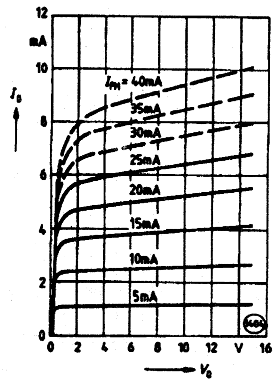
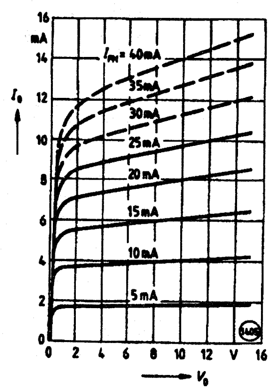


Figure 4. Output characteristics—ISFH6326
Output current vs. output voltage
(T_A=25°C, V_{CC}=5 V)



Optocouplers (Optoisolators) 5

Figure 5. Permissible forward current of emitting diode vs. ambient temperature

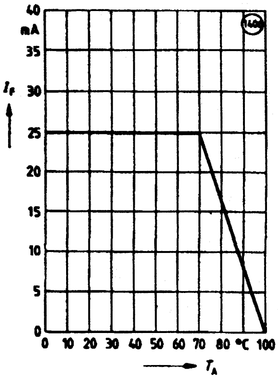


Figure 8. Small signal transfer ratio vs. forward current V_{CC}=5 V, T_A=25°C

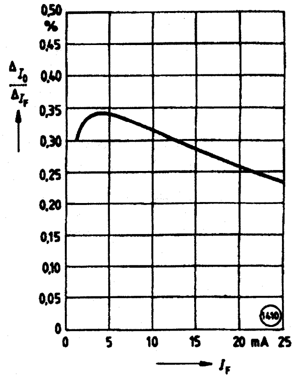


Figure 11. Delay times vs. ambient temperature
I_F=16 mA, V_{CC}=5 V, SFH6325: R_L=4.1 kΩ, SFH6326: R_L=1.9 kΩ

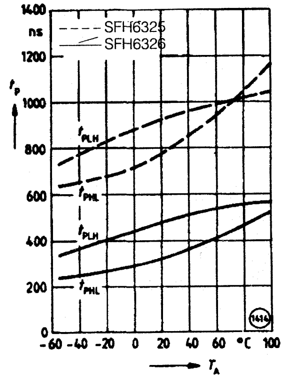


Figure 6. Permissible total power dissipation vs. ambient temperature

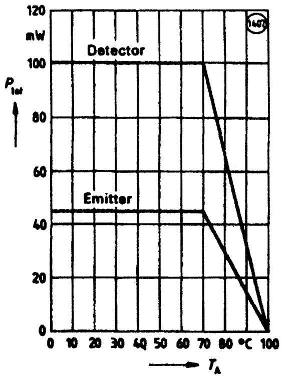


Figure 9. Current transfer ratio (normalized) vs. ambient temperature
normalized to I_F=16 mA, V_O=0.4 V, V_{CC}=5 V, T_A=25°C

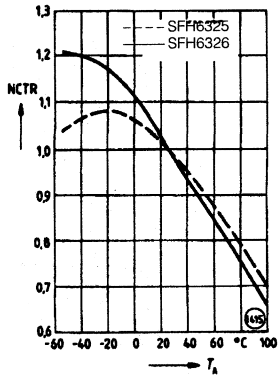


Figure 12. Current transfer ratio (normalized) vs. forward current
I_F=16 mA, V_O=0.4 V, V_{CC}=5 V, T_A=25°C

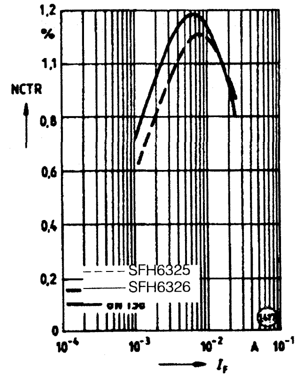


Figure 7. Forward current of emitting diode vs. forward voltage T_A=25°C

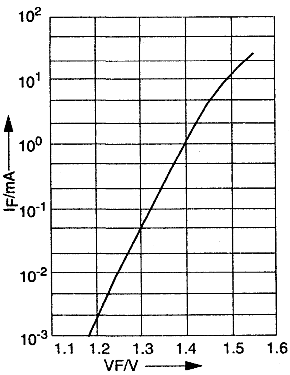
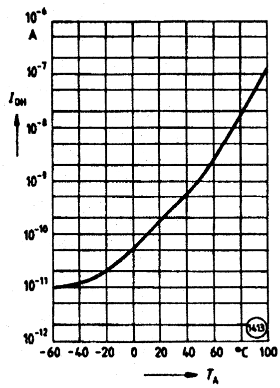


Figure 10. Output current (high) vs. ambient temp. V_O=V_{CC}=5 V, I_F=0



SFH6345

High Speed 5.3 kV Optocoupler

FEATURES

- **Direct Replacement for HCPL4503**
- **High Speed Optocoupler without Base Connection**
- **GaAIAs Emitter**
- **Integrated Detector with Photodiode and Transistor**
- **High Data Transmission Rate: 1 MBit/s**
- **TTL Compatible**
- **Open Collector Output**
- **CTR at I_F=16 mA, V_O=0.4 V, V_{CC}=4.5 V, T_A=25°C: ≥19%**
- **Good CTR Linearity Relative to Forward Current**
- **Field Effect Stable**
- **Low Coupling Capacitance**
- **Very High Common Mode Transient Immunity dV/dt: ≥15 kV/µs at V_{CM}=1500 V**
- **Insulation Test Voltage: 5300 VAC_{PK}**
- **VDE 0884 Available with Option 1**
- **UL Approval, File #E52744**

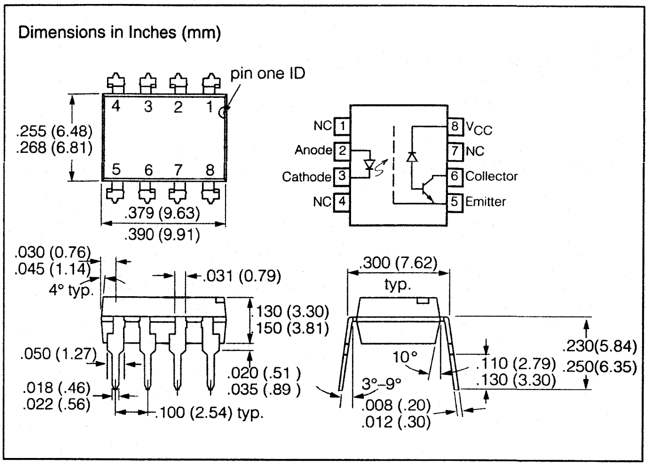
APPLICATIONS

- **Data Communications**
- **IGBT Drivers**
- **Programmable Controllers**

DESCRIPTION

The SFH6345 is an optocoupler with a GaAIAs infrared emitting diode, optically coupled to an integrated photodetector consisting of a photodiode and a high speed transistor in a DIP-8 plastic package. The device is similar to the 6N135 but has an additional Faraday shield on the detector which enhances the input-output dv/dt immunity.

Signals can be transmitted between two electrically separated circuits up to frequencies of 2 MHz. The potential difference between the circuits to be coupled should not exceed the maximum permissible reference voltages.



Absolute Maximum Ratings

Emitter (GaAIAs)

Reverse Voltage ..... 3 V
DC Forward Current ..... 25 mA
Surge Forward Current (t_p≤1 µs, 300 pulses/sec.) ..... 1 A
Total Power Dissipation ..... 45 mW

Detector (Si Photodiode + Transistor)

Supply Voltage ..... –0.5 to 30 V
Output Voltage ..... –0.5V to 25 V
Output Current ..... 8 mA
Total Power Dissipation ..... 100 mW

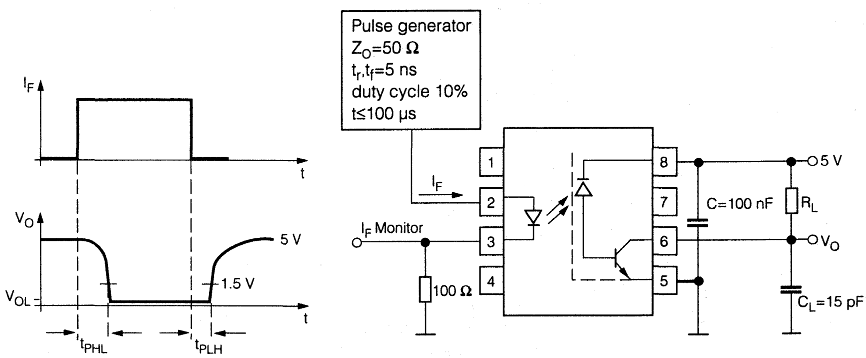
Package Insulation

Isolation Test Voltage
between emitter and detector ..... 5300 VAC_{PK}
(refer to climate DIN 40046, part 2, Nov. 74)
Creepage ..... ≥7 mm min.
Clearance ..... ≥7 mm min.
Comparative Tracking Index
per DIN IEC 112/VDE0303, part 1 ..... ≥175
Isolation Resistance
V_{IO}=500 V, T_A=25°C, R_{ISOL} ..... $\geq 10^{12}$ Ω
V_{IO}=500 V, T_A=100°C, R_{ISOL} ..... $\geq 10^{11}$ Ω
Storage Temperature Range ..... –55 to +150°C
Ambient Temperature Range ..... –55 to +100°C
Junction Temperature ..... 100°C
Soldering Temperature (t=10 sec. max.) ..... 260°C
Dip soldering: distance to seating plane ≥1.5 mm

Characteristics (T_A=0° to 70°C, unless otherwise specified, typical values T_A=25°C)

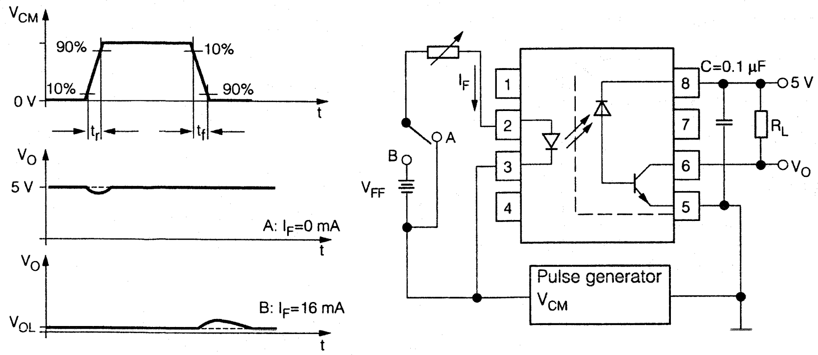
Description	Symbol	Min.	Typ.	Max.	Unit	Condition
Emitter (IR GaAlAs)						
Forward Voltage	V_F		1.6	1.9	V	I_F=16 mA
Reverse Current	I_R		0.5	10	µA	V_R=3 V
Capacitance	C_0		75		pF	V_R=0 V, f=1 MHz
Thermal Resistance	R_{thJA}		700		°K/W	
Detector (Si Photodiode + Transistor)						
Supply Current, Logic High	I_{CCH}		0.01	1	µA	I_F=0, V_O (open), V_{CC}=15 V, T_A=25°C
				2		I_F=0, V_O (open), V_{CC}=15 V
Output Current, Output High	I_{OH}		.003	0.5	µA	I_F=0, V_O=V_{CC}=5.5 V, T_A=25°C
			.01	1		I_F=0, V_O=V_{CC}=15 V, T_A=25°C
			—	50		I_F=0, V_O=V_{CC}=15 V
Capacitance	C_{CE}		3		pF	V_{CE}=5 V, f=1 MHz
Thermal Resistance	R_{thJA}		300		°K/W	
Package						
Coupling Capacitance	C_C		0.6		pF	
Coupling Transfer Ratio	I_C/I_F	19	30		%	I_F=16 mA, V_O=0.4 V, V_{CC}=4.5 V, T_A=25°C
		15	—			I_F=16 mA, V_O=0.5 V, V_{CC}=4.5 V
Collector Emitter Saturation Voltage	V_{OL}		0.1	0.4	V	I_F=16 mA, I_O=2.4 mA, V_{CC}=4.5 V, T_A=25°C
Supply Current, Logic Low	I_{CCL}		80	200	µA	I_F=16 mA, V_O open, V_{CC}=15 V

Figure 1. Switching times (typ.)



Description	Symbol	Min.	Typ.	Max.	Unit
Propagation Delay Time (High–Low) I_F=16 mA, V_{CC}=5 V, R_L=1.9 kΩ, T_A=25°C	t_{PHL}		0.3	0.8	µs
Propagation Delay Time (Low–High) I_F=16 mA, V_{CC}=5 V, R_L=1.9 kΩ, T_A=25°C	t_{PLH}		0.3	0.8	µs

Figure 2. Common mode transient immunity



Description	Symbol	Min.	Typ.	Max.	Unit
Common Mode Transient Immunity (High) I_F=0, V_{CM}=1500 V_{P-P}, R_L=1.9 kΩ, V_{CC}=5 V, T_A=25°C	$\|CM_H\|$	15	30		kV/µs
Common Mode Transient Immunity (Low) I_F=16 mA, V_{CM}=1500 V_{P-P}, R_L=1.9 kΩ, V_{CC}=5 V, T_A=25°C	$\|CM_L\|$	15	30		kV/µs

Figure 3. LED forward current vs. forward voltage

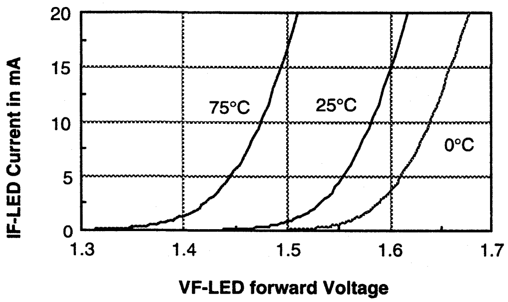


Figure 5. Permissible power dissipation vs. temp.

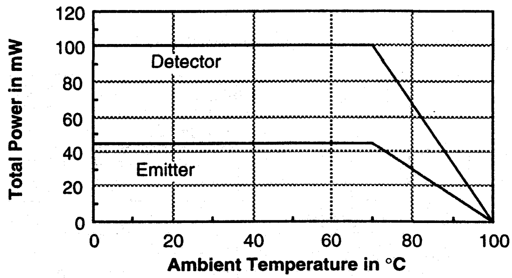


Figure 4. Permissible forward LED current vs. temperature

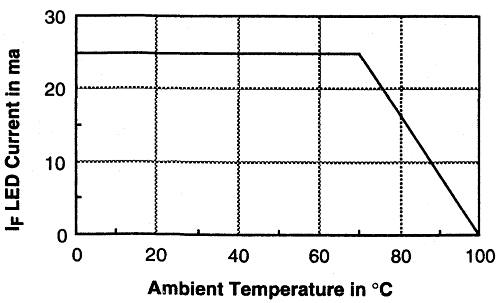


Figure 6. Output current vs. output voltage

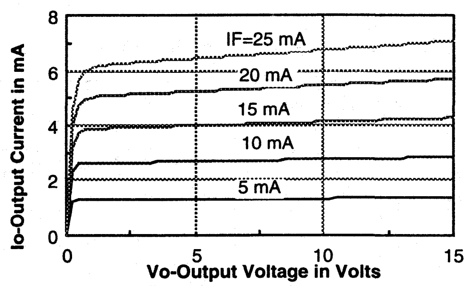


Figure 7. Output current (high) vs. temperature

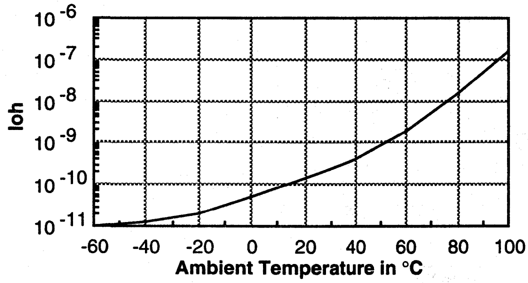


Figure 8. NCTR vs. IF

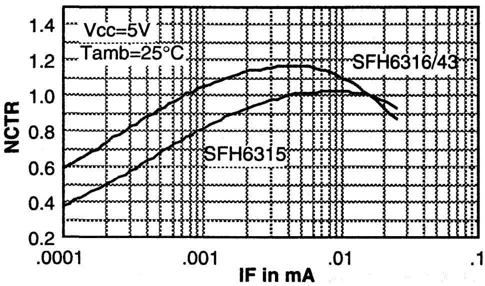


Figure 9. NCTR vs. temperature (SFH6316/43)

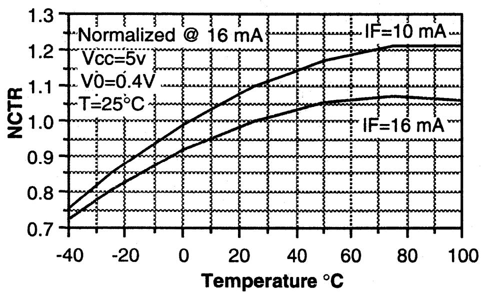
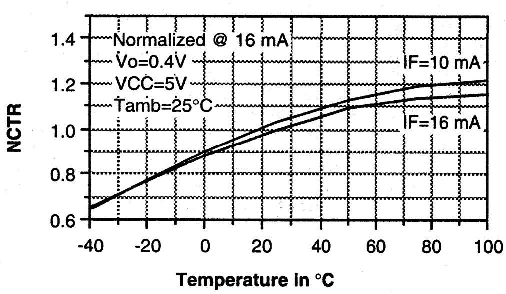


Figure 10. NCTR vs. temperature (SFH6315)



SIEMENS

SFH6700/6719 SFH6701/6711 SFH6702/6712 SFH6705

Low Input Current Logic Gate Optocoupler

Preliminary Data Sheet

FEATURES

- **Data Rate 5 MBits/s (2.5 MBit/s over Temperature)**
- **Buffer**
- **Isolation Test Voltage, 2500 VAC_{RMS} for 1 min.**
- **TTL, LSTTL and CMOS Compatible**
- **Internal Shield for Very High Common Mode Transient Immunity**
- **Wide Supply Voltage Range (4.5 to 15 V)**
- **Low Input Current (1.6 mA to 5 mA)**
- **Three State Output (SFH6700/19)**
- **Totem Pole Output (SFH6701/02/11/12)**
- **Open Collector Output (SFH6705)**
- **Specified from 0°C to 85°C**

APPLICATIONS

- **Industrial Control**
- **Replace Pulse Transformers**
- **Routine Logic Interfacing**
- **Motion/Power Control**
- **High Speed Line Receiver**
- **Microprocessor System Interfaces**
- **Computer Peripheral Interfaces**

DESCRIPTION

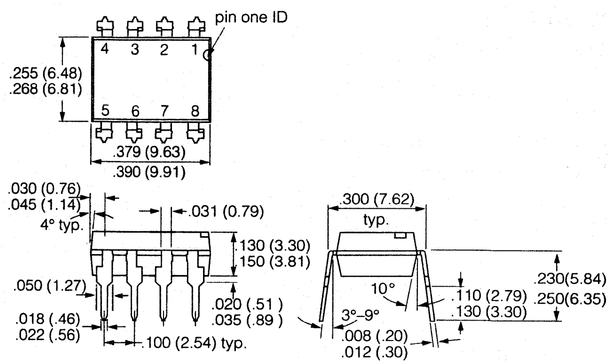
The SFH67xx high speed optocoupler series consists of a GaAlAs infrared emitting diode, optically coupled with an integrated photodetector. The detector incorporates a Schmitt-Trigger stage for improved noise immunity. Using the Enable input, the output can be switched to the high ohmic stage, which is necessary for data bus applications. A Faraday shield provides a common mode transient immunity of1000 V/µs at V_{CM}=50 V for SFH6700/01/02/05 and 2500 V/µs at V_{CM}=400 V for SFH6711/12/19.

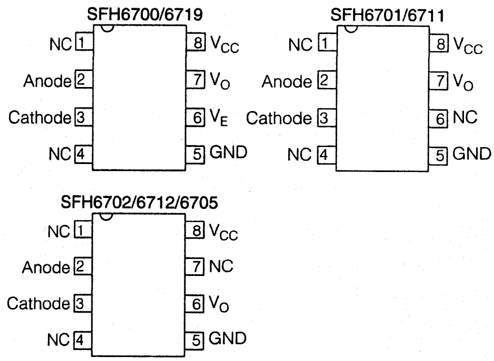
The SFH67xx uses an industry standard DIP8 package. With standard lead bending, creepage distance and clearance of ≥7 mm with lead bending options 6, 7, and 9 ≥8 mm are achieved.

Truth Table SFH6701/11/02/12/05 Positive Logic)

IR Diode	Output
on	H
off	L

Dimensions in Inches (mm)





Truth Table SFH6700/19 Positive Logic

IR Diode	Enable	Output
on	H	Z
off	H	Z
on	L	H
off	L	L

Maximum Ratings

Parameter	Sym.	Min.	Max.	Units
Emitter				
Reverse Voltage	V_R		3	V
DC Forward Current	I_F		10	mA
Surge Forward Current (tp≤1 µs, 300 pulses/s)	I_{FSM}		1	A
Total Power Dissipation	P_{tot}		20	mW
Detector				
Supply Voltage	V_{CC}	–0.5	15	V
Three State Enable Voltage (SFH6700/19 only)	V_{EN}	–0.5	15	V
Output Voltage	V_O	–0.5	15	V
Average Output Current	I_O		25	mA
Total Power Dissipation	P_{tot}		100	mW
Package				
Storage Temperature Range	T_{STG}	–55	125	°C
Ambient Temperature Range	T_A	–40	85	°C
Lead Soldering Temperature (t=10 sec.)	T_S		260	°C
Isolation Test Voltage (t=1 min.)	V_{ISO}	2500		VAC_{RMS}
Pollution Degree			2	
Creepage Distance and Clearance: Standard Lead Bending		7		mm
Creepage Distance and Clearance: Options 6, 7, 9		8		
Comparative Tracking Index per DIN IEC112/ VDE 0303, part 1		175	400	
Isolation Resistance: V_{IO}=500 V, T_A=25°C	R_{ISO}	10^{12}		Ω
Isolation Resistance: V_{IO}=500 V, T_A=100°C		10^{11}		

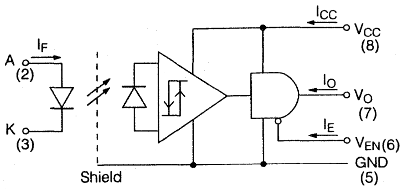
Recommended Operating Conditions

A 0.1 µF bypass capacitor connected between pins 5 and 8 must be used.

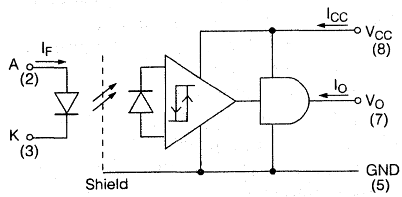
Parameter	Symbol	Min.	Max.	Unit
Supply Volage	V_{CC}	4.5	15	V
Enable Voltage High (SFH6700/19)	V_{EH}	2.0	15	V
Enable Voltage Low (SFH6700/19)	V_{EL}	0	0.8	V
Forward Input Current	I_{Fon}	1.6(1)	5	mA
Forward Input Current	I_{Foff}	–	0.1	mA
Operating Temperature	T_A	0	85	°C
Output Pull-up Resistor (SFH6705 only)	R_L	350	4k	Ω
Fan Out (SFH6705 at R_L=1 KΩ)	N		16	LS TTL Loads

1. We recommend using a 2.2 mA to permit at least 20% CTR degradation guard band.

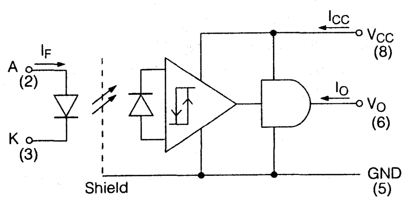
Figure 1. Schematics



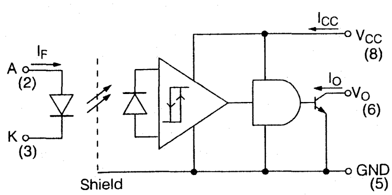
SFH6700/19



SFH6701/11



SFH6702/12



SFH6705

Characteristics

0°C≤ T_A≤85°C; 4.5 V≤V_{CC}≤15 V; 1.6 mA≤I_{Fon}≤5 mA; 2.0≤V_{EH}≤15 V; 0≤ V_{EL}≤0.8 V; 0 mA≤I_{Foff}≤0.1 mA
Typical values: T_A=25°C; V_{CC}=5 V; I_{Fon}=3 mA unless otherwise specified

Parameter	Sym.	Min.	Typ.	Max.	Unit	Test Condition
Emitter						
Forward Voltage	V_F		1.6	1.75	V	I_F=5 mA, T_A=25°C
				1.8	V	I_F=5 mA
Input Current Hysteresis	I_{HYS}		0.1		mA	V_{CC}=5 V, I_{HYS}=I_{Fon}–I_{Foff}
Reverse Current	I_R		0.5	10	µA	V_R=3 V, T_A=25°C
Capacitance	C_0		60		pF	V_R=0 V, f=1 MHz, T_A=25°C
Thermal Resistance	R_{thJA}		700		K/W	
Detector						
Logic Low Output Voltage	V_{OL}			0.5	V	I_{OL}=6.4 mA
Logic High Output Voltage (except SFH6705)	V_{OH}	2.4	*		V	I_{OH}=–2.6 mA, *V_{OH}=V_{CC}–1.8 V
Output Leakage Current (V_{OUT}>V_{CC}) (except SFH6705)	I_{OHH}		0.5	100	µA	V_O=5.5 V, V_{CC}=4.5 V, I_F=5 mA
			1	500	µA	V_O=15 V, V_{CC}=4.5 V, I_F=5 mA
Output Leakage Current (SFH6705 only)	I_{OHH}		0.5	100	µA	V_O=5.5 V, V_{CC}=5.5 V, I_F=5 mA
			1	500	µA	V_O=15 V, V_{CC}=15 V, I_F=5 mA
Logic High Enable Voltage (SFH6700/19 only)	V_{EH}	2.0			V	
Logic Low Enable Voltage (SFH6700/19 only)	V_{EL}			0.8	V	
Logic High Enable Current (SFH6700/19 only)	I_{EH}			20	µA	V_{EN}=2.7 V
				100	µA	V_{EN}=5.5 V
			0.00 1	250	µA	V_{EN}=15 V
Logic Low Enable Current (SFH6700/19 only)	I_{EL}	–320	–50		µA	V_{EN}=0.4 V
High Impedance State Output Current (SFH6700/19 only)	I_{OZL}	–20			µA	V_O=0.4 V, V_{EN}=2.0 V, I_F=5 mA
	I_{OZH}			20	µA	V_O=2.4 V, V_{EN}=2.0 V, I_F=0
				100	µA	V_O=5.5 V, V_{EN}=2.0 V, I_F=0
			0.00 1	500	µA	V_O=15 V, V_{EN}=2.0 V, I_F=0
Logic Low Supply Current	I_{CCL}		3.7	6.0	mA	V_{CC}=5.5 V, I_F=0
			4.1	6.5	mA	V_{CC}=15 V, I_F=0
Logic High Supply Current	I_{CCH}		3.4	4.0	mA	V_{CC}=5.5 V, I_F=5 mA
			3.7	5.0	mA	V_{CC}=15 V, I_F=5 mA
Logic Low Short Circuit Output Current	I_{OSL}(2)	25			mA	V_O=V_{CC}=5.5 V, I_F=0
		40			mA	V_O=V_{CC}=15 V, I_F=0
Logic High Short Circuit Output Current (except SFH6705)	I_{OSH}(2)			–10	mA	V_{CC}=5.5 V, Vo=0 V , I_F=5 mA
				–25	mA	V_{CC}=15 V, Vo=0 V, I_F=5 mA
Thermal Resistance	R_{thJA}		300		K/W	
Package						
Coupling Capacitance	C_{IO}		0.6		pF	f=1 MHz, pins 1–4 and 5–8 shorted together
Isolation Resistance	R_{ISO}	10^{12}			Ω	V_{IO}=500 V, T_A=25°C
		10^{11}			Ω	V_{IO}=500 V, T_A=100°C

2. Output short circuit time ≤10 ms.

Switching Times (3)

0°C≤ T_A≤85°C; 4.5 V≤V_{CC}≤15 V; 1.6 mA≤I_{Fon}≤5 mA; 2.0≤V_{EH}≤15 V (SFH6700/19);
0≤ V_{EL}≤0.8 V (SFH6700/19); 0 mA≤I_{Foff}≤0.1 mA
Typical values: T_A=25°C; V_{CC}=5 V; I_{Fon}=3 mA unless otherwise specified

Parameter, SFH6700/01/02/11/12/19	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Propagation Delay Time to Logic Low Output Level	t_{PHL}		120		ns	Without Peaking Capacitor
			115	300		With Peaking Capacitor
Propagation Delay Time to Logic Low Output Level	t_{PLH}		125		ns	Without Peaking Capacitor
			90	300		With Peaking Capacitor
Output Enable Time to Logic High (SFH6700/19)	t_{PZH}		20		ns	
Output Enable Time to Logic Low (SFH6700/19)	t_{PZL}		25		ns	
Output Disable Time from Logic High (SFH6700/19)	t_{PHZ}		50		ns	
Output Disable Time from Logic Low (SFH6700/19)	t_{PLZ}		50		ns	
Output Rise Time	t_r		40		ns	10% to 90%
Output Fall Time	t_f		10		ns	90% to 10%

Switching Times (3)

Typical values: T_A=25°C, V_{CC}=5 V; I_{Fon}=3 mA, R_L=390 Ω, unless otherwise specified

Parameter, SFH6705	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Propagation Delay Time to Logic Low Output Level	t_{PHL}		115		ns	Without Peaking Capacitor
			105	300		With Peaking Capacitor
Propagation Delay Time to Logic Low Output Level	t_{PLH}		125		ns	Without Peaking Capacitor
			90	300		With Peaking Capacitor
Output Rise Time	t_r		25		ns	10% to 90%
Output Fall Time	t_f		4		ns	90% to 10%

Common Mode Transient Immunity T_A=25°C, V_{CC}=5 V(4)

Parameter	Device	Symbol	Min.	Unit	Test Condition
Logic High Common Mode Transient Immunity	SFH6700/01/02/05	$\|CM_H\|$(4)	1000	V/µs	$\|V_{CM}\|$=50 V, I_F=1.6 mA
	SFH6711/12/19		2500	V/µs	$\|V_{CM}\|$=400 V, I_F=1.6 mA
Logic Low Common Mode Transient Immunity	SFH6700/01/02/05	$\|CM_L\|$(4)	1000	V/µs	$\|V_{CM}\|$=50 V, I_F=0
	SFH6711/12/19		2500	V/µs	$\|V_{CM}\|$=400 V, I_F=0

3. A 0.1 µF bypass capacitor connected between pins 5 and 8 must be used.
4. CM_H is the maximum slew rate of a common mode voltage V_{CM} at which the output voltage remains at logic high level (V_O>2 V).
   CM_L is the maximum slew rate of a common mode voltage V_{CM} at which the output voltage remains at logic low level (V_O<0.8 V).

Figure 2. Permissible total power disipation vs. temperature

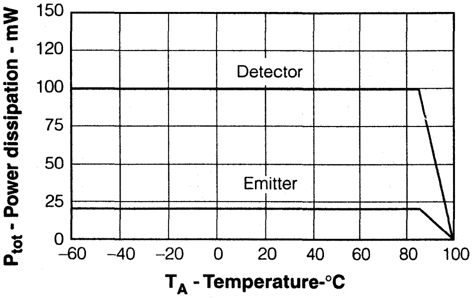


Figure 3. Typical iput diode forward current vs. forward voltage

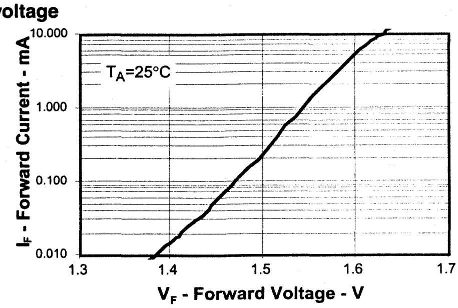


Figure 4. Typical forward input voltage vs. temperature

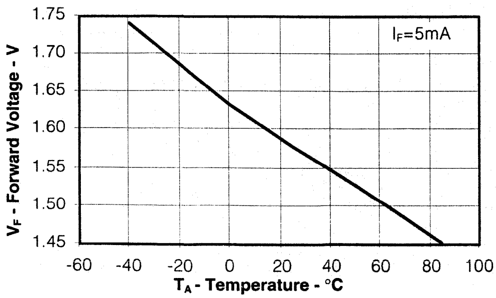


Figure 8. Typical output leakage current vs. temperature

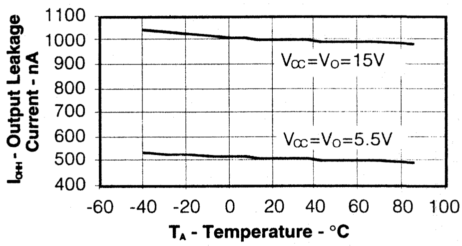


Figure 5. Typical output voltage vs. forward input current (except SFH6705)

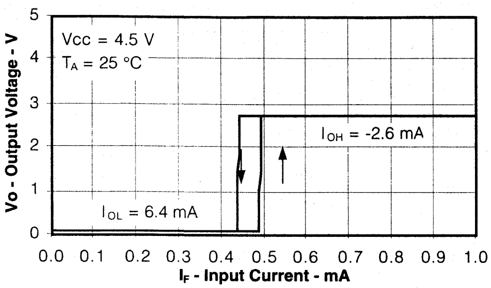


Figure 9. Typical low level output current vs. temperature

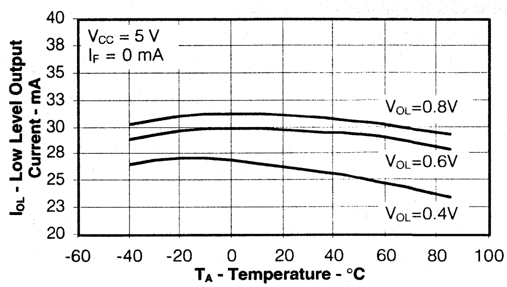


Figure 6. Typical output Fforward voltage vs. forward input current (only SFH6705)

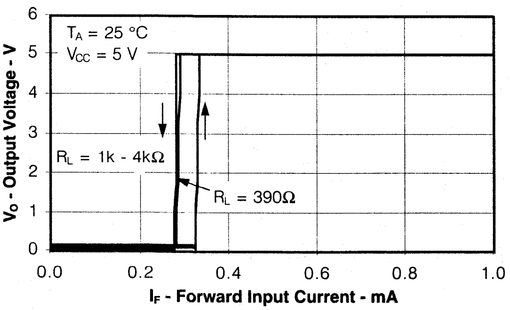


Figure 10. Typical low level output voltage vs. temperature

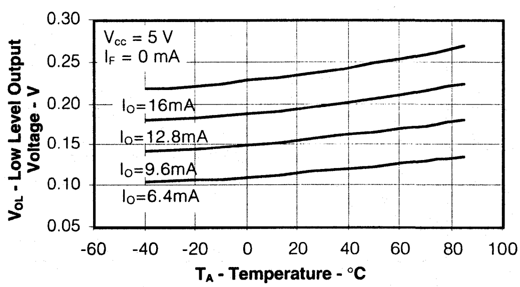


Figure 7. Typical supply current vs. temperature

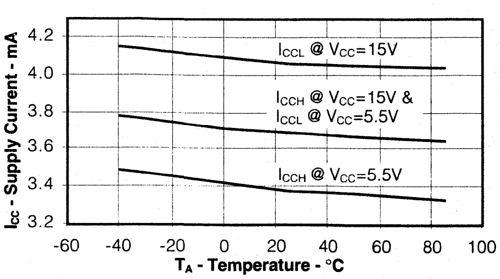


Figure 11. Typical high level output current vs. temperature (except SFH6705)

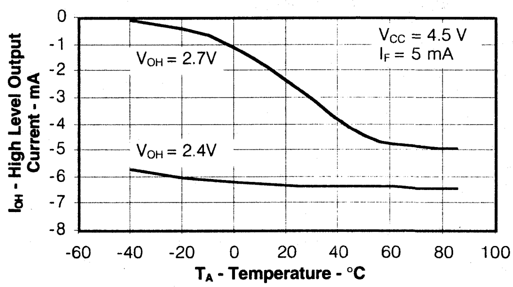


Figure 12. Typical rise, fall time vs. temperature (except SFH6705)

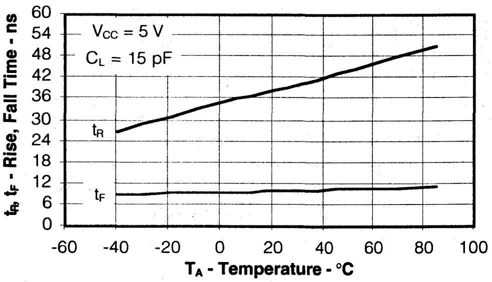


Figure 13. Typical propagation delays to logic high vs. temperature (except SFH6705)

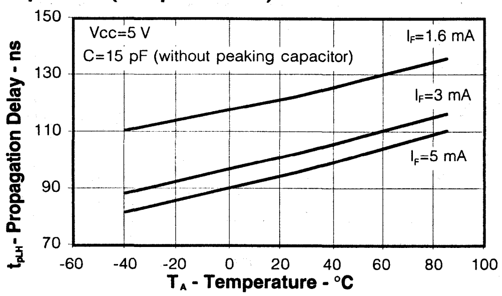


Figure 14. Typical propagation delays to logic high vs. temperature (except SFH6705)

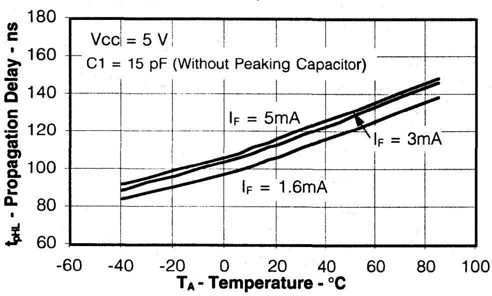


Figure 15. Typical propagation delays to logic high vs. temperature (except SFH6705)

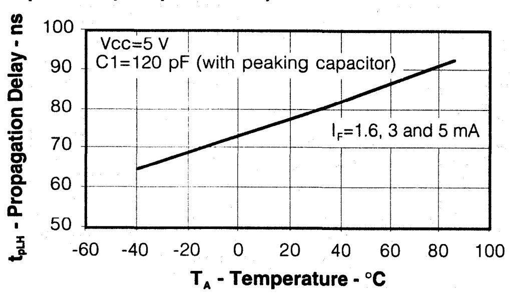


Figure 16. Typical propagation delays to logic low vs. temperature

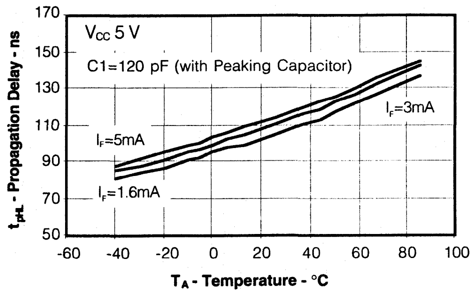


Figure 17. Typical propagation delays to logic high vs. temperature

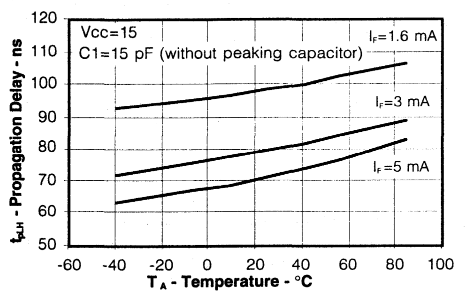


Figure 18. Typical propagation delays to logic low vs. temperature

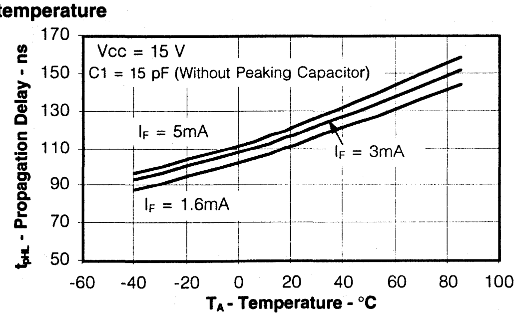


Figure 19. Typical propagation delays to logic high vs. temperature

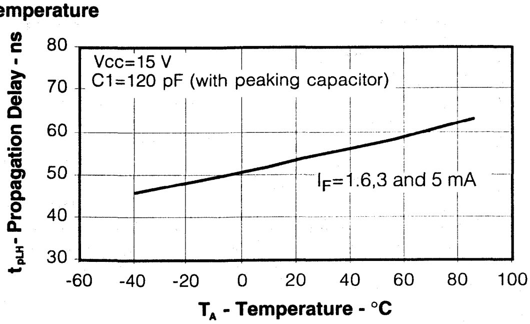


Figure 20. Typical propagation delays to logic low vs. temperature (except SFH6705)

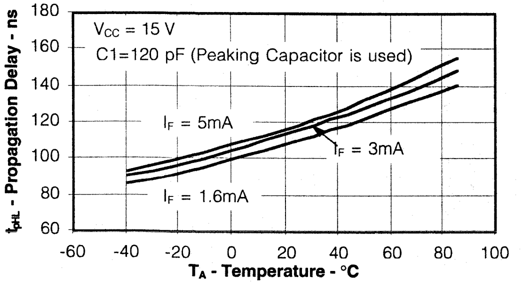


Figure 24. Typical propagation delays to high level vs. temperature (only SFH 6705)

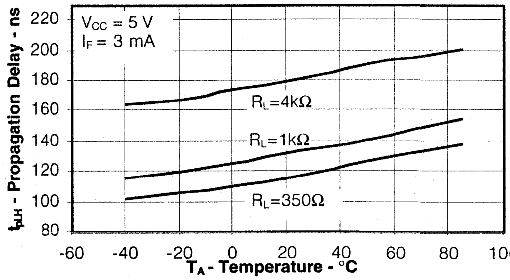


Figure 21. Typical logic low enable propagation delays vs. temperature (only SFH6700/11)

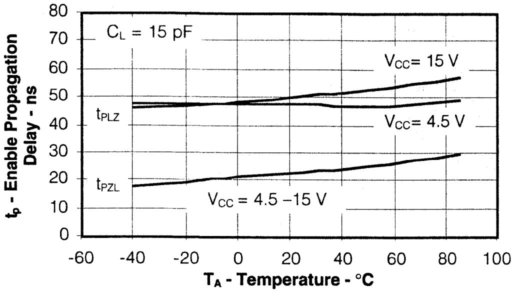


Figure 25. Typical progagation delays to low level vs. temperature (only SFH 6705)

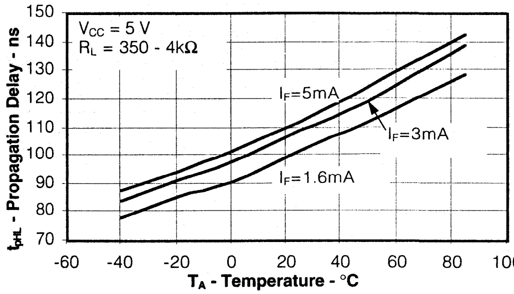


Figure 22. Typical logic high enable propagation delays vs. temperature (only SFH6700/11)

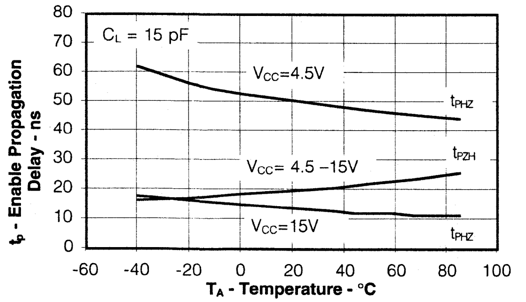


Figure 26. Typical rise, fall time vs. temperature (only SFH6705)

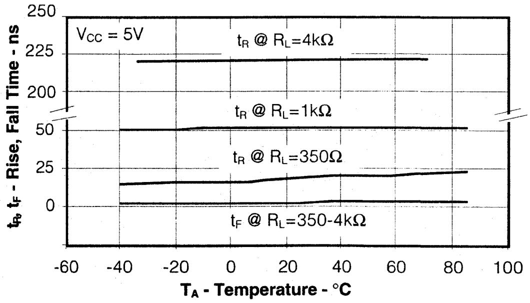


Figure 23. Typical propagation delays vs. pulse Input current (only SFH6705)

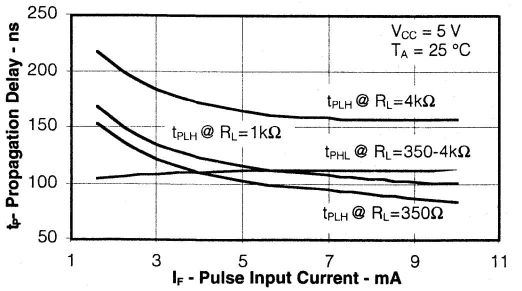
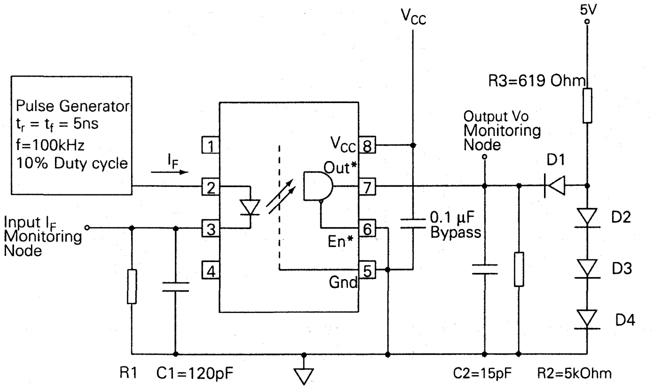


Figure 27. Test circuit for t_{PLH}, t_{PHL}, t_r and t_f—SFH6700/01/02/11/12/19



The Probe and Jig Capacitances are included in C1 and C2

All diodes are 1N916 or 1N3064

R1	2.15 kOhm	1.1 kOhm	681 Ohm
I_F (ON)	1.6 mA	3 mA	5 mA

* SFH6701/02/11/12 without V_{EN}
* SFH6702/12 Pin 6 V_{OUT} and Pin 7 n.c.

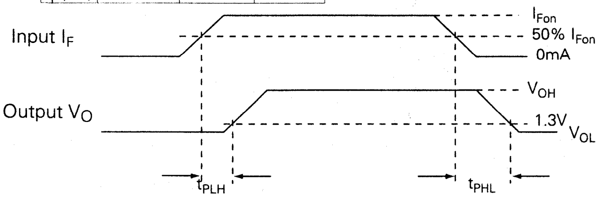
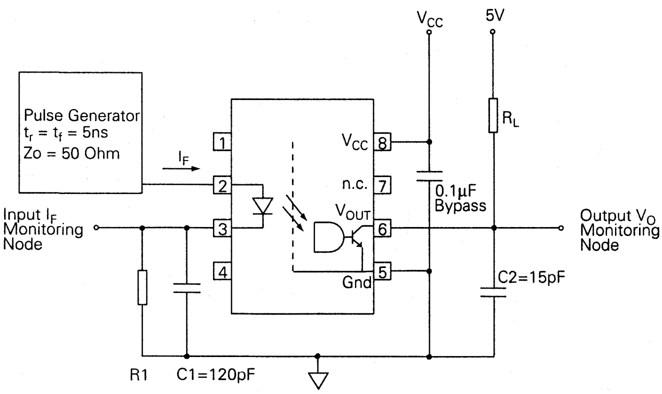


Figure 28. Test circuit for t_{PLH}, t_{PHL}, t_r and t_f—SFH6705



The Probe and Jig Capacitances are included in C1 and C2

R1	2.15 kOhm	1.1 kOhm	681 Ohm
I_F (ON)	1.6 mA	3 mA	5 mA

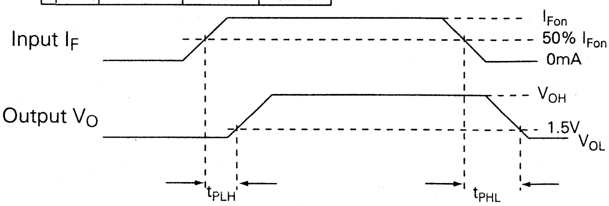


Figure 29. Test circuit for t_{PHZ}, t_{PZH}, t_{PLZ} and t_{PZL}–SFH6700/19

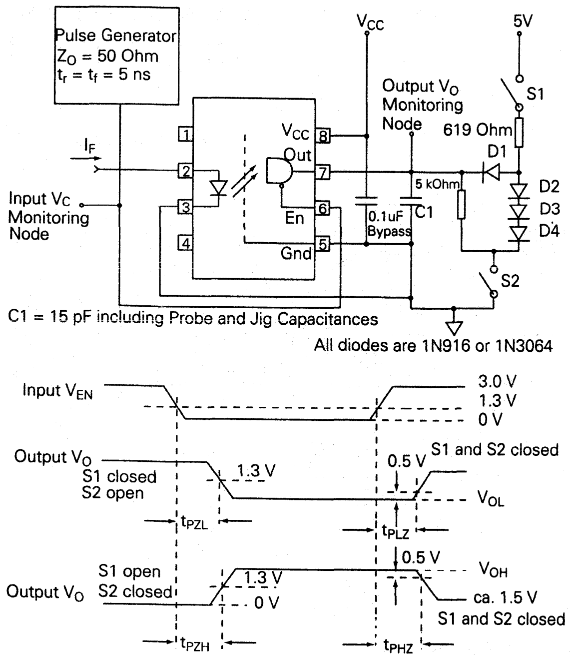


Figure 30. Test circuit for common mode transient immunity and typical waveforms—SFH 6700/01/02/11/12/19

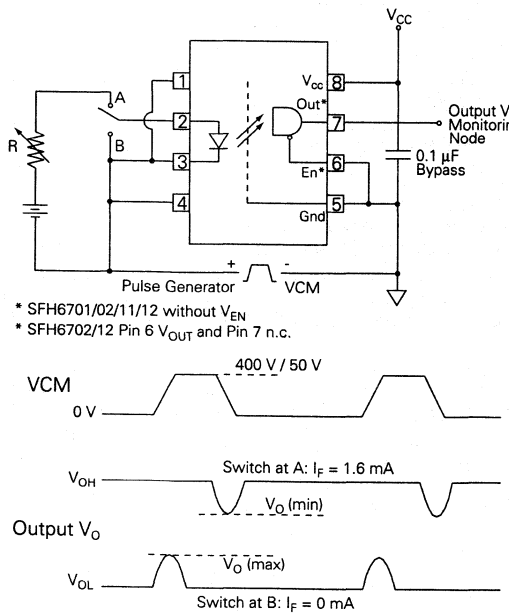
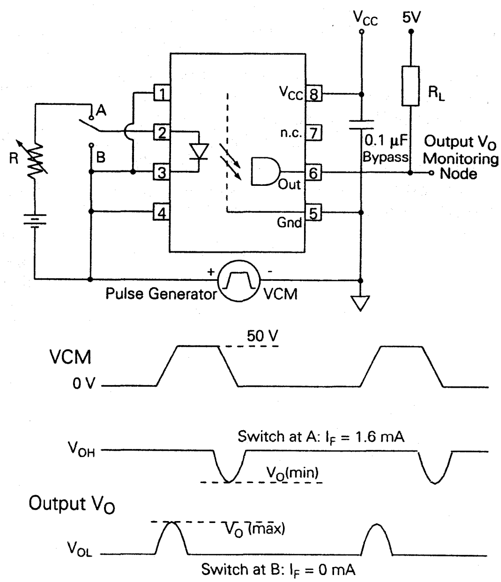


Figure 31. Test circuit for common modetransient immunity and typical waveforms—SFH6705$_L$



Optocouplers (Optoisolators) 5

SIEMENS

SFH 6943

Low Current Input Mini Optocoupler

Preliminary Data Sheet

FEATURES

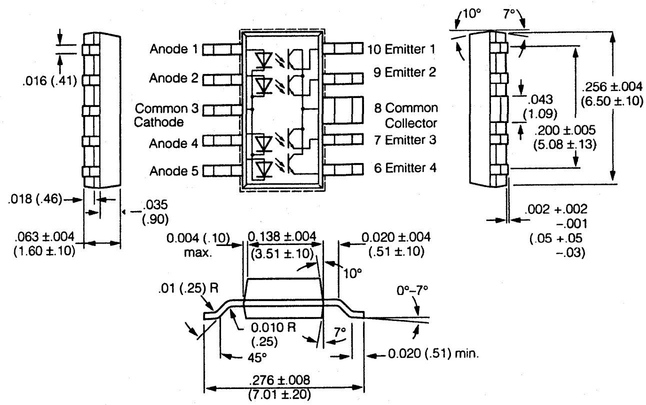
- **Transistor Optocoupler in SOT223/10 Package**
- **End Stackable, 1.27 mm Spacing**
- **Low Current Input**
- **Very High CTR, 150% Typical at I_F=1 mA, V_{CE}=5V**
- **Good CTR Linearity Versus Forward Current**
- **Minor CTR Degradation**
- **Field Effect Stable by TRIOS® (TRansparent IOn Shield)**
- **High Collector-Emitter Voltage, V_{CEO}=70 V**
- **Low Coupling Capacitance**
- **High Common Mode Transient Immunity**
- **Isolation Test Voltage: 2500 VDC**

APPLICATIONS

- **Telecommunication**
- **SMT**
- **PCMCIA**
- **Instrumentation**

DESCRIPTION

The SFH6943 is a four channel mini-optocoupler suitable for high density packaged PCB application. It has a minimum of 2500 VDC isolation from input to output. The device consists of four phototransistors as detectors. Each channel is individually controlled. The optocoupler is housed in a SOT223/10 package. All the cathodes of the input LEDs and all the collectors of the output transistors are commoned enabling a pin count reduction from 16 pins to 10 pins—a significant space savings as compared to four channels that are electrically isolated individually.



Absolute Maximum Ratings

Emitter(GaAlAs)

Reverse Voltage .... 3 V
DC Forward Current .... 5 mA
Surge Forward Current (t_P≤10 µs) .... 100 mA
Total Power Dissipation .... 10 mW

Detector (Si Phototransistor)

Collector-Emitter Voltage .... 70 V
Emitter-Collector Voltage .... 7 V
Collector Current .... 10 mA
Surge Collector Current (t_P<1 ms) .... 20 mA
Total Power Dissipation .... 20 mW

Package Insulation

Isolation Test Voltage (between emitter and detector,
refer to climate DIN 40046, part 2, Nov. 74) .... 2500 VDC
Creepage .... ≥4 mm
Clearance .... ≥4 mm
Comparative Tracking Index per DIN IEC 112/VDE0303, part 1 175
Isolation Resistance
V_{IO}=100 V, T_A=25°C .... $\geq 10^{11}\ \Omega$
V_{IO}=100 V, T_A=100°C .... $\geq 10^{10}\ \Omega$
Storage Temperature Range .... –55 to +150°C
Ambient Temperature Range .... –55 to +100°C
Junction Temperature .... 100°C
Soldering Temperature (t=10 sec. max.)
Dip soldering plus reflow soldering processes .... 260°C

Characteristics (T_A=25°C, unless otherwise specified)

Description	Symbol	Min.	Typ.	Max.	Unit
Emitter (IR GaAs)					
Forward Voltage, I_F=5 mA	V_F		1.25		V
Reverse Current, V_R=3 V	I_R		0.01	10	µA
Capacitance, V_R=0 V, f=1 MHz	C_0		5		pF
Thermal Resistance	R_{thJA}		1000		°K/W
Detector (Si Phototransistor)					
Collector-Emitter Voltage, I_{CE}=10 µA	V_{CEO}	70			V
Emitter-Collector Voltage, I_{EC}=10 µA	V_{ECO}	7			V
Capacitance, V_{CE}=5 V, f=1 MHz	C_{CE}		6		pF
Thermal Resistance	R_{thJA}		500		°K/W
Package					
Coupling Capacitance	C_C		1		pF

Description	Symbol	-2	-3	-4	Unit	Condition
Coupling Transfer Ratio	I_E/I_F	63–200	100–320	160–500	%	I_F=1 mA, V_{CE}=1.5 V
Coupling Transfer Ratio	I_E/I_F	typ, 100 (≥32)	typ, 160 (≥50)	typ, 250 (≥80)	%	I_F=0.5 mA, V_{CC}=5 V
Collector-Emitter Leakage Current	I_{CEO}	50	50	50	nA	V_{CE}=10 V

Figure 1. Switching times (non-saturated), typical

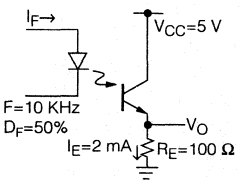
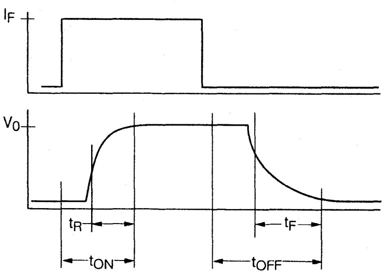


Figure 2. Switching waveform (non-saturated)



Description	Symbol	Value	Unit	Test Conditions
Turn-on Time	t_{on}	3	µs	I_E=2 mA, R_E=100 Ω, T_A=25°C, V_{CC}=5 V
Rise Time	t_r	2.6		
Turn-off Time	t_{off}	3.1		
Fall Time	t_f	2.8		

Figure 3. LED current versus LED voltage $V_F=f(I_F)$

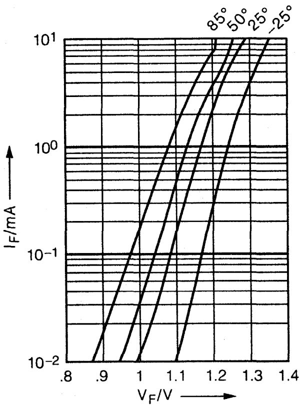


Figure 4. Non-saturated current transfer normalized to I_F=1 mA, NCTR=f(I_F)

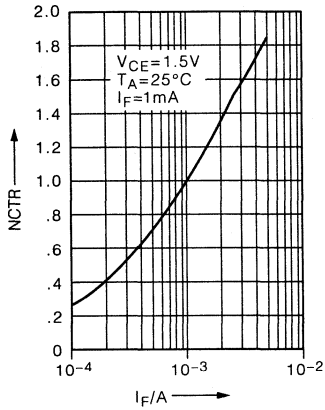


Figure 5. Transistor capacitance (typ.) T_A=25°C, f=1MHz, $C_{CE}=f(V_{CE})$

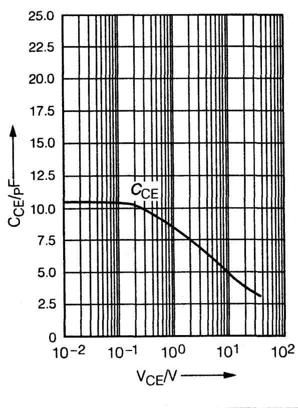


Figure 6. Collector-emitter leakage-current (typ.) I_F=0, T_A=25°C, $I_{CEO}=f(V_{CE})$

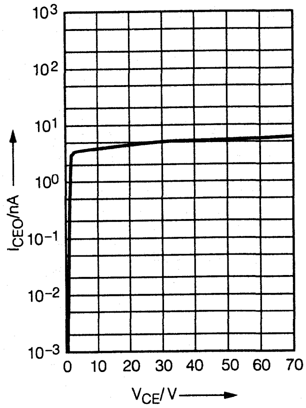


Figure 7. Permissible forward current diode $I_F=f(T_A=25°C)$

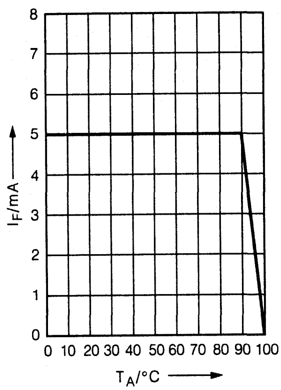


Figure 8. Permissible power dissipation $P_{tot}=f(T_A)$

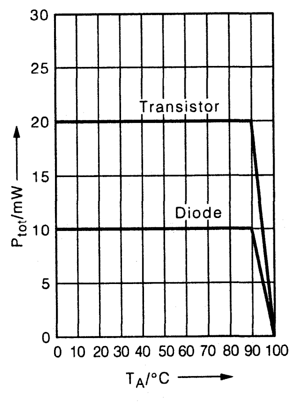


Figure 9. T_A**=25°C,** I_F**=1 mA,** V_{CC}**=5 V,** t_{on}, t_r, t_{off}, $t_t=f(R_L)$

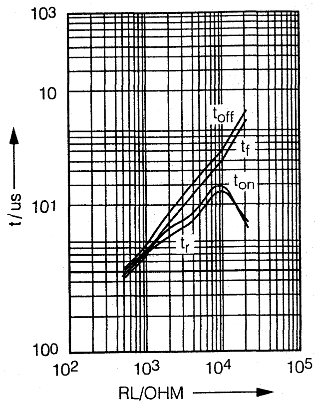
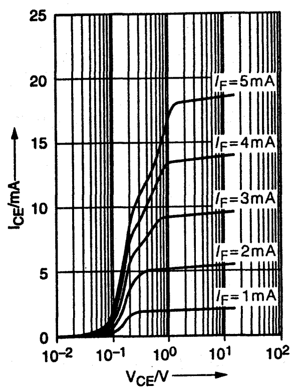
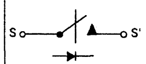
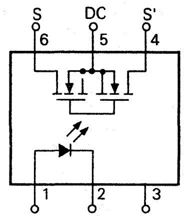
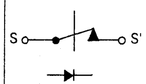
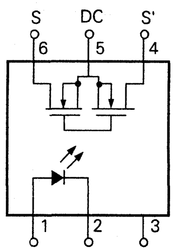


Figure 10. Transistor output charcteristics T_A=25°C, I_{CE}=1 (V_{CE}, I_F)

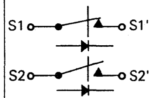
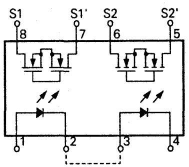
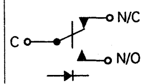
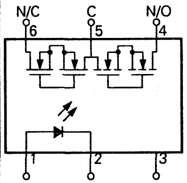
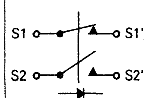
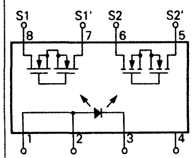
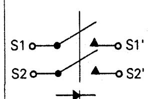
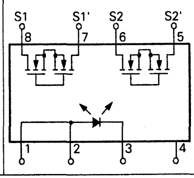


High-Voltage Solid State Relays • Selection Guide

Product Group	Contact Form	Base Part No.	Output Characteristics: Load Voltage Max. (V)	Load Current Max. Recommended (mA)		ON-Resistance Max. at 25°C (Ω)		Current Limit Typ. at 25°C I_F=5 mA		Operate Time Max. at 25°C I_F=5 mA, *I_F=10 mA (ms)		Input Characteristics: LED Operate Current Min. (mA)		I/O Isolation (Min.) (Vrms)	Package	Current Transfer Ratio
				ac/dc	dc	ac/dc	dc	ac/dc	dc	ton	toff	25°C Test Specifications	Recommended Current for 85°C Operation			
Optically Coupled SSRs 	1 Form A 	LH1517AT	150	400	800	3	0.85			3.0*	3.0*	2.0	6.0	3750	6-pin	NA
		LH1510AT	200	200	350	15	3.75	360	720	2.0*	2.0*	2.0	5.0	5300	6-pin	NA
		LH1541AT1[1]	200	50		160				0.25	0.25	2.0	5.0	5300	6-pin	NA
		LH1518AT	250	130	300	20	5.00	200		3.0	3.0	2.0	5.0	5300	6-pin	NA
		LH1519AT	250	225	450	10	2.50	380		3.0	3.0	2.0	5.0	3750	6-pin	NA
		LH1191AT1	280	120		33		210		2.0	2.0	2.5	6.0	3750	6-pin	NA
		LH1085AT1	350	135		37		300		2.0	2.0	2.5	6.0	3750	6-pin	NA
		LH1540AT	350	120	250	25	6.25	210		2.0	2.0	2.0	5.0	5300	6-pin	NA
		LH1500AT	350	150	250	25	6.25	270		2.0	2.0	2.0	5.0	5300	6-pin	NA
		LH1530AT	350	150	250	25	6.25			1.0*	1.0*	2.0	5.0	5300	6-pin	NA
		LH1550AT1	350	100		50		200		3.0	3.0	2.0	5.0	5300	6-pin	NA
		LH1504AT1[2]	400	95		34		210		5.0	5.0	2.0	5.0	5300	6-pin	NA
		LH1547AT1[6]	400	95		34		210		5.0	5.0	2.0	5.0	5300	6-pin	NA
		LH1525AT	400	120	250	33	8.25	210		0.8	0.4	0.5	2.0	5300	6-pin	NA
		LH1516AT	400	200	450	10	2.50	375		3.0*	3.0*	2.0	5.0	3750	6-pin	NA
		LH1535AT	400	120	250	25	6.25	210		2.0	2.0	2.5	5.5	5300	6-pin	NA
Optically Coupled SSRs 	1 Form B 	LH1511AT	200	200	350	15	3.75			3.0*	3.0*	2.0	5.0	5300	6-pin	NA
		LH1501AT	350	150	250	25	6.25			3.0	3.0	2.0	5.0	5300	6-pin	NA

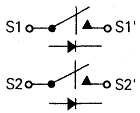
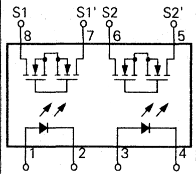
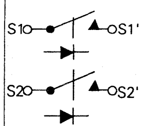
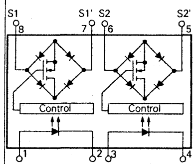
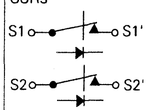
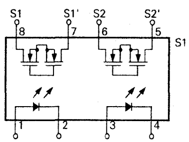
1. Low capacitance SSR (3.5 pF).
2. Diode offset in I/V characteristics, contact form similar to one half of LH1524 AB
3. Break-before-make operation.
4. High-frequency SSR (<50 MHz).
5. Current through both poles operating simultaneously. Load current for individual pole operations is higher.
6. 1 Form A, DC relay.

High-Voltage Solid State Relays • Selection Guide

Product Group	Contact Form	Base Part No.	Output Characteristics: Load Voltage Max. (V)	Load Current Max. Recommended (mA)		ON-Resistance Max. at 25°C (Ω)		Current Limit Typ. at 25°C I_F=5 mA		Operate Time Max. at 25°C I_F=5 mA, *I_F=10 mA (ms)		Input Characteristics: LED Operate Current Min. (mA)		I/O Isolation (Min.) (Vrms)	Package	Current Transfer Ratio
				ac/dc	dc	ac/dc	dc	ac/dc	dc	ton	toff	25°C Test Specifications	Recommended Current for 85°C Operation			
Optically Coupled SSRs 	1 Form A/B,C 	LH1512AB	200	200		15		360		3.0*	3.0*	2.0	5.0	5300	8-pin	NA
		LH1502AB[3]	350	150		25		270		6.0*	3.0*	2.0	5.0	5300	8-pin	NA
Optically Coupled SSRs 	1 Form C 	LH1527BT	350	125		33				4.0*	4.0*	3.0	7.0	3750	6-pin	NA
		LH1537AT[3]	250	150		20				4.0*	4.0*	3.0	7.0	3750	8-pin	NA
Optically Coupled SSRs 	1 Form C 	LH1527BB	350	125		33				4.0*	4.0*	3.0	7.0	3750	8-pin	NA
		LH1537AB	250	150		20				4.0*	4.0*	3.0	7.0	3750	8-pin	NA
Optically Coupled SSRs 	2 Form A 	LH1514AB[4]	15	150		8				1.0*	1.0*	3.0	8.0	3750	8-pin	NA
		LH1513AB	200	140		15		360		2.5*	2.5*	3.0	8.0	3750	8-pin	NA
		LH1503AB	350	110		25		270		2.5*	2.5*	3.0	8.0	3750	8-pin	NA

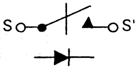
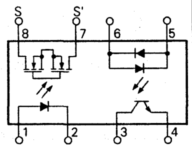
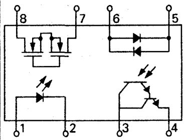
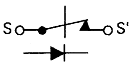
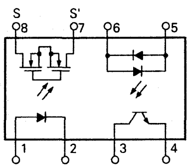
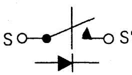
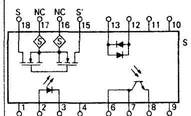
1. Low capacitance SSR (3.5 pF).
2. Diode offset in I/V characteristics, contact form similar to one half of LH1524 AB
3. Break-before-make operation.
4. High-frequency SSR (<50 MHz).
5. Current through both poles operating simultaneously. Load current for individual pole operations is higher.
6. 1 Form A, DC relay.

High-Voltage Solid State Relays • Selection Guide

Product Group	Contact Form	Base Part No.	Output Characteristics									Input Characteristics				
			Load Voltage Max. (V)	Load Current Max. Recommended (mA)		ON-Resistance Max. at 25°C (Ω)		Current Limit Typ. at 25°C I_F=5 mA		Operate Time Max. at 25°C I_F=5 mA, *I_F=10 mA (ms)		LED Operate Current Min. (mA)		I/O Isolation (Min.) (Vrms)	Package	Current Transfer Ratio
				ac/dc	dc	ac/dc	dc	ac/dc	dc	ton	toff	25°C Test Specifications	Recommended Current for 85°C Operation			
Optically Coupled SSRs 	Dual 1 Form A 	LH1522AB	200	140[5]		15		360		2.0*	2.0*	2.0	5.0	3750	8-pin	NA
		LH1544AB[1]	200	40[5]		160				0.25	0.25	2.0	5.0	3750	8-pin	NA
		LH1505AB	250	120[5]		20		200		4.0	4.0	2.0	5.0	5300	8-pin	NA
		LH1520AB	350	110[5]		25		270		2.0	2.0	2.0	5.0	5300	8-pin	NA
		LH1531AB	350	110[5]		25				1.0*	1.0*	2.0	5.0	5300	8-pin	NA
		LH1532AB	350	110[5]		25		210		2.0	2.0	2.0	5.0	5300	8-pin	NA
		LH1533AB	350	70[5]		50		200		3.0	3.0	2.0	5.0	5300	8-pin	NA
		LH1526AB	400	90[5]		33		210		0.8	0.4	2.0	5.0	3750	8-pin	NA
Optically Coupled SSRs 	Dual 1 Form A 	LH1524AB[2]	400	70[5]		34		210		5.0	5.0	0.5	2.0	3750	8-pin	NA
Optically Coupled SSRs 	Dual 1 Form B 	LH1523AB	200	140		15				3.0*	3.0*	2.0	5.0	5300	8-pin	NA
		LH1521AB	350	110		25				3.0	3.0	2.0	5.0	5300	8-pin	NA

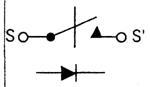
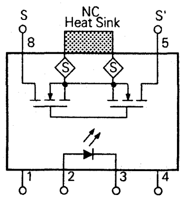
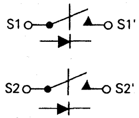
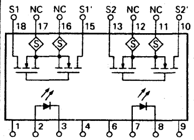
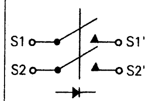
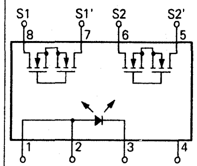
1. Low capacitance SSR (3.5 pF).
2. Diode offset in I/V characteristics, contact form similar to one half of LH1524 AB
3. Break-before-make operation.
4. High-frequency SSR (<50 MHz).
5. Current through both poles operating simultaneously. Load current for individual pole operations is higher.
6. 1 Form A, DC relay.

High-Voltage Solid State Relays • Selection Guide

Product Group	Contact Form	Base Part No.	Load Voltage Max. (V)	Load Current Max. Recommended (mA)		ON-Resistance Max. at 25°C (Ω)		Current Limit Typ. at 25°C I_F=5 mA		Operate Time Max. at 25°C I_F=5 mA, *I_F=10 mA (ms)		LED Operate Current Min. (mA)		I/O Isolation (Min.) (Vrms)	Package	Current Transfer Ratio
				Output Characteristics								Input Characteristics				
				ac/dc	dc	ac/dc	dc	ac/dc	dc	ton	toff	25°C Test Specifications	Recommended Current for 85°C Operation			
Telecom Switches 	1 Form A/Optocoupler 	LH1529AB	350	120		25		210		2.5	2.5	2.0	5.0	5300	8-pin	33
		LH1529BB	350	120		25		210		2.5	2.5	2.0	5.0	5300	8-pin	100
		LH1549AB	400	120		33		210		2.0	0.5	1.0	3.0	5300	8-pin	33
Telecom Switches	1 Form A/Darlington 	LH1539AB	350	120		25		210		2.5	2.5	2.0	5.0	3750	8-pin	300
Telecom Switches 	1 Form B/Optocoupler 	LH1528AB	350	150		25				3.0	3.0	2.0	5.0	3750	8-pin	33
PCMCIA Telecom Switch 	1 Form A/Optocoupler 	LH1548ACE	400	110		33		210		1.0	0.5	0.5	2.5	1500	18-pin	33

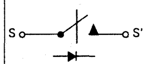
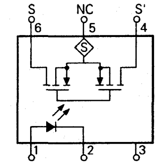
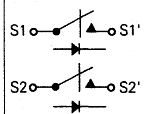
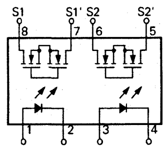
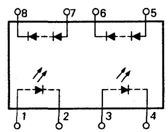
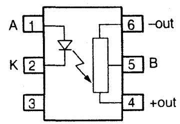
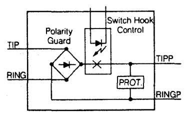
1. Low capacitance SSR (3.5 pF).
2. Diode offset in I/V characteristics, contact form similar to one half of LH1524 AB
3. Break-before-make operation.
4. High-frequency SSR (<50 MHz).
5. Current through both poles operating simultaneously. Load current for individual pole operations is higher.
6. 1 Form A, DC relay.

High-Voltage Solid State Relays • Selection Guide

Product Group	Contact Form	Base Part No.	Output Characteristics: Load Voltage Max. (V)	Load Current Max. Recommended (mA)		ON-Resistance Max. at 25°C (Ω)		Current Limit Typ. at 25°C I_F=5 mA		Operate Time Max. at 25°C I_F=5 mA, *I_F=10 mA (ms)		Input Characteristics: LED Operate Current Min. (mA)		I/O Isolation (Min.) (Vrms)	Package	Current Transfer Ratio
				ac/dc	dc	ac/dc	dc	ac/dc	dc	ton	toff	25°C Test Specifications	Recommended Current for 85°C Operation			
PCMCIA Relays 	1 Form A 	LH1525ACD	400	110		33		210		1.0	0.5	0.5	2.5	1500	8-pin	NA
PCMCIA Relays 	Dual 1 Form A 	LH1526ACE	400	80		33		210		1.0	0.5	0.5	2.5	1500	18-pin	NA
High Frequency Relays (T1 Applications) 	2 Form A 	LH1514AB[4]	15	150		8				1.0*	1.0*	3.0	8.0	3750	8-pin	NA

1. Low capacitance SSR (3.5 pF).
2. Diode offset in I/V characteristics, contact form similar to one half of LH1524 AB
3. Break-before-make operation.
4. High-frequency SSR (<50 MHz).
5. Current through both poles operating simultaneously. Load current for individual pole operations is higher.
6. 1 Form A, DC relay.

High-Voltage Solid State Relays • Selection Guide

Product Group	Contact Form	Base Part No.	Output Characteristics									Input Characteristics				
			Load Voltage Max. (V)	Load Current Max. Recommended (mA)		ON-Resistance Max. at 25°C (Ω)		Current Limit Typ. at 25°C I_F=5 mA		Operate Time Max. at 25°C I_F=5 mA, *I_F=10 mA (ms)		LED Operate Current Min. (mA)		I/O Isolation (Min.) (Vrms)	Package	Current Transfer Ratio
				ac/dc	dc	ac/dc	dc	ac/dc	dc	ton	toff	25°C Test Specifications	Recommended Current for 85°C Operation			
Instrumentation Relays 	1 Form A 	LH1541AT1[1]	200	50		160				0.25	0.25	2.0	5.0	3750	6-pin	NA
Instrumentation Relays 	Dual 1 Form A 	LH1544AB[1]	200	40^5		160				0.25	0.25	2.0	5.0	3750	8-pin	NA
Mosfet Drivers		LH1262	15		14 µA I_F=10 mA					35 µs I_F=20 mA typ.	90 µs I_F=20 mA typ.			3750	8-pin	
		LH1485	300	50 mA input pins 5–4						3.5 µs Typ	300 ns Typ	10		5300	6-pin	
DAA Interface		LH2559	350 V	100		24				5	5	5		3750	8-pin	

1. Low capacitance SSR (3.5 pF).
2. Diode offset in I/V characteristics, contact form similar to one half of LH1524 AB
3. Break-before-make operation.
4. High-frequency SSR (<50 MHz).
5. Current through both poles operating simultaneously. Load current for individual pole operations is higher.
6. 1 Form A, DC relay.

∂PCMCIA Schematics

Figure 1. 1 Form A (SOP)

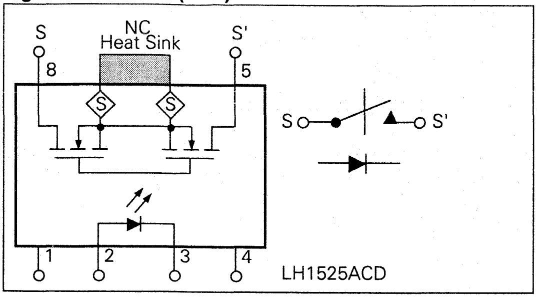


Figure 2. Dual 1 Form A (SOP)

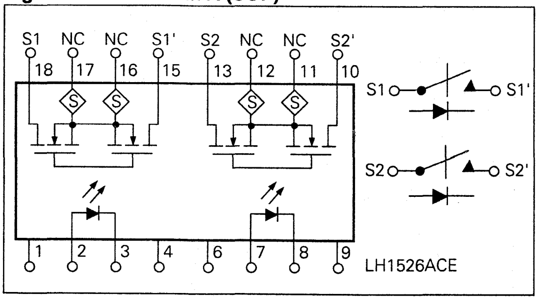
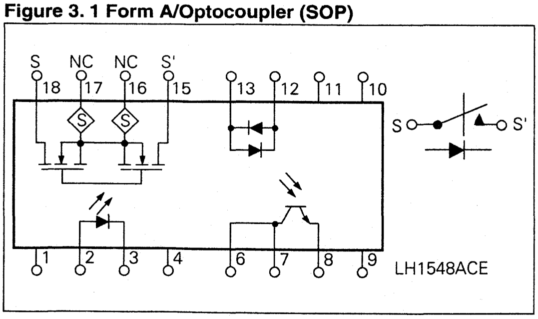


Figure 3. 1 Form A/Optocoupler (SOP)



Telecom Switches Schematics

Figure 4. 1 Form A/Optocoupler

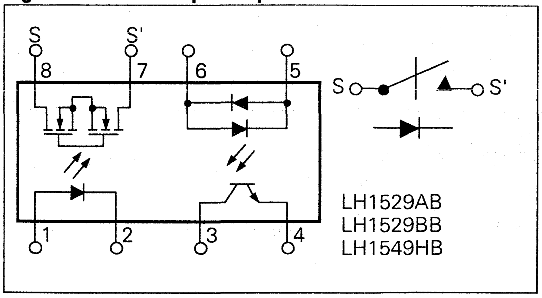
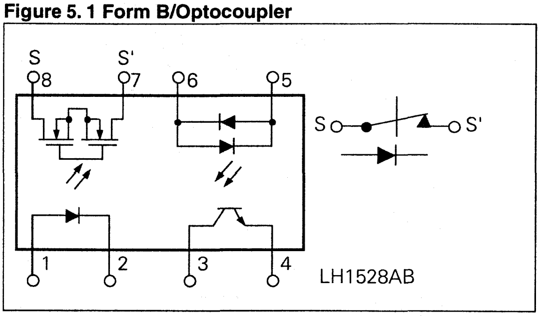


Figure 5. 1 Form B/Optocoupler



Relay Schematics

Figure 6. 1 Form A

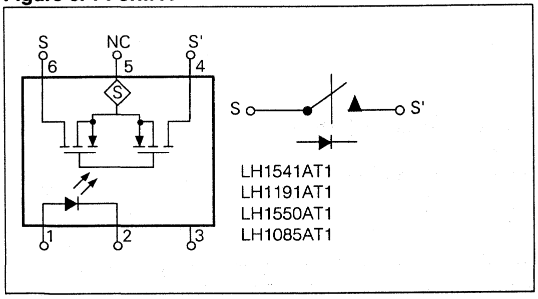


Figure 7. 1 Form A

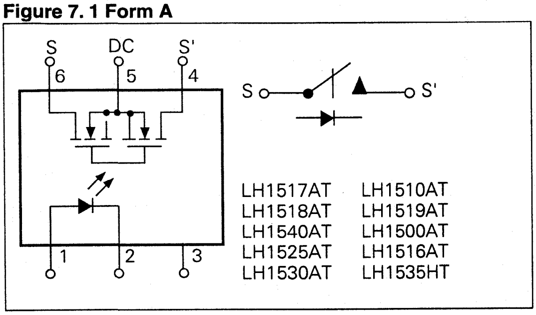


Figure 8. 1 Form A

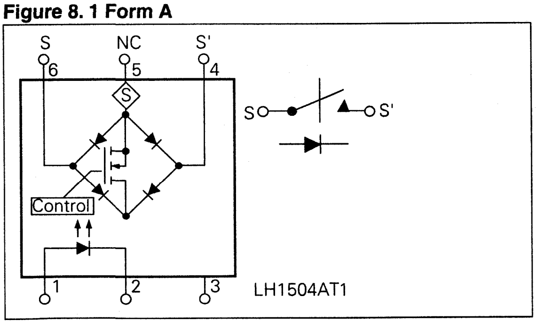


Figure 9. 1 Form A, DC

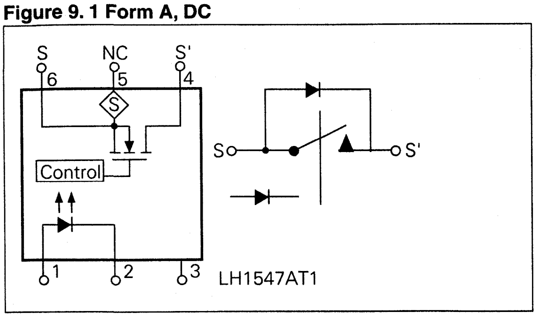


Figure 10. 1 Form B

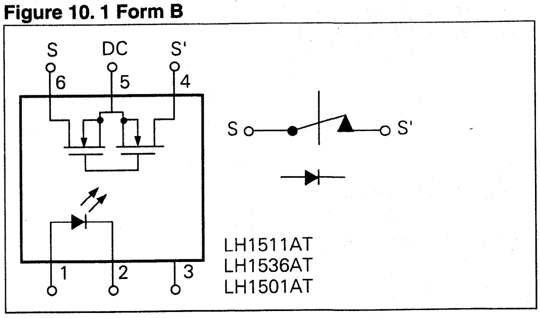


Figure 11. 1 Form A/B, C

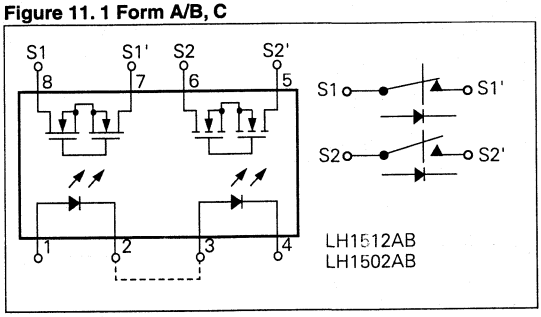


Figure 12. 1 Form C

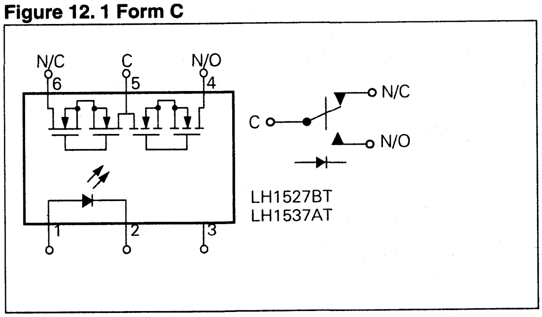


Figure 13. 1 Form C

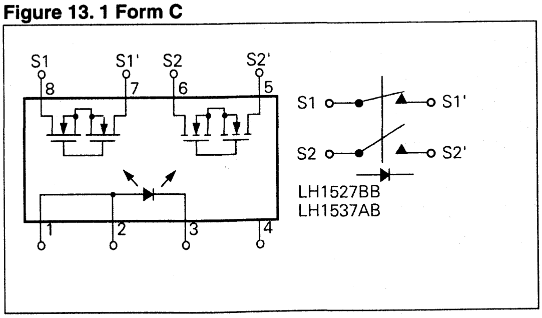


Figure 14. 2 Form A

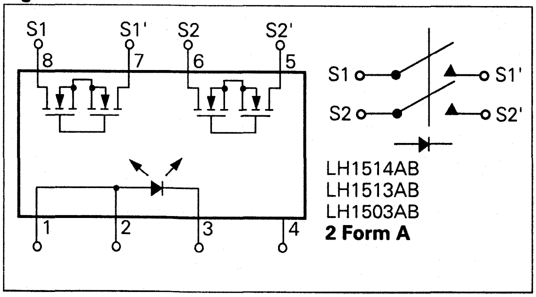


Figure 15. Dual 1 Form A

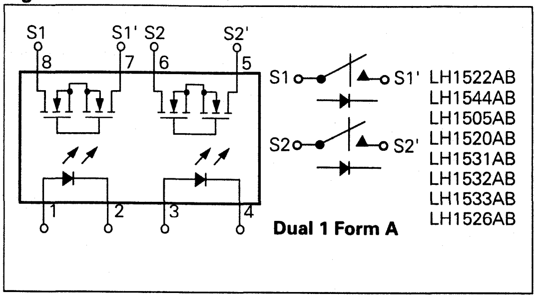


Figure 16. Dual 1 Form A

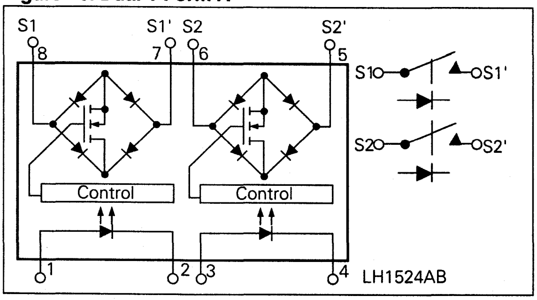


Figure 17. Dual 1 Form B

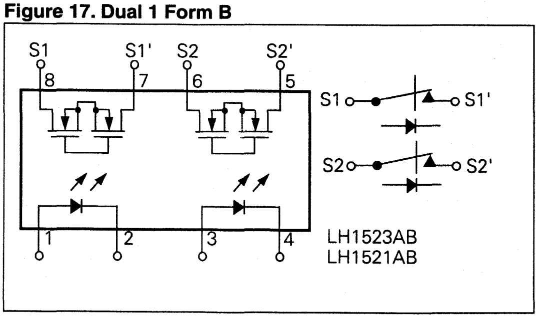


Figure 18. 2 Form A

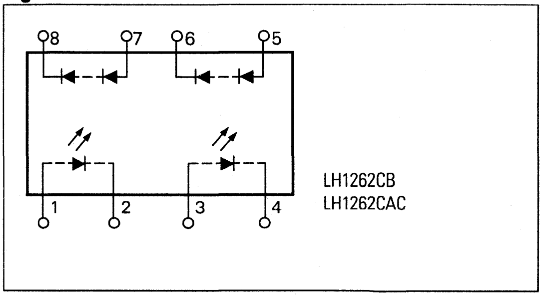


Figure 19. Dual 1 Form A

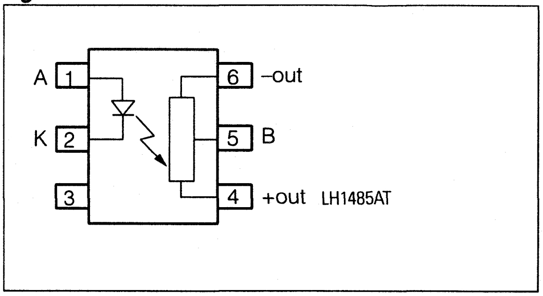
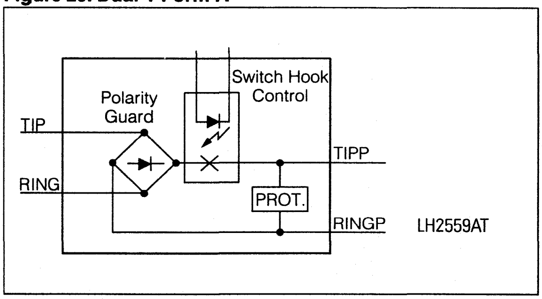


Figure 20. Dual 1 Form A



Package Outline Dimensions

Figure 1. 6-pin DIP

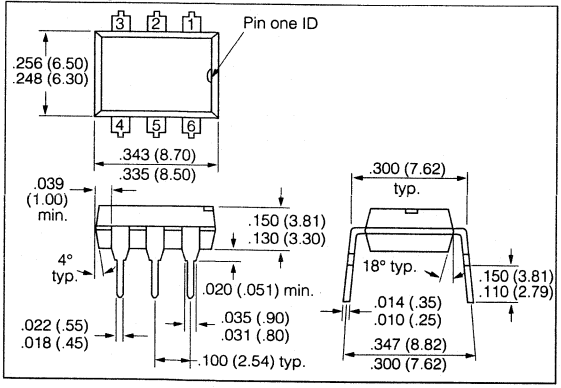


Figure 2. 6-pin, SMD

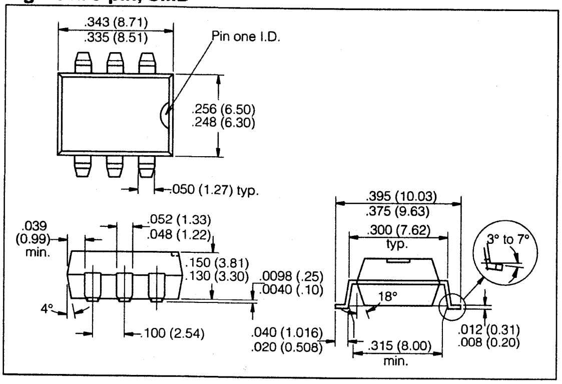


Figure 3. 8-pin DIP

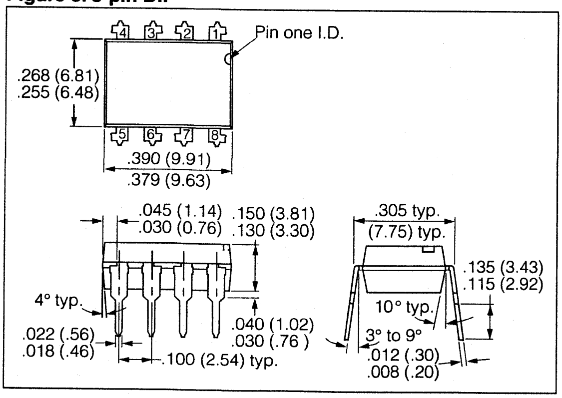


Figure 4. 8-pin, SMD

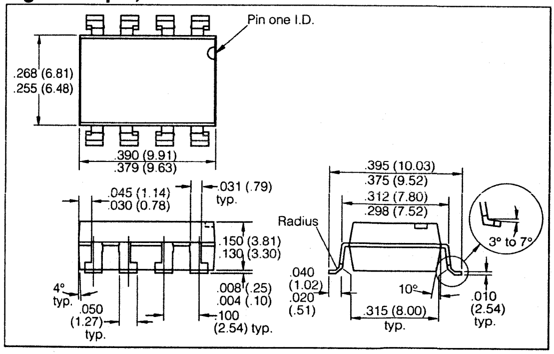


Figure 5. 8-pin SOP (PCMCIA)

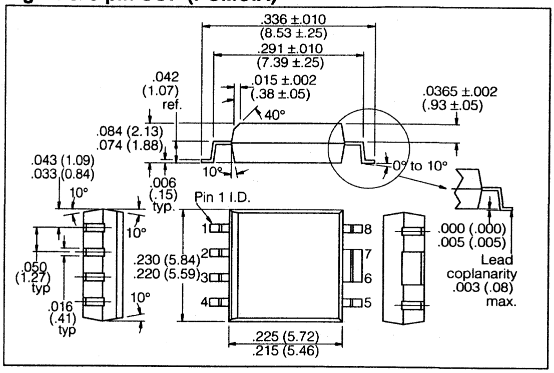
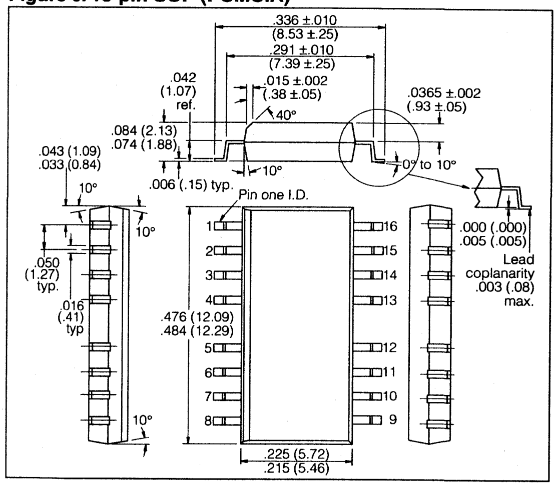


Figure 6. 18-pin SOP (PCMCIA)



Component Safety Recognition

DESCRIPTION

The Solid State Relays in this data book have been recognized for safety by the following organizations:

- Underwriters Laboratories (UL) recognized
- Canadian Standards Association (CSA) certified
- British Approvals Board for Telecommunications (BABT) certified

Component recognition/certification can save the equipment manufacturers time and money when applying for safety approvals. Safety recognition guarantees that the SSRs have been inspected for safe design practices and construction and that the SSRs are 100% tested to a strenuous input-to-output isolation voltage 20% higher than the rated voltage (4500 Vrms). To ensure continued product integrity, the safety agencies inspect Siemens manufacturing facilities on a periodic basis. Specifics on each agency and the safety recognition numbers assigned to Siemens are listed as follows:

UL, Siemens File Number 52744

All solid state relays in this data book are recognized to the UL standard for Optical Isolator UL 1577.

CSA, File Number CA 93751

All solid state relays in this data book are approved to CSA Class 9073-30.

BABT, Certificate Number 605700

Most solid state relays in this data book are covered. Consult factory for details

Quality and Reliability

At Siemens, quality and reliability are not accidental by-products but are established as strategic business assets. Our primary objective is to produce precision error-free integrated circuits that exceed the required device specifications (quality) and offer continual high performance over an extended service life (reliability).

To produce high-quality, reliabile solid-state relays, Siemens performs a comprehensive set of established procedures during and after the manufacturing process.

A rigorous qualification process is performed to ensure that the design meets the Siemens standards for quality and reliability. Typical tests performed during the qualification process are outlined in Table 1. Next, as part of the manufacturing process, Siemens tests 100% of the devices according to the electrical tests shown in Table 2. After the in-process testing is complete, an independent quality and inspection organization selects a representative sampling of devices from each production lot and subjects them, once again, to the tests in Table 2. Finally, to ensure on-going product reliability, Siemens performs tests shown in Table 1 on a periodic basis.

Table 1. Qualification and Reliability Tests and Methods

Name of Test	Method of Test	Method Document
High-Temperature Operation Bias (HTOB)*	1005	MIL STD 883C
Temperature Humidity Bias (THB)*	‡	—
Temperature Cycle (TC)*	1010	MIL STD 883C
Lead Tension (TN)*	2004	MIL STD 883C
Lead Fatigue (LF)*	2004	MIL STD 883C
Solderability (SLDR)*	2003	MIL STD 883C
Steam Bomb	—	Siemens Method A89AL0111
Thermal Shock	1010	MIL STD 883C
Moisture Resistance	1004	MIL STD 883C
Salt Atmosphere	1009	MIL STD 883C
Solvent Resistance	2015	MIL STD 883C
Physical Dimensions	2016	MIL STD 883C
X-Ray	2012	MIL STD 883C

* Ongoing reliability monitor.
‡ Conditions are 85°C ± 3°C and 85% ± 3% relative humidity under operating bias.

Table 2. In-Process and Quality Tests

LED Forward Voltage
LED Reverse Leakage Current
LED Forward Current for Output Turn-on
LED Forward Current for Output Turn-off
Output On-resistance
Output Off-state Leakage Current
Output Current Limit (where applicable)
Output On-state Voltage (LH1504, LH1524)
Output Breakdown Voltage
I/O Isolation Voltage
Turn-on Time
Turn-off Time
Transfer Off-time (LH1502, LH1527, LH1537)

ESD

Siemens uses a human-body model (HBM) for ESD susceptibility testing.

HBM is associated with a person who acquires a charge when walking, sitting, unpacking, etc. When a charged individual touches a device, as in hand assembly operation, some of the energy stored on the individual's body is transferred or discharged to the device or through the device to ground.

Siemens SSRs are subjected to HBM discharges up to 2 kV. SSRs are rated at the voltage level where no failures occur. The results of the ESD evaluation are shown in Table 3.

Table 3. ESD Rating

Device	HBM
LH1500	1.5 kV
LH1501	2.0 kV
LH1502	2.0 kV
LH1503	1.0 kV
LH1504	2.0 kV
LH1505	2.0 kV
LH1510	1.5 kV
LH1511	2.0 kV
LH1512	2.0 kV
LH1513	1.0 kV
LH1516	2.0 kV

Device	HBM
LH1517	2.0 kV
LH1518	2.0 kV
LH1519	2.0 kV
LH1520	2.0 kV
LH1521	2.0 kV
LH1522	2.0 kV
LH1523	2.0 kV
LH1524	2.0 kV
LH1530	2.0 kV
LH1540	2.0 kV

SIEMENS

Part Numbers, Coding and Ordering

Coding

Table 1. Coding Scheme

LH1529 A AC 1

- **1**: No dc contact for 6 pin package, at Pin 5
- **AC**: Package Configuration
  1 or 2 Alpha Sufffix designator
  - A=8-pin DIP
  - T=6-pin DIP
  - AB=6-pin Gull Wing
  - AC=8-pin Gull Wing
  - CC=8-pin "S" Bend Gull Wing
  - CD=8-pin SOP
  - CE=18-pin SOP
- **A**: Electrical Variation
  - A=No variation from test specification
  - B,C, etc.=Test specification variation
- **LH1529**: Device Identifier

Ordering Information

Table 2. Table 2. 6-/8-Pin DIP (Tubes)

Device	Package
LH1085 AT1	6-Pin, Plastic DIP
LH1191 AT1	6-Pin, Plastic DIP
LH1500AT	6-Pin, Plastic DIP
LH1501AT	6-Pin, Plastic DIP
LH1502AB	8-Pin, Plastic DIP
LH1503AB	8-Pin, Plastic DIP
LH1504AT1	6-Pin, Plastic DIP
LH1505AB	8-Pin, Plastic DIP
LH1510AT	6-Pin, Plastic DIP
LH1511AT	6-Pin, Plastic DIP
LH1512AB	8-Pin, Plastic DIP
LH1513AB	8-Pin, Plastic DIP
LH1514AB	8-Pin, Plastic DIP
LH1516AT	6-Pin, Plastic DIP
LH1517AT	6-Pin, Plastic DIP
LH1518AT	6-Pin, Plastic DIP
LH1519AT	6-Pin, Plastic DIP
LH1520AB	8-Pin, Plastic DIP
LH1521AB	8-Pin, Plastic DIP
LH1522AB	8-Pin, Plastic DIP
LH1523AB	8-Pin, Plastic DIP
LH1524AB	8-Pin, Plastic DIP
LH1525AT	6-Pin, Plastic DIP
LH1527BB	8-Pin, Plastic DIP
LH1527BT	6-Pin, Plastic DIP
LH1528AB	8-Pin, Plastic DIP
LH1529AB	8-Pin, Plastic DIP
LH1529BB	8-Pin, Plastic DIP
LH1530AT	6-Pin, Plastic DIP
LH1531AB	8-Pin, Plastic DIP
LH1532AB	8-Pin, Plastic DIP
LH1533AB	8-Pin, Plastic DIP
LH1535AT	6-Pin, Plastic DIP
LH1537AB	8-Pin, Plastic DIP
LH1537AT	6-Pin, Plastic DIP
LH1540AT	6-Pin, Plastic DIP
LH1541AT1	6-Pin, Plastic DIP
LH1544AB	8-Pin, Plastic DIP
LH1547AT1	6-Pin, Plastic DIP
LH1549AB	8-Pin, Plastic DIP
LH1550AT1	6-Pin, Plastic DIP
LH2559AB	8-Pin, Plastic DIP

Note:
When ordering parts on tape and reel add suffix 'TR' to the end of the part number.
1. Example: To order LH1500AAB in tape and reel, order as LH1500AAB-TR.
2. Devices on tape and reel in 1000 piece increments.

Table 3. 6-/8-Pin Surface Mount (Tubes)

Device	Package
LH1085AAB1	6-Pin
LH1191AAB1	6-Pin
LH1500AAB	6-Pin
LH1501AAB	6-Pin
LH1502AAC	8-Pin
LH1503AAC	8-Pin
LH1504AAB1	6-Pin
LH1505AAC	8-Pin
LH1510AAB	6-Pin
LH1511AAB	6-Pin
LH1512AAC	8-Pin
LH1513AAC	8-Pin
LH1514AAC	8-Pin
LH1516AAB	6-Pin
LH1517AAB	6-Pin
LH1518AAB	6-Pin
LH1519AAB	6-Pin
LH1520AAC	8-Pin
LH1521AAC	8-Pin
LH1522AAC	8-Pin
LH1523AAC	8-Pin
LH1524AAC	8-Pin
LH1525AAB	6-Pin
LH1527BAB	6-Pin
LH1527BAC	8-Pin
LH1528AAC	8-Pin
LH1529AAC	8-Pin
LH1529BAC	8-Pin
LH1530AAB	6-Pin
LH1531AAC	8-Pin
LH1532AAC	8-Pin
LH1533AAC	8-Pin
LH1535AAB	6-Pin
LH1537AAB	6-Pin
LH1537AAC	8-Pin
LH1540AAB	6-Pin
LH1541AAB1	6-Pin
LH1544AAC	8-Pin
LH1547AAB1	6-Pin
LH1549AAC	8-Pin
LH1550AAB1	6-Pin
LH2559AAC	8-Pin

SIEMENS

Packaging and Shipping

Description

Solid State Relays are available in plastic dual-in-line packages (DIP), SOP packages, and in a surface-mount, gull-wing, lead bend configuration. SSRs purchased in the DIP configuration are shipped in tubes. SSRs purchased in a gull-wing configuration can be shipped in tubes or on carrier tape. This section provides stick specifications, tape and reel specifications, and component information.

Tube Specifications

Figure 1 shows the physical dimensions of transparent, antistatic, plastic shipping tubes. Figure 2 shows tube safety agency labeling and orientation information.

The following table lists the number of parts per tube.

Devices per Tube

Package	Quantity
6-pin DIP	50
6-pin gull wing	50
8-pin DIP	50
8-pin gull wing	50
8-pin SOP	90
18-pin SOP	45

Figure 1. Shipping tube specifications for DIP packages

Dimensions in inches (mm)

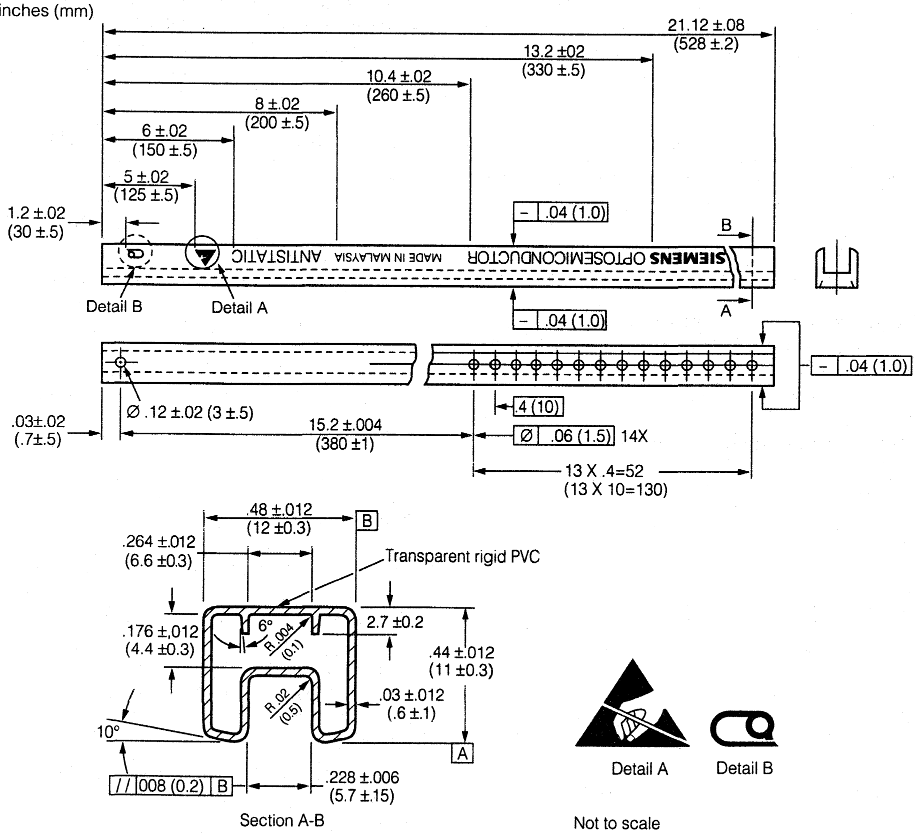
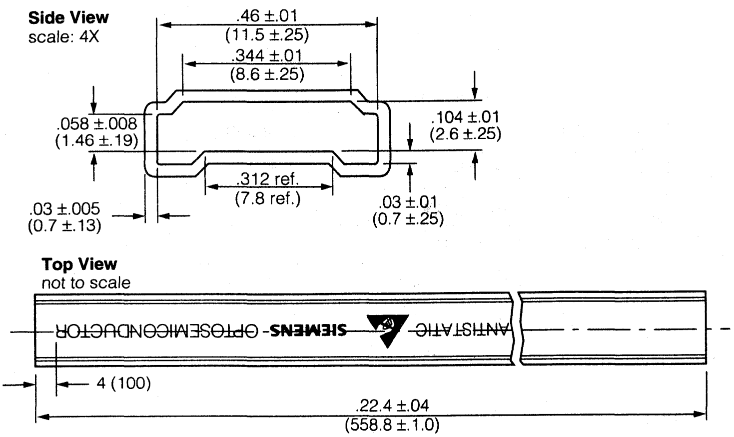


Figure 2. Shipping tube apecifications for SOP packages

Dimensions in inches (mm)



Tape and Reel Specifications

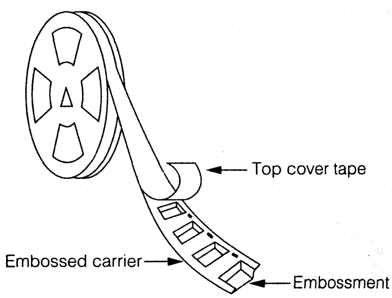
Surface-mounted devices are packaged in embossed tape and wound onto 13-inch molded plastic reels for shipment, to comply with Electronics Industries Association Standard EIA-481, revision A.

Leaders and Trailers

The carrier tape and cover tape are not spliced. Both tapes are one single uninterrupted piece from end to end, as shown in Figure 2. Both ends of the tape have empty pockets meeting these requirements.

- Trailer end (inside hub of reel) is 300 mm minimum.
- Leader end (outside of reel) is 500 mm minimum and 560 mm maximum.
- Unfilled leader and trailer pockets are sealed.
- Leaders and trailers are taped to tape and hub, respectively, with masking tape.
- All materials are static-dissipative.

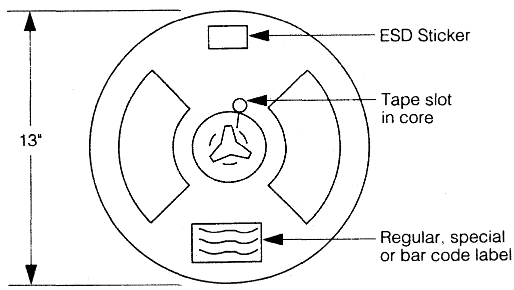
Figure 3. Tape and reel shipping medium



Reels

As shown in Figure 4, all reels contain standard areas for the placement of ESD stickers and labels. Each reel also has a tape slot in its core. The overall reel dimension is 13 inches. Reels contain 1000 6- or 8-pin gull-wing parts and could have up to three inspection lots.

Figure 4. Shipping medium and label placement



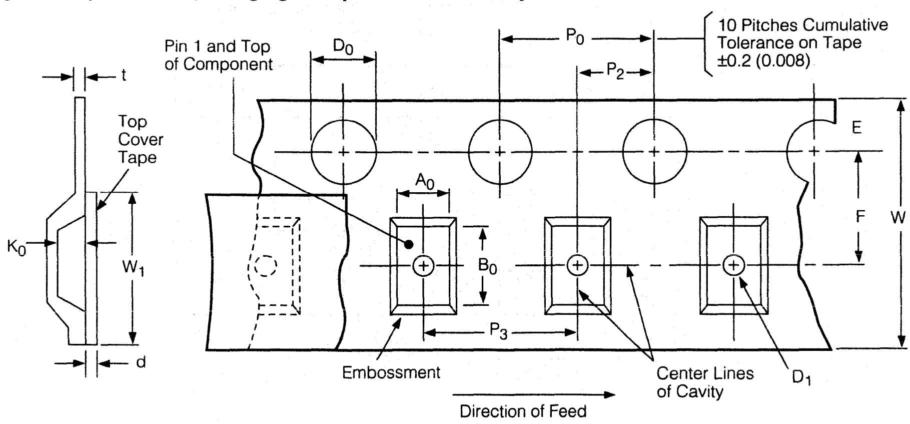
Component Soldering

- Wave soldering: 270°C, ≤7 s
- Surface mount soldering methods, including infrared reflow:
  - Maximum temperature: ≤250°C
  - Maximum temperature must be reached in ≤360 s.
  - Time above solder liquids temperature (183°C) must be reached in ≤180 s.
  - Only one excursion above 183°C allowed

Carrier Tape

Figures 5 through 8 describe the carrier tape dimensions and the device orientation.

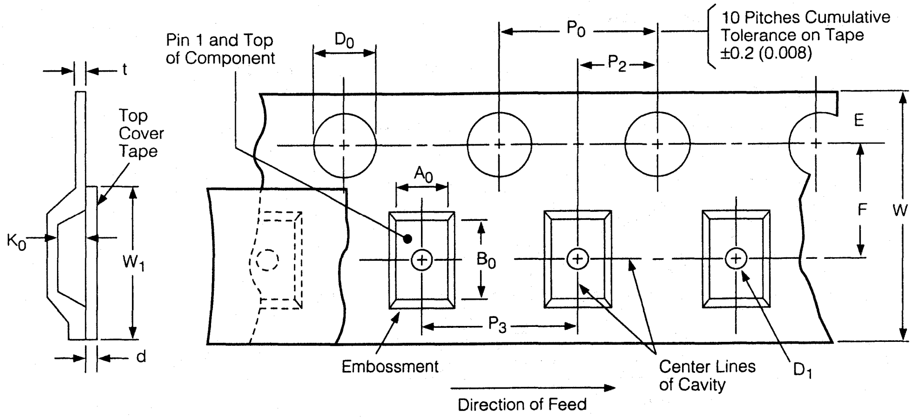
Figure 5. Tape and reel packaging for 6-pin Solid State Relays



The tape is 16 mm and is wound on a 33 cm reel. There are 1000 parts per reel.
Taped and reeled 6-pin Solid-State Relays conform to EIA-481-2.

Description	Symbol	Dimensions in Inches (mm)	Notes
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cumulative pitch error +0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 (12.0)	
Compartment	K_0 A_0 B_0	.158 (4.01) .402 (10.21) .362 (9.2)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Figure 6. Tape and reel packaging for 8-pin Solid State Relays



The tape is 16 mm and is wound on a 33 cm reel. There are 1000 parts per reel.
Taped and reeled 8-pin Solid-State Relays conform to EIA-481-2.

Description	Symbol	Dimensions in Inches (mm)	Notes
Tape width	W	.630 ±.012 (16.0 ±.3)	
Carrier tape thickness	t	.012 (0.3) max.	
Pitch of sprocket holes	P_0	.157 ±.004 (4 ±0.1)	Cumulative pitch error +0.2 mm/10 pitches
Diameter of sprocket holes	D_0	.059 (1.5) min	
Distance of sprocket holes	E	.069 ±.004 (1.75 ±0.1)	
Distance of compartment	F P_2	.295 ±.002 (7.5 ±.05) .079 ±.002 (2 ±0.05)	Center hole to center compartment
Distance of compartment to compartment	P_3	.472 (12.0)	
Compartment	K_0 A_0 B_0	.167 (4.24) .402 (10.2) .406 (10.3)	
Hole in compartment	D_1	.059 (1.5)	
Width of fixing tape	W_1 d	.523 (13.3) .004 (0.1) max.	The fixing tape shall not cover the sprocket holes, nor protrude beyond the carrier tape so not to exceed maximum tape width
Device tilt in the compartment		10° max.	
Minimum bending radius		1.18 (30)	

Figure 7. Conductive embossed carrier dimensions for 8-lead PCMCIA packages

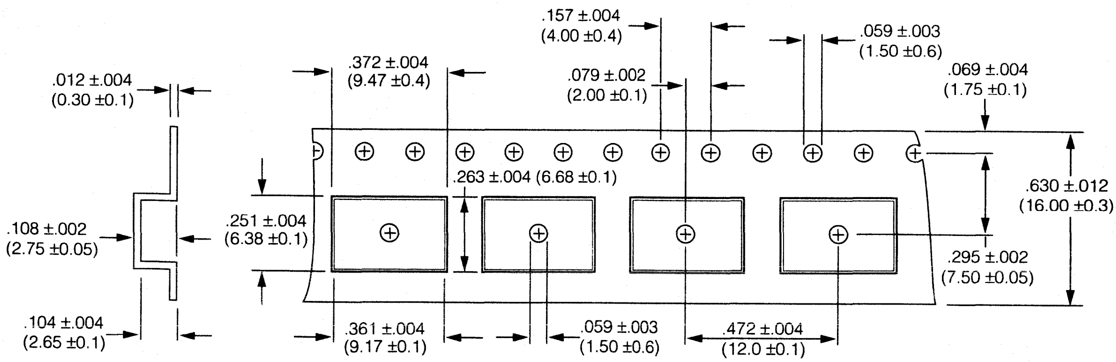
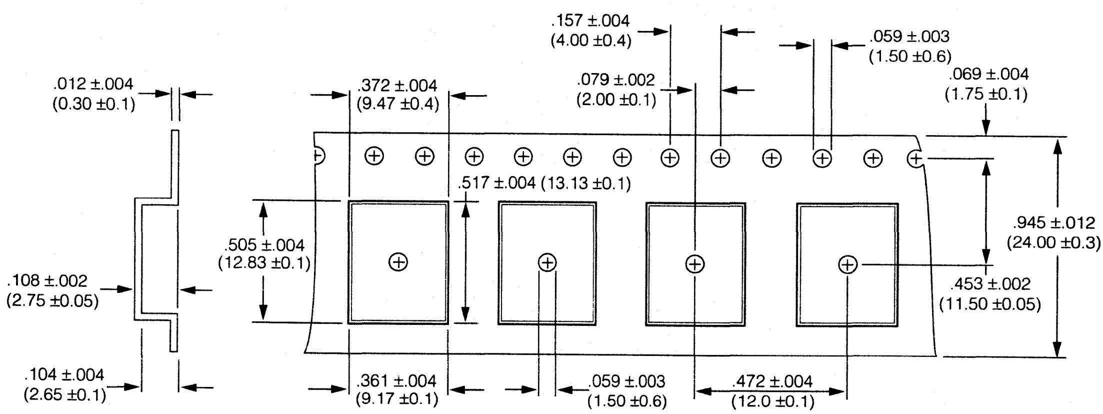


Figure 8. Conductive embossed carrier dimensions for 18-lead PCMCIA packages



SIEMENS

High Voltage Solid State Relays General Information

FEATURES

- 3750 Vrms or 5300 Vrms I/O isolation
- Current-limit protection built-in
- Linear ac/dc operation
- High-reliability monolithic receptor
- Extremely low leakage current (pA)
- High contact off-impedance (GΩ)
- Low power consumption (1 mW—12 mW)
- Very low switch offset (typically 0.1 µV)
- Logic compatible
- Clean, bounce-free switching
- Built-in 1 Form C break-before-make
- High surge capability
- Insensitive to dv/dt
- Surface mountable
- Compatible with UL1459 and FCC 68.302
- UL recognized
- CSA certified
- BABT certificate of recognition to BS6301

BENEFITS

- Long life
- Maintenance free
- Current-limit SSRs can sustain repeated faults without damage
- Minimizes drive circuitry
- Noiseless
- Immune to shock
- Immune to environmental hazards such as salt, dirt, and humidity
- No arcing
- No mounting restrictions
- Preapproved for DAA applications
- High reliability
- Easily configured in series or in parallel for increased voltage or current

DESCRIPTION

Siemens Solid State Relays (SSRs) are miniature, optically-coupled relays with high-voltage MOSFET outputs. The relays are capable of switching ac or dc loads from as little as nanovolts to hundreds of volts. Likewise, the relays can switch currents in the range of nanoamps to hundreds of milliamps. The MOSFET switches are ideal for small signal switching and are primarily suited for dc or audio frequency applications.

Siemens offers integrated current limiting on many of its relays. If load current through the relay exceeds the rated value, the relay clamps the current at a predefined value. If the excessive load current persists, the limiting circuit has a foldback feature to minimize relay power dissipation. The current-limit circuit has a multitude of uses. It can be used in telephony to clamp excessive currents emanating from lightning strikes and/or power-main crosses or in instrumentation and industrial application to squelch transients from reactive loads. The current-limit circuit also provides short-circuit protection in power-feed applications.

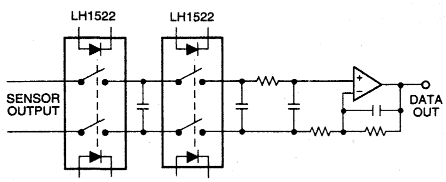
The SSRs feature a monolithic output die that minimizes wire bonds and permits easy integration of high-performance circuits such as current limiting in normally-open switches. The output die contains all the necessary circuitry to perform a relay function, including the photodiode receptor array, turn-on and turn-off control circuitry, and the MOSFET switches. The optically-coupled input is controlled by a highly efficient GaAlAs infrared LED.

Siemens SSRs are available in a 6- or 8-pin through-hole DIP or in gull-wing surface-mount packages. Some parts are also offered in 8- or 18-pin small-outline packages (SOPs). The SOPs are size and height compatible with PCMCIA Type 2 cards. A 0.4 mm distance through insulation spacing is also available on "H" suffix coded parts. Refer to the Parts Coding section for a more in-depth description of these parts.

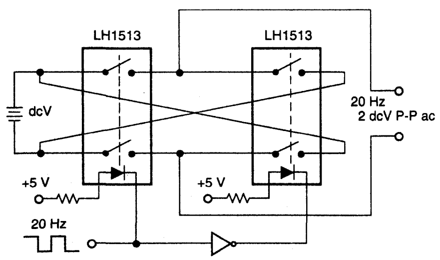
Typical Applications

- ac Switch
- Telephone
- Heater Control
- Light Control
- Switching Systems
- Voltmeters
- Test Equipment
- Modems
- Programmable Controllers
- FAX
- Data Acquisition Systems
- Security Equipment
- Electric Meters
- Ring Relay

Application	Flying Capacitor
Function	Flying Capacitor Switch
Equipment	Data Acquisition Systems
	Multiplexers
	Scanners



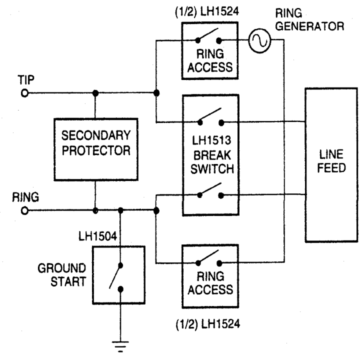
Application	Ring Generators
Function	Square Wave Generator
Equipment	PBX
	Central Office Equipment
	Ring Generator



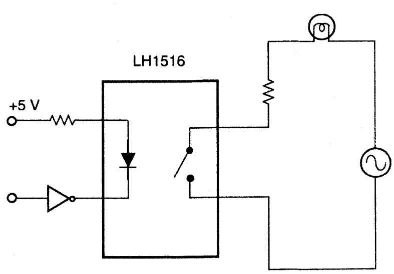
Typical Applications (continued)

- Service Equipment
- E&M Signaling
- Multiplexers
- Scanners
- Motor Controls
- Output Modules
- Thermostats
- Answering Machines
- Battery Switch
- Board Testers
- Gas Pumps
- Appliances

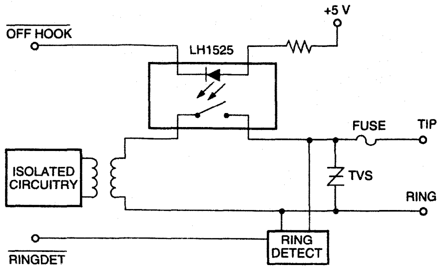
Application	Telephone Line Interface/SLIC
Function	Ring Relay
	Break Switch
	Ground Start
	Test Access
	E&M Signalling
Equipment	Subscriber Line Interface Circuits
	PBX
	Switching Systems
	Test/Service Equipment



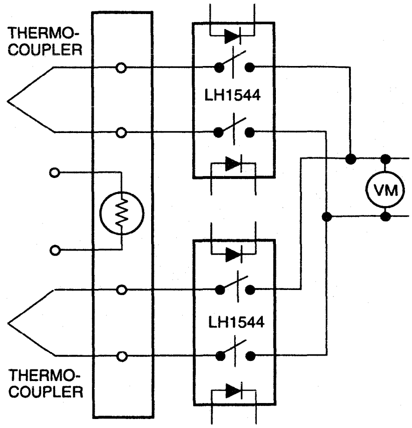
Application	Lamp, Light, Indicator Control
Function	ac Switch
Equipment	Programmable Controllers
	Thermostats
	Control Panels
	Industrial Controls



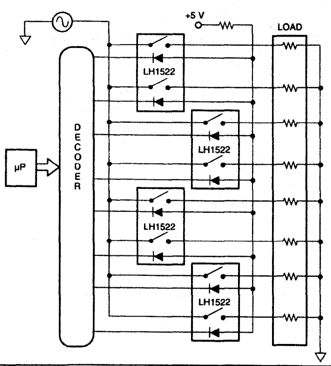
Application	Data Access Arrangement (DAA)
Function	Current-Limited Switchhook Control
Equipment	Modems
	Security Equipment
	Answering Machines
	Telephones
	FAX



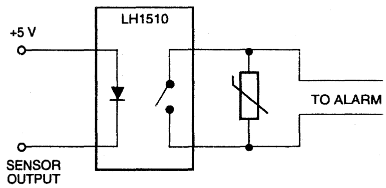
Application	Thermocouple Switching
Function	Thermocouple Matrix Control
Equipment	Scanners
	Data Acquisition Systems
	Programmable Controllers



Application	Multiplexer
Function	Analog Signal Multiplexer
	Analog Input Module
Equipment	Instrumentation
	Voltmeters
	Test Equipment
	Board Testers
	Scanners
	Data Acquisition Systems

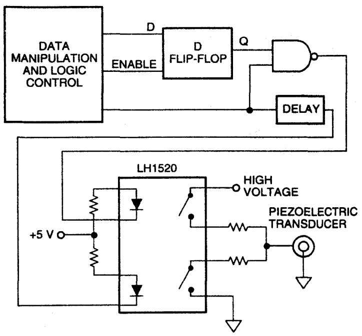


Application	Alarm Switch
Function	Glass Break Indicator
	Fire, Smoke Detector
Equipment	Security Systems
	Fire/Smoke Alarms

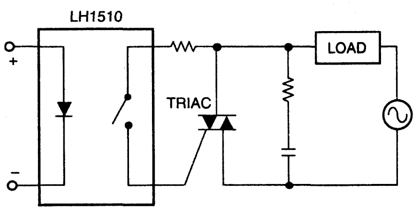


Solid State Relays 6

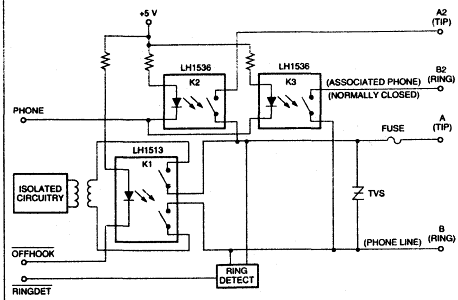
Application	Print Head Driver
Function	Current-Limited Drivers
	Piezoelectric Transducer
	High-Voltage Print Head
Equipment	Ink Jet Printers
	Display Drivers
	Thermal Printers



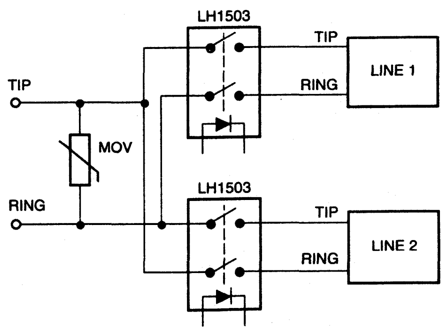
Application	Motor, Light, Heat, Solenoid Control
Function	Triac Predriver
Equipment	Industrial Controls
	Programmable Controllers
	Factory Automation Equipment
	Appliances



Application	Talk/Data Switch
Function	On/Off-hook Control
Equipment	Modems
	FAX



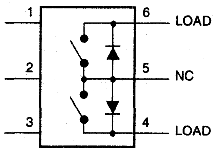
Application	Two-Line PSTN Interface
Function	On/Off-hook Control
Equipment	Telephone Equipment
	Test/Service Equipment

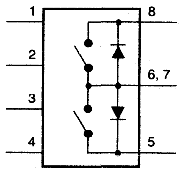


Wiring Diagrams

ac/dc OUTPUT CONFIGURATIONS

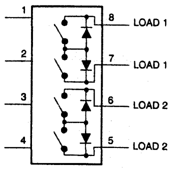
SINGLE LOAD



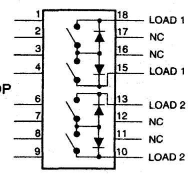


SOP

TWO LOADS

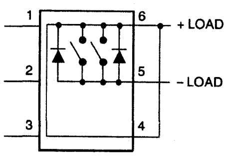


SOP

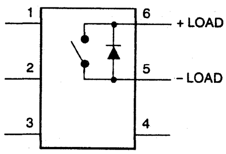


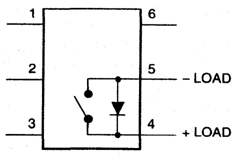
dc OUTPUT CONFIGURATIONS

SINGLE LOAD
— REDUCED RON
— INCREASED LOAD CURRENT
— REDUNDANCY

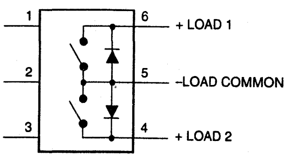


SINGLE LOAD





TWO LOADS



SIEMENS

LH1500, LH1504
LH1510, LH1516
1 Form A

Absolute Maximum Ratings T_A=25°C

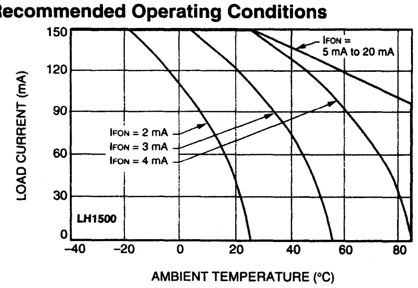
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

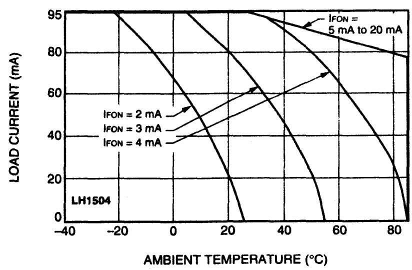
Parameter	Symbol	Test Conditions	LH1500	LH1504	LH1510	LH1516	Units
Ambient Operating Temperature range	T_A	—	–40 to +85				°C
Storage Temperature Range	T_{stg}	—	–40 to +150				
Pin Soldering Temperature	T_S	t=10 s max	260				
Input/Output Isolation Voltage*	V_{ISO}	—	3750				Vrms
LED Continuous Forward Current	I_F	—	50				mA
LED Reverse Voltage	V_R	$I_R \le 10\ \mu A$	8				V
dc or Peak ac Load Voltage	V_L	$I_L \le 50\ \mu A$	350	400	200	400	
Continuous dc Load Current Bidirectional Operation Unidirectional Operation	I_L	—	 150 250	 95 —	 200 350	 240 450	mA
Peak Load Current	I_P	t=100 ms (single shot)	†	†	†	†	mA
Output Power Dissipation (continuous)	P_{DISS}	—	600	550		600	mW

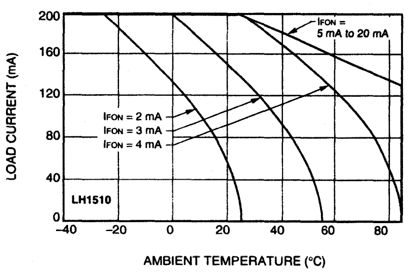
* 5300 Vrms input/output isolation voltage available on some products. Consult factory.

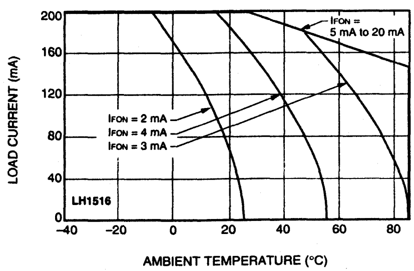
† Refer to Current Limit Performance Application Note 58 for a discussion on relay operation during transient currents.

Recommended Operating Conditions









Electrical Characteristics T_A=25°C

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

	Parameter	Symbol	Test Conditions	Values	LH1500	LH1504	LH1510	LH1516	Units
INPUT	LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA t=10 ms	Min	—	—	—	—	mA
				Typ	1.0	0.5	1.0	0.9	mA
				Max	2.0	2.0	2.0	2.0	mA
	LED Forward Current for Switch Turn-off	I_{Foff}		Min	0.2	0.1	0.2	0.2	mA
				Typ	0.9	0.4	0.9	0.8	mA
				Max	—	—	—	—	mA
			V_L	±	300	350	150	350	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	1.15	1.15	V
				Typ	1.26	1.26	1.26	1.26	V
				Max	1.45	1.45	1.45	1.45	V
OUTPUT	ON-resistance ac/dc Pin 4 (±) to 6 (±)	R_{ON}	I_F=5 mA I_L=50 mA	Min	12	12*	6	5	Ω
				Typ	20	23*	10	7	Ω
				Max	25	34*	15	10	Ω
	dc Pin 4, 6 (+) to 5 (±)		I_F=5 mA I_L=100 mA	Min	3.00	—	1.50	1.25	Ω
				Typ	5.00	—	2.50	2.00	Ω
				Max	6.25	—	3.75	2.50	Ω
	OFF-resistance	R_{OFF}	I_F=0 mA V_L=±100 V	Min	0.5	0.5	0.5	0.5	GΩ
				Typ	5000	5000	5000	2500	GΩ
				Max	—	—	—	—	GΩ
	ON-state Voltage	—	I_L=1 mA	Min	—	1.2	—	—	V
				Typ	—	1.4	—	—	V
				Max	—	1.8	—	—	V
			I_L=90 mA t=10 ms	Min	—	3.0	—	—	V
				Typ	—	3.6	—	—	V
				Max	—	5.0	—	—	V
	Current Limit ac/dc Pin 4 (±) to 6 (±) dc Pin 4, 6 (+) to 5 (±)	I_{LMT}	I_F=5 mA t=5 ms	Min	230	150	300	290	mA
				Typ	270	210	360	400	mA
				Max	370	270	450	550	mA
			V_L	±	6	11	5	5	V
			I_F=5 mA, V_L=4 V t=5 ms	Min	—	—	600	—	mA
				Typ	—	—	720	—	mA
				Max	—	—	920	—	mA
	Off-state Leakage Current	—	I_F=0 mA V_L=±100 V	Min	—	—		—	nA
				Typ	0.02	0.02	0.02	0.04	nA
				Max	200	200	200	200	nA
			I_F=0 mA	Min	—	—	—	—	µA
				Typ	—	—	—	—	µA
				Max	1.0	1.0	1.0	1.0	µA
			V_L	±	350	400	200	400	V
	Output Capacitance Pin 4 to 6	—	I_F=0 mA V_L=1 V	Min	—	—	—	—	pF
				Typ	55	2.5	60	150	pF
				Max	—	—	—	—	pF
			I_F=0 mA V_L=50 V	Min	—	—	—	—	pF
				Typ	10	2	15	30	pF
				Max	—	—	—	—	pF
	Switch Offset	—	I_F=5 mA	Min	—	—	—	—	µV
				Typ	0.15	—	0.15	0.1	µV
				Max	—	—	—	—	µV
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	—	—	pF
				Typ	0.8	0.8	0.8	0.8	pF
				Max	—	—	—	—	pF
	Turn-on Time	t_{on}	I_F=5 mA I_L=50 mA	Min	—	—	—	—	ms
				Typ	1.2	1.6	1.0†	1.1†	ms
				Max	2.0	5.0	2.0†	3.0†	ms
	Turn-off Time	t_{off}	I_F=5 mA I_L=50 mA	Min	—	—	—	—	ms
				Typ	0.5	2.0	0.7†	0.8†	ms
				Max	2.0	5.0	2.0†	3.0†	ms

* R_{ON}=V (50 mA) – V (20 mA)/30 mA, †I_F=10 mA.

Solid State Relays 6

SIEMENS

LH1517, LH1518, LH1519

1 Form A

Absolute Maximum Ratings T_A=25°C

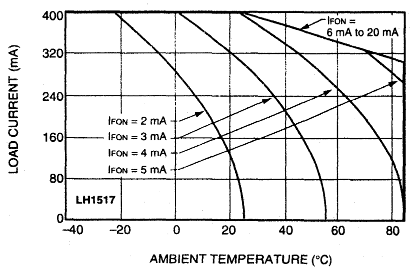
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

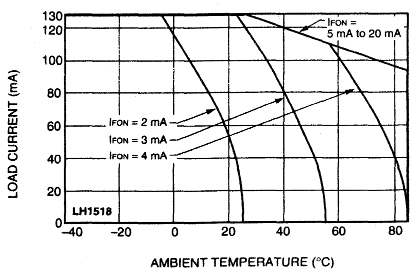
Parameter	Symbol	Test Conditions	LH1517	LH1518	LH1519	Units
Ambient Operating Temperature range	T_A	—	–40 to +85			°C
Storage Temperature Range	T_{stg}		–40 to +150			
Pin Soldering Temperature	T_S	t=10 s max	260			
Input/Output Isolation Voltage*	V_{ISO}	—	3750			Vrms
LED Continuous Forward Current	I_F		50			mA
LED Reverse Voltage	V_R	$I_R \leq 10\ \mu A$	8			V
dc or Peak ac Load Voltage	V_L	$I_L \leq 50\ \mu A$	200	250		
Continuous dc Load Current Bidirectional Operation Unidirectional Operation	I_L	—	 400 800	 155 300	 240 450	mA
Peak Load Current	I_P	t=100 ms (single shot)	1200	†	†	
Output Power Dissipation (continuous)	P_{DISS}	—	600	550		mW

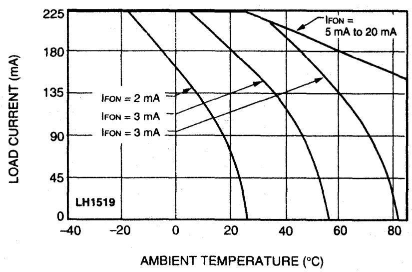
* 5300 Vrms input/output isolation voltage available on some products. Consult factory.

† Refer to Current-Limit Performance Application Note for a discussion on relay operation during transient currents.

Recommended Operating Conditions







Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

	Parameter	Symbol	Test Conditions	Values	LH1517	LH1518	LH1519	Units
INPUT	LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA, t=10 ms	Min	—	—	—	mA
				Typ	0.9	0.8	0.9	mA
				Max	2.0	2.0	2.0	mA
	LED Forward Current for Switch Turn-off	I_{Foff}		Min	0.2	0.2	0.2	mA
				Typ	0.8	0.7	0.8	mA
				Max	—	—	—	mA
			V_L	±	100	200	200	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	1.15	V
				Typ	1.26	1.26	1.26	V
				Max	1.45	1.45	1.45	V
OUTPUT	ON-resistance ac/dc Pin 4 (±) to 6 (±)	R_{ON}	I_F=5 mA, I_L=50 mA	Min	1	10	3	Ω
				Typ	2	15	6	Ω
				Max	3	20	10	Ω
	dc Pin 4, 6 (+) to 5 (±)		I_F=5 mA, I_L=100 mA	Min	0.25	2.50	0.75	Ω
				Typ	0.50	3.75	1.50	Ω
				Max	0.85	5.00	2.50	Ω
	OFF-resistance	R_{OFF}	I_F=0 mA, V_L=±100 V	Min	0.5	0.5	0.5	GΩ
				Typ	2500	5000	2500	GΩ
				Max	—	—	—	GΩ
	ON-state Voltage	—	I_L=1 mA	Min	—	—	—	V
				Typ	—	—	—	V
				Max	—	—	—	V
			I_L=90 mA, t=10 ms	Min	—	—	—	V
				Typ	—	—	—	V
				Max	—	—	—	V
	Current Limit ac/dc Pin 4 (±) to 6 (±)	I_{LMT}	I_F=5 mA, t=5 ms	Min	—	170	330	mA
				Typ	—	200	450	mA
				Max	—	280	550	mA
			VL	±	—	6	4	V
	dc Pin 4, 6 (+) to 5 (±)		I_F=5 mA, V_L=4 V, t=5 ms	Min	—	—	—	mA
				Typ	—	—	—	mA
				Max	—	—	—	mA
	Off-state Leakage Current	—	I_F=0 mA, V_L=±100 V	Min	—	—	—	nA
				Typ	0.04	0.02	0.04	nA
				Max	200	200	200	nA
			I_F=0 mA	Min	—	—	—	µA
				Typ	—	—	—	µA
				Max	1.0	1.0	1.0	µA
			V_L	±	150	250		V
	Output Capacitance Pin 4 to 6	—	I_F=0 mA, V_L=1 V	Min	—	—	—	pF
				Typ	185	55	100	pF
				Max	—	—	—	pF
			I_F=0 mA, V_L=50 V	Min	—	—	—	pF
				Typ	45	10	20	pF
				Max	—	—	—	pF
	Switch Offset	—	I_F=5 mA	Min	—	—	—	V
				Typ	0.1	0.15	0.1	V
				Max	—	—	—	V
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	—	pF
				Typ	0.8	0.8	0.8	pF
				Max	—	—	—	pF
	Turn-on Time	t_{on}	I_F=5 mA, I_L=50 mA	Min	—	—	—	ms
				Typ	1.7†	1.4	2.0	ms
				Max	3.0†	3.0	3.0	ms
	Turn-off Time	t_{off}	I_F=5 mA, I_L=50 mA	Min	—	—	—	
				Typ	1.3†	0.7	0.9	ms
				Max	3.0†	3.0	3.0	ms

* I_F=1.5 mA
† I_F=10 mA
‡ I_L=25 mA

SIEMENS

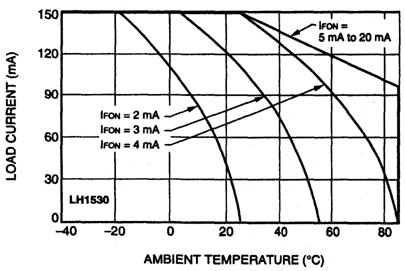
LH1530, LH1535, LH1540
LH1541, LH1550
1 Form A

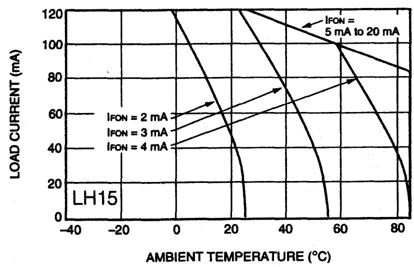
Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

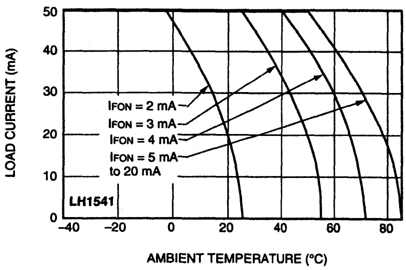
Parameter	Symbol	Test Conditions	LH1530	LH1535/ LH1540	LH1541	LH1550	Units
Ambient Operating Temperature Range	T_A	—	–40 to +85	–40 to +85	–40 to +85	–40 to + 85	°C
Storage Temperature Range	T_{stg}	—	–40 to +150	–40 to +150	–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max	260	260	260	260	°C
Input/Output Isolation Voltage*	V_{ISO}	—	3750	3750	3750	3750	Vrms
LED Continuous Forward Current	I_F	—	50	50	50	50	mA
LED Reverse Voltage	V_R	$I_R \leq 10\ \mu A$	8	8	8	5	V
dc or Peak ac Load Voltage	V_L	$I_L \leq 50\ \mu A$	350	400/350	200	350	V
Continuous dc Load Current Bidirectional Operation Unidirectional Operation	I_L	—	 150 250	 120 250	 55 —	 100 —	 mA mA
Peak Load Current	I_P	t=100 ms (single shot)	400	†	100	†	mA
Output Power Dissipation (continuous)	P_{DISS}	—	550	550	550	550	mW

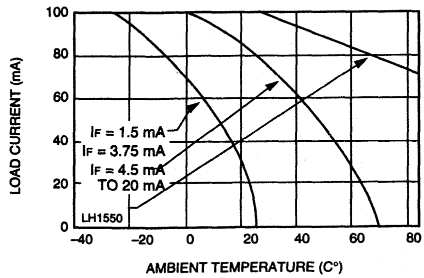
* 5300 Vrms input/output isolation voltage available on some products. Consult factory.
† Refer to Current-Limit Performance Application Note for a discussion on relay operation during transient currents

Recommended Operating Conditions









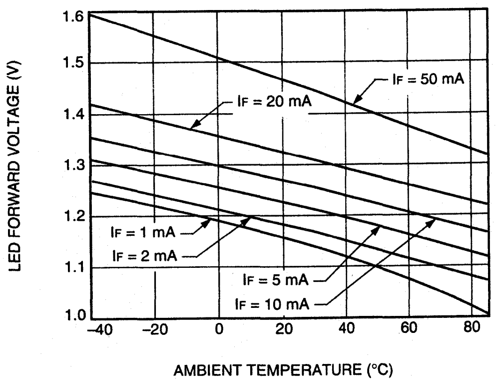
Electrical Characteristics T_A=25°C

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

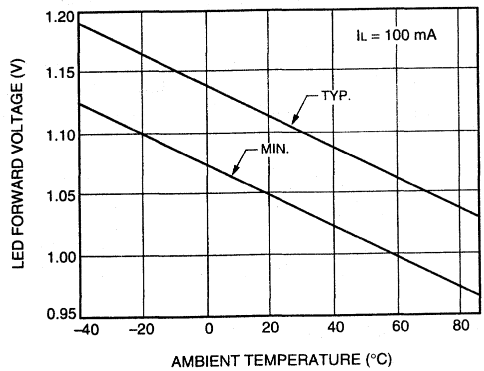
	Parameter	Symbol	Test Conditions	Values	LH1530	LH1535/ LH1540	LH1541	LH1550	Units
INPUT	LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA t=10 ms	Min	—	—	—	—	mA
				Typ	1.0	1.0	0.6	1.2	mA
				Max	2.0	2.0	2.0	2.5	mA
	LED Forward Current for Switch Turn-off	I_{Foff}		Min	0.2	0.2	0.1	0.01	mA
				Typ	0.9	0.9	0.5	1.100	mA
				Max	—	—	—	—	mA
			V_L	±	300	350/300	150	300	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	1.10*	1.10*	V
				Typ	1.26	1.26	1.19*	1.19*	V
				Max	1.45	1.45	1.45*	1.45*	V
OUTPUT	ON-resistance ac/dc Pin 4 (±) to 6 (±)	R_{ON}	I_F=5 mA I_L=50 mA	Min	12	12	70	25‡	Ω
				Typ	18	20	110	37‡	Ω
				Max	25	25	160	50‡	Ω
	dc Pin 4, 6 (+) to 5 (±)		I_F=5 mA I_L=100 mA	Min	3.00	3.00	—	—	Ω
				Typ	5.00	5.00	—	—	Ω
				Max	6.25	6.25	—	—	Ω
	OFF-resistance	R_{OFF}	I_F=0 mA V_L=±100 V	Min	0.5	0.5	0.5	0.5	GΩ
				Typ	5000	5000	10000	5000	GΩ
				Max	—	—	—	—	GΩ
	ON-state Voltage	—	I_L=1 mA	Min	—	—	—	—	V
				Typ	—	—	—	—	V
				Max	—	—	—	—	V
			I_L=90 mA t=10 ms	Min	—	—	—	—	V
				Typ	—	—	—	—	V
				Max	—	—	—	—	V
	Current Limit ac/dc Pin 4 (±) to 6 (±)	I_{LMT}	I_F=5 mA t=5 ms	Min	—	170	—	150	mA
				Typ	—	210	—	200	mA
				Max	—	250	—	270	mA
			V_L	±	—	6	—	13	V
	dc Pin 4, 6 (+) to 5 (±)		I_F=5 mA, V_L=4 V t=5 ms	Min	—	—	—	—	mA
				Typ	—	—	—	—	mA
				Max	—	—	—	—	mA
	Off-state Leakage Current	—	I_F=0 mA V_L=±100 V	Min	—	—	—	—	nA
				Typ	0.1	0.32	0.4	0.3	nA
				Max	200	200	200	200	nA
			I_F=0 mA	Min	—	—	—	—	µA
				Typ	—	—	—	—	µA
				Max	1.0	1.0	1.0	1.0	µA
			V_L	±	350	400/350	200	350	V
	Output Capacitance Pin 4 to 6	—	I_F=0 mA V_L=1 V	Min	—	—	—	—	pF
				Typ	55	55	4.8	40	pF
				Max	—	—	—	—	pF
			I_F=0 mA V_L = 50 V	Min	—	—	—	—	pF
				Typ	10	10	3.6	8	pF
				Max	—	—	—	—	pF
	Switch Offset	—	I_F=5 mA	Min	—	—	—	—	V
				Typ	0.15	0.15	0.15	0.15	V
				Max	—	—	—	—	V
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	—	—	pF
				Typ	0.8	0.8	0.8	0.8	pF
				Max	—	—	—	—	pF
	Turn-on Time	t_{on}	I_F=5 mA I_L=50 mA	Min	—	—	—	—	ms
				Typ	0.5†	1.2	0.12	1.4	ms
				Max	1.0†	2.0	0.25	3.0	ms
	Turn-off Time	t_{off}	I_F=5 mA I_L=50 mA	Min	—	—	—	—	ms
				Typ	0.5†	0.5	0.03	0.5	ms
				Max	1†	2.0	0.25	3.0	ms

* I_F=5 mA.
† I_F=10 mA.
‡ I_L=100 mA, t=10 ms

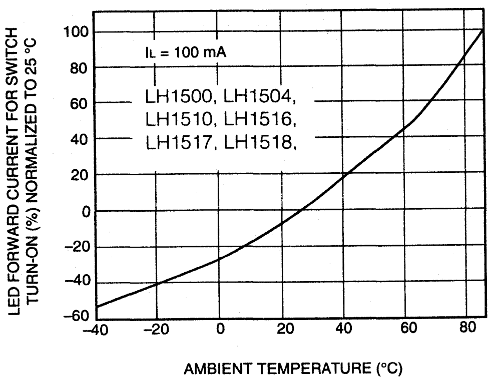
A. LED Voltage vs. Temperature



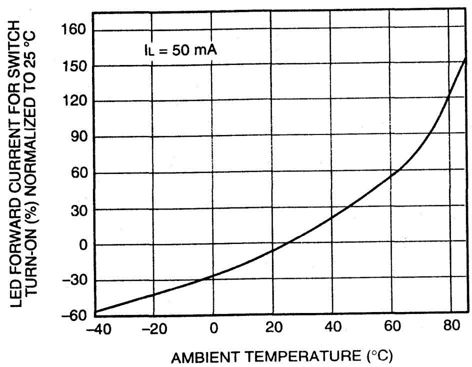
B. LED Dropout Voltage vs. Temperature



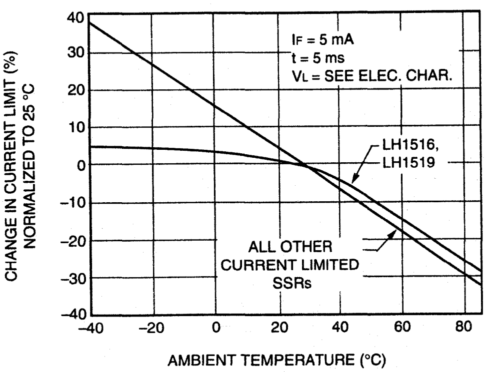
C. LED Current for Switch Turn-On vs. Temperature



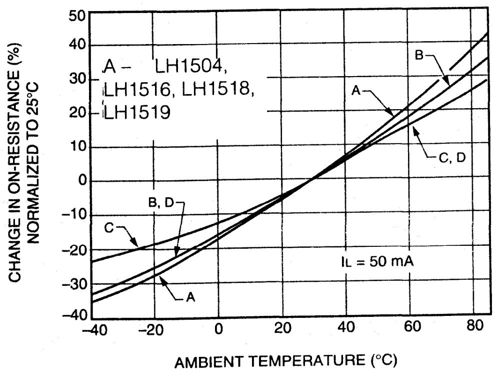
D. LED Current for Switch Turn-On vs. Temperature (LH1541)



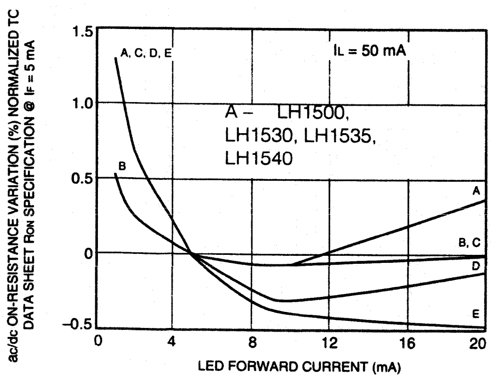
E. Current Limit vs. Temperature



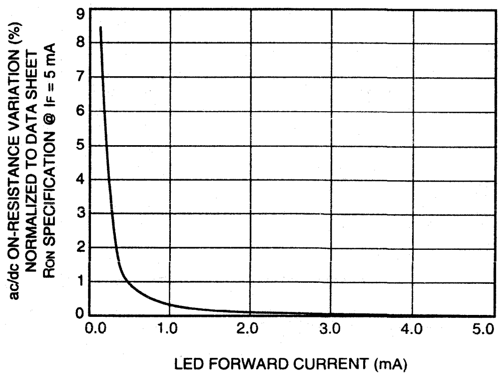
F. ON-Resistance vs. Temperature



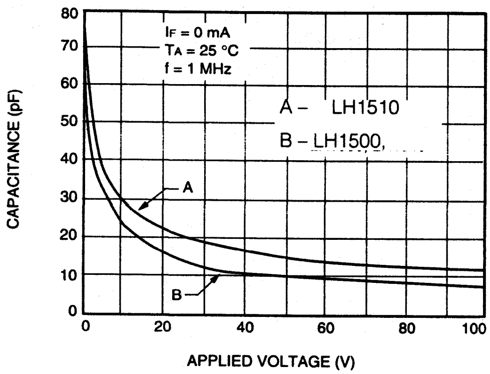
A. Variation in ON-Resistance vs. LED Current



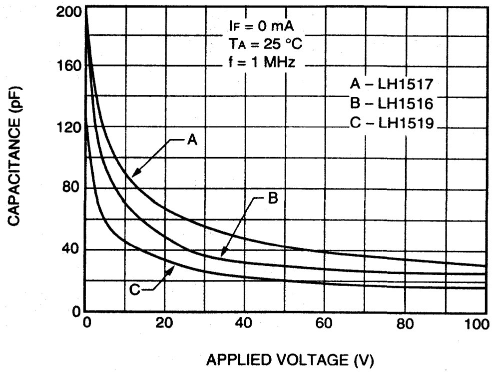
B. Variation in ON-Resistance vs. LED Current (LH1525)



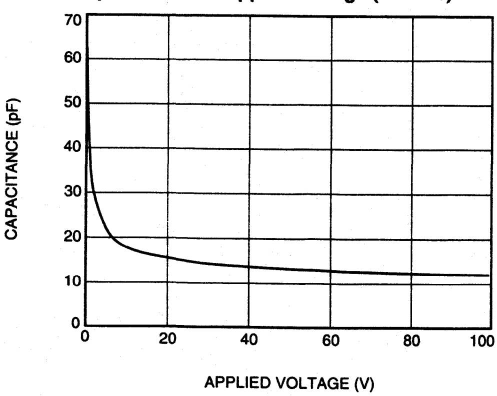
C. Switch Capacitance vs. Applied Voltage



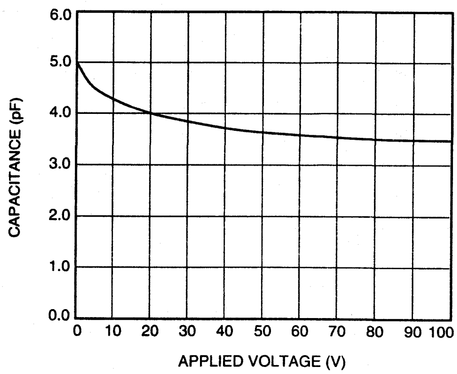
D. Switch Capacitance vs. Applied Voltage



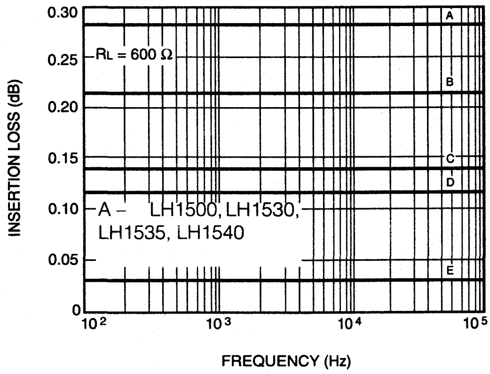
E. Switch Capacitance vs. Applied Voltage (LH1525)



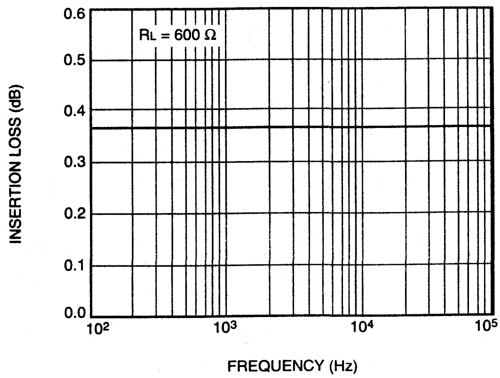
F. Switch Capacitance vs. Applied Voltage (LH1541)



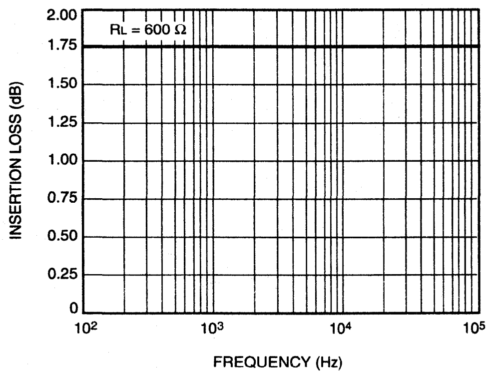
A. Insertion Loss vs. Frequency



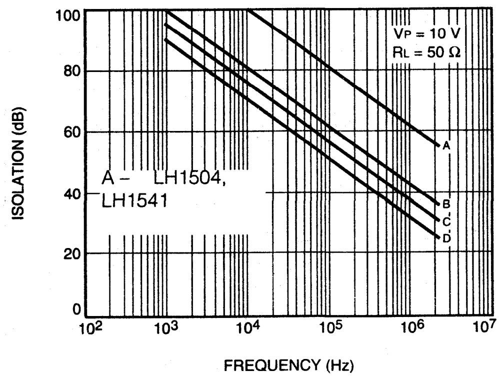
B. Insertion Loss vs. Frequency (LH1525)



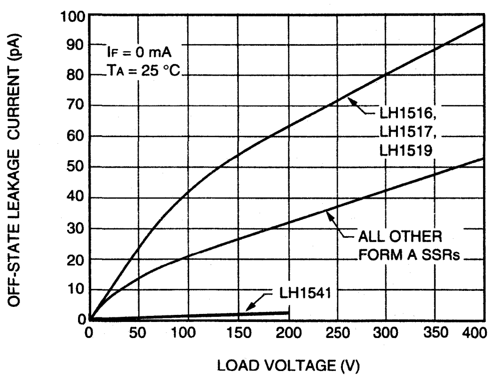
C. Insertion Loss vs. Frequency (LH1541)



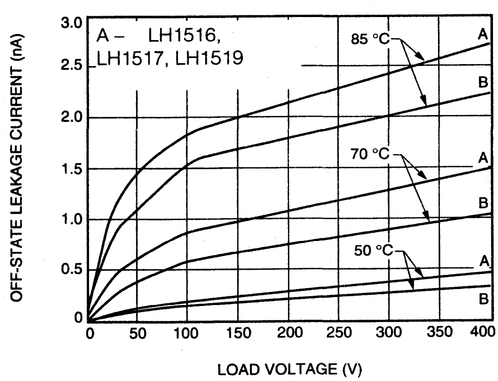
D. Output Isolation



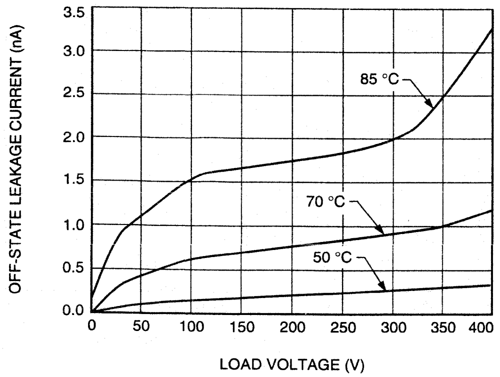
E. Leakage Current vs. Applied Voltage



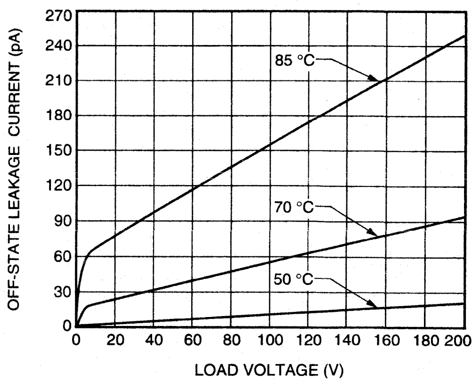
F. Leakage Current vs. Applied Voltage at Elevated Temperatures



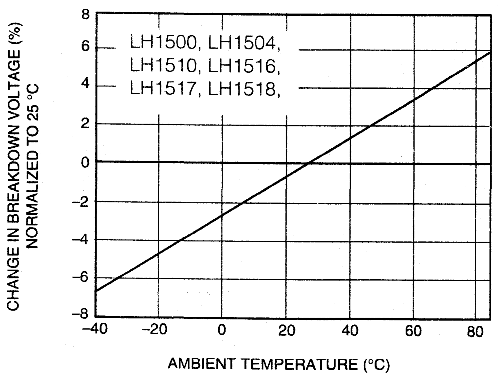
A. Leakage Current vs. Applied Voltage at Elevated Temperatures (LH1525)



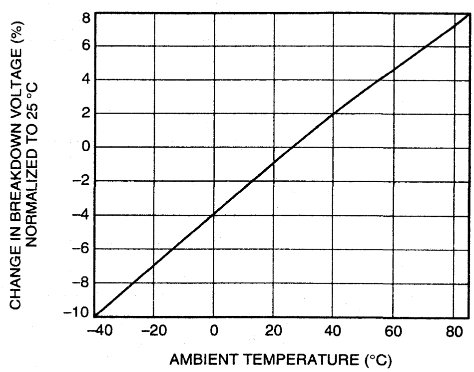
B. Leakage Current vs. Applied Voltage at Elevated Temperatures (LH1541)



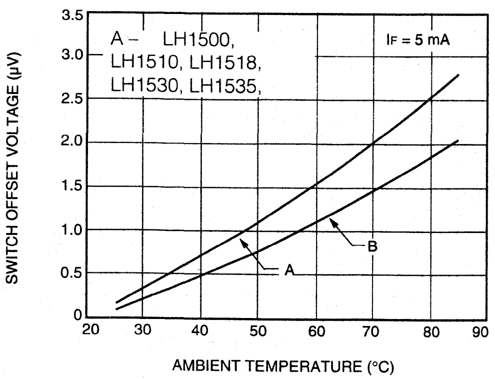
C. Switch Breakdown Voltage vs. Temperature



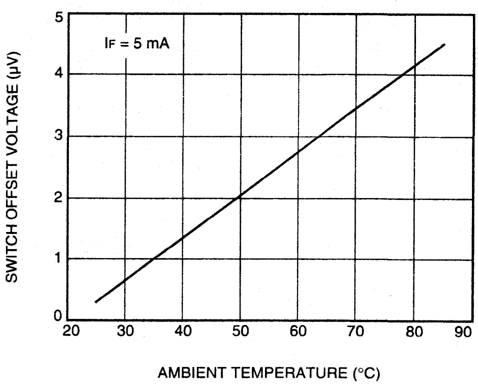
D. Switch Breakdown Voltage vs. Temperature (LH1541)



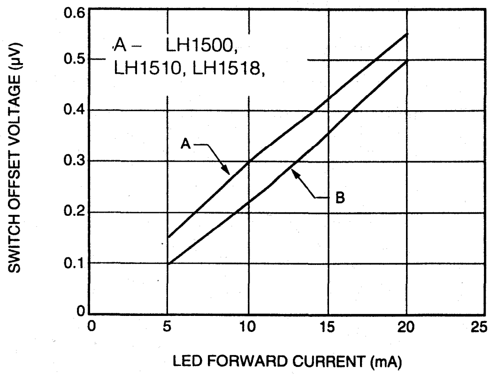
E. Switch Offset Voltage vs. Temperature



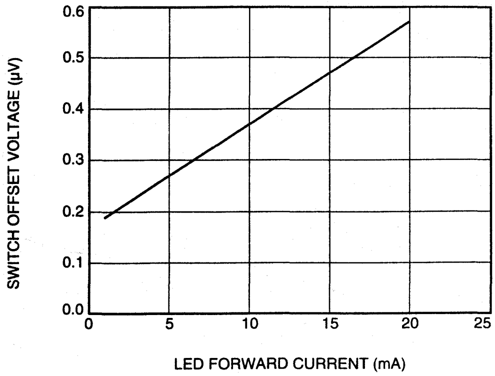
F. Switch Offset Voltage vs. Temperature (LH1525)



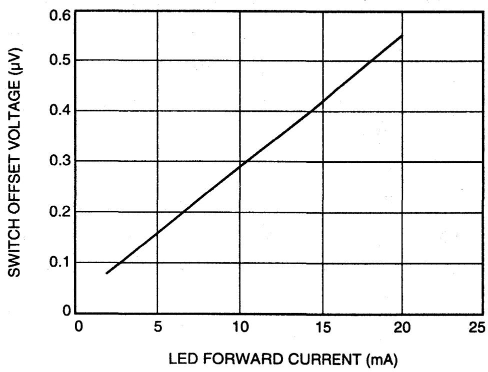
A. Switch Offset Voltage vs. LED Current



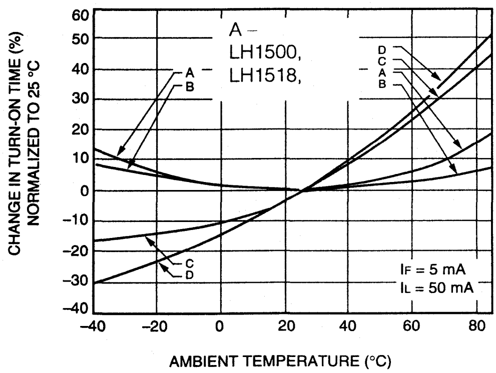
B. Switch Offset Voltage vs. LED Current (LH1525)



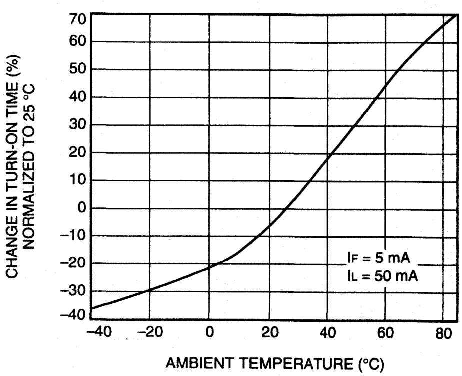
C. Switch Offset Voltage vs. LED Current (LH1541)



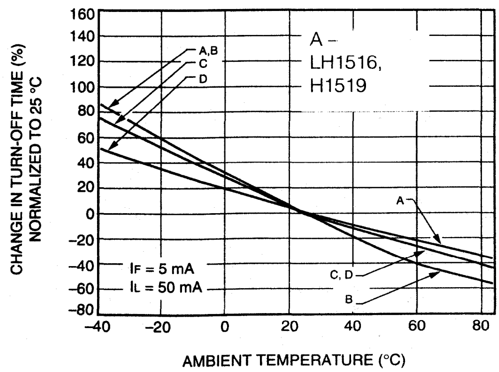
D. Turn-On Time vs. Temperature



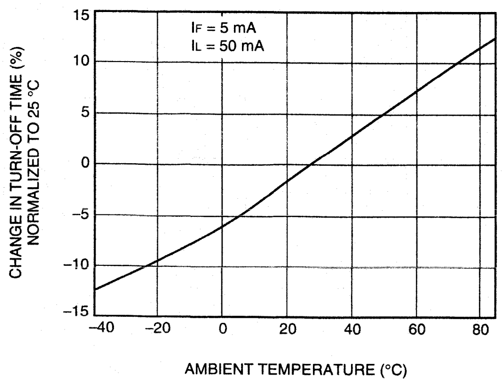
E. Turn-On Time vs. Temperature (LH1541)



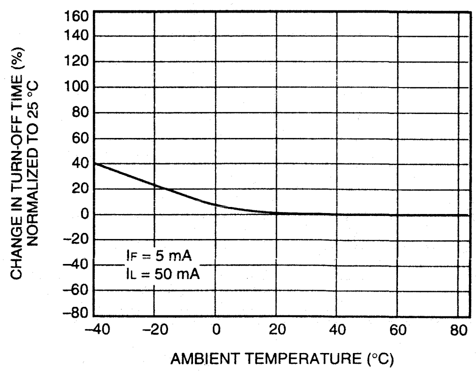
F. Turn-Off Time vs. Temperature



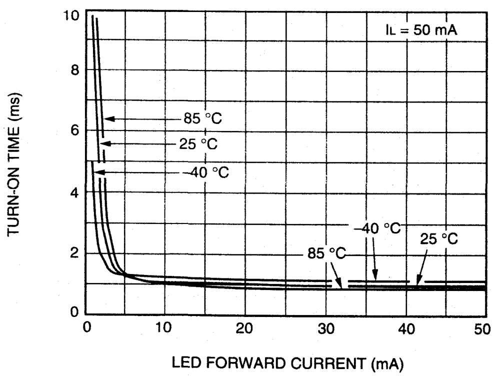
A. Turn-Off Time vs. Temperature (LH1525)



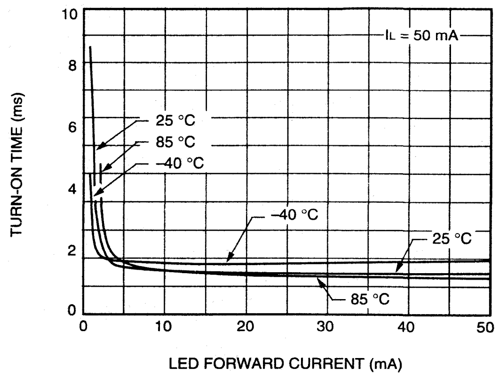
B. Turn-Off Time vs. Temperature (LH1541)



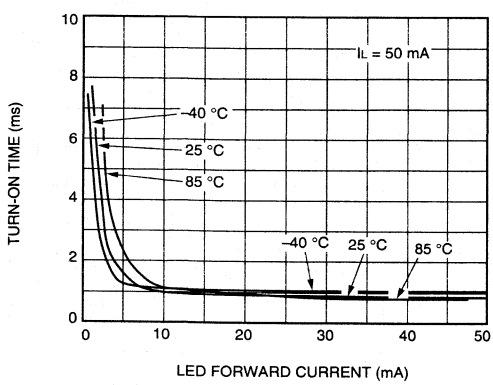
C. Turn-On Time vs. LED Current (LH1500, LH1518, LH1540)



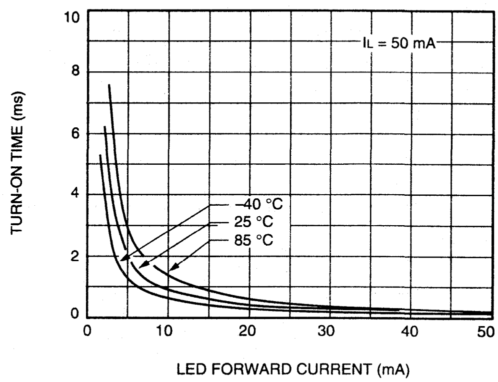
D. Turn-On Time vs. LED Current (LH1504)



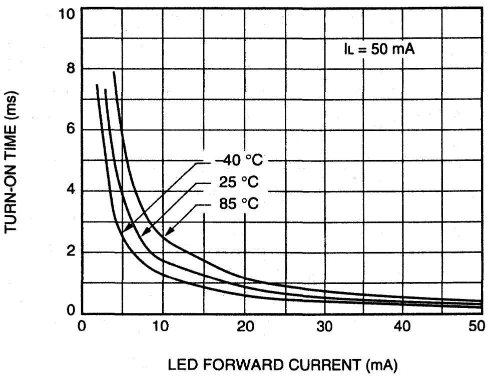
E. Turn-On Time vs. LED Current (LH1510)



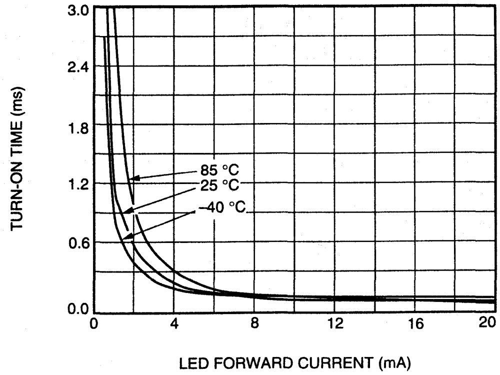
F. Turn-On Time vs. LED Current (LH1516, LH1519)



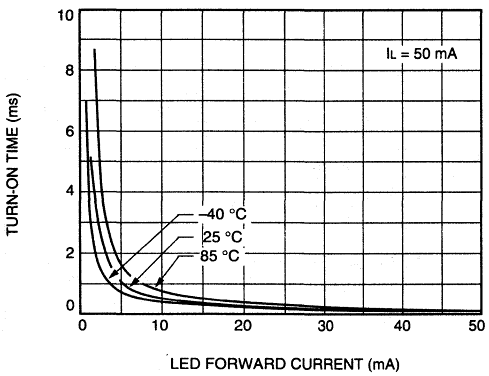
A. Turn-On Time vs. LED Current (LH1517)



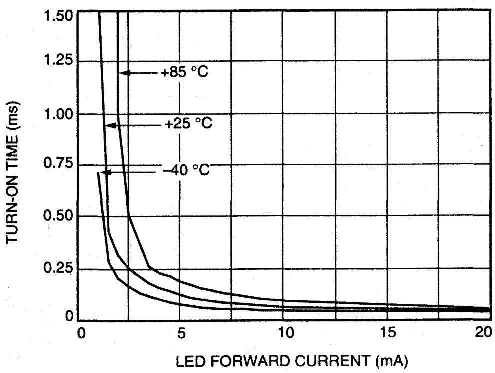
B. Turn-On Time vs. LED Current (LH1525)



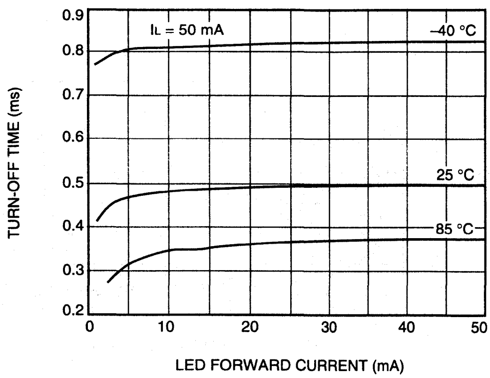
C. Turn-On Time vs. LED Current (LH1530)



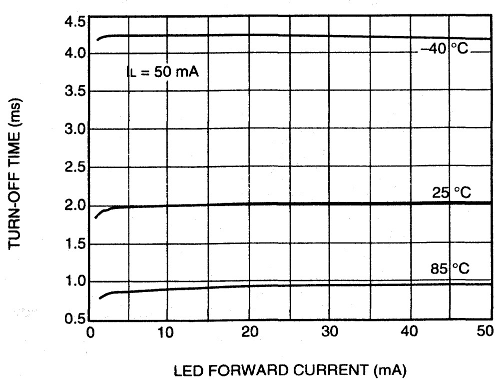
D. Turn-On Time vs. LED Current (LH1541)



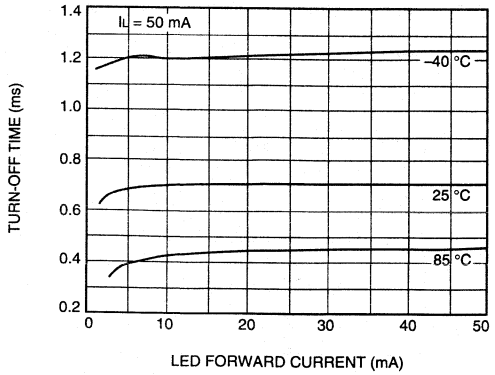
E. Turn-Off Time vs. LED Current (LH1500, LH1530, LH1540)



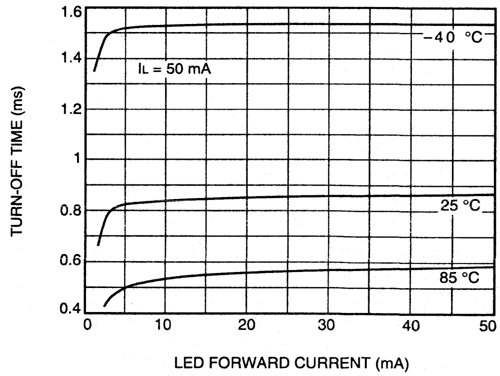
F. Turn-Off Time vs. LED Current (LH1504)



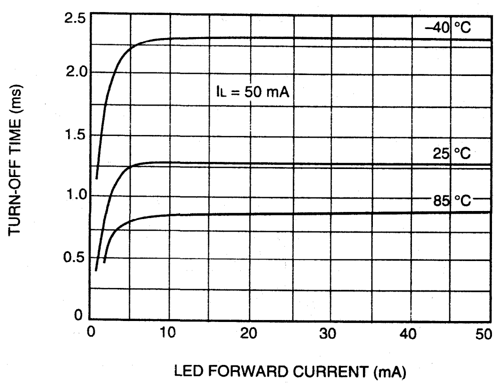
A. Turn-Off Time vs. LED Current (LH1510, LH1518)



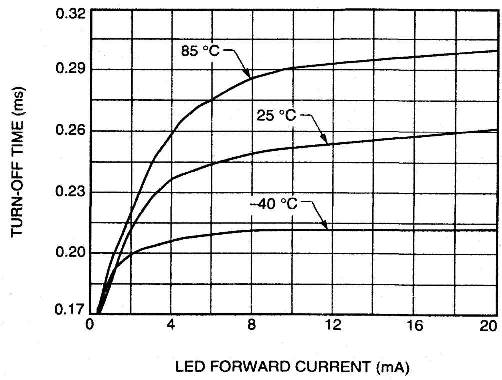
B. Turn-Off Time vs. LED Current (LH1516, LH1519)



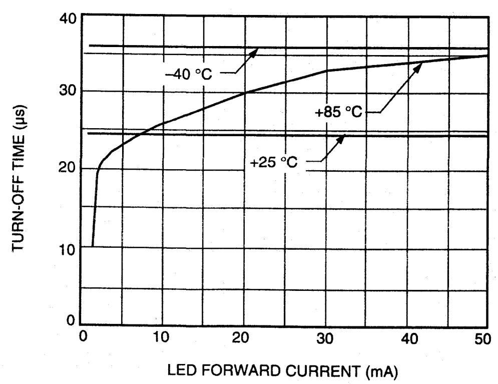
C. Turn-Off Time vs. LED Current (LH1517)



D. Turn-Off Time vs. LED Current (LH1525)

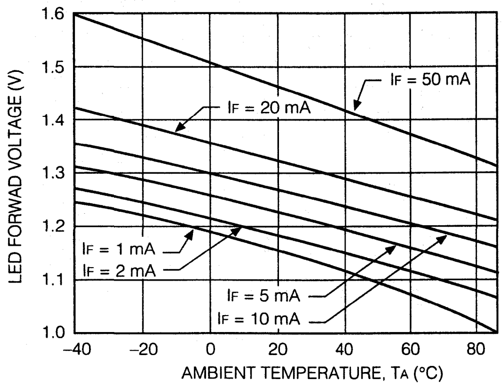


E. Turn-Off Time vs. LED Current (LH1541)

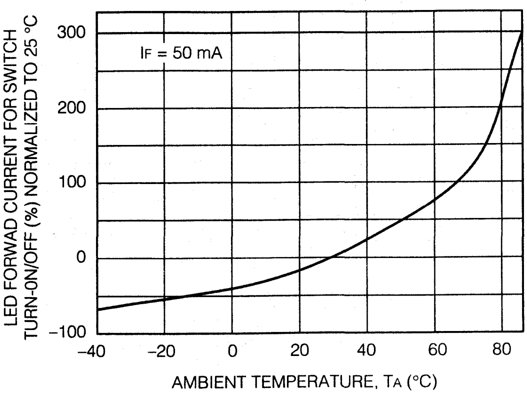


Typical Performance Characteristics, LH1550

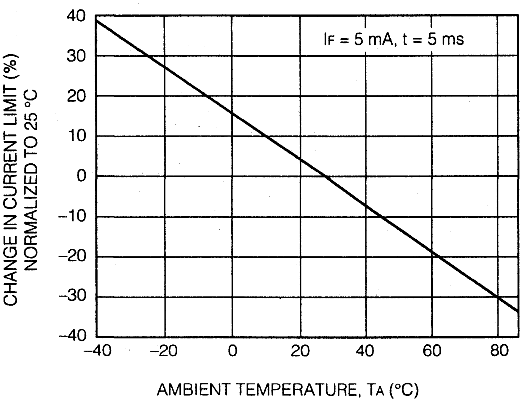
A. LED Voltage vs. Temperature



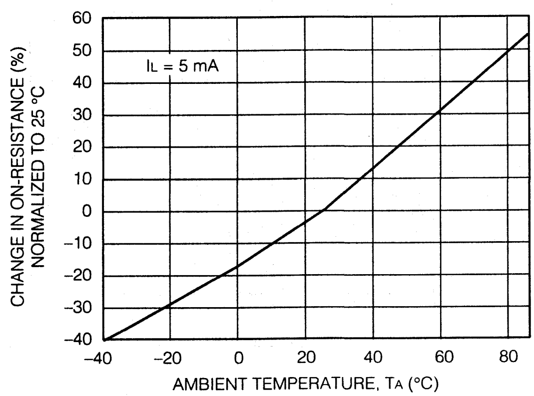
B. LED Current for Switch Turn-On/Off vs. Temperature



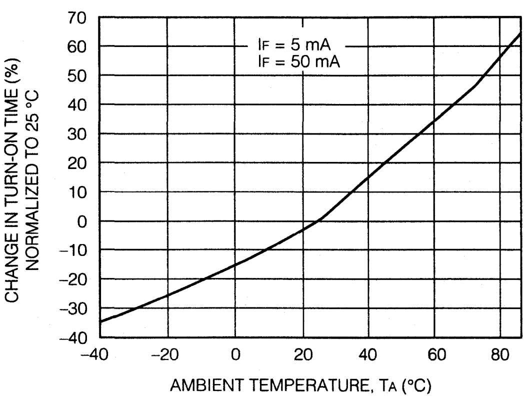
C. Current Limit vs. Temperature



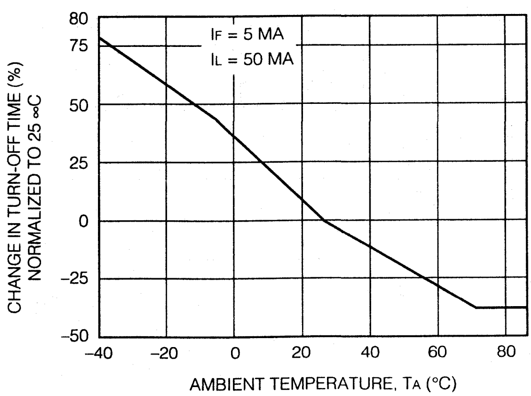
D. ON-Resistance vs. Temperature



E. Turn-Off Time vs. Temperature



F. Turn-Off Time vs. Temperature



LH1503, LH1513

2 Form A

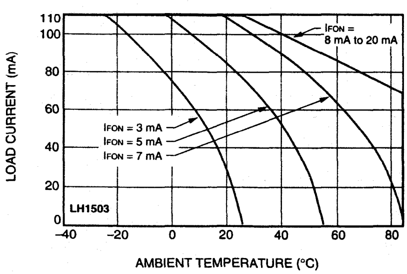
Absolute Maximum Ratings T_A=25°C

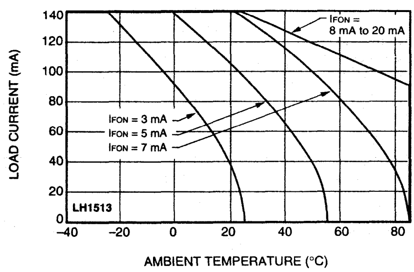
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

Parameter	Symbol	Test Conditions	LH1503	LH1513	Units
Ambient Operating Temperature Range	T_A	—	–40 to +85	–40 to +85	°C
Storage Temperature Range	T_{stg}	—	–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max	260	260	°C
Input/Output Isolation Voltage	V_{ISO}	—	3750	3750	Vrms
Pole-to-Pole Isolation Voltage (S1 to S2)	—	—	500	500	V
LED Continuous Forward Current	I_F	—	50	50	mA
LED Reverse Voltage	V_R	$I_R \leq 10\ \mu A$	8	8	V
dc or Peak ac Load Voltage	V_L	$I_L \leq 50\ \mu A$	350	200	V
Continuous dc Load Current	I_L	—			
One Pole Operating			150	200	mA
Two Poles Operating			110	140	mA
Peak Load Current	I_P	t=100 ms (single shot)	*	*	mA
Output Power Dissipation (continuous)	P_{DISS}	—	600	600	mW

* Refer to Current-Limit Performance Application Note for a discussion on relay operation during transient currents.

Recommended Operating Conditions

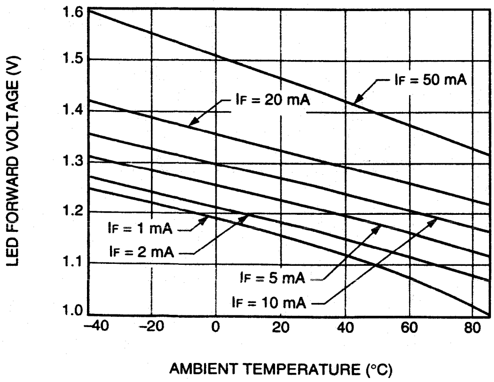




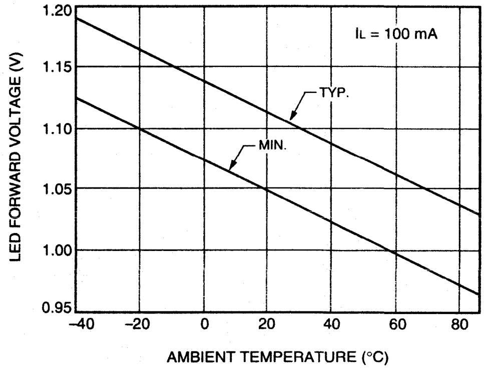
Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

	Parameter	Symbol	Test Conditions	Values	LH1503	LH1513	Units
INPUT	LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA t=10 ms	Min	—	—	mA
				Typ	2.0	2.0	mA
				Max	3.0	3.0	mA
	LED Forward Current or Switch Turn-off	I_{Foff}	—	Min	0.2	0.2	mA
				Typ	1.8	1.8	mA
				Max	—	—	mA
			V_L	±	300	150	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	V
				Typ	1.26	1.26	V
				Max	1.45	1.45	V
OUTPUT	ON-resistance	R_{ON}	I_F=5 mA I_L=50 mA	Min	12	6	Ω
				Typ	20	10	Ω
				Max	25	15	Ω
	Pole-to-pole ON-resistance Matching (S1 to S2)	—	I_F=5 mA I_L=50 mA	Min	—	—	ΔΩ
				Typ	0.2	0.1	ΔΩ
				Max	2.0	1.0	ΔΩ
	OFF-resistance	R_{OFF}	I_F=0 mA V_L=±100 V	Min	0.5	0.5	GΩ
				Typ	5000	5000	GΩ
				Max	—	—	GΩ
	Current Limit	I_{LMT}	I_F=5 mA t=5 ms	Min	230	300	mA
				Typ	270	360	mA
				Max	370	460	mA
			V_L	±	6	5	V
	Off-state Leakage Current	—	I_F=0 mA V_L=±100 V	Min	—	—	nA
				Typ	0.02	0.02	nA
				Max	200	200	nA
			I_F=0 mA	Min	—	—	µA
				Typ	—	—	µA
				Max	1.0	1.0	µA
			V_L	±	350	200	V
	Output Capacitance	—	I_F=0 mA V_L=1 V	Min	—	—	pF
				Typ	55	60	pF
				Max	—	—	pF
			I_F=0 mA V_L=50 V	Min	—	—	pF
				Typ	10	15	pF
				Max	—	—	pF
	Pole-to-pole Capacitance (S1 to S2)	—	I_F=0 mA	Min	—	—	pF
				Typ	3.0	3.0	pF
				Max	—	—	pF
			I_F=5 mA	Min	—	—	pF
				Typ	4.0	4.0	pF
				Max	—	—	pF
	Switch Offset	—	I_F=5 mA	Min	—	—	µV
				Typ	0.15	0.15	µV
				Max	—	—	µV
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	pF
				Typ	1.1	1.1	pF
				Max	—	—	pF
	Turn-on Time	t_{on}	I_F=10 mA I_L=50 mA	Min	—	—	ms
				Typ	1.6	1.6	ms
				Max	2.5	2.5	ms
	Turn-off Time	t_{off}	I_F=10 mA I_L=50 mA	Min	—	—	ms
				Typ	0.65	0.65	ms
				Max	2.5	2.5	ms

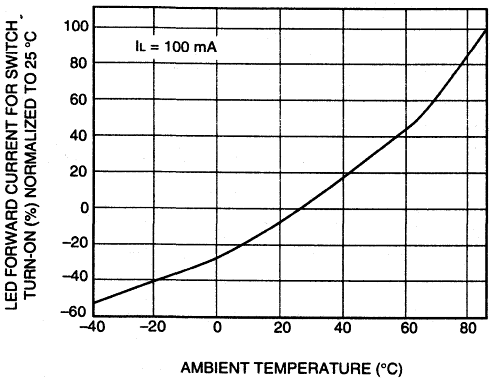
A. LED Voltage vs. Temperature



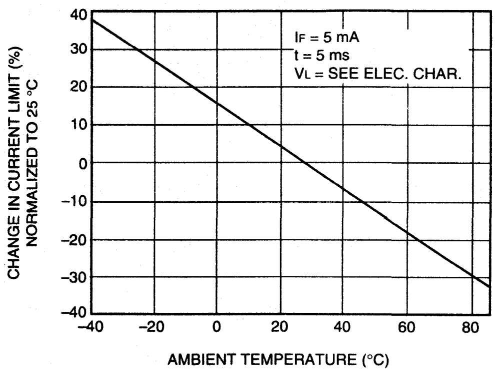
B. LED Dropout Voltage vs. Temperature



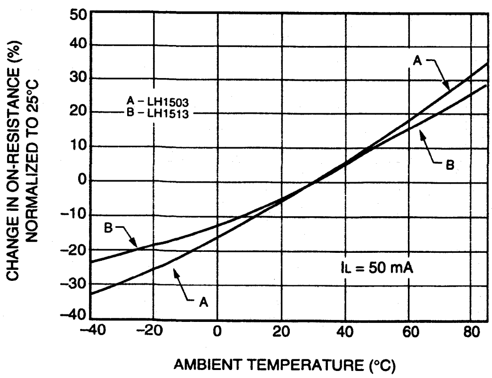
C. LED Current for Switch Turn-On vs. Temperature



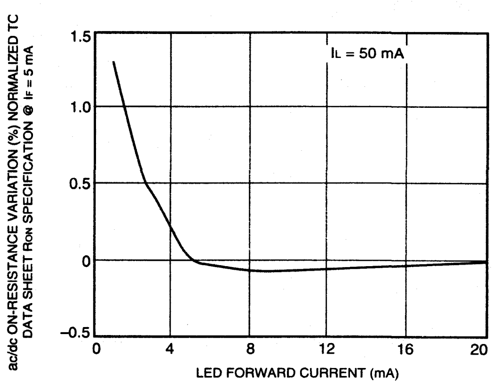
D. Current Limit vs. Temperature



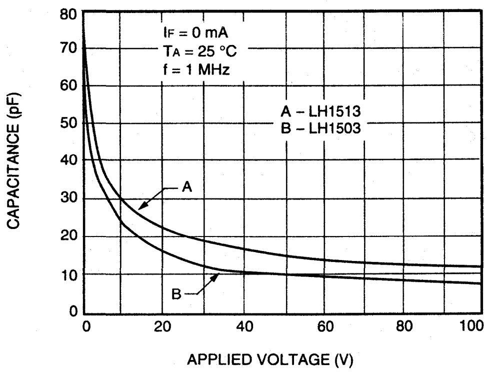
E. ON-Resistance vs. Temperature



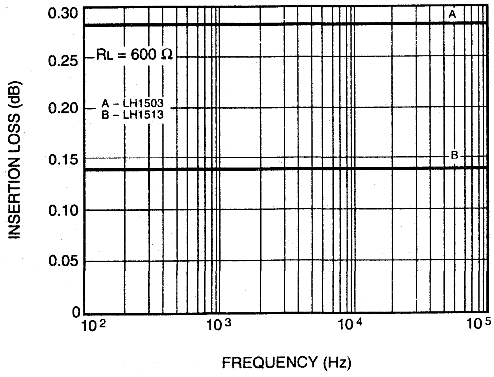
F. Variation in ON-Resistance vs. LED Current



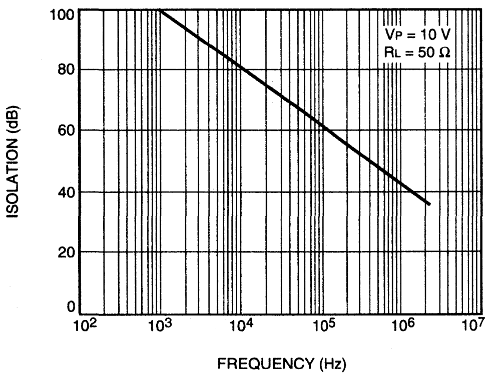
A. Switch Capacitance vs. Applied Voltage



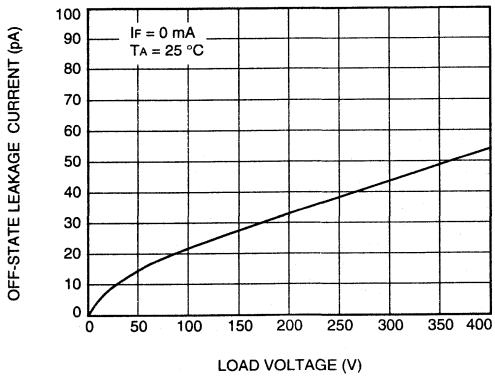
B. Insertion Loss vs. Frequency



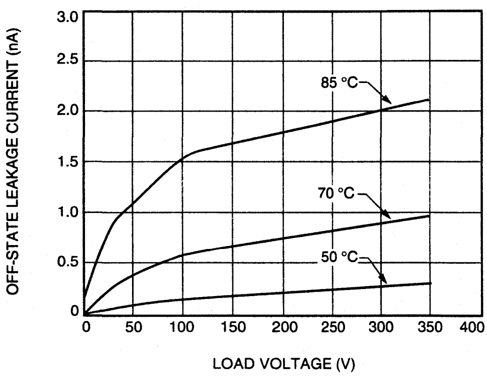
C. Output Isolation



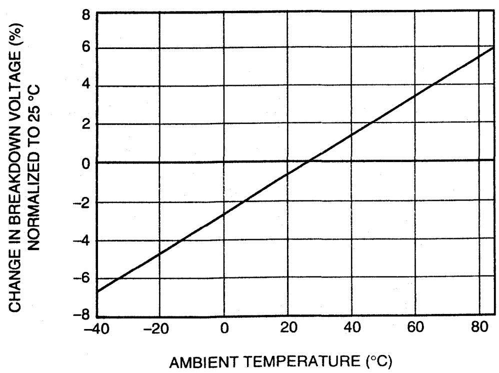
D. Leakage Current vs. Applied Voltage



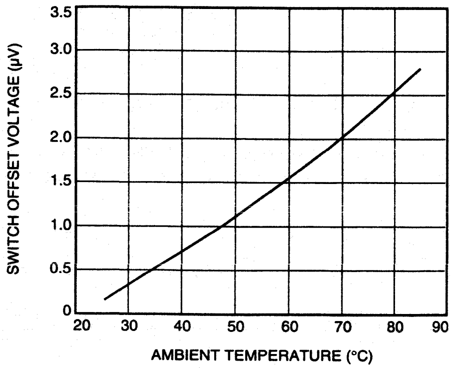
E. Leakage Current vs. Applied Voltage at Elevated Temperatures



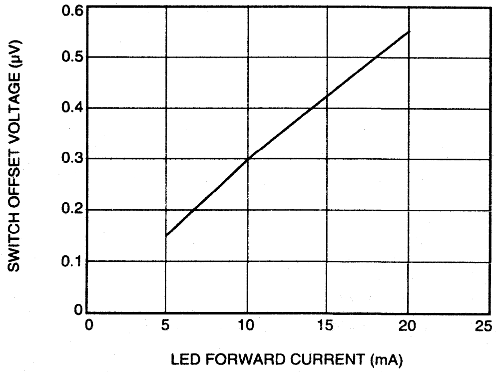
F. Switch Breakdown Voltage vs. Temperature



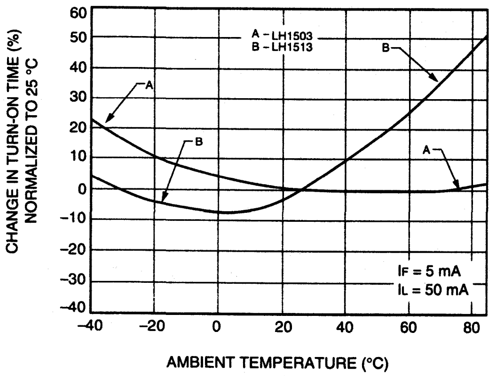
A. Switch Offset Voltage vs. Temperature



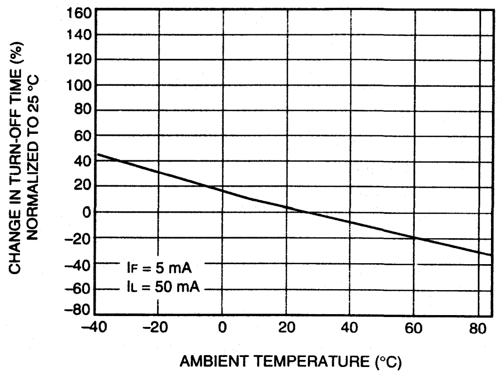
B. Switch Offset Voltage vs. LED Current



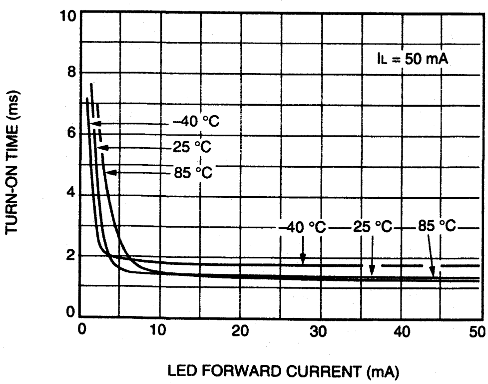
C. Turn-On Time vs. Temperature



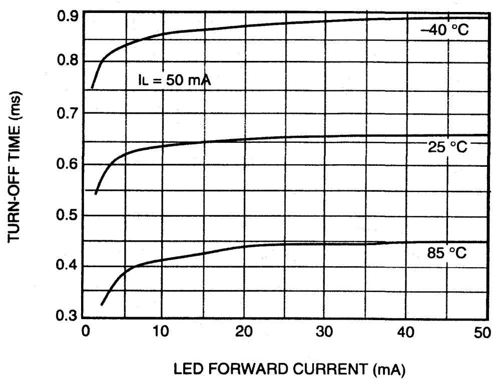
D. Turn-Off Time vs. Temperature



E. Turn-On Time vs. LED Current



F. Turn-Off Time vs. LED Current



SIEMENS

LH1505, LH1520 LH1522, LH1524

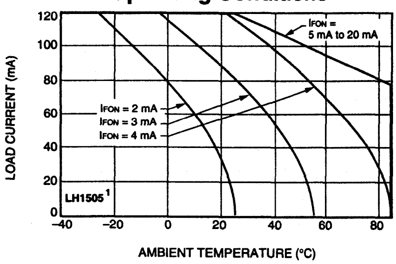
Dual 1 Form A

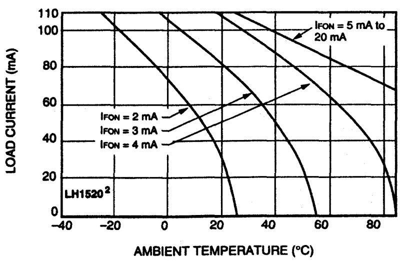
Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

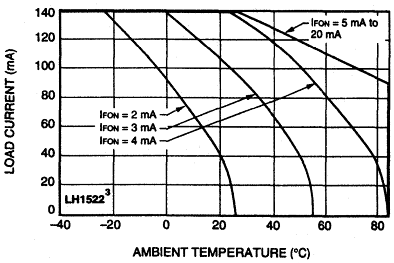
Parameter	Symbol	Test Conditions	LH1505	LH1520	LH1522	LH1524	Units
Ambient Operating Temperature Range	T_A	—	–40 to +85	–40 to +85	–40 to +85	–40 to + 85	°C
Storage Temperature Range	T_{stg}	—	–40 to +150	–40 to +150	–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max	260	260	260	260	°C
Input/Output Isolation Test Voltage	V_{ISO}	t=1 s I_{ISO}=10 µA max	5300	5300	5300	5300	Vrms
Pole-to-Pole Isolation Voltage (S1 to S2)†	—	Dry air, dust free, at sea level	1600	1600	1600	1600	V
LED Continuous Forward Current	I_F	—	50	50	50	50	mA
LED Reverse Voltage	V_R	$I_R \leq$ 10 µA	8	8	8	8	V
dc or Peak ac Load Voltage	V_L	$I_L \leq$ 50 µA	250	350	200	400	V
Continuous dc Load Current: One pole operating Two poles operating	I_L	—	 130 120	 150 110	 200 140	 95 70	 mA mA
Peak Load Current	I_P	t=100 ms (single shot)	*	*	*	*	mA
Output Power Dissipation (continuous)	P_{DISS}	—	600	600	600	600	mW

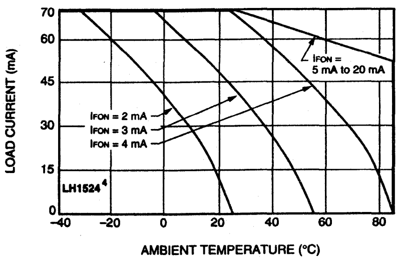
* Refer to Current-Limit Performance Application Note for a discussion on relay operation during transient currents.
† Breakdown occurs between the output pins external to the package

Recommended Operating Conditions









Electrical Characteristics T_A=25°C

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

	Parameter	Symbol	Test Conditions	Values	LH1505	LH1520	LH1522	LH1524	Units
INPUT	LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA t=10 ms	Min	—	—	—	—	mA
				Typ	1.0	1.0	1.0	0.5	mA
				Max	2.0	2.0	2.0	2.0	mA
	LED Forward Current for Switch Turn-off	I_{Foff}	—	Min	0.2	0.2	0.2	0.1	mA
				Typ	0.9	1.1	1.1	0.4	mA
				Max	—	—	—	—	mA
			V_L	±	200	300	150	350	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	1.15	1.15	V
				Typ	1.26	1.26	1.26	1.26	V
				Max	1.45	1.45	1.45	1.45	V
OUTPUT	ON-resistance	R_{ON}	I_F=5 mA I_L=50 mA	Min	10	12	6	12*	Ω
				Typ	15	20	10	23*	Ω
				Max	20	25	15	34*	Ω
	OFF-resistance	R_{OFF}	I_F=0 mA V_L=±100 V	Min	0.5	0.5	0.5	0.5	GΩ
				Typ	5000	5000	5000	5000	GΩ
				Max	—	—	—	—	GΩ
	ON-state Voltage	—	I_L=1 mA	Min	—	—	—	1.2	V
				Typ	—	—	—	1.4	V
				Max	—	—	—	1.8	V
			I_L=90 mA t=10 ms	Min	—	—	—	3.0	V
				Typ	—	—	—	3.6	V
				Max	—	—	—	5.0	V
	Current Limit	i_{LMT}	I_F=5 mA t=5 ms	Min	170	230	300	150	mA
				Typ	200	270	360	210	mA
				Max	280	370	460	270	mA
			V_L	±	6	6	5	11	V
	Off-state Leakage Current	—	I_F=0 mA V_L=±100 V	Min	—	—	—	—	nA
				Typ	0.02	0.02	0.02	0.02	nA
				Max	200	200	200	200	nA
			I_F=0 mA	Min	—	—	—	—	μA
				Typ	—	—	—	—	μA
				Max	1.0	1.0	1.0	1.0	μA
			V_L	±	250	350	200	400	V
	Output Capacitance	—	I_F=0 mA V_L=1 V	Min	—	—	—	—	pF
				Typ	55	55	60	2.5	pF
				Max	—	—	—	—	pF
			I_F=0 mA V_L=50 V	Min	—	—	—	—	pF
				Typ	10	10	15	2.0	pF
				Max	—	—	—	—	pF
	Pole-to-pole Capacitance (S1 to S2)	—	I_F=5 mA	Min	—	—	—	—	pF
				Typ	0.5	0.5	0.5	0.5	pF
				Max	—	—	—	—	pF
	Switch Offset	—	I_F=5 mA	Min	—	—	—	—	μV
				Typ	0.15	0.15	0.15		μV
				Max	—	—	—	—	μV
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	—	—	pF
				Typ	1.1	1.1	1.1	1.1	pF
				Max	—	—	—	—	pF
	Turn-on Time	t_{on}	I_F=5 mA I_L=50 mA	Min	—	—	—	—	ms
				Typ	1.4†	1.4	1.0‡	1.6	ms
				Max	4.0†	2.0	2.0‡	5.0	ms
	Turn-off Time	t_{off}	I_F=5 mA I_L=50 mA	Min	—	—	—	—	ms
				Typ	0.7†	0.7	0.7‡	2.0	ms
				Max	4.0†	2.0	2.0‡	5.0	ms

* R_{ON}=V(50 mA) – V (20 mA)/ 30 mA, †I_L=100 mA, ‡I_F=10 mA.

The following information refers to the SSR Recommended Operating Conditions on the previous page.

1) Both relays on with equal load currents. For single relay operation, refer to the LH1518 Recommended Operating Conditions graph.
2) Both relays on with equal load currents. For single relay operation, refer to the LH1500 Recommended Operating Conditions graph.
3) Both relays on with equal load currents. For single relay operation, refer to the LH1510 Recommended Operating Conditions graph.
4) Both relays on with equal load currents. For single relay operation, refer to the LH1504 Recommended Operating Conditions graph.

SIEMENS

LH1531, LH1532, LH1544

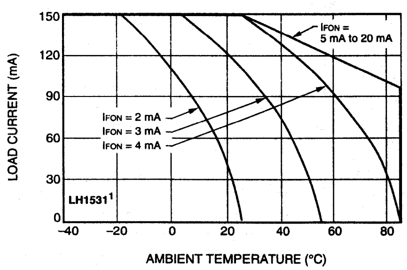
Dual 1 Form A

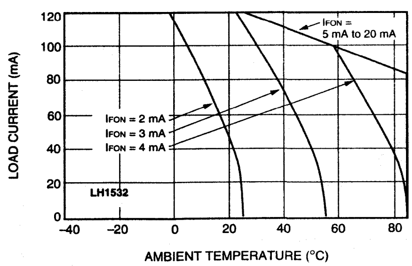
Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

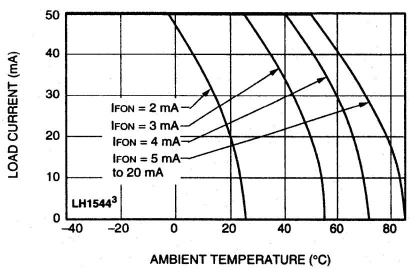
Parameter	Symbol	Test Conditions	LH1531	LH1532	LH1544	Units
Ambient Operating Temperature Range	T_A	—	–40 to +85	–40 to +85	–40 to + 85	°C
Storage Temperature Range	T_{stg}	—	–40 to +150	–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max	260	260	260	°C
Input/Output Isolation Test Voltage	V_{ISO}	t=1 Sec	5300	5300	5300	Vrms
Pole-to-Pole Isolation Voltage (S1 to S2)†	—	Dry air, dust free, at sea level	1600	1600	1600	V
LED Continuous Forward Current	I_F	—	50	50	50	mA
LED Reverse Voltage	V_R	$I_R \leq 10\ \mu A$	8	8	8	V
dc or Peak ac Load Voltage	V_L	$I_L \leq 50\ \mu A$	350	350	200	V
Continuous dc Load Current One Pole Operating Two Poles Operating	I_L	—	 150 110	 120 110	 55 40	 mA mA
Peak Load Current	I_P	t=100 ms (single shot)	400	*	100	mA
Output Power Dissipation (continuous)	P_{DISS}	—	600	600	600	mW

* Refer to Current-Limit Performance Application Note for a discussion on relay operation during transient currents.
† Breakdown occurs between the output pins external to the package.

SSR Recommended Operating Conditions







Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

	Parameter	Symbol	Test Conditions	Values	LH1531	LH1532	LH1544	Units
INPUT	LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA, t=10 ms	Min	—	—	—	mA
				Typ	1.0	1.0	0.9	mA
				Max	2.0	2.0	2.0	mA
	LED Forward Current for Switch Turn-off	I_{Foff}	—	Min	0.2	0.2	0.2	mA
				Typ	0.9	0.9	0.8	mA
				Max	—	—	—	mA
			V_L	±	300	300	150	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	1.10*	V
				Typ	1.26	1.26	1.19*	V
				Max	1.45	1.45	1.45*	V
OUTPUT	ON-resistance	R_{ON}	I_F=5 mA, I_L=50 mA	Min	12	12	70	Ω
				Typ	18	20	110	Ω
				Max	25	25	160	Ω
	OFF-resistance	R_{OFF}	I_F=0 mA, V_L=±100 V	Min	0.5	0.5	0.5	GΩ
				Typ	5000	5000	10000	GΩ
				Max	—	—	—	GΩ
	ON-state Voltage	—	I_L=1 mA	Min	—	—	—	V
				Typ	—	—	—	V
				Max	—	—	—	V
			I_L=90 mA, t=10 ms	Min	—	—	—	V
				Typ	—	—	—	V
				Max	—	—	—	V
	Current Limit	I_{LMT}	I_F=5 mA, t=5 ms	Min	—	170	—	mA
				Typ	—	210	—	mA
				Max	—	250	—	mA
			V_L	±	—	6	—	V
	Off-state Leakage Current	—	I_F=0 mA, V_L=±100 V	Min	—	—	—	nA
				Typ	0.02	0.02	0.01	nA
				Max	200	200	200	nA
			I_F=0 mA	Min	—	—	—	µA
				Typ	—	—	—	µA
				Max	1.0	1.0	1.0	µA
			V_L	±	350	350	200	V
	Output Capacitance	—	I_F=0 mA, V_L=1 V	Min	—	—	—	pF
				Typ	55	55	0	pF
				Max	—	—	—	pF
			I_F=0 mA, V_L=50 V	Min	—	—	—	pF
				Typ	10	10	0.5	pF
				Max	—	—	—	pF
	Pole-to-pole Capacitance (S1 to S2)	—	I_F=5 mA	Min	—	—	—	pF
				Typ	0.5	0.5	0.5	pF
				Max	—	—	—	pF
	Switch Offset	—	I_F=5 mA	Min	—	—	—	µV
				Typ	0.15	0.15	0.1	µV
				Max	—	—	—	µV
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	—	pF
				Typ	1.1	1.1	1.1	pF
				Max	—	—	—	pF
	Turn-on Time	t_{on}	I_F=5 mA, I_L=50 mA	Min	—	—	—	ms
				Typ	1.0†	1.4	0.13‡	ms
				Max	2.0†	2.5	0.25‡	ms
	Turn-off Time	t_{off}	I_F=5 mA, I_L=50 mA	Min	—	—	—	ms
				Typ	1.0†	0.7	0.06‡	ms
				Max	2.0†	2.5	0.25‡	ms

* I_F=5 mA, † I_F=10 mA, ‡ I_L=12.5 mA

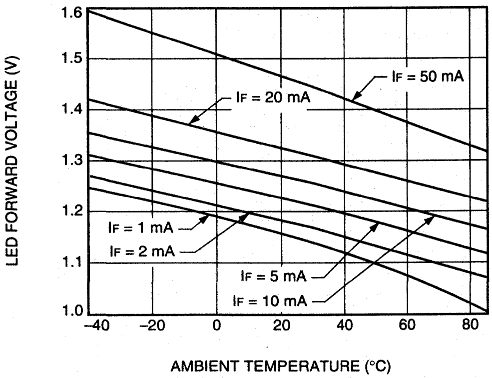
The following information refers to the SSR Recommended Operation Conditions on the previous page.

1) Both relays on with equal load currents. For single relay operation, refer to the LH1530 Recommended Operating Conditions graph.

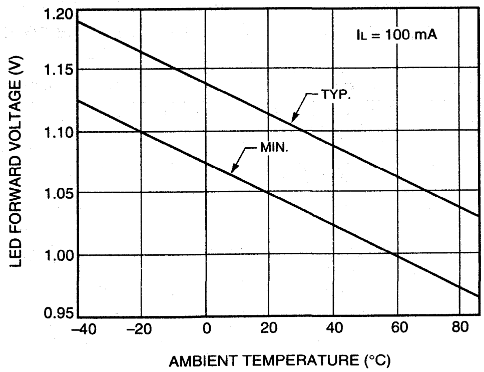
2) Both relays on with equal load currents. For single relay operation, refer to the LH1540 Recommended Operating Conditions graph.

3) Single relay operation.

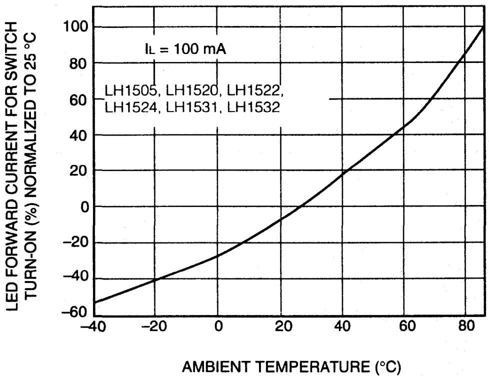
A. LED Voltage vs. Temperature



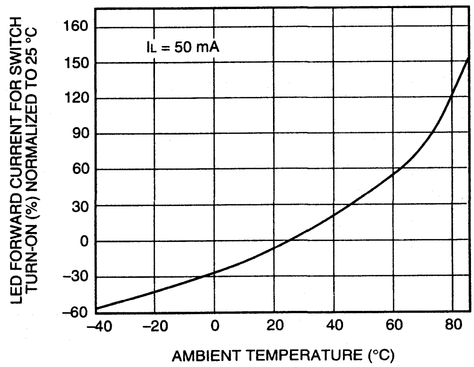
B. LED Dropout Voltage vs. Temperature



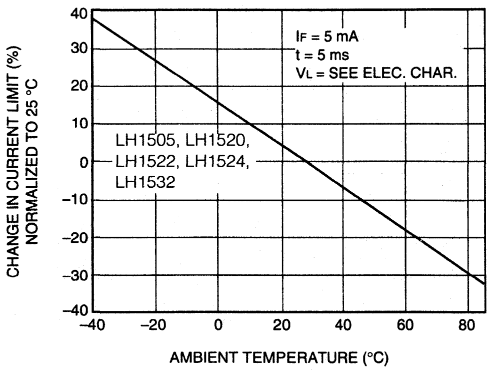
C. LED Current for Switch Turn-On vs. Temperature



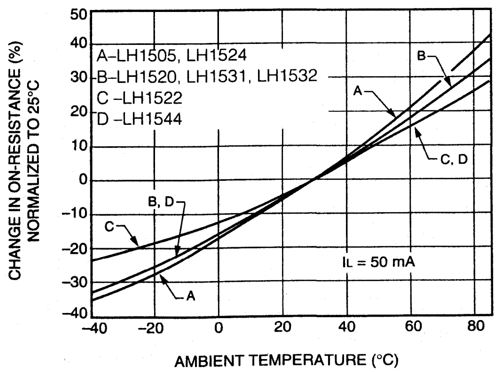
D. LED Current for Switch Turn-On vs. Temperature (LH1544)



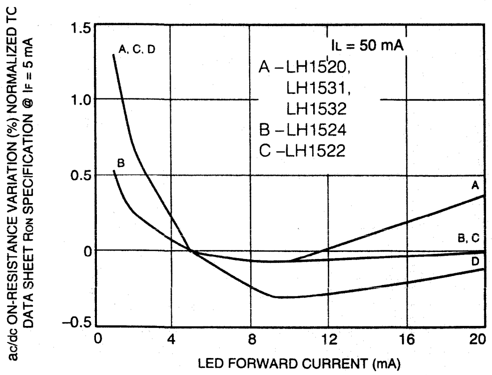
E. Current Limit vs. Temperature



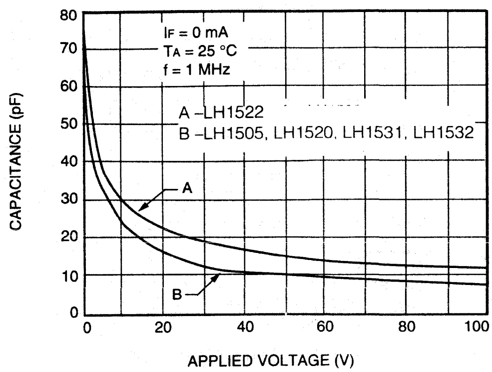
F. ON-Resistance vs. Temperature



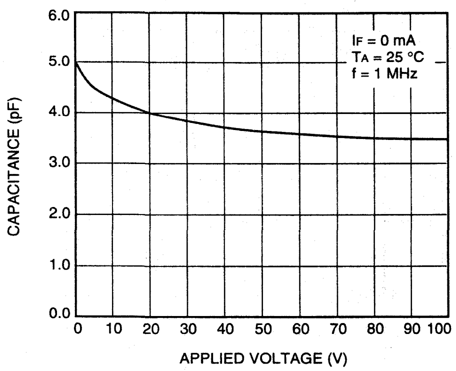
A. Variation in ON-Resistance vs. LED Current



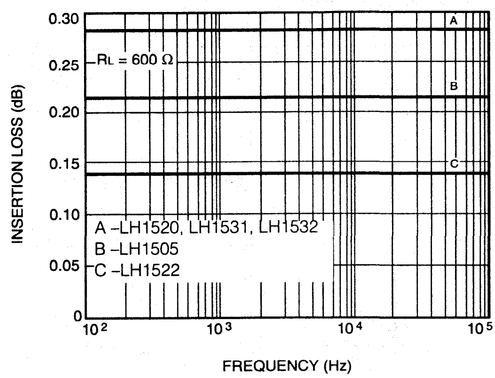
B. Switch Capacitance vs. Applied Voltage



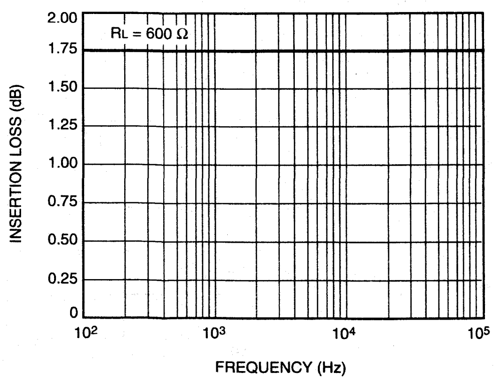
C. Switch Capacitance vs. Applied Voltage (LH1544)



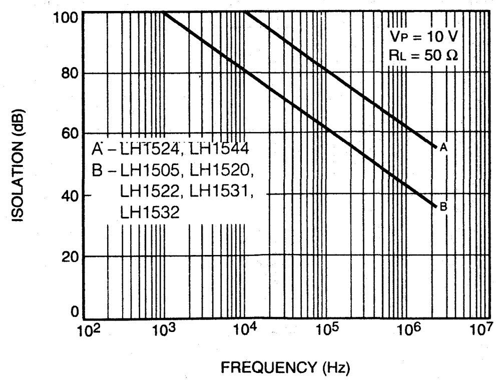
D. Insertion Loss vs. Frequency



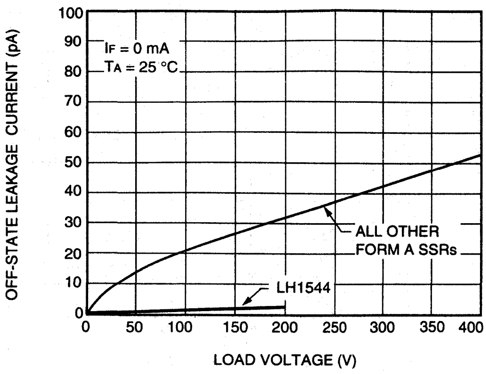
E. Insertion Loss vs. Frequency (LH1544)



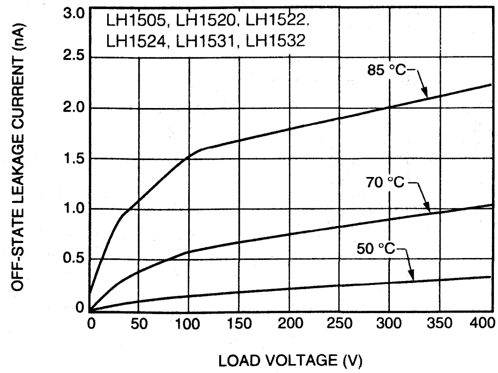
F. Output Isolation



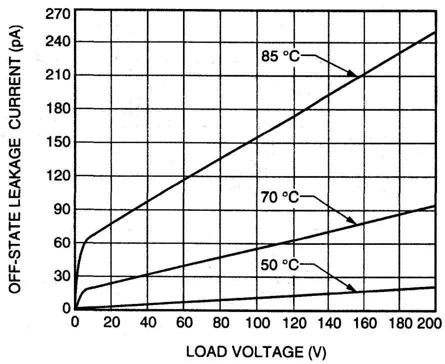
A. Leakage Current vs. Applied Voltage



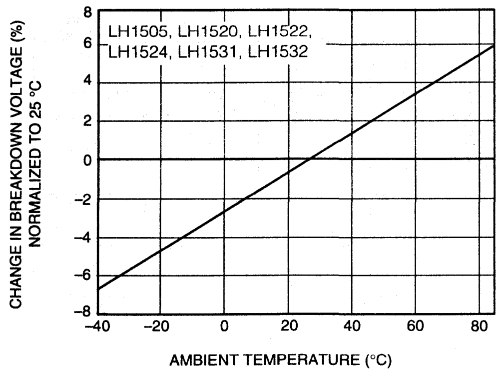
B. Leakage Current vs. Applied Voltage at Elevated Temperatures



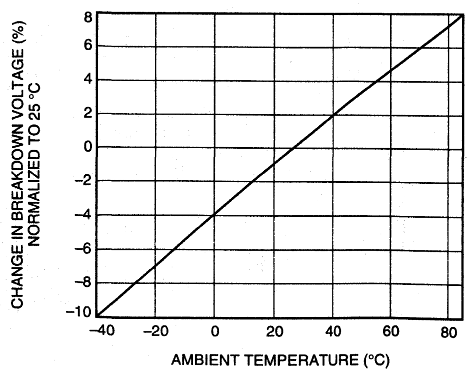
C. Leakage Current vs. Applied Voltage at Elevated Temperatures (LH1544)



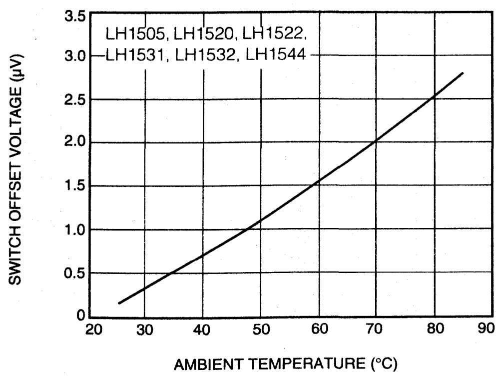
D. Switch Breakdown Voltage vs. Temperature



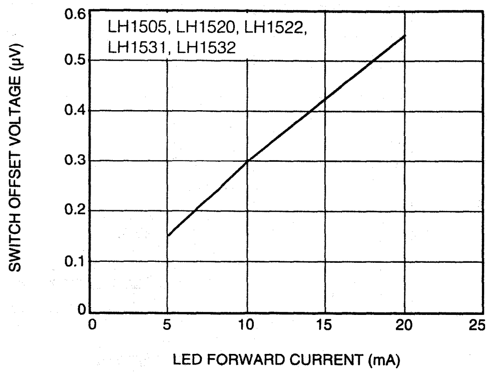
E. Switch Breakdown Voltage vs. Temperature (LH1544)



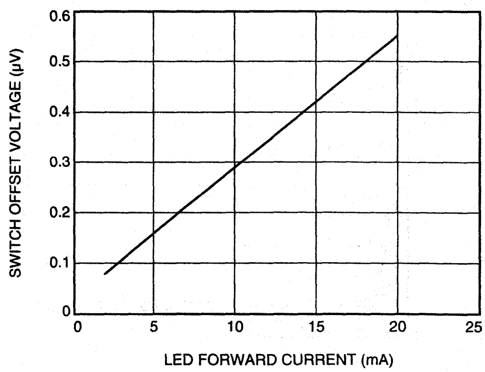
F. Switch Offset Voltage vs. Temperature



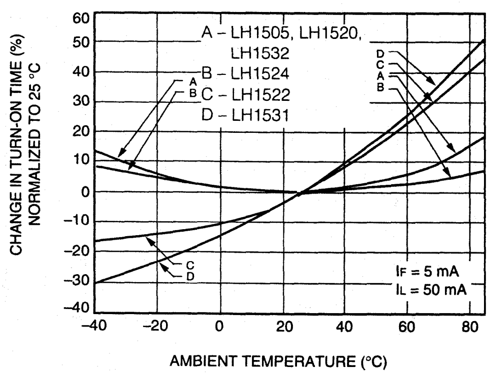
A. Switch Offset Voltage vs. LED Current



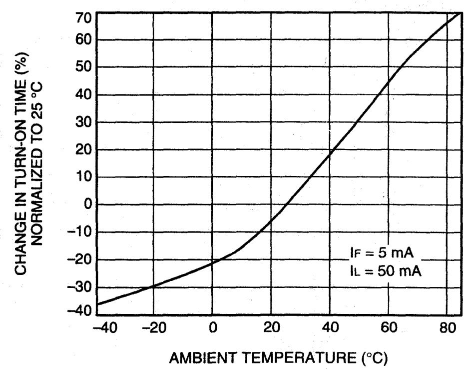
B. Switch Offset Voltage vs. LED Current (LH1544)



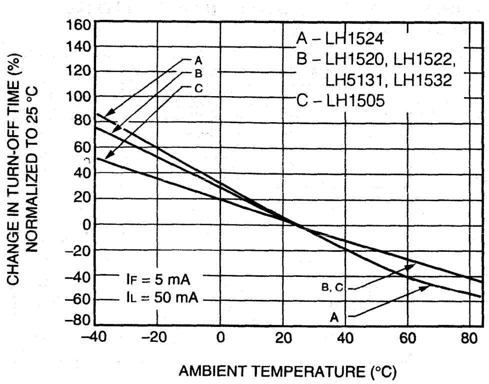
C. Turn-On Time vs. Temperature



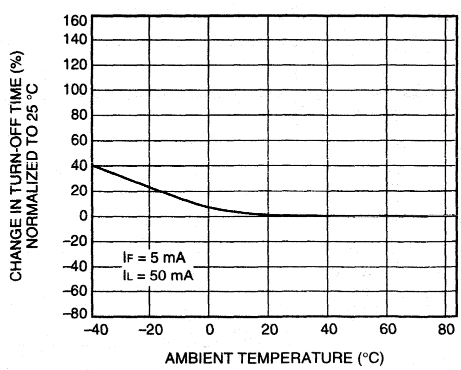
D. Turn-On Time vs. Temperature (LH1544)



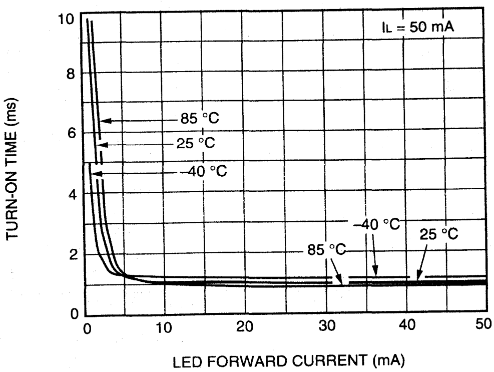
E. Turn-Off Time vs. Temperature



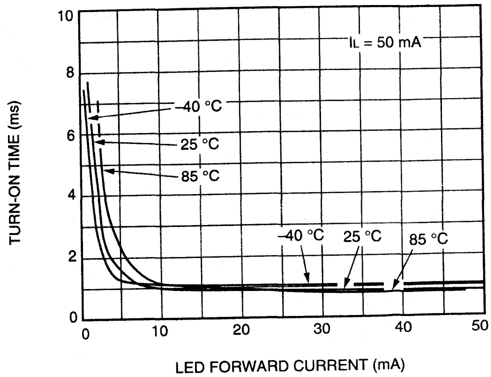
F. Turn-Off Time vs. Temperature (LH1544)



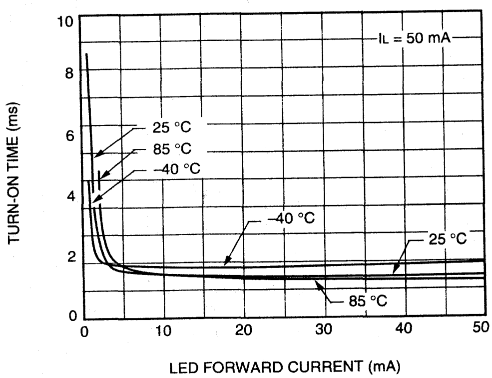
A. Turn-On Time vs. LED Current (LH1505, LH1520, LH1532)



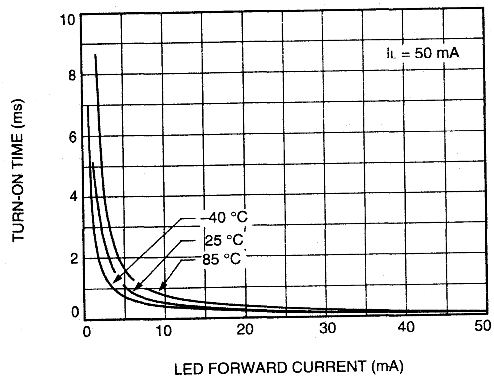
B. Turn-On Time vs. LED Current (LH1522)



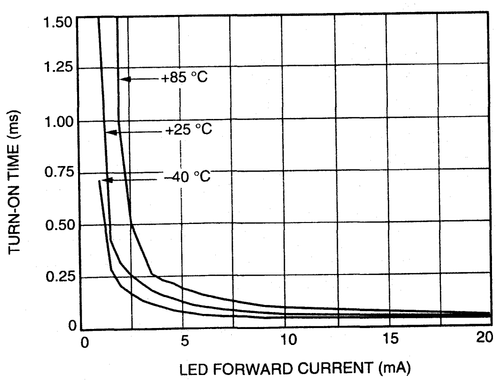
C. Turn-On Time vs. LED Current (LH1524)



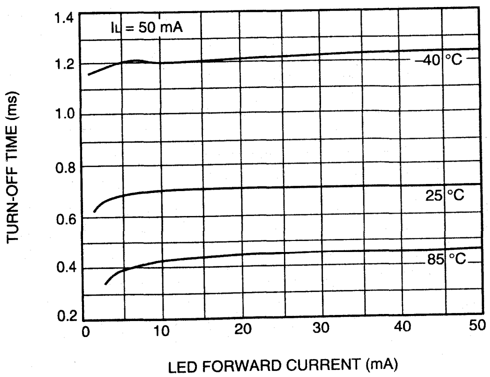
D. Turn-On Time vs. LED Current



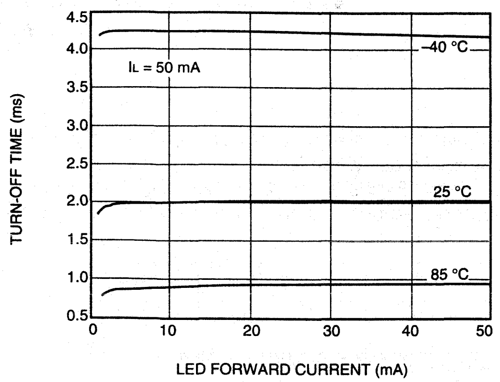
E. Turn-On Time vs. LED Current (LH1544)



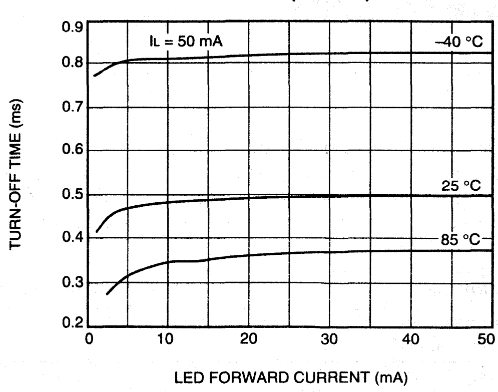
F. Turn-Off Time vs. LED Current (LH1505, LH1520, LH1522, LH1532)



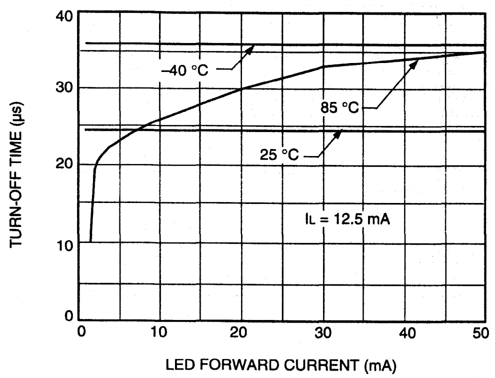
A. Turn-Off Time vs. LED Current (LH1524)



B. Turn-Off Time vs. LED Current (LH1531)



C. Turn-Off Time vs. LED Current (LH1544)



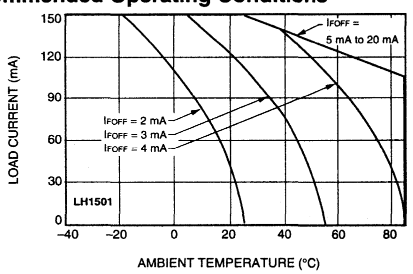
Solid State Relays 6

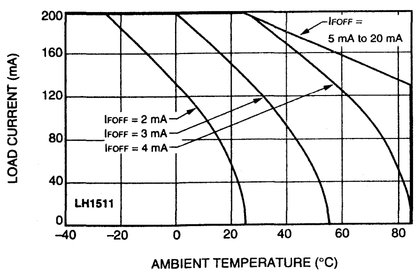
LH1501, LH1511
1 Form B

Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

Parameter	Symbol	Test Conditions	LH1501	LH1511	Units
Ambient Operating Temperature Range	T_A	—	–40 to +85	–40 to +85	°C
Storage Temperature Range	T_{stg}	—	–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max	260	260	°C
Input/Output Isolation Test Voltage	V_{ISO}	Vrms t=1 s I_{ISO}=10 µA max	5300	5300	Vrms
LED Continuous Forward Current	I_F	—	50	50	mA
LED Reverse Voltage	V_R	$I_R \leq 10$ µA	8	8	V
dc or Peak ac Load Voltage	V_L	$I_L \leq 50$ µA	350	200	V
Continuous dc Load Current Bidirectional Operation Unidirectional Operation	I_L	—	 150 250	 200 350	 mA mA
Peak Load Current	I_P	t=100 ms (single shot)	400	600	mA
Output Power Dissipation (continuous)	P_{DISS}	—	550	550	mW

Recommended Operating Conditions



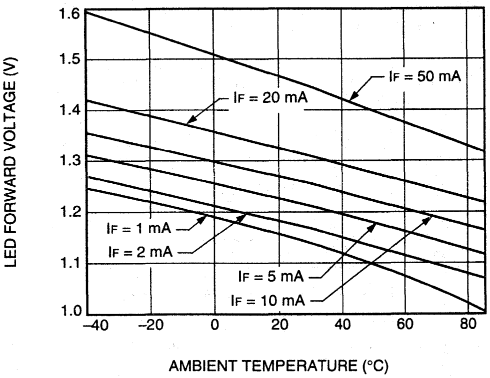


Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

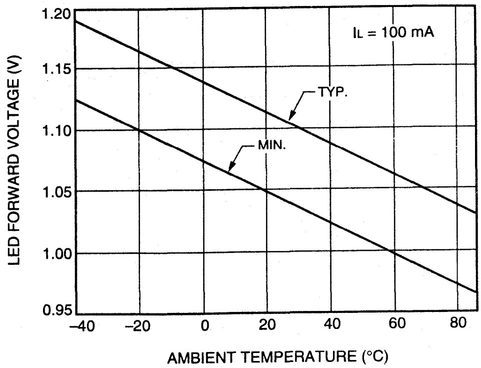
	Parameter	Symbol	Test Conditions	Values	LH1501	LH1511	Units
INPUT	LED Forward Current for Switch Turn-off	I_{Foff}	—	Min	—	—	mA
				Typ	1.0	1.0	mA
				Max	2.0	2.0	mA
			V_L	±	300	150	V
	LED Forward Current for Switch Turn-on	I_{Fon}	t=10 ms	Min	0.2	0.2	mA
				Typ	0.9	0.9	mA
				Max	—	—	mA
			I_L	±	150	200	mA
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	V
				Typ	1.26	1.26	V
				Max	1.45	1.45	V
OUTPUT	ON-resistance ac/dc Pins 4, 6 (+) to 5 (–) dc Pins 4, 6 (+) to 5 (–)	R_{ON}	I_F=0 mA I_L=50 mA	Min	12	6	Ω
				Typ	20	10	Ω
				Max	25	15	Ω
			I_F=0 mA I_L=100 mA	Min	3.00	1.50	Ω
				Typ	5.00	2.50	Ω
				Max	6.25	3.75	Ω
	OFF-resistance	R_{OFF}	I_F=5 mA V_L=±100 V	Min	0.1	0.1	GΩ
				Typ	1.4	1.4	GΩ
				Max	—	—	GΩ
	Off-state Leakage Current	—	I_F=5 mA V_L=±100 V	Min	—	—	µA
				Typ	0.07	0.07	µA
				Max	1.0	1.0	µA
			I_F=5 mA	Min	—	—	µA
				Typ	0.08	0.07	µA
				Max	1.0	1.0	µA
			VL	±	350	200	V
	Output Capacitance	—	I_F=5 mA V_L=1 V	Min	—	—	pF
				Typ	45	35	pF
				Max	—	—	pF
			I_F=5 mA V_L=50 V	Min	—	—	pF
				Typ	10	15	pF
				Max	—	—	pF
	Switch Offset	—	I_F=0 mA	Min	—	—	µV
				Typ	0.1	0.1	µV
				Max	—	—	µV
	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	pF
				Typ	0.8	0.8	pF
				Max	—	—	pF
	Turn-off Time	t_{off}	I_F=5 mA I_L=50 mA	Min	—	—	ms
				Typ	2.0	1.0*	ms
				Max	3.0	3.0*	ms
	Turn-on Time	t_{on}	I_F=5 mA I_L=50 mA	Min	—	—	ms
				Typ	1.0	1.2*	ms
				Max	3.0	3.0*	ms

* I_F=10 mA.

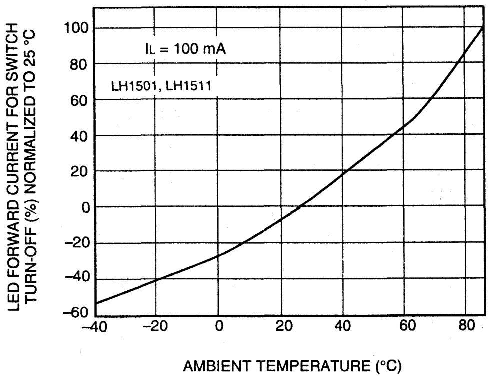
A. LED Voltage vs. Temperature



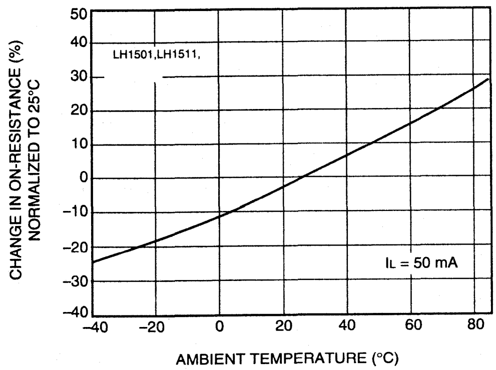
B. LED Dropout Voltage vs. Temperature



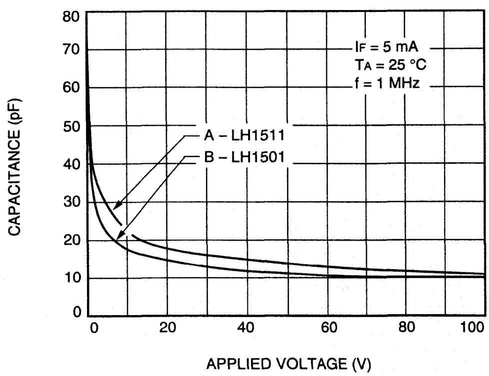
C. LED Current for Switch Turn-Off vs. Temperature



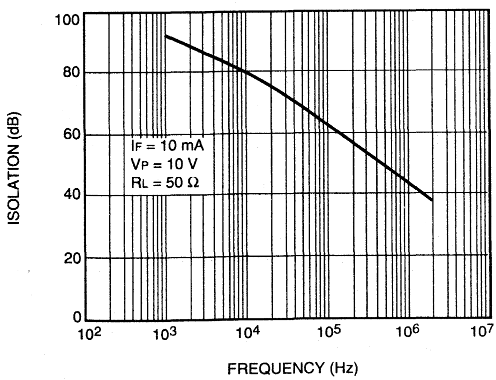
D. ON-Resistance vs. Temperature



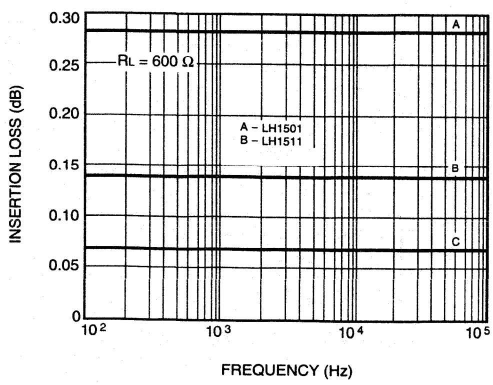
E. Switch Capacitance vs. Applied Voltage



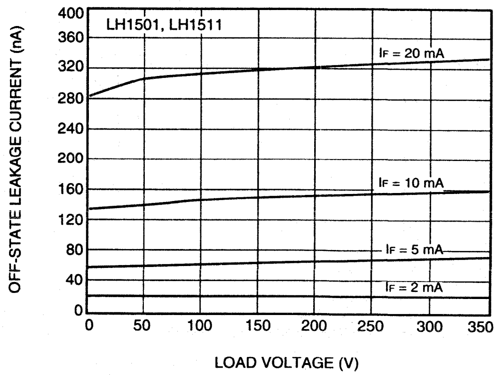
F. Output Isolation



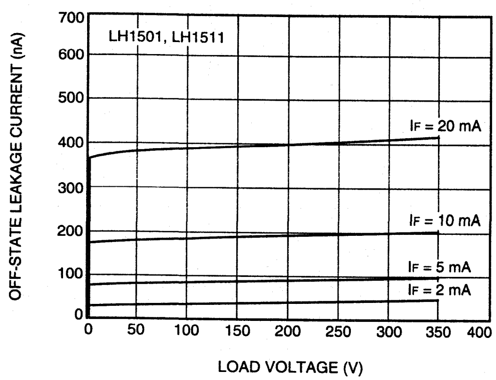
G. Insertion Loss vs. Frequency



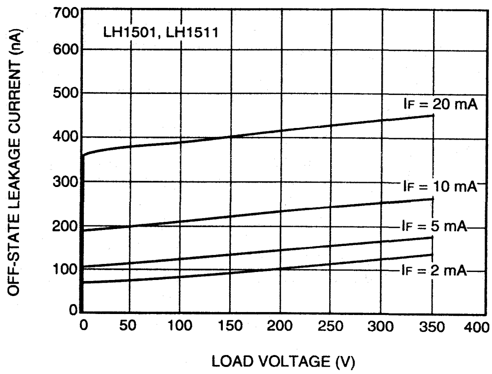
H. Leakage Current vs. Applied Voltage @ 25°C



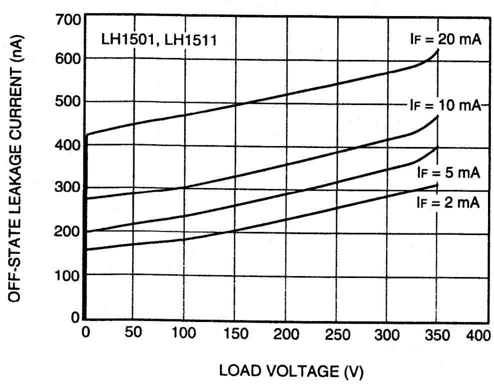
I. Leakage Current vs. Applied Voltage @ 50°C



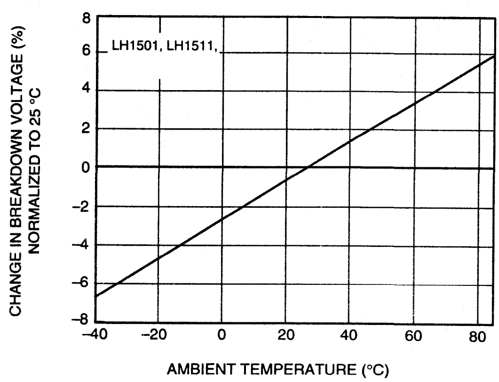
J. Leakage Current vs. Applied Voltage @ 70°C



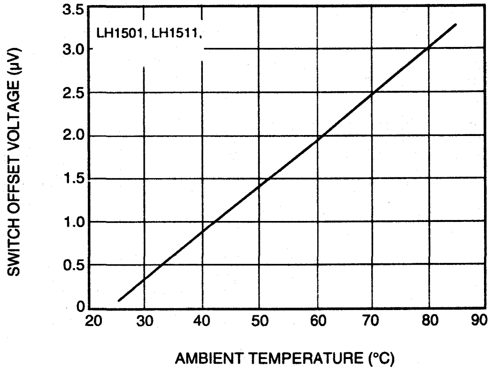
K. Leakage Current vs. Applied Voltage @ 85°C



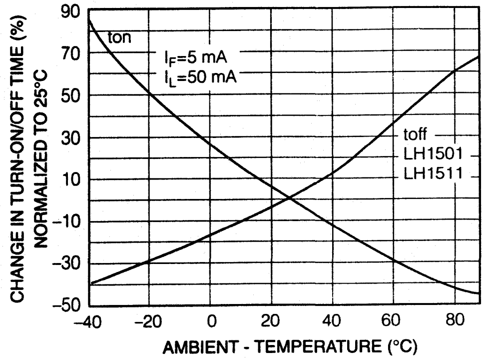
L. Switch Breakdown Voltage vs. Temperature



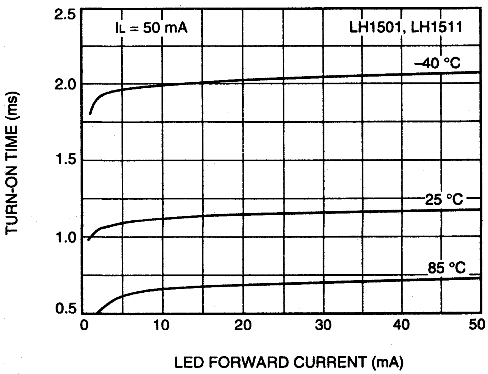
M. Switch Offset Voltage vs. Temperature



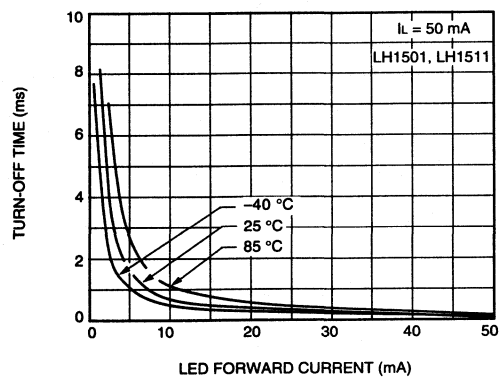
N. Turn-On/Off vs. Temperature



O. Turn-On Time vs. LED Current



P. Turn-Off Time vs. LED Current



LH1521, LH1523

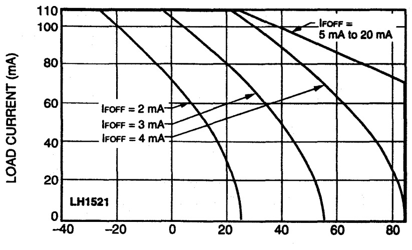
Dual 1 Form B

Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

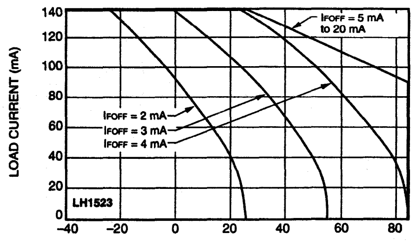
Parameter	Symbol	Test Conditions	LH1521	LH1523	Units
Ambient Operating Temperature Range	T_A	—	–40 to +85	–40 to +85	°C
Storage Temperature Range	T_{stg}	—	–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max	260	260	°C
Input/Output Isolation Test Voltage	V_{ISO}	Vrms t=1 s I_{ISO}=10 µA max	5300	5300	Vrms
Pole-to-Pole Isolation Voltage* (S1 to S2)	—	Dry air, dust free, at sea level	1600	1600	V
LED Continuous Forward Current	I_F	—	50	50	mA
LED Reverse Voltage	V_R	$I_R \leq$ 10 µA	8	8	V
dc or Peak ac Load Voltage	V_L	$I_L \leq$ 50 µA	350	200	V
Continuous dc Load Current One Pole Operating Two Poles Operating	I_L	—	 150 110	 200 140	 mA mA
Peak Load Current	I_P	t=100 ms (single shot)	400	600	mA
Output Power Dissipation (continuous)	P_{DISS}	—	600	600	mW

* Breakdown occurs between the output pins external to the package.

Recommended Operating Conditions



Both relays on with equal load currents. For a single relay operation, refer to LH1501 Recommended Operating Conditions graph.



Both relays on with equal load currents. For a single relay operation, refer to LH1511 Recommended Operating Conditions graph.

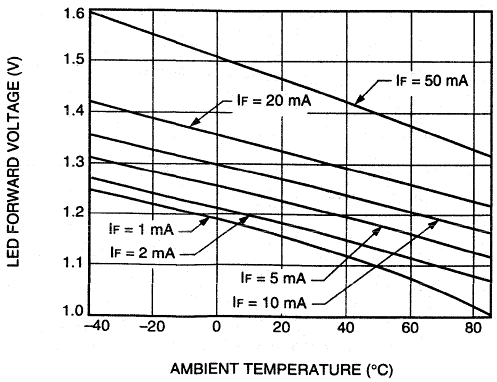
Solid State Relays 6

Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

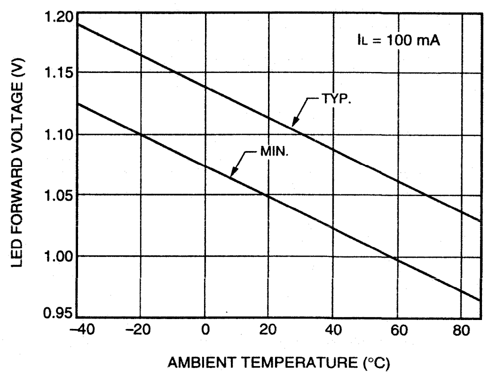
	Parameter	Symbol	Test Conditions	Values	LH1521	LH1523	Units
INPUT	LED Forward Current for Switch Turn-off	I_{Foff}	—	Min	—	—	mA
				Typ	1.0	1.0	mA
				Max	2.0	2.0	mA
			V_L	±	300	150	V
	LED Forward Current for Switch Turn-on	I_{Fon}	t=10 ms	Min	0.2	0.2	mA
				Typ	0.9	0.9	mA
				Max	—	—	mA
			I_L	±	150	200	mA
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	V
				Typ	1.22	1.22	V
				Max	1.45	1.45	V
OUTPUT	ON-resistance	R_{ON}	I_F=0 mA I_L=50 mA	Min	12	6	Ω
				Typ	20	10	Ω
				Max	25	15	Ω
	OFF-resistance	R_{OFF}	I_F=5 mA V_L=±100 V	Min	0.1	0.1	GΩ
				Typ	1.4	1.4	GΩ
				Max	—	—	GΩ
	Off-state Leakage Current	—	I_F=5 mA V_L=±100 V	Min	—	—	µA
				Typ	0.07	0.07	µA
				Max	1.0	1.0	µA
			I_F=5 mA	Min	—	—	µA
				Typ	0.08	0.07	µA
				Max	1.0	1.0	µA
			V_L	±	350	200	V
	Output Capacitance	—	I_F=5 mA V_L=1 V	Min	—	—	pF
				Typ	35	45	pF
				Max	—	—	pF
			I_F=5 mA V_L=50 V	Min	—	—	pF
				Typ	10	15	pF
				Max	—	—	pF
	Pole-to-pole Capacitance	—	I_F=0 mA	Min	—	—	pF
				Typ	0.5	0.5	pF
				Max	—	—	pF
	Switch Offset	—	I_F=0 mA	Min	—	—	µV
				Typ	0.1	0.1	µV
				Max	—	—	µV
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	pF
				Typ	1.1	1.1	pF
				Max	—	—	pF
	Turn-off Time	t_{off}	I_F=5 mA I_L=50 mA	Min	—	—	ms
				Typ	2.0	1.0*	ms
				Max	3.0	3.0*	ms
	Turn-on Time	t_{on}	I_F=5 mA I_L=50 mA	Min	—	—	ms
				Typ	1.0	1.2*	ms
				Max	3.0	3.0*	ms

* I_F=10 mA.

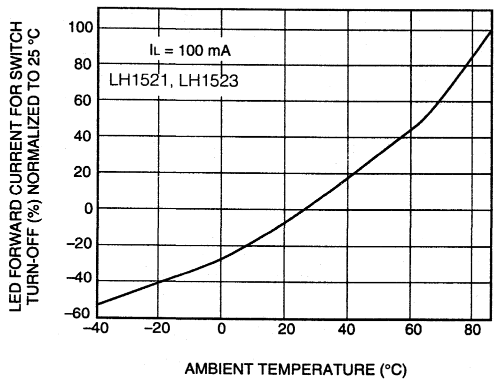
A. LED Voltage vs. Temperature



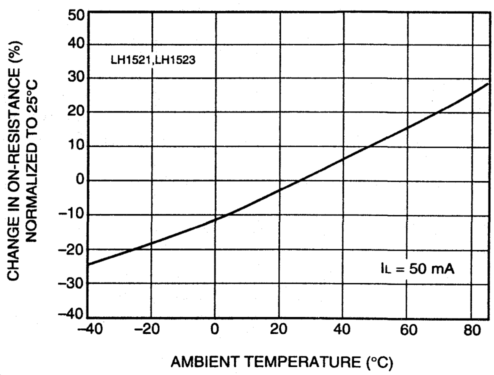
B. LED Dropout Voltage vs. Temperature



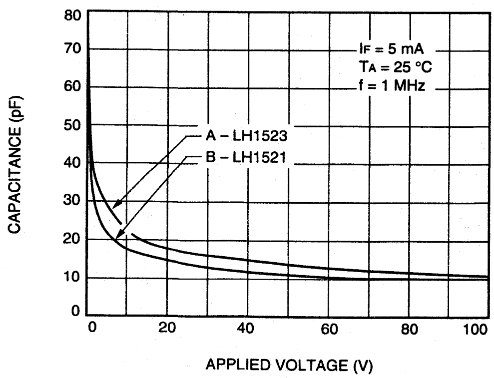
C. LED Current for Switch Turn-Off vs. Temperature



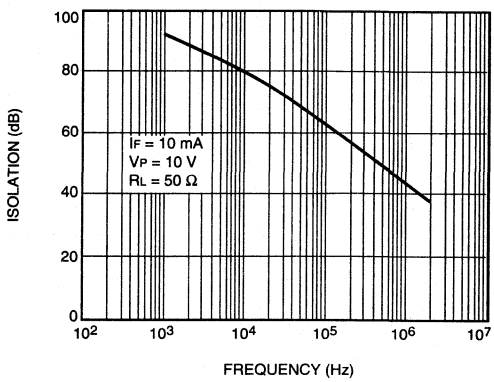
D. ON-Resistance vs. Temperature



E. Switch Capacitance vs. Applied Voltage

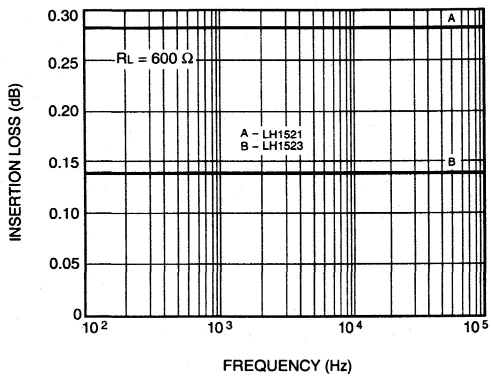


F. Output Isolation

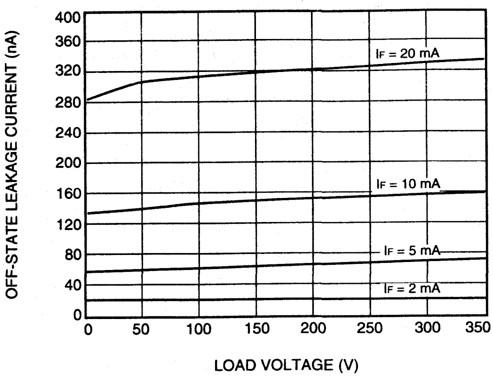


Solid State Relays
6

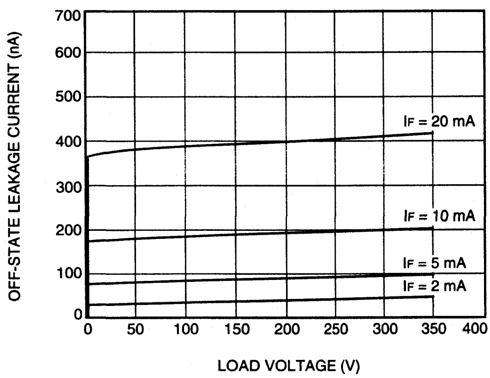
A. Insertion Loss vs. Frequency



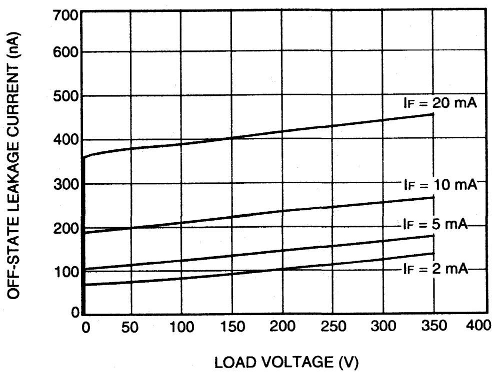
B. Leakage Current vs. Applied Voltage @ 25°C



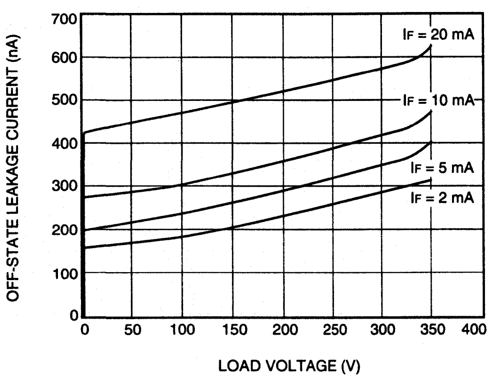
C. Leakage Current vs. Applied Voltage @ 50°C



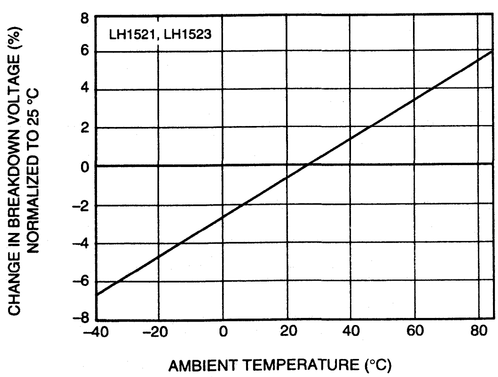
D. Leakage Current vs. Applied Voltage @ 70°C



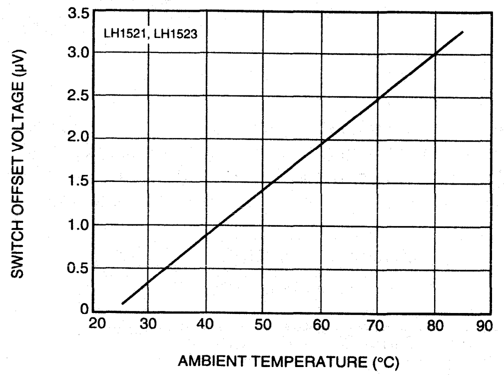
E. Leakage Current vs. Applied Voltage @ 85°C



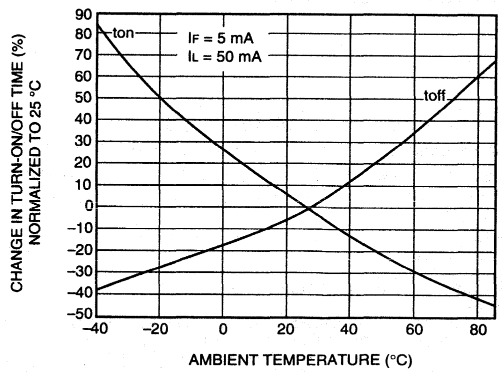
F. Switch Breakdown Voltage vs. Temperature



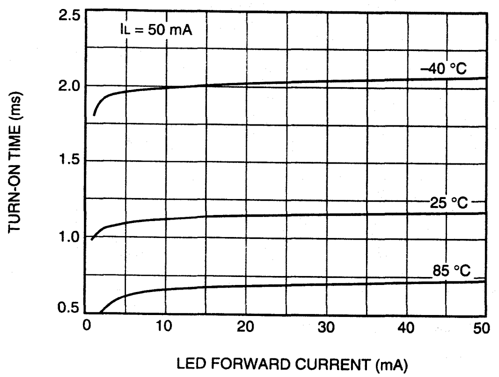
A. Switch Offset Voltage vs. Temperature



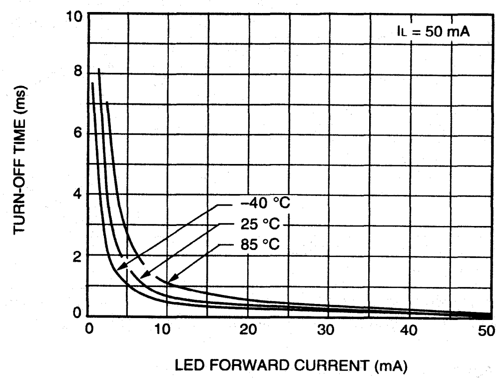
B. Turn-On/Off Time vs. Temperature



C. Turn-On Time vs. LED Current



D. Turn-Off Time vs. LED Current



SIEMENS

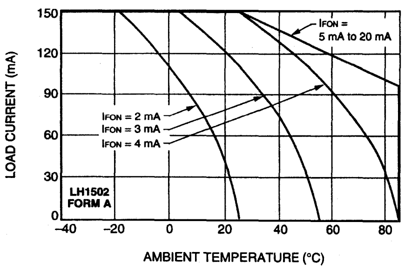
LH1502, LH1512
1 Form A/B, C

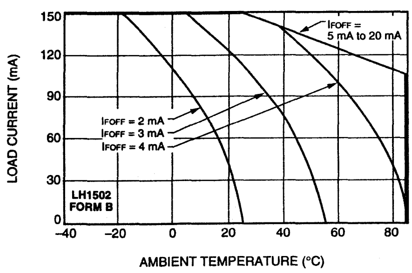
Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

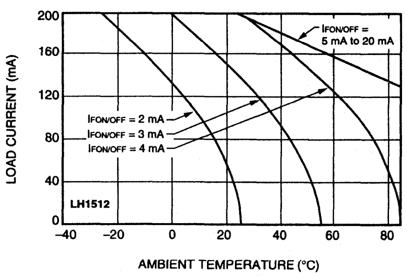
Parameter	Symbol	Test Conditions		LH1502	LH1512	Units
Ambient Operating Temperature Range	T_A	—		–40 to +85	–40 to +85	°C
Storage Temperature Range	T_{stg}	—		–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max		260	260	°C
Input/Output Isolation Test Voltage	V_{ISO}	t=1 s I_{ISO}=10 µA max		5300	5300	Vrms
Pole-to-Pole Isolation Voltage* (S1 to S2)	—	Dry air, dust free, at sea level		1600	1600	V
LED Continuous Forward Current	I_F	—		50	50	mA
LED Reverse Voltage	V_R	$I_R \leq$ 10 µA		8	8	V
dc or Peak ac Load Voltage	V_L	$I_L \leq$ 50 µA		350	200	V
Continuous dc Load Current (Form C operation)	I_L	—		150	200	mA
Peak Load Current	I_P	t=100 ms	Form A	†	†	mA
		(single shot)	Form B	400	600	mA
Output Power Dissipation (continuous)	P_{DISS}	—		600	600	mW

* Breakdown occurs between the output pins external to the package.
† Refer to Current-Limit Performance application note for a discussion on relay operation during transient currents.

Recommended Operating Conditions







Electrical Characteristics T_A=25°C

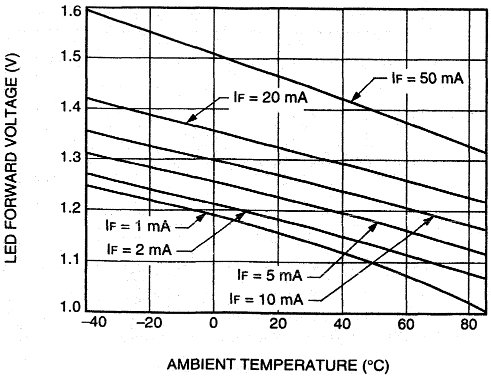
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirement.

	Parameter	Symbol	Test Condition	Values	LH1502	LH1512	Units
INPUT	LED Forward Current for Switch Turn-on (NO)	I_{Fon}	I_L=100 mA t=10 ms	Min	—	—	mA
				Typ	0.6	0.6	mA
				Max	2.0	2.0	mA
	LED Forward Current for Switch Turn-off (NO)	I_{Foff}	—	Min	0.2	0.2	mA
				Typ	0.5	0.5	mA
				Max	—	—	mA
			V_L	±	300	150	V
	LED Forward Current for Switch Turn-on (NC)	I_{Fon}	I_L=100 mA t=10 ms	Min	0.2	0.2	mA
				Typ	0.9	0.9	mA
				Max	—	—	mA
	LED Forward Current for Switch Turn-off (NC)	I_{Foff}	—	Min	—	—	mA
				Typ	1.0	1.0	mA
				Max	2.0	2.0	mA
			V_L	±	300	150	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	V
				Typ	1.26	1.26	V
				Max	1.45	1.45	V
OUTPUT	ON-resistance: (NO, NC)	R_{ON}	I_F=5 mA (NO), 0 mA (NC) I_L=50 mA (NC)	Min	12	6	Ω
				Typ	20	10	Ω
				Max	25	15	Ω
	OFF-resistance (NO)	R_{OFF}	I_F=0 mA V_L=±100 V	Min	0.5	0.5	GΩ
				Typ	5000	5000	GΩ
				Max	—	—	GΩ
	(NC)		I_F=5 mA V_L=±100 V	Min	0.1	0.1	GΩ
				Typ	1.4	1.4	GΩ
				Max	—	—	GΩ
	Current Limit (NO)	I_{LMT}	I_F=5 mA t=5 ms	Min	230	300	mA
				Typ	270	360	mA
				Max	370	460	mA
			V_L	±	6	5	V
	Off-state Leakage Current (NO)	—	I_F=0 mA V_L=±100 V	Min	—	—	nA
				Typ	0.02	0.02	nA
				Max	200	200	nA
	(NC)		I_F=5 mA V_L=±100 V	Min	—	—	µA
				Typ	0.07	0.07	µA
				Max	1.0	1.0	µA
	(NO, NC)		I_F=0 mA (NO) I_F=5 mA (NC)	Min	—	—	µA
				Typ	—	—	µA
				Max	1.0	1.0	µA
			V_L	±	350	200	V
	Output Capacitance (NO)		I_F=0 mA V_L=1 V	Min	—	—	pF
				Typ	55	60	pF
				Max	—	—	pF
			I_F=0 mA V_L=50 V	Min	—	—	pF
				Typ	10	15	pF
				Max	—	—	pF
	(NC)		I_F=5 mA V_L=1 V	Min	—	—	pF
				Typ	35	45	pF
				Max	—	—	pF
			I_F=5 mA V_L=50 V	Min	—	—	pF
				Typ	10	15	pF
				Max	—	—	pF
	Pole-to-pole Capacitance (S1 to S2)		I_F=0 mA	Min	—	—	pF
				Typ	0.5	0.5	pF
				Max	—	—	pF
	Switch Offset (NO)		I_F=5 mA (NO) I_F=5 mA (NC)	Min	—	—	µV
				Typ	0.15	0.15	µV
				Max	—	—	µV
	Switch Offset (NC)		I_F=0 mA (NC) I_F=5 mA (NO)	Min	—	—	µV
				Typ	0.1	0.1	µV
				Max	—	—	µV

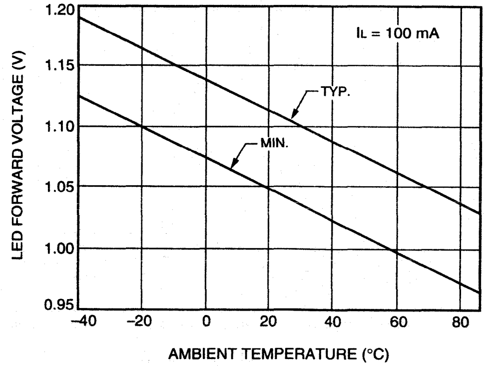
6 Solid State Relays

	Parameter	Symbol	Test Condition	Values	LH1502	LH1512	Units
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	pF
				Typ	1.1	1.1	pF
				Max	—	—	pF
	Turn-on Time (NO)	t_{on}	I_F=10 mA, I_L=50 mA	Min	NA	—	ms
				Typ	NA	1.4	ms
				Max	NA	3.0	ms
	Turn-on Time (NC)	t_{on}	I_F=10 mA, I_L=50 mA	Min	NA	—	ms
				Typ	NA	1.2	ms
				Max	NA	3.0	ms
	Turn-off Time (NO)	t_{off}	I_F=10 mA, I_L=50 mA	Min	NA	—	ms
				Typ	NA	0.7	ms
				Max	NA	3.0	ms
	Turn-off Time (NC)	t_{off}	I_F=10 mA, I_L=50 mA	Min	NA	—	ms
				Typ	NA	2.0	ms
				Max	NA	3.0	ms
	Turn-on Time (NO)	t_{on}	I_F=10 mA, I_L=37.5 mA, V_L=150 V	Min	1.0	NA	ms
				Typ	3.2	NA	ms
				Max	6.0	NA	ms
	Turn-on Time (NC)	t_{on}	I_F=10 mA, I_L=37.5 mA, V_L=150 V	Min	1.0	NA	ms
				Typ	3.8	NA	ms
				Max	6.0	NA	ms
	Turn-off Time (NO)	t_{off}	I_F=10 mA, I_L=37.5 mA, V_L=150 V	Min	—	NA	ms
				Typ	1.6	NA	ms
				Max	3.0	NA	ms
	Turn-off Time (NC)	t_{off}	I_F=10 mA, I_L=37.5 mA, V_L=150 V	Min	—	NA	ms
				Typ	0.8	NA	ms
				Max	3.0	NA	ms
	Transfer OFF Time (NC off to NO on)	ttfr	I_F=10 mA, I_L=37.5 mA, V_L=150 V	Min	0	NA	µs
				Typ	800	NA	µs
				Max	—	NA	µs
	Transfer OFF Time (NO off to NC on)	ttfr	I_F=10 mA, I_L=37.5 mA, V_L=150 V	Min	0	NA	µs
				Typ	1500	NA	µs
				Max	—	NA	µs

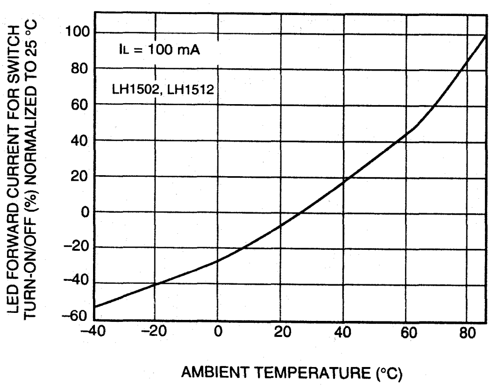
A. LED Voltage vs. Temperature



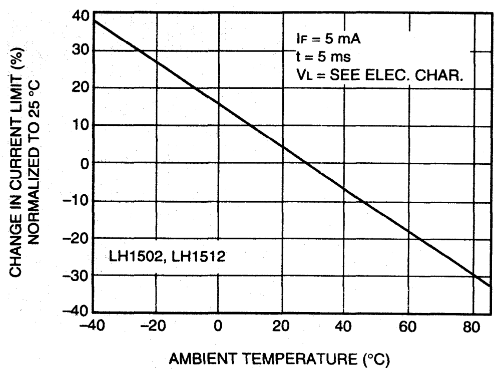
B. LED Dropout Voltage vs. Temperature



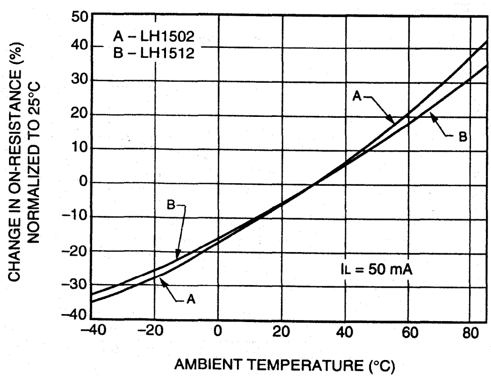
C. LED Current for Switch Turn-Off vs. Temperature



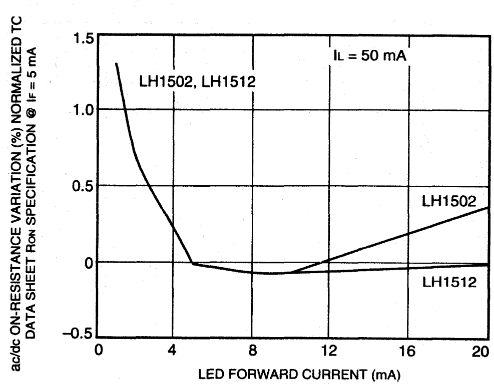
D. Current Limit vs. Temperature



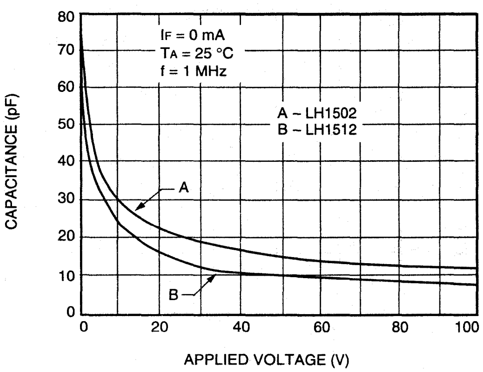
E. ON-Resistance vs. Temperature



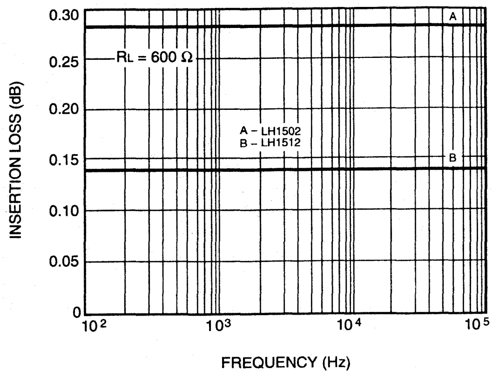
F. Variation in ON-Resistance vs. LED Current



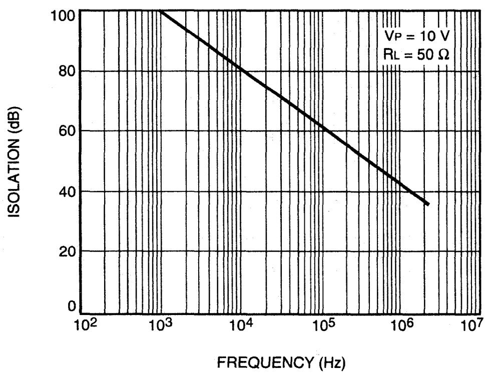
A. Switch Capacitance vs. Applied Voltage



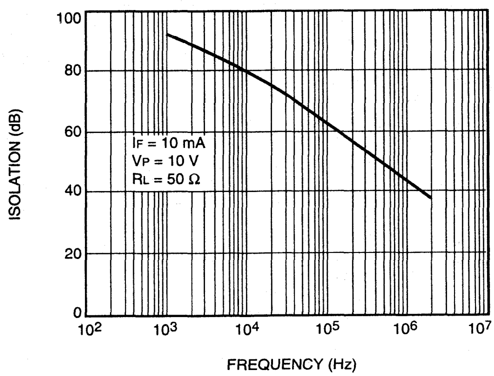
B. Insertion Loss vs. Frequency



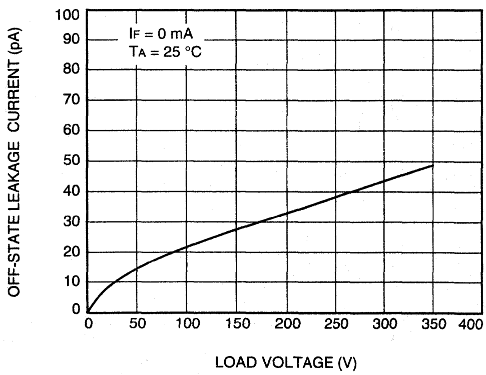
C. NO Output Isolation



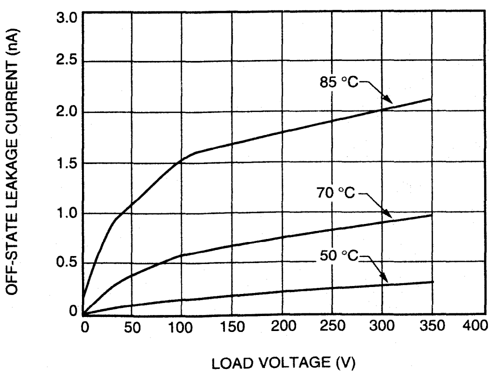
D. NC Output Isolation



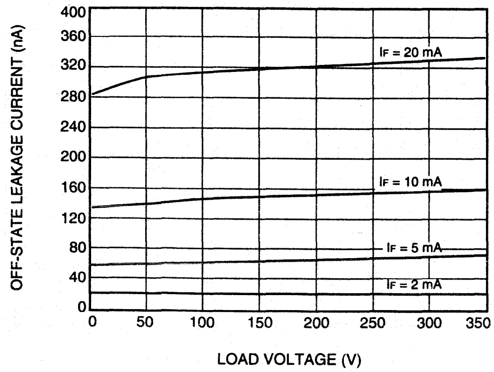
E. NO Leakage Current vs. Applied Voltage



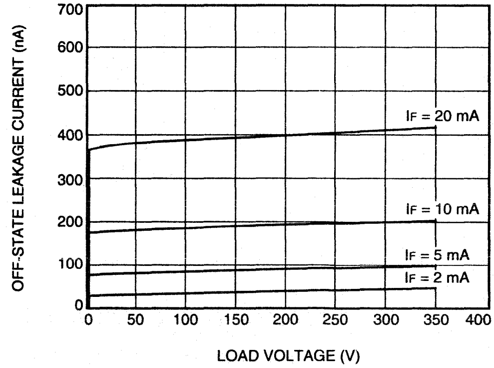
F. NO Leakage Current vs Applied Voltage @ Elevated Temperatures



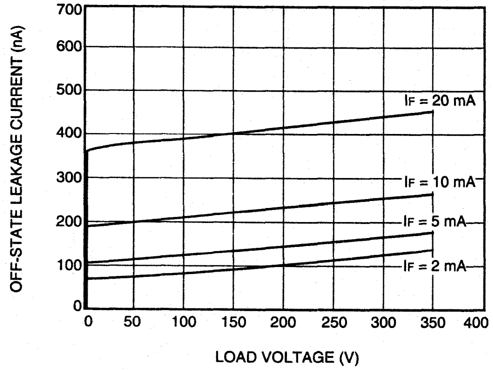
A. NC Leakage Current vs. Applied voltage @ 25°C



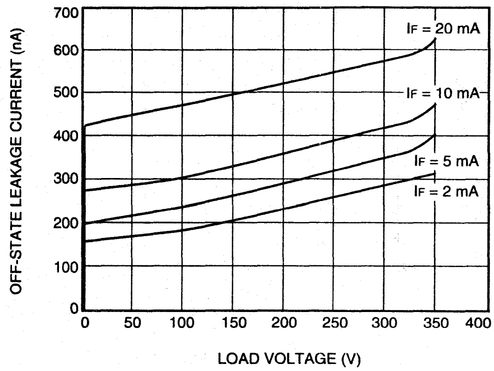
B. NC Leakage Current vs. Applied voltage @ 50°C



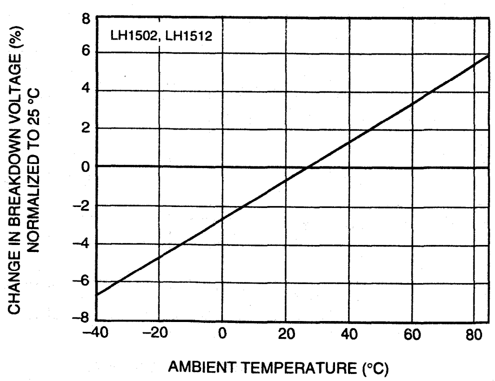
C. NC Leakage Current vs. Applied voltage @ 70°C



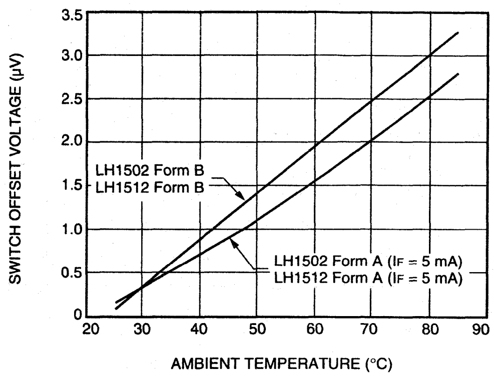
D. NC Leakage Current vs. Applied voltage @ 85°C



E. Switch Breakdown Voltage vs. Temperature

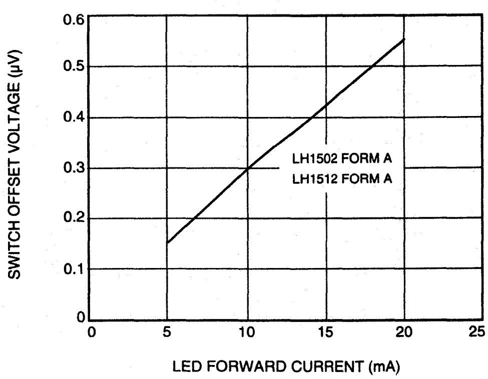


F. Switch Offset Voltage vs. Temperature

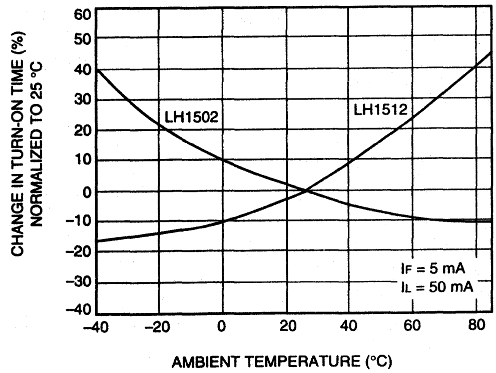


Solid State Relays 6

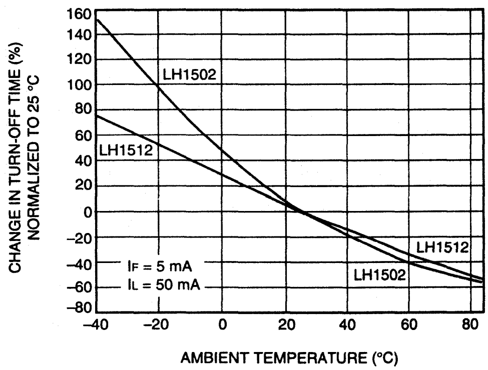
A. NO Switch Offset Voltage vs. LED Current



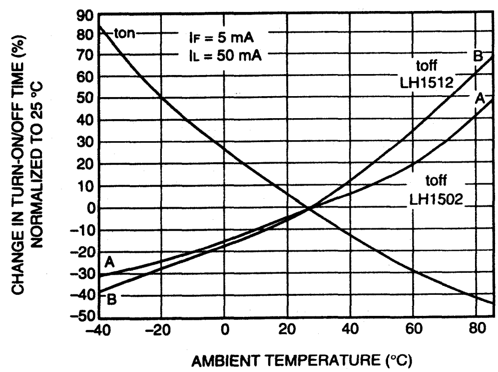
B. NO Turn-On Time vs. Temperature



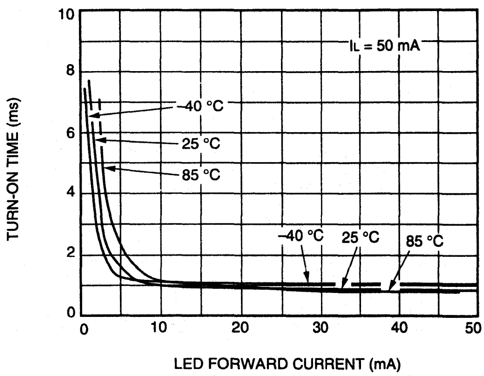
C. NO Turn-Off Time vs. Temperature



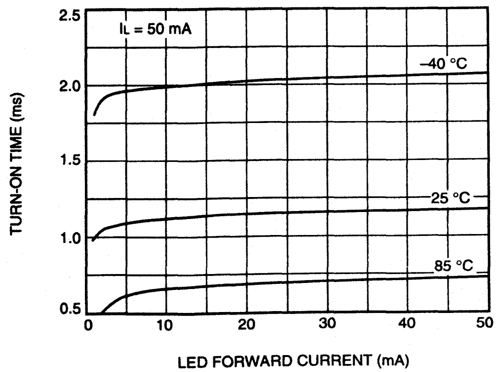
D. NC Turn-On/Off Time vs. Temperature



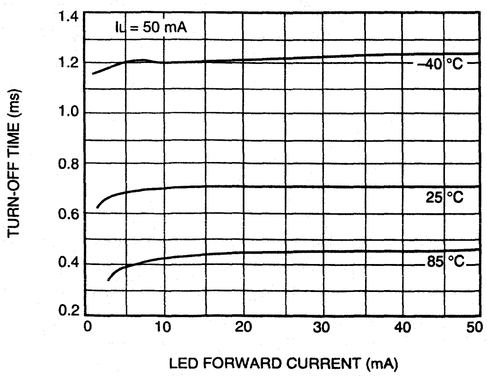
E. NO Turn-On Time vs. LED Current (LH1512)



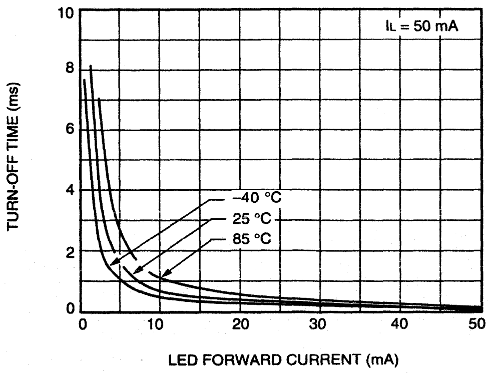
F. NC Turn-On Time vs. LED Current (LH1512)



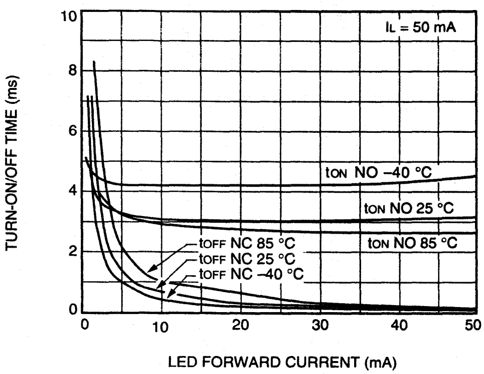
A. NO Turn-Off Time vs. LED Current (LH1512)



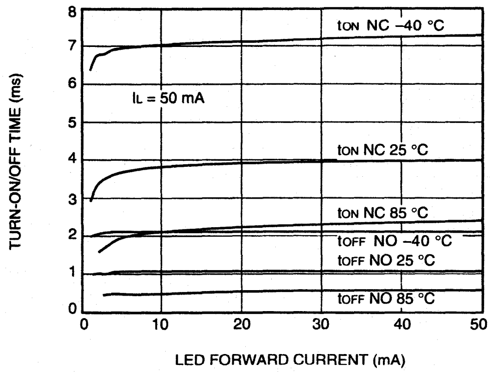
B. NC Turn-Off Time vs. LED Current (LH1512)



C. NC Turn-Off and NO Turn-ON Time vs. LED Current (LH1502)



D. NO Turn-Off and NC Turn-ON Time vs. LED Current (LH1502)



SIEMENS

LH1527, LH1537

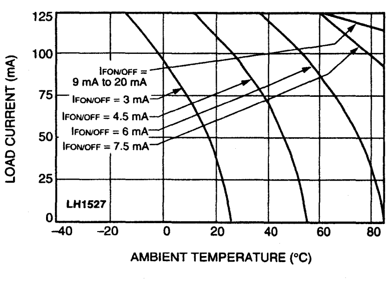
1 Form C

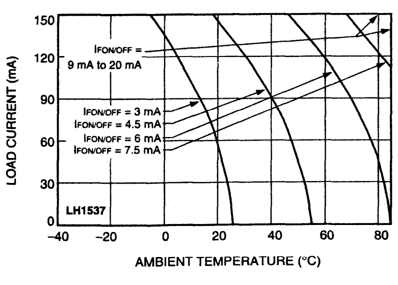
Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

Parameter	Symbol	Test Conditions	LH1527	LH1537	Units
Ambient Operating Temperature Range	T_A	—	–40 to +85	–40 to +85	°C
Storage Temperature Range	T_{stg}	—	–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max	260	260	°C
Input/Output Isolation Voltage	V_{ISO}	—	3750	3750	Vrms
Pole-to-Pole Isolation Voltage* (S1 to S2)	—	Dry air, dust free, at sea level	1600	1600	V
LED Continuous Forward Current	I_F	—	50	50	mA
LED Reverse Voltage	V_R	$I_R \leq 10\ \mu A$	8	8	V
dc or Peak ac Load Voltage	V_L	$I_L \leq 50\ \mu A$	350	250	V
Continuous dc Load Current (Form C Operation)	I_L	—	125	150	mA
Peak Load Current	I_P	t=100 ms (single shot)	350	500	mA
Output Power Dissipation (continuous)	P_{DISS}	—			
6-Pin Package			500	500	mW
8-Pin Package			600	600	mW

* Breakdown occurs between the output pins external to the package.

Recommended Operating Conditions





Electrical Characteristics T_A=25°C

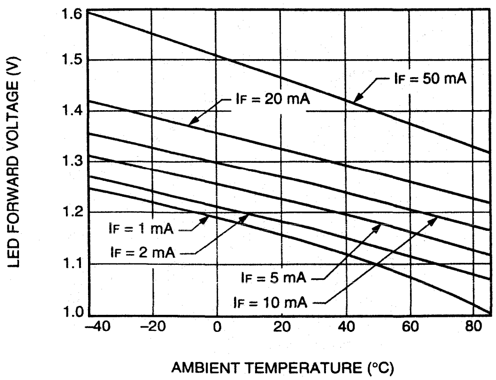
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

	Parameter	Symbol	Test Condition	Values	LH1527	LH1537	Units
INPUT	LED Forward Current for Switch Turn-on (NO)	I_{Fon}	I_L=100 mA t=10 ms	Min	—	—	mA
				Typ	2.0	2.0	mA
				Max	3.0	3.0	mA
	LED Forward Current for Switch Turn-off (NO)	I_{Foff}	—	Min	0.2	0.2	mA
				Typ	1.0	1.0	mA
				Max	—	—	mA
			V_L	±	300	200	V
	LED Forward Current for Switch Turn-on (NC)	I_{Fon}	I_L=100 mA t=10 ms	Min	0.2	0.2	mA
				Typ	0.6	0.6	mA
				Max	—	—	mA
	LED Forward Current for Switch Turn-off (NC)	I_{Foff}	—	Min	—	—	mA
				Typ	0.7	0.7	mA
				Max	3.0	3.0	mA
			V_L	±	300	200	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	V
				Typ	1.26	1.26	V
				Max	1.45	1.45	V
OUTPUT	ON-resistance: (NO, NC)	R_{ON}	I_F=5 mA (NO), 0 mA (NC) I_L=50 mA (NC)	Min	17*	8	Ω
				Typ	25*	12	Ω
				Max	33*	16	Ω
	OFF-resistance (NO)	R_{OFF}	I_F=0 mA V_L=±100 V	Min	0.5	0.5	GΩ
				Typ	600	600	GΩ
				Max	—	—	GΩ
	(NC)		I_F=5 mA V_L=±100 V	Min	0.1	0.1	GΩ
				Typ	5.0	5.0	GΩ
				Max	—	—	GΩ
	Off-state Leakage Current (NO)	—	I_F=0 mA V_L=±100 V	Min	—	—	nA
				Typ	0.17	0.17	nA
				Max	200	200	nA
	(NC)		I_F=5 mA V_L=±100 V	Min	—	—	µA
				Typ	0.02	0.02	µA
				Max	1.0	1.0	µA
	(NO, NC)		I_F=0 mA (NO) I_F=5 mA (NC)	Min	—	—	µA
				Typ	—	—	µA
				Max	1.0	1.0	µA
			V_L	±	350	250	V
	Output Capacitance (NO)	—	I_F=0 mA V_L=1 V	Min	—	—	pF
				Typ	55	60	pF
				Max	—	—	pF
			I_F=0 mA V_L=50 V	Min	—	—	pF
				Typ	10	15	pF
				Max	—	—	pF
	(NC)		I_F=5 mA V_L=1 V	Min	—	—	pF
				Typ	35	45	pF
				Max	—	—	pF
			I_F=5 mA V_L=50 V	Min	—	—	pF
				Typ	10	15	pF
				Max	—	—	pF

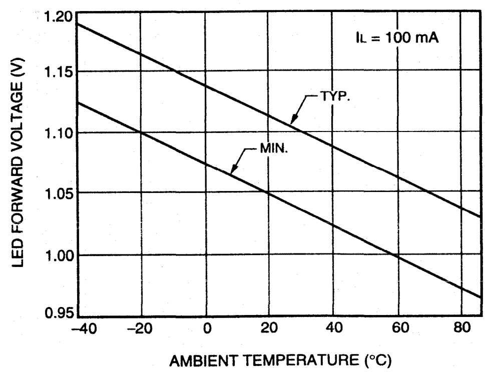
	Parameter	Symbol	Test Condition	Values	LH1527	LH1537	Units
OUTPUT	Pole-to-pole Capacitance (S1 to S2)	—	I_F=0 mA	Min	—	—	pF
				Typ	0.5	0.5	pF
				Max	—	—	pF
	Switch Offset (NO)	—	I_F=5 mA (NO) I_F=5 mA (NC)	Min	—	—	µV
				Typ	0.15	0.15	µV
				Max	—	—	µV
	Switch Offset (NC)		I_F=0 mA (NC) I_F=5 mA (NO)	Min	—	—	µV
				Typ	0.1	0.1	µV
				Max	—	—	µV
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	pF
				Typ	1.1	1.1	pF
				Max	—	—	pF
	Turn-on Time (NO)	t_{on}	I_F=10 mA I_L=37.5 mA V_L=150 V*	Min	0.5	0.5	ms
				Typ	3.1	3.1	ms
				Max	4.5	4.5	ms
	Turn-on Time (NC)	t_{on}	I_F=6 mA I_L=100 mA V_L=50 V*	Min	0.5	0.5	ms
				Typ	2.3	2.3	ms
				Max	4.5	4.5	ms
	Turn-off Time (NO)	t_{off}	I_F=1 mA I_L=37.5 mA V_L=STC V*	Min	—	—	ms
				Typ	1.2	1.2	ms
				Max	4.5	4.5	ms
	Turn-off Time (NC)	t_{off}	I_F=10 mA I_L=37.5 mA V_L=150 V*	Min	—	—	ms
				Typ	1.6	1.6	ms
				Max	4.5	4.5	ms
	Transfer OFF Time (NC off to NO on)	ttfr	I_F=10 mA I_L=37.5 mA V_L=150 V*	Min	0	0	ms
				Typ	0.6	0.6	ms
				Max	—	—	ms

* Single application.

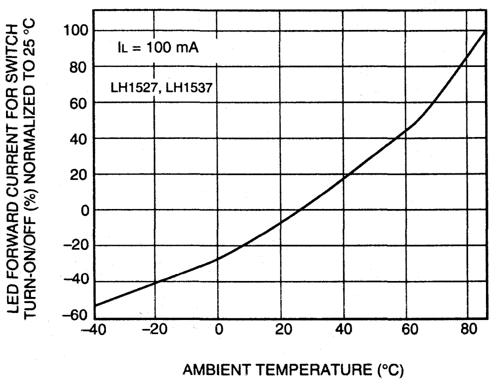
A. LED Voltage vs. Temperature



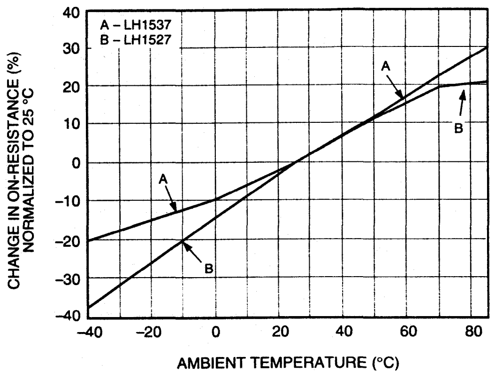
B. LED Dropout Voltage vs. Temperature



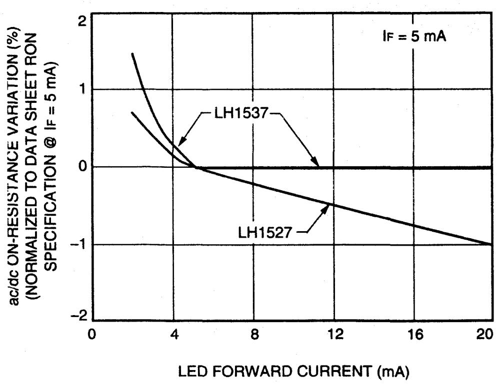
C. LED Current for Switch Turn-Off vs. Temperature



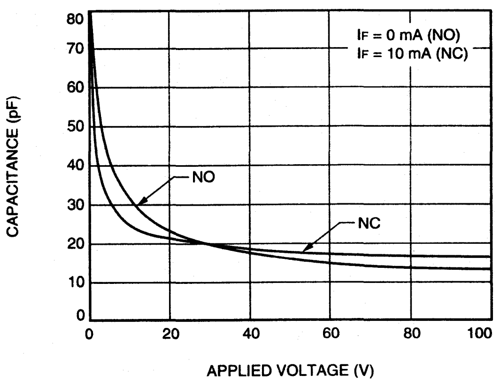
D. ON-Resistance vs. Temperature



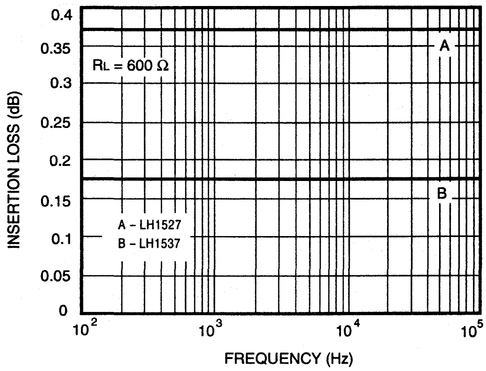
E. Variation in ON-Resistance vs. LED Current



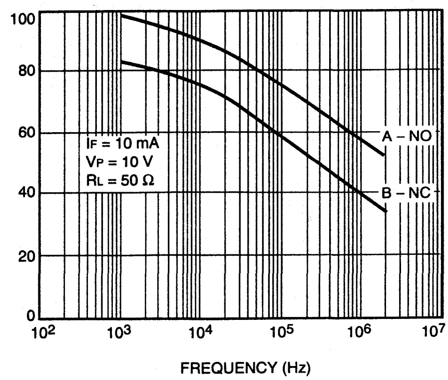
F. Switch Capacitance vs. Applied Voltage



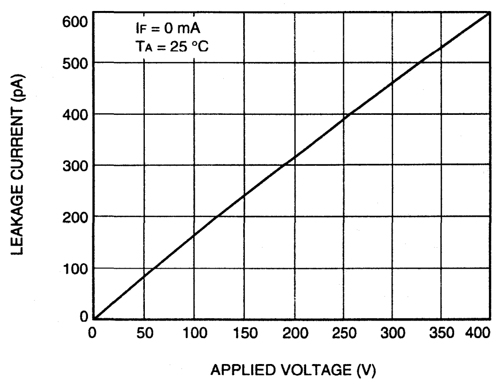
A. Insertion Loss vs. Frequency



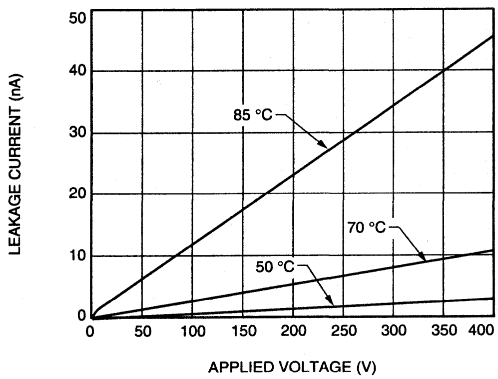
B. Output Isolation



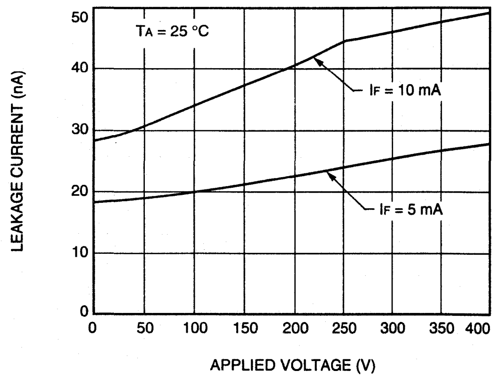
C. Leakage Current vs. Applied Voltage (NO)



D. Leakage Current vs. Applied Voltage at Elevated Temperatures (NO)

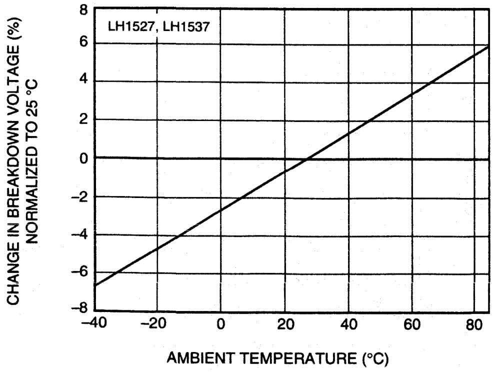


E. Leakage Current vs. Applied Voltage (NC)

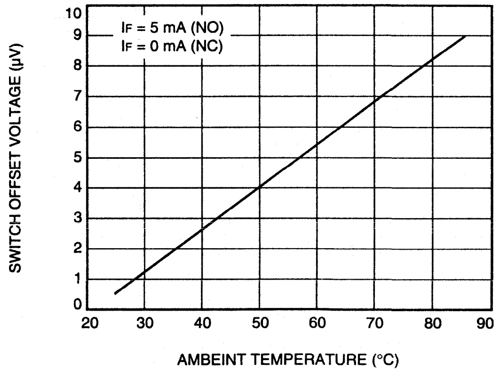


F. Leakage Current vs. Applied Voltage at Elevated Temperatures (NC)

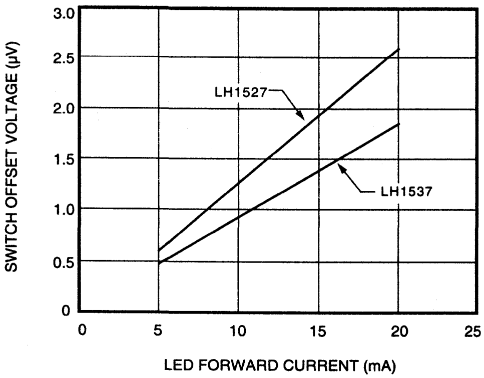
A. Switch Breakdown Voltage vs. Temperature



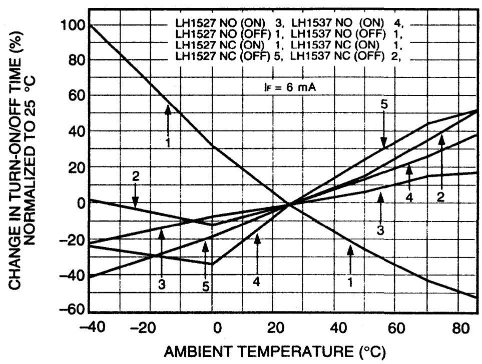
B. Switch Offset Voltage vs. Temperature



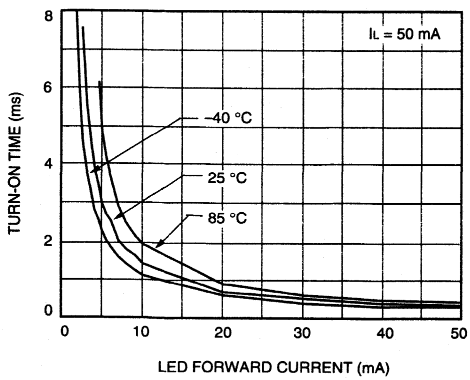
C. Switch Offset Voltage vs. LED Current



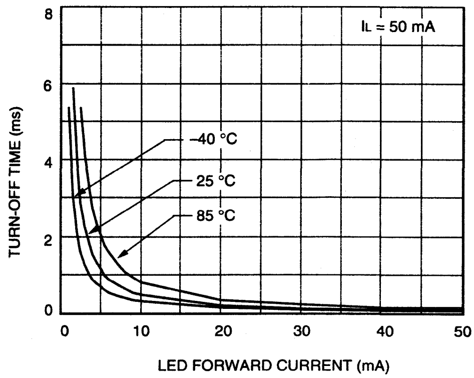
D. t_{on}/t_{off} vs. Temperature



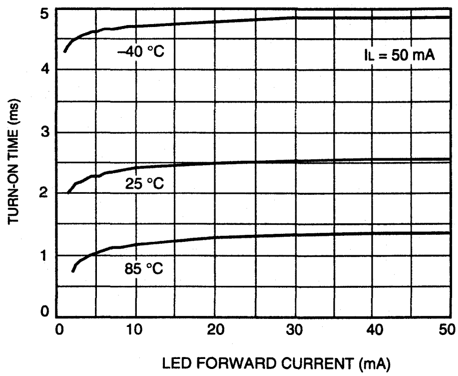
E. NO Turn-On Time vs. LED Current



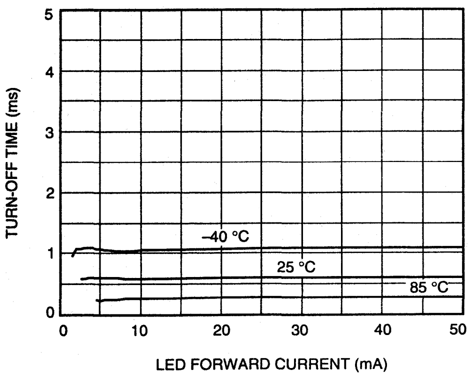
F. NC Turn-Off Time vs. LED Current



A. NC Turn-On Time vs. LED Current



B. NO Turn-Off Time vs. LED Current



- Very low operating current

SIEMENS

LH1525ACD, LH1526ACE

1 Form A, Dual 1 Form A SOP Solid-State Relays

FEATURES
- High-speed operation
- 1500 Vrms I/O isolation
- Current-limit protection
- High surge capability
- Linear, ac/dc operation
- Clean, bounce-free switching
- Extremely low power consumption
- High-reliability monolithic receptor
- Surface-mountable

APPLICATIONS
- PCMCIA Type 2 cards
- Battery powered switch applications
- General telecom switching
- Telephone line interface
  - On/off hook
  - Ring relay
  - Ground start
- Programmable controllers
- Instrumentation

DESCRIPTION
The LH1525 and LH1526 relays are SPST normally open switches (1 Form A and Dual 1 Form A respectively) in small-outline packages (SOP). They require a minimal amount of LED drive current to operate, making them ideal for battery powered and power consumption sensitive applications.

The relays are constructed using a GaAlAs LED for actuation control and an integrated monolithic die for the switch output. The die, fabricated in a high-voltage dielectrically isolated BCDMOS technology, is comprised of a photodiode array, switch-control circuitry, and MOSFET switches. In addition, the relays employ current-limiting circuitry enabling it to pass FCC 68.302 and other regulatory surge requirements when overvoltage protection is provided.

The LH1525 (1 Form A) is packaged in an 8-pin, plastic SOP (LH1525ACD). The LH1526 (Dual 1 Form A) is packaged in an 18-pin plastic SOP (LH1526ACE). Both devices are available in sticks or on tape and reel.

Figure 1. LH1525ACD Functional/Pin Diagram

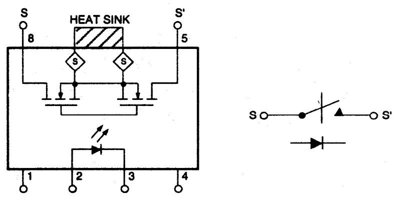
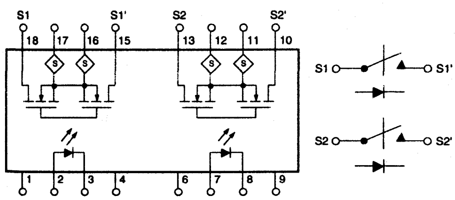


Figure 2. LH1526ACE Functional/Pin Diagram

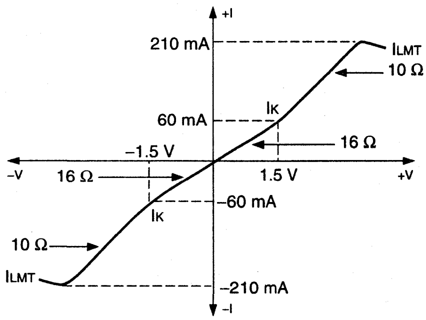


Solid State Relays 6

Functional Description

Figure 3 shows the switch characteristics of the relays. The relay exhibits an ON-resistance that is exceptionally linear through the origin and up to the knee current (Ik). Beyond Ik, the incremental resistance decreases, minimizing internal power dissipation. Overload currents are clamped at ILMT by the internal current-limit circuitry. The current-limiting circuitry exhibits a negative temperature coefficient, thereby reducing the current-limit value when relay temperature is increased. An extended clamp condition, which increases relay temperature, decreases the current-limit value, resulting in a current foldback characteristic. When the overload is removed, the relay resumes its normal ON-resistance characteristic.

Figure 3. Typical ac/dc ON Characteristics



In a 1 Form A relay, to turn the relay on, forward current is applied to the LED. The amount of current applied determines the amount of light produced for the photodiode array. This photodiode array develops a drive-voltage for the MOSFET switch outputs. For high-temperature or high-load current operations, more LED current is required.

Thermal Considerations

To minimize thermal resistance, pins 6 and 7 of the LH1525ACD are formed into a tab. This tab should be soldered to a printed circuit board land pattern of equal or greater size. **Do Not** run metal underneath the device or the input-to-output isolation could be jeopardized. Likewise on the LH1526ACE, pins 11, 12, 16, and 17 should be soldered to a printed-circuit board land pattern of equal or greater size.

Absolute Maximum Ratings At 25°C

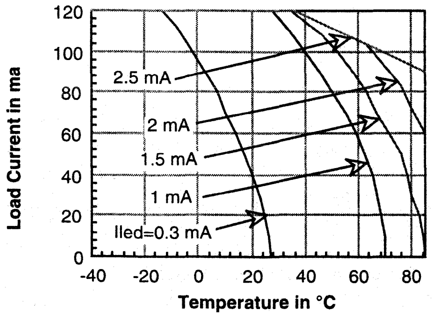
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect the device reliability.

Parameter	Symbol	Value	Unit
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C
Pin Soldering Temperature (t=5 s max.)	T_S	260	°C
Input/Output Isolation Voltage	V_{ISO}	1500	Vrms
LED Input Ratings:			
Continuous Forward Current	I_F	50	mA
Reverse Voltage	V_R	5	V
Output Operation:			
dc or Peak ac Load Voltage ($I_L \leq 50\ \mu A$)	V_L	400	V
Continuous dc Load Current:			
One pole operating	I_L	110	mA
Two poles operating (LH1526 only)	I_L	80	mA
Power Dissipation:			
LH1525	P_{DISS}	550	mW
LH1526	P_{DISS}	600	mW
Thermal Resistance, Junction to Ambient	RΘJA	120	C/W

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on (T_A=–40°C to +85°C)	I_{FON}	1.5	—	20	mA

Recommended Operating Conditions



Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on	I_{FON}	I_L=100 mA, t=10 ms	—	0.2	0.5	mA
LED Forward Current for Switch Turn-off	I_{FOFF}	V_L= ±350 V, t=100 ms	0.01	0.1	—	mA
LED Forward Voltage	V_F	I_F = 1.5 mA	0.80	1.15	1.40	V
ON-resistance: Pin 4 (±) to 6 (±)	R_{ON}	I_F=1.5 mA, I_L=±50 mA	17	25	33	Ω
Current Limit	I_{LMT}	I_F=1.5 mA, t=5 ms, V_L=7 V	170	210	270	mA
Output Off-state Leakage Current	—	I_F=0 mA, V_L=±100 V	—	0.04	200	nA
		V_L=±400 V	—	—	1.0	µA
Turn-on Time	t_{on}	I_F=1.5 mA, I_L=50 mA	—	1.0	—	ms
		I_F=5.0 mA, I_L=50 mA	—	0.3	1.0	ms
Turn-off Time	t_{off}	I_F=1.5 mA, I_L=50 mA	—	0.2	—	ms
		I_F=5.0 mA, I_L=50 mA	—	0.25	0.5	ms

SIEMENS

LH1533
Dual 1 Form A
High-Voltage Solid State Relays

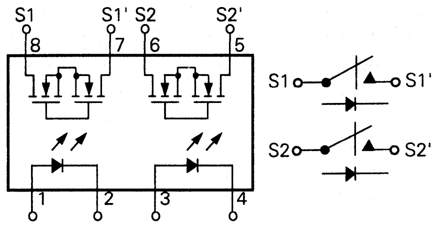
FEATURES
- Load voltage, 350 V
- Load current 70 mA
- TR_{ON}, typical at 100 mA
- 3750 Vrms I/O isolation
- Current-limit protection
- High-surge capability
- Linear, ac/dc or dc operation
- Clean, bounce-free switching
- Low power consumption
- High-reliability monolithic receptor
- Surface-mountable

APPLICATIONS
- General telecom switching
  - On/off-hook
  - Dial pulse
  - Ground start
  - Ground fault protection
- Instrumentation
- Industrial controls
- Peripherals

DESCRIPTION
The LH1533 (Dual 1 Form A) relays are SPST normally open switches that can replace electromechanical relays in many applications. The relays are constructed using a GaAlAs LED for actuation control and an integrated monolithic die for the switch output. The die, fabricated in a high-voltage dielectrically isolated BICMOS technology, is comprised of a photodiode array, switch control circuitry, and MOSFET switches. In addition, the relay employs current-limiting circuitry enabling it to pass FCC 68.302 and other regulatory voltage surge requirements when overvoltage protection is provided.

The LH1533 (Dual 1 Form A) relay is packaged in an 8-pin DIP (LH1533AB) or in a surface-mount, option 9 (LH1533AAC). The surface-mount devices are available in sticks or on tape and reel.

Figure 1. Functional Diagram



Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other condition in excess of those given in the operational sections of the data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect the device reliability.

Parameter	Symbol	Value	Unit
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–40 to +150	°C
Pin Soldering Temperature (t=10 s max.)	T_S	260	°C
Input/Output Isolation Test Voltage (t=1 sec)	V_{ISO}	5300	Vrms
LED Input Ratings:			
Continuous Forward Current	I_F	50	mA
Reverse Voltage (I_R≤10 µA)	V_R	5	V
Output Ratings:			
dc or Peak ac Load Voltage (I_L≤50 µA)	V_L	350	V
Continuous dc Load Current			
LH1533 (One Pole Operating)	I_L	90	mA
LH1533 (Two Poles Operating)	I_L	70	mA
Power Dissipation			
LH1533	P_{DISS}	600	mW

Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA, t=10 ms	–	–	2.5	mA
LED Forward Current for Switch Turn-off	I_{Foff}	V_L=±300 V	0.01	–	–	mA
LED Forward Voltage	V_F	I_F=5 mA	0.9	1.2	1.4	V
ON-resistance	R_{ON}	I_F=5 mA, I_L=±90 mA	25	37	50	Ω
Current Limit	I_{LMT}	I_F=5 mA, t=5 ms, V_L=13 V	150	200	270	mA
Output Off-state Leakage Current	–	I_F=0 mA, V_L=±350 V	–	–	1.0	µA
Turn-on Time	t_{on}	I_F=5 mA, I_L=50 mA	–	–	3.0	ms
Turn-off Time	t_{off}	I_F=5 mA, I_L=50 mA	–	–	3.0	ms

SIEMENS

LH1525
LH1526

1 Form A, Dual 1 Form A High-Voltage Solid State Relays

FEATURES

	LH1525	LH1526	Units
Load Voltage	400	400	V
Load Current ac/dc dc	 120 250	 120 250	 mA mA
Typical R_{ON}	25	25	Ω
Typical Operating Current	500	500	µA
t_{on}/t_{off} (max)	0.8/0.4	0.8/0.4	ms
Current Limit: ac/dc	 Yes	 Yes	 —

- Extremely low operating current
- High-speed operation
- 3750 Vrms I/O isolation
- Current-limit protection
- High surge capability
- Linear, ac/dc operation
- dc-only option
- Clean, bounce-free switching
- Low power consumption
- High-reliability monolithic receptor
- Surface-mountable

APPLICATIONS

- General telecom switching:
  - Telephone line interface
  - On/off hook
  - Ring relay
  - Break switch
  - Ground start
- Battery-powered switch applications
- Industrial controls:
  - Microprocessor control of solenoids, lights, motors, heaters, etc.
- Programmable controllers
- Instrumentation

DESCRIPTION

The LH1525 and LH1526 relays as SPST normally open switches (1 Form A) that can replace electromechanical relays in many applications. The relays require a minimal amount of LED drive current to operate, making it ideal for battery-powered and power consumption sensitive applications. The relay is constructed using a GaAIAs LED for actuation control and an integrated monolithic die for the switch output. The die, fabricated in a high-voltage dielectrically isolated BCDMOS technology, comprised of a photodiode array, switch-control circuitry, and MOSFET switches. In addition, the relay employs current-limiting circuitry, enabling it to pass FCC 68.302 and other regulatory surge requirements when overvoltage protection is provided. The relay can be configured for ac/dc or dc-only operation.

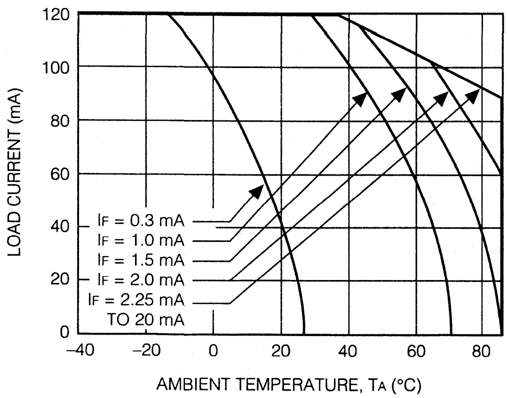
The LH1525 is packaged in a 6-pin, plastic DIP (LH1525AT) or in a surface-mount gull wing (LH1525AAB). The LH1526 is packaged in a 8-pin, plastic DIP (LH1526AB) or in a surface-mount gull wing (LH1526AAC). Both devices are available in sticks or on tape and reel.

Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect device reliability.

Parameter	**Symbol**	**Value**	**Unit**
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–40 to +150	°C
Pin Soldering Temperature (t=10 s max.)	T_S	260	°C
Input/Output Isolation Test Voltage (t=1 sec)	V_{ISO}	5300	Vrms
LED Input Ratings:			
Continuous Forward Current	I_F	50	mA
Reverse Voltage	V_R	8	V
Output Operation LH1525, LH1526 (ea. ch.):			
dc or Peak ac Load Voltage (I_L=≤50 µA)	V_L	400	V
Continuous dc Load Current:			
Bidirectional Operation, Pin 4 to 6 (LH1525)	I_L	125	mA
Unidirectional Operation, Pins 4, 6 (+) to Pin 5 (–)	I_L	250	mA
Two Role Operation (LH1526 only)	I_L	100	mA
Power Dissipation:			
LH1525	P_{DISS}	550	mW
LH1526	P_{DISS}	600	mW

Solid State Relays 6

Recommended Operating Conditions

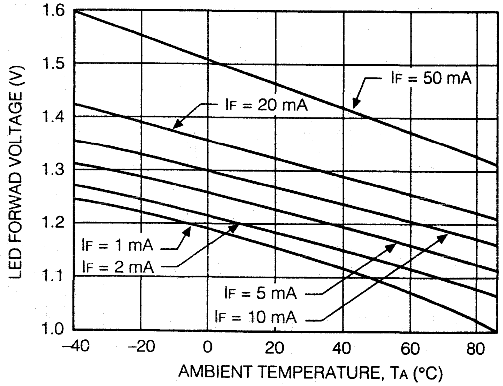


Electrical Characteristics T_A=25°C
Mimimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

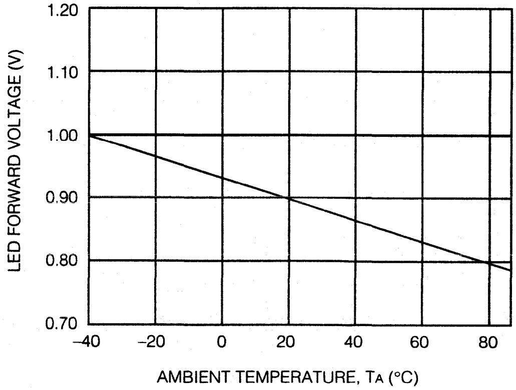
Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Input						
LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA, t=10 ms	—	0.3	0.5	mA
LED Forward Current for Switch Turn-off	I_{Foff}	V_L= ±350 V, t=100 ms	0.001	0.1	—	mA
LED Forward Voltage	V_F	I_F=1.5 mA	0.80	1.15	1.40	V
Output						
ON-resistance: ac/dc, each pole dc Pins 4, 6 (+) to 5 (–) (LH1525 only)	R_{ON}	 I_F=1.5 mA, I_L=±50 mA I_F=1.5 mA, I_L=100 mA	 17 4.25	 25 6.25	 33 8.25	 Ω Ω
OFF-resistance	R_{OFF}	I_F=0 mA, V_L=±100 V	—	5000	—	GΩ
Current Limit	I_{LMT}	I_F=1.5 mA, t=5 ms, V_L=7 V	170	210	270	mA
Output Off-state Leakage Current	—	I_F=0 mA, V_L=±100 V I_F=0 mA, V_L=±400 V	— —	0.04 —	200 1.0	nA µA
Output Capacitance	—	I_F=0 mA, V_L=1 V I_F=0 mA, V_L=50 V	— —	37 13	— —	pF pF
Switch Offset	—	I_F=5 mA	—	0.25	—	µV
Transfer						
Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	—	0.8	—	pF
Turn-on Time	t_{on}	I_F=1.5 mA, I_L=50 mA I_F=5.0 mA, I_L=50 mA	— —	1.00 0.25	— 0.8	ms ms
Turn-off Time	t_{off}	I_F=1.5 mA, I_L=50 mA I_F=5.0 mA, I_L=50 mA	— —	0.20 0.25	— 0.4	ms ms

Typical Performance Characteristics

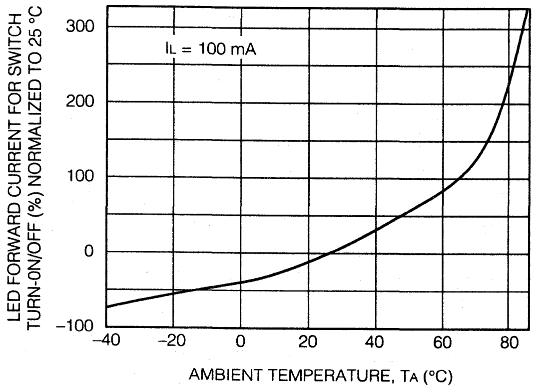
A. LED Voltage vs. Temperature



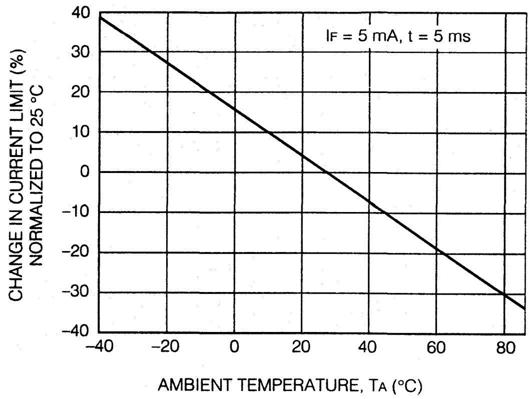
B. LED Dropout Voltage vs. Temperature



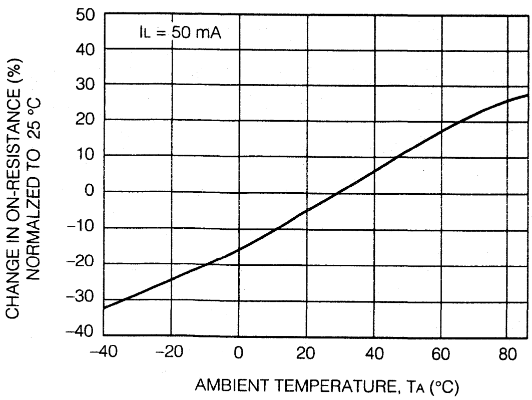
C. LED Current for Switch Turn-On/Off vs. Temperature



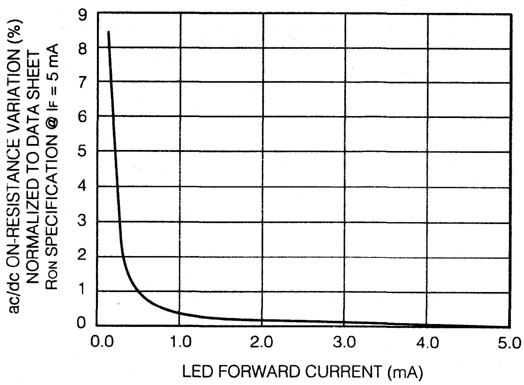
D. Current Limit vs. Temperature



E. ON-Resistance vs. Temperature

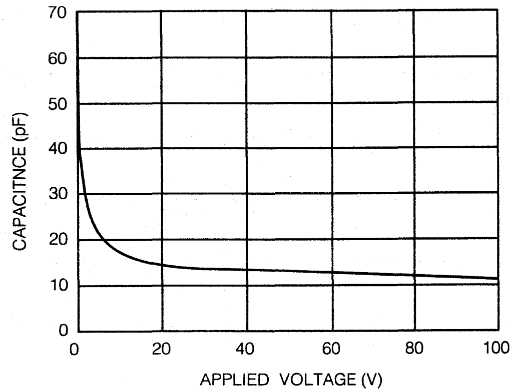


F. Variation in ON-Resistance vs. LED Current

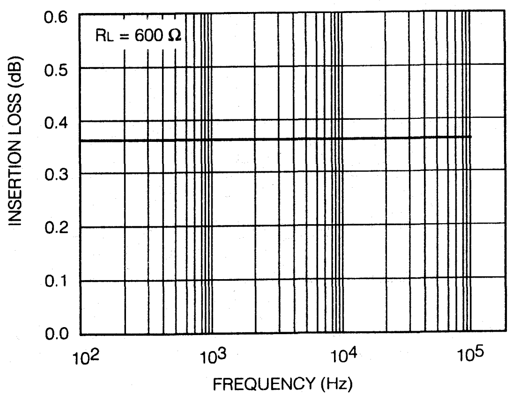


Typical Performance Characteristics (continued)

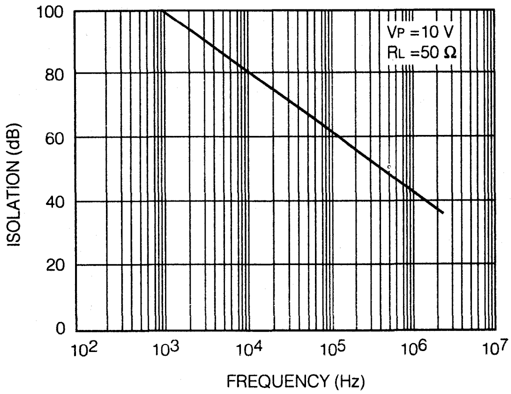
A. Switch Capacitance vs. Applied Voltage



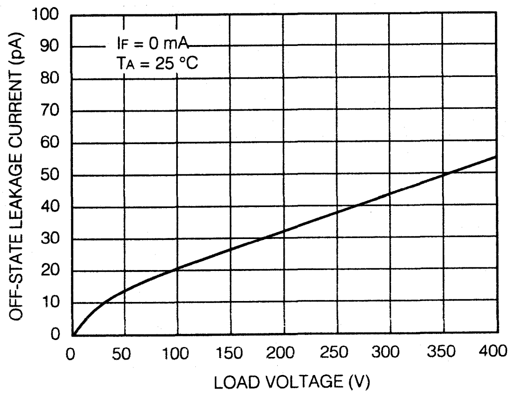
B. Insertion Loss vs. Frequency



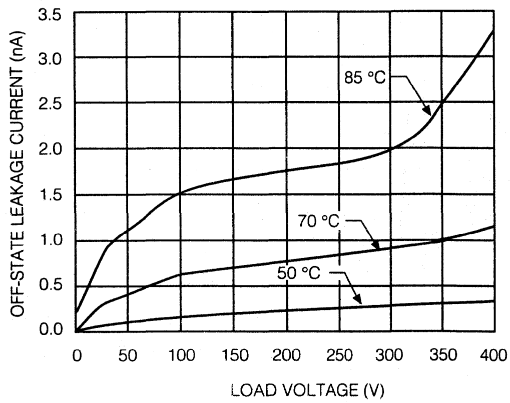
C. Output Isolation



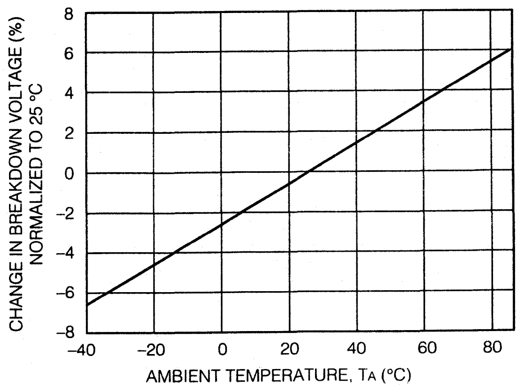
D. Leakage Current vs. Applied Voltage



E. Leakage Current vs. Applied Voltage at Elevated Temperatures

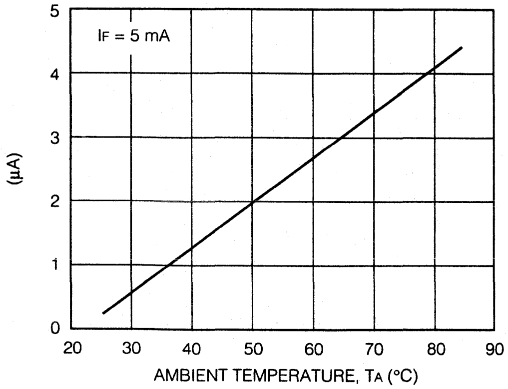


F. Switch Breakdown Voltage vs. Temperature

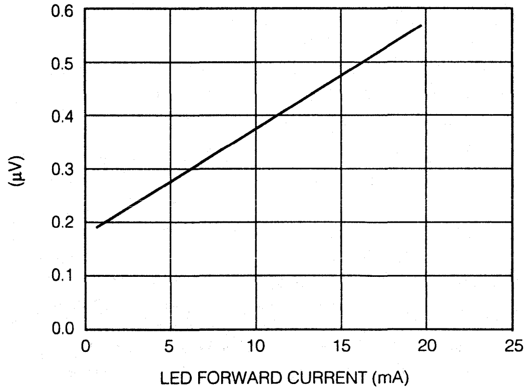


Typical Performance Characteristics (continued)

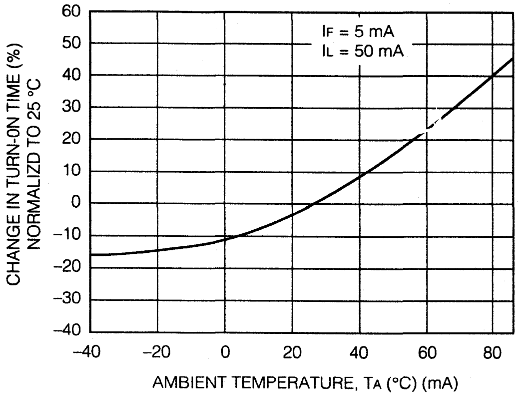
A. Switch Offset Voltage vs. Temperature



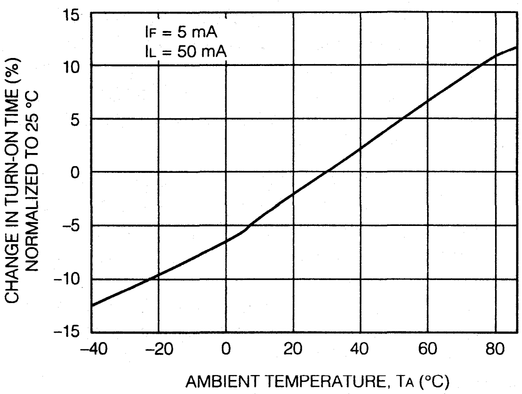
B. LED Offset Voltage vs. LED Current



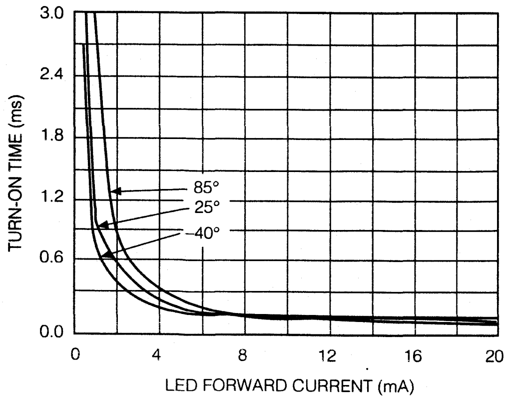
C. Turn-On Time vs. Temperature



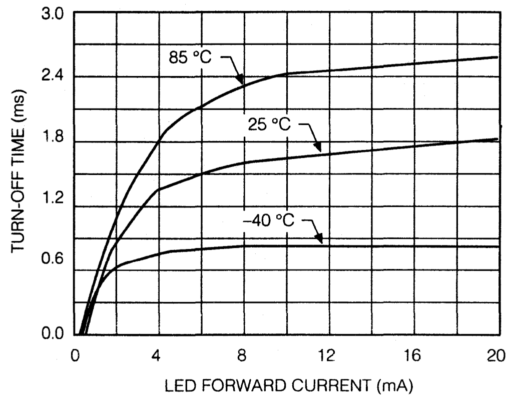
D. Turn-Off Time vs. Temperature



E. Turn-On Time vs. LED Current



F. Turn-off Time vs. LED Current



Solid State Relays 6

APPLICATIONS

Input Control

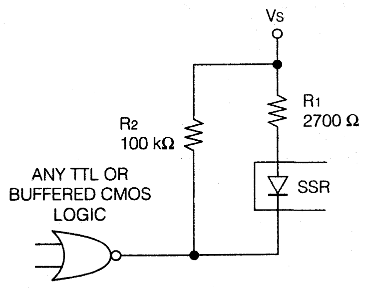
The LH1525 low turn-on current SSR has highly sensitive photo-detection circuits that will detect even the most minute currents flowing through the LED. Leakage current must be considered when designing a circuit to turn on and off these relays.

Figure 23 shows a typical logic circuit for providing LED drive current. R1 is the input resistor that limits the amount of current flowing through the LED. For 5 V operation, a 2700 Ω resistor will limit the drive current to about 1.4 mA. Where high-speed actuation is desireable, use a lower value resistor for R1. An additional RC peaking circuit is not required with the LH1525 relay.

R2 is an optional pull-up resistor which pulls the logic level high ouput (V_{OH}) up toward the V_S potential. The pull-up resistance is set at a high value to minimize the overall current drawn from the V_S. The primary purpose of this resistor is to keep the differential voltage across the LED below its turn-on threshold. LED dropout voltage is graphed vs. temperature in the Typical Performance Characteristics section. When the logic gate is high, leakage current will flow through R_2. R_2 will draw up to 8 µA before developing a voltage potential which might possibly turn on the LED.

Many applications will operate satisfactorily without a pull-up resistor. In the logic circuit in Figure 1 the only path for current to flow is back into the logic gate. Logic leakage is usually negligible. Each application should be evaluated, however, over the full operating temperature range to make sure that leakage current through the input control LED is kept to a value less than the minimum LED forward current for switch turn-off specification.

Figure 1. Input Control Circuit



SIEMENS

LH1547
1 Form A
dc High-Voltage Solid State Relay

FEATURES

	LH1547	Units
Load Voltage	400	V
Load Current	120	mA
Typical R_{ON}	23	Ω

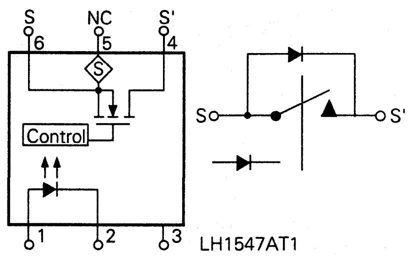
- 3750 Vrms I/O isolation
- Current-limit protection
- Linear dc operation
- High-surge capability
- Clean, bounce-free switching
- Low power consumption
- High-reliability monolithic receptor
- Surface-mountable

APPLICATIONS
- General telecom switching
- Programmable controllers
- Industrial controls
- Instrumentation
- Peripherals

DESCRIPTION
The LH1547 is a SPST normally open unidirectional relay that can switch ac and dc signals. The relay is constructed using a GaAIAs LED for actuation control and an integrated monolithic die for the switch output. The die, fabricated in a high-voltage dielectrically isolated BICMOS technology, is comprised of a photodiode array, switch control circuitry, and a DMOS switch.

The LH1547 relay is packaged in a 6-pin DIP (LH1547AT1) or in a surface-mount gull wing (LH1547AAB1).

Figure 1. Functional Diagram (LH1547)



Solid State Relays
6

Absolute Maximum Ratings T_A=25°C
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect the device reliability.

Parameter	Symbol	Value	Unit
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–40 to +150	°C
Pin Soldering Temperature (t=10 s max.)	T_S	260	°C
Input/Output Isolation Test Voltage (t=1 sec)	V_{ISO}	5300	Vrms
LED Input Ratings:			
Continuous Forward Current	I_F	50	mA
Reverse Voltage (I_R≤10 µA)	V_R	10	V
Output Operation:			
dc or Peak ac Load Voltage (I_L≤50 µA)	V_L	400	V
Continuous dc Load Current	I_L	120	mA
Power Dissipation	P_{DISS}	500	mW

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on (T_A=–40°C to +85°C)	I_{FON}	5	—	20	mA

Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on	I_{Fon}	I_L=90 mA, t=10 ms	—	0.9	2	mA
LED Forward Current for Switch Turn-off	I_{Foff}	V_L=±350 V	0.1	0.4	—	mA
LED Forward Voltage	V_F	I_F=10 mA	1.15	1.22	1.45	V
ON-resistance	R_{ON}	I_F=5 mA	12	23	34	Ω
OFF-resistance	R_{OFF}	I_F=0 mA, V_L=±100 V	—	3300	—	GΩ
Current Limit	I_{LMT}	I_F=5 mA, t=5 ms V_L=10 V	150	210	270	mA
Output Off-state Leakage Current	—	I_F=0 mA, V_L=±100 V	—	0.03	200	nA
		V_L=±400 V	—	—	1.0	µA
Turn-on Time	t_{on}	I_F=5 mA, V_L=50 V R_L=1 kΩ	—	1.6	5.0	ms
Turn-off Time	t_{off}	I_F=5 mA, V_L=50 V R_L=1 kΩ	—	2.2	5.0	ms

SIEMENS

LH1191
High-Voltage Solid State Relay

FEATURES
- 1500 Vrms input/output isolation
- High-surge capability
- Low ON-resistance
- Clean, bounce-free switching
- dv/dt typically better than 500 V/μs
- Low power consumption
- Monolithic IC reliability

APPLICATIONS
- Telecom switching
- Transducer driver
- High-voltage testers
- Industrial controls
- Triac predriver
- Isolation switching

DESCRIPTION
The LH1191 High-Voltage, Solid State Relay is a single pole, normally open switch (1 Form A) that can replace electromechanical relays in many applications. The relay features logic-level input control of isolated high-voltage switch outputs. The output is rated at 280 V and can handle loads up to 120 mA. The relay can switch both ac and dc loads and is ideal for audio frequency or dc applications. Typical ON-resistance at 25 mA is 25 Ω.

The LH1191 relay consists of a GaAlAs LED that optically couples control signals to a monolithic integrated circuit. Optical coupling provides 1500 Vrms of input/output isolation. The integrated circuit is a dielectrically isolated, high-voltage die comprised of photodiode arrays, switch control circuitry, and high-voltage DMOS transistor switches.

In operation, the device is exceptionally linear up to 55 mA. Beyond 55 mA, the incremental resistance decreases, thereby minimizing internal power dissipation. Overload currents are clamped at 210 mA by internal current limiting. An extended clamp condition, which increases relay temperature, results in a reduction in clamp current, thereby further reducing internal power dissipation and preserving the relay's integrity. The relay is packaged in a 6-pin, plastic DIP (LH1191AT1) or in a 6-pin, surface-mount, gull-wing configuration (LH1191AAB1).

Absolute Maximum Ratings T_A=25°C
Stresses exceeding the values listed under Absolute Maximum Ratings can cause permanent damage to the device. This is an absolute stress rating only. Functional operation of the device at these or any other conditions in excess of those indicated in the operational sections of this data sheet is not implied. Exposure to maximum-rating conditions for extended periods ot time can adversely affect the device reliability.

Rating	Symbol	Value	Unit
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C
Pin Soldering Temperature (t=7 s max.)	T_S	270	°C
Input/Output Isolation Voltage (t=60 s min.)	V_{ISO}	1500	Vrms
LED Input Ratings:			
Continuous forward current	I_F	20	mA
Reverse voltage	V_R	10	V
Output Operation:			
dc or peak ac load voltage ($I_L \leq 50\ \mu A$)	V_L	280	V
Continuous dc load current	I_L	135	mA
Power Dissipation	P_{DISS}	500	mW

Recommended Operating Conditions T_A=25°C
(unless otherwise specified)

Parameter	Symbol	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on (T_A=–40°C to +85°C)	I_{FON}	6	10	20	mA
Continuous dc Load Current	I_L	—	55	120	mA
ac rms Load Current	—	—	35	85	mA

Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

Characteristics	Symbol	Test Condition	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on	I_{Fon}	I_L (min)=120 mA, V_L=±7 V, t=10 ms	—	1.3	2.5	mA
LED Forward Current for Switch Turn-off	I_{Foff}	I_F=0.2 mA, V_L=±250 V	0.2	1.2	—	mA
LED Forward Voltage	V_F	I_F=10 mA	1.15	1.22	1.45	V
ON-resistance	R_{ON}	I_F=5 mA, I_L= ±25 mA	11	25	33	Ω
Current Limit	I_{LMT}	I_F=5 mA, V_L=±7 V, t=10 ms	140	210	260	mA
Ouput Off-state Leakage Current	—	I_F=0, V_L=±100 V	—	0.03	200	nA
Turn-on Time	t_{on}	I_F=5 mA, V_L=+150 V, R_L=4 kΩ	—	1.4	2.0	ms
Turn-off Time	t_{off}	I_F=5 mA, V_L=+150 V, R_L=4 kΩ	—	0.9	2.0	ms
Feedthrough Capacitance Pin 4 to 6	—	I_F=0, V_L=4 Vp-p, 1 kHz	—	24	—	pF

SIEMENS

LH1085
High-Voltage Solid State Relay

FEATURES
- 1500 Vrms input/output isolation
- Low ON-resistance
- Clean, bounce-free switching
- dv/dt typically better than 500 V/µs
- Low power consumption
- Monolithic IC reliability

APPLICATIONS
- High-voltage testers
- Industrial controls
- Telecom switching
- Triac predriver
- Isolation switching

DESCRIPTION
The LH1085 High-Voltage, Solid State Relay is a single pole, normally open switch (1 Form A) that can replace electromechanical relays in many applications. The relay features logic-level input control of isolated high-voltage switch outputs. The output is rated at 350 V and can handle loads up to 135 mA. The relay can switch both ac and dc loads and is ideal for audio frequency or dc applications. Typical ON-resistance at 25 mA is 30 Ω.

The LH1085 relay consists of a GaAlAs LED that optically couples control signals to a monolithic integrated circuit. Optical coupling provides 1500 Vrms of input/output isolation. The integrated circuit is a dielectrically isolated, high-voltage die comprised of photodiode arrays, switch control circuitry, and high-voltage DMOS transistor switches.

In operation, the device is exceptionally linear up to 45 mA. Beyond 45 mA, the incremental resistance decreases, thereby minimizing internal power dissipation. Overload currents are clamped at 300 mA by internal current limiting. An extended clamp condition, which increases relay temperature, results in a reduction in clamp current, thereby further reducing internal power dissipation and preserving the relay's integrity. The relay is packaged in a 6-pin, plastic DIP (LH1085AT1) or in a 6-pin, surface-mount, gull-wing configuration (LH1085AAB1).

Absolute Maximum Ratings T_A=25°C
Stresses exceeding the values listed under Absolute Maximum Ratings can cause permanent damage to the device. This is an absolute stress rating only. Functional operation of the device at these or any other conditions in excess of those indicated in the operational sections of this data sheet is not implied. Exposure to maximum-rating conditions for extended periods ot time can adversely affect the device reliability.

Rating	Symbol	Value	Unit
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C
Pin Soldering Temperature (t=7 s max.)	T_S	270	°C
Input/Output Isolation Voltage (t=60 s min.)	V_{ISO}	1500	Vrms
LED Input Ratings:			
Continuous forward current	I_F	20	mA
Reverse voltage	V_R	10	V
Output Operation:			
dc or peak ac load voltage ($I_L \leq 50$ µA)	V_L	350	V
Continuous dc load current	I_L	135	mA
Peak load current (t=10 ms)	I_P	400	mA
Power Dissipation	P_{DISS}	500	mW

Recommended Operating Conditions T_A=25°C
(unless otherwise specified)

Parameter	Symbol	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on (T_A=–40°C to +85°C)	I_{FON}	8	10	20	mA
Continuous dc Load Current	I_L	—	45	135	mA
ac rms Load Current	—	—	30	135	mA

Electrical Characteristics T_A=25°C
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

Characteristics	Symbol	Test Condition	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on	I_{Fon}	I_L (min)=150 mA, V_L=±9 V, t=10 ms	—	1.3	2.5	mA
LED Forward Current for Switch Turn-off	I_{Foff}	I_F=0.2 mA, V_L=±300 V	0.2	1.2	—	mA
LED Forward Voltage	V_F	I_F=10 mA	1.15	1.22	1.45	V
ON-resistance	R_{ON}	I_F=5 mA, I_L= ±25 mA	20	30	37	Ω
Current Limit	I_{LMT}	I_F=5 mA, V_L=±9, t=10 ms	225	300	400	mA
Ouput Off-state Leakage Current	—	I_F=0, V_L=±100 V	—	0.03	200	nA
Turn-on Time	t_{on}	I_F=5 mA, V_L=+150 V, R_L=4 kΩ	—	1.4	2.0	ms
Turn-off Time	t_{off}	I_F=5 mA, V_L=+150 V, R_L=4 kΩ	—	0.9	2.0	ms
Feedthrough Capacitance Pin 4 to 6	—	I_F=0, V_L=4 Vp-p, 1 kHz	—	24	—	pF

Telecom Switches

FEATURES

- Solid state relay and an autopolarity optocoupler in a single package
- Low-profile, small-outline package (SOP) available
- Up to 5300 Vrms I/O minimum
- Surface mountable
- Optocoupler
  - — Bidirectional current detection
- Solid state relay
  - — 1 Form A or B contacts
  - — Current-limit protection
  - — High-surge capability
  - — Linear, ac/dc operation
  - — Clean, bounce-free switching
  - — Low power consumption
  - — High-reliability monolithic receptor
- UL recognized
- CSA certified
- BABT certificate of recognition to BS6301

APPLICATIONS

- General telecom switching
  - — On/off-hook control
  - — Dial pulse
  - — Ring-current detection
  - — Loop-current sensing
- PCMCIA Type 2 modem cards

DESCRIPTION

A Telecom Switch consists of an optically isolated, SPST solid-state relay (SSR) and a bidirectional input optocoupler in a single package. The SSR is ideal for performing switchhook and dial-pulse switching while the optocoupler performs ring detect and loop current sensing functions.

The SSR is integrated on a monolithic receptor die by using a Smart Power BiCMOS technology. The SSR features low ON-resistance, high breakdown voltage, and current-limit circuitry that protects the relay from telephone line induced lightning surges.

The optocoupler provides bidirectional current sensing via two antiparallel GaAlAs infrared emitting diodes. The optocoupler provides a minimum current transfer ratio (CTR) of 33% or 100%.

The Telecom Switches are available in four different packaging configurations: an 8-pin, plastic DIP; an 8-pin, surface-mount gull wing for circuit board mounting; an 8-pin, S-bend gull wing; and an 18-pin, 2 mm high, small-outline package for use in Type 2 PCMCIA boards.

Telecom Switches — Opto Channel CTR Selection Table

Contact Form	Part Number	Optocoupler: Output Characteristics — Current Transfer Ratio (Min) I_F=6 mA, V_{CE}=0.5 V	Optocoupler: Input Characteristics — LED Continuous Forward Current	I/O Isolation (Min)	Package Type (see Selection Guide)
		%	mA	Vrms	
1 Form A	LH1529AB	33	50	5300	8-pin DIP
	LH1529AAC				8-pin SMD
	LH1529ACC				8-pin S Bend
	LH1529BB	100	50	5300	8-pin DIP
	LH1529BAC				8-pin SMD
	LH1529BCC				8-pin S Bend
	LH1548ACE*	33	50	1500	18-pin SOP
	LH1549AB*	33	120	5300	8-pin DIP
	LH1549AAC*				8-pin SMD
	LH1549ACC*				8-pin S Bend
1 Form B	LH1528AB	33	50	5300	8-pin DIP
	LH1528AAC				8-pin SMD
	LH1528ACC				8-pin S Bend

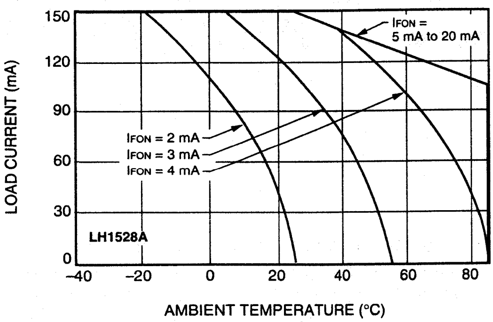
* Specifications are preliminary.

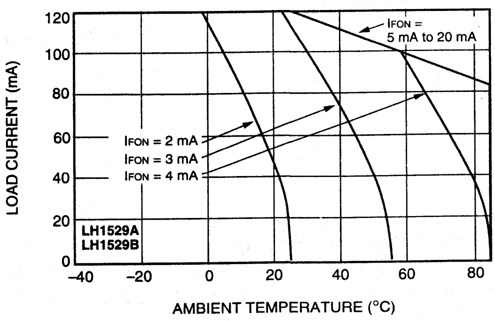
1 Form B/Phototransistor LH1528
1 Form A/Phototransistor LH1529, LH1549

Absolute Maximum Ratings T_A=25°
Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of this document. Exposure to Absolute Maximum Ratings for extended periods of time can adversely affect reliability.

Parameter	Symbol	Test Conditions	LH1528A	LH1529A	LH1529B	LH1549A	Units
Ambient Operating Temperature Range	T_A	—	–40 to +85	–40 to +85	–40 to +85	–40 to +85	°C
Storage Temperature Range	T_{stg}	—	–40 to +150	–40 to +150	–40 to +150	–40 to +150	°C
Pin Soldering Temperature	T_S	t=10 s max	260	260	260	260	°C
Input/Output Isolation Voltage	V_{ISO}	—	3750	3750	3750	5300	Vrms
SSR Ratings							
LED Continuous Forward Current	I_F	—	50	50	50	50	mA
LED Reverse Voltage	V_R	$I_R \leq 10\ \mu A$	5	5	5	5	V
dc or Peak ac Load Voltage	V_L	$I_L \leq 50\ \mu A$	350	350	350	400	V
Continuous dc Load Current Unidirectional Operation	I_L	—	150	120	120	120	mA
Output Power Dissipation (continuous)	P_{DISS}	—	600	600	600	600	mW
Optocoupler Ratings							
LED Continuous Forward Current	I_F	—	50	50	50	120	mA
Collector-Emitter Breakdown Voltage	BV_{CEO}	—	30	30	30	30	V
Phototransistor Power Dissipation	P_{DISS}	—	150	150	150	150	mW

SSR Recommended Operating Conditions





Electrical Characteristics T_A=25°C
SSR Characteristics

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

	Parameter	Symbol	Test Conditions	Values	LH1528A	LH1529A	LH1529B	LH1549A	Units
INPUT	LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA t=10 ms	Min	0.2	—	—	—	mA
				Typ	0.9	0.7	0.7	0.5	mA
				Max	—	2.0	2.0	1.0	mA
	LED Forward Current for Switch Turn-off	I_{Foff}		Min	—	0.2	0.2	0.1	mA
				Typ	1.0	0.6	0.6	0.4	mA
				Max	2.0	—	—	—	mA
			V_L	±	300	300	300	350	V
	LED Forward Voltage	V_F	I_F=10 mA	Min	1.15	1.15	1.15	0.80	V
				Typ	1.26	1.26	1.26	1.20	V
			I_F=3 mA (LH1549)	Max	1.45	1.45	1.45	1.40	V
OUTPUT	ON-resistance ac/dc Pins 4 (±) to 6 (±)	R_{ON}	I_F=5 mA I_F=0 mA (LH1528) I_L=50 mA	Min	12	12	12	17	Ω
				Typ	20	20	20	25	Ω
				Max	25	25	25	33	Ω
	Current Limit ac/dc Pins 4 (±) to 6 (±)	I_{LMT}	I_F=5 mA t=5 ms	Min	—	170	170	170	mA
				Typ	—	210	210	210	mA
				Max	—	250	250	270	mA
			V_L	±	—	6	6	7	V
	Off-state Leakage Current	—	I_F=0 mA I_F=5 mA (LH1528) V_L=100 V	Min	—	—		—	nA
				Typ	70	0.02	0.02	0.04	nA
				Max	1000	200	200	200	nA
			I_F=0 mA I_F=5 mA (LH1528)	Min	—	—	—	—	µA
				Typ	0.08	—	—	—	µA
				Max	1.0	1.0	1.0	1.0	µA
			V_L	±	350	350	350	400	V
	Output Capacitance Pin 7 to 8	—	I_F=0 mA I_F=5 mA (LH1528) V_L=1 V	Min	—	—	—	—	pF
				Typ	45	55	55	50	pF
				Max	—	—	—	—	pF
			I_F=0 mA I_F=5 mA (LH1528) V_L=50 V	Min	—	—	—	—	pF
				Typ	10	10	10	9	pF
				Max	—	—	—	—	pF
TRANSFER	Input/Output Capacitance	C_{ISO}	V_{ISO}=1 V	Min	—	—	—	—	pF
				Typ	1.3	1.3	1.3	1.3	pF
				Max	—	—	—	—	pF
	Turn-on Time	t_{ON}	I_F=5 mA I_L=50 mA	Min	—	—	—	—	ms
				Typ	2.0	1.3	1.3	0.5	ms
				Max	3.0	2.5	2.5	2.0	ms
	Turn-off Time	t_{OFF}	I_F=5 mA I_L=50 mA	Min	—	—	—	—	ms
				Typ	1.0	0.6	0.6	0.1	ms
				Max	3.0	2.5	2.5	0.5	ms

† IL = 25mA.

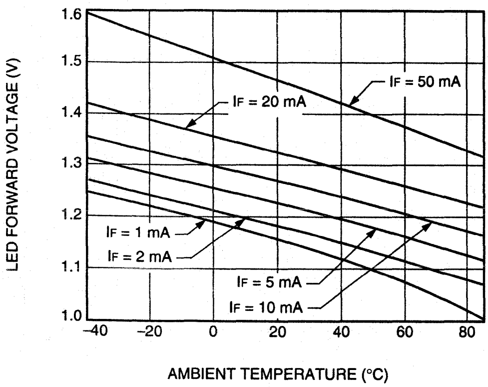
Electrical Characteristics (cont'd)
T_A=25°C Optocoupler Characteristics

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

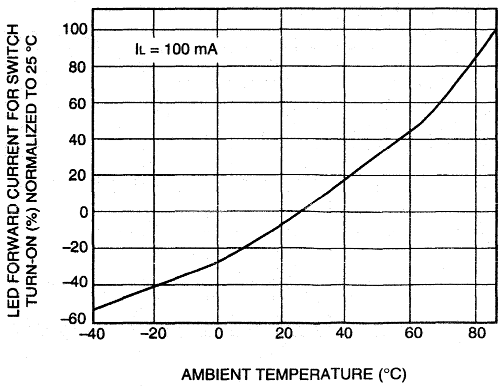
	Parameter	Symbol	Test Conditions	Values	LH1528A	LH1529A	LH1529B	LH1549H	Units
INPUT	LED Forward Voltage	V_F	I_F=10 mA	Min	0.9	0.9	0.9	0.9	V
				Typ	1.2	1.2	1.2	1.2	V
				Max	1.5	1.5	1.5	1.5	V
OUTPUT	Saturation Voltage	V_{CE}(Sat)	I_F=16 mA, I_C=2 mA	Min	—	—	—	—	V
				Typ	0.7	0.7	0.7	0.7	V
				Max	0.5	0.5	0.5	0.5	V
	Leakage Current	I_{CEO}	I_F=0 mA, V_{CE}=5 V	Min	—	—	—	—	nA
				Typ	—	—	—	—	nA
				Max	500	500	500	500	nA
	Trickle Current Leakage	I_{CEO}	I_F=5 µA, V_{CE}=5 V	Min	—	—	—	—	µA
				Typ	—	—	—	—	µA
				Max	1	1	1	1	µA
TRANSFER	dc Current Transfer Ratio	CTR	I_F=6 mA, V_{CE}=0.5 V	Min	33	33	100	33	%
				Typ	165	165	165	165	%
				Max	—	—	—	—	%

SSR Characteristics

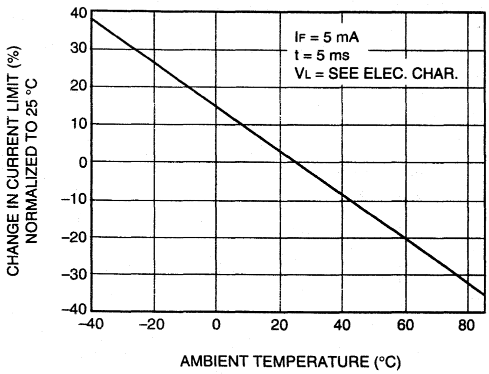
A. LED Voltage vs. Temperature



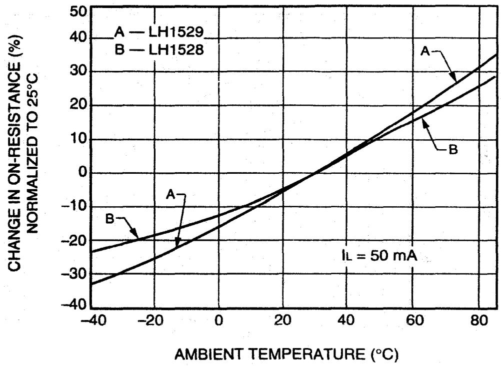
B. LED Current for Switch Turn-OnOff vs. Temperature



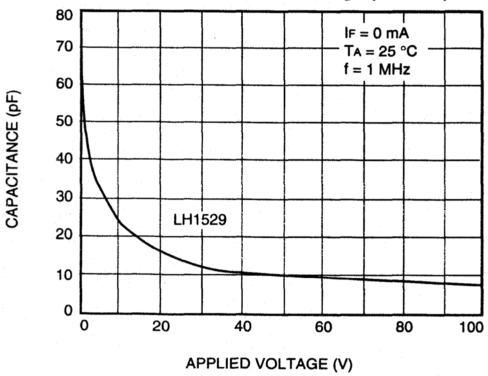
C. Current Limit vs. Temperature



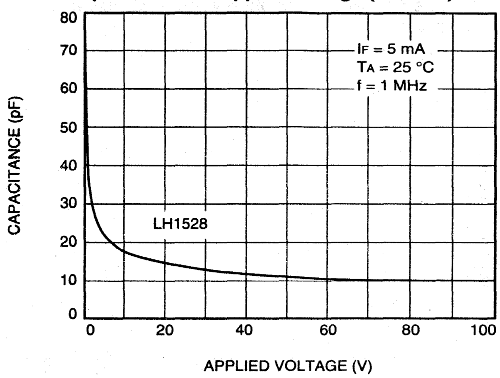
D. ON-Resistance vs. Temperature



E. Switch Capacitance vs. Applied Voltage (LH1529)

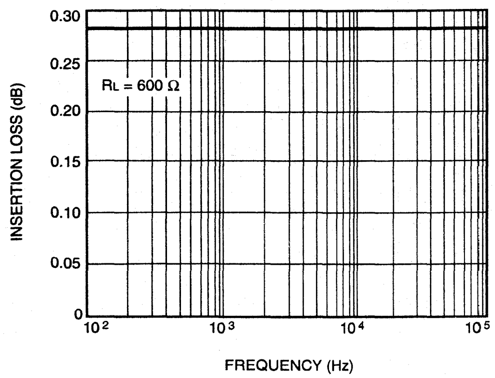


F. Switch Capacitance vs. Applied Voltage (LH1528)

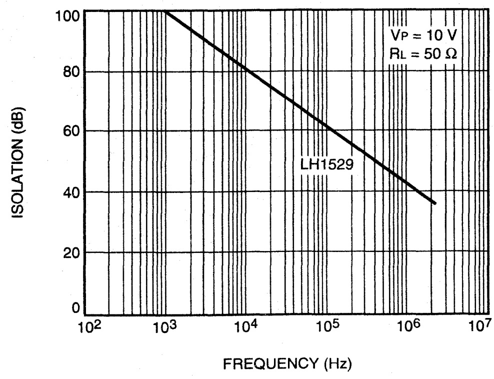


SSR Characteristics (LH1549 not included) (continued)

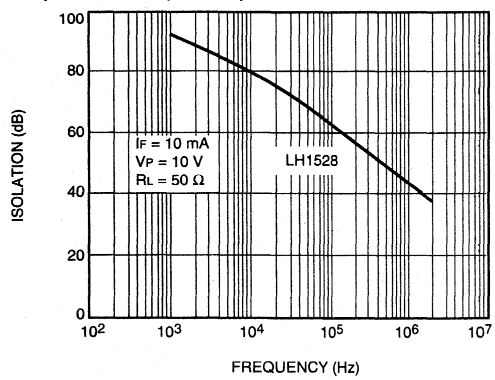
A. Insertion Loss vs. Frequency



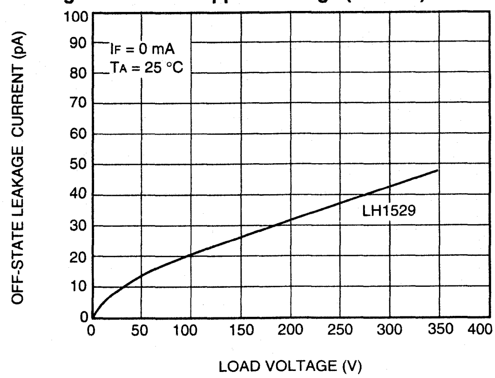
B. Output Isolation (LH1529)



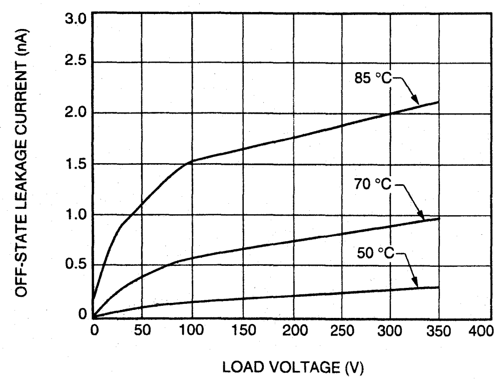
C. Output Isolation (LH1528)



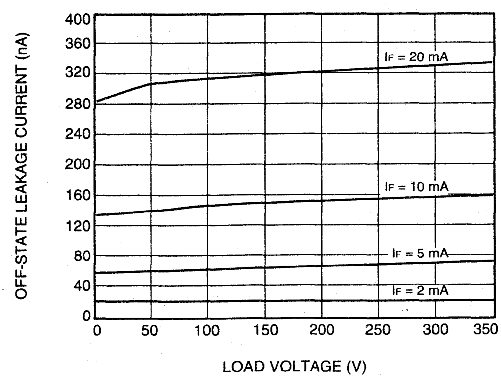
D. Leakage Current vs. Applied Voltage (LH1529)



E. Leakage Current vs. Applied Voltage at Elevated Temperatures (LH1529)

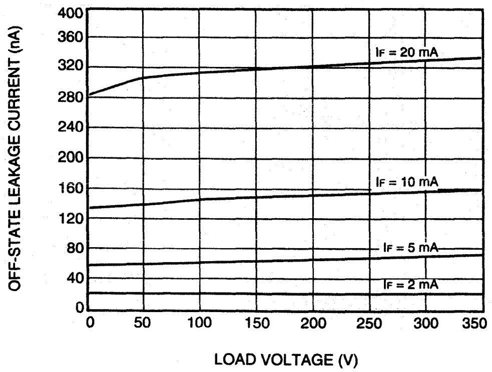


F. Leakage Current vs. Applied Voltage (LH1528)

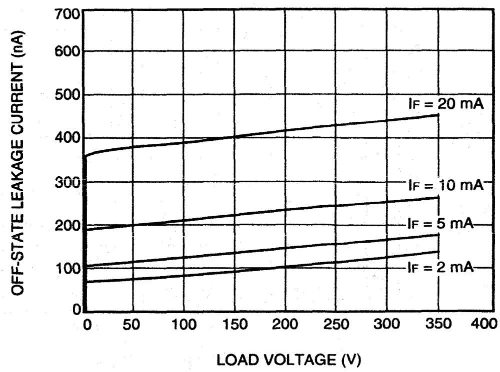


SSR Characteristics (LH1549 not included) (continued)

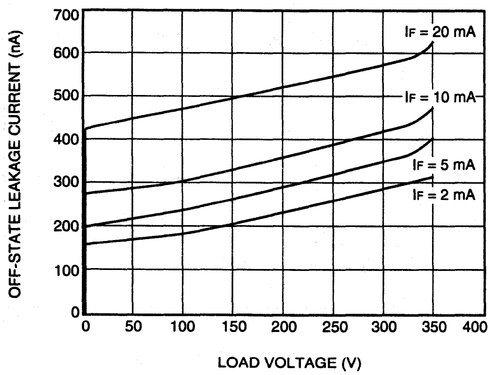
A. Leakage Current vs. Applied Voltage at 50°C (LH1528)



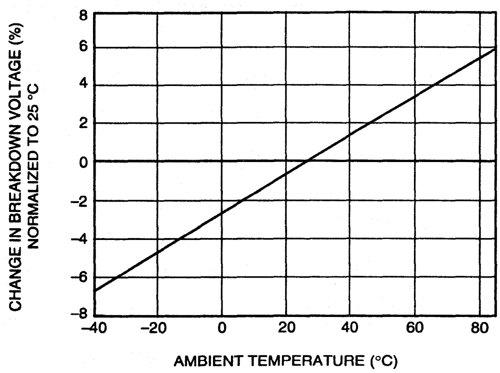
B. Leakage Current vs. Applied Voltage at 70°C (LH1528)



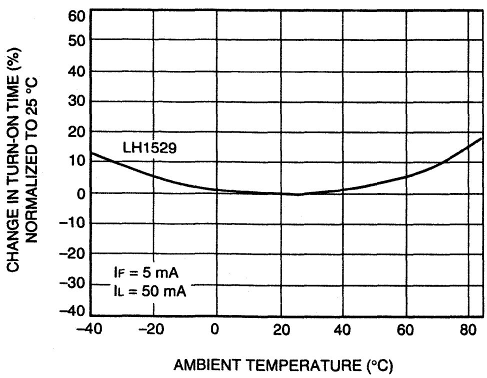
C. Leakage Current vs. Applied Voltage at 85°C (LH1528)



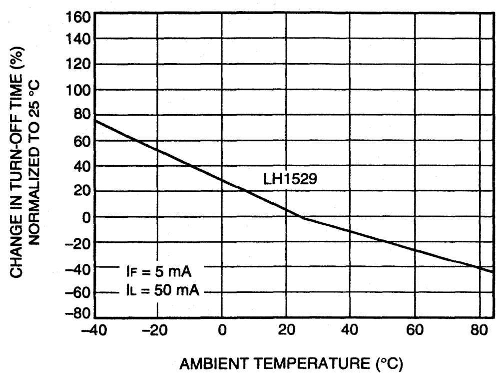
D. Switch Breakdown Voltage vs. Temperature



E. Turn-On Time vs. Temperature (LH1529)

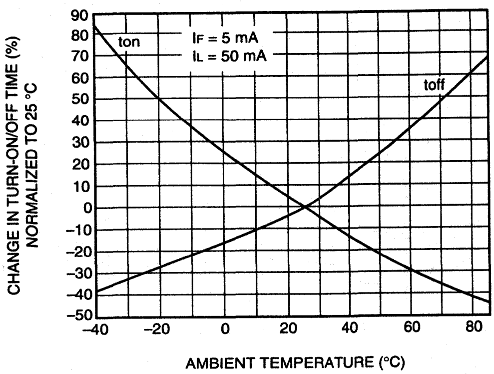


F. Turn-Off Time vs. Temperature (LH1529)

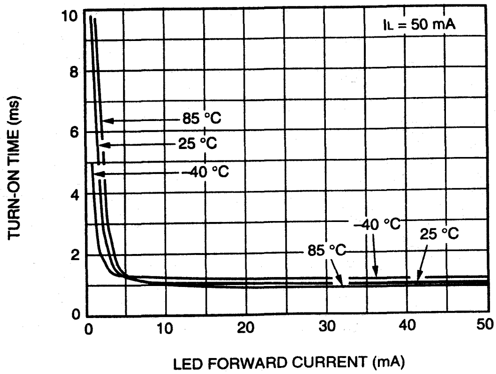


SSR Characteristics (LH1549 not included) (continued)

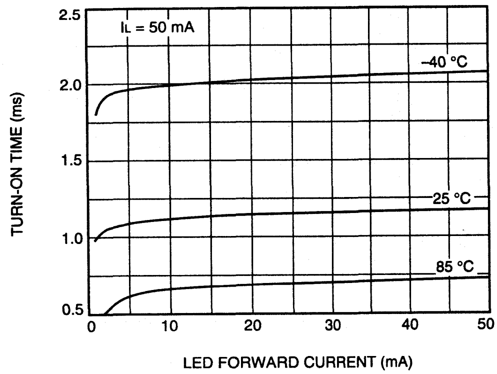
A. Turn-On/Off Time vs. Temperature (LH1528)



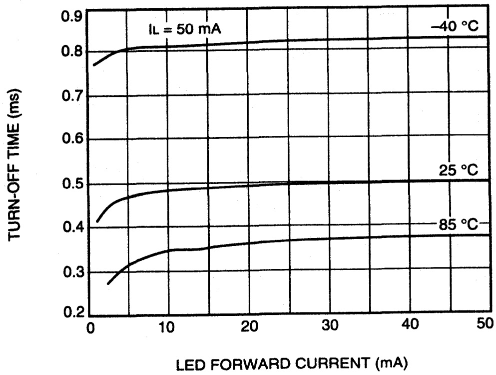
B. Turn-On Time vs. LED Current (LH1529)



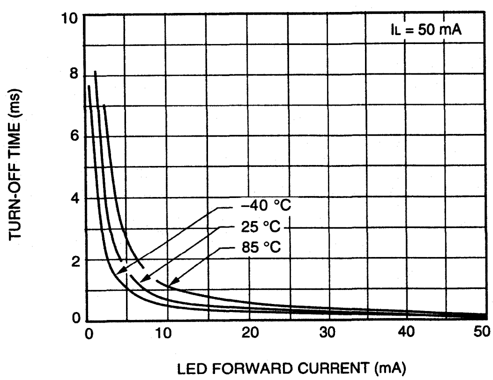
C. Turn-On Time vs. LED Current (LH1528)



D. Turn-Off Time vs. LED Current (LH1529)

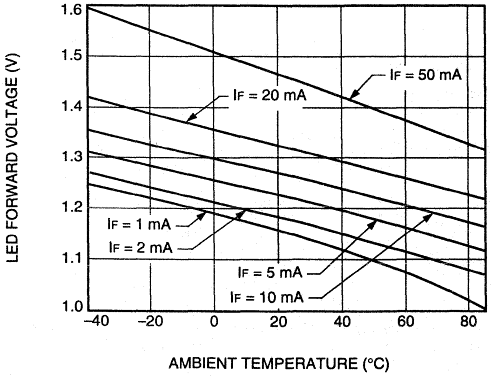


E. Turn-Off Time vs. LED Current (LH1528)

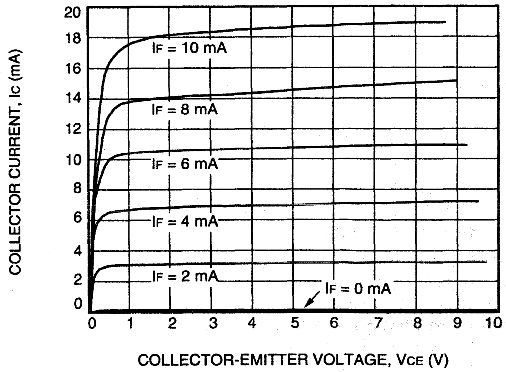


Optocoupler Characteristics (LH1549 not included)

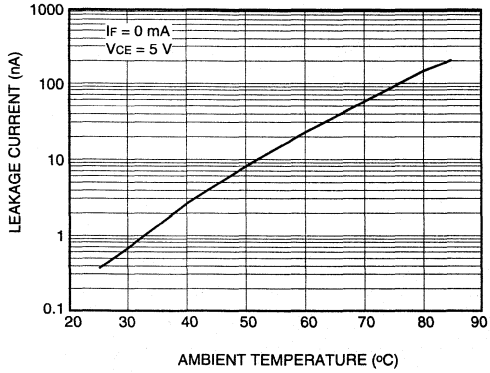
A. LED Voltage vs. Temperature



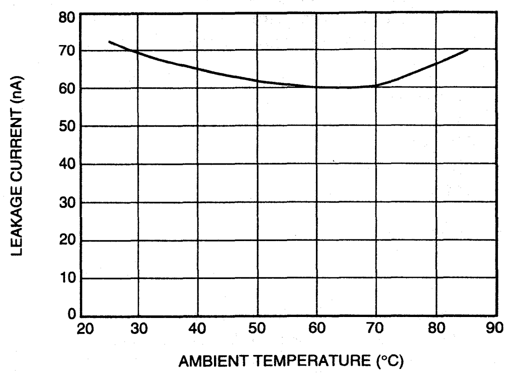
B. Transfer Characteristics



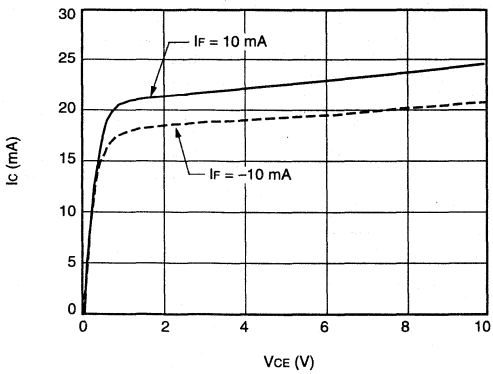
C. Dark Current Leakage vs. Temperature



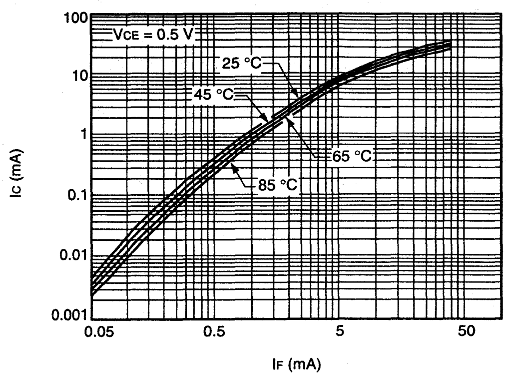
D. Trickle Leakage Current vs. Temperature



E. Symmetry



F. Current Transfer Ratio (CTR) vs. Temperature



SIEMENS

LH1539
1 FORM A / PHOTO DARLINGTON

FEATURES
- **Solid state relay and autopolarity optocoupler in one 8-pin package**
- **3750 V_{RMS} I/O isolation**
- **Surface mountable**
- **Optocoupler**
  - **— Bidirectional current detection**
  - **— High CTR: >300%**
- **Solid state relay**
  - **— Low operating current**
  - **— Typical R_{ON}: 25 Ω**
  - **— Load voltage: 400 V**
  - **— Load current: 120 mA**
  - **— Current-limit protection**
  - **— High-surge capability**
  - **— Linear, ac/dc operation**
  - **— Clean, bounce-free switching**
  - **— Low power consumption**
  - **— High-reliability monolithic receptor**

APPLICATIONS
- **General telecom switching**
  - **— On/off-hook switching**
  - **— Dial pulse**
  - **— Ring current detection**
  - **— Loop current sensing**

DESCRIPTION
The LH1539 telecom switch consists of an optically isolated solid state relay (SSR) and a bidirectional input optocoupler in a single 8-pin package. The SSR is ideal for switchhook and dial-pulse switching while the optocoupler performs ring detect and loop current sensing functions. Both the SSR and optocoupler provide 3750 VRMS of input-to-output isolation voltage.

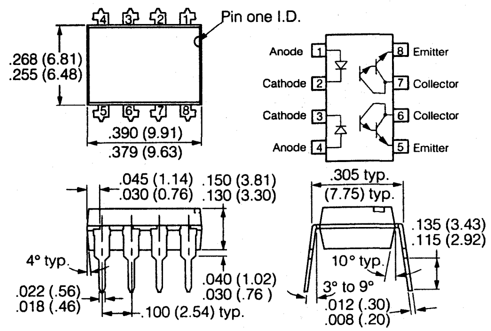
The SSR is integrated on a monolithic receptor die using smart power BICMOS technology. The SSR features low ON-resistance, high breakdown voltage, and current-limit circuitry that protects the relay from telephone line induced lightning surges.

The optocoupler provides bidirectional current sensing via two antiparallel GaAs infrared emitting diodes. Very high current transfer ratio (CTR) is achieved by coupling to a photodarlington transistor. This high CTR allows the user to minimize the size of the ring detector capacitor.

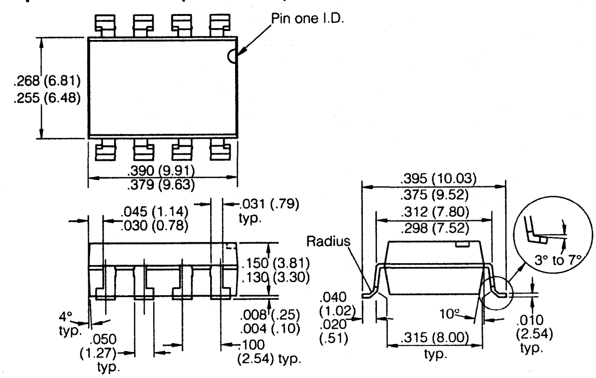
The telecom switch is packaged in an 8-pin, plastic DIP (LH1539AB) or in a surface mount configuration (LH1539AAC).

Dimensions in Inches (mm)

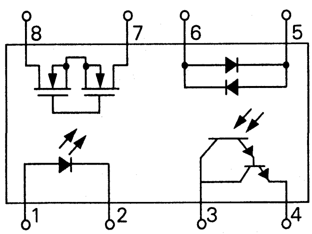
8-pin DIP (LH1539AB)



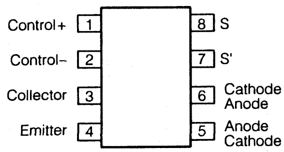
8-pin Surface Mount (LH1539AAC)



Functional Diagram



Pin Diagram



Absolute Maximum Ratings (at 25°C)

Stresses exceeding the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those indicated in the operational sections of this data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect device reliability.

Parameter	Symbol	Value	Unit	Condition
SSR				
LED Continuous Forward Current	I_F	50	mA	
LED Reverse Voltage	V_R	8	V	$I_R \leq 10\ \mu A$
dc or Peak ac Load Voltage	V_L	400	V	$I_L \leq 50\ \mu A$
Continuous dc Load Current	I_L	120	mA	
Optocoupler				
LED Continuous Forward Current	I_F	50	mA	
LED Reverse Voltage	V_R	3	V	$I_R \leq 10\ \mu A$
Collector-Emitter Breakdown Voltage	BV_{CEO}	30	V	
Photodarlington Power Dissipation	P_{DISS}	150	mW	
Package				
Ambient Operating Temperature Range	T_A	–40 to +85	°C	
Storage Temperature Range	T_{STG}	–40 to +85	°C	
Pin Soldering Temperature	T_S	269	°C	t=10 s max.
Input/Output Isolation Voltage	V_{ISO}	3750	V_{RMS}	t=60 s min.
Total Package Power Dissipation	P_{DISS}	600	mW	

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
LED Forward Current, Switch Turn-on	I_{Fon}	3.0	—	20	mA	T_A=–40°C to +85°C

Electrical Characteristics (T_A=25°C)

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical vlues are for information puposes only and are not part of the testing requirements.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
SSR						
LED Forward Current, Switch Turn-on	I_{Fon}	—	0.5	1.0	mA	I_L=100 mA, t=10 ms
LED Forward Current, Switch Turn-off	I_{Foff}	0.1	0.4	—	mA	V_L=±300 V
LED Forward Voltage	V_F	0.8	1.2	1.4	V	I_F=3 mA
ON-resistance	R_{ON}	17	25	33	Ω	I_F=3 mA, I_L=±50 mA
OFF-resistance	R_{OFF}	—	5000	—	GΩ	I_F=0 mA, V_L=±100 V
Current Limit	I_{LMT}	170	210	270	mA	I_F=5 mA, t=5 ms
Output Off-state Leakage Current	—	—	0.04	100	nA	I_F=0 mA, V_L=±100 V
Output Capacitance Pins 4 to 6	—	—	55 10	— —	pF pF	I_F=0 mA, V_L=1 V I_F=0 mA, V_L=50 V
Turn-on Time	t_{on}	—	—	2.0	ms	I_F=5 mA, I_L=50 mA
Turn-off Time	t_{off}	—	—	0.5	ms	I_F=5 mA, I_L=50 mA
Optocoupler						
LED Forward Voltage	V_F	0.9	1.2	1.5	V	I_F=10 mA
dc Current Tranfer Ratio	CTR	300	—	—	%	I_F=0.05 mA, V_{CE}=0.9 V
Saturation Voltage	V_{CEsat}	—	—	1.0	V	I_F=0.05 mA, I_C=0.15 mA
Leakage Current	I_{CEO}	—	—	N/A	—	I_F=0 mA, V_{CE}=5 V

SIEMENS

LH1548ACE

SOP Telecom Switch

FEATURES

- Solid state relay and an autopolarity optocoupler in a low-profile, small-outline package
- 1500 Vrms I/O isolation
- Surface-mountable
- Optocoupler
  - Bidirectional current detection
- Solid state relay
  - 1 Form A contact
  - Typical R_{ON}: 25 Ω
  - Load voltage: 400 V
  - Load current: 110 mA
  - Current-limit protection
  - High-surge capability
  - Linear, ac/dc operation
  - Clean, bounce-free switching
  - Low power consumption
  - High-reliability monolithic receptor

APPLICATIONS

- PCMCIA Type 2 modem cards
- General telecom switching
  - On/off-hook control
  - Dial pulse
  - Ring-current detection
  - Loop-current sensing

DESCRIPTION

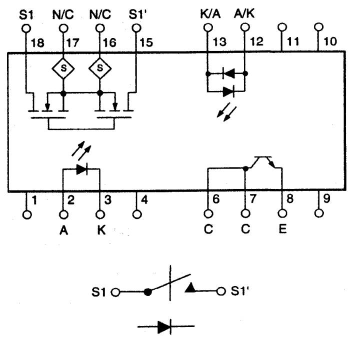
The LH1548 SOP Telecom Switch consists of an optically isolated, SPST normally open solid-state relay (SSR) and a bidirectional input optocoupler in a single, small-outline package (SOP). The SSR is ideal for performing switchhook and dial-pulse switching while the optocoupler performs ring detect and loop current sensing functions. The package is only 79 mils high (2 mm) making it compatible with center-mounted PCMCIA Type 2 boards.

The SSR is integrated on a monolithic receptor die by using a Smart Power BiCMOS technology. It features low ON-resistance, high breakdown voltage, and current-limit circuitry that protects the relay from telephone line induced lightning surges.

The optocoupler provides bidirectional current sensing via two antiparallel GaAlAs infrared emitting diodes. The optocoupler provides a minimum current transfer ratio (CTR) of 33%.

The telecom switch is packaged in an 18-pin, low-profile SOP package. The middle pins (5 and 14) are not used in this package configuration. Therefore, only 16 pins extend from the package. The pin-to-pin spacing for this package is 50 mils (1.27 mm) and the height, flush to board, is only 79 mils (2 mm)

Figure 1. Functional Diagram.



Absolute Maximum Ratings (At 25°C)

Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those indicated in the operational sections of the data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect device reliability.

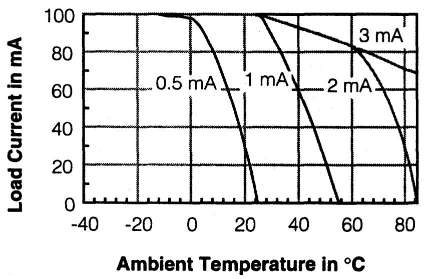
Parameter	**Symbol**	**Value**	**Unit**
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–40 to +125	°C
Pin Soldering Temperature (t=5 s max.)	T_S	260	°C
Input/Output Isolation Voltage	V_{ISO}	1500	Vrms
SSR Ratings:			
LED Continuous Forward Current	I_F	50	mA
LED Reverse Voltage (IR ≤ 10 µA)	V_R	5	V
dc or Peak ac Load Voltage (IL ≤ 50 µA)	V_L	400	V
Continuous dc Load Current	I_L	110	mA
Optocoupler Ratings:			
LED Continuous Forward Current	I_F	50	mA
Collector to Emitter Breakdown Voltage	BV_{CEO}	30	V
Phototransistor Power Dissipation	P_{DISS}	30	mW
Total Package Power Dissipation	P_{DISS}	600	mW

Solid State Relays 6

SSR Recommended Operating Conditions

Parameter	**Symbol**	**Min**	**Typ**	**Max**	**Unit**
LED Forward Current for Switch Turn-on (T_A=–40°C to +85°C)	I_{FON}	3.0	—	20	mA

Recommended Operating Conditions



Electrical Specifications (T_A=25°C)

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

Table 1. SSR Electrical Characteristic

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on	I_{Fon}	I_L=100 mA, t=10 ms	—		0.5	mA
LED Forward Current for Switch Turn-off	I_{Foff}	V_L=±350 V, t=100 ms	0.001	0.1	—	mA
LED Forward Voltage	V_F	I_F=1.5 mA	0.80	1.15	1.40	V
ON-resistance	R_{ON}	I_F=1.5 mA, I_L=±50 mA	17	26	33	Ω
Current Limit	I_{LMT}	I_F=1.5 mA, t=5 ms, V_L=±7 V	170	210	270	mA
Output Off-state Leakage Current	—	I_F=0 mA, V_L=±100 V I_F=0 mA, V_L=±400 V	— —	0.04 —	200 1.0	nA μA
Turn-on Time	t_{ON}	I_F=5 mA, I_L=50 mA	—	—	1.0	ms
Turn-off Time	t_{OFF}	I_F=5 mA, I_L=50 mA	—	—	0.5	ms

Table 2. Optocoupler Electrical Characteristic

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
LED Forward Voltage	V_F	I_F=10 mA	0.9	1.2	1.5	V
dc Current Transfer Ratio	CTR	I_F=6.0 mA, V_{CE}=0.5 V	33	—	—	%
Saturation Voltage	$V_{CE\,(sat)}$	I_F=16 mA, I_C=2 mA	—	.07	0.5	V
Dark Current Leakage	I_{CEO}	I_F=0 mA, V_{CE}=5 V	—	—	500	nA
Trickle Current Leakage	I_{CEO}	I_F=5 μA, V_{CE}=5 V	—	—	1	μA

SIEMENS

LH1514
2 Form A
High-Frequency Solid-State Relay

FEATURES
- Load voltage, 15 V
- Load current, 150 mA
- Switching capability up to 50 MHz
- Blocking capability dependent upon signal dv/dt
- Low and typical R_{ON}, 5 Ω
- 1 ms actuation time
- Low power consumption
- 3750 Vrms I/O isolation
- Balanced switching
- Linear ac/dc operation
- Clean, bounce-free switching
- High-reliability monolithic receptor
- Surface-mountable
- UL Recognized

APPLICATIONS
- Protection switching (T1 sparing)
  —Digital access cross connects
  —D-type channel breaks
  —Intraoffice data routing
- Transmission switching
  —T1 multiplexing
  —DSO (64 Kbits/s)
  —DS1 (1.544 Mbits/s)
  —E1, DS1A (2.048 Mbits/s)
  —DS1C (3.152 Mbits/s)
  —DS2 (6.312 Mbits/s)
- Instrumentation
  —Scanners
  —Testers
  —Measurement equipment

DESCRIPTION
The LH1514 is a DPST normally open (2 Form A) SSR that can be used in balanced high-frequency applications like T1 switching. With its low ON-resistance and high actuation rate, the LH1514 is also very attractive as a general-purpose 2 Form A SSR for balanced signals.

The relays are constructed using a GaAlAs LED for actuation control and an integrated monolithic die for the switch output. The die, fabricated in a dielectrically isolated Smart Power BiCMOS, is comprised of a photodiode array, switch control circuitry, and NMOS switches.

In balanced switching applications, internal circuitry shunts high-frequency signals between two poles when the SSR is off. This balanced T termination technique provides high isolation for the load.

The relay is packaged in an 8-pin, plastic DIP (LH1514AB) or in a surface-mount gull wing (LH1514AAC).

Figure 1. Functional Diagram

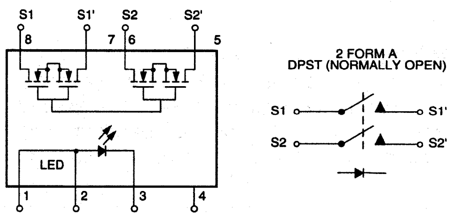
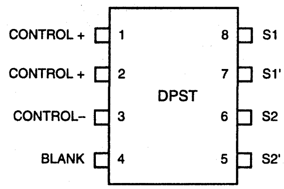


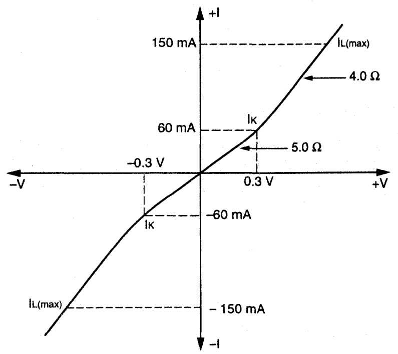
Figure 2. Pin Diagram and Pin Outs



Functional Description

Figure 3 shows the switch characteristics of the relay. The relay exhibits an ON-resistance that is exceptionally linear up to the knee current (IK). Beyond IK, the incremental resistance decreases, minimizing internal power dissipation.

Figure 3. Typical ON Characteristics



In a 2 Form A relay, to turn the relay on, forward current is applied to the LED. The amount of current applied determines the amount of light produced for the photodiode array.

This photodiode array develops a drive voltage for both NMOS switch outputs. For high-temperature or high-load current operations, more LED current is required.

For high-frequency applications, the LH1514 must be wired as shown in the Figure 16 application diagram to minimize transmission crosstalk and bleed-through. A single LH1514 package switches a single transmit twisted pair or a single receive twisted pair. In this configuration when the SSR is turned off, the SSR parries high-frequency signals by shunting them through the SSR, thereby isolating the transformer load.

When switching alternate mark inversion (AMI) coding transmission, the most critical SSR parameter is dv/dt bleed-through. This bleed-through is a result of the rise and fall time slew rates of the 3 V AMI pulses. The test circuit in Figure 4 illustrates these bleed-through glitches. It is important to recognize that the transmission limitations of the LH1514 are bleed-through related and not frequency related. The maximum frequency the LH1514 SSR can switch will be determined by the pulse rise and fall times and the sensitivity of the receive electronics to the resultant bleed-through.

At data rates above 2 Mbits/s, the 50 pF pole-to-pole capacitance of the LH1514 should be considered when analyzing the load match to the transmission line. Please refer to the *T1 Switching with the LH1514 SSR* Application Note for further information on load-matching and off-state blocking.

Absolute Maximum Ratings At 25°C

Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect the device reliability.

Parameter	Symbol	Value	Unit
Ambient Operating Temperature Range	T_A	–40 to +85	°C
Storage Temperature Range	T_{stg}	–40 to +150	°C
Pin Soldering Temperature (t=10 s max.)	T_S	260	°C
Input/Output Isolation Voltage	V_{ISO}	3750	Vrms
LED Input Ratings: Continuous Forward Current Reverse Voltage ($I_R \leq 10\ \mu A$)	 I_F V_R	 50 10	 mA V
Output Operation: dc or Peak ac Load Voltage ($I_L \leq 1\ \mu A$) Continuous dc Load Current Each Pole, Two Poles Operating Simultaneously	 V_L I_L	 15 150	 V mA
Power Dissipation	P_{DISS}	600	mW

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
LED Forward Current for Switch Turn-on (T_A=–40°C to +85°C)	I_{Fon}	8	—	20	mA

Electrical Characteristics T_A=25°C

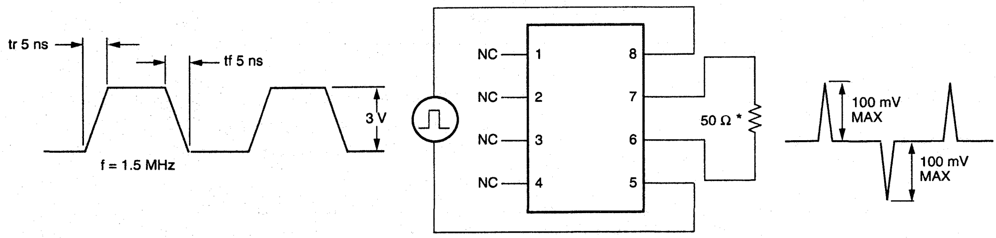
Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
LED Forward Current or Switch Turn-on	I_{Fon}	I_L=100 mA, t=10 ms	—	2.0	3.0	mA
LED Forward Current for Switch Turn-off	I_{Foff}	V_L=±10 V	0.2	1.8	—	mA
LED Forward Voltage	V_F	I_F=10 mA	1.15	1.26	1.45	V
ON-resistance	R_{ON}	I_F=10 mA, I_L=±50 mA	3.0	5.0	8.0	Ω
Pole-to-pole ON-resistance Matching (S1 to S2)	—	I_F=10 mA, I_L=±50 mA	—	0.2	1.0	DΩ
Output Off-state Bleed-through*	—	f=1.5 MHz square wave tr/tf=5 ns (See Figure 4.)	—	70	100	mV_{peak}
Output Off-state Leakage	—	I_F=0 mA, V_L=±5 V V_L=±15 V	— —	3×10^{-12} 20×10^{-12}	200×10^{-9} 1.0×10^{-6}	A A
Output Off-state Leakage Pole-to-pole	—	I_F=10 mA Pins 7, 8 ±3 V Pins 5, 6 Gnd	—	1.0	5	µA
	—	Pins 7, 8 ±15 V Pins 5, 6 Gnd	—	2.0	50	µA
Output Capacitance Pins 5 to 6, 7 to 8	—	I_F=0 mA, V_L=0	—	20	—	pF
Pole-to-pole Capacitance (S1 to S2)	—	I_F=0 mA, V_L=0 V I_F=10 mA, V_L=0 V	— —	20 50	— —	pF pF
Turn-on Time	t_{on}	I_F=10 mA, I_L=20 mA	—	0.4	1.0	ms
Turn-off Time	t_{off}	I_F=10 mA, I_L=20 mA	—	0.6	1.0	ms

* Guaranteed by component measurement during wafer probe.

Test Circuit

Figure 4. Off-State Bleed-Through



* 50 Ω load is derived from T1 applications where a 100 Ω load is paralleled with a 100 Ω line.

Typical Performance Characteristics

Figure 5. LED Forward Current for Switch Turn-On/Off

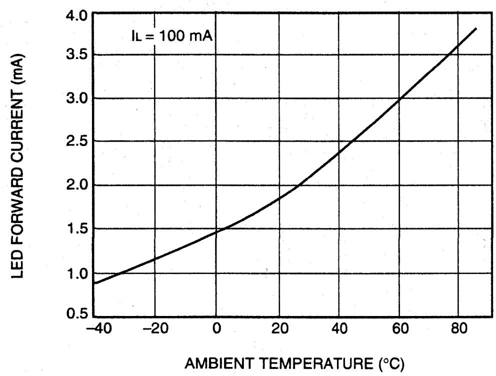


Figure 6. ON-Resistance vs. Temperature

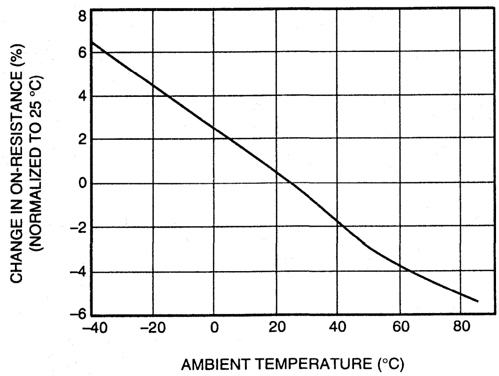


Figure 7. Leakage Current vs. Applied Voltage

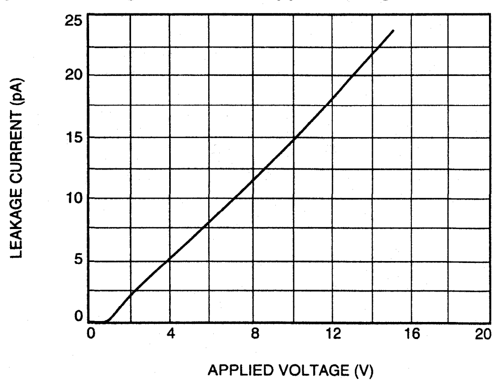
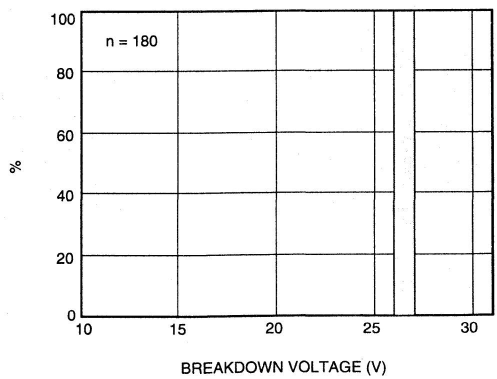


Figure 8. Breakdown Voltage Distribution



Typical Performance Characteristics (continued)

Figure 9. Output Isolation

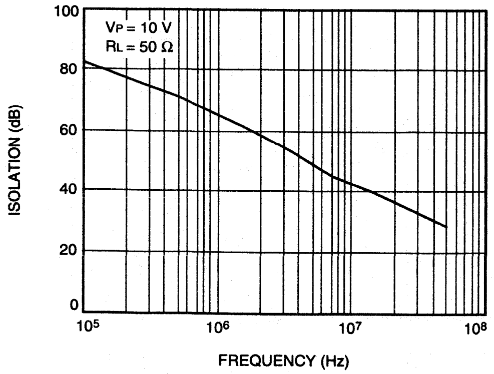


Figure 10. Bleed-Through Voltage vs. Rise Time

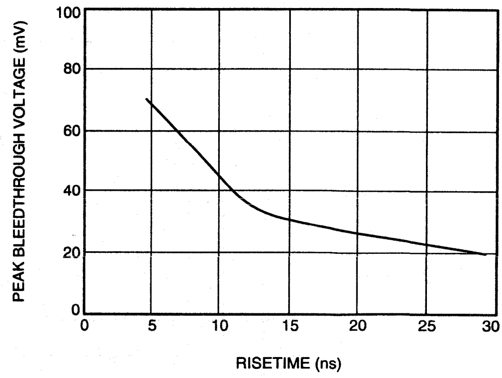


Figure 11. Insertion Loss (per Pole) vs. Frequency

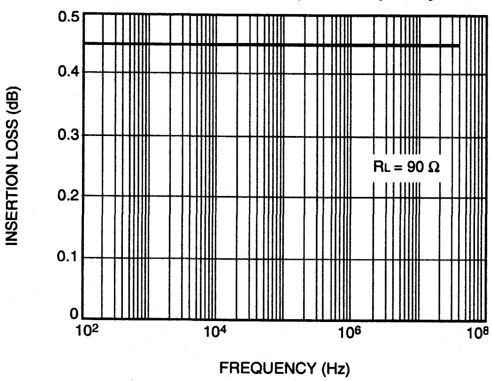


Figure 12. t_{ON}/t_{OFF} vs. Temperature

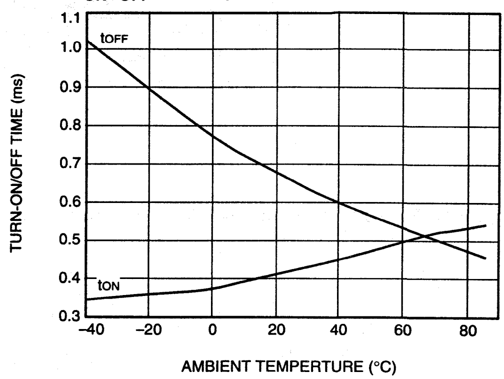


Figure 13. t_{ON} vs. LED Forward Current

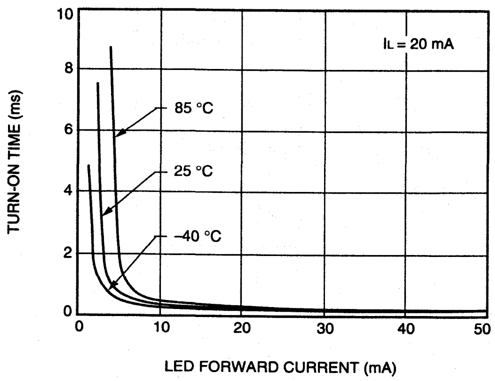
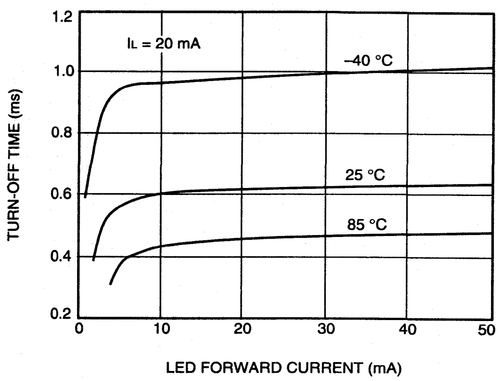


Figure 14. t_{OFF} vs. LED Forward Current



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Applications

Figure 15. Protection Switching Application: T1 Interface Operating; Spare in Test Loopback Mode

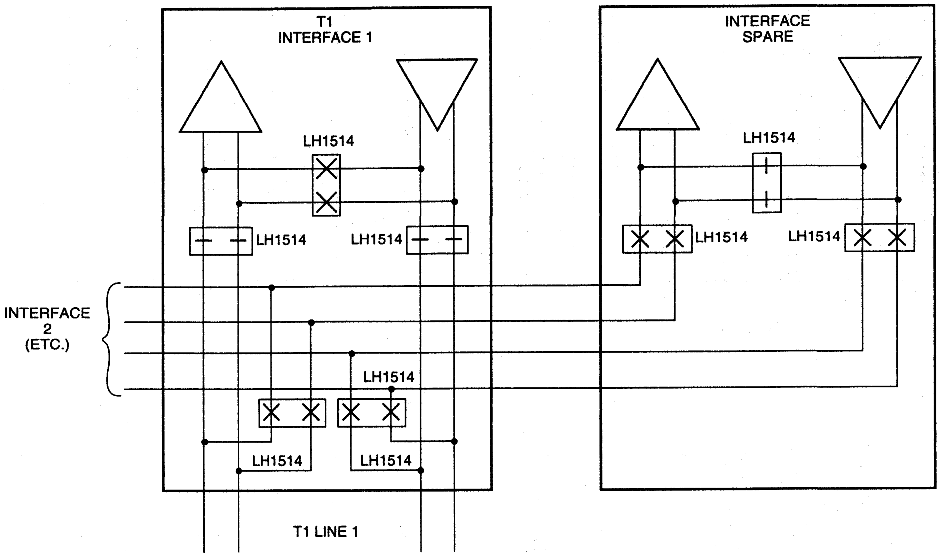
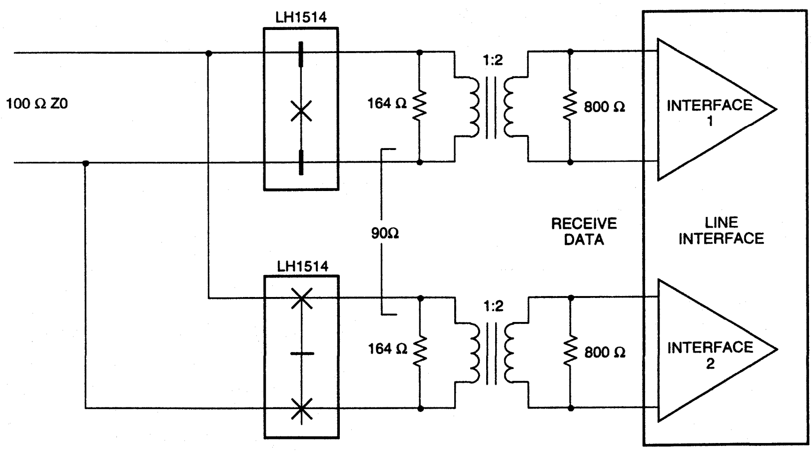


Figure 16. T1 Multiplexer Receive Data (Interface 1, Operating)



LH2559

High-Voltage Interface IC
Polarity Guard and Switch Hook Control

FEATURES
- Low voltage drop polarity guard (1.4 V max at 20 mA), ideal for line-powered DAA circuits
- On-chip protection for associated DAA circuitry
- Isolated switchhook, suitable for pulse dialing
- Three functions integrated into one package, ideal for space-constrained applications
- Isolation in excess of 3750 Vrms to facilitate meeting domestic and foreign regulatory requirements
- Easy interface to AT&T and other DAA circuits
- Ideal for use in modems, answering machines, FAX machines, and other customer premises equipment

APPLICATIONS
- Modems
- FAX machines
- Answering machines
- Key telephone systems
- Equipment attached to the customer premises side of the telephone line

DESCRIPTION
The LH2559 High-Voltage Interface IC is an integrated high-voltage switch that contains a solid-state switchhook relay, a low-voltage drop polarity guard, and a protection circuit across the outputs.

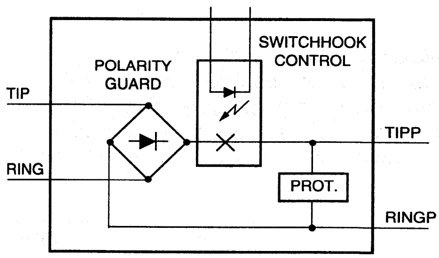
The solid-state switchhook relay is an optically coupled, low ON-resistance, MOSFET device. The 8-pin DIP/SOG version has an insulating barrier of 3750 Vrms. This device has a voltage break-down rating of 400 V.

A feature of this device is the polarity guard. A combination of diodes and MOSFETs provides for a low-voltage drop on long loops. The maximum voltage drop across both the polarity guard and the solid-state switchhook relay is only 1.4 V at 20 mA.

The 18 V protection circuit is provided to ensure the integrity of coupled low-voltage DAA circuitry, such as AT&T's ATTD2560 Interface Circuit for Optically Coupled Data Access Arrangements.

The LH2559 is packaged in an 8-pin DIP (LH2559AB) or in an 8-pin surface-mount gull-wing package (LH2559AAC).

Figure 1. Functional Block Diagram



Pin Information

Figure 2. 8-Pin DIP Diagram for LH2559

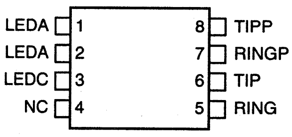


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Table 1. PIN Descriptions for 8-Pin DIP/SOG Package

DIP/SOG	Symbol	Description
1	LEDA	The anode side of the LED that controls the switch.
2	LEDA	The anode side of the LED that controls the switch.
3	LEDC	The cathode side of the LED that controls the switch.
4	NC	No connection. Do NOT use as tie points.
5	RING	Ring conductor of the incoming telephone line.
6	TIP	Tip conductor of the incoming telephone line.
7	RINGP	Ring conductor of the telephone line on the user side of the polarity guard. This is a polarized RING conductor, negative with respect to TIPP.
8	TIPP	Tip conductor of the telephone line on the user side of the switchhook. This is a switched and polarized positive TIP conductor.

Functional Description

As shown in Figure 1, the LH2559 contains three functional blocks: a solid-state switchhook relay, a polarity guard, and a protection circuit.

The switchhook function is performed by using an isolated MOSFET switch that has an ON-resistance of approximately 7 Ω. This switch is controlled by an optically coupled, isolated relay-driver circuit. The relay-driver circuit is controlled by the LED input pins. When current is applied to the LED, the switch goes to an off-hook condition. The LED has an input/output isolation of 3750 Vrms, and the MOSFET switch has a breakdown voltage of 400 V. These parameters will easily meet the isolation/breakdown requirements of many regulatory agencies.

The polarity guard functions as a diode bridge, always biasing the TIPP lead positive with respect to the RINGP lead. A combination of MOSFETs and diodes is used to reduce the forward voltage drop through the device (including the switchhook) to 1.4 V maximum at 20 mA. This allows a full 4.6 V to be available to the other DAA circuitry on the equipment side of the switchhook and while still meeting the requirements of FCC Part 68 on a long loop. The device also contains an internal 18 V protection circuit to protect external equipment connected to the outputs of the device during the off-hook state.

Absolute Maximum Ratings (At 25°C)

Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those indicated in the operational sections of the data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect device reliability.

Parameter	Symbol	Value	Unit
Power Supply	V_{SS}	5 V ± 10%	V
Ambient Operating Temperature Range	T_A	0 to 70	°C
Pin Soldering Temperature: (t=10 s max) 8-pin DIP/SOG	T_S	260	°C
Input/Output Isolation Voltage: (t=60 s min) 8-pin DIP/SOG	V_{ISO}	3750	Vrms
Breakdown Voltage TIP—TIPP	V_{BD}	400	V
LED Input Ratings: Continuous Forward Current Reverse Voltage ($I_R \leq 10$ μA)	 I_F V_R	 50 5	 mA V

Electrical Specifications (T_A=25°C)

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information purposes only and are not part of the testing requirements.

Table 2. Device Characteristics

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Off-state Leakage Current	I_{TIPP}	I_F=0 mA, V_{TIP}=400 V, V_{RING}=0 V, TIPP and RINGP tied together	—	—	16	μA
Total ON-resistance	R_{ON}	I_F=5 mA, I_{TIP}=30 mA, V_{RING}=0 V R_{ON}=[V (50 mA) – V (20 mA)] ÷ 30 mA TIPP and RINGP tied together	12	—	24	Ω
Total On-state Voltage	V_{TIP}	I_F=5 mA, I_{TIP}=20 mA, V_{RING}=0 V, TIPP and RINGP tied together	—	—	1.4	V
Turn-on Time	t_{on}	V_{TIPP}=0 V, V_L=50 V, TIP=R_L, R_L=1 kΩ , I_F=step from 0 mA to 5 mA	—	—	5	ms
Turn-off Time	t_{off}	V_{TIPP}=0 V, V_L=50 V, TIP=R_L, R_L=1 kΩ , I_F=step from 5 mA to 0 mA*	—	—	5	ms
Breakdown Voltage	V_{BD}	I_F=0 mA, Voltage applied between TIP and RING, TIPP and RINGP tied together	400	—	—	V
Isolation Voltage: 8-pin DIP/SOG	—	Between pins 1—4 and 5—8	3750	—	—	Vrms
LED Forward Current for Switch Turn-on	I_{FON}	I_{TIP}=100 mA, t=5 ms	—	0.2	5	mA
LED Forward Current for Switch Turn-off	I_{FOFF}	V_{TIP} V_{TIPP}=400 V, t=5 ms	0.01	0.1	—	mA
LED Forward Voltage	V_F	I_F=10 mA	1.15	1.26	1.45	V
LED Reverse Breakdown Voltage	V_{LBD}	—	5	—	—	V
Protection Voltage	V_{PROT}	—	16	18	20	V

*V_L is a power supply connected to the TIP pin through a resistance R_L.

SIEMENS

LH1262CB/CAC

Dual Photovoltaic MOSFET Driver

Preliminary Data Sheet

FEATURES
- **High open circuit voltage**
- **High short circuit current**
- **High I/O isolation voltage**
- **Logic compatible input**
- **High reliability**

APPLICATIONS
- **High-side driver**
- **Solid state relays**
- **Floating power supply**
- **Power control**
- **Data acquisition**
- **ATE**
- **Isolated switching**

DESCRIPTION

The LH1262CB/CAC Photovoltaic MOSFET Driver consists of two LEDs optically coupled to two photodiode arrays. The photodiode array provides a floating source with adequate voltage and current to drive high-power MOSFET transistors. Optical coupling provides a high I/O Isolation voltage. In order to turn the MOSFET off, an external resistance (gate-to-source) is required for gate discharge.

The device is packaged in an 8-pin, plastic DIP (LH1262CB) or as a surface-mount gull wing (LH1262CAC).

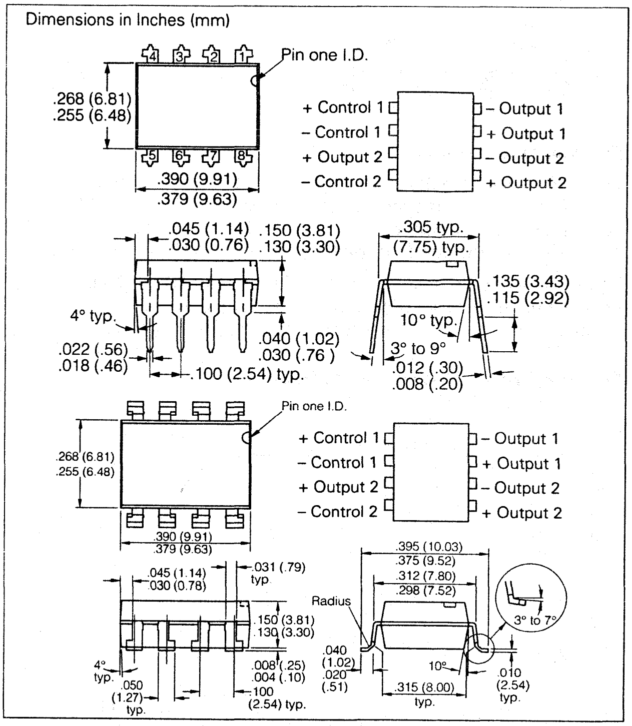
Absolute Maximum Ratings at 25°C

Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to maximum rating conditions for extended periods can adversely affect device reliability.

Ambient Operating
  Temperature Range (T_A)................–40°C to +100°C
Storage Temperature Range (T_{stg}) ....–40°C to +150°C
Pin Soldering Time (t=7 s max.) (T_S)..................270°C
Input/Output Isolation Voltage
  (t=60 s min.) (V_{ISO}) .... 3750 V_{RMS}
LED Input Ratings
  Continuous Forward Current(I_F)..................... 50 mA
  Reverse Voltage ($I_R \leq 10$ µA)t(V_R) ....5 V
Photodiode Array Reverse Voltage
  ($I_R \leq 2$ µA)t(V_R) ....500 V

Electrical Characteristics Notes

*f=1 kHz, pulse width=100µs, load (R_L)= 1 MΩ, 15 pF; measured at 90% rated voltage (t_{on}), 10% rated volatge (t_{off}). Actuation speed depends upon the external t_{on} and t_{off} circuitry and the gate capacitance of the MOSFET.

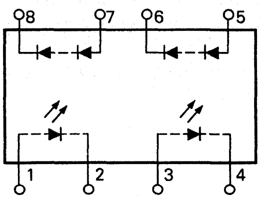


Electrical Characteristics (T_A=25°C)

Minimum and maximum values are testing requirements. Typical values are characteristics of the device and are the result of engineering evaluations. Typical values are for information only and not part of the testing requirements.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
LED Forward Voltage	V_F	1.15	1.26	1.45	V	I_F=10 mA
Detector Forward Voltage	V_F (PDA)		14		V	I_F=10 µA
Detector Reverse Voltage	V_R (PDA)		700		V	I_R=2 µA
Open circuit Voltage (pins 5,6 or 7,8)	V_{OC}	10	13.5	15	V	I_F=5 mA
	V_{OC}		14		V	I_F=10 mA
	V_{OC}		14.5		V	I_F=20 mA
Short circuit Current (pins 5,6 or 7,8)	I_{SC}	1	4.0	6.5	µA	I_F=5 mA
	I_{SC}	2.6	8	14	µA	I_F=10 mA
	I_{SC}		17		µA	I_F=20 mA
Turn-On Time	t_{on}		35		µs	I_F=20 mA*
Turn -Off Time	t_{off}		90		µs	I_F=20 mA*

Figure 1. Functional diagram

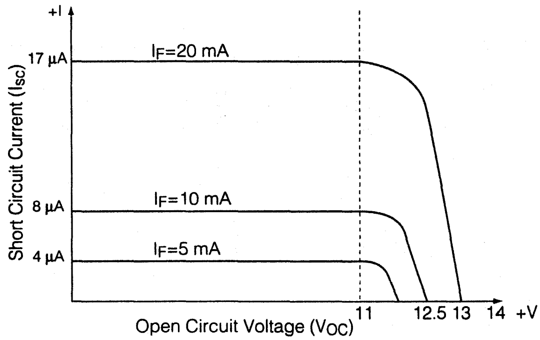


Functional Description

Figure 2 outlines the IV characteristics of the illuminated photodiode array (PDA). For operation at voltages below V_{OC}, the PDA acts as a nearly constant current source. The actural region of operation depends upon the load.

The amount of current applied to the LED (pins 1 and 2 or 3 and 4) determines the amount of light produced for the PDA. For high temperature operation, more LED current may be required.

Figure 2. Typical PDA ON characteristics



Typical Performance Characteristics

Figure 3. Output voltage vs. LED forward current

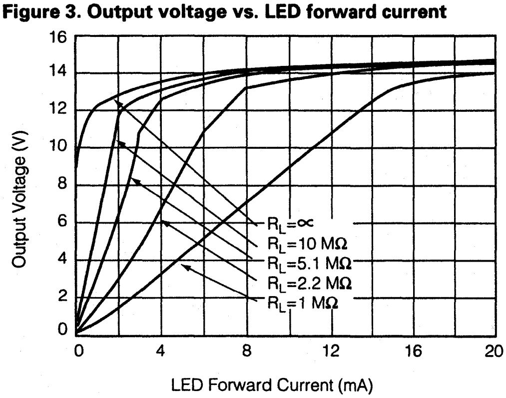


Figure 4. Short circuit current vs. LED forward current

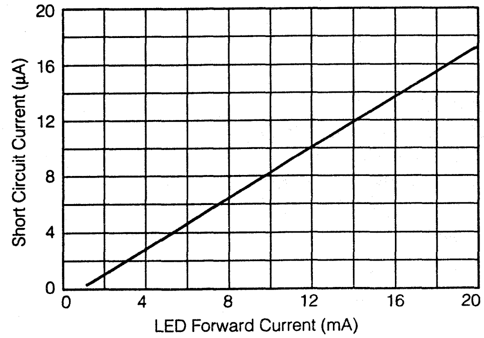


Figure 5. Open circuit voltage vs. temperature

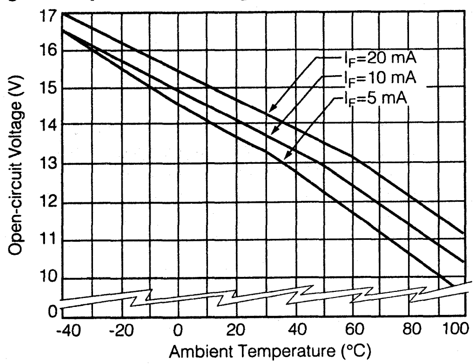


Figure 6. Short circuit current vs. temperature

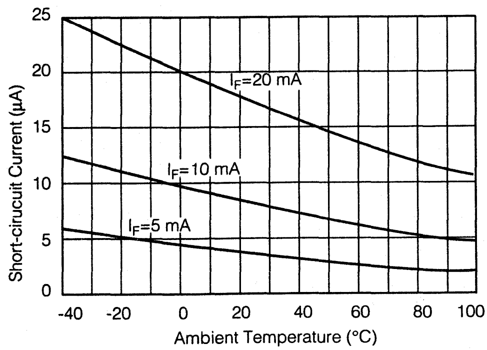


Figure 7. LED forward voltage vs. temperature

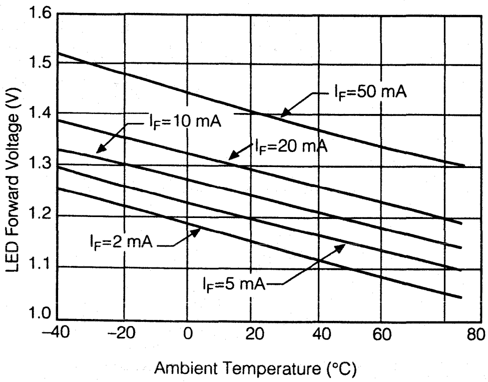


Figure 8. t_{ON}/t_{OFF} vs. load capacitance

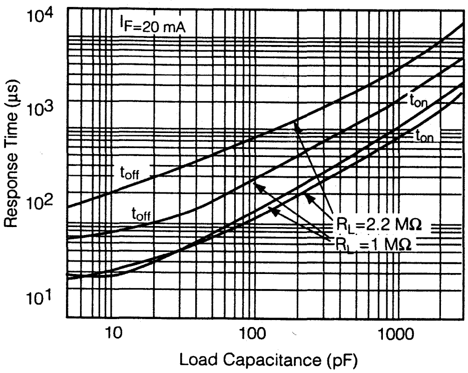
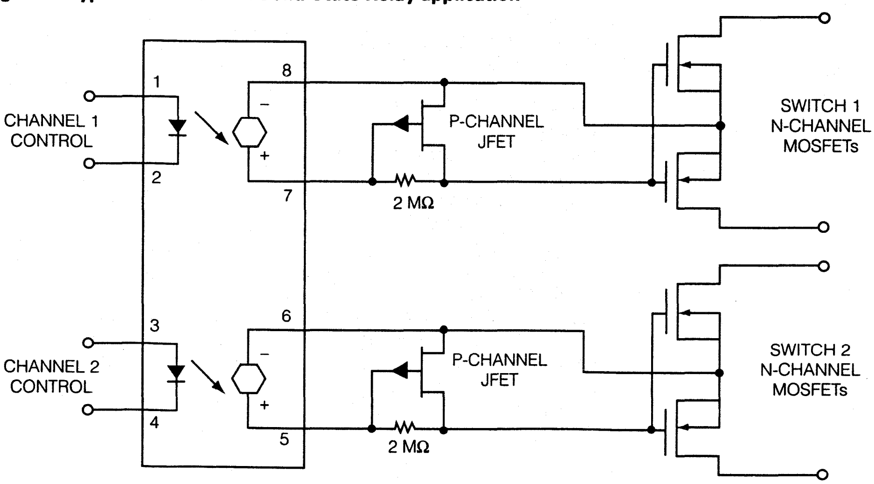


Figure 9. Typical Dual Form A Solid State Relay application



SIEMENS

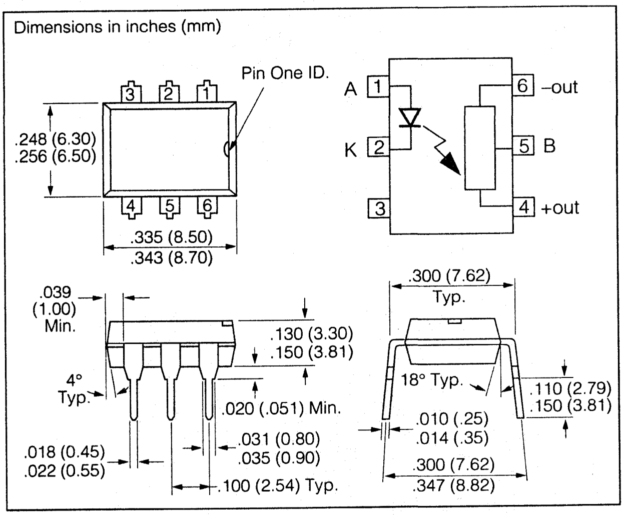
LH 1485

OPTICALLY COUPLED HIGH SPEED MOSFET DRIVERS OPTOCOUPLER

FEATURES
- **Fast Turn On**
- **Fast Turn Off**
- **Low Input Current**
- **Isolation Test Voltage, 5300 VAC_{RMS}**

APPLICATIONS
- **Motor Drive Controls**
- **IGBT-predrivers**
- **AC/DC Power Inverters**

DESCRIPTION
The IL485 is a photovoltatic generator (optically coupled) designed to drive highly capacitive loads such as the gate of a power MOSFET transistor and at the same time provide isolation and floating voltage supply capability. The coupler consists of a GaAlAs light emitting diode as input control and a custom photo IC chip with photodiode arrary (PDA) as output device. When the LED is turned on, the emitted light produces a voltage in the PDA. The output of the PDA is used to drive the gate of a power MOSFET. The photo IC chip contains additional circuitry to enhance the switching speeds, (both turn on turn off). The optocoupler is packaged in a 6 pin DIP.



Maximum Ratings

Emitter

Reverse Voltage .... 4 V
Forward Current .... 60 mA
Peak Forward Current .... 600 mA
Power Dissipation .... 100 mW
Thermal Resistance .... 700 °C/W

Detector

Breakdown Voltage (pin 5 to 6) .... 300 V
Peak Input Current (pin 5 to 4) .... 50 mA
Reverse Current (pin 5 to 6, V=100 V) .... 200 nA
Power Dissipation (pin 5 to 4) .... 150 mW

Package

Insulation Thickness between Emitter and Detector .... ≥0.4 mm
Isolation Test Voltage (1 sec.) .... 5300 VAC_{RMS}
Isolation Resistance
 V_{IO}=500 V, T_A=25°C .... $\geq 10^{12}\ \Omega$
 V_{IO}=500 V, T_A=100°C .... $\geq 10^{11}\ \Omega$
Comparative Tracking Index per
 DIN IEC 112/VDE 303, Part 1 .... ≥175
Total Power Dissipation .... 250 mW
Storage Temperature Range .... –55°C to +150°C
Operating Temperature Range .... –55°C to +100°C
Junction Temperature .... 100°C
Soldering Temperature (max. 10 sec.,
 dip soldering distance to seating plane >1.5 mm) .... 260°C

Electrical Characteristics

Parameter		Symbol	Min.	Typ.	Max.	Unit	Condition
Input — Emitter							
LED Forward Voltage		V_F	0.9	1.5	2.1	V	I_F=10 mA
LED Junction Capacitance		C_J		25		pF	V_R=0 V, f=1 MHz
MOSFET Driver Output with External Biasing (see Figure 1 and Figure 3)							
Zener Voltage (pin 4 to 6)		V_Z		13		V	I_{ZT}=10 µA
Dynamic Output Voltage (pin 4 to 6)		V_{OUT}	9	11		V	C_L=2000 pF, V_B=20 V, I_F=10 mA
Dynamic Output Current (pin 4 to 6)		I_{OUT}		5		mA	C_L=2000 pF, V_B=20 V, I_F=10 mA
				15			C_L=2000 pF, V_B=20 V, I_F=40 mA
Dynamic Output Resistance	Sourcing (pin 4)	R_{OUT}		300		Ω	I_F=10 mA
	Sinking (pin 4)			20			
Turn-on Time		t_{ON}		3.5	5	µs	C_L=2000 pF, I_F=40 mA Measure at V_{OUT}=5 V, V_B=20 V
Turn-off Time		t_{OFF}		3.5	5	µs	C_L=2000 pF, I_F=40 mA Measure at V_{OUT}=2 V, V_B=20 V
MOSFET Driver Output without External Biasing (see Figure 2 and Figure 3)							
Output Open Circuit Voltage (pin 4 to 6)		V_{OC}	8	10		V	I_F=10 mA
Output Short Circuit Current (pin 4 to 6)		I_{SC}	2.1	4		µA	I_F=10 mA
			8.4	16			
Dynamic Output Resistance Sinking (pin 4)		R_{OUT}		20		Ω	I_F=10 mA
Turn-on Time		t_{ON}		650	1000	µs	C_L=2000 pF (see Figure 3) Measure at V_{OUT}=5 V, I_F=40 mA
Turn-off Time		t_{OFF}		3	5	µs	C_L=2000 pF (seeFigure 3) Measure at V_{OUT}=2 V, I_F=40 mA
MOSFET Driver Output Switching Speed (see Figure 3, Figure 4, Figure 5)							
Rise time		t_R		500		ns	M1 Cgs=2000 pF, V_S=50 V Measure at 90%–10% M1 V_{DS} (see Figure 4)
Turn-on Time		t_{ON}		3.5		µs	
Fall time		t_F		300		ns	
Turn-off Time		t_{OFF}		3.5		µs	
Package Isolation Characteristics							
Input-Output CMRR		dv/dt		15 kV		V/µs	V_{CM}=1000 V
Coupling Capacitance		C_{IO}		1		pF	f=1 MHz

Solid State Relays 6

Figure 1. Switching time measurement with external voltage bias

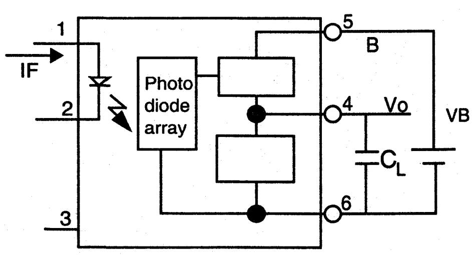


Figure 2. Switching time measurement

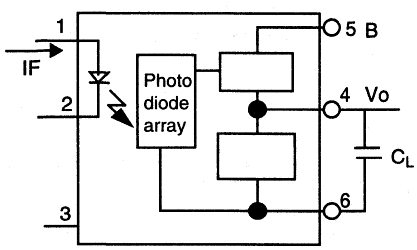


Figure 3. IL485 connected in AC load switching configuration

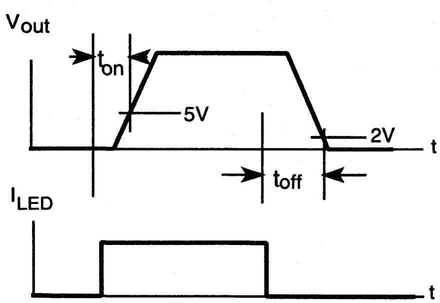


Figure 4. Switching time measurement without voltage bias

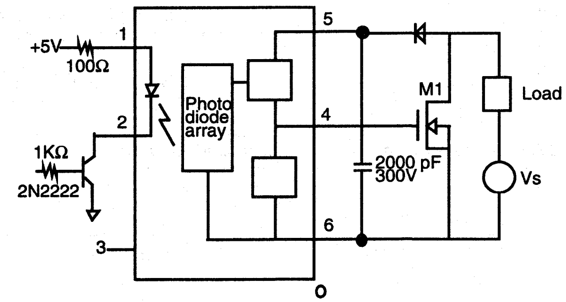
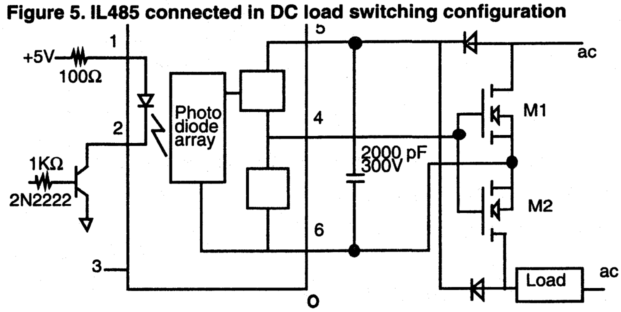
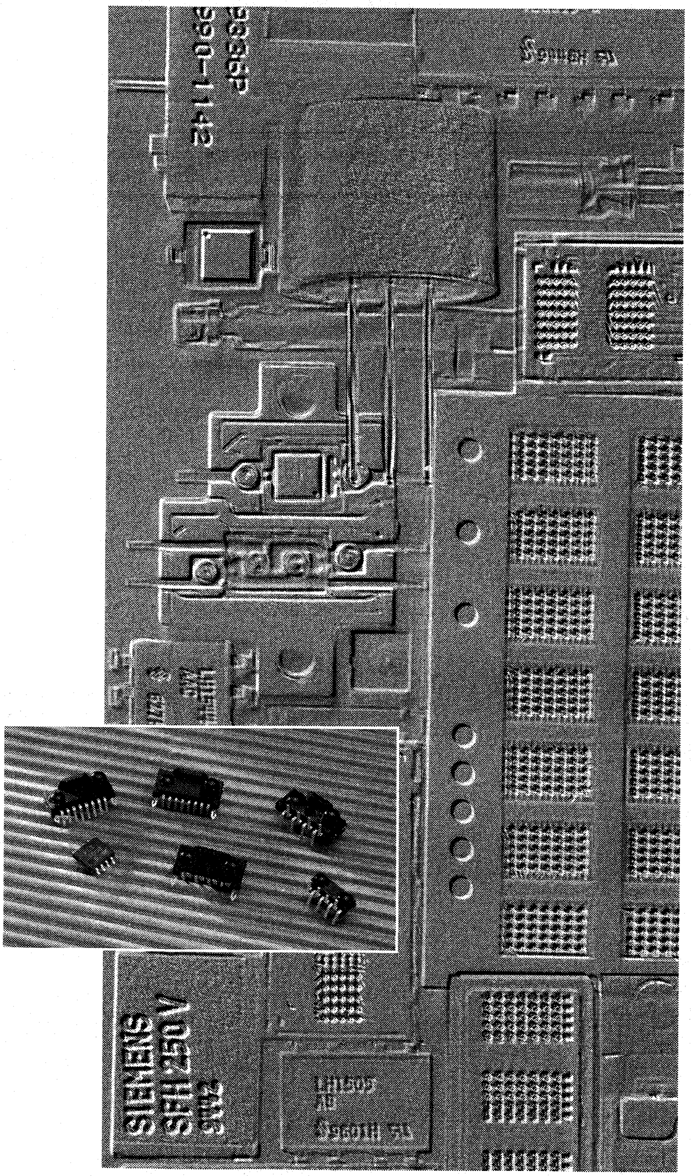


Figure 5. IL485 connected in DC load switching configuration





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Intelligent Display® Devices

Numeric Displays

LED Lamps

Optocouplers

Solid State Relays (SSRs)

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- Laser Diodes
- Photodiodes

Fiber Optic Data Links
- Transceivers
- Cable Assemblies

Infrared Emitters

Photodiodes

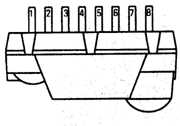
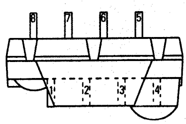
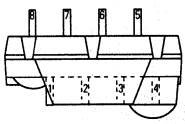
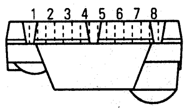
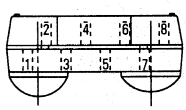
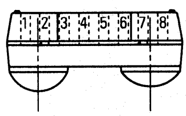
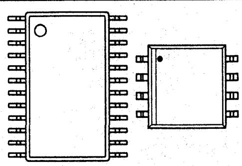
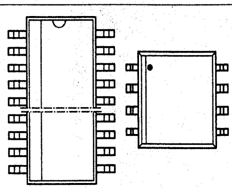
Phototransistors

Photovoltaic Cells

Application Notes

IR DataCOM Products

Types and Package Outlines

Type	Part Number	Data Rates	Package Outline	Page
Right Angle SIP	IRM3000	115 @ 3 V 4 Mb/s 3 V		7–9
	RM3401			7–12
Alternating SIP	IRM3100	115 @ 3 V 4 Mb/s 3 V		7–9
	IRM3405			7–12
Alternating SIP (SMD)	IRM3015	115 @ 3 V 4 Mb/s 3 V		7–9
	IRM3415			7–12
Gullwing SIP (SMD)	IRM3003	115 @ 3 V 4 Mb/s 3 V		7–9
	IRM3402			7–12
Slimline Alternating SIP (SMD)	IRM6000	115 @ 3 V		7–15
Slimline Gullwing SIP (SMD)	IRM6002			
Optical DAA Kit	DAA2000 Kit (DL207/ DM207, IL388)			7–1
	DAA2100 Kit (DL208/ DM208, IL388)			7–5

Infrared DataCOM Products

The IR DataCOM group is dedicated to providing the highest quality infrared communications devices for the lowest possible cost to the consumer. Our two major product offerings include Infrared Datalink products and full featured optical Data Access Arrangements (DAA).

Key IrDA Datalink Features

- Low-cost implementation
- Low power consumption
- Directed point-to-point connectivity
- High noise immunity

Siemens standard products are designed to meet the growing needs of IR datalink communications. All products are compatible with the IrDA physical layer specification 1.0 and 1.1e.

115.2 Kb/s, 3V: IRM30xx

Fully integrated IrDA-compatible transceiver that supports data rates of 9.6 Kb/s to 115.2 Kb/s at Vcc=3V. Package is easily adaptable for pick-and-place equipment and is available in different pin configurations.

4 Mb/s: IRM34xx

Provides data transfer rate of up to 4Mb/s backward compatible down to 9.6 Kb/s. Features differential PIN diode input for interference rejection and is mode selectable between SIR and FIR.

115.2 Kb/s: Slimline

IrDA-compatible transceiver that supports data rates of up to 115.2 Kb/s. Very small package size measures only 4.3 mm in height, 9.4 mm in width and 4.1 mm in depth. An excellent choice for applications with restricted board space.

Optical DAA Products

The Siemens Optical DAA is a full-featured telephone line isolation device that combines small size with high performance.

DAA2000 Kit

Consisting of two linear optocouplers (IL388s) and two custom integrated circuits (DL207 and DM207), the DAA2000 is ideal for modem applications where space is limited. The two ICs are packaged in small 24-pin TSSOP packages and the optocouplers are packaged using Siemens' exclusive Slimline technology.

DAA2100 Kit

Almost the same as the DAA2000, this basic DAA provides many outstanding features in a slightly larger package configuration. The optocouplers are still packaged in our Slimline package, but the integrated circuits are packaged in 24-pin SOICs.

DAA Features

- 3 V operation on modem side
- Wake-on-ring power management
- Line-side over-current protection
- 10 Hz to 4 KHz bandwidth

SIEMENS

DAA2000

Optical DAA Kit

Preliminary

FEATURES

- **V.32 and V.34 Compatibility**
- **Supports Ring Detect and Wake On Ring**
- **On-hook Monitor Provides for Caller ID and Voice/Fax/Data Steer Functions**
- **On-hook Monitor Draws <1 mA**
- **Over Current and Thermal Limiting**
- **On-hook Line Voltage Measurement**
- **Line Current Sense**
- **3 Volt (Modem Side) Operation**
- **Low Gain Drift**
- **56 Kbps Compatible**
- **Universal Applications**
- **100% Low Profile Surface Mount**
- **Compatible to FCC Part 68**
- **UL and CSA Registered**

DESCRIPTION

The DAA2000 is a kit consisting of a DL207 Line-Side Integrated Circuit, a DM207 Modem-Side Integrated Circuit and two IL388 Linear Optocouplers. When configured along with the other specified components, the final circuit provides for a full featured Optical DAA that meets or exceeds all of the appropriate government regulations for such a device.

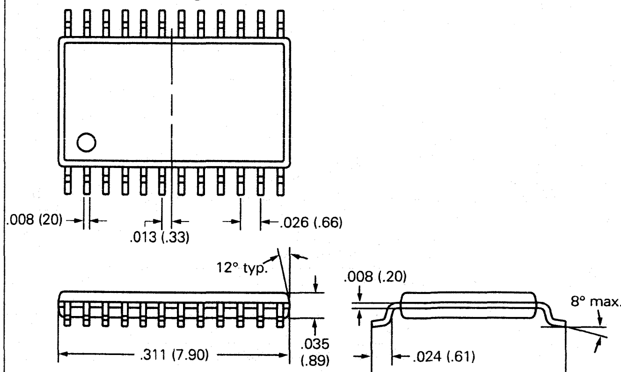
All of the components in the kit are packaged in easy to assemble surface mount format. The DL207 and DM207 have standard 24-pin TSSOP packages and the IL388, an 8-pin Siemens Slimline surface mount package. The user can easily assemble the DAA function directly onto a mother board along with all of the other SMD components, eliminating costly special or hand insert operations. With this kit the actual DAA function takes less than two square inches of board space.

The DAA2000 is a full featured Optical DAA that takes into consideration the needs of today's portable and multimedia equipment. Added features of the DAA2000 such as line current sense, snooping and line V/F make the circuit ideal for enhanced modems which support speaker phones, answering machines, simultaneous voice and fax, caller ID and voice/fax/data steering.

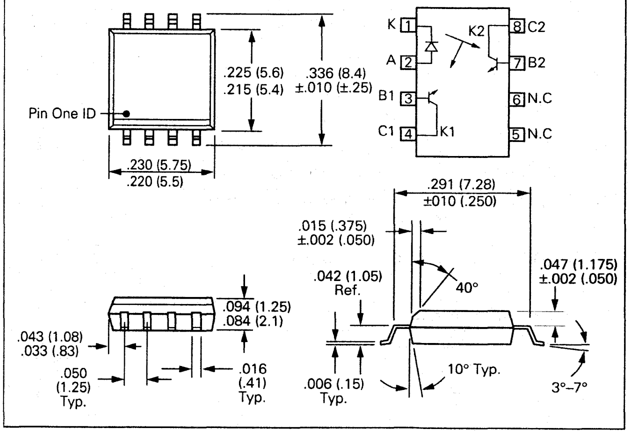
The DAA2000's unique "Wake on Ring" feature allows it to draw no current when idle except when ringing is detected.The DAA2000 circuit may be powered from an unregulated power source such as a battery up to 7 volts—allowing the designer to power up the computer switching power supply from the ring detect output (a high going signal).

Package Dimensions in Inches (mm)

DL207, DM207 Integrated Circuits



IL388 Linear Optocoupler



Maximum Ratings

Parameter	DL207	DM207
Supply voltage	10 V	7 V
Input current	10 mA	—
Tip and ring voltage	350 V	—
Package	**Value**	
Total package dissipation at 25° ambient	TBD	
Derate linearly from 25°C	TBD	
Storage temperature	–20°C to +85°C	
Operating temperature	–0°C to +70°C	
Soldering time at 260°C, $^1/_8$" from body	5 sec.	

MAY 23, 1997

Pin Configurations

DL207			DM207		
Pin	**Symbol**	**Function**	**Pin**	**Symbol**	**Function**
1	HLDR	Connection for resistor which sets 600 Ω AC termination impedance	1	CIB	Capacitor connection (C1)
2	LEDCT	Receive linear optoisolator LED cathode connection	2	VREF	Internal 1.25 V precision band gap reference
3	HLDCAP	Holding circuit decoupling capacitor connection	3	C2	Capacitor connection (C2)
4	HKP	Positive hook switch driver output	4	RXCT	Receive photodiode return
5	HKN	Negative hook switch driver output	5	RXAN	Receive photodiode input
6	LINPWR	Diagnostics pin	6	SNPL	Negative assertion snoop mode control input
7	HLFWV	Shorting this pin to Vdd produces halfwave ring detect output	7	SNP	Positive assertion snoop mode control input
8	LR2	Line resistor connection	8	HIN	Diagnostics pin, do not connect
9	LR1	Line resistor connection	9	SRVAN	Transmit servo photodiode anode
10	END	Connection for resistor to CEN	10	SRVCT	Transmit servo photodiode cathode
11	CEN	Connection for resistor to C1A	11	TXAMP	Current input for transmit audio
12	CIA	Connection for capacitor (C1)	12	VDD	Power 3–7 V
13	CIB	Connection for capacitor (C1)	13	LEDCT	Transmit linear optoisolator LED cathode connection
14	BIASEN	Diagnostics pin	14	VSS	Ground return
15	C2	Connection for capacitor (C2)	15	AUD-OUT	Auxiliary audio amplifier output
16	TXCT	Transmit photodiode return	16	AUDIN	Inverting input for auxiliary audio amplifier
17	TXAN	Transmit photodiode input	17	TXBIAS	Connection for resistor which sets servo photocurrent DC bias
18	SNPCAP	Connection for Snoop RC	18	ACREF	Audio AC reference for input and output audio signals
19	VFCAP	Connection for V/F capacitor and resistor	19	RXOUT	Audio output
20	HIN	Diagnostics pin, do not connect	20	OFFHK	Positive assertion off-hook control input
21	SRVAN	Receive servo photodiode anode	21	OFFHKL	Negative assertion off-hook control input
22	SRVCT	Receive servo photodiode cathode	22	RNG	Ring detect output
23	VSS	Line-side return	23	LSTAT	Line status output
24	VDD	Line-side supply signal	24	CIA	Capacitor connection (C1)
IL388					
Pin	**Symbol**	**Function**	**Pin**	**Symbol**	**Function**
1	A	Cathode	5	N.C.	
2	K	Anode	6	N.C.	
3	B1	Base 1	7	B2	Base 2
4	C1	Collector 1	8	C2	Collector 2

Ring Detector Characteristics (25°C)

Parameter	Value	Unit	Condition
Threshold Adjustment	15 ±30%	V_{RMS}	Option to set higher
Output Type	Full wave or half wave		

Distortion (25°C)

Parameter	Value	Unit	Condition
Transmit Total Harmonic Distortion	<–70	dB	Transmit and receive in-band below –3 dBm single frequency tone, 200 Hz to 3400 Hz
Receive Total Harmonic Distortion	<–75	dB	At receiver output below –3 dBm receive signal, 200 Hz to 3400 Hz
In-band Noise	<–80	dBm	3 kHz flat bandwidth

DC Characteristics (25°C)

Parameter	Min.	Typ.	Max.	Unit	Condition
Operating Voltage	3		7	V	Modem-side
Operating Current	4	6	10	mA	Modem-side
Current Limit Threshold	120		160	mA	Through Hook Switch
Over Current Protection	NA	NA	NA		No damage from 350 V across Tip and Ring while off-hook
Surge Rise Time	2000			V/µs	No damage when applied across Tip and Ring
Isolation Voltage	1500			V_{RMS}	Line-side to Modem-side
Isolation Voltage	2500			V_{SURGE}	Line-side to Modem-side
Operating Power			1	W	Off-hook
Surge Suppressor Break-over Voltage			350	V	25 A for 0.5 ms

On-hook Characteristics (25°C)

Parameter	Value	Unit	Condition
DC Resistance	10	MΩ	Tip to Ring
DC Resistance	>200	MΩ	Tip and Ring to GND
AC Impedance	≥150	KΩ	Tip to Ring at <10 V_{RMS} and 0–4000 Hz
Ringer Equivalence Number	<1	REN	

Off-hook Characteristics (25°C)

Parameter	Value	Unit	Condition
DC Resistance	330	Ω	Tip to Ring at 20 mA
Line Current Range	10 to 120	mA	
AC Impedance	600 ±5%	Ω	Tip to Ring
Return Loss	>26	dB	Against 600 Ω, from 200 Hz to 4000 Hz

Transmission/Receiver Characteristics (25°C)

Parameter	Value	Unit	Condition
Frequency Response	100 to 5000	Hz	<3 dB down
Trans-hybrid Loss	32	dB	Against 600 Ω
Transmit Gain	0 ±0.5	dB	1 KHz
Receiver Gain	–6 ±0.5	dB	1 KHz
Maximum Transmit Level	>3	dBm	Single tone sine wave
Maximum Receive Level	>3	dBm	Single tone sine wave
Maximum Receive Output	5	mA	Sink and source
Maximum Aux Audio Output	5	mA	Sink and source

Figure 1. DAA2000 functional block diagram

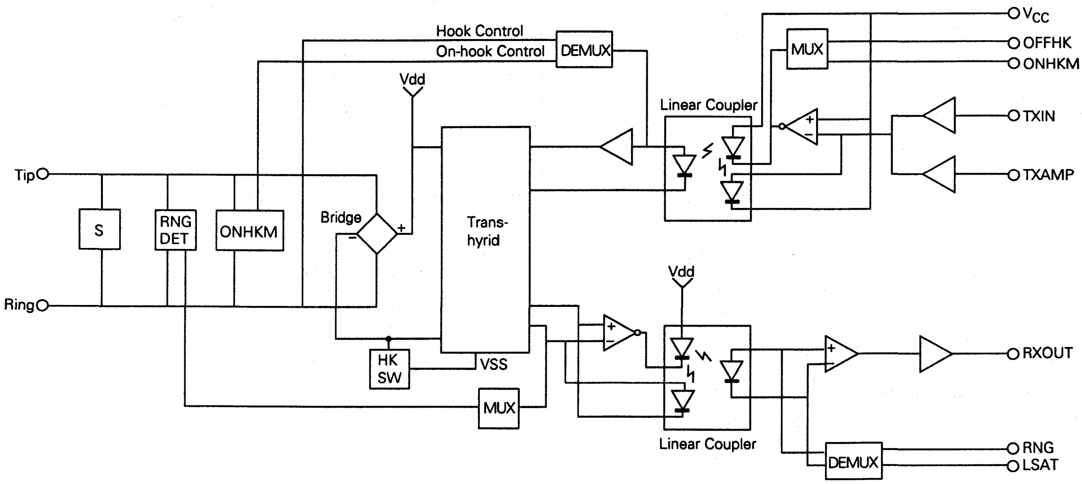
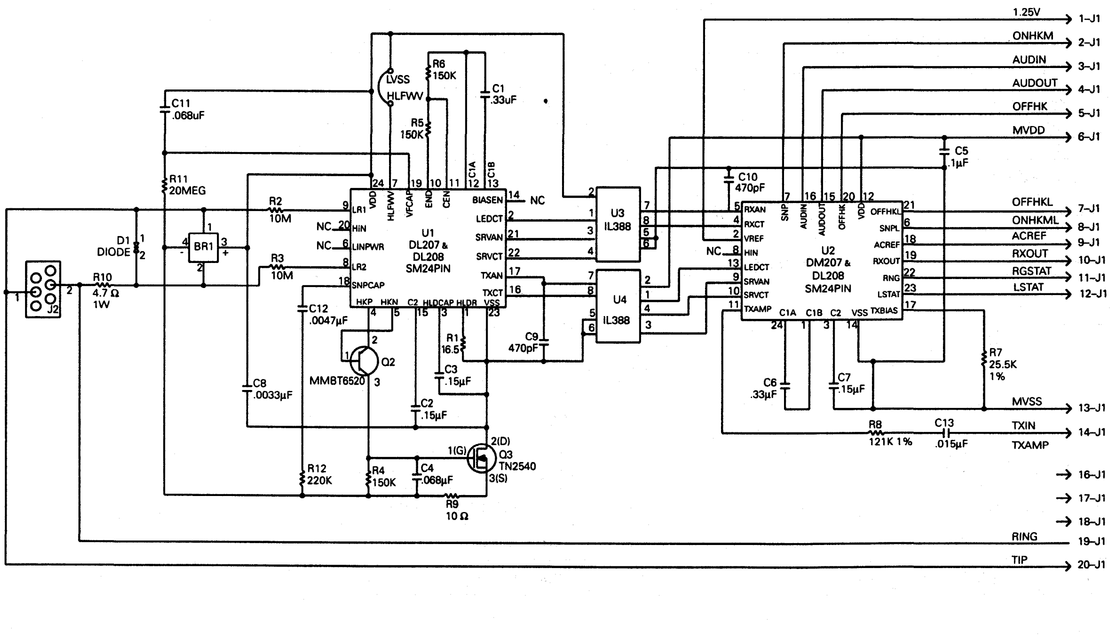


Figure 2. DAA2000 reference schematic (North American and Japanese version)



SIEMENS

DAA2100

Optical DAA Kit

Preliminary

FEATURES

- **V.32 and V.34 compatibility**
- **Supports ring detect and wake on ring**
- **10 Hz to 4 KHz bandwidth (ideal for 56 K modem operation)**
- **Over current and thermal limiting**
- **3 Volt (modem side) operation**
- **Low gain drift**
- **Easy to use kit**
- **100% solid state construction**
- **100% low profile surface mount**
- **Compatible to FCC Part 68**
- **UL and CSA registered**

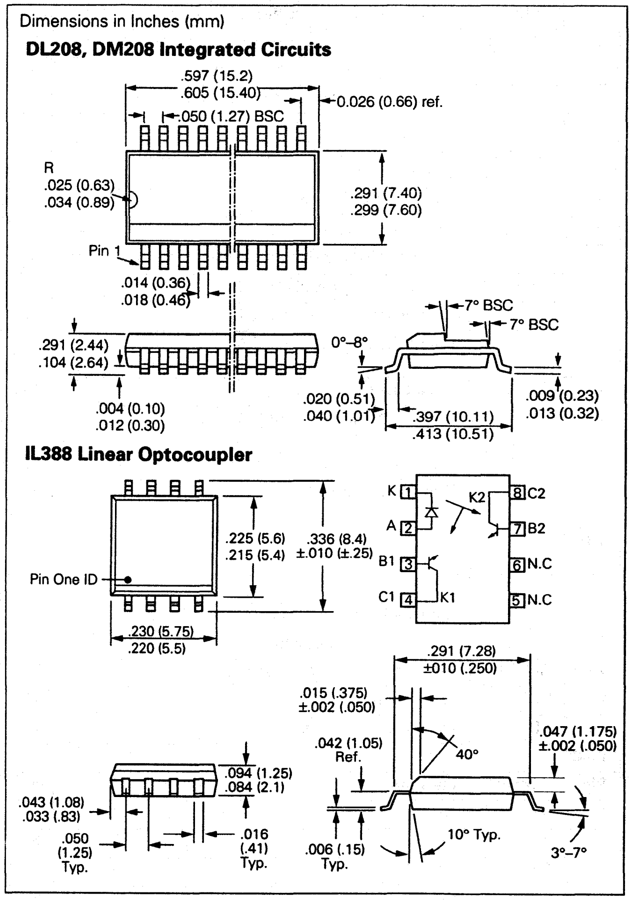
DESCRIPTION

The DAA2100 is a kit consisting of a DL208 Line-Side Integrated Circuit, a DM208 Modem-Side Integrated Circuit and two IL388 Linear Optocouplers. When configured along with the other specified components, the final circuit provides for a full featured Optical DAA that meets or exceeds all of the appropriate government regulations for such a device.

All of the components in the kit are packaged in easy to assemble surface mount format. The DL208 and DM208 have standard 24-pin SOIC packages and the IL388, an 8-pin Siemens Slimline surface mount package. The user can easily assemble the DAA function directly onto a mother board along with all of the other SMD components, eliminating costly special or hand insert operations. With this kit the actual DAA function takes less than two square inches of board space.

The DAA21000 is a basic Optical DAA that takes into consideration the needs of today's ISA modem card requirements. Basic features include integrated transhybrid ring detect and hook switch control.

The DAA2100's unique "Wake on Ring" feature allows it to draw no current when idle except when ringing is detected.The DAA2100 circuit may be powered from an unregulated power source such as a battery up to 7 volts—allowing the designer to power up the computer switching power supply from the ring detect output (a high going signal). In addition, when an "Off Hook" signal is presented, the DM will power up. Since the "Off-Hook" signal is high going, turning off the power to the modem circuitry will force the hook switch pin to the low "On-Hook" condition, turning off the DM.



Maximum Ratings

Parameter	DL208	DM208
Supply voltage	10 V	7 V
Input current	10 mA	—
Tip and ring voltage	350 V	—
Package	**Value**	
Total package dissipation at 25° ambient	TBD	
Derate linearly from 25°C	TBD	
Storage temperature	–20°C to +85°C	
Operating temperature	–0°C to +70°C	
Soldering time at 260°C, 1/8" from body	5 sec.	

Pin Configurations

DL208			DM208		
Pin	**Symbol**	**Function**	**Pin**	**Symbol**	**Function**
1	HLDR	Connection for resistor which sets 600 Ω AC termination impedance	1	CIB	Capacitor connection (C1)
2	LEDCT	Receive linear optoisolator LED cathode connection	2	VREF	Internal 1.25 V precision band gap reference
3	HLDCAP	Holding circuit decoupling capacitor connection	3	C2	Capacitor connection (C2)
4	HKP	Positive hook switch driver output	4	RXCT	Receive photodiode return
5	HKN	Negative hook switch driver output	5	RXAN	Receive photodiode input
6			6		
7	HLFWV	Shorting this pin to Vdd produces halfwave ring detect output	7		
8	LR2	Line resistor connection	8	HIN	Diagnostics pin, do not connect
9	LR1	Line resistor connection	9	SRVAN	Transmit servo photodiode anode
10	END	Connection for resistor to CEN	10	SRVCT	Transmit servo photodiode cathode
11	CEN	Connection for resistor to C1A	11	TXAMP	Current input for transmit audio
12	CIA	Connection for capacitor (C1)	12	VDD	Power 3–7 V
13	CIB	Connection for capacitor (C1)	13	LEDCT	Transmit linear optoisolator LED cathode connection
14	BIASEN	Diagnostics pin	14	VSS	Ground return
15	C2	Connection for capacitor (C2)	15	AUD-OUT	Auxiliary audio amplifier output
16	TXCT	Transmit photodiode return	16	AUDIN	Inverting input for auxiliary audio amplifier
17	TXAN	Transmit photodiode input	17	TXBIAS	Connection for resistor which sets servo photocurrent DC bias
18			18	ACREF	Audio AC reference for input and output audio signals
19			19	RXOUT	Audio output
20	HIN	Diagnostics pin, do not connect	20	OFFHK	Positive assertion off-hook control input
21	SRVAN	Receive servo photodiode anode	21	OFFHKL	Negative assertion off-hook control input
22	SRVCT	Receive servo photodiode cathode	22	RNG	Ring detect output
23	VSS	Line-side return	23		
24	VDD	Line-side supply signal	24	CIA	Capacitor connection (C1)

IL388					
Pin	**Symbol**	**Function**	**Pin**	**Symbol**	**Function**
1	A	Cathode	5	N.C.	
2	K	Anode	6	N.C.	
3	B1	Base 1	7	B2	Base 2
4	C1	Collector 1	8	C2	Collector 2

Ring Detector Characteristics (25°C)

Parameter	Value	Unit	Condition
Threshold Adjustment	15 ±30%	V_{RMS}	Option to set higher
Output Type	Full wave or half wave		

Distortion (25°C)

Parameter	Value	Unit	Condition
Transmit Total Harmonic Distortion	<–75	dB	Transmit and receive in-band below –9 dBm single frequency tone, 100 Hz to 4000 Hz
Receive Total Harmonic Distortion	<–80	dB	At receiver output below –9 dBm receive signal, 10 Hz to 4000 Hz
In-band Noise	<–80	dBm	3 kHz flat bandwidth

DC Characteristics (25°C)

Parameter	Min.	Typ.	Max.	Unit	Condition
Operating Voltage	3		7	V	Modem-side
Operating Current	4	6	10	mA	Modem-side
Current Limit Threshold	120		160	mA	Through Hook Switch
Over Current Protection	NA	NA	NA		No damage from 350 V across Tip and Ring while off-hook
Surge Rise Time	2000			V/µs	No damage when applied across Tip and Ring
Isolation Voltage	1500			V_{RMS}	Line-side to Modem-side
Isolation Voltage	2500			V_{SURGE}	Line-side to Modem-side
Operating Power			1	W	Off-hook
Surge Suppressor Break-over Voltage			350	V	25 A for 0.5 ms

On-hook Characteristics (25°C)

Parameter	Value	Unit	Condition
DC Resistance	10	MΩ	Tip to Ring
DC Resistance	>200	MΩ	Tip and Ring to GND
AC Impedance	≥150	KΩ	Tip to Ring at <10 V_{RMS} and 0–4000 Hz
Ringer Equivalence Number	<1	REN	

Off-hook Characteristics (25°C)

Parameter	Value	Unit	Condition
DC Resistance	330	Ω	Tip to Ring at 20 mA
Line Current Range	10 to 120	mA	
AC Impedance	600 ±5%	Ω	Tip to Ring
Return Loss	>26	dB	Against 600 Ω, from 10 Hz to 4000 Hz

Transmission/Receiver Characteristics (25°C)

Parameter	Value	Unit	Condition
Frequency Response	10 to 5000	Hz	<3 dB down
Trans-hybrid Loss	32	dB	Against 600 Ω
Transmit Gain	0 ±0.5	dB	
Receiver Gain	–6 ±0.5	dB	
Maximum Transmit Level	>3	dBm	Single tone sine wave
Maximum Receive Level	>3	dBm	Single tone sine wave
Maximum Receive Output	5	mA	Sink and source
Maximum Aux Audio Output	5	mA	Sink and source

Figure 1. DAA2100 functional block diagram

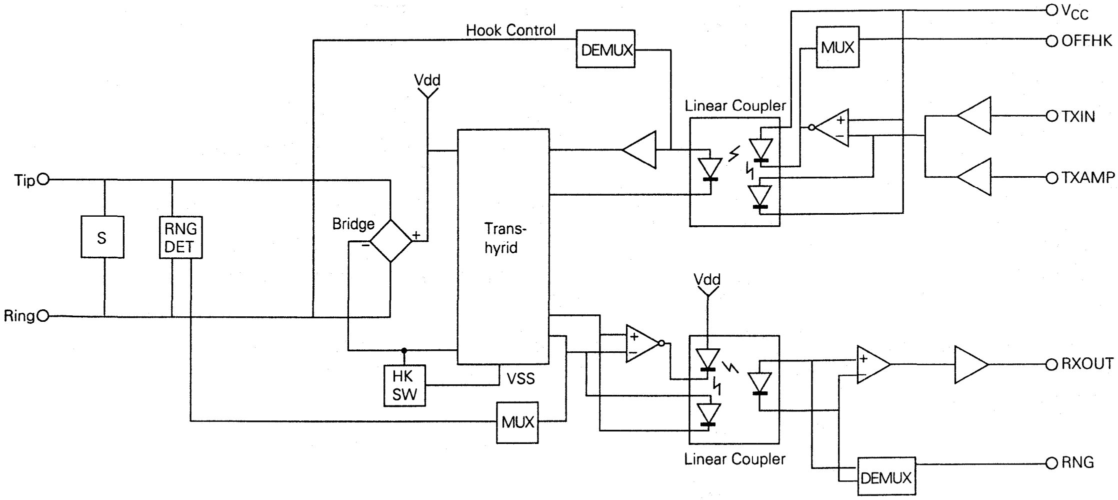
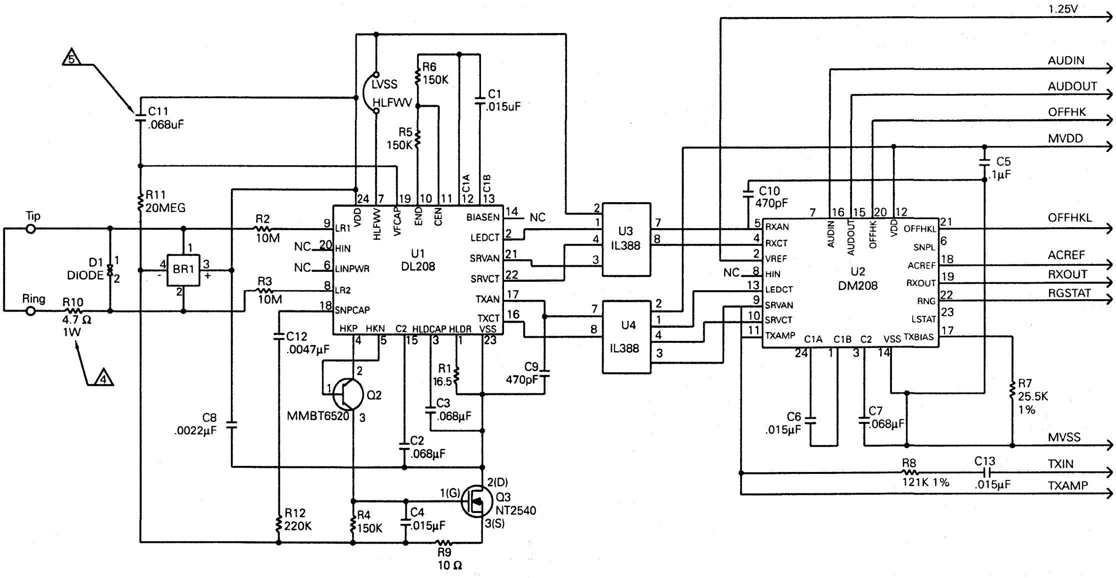


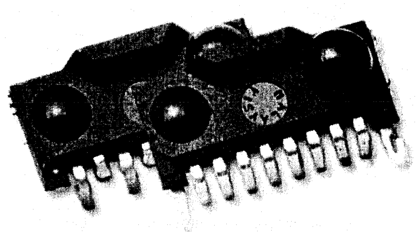
Figure 2. DAA2100 reference schematic



IRM3000/3003/3015/3100

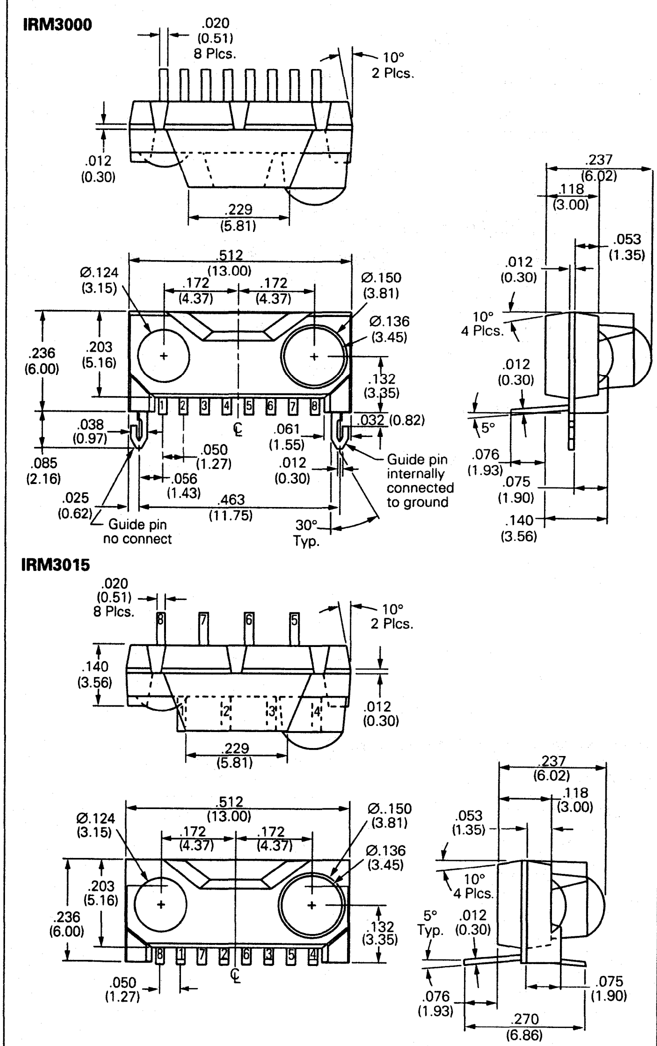
3 V Infrared Data Transceiver

Preliminary



IRM3100 IRM3000

Dimensions in inches (mm)



FEATURES

- **Compatible with IrDA Specifications**
- **Wide Dynamic Range**
- **Automatic Threshold Control**
- **Shutdown Feature Reduces Quiescent Current in Standby Mode**
- **Surface Mounted Package, Ideal for Automated Assembly**

APPLICATIONS

- **Wireless Computer and Peripheral Communications**
- **Wireless Computer and Telephone Communications**
- **Interactive TV and Remote Control**

DESCRIPTION

The IRM3000/3003/3015/3100 is an integrated Infrared transceiver that is compatible with the IrDA Serial Infrared (SIR) Physical Layer Link Specification. Housed in a single molded epoxy surface mount package, this unique product lends itself easily to automated pick and place assembly.

State of the art BiCMOS circuitry coupled with Siemens optoelectronic expertise makes for a product that outperforms its closest rival. Siemens unique circuit configuration automatically compensates for the wide range of potential illumination prevalent in the usage of the transceiver as the distance between the communicating devices changes over the allowable range. Also incorporated in the module is a unique shutdown feature which allows for a power down mode. This will greatly aid in lowering the quiescent current when the module is not being used. In normal operation the shutdown pin should be held low.

A current limiting resistor should be used between the LED anode and V_{CC} (See table below for recommended values.) For operation at 2.7 V, the LED anode should be tied directly to V_{CC}.

Resistor Values

Parameter	Value				Unit
Operating Voltage V_{CC}	2.7	3.0	4.0	5.0	V
Resistor Value	0	0	1.8	3.3	Ω

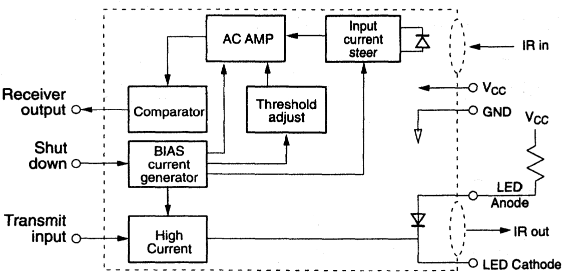
IRM3000/3003 Pin Functions

Pin no.	Function	Pin no.	Function	Pin no.	Function
1	LED Anode	4	Receive	7	NC
2	LED Cathode	5	Shut down	8	GND
3	Transmit	6	V_{CC}		

IRM3015/3100 Pin Functions

Pin no.	Function	Pin no.	Function	Pin no.	Function
1	LED Cathode	4	GND	7	Transmit
2	Receive	5	NC	8	LED Anode
3	V_{CC}	6	Shut down		

Figure 1. Block diagram



IR Convection Reflow Soldering

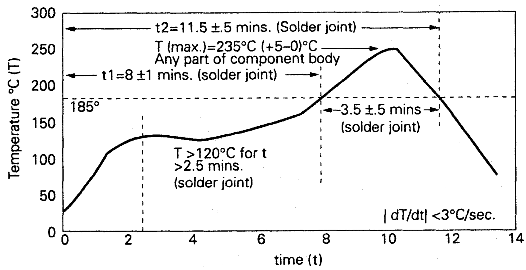
As with all optoelectronic devices, the IRM3000/3003/3015/3100 is sensitive to temperature rates of change and peak temperatures during the solder process. It is not designed for any application in which the component would be directly immersed in molten solder. Optimum performance will be achieved with convection IR reflow soldering.

A preheat of up to 120°C for 2.5 minutes is recommended with a ramp-up to soldering heat of a maximum of 4°C/sec.

The maximum peak temperature is 240°C and should not exceed 10 seconds at that temperature.

Cool down rate should not exceed 3°C/sec. See Figure 2.

Figure 2. Infrared reflow soldering profile



Absolute Maximum Ratings at 25°C

Parameter	Test Condition	Symbol	Value	Unit
Supply voltage range		V_{CC}	–0.5 to +6	V
Input currents	All pins		10	mA
Output sinking current			25	mA
Storage temperature		T_S	–25 to +85	°C
Ambient temperature	Operating	T_A	0 to 70	°C
Junction temperature		T_J	125	°C
Power dissipation		P_{tot}	200	mW
Average IR LED current	DC	I_{LED}	100	mA
Rep pulsed IR LED current	<90 µs, t_{on}, <20%	$I_{LED\ (RP)}$	500	mA
Peak IR LED current	<2 µs, t_{on}, <10%	$I_{LED\ (PK)}$	1.0	A
IR LED anode voltage		V_{LEDA}	–0.5 to V_{CC}+0.5 V	V
IR LED cathode voltage		V_{LEDK}	–0.5 to V_{CC}+0.5 V	V
Transmit data input voltage		V_{TXD}	–0.5 to V_{CC}+0.5 V	V
Receive data output voltage		V_{RXD}	–0.5 to V_{CC}+0.5 V	V

Basic Module Parameters

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Supply voltage range		V_{CC}	2.7		5.5	V
Supply current receive	SD=low or NC, Receive mode	I_{SR}	—	0.6	1.0	mA
Supply current	SD high, standby mode	I_{SSB}			0.25	mA

Receive Parameters

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Output voltage low		V_{OL}		0.5	0.8	V
Output voltage high		V_{OH}	V_{CC}–0.5			V
Output current					4	mA
Logic high input irradiance	Bit error rate=10^{-8}	E_{IHmin}	4			µW/cm^2
Logic high input irradiance	In band irradiance maximum	E_{IHmax}			500	mW/cm^2
Maximum DC irradiance	Ambient interference DC	E_{ADC}	490			µW/cm^2
Minimum detection threshold irradiance		E_{Emin}		3.0		µW/cm^2
Logic low input irradiance	Ambient interference pulsed	E_{IL}			0.4	µW/cm^2
Rise time, fall time	C=15 pf	t_r, t_f	20		200	ns
Output pulse width	115.2 Kb/s		1	1.6	6	µs
Output delay leading edge	Output level=0.5 x V_{CC}, E_{IH}=4 µW/cm^2				2	µs
Contributed systematic jitter		CSJ			0.2	µs
Output delay trailing edge	Output level=0.5 x V_{CC}, E_{IH}=4 µW/cm^2			1	5	µs
Latency	Recovery of last transmitted pulse to 1.1 x threshold sensitivity	IL		100	600	µs

Transmit Parameters

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Driver current IR LED	See note	I_{LED}	250	350	500	mA
Logic low input voltage		V_{IL}	0		0.3	V
Logic high input voltage		V_{IH}	2.5		V_{CC}	V
Output radiant intensity	5 V, α=15°, current limiting resistor in series with LED	R_I	40	80	500	mW/Sr
Half angle		α		22		Deg.
Peak wavelength, emission		λ_P		880		nm
Spectral bandwidth	I_F=100 mA	Δl		80		nm
Optical rise/fall time	10% to 90%, 90% to 10%	t_r, t_f		200	600	ns
Optical overshoot					25	%
Contributed systematic jitter					0.2	µs

Note:

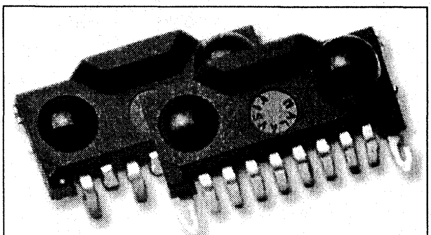
1. For proper operation, the LED anode should be connected to V_{CC} using a current limiting resistor. For recommended resistor values see Resistor Values table.

SIEMENS

IRM3401/3402/3405/3415

Infrared Data Transceiver

Preliminary



IRM3405 IRM3401

FEATURES

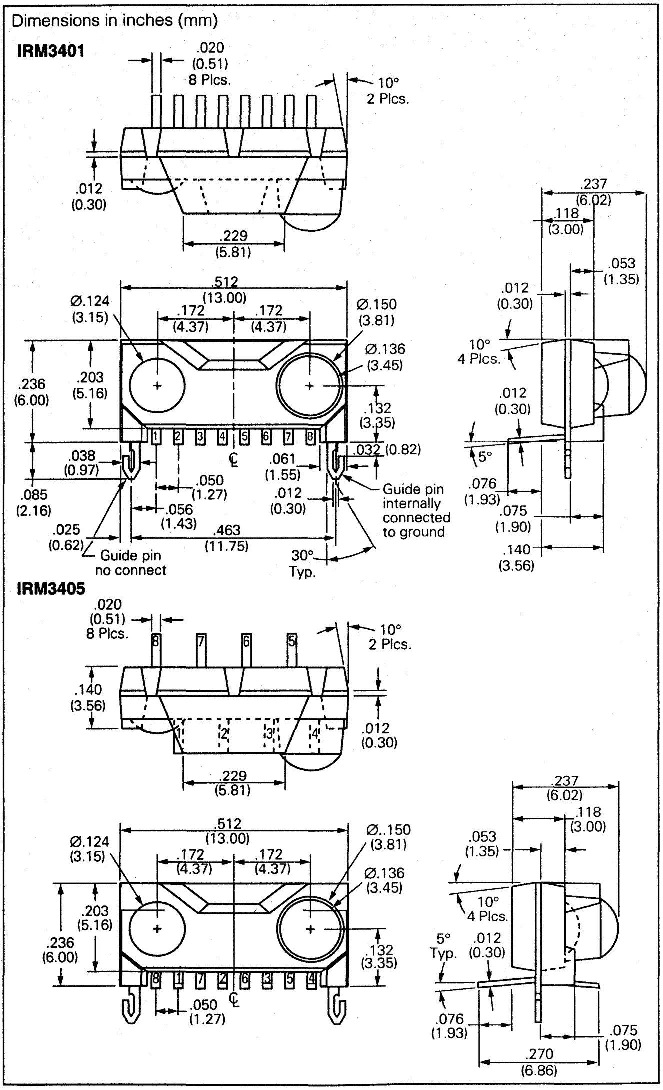
- **Meets All Applicable IrDA Specifications**
- **IrDA Data Rates Up to 4.0 Mb/s**
- **Wide Dynamic Range**
- **Differential PIN Diode Input for Superior Interference Rejection**
- **Mode Selection between 115 Kb/s–4 Mb/s Data Rate**
- **Shutdown Feature Reduces Quiescent Current in Standby Mode**
- **Surface Mounted Package, Ideal for Automated Assembly**

DESCRIPTION

The IRM 3401/3402/3405/3415 is a fully contained Infrared transceiver that is compatible with the IrDA 4 Mb/s Physical Layer Link Specification. Housed in a single molded epoxy surface mount package, this unique products lends itself easily to automated pick and place assembly.

With state of the art BiCMOS circuitry coupled with Siemens optoelectronic expertise, the IRM 3401/3402/3405/3415 outperforms its closest rival. Siemens has incorporated a mode selection pin that toggles the device to operate in high speed or low speed mode. Also incorporated in the module is a unique shutdown feature which allows for a power down mode that considerably lowers the quiescent current when the module is not being used. In normal operation the shutdown mode should be held low. Mode select determines the data rate. Low for 115 Kb/s, high for 1.152 Mb/s and 4 Mb/s.

The differential PIN diode input causes no DC offset or drift, a constant gain factor, and infinite common-mode rejection.



IRM3401/3402 Pin Functions

Pin no	Function	Pin no	Function	Pin no.	Function	Pin no	Function
1	LED Anode	3	Transmit	5	SD/MS	7	N/C
2	LED Cathode	4	Receive	6	V_{CC}	8	GND

IRM3405/3415 Pin Functions

Pin no	Function	Pin no.	Function	Pin no	Function	Pin no.	Function
1	LED Cathode	3	V_{CC}	5	N/C	7	Transmit
2	Receive	4	GND	6	SD/MS	8	LED Anode

IR Convection Reflow Soldering

As with all optoelectronic devices, the IRM3401/3402/3405/3415 is sensitive to temperature rates of change and peak temperatures during the solder process. It is not designed for any application in which the component would be directly immersed in molten solder.
Optimum performance will be achieved with convection IR reflow soldering.

A preheat of up to 120°C for 2.5 minutes is recommended with a rampup to soldering
heat of a maximum of 4°C/second.

The maximum peak temperature is 240°C and should not exceed 10 seconds at that temperature. Cool down rate should not exceed 3°C/second. See Figure 1.

Figure 1. Infrared reflow soldering profile

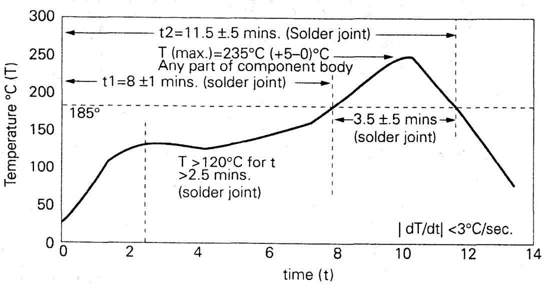
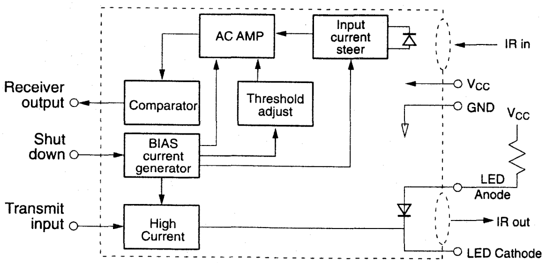


Figure 2. Block diagram



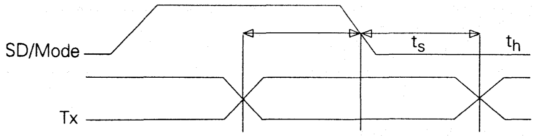
Mode Switching

Normally the IRM3401/3402/3405/3415 initializes in the SIR (9.6 Kb/s–1.152 Mb/s) mode upon power-up.Switching the module to FIR 4 Mb/s Mode can be achieved as follows:

Switching the module to FIR (4Mb/s) mode can be achieved as follows:

- Bring SD/MODE pin to a logic "High" status.
- Bring T_X input to a logic "High" status. Wait for t_s>=200 ns.
- Bring SD/MODE pin to a logic "Low" status. The negative transition of this pulse will set the module mode to 4 Mb/s data rate by reading the state of T_X.
- Bring T_X to a logic "Low" after waiting for t_h >=200 ns. T_h is limited by the maximum allowed pulse length.

Figure 3. Switching mode



pulse will set the device into 4Mbps data rate mode.

Switching to SIR (9.6 Kb/s–1.15 Mb/s) Mode

- Bring SD/MODE pin to a logic "High" status.
- Bring T_X input to a logic "High" status. Wait for t_s>=200 ns.
- Bring SD/Mode pin to a logic "Low" status. The negative transition of this pulse will set the module mode to 115 Kb/s data rate by reading the state of T_X.
- Bring T_X to a logic "Low" after waiting for t_h >=200 ns. T_h is limited by the maximum allowed pulse length.

Basic Module Parameters

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Supported data rates		D_{TR}	0.0096		4.0	Mb/s
Supply voltage range		V_{CC}	3.0	5	5.5	V
Supply current receive	SD=low or NC receive mode	I_{SR}	5	6	7	mA
Supply current	SD high, standby mode	I_{SSB}			100	µA

Absolute Maximum Ratings at 25°C

Parameter	Test Condition	Symbol	Value	Unit
Supply voltage range		V_{CC}	3.0	V
Input currents	All pins		10	mA
Output sinking current			25	mA
Storage temperature		T_S	–25 to +85	°C
Ambient temperature	Operating	T_A	0 to 70	°C
Lead solder temperature	230°C		<10	sec.
Junction temperature		T_J	125	°C
Power dissipation		P_{tot}		mW
Average IR LED current	DC	I_{LED}	200	mA
Rep pulsed IR LED current	<90 µs, t_{on}, <25%	$I_{LED\ (RP)}$	800	mA
IR LED anode voltage		V_{LEDA}	–0.5 to V_{CC}+0.5 V	V
IR LED cathode voltage		V_{LEDK}	–0.5 to V_{CC}+0.5 V	V
Transmit data input voltage		V_{TXD}	–0.5 to V_{CC}+0.5 V	V
Receive data output voltage		V_{RXD}	–0.5 to V_{CC}+0.5 V	V

Receive Parameters

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Output voltage low	I_{OL}=4 mA	V_{OL}		0.5	0.8	V
Output voltage high	I_{OH}=–4 mA	V_{OH}	V_{CC}–.5			V
Logic high input irradiance	Bit error rate=10^{-9}	E_{IHmin}	10			µW/cm^2
Logic high input irradiance	In band irradiance maximum	E_{IHmax}			500	mW/cm^2
Maximum DC irradiance	Ambient interference DC	E_{ADC}	490			µW/cm^2
Minimum detection threshold irradiance	4.0 Mb/s	E_{Emin}		6.0		µW/cm^2
Logic low input irradiance	Ambient interference pulsed	E_{IL}			0.4	µW/cm^2
Rise time, fall time		t_R, t_F	10		35	ns
Output pulse width	4.0 Mb/s/sec.		85		165	ns
Output delay				1	2	µs
Latency	Recovery of last transmitted pulse to 1.1 x threshold sensitivity	IL			120	µs

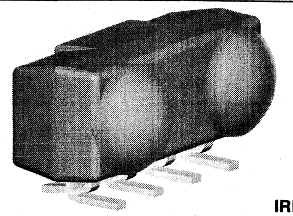
Transmit Parameters

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Driver current IR LED	Current limiting resistor in series to LED. R=3.9 Ω at 5 V	I_{LED}		700	800	mA
Logic low input voltage		V_{IL}	0		0.3	V
Logic high input voltage		V_{IH}	2.5		V_{CC}	V
Output radiant intensity	Rext=3.9 Ω at 5 V, α=15°	R_I	100	140	200	mW/Sr
Half angle		α		22		Deg.
Peak wavelength, emission		λ_P		880		nm
Spectral bandwidth	I_F=100 mA	Δl		80		nm
Optical rise/fall time	10% to 90%, 90% to 10%, I_F=100 mA	t_r, t_f		25	40	nsec
Optical overshoot					25	%

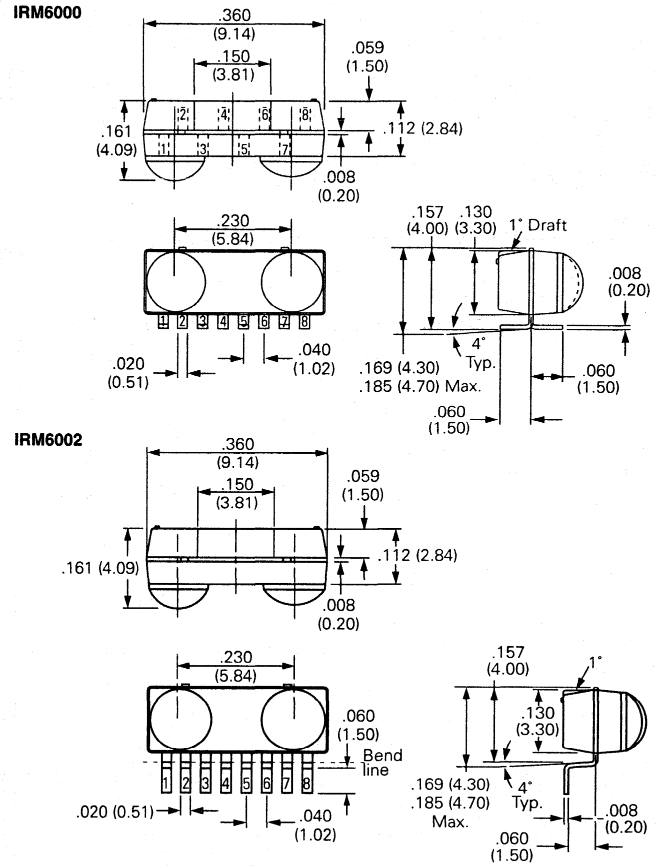
IRM6000/6002

Infrared Data Transceiver

Preliminary



IRM6000



FEATURES

- **Small Package Size: 4.3 mm x 4.1 mm x 9.4 mm**
- **Compatible with IrDA Specifications**
- **IrDA Data Rates up to 115.2 Kb/s**
- **Wide Dynamic Range**
- **Slim Package for Telephonic Applications**
- **Shutdown Feature Reduces Quiescent Current in Standby Mode**
- **Surface Mounted Package Ideal for Automated Assembly**

APPLICATIONS

- **Portable Computers**
- **Printers**
- **Telephony**
- **Industrial Hand-Held Devices**
- **Personal Data Assistants (PDA)**
- **Pagers**
- **Consumer Electronics**

DESCRIPTION

The IRM 6000/6002 is a slim package, fully contained Infrared transceiver that is compatible with the IrDA 115.2 Kb/s Physical Layer Link Specification. Housed in a single molded epoxy surface mount package this unique product lends itself easily to automated pick and place assembly.

The state of the art BiCMOS circuitry coupled with the optoelectronic expertise of Siemens makes for a product that outperforms its closest rival. Also incorporated in the module is a unique shutdown feature which allows for a power down mode. This will greatly aid in lowering the quiescent current when the module is not being used. In normal operation the shutdown pin should be held low. SD feature works in receive mode only. XMT is not affected by SD

The slim package makes this device ideal for cellular telephone and PDA applications.

A current limiting resistor should be used between the LED anode and V_{CC} (See table below for recommended values). For operation at 2.7 V, the LED anode should be tied directly to V_{CC}.

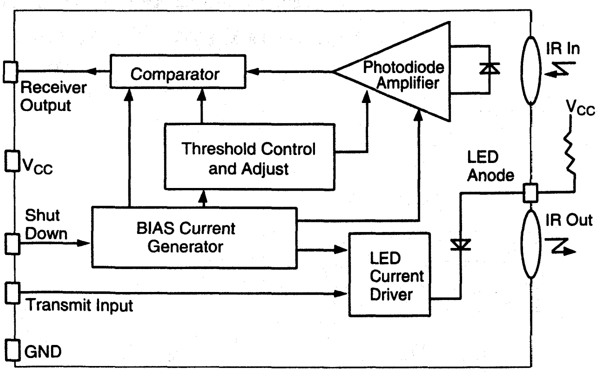
Resistor Values

Parameter	Value				Unit
Operating Voltage V_{CC}	2.7	3.0	4.0	5.0	V
Resistor Value	0	0	1.8	3.3	Ω

Pin Functions IRM6000

Pin no.	Function	Pin no.	Function	Pin no.	Function	Pin no.	Function
1	NC	3	V_{CC}	5	GND	7	THX
2	NC	4	SD	6	RHX	8	LED Anode

Figure 1. Block diagram



Basic Module Parameters

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Supported data rates		D_{TR}	9.6		115.2	Kb/s
Supply voltage range		V_{CC}	2.7		5.5	V
Supply current receive	SD=low receive mode	I_{SR}		0.16	0.2	mA
Supply current	SD high, standby mode	I_{SSB}			0.60	µA

IR Convection Reflow Soldering

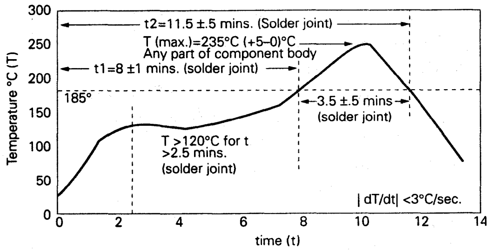
As with all optoelectronic devices, the IRM 6000/6002 is sensitive to temperature rates of change and peak temperatures during the solder process. It is not designed for any application in which the component would be directly immersed in molten solder. Optimum performance will be achieved with convection IR reflow soldering.

A preheat of up to 120°C for 2.5 minutes is recommended with a ramp up to soldering heat of a maximum of 4°C/second.

The maximum peak temperature is 240°C and should not exceed 10 seconds at that temperature.

Cool down rate should not exceed 3°C/second. See Figure 2.

Figure 2. Infrared reflow soldering profile



Absolute Maximum Ratings at 25°C

Parameter	Test Condition	Symbol	Value	Unit
Supply voltage range		V_{CC}	0 to +6	V
Input currents	All pins		10	mA
Output sinking current			25	mA
Storage temperature		T_S	–25 to +85	°C
Lead solder temperature	260°C		<10	sec.
Ambient temperature	Operating	T_A	0 to 70	°C
Junction temperature		T_J	120	°C
Power dissipation		P_{tot}	200	mW
Average IR LED current	DC	I_{LED}	100	mA
Rep pulsed IR LED current	<90 µs, t_{on}, <25%	$I_{LED (RP)}$	500	mA
IR LED anode voltage		V_{LEDA}	–0.5 to V_{CC}+0.5 V	V
IR LED cathode voltage		V_{LEDK}	–0.5 to V_{CC}+0.5 V	V
Transmit data input voltage		V_{TXD}	–0.5 to V_{CC}+0.5 V	V
Receive data output voltage		V_{RXD}	–0.5 to V_{CC}+0.5 V	V

Receive Parameters

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Output voltage low		V_{OL}		0.5	0.8	V
Output voltage high		V_{OH}	V_{CC}–0.5			V
Output current					4	mA
Logic high input irradiance	Bit error rate=10^{-8}	E_{IHmin}	4			µW/cm^2
Logic high input irradiance	In band irradiance maximum	E_{IHmax}			500	mW/cm^2
Maximum DC irradiance	Ambient interference DC	E_{ADC}	490			µW/cm^2
Minimum detection threshold irradiance		E_{Emin}		3.0		µW/cm^2
Logic low input irradiance	Ambient interference pulsed	E_{IL}			0.4	µW/cm^2
Rise time, fall time	C=15 pF	t_r,	20		200	ns
Output pulse width	115.2 Kb/s		1	1.6	6	µs
Output delay leading edge	Output level=0.5xV_{CC}, E_{IH}=4 µW/cm^2				2	µs
Contributed systematic jitter		CSJ			0.2	µs
Output delay trailing edge	Output level=0.5xV_{CC}			1	5	µs
Latency		IL		100	600	µs

Transmit Parameters

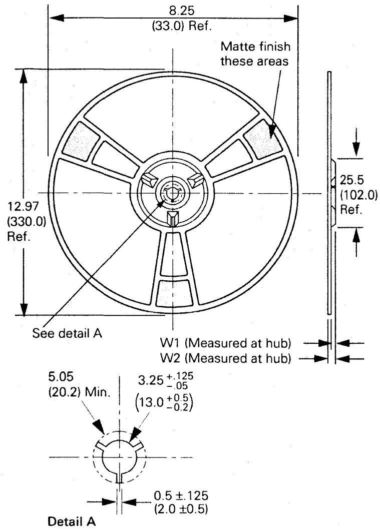
Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Driver current IR LED	Current limiting resistor in series with LED, see Table 1.	I_{LED}	250	350	500	mA
Logic low input voltage		V_{IL}	0		0.3	V
Logic high input voltage		V_{IH}	2.5		V_{CC}	V
Output radiant intensity	5 V, α=15°, current limiting resistor in series with LED	R_I	40	80	500	mW/Sr
Half angle		α		22		Deg.
Peak wavelength, emission		λ_P		880		nm
Spectral bandwidth	I_F=100 mA	Δl		80		nm
Optical rise/fall time	10% to 90%, 90% to 10%	t_r, t_f		200	600	nsec
Optical overshoot					25	%
Contributed systematic jitter					0.2	µs

SIEMENS

Packaging for IrDT Products

With the unique pad on top of the Siemens transceiver modules, pick-and place equipment can easily be implemented for mass production volumes. The primary and preferred shipping for all transceiver modules is on tape and reel. For low quantity usage, Siemens can also ship products in tubes. For tape and reel, the following parameters apply:

Figure 1. Reel dimensions in inches (mm)



Manufacturer	Advantek
Type	Antistatic LOKREEL®
Part Number	RD
Surface Resistivity	≤10 11 ohms/square
Material	High Impact Polystyrene
Shelf life	2 years
Color	White

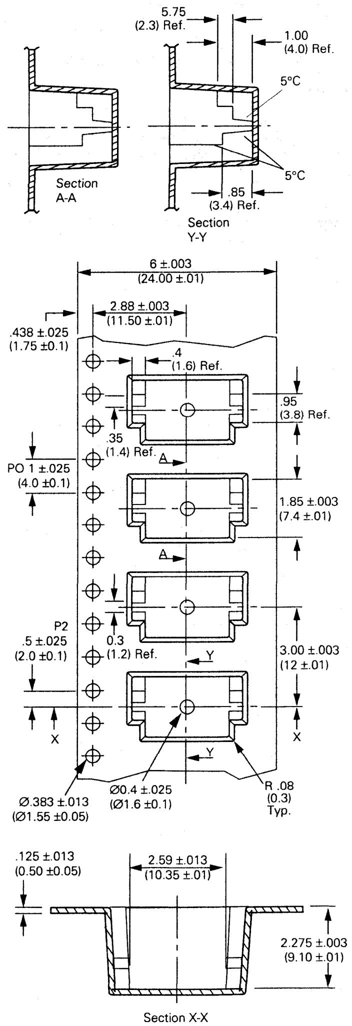
Nominal Hub Depth	**W1**	**W2 max**
4 mm	4.4	7.1
8 mm*	8.4	11.1
16 mm**	16.4	19.1
29 mm	28.4	31.1

*Hubs being used by Siemens

Notes:

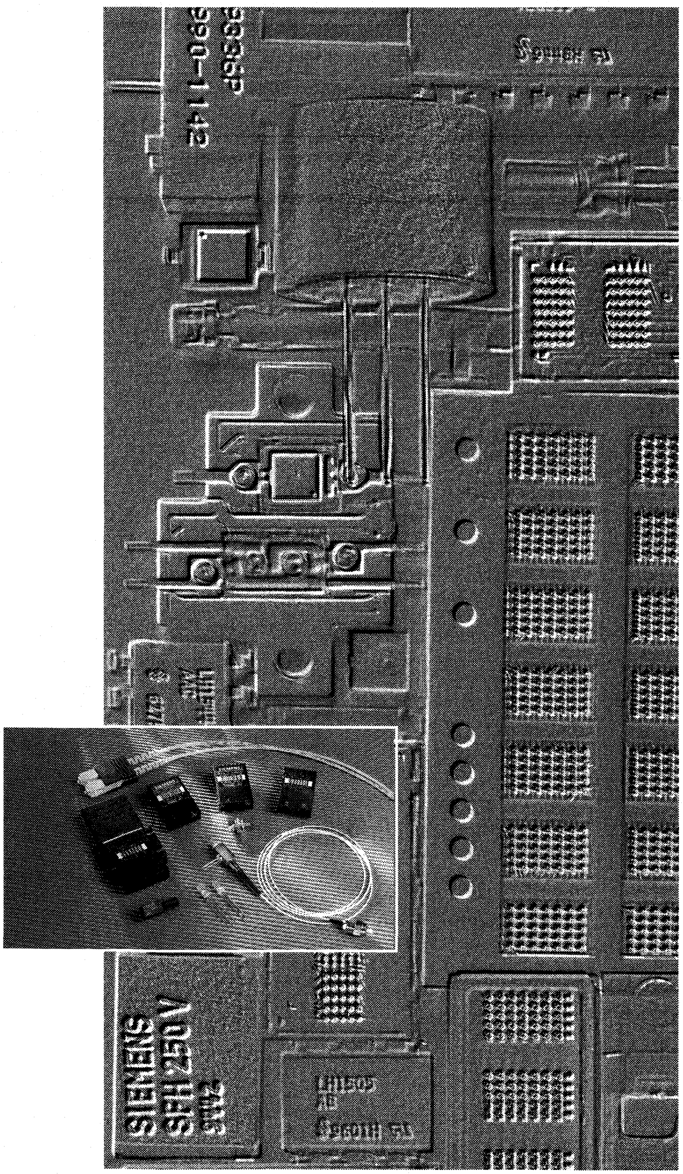
1. 13 inch reels halves come in 3 hubs widths.
2. 8 mm and 16 mm with a 4 inch core.
3. Two 8 mm halves make a 16 mm reel. 8 mm and 16 mm halves make a 24 mm reel.
4. The 16 mm and 16 mm halves make a 32 mm reel.

Figure 2. Tape dimensions in inches (mm)



All tubes and reels are sealed in antistatic plastic bags along with desiccant packets. The sealed plastic bags are then placed in protective cardboard shipping container. Moisture sensitive devices label will be placed on each internal package and external carton.

The devices are ESD sensitive hence proper handling care should be taken while handling them. This includes ground straps for operators and grounded work benches.



Custom Optoelectronic Products

Intelligent Display® Devices

Numeric Displays

LED Lamps

Optocouplers

Solid State Relays (SSRs)

IR DataCOM Products

Fiber Optics
- **Components**
- **Laser Diodes**
- **Photodiodes**

Fiber Optic Data Links
- **Transceivers**
- **Cable Assemblies**

Infrared Emitters

Photodiodes

Phototransistors

Photovoltaic Cells

Application Notes

Plastic Fiber Components
Emitters

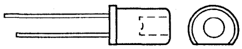
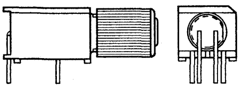
Package Outline	Model	Φ_{OUT} (µW)	λ_{PEAK} (nm)	Switching Time (µs)	Package	Page
	SFH450	25	950	1.0	T1^{3}/$_{4}$	8A–5
	SFH750		660	0.1		8A–8
	SFH756	100	660	0.1		8A–10
	SFH450V	25	950	1.0	Connector Housing	8A–5
	SFH750V		660	0.1		8A–8
	SFH756V	100	660	0.1		8A–10

Photo Detectors

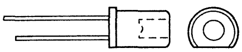
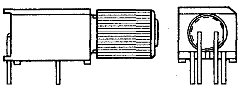
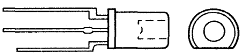
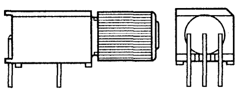
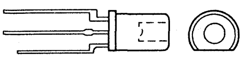
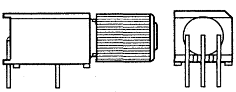
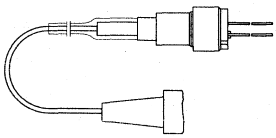
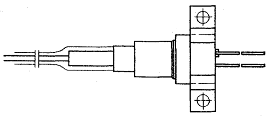
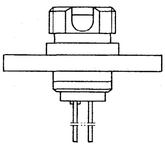
Package Outline	Model	Type	Detector Current (µA)	Rise/ Fall Time (µs)	Dark Current (nA)	Package	Page
	SFH250	Diode	1.6 (660 nm) 2.5 (950 nm)	0.01	10	T1^{3}/$_{4}$	8A–1
	SFH250V					Connector Housing	
	SFH350	Transistor	160 (660 nm)	20	50	T1^{3}/$_{4}$	8A–3
	SFH350V					Connector Housing	

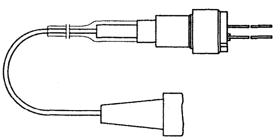
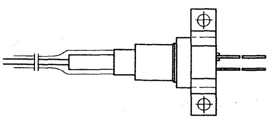
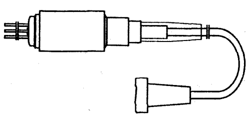
Photo Receivers

Package Outline	Model	$\Phi_{input\ at\ treshold}$ (µW)	Φ_{IN} (Low Output) µW (dBm)	Φ_{IN} (High Output) µW (dBm)	Delay (ns)	Package	Page
	SFH551/I-1	4 to 6	6 to 400 (–22 to –4)	0.1 (–40)	150	T1^{3}/$_{4}$	8A–7
	SFH551/IV-1					Connector Housing	

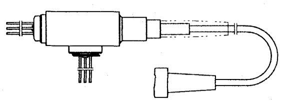
Communication Fiber Optic Components
Laser Diodes

Package Outline	Model	Wave-length (nm)	Spectral Width (nm)	Optical Power (mW)	Rise/ Fall Time (ns)	Package	Page
	STL51004G/N/Z			0.2			
	STM51004G/N/Z	1280–1330		0.5		Coaxial Optional Connector	8B–17
	STH51004G/N/Z		5	1.0	1.0		
	STL81004G/N/Z	1510–1590		0.2			8B–21
	STM81004G/N/Z			0.5			
	STL51005G/N/Z			0.2			
	STM51005G/N/Z	1280–1330		0.5		Coaxial with Flange Optional Connector	8B–17
	STH51005G/N/Z		5	1.0	1.0		
	STL81005G/N/Z	1510–1590		0.2			8B–21
	STM81005G/N/Z			0.5			
	STL51007G/N	1280–1330		0.2			8B–19
	STM51007G/N		5	0.5	1.0	Receptacle FC or SC	
	STL81007G/N	1510–1590		0.2			8B–23

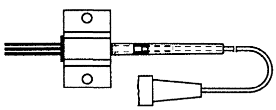
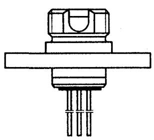
DFB Laser Diodes

Package Outline	Model	Wave-length (nm)	Spec-tral Width (nm)	Optical Power (mW)	Optical Isola-tion (dB)	Rise/ Fall Time (ns)	Package	Page
	STH61004G/N/Z				N/A	0.5	Coaxial Optional Connector	8B–13
	STH61005G/N/Z	1280–1330	0.5	1.0			Coaxial with Flange Optional Connector	
	STH61008G/N/Z				30	0.25	Rectangular	8B–15

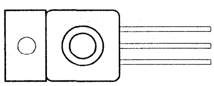
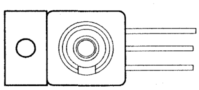
Communication Fiber Optic Components
Bidirectional Modules

Package Outline	Model	Emission			Photodetector		Optical Crosstalk (dB)	Package	Page
		Wave-length (nm)	Spectral Width (nm)	Optical Power (mW)	Spectral Sensitivity (A/W)	Dark Current (nA)			
	SBL51214G/N/Z	1270–1350	5.0	0.2	0.30 (1300 nm)	50	–22	Module Optional Connec-tor	8B–1
	SBM51214G/N/Z			0.5					
	SBL51414G/N/Z	1270–1350		0.2	0.65 (1550 nm)		–47		8B–4
	SBM51414G/N/Z			0.5					
	SBL81314G/N/Z	1510–1590		0.2	0.65 (1300 nm)		–47		8B–7
	SBM81314G/N/Z			0.5					

Photodiodes

Package Outline	Model	Spectral Sensitivity (A/W)	Dark Current (nA)	Rise/Fall Time (ns)	Package	Page
	SRD00214H/W	0.75 (1300 nm)	50	0.5	Coaxial MMF Optional Connector	8B–10
	SRD00215H/W				Coaxial with Flange MMF Optional Connector	
	SRD00217H	0.80 (1300 nm)	50	0.5	Receptacle FC	8B–12

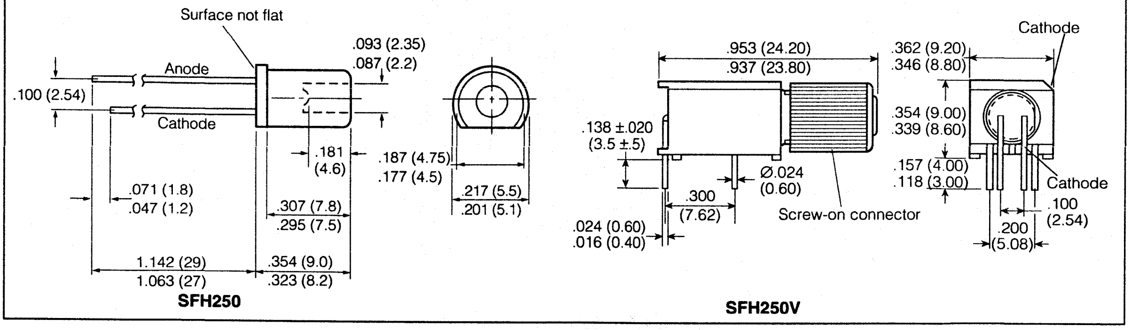
High Power Laser Diodes

Package Outline	Model	Pover (W)	Wavelength (nm)	Package	Page
	SPL 2Y81	1.0	808	TO-220 Window	8C–4
	SPL 2Y85		850		
	SPL 2Y94		940		
	SPL 2F81	0.75	808	TO-220 FC Receptacle	8C–1
	SPL 2F85		850		
	SPL 2F94		940		

SIEMENS

5 mm LED PACKAGE SFH250
PLASTIC CONNECTOR HOUSING SFH250V
Plastic Fiber Optic Photodiode Detector

Dimensions in inches (mm)



FEATURES
- **2.2 mm aperture holds standard 1000 micron plastic fiber**
- **No fiber stripping required**
- **Fast switching time**
- **Very good linearity**
- **Sensitive in the near IR and visible range**
- **Molded microlens for efficient coupling**
- **SFH250V only**
  - **Plastic connector housing**
  - **Mounting screw attached to connector**
  - **Interference free transmission from light-tight housing**
  - **Transmitter and receiver can be flexibly positioned**
  - **No cross talk**
  - **Auto insertable and wave solderable**
  - **Supplied in tubes**

APPLICATIONS
- **Household electronics**
- **Power electronics**
- **Optical networks**
- **Medical instruments**
- **Automotive electronics**
- **Light barriers**

See Appnotes 40, 41, 43 for application information.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55° to +100°C
Soldering Temperature (2 mm from case bottom) (T_S) t≤5 s .... 260°C
Reverse Voltage (V_R) .... 30 V
Power Dissipation (P_{TOT}) T_A=25°C .... 100 mW
Thermal Resistance (R_{thJA}) .... 750 K/W
Junction Temperature (T_J) .... 100°C

Characteristics (T_A=25°C)

Parameter	Symbol	Value	Unit	Condition
Max. Photosensitivity Wavelength	λ_{SMAX}	850	nm	
Photosensitivity, Spectral Range	l	400 to 1100		S=10% of S_{MAX}
Dark Current	I_R	1(≤10)	nA	V_R=20 V
Capacitance	C_0	11	pF	V_R=0 V, f=1 mHz, E_V=0 lx
Rise and Fall Time of Photocurrent 10% to 90% and 90% to 10%	t_R, t_F	10	ns	R_L=50 Ω, V_R=30 V, λ=880 nm
Noise Equivalent Power	NEP	2.9 x 10^{-14}	W/√Hz	
Detection Limit	D*	3.5 x 10^{12}	cm•√Hz/W	V_R=20m
Photocurrent, V_R=5 V	I_P	3(≥1.6) 4(≥2.5)	µA	λ=660 nm λ=950 nm
Open Circuit Voltage	V_O	300	mV	
Temperature Coefficient I_P	TC_I	–0.04 0.04 0.2	%/K	λ=560–660 nm λ=830 nm λ=950 nm
Temperature Coefficient V_L	TC_V	–2.6	mV/K	

Figure 1.Relative spectral sensitivity
$S_{REL}=f(\lambda)$

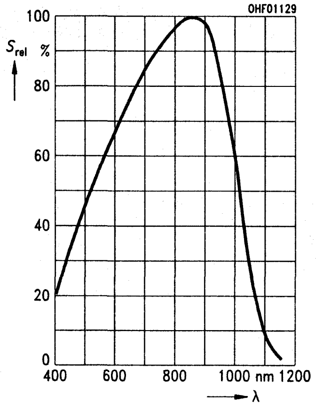


Figure 3.Capacitance
$C_o=f(V_R)$, f=1 MHz, $E_v=0$

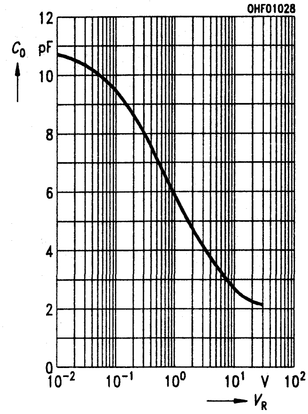


Figure 2.Dark Current
$I_R=f(V_R)$, $T_A=25°C$

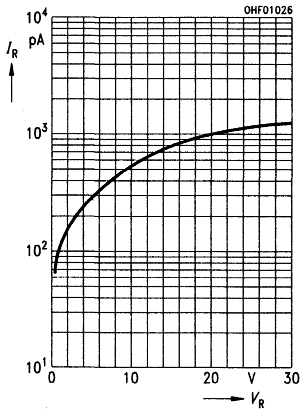
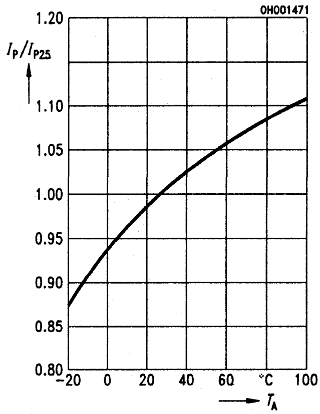
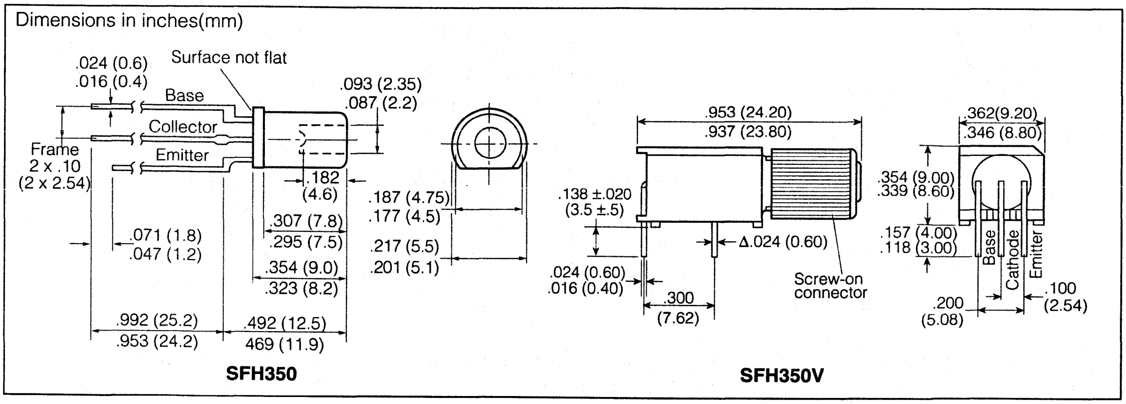


Figure 4.Photocurrent
$I_P/I_{P25}=f(T_A)$, λ=950 nm



SIEMENS

5 mm LED PACKAGE SFH350
PLASTIC CONNECTOR HOUSING SFH350V
Plastic Fiber Optic Phototransistor Dectector



FEATURES
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APPLICATIONS
- **Household electronics**
- **Power electronics**
- **Optical networks**
- **Medical instruments**
- **Automotive electronics**
- **Light barriers**

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG})............... –55° to 100°C
Soldering Temperature (2 mm from case bottom) (TS) t≤5 s..................... 260°C
Collector-emitterVoltage (V_{CE})..50 V
Collector Current (I_C)..50 mA
Collector Peak Current (I_{CP}) ≤10 sec..100 mA
Emitter Base Voltage (V_{EB})...7V
Power Dissipation (P_{TOT}) T_A=25°C..200 mW
Thermal Resistance (R_{thJA})..375 K/W
Reverse Voltage (V_R)..30 V

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Maximum Photosensitivity Wavelength	λ_{SMAX}	850	nm	
Photosensitivity Spectral Range	l	400 to 1100		S=10% of S_{MAX}
Capacitance, f=1 MHz, E_V=0 lx	C_{CE} C_{CB} C_{EB}	10.5 21.5 20.5	pF	V_{CE}=0 V V_{CB}=0 V V_{EB}=0 V
Rise and Fall Time, Photocurrent	t_R, t_F	20	µs	R_L=1 KΩ, I_C=1.0 mA, V_{CE}=5 V, λ=959 nm
Current Gain	HFE	500	—	
Collector Dark Current	I_{CEO}	2 (≤50)	nA	V_{CE}=10 V
Photocurrent, V_{CE}=5 V	I_{CE}	0.8 (≥0.16)	mA	λ=660 nm
Temperature Coefficient, HFE	TC_{HFE}	0.55	%/K	
Temperature Coefficient, I_{CE}	TC_I	0.34 0.49 0.66		λ=560 to 660 nm, λ=830 nm, λ=950 nm

See Appnotes 40, 41, 43 for application information.

Figure 1. Relative spectral sensitivity $S_{REL}=f(\lambda)$

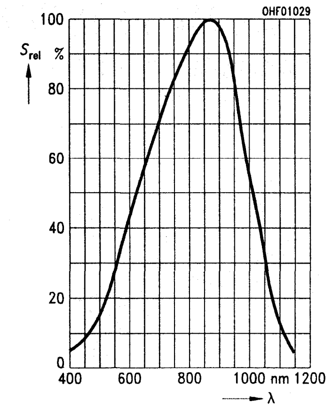


Figure 2. Capacitance $C=f(V_R)$, $f=1$ MHz, $E_V=0$

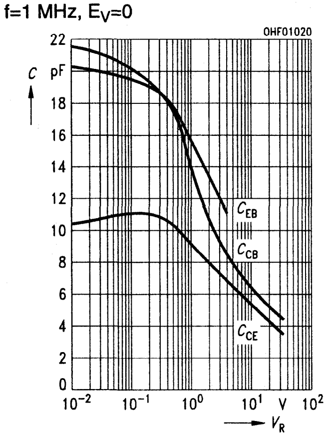


Figure 3. Photocurrent $I_C=f(\Phi_{OUT})$, $V_{CE}=5$ V, $\lambda=560$ to 950 nm

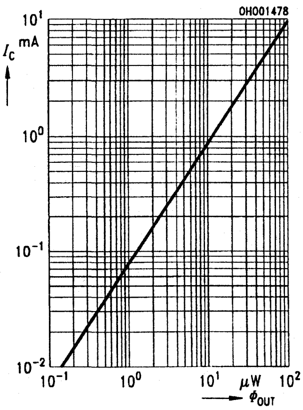


Figure 4. Current gain $HFE=f(I_C)$, $V_{CE}=5$ V, $T_A=25°C$

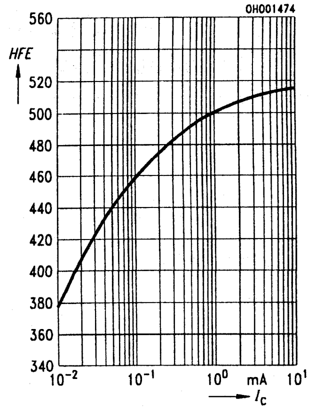


Figure 5. Output characteristics $I_C=f(V_{CE})$, I_B=parameter

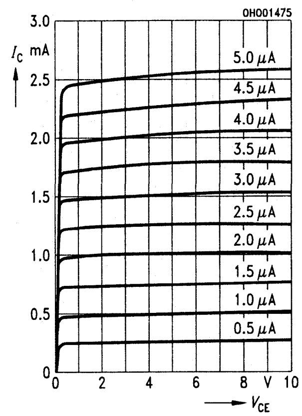


Figure 6. Response time $t=f(I_C)$, $V_{CC}=5$ V, $\lambda=950$ nm

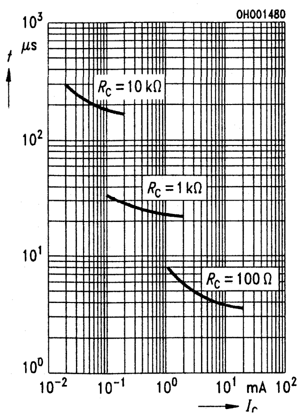


Figure 7. Photocurrent $I_C/I_{C25}=f(T_A)$, $V_{CE}=5$ V, λ=paramete

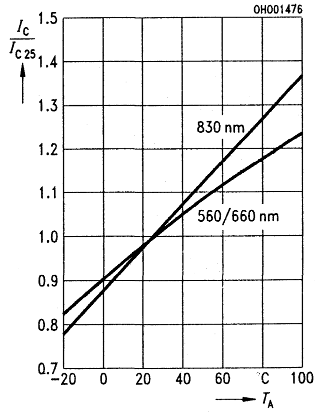
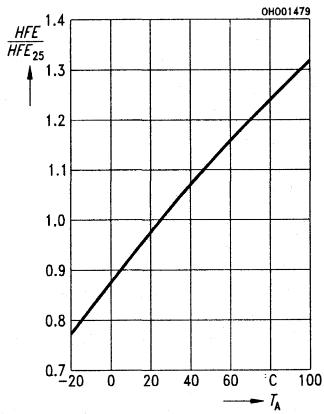


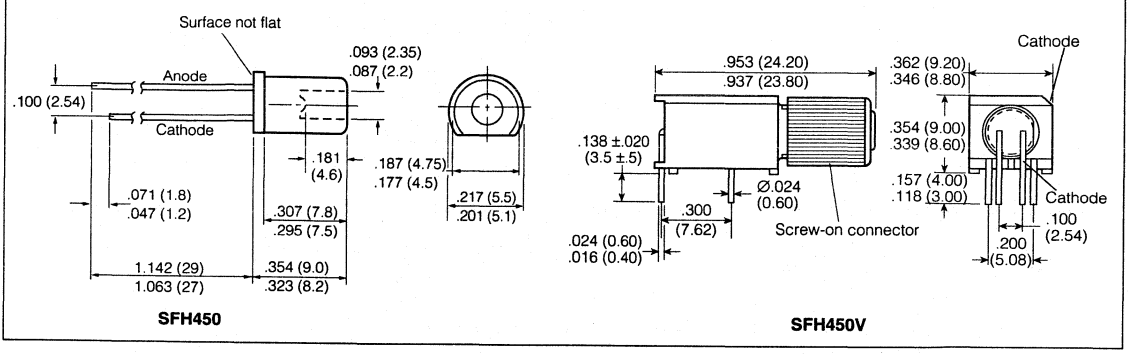
Figure 8. Current gain $HFE/HFE_{25}=f(T_A)$, $V_{CE}=5$ V, $I_C=1$ mA



SIEMENS

5 mm LED PACKAGE SFH450
PLASTIC CONNECTOR HOUSING SFH450V
Plastic Fiber Optic Emiter

Dimensions in inches (mm)



FEATURES

- **2.2 mm aperture holds standard 1000 micron plastic fiber**
- **No fiber stripping required**
- **Good linearity**
- **Sensitive in visible and near IR range**
- **Molded microlens for efficient coupling**
- **SFH450V only**
  - **Plastic connector housing**
  - **Mounting screw attached to connector**
  - **Interference free transmission from light-tight housing**
  - **Transmitter and receiver can be flexibly positioned**
  - **No cross talk**
  - **Auto insertable and wave solderable**
  - **Supplied in tubes**

APPLICATIONS

- **Household electronics**
- **Power electronics**
- **Optical networks**
- **Medical instruments**
- **Automotive electronics**
- **Light barriers**

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG}) .... –55° to 100°C
Junction Temperature (T_J) .... 100°C
Soldering Temperature (2 mm from case bottom) (T_S) t≤5 s .... 260°C
Reverse Voltage (V_R) .... 5 V
Forward Current, DC (I_F) .... 130 mA
Surge Current (I_{FSM}) t≤10 µsec, D=0. .... 3.5 A
Power Dissipation (P_{TOT}) T_A=25°C .... 200 mW
Thermal Resistance, Junction/Air (R_{thJA}) .... 375 K/W

Characteristics (T_A=25°C)

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	950	nm	
Spectral Bandwidth	$\Delta\lambda$	55		
Switching Times (10% to 90% and 90% to 10%)	t_R, t_F	1	µs	R_L=47 Ω, I_F=10 mA
Capacitance	C_0	40	pF	
Forward Voltage	V_F	1.3 (≤1.5)	V	I_F=10 mA
Output Power Coupled into Plastic Fiber (1 mm core diameter), distance lens to fiber ≤0.1 mm, polished fiber	Φ_{IN}	90 (≥25)	µW	I_F=10 mA
Temperature Coefficient, Φ_{IN}	TC_{Φ}	–0.5	%/K	
Temperature Coefficient, V_F	TC_V	–1.5	mV/K	
Temperature Coefficient, λ_{PEAK}	TC_{λ}	0.3	nm/K	

See Appnotes 40, 41, 43 for application information.

Figure 1. Relative spectral emission
$I_{REL}=f(\lambda)$

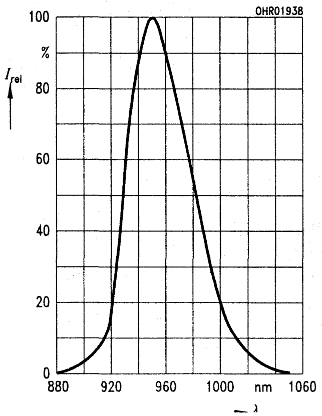


Figure 2. Forward current $I_F=f(V_F)$–SFH450
(Single pulse, duration=20μs)–SFH450V

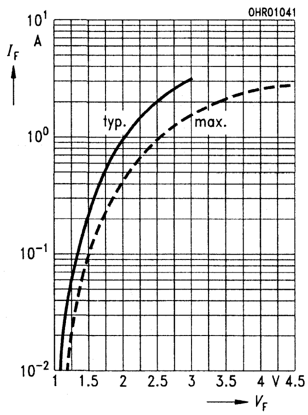


Figure 3. Relative output power
$\Phi_{IN}/\Phi_{IN(10\ mA)}=f(I_F)$

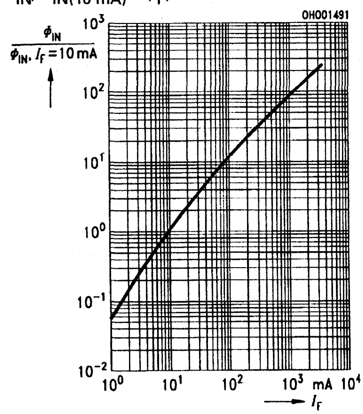


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

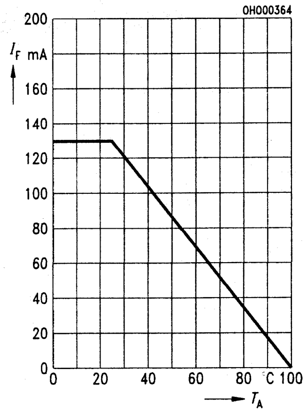
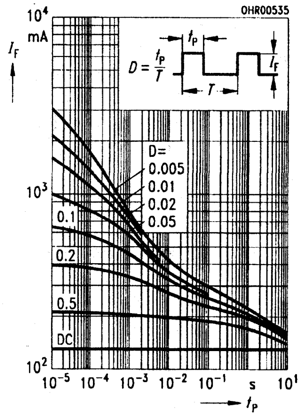


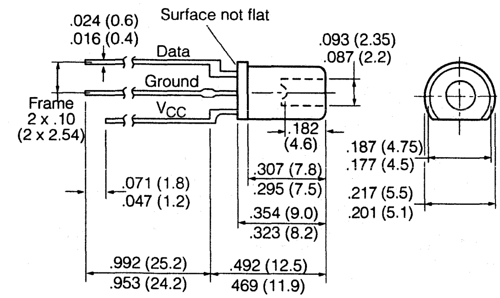
Figure 5. Permissible pulse load–SFH450V
$I_F=f(t_P)$, duty cycle D=parameter, T_A=25°C



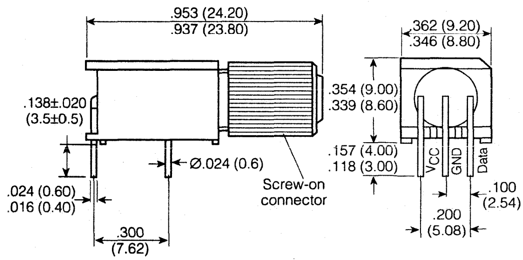
SIEMENS

5 mm LED PACKAGE SFH551/1-1
RIGHT ANGLE HOUSING SFH551/1V-1
Plastic Fiber Optic Integrated Photodetector

Dimensions in inches (mm)



SFH551/1-1



SFH551/1-V-1

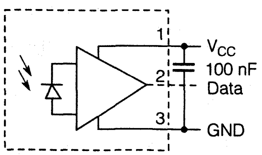
FEATURES

- **Bipolar IC with open-collector output**
- **Digital output, TTL compatible, open collector**
- **Uses Schmidtt trigger for noise immunity**
- **Suitable for 2.2 mm plastic fiber with 1 mm core diameter**
- **Transfer rate ≤5 MBit/s**
- **Low switching threshold**
- **High sensitivity from integrated µlens**
- **SFH551/1-1: T1¾ (5 mm) package**
- **SFH551/1V-1: right angle plastic housing**
- **SFH551/1V-1: easy coupling to plastic fiber without stripping or decladding**

Maximum Ratings

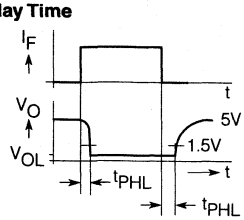
Storage Temperature Range (T_{STG}).....–55 to 100°C
Operating Temperature Range (T_{OP}).....–40 to 85°C
Supply Voltage (V_{CC})............................–0.5 to 15 V
Output Voltage (V_O)...............................–0.5 to 15 V
Output Current (I_O)...50 mA
Power Dissipation (output) (P_O) ....85 mW

Block Diagram



A bypass capacitor (100 nF) near the device is necessary between V_{CC} and ground.

Delay Time



DESCRIPTION

The SFH551/1-1 is a photodetector to be used with 1000 micron plastic optical fiber. This device amplifies incoming signals via a DC coupled trans-impedance amplifier, and its open collector output is TTL compatible. The SFH551/1-1 includes a Schmidtt trigger function to provide stable outputs over the entire dynamic range. This helps prevent false data signals due to noise on the power supply or ground line.

The SFH551/1-1 comes in a T1$^3/_4$ plastic package with a tubular aperture wide enough to accomodate fiber and cladding. The SFH551/1V-1 is housed in a unique plastic right angle package for easy coupling between the fiber and the photodetector.

The SFH551/1V-1 is suitable for data communication uses such as: LANs, medical equipment, and automotive electronics.

Characteristics T_A=25°C, V_{CC}=4.75 V to 5.25 V

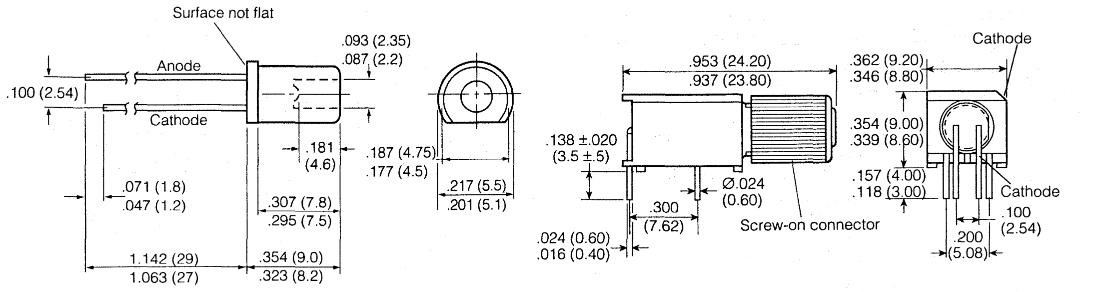
Parameter	Symbol	Value	Unit	Condition
Current Consumption without output current	I_{CC}	4 (<8)	mA	V_{CC}=5 V
Output Voltage, Low	V_{OL}	0.4 (≤0.6)	V	I_{OL}=13 mA, Φ_{outL}≥4 mW
Output Current, High	I_{OH}	5 (≤300)	µA	V_{OH}=5.25 V, Φ_{outH}≤0.1 mW
Optical Power, Low	Φ_{outL}	6 to 500 –22 to –3	µW dBm	λ=660 nm
Optical Power, High	Φ_{outH}	≤0.1 –40	µW dBm	λ=660 nm
Delay Times	t_{PHL} t_{PLH}	<100 <250	ns ns	Φ_{outL}=6 µW to 50 µW R_L=390 Ω, C_L=15 pF, l=1 m
Pull Up Resistance	R_L	>330	Ω	V_{CC}=5 V

See Appnote 40, 41, 43 for application information.

SIEMENS

T1¾ (5 mm) LED PACKAGE SFH750
PLASTIC CONNECTOR HOUSING SFH750V
Plastic Fiber Optic Emitter

Dimensions in inches (mm)



SFH750 **SFH750V**

FEATURES
- **2.2 mm aperture holds standard 1000 micron plastic fiber**
- **No fiber stripping required**
- **Good linearity**
- **Sensitive in visible and near IR range**
- **Molded microlens for efficient coupling**
- **SFH750V only**
  - **Plastic connector housing**
  - **Mounting screw attached to connector**
  - **Interference free transmission from light-tight housing**
  - **Transmitter and receiver can be flexibly positioned**
  - **No cross talk**
  - **Auto insertable and wave solderable**
  - **Supplied in tubes**

APPLICATIONS
- **Household electronics**
- **Power electronics**
- **Optical networks**
- **Medical instruments**
- **Automotive electronics**
- **Light barriers**
- **Motor control**

Maximum Ratings
Operating and Storage
Temperature Range (T_{OP}, T_{STG}) .... –55° to 100°C
Junction Temperature (T_J) .... 100°C
Soldering Temperature
(2 mm from case bottom) (T_S) t≤5 s .... 260°C
Reverse Voltage (V_R) .... 5 V
Forward Current, (I_F) .... 45 mA
Surge Current (I_{FSM}) t≤10 µsec, D=0. .... 1 A
Power Dissipation (P_{TOT}) .... 150 mW
Thermal Resistance, Junction/Air (R_{thJA}) .... 500 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	660	nm	
Spectral Bandwidth	$\Delta\lambda$	35		
Switching Times 10% to 90% and 90% to 10%	t_R t_F	0.12 0.05	µs	R_L=47 Ω, I_F=10 mA
Capacitance	C_0	25	pF	f=1 MHz, V_R=0 V
Forward Voltage	V_F	1.6 (≤2.0)	V	I_F=10 mA
Output Power Coupled into Plastic Fiber (1 mm core diameter), distance lens to fiber ≤0.1 mm, polished fiber	Φ_{IN}	9 (≥25)	µW	
Temperature Coefficient, Φ_{IN}	TC_{Φ}	–0.8	%/K	
Temperature Coefficient, V_F	TC_V	–1.5	mV/K	
Temperature Coefficient, λ_{PEAK}	TC_{λ}	0.17	nm/K	

See Appnotes 40, 41, 43 for application information.

Figure 1. Relative spectral emission–V I_{REL}=f(l) **SFH750**

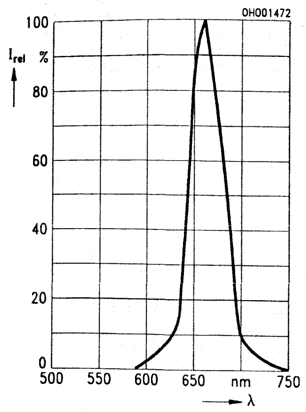


Figure 2. Maximum permissible forward current I_F=f (T_A)

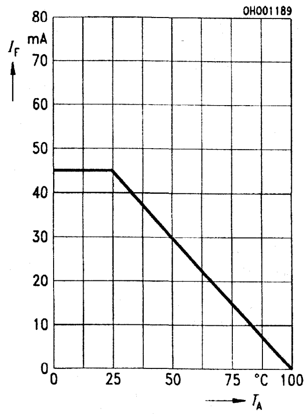


Figure 3. Forward current I_F=f(V_F),single pulse, duration=20 µs

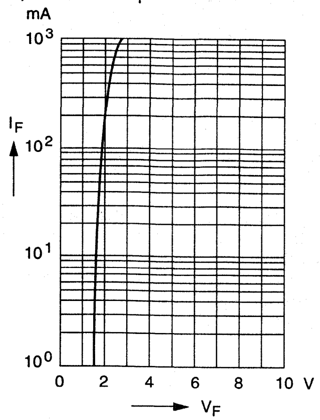


Figure 4. Permissible pulse load I_F=f (T_A) duty cycle D=parameter, T_A=25°C

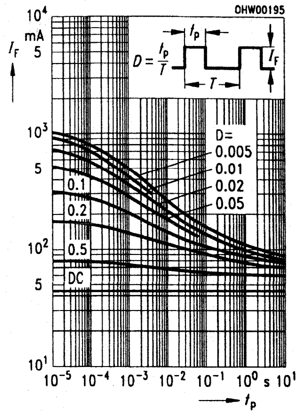
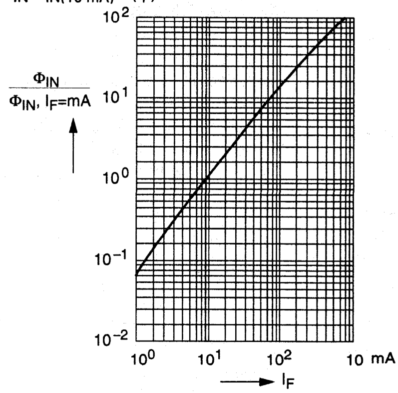


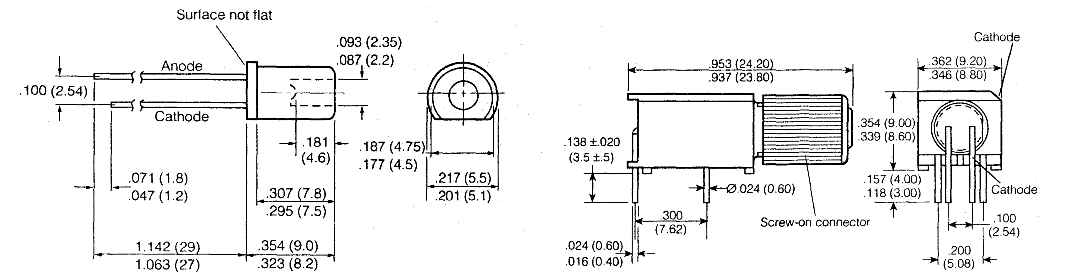
Figure 5. Relative optical output power $F_{IN}/F_{IN(10\ mA)}$=f(I_F)



SIEMENS

5 mm LED PACKAGE SFH756
PLASTIC CONNECTOR HOUSING SFH756V
Plastic Fiber Optic Emitter

Dimensions in inches (mm)



SFH756 **SFH756V**

FEATURES

- **2.2 mm aperture holds standard 1000 micron plastic fiber**
- **No fiber stripping required**
- **Good linearity**
- **Molded microlens for efficient coupling**
- **SFH756V only**
  - **Plastic connector housing**
  - **Mounting screw attached to connector**
  - **Interference free transmission from light-tight housing**
  - **Transmitter and receiver: flexible positioning**
  - **No cross talk**
  - **Auto inseratable and wave solderable**
  - **Supplied in tubes**

APPLICATIONS

- **Household electronics**
- **Power electronics**
- **Optical networks**
- **Medical instruments**
- **Automotive electronics**
- **Light barriers**
- **Motor controls**

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... 100°C
Soldering Temperature (2 mm from case bottom) (T_S) t≤5 s .... 260°C
Reverse Voltage (V_R) .... 3 V
Forward Current (I_F) .... 50 mA
Surge Current t≤10 µs, D=0 (I_{FSM}) .... 1 A
Power Dissipation (P_{TOT}) T_A=25°C .... 120 mW
Thermal Resistance, Junction to Air (R_{thJA}) .... 450 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{Peak}	660	nm	
Spectral Bandwidth	$\Delta\lambda$	25		
Switching Times 10% to 90% and 90% to 10%	t_R, t_F	0.1	µs	R_L=50 Ω, I_F=50 mA
Capacitance	C_0	30	pF	f=1 mHz, V_R=0 V
Forward Voltage	V_F	2.1 (≤2.8)	V	I_F=50 mA
Output Power Coupled into Plastic Fiber(1)	Φ_{IN}	200 (≥100)	µW	I_F=10 mA
Temperature Coefficient Φ_{IN}	TC_Φ	–0.4	%/K	
Temperature Coefficient V_F	TC_V	–3	mV/K	
Temperature Coefficient λ_{Peak}	TC_λ	0.16	nm/K	

Note

1. The output power coupled into plastic fiber is measured using a large area detector at the end of a short length of fiber (about 30 cm). This value must not be used for calculating the power budget for a fiber optic system with a long fiber because the numerical aperture of plastic fiber decreases in the first few meters. Therefore the fiber seems to display higher attenuation over the first few meters than specified.

See Appnotes 40, 41, 43 for application information.

Figure 1. Relative spectral emission
$I_{rel}=f(\lambda)$

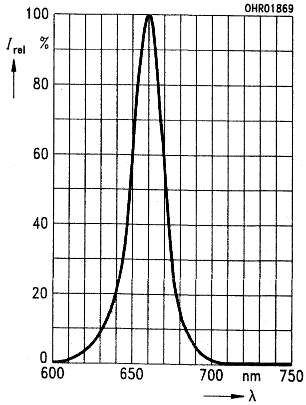


Figure 2. Max. permissible forward current $I_F=f(T_A)$, R_{thJA}=450 K/W

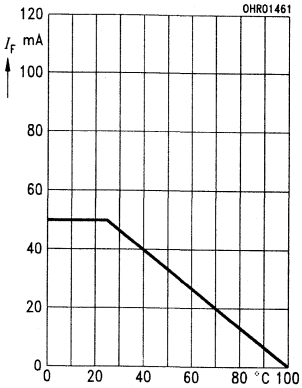


Figure 3. Relative output power
I_e/I_e(50 mA)=f(I_F) single pulse, duration=20µs

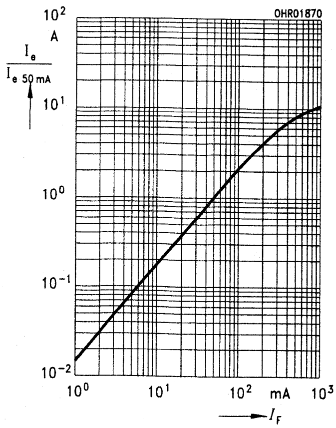


Figure 4. Forward current
IF=f(VF) Single pulse t=20 µs

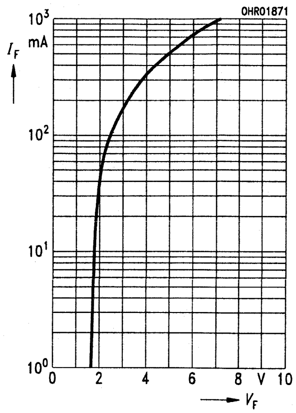
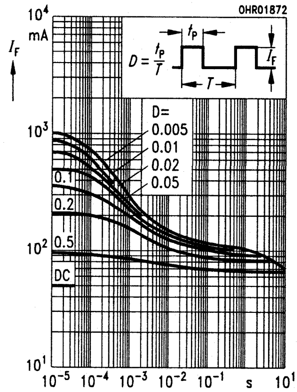


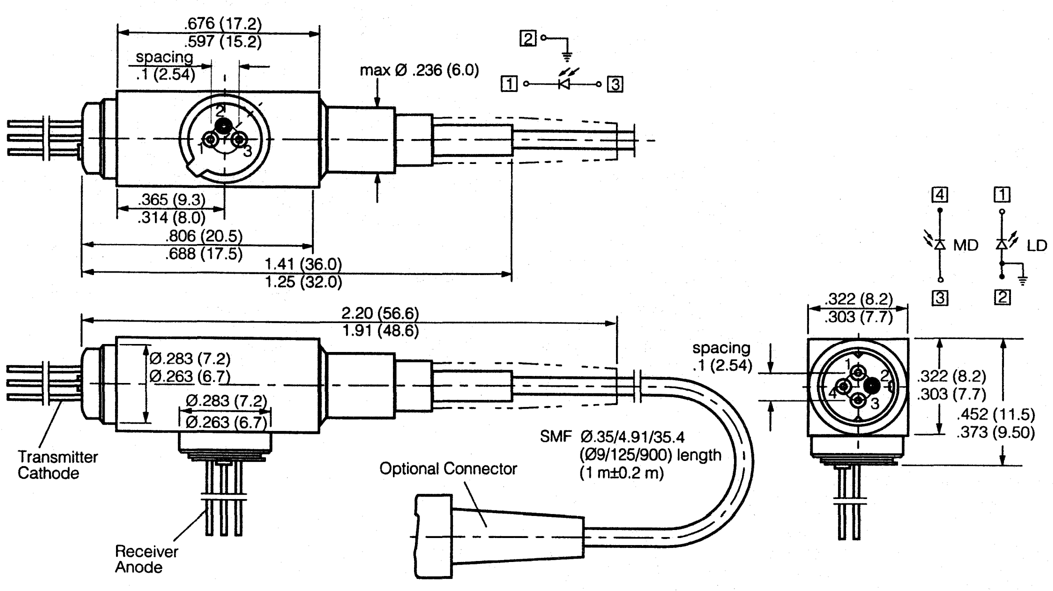
Figure 5. Permissible pulse handling capability $I_F=f(t_p)$, T_A=25°C, duty cycle D= Parameter



Fiber Optics Components Laser Diodes
8

SIEMENS

LOW POWER SBL51214G/N/Z
MEDIUM POWER SBM51214G/N/Z
1300/1300 nm BIDI™ Transceiver Optical Module



FEATURES
- **Bidirectional transmission in one optical window**
- **Designed for passive optical networks**
- **Integrated beam splitter**
- **Laser diode with Multi-quantum well structure**
- **Suitable for Bit rates up to 1 Gbit/s**
- **Ternary photodiode at rear mirror to monitor and control radiant power**
- **Low noise/high bandwidth PIN diode**
- **Hermetically sealed subcomponents, similar to TO-18**
- **With single mode fiber pigtail with optional connector**

Maximum Ratings

Output power ratings refer to the optical port. The operating temperature of the submount is identical to the case temperature.

Module

Operating and Storage Temperature Range at Case(T_C, T_{STG}) .... –40 to +85°C
Soldering Temperature (T_S), t_{max}=30 s 2 mm from bottom edge of case .... 260°C

Laser Diode

Forward Current (I_{Fmax}) .... 150 mA
Radiant Power CW (Φ_e) ....
SBL .... 1 mW
SBM 2mW
Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

Forward Current (I_{Fmax}) .... 2 mA
Reverse Voltage (V_{Rmax}) .... 10 V

PIN Photodiode

Forward Current (I_{Fmax}) .... 2 mA
Reverse Voltage (V_{RR}) .... 10 V
Maximum Optical Power into Optical Port ($\Phi_{port\ max}$) .... 1.5 mW

Characteristics All optical data refer to the optical port at T_C=25°C unless specified

Parameter		Symbol	Value	Unit	Condition
Laser Diode					
Optical Output Power CW	SBL51214x	Φ_e	>0.2	mW	
	SBM51214x		>0.5		
Emission Wavelength, Center of Range	SBL51214x	λ	1270–1350	nm	Φ_e=0.2 mW
	SBM51214x				Φ_e=0.5 mW
Spectral Bandwidth	SBL51214x	$\Delta\lambda$	<5		Φ_e=0.2 mW (RMS)
	SBM51214x				Φ_e=0.5 mW (RMS)
Threshold Current		I_{th}	2–45	mA	–40 to +85°C
Forward Voltage	SBL51214x	V_F	<1.5	V	Φ_e=0.2 mW
	SBM51214x				Φ_e=0.5 mW
Radiant Power at I_{th}	SBL51414x	Φ_{eth}	<20	µW	
	SBM51414x		<50		
Current above Threshold, 25°C	SBL51214x	ΔI_F	10–35	mA	Φ_e=0.4 mW
	SBM51214x				Φ_e=1 mW
Current above Threshold, –40 to +85°C	SBL51214x	ΔI_F	7–50		Φ_e=0.4 mW
	SBM51214x				Φ_e=1 mW
Variation of 1st Derivative of P/I	SBL51214x	dP/dI	–30 to 30	%	0.05 –0.4 mW
	SBM51214x				0.1 –1 mW
Differential Series Resistance		r_S	<8	Ω	
Rise Time/Fall Time, 10%–90%		t_R, t_F	<1	ns	
Temperature Coefficient, Wavelength		TC_λ	<0.5	nm/K	
Monitor Diode					
Dark Current		I_R	<200	nA	V_R=2 V, Φ_e=0, T_C=85°C
Photocurrent, V_R=2 V	SBL51214x	I_P	100–1000	µA	Φ_e=0.2 mW
	SBM51214x		200–1200		Φ_e=0.5 mW
Capacitance		C_2	<10	pF	V_R=2 V, f=1 MHz
Tracking Error		TE	–1 to 1	dB	V_R=2 V (Note 1)
Detector					
Dark Current		I_R	<50	nA	V_R=2 V, Φ_e=0, T_C=85°C
Spectral Sensitivity		S_λ	>0.30	A/W	V_R=2 V, λ=1300 nm
Capacitance		C_2	<1.5	pF	V_R=2 V, f=1 MHz
Rise Time/Fall Time, 10%–90%		t_R, t_F	<1	ns	V_R=2 V
Module					
Optical Crosstalk (see Note 2)		CRT	<–22	dB	

Notes

1. The tracking error TE is the variation rate of Φ_e at constant current I_{mon} over a specified temperature range and relative to the reference point: $I_{mon,\ ref}=I_{mon}(T=25°C,\ \Phi_e=0.2\ mW)$. Thus, TE is given by:

$$TE\ [dB]=10 \times \log \frac{\Phi_e\ [T_C\} - \Phi_e\ [25°C]}{\Phi_e\ [25°C]}$$

2.Optical cross talk is defined as CRT=10 • log ($I_{Det,0}/I_{Det,1}$) with: $I_{Det,0}$ the photocurrent with Φ_e=0.2 mW, CW laser operation, V_R=2 V and $ID_{Det,1}$ the photocurrent without Φ_e, but 0.2 mW optical input power, λ=1380 nm.

Additional Information

T=25°C Threshold current, current above threshold for 0.4 mW output power, monitor current for 0.2 mW output power, peak wavelength.

T=85°C Threshold current, current above threshold for 0.4 mWoutput power, monitor current for 0.2 mW output power.

End of Life Values

Description	Sym	Value	Unit	Condition
Threshold Current at T=85°C	Ith	<60	mA	
Current above Threshold, over full temperature range, at $I_{mon.ref}=I_{mon}$	ΔI_F	7–70		T=25°C, Φ_e=0.4 mW, BOL
Tracking Error (see Note 1)	TE	–1.5 to 1.5	dB	
Detector Dark Current	I_R	<400	nA	V_R=2 V, T=85°C
Monitor Dark Current,		<1	µA	V_R=2 V, T=85°C

Type: Single Mode, Silica

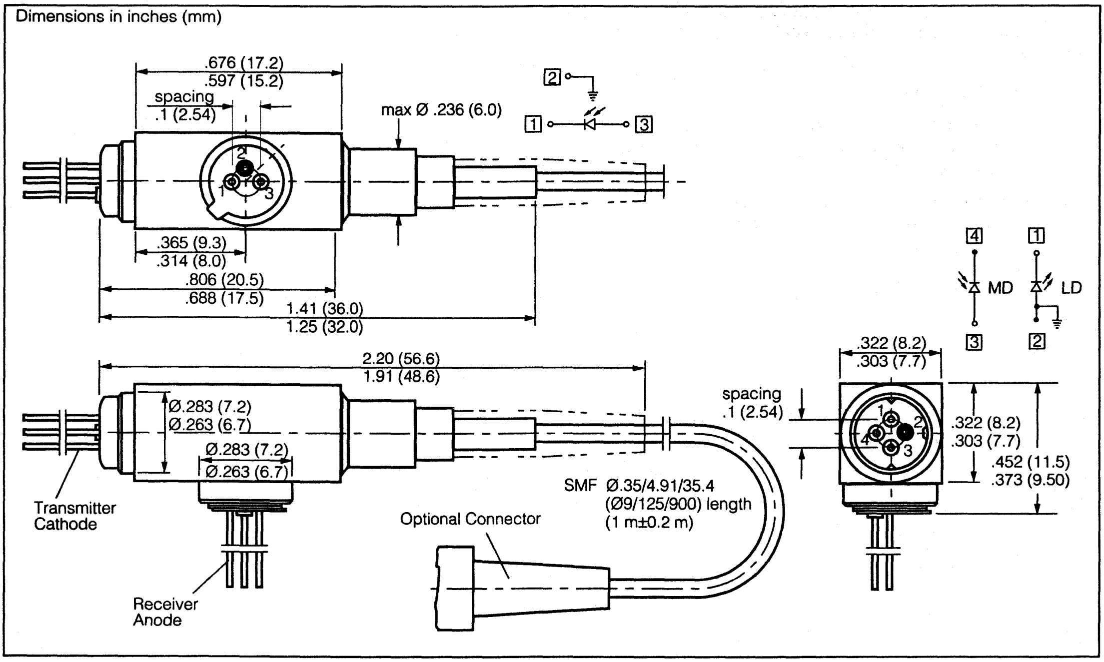
Description	**Value**	**Unit**
Mode Field Diameter	9±1	µm
Cladding Diameter	125±2	
Mode Field/Cladding Concentricity Error	<1	
Cladding Non-circularity	<2	%
Mode Field Non-circularity	<6	
Cut-off Wavelength	>1270	nm
Jacket Diameter	0.9 ±0.1	mm
Bending Radius	>30	
Tensile Strength Fiber Case	>5	N
Length	1 ±0.2	m

Connector Option

Model	**Connector**
SBL51214G SBM51214G	FC/PC
SBL51214N SBM51214N	SC/PC
SBL51214Z SBM51214Z	No Connecter

SIEMENS

LOW POWER SBL51414G/N/Z
MEDIUM POWER SBM51414G/N/Z
1300 nm Emitting, 1550 nm Receiving BIDI™ Transceiver Optical Module



FEATURES

- **Bidirectional transmission in 2nd and 3rd optical window**
- **Designed for passive optical networks**
- **Integrated wavelength division multiplexer**
- **Laser diode with Multi-quantum well structure**
- **Suitable for Bit rates up to 1 Gbit/s**
- **Ternary photodiode at rear mirror to monitor and control radiant power**
- **Low noise/high bandwidth PIN diode**
- **Hermetically sealed subcomponents, similar to TO-18**
- **With single mode fiber pigtail with optional connector**

Maximum Ratings

Output power ratings refer to the optical port. The operating temperature of the submount is identical to the case temperature.

Module

Operating and Storage Temperature Range at
Case(T_C, T_{STG}) .... –40 to +85°C
Soldering Temperature (T_S), t_{max}=30 s
2 mm from bottom edge of case .... 260°C

Laser Diode

Forward Current (I_{Fmax}) .... 150 mA
Radiant Power CW (Φ_e) ....
SBL .... 1 mW
SBM 2mW
Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

Forward Current (I_{Fmax}) .... 2 mA
Reverse Voltage (V_R) .... 10 V

PIN Photodiode

Forward Current (I_{Fmax}) .... 2 mA
Reverse Voltage (V_{RR}) .... 10 V
Maximum Optical Power into Optical Port ($\Phi_{por\ tmax}$) .... 1.5 mW

Characteristics All optical data refer to the optical port at T_C=25°C unless specified

Parameter		Symbol	Value	Unit	Condition
Laser Diode					
Optical Output Power CW	SBL51414x	Φ_e	>0.2	mW	
	SBM51414x		>0.5		
Emission Wavelength, Center of Range	SBL51414x	λ	1270–1350	nm	Φ_e=0.2 mW
	SBM51414x				Φ_e=0.5 mW
Spectral Bandwidth	SBL51414x	$\Delta\lambda$	<5		Φ_e=0.2 mW (RMS)
	SBM51414x				Φ_e=0.5 mW (RMS)
Threshold Current		I_{th}	2–45	mA	–40 to +85°C
Forward Voltage	SBL51414x	V_F	<1.5	V	Φ_e=0.2 mW
	SBM51414x				Φ_e=0.5 mW
Radiant Power at I_{th}	SBL51414x	Φ_{eth}	<20	µW	
	SBM51414		<50		
Current above Threshold, 25°C	SBL51414x	ΔI_F	10–35	mA	Φ_e=0.4 mW
	SBM51414x				Φ_e=1 mW
Current above Threshold, –40 to +85°C	SBL51414x	ΔI_F	7–50		Φ_e=0.4 mW
	SBM51414x				Φ_e=1 mW
Variation of 1st Derivative of P/I	SBL51414x	dP/dI	–30 to 30	%	0.05–0.4 mW
	SBM51414x				0.1–1 mW)
Differential Series Resistance		r_S	<8	W	
Rise Time/Fall Time, 10%–90%		t_R, t_F	<1	ns	
Temperature Coefficient, Wavelength		TC_λ	<0.5	nm/K	
Monitor Diode					
Dark Current		I_R	<200	nA	V_R=2 V, Φ_e=0, T_C=85°C
Photocurrent, V_R=2 V	SBL51414x	I_P	100–1000	µA	Φ_e=0.2 mW
	SBM51414x		200–1200		Φ_e=0.5 mW
Capacitance		C_2	<10	pF	V_R=2 V, f=1 MHz
Tracking Error		TE	–1 to 1	dB	V_R=2 V (see Note 1)
Detector					
Dark Current		I_R	<50	nA	V_R=2 V, Φ_e=0, T_C=85°C
Spectral Sensitivity		S_λ	>0.65	A/W	V_R=2 V, λ=1550 nm
Capacitance		C_2	<1.5	pF	V_R=2 V, f=1 MHz
Rise Time/Fall Time, 10%–90%		t_R,t_F	<1	ns	V_R=2 V
Module					
Optical Crosstalk (see Note 2)		CRT	<–47	dB	

Fiber Optics Components Laser Diodes 8

Notes

1. The tracking error TE is the variation rate of Φ_e at constant current I_{mon} over a specified temperature range and relative to the reference point: $I_{mon,\ ref}=I_{mon}(T=25°C,\ \Phi_e=0.2\ mW)$. Thus, TE is given by:

$$TE\ [dB] = 10 \times \log \frac{\Phi_e\ [Tc\} - \Phi_e\ [25°C]}{\Phi_e\ [25°C]}$$

2.Optical cross talk is defined as CRT=10 • log ($I_{Det,0}/I_{Det,1}$) with: $I_{Det,0}$ the photocurrent with Φ_e=0.2 mW, CW laser operation, V_R=2 V and $ID_{Det,1}$ the photocurrent without Φ_e, but 0.2 mW optical input power, λ=1550 nm.

Additional Information

T=25°C Threshold current, current above threshold for 0.4 mW output power, monitor current for 0.2 mW output power, peak wavelength.

T=85°C Threshold current, current above threshold for 0.4 mW output power, monitor current for 0.2 mW output power.

End of Life Values

Description	Sym	Value	Unit	Condition
Threshold Current at T=85°C	Ith	<60	mA	
Current above Threshold, over full temperature range, at $I_{mon.ref}=I_{mon}$	ΔI_F	7–70		T=25°C, Φ_e=0.4 mW, BOL
Tracking Error (see Note 1)	TE	–1.5 to 1.5	dB	
Detector Dark Current	I_R	<400	nA	V_R=2 V, T=85°C
Monitor Dark Current,		<1	µA	

Type: Single Mode, Silica

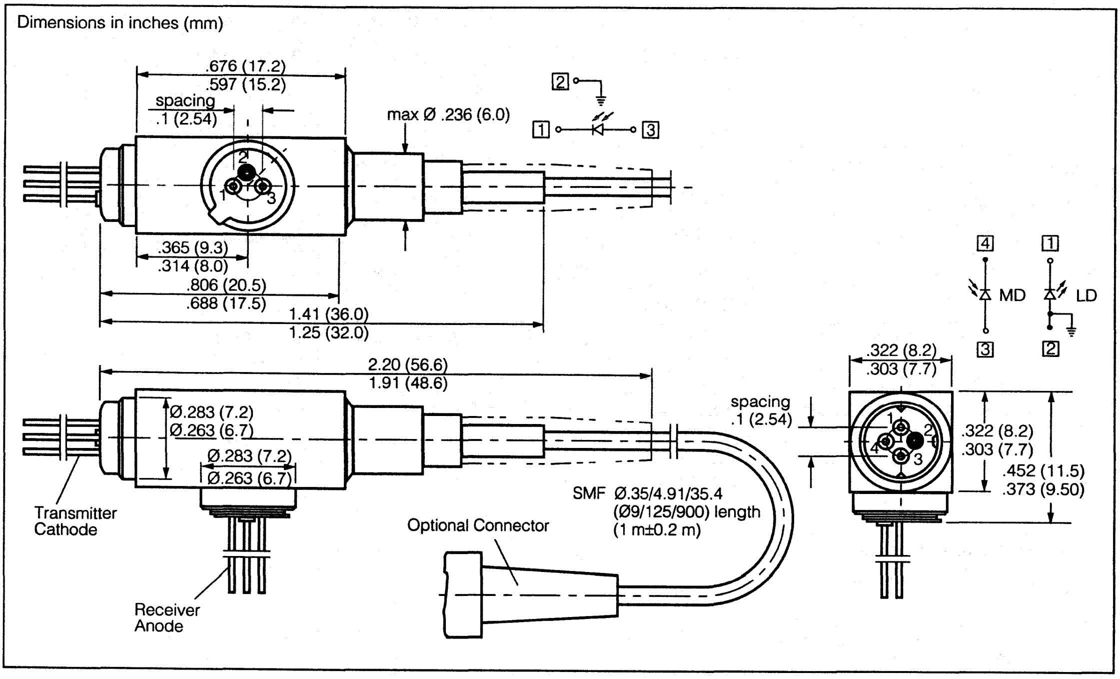
Description	Value	Unit
Mode Field Diameter	9±1	µm
Cladding Diameter	125±2	
Mode Field/Cladding Concentricity Error	<1	
Cladding Non-circularity	<2	%
Mode Field Non-circularity	<6	
Cut-off Wavelength	>1270	nm
Jacket Diameter	0.9 ±0.1	mm
Bending Radius	>30	
Tensile Strength Fiber Case	>5	N
Length	1 ±0.2	m

Connector Options

Model	Connector
SBL51414G SBM51414G	FC/PC
SBL51414N SBM51414N	SC/PC
SBL51414Z SBM51414Z	No Connecter

SIEMENS

LOW POWER SBL81314G/N/Z
MEDIUM POWER SBM81314G/N/Z
1550 nm Emitting, 1300 nm Receiving
BIDI™ Transceiver Optical Module



FEATURES

- **Bidirectional transmission in 2nd and 3rd optical window**
- **Designed for passive optical networks**
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- **Laser diode with Multi-quantum well structure**
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- **Low noise/high bandwidth PIN diode**
- **Hermetically sealed subcomponents, similar to TO-18**
- **With single mode fiber pigtail with optional connector**

Maximum Ratings

Output power ratings refer to the optical port. The operating temperature of the submount is identical to the case temperature.

Module

Operating and Storage Temperature Range
at Case(T_C, T_{STG}) .... –40 to +85°C

Soldering Temperature (T_S), t_{max}=30 s
2 mm from bottom edge of case .... 260°C

Laser Diode

Forward Current (I_{Fmax}) .... 150 mA

Radiant Power CW (Φ_e) ....
SBL .... 1 mW
SBM .... 2 mW

Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

Forward Current (I_{Fmax}) .... 2 mA

Reverse Voltage (V_R) .... 10 V

PIN Photodiode

Forward Current (I_{Fmax}) .... 2 mA

Reverse Voltage (V_{RR}) .... 10 V

Maximum Optical Power into Optical Port ($\Phi_{por\ tmax}$) .... 1.5 mW

Characteristics All optical data refer to the optical port at T_C=25°C unless specified

Parameter		Symbol	Value	Unit	Condition
Laser Diode					
Optical Output Power CW	SBL81314x	Φ_e	>0.2	mW	
	SBM81314x		>0.5		
Emission Wavelength, Center of Range	SBL81314x	λ	1510–1590	nm	Φ_e=0.2 mW
	SBM81314x				Φ_e=0.5 mW
Spectral Bandwidth	SBL81314x	$\Delta\lambda$	<5		Φ_e=0.2 mW (RMS)
	SBM81314x				Φ_e=0.5 mW (RMS)
Threshold Current, –40 to +85°C		I_{th}	8–60	mA	
Forward Voltage	SBL81314x	V_F	<1.5	V	Φ_e=0.2 mW
	SBM81314x				Φ_e=0.5 mW
Radiant Power at I_{th}	SBL81314x	Φ_{eth}	<20	µW	
	SBM81314x		<50		
Current above Threshold, 25°C	SBL81314x	ΔI_F	10–35	mA	Φ_e=0.4 mW
	SBM81314x				Φ_e=1 mW
Current above Threshold, –40 to +85°C	SBL81314x	ΔI_F	7–50		Φ_e=0.4 mW
	SBM81314x				Φ_e=1 mW
Variation of 1st Derivative of P/I	SBL81314x	dP/dI	–30 to 30	%	0.05–0.4 mW
	SBM81314x				0.1–1 mW
Differential Series Resistance		r_S	<8	W	
Rise Time/Fall Time (10%–90%)		t_R,t_F	<1	ns	
Temperature Coefficient, Wavelength		TC_λ	<0.5	nm/K	
Monitor Diode					
Dark Current, V_R=2 V, $\Phi_{e=}$0, T_C=85°C		I_R	<200	nA	
Photocurrent, V_R=2 V	SBL81314x	I_P	100–1000	µA	Φ_e=0.2 mW
	SBM81314x		200–1200		Φ_e=0.5 mW
Capacitance, V_R=2 V, f=1 MHz		C_2	<10	pF	
Tracking Error, V_R=2 V (see Note 1)		TE	–1 to 1	dB	
Detector					
Dark Current, V_R=2 V, $\Phi_{e=}$0, T_C=85°C		I_R	<50	nA	
Spectral Sensitivity, V_R=2 V, λ=1550 nm		S_λ	>0.65	A/W	
Capacitance, V_R=2 V, f=1 MHz		C_2	<1.5	pF	
Rise Time/Fall Time, V_R=2 V (10%–90%)		t_R,t_F	<1	ns	
Module					
Optical Crosstalk (see Note 2)		CRT	<–47	dB	

Notes

1. The tracking error TE is the variation rate of Φ_e at constant current I_{mon} over a specified temperature range and relative to the reference point: $I_{mon,\ ref}=I_{mon}(T=25°C,\ \Phi_e=0.2\ mW)$. Thus, TE is given by:

$$TE\ [dB]=10 \times \log \frac{\Phi_e\ [Tc\} - \Phi_e\ [25°C]}{\Phi_e\ [25°C]}$$

2.Optical cross talk is defined as $CRT=10 \bullet \log (I_{Det,0}/I_{Det,1})$ with: $I_{Det,0}$ the photocurrent with Φ_e=0.2 mW, CW laser operation, V_R=2 V and $ID_{Det,1}$ the photocurrent without Φ_e, but 0.2 mW optical input power, λ=1550 nm.

Additional Information

T=25°C Threshold current, current above threshold for 0.4 mW output power, monitor current for 0.2 mW output power, peak wavelength.

T=85°C Threshold current, current above threshold for 0.4 mW output power, monitor current for 0.2 mW output power.

End of Life Values

Description	Sym.	Value	Unit	Condition
Threshold Current at T=85°C	Ith	<60	mA	
Current above Threshold, over full temperature range, at $I_{mon.ref}=I_{mon}$	ΔI_F	7–70		T=25°C, Φ_e=0.4 mW, BOL
Tracking Error (see Note 1)	TE	–1.5 to 1.5	dB	
Detector Dark Current	I_R	<400	nA	V_R=2 V, T=85°C
Monitor Dark Current		<1	µA	

Type: Single Mode, Silica

Description	Value	Unit
Mode Field Diameter	9±1	µm
Cladding Diameter	125±2	
Mode Field/Cladding Concentricity Error	<1	
Cladding Non-circularity	<2	%
Mode Field Non-circularity	<6	
Cut-off Wavelength	>1270	nm
Jacket Diameter	0.9 ±0.1	mm
Bending Radius	>30	
Tensile Strength Fiber Case	>5	N
Length	1 ±0.2	m

Connector Options

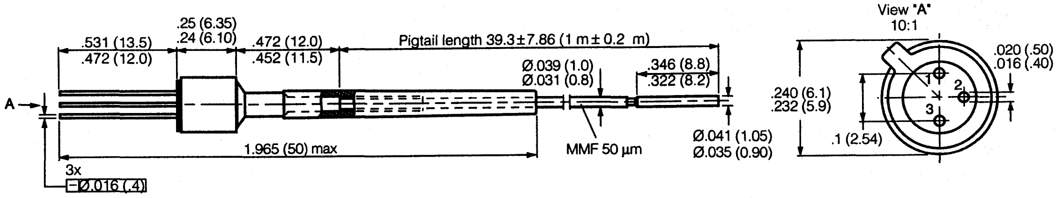
Model	Connector
SBL81314G SBM81314G	FC/PC
SBL81314N SBM81314N	SC/PC
SBL81314Z SBM81314Z	No Connecter

SIEMENS

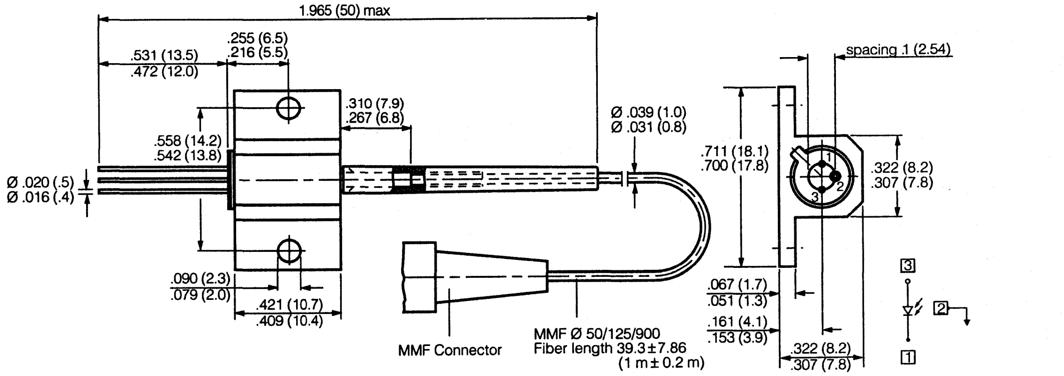
SRD00214H/W
MMF PIGTAIL and FLANGE SRD00215H/W
Ternary PIN Photodiode

Dimensions in inches (mm)

SRD00214H/W



SRD00215H/W



FEATURES

- **InGaAs/InP, PIN photodiode**
- **Designed for telecom applications**
- **Sensitive receiver for 2nd and 3rd optical window (1300 nm and 1550 nm)**
- **Suitable for bit rates up to 1.2 Gbit/s**
- **Low junction and low package capacitance**
- **Fast switching times**
- **Low dark current**
- **Low noise**
- **High reverse current stability from planar structure**
- **Hermetically sealed 3 pin metal case**
- **Coax with or without flange and optional connector**

Maximum Ratings

Forward Current (I_F) .... 10 mA
Reverse Voltage (V_R) .... 20 V
Operating and Storage Temperature (T_{OP}, T_{STG}) .... –40 to +85°C
Maximum Radiant Power in Optical Port, V_R=5 V (Φ_{port}) .... 1 mW
Soldering Time (wave/dip soldering) (t_S) .... 10 s
distance bet. solder point and base plate ≥ 2 mm, 260°C

Characteristics All optical data refer to a coupled 10/125 µm SM fiber, T_A=25°C, unless otherwise specified

Parameter	Symbol	Value	Unit	Condition
Spectral Sensitivity	S_λ	0.9 (≥0.8)	A/W	λ=1300 nm, V_R= 2 V
Change in Spectral Spectral Sensitivity in Operating Temperature Range	S_λ	≤0.2	%/K	
Rise Time/Fall Time (10%–90%)	t_R, t_F	≤0.3 (≤0.5)	ns	R_L=50 Ω, λ=1310 nm, Φ_{port}=100 µW, V_R=2 V
Total Capacitance (Φ_{port}=0, f=1 MHz)	C_2	1 (≤1.5)	pF	V_R=2 V
Dark Current (T_A=85°C $\Phi_{e=}$0)	I_D	1 (<50)	nA	
Back Reflection of Optical Power into Optical Port	R	≤–20	dB	

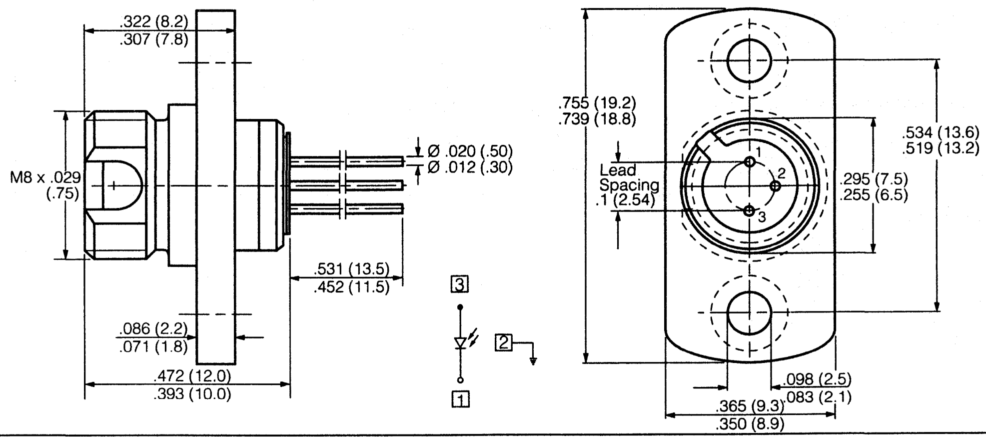
Connector Options

Model	Connector
SRD00214/5H	FC/PC
SRD00214/5W	No Connector

SIEMENS

FC RECEPTACLE and FLANGE SRD00217H
Ternary PIN Photodiode

Dimensions in inches (mm)



FEATURES
- **InGaAs/InP, PIN photodiode**
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- **Sensitive receiver for 2nd and 3rd optical window (1300 nm and 1550 nm)**
- **Suitable for bit rates up to 1.2 Gbit/s**
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- **Fast switching times**
- **Low dark current**
- **Low noise**
- **High reverse current stability from planar structure**
- **Hermetically sealed 3 pin metal case**

Maximum Ratings

Forward Current (I_F) .... 10 mA
Reverse Voltage (V_R) .... 20 V
Operating and Storage Temperature (T_{OP}, T_{STG}) .... –40 to +85°C
Maximum Radiant Power in Optical Port, V_R=5 V (Φ_{port}) .... 1 mW
Soldering Time (wave/dip soldering) (t_S) .... 10 s
distance bet. solder point and base plate≥ 2 mm, 260°C

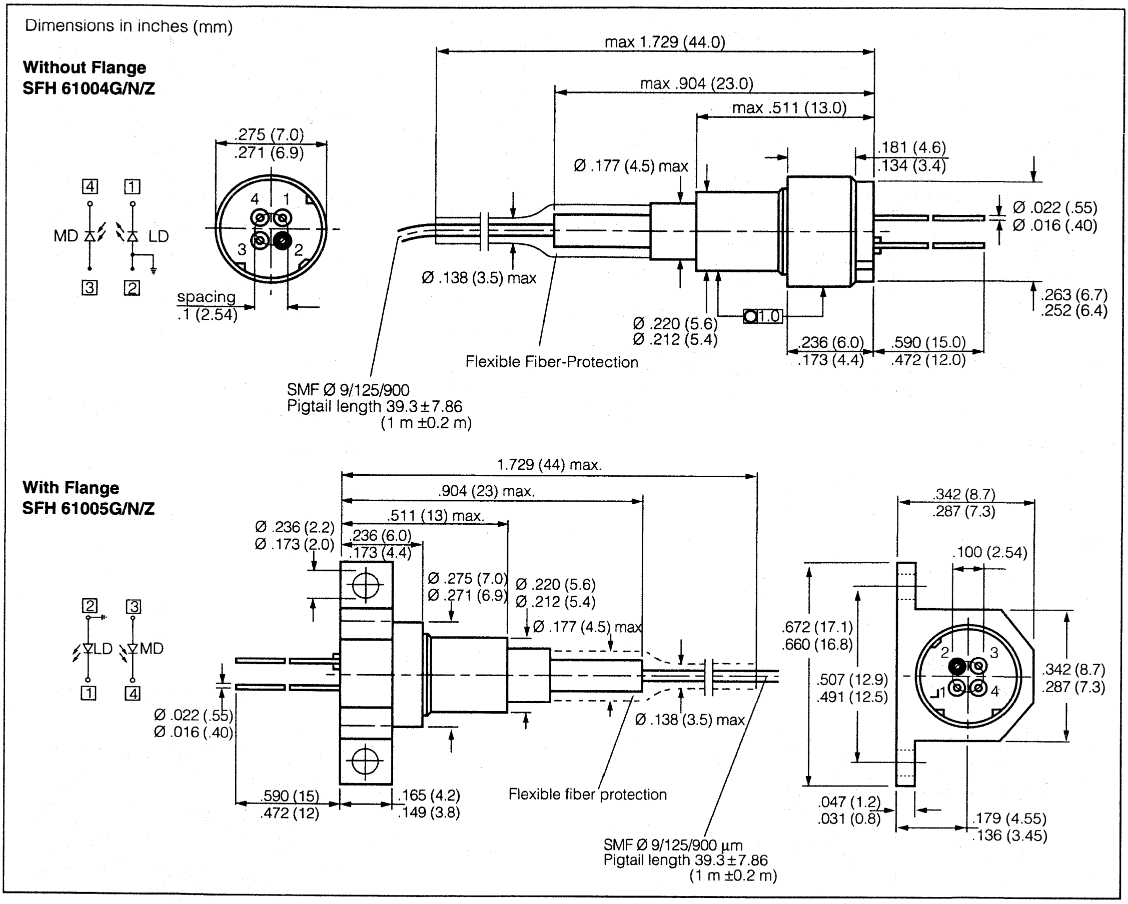
Characteristics All optical data refer to a coupled 10/125 µm SM fiber, T_A=25°C, unless otherwise specified

Parameter	Symbol	Value	Unit	Condition
Spectral Sensitivity	S_λ	0.9 (≥0.80)	A/W	λ=1300 nm, V_R= 5 V
Change in Spectral Spectral Sensitivity in Operating Temperature Range	$S\lambda$	≤0.2	%/K	
Rise Time/Fall Time (10%–90%)	t_R, t_F	≤0.3 (≤0.5)	ns	R_L=50 Ω, λ=1310 nm, Φ_{port}=100 µW V_R=5 V
Total Capacitance (Φ_{port}=0, f=1 MHz)	C_2	1 (≤1.5)	pF	V_R=2 V
Dark Current (T_A=85°C $\Phi_{e=}$0)	I_D	1 (<50)	nA	
Back Reflection of Optical Power into Optical Port	R	≤–20	dB	

SIEMENS

STH61004G/N/Z
STH61005G/N/Z

1300 nm DFB Laser in Coaxial Package with SM-Pigtail, 622 MBit/s Long Reach



FEATURES

- **Designed for use in high-speed and long-haul fiber-optic neworks**
- **Laser diode with multi-quantum well and gain coupled structure**
- **Suitable for bit rates up to 622 Mbit/s (STM-4) without thermoelectric cooler and optical isolator**
- **Ternary photodiode at rear mirror to monitor and control radiant power**
- **Hermetically sealed subcomponents, similar to TO-18**
- **SM pigtail with or without flange and optional connector**

Maximum Ratings

Output power ratings refer to SM fiber outport. The operating temperature of the submount is identical to the case temperature.

Module

Operating Temperature Range at Case(T_C) .... –40 to +85°C
Storage Temperature Range (T_{STG})............................ –40 to +85°C
Soldering Temperature (T_S), t_{max}=10 s
2 mm from bottom edge of case .... 260°C

Laser Diode

Forward Current (I_{Fmax}) .... 120 mA
Radiant Power CW (Φ_e) .... 4 mW
Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

Reverse Voltage (V_{Rmax}) .... 10 V

Characteristics All optical data refer to a coupled 10/125um SM fiber, T_C=25°C

Parameter	Symbol	Value	Unit
Laser Diode			
Optical Output Power, CW	Φ_e	>1.0	mW
Emission Wavelength,Center of Range $\Phi_{e=}$1 mW	λ	1280–1330	nm
Spectral Bandwidth $\Phi_{e=}$1 mW (RMS)	Δλ	<0.5	
Side Mode Suppression Ratio	SSR	>35	dB
Threshold Current (–40 to +85°C)	I_{th}	5–55	mA
Forward Voltage $\Phi_{e=}$1 mW	V_F	<1.5	V
Radiant Power at Threshold	Φ_{eth}	<80	µW
Slope Efficiency (–40 to +85°C)	η	25–150	mW/A
Differential Series Resistance	r_S	<8	Ω
Rise Time/Fall Time (10%–90%)	t_R,t_F	<0.5	ns
Temperature Coefficient, Emision Wavelength Center	TC_λ	<0.15	nm/K
Monitor Diode			
Dark Current, V_R=2 V, $\Phi_{e=}$0, T_C=85°C	I_R	<500	nA
Photocurrent, $\Phi_{e=}$1 mW	I_P	100–1000	µA

Connector Options

Model	Connector
STH 61004/5 G	FC/PC
STH 61004/5 N	SC/PC
STH 61004/5 Z	No Connector

Figure 1. Laser diode
Radiant Power in Singlemode Fibre

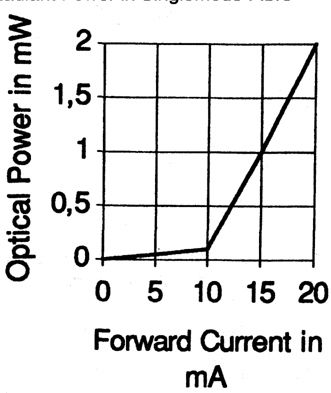


Figure 2. Relative radiant power $\Phi_{e=}f(\lambda)$

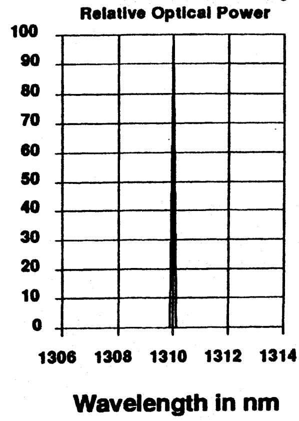


Figure 3. Laser forward current I_F=f(V_F)

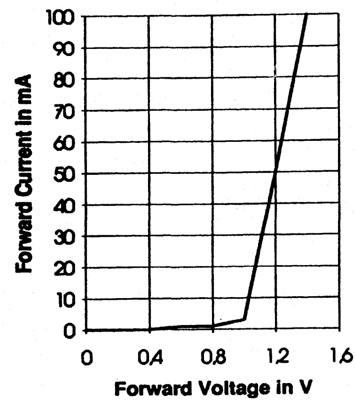
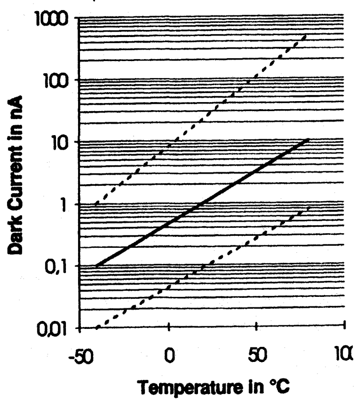


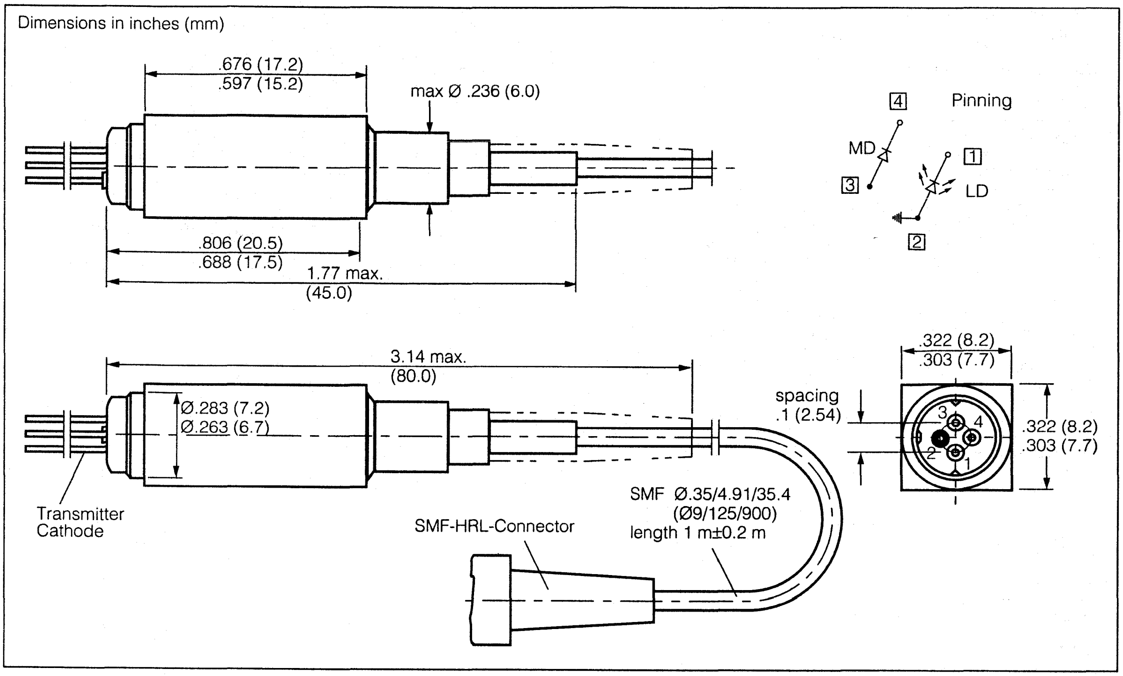
Figure 4. Monitor diode dark current
I_R=f(T_A), Φ_{port}=0, V_R=5V



SIEMENS

STH61008G/N/Z

1300 nm DFB Laser in Coaxial Package with SM-Pigtail, with Optical Isolator for 2.5 Gbit/s Application



FEATURES

- **Designed for use in high-speed and long-haul Fiber-optic networks**
- **Laser diode with multi-quantum well and gain coupled structure**
- **Suitable for bit rates up to 2,5 Gbit/s (STM-16) with optical isolator, without cooler**
- **Ternary photodiode at rear mirror to monitor and control radiant power**
- **Hermetically sealed subcomponents, similar to TO-18**
- **SM pigtail with optional connector**

Maximum Ratings

Output power ratings refer to the SM fiber outport. The operating temperature of the submount is identical to the case temperature.

Module

Operating and StorageTemperature Range at
Case (T_C, T_{STG}) .... –40 to +85°C
Soldering Temperature (T_S), t_{max}=10 s
2 mm from bottom edge of case .... 260°C

Laser Diode

Forward Current (I_{Fmax}) .... 120 mA
Radiant Power CW (Φ_e) .... 4 mW
Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

Reverse Voltage (V_{Rmax}) .... 10 V

Characteristics All optical data refer to a coupled 10/125um SM fiber, T_C=25°C

Parameter	Symbol	Value	Unit	Condition
Laser Diode				
Optical Output Power CW	Φ_e	>1.0	mW	
Emission Wavelength, Center of Range	λ	1280–1330	nm	$\Phi_{e=}$1 mW
Spectral Bandwidth	$\Delta\lambda$	<0.5	nm	$\Phi_{e=}$1 mW (RMS)
Side mode suppression ratio	SSR	>35	dB	
Threshold Current	I_{th}	5–55	mA	–40 to +85°C
Forward Voltage	V_F	<1.5	V	$\Phi_{e=}$1 mW
Radiant Power at threshold	Φ_{eth}	<80	µW	
Slope Efficiency	η	25 to 150	mW/A	–40 to +85°C
Differential Series Resistance	r_S	<8	Ω	
Rise Time/Fall Time	t_R,t_F	<0.25	ns	10%–90%
Temperature Coefficient, Wavelength Center	TC_λ	<0.15	nm/K	
Olptical Isolation		>30	dB	T=25°C
Monitor Diode				
Dark Current	I_R	<500	nA	V_R=2 V, $\Phi_{e=}$0, T_C=85°C
Photocurrent	I_P	100–1200	µA	$\Phi_{e=}$1 mW

Connector Options

Model	Connector
STH61008G	FC/PC
STH61008N	SC/PC
STH61008Z	No Connecter

Figure 1. Laser diode
Radiant power in singlemode fiber

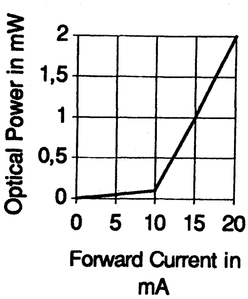


Figure 2. Relative radiant power $\Phi_{e=}f(\lambda)$

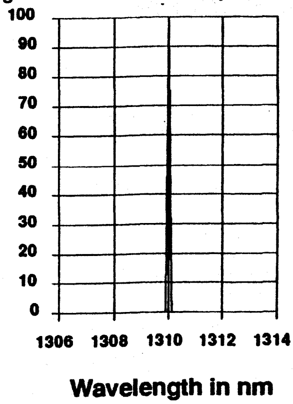


Figure 3. Laser forward current $I_F=f(V_F)$

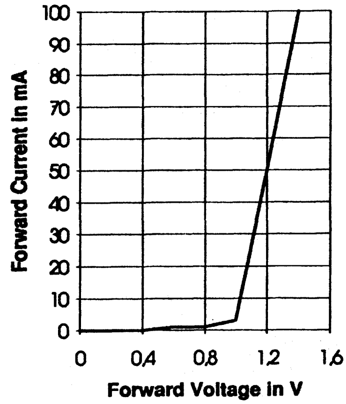
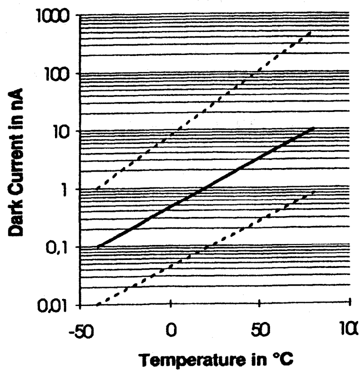
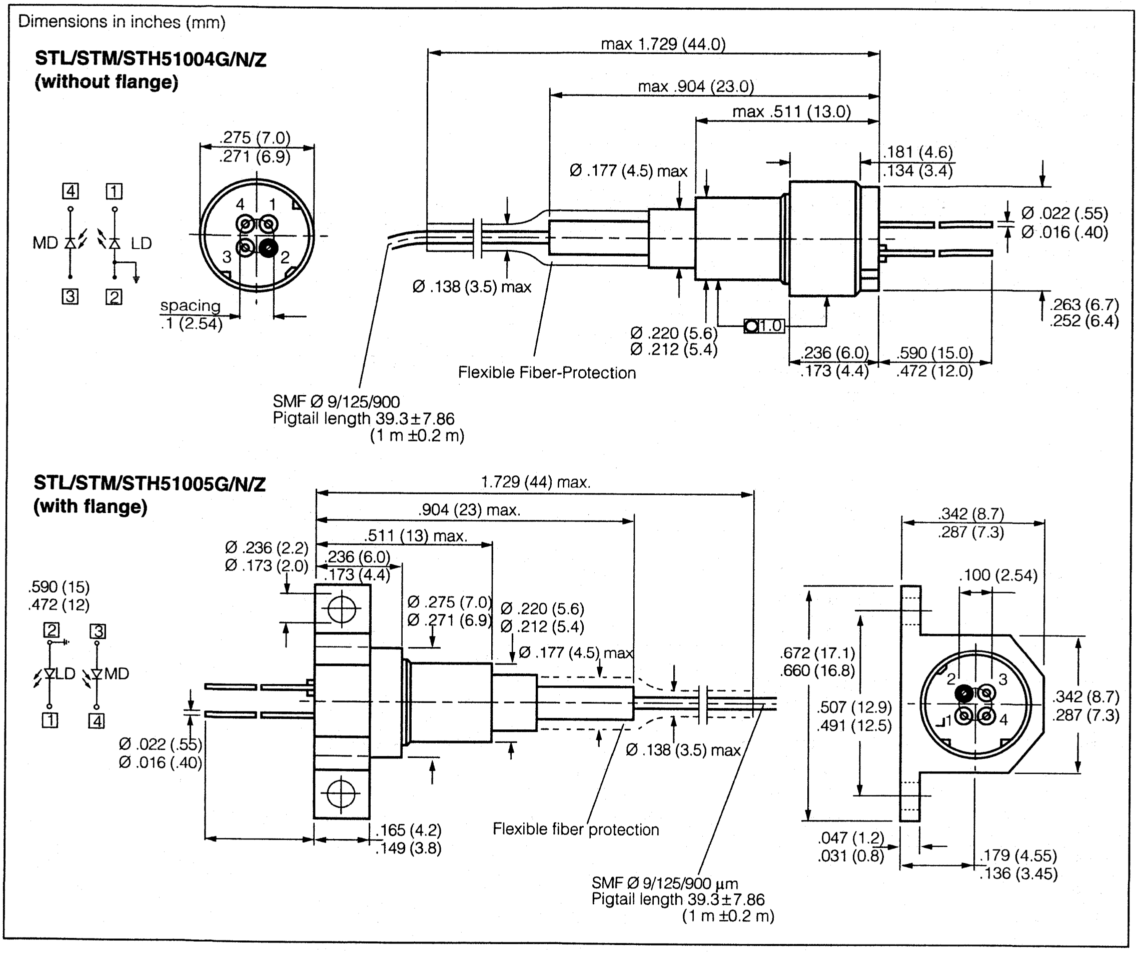


Figure 4. Monitor diode dark current
$I_R=f(T_A)$, Φ_{port}=0, V_R=5V



SIEMENS

LOW POWER STL51004/51005G/N/Z
MEDIUM POWER STM51004/51005G/N/Z
HIGH POWER STH51004/51005G/N/Z
1300 nm Laser in Coaxial Package with SM-Pigtail



FEATURES

- **Designed for fiber optic networks**
- **Laser diode with Multi-quantum well structure**
- **Suitable for Bit rates up to 1 Gbit/s**
- **Ternary photodiode at rear mirror to monitor and control radiant power**
- **Hermetically sealed subcomponents, similar to TO 18**
- **SM pigtail with or without flange and optional connector**

Maximum Ratings

Output power ratings refer to the SM fiber output. The operating temperature of the submount is identical to the case temperature.

Module

Operating Temperature Range at Case(T_C) .... –40 to +85°C
Storage Temperature Range (T_{STG}) .... –40 to +85°C
Soldering Temperature (T_S) .... 260°C
tmax=10 s, 2mm from bottom edge of case

Laser Diode

Direct Forward Current (I_{Fmax}) .... 120 mA
Radiant Power CW (Φ_e)
STL .... 1 mW
STM .... 2 mW
STH .... 4 mW
Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

Reverse Voltage (V_{Rmax}) .... 10 V

Characteristics

All optical data refer to a coupled 10/125 µm SM fiber, T_C=25°C s

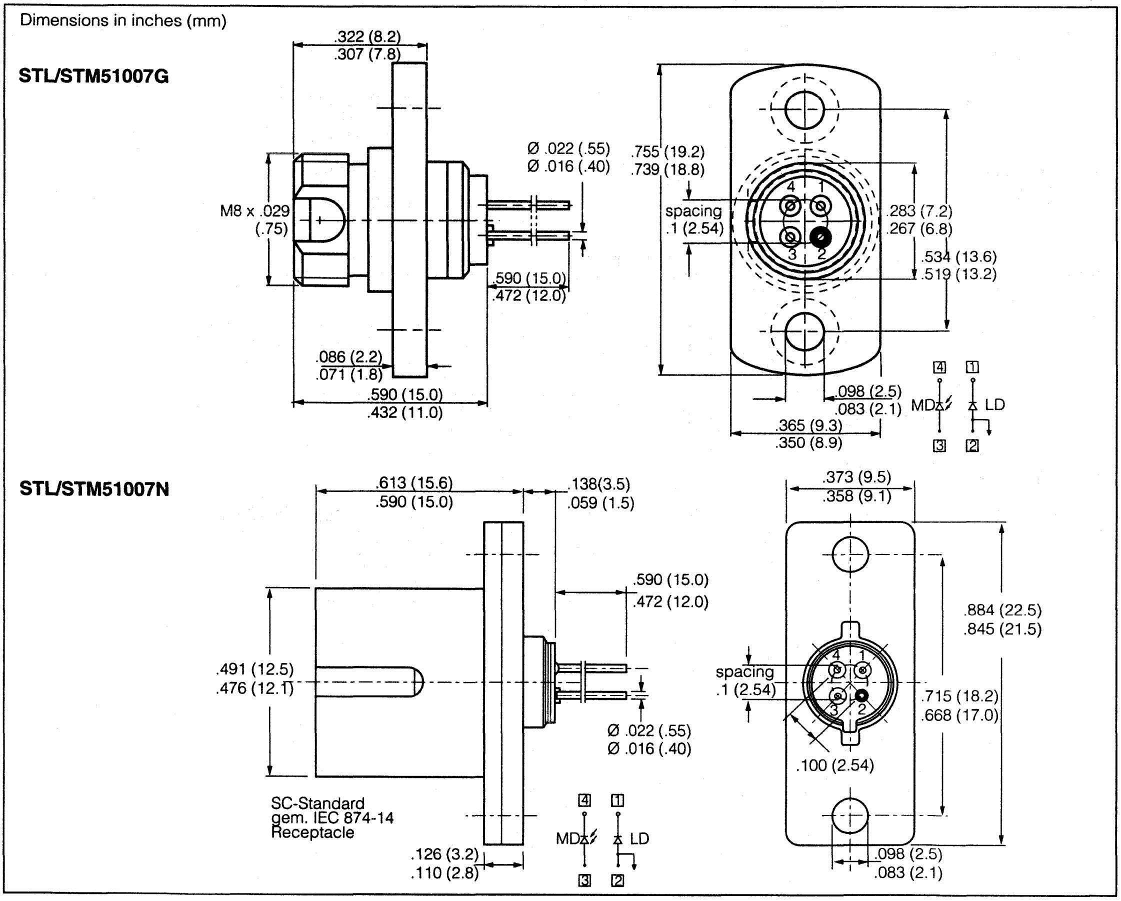
Parameter		Symbol	Value	Unit	Condition
Laser Diode					
Optical Output Power CW	STL51004/5x	Φ_e	>0.2	mW	
	STM51004/5x		>0.5		
	STH51004/5x		>1.0		
Emission Wavelength, Center of Range	STL51004/5x	λ	1280–1330	nm	Φ_e=0.2mW
	STM51004/5x				Φ_e=0.5mW
	STH51004/5x				Φ_e=1mW
Spectral Bandwidth	STL51004/5x	$\Delta\lambda$	<5		Φ_e=0.2 mW (RMS)
	STM51004/5x)				Φ_e=0.5 mW (RMS
	STH51004/5x				Φ_e=1 mW (RMS)
Threshold Current		I_{th}	2 –45	mA	–40 to +85°C
Forward Voltage	STL51004/5x	V_F	<1.5	V	Φ_e=0.2 mW
	STM51004/5x				Φ_e=0.5 mW
	STH51004/5x				Φ_e=1 mW
Radiant Power at Threshold	STL51004/5x	Φ_{eth}	<10	µW	
	STM51004/5x		<40		
	STH51004/5x		<80		
Slope Efficiency	STL51004/5x	η	8–60	mW/A	–40 to +85°C
	STM51004/5x		20–100		
	STH51004/5x		40–160		
Differential Series Resistance		r_S	<8	W	
Rise Time/Fall Time		t_R,t_F	<1	ns	
Monitor Diode					
Dark Current		I_R	<500	nA	V_R=5 V, Φ_e=0, T_C=85°C
Photocurrent	STL51004/5x	I_P	100–1000	µA	Φ_e=0.2 mW
	STL51004/5x				Φ_e=0.5 mW
	STL51004/5x				Φ_e=1 mW

Connector Options

Model	Connector	Model	Connector	Model	Connector
STL51004/5G STM51004/5G STH51004/5G	FC/PC	STL51004/5N STM51004/5N STH51004/5N	SC/PC	STL51004/5Z STM51004/5Z STH51004/5Z	No connecter

SIEMENS

LOW POWER STL51007G/N
MEDIUM POWER STM51007G/N
1300 nm Laser in FC or SC Receptacle Package



FEATURES
- **Designed for fiber optic networks**
- **Laser diode with Multi-quantum well structure**
- **Suitable for Bit rates up to 1 Gbit/s**
- **Ternary photodiode at rear mirror to monitor and control radiant power**
- **Hermetically sealed subcomponents, similar to TO-18**
- **SM receptacle with 2-hole fange and optional connector**

Maximum Ratings

Output power ratings refer to the SM fiber output. The operating temperature of the submount is identical to the case temperature.

Module

Operating/Storage Temperature Range at
Case (T_C, T_{STG}) .... –40 to +85°C
Soldering Temperature (T_S) .... 260°C
tmax=10 s, 2 mm from bottom edge of case

Laser Diode

Direct Forward Current (I_{Fmax}) .... 120 mA
Radinat Power CW (Φ_e) ....
STL .... 1 mW
STM 2mw
Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

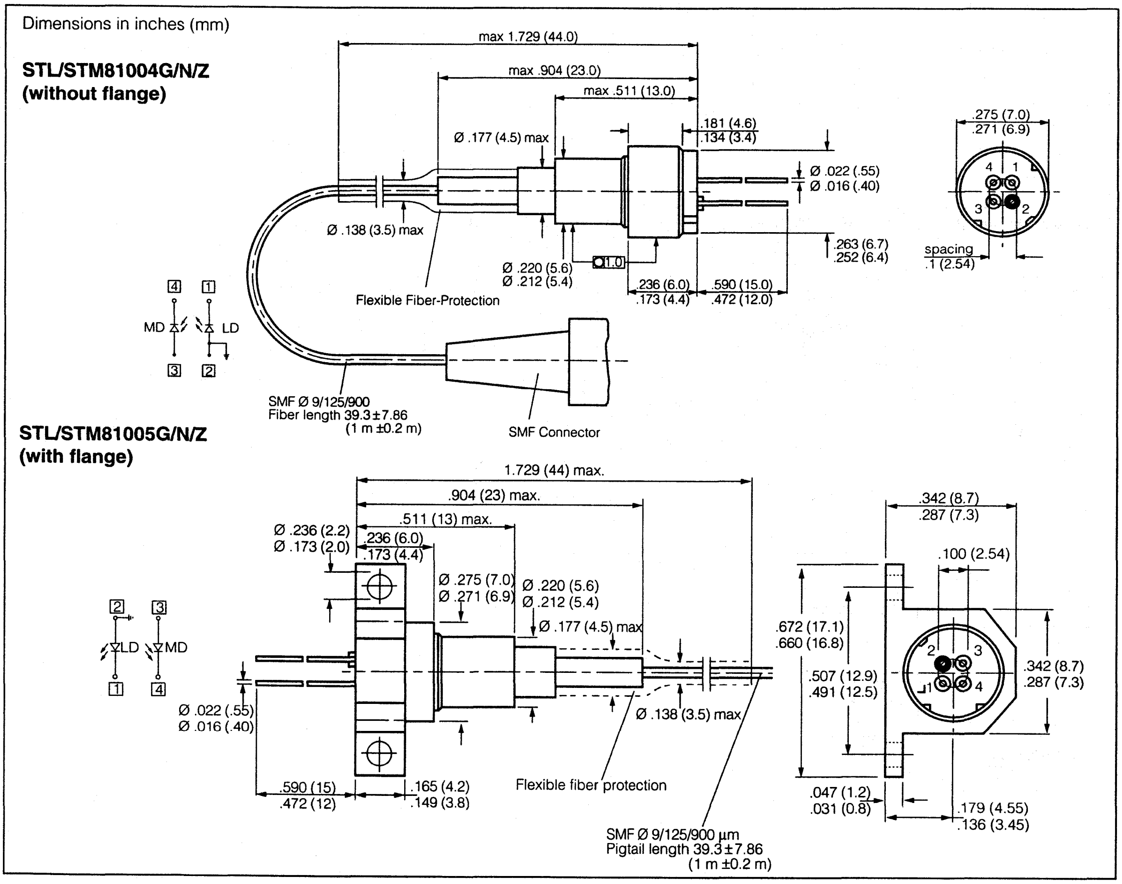
Reverse Voltage (V_{Rmax}) .... 10 V

Characteristics All optical data refer to a coupled 10/125 µm SM fiber, T_C=25°C

Parameter		Symbol	Value	Unit	Condition
Laser Diode					
Optical Output Power CW	STL51007G/N	Φ_e	>0.2	mW	
	STM51007G/N		>0.5		
Emission Wavelength, Center of Range	STL51007G	λ	1280–1330	nm	Φ_e=0.2mW
	STM51007G				Φ_e=0.5mW
Spectral Bandwidth	STL51007G	$\Delta\lambda$	<5		Φ_e=0.2 mW (RMS)
	STM51007G				Φ_e=0.5 mW (RMS)
Threshold Current		I_{th}	2–45	mA	–40 to +85°C
Forward Voltage	STL51007G	V_F	<1.5	V	Φ_e=0.2 mW
	STM51007G				Φ_e=0.5 mW
Radiant Power at Threshold	STL51007G	Φ_{eth}	<10	µW	
	STM51007G		<40		
Slope Efficiency	STL51007G	η	8–60	mW/A	–40°C to +85°C
	STM51007G		20–100		
Differential Series Resistance		r_S	<8	W	
Rise Time/Fall Time		t_R, t_F	<1	ns	
Monitor Diode					
Dark Current		I_R	<500	nA	V_R=5 V, Φ_e=0, T_C=85°C
Photocurrent	STL51007G	I_P	100–1000	µA	Φ_e=0.2 mW
	STM51007G				Φ_e=0.5 mW

SIEMENS

LOW POWER STL81004/81005G/N/Z
MEDIUM POWER STM81004/81005G/N/Z
1550 nm Laser in Coaxial Package with SM-Pigtail and Optional Connector



FEATURES

- **Designed for fiber optic networks**
- **Laser diode with multi-quantum well structure**
- **Suitable for bit rates up to 1 Gbit/s**
- **Ternary photodiode at rear mirror to monitor and control radiant power**
- **Hermetically sealed subcomponents, similar to TO-18**
- **SM pigtail with or without flange and optional connector**

Maximum Ratings

Output power ratings refer to the SM fiber output. The operating temperature of the submount is identical to the case temperature.

Module

Operating/Storage Temperature Range
at Case (T_C, T_{STG}) .... –40 to +85°C
Soldering Temperature (T_S) .... 260°C
tmax=10 s, 2 mm from bottom edge of case

Laser Diode

Direct Forward Current (I_{Fmax}) .... 120 mA
Radinat Power CW (Φ_e)
STL .... 1 mW
STM .... 2 mW
Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

Reverse Voltage (V_{Rmax}) .... 10 V

Characteristics All optical data refer to a coupled 10/125 µm SM fiber, T_C=25°C

Parameter		Symbol	Value	Unit	Condition
Laser Diode					
Optical Output Power CW	STL81004/5X	Φ_e	>0.2	mW	
	STM81004/5X		>0.5		
Emission Wavelength, Center of Range	STL81004/5x	λ	1510–1590	nm	Φ_e=0.2mW
	STM81004/5x				Φ_e=0.5mW
Spectral Bandwidth	STL81004/5x	Δλ	<5		Φ_e=0.2 mW (RMS)
	STM81004/5x				Φ_e=0.5 mW (RMS)
Threshold Current		I_{th}	8 –60	mA	–40 to +85°C
Forward Voltage	STL81004/5x	V_F	<1.5	V	Φ_e=0.2 mW
	STM81004/5x				Φ_e=0.5 mW
Radiant Power at Threshold	STL81004/5x	Φ_{eth}	<10	µW	
	STM81004/5x		<40		
Slope Efficiency	STL81004/5x	η	8–60	mW/A	–40°C to +85°C
	STM81004/5x		20–100		
Differential Series Resistance		r_S	<8	W	
Rise Time/Fall Time		t_R, t_F	<1	ns	
Monitor Diode					
Dark Current		I_R	<500	nA	V_R=5 V, Φ_e=0, T_C=85°C
Photocurrent	STL81004/5x	I_P	100–1000	µA	Φ_e=0.2 mW
	STL81004/5x				Φ_e=0.5 mW

Connector Options

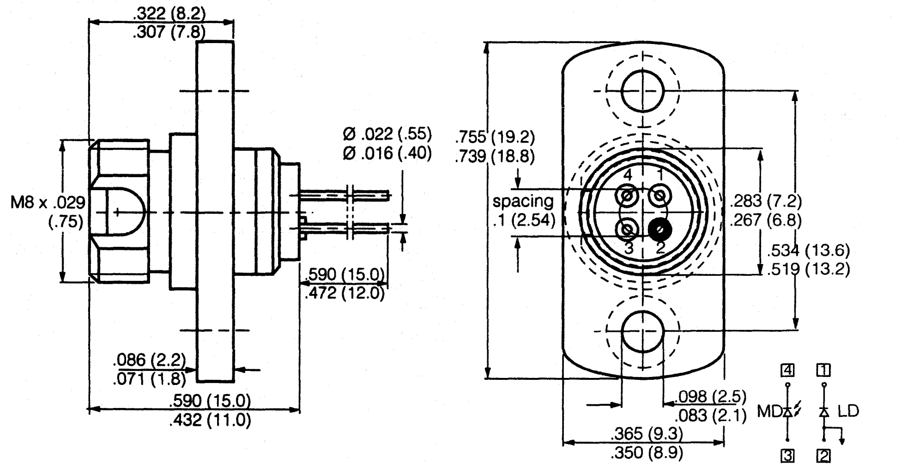
Model	Connector
STL81004/5G STM81004/5G	FC/PC
STL81004/5N STM81004/5N	SC/PC
STL81004/5Z STM81004/5Z	No Connector

SIEMENS

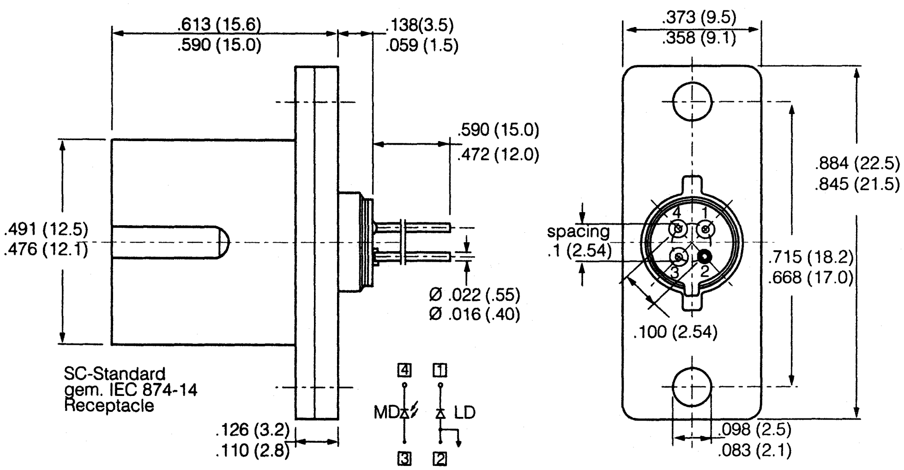
LOW POWER STL81007G/N
1500 nm Laser in Receptacle Package

Dimensions in inches (mm)

STL81007G



STL81007N



FEATURES

- **Designed for fiber optic networks**
- **Laser diode with multi-quantum well structure**
- **Suitable for bit rates up to 1 Gbit/s**
- **Ternary photodiode at rear mirror to monitor and control radiant power**
- **Hermetically sealed subcomponents, similar to TO-18**
- **SM receptacle with 2-hole flange and optional connector**

Maximum Ratings Output power ratings refer to the SM fiber output. The operating temperature of the submount is identical to the case temperature.

Module

Operating and Storage Temperature Range at Case(T_C, T_{STG}) .... –40 to +85°C

Soldering Temperature (T_S) .... 260°C

tmax=10 s, 2 mm from bottom edge of case

Laser Diode

Direct Forward Current (I_{Fmax}) .... 120 mA

Radinat Power CW (Φ_e) .... 1 mW

Reverse Voltage (V_{Rmax}) .... 2 V

Monitor Diode

Reverse Voltage (V_{Rmax}) .... 10 V

Characteristics

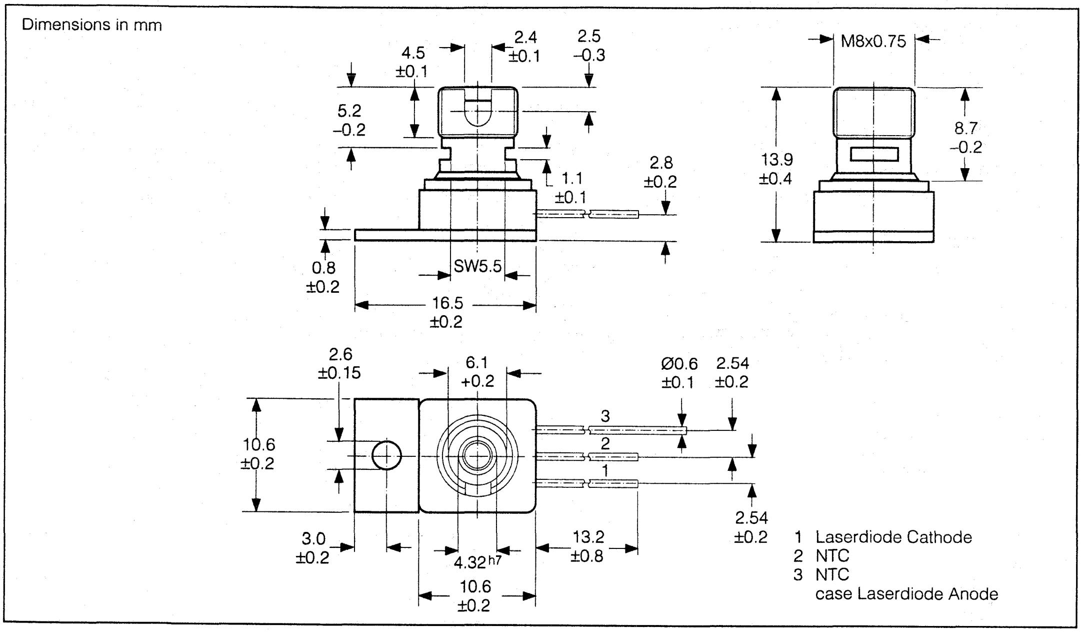
All optical data refer to a coupled 10/125 µm SM fiber, T_C=25°C

Parameter	Symbol	Value	Unit	
Laser Diode				
Optical Output Power CW	Φ_e	>0.2	mW	
Emission Wavelength, Center of Range	λ	1510–1590	nm	Φ_e=0.2mW
Spectral Bandwidth	$\Delta\lambda$	<5		Φ_e=0.2 mW (RMS)
Threshold Current	I_{th}	8–60	mA	–40 to +85°C
Forward Voltage	V_F	<1.5	V	Φ_e=0.2 mW
Radiant Power at Threshold	Φ_{eth}	<10	µW	
Slope Efficiency	η	8–60	mW/A	–40 to +85°C
Differential Series Resistance	r_S	<8	W	
Rise Time/Fall Time	t_R,t_F	<1	ns	
Monitor Diode				
Dark Current	I_R	<500	nA	V_R=5 V, Φ_e=0, T_C=85°C
Photocurrent	I_P	100–1000	µA	Φ_e=0.2 mW

SIEMENS

808 nm SPL 2F81*
850 nm SPL 2F85*
940 nm SPL 2F94*

Laser Diode in TO-220 Package with FC-connector 0.75 W cw (Class 4 Product)



FEATURES

- **Efficient radiation source for pulsed and CW-operation**
- **Reliable inGa(Al)As strained quantum-well material**
- **Small TO-220 package with efficient thermal coupling**
- **Includes thermistor to control temperature/ wavelength**
- **Single emitting area 200 µm x 1 µm**
- **FC-type connector for efficient fiber coupling**

Note

Other wavelengths in the 780 nm to 980 nm range are available upon request.

*** Formerly SFH 487406, SFH 487426, and SFH487446 respectively.**

APPLICATIONS

- **Pumping solid state lLasers (Nd: YAG, Yb: YAG, . . .)**
- **Medical**
- **Laser soldering**
- **Energy transmission**
- **Testing and measuring**

NOTES FOR OPERATION

Eye Protection

This laser is a **Class 4 Laser** product. Refer to the relevant safety regulations for protection during handling and operation.

Overload Protection

The specified values are valid as long as the diode has not been overloaded. Voltage spikes from the power supply unit, even when applied for nanoseconds only, may cause irreversible damage to the laser diode. Such spikes may occur when the power supply is turned on or off, or they may reach the laser diode from the line via coupling capacitance of electronically controlled devices.

The power supply should therefore be provided with appropriate protection circuits.

HANDLING NOTES

1. Package

To avoid electrostatic damage, it is recommended to observe the same rules as for handling MOS-devices.

2. Mechanical attachment

2.1 Mounting hole (suitable for M 2.5)
Because of the good thermal conductivity of the TO 220 base plate (copper), the heat loss is properly dissipated even if the component is attached on one side only. Some mounting techniques are shown below (Fig. 1-3).

2.2 For exact positioning of the TO component and other parts, e.g. lenses, the TO 220 package can be attached with appropriate clamping devices or by screws (max. M2.5).

Figure 1.

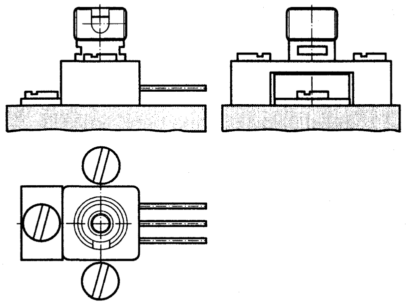


Figure 2.

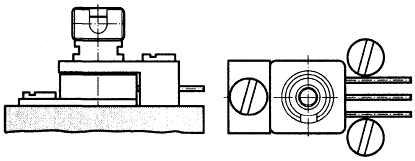
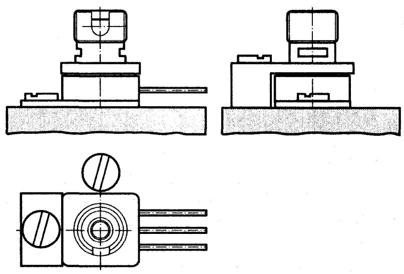


Figure 3.



3. Soldering

When soldering the TO base to a heat sink, do not exceed the following limits:

Max. soldering temperature: 125°C

Max. soldering time: 1 min

Maximum Ratings T_A=25°C

Output Power (continuous wave)[1] (P_{OPT}) .... 0.8 W
Output Power (quasi-continuous wave)[1] (P_{QCW}) .... 1.1 W
t_P≤150 µs, Duty Cycle ≤1%
Reverse Voltage (V_R) .... 3 V
Operating Temperature (T_{OP}) .... −10 to +60°C
Storage Temperature (T_{STG}) .... −40 to +70°C
Maximum Soldering Temperature (T_S), max. 5 s .... 250°C

1.Optical data refer to output after a fiber of 5 m length (core Ø 125 µm, 0.35 NA, attenuation 8 dB/km).

Characteristics (T_A=25°C)

Parameter		Symbol	Value Min.	Value Typ.	Value Max.	Unit
Emission Wavelength[1]		λ_{peak}	803	808	813	nm
			840	850	860	
			935	940	945	
Spectral Width (FWHM)[1]		$\Delta\lambda$		2		nm
Output Power[2]		P_{opt}		0.75		W
Differential Efficiency[2]	SPL 2F81, 808 nm	η	0.60	0.70	0.85	W/A
	SPL 2F85, 850 nm		0.60	0.70	0.80	
	SPL 2F94, 940 nm		0.55	0.60	0.70	
Threshold Current	SPL 2F81, 808 nm	I_{th}	0.40	0.45	0.55	A
	SPL 2F85, 850 nm		0.30	0.40	0.50	
	SPL 2F94, 940 nm		0.30	0.35	0.40	
Operating Current[1]	SPL 2F81, 808 nm	I_{op}	1.3	1.5	1.8	A
	SPL 2F85, 850 nm		1.3	1.5	1.8	
	SPL 2F94, 940 nm		1.4	1.6	1.8	
Operating Voltage[1]		V_{op}		2.0		V
Differential Series Resistance		r_S		0.2	0.4	Ω
Characteristic Temperature Threshold[3]		T_0		150		K
Temperature Coefficient of Current		$\partial I_{op}/\partial T$		0.5		%/K
Temperature Coefficient of Wavelength[4]		$\partial\lambda/\partial T$	0.25	0.27	0.30	nm/K
Thermal Resistance, (junction→heat sink)		R_{thJA}		10		K/W
NTC Thermistor				**Typical Values**		
Resistance at room temperature (25°C)		R_{NTC}		10		kΩ

1. Standard operating conditions refer to 0.75 W after 5 m of fiber (core Ø 125 µm, 0.35 NA, attenuation 8 dB/km).
2. Optical power measurements refer to output from fiber.
3. Model for the thermal behavior of threshold current: $I_{th}(T_2)=I_{th}(T_1) \times \exp (T_2 - T_1)/T_0$
4. Depending on emission wavelength.

Optical Characteristics (T_A=25°C)

Figure 4. Radiant power P_{opt} versus (I_F)

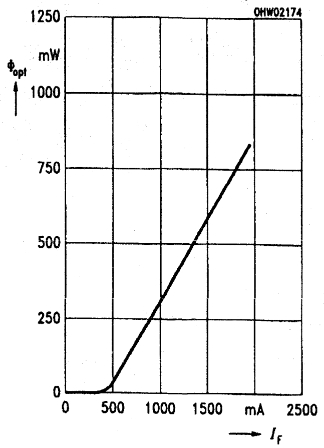


Figure 5. Mode spectrum I_{REL} versus (λ)

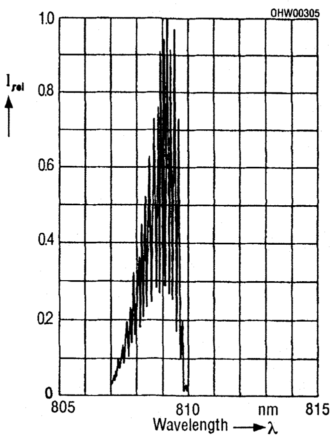
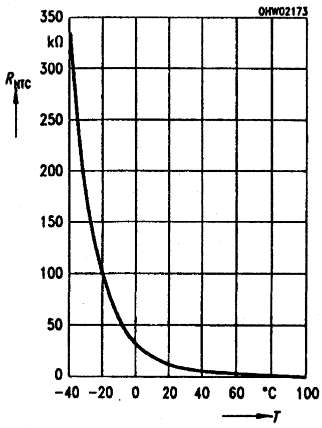


Figure 6. NTC Thermistor R_T=f(T_A) (P_{opt}=1.0 W)$R_{T25°C}$=10 kΩ ±1%)

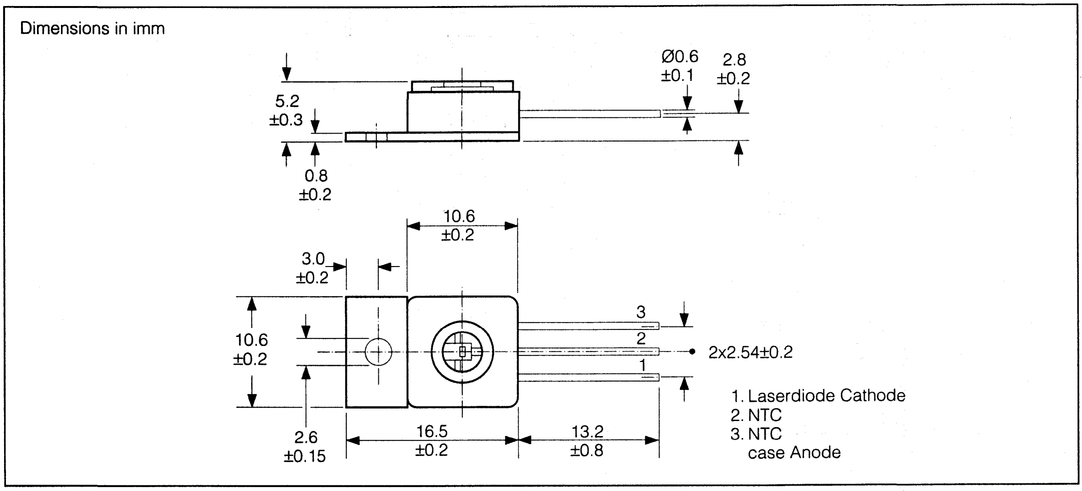


Fiber Optics Components Laser Diodes 8

SIEMENS

808 nm SPL 2Y81*
850 nm SPL 2Y85*
940 nm SPL 2Y94*

Laser Diode in TO-220 Package
1.0 W cw (Class 4 Laser Product)



FEATURES

- **Efficient radiation source for pulsed and CW-operation**
- **Reliable InGa(Al)As strained layer quantum-well material**
- **Small TO-220 package with efficient thermal coupling**
- **Includes thermistor to control temperature/ wavelength**
- **Single emitting area 200 µm x 1 µm**
- **Cylindrical correction for a near circular Farfield pattern**

Note

Other wavelengths in the range of 780 nm to 980 nm are available upon request.

***Formerly SFH 487401, SFH 487421, and SFH487441 respectively.**

APPLICATIONS

- **Pumping solid state lasers (Nd: YAG, Yb: YAG, . . .)**
- **Medical applications**
- **Laser soldering**
- **Energy transmission**
- **Testing and measuring applications**

NOTES FOR OPERATION

Eye Protection

This laser is a Class 4 Laser product. Refer to the relevant safety regulations for protection during handling and operation.

Overload Protection

The specified values are valid as long as the diode has not been overloaded. Voltage spikes from the power supply unit, even when applied for nanoseconds only, may cause irreversible damage to the laser diode. Such spikes may occur when the power supply is turned on or off or they may reach the laser diode from the line via coupling capacitance of electronically controlled devices.

The power supply should therefore be provided with appropriate protection circuits.

HANDLING NOTES

1. Package

To avoid electrostatic damage, it is recommended to observe the same rules as for handling MOS-devices.

2. Mechanical attachment

2.1 Mounting hole (suitable for M 2.5)
Because of the good thermal conductivity of the TO 220 base plate (copper), the heat loss is properly dissipated even if the component is attached on one side only. Some mounting techniques are shown below (Fig. 1-3).

2.2 For exact positioning of the TO component and other parts, e.g. lenses, the TO 220 package can be attached with appropriate clamping devices or by screws (max. M2.5).

Figure 1.

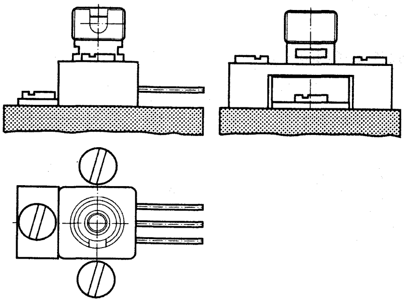


Figure 2.

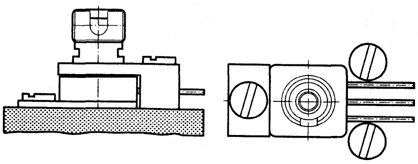
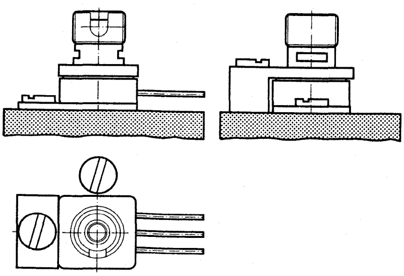


Figure 3.



3. Soldering

When soldering the TO base to a heat sink, do not exceed the following limits:
Max. soldering temperature: 125°C
Max. soldering time: 1 min

Maximum Ratings T_A=25°C

Output Power (continuous wave) [1] (P_{OPT}) .... 1.1 W
Output Power (quasi-continuous wave)[1] (P_{QCW}) .... 1.5 W
t_P≤150 µs, Duty Cycle ≤1%
Reverse Voltage (V_R) .... 3 V
Operating Temperature (T_{OP}) .... −10 to +60°C
Storage Temperature (T_{STG}) .... −40 to +85°C
Maximum Soldering Temperature (T_S), max. 5 s .... 250°C

1.Optical power measurements refer to a detector with NA=0.6.

Characteristics (T_A=25°C)

Parameter		Symbol	Value Min.	Value Typ.	Value Max.	Unit
Emission Wavelength[1]		λ_{peak}	803	808	813	nm
			840	850	860	
			935	940	945	
Spectral Width (FWHM)[1]		$\Delta\lambda$		2		nm
Output Power[2]		P_{opt}		1.0		W
Differential Efficiency[2]	SPL 2Y81, 808 nm	η	0.75	0.95	1.1	W/A
	SPL 2Y85, 850 nm		0.75	0.85	1.0	
	SPL 2Y94, 940 nm		0.70	0.80	0.9	
Threshold Current	SPL 2Y81, 808 nm	I_{th}	0.40	0.45	0.55	A
	SPL 2Y85,850 nm		0.30	0.40	0.50	
	SPL 2Y94, 940 nm		0.30	0.35	0.40	
Operating Current[1]	SPL 2Y81, 808 nm	I_{op}	1.3	1.5	1.8	A
	SPL 2Y85,850 nm		1.3	1.5	1.8	
	SPL 2Y94, 940 nm		1.4	1.6	1.8	
Operating Voltage[1]		V_{op}		2.0		V
Differential Series Resistance		r_S		0.2	0.4	Ω
Characteristic Temperature Threshold[3]		T_0		150		K
Temperature Coefficient of Current		$\partial I_{op}/\partial T$		0.5		%/K
Temperature Coefficient of Wavelength[4]		$\partial\lambda/\partial T$	0.25	0.27	0.30	nm/K
Thermal Resistance, (junction→heat sink)		R_{thJA}		10		K/W
NTC Thermistor				**Typical Values**		
Resistance at room temperature (25°C)		R_{NTC}		10		kΩ

1. Standard operating conditions refer to 1 W cw measured with NA=0.6.
2. Optical power measurements refer to a detector with NA=0.6.
3. Model for the thermal behavior of threshold current: $I_{th}(T_2)=I_{th}(T_1) \times \exp(T_2 - T_1)/T_0$
4. Depending on emission wavelength.

Optical Characteristics (T_A=25°C)

Figure 4. Radiant power P_{opt} versus (I_F)

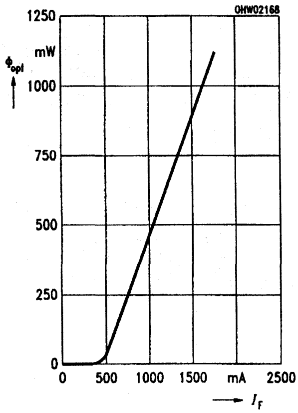


Figure 5. Mode spectrum I_{REL} versus λ (P_{opt}=1.0 W)

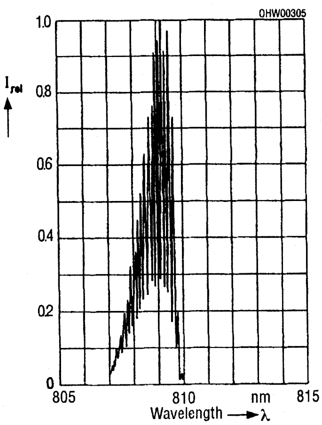


Figure 6. Farfield distribution parallelF) to junction I_{REL} versus $\theta_{||}$

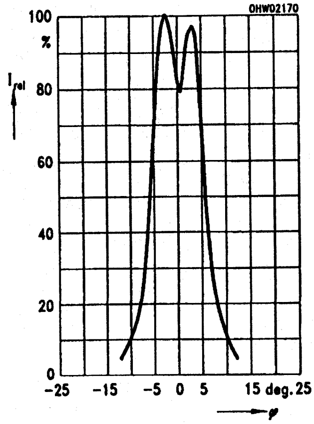
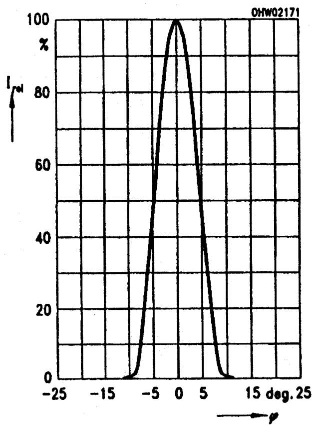
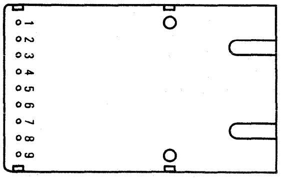
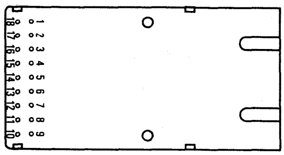
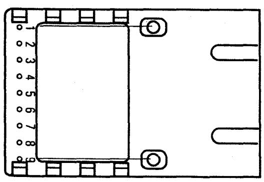
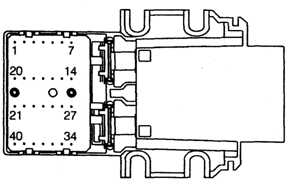
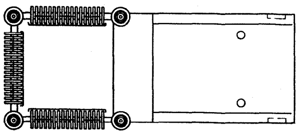


Figure 7. |Farfield distribution paralleto junction I_{REL} versus $\theta_{\perp}$



Fiber Optic Transceivers

Package Outline	Part No.	Fiber Type	Standard	Wave-length (nm)	Data Rate (MBd)	Pin Row	Page
	V23806-A84-C2 *TC-155C1EPSM*	Single Mode	ATM	1300	155	1x9	9–6
	V23806-A84-C42 *TC-155C2EP28-E*	Single Mode	ATM	1300	155 Long Haul	1x9	9–15
	V23806-A84-C32 *TC-622C2EP14-E*	Single Mode	ATM	1300	622	1x9	9–10
	V23809-K15-C10 (5 V) *TC-1250GE1300*	Single Mode	Gigabit Ethernet	1300	1.3 GBd	1x9	9–45
	V23809-K15-C310 (3.3 V) *TC-1250PHGE1300*						
	V23809-J17-C10 *TC-1000C2PH*	Single Mode	FC	1300	1.0625 GBd	1x9	9–42
	V23806-A84-C1 *TC-155C2EPSM*	Single Mode	ATM	1300	155	2x9	9–2
	V23806-A84-C51 *TC-622C2EPCR*	Single Mode	ATM	1300	622	2x9	9–19
	V23809-A3-C10 (11 dB) *TC-125C2PH11*	Multimode	FDDI/ Fast Ethernet	1300	130	1x9	9–24
	V23809-A3-C11 (7 dB) *TC-125C2PH7*						
	V23809-C8-C10 (10 dB) *TC-155C2PH10*	Multimode	ATM	1300	155/194	1x9	9–28
	V23809-C8-C11 (8 dB) *TC-155C2PH8*	Multimode	ATM	1300	155/194	1x9	
	V23809-E1-E16 (short pin) *TC-200P1EP*	Multimode	ESCON Serial	1300	200	4x7	9–32
	V23809-E1-E17 (long pin) *TC-200P1EPLPM*						
	V23809-E1-E40 *TC-200P1FSOL*	Multimode	ESCON Parallel	1300	200	3x17	9–36

Fiber Optic Cable Assemblies

Connector Type	Cable Type	Application	Description	Page
SC Duplex	Duplex Zipcord	FC, ANSI LC FDDI	SC Duplex Jumper	9–56
Duplex ESCON	Duplex Round	ESCON, SBCON	ESCON Jumper	9–49
Duplex ESCON, ST, MT push-pull	Multi-Fiber/Trunk	ESCON, SBCON	ESCON Multi-Jumper	9–51
FDDI-MIC, SC Duplex, ST, and others	Duplex Round/Zipcord	FC, FDDI, ATM, SONET	Patch Cables and Pigtails	9–52
SC, FC/PC, ST, and others	Simplex	ATM, SONET/SDH	Patch Cables and Pigtails	
MT, MT push-pull	Ribbon	PAROLI	Patch Cables and Pigtails	

Cable Assembly Part Numbering System

J □

Simplex: S
DIB: D
Zipcord: Z
900 Buffer: B

Multi-jumper/Trunk Assemblies: J □□

2-digit fiber count: (04 - 72)

– □□□ □□ □□□ □ □

Fiber (Type/Core Size)
MM 62.5/125 µm = 062
MM 50/125 µm = 050
SM 9/125 µm = 010

Connector
QQ, FF, etc...

Length
Meters

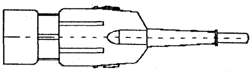
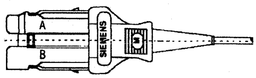
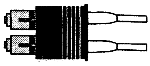
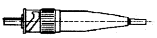
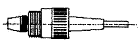
Options
Plenum: P
Duplex-Clip: C

Example:

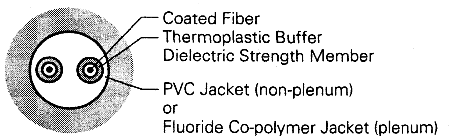
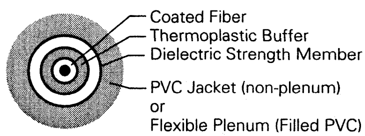
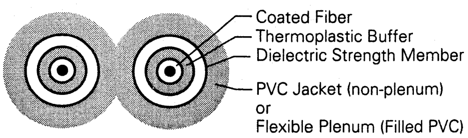
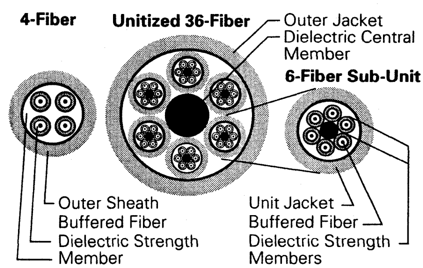
Duplex DIB Cable, multimode 62.5/125 µm, assembled with 1 x ESCON-compatible Connector and 2 x ST Connectors, length 15 meters
➜ Part Number: **JD-062QT015**

Connector and Cable Information

Connector Specifications

Outline Drawing	Plug Connector	Ferrule	Type insertion Loss mm/SM	Connection	Abbreviation
	Duplex ESCON Siemens	Zirconia	2/0.3 dB	Snap-in	Q
	FDDI-MIC Siemens	Zirconia	2/0.3 dB	Snap-in	F
	Duplex SC Siemens	Zirconia	2/0.3 dB	Snap-in	S
	SC	Zirconia	2/0.3 dB	Snap-in	S
	ST[II]	Zirconia	2/0.3 dB	Bayonet Joint	T
	Biconic	Plastic	0.3/0.5 dB	Screw Connection	B
	FC	Zirconia	2/0.3 dB	Screw Connection	C
	MTP	MT (4–12 fiber)	0.5/1.0 dB	Snap-in	M
	Pigtail			Open End (for splicing)	O

Cable Specifications

Duplex Cable Round		**Simplex Cable Fiber**	
Zipcord Cable 2-Fiber		**Multi-fiber Trunk Cable**	

EMC
Electro Magnetic Compatibility

EMC (Electro Magnetic Compatibility)

During development of this transceiver Siemens put considerable effort into guaranteeing excellent EMC performance. The EMC tests are based on the International Standards of information technology equipment (computers, peripherals, LAN equipment). The transceiver meets all EMC requirements at high test levels without additional shielding as required for the complete equipment for CE-certification. During EMC tests the transceiver is plugged into a PCB assembled with the power supply filter elements described in the application note.

Emission Test

The emission test is based on the EN 55022 = CISPR22, Class B standard (This includes FCC Class B). The emission is tested in a range of 30 MHz to 1 GHz. The noise in a range of 30 MHz to 1 GHz is always at least 6 dB below Class B limits (these are 16 dB below Class A limits).

Immunity Test, Electrostatic Discharge

The immunity test for electrostatic discharge is based on EN 61000-4-2=IEC 1000-4-2 standard. Discharges of ±15 kV with a Human Body Model probe on the receptacle cause no damage to the module. Best immunity against ESD is achieved if the chassis enclosure has as few small cutouts as possible and there is no direct electrical connection between chassis enclosure and the PCB with transceiver. There should be no chassis enclosure connection to the transceiver; not even to the receptacle.

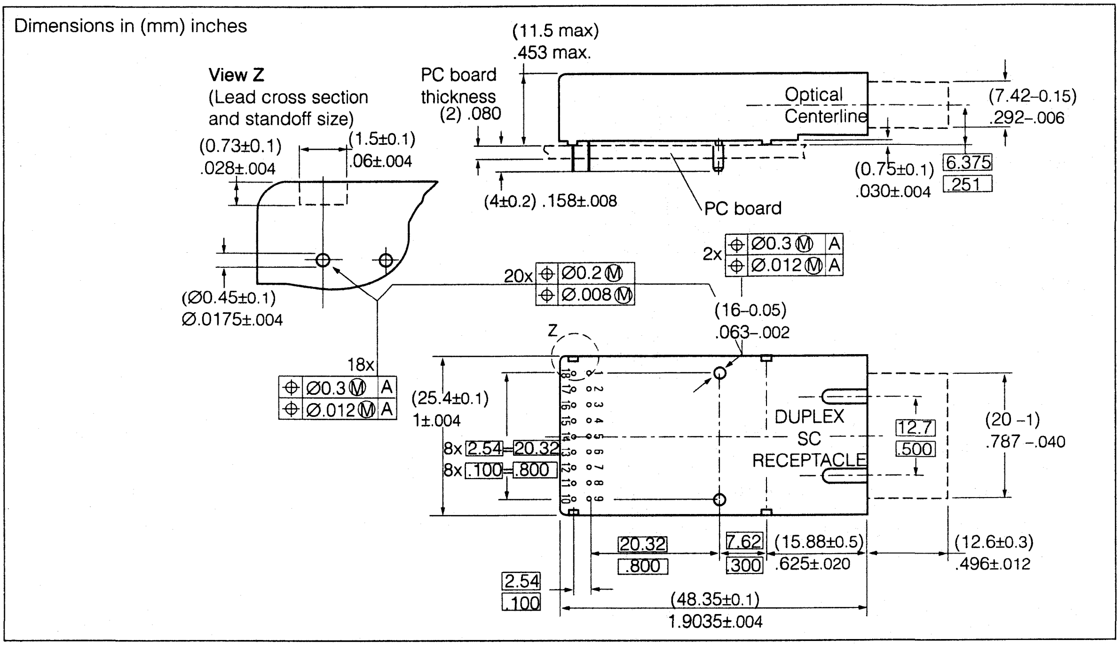
Immunity Test, Radio Frequency Electromagnetic Field

The immunity test for the radio frequency electromagnetic field is based on IEC 1000-4-3=ENV 50140 and pr ENV 50204 (in future EN 61000-4-3) standard. With a field strength of 10 V/m rms the noise frequency ranges from 10 MHz to 1 GHz. The specified sensitivity of the transceiver is guaranteed during the immunity test to ensure a highly reliable product.

SIEMENS

V23806-A84-C1

Single Mode 155 MBd ATM Transceiver 2x9



PIN Description

Pin#	Name	Pin#	Name	Pin#	Name
1	Rx V_{EE}	8	Tx D	14	Pwr Mon
2	Rx D	9	Tx V_{EE}	15	NC
3	Rx Dn	10	NC	16	NC
4	SD	11	Tx Alm	17	NC
5	Rx V_{CC}	11	Tx Alm	18	NC
6	Tx V_{CC}	12	Tx En	S1, S2	V_{EE} (GND)
7	Tx Dn	13	Bias Mon		

FEATURES

- **Compliant with existing standards**
- **Compact integrated transceiver unit with**
  - **MQW laser diode transmitter**
  - **InGaAs PIN-photo diode receiver**
  - **Duplex SC receptacle**
- **Class 1 FDA and IEC laser safety compliant**
- **Single power supply (5V)**
- **Loss of optical signal indicator**
- **Integrated clock recovery module (PLL)**
- **PECL differential inputs and outputs**
- **Wave solderable and washable with included process plug**

Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation [1] .... Tbd W
Supply Voltage (V_{CC}–V_{EE}) .... 6 V
Data Input Levels .... V_{EE} to V_{CC}+0.5 V
Differential Data Input Voltage .... –2.5 to 2.5 V
Operating Case Temperature .... 0 to 70°C
Storage Ambient temperature .... –40°C to 85°C
Soldering Conditions Temp/Time
(MIL-STD 883C, Method 2003) .... 250/5.5°C/s

Notes

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}–2 V.

DESCRIPTION

This data sheet describes the Siemens single mode ATM transceiver, which complies with the ATM Forum's *Network Compatible ATM for Local Network Applications* document and ANSI's *Broadband ISDN—Customer Installation Interfaces*, Physical Media Dependent Specification, T1.646-1995.

ATM is being developed to facilitate solutions in multimedia applications and real time transmission. The data rate is scalable, and the ATM protocol is the basis of the broadband public networks being standardized in the International Telecommunications Union (ITU), the former International Telegraph and Telephone Consultative Committee (CCITT). ATM can also be used in local private applications.

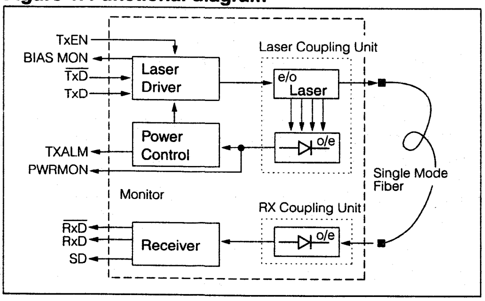
This Siemens single mode ATM transceiver is a single unit comprised of a transmitter, a receiver, and an SC receptacle. It thereby frees the customer from many alignment and PC board layout concerns. The module is designed for low cost WAN applications. It can be used as the network end device interface in workstations, servers, and storage devices, and in a broad range of network devices such as bridges, routers, intelligent hubs, and wide area ATM switches.

The transceiver operates at 622.080 Mbits per second from a single power supply (+5 Volt). The full differential data inputs and data and clock outputs are PECL compatible.

Functional Description of 2x9 Pin Row Transceiver

This transceiver is designed to transmit serial data via single mode cable.

Figure 1. Functional diagram



The receiver component converts the optical serial data into PECL compatible electrical data (RD and RDnot). The Signal Detect (SD, active high) shows whether an optical signal is present. If no optical input signal is present the receiver data outputs are switched to static low level (RD=low, Rdnot=high).

The transmitter converts electrical PECL compatible serial data (TD and TDnot) into optical serial data. It contains a laser driver circuit which drives the modulation and bias current of the laser diode. The currents are controlled by a power control circuit to guarantee a constant output power of the laser over temperature and aging. The power control uses the output of the monitor pin diode (mechanically built in the laser coupling unit) for the controlling function to prevent the laser power from exceeding the operating limits.

The laser can be switched on with a logical high signal on the Laser Enable Pin (LEN). The PWRMON Pin shows a voltage reflecting the optical power output. The bias current is monitored on the BIASMON Pin. Both signals can be used to supervise the function of the module.

The signal TXALM indicates an increasing of the optical output power of more than 2dB. Aging control is possible using the bias monitor output (BIASMON).

To build a laser Class 1 system it is necessary to use an application circuit to switch off the laser if a fault occurs.

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units
Case Temperature	T_C	0		70	°C
Power Supply Voltage	V_{CC}–V_{EE}	4.75	5.0	5.25	V
Supply Current(1)	I_{CC}		150	250	mA
Transmitter					
Data Input High Voltage	V_{IH}–V_{CC}	–1165		–880	mV
Data Input Low Voltage	V_{IL}–V_{CC}	–1810		–1475	
Input Data Rise/Fall, 10–90%	t_R, t_F	0.4		1.3	ns
TxEN Input High Voltage	V_{TIH}	2			V
TxEN Input Low Voltage	V_{TIL}			0.8	
TxEN Input High Current	V_{TIH}			0.8	mA
TxEN Input Low Current	V_{TIL}	-1			
TxALM Output High Voltage	V_{TOH}	3.2			V
TxALM Output Low Voltage	V_{TOL}			0.7	
TxALM Output High Current	I_{TOH}	-3			mA
TxALM Output Low Current	I_{TOL}			3	
Receiver					
Output Current	I_O			25	mA
Input Center Wavelength	λ_C	1260		1360	nm

Transmitter Electro-Optical Characteristics

Transmitter	Symbol	Min.	Typ.	Max.	Units
Output Power (Average)	P_O	–15	–11	-8	dBm
Center Wavelength	λ_C	1260		1360	nm
Spectral Width (FWHM), rms	$\Delta\lambda$			7.7	
Output Rise time	t_R			2.5	ns
Output Fall time	t_F			3	
Extinction Ratio (dynamic)	ER	8.2			dB
Eye Diagram(1)					

Receiver Electro-Optical Characteristics

Receiver	Symbol	Min.	Typ.	Max.	Units
Sensitivity (Ave. Power)(1)	P_{IN}		-33	–29.0	dBm
Saturation (Ave. Power)	P_{SAT}	-8	-7		
Signal Detect Assert Level(2)	P_{SDA}		-36	-33	
Signal Detect Deassert Level(3)	P_{SDD}	-42	37.5		
Signal Detect Hysteresis	P_{SDA}– P_{SDD}		1.5		dB
Signal Detect Assert Time	t_{ASS}		1		ms
Signal Detect Deassert Time	t_{DAS}		5		
Output LO Voltage(4)	V_{OL}-V_{CC}	–1950		–1630	mV
Output HI Voltage(4)	V_{OH}-V_{CC}	–1025		–735	
Output Data Rise /Fall Time, 10–90%	t_R, t_F			1.3ns	ns
Output SD Rise/Fall Time(5)				40ns	

Notes

1. Minimum average optical power at which the BER is less than 1x10E–10. Measured with a 2^{23}–1 NRZ PRBS as recommended by ANSI T1E1.2, SONET OC-3, and ITU G.957
2. An increase in optical power above the specified level will switch the SIGNAL DETECT from a LO state to a HI state.
3. A decrease in optical signal below the specified level will switch the SIGNAL DETECT from a HI state to a LO state.
4. PECL 10K compatible. Load is 50 Ω into V_{CC} –2V. Measured under DC conditions at 25°C. For dynamic measurements a tolerance of 50 mV should be added, V_{CC}=5V.
5. PECL compatible. A high level on this output shows that an optical signal is applied to the optical input.

Reliability (Qualification Results)

Test Temperature (HTB)	85°C/358 K
Reference Temperature	25°C/298 K
Duration of HTB Test	>4000 hrs
Activation Energy	0,85 eV
Confidencel Level	90%
Number of Tested Modules	> 30
Average Failure	λ≤ 74dpm/khrs
Lifetime	ti > 10 years

PIN Description 2x9 Pin Row

Pin Name		Level	Pin #	Description
TxEn	Tx Enable	TTL-Input active high	12	High level on this input switches the Laser on. High > 2.0 ; Low < 0.8
SD	RX Signal Detect	PECL-Output active high	4	High level on this output shows an optical signal is applied to the optical input.
Tx Alm	Tx+2dB Alarm	TTL Output active high	11	High level on this output indicates an increase of optical operating power output of+2 dB.
Pwr Mon*	Power Monitor	Analog Voltage	14	Shows an analog voltage which is proportional to the light output and can be used for Laser safety functions. Output Voltage Vmon=2.0±0.2 V, Source Resistance. Rs=100 kW
Bias Mon	Bias Monitor	Analog Voltage	13	Shows an analog voltage which is proportional to the laser bias current. Use to check proper laser operation and for end of life indications. Limit: Bias Current Ibias <60mA Output Voltage V_O=V_{CC}–Ibias * 42 W, Source Resistance Rs=500 Ohm
RxD	Rx Output Data	PECL Output	2	Receiver output data
RxDn	Rx Output Data		3	Inverted receiver output data
TxD	Tx Input Data	PECL Input	8	Transmitter input data
TxDn			7	Inverted transmitter input data
RxVee	Rx Ground	Power Supply	1	Negative power supply, normally ground
TxVee	Tx Ground		9	
RxVcc	Rx +5 V		5	Positive power supply, +5 V
TxVcc	Tx +5 V		6	
NC			10, 15–18	Pins not connected

* For Laser fault supervision: Check this output for 1.5 V< Vout < 2.5 V; if it is not, switch off laser via TX En pin.

LASER SAFETY

This single mode ATM transceiver is a Class 1 laser product. It complies with IEC 825-1 and FDA 21 CFR 1040.10 and 1040.11. The transceiver must be operated under recommended operating conditions.

Caution

The use of optical instruments with this product will increase eye hazard!

General Restrictions

Classification is only valid if the module is operated within the specified temperature and voltage limits. The system using the module must provide power supply protection that guarantees that the system power source will cease to provide power if the maximum recommended operation limit or more is detected on the +5V at the power source. The temperature of the module case must be in the temperature range given in the recommended operating limits. These limits guarantee the laser safety.

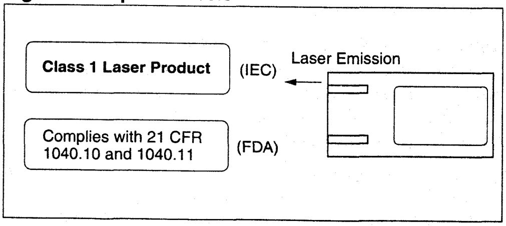
Usage Restrictions

The optical ports of the modules shall be terminated with an optical connector or with a dust plug.

Note

Failure to adhere to the above restrictions could result in a modification that is considered an act of "manufacturing," and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration (ref. 21 CFR 1040.10 (i)).

Figure 2. Required labels



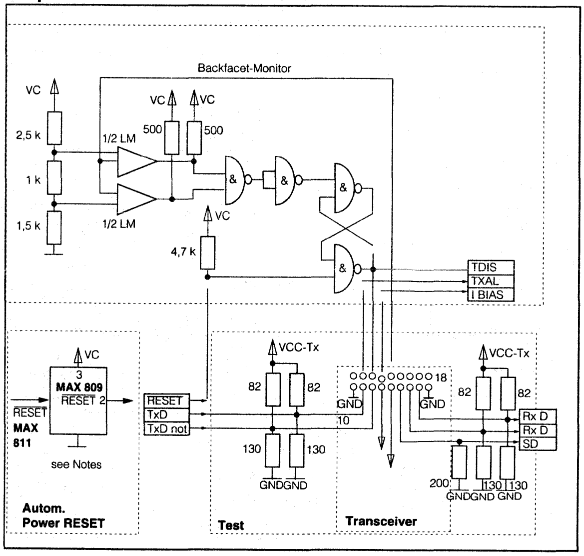
Additional Information

Laser Data

Wavelength	1300 nm
Total output power (in accordance with IEC: 50mm aperture at 10cm distance)	1mW
Total output power (in accordance with FDA: 7mm aperture at 20cm distance)	180µW
Beam divergence	4°

APPLICATION NOTE FOR 2X9 PIN ROW TRANSCEIVER

Proposal for Automatic Laser Shutdown



Notes

1. Minimum length of RESET pulse is 3 ms.
2. After switch on (Vcc) manual RESET necessary or automatic RESET with IC (e. g. MAX 809).

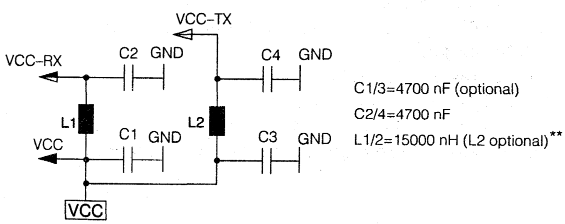
$\overline{RESET}$	Function	C	Laser	TDIS
low	Norm	high	ON	high
	Fail	low		
high	Norm	high		high*
	Fail	low	OFF	low

* Depends on previous flip-flop state.

The shut down circuit checks the monitor voltage (PWRMON). A deviation of ± 0.5 V shuts down the laser in the circuit shown above. The transceiver can be reenabled using the reset circuit.

The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module VCC-RX/VCC-TX.

A GND plane under the module is required for good EMI and sensitivity performance. Studs must be connected this GND plane.



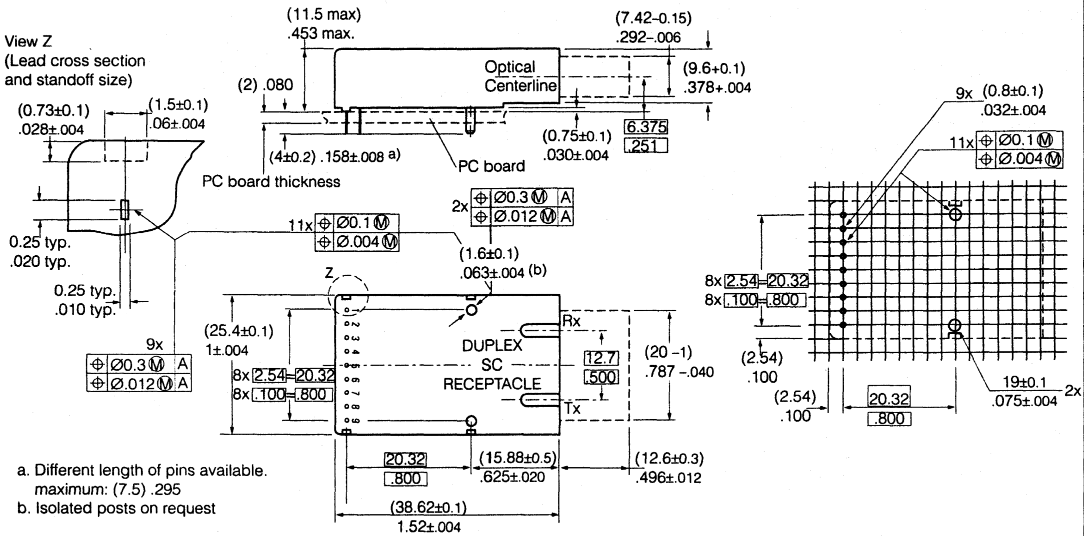
** Recommended choke is Siemens Matsushita B78108-S1153-K or B78148 S1153-K (Q_{min}=60, max. DC resistance=0.6 Ohm).

Fiber Optic Data Links 9

V23806-A84-C2

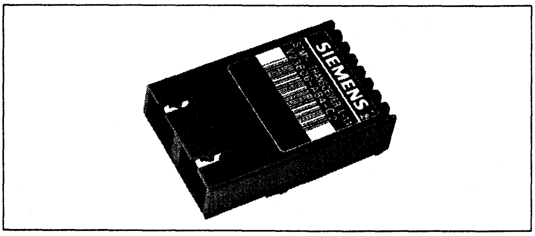
Single Mode 155 MBd ATM Transceiver 1x9

Dimensions in (mm) inches



a. Different length of pins available. maximum: (7.5) .295

b. Isolated posts on request



FEATURES

- **Compliant with existing standards**
- **Compact integrated transceiver unit with**
  - **MQW laser diode transmitter**
  - **InGaAs PIN-photodiode receiver**
  - **Duplex SC receptacle**
- **Class 1 FDA (Accession No. 95 20 890) and IEC laser safety compliant**
- **Single power supply (5 V)**
- **Loss of optical signal indicator**
- **PECL differential inputs and outputs**
- **Wave solderable and washable with included process plug**

Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation (1) .... 1.5 W
Supply voltage (V_{CC}–V_{EE}).. 6 V
Data Input Levels.. GND to V_{CC}+0.5 V
Differential Data Input Voltage .... 2.5 V
Operating Case Temperature .... 0 to 70°C
Storage Ambient temperature .... –40°C to 85°C
Soldering Conditions Temp/Time
(MIL-STD 883 C Method 2003) .... 250/5.5°C/s

Notes

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}–2 V.

DESCRIPTION

This data sheet describes the Siemens single mode ATM transceiver, which complies with the ATM Forum's Network Compatible ATM for Local Network Applications document and ANSI's *Broadband ISDN—Customer Installation Interfaces, Physical Media Dependent Specification,* T1E1.2.

ATM is being developed to facilitate solutions in multimedia applications and real time transmission. The data rate is scalable, and the ATM protocol is the basis of the broadband public networks being standardized in the International Telecommunications Union (ITU), the former International Telegraph and Telephone Consultative Committee (CCITT). ATM can also be used in local private applications.

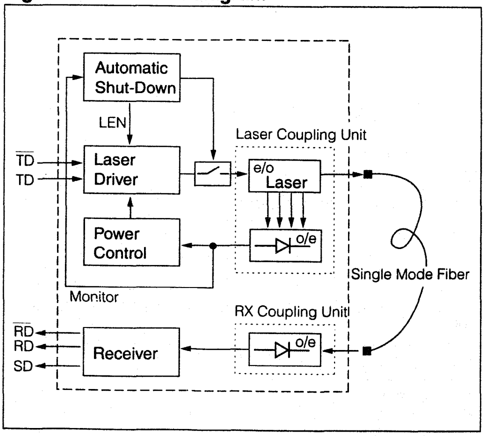
The Siemens single mode ATM transceiver is a single unit comprised of a transmitter, a receiver, and an SC receptacle. It thereby frees the customer from many alignment and PC board layout concerns. The module is designed for low cost LAN and WAN applications. It can be used as the network end device interface in workstations, servers, and storage devices, and in a broad range of network devices such as bridges, routers, intelligent hubs, as well as local and wide area ATM switches.

This transceiver operates at 155.520 Mbits per second from a single power supply (+5 Volt). The full differential data inputs and outputs are PECL compatible.

Functional Description of 1x9 Pin Row Transceiver

This transceiver is designed to transmit serial data via single mode cable.

Figure 1. Functional diagram



The receiver component converts the optical serial data into PECL compatible electrical data (RD and RDnot). The Signal Detect (SD, active high) shows whether an optical signal is present.

The transmitter converts electrical PECL compatible serial data (TD and TDnot) into optical serial data. It contains a laser driver circuit which drives the modulation and bias current of the laser diode. The currents are controlled by a power control circuit to guarantee a constant output power of the laser over temperature and aging. The power control uses the output of the monitor pin diode (mechanically built in the laser coupling unit) for the controlling function to prevent the laser power from exceeding the operating limits.

This module is a laser Class 1 product due to an integrated automatic shutdown circuit, which disables the laser when it detects transmitter failures.

The transceiver contains a supervisory circuit to monitor the power supply. This circuit makes an internal reset signal whenever the supply voltage declines below the reset threshold. It keeps the reset signal active for at least 140 milliseconds after the voltage has risen above the reset threshold. During this time the laser is inactive.

Recommended Operating Conditions

Parameter	Sym.	Min.	Typ.	Max.	Units
Case Temperature	T_C	0		70	°C
Power Supply Voltage	V_{CC}–V_{EE}	4.75	5.0	5.25	V
Supply Current(1)	I_{CC}		150	250	mA
Transmitter					
Data Input High Voltage	V_{IH}–V_{CC}	–1165		–880	mV
Data Input Low Voltage	V_{IL}–V_{CC}	–1810		–1475	
Input Data Rise/Fall, 10-90%	t_R, t_F	0.4		1.3	ns
Receiver					
Output Current	I_O			25	mA
Input Center Wavelength	λ_C	1260		1360	nm

Transmitter Electro-Optical Characteristics

Transmitter	Sym.	Min.	Typ.	Max.	Units
Output Power (Average)	P_O	–15.0	–11.0	–8.0	dBm
Center Wavelength	λ_C	1260		1360	nm
Spectral Width (FWHM)	σ_λ			7.7	
Output Rise time	t_R	0.6		2.5	ns
Output Fall time	t_F			3.0	
Extinction Ratio (dynamic)	ER	8.2			dB
Reset Threshold for TXVCC(9)	V_{TH}	4.25	4.38	4.5	V
Reset Active Timeout(9)	t_{RES}	140	240	560	ms
Eye Diagram(1)					

Receiver Electro-Optical Characteristics

Receiver	Symbol	Min.	Typ.	Max.	Units
Sensitivity (Average Power)(2)	P_{IN}		-33.0	-29.0	dBm
Saturation (Average Power)	P_{SAT}	-8.0			
Signal Detect Assert Level(3)	P_{SDA}	-43	-36,0	-33.5	
Signal Detect Deassert Level(4)	P_{SDD}	-44.5	37.5	-35.0	
Signal Detect Hysteresis	$P_{SDA}-P_{SDD}$	1.0	1.5	3.0	dB
Signal Detect Assert Time(7)	t_{ASS}	10	30	100	
Signal Detect Deassert Time(8)	t_{DAS}	30	150	350	
Output LO Voltage(5)	$V_{OL}-V_{CC}$	−1950		−1630	mV
Output HI Voltage(5)	$V_{OH}-V_{CC}$	−1025		-735	
Output Data Rise/Fall Time, 10–90%	t_R, t_F			1.3ns	ns
Output SD Rise/Fall Time(6)				40ns	

Notes

1. Transmitter meets ANSI T1E1.2, SONET OC-3, and ITU G.957 mask patterns.
2. Minimum average optical power at which the BER is less than 1x10E–10. Measured with a 223-1 NRZ PRBS as recommended by ANSI T1E1.2, SONET OC-3, and ITU G.957
3. An increase in optical power above the specified level will cause the SIGNAL DETECT to switch from a LO state to a HI state.
4. A decrease in optical power below the specified level will cause the SIGNAL DETECT to switch from a HI state to a LO state.
5. PECL 10K compatible. Load is 50 Ω into V_{CC}–2V .Measured under DC conditions at 25°C. For dynamic measurements a tolerance of 50 mV should be added, V_{CC}=5V.
6. PECL compatible. A high level on this output shows that an optical signal is applied to the optical input.
7. Measured by switching the light from <–40 dBm to -25 dBm.
8. Measured by switching the light from –25 dBm to <–40 dBm. Switching from higher power levels increases this time.
9. Laser power is shut down if power supply is below V_{TH} and switched on if power supply is above V_{TH} after T_{res}.

Reliability (Qualification Results)

Test Temperature (HTB)	85°C/358 K
Reference Temperature	25°C/298 K
Duration of HTB Test	>4000 hrs
Activation Energy	eV 0.85
Confidence Level	% 90
Number of Tested Modules	>30
Average Failure	λ≤ 74dpm/khrs
Lifetime	ti >10 years

PIN Description

Pin Name		Level/Logic	Pin #	Description
RxVee	Rx Ground	Power Supply	1	Negative power supply, normally ground
RD	Rx Output Data	PECL Output	2	Receiver output data
RDn			3	Inverted receiver output data
Rx SD	RX Signal Detect	PECL Output active high	4	High level on this output shows an optical signal is applied to the optical input.
RxVcc	Rx +5V	Power Supply	5	Positive power supply, +5 V
TxVcc	Tx +5V	Power Supply	6	Positive power supply, +5 V
TDn	Tx Input Data	PECL Input	7	Inverted transmitter input data
TD		PECL Input	8	Transmitter input data
TxVee	Tx Ground	Power Supply	9	Negative power supply, normally ground

LASER SAFETY

This single mode ATM transceiver is a Class 1 laser product. It complies with IEC 825-1 and FDA 21 CFR 1040.10 and 1040.11. The transceiver must be operated under recommended operating conditions.

Caution
The use of optical instruments with this product will increase eye hazard!

General Restrictions

Classification is only valid if the module is operated within the specified temperature and voltage limits. The system using the module must provide power supply protection that guarantees that the system power source will cease to provide power if the maximum recommended operation limit or more is detected on the +5V at the power source. The temperature of the module case must be in the temperature range given in the recommended operating limits. These limits guarantee the laser safety.

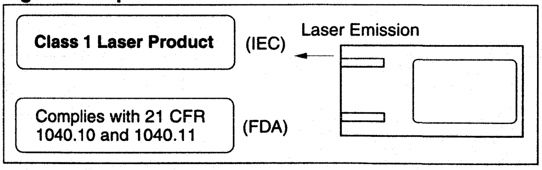
Usage Restrictions

The optical ports of the modules shall be terminated with an optical connector or with a dust plug.

Note

Failure to adhere to the above restrictions could result in a modification that is considered an act of "manufacturing," and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration [ref. 21 CFR 1040.10 (i)].

Figure 2. Required labels



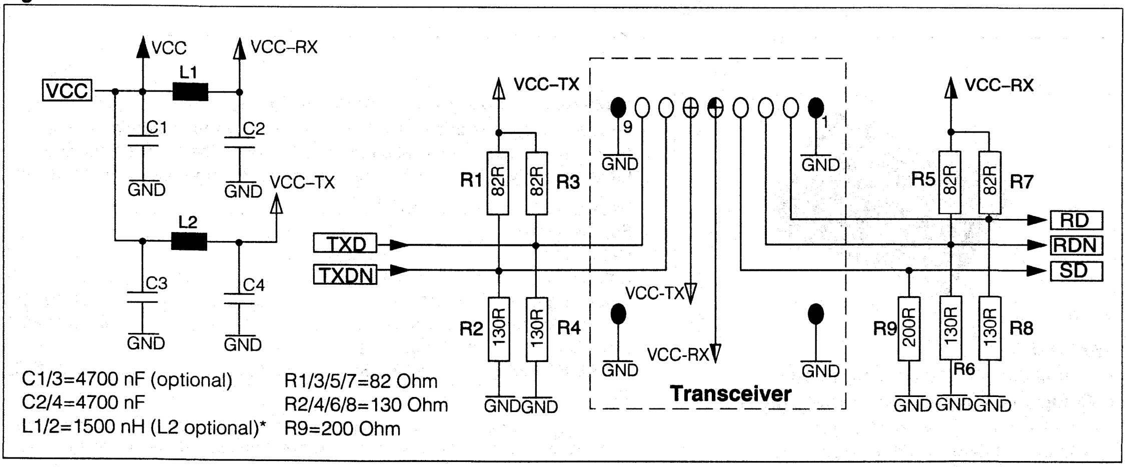
Additional Information

Laser Data

Wavelength	1300 nm
Total output power (in accordance with IEC: 50 mm aperture at 10 cm distance)	1 mW
Total output power (in accordance with FDA: 7 mm aperture at 20 cm distance)	180 µW
Beam divergence	4°

APPLICATION NOTE FOR 1X9 PIN ROW TRANSCEIVER

Figure 3.



* Recommended choke is Siemens Matsushita B78108-S1153-K or B78148-S1153-K (Q_{min}=60, max. DC resistance =0.6 Ohm)

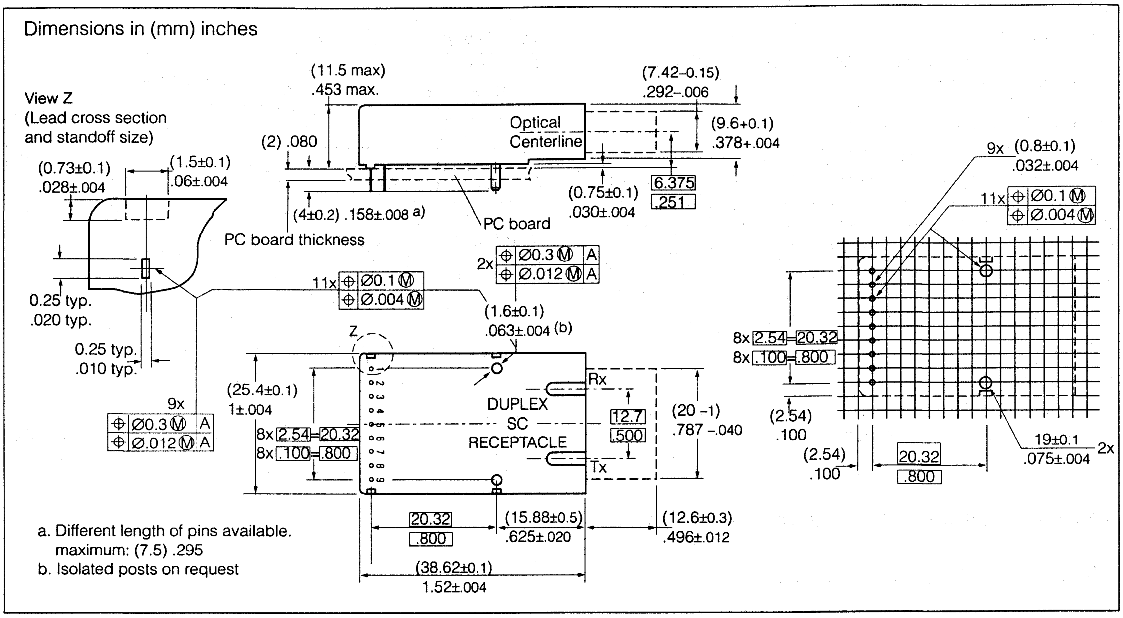
The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module V_{CC}-RX/V_{CC}-TX.

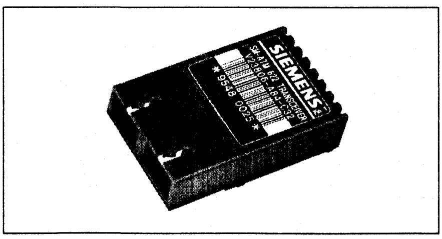
A GND plane under the module is required for good EMI and sensitivity performance. Studs must be connected to this GND plane.

The transceiver contains an automatic shutdown circuit. Reset is only possible if the power is turned off, then on again. (V_{CC}TX switched below VTH)

V23806-A84-C32

Single Mode 622 MBd ATM Transceiver 1x9





Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation (1) .... 1.5 W
Supply voltage (V_{CC}–V_{EE}) .... 6 V
Data Input Levels(PECL) .... V_{CC}–0.7 V
Differential Data Input Voltage .... 3 V
Operating Case Temperature .... 0 to 70°C
Storage Ambient temperature .... –40°C to 85°C
Soldering Conditions Temp/Time
(MIL-STD 883C, Method 2003) .... 250/5.5°C/s

Notes

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}–2 V.

FEATURES

- **Compliant with existing standards**
- **Compact integrated transceiver unit with**
  - **MQW laser diode transmitter**
  - **InGaAs PIN-photo diode receiver**
  - **Duplex SC receptacle**
- **Class 1 FDA (Accession No. 95 20 890 supplement 0.01) and IEC laser safety compliant**
- **Single power supply (5 V)**
- **Loss of optical signal indicator, TTL compatible**
- **Class 1 FDA an IEC laser safety compliant**
- **PECL differential inputs and outputs**
- **Wave solderable and washable with included process plug**

DESCRIPTION

This data sheet describes the Siemens single mode ATM transceiver, which complies with the ATM Forum's *Network Compatible ATM for Local Network Applications* document and ANSI's *Broadband ISDN—Customer Installation Interfaces, Physical Media Dependent Specification*, T1.646-1995.

ATM is being developed to facilitate solutions in multimedia applications and real time transmission. The data rate is scalable, and the ATM protocol is the basis of the broadband public networks being standardized in the International Telecommunications Union (ITU), the former International Telegraph and Telephone Consultative Committee (CCITT). ATM can also be used in local private applications.

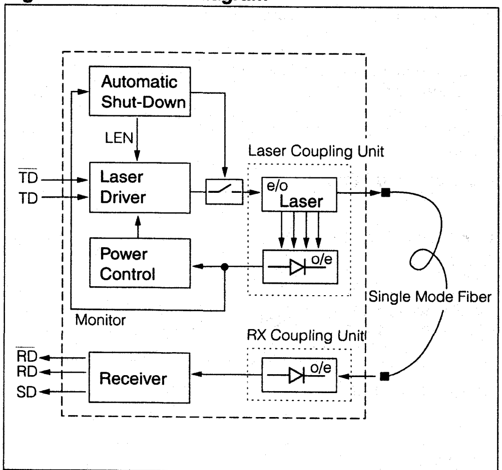
The Siemens single mode ATM transceiver is a single unit comprised of a transmitter, a receiver, and an SC receptacle. It thereby frees the customer from many alignment and PC board layout concerns. The module is designed for low cost WAN applications. It can be used as the network end device interface in workstations, servers, and storage devices, and in a broad range of network devices such as bridges, routers, intelligent hubs, and wide area ATM switches.

This transceiver operates at 622.080 Mbits per second from a single power supply (+5 Volt). The full differential data inputs and data and clock outputs are PECL compatible.

Functional Description of 1x9 Pin Row Transceiver

The transceiver is designed to transmit serial data via single mode cable.

Figure 1. Functional diagram



The receiver component converts the optical serial data into ECL-compatible electrical data (RD and RDnot). The Signal Detect (SD, active high) shows whether a optical signal is present. If no optical input signal is present the receiver data outputs are switched to static low level (RD = Low, Rdnot = high).

The transmitter converts electrical ECL compatible serial data (TD and TDnot) into optical serial data. It contains a laser driver circuit which drives the modulation and bias current of the laser diode. The currents are controlled by a power control circuit to guarantee a constant output power of the laser over temperature and aging. The power control uses the output of the monitor pin diode (mechanically built in the laser coupling unit) for the controlling function to prevent the laser power from exceeding the operating limits.

This module ensures single fault condition with an integrated automatic shutdown circuit, which disables the laser when it detects transmitter failures. A reset is only possible by turnng the power off, then on again.

The transceiver contains a supervisory circuit to control the power supply. This circuit makes an internal reset signal whenever the supply voltage declines below the reset threshold. It keeps the reset signal active for at least 140 milliseconds after the voltage has risen above the reset threshold. During this time the laser is inactive.

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units
Case Temperature	T_C	0		70	˚C
Power Supply Voltage	$V_{CC}-V_{EE}$	4.75	5.0	5.25	V
Supply Current[(1)]	I_{CC}		150	250	mA
Transmitter					
Data Input High Voltage	$V_{IH}-V_{CC}$	–1165		–880	mV
Data Input Low Voltage	$V_{IL}-V_{CC}$	–1810		–1475	
Input Data Rise/Fall, 10-90%	t_R, t_F	0.4		1.3	ns
Receiver					
Output Current	I_O			25	mA
Input Center Wavelength	λ_C	1260		1360	nm

Notes

1. For $V_{CC}-V_{EE}$ (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}–2 V.

Transmitter Electro-Optical Characteristics

Transmitter	Symbol	Min.	Typ.	Max.	Units
Output Power (Average)	P_O	–15.0	–11.0	–8.0	dBm
Center Wavelength	λ_C	1293		1334	nm
Spectral Width (FWHM)	$\Delta\lambda$			2.4	
Reset Threshold for T_XV_{CC}[(1)]	V_{th}	4.25	4.38	4.5	V
Reset Active Timeout[(1)]		140	240	560	ms
Extinction Ratio (dynamic)	ER	8.2			dB
Eye Diagram[(2)]	ED				

1. Power supply Tx is shut down and switched on above V_{TH} after the reset active timeout.
2. Transmitter meets ANSI T1E1.2, SONET OC-12, and ITU G.957 mask patterns.

Receiver Electro-Optical Characteristics

Receiver	Symbol	Min.	Typ.	Max.	Units
Sensitivity (Average Power)(1)	P_{IN}		-33.0	-29.0	dBm
Saturation (Average Power)	P_{SAT}	-8.0			
Signal Detect Assert Level(2)	P_{SDA}		tbd	tbd	
Signal Detect Deassert Level(3)	P_{SDD}	tbd			
Signal Detect Hysteresis	$P_{SDA}-P_{SDD}$		1.5		dB
Signal Detect Assert Time(6)	t_{ASS}		30		µs
Signal Detect Deassert Time(7)	t_{DAS}		150		
Output LO Voltage(4)	$V_{OL}-V_{CC}$	-1950		-1630	mV
Output HI Voltage(4)	$V_{OH}-V_{CC}$	-1025		-735	
Output SD, Rise/Fall Time(5)	t_R, t_F			40ns	V
Output Data Rise/ Fall Time, 20–80%					

Notes

1. Minimum average optical power at which the BER is less than 1x10E-10. Measured with a 2^{23}-1 NRZ PRBS as recommended by ANSI T1E1.2, SONET OC-12, and ITU G.957.
2. An increase in optical power above the specified level will cause the SIGNAL DETECT output to switch from a LO state to a HI state.
3. A decrease in optical power below the specified level will cause the SIGNAL DETECT to change from a HI state to a LO state.
4. PECL 10K compatible. Load is 50 Ω into V_{CC}–2V .Measured under DC conditions at 25°C. For dynamic measurements a tolerance of 50 mV should be added, V_{CC}=5V.
5. PECL compatible. A high level on this output shows that an optical signal is applied to the optical input.
6. Measured by switching the light from <–40 dBm to –25 dBm.
7. Measured by switching the light from –25 dBm to <–40 dBm. Switching from higher power levels increases this time.

LASER SAFETY

This single mode ATM transceiver is a Class 1 laser product. It complies with IEC 825-1 and FDA 21 CFR 1040.10 and 1040.11. The transceiver must be operated under the recommended operating conditions.

Caution

The use of optical instruments with this product will increase eye hazard!

General Restrictions

Classification is only valid if the module is operated within the specified temperature and voltage limits. The system using the module must provide power supply protection that guarantees that the system power source will cease to provide power if the maximum recommended operation limit or more is detected on the +5 V at the power source. The temperature of the module case must be in the temperature range given in the recommended operating limits. These limits guarantee the laser safety.

PIN Description

Pin Name		Level/ Logic	Pin#	Description
R_XV_{EE}	Rx Ground	Power Supply	1	Negative power supply, normally ground
RD	Rx Output Data	PECL Output	2	Receiver output data
RDn			3	Inverted receiver output data
Rx SD	RX Signal Detect	PECL Output active high	4	A high level on this output shows an optical signal is applied to the optical input.
R_V_{CC}	Rx +5 V	Power Supply	5	Positive power supply, +5 V
T_V_{CC}	Tx +5 V		6	
TDn	Tx Input Data	PECL Input	7	Inverted transmitter input data
TD			8	Transmitter input data
T_XV_{EE}	Tx Ground	Power Supply	9	Negative power supply, normally ground
	Ground		S1/2	V_{EE}/GND Support Stud (GND) connect to V_{EEnb}

Usage Restrictions

The optical ports of the modules must be terminated with an optical connector or with a dust plug.

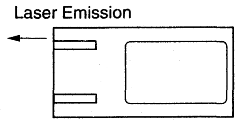
Note

Failure to adhere to the above restrictions could result in a modification that is considered an act of "manufacturing", and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration (ref. 21 CFR 1040.10 (i)).

Figure 2. Required labels

Class 1 Laser Product (IEC)

Complies with 21 CFR 1040.10 and 1040.11 (FDA)



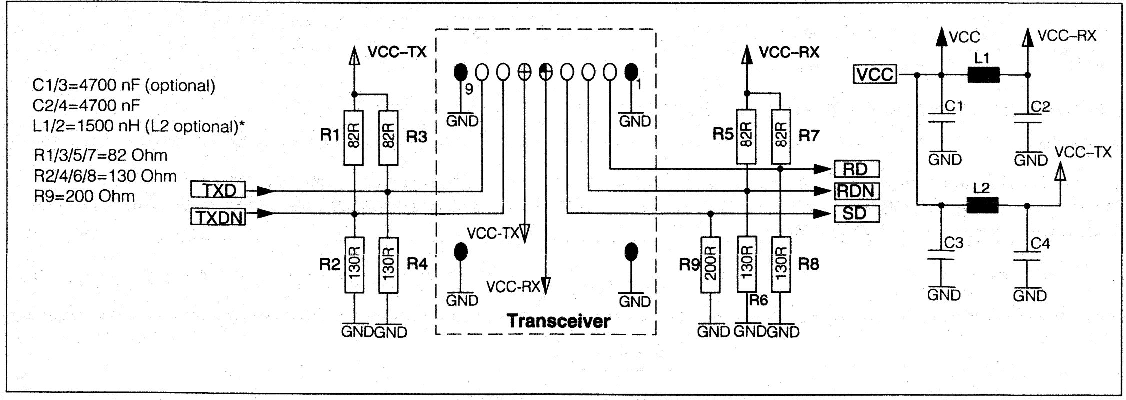
Additional Information

Laser Data

Wavelength	1300 nm
Total output power (as defined by IEC: 50 mm aperture at 10 cm distance)	1 mW
Total output power (as defined by FDA: 7 mm aperture at 20 cm distance)	180 µW
Beam divergence	4°

APPLICATION NOTE FOR 1X9 PIN ROW TRANSCEIVER

Figure 3. Schematic



* Recommended choke is Siemens Matsushita B78108-S1153-K or B78148-S1153-K (Q_{min}=60, max. DC resistance =0.6 Ohm).

The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module VCC-RX/VCC-TX.

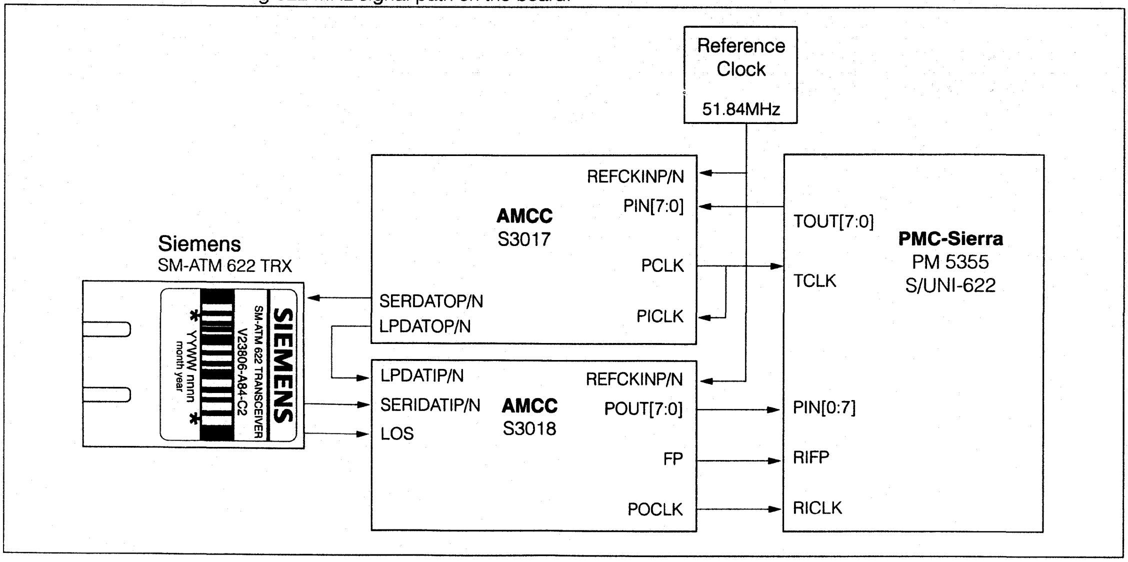
A GND plane under the module is required for good EMI and sensitivity performance. Studs must be connected to this GND plane.

The transceiver contains an automatic shutdown circuit. Reset is only possible when the power off is switched off, then on again. (VCCTX=0V).

SONET/ATM APPLICATIONS FOR 1X9 PIN ROW TRANCEIVERS

Description

The 1x9 Pin Row transceiver requires an external clock recovery device. The best solution is the use of transceiver circuits (serializer / deserializer) which include the clock recovery function. This avoids any additional circuitry skew problems between data and clock and a radiating 622 MHz signal path on the board.



RxTx Chipsets including PLL Function

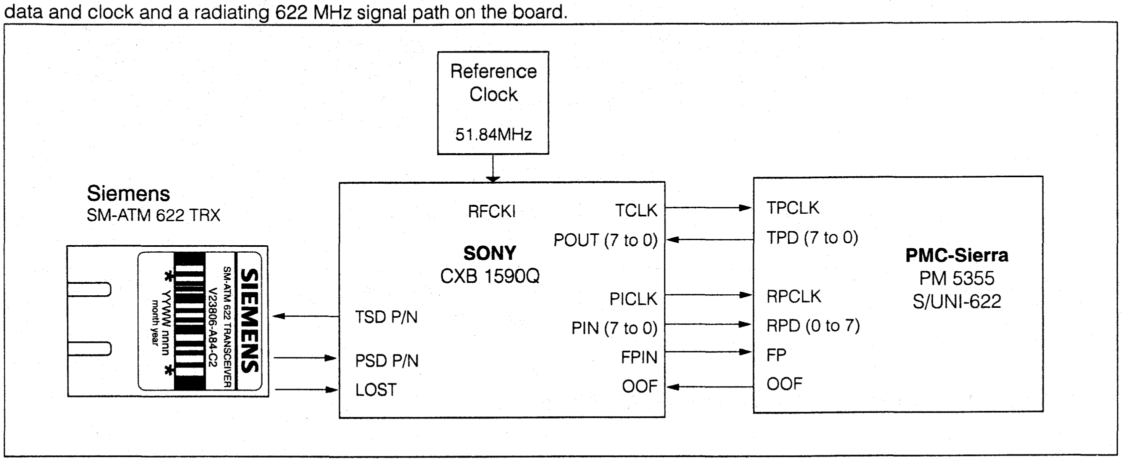
AMCC	Receiver S3017, Transmitter S3018	(Preliminary, detailed description available)
Sony:	Transceivers CXB 1590 Q	(Preliminary, detailed description available)
Texas Instruments	Transceivers TNETA 16611	(Preliminary)

Detailed information is available upon request.

ATM APPLICATIONS FOR 1X9 PIN ROW TRANCEIVERS

Description

The 1x9 Pin Row transceiver requires an external clock recovery device. The best solution is the use of transceiver circuits (serializer / deserializer) which include the clock recovery function. This avoids any additional circuitry skew problems between data and clock and a radiating 622 MHz signal path on the board.



RxTx Chipsets including PLL Function

AMCC	Receiver S3017, Transmitter S3018	Preliminary, detailed description available
Sony:	Transceivers CXB 1590 Q	Preliminary, detailed description available
Texas Instruments	Transceivers TNETA 16611	Preliminary

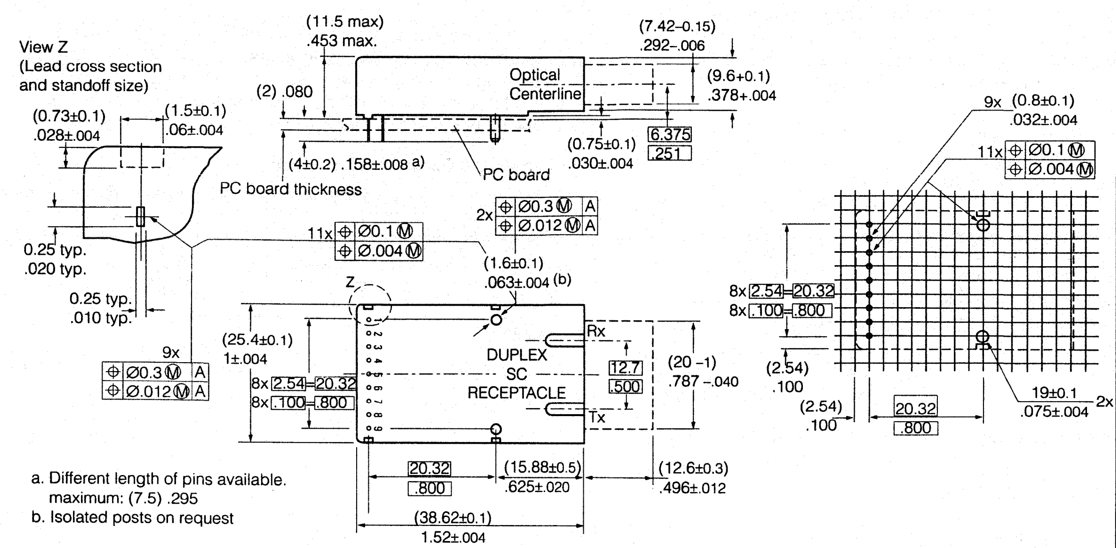
Detailed Information is available upon request.

SIEMENS

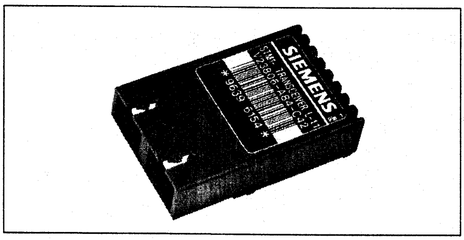
V23806-A84-C42

Single Mode 155 MBd ATM Long Haul Transceiver 1x9

Dimensions in (mm) inches



a. Different length of pins available.
maximum: (7.5) .295
b. Isolated posts on request



FEATURES

- **Compliant with ITU-T recommendation G 957**
- **Compact integrated transceiver unit with**
  - **MQW laser diode transmitter**
  - **InGaAs PIN-photodiode receiver**
  - **Duplex SC receptacle**
- **Laser safety Class 1 according to IEC**
- **Laser safety Class 1 according to FDA, under normal operating conditions**
- **Single power supply (5 V)**
- **Loss of optical signal indicator**
- **PECL differential inputs and outputs**
- **Wave solderable and washable with included process plug**
- **Typical dynamic range of 38 dB**

Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation [1] .... 1.5 W
Supply voltage (V_{CC}–V_{EE}) .... 6 V
Data Input Levels (PECL) .... V_{CC}–0.7 V
Differential Data Input Voltage .... 3 V
Operating Case Temperature .... 0 to 70°C
Storage Ambient temperature .... –40°C to 85°C
Soldering Conditions Temp/Time
(MIL-STD 883C, Method 2003) .... 250/5.5°C/s

Notes:

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 W to V_{CC} –2 V.

DESCRIPTION

This data sheet describes the Siemens single mode ATM long haul transceiver.

ATM is being developed to facilitate solutions in multimedia applications and real time transmission. The data rate is scalable, and the ATM protocol is the basis of the broadband public networks being standardized in the International Telecommunications Union (ITU), the former International Telegraph and Telephone Consultative Committee (CCITT). ATM can also be used in local private applications.

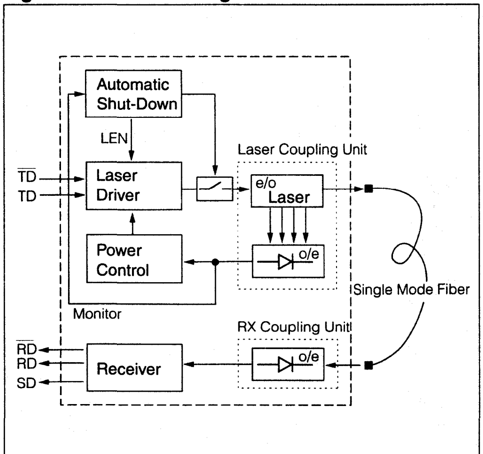
The Siemens single mode ATM long haul transceiver is a single unit comprised of a transmitter, a receiver and an SC receptacle. It thereby frees the customer from many alignment and PC board layout concerns. The module is designed for low cost WAN applications. It can be used as the network end device interface in workstations, servers, and storage devices, and in a broad range of network devices such as bridges, routers, intelligent hubs, and wide area ATM switches.

This transceiver operates at 155.520 Mbits per second from a single power supply (+5 Volt). The full differential data inputs and outputs are PECL compatible.

Functional Description of 1x9 Pin Row Transceiver

This transceiver is designed to transmit serial data via single mode cable.

Figure 1. Functional diagram



The receiver component converts the optical serial data into PECL compatible electrical data (RD and RDnot). The Signal Detect (SD, active high) shows whether an optical signal is present.

The transmitter converts electrical PECL compatible serial data (TD and TDnot) into optical serial data. It contains a laser driver circuit which drives the modulation and bias current of the laser diode. The currents are controlled by a power control circuit to guarantee a constant output power of the laser over temperature and aging. The power control uses the output of the monitor pin diode (mechanically built in the laser coupling unit) for the controlling function to prevent the laser power from exceeding the operating limits.

This module is a laser Class 1 product due to an integrated automatic shutdown circuit, which disables the laser when it detects transmitter failures.

The transceiver contains a supervisory circuit to monitor the power supply. This circuit makes an internal reset signal whenever the supply voltage declines below the reset threshold. It keeps the reset signal active for at least 140 milliseconds after the voltage has risen above the reset threshold. During this time the laser is inactive.

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units
Case Temperature	T_C	0		70	°C
Power Supply Voltage	V_{CC}–V_{EE}	4.75	5.0	5.25	V
Supply Current(1)	I_{CC}		150	250	mA
Transmitter					
Data Input High Voltage	V_{IH}–V_{CC}	–1165		–880	mV
Data Input Low Voltage	V_{IL}–V_{CC}	–1810		–1475	
Input Data Rise/Fall Time, 10–90%	t_R, t_F	0.4		1.3	ns
Receiver					
Output Current	I_O			25	mA
Input Center Wavelength	λ_C	1260		1360	nm

Note

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC} –2 V.

Transmitter Electro-Optical Characteristics

Transmitter	Symbol	Min.	Typ.	Max.	Units
Output Power (Average)	P_O	–5	–3	–0	dBm
Center Wavelength	λ_C	1280		1335	nm
Spectral Width (FWHM)	σ_λ		2.4	3	
Output Rise Time	t_R	0.6		2.5	ns
Output Fall Time	t_F			3	
Extinction Ratio (dynamic)	ER	10			dB
Reset Threshold for T_XV_{CC}(9)	V_{TH}	4.25	4.38	4.5	V
Reset Active Timeout(9)	t_{RES}	140	240	560	ms
Eye Diagram(1)					

Receiver Electro-Optical Characteristics

Receiver	Symbol	Min.	Typ.	Max.	Units
Sensitivity (Ave. Power)(2)	P_{IN}		–38	–35	dBm
Saturation (Ave. Power)	P_{SAT}	0			
Signal Detect Assert Level(3)	P_{SDA}		–40.5	–38	
Signal Detect Deassert Level(4)	P_{SDD}	–45	–42		
Signal Detect Hysteresis	P_{SDA}– P_{SDD}	1	1.5	3	dB
Signal Detect Assert Time(7)	t_{ASS}	10	40	100	µs
Signal Detect Deassert Time(8)	t_{DAS}	30	680	1000	
Output LO Voltage(5)	V_{OL}–V_{CC}	–1950		–1630	mV
Output HI Voltage(5)	V_{OH}–V_{CC}	–1025		–735	
Output Data, Rise/Fall Time, 10–90%	t_R, t_F			1.3 ns	ns
Output SD Rise/Fall Time(6)				40 ns	

Notes

1. Transmitter meets ANSI T1E1.2, SONET OC-3, and ITU G.957 mask patterns.
2. Minimum average optical power at which the BER is less than 1x10E-10. Measured with a 2^{23}-1 NRZ PRBS as recommended by ANSI T1E1.2, SONET OC-3, and ITU G.957
3. An increase in optical power above the specified level will cause the SIGNAL DETECT to switch from a LO state to a HI state.
4. A decrease in optical power below the specified level will cause the SIGNAL DETECT to switch from a HI state to a LO state.
5. PECL 10K compatible. Load is 50 Ω into V_{CC}–2V. Measured under DC conditions at 25°C. For dynamic measurements a tolerance of 50 mV should be added, V_{CC}=5V.
6. PECL compatible. A high level on this output shows that an optical signal is applied to the optical input.
7. Measured by switching the light from <–40 dBm to –25 dBm.
8. Measured by switching the light from –25 dBm to <–40 dBm. Switching from higher power levels increases this time.
9. Laser power is shut down if power supply is below V_{TH} and switched on if power supply is above V_{TH} after t_{RES}.

LASER SAFETY

This single mode transceiver is a Class 1 laser product. It complies with IEC 825-1 and FDA/CDRH 21 CFR 1040.10 and 1040.11. The transceiver must be operated under the recommended operating conditions.

Caution

The use of optical instruments with this product will increase eye hazard!

Do not view into the open optical port for more than 60 seconds.

General Restrictions

Classification is only valid if the module is operated within the specified temperature and voltage limits. The system using the module must provide power supply protection that guarantees that the system power source will cease to provide power if the maximum recommended operation limit or more is detected on the +5 V at the power source. The temperature of the module case must be in the temperature range given in the recommended operating limits. These limits guarantee the laser safety.

Usage Restrictions

The optical ports of the modules shall be terminated with an optical connector or with a dust plug.

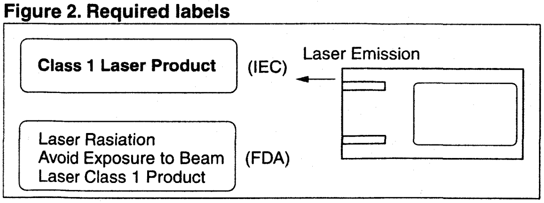
Note

Failure to adhere to the above restrictions could result in a modification that is considered an act of "manufacturing," and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration [ref. 21 CFR 1040.10 (i)].

PIN Description

Pin Name		Level/ Logic	Pin#	Description
RxV_{ee}	Rx Ground	Power Supply	1	Negative power supply, normally ground
RD	Rx Output Data	PECL Output	2	Receiver output data
RDn			3	Inverted receiver output data
Rx SD	RX Signal Detect	PECL-Output active high	4	A high level on this output shows that an optical signal is applied to the optical input.
Rx-V_{CC}	Rx +5V	Power Supply	5	Positive power supply, +5V
TxV_{CC}	Tx +5V		6	Positive power supply, +5V
TDn	Tx Input Data	PECL Input	7	Inverted transmitter input data
TD			8	Transmitter input data
TxV_{EE}	Tx Ground	Power Supply	9	Negative power supply, normally ground
	Ground		S1/2	V_{EE}/GND Support Stud (GND) connect to V_{EEnb}

Figure 2. Required labels



Additional Information

Laser Data

Wavelength	1300 nm
Total output power (as defined by IEC: 50 mm aperture at 10 cm distance)	µW
Total output power (as defined by FDA: 7 mm aperture at 20 cm distance)	600 µW
Beam divergence	4°

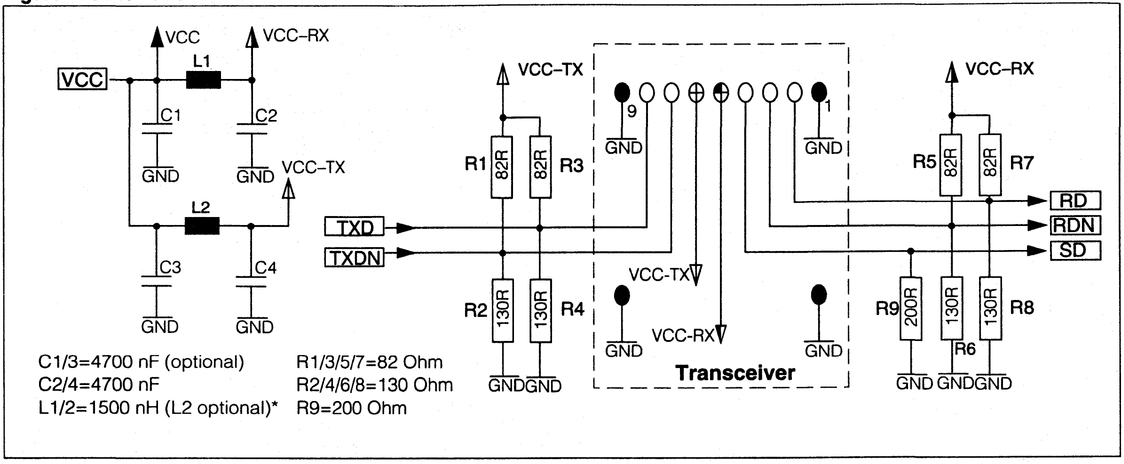
APPLICATION NOTE FOR 1X9 PIN ROW TRANSCEIVER

The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module VCC-RX/VCC-TX.

A GND plane under the module is required for good EMI and sensitivity performance. Studs must be connected to this GND plane.

The transceiver contains an automatic shutdown circuit. Reset is only possible if the power is turned off and then on again. (VCCTX switched below VTH)

Figure 1. Schematic

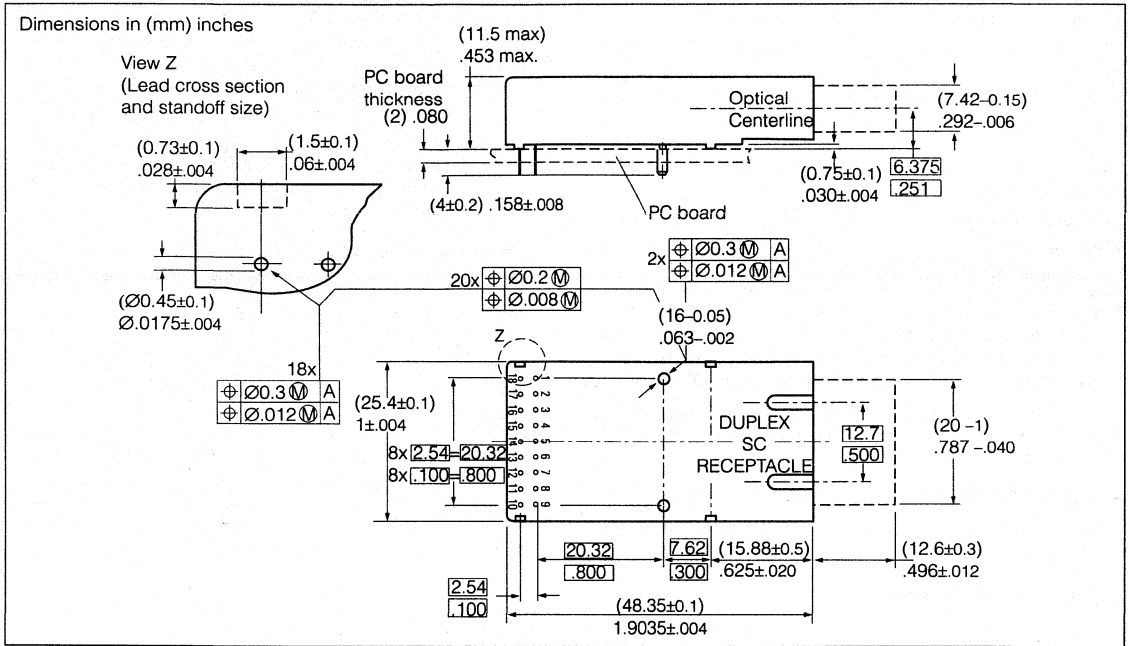


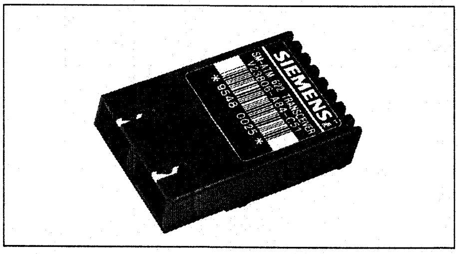
* Recommended choke is Siemens Matsushita B78108-S1153-K or B78148-S1153-K (Q_{min}=60, max. DC resistance =0.6 Ohm).

SIEMENS

V23806-A84-C51

Single Mode 622 MBd ATM Transceiver 2x9 with Clock Recovery





FEATURES
- Compliant with existing standards
- Compact integrated transceiver unit with
  - MQW laser diode transmitter
  - InGaAs PIN-photo diode receiver
  - Duplex SC receptacle
- Class 1 FDA and IEC laser safety compliant
- Single power supply (5V)
- Loss of optical signal indicator
- Integrated clock recovery module (PLL)
- PECL differential inputs and outputs
- Wave solderable and washable with included process plug

Maximum Ratings (Absolute maximum stress)
Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation (1) .... Tbd W
Supply voltage (V_{CC}–V_{EE}) .... 6 V
Data Input Levels .... V_{EE} to V_{CC}+0.5 V
Differential Data Input Voltage .... –2.5 to 2.5 V
Operating Case Temperature .... 0 to 70°C
Storage Ambient temperature .... –40°C to 85°C
Soldering Conditions Temp/Time
(MIL-STD 883 C Method 2003) .... 250/5.5°C/s

Notes
1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}– 2 V.

PIN Description

Pin#	Function	Pin#	Function	Pin#	Function
1	Rx Ground	7	Tx Input Data	13	Bias Mon.
2	Rx Output Data	8		14	Pwr Mon.
3		9	Tx Ground	15	NC
4	RX Signal Detect	10	NC	16	NC
5	Rx +5V	11	Tx+2 dB Alarm	17	NC
6	Tx +5V	12	Tx Enable	18	NC
S1, S2	V_{EE}, Support Stud (GND)				

DESCRIPTION

This data sheet describes the Siemens single mode ATM transceiver, which complies with the ATM Forum's *Network Compatible ATM for Local Network Applications* document and ANSI's *Broadband ISDN - Customer Installation Interfaces*, Physical Media Dependent Specification, T1.646-1995.

ATM is being developed to facilitate solutions in multimedia applications and real time transmission. The data rate is scalable, and the ATM protocol is the basis of the broadband public networks being standardized in the International Telecommunications Union (ITU), the former International Telegraph and Telephone Consultative Committee (CCITT). ATM can also be used in local private applications.

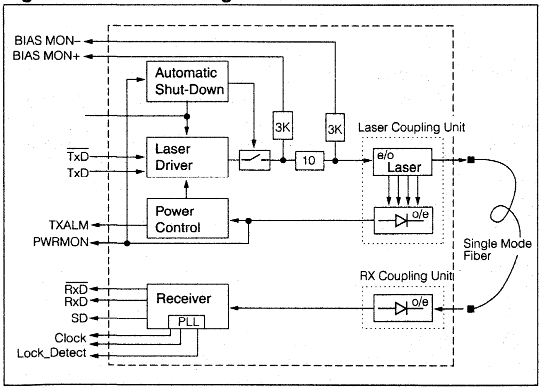
This Siemens single mode ATM transceiver is a single unit comprised of a transmitter, a receiver, a clock recovery module, and an SC receptacle. It thereby frees the customer from many alignment and PC board layout concerns. The module is designed for low cost WAN applications. It can be used as the network end device interface in workstations, servers, and storage devices, and in a broad range of network devices such as bridges, routers, intelligent hubs, and wide area ATM switches.

This transceiver operates at 622.080 Mbits per second from a single power supply (+5 Volt). The full differential data inputs and data and clock outputs are PECL compatible.

Functional Description of 2x9 Pin Row Transceiver

This transceiver is designed to transmit serial data via single mode cable.

Figure 1. Functional diagram



The receiver component converts the optical serial data into PECL compatible electrical data (RD and Rdnot). It provides also a recovered in-phase clock and clock not signal. The Signal Detect (SD, active high) shows whether an optical signal is present. If no optical input signal is present the receiver data outputs are switched to static low level (RD=low, Rdnot=high).

Lock Detect indicates whether the PLL is recovering the 622.08 MHz and is locked onto the received data.

The transmitter part converts electrical PECL compatible serial data (TD and TDnot) into optical serial data. It contains a laser driver circuit which drives the modulation and bias current of the laser diode. The currents are controlled by a power control circuit to guarantee a constant output power of the laser over temperature and aging. The power control uses the output of the monitor pin diode (mechanically built into the laser coupling unit) for the controlling function to prevent the laser power from exceeding the operating limits.

The laser can be switched off with a logical high signal on the Transmitter Disable Pin (TxDIS). The PWRMON Pin shows a voltage reflecting the optical power output. The bias current is monitored on the BIASMON Pin.' Both signals can be used to supervise the function of the module.

The signal TXALM (optional) indicates an increasing of the optical output power of more than 2dB. Aging control is possible using the bias monitor output (BIASMON). The module has an integrated shut down function which switches the laser off in the event of an internal failure.

Recommended Operating Conditions

Parameter	Sym.	Min.	Typ.	Max.	Units
Case Temperature	T_C	0		70	°C
Power Supply Voltage	V_{CC}–V_{ee}	4.75	5	5.25	V
Supply Current(1)	I_{CC}		Tbd	Tbd	mA
Transistor					
Data Input High Voltage	V_{IH}–V_{CC}	–1165		–880	mV
Data Input Low Voltage	V_{IL}–V_{CC}	–1810		–1475	
Input Data Rise/Fall Time, 10–90%	t_R, t_F	0.4		1.3	ns
TxEN Input High Voltage	V_{TIH}	2			V
TxEN Input Low Voltage	V_{TIL}			0.8	
TxEN Input High Current	V_{TIH}				mA
TxEN Input Low Current	V_{TIL}	–1			
TxALM Output High Voltage	V_{TOH}	3.2			V
TxALM Output Low Voltage	V_{TOL}			0.7	
TxALM Output High Current	I_{TOH}	–3			mA
TxALM Output Low Current	I_{TOL}			3	
Receiver					
Output Current	I_O			25	mA
Input Center Wavelength	λ_C	1260		1360	nm

Note

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}– 2 V.

Transmitter Electro-Optical Characteristics

Transmitter	Sym.	Min.	Typ.	Max.	Units
Output Power (Average)	P_O	–15.0	–11.0	-8.0	dBm
Center Wavelength	λC	1274		1356	nm
Spectral Width, RMS	$\Delta\lambda$			2.5	
Output Rise Time	t_R		240	Tbd	ps
Output Fall Time	t_F		240		
Extinction Ratio (dynamic)	ER	8.2			dB
Eye Diagram(1)	ED				
Reset Threshold for TxV_{CC}(2)	V_{th}	4.25	4.38	4.5	V
Reset Active Timeout(2)		140	240	560	ms

Notes

1. Transmitter meets ANSI T1E1.2, SONET OC-12, and ITU G.957 mask patterns.
2. Power supply Tx is shut down and switched on above VTH after the reset active timeout.

   This module is a laser Class 1 product due to an integrated automatic shutdown circuit, which disables the laser when it detects transmitter failures. The transceiver contains a supervisory circuit to monitor the power supply. This circuit makes an internal reset signal whenever the supply voltage declines below the reset threshold. It keeps the reset signal active for at least 140 milliseconds after the voltage has risen above the reset threshold. During this time the laser is inactive. The supervisory circuitry can be reset by switching TxDIS from high to low

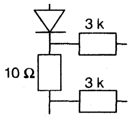
Receiver Electro-Optical Characteristics

Receiver	Symbol	Min.	Typ.	Max.	Units
Sensitivity (Ave. Power)(1)	P_{IN}		–33	–29	dBm
Saturation (Ave. Power)	P_{SAT}	-8.0	-3.0		
Signal Detect Assert Level(2)	P_{SDA}		tbd	–29	
Signal Detect Deassert Level(3)	P_{SDD}				
Signal Detect Hysteresis	P_{SDA}–P_{SDD}		1.5		dB
Signal Detect Assert Time	t_{ASS}		1		ms
Signal Detect Deassert Time	t_{DAS}		5		
Output LO Voltage(4)	V_{OL}–V_{CC}	–1950		–1630	mV
Output HI Voltage(4)	V_{OH}–V_{CC}	–1025		-735	
Output Data, Rise/Fall Time, 10–90%	t_R, t_F		Tbd	1	ns
Output SD, Rise/Fall Time(6)				40	
Output SD LO TTL-voltage(6)	V_{SDL}		Tbd		V
Output SD HI TTL-voltage(6)	V_{SDH}				
Jitter Tolerance(6)	JTo				UI
Jitter Transfer	JTr				
Jitter Generation	JGe				

Notes

1. Minimum average optical power at which the BER is less than 1 x 10E-10. Measured with a 2^{23}-1 NRZ PRBS as recommended by ANSI T1E1.2, SONET OC-12, and ITU G.957
2. An increase in optical power above the specified level will cause the SIGNAL DETECT from a LO state to a HI state.
3. A decrease in optical power below the specified level will cause the SIGNAL DETECT from a HI state to a LO state.
4. PECL 10K compatible. Load is 50 Ω into V_{CC}–2 V. Measured under DC conditions at 25°C. For dynamic measurements a tolerance of 50 mV should be added, V_{CC}=5 V.
5. PECL compatible. A high level on this output shows that an optical signal is applied to the optical input.
6. According to ITU G. 958 and 825. Details to be specified.

PIN Description 2x9 Pin Row

Pin Name		Level	Pin#	Description
TxDis	Tx Enable	TTL-Input active high	12	A rising slope switches the Laser off. High >2.0 ; Low <0.8
SD	RX Signal Detect	PECL-Output active high	4	A high level on this output shows that an optical signal is applied to the optical input.
Tx Alm (optional)	Tx+2dB Alarm	TTL Output active high	11	A high level on this output indicates an increase in optical operating power output of+2 dB.
Pwr Mon*	Power Monitor	Analog Voltage	10	This output shows an analog voltage which is proportional to the light output. This output can be used for Laser safety functions. Output Voltage Vmon=2.0±0.2 V, Source Resistance. Rs=100 kW
Bias Mon	Bias Monitor 	Analog Voltage Bias Mon + Bias Mon –	 13 14	This output shows an analog voltage which is proportional to the laser bias current. Use this output to check proper laser operation and for end of life indications. Limit: Bias Current Ibias <60 mA
RxD	Rx Output Data	PECL Output	2	Receiver output data..
RxDn			3	Inverted receiver output data
TxD	Tx Input Data	PECL Input	8	Transmitter input data
TxDn			7	Inverted transmitter input data
RxVee	Tx Ground	Power Supply	1	Negative power supply, normally ground
TxVee	Tx Ground		9	
RxVcc	Rx +5 V		5	Positve power supply, +5V
TxVcc	Tx +5 V		6	
RxCLK	Clock Output	PECL Output	15	Receiver Clock Output
	Clock Output Not		16	Inverted Receiver Clock Output
Lock Det. (optional)	Lock Detect	TTL Output	17	A high level shows PLL has locked to signal
NC			18	Pins are not connected

LASER SAFETY

This single mode ATM transceiver is a Class 1 laser product. It complies with IEC 825-1 and FDA 21 CFR 1040.10 and 1040.11. The transceiver must be operated under recommended operating conditions.

Caution
The use of optical instruments with this product will increase eye hazard!

General Restrictions

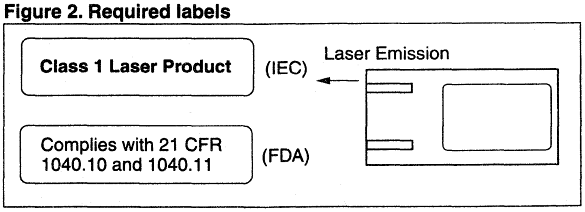
Classification is only valid if the module is operated within the specified temperature and voltage limits. The system using the module must provide power supply protection that guarantees that the system power source will cease to provide power if the maximum recommended operation limit or more is detected on the +5V at the power source. The case temperature of the module must be in the temperature range given in the recommended operating limits. These limits guarantee the laser safety.

Usage Restrictions

The optical ports of the modules shall be terminated with an optical connector or with a dustplug.

Note
Failure to adhere to the above restrictions could result in a modification that is considered an act of "manufacturing," and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration (ref. 21 CFR 1040.10 (i)).

Figure 2. Required labels

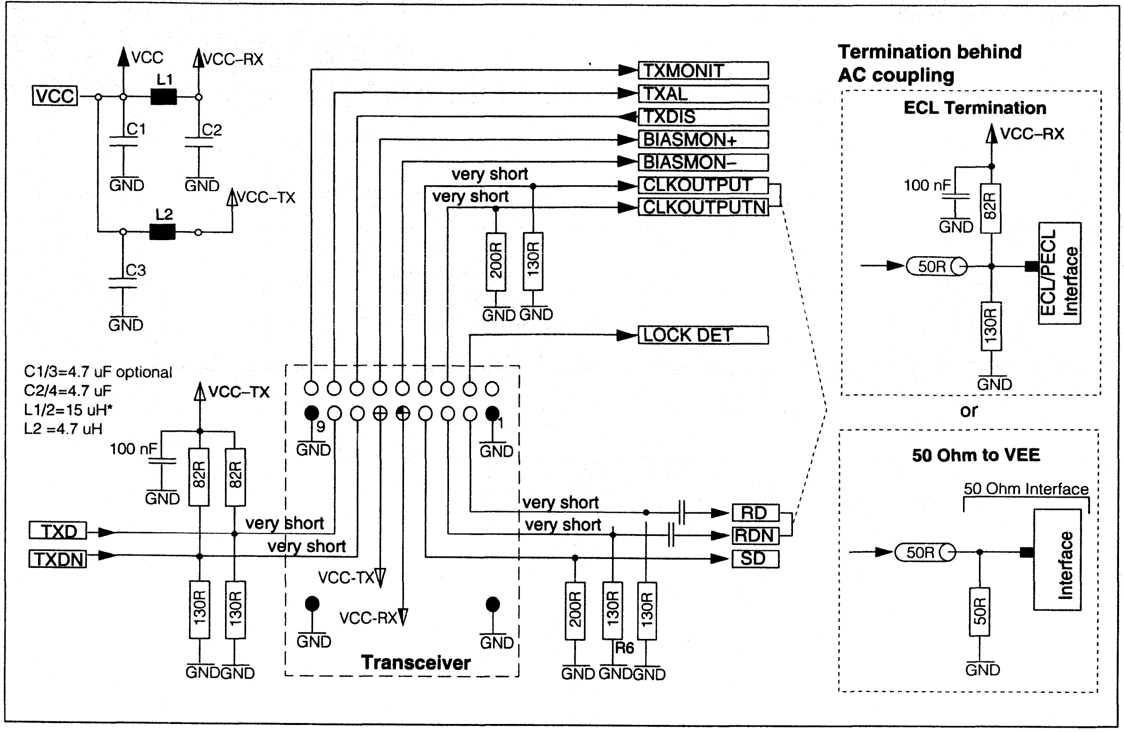


Additional Information

Laser Data

Wavelength	1300 nm
Total output power (as defined by IEC: 50 mm aperture at 10 cm distance)	µW
Total output power (as defined by FDA: 7 mm aperture at 20 cm distance)	600 µW
Beam divergence	4°

APPLICATION NOTE FOR 2X9 PIN ROW TRANSCEIVER



* Recommended choke is Siemens Matsushita B78108-S1153-K or B78148-S1153-K (Q_{min}=60, max. DC resistance =0.6 Ohm).

The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module VCC-RX/VCC-TX.

A GND plane under the module is required for good EMI and sensitivity performance. Studs must be connected to this GND plane.

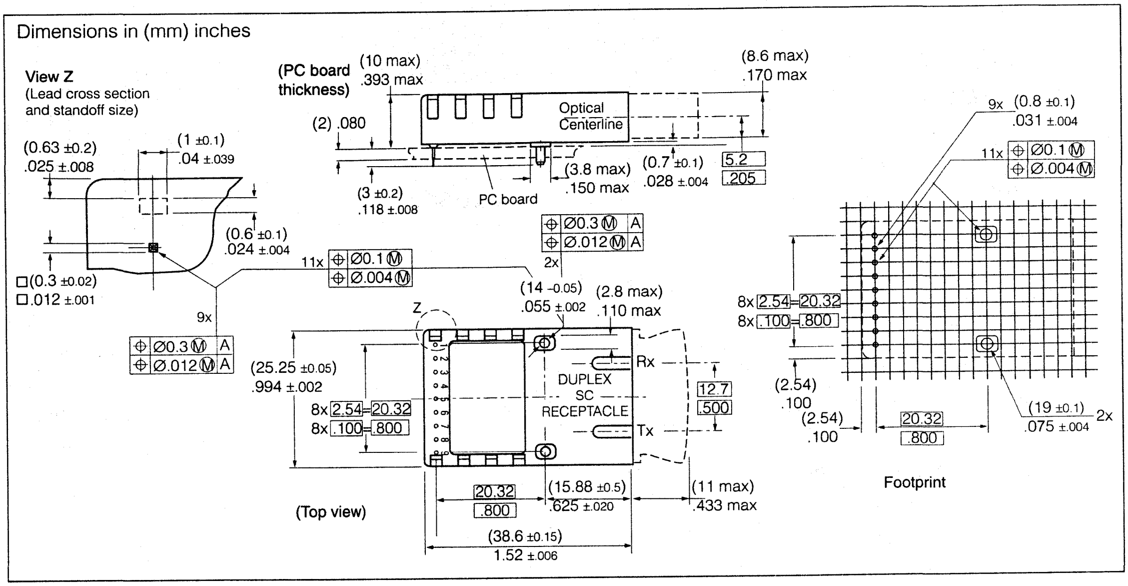
The transceiver contains an automatic shutdown circuit. Reset is only possible when power is turned off, then on again (VCCTX=0V), or by disabling the transmitter with TxDIS and enabling it after at least 500ms (TBD).

The receiver data and clock signals should be terminated with 50 Ohms at the far end. 200 Ohm terminations should be placed very close to the receiver data and clock pins in combination with AC coupling for the following interface circuitries, which can be 50 Ohm devices or ECL circuitries.

SIEMENS

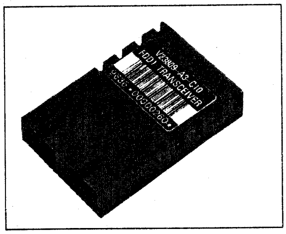
11 dB V23809-A3-C10
7 dB V23809-A3-C11

Multimode 1300 nm LED Fast Ethernet/FDDI 130 MBd Transceiver



FEATURES

- Fully compliant with all major existing standards
- Compact integrated transceiver unit with duplex SC receptacle
- Single power supply with 3.0 V to 5.5 V range
- Extremely low power consumption < 0.7 W at 3.3 V
- Excellent EMI performance
- PECL 100K compatible differential inputs and outputs
- System is optimized for 62.5/50 µm graded index fiber
- Industry standard multisource footprint
- Very low profile for high slot density
- Wave solderable and washable with process plug
- Test board available
- UL-94 V-0 certified
- ESD Class 2, per MIL-STD 883 Method 3015
- Compliant with FCC (Class B) and EN 55022
- For distances of up to 2 km



APPLICATIONS

- Fast Ethernet
- LCF-FDDI short links (500 m)
- FDDI (Backbone, 2.000 m and more)
- High speed computer links
- Local area networks
- High definition digital television
- Switching systems

Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation (PD)
5 V .... 1 W
3.3 V .... 0.7 W
Supply voltage (V_{CC}–V_{EE}) .... –0.5 to 7 V
Data Input Levels (V_{IN}) PECL .... V_{EE}–V_{CC} V
Differential Data Input Voltage (ΔV_{IN}) .... 3 V
Operating Case Temperature (T_{case}) .... 0 to 85°C
Storage Ambient temperature (T_{stg}) .... –40°C to 85°C
Humidity/temperature Test Condition(R_H) .... 85/85%°C
Soldering Conditions Temp/Time
(T_{sold}) MIL-STD 883C, Method 2003 .... 270/10°C/s
ESD Resistance, all pins to V_{EE}, Human Body (ESD) 1.5kV

DESCRIPTION

This data sheet describes the Siemens FDDI/Fast Ethernet Transceiver, which belongs to the Siemens Multistandard Transceiver Family. It is fully compliant with the current Fiber Distributed Data Interface (FDDI) Low Cost Fiber Physical Layer Medium Dependent (LCF-PMD) draft standard [1] and the FDDI PMD standard [2].

FDDI is a Dual Token Ring standard developed in the U.S. by the Accredited National Standards Committee(ANSC) X3T9, within the Technical Committee X3T9.5. It is applied to the local area networks of stations transferring data at 100 Mbits/s with a 125 MBaud transmission rate. LCF FDDI is specially developed for short distance applications of up to 500 m (Fiber to the Desk) as compared to 2 km for backbone applications.

Fast Ethernet is being developed because of the higher bandwidth need in local area networking, based on the proven effectiveness of millions of installed Ethernet systems.

The Siemens low cost multistandard transceiver is a single unit comprised of a transmitter, a receiver and an SC receptacle. This frees the customer from many alignment and PC board layout concerns. The modules are designed for low cost applications.

The inputs/outputs are PECL compatible and the unit operates from 3.0 V to 5.5 V power supply. As an option, the data output stages can be switched to static levels during absence of light as indicated by the Signal Detect function.It can be directly interfaced with available chipsets.

The excellent performance of the Siemens Multistandard Transceiver Family is the result of long term experience. The reliability of our modules is proven by high volume production.

1) FDDI Token Ring, Low Cost Fiber Physical Layer Medium Dependent (LCF-PMD) ANSI X3T9.5 / 92 LCF-PMD / Proposed Rev. 1.3, September 1, 1992. Draft Proposed American National Standard

2) FDDI Token Ring, Physical Layer Medium Dependent (PMD) ANSI X3.166-1990 American National Standard; ISO/IEC 9314-3: 1990

Recommended Operating Conditions

Parameter	Sym.	Min.	Typ.	Max.	Units
Ambient Temperature	T_C	0		70	°C
Power Supply Voltage	V_{CC}–V_{ee}	3		5.5	V
Supply Current 3.3 V	I_{CC}			190	mA
Supply Current 5 V[1]				210	
Transmitter					
Data Input High Voltage	V_{IH}–V_{CC}	–1165		–880	mV
Data Input Low Voltage	V_{IL}–V_{CC}	–1810		–1475	
Threshold Voltage	V_{bb}–V_{CC}	–1420		–1240	
Input Data, Rise/Fall Time, 20–80%	t_R, t_F	0.4		1.3	ns
Data High Time[2]	t_{on}			1000	
Receiver					
Output Current	I_o			25	mA
Input duty Cycle Distortion	t_{DCD}			1.0	ns
Input Data Dependent Jitter	t_{DDj}				
Input Random Jitter	t_{Rj}			0.76	
Input Center Wavelength	l_C	1260		1380	nm
Electrical Output Load[3]	R_L		50		Ω

Notes:

1. For V_{CC}–V_{EE} (min.,max.) 50% duty cycle. The supply current (Icc2 + Icc3) does not include the load drive current (Icc1). Add max. 45mA for the three outputs. Load is 50 Ω into V_{CC} -2V
2. To maintain good LED reliability, the device should not be held in the ON-state for more than the specified time. Normal operation should be done with 50% duty cycle
3. To achieve proper PECL output levels the 50 Ω termination should be done to V_{CC} -2V. For correct termination see the application note,

Reliability (Qualification Results)

Test Temperature (HTB)	85°C / 358K
Reference Temperature	25°C / 298K
Duration of HTB Test	> 5000 hrs
Activation Energy	0.7 eV
Confidence Level	60 %
Number of tested modules	> 120

Transmitter Electro-Optical Characteristics under recommended operation conditions

Transmitter	Sym.	Min.	Typ.	Max.	Units
Data Rate	DR			13	MBaud
Launched Power (Average) into 62.5 µm Fiber for –A3–C11(1, 4)	P_O	–22	–18	–14	dBm
Launched Power (Average) into 62.5 µm Fiber for –A3–C10(1, 4)		–20	–16		
Center Wavelength(2, 4)	l_C	1270		1380	nm
Spectral Width (FWHM)–A3–C11(3, 4)	$\Delta\lambda$			250	
Spectral Width (FWHM)–A3–C10(3, 4)				200	
Output Time, Rise/Fall– A3–C10, 10–90%(5)	t_R	0.6		3	ns
Output Time, Rise/Fall– A3–C11, 10–90%(5)	t_F			4	
Temperature Coefficient, Optical Optput Power	TCp			0.03	dB/°C
Extinction Ratio (dynamic)(4, 6)	ER			10	%
Optical Power Low(7)	P_{TD}			–45	dBm
Duty Cycle Distortion(8, 9)	t_{DCD}			1	ns
Data Dependent Jitter(8, 10)	t_{DDJ}			0.6	
Random Jitter(8, 11)	t_{RJ}			0.76	

Notes

1. Measured at the end of 5 meters of 62.5/125/0.275 graded index fiber using calibrated power meter and a precision test ferrule. Cladding modes are removed. Values valid for EOL and worst-case temperature.
2. Center wavelength is defined as the midpoint between the two 50% levels of the optical spectrum of the LED.
3. Spectral width (full width, half max.) is defined as the difference between 50% levels of the optical spectrum of the LED.
4. The input data pattern is the Halt Line State (12.5 MHz square wave).
5. 10 to 90% levels. Measured using the Halt Line State 12.5 MHz square wave pattern with an optoelectronic measurement system (detector and oscilloscope) having 3 dB bandwidth ranging from less than 0.1MHz to more than 750 MHz.
6. Extinction Ratio is defined as PL/PH x 100%. Measurement system as in Note 5.
7. Optical Power Low is the output power level when a steady-state low data pattern (FDDI Quiet Line State) is used to drive the transmitter. Value valid <1 ms after input low.
8. Test method as for FDDI-PMD. Jitter values are peak-to-peak.
9. DCD is defined as 0.5 [(width of wider state)–(width of narrower state)]. It is measured with stream of Idle Symbols (62.5 MHz square wave).
10. DDJ is measured with the same pattern as for FDDI-PMD.
11. RJ is measured with the Halt Line State (12.5 MHz square wave).

Receiver Electro-Optical Characteristics

Receiver	Sym.	Min.	Typ.	Max.	Units
Data Rate	DR	5		135	MBaud
Sensitivity (Average Power)–A3–C11(1)	P_{IN}		–33	–29	dBm
Sensitivity (Average Power) Center–A3–C11(2)			–35		
Sensitivity (Average Power)–A3–C10(1)			–34	–31	
Sensitivity (Average Power) Center–A3–C10(2)			–36		
Saturation (Average Power)(2)	P_{SAT}	–14	–11		
Duty Cycle Distortion(3, 6)	t_{DCD}			1	ns
Deterministic Jitter(4, 6)	t_{DJ}			1	
Random Jitter(5, 6)	t_{RJ}				
Signal Detect Assert Level(7)	P_{SDA}	–43.5		–30	dBm
Signal Detect Deassert Level(8)	P_{SDD}	–4.5		–31.5	
Signal Detect Hysteresis	$P_{SDA}-P_{SDD}$	1.5			dB
Output LO Voltage(9)	$V_{OL}-V_{CC}$	–1810		–1620	mV
Output HI Voltage(9)	$V_{OH}-V_{CC}$	–1025		–880	
Output Data Rise/Fall Time, 20–80%	t_R, t_F			1.3	ns
Output SD Rise/FallTime, 20–80%		12		40	

Notes

1. For a bit error rate (BER) of less than 1x10E-12 over a receiver eye opening of least 1.5 ns. Measured with a 2^{23}-1 PRBS at 155 MBd.
2. For a BER of less than 1x10E-12. Measured in the center of the eye opening with a 2^{23}-1 PRBS at 155 MBd.
3. Measured at an average optical power level of -20 dBm with a 62.5 MHz square wave.
4. Measured at an average optical power level of -20 dBm.
5. Measured at -33 dBm average power.
6. All jitter values are peak-to-peak.
7. An increase in optical power through the specified level will cause the SIGNAL detect output to switch from a LO state to a HI state.
8. A decrease in optical power through the specified level will cause the SIGNAL detect output to switch from a HI state to a LO state.
9. ECL 100K compatible. Load is 50 Ω into V_{CC}–2 V. Measured under DC conditions. For dynamic measurements a tolerance of 50 mV should be added for V_{CC}=5 V.

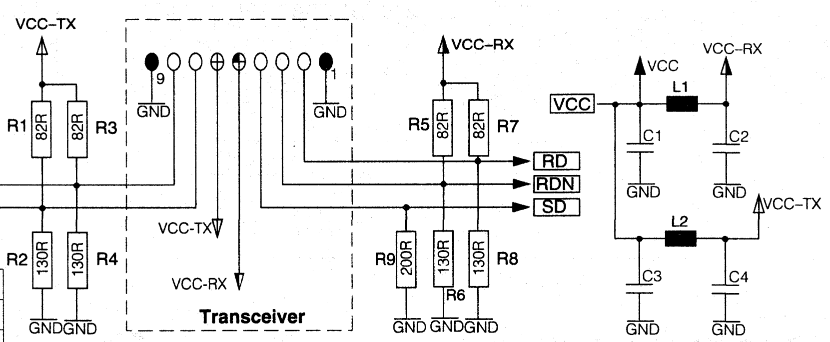
PIN Description

Pin Name		Level/Logic	Pin#	Description
R_xV_{ee}	Rx Ground	Power Supply	1	Negative power supply, normally ground
RD	Rx Output Data	PECL Output	2	Receiver output data
RDn			3	Inverted receiver output data
RxSD	RX Signal Detect	PECL-Output active high	4	High level on this output shows there is an optical signal.
R_xV_{CC}	Rx +5 V	Power Supply	5	Positive power supply, +5V
T_xV_{CC}	Tx +5 V		6	
TxDn	Tx Input Data	PECL Input	7	Inverted transmitter input data
TxD			8	Transmitter input data
T_xV_{ee}	Tx Ground	Power Supply	9	Negative power supply, normally ground
Case	Support	Not connected	S1/S2	Support stud, not connected

APPLICATION NOTE FOR 1X9 PIN ROW TRANSCEIVER

Figure 1. Schematic

C1/3=4700 nF (optional)
C2/4=4700 nF
L1/2=15000 nH
(L2 is optional)



R in Ohm	5 V	4 V	3.3 V
R1/3	82	100	127
R2/4	130	100	83
R5/7	82	100	127
R6/8	130	100	83

R9=200 Ohm

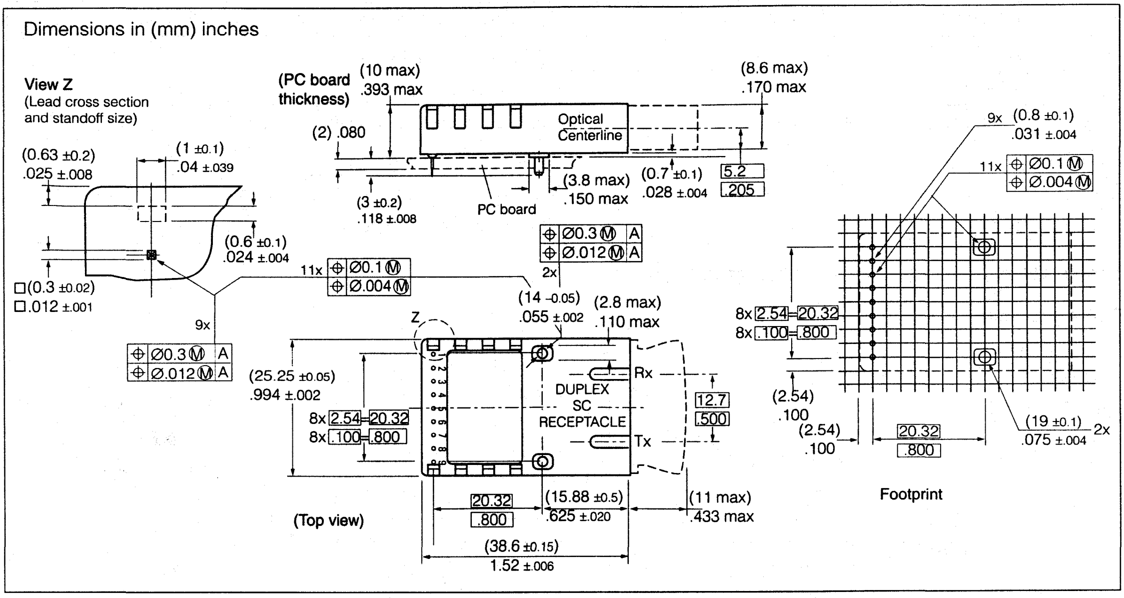
The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module VCC-RX/VCC-TX.

A GND plane under the module is recommended for good EMI and sensitivity performance.

SIEMENS

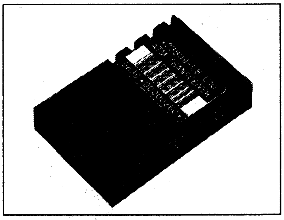
10 dB V23809-C8-C10
8 dB V23809-C8-C11

Multimode 1300 nm LED ATM 155/194 MBd Transceiver



FEATURES

- Fully compliant with all major standards
- Compact integrated transceiver unit with duplex SC receptacle
- Single power supply with 3.0 V to 5.5 V range
- Extremely low power consumption < 0.7 W at 3.3 V
- Excellent EMI performance
- PECL 100K compatible differential inputs and outputs
- System optimized for 62.5/50 µm graded index fiber
- Industry standard multisource footprint
- Very low profile for high slot density
- Wave solderable and washable with process plug
- Test board available
- UL-94 V-0 certified
- ESD Class 2 per MIL-STD 883 Method 3015
- Compliant with FCC (Class B) and EN 55022
- For distances of up to 2 km



APPLICATIONS

- ATM switches/bridges/ routers
- High speed computer links
- Local area networks
- High definition digital television
- Switching systems

Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation (PD)
- 5 V .... 1 W
- 3.3 V .... 0.7 W

Supply Voltage (V_{CC}–V_{EE}) .... –0.5 to 7 V
Data Input Levels (V_{IN}) PECL .... V_{EE}–V_{CC} V
Differential Data Input Voltage .... 3 V
Operating Case Temperature .... 0 to 85°C
Storage Ambient temperature .... –40°C to 85°C
Soldering Conditions Temp/Time
(T_{sold}) MIL-STD 883C, Method 2003 .... 270/10°C/s.
ESD Resistance (all pins to V_{EE}, Human Body) .... 1.5 kV

DESCRIPTION

This data sheet describes the Siemens ATM Transceiver, which belongs to the Siemens Multistandard Transceiver Family. It is fully compliant with the proposed Asynchronous Transfer Mode ATM OC-3 proposed standard.

ATM is being developed because of the need for multimedia applications, including real-time transmission. The data rate is scalable and the ATM protocol is the basis of the broadband public networks being standardized in the International Telegraph and Telephone Consultative Committee (CCITT). ATM can also be used in local private applications.

The Siemens low cost ATM transceiver is a single unit comprised of a transmitter, a receiver and an SC receptacle. This frees the customer from many alignment and PC board layout concerns. The modules are designed for low cost applications.

The inputs/outputs are PECL compatible and the unit operates from 3.0 V to 5.5 V power supply. As an option, the data output stages can be switched to static levels during absence of light, as indicated by the Signal Detect function. It can be directly interfaced with available chipsets.

The excellent performance of the Siemens Multistandard Transceiver Family is the result of long term experience. The reliability of our modules is proven by high volume production.

Recommended Operating Conditions

Parameter	Sym.	Min.	Typ.	Max.	Units
Ambient Temperature	T_C	0		70	°C
Power Supply Voltage	$V_{CC}-V_{EE}$	3		5.5	V
Supply Current 3.3 V	I_{CC}			190	mA
Supply Current 5 V(1)				210	
Transmitter					
Data Input High Voltage	$V_{IH}-V_{CC}$	–1165		–880	mV
Data Input Low Voltage	$V_{IL}-V_{CC}$	–1810		–1475	
Threshold Voltage	$V_{bb}-V_{CC}$	–1420		–1240	
Input Data Rise/Fall, 20–80%	t_R, t_F	0.4		1.3	ns
Data High Time(2)	t_{on}			1000	
Receiver					
Output Current	I_O			25	mA
Input duty Cycle Distortion	t_{DCD}			1.0	ns
Input Data Dependent Jitter	t_{DDj}				
Input Random Jitter	t_{Rj}			0.76	
Input Center Wavelength	l_C	1260		1380	nm
Electrical Output Load(3)	R_L		50		Ω

Notes:

1. For Vcc-Vee (min., max.) 50% duty cycle. The supply current (Icc2 + Icc3) does not include the load drive current (Icc1). Add max. 45 mA for the three outputs. Load is 50 Ω into V_{CC} –2V
2. To maintain good LED reliability, the device should not be held in the ON-state for more than the specified time. Normal operation should be done with 50% duty cycle
3. To achieve proper PECL output levels the 50 Ω termination should be done to V_{CC} –V. For correct termination see the application note.

Reliability (Qualification Results)

Test Temperature (HTB)	85°C / 358K
Reference Temperature	25°C / 298K
Duration of HTB Test	>5000 hrs
Activation Energy	0.7 eV
Confidence Level	60 %
Number of tested modules	>120

Fiber Optic Data Links 9

Transmitter Electro-Optical Characteristics

Transmitter	Sym.	Min.	Typ.	Max.	Units
Data Rate	DR			170	MBaud
Launched Power (Average) into 62.5μm Fiber for –C8–C10[1, 4]	P_O	–20	–16	–14	dBm
Launched Power (Average) into 62.5μm Fiber for –C8–C11[1, 4]		–22	–17		
Center Wavelength[2, 4]	λC	1270		1360	nm
Spectral Width (FWHM)[3, 4]	Δλ			170	
Output Rise/Fall Time, 10–90%[4, 5]	t_R, t_F	0.6		2.5	ns
Temperature Coefficient of Optical Optput Power	TCp			0.03	dB/°C
Extinction Ratio (dynamic)[4, 6]	ER			10	%
Duty Cycle Distortion[7]	t_{DCD}			0.6	ns
Data Dependent Jitter[7]	t_{DDJ}			0.3	
Random Jitter[7]	t_{RJ}			0.6	

Notes

1. Measured at the end of 5 meters of 62.5/125/0.275 graded index fiber using calibrated power meter and a precision test ferrule. Cladding modes are removed. Values valid for EOL and worst-case temperature.
2. Center wavelength is defined as the midpoint between the two 50% levels of the optical spectrum of the LED.
3. Spectral width (full width, half max) is defined as the difference between 50% levels of the optical spectrum of the LED.
4. The input data pattern is a 12.5 MHz square wave pattern.
5. 10 to 90% levels. Measured using the 12.5 MHz square wave pattern with an optoelectronic measurement system (detector and oscilloscope) having 3 dB bandwidth ranging from less than 0.1 MHz to more than 750 MHz.
6. Extinction Ratio is defined as PL/PH x 100%. Measurement system as in Note 5.
7. The test method is not yet mentioned in the ATM standard draft. The FDDI test routines apply as long as these are not changed.

Receiver Electro-Optical Characteristics

Receiver	Sym.	Min.	Typ.	Max.	Units
Data Rate	Dr	5		170	MBaud
Sensitivity (Average Power)[1]	P_{IN}		–32	–30	dBm
Sensitivity (Average Power) Center[2]			–35.5		
Saturation (Average Power)[2]	P_{SAT}	–14	–11		
Duty Cycle Distortion[3, 6]	t_{DCD}			1	ns
Deterministic Jitter[4, 6]	t_{DJ}			1	
Random Jitter[5, 6]	t_{RJ}				
Signal Detect Assert Level[7]	P_{SDA}	–42.5		–30	dBm
Signal Detect Deassert Level[8]	P_{SDD}	–45		–31.5	
Signal Detect Hysteresis	P_{SDA}– P_{SDD}	1.5			dB
Output LO Voltage[9]	V_{OL}– V_{CC}	–1810		–1620	mV
Output HI Voltage[9]	V_{OH}– V_{CC}	–1025		–880	
Output Data Rise/Fall Time, 20–80%	t_R, t_F			1.3	ns
Output SD Rise/Fall Time, 20–80%				40	

Notes

1. For a bit error rate (BER) of less than 1x10E-12 over a receiver eye opening of least 1.5 ns. Measured with a 2^7-1 PRBS at 194 MBd.
2. For a BER of less than 1x10E-12. Measured in the center of the eye opening with a 2^7-1 PRBS at 194 MBaud.
3. Measured at an average optical power level of -20 dBm with a 62.5 MHz square wave.
4. Measured at an average optical power level of -20 dBm .
5. Measured at -33 dBm average power.
6. All jitter values are peak-to-peak. RX output jitter requirements are not considered in the ATM standard draft. In general the same requirements as for FDDI are met.
7. An increase in optical power through the specified level will cause the SIGNAL detect output to switch from a LO state to a HI state.
8. A decrease in optical power through the specified level will cause the SIGNAL detect output to switch from a HI state to a LO state.
9. ECL 100K compatible. Load is 50 Ω into V_{CC} –2V. Measured under DC conditions. For dynamic measurements a tolerance of 50 mV should be added for V_{CC}=5 V.

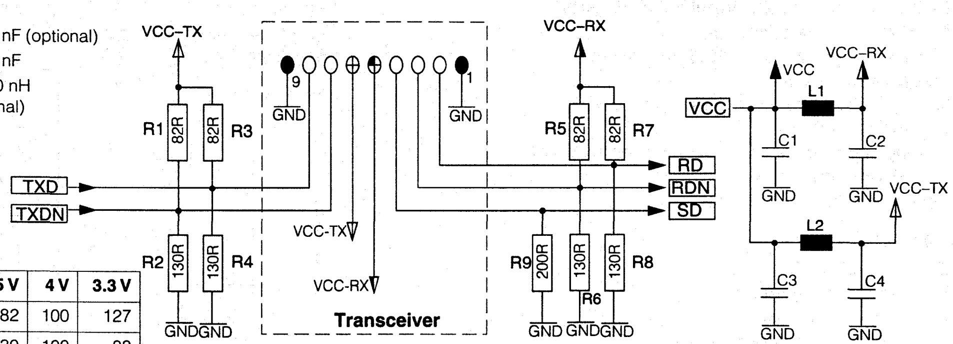
PIN Description

Pin Name		Level/Logic	Pin#	Description
R_xV_{EE}	Rx Ground	Power Supply	1	Negative power supply, normally ground
RD	Rx Output Data	PECL Output	2	Receiver output data
RDn			3	Inverted receiver output data
RxSD	RX Signal Detect	PECL-Output active high	4	High level on this output shows there is an optical signal.
R_xV_{CC}	Rx +5 V	Power Supply	5	Positive power supply, +5V
T_xV_{CC}	Tx +5 V		6	
TxDn	Tx Input Data	PECL Input	7	Inverted transmitter input data
TxD			8	Transmitter input data
T_xV_{EE}	Tx Ground	Power Supply	9	Negative power supply, normally ground
Case	Support	Not Connected	S1/S2	Support stud, not connected

APPLICATION NOTE FOR 1X9 PIN ROW TRANSCEIVER

Figure 1. Schematic

C1/3=4700 nF (optional)
C2/4=4700 nF
L1/2=15000 nH
(L2 is optional)



R in Ohm	5 V	4 V	3.3 V
R1/3	82	100	127
R2/4	130	100	83
R5/7	82	100	127
R6/8	130	100	83

R9=200 Ohm

The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module VCC-RX/VCC-TX.

A GND plane under the module is recommended for good EMI and sensitivity performance.

SIEMENS

SHORT PIN V23809-E1-E16
LONG PIN V23809-E1-E17
1300 nm ESCON® Serial Transceiver

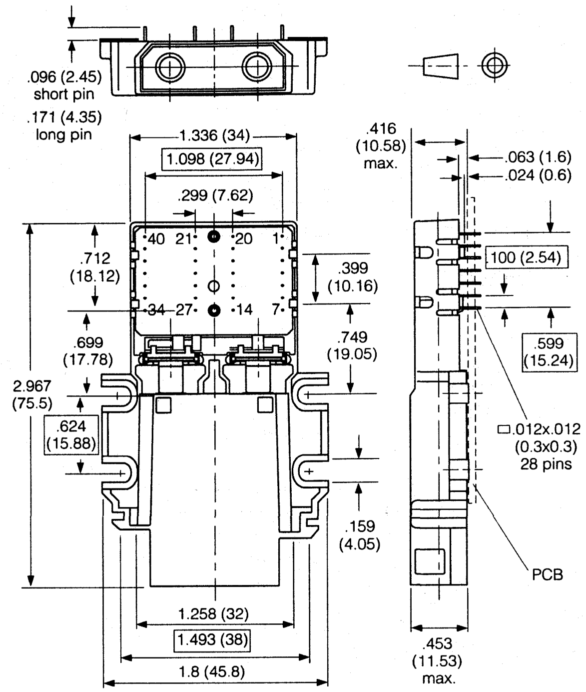
Preliminary Data Sheet

FEATURES
- Complies with ESCON and SBCON standards
- Transceiver includes transmitter, receiver and ESCON/SBCON receptacle
- Transceiver mates keyed ESCON/SBCON connector
- Data rates for ESCON/SBCON applications from 10 to 200 MBaud
- Data rates for individual applications from 10 to 320 MBaud
- Transmission distance of 3 Km and more
- Single power supply of 3.0 V to 5.5 V
- Extremely low power consumption <0.7 W at 3.3 V
- PECL 100K differential inputs and outputs
- Excellent EMI performance
- System is optimized for 62.5 and 50 μm graded index fiber
- 0.7" spacing between optical interface of transmitter and receiver
- Through-hole technology with either 2.45 mm or 4.35 mm pin length
- Low profile for high slot density

APPLICATIONS
- ESCON architecture
- High speed computer links
- Local area networks
- High definition/digital television
- Switching systems
- Control systems

ESCON® is a registered trademark of IBM.

Dimensions in inches (mm)



Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Power Dissipation (PD)[1]
- 5 V .... 1 W
- 3.3 V .... 0.7 W

Supply voltage (V_{CC}–V_{EE}) .... –0.5 V to7 V

Data Input Levels (PECL) (V_{IN}) .... V_{EE} to V_{CC}

Differential Data Input Voltage (ΔV_{IN}) .... 3 V

Operating Case Temperature (Tcase) .... –25 to 85°C

Storage Ambient temperature(T_{stg}) .... –40°C to 100°C

Humidity/Temperature Test Condition (R_H) .... 85 %/°C

Lifetest Condition (Operating) (Tamb/life) .... °C/h

Soldering Conditions, Temp/Time
(MIL-STD 883C, Method 2003) .... 270/10°C/s

ESD Resistance (all pins to V_{EE}, Human Body) (ESD)
(MIL-STD 883C, Method 3015) .... 1.5 kV

Note:

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle.

DESCRIPTION

The Siemens ESCON/SBCON optical devices, along with the ESCON / SBCON optical duplex connector, are best suited for high speed fiber optic duplex transmission systems operating at a wavelength of 1300nm. The system is fully compatible with the IBM ESCON standard and the upcoming SBCON standard of ANSI. It includes a transmitter and a receiver for data rates of up to 320MBaud. A non-dissipative plastic receptacle matches the ESCON/SBCON duplex connector.

The inputs/outputs are PECL compatible and the unit operates on a single power supply from 3.0 to 5.5V. As an option, the data output stages can be switched to static low levels during absence of light as indicated by the Signal Detect function.

The optical interface of transmitter and receiver have standard 0.7" spacing. The receptacle and connector have been keyed in order to prevent reverse insertion of the connector into the receptacle. After proper insertion the connector is securely held by a snap-in lock mechanism.

The transmitter converts a serial electrical PECL input signal with data rates of up to 320MBaud to an optical serial signal. The receiver converts this signal back to an electrical serial signal, depending on the detected optical rate.

Recommended Operating Conditions

Parameter	Sym.	Min.	Typ.	Max.	Units
Ambient Temperature	T_C	0		70	°C
Power Supply Voltage	$V_{CC}-V_{ee}$	3		5.5	V
Supply Current 3.3 V(1)	I_{CC}			190	mA
Supply Current 5 V(1)				210	
Transmitter					
Data Input High Voltage	$V_{IH}-V_{CC}$	–1165		–880	mV
Data Input Low Voltage	$V_{IL}-V_{CC}$	–1810		–1475	
Threshold Voltage	$V_{bb}-V_{CC}$	–1420		–1240	
Input Data Rise/Fall Time, 20–80%	t_R, t_F	0.4		1.3	ns
Data High Time(2)	t_{on}			1000	
Receiver					
Output Center	I_O			25	mA
Input Center Wavelength	λ_C	1260		1380	nm
Electrical Output Load(3)	R_L		50	1000	Ω

Notes

1. For V_{CC} –V_{EE} (min.,max.) 50% duty cycle.
2. To maintain good LED reliability the device should not be held in the ON-state for more than the specified time. Normal operation should be done with 50% duty cycle.
3. To achieve proper PECL output levels the 50 Ω termination should be done to V –2 V.

Reliability (Qualification Results)

Test Temperature (HTB)	115°C/388 K
Reference Temperature	35°C/308 K
Duration of HTB Test	>2000 hrs
Activation Energy	0.7 eV
confidencel Level	60%
Number of Tested Modules	> 100

Transmitter Electro-Optical Characteristics
(Values in parentheses are for 320 MBd)

Transmitter	Sym.	Min.	Typ.	Max.	Units
Data Rate	DR	0		200 (320)	MBaud
Supply Current 3.3 V(4)	I_{CC}		100		
Supply Current 5 V(4)			130		
Launched Power (Ave.) BOL into 62.5 μm Fiber (5, 6, 7)	P_O	–21 (–22)	–16.5	–14	dBm
Launched Power (Ave.) EOL into 62.5 μm Fiber (5, 6, 7, 10)		–22 (–23)			
Center Wavelength(8)	λ_C	1285		1355	nm
Spectral Width (FWHM)(9)	$\sigma\lambda$			160	
Temperature Coefficient, Optical Output Power	TCp			0.03	dB/°C
Output Rise/Fall Time, 20–80%	t_R, t_F		1	1.7 (2)	ns
Deterministic Jitter(11)	J_d		0.6	0.8	
Random Jitter(12)	J_r			0.06	
Extinction Ratio (dynamic)(13)	ER		–16	–13	dB

Notes

4. Transmitter operating at 200 MBaud and 50% duty cycle.
5. Measured at the end of 1 meter fiber, cladding modes removed at a data rate of between 50 and 200 MBaud, 50% duty cycle.
6. Po [dBm]=10 log (Po/1 mW).
7. Po (BOL) >–20 dBm and Po (EOL) >–21.5dBm at T_{case}=60°C.
8. Measured at T_{case}=60°C.
9. Full width, half magnitude of peak wavelength.
10. Over 105 hours lifetime at T_{amb}=35°C.
11. Deterministic Jitter measured at 200MBaud with Jitter Test Pattern shown in Figure 3. In the test pattern are five positive and five negative transitions. Measure the time of the 50% crossing of all 10 transitions. The time of each crossing is then compared to the mean expected time of the crossing. The DJ is the range of the timing variations.
12. RMS value is measured with 1010 pattern at 200 MBaud. Peak-to-peak value is determined as RMS multiplied by 14 for BER 1E-12.
13. Extinction ratio is the logarithmic measure of the optical power in the OFF state (POFF) to twice the average power (P0): ER=10 log [(2xP0)/POFF]; optical power measured in mW or E=ΩP0+3 dBΩ –POFF; optical power measured in dBm.

Receiver Electro-Optical Characteristics

(values in parentheses are for 320 MBd)

Receiver	Symbol	Min.	Typ.	Max.	Units
Data Rate	Dr	10		200 (320)	MBaud
Supply current (w/o ECL outputs)(1)	I_{CC}		80	90	mA
Sensitivity (Average Power) BOL(2, 3, 4)	P_{IN}	–32.5 (–29)	–35.5		dBm
Sensitivity (Average Power) EOL(2, 3, 4, 5)		–32 (–28.5)	–35		
Saturation (Average Power)	P_{SAT}	–14			
Signal Detect Assert Level(6)	P_{SDA}	–44.5		–36	
Signal Detect Deassert Level(6)	P_{SDD}	–45		–37.5	
Signal Detect Hysteresis	P_{SDA}– P_{SDD}	0.5	1.5	3	dB
Signal Detect Reaction Time	SDreac	3		500	µs
Output LO Voltage(7)	V_{OL}– V_{CC}	–1810		–1620	mV
Output HI Voltage(7)	V_{OH}– V_{CC}	–1025		–880	
Output Data Rise/Fall Time, 20–80%(7)	t_R, t_F	0.5	0.7	1.3	ns
Output SD Rise/Fall Time, 20–80%				40	
Deterministic Jitter (8, 9)	J_d		0.35	0.45	
Random Jitter(10)	J_r			0.15	

Notes

1. For V_{CC} –V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 60 mA for the four outputs. Load is 50 Ω to V_{CC} –2 V.
2. Measured at the end of 1 meter fiber, cladding modes removed at a data rate of between 50 and 200 MBaud, 50% duty cycle.
3. Po [dBm]=10 log (Po [mW])
4. Measured at BER=1E-12, 200 MBaud transmission rate and 50% duty cycle 2^7-1 PRBS pattern, center wavelength between 1200 nm and 1500 nm, fiber type 62.5/125µm/0.29 NA or 50/125 µm/0.2 NA, input optical rise and fall times are 1.2 and 1.5ns (20–80%) respectively.
5. Over 10^5 hours lifetime at T_{amb}=35°C
6. Indicating the presence or absence of optical power at the receiver input. Signal detect at logic "high" when asserted. All powers are average power levels. Pattern 2^7-1 at 200 MBaud.
7. Load is 50 Ω to V_{CC}–2 V. A minimum measurement tolerance of 50mV should be allowed due to dynamic measurement of data outputs.
8. Deterministic Jitter measured at 200 MBaud with Jitter Test Pattern shown in Figure 3. In the test pattern are five positive and five negative transitions. Measure the time of the 50% crossing of all 10 transitions. The time of each crossing is then compared to the mean expected time of the crossing. The DJ is the range of the timing variations.
9. Measured at optical input power level greater than -200 dBm.
10. Largely due to thermal noise. Measured at -33.0 dBm. To convert from specified RMS value to peak-to-peak value (at BER 1E-12) multiply value by 14.

Pin Description for ESCON Serial Transceiver 4x7 Pin Row

Pin#	Pin Name		Level / Logic	Description
1	TxVbb		PECL Input	Threshold voltage for unused input when transmitter driven with single ended input signal
2–7, 14,17,18	TxVee	Tx Ground	Power Supply	Negative TX supply voltage
15,16	TxVcc	Tx +5V	Power Supply	Power supply for TX
19	TxD	Tx Input Data	PECL Input	Transmitter input data
20	TxDn	Tx Input Data	PECL Input	Inverted transmitter input data
21	RxDn	Rx Output Data Inverted	PECL Output	Inverted data output
22	RxD	Rx Output Data	PECL-Output	Data output. A logic high on the pin with a logic low on complementary pin means a high-level of light received
23,25, 34–38	RxVee	Rx Ground	Power Supply	Negative RX supply voltage
24	RxVcc1	Rx +5V	Power Supply	Power supply—receiver buffer & output stages
26,27	RxVcc2	Rx +5V	Power Supply	Power supply preamp & bias—photodiode
39	RxSD	Rx Signal Detect	PECL Output active high	A high level on this output shows an optical signal is applied to the optical input
40	RXSDn	Rx Signal Detect Inverted	PECL Output active low	A low level on this output shows an optical signal is applied to the optical input

Figure 1. Transceiver to jumper Installation

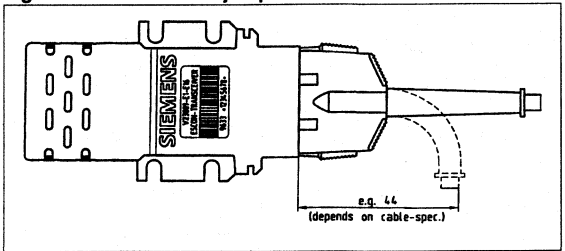


Figure 2. Signal detect threshold and hysteresis

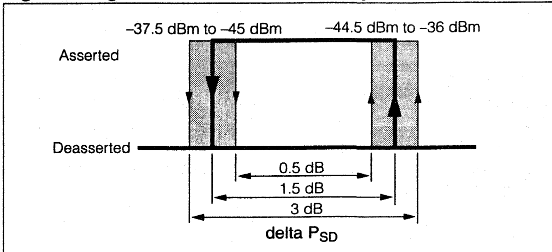
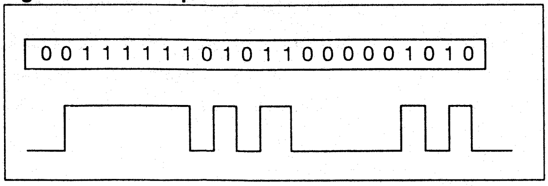


Figure 3. Jitter test pattern



APPLICATION NOTE

Power Supply Filtering

In most of the applications using ESCON 200 MBd optical transceivers additional high speed circuits such as switching power supply, clock oscillator or high speed multiplexer are present on the application board. These often create power supply noise at a high spectral bandwidth caused by very fast transitions in today's chip technology.

The Siemens ESCON Transceiver Family provides superior EMI performance regarding emission and immission of radiation and provides immunity against conductive noise. Some basic recommendations are given in this document to ensure proper functionality in the field.

Receiver Section

For the receiver part of an ESCON transceiver the footprint shows 2 power supply sections:

Vcc1-PIN 24, Vcc2-PIN 26,27 (see dimensional drawing).

Vcc1 is the power supply for the post amplifier and the ECL output stages of the receiver.

Vcc2 supplies more sensitive parts of the receiver.

PIN 26 and 27 are the supply pins for the preamplifier and the bias for the photodiode.

Transmitter Section

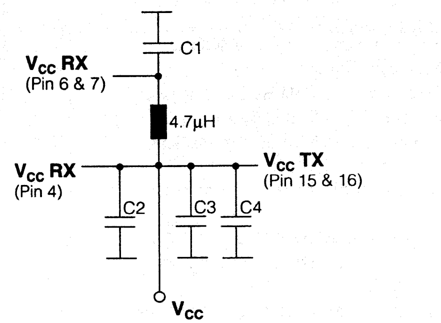
The transmitter consists of only one power supply.

Its LED diode driving current is in the range of 60mA. This is very high compared to the switching currents on the receiver section. For buffering these peaks, external capacitors are recommended. An additional effect of these capacitors will be to reduce ringing on the power supply of the customer's board.

Transceiver Filtering

For the overall functionality, the sensitive stage of the receiver section (Vcc2) must be decoupled from the output stages and from high switching currents on the transmitter section.

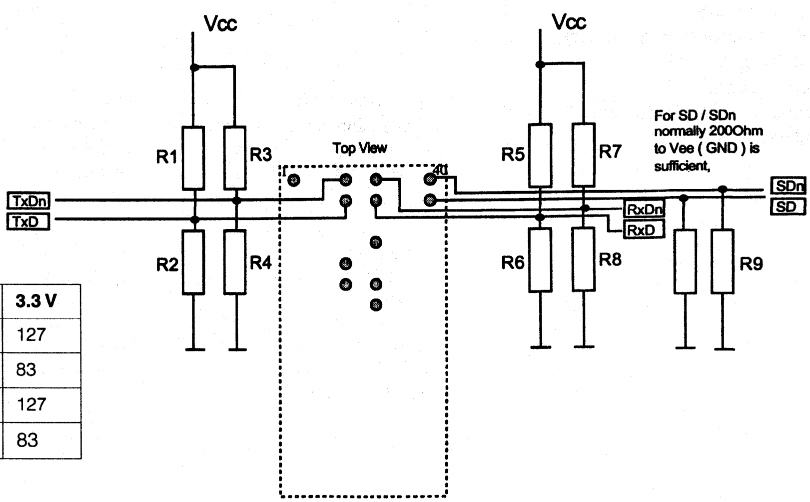
Figure 4. Filtering circuitry



C1, C2, C3: 100 nF   Ceramic Capacitors
C4: 2.2 to 6.8 µF

The use of SMD components is recommended.

In addition, common layout rules such as short connection between capacitors and pins, ground layers etc., should be applied for optimum board design and operation.



R in Ω	5 V	4 V	3.3 V
R1/3	82	100	127
R2/4	130	100	83
R5/7	82	100	127
R6/8	130	100	83

R9=200 Ω

SIEMENS

V23809-E1-E40

1300 nm ESCON® Parallel Transceiver 8B/10B

Preliminary Data Sheet

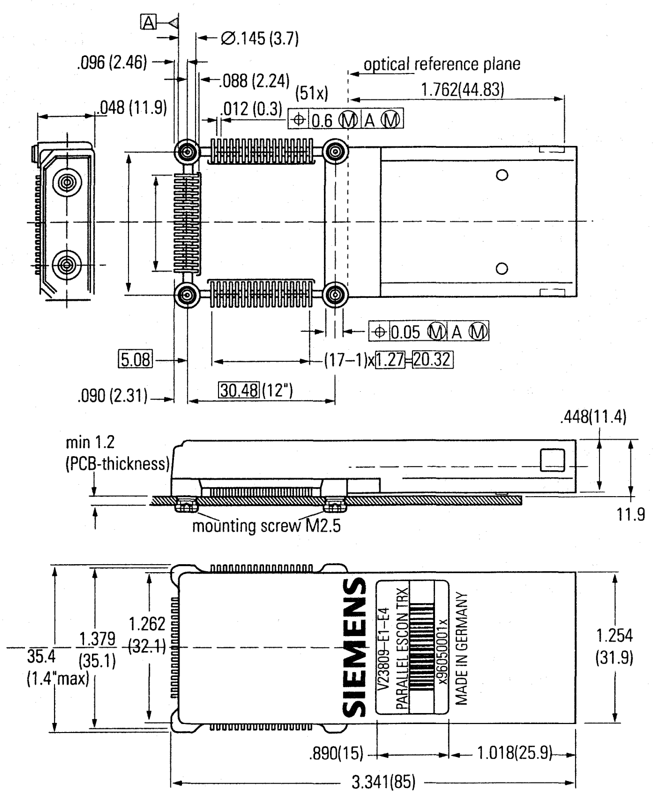
FEATURES

- **Complies with ESCON and SBCON standards**
- **Fully compatible with parallel transceiver V23806-A6-X1**
- **Transceiver includes clock recovery module, P-S /S-P and ESCON/SBCON receptacle**
- **Optional 8B/10B coder/decoder function**
- **SMT component for easy mounting on surface mount PC boards**
- **Transceiver mates keyed ESCON/ SBCON connector**
- **Data rates for ESCON/SBCON applications from 100 to 200 MBaud**
- **Data rates for individual applications from 100 to 300 MBaud**
- **Transmission distance of 3 km and more**
- **Single power supply of 3.0 V to 5.5 V**
- **Extremely low power consumption <2 W at 3.3 V**
- **All inputs and outputs TTL compatible**
- **Excellent EMI performance**
- **System optimized for 62.5 and 50 μm graded index fiber**
- **0.7" spacing between optical interface of transmitter and receiver**
- **Low profile for high slot density**

APPLICATIONS

- **ESCON architecture**
- **High speed computer links**
- **Local area networks**
- **High definition/digital television**
- **Switching systems**
- **Control systems**
- **FC transceiver version with SC duplex shell planned**

Dimensions in inches (mm)



Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Power Dissipation (PD)	2 W
Supply voltage (V_{CC}–V_{EE})	–0.5 V to7 V
Maximum Inqut Voltage (V_{IN})	V_{EE} to V_{CC}
Operating Case Temperature (Tcase)	–25 to 85°C
Humidity/Temperature Test Condition (R_H)	85/85 %/°C
Lifetest Condition (Tamb/life)	115/1000°C/h
Soldering Conditions Temp/Time (T_{sold})	260/10°C/s
ESD Resistance (all pins to V_{EE}, Human Body) (ESD)	1.5 kV
Output Current (I_o)	50 mA

ESCON® is a registered trademark of IBM.

DESCRIPTION

The Siemens ESCON/SBCON optical devices, along with the ESCON/SBCON optical duplex connector, are best suited for high speed fiber optic duplex transmission systems operating at a wavelength of 1300 nm. The system is fully compatible with the IBM ESCON standard and the upcoming SBCON of ANSI. It includes a transmitter and a receiver as well as the clock recovery function and the serial/parallel interfaces. In addition, an 8 B/10 B coder-decoder function can be used optionally.

The ESCON Parallel Transceiver is designed for data rates of up to 300 MBaud. A non-dissipative plastic receptacle matches the ESCON duplex connector.

The inputs/outputs are TTL compatible and the unit operates on a single power supply from 3.0 to 5.5 V.

The optical interface of transmitter and receiver have standard 0.7" spacing. Receptacle and connector have been keyed in order to prevent reverse insertion of the connector into the receptacle. After proper insertion the connector is securely held by a snap-in lock mechanism.

The transmitter converts parallel electrical TTL input signals into an optical serial signal at data rates of between 100 and 300 MBaud. The receiver performs clock recovery on the incoming data stream and converts data to a parallel output.

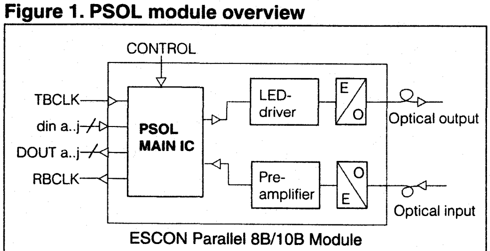
New Built-in Functions

The ESCON Parallel Transceiver 8B/10B contains an encoder/decoder unit, a serial/parallel converter part, a synthesizer/clock recovery PLL section, and a TTL input and a PECL output interface, as well as the serial electro-optical converting function.

The data from the parallel TTL input interface are converted to a serial bitstream feeding an LED driver. The differential receiver signal is converted to parallel data words at the TTL output.

This transceiver meets the requirements for the IBM ESCON® standard.

Figure 1. PSOL module overview



ESCON Parallel 8B/10B Module

The transceiver can be operated in two modes:

a) FSOL mode: conversion of 10 bit electrical data words to a serial bitstream and conversion of a serial bitstream to 10 bit-wide electrical data words.

In this mode the transceiver can be used as a plug-in replacement for the Parallel Transceiver V23806-A6-X1.

b) PSOL mode: conversion of 8 bit electrical data words to a serial optical bitstream using an 8B/10B encoder for optical data transmission and conversion of a serial bitstream to 10 bit-wide electrical data words using a 10B/8B decoder.

Switching between the two modes is done by applying Vcc or GND to the $\overline{FSOL}$/PSOL pins respectively.

Figure 2. Functionality: PSOL main IC in FSOL mode

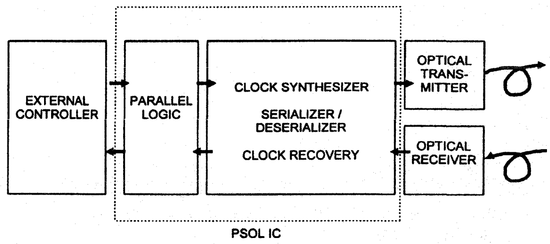
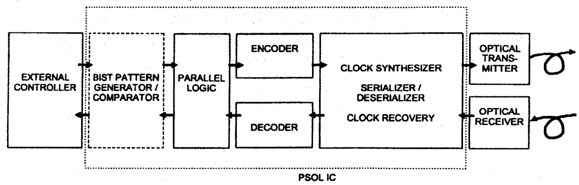


Figure 3. Functionality: PSOL main IC in PSOL mode



Recommended Operating Conditions

Parameter	Sym.	Min	Max	Units
Operating Ambient Temperature	T_C	0	70	°C
Power Supply Voltage	$V_{CC}–V_{EE}$	3	5.5	V
Supply Current 3.3 V	I_{CC}		300	mA
Supply Current 5 V			400	
Data Input High Voltage	V_{IH}	2	V_{CC}	V
Data Input Low Voltage	V_{IL}	V_{ee}	0.8	
Input Data Rise/Fall, 10–90%	t_R, t_F	0.4	1.3	ns
Output Current High	I_O		–0.4	mA
Output Current Low	I_{CC2}		4	

Transmitter Electro-Optical Characteristics

(Values in parentheses are for 300 MBd)

Transmitter	Sym.	Min.	Typ.	Max.	Units
Data Rate	DR	100		200 (320)	MBaud
Supply Current 3.3 V(1)	I_{CC}			200	mA
Supply Current 5 V(1)				300	
Launched Power (Ave.) BOL into 62.5μm Fiber (2, 3, 4)	P_O	–21 (–22)	–16.5	–14	dBm
Launched Power (Ave.) EOL into 62.5μm Fiber (2, 3, 4, 7)		–22 (–23)			

9
Fiber Optic Data Links

Transmitter	Sym.	Min.	Typ.	Max.	Units
Center Wavelength[5, 6]	l_C	1285		1355	nm
Spectral Width (FWHM)[6]	σλ			160	
Temperature Coefficient, Optical Optput Power	TCp			0.03	dB/°C
Output Rise/Fall Time, 20–80%[6]	t_R, t_F		1	1.7 (2)	ns
Deterministic Jitter[8]	J_d		0.6	0.8	
Random Jitter[9]	J_r			0.06	
Extinction Ratio (dynamic)[10]	ER		–16	–13	dB

Notes

1. Transmitter operating at 200 MBaud and 50% duty cycle.
2. Measured at the end of 1 meter fiber, cladding modes removed at a data rate of between 50 and 200 MBaud, 50% duty cycle.
3. Po [dBm]=10 log (Po/1 mW)
4. Po (BOL) >–20dBm and Po (EOL) >–21.5 dBm at T_{case}=60°C.
5. Measured at T_{case}=60°C
6. Full width, half magnitude of peak wavelength: special relationship between λc, dλ, tr/tf according to FC-PH Rev 4.3 Paragraph 6.3.2. and Fig.26. Spectral width must be considered.
7. Over 10^5 hours lifetime at T_{amb}=35°C
8. Deterministic Jitter, measured at 200 MBaud with Jitter Test Pattern shown in Figure 5. In the Test Pattern are five positive and five negative transitions. Measure the time of the 50% crossing of all 10 transitions. The time of each crossing is then compared to the mean expected time of the crossing. The DJ is the range of the timing variations.
9. RMS value measured with 1010 pattern at 200 Mbaud. Peak-to-peak value is determined as RMS multiplied by 14 for BER 1E-12.
10. Extinction ratio is the logarithmic measure of the optical power in the OFF state (POFF) to twice the average power (P0):
    ER=10 log [(2xP0)/POFF]; optical power measured in mW or
    ER=ΩP0+3dBΩ–POFF; optical power measured in dBm

Receiver Electro-Optical Characteristics

(Values in parentheses are for 300 MBd)

Receiver	Sym.	Min.	Typ.	Max.	Units
Data Rate	Dr	100		200 (300)	MBaud
Supply Current [1]	I_{CC}			100	mA
Sensitivity (Average Power)BOL[2, 3, 4]	P_{IN}	–32.5 (–29)	–35.5		dBm
Sensitivity (Average Power) EOL[2, 3, 4, 5]		–32 (–28.5)	–35		
Saturation (Average Power)	P_{SAT}	–14			
Signal Detect Assert Level[6]	P_{SDA}	–44.5		–36,0	
Signal Detect Deassert Level[6]	P_{SDD}	–45		–37.5	
Signal Detect Hysteresis	P_{SDA}–P_{SDD}	0.5	1.5	3	dB
Signal Detect Reaction Time	SDreac	3		500	µs

Receiver	Sym.	Min.	Typ.	Max.	Units
Signal Detect Hysteresis	P_{SDA}–P_{SDD}	0.5	1.5	3	dB
Signal Detect Reaction Time	SDreac	3		500	µs
Max. Deterministic Jitter Optical Input[7, 9]	J_d			0.19	% of Unit Intervals
Max. Random Jitter RMS Optical Input[8, 9]	J_r			0.09	

Notes

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle.
2. Measured at the end of 1 meter fiber, cladding modes removed at a data rate of between 50 and 200 MBaud, 50% duty cycle.
3. Po [dBm]=10 log (Po [mW])
4. Measured at BER=1E-12, 200 MBaud transmission rate and 50% duty cycle 2^7-1 PRBS pattern; center wavelength between 1200nm and 1500 nm, fiber type 62.5/125 µm/0.29 NA or 50/125 µm/0.2 NA; input optical rise and fall times are 1.2 ns and 1.5 ns (20% - 80%) respectively.
5. Over 10^5 hours lifetime at T_{amb}=35°C
6. Indicates the presence or absence of optical power at the receiver input. Signal detect at logic "high" when asserted. All powers are average power levels. Pattern 2^7-1 at 200 MBaud.
7. Deterministic Jitter measured at 200 MBaud with Jitter Test Pattern shown in Figure 5. In the test pattern are five positive and five negative transitions. Measure the time of the 50% crossing of all 10 transitions. The time of each crossing is then compared to the mean expected time of the crossing. The DJ is the range of the timing variations.
8. To convert from specified RMS value to peak-to-peak value (at BER 1E-12) multiply value by 14.
9. Jitter at optical input. Jitter magnitudes above specified level may increase the bit error rate.

Transceiver Pin Description 10 Bit Interface: FSOL Mode

In this mode the transceiver is compatible with the former version, V23806-A6-X1

Pin#	Pin Name	Level/Logic	Description
1, 6, 9, 26, 43, 45, 48, 51	Vee	Power Supply	Ground attached to the case
2	Vcc PRE		Preamplifier positive power supply
3	SIGDET	TTL out	Signal detected
4	LOCKREF	TTL in	Control input for RX PLL
5	SYNCEN		Control of byte alignment operation
7,8	VccFAST	Power Supply	Bipolar IC positive power supply
10 to 19	Dout a to j	TTL out	Data output parallel 10 channels
20	RBCLK	TTL out	Read byte clock
21	PAROUT		Parity bit out
22	BSYNC		Byte synchronization operation
23	PARERR	TTL out	Parity bit error

Pin#	Pin Name	Level/Logic	Description
24,25	VccSLOW	Power Supply	Logic positive power supply
27	Loopsel a	TTL in	Test loop select
28	Loopsel b		
29	RESREC		Receiver reset
30	RESFF		Reset all flip-flops
31	TBCLK		Transmit byte clock
32	PARIN		Parity bit in
33 to 42	Din j to a		Data input parallel 10 channels
44	TESTCLK		Test clock. In test mode this clock is the bit clock
46	TESTMOD		If this signal is low TESTCLK is used
47	TXOFF		Transceiver off when logical high
49,50	Vcc DRI	Power Supply	LED driver positive power supply

Transceiver Pin Description 8 Bit interface: PSOL Mode

Pin#	Pin Name	Level/ Logic	Description
1, 6, 26, 43, 45, 48, 51	Vee	Power Supply	Ground attached to the case
2	Vcc PRE		Preamplifier positive power supply
3	SIGDET	TTL out	Signal detected
4	$\overline{R}$		Read pulse for external FIFOs
5	SYNCEN	TTL in	Control of byte alignment operation
7,8	VccFAST	Power Supply	Positive power supply of the bipolar IC
9	$\overline{PSOL1}$/ PSOL2	TTL in	Mode select for PSOL Mode 1 or Mode 2
10	RK	TTL out	Receiver special character flag
11 to 18	Dout A to H		Decoded data output parallel 8 channels
19	RCV		Receiver code violation
20	RBCLK		Read byte clock
21	PAROUT		Parity bit out
22	$\overline{W}$		Write pulse for external FIFOs
23	PARERR		Parity bit error
24, 25	VccSLOW	Power Supply	Logic positive power supply

Pin#	Pin Name	Level/ Logic	Description
27	Loopsel a	TTL in	Test loop select
28	Loopsel b		
29	$\overline{EPI}$		Enable parallel input
30	$\overline{ENPI}$		Enable next parallel input
31	TBCLK		Transmit byte clock
32	PARIN		Parity bit in
33	TCV		Transmitter code violation
34 to 41	Din H to A		Uncoded data input parallel 8 channels
42	TK		Transmitter special character flag
44	$\overline{RAW}$/COD		Select Raw Mode/Coder Mode
46	$\overline{BIST}$		Enable built-in self test
47	TXOFF		Transceiver off when logical high
49, 50	Vcc DRI	Power Supply	LED driver positive power supply

Figure 4. Signal detect threshold and hysteresis

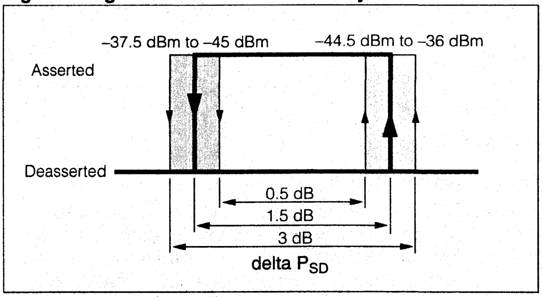
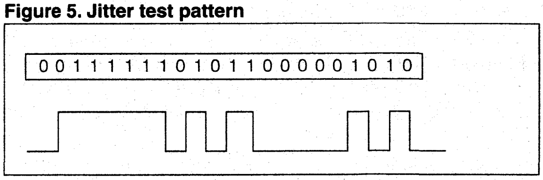
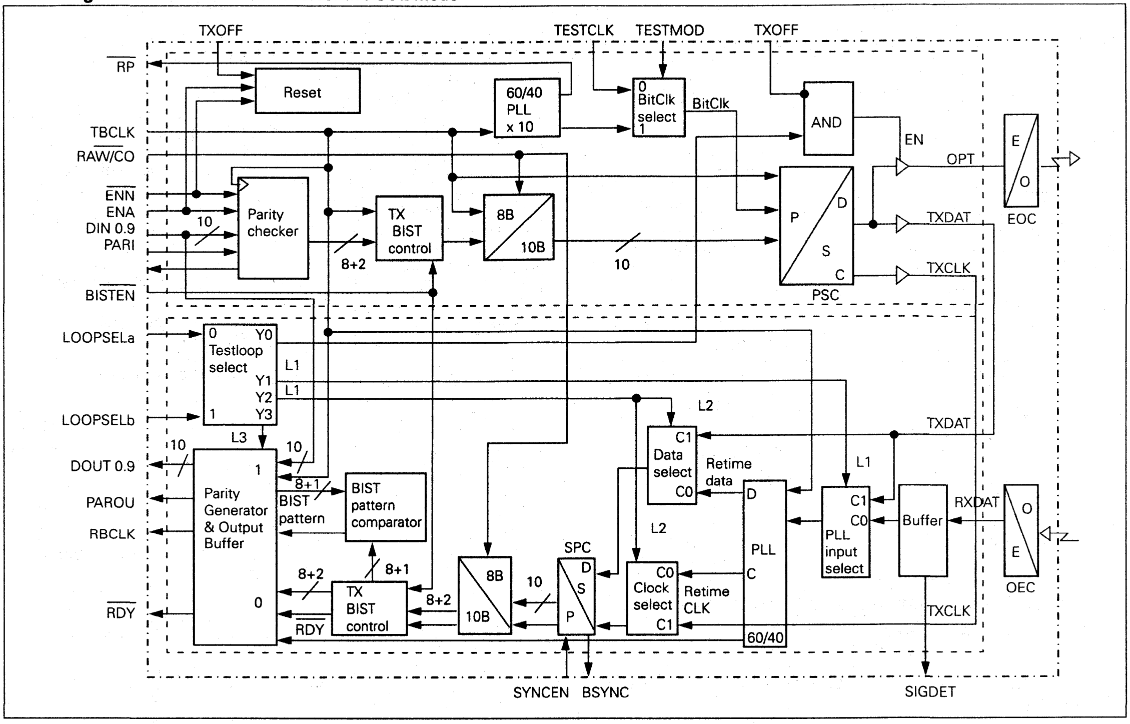


Figure 5. Jitter test pattern



Block diagram of the ESCON transceiver in PSOL mode



APPLICATION NOTE

Power Supply Filtering

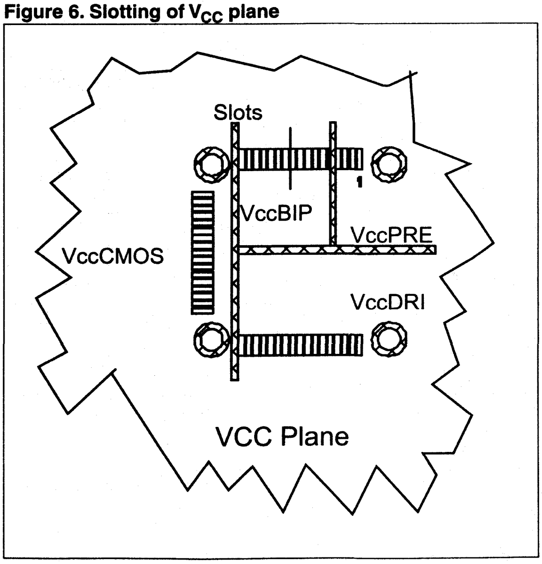
In most of the applications using ESCON 200 MBd Optical Transceivers, additional high speed circuits such as switching power supply, clock oscillator, or high speed multiplexer are present on the application board. These often create power supply noise at a high spectral bandwidth, caused by very fast transitions in today's chip technology.

The Siemens ESCON Transceiver Family provides superior EMI performance regarding emission and immission of radiation and provides immunity against conductive noise. Some basic recommendations are given in this document to ensure proper functionality in the field.

For proper operation the use of a multilayer board with ground and Vcc plane is strongly recommended. The Vcc plane should be slotted as shown in Figure 6 to avoid crosstalk between different circuitry inside the module. The metallized package is internally connected to the V_{EE}-pins of the module. Nevertheless the package must be connected externally to ground for best shielding characteristics. Ground contact should be made with the ground rings shown in Figure 6. Because of high switching currents at V_{CC}DRI, the use of an external 6.8 to 22 µF capacitor is recommended at V_{CC}DRI.

The observance of normal design rules for high speed digital systems is sufficient to ensure safe operation.

Figure 6. Slotting of V_{CC} plane



Note: Slots are non-copper areas inside the V_{CC} plane to avoid cross-current flow

Figure 7. Recommended footprint

The avoidance of any component or non-isolated structure, like tracks or vias, under the transceiver is strongly recommended.

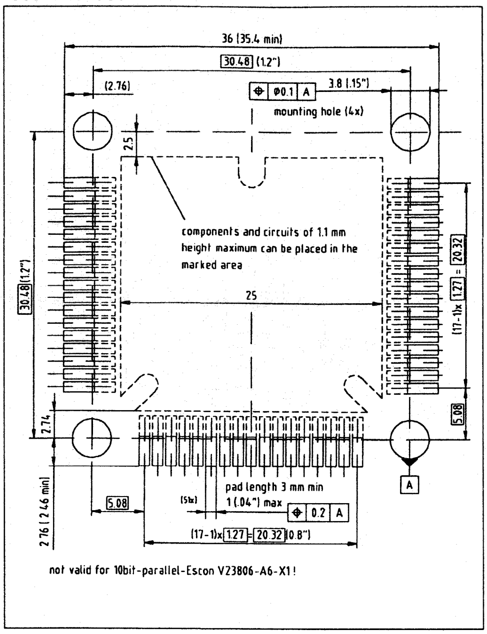
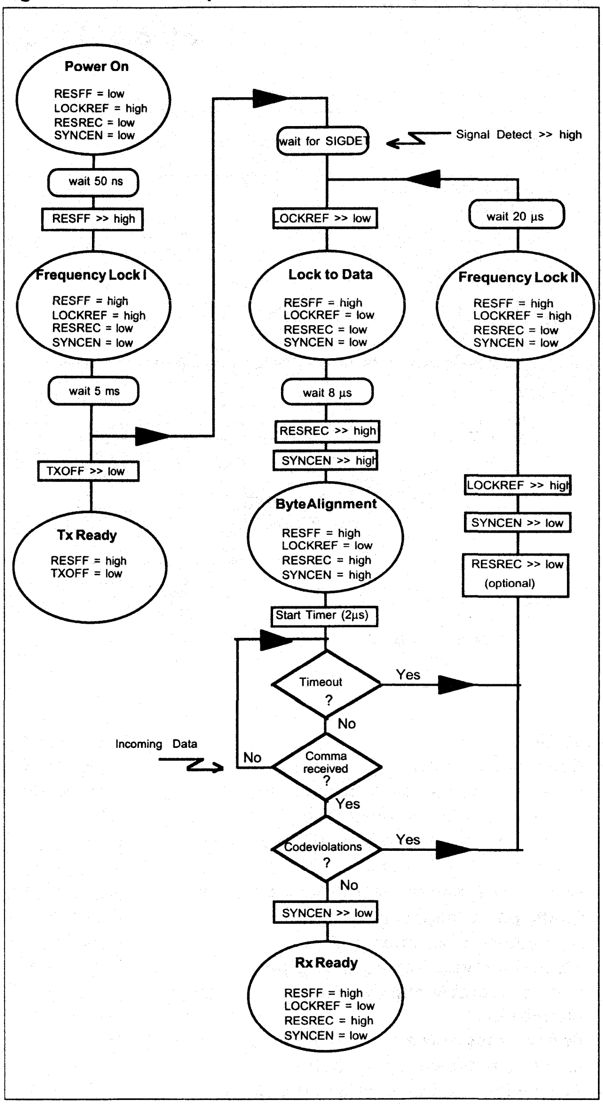


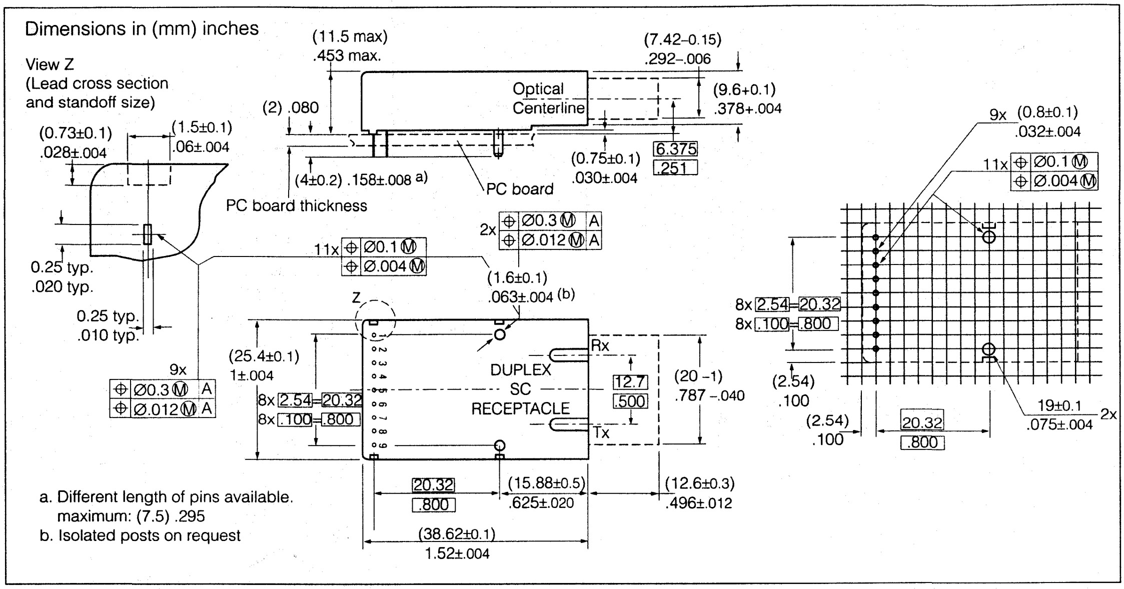
Figure 8. Power-on sequence in FSOL mode



SIEMENS

V23809-J17-C10

Single Mode 1.0625 GBd FC Laser Transceiver 1x9



FEATURES

- **Compliant with existing standards**
- **Compact integrated transceiver unit with**
  - **MQW laser diode transmitter**
  - **InGaAs PIN-photo diode receiver**
  - **Duplex SC receptacle**
- **Class 1 FDA and IEC laser safety compliant**
- **Single power supply (5 V)**
- **Signal detect indicator**
- **PECL differential inputs and outputs**
- **Wave solderable and washable with included process plug**
- **Performance exceeds FC 100-SM-LL-I**
- **Link length typical up to 10 Km**
- **Typical loss budget of more than 20 dB**

Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation [1] .... 1.5 W
Supply voltage (V_{CC}–V_{EE}) .... 6 V
Data Input Levels (PECL) .... V_{CC}–0.7 V
Differential Data Input Voltage .... 3 V
Operating Case Temperature .... 0 to 70°C
Storage Ambient temperature .... –40°C to 85°C
Soldering Conditions Temp/Time
(MIL-STD 883C, Method 2003) .... 250/5.5°C/s

Note:

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}–2 V.

DESCRIPTION

This data sheet describes the Siemens single mode FC transceiver, which complies with the Fibre Channel Physical and Signaling Interface (FC-PH), ANSI X3T11 Fiber Channel Physical Standard Class 100-SM-LL-I, Revision 4.3.

The appropriate fiber optic cable is 9 µm (mode field diameter) single mode fiber with Duplex SC connector.

The Siemens single mode FC transceiver is a single unit comprised of a transmitter, a receiver and an SC receptacle. It thereby frees the customer from many alignment and PC board layout concerns. The module is designed for low cost LAN and WAN applications. It can be used as the

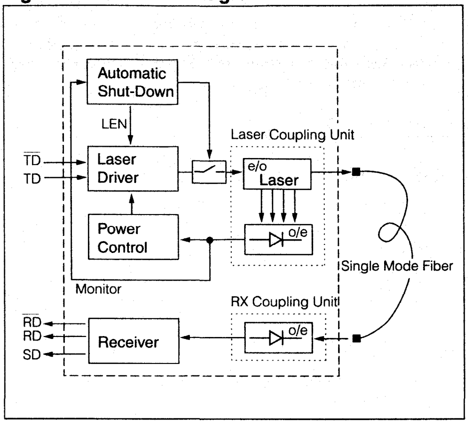
DESCRIPTION (continued) network end device interface in workstations, servers, and storage devices, and in a broad range of network devices such as bridges, routers, intelligent hubs, and local and wide area switches.

This transceiver operates at 1.0625 Gbits per second from a single power supply (+5 Volt). The full differential data inputs and outputs are PECL compatible.

Functional Description of 1x9 Pin Row Transceiver

This transceiver is designed to transmit serial data via single mode cable.

Figure 1. Functional diagram



The receiver component converts the optical serial data into PECL compatible electrical data (RD and RDnot). The Signal Detect (SD, active high) shows whether an optical signal is present.

The transmitter converts electrical PECL compatible serial data (TD and TDnot) into optical serial data. It contains a laser driver circuit which drives the modulation and bias current of the laser diode. The currents are controlled by a power control circuit to guarantee a constant output power of the laser over temperature and aging. The power control uses the output of the monitor pin diode (mechanically built in the laser coupling unit) for the controlling function to prevent the laser power from exceeding the operating limits.

This module ensures single fault condition with an integrated automatic shutdown circuit, which disables the laser when it detects transmitter failures. A reset is only possible by turning the power off, then on again.

The transceiver contains a supervisory circuit to control the power supply. This circuit makes an internal reset signal whenever the supply voltage declines below the reset threshold. It keeps the reset signal active for at least 140 milliseconds after the voltage has risen above the reset threshold. During this time the laser is inactive.

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units
Case Temperature	T_C	0		70	°C
Power Supply Voltage	$V_{CC}-V_{EE}$	4.75	5.0	5.25	V
Supply Current(1)	I_{CC}		150	300	mA
Transmitter					
Data Input High Voltage	$V_{IH}-V_{CC}$	–1165		–880	mV
Data Input Low Voltage	$V_{IL}-V_{CC}$	–1810		–1475	
Input Data Rise/Fall Time, 10–90%	t_R, t_F	100		750	ps
Receiver					
Input Center Wavelength	λ_C	1260		1360	nm

Note

1. For $V_{CC}-V_{EE}$ (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}–2 V.

Transmitter Electro-Optical Characteristics

Transmitter	Symbol	Min.	Typ.	Max.	Units
Launched Power (Average)(1)	P_O	–12	–7	–3	dBm
Center Wavelength	l_C	1274		1356	nm
Spectral Width (RMS)	σ_λ			3	
Relative Intensity Noise	RIN			–116	dB/Hz
Extinction Ratio (dynamic)	ER	9			dB

Note

1. Values will be modified to FC Standard; valid only for engineering samples.

Receiver Electro-Optical Characteristics

Receiver	Symbol	Min.	Typ.	Max.	Units
Sensitivity (Average Power)(1)	P_{IN}	–20	28.5		dBm
Saturation (Average Power)	P_{SAT}	–3	–4		
Signal Detect Assert Level(2)	P_{SDA}		–32		
Signal Detect Deassert Level(3)	P_{SDD}		–34		
Signal Detect Hysteresis	$P_{SDA}-P_{SDD}$		1.5		dB
Output LO Voltage(4)	$V_{OL}-V_{CC}$	–1950		–1600	mV
Output HI Voltage(4)	$V_{OH}-V_{CC}$	-980		–720	
Output Data Rise/Fall Time, 20–80%	t_R, t_F		300	375	ps
Return Loss of Receiver	A_{RL}	12			dB

Notes

1. Minimum average optical power at which the BER is less than 1 x 10E-12. Measured with a 2^{23}-1 NRZ PRBS.
2. An increase in optical power above the specified level will cause the SIGNAL DETECT output to switch from a LO state to a HI state.
3. A decrease in optical power below the specified level will cause the SIGNAL DETECT to change from a HI state to a LO state.
4. PECL 10K compatible. Load is 50 Ω into V_{CC} -2V. Measured under DC conditions. For dynamic measurements a tolerance of 50 mV should be added, V_{CC}=5 V.

PIN Description

Pin Name		Level/Logic	Pin#	Description
R_xV_{ee}	Rx Ground	Power Supply	1	Negative power supply, normally ground
RD	Rx Output Data	PECL Output	2	Receiver output data
RDn			3	Inverted receiver output data
SD	RX Signal Detect	PECL Output active high	4	High level on this output shows there is an optical signal.
R_xV_{CC}	Rx +5 V	Power Supply	5	Positive power supply, +5 V
T_xV_{CC}	Tx +5 V		6	
TDn	Tx Input Data	PECL Input	7	Inverted transmitter input data
TD			8	Transmitter input data
T_xV_{ee}	Tx Ground	Power Supply	9	Negative power supply, normally ground
Case	Ground		S1/2	CASE/V_{EE}, Support Stud (GND)

LASER SAFETY

This single mode transceiver is a Class 1 laser product. It complies with IEC 825-1 and FDA 21 CFR 1040.10 and 1040.11. The transceiver must be operated under the recommended operating conditions.

Caution

The use of optical instruments with this product will increase eye hazard!

General Restrictions

Classification is valid only if the module is operated within the specified temperature and voltage limits. The system using the module must provide power supply protection that guarantees that the system power source will cease to provide power if the maximum recommended operation limit or more is detected on the +5 V at the power source. The temperature of the module case must be in the temperature range given in the recommended operating limits. These limits guarantee the laser safety.

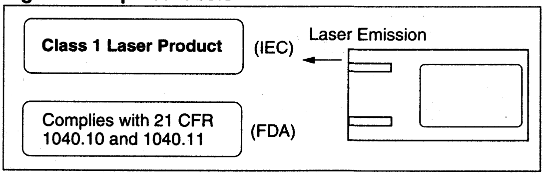
Usage Restrictions

The optical ports of the modules must be terminated with an optical connector or with a dustplug.

Note

Failure to adhere to the above restrictions could result in a modification that is considered an act of "manufacturing," and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration (ref. 21 CFR 1040.10 (i)).

Figure 2. Required labels

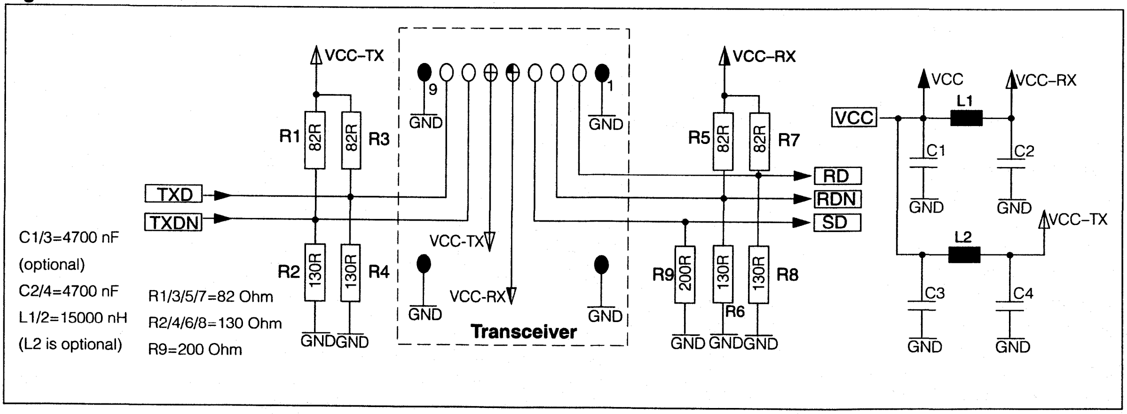


Laser Data

Wavelength	1300 nm
Total output power (as defined by IEC: 50 mm aperture at 10 cm distance)	1 mW
Total output power (as defined by FDA: 7 mm aperture at 20 cm distance)	180 µW
Beam divergence	4°

APPLICATION NOTE FOR 1X9 PIN ROW TRANSCEIVER

Figure 3. Schematic



The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module VCC-RX/VCC-TX.

The transceiver contains an automatic shutdown circuit. Reset is only possible when the power is turned off, then on again (VCCTX switched below V_{TH}).

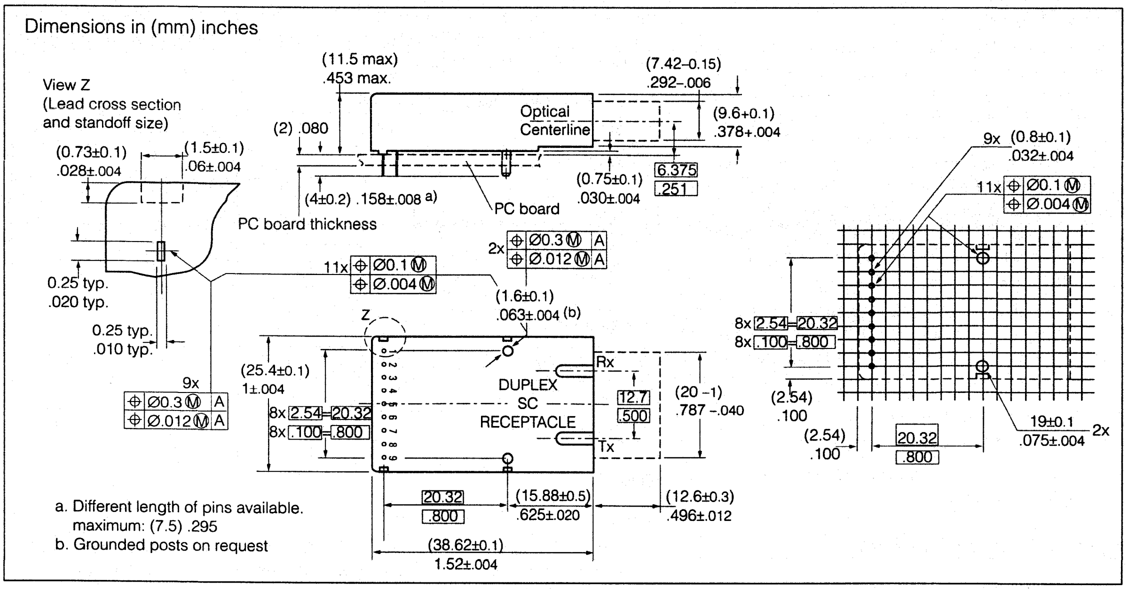
Application board available.

SIEMENS

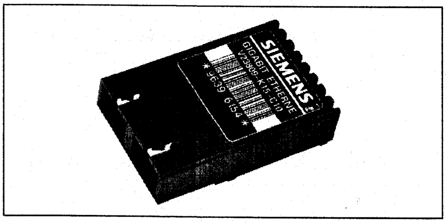
5 V V23809-K15-C10
3.3 V V23809-K15-C310

Single Mode 1.3 GBd Gigabit Ethernet Transceiver 1x9

Preliminary Data Sheet



a. Different length of pins available.
maximum: (7.5) .295
b. Grounded posts on request



FEATURES

- **Compliant with existing standards (IEEE Draft P 802.3z/D1)**
- **Compact integrated transceiver unit with**
  - **MQW laser diode transmitter**
  - **InGaAs PIN-Photo diode receiver**
  - **Duplex SC receptacle**
- **Class 1 FDA and IEC laser safety compliant**
- **Single power supply (5 V and 3.3 V)**
- **Signal detect indicator**
- **PECL differential inputs and outputs**
- **Wave solderable and washable with included process plug**
- **For distances of up to 3 km on single mode fiber, and up to 500 m (under development) on multimode fiber**

Maximum Ratings (Absolute maximum stress)

Exceeding any one of these values may destroy the device immediately. However, the electro-optical characteristics described in the following tables are only valid for use under the recommended operating conditions.

Package Power Dissipation (1)	Tbd
Supply voltage (V_{CC}–V_{EE})	6 V
Data Input Levels (PECL)	V_{CC}–0.5 V
Differential Data Input Voltage	3 V
Operating Case Temperature	0 to 70°C
Storage Ambient temperature	–40°C to 85°C
Soldering Conditions Temp/Time (MIL-STD 883C, Method 2003)	250/5.5°C/s

Note

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}–2 V.

DESCRIPTION

This data sheet describes Siemens single mode transceiver. It is based on the Physical Medium Depend (PMD) sublayer and baseband medium, type 1000BASE-LX (Long Wavelength Laser).

The appropriate fiber optic cable is 9mm (mode field diameter) single mode fiber (up to 3 km) with Duplex SC connector.

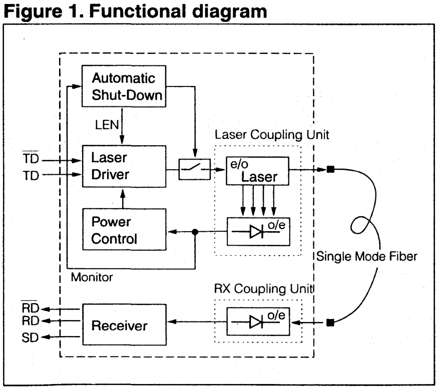
The Siemens single mode transceiver is a single unit comprised of a transmitter, a receiver and an SC receptacle. It thereby frees the customer from many alignment and PC board layout concerns. The module is designed for low cost LAN, WAN and Gigabit Ethernet applications. It can be used as the network end device interface in mainframes, workstations, servers, and storage devices, and in a broad range of network devices such as bridges, routers, intelligent hubs, and local and wide area switches.

This transceiver operates at 1.3 Gbits per second from a single power supply (+5 Volt or 3.3 Volt). The full differential data inputs and outputs are PECL compatible.

Functional Description of 1x9 Pin Row Transceiver

This transceiver is designed to transmit serial data via single mode cable.

Figure 1. Functional diagram



The receiver component converts the optical serial data into PECL compatible electrical data (RD and RDnot). The Signal Detect (SD, active high) shows whether an optical signal is present.

The transmitter converts electrical PECL compatible serial data (TD and TDnot) into optical serial data. It contains a laser driver circuit which drives the modulation and bias current of the laser diode. The currents are controlled by a power control circuit to guarantee a constant output power of the laser over temperature and aging. The power control uses the output of the monitor pin diode (mechanically built into the laser coupling unit) for the controlling function to prevent the laser power from exceeding the operating limits.

This module assures single fault condition with an integrated automatic shutdown circuit, which disables the laser when it detects transmitter failures. A reset is only possible by turning the power off, then on again.

The transceiver contains a supervisory circuit to control the power supply. This circuit makes an internal reset signal whenever the supply voltage declines below the reset threshold. It keeps the reset signal active for at least 140 milliseconds after the voltage has risen above the reset threshold. During this time the laser is inactive.

Recommended Operating Conditions

Parameter		Symbol	Min.	Typ.	Max.	Units
Case Temperature		T_C	0		70	°C
Power Supply Voltage	K15–C10	V_{CC}–V_{EE}	4.75	5.0	5.25	V
	K15–C310		3	3.3	3.6	
Supply Current(1)	K15–C10	I_{CC}		tbd	tbd	mA
	K15–C310				tbd	
Transmitter						
Data Input High Voltage		V_{IH}-V_{CC}	–1165		–880	mV
Data Input Low Voltage		V_{IL}-V_{CC}	–1810		–1475	
Input Data Rise/Fall Time 10–90%		t_R, t_F	100		750	ps
Receiver						
Input Center Wavelength		λ_C	1270		1355	nm

1. For V_{CC}–V_{EE} (min, max). 50% duty cycle. The supply current does not include the load drive current of the receiver output. Add max. 45 mA for the three outputs. Load is 50 Ω to V_{CC}–2 V.

Transmitter Electro-Optical Characteristics

Transmitter	Symbol	Min.	Typ.	Max.	Units
Launched Power (Average)(1)	P_O	–13		–3	dBm
Center Wavelength	l_C	1270		1355	nm
Spectral Width (RMS)	$\sigma\lambda$			4	
Relative Intensity Noise	RIN			–116	dB/Hz
Extinction Ratio (dynamic)	ER	9			dB
Reset Threshold(2)	T_{th}		2.9		V
Reset Time Out(2)	T_{res}	140	240	560	ms

Receiver Electro-Optical Characteristics

Receiver	Symbol	Min.	Typ.	Max.	Units
Sensitivity (Average Power)(3)	P_{IN}		–22	–20	dBm
Saturation (Average Power)	P_{SAT}			–3	
Signal Detect Assert Level(4)	P_{SDA}		TBD		
Signal Detect Deassert Level(5)	P_{SDD}	TBD			
Signal Detect Hysteresis	P_{SDA}-P_{SDD}		1.5		dB
Output LO Voltage(6)	V_{OL}-V_{CC}	–1950		–1600	mV
Output HI Voltage(6)	V_{OH}-V_{CC}	–980		–720	
Output Data Rise/Fall Time, 20–80%	t_R, t_F			375	ps
Return Loss of Receiver	A_{RL}	12			dB

Notes

1. Into SM fiber, 9 µm diameter
2. Laser power is shut down if power supply is below V_{TH} and switched on if power supply is above V_{TH} after T_{res}.
3. Minimum average optical power at which the BER is less than 1x10E-12 or lower. Measured with a 2^7-1 NRZ PRBS and ER=9 dB.
4. An increase in optical power above the specified level will cause the SIGNAL DETECT output to switch from a LO state to a HI state.
5. A decrease in optical power below the specified level will cause the SIGNAL DETECT to change from a HI state to a LO state.
6. PECL 10K compatible. Load is 50 Ω into V_{CC} -2 V. Measured under DC conditions. For dynamic measurements a tolerance of 50 mV should be added. V_{CC}=5 V.

PIN Description

Pin Name		Level/Logic	Pin#	Description
R_xV_{ee}	Rx Ground	Power Supply	1	Negative power supply, normally ground
RD	Rx Output Data	PECL Output	2	Receiver output data
RDn			3	Inverted receiver output data
SD	RX Signal Detect	PECL-Output active high	4	High level on this output shows there is an optical signal.
R_xV_{CC}	Rx3 V/5 V	Power Supply	5	Positive power supply, 3 V/5 V
T_xV_{CC}	Tx3 V/5 V		6	
TDn	Tx Input Data	PECL Input	7	Inverted transmitter input data
TD			8	Transmitter input data
T_xV_{ee}	Tx Ground	Power Supply	9	Negative power supply, normally ground
Case	Support	Mech. Support	S1/2	Support stud (floating)

LASER SAFETY

This single mode transceiver is a Class 1 laser product. It complies with IEC 825-1 and FDA 21 CFR 1040.10 and 1040.11. The transceiver must be operated under the recommended operating conditions.

Caution

The use of optical instruments with this product will increase eye hazard!

General Restrictions

Classification is only valid if the module is operated within the specified temperature and voltage limits. The system using the module must provide power supply protection that guarantees that the system power source will cease to provide power if the maximum recommended operation limit or more is detected on the +5 V at the power source. The temperature of the module case must be in the temperature range given in the recommended operating limits. These limits guarantee the laser safety.

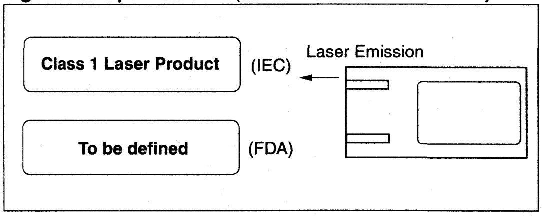
Usage Restrictions

The optical ports of the modules must be terminated with an optical connector or with a dust plug.

Note

Failure to adhere to the above restrictions could result in a modification that is considered an act of "manufacturing," and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration (ref. 21 CFR 1040.10 (i)).

Figure 2. Required labels (to be defined for U.S. market)

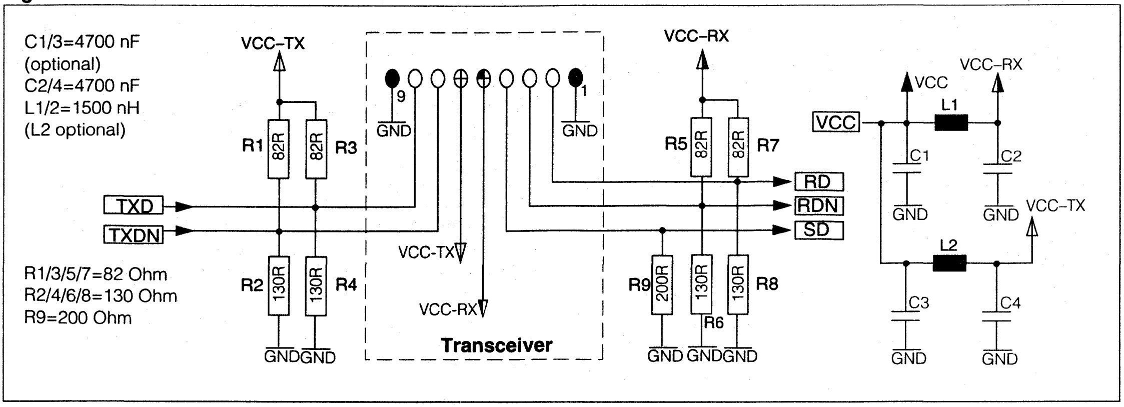


Laser Data

Wavelength	1300 nm
Total output power (as defined by IEC: 50 mm aperture at 10 cm distance)	less than 2 mW
Total output power (as defined by FDA: 7 mm aperture at 20 cm distance)	less than 180 µW
Beam divergence	4°

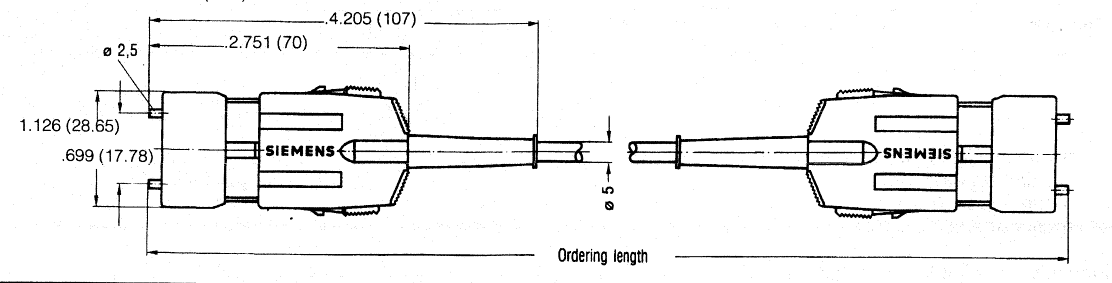
APPLICATION NOTE FOR 1X9 PIN ROW TRANSCEIVER

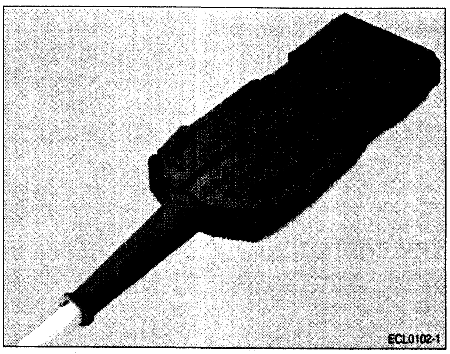
Figure 3. Schematic



The power supply filtering is required for good EMI performance. Use short tracks from the inductor L1/L2 to the module VCC-RX/VCC-TX.

The transceiver contains an automatic shutdown circuit. Reset is only possible when the power is turned off, then on again (VCCTX switched below V_{TH}).





Features

- **Mates with the Siemens Tx/Rx assembly**
- **Low insertion loss, typical 0.2 dB**
- **Cables with 2 fibers G62.5/125 µm with lengths up to 2000 meters**
- **Ceramic ferrules (no corrosion, no abrasion)**
- **Retractable shroud for additional ferrule protection**
- **Snap-in design protects against unintentional disconnection and against excessive strain**
- **Keying of connector and shell prevents reverse connection**
- **Safe cable strain relief**
- **Shock-proof plastic connector housing with integrated cable bend limiter**

ESCON® is a registered trademark of IBM.

Description

The Siemens Duplex Jumper Cable with two ESCON connectors is specially designed for the Siemens 200 MBaud Transmission System. It is available with two 62.5/125 µm and 50/125 µm fibers. A single mode version with the necessary keying is also available. The ESCON connector has a shock-proof plastic housing with a retractable shroud to protect the ceramic ferrules from damage. A keying of the ESCON connector and the shell guarantees correct insertion of the connector.

Absolute Maximum Ratings

Storage/Shipping Temperature (T_{stg}) .... –40 to 70°C
Storage/Shipping Humidity(RH_{stg}) .... 5 to 100 %
Operating Temperature (T_{amb}) .... 0 to 70°C
Operating Humidity (RH_A) .... 8 to 80 %
Tension Applied to Mounted Cable(F_{cable}) .... 200 N
Tension Applied to Connector (F_{con}) .... 100 N
Bend Radius for Long Term Installation at 600 N .... 48 mm

Mechanical/Optical/Transmission Characteristics and Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
Insertion Loss		0.2	1.0	dB
Mechanical Life (Plugging Cycles)	1500			
Attenuation at 1300 nm			2.0	dB/km
Bandwidth	500			MHz/km

Other Technical Data:

Corrosive atmosphere (25°C; 75% RH; 10d)	ppb: 200 SO_2 + 10 H_2S + 200 NO_2 + 10 Cl_2
Vibration	5 to 500 Hz/0.73 g

ORDERING INSTRUCTIONS

Part number

V	2	3	8	6	1	–	L			4	1	–				

Identification digits for single mode/multimode application
11=multimode 62,5/125 µm
33=single mode 9/125 µm
44=multimode 50/125 µm

Identification digit for cable length

A=1 to 999 m (only full meters), e.g. A003 = three meters
B=100 to 999 cm (centimeters, below 10 m, not for full meters)
T=1000 to 1999 m (only full meters), e.g. T010 = one thousand and ten meters

Cable length

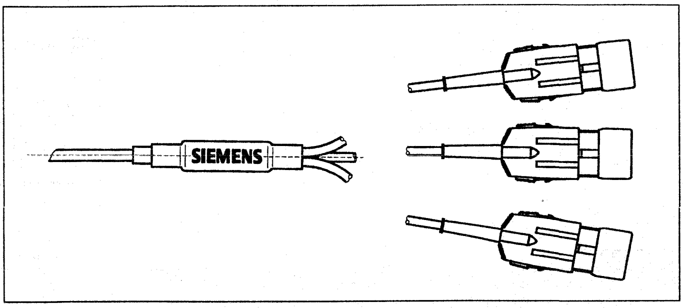
Tolerances:
Up to 8 m +16 cm
Above 8 m: +2 % of cable length

Example for ordering

1 Fiber optic cable, grad.-index fiber 2 x 62.5/125 (duplex) with 2 ESCON connectors, 5 m cable length:
V23861-L1141-A5

SIEMENS

Fiber Optic Jumpers ESCON® Multi-jumper



FEATURES

- **Possibility of up to 12 ESCON channels (36 in the US) with one cable**
- **No splices**
- **Single cable whips/duplex legs (standard length 2 meters/cable-end) allow quick and easy installation**
- **Saves space in cable channels**
- **Multimode and single mode versions are available in riser or plenum PVC (halogen-free cable also available)**
- **Solid construction: shock-proof plastic connector housing and tread resistant multifiber cable**
- **Custom configurations available**

APPLICATIONS

- **Interconnect ESCON devices (mainframes, directors, tape drives, disc drives) and cabinets.**

Advantage

The Siemens ESCON Multi-Jumper enables installation of up to 12 ESCON channels (36 in the U.S.) with one cable. The compact construction of the ESCON Multi-Jumper saves space in cable channels (e.g. fiber trays, ducts, etc.).

Construction

Multiple fibers break out to the ESCON connectors via reinforced transitions through cable furcation (PVC tubing). The fibers are not spliced and are protected against draw force and crushes.The cable whips (duplex leg lengths) allow the connection of individual ESCON channels with a standard length of 2 meters from the cable end. Other lengths are available.

The ESCON Multi-Jumper is available in single mode and multimode versions, in riser or plenum PVC. Halogen-free cable is also available.

ESCON® is a registered trademark of IBM.

Technical Data

Parameter	Unit	Channels			
		2	**4**	**8**	**12**
Insertion loss (typ.)	dB	0,2			
Min. bandwith	MHz x km	500			
Number of connections		200			
Number of duplex connectors per side		2	4	8	12
Cable diameter (outside)	mm	6.2		8.3	10.6
Cable diameter (cable whips)		4.8			
Operating temperature	˚C	–20/+70			
Bend radius, cable (min.)	mm	93		125	159
Bend radius, cable whips (min.)		45			
Crush resistance, cable	N/cm	1500			
Operating hours	h	100,000			
Failure ratio (1fit=10^{-9} x h^{-1})	fit	5	10	20	25

ESCON Multi-jumper			U.S. Part Number	German Part Number
Channels	**ESCON Connectors per side**	**Fiber**		
2	2	62.5/125 µm	J04-062QQ***	V23862-F5041-A*
4	4		J08-062QQ***	V23862-F5241-A*
8	8		J16-062QQ***	V23862-F5641-A*
12	12		J24-062QQ***	V23862-F6041-A*
18	18		J36-062QQ*** *(U.S. only)*	
36	36		J72-062QQ*** *(U.S. only)*	

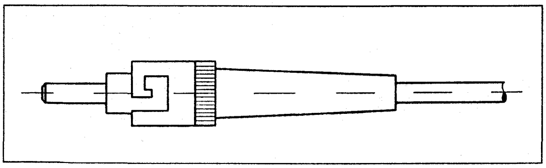
***/* length in meters

Call your local Siemens office for versions with ST, SC, MT and other connector types.

SIEMENS

Fiber Optic Jumpers Patch Cables and Pigtails

ST® Connector



Description

Patch cables are available as multimode or single mode fiber in a simplex cable (single fiber) or duplex cable (zipcord) connectorized on both sides with ST connectors. Standard lengths (2 meters and 3 meters, multimode) are available from stock.

Pigtails are available as cable (with PVC jacket and strength member), loose-tube fiber, or 900mm buffered fiber-only connectorized on one side with an ST connector. Standard lengths (2 meters, multimode) are available from stock.

The patch cables and pigtails are individually tested, and a test certificate is provided for each one.

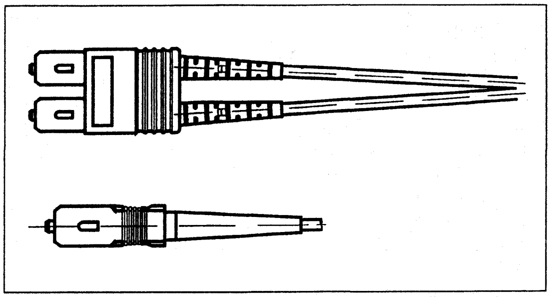
Technical Data

Parameter	Values			Unit
Core Diameter	9/125	50/125	62.5/125	µm
Ferrule	ZrO_2-Ceramic			
Ferrule Diameter	2.499 ±0.0005	2.499 ±0.001	2.499 ±0.0001	mm
Typical Attenuation	≤0.2			dB
Return Loss	≥35*	—	—	
Cycles	500			
Operating Temperature	0 to +70			°C
Storage Temperature	–40 to +70.			
Strain Relief (cable version)	> 100			N

* Higher values available

ST® is a registered trademark of AT&T.

SC Connector



Description

Patch cables are available as multimode or single mode fiber in a simplex (single fiber) or duplex cable (zipcord) connectorized on both sides with SC connectors.

Pigtails are available as cable, loose-tube fiber, or 900 mm buffered fiber-only connectorized on one side with an SC connector.

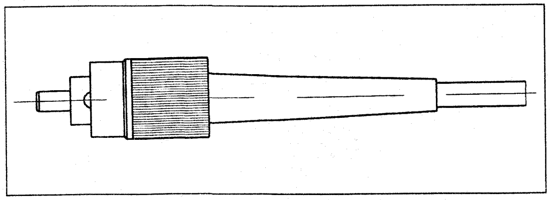
The patch cables and pigtails are individually tested, and a test certificate is provided for each one.

Technical Data

Parameter	Values			Unit
Core Diameter	9/125	50/125	62.5/125	µm
Ferrule	ZrO_2-Ceramic			
Ferrule Diameter	2.499 ±0.0005	2.499 ±0.001		mm
Typical Attenuation	≤0.2			dB
Return Loss	≥35*	—		
Cycles	500			
Operating Temperature	0 to +70			°C
Storage Temperature	–40 to +70			
Strain Relief (cable version)	> 100			N

* Higher values available

FC/PC Connector



Description

Patch cables are available as simplex or duplex cable (zip-cord) connectorized on both sides with FC/PC connectors.

Pigtails are available as cable, loose-tube fiber, or 900mm buffered fiber-only connectorized on one side with an FC/PC connector.

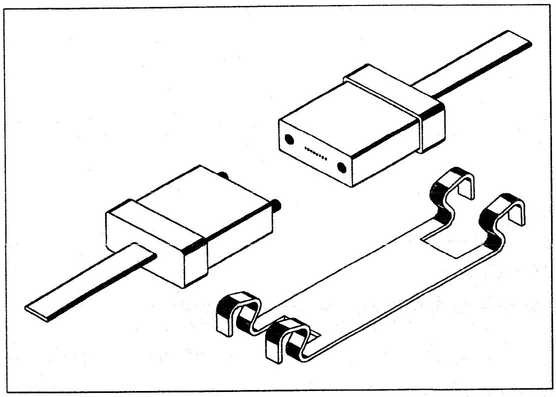
The patch cables and pigtails are individually tested, and a test certificate is provided for each one.

Technical Data

Parameter	Values			Unit
Core Diameter	9/125	50/125	62.5/125	µm
Ferrule	ZrO_2-Ceramic			
Ferrule Diameter	2,499 ±0.0005	2,499 ±0.001	2,499 ±0.0001	mm
Typical Attenuation	≤0.2			dB
Return Loss	≥35*			
Cycles	500			
Operating Temperature	0 to +70			°C
Storage Temperature	-40 to +70°C			
Strain Relief (cable version)	> 100			N

* Higher values on request

MT Connector



Description

MT technology is suitable for parallel data transmission (ARRAY technology). The MT ferrule accomodates four to twelve fibers.

The MT connector can be integrated into the SIPAC® backplane-connector system.

The MT connector is available in two versions:

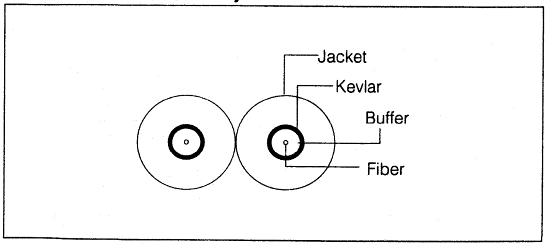
- MT push-pull connector assembled to fiber ribbon (without strain relief) or to ribbon cable (strain relief). It enables mating to a device or an adapter allowing a more rugged assembly construction.
- MT ferrule with fiber ribbon
  MT ferrules are coupled by a spring only (no strain relief).

Technical Data

Parameter	Values			Unit
Core Diameter	9/125	50/125	62.5/125	µm
Ferrule	Plastic			
Ferrule Diameter (L/W/H)	8x6.9x3			mm
Endface	8°angle polish	flat polish		
Insertion Loss per Fiber, max.	<1			dB
Cycles	200			
Return Loss	>50	—		dB
Operating Temperature	0 to +70			°C
Insertion Temperature	–40 to +70			

SIPAC® is a registered trademark of Siemens.

Duplex Cable (Zipcord)



Description

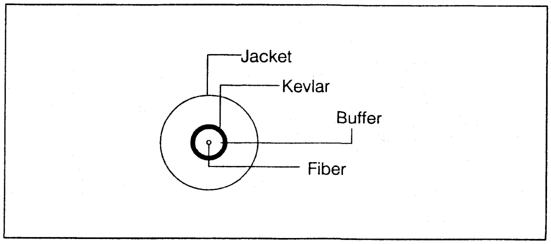
The cable shown is suitable for routing in pipes and cable ducts. It can also be used for linking mobile equipment.

The standard length of the whips for the ST® Patchcable is 30 cm.

Technical Data

Parameter	Values			Unit
Core diameter	9/125	50/125	62.5/125	µm
Cable outside Diameter	2.9x5.8			mm
Cable Weight	16			kg/km
Tension Load During installation, max.	1000			N
Crush Resistance	500			N/cm
Operating Temperature	0 –+70			°C
Storage Temperature	–40 –+70			
Bend Radius in Operation, min.	30			mm
Attenuation 850/ 1300/1550 nm	–/0.5/0.4	3/1/–	3.5/1/–	dB/km
Bandwidth 850/ 1300 nm	—	200/800	200/500	MHz/ km
Dispersion 1300/ 1550 nm, max	3.5/19	—		ps/km/nm

Simplex Cable



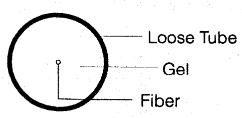
Description

The cable shown is suitable for routing in pipes and cable ducts. It can also be used for linking mobile equipment.

Technical Data

Parameter	Values			Unit
Core diameter	9/125	50/125	62.5/125	µm
Cable outside Diameter	2.9			mm
Cable Weight	8			kg/km
Tension Load During installation, max	500			N
Crush Resistance	500			N/cm
Operating Temperature	0 to +70			°C
Storage Temperature	–40 to +70			
Bend Radius in Operation, min	30			mm
Attenuation 850/ 1300/1550 nm	–/0.5/0.4	3/1/–	3.5/1/–	dB/km
Bandwidth 850/ 1300nm	—	200/800	200/500	MHz/km
Dispersion 1300/ 1550 nm, max	3.5/19	—		ps/km/nm

Fiber 0.9 mm



Description

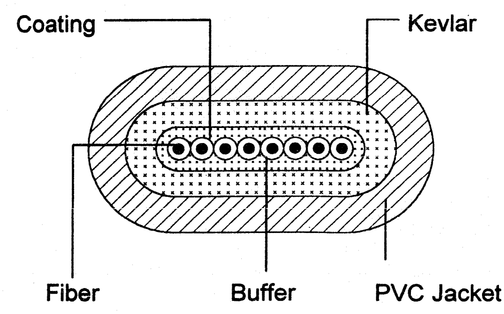
This fiber is suitable for installation in splicing cassettes. The fiber is protected by a PVC sheath.

The fiber is available with or without a gel in the loose tube.

Technical Data

Parameter	Values			Unit
Core diameter	9/125	50/125	62.5/125	µm
Operating Temperature	0 to +70			°C
Storage Temperature	–40 to +70			
Bend Radius in Operation, min.	30			mm
Attenuation 850/ 1300/1550 nm	–/0.5/0.4	3/1/–	3.5/1/–	dB/km
Bandwidth 850/ 1300nm	—	200/800	200/500	MHz/km
Dispersion 1300/ 1550 nm, max	3.5/19	—		ps/km/nm

Ribbon Cable



Description

The ribbon cable is suitable for flexible indoor routing.

Cable construction:

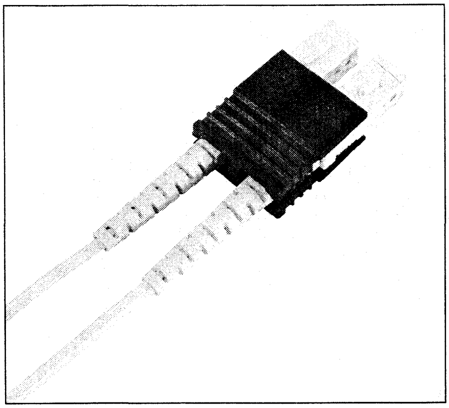
- Fiber bundle with four, eight or twelve separate coated fibers
- Colored ribbon to differentiate the separate fibers
- Strain relief with kevlar
- PVC jacket
- Flammability in accordance with UL 1666

Technical Data

Parameter	Values			Unit
Core Diameter	9/125	50/125	62.5/125	µm
Cable outside Diameter	4x2			mm
Cable Weight	9.2			kg/km
Tension Load During installation, max	500			N
Crush Resistance	750			N/cm
Operating Temperature	0 to +70			°C
Storage Temperature	–40 to +70°			
Bend Radius in Operation, min.	30			mm
Attenuation 850/ 1300/1550 nm	–/0.5/0.4	3/1/–	3.5/1/–	dB/km
Bandwidth 850/ 1300nm	—	200/800	200/500	MHz/km
Dispersion 1300/ 1550 nm. max	3.5/19	—		ps/km/nm

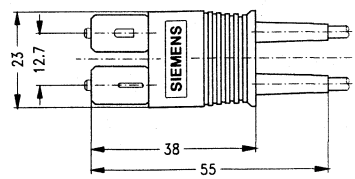
SIEMENS

SC Duplex Jumper

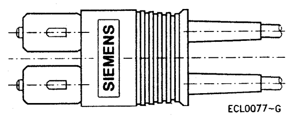


Dimensions in mm

Single Mode Keying



Multimode Keying



Features

- **Fully compatible with ANSI fiber channel standard**
- **Fully compatible with ANSI low cost fiber**
- **Siemens SC duplex clamp is in accordance with ANSI standard**
- **Push-pull design**
- **Multimode and single mode connectors available**
- **Precision zirconia ferrules (free of corrosion, no abrasion)**
- **Keying for multimode and single mode**

Description

The Siemens Duplex Jumper with SC Duplex connectors is designed in accordance with ANSI Standard for Fiber Channel and Low Cost Fiber. The small dimensions of the Duplex Clamp guarantees a high packing density for transceiver modules on boards. The single mode keying features the small nose on the transmitter side. It prevents connections of a multimode connector to a single mode transmitter.

Absolute Maximum Ratings

Storage/Shipping Temperature (T_{stg}) .... –40 to 70°C
Storage/Shipping Humidity(RH_{stg}) .... 5 to 100 %
Operating Temperature (T_{amb}) .... 0 to 70°C
Operating Humidity (RH_A) .... 8 to 80 %
Tension Applied to Mounted Cable(F_{cable}) .... 200 N
Tension Applied to Connector (F_{con}) .... 100 N
Bend Radius for Long-Term Installation at 600 N .... 48 mm
Cable Crush Resistance .... 400 N/cm

Mechanical/Optical/Transmission Characteristics and Recommended Operating Conditions

Parameter		Min.	Typ.	Max.	Unit
Core Diameter		9/50/62.5			µm
Insertion Loss			0.3/0.3/0.3	0.5/0.5/0.5	dB
Return Loss (Single Mode Only)		30/—/—			
Mechanical Life (Plugging Cycles)		250	> 1000		
Attenuation	850 nm		—/3.0/3.0	—/3.5/3.75	dB/km
	1300 nm		0.5/1.0/1.0	1.0/2.0/1.5	
	1550 nm		0.4/—/—	0.75/—/—	
Bandwidth length product	850 nm	—/500/160			MHz/km
	1300 nm	—/500/500			
Zero Dispersion Wavelength		1300/—/—	1310/—/—	1322/—/—	nm
Zero Dispersion Slope				0.095/—/—	ps/ (nm^2km)
Dispersion (at 1285-1330 nm)				3.5/—/—	

ORDERING INSTRUCTIONS

Part number	V	2	3	8	5	9	–					3	–				

Type:
SC Duplex Jumper (FCS)

Identification digits for core
A = 9/125 µm
B = 50/125 µm
C = 62.5/125 µm

Cable type
21 = Duplex Zipcord 3.0 x 6.0 mm Riser
25 = Duplex Zipcord 3.0 x 6.0 mm Plenum
27 = Duplex Zipcord 3.0 x 6.0 mm Halogenfree

Connectors
0 = SC duplex – SC duplex
1 = SC duplex – FSMA (only multimode)
2 = SC duplex – DIN
3 = SC duplex – ST[I]®
4 = SC duplex – ST[II]®
5 = SC duplex – ESCON®
6 = SC duplex – FDDI
7 = SC duplex – FC/PC
8 = SC duplex – SC simplex
9 = SC duplex – mini BNG

Identification digit for cable length
A = m (1 … 999 m)
B = cm (30 … 999 cm, no full meters)
D = x 10 m (1000 … 3000 m)
F = m + 0.5 m (1.5 … 999.5 m)
T = 1000 m + (1001 … 1999 m)

Cable length

Ordering Instructions for Ordering in the U.S.

Part number	J	Z	–				S	S				C	P

Type:
SC Duplex Jumper (FCS)

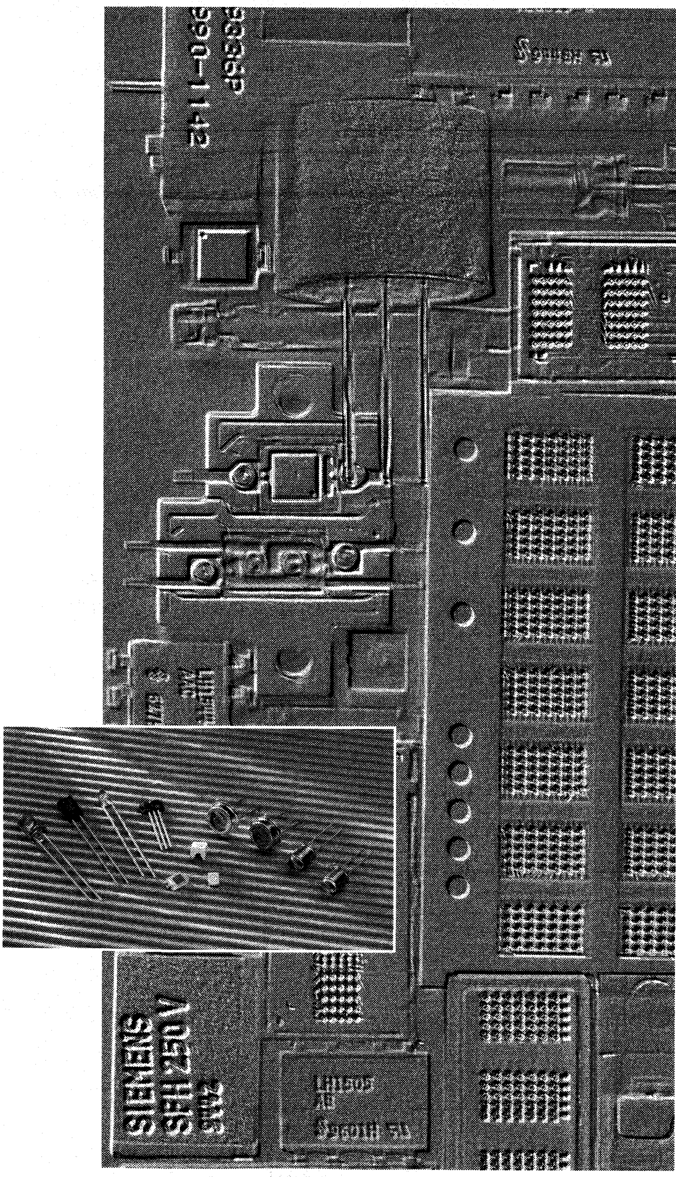
Identification digits for core
062 = 62.5/125 µm
050 = 50/125 µm
009 = 9/125 µm

SC to SC Connector Jumper

Cable length in meters
e. g. 003 = 3 meters

Duplex Clip

Plenum



Custom Optoelectronic Products

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LED Lamps

Optocouplers

Solid State Relays (SSRs)

IR DataCOM Products

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- Components
- Laser Diodes
- Photodiodes

Fiber Optic Data Links
- Transceivers
- Cable Assemblies

Infrared Emitters

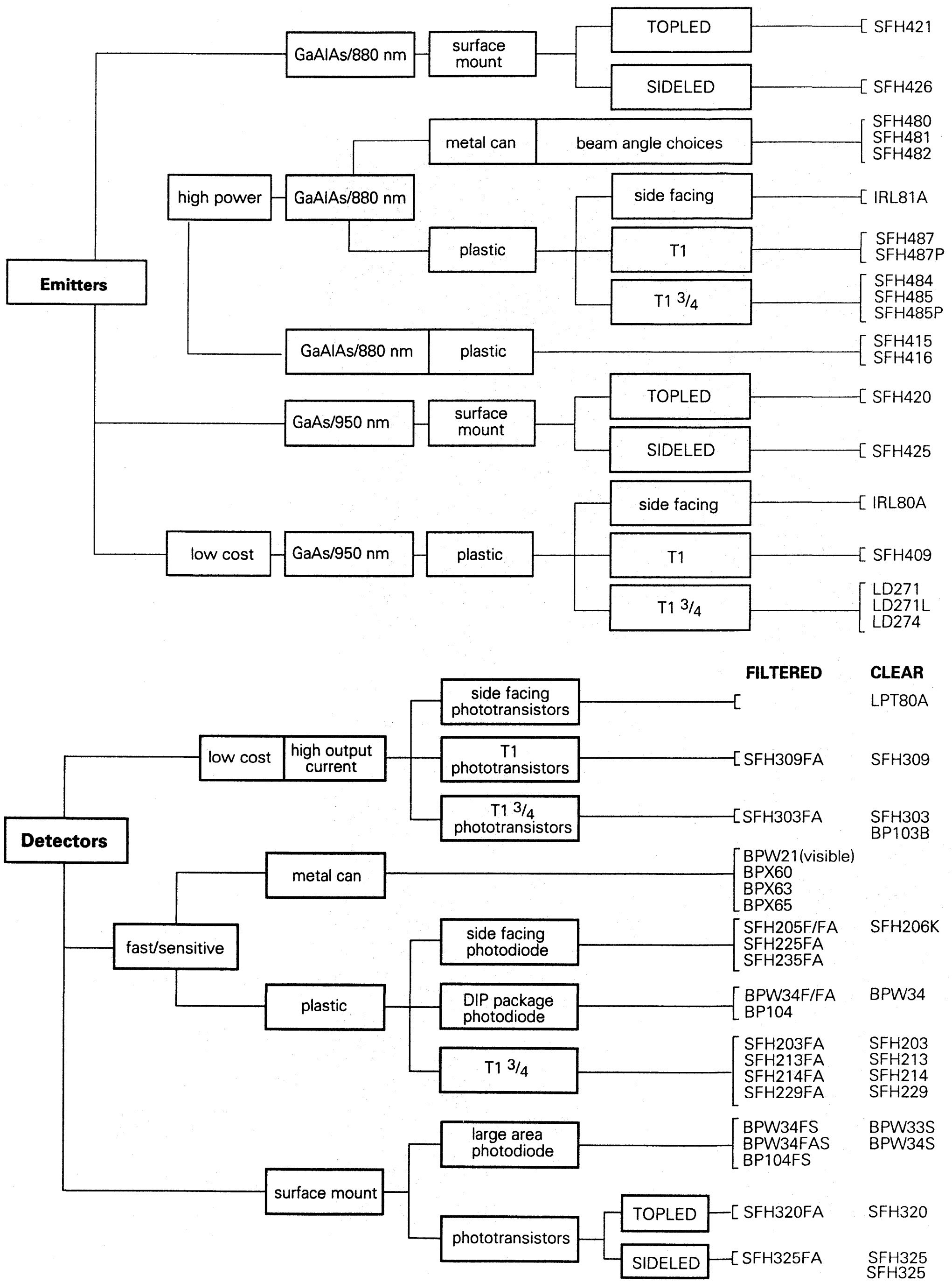
Photodiodes

Phototransistors

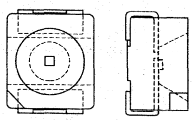
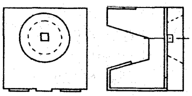
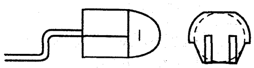
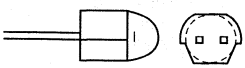
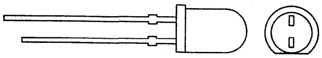
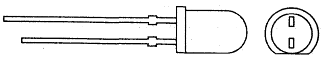
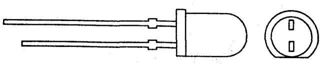
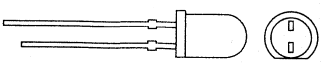
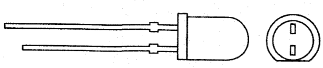
Photovoltaic Cells

Application Notes

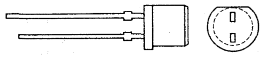
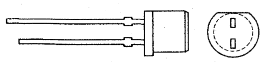
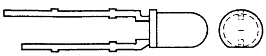
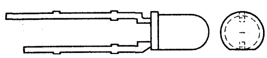
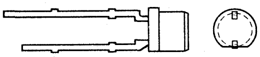
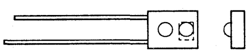
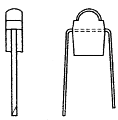
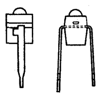
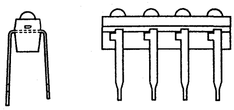
IR Selection Chart



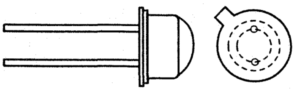
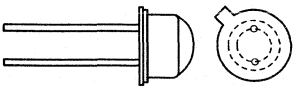
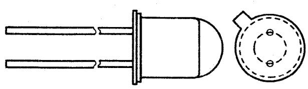
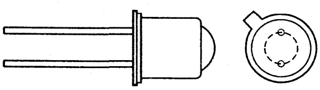
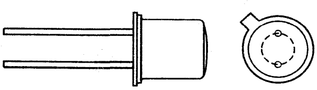
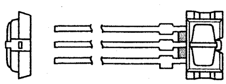
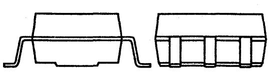
Infrared Emitters

Package Outline	Part Number	Package Type	Half Angle	Radiant Intensity		Surge Current (t<10µs) A	Features	Page
				I_E (mW/sr)	mA			
	SFH420	SMT TOP-LED	±60°	≥2.5	100	3.0	GaAs, 950 nm. On tape and reel.	10–20
	SFH421	SMT TOP-LED	±60°	≥4.0		2.5	GaAlAs, 880 nm. On tape and reel.	10–22
	SFH425	SMT SIDE-LED	±60°	≥2.5	100	—	GaAs, 950 nm. On tape and reel.	10–20
	SFH426	SMT SIDE-LED	±60°	≥4		2.5	GaAlAs, 880 nm. On tape and reel.	10–22
	SFH4580	T1¾ (5 mm) plastic	±15°	≥25	100	2.5	IR remote control. GaAs, 880 nm. Matches photo-diode SFH2540/ 2545.	10–46
	SFH4585							
	LD271/L	T1¾ (5 mm) gray plastic	±25°	15 (≥10)	100	3.5	GaAs, 950 nm. IR remote control. Matches photo-diode SFH203 or phototransistor SFH 300.	10–7
	LD271H/HL			>16				
	LD274-2	T1¾ (5 mm) gray plastic	±10°	50–100	100	3.0	GaAs, 950 nm. IR remote control. Matches photode-tectors BP104, SFH300.	10–9
	LD274-3			≥80				
	SFH415	T1¾ (5 mm) plastic	±17°	≥25	100	3	GaAs, 950 nm. IR remote control SFH415: matches SFH203, SFH300.	10–18
	SFH415-T			25–50				
	SFH415-U			≥40				
	SFH416-R		±28°	≥10				
	SFH484	T1¾ (5 mm) clear blue tinted plastic	±8°	50–160	100	2.5	GaAlAs, 880 nm. IR remote control.	10–31
	SFH484-1			50–100				
	SFH484-2			≥80				
	SFH485	T1¾ (5 mm) clear blue tinted plastic	±20°	16–80	100	2.5	GaAlAs, 880 nm. IR remote control.	
	SFH485-2			≥25				
	SFH486	T1¾ (5 mm) clear plastic	±11°	40	mW/sr	2.5	GaAlAs, 880 nm. IR remote control..	10–35

Infrared Emitters

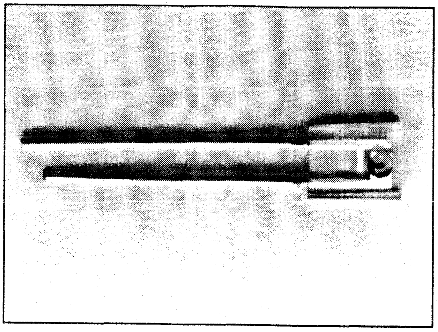
Package Outline	Part Number	Package Type	Half Angle	Radiant Intensity		Surge Current (t<10µs) A	Features	Page
				I_E (mW/sr)	mA			
	SFH485P	T1¾ (5 mm) clear plastic	±40°	>3.15	100	2.5	GaAlAs, 880 nm. Low cost replacement for metal can package.	10–33
	SFH495P	T1¾ (5 mm) clear plastic	±35°	200	1 A	1	GaAlAs, 945 nm. IR remote control.	10–41
	SFH409	T1 (3 mm) gray plastic	±20°	≥6.3	100	3	GaAs, 950 nm. IR remote control. Matches phototransistor SFH309.	10–16
	SFH409-1			6.3–12.5				
	SFH409-2			≥10				
	SFH487	T1 (3 mm) clear blue-tinted plastic.	±20°	≥12.5	100	2.5	GaAs, 880 nm. IR remote control. Matches phototransistor SFH309.	10–37
	SFH487-2			≥20				
	SFH487P	T1 (3 mm) clear blue-tinted plastic.	±65°	>2	100	2.5	GaAs, 880 nm. Low cost replacement for metal can package.	10–39
	IRL80A	Miniature-clear plastic, side-facing.	±30°	≥0.4	20	NA	IRL80A–GaAs, 950 nm. IRL81A–GaAlAs, 880 nm. Matches phototransistor LPT80A.	10–1
	IRL81A		±25°	≥1.0				
	SFH405	Miniture. 039" (1 mm) wide, radial leads	±16°	≥1.6	40	1.6	GaAs, 950 nm. Matches phototransistor SFH305.	10–14
	LD261	Single diode	±30°	5 (≥2.5)	50	1.6	GaAs, 950 nm. Miiniature, radial leads.	10–5
	LD262	2 diodes					GaAs, 950 nm. Miniature, radial leads. Ideal for card readers. Matches phototransistors BPX81, BPX80 series.	
	LD263	3 diodes						
	LD264	4 diodes						
	LD265	5 diodes						
	LD266	6 diodes						
	LD267	7diodes						
	LD268	8 diodes						
	LD269	9 diodes						
	LD260	10 diodes						

Infrared Emitters

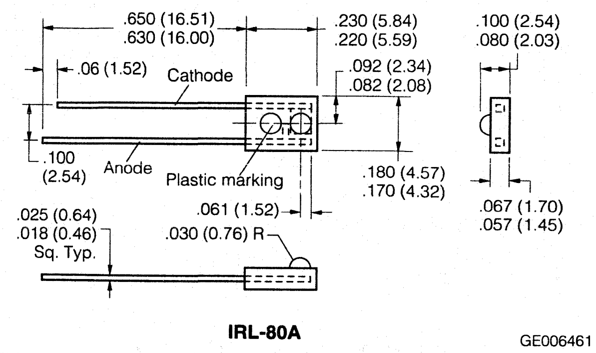
Package Outline	Part Number	Package Type	Half Angle	Radiant Intensity I_E(mW/sr)	Radiant Intensity mA	Surge Current (t<10µs) A	Features	Page
	LD242-2	TO-18 epoxy glob top.	±40°	4–8	100	3	GaAs, 950 nm. Matches pho-totransistor BP103 or photodiode BPX63.	10–3
	LD242-3			≥6.3				
	LD242 E7800			1–3.2				
	SFH464	TO-18 epoxy glob top.	±23°	≥1	50	1	GaAlAs, 660 nm. Matches pho-totransistor BP103.	10–24
	SFH483	TO-18 epoxy glob top.	±23°	—	—	2.5	GaAlAs, 880 nm.	10–29
	SFH400	TO-18 round glass lens.	±6°	20	100	3	GaAs, 950 nm. Matches pho-totransistor BPX43.	10–11
	SFH400-3			≥32				
	SFH480-2	TO-18 round glass lens.	±6°	≥40	100	2.5	GaAlAs, 880 nm. Matches SFH216.	10–26
	SFH480-3			≥63				
	SFH401-2	TO-18 dome glass lens.	±15°	10–20	100	3	GaAs, 950 nm. Matches pho-totransistor BPY62.	10–11
	SFH401-3			≥16				
	SFH481	TO-18 dome glass lens.	±15°	≥10	100	2.5	GaAlAs, 880 nm. Matches BPX43, BPY62.	10–26
	SFH481-1			10–20				
	SFH481-2			≥16				
	SFH402-2	TO-18 flat glass lens.	±40°	≥2.5	100	3	GaAs, 950 nm. Matches pho-totransistor BPX38 or photodiodes BPX65/66.	7–11
	SFH402-3			≥4.0				
	SFH482	TO-18 flat glass lens.	±30°	≥3.15	100	2.5	Wide angle. GaAlAs, 880 nm.	10–26
	SFH482-1			3.15–6.3				
	SFH482-2			≥5				
	SFH482-3			≥8				
	SFH900	Miniature plastic, daylight filter.	—	>0.25	Collector Emitter Current mA	1.5	Reflective light bar-rier for short (≤5 mm) distances.	10–43
	SFH900-1			.25–.50				
	SFH900-2			.40–.80				
	SFH900-3			.63–1.25				
	SFH900-4			≥1.0				
	SFH9101 SFH9102	6 pin SMT.	—	—	—	1.5	Light reflection switch. No cross talk.	10–48

SIEMENS

GaAs IRL 80A
GaAlAs IRL 81A
Infrared Emitter



Dimensions in inches (mm)



FEATURES

- **GaAs infrared emitting diode**
- **Clear plastic package with lateral emission**
- **Low cost plastic package**
- **Long term stability**
- **Wide beam**
  - **IRL80A: ±30°C**
  - **IRL81A: ±25°C**
- **Matches phototransistor LPT 80 A phototransistor**
  - **IRL81A: in near infrared range**

APPLICATIONS

- **Beam interruption usage**
- **Light barriers**

DESCRIPTION

The IRL 80A is a GaAs infrared emitting diode while the IRL 81A is a GaAlAs IRED. The miniature side-facing device has a chip that emits radiation from the side of the clear package.

Maximum Ratings T_A=25°C

Operating/Storage Temperature Range (T_{OP}, T_{STG})................–40° to +100°C
Soldering Temperature (≥ .15 mm from case bottom) t=5 ....240°C
Reverse Voltage (V_R)
IRL 80A.......................................3 V
IRL 81A.......................................5 V
Forward Current (I_F)
IRL 80A....................................... 60 mA
IRL 81A....................................... 100 mA
Power Dissipation (P_{TOT})
IRL 80A.......................................100 mW
IRL 81A.......................................200 mW
Derate Above T_A>25°C
IRL 80A ....1.33 mW/°C
RL 81A ....2.67 mW/°C
Thermal Resistance (R_{thJA}).......................................750 k/W

Characteristics T_A=25°C

Parameter	Symbol	IRL80A	IRL81A	Unit	Condition
Peak Wavelength, I_{MAX}	λ_{PEAK}	950	880	nm	
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	20	36 to 44		
Half Angle	φ	±30	±25	Deg.	
Forward Voltage	V_F	≤1.5	1.5 (≤2.0)	V	I_F=20 mA
Radiant Intensity(1)	I_E	≥0.4	≥1.0	mW/sr	
Total Radiant Flux	Φ_E	—	1.5	mW	

Note
1. A 1 cm^2 silicon detector is aligned with the mechanical axis. No aperature is used.

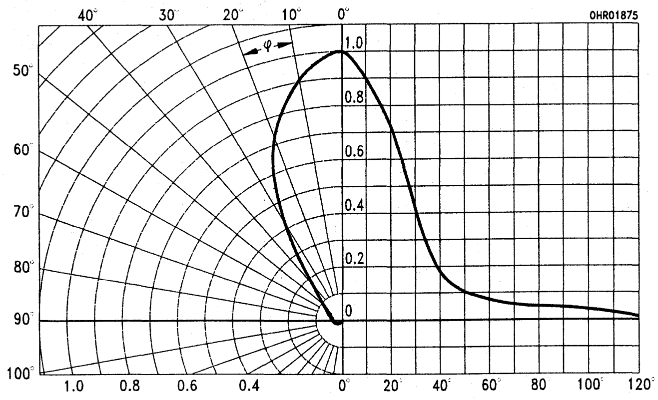


Figure 1. Radiation characteristic I_{REL}=f(φ) IRL80A

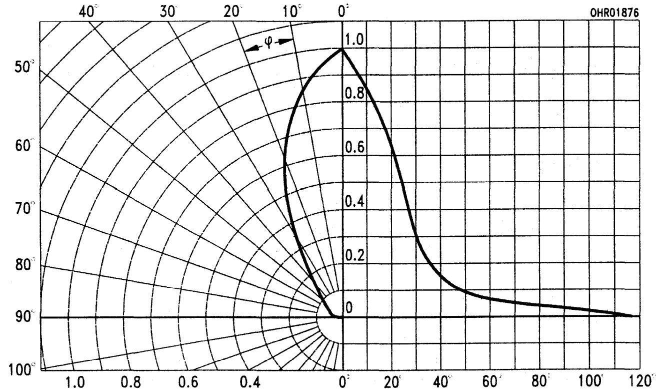


Figure 2. Radiation characteristic I_{REL}=f(φ) IRL81A

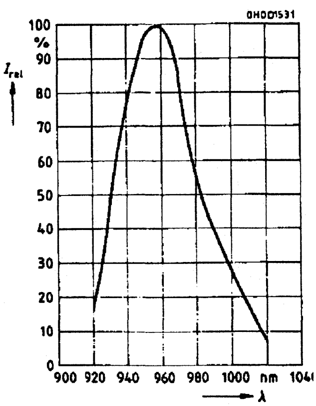


Figure 3. Relative spectral emission I_{REL}=f(λ) IRL80A

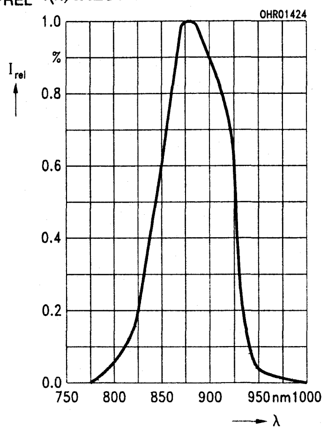


Figure 4. Relative spectral emission I_{REL}=f(λ) IRL81A

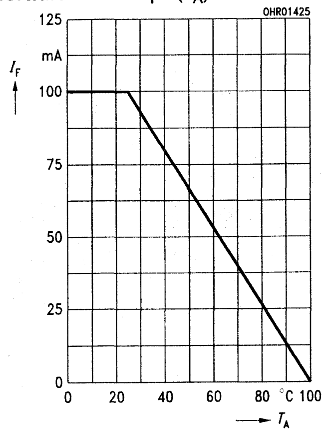


Figure 5. Maximum permissible forward current I_F=f(T_A) IRL81A

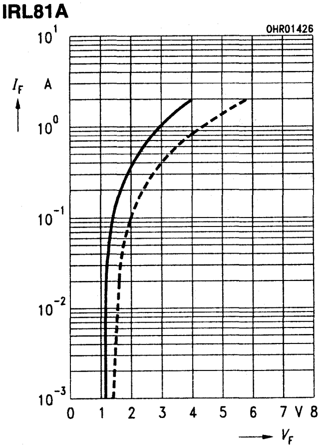
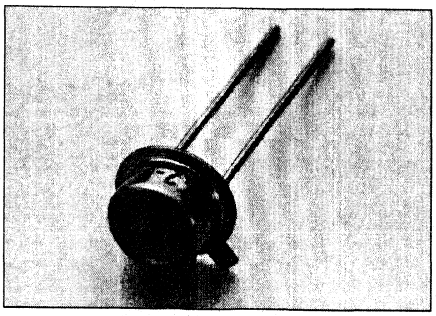


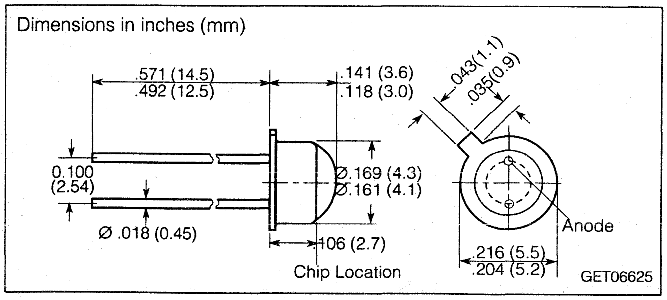
Figure 6. Forward current I_{REL}=f(Tλ) IRL81A

SIEMENS

LD242

GaAs Infrared Emitter





FEATURES
- **GaAs infrared emitting diode, fabricated in a liquid phase epitaxy process**
- **Cathode electrically connected to case**
- **High reliability**
- **Wide beam**
- **Same package as BP103, BPX63, SFH464, SFH 483**
- **DIN humidity category per DIN 40 040 GQG**
- **Package**
  - **Base plate per 18 A3 DIN 41876 (TO 18)**
  - **Transparent epoxy resin lens**
  - **Lead spacing 0.100" (2.54 mm)**

APPLICATIONS
- **IR remote control and sound transmission**
- **Photointerrupters**

Maximum Ratings
Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F)T_C=25°C .... 300 mA
Surge Current (I_{FSM}) t=10 µs, D=0 .... 3 A
Power Dissipation (P_{TOT})T_C=25°C .... 470 mW
Thermal Resistance (R_{thJA}) .... 450 K/W
(R_{thJC}) .... 160 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	950	nm	I_F=100 mA,
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	55		
Half Angle	φ	±40	Deg.	
Active Chip Area	A	0.25	mm²	
Active Chip Dimensions	L x W	0.5 x 0.5	mm	
Distance, Chip Surface to Lens Top	H	0.3 to 0.7		
Switching Times, I_E, 10% to 90% and 90% to 10%,	t_R, t_F	1	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_0	40	pF	V_R=0 V
Forward Voltage	V_F	1.3 (≤1.5)	V	I_F=100 mA
		1.9 (≤2.5)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Radiant Flux, Total	Φ_E	16	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.55	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	–1.5	mV/K	
Temperature Coefficient, λ_{PEAK}	TC_λ	0.3	nm/K	

Radiant Intensity Selections	Symbol	242-2	242-3	242 E7800[1]	Unit	Condition
I_E in Axial Direction at a steradian: Ω=0.01 sr	I_E	4 to 8	>6.3	1 to 3.2	mW/sr	I_F=100 mA, t_P=20 ms
	I_{Etyp}	50	75	–		I_F=100 mA, t_P=100 µs

Note:
1. An aperture is used in front of the component for measuring the radiant intensity and the half angle (diameter of the aperture: 1.1 mm; distance of aperture to case back side: 4 mm). This ensures that only the radiation in axial direction emitting directly from the chip surface will be evaluated during radiant intensity measurement. This measurement is denoted by "E7800" added to the part number.
2. Radiation reflected by the bottom plate (stray radiation) will not be evaluated. These reflections impair the projection of the chip surface by additional optics (e.g. long-range light reflection switches). In respect of the application of the component, these reflections are generally suppressed by apertures as well. This measuring procedure corresponding with the application provides more useful values.

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

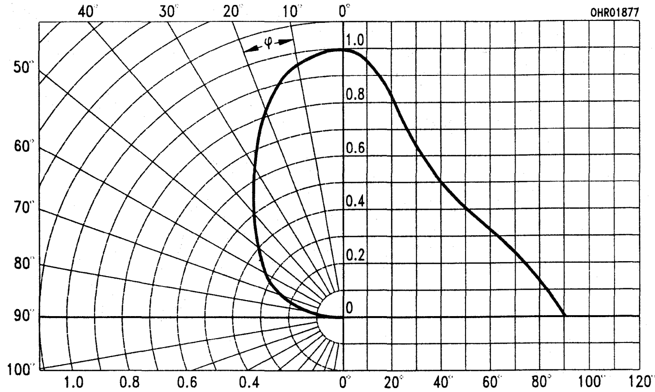


Figure 2. Relative spectral emission
$I_{REL}=f(\lambda)$

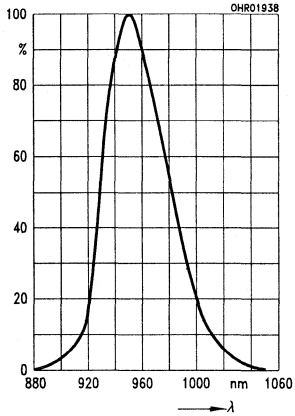


Figure 3. Radiant intensity
I_E/I_E100mA=$f(I_F)$, Single pulse, τ=20 µs

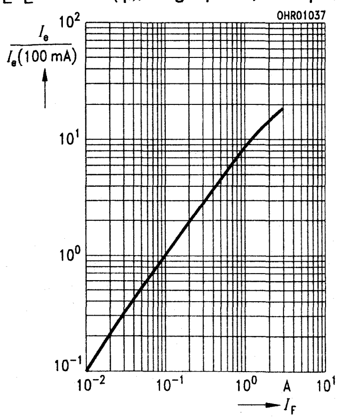


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

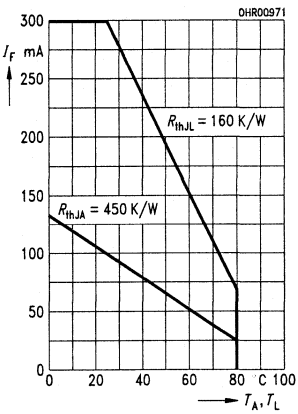


Figure 5. Forward current $I_F=f(V_F)$

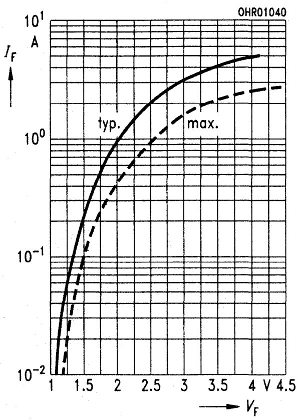
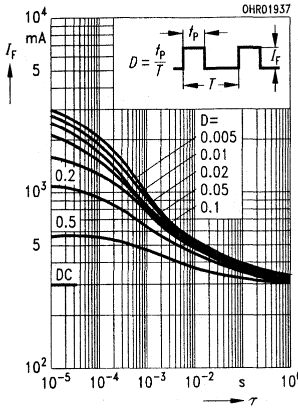
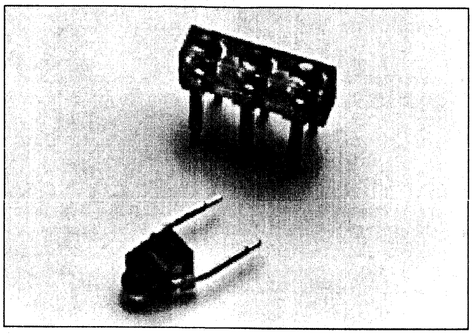


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, T_C=25°C, duty cycle D=parameter

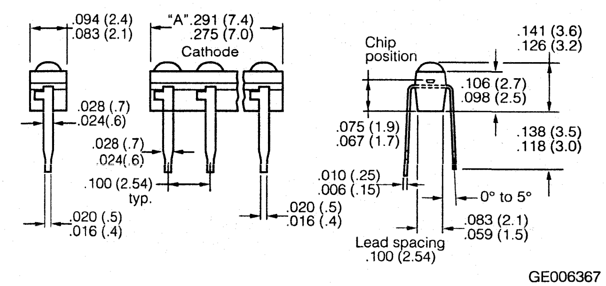


SIEMENS

SINGLE DIODE LD 261
ARRAYS LD 262–269/260
Infrared Emitters



Dimensions in inches (mm)



FEATURES

- **GaAs IR emitterdiode, made in a liquid phase epitaxy process**
- **High reliability**
- **Matches BPX 80–89 photofransistors**
- **Availability:**

"A" Dimension (in mm)		**Min.**	**Max.**
One Diode	**LD 261**	**2.1**	**2.4**
Two Diodes	**LD 262**	**4.5**	**4.9**
Three Diodes	**LD 263**	**7.0**	**7.4**
Four Diodes	**LD 264**	**9.6**	**10.0**
Five Diodes	**LD 265**	**12.1**	**12.5**
Six Diodes	**LD 266**	**14.6**	**15.0**
Seven Diodes	**LD 267**	**17.2**	**17.6**
Eight Diodes	**LD 268**	**19.7**	**20.1**
Nine Diodes	**LD 269**	**22.3**	**22.7**
Ten Diodes	**LD 260**	**24.8**	**25.2**

- **Package**
  - **Transparent epoxy resin lens**
  - **Solder tabs**
  - **Cathode marking : projection at solder leads**

APPLICATIONS

- **Miniature photointerrupters**
- **Punched tape-readers**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The LD260–269 series, GaAs infrared emitting diodes, emit radiation at a wavelength in the near infrared range. These miniature devices come in a grey plastic package and are available as a single diode or as two- through ten-element arrays. The terminals are solder pins with 0.10" lead spacing. The LD260-269 series is designed for use with BPX 80-89 phototransistor when the spacing between each is approximately 10 mm. These devices can easily be mounted on PC boards and in thick film circuits for simple or complex scanning systems.

Maximum Ratings T_A=25°C

Storage Temperature (T) .... –40° + 80°C
Junction Temperature (T_j) .... 80°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 50 mA
Surge Current (I_{FSM}) t≤10 µs, D=0 .... 1.6 A
Power Dissipation (P_{TOT}) .... 70 mW
Thermal Resistance (R_{thJA}, R_{thJL}) .... 750, 650 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ	950	nm	I_F=50 mA, t_P=20 ms
Spectral Bandwidth, 50% I_{MAX}	Δλ	55		
Half Angle	φ	±30	Deg.	
Active Chip Area	A	0.25	mm²	
	L x W	0.5 x 0.5	mm	
Distance, Die Surface to Lens Top	H	1.3 to 1.9		
Switching Time, I_E 10% to 90%, 90% to 10%	t_R,t_F	1	µs	I_F=50 mA, R_L=50 Ω
Capacitance	C_0	40	pF	V_R=0 V
Forward Voltage	V_F	1.25 (≤1.4)	V	I_F=50 mA, t_P=20 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	$Φ_E$	9	mW	
Temp. Coefficient, I_E or $Φ_E$	TC_I	–0.55	%/K	I_F=50 mA
Temp. Coefficient, V_F	TC_V	–1.5	mV/K	
Temp. Coefficient, $λ_{PEAK}$	$TC_λ$	0.3	nm/K	
Radiant Intensity LD262–269/260	I_E	5 (≥2.5) typ.	mW/sr	I_F=50 mA, t_P=20 ms
Radiant Intensity LD261		2 to 6.3		
Radiant Intensity LD261-5		3.2 to 6.3		

Figure 1. Radiation characteristic I_{REL}=f(φ)

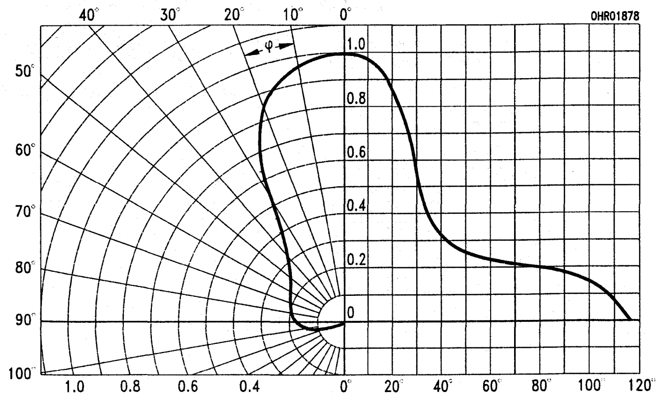


Figure 2. Relative spectral emission
I_{REL}=f(λ)

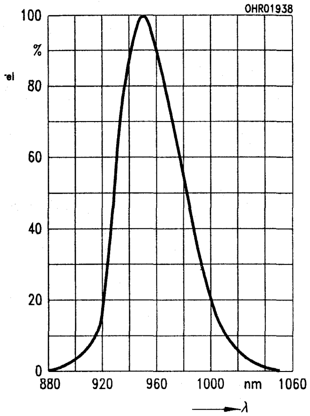


Figure 3. Radiant intensity
I_E/I_E100 mA=f(I_F), Single pulse, τ=20 µs

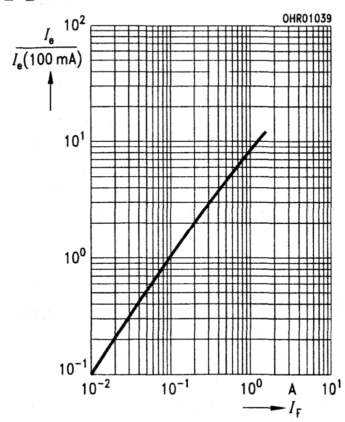


Figure 4. Maximum permissible forward current I_F=f(T_A)

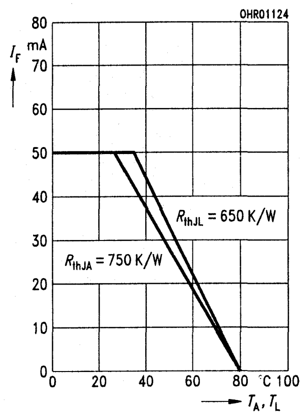


Figure 5. Forward current I_F=f(V_F)

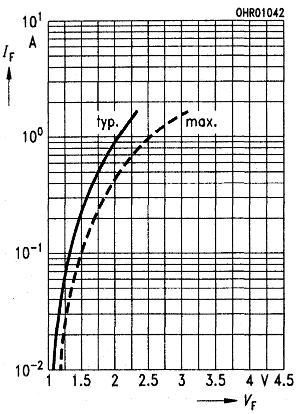
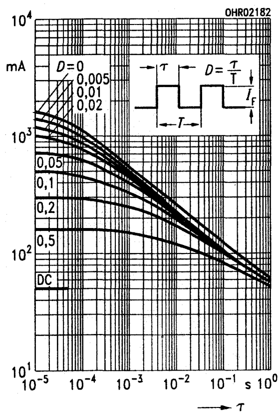
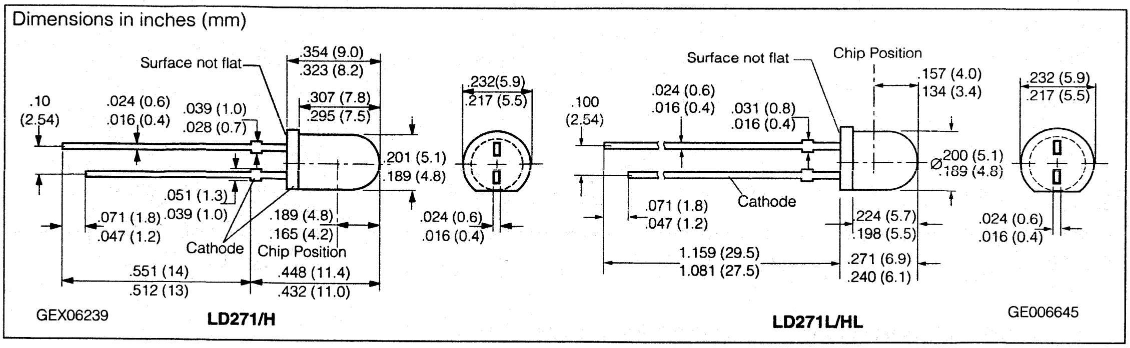


Figure 6. Permissible pulse handling capability I_F=f(τ), T_C=25°C, duty cycle D=Parameter



SIEMENS

LD271/H
1" LEADS LD271L/HL
GaAs Infrared Emitter



FEATURES
- **GaAs infrared emitting diode, fabricated in a liquid phase epitaxy process**
- **High reliability**
- **High pulse handling capability**
- **long leads**
- **Radiant intensity selections**
- **Same package as SFH 300, SFH 203**
- **Gray epoxy resin lens**
- **Solder tabs leads spacing .100 (2.54 mm)**

APPLICATIONS
- **IR remote control of hi-fi stereos and TVs, video tape recorders, dimmers**
- **Remote control of various equipment**

Photointerrupters **DESCRIPTION**

LD271/L is an infrared emitting diode and emits radiation in the near infrared range (950 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. The device is enclosed in a T1$^3/_4$ (5 mm) plastic package.

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 130 mA
Surge Current (I_{FSM}) t=10 µs, D=0 .... 3.5 A
Power Dissipation (P_{TOT}) .... 210 mW
Thermal Resistance (R_{thJA}) .... 330 K/W

Characteristics T_A=25°C

Parameter	Sym.	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	950	nm	I_F=100 mA, t_P=20 ms
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	55		I_F=100 mA
Half Angle	φ	±25	Deg.	
Active Chip Area	A	0.25	mm^2	
Active Chip Area Dimensions	L x W	0.5 x 0.5	mm	
Distance, Chip Surface to Case Surface	H	4.0 to 4.6		
Switching Times, I_E, 10% to 90% and 90% to 10%,	t_R, t_F	1	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_0	40	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.30 (≤1.5)	V	I_F=100 mA, t_P=20 ms
		1.90 (≤2.5)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Radiant Flux, Total	Φ_E	18	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.55	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	–1.5	mV/K	
Temperature Coefficient, λ_{PEAK}	TC_λ	0.3	nm/K	

Description	Symbol	271 271L	271H 271HL	Unit	Condition
Radiant Intensity I_E in Axial Direction at a steradian of Ω=0.01 sr	I_E	15 (≥10)	>16	mW/sr	I_F=100 mA, t_P=20 ms
	I_{Etyp}	120	—		I_F=1 A, t_P=100 µs

Infrared Emitters 10

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

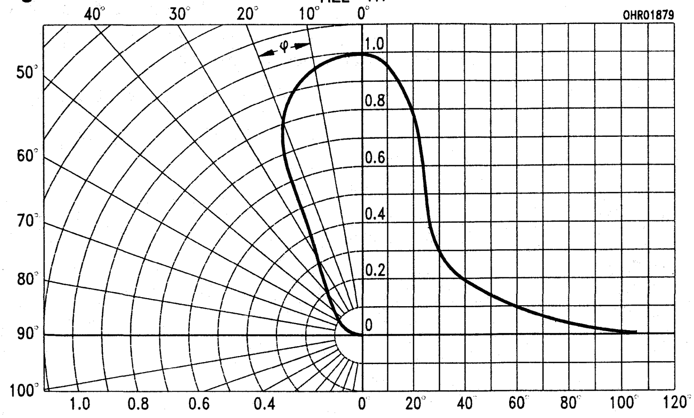


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, $T_C=25°C$, duty cycle D=parameter

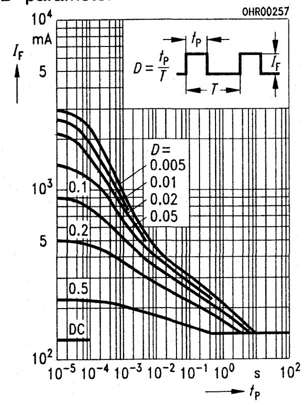


Figure 2. Relative spectral emission $I_{REL}=f(\lambda)$

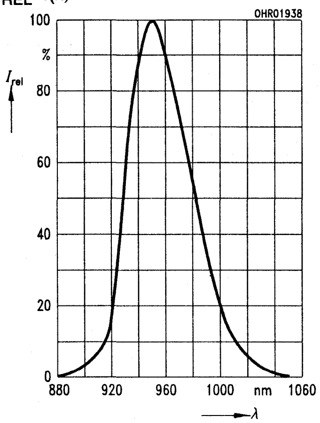


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

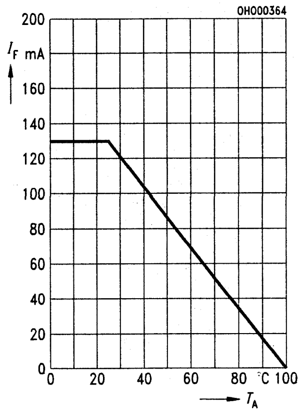


Figure 3. Radiant intensity I_E/I_E100mA=f(I_F), Single pulse, τ=20 µs

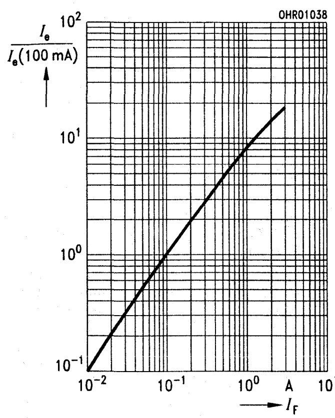
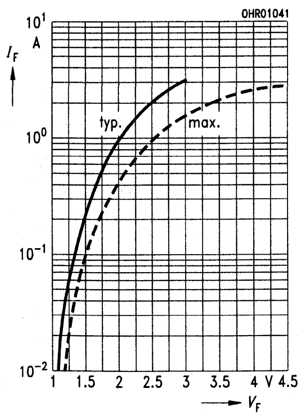


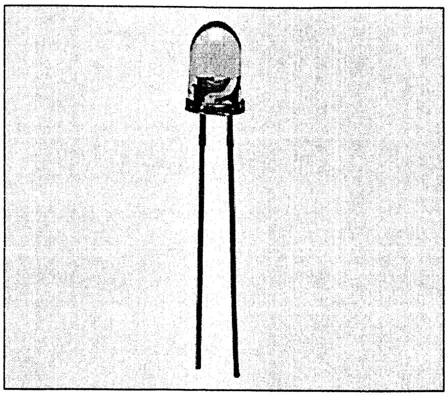
Figure 5. Forward current $I_F=f(V_F)$, single pulse, t_P=20µs

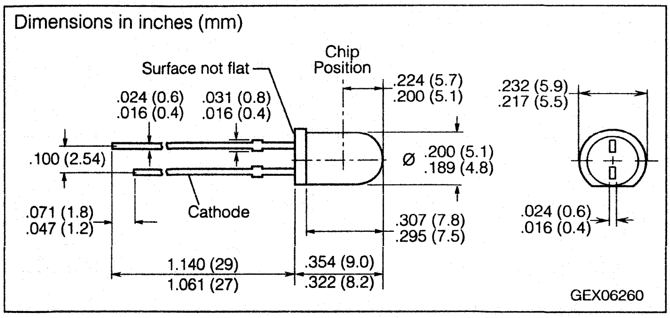


SIEMENS

LD274

GaAs Infrared Emitter





FEATURES

- **Extermely narrow half angle**
- **GaAs infrared emitting diode, fabricated in a liquid phase epitaxy process**
- **High reliability**
- **High pulse handling capability**
- **Radiant intensity selections**
- **Same package as SFH484**
- **Package**
  - **T1$^{3}/_{4}$ (5 mm) LED package**
  - **Gray epoxy resin Lens**
  - **Solder tabs lead spacing 0.100" (2.54 mm)**
  - **Cathode marking: Shorter solder tab, flat**

DESCRIPTION

The LD274 is a GAs IR emitter with an emitted wavelength of 950 nm. The LD274 has a narrow beam. This high power device is suitable for remote control applications.

Maximum Ratings T_A=25°C

Operating/Storage Temperature
Range (T_{OP}, T_{STG})........................ –55° to +100°C
Junction Temperature (T_J)............................. 100°C
Reverse Voltage (V_R)... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t=10 µs, D=0..................... 3 A
Power Dissipation (P_{TOT})............................ 165 mW
Thermal Resistance (R_{thJA})........................ 450 K/W

Characteristics T_A=25°C

Parameter	Sym.	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	950	nm	I_F=100 mA, t_P=20 ms
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	55		
Half Angle	φ	±10	Deg.	
Active Chip Area	A	0.09	mm^2	
Active Chip Area Dimensions	L x W	0.3 x 0.3	mm	
Distance, Chip Surface to Case Surface	H	4.9 to 5.5		
Switching Times, I_E, 10% to 90% and 90% to 10%,	t_R, t_F	1	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_O	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.30 (≤1.5)	V	I_F=100 mA, t_P=20 ms
		1.90 (≤2.5)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Radiant Flux, Total	Φ_E	15	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.55	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	–1.5	mV/K	
Temperature Coefficient, λ	TC_λ	0.3	nm/K	

Radiant Intensity Selections	Sym.	274	274 -2	274 -3*	Unit	Condition
I_E in Axial Direction at Solid Angle of Ω=0.01 sr	I_{Emin}	50	50	80	mW/sr	I_F=100 mA, t_P=20 ms
	I_{Emax}	—	100	—		
	I_{Etyp}	350	600	800		I_F=1 A, t_P=100 µs

*Availability subject to yield

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

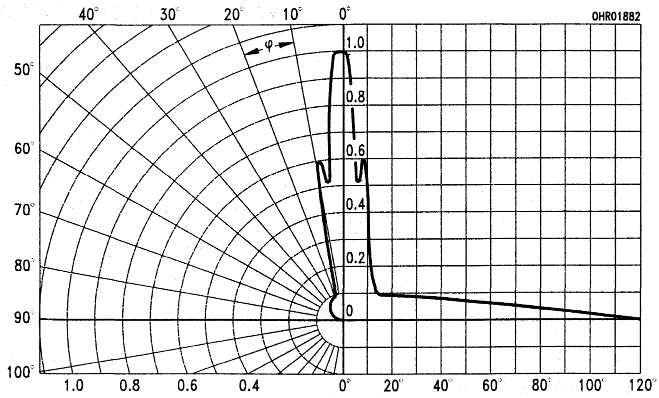


Figure 2. Relative spectral emission
$I_{REL}=f(\lambda)$

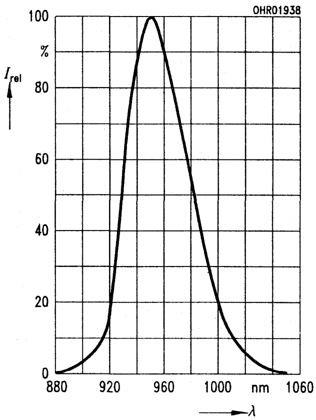


Figure 3. Radiant intensity
I_E/I_E100 mA=f(I_F), single pulse, τ=20 μs

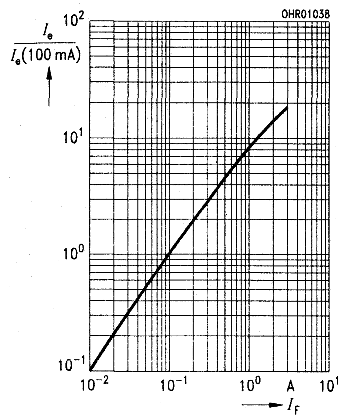


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

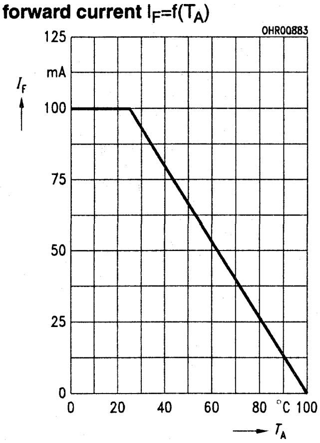


Figure 5. Forward current $I_F=f(V_F)$,
single pulse, t_P=20 μs

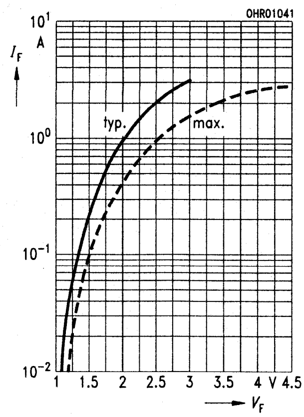
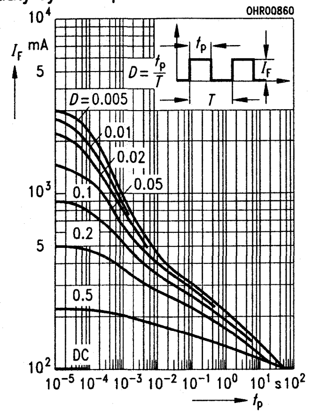
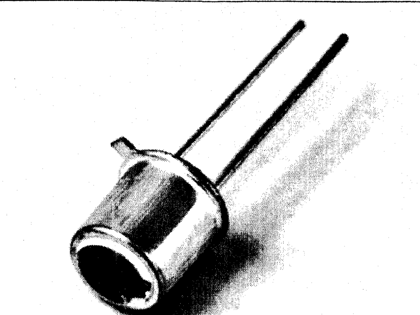


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, $T_C=25°C$, duty cycle D=parameter

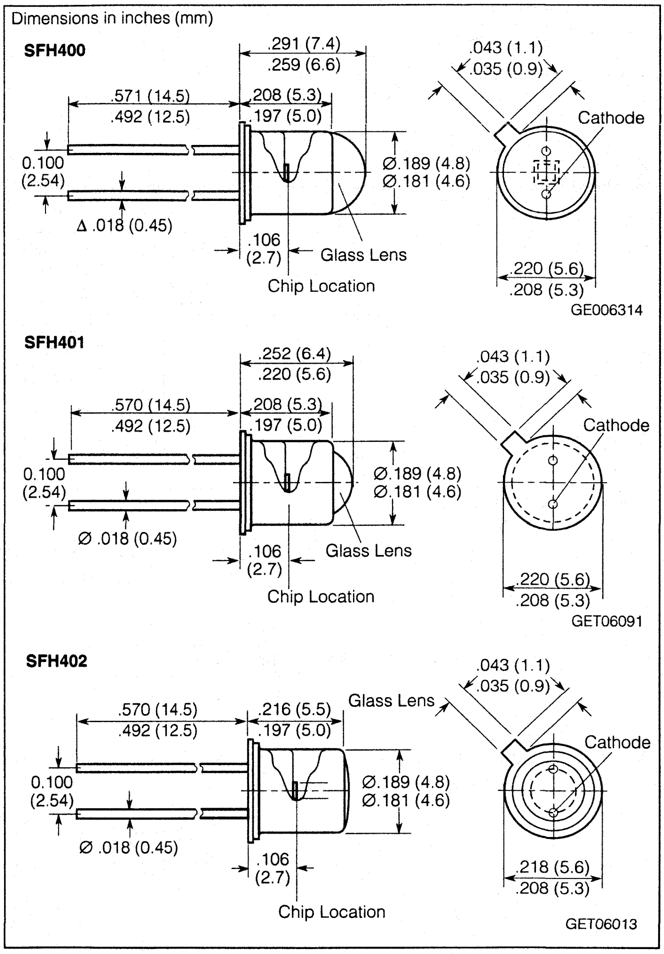


SIEMENS

SFH400
SFH401
SFH402
GaAs Infrared Emitter



SFH401



FEATURES
- **Half angle**
  - **SFH 400, ±6°**
  - **SFH 401, ±15°**
  - **SFH 402, ±40°**
- **Fabricated in a liquid phase epitaxy process**
- **Cathode is electrically connected to the case**
- **High reliability**
- **Radiant intensity selections**
- **SFH 400: Same package as SFH 216**
- **SFH 401: Same package as BPX 43, BPY 62**
- **SFH 402: Same package as BPX 38, BPX 65**
- **Package**
  - **18 A3 DIN 41876 (TO 18), glass lens, hermetically sealed**
  - **Solder tab lead spacing 0.100" (2.54 mm)**

APPLICATIONS
- **Photointerrupters**
- **IR remote control**
- **Industrial electronics**
- **For drive and control circuits**

Maximum Ratings T_C=25°C

Operating/Storage Temperature (T_A, T_{STG})	–55 to +100°C
Junction Temperature (T_J)	100°C
Reverse Voltage (V_R)	5 V
Forward Current (I_F)	300 mA
Surge Current (I_{FSM}) t=10 ms, D=0	3 A
Power Dissipation (P_{TOT})	470 mW
Thermal Resistance (R_{thJA})	450 K/W
(R_{thJC})	200 KW
Peak Wave Length (λ_{PEAK}) I_F=100 mA, I_F=20 ms	950nm

Characteristics T_A=25°C

Parameter		Symbol	Value	Unit	Condition
Spectral Bandwidth, 50% of I_{MAX}		$\Delta\lambda$	55	nm	I_F=100 mA, t_p=20 ms
Half Angle	SFH400	φ	±6	Deg.	
	SFH401		±15		
	SFH402		±40		
Active Chip Area		A	0.25	mm^2	
Active Chip Area Dimensions		L x W	0.5 x 0.5	mm	
Distance, Chip Surface to Case Surface	SFH400	H	4.0 to 4.8		
	SFH401		2.8 to 3.7		
	SFH402		2.1 to 2.7		
Switching Time, I_E 10% to 90%, 90% to 10%		t_R, t_F	1	µs	I_F=100 mA, R_L=50 Ω
Capacitance		C_0	40	pF	V_R=0 V, f=1 MHz
Forward Voltage		V_F	1.30 (≤1.5)	V	I_F=100 mA, t_p=20 ms
			1.90 (≤2.5)		I_F=1 A, t_p=100 µs
Reverse Current		I_R	0.01 (≤1)	µA	V_R=5 V
Radiant Flux, Total		Φ_E	8	mW	I_F=100 mA, t_p=20 ms
Temperature Coefficient, I_E or Φ_E		TC_I	–0.55	%/K	I_F=100 mA
Temperature Coefficient, V_F		TC_V	–1.5	mV/K	
Temperature Coefficient, λ		TC_λ	+0.3	nm/K	

Radiant Intensity Selections
I_E in axial direction at steradian, Ω=0.01 sr

Description	Sym.	400	400-3	401-2	401-3	402-2	402-3	Unit
I_F=100 mA, t_p=20 ms	I_{Emin}	20	32	10	16	2.5	4	mW/sr
	I_{Emax}	—	—	20	—	—	—	
I_F=1 A, t_p=100 µs	I_{Etyp}	300	320	120	190	40	40	

Figure 3. Relative spectral emission
I_{REL}=f(λ)

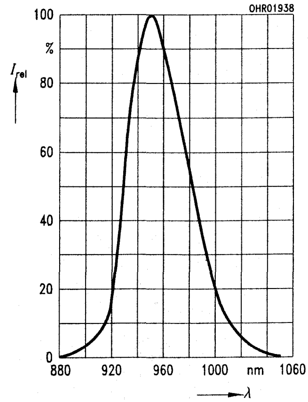


Figure 4. Relative radiant intensity
$I_E/I_{E100\ mA}$=f(I_F), single pulse, τ=20 µs

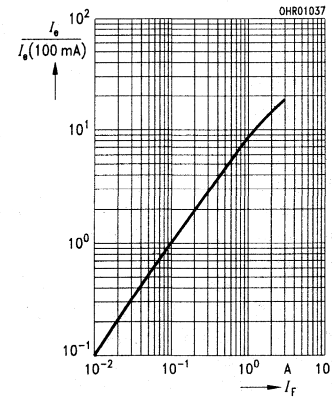


Figure 1. Maximum permissible forward current I_F=f(T_A)

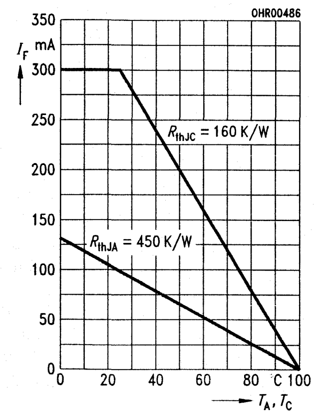


Figure 2. Forward current I_F=f(V_F)

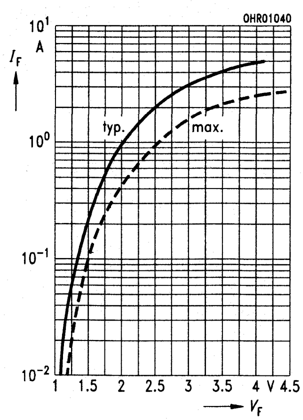


Figure 5. Permissiable pulse handling
I_F=f(τ), T_C=25°C, R_{thJC}=160 K/W duty cycle D=parameter,

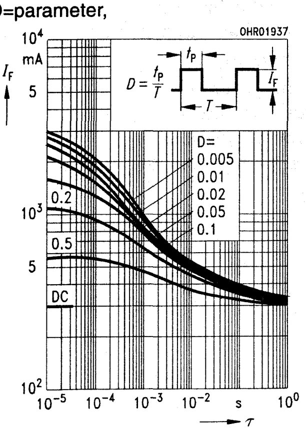


Figure 6. Radiation characteristic, SFH400 $I_{REL}=f(\varphi)$

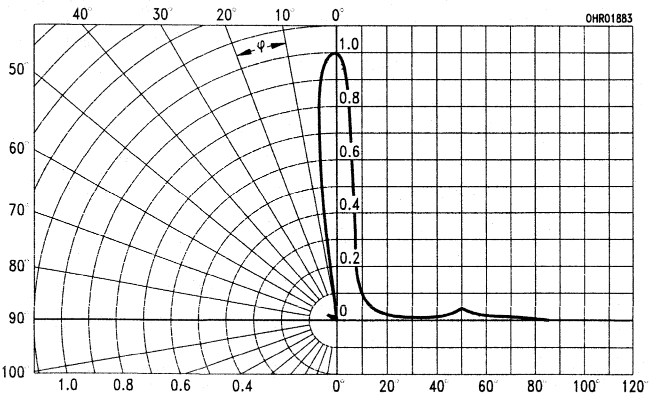


Figure 7. Radiation characteristic, SFH401 $I_{REL}=f(\varphi)$

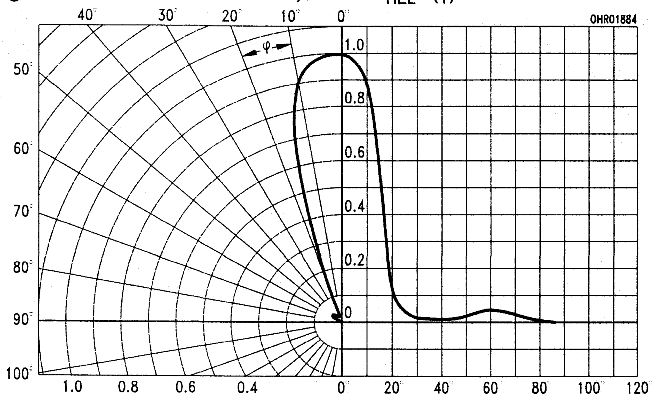
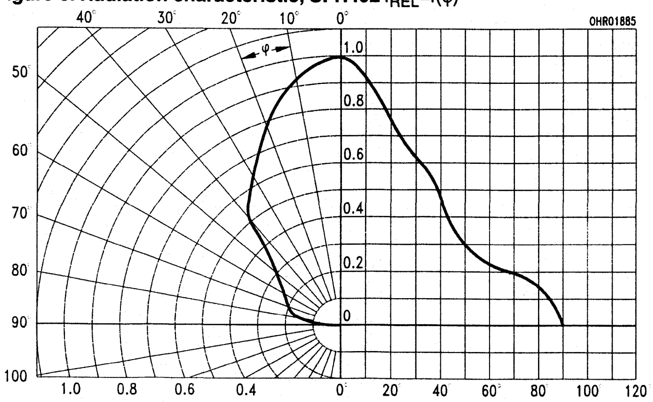


Figure 8. Radiation characteristic, SFH402 $I_{REL}=f(\varphi)$

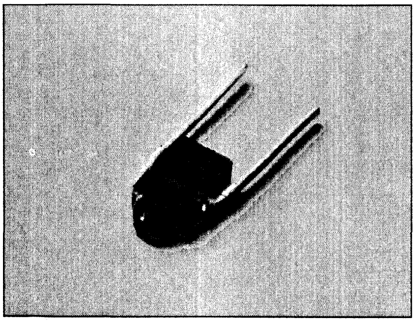


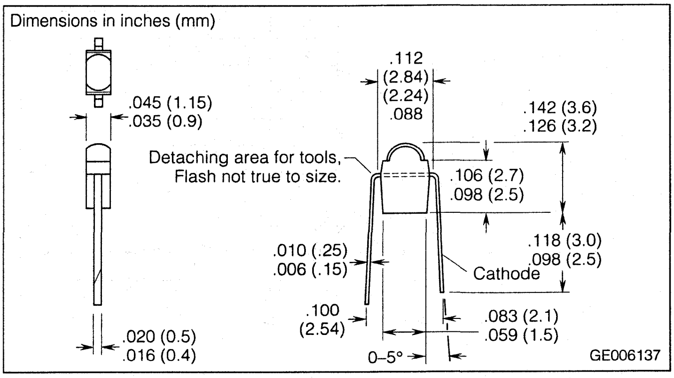
Infrared Emitters 10

SIEMENS

SFH405

Infrared Emitter





FEATURES

- **GaAs IR emitter, made in liquid phase epitaxy process**
- **High reliability**
- **High radiant intensity**
- **High pulse handing capability**
- **Same Package as SFH 305**
- **Package**
  - **Miniature lead frame**
  - **Transparent epoxy resin**
  - **Solder tabs lead spacing**
  - **Cathode marking: beveled leads**

APPLICATIONS

- **Minature photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

Maximum Ratings T_A=25°C

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Junction Temperature (T_J) .... 80°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 40 mA
Surge Current (I_{FSM}) t≤10 µs, D=0 .... 1.6 A
Power Dissipation (P_{TOT}) .... 65 mW
Thermal Resistance (R_{thJA}) .... 950 K/W
(R_{thJL}) .... 850 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	950	nm	I_F=40 mA, t_P=20 ms
Spectral Bandwidth, 50% I_{MAX}	Δλ	55		
Half Angle	φ	±16	Deg.	
Active Chip Area	A	0.25	mm²	
Active Chip Area Dimensions	L x W	0.5 x 0.5	mm	
Distance, Chip Surface to Lens Top	H	1.3 to 1.9		
Switching Times, I_E, 10% to 90% and 90% to 10%	t_R, t_F	1	µs	I_F=40 mA, R_L=50 Ω
Capacitance	C_0	40	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.25 (≤1.4)	V	I_F=40 mA
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Temp. Coefficient, I_E or Φ_E	TC_I	–0.55	%/K	I_F=40 mA
Temp. Coefficient, V_F	TC_V	–1.5	mV/K	
Temp. Coefficient, λ_{PEAK}	TC_λ	0.3	nm/K	
Radiant Intensity, I_E in Axial Direction at Steradian of Ω=0.01 sr	I_e	2.5 (>1.6)	mW/sr	I_F=40 mA, t_P=20 ms

Figure 1. Radiation characteristics $I_{REL}=f(\varphi)$

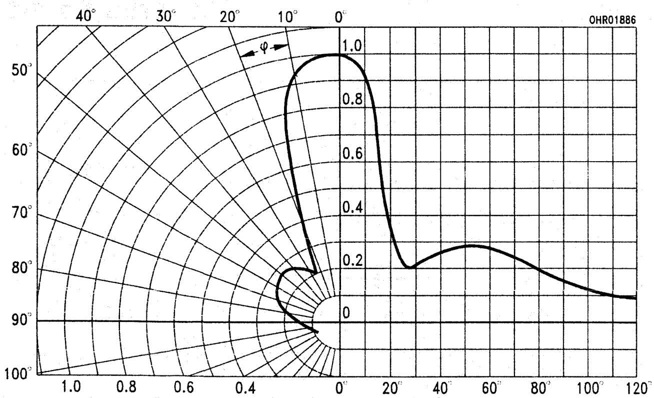


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, $T_A=25°C$, duty cycle D=Parameter

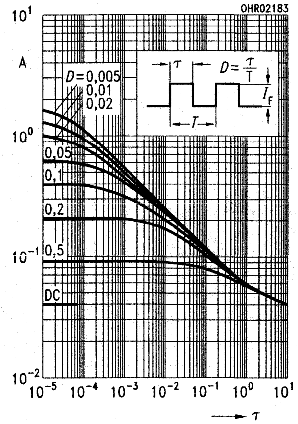


Figure 2. Relative spectral emission $I_{REL}=f(\lambda)$

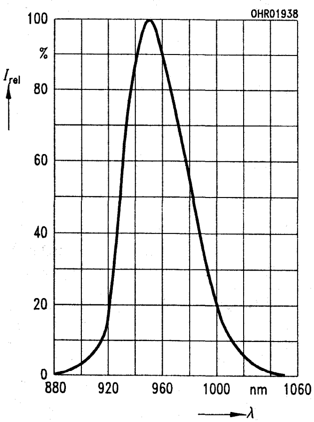


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

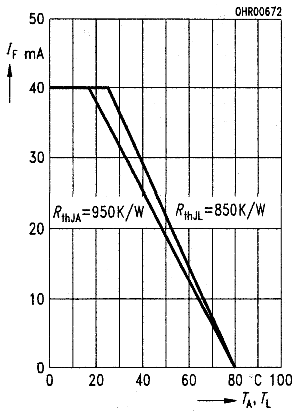


Figure 3. Radiant intensity I_E/I_E100 mA=f(I_F), Single pulse, τ=20 µs

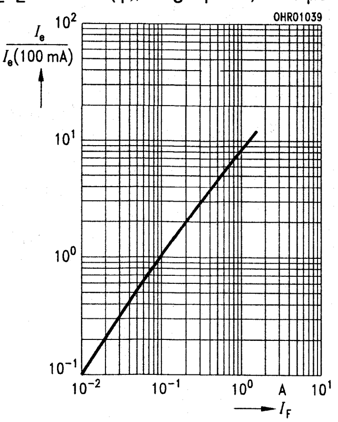
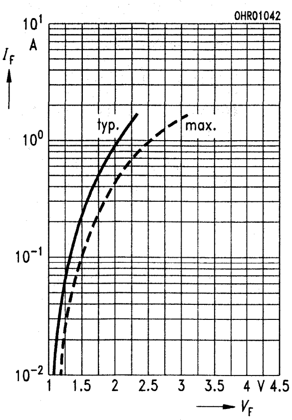
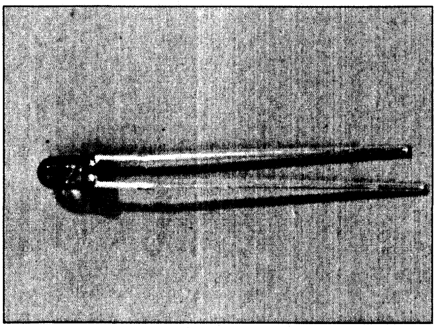


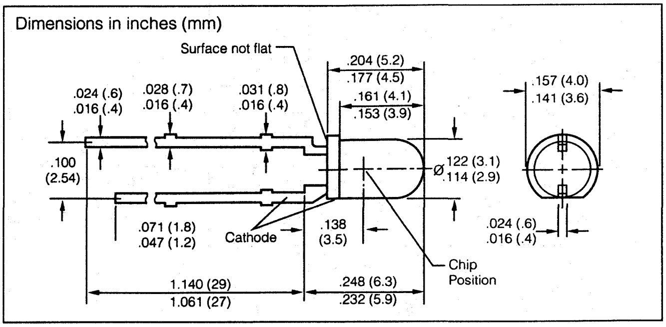
Figure 5. Forward current $I_F=f(V_F)$, Single pulse, τ=20 µs



SIEMENS

SFH 409
Infrared Emitter





FEATURES
- **GaAs IR emitter made in a liquid phase epitaxy process**
- **High reliability**
- **High Pulse handing capability**
- **Radiant intensity selections**
- **Match SFH309 and SFH487, phototransistors**
- **Package**
  - **T1 (3 mm)**
  - **Gray epoxy resin**
  - **Solder tabs lead spacing**
  - **Cathode marking: short lead**

APPLICATONS
- **Photointerrupters**
- **IR remote control of various equipment**

DESCRIPTION
The SFH 409 is a GaAs Infrared Emitting Diode in a standard T1 plastic package. It is designed for a variety of low cost, high volume applications such as IR remote control and other consumer and entertainment products.

Maximum Ratings T_A=25°C

Operating/Storage Temperature
Range (T_{OP}, T_{STG})....................... −55° to +100°C
Junction Temperature (T_J)............................ 100°C
Reverse Voltage (V_R).. 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t≤10 µs, D=0 .... 3 A
Power Dissipation (P_{TOT}) .... 165 mW
Thermal Resistance (R_{thJA}) .... 450 K/W

Characteristics T_A=25°C

Parameter	Sym.	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	950	nm	I_F=100 mA, t_P=20 ms
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	55		
Half Angle	φ	±20	Deg.	
Active Chip Area	A	0.09	mm^2	
Active Chip Area Dimensions	L x W	0.3 x 0.3	mm	
Distance, Chip Surface to Lens Top	D	2.6		
Switching Times, I_E, 10% to 90% and 90% to 10%	t_R, t_F	1	µs	I_F=50 mA, R_L=50 Ω
Forward Voltage	V_F	1.3 (≤1.5)	V	I_F=100 mA, t_P=100 µs
		1.9 (≤2.5)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	Φ_E	15	mW	I_F=100 mA, t_P=20 mS
Temp. Coefficient, I_E or Φ_E	TC_I	−0.55	%/K	
Temp. Coefficient, V_F	TC_V	−1.5	mV/K	
Temp. Coefficient, λ_{PEAK}	TC_λ	0.3	nm/K	

Radiant Intensity Selections	Sym.	SFH 409	SFH 409-1[1]	SFH 409-2	Unit	Condition
I_E in axial direction at steradian of : Ω=0.01 sr	I_E	≥6.3	6.3–12.5	≥10	mW/sr	I_F=100 mA, t_P=20 ms
	I_E typ.	—	75	120		I_F=1 A, t_P=100 µs

1. Available only on request.

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

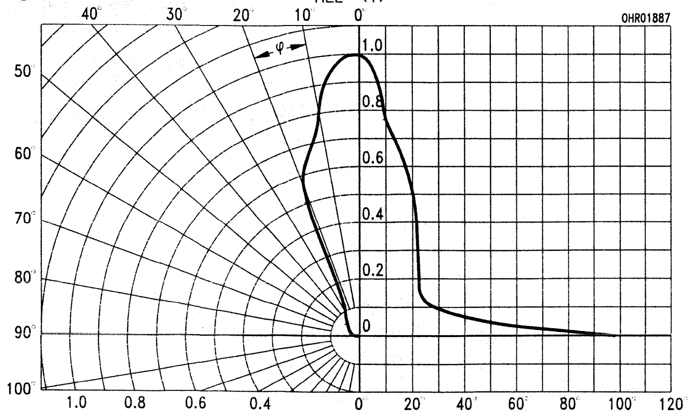


Figure 2. Relative spectral emission $I_{REL}=f(\lambda)$

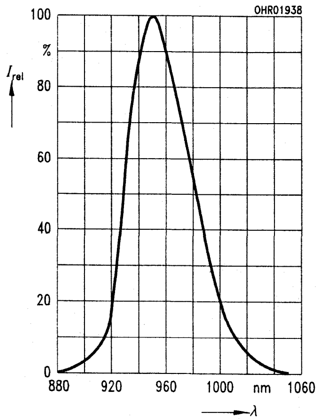


Figure 3. Radiant intensity $I_E/I_E100mA=f(I_F)$, Single pulse, $\tau=20\ \mu s$

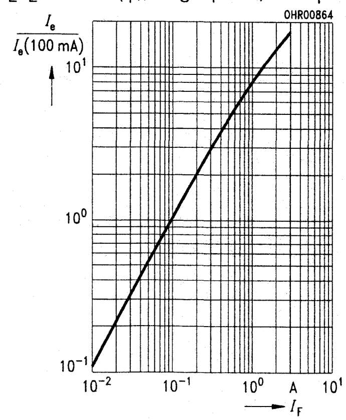


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

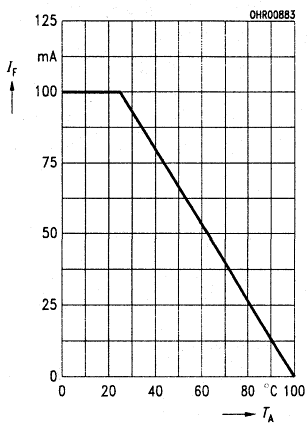


Figure 5. Forward current $I_F=f(V_F)$

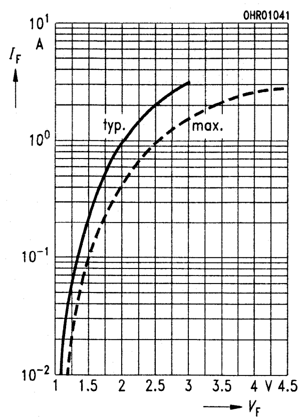
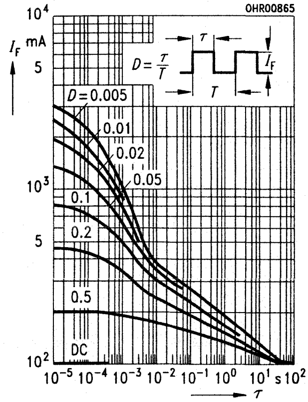


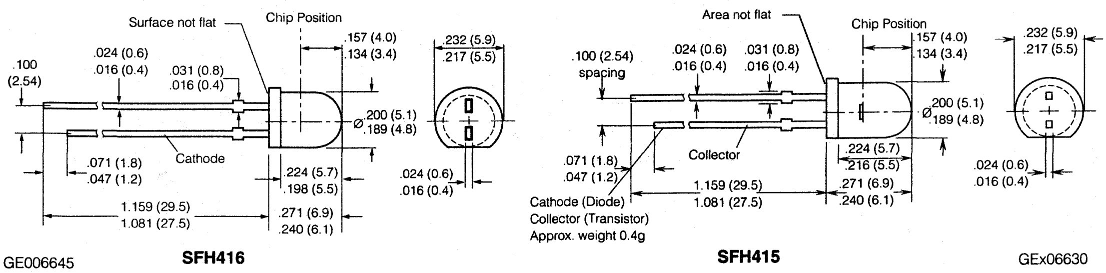
Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, $T_C=25°C$, duty cycle D=Parameter



SIEMENS

SFH415
SFH416
GaAs Infrared Emitter

Dimensions in inches (mm)



FEATURES
- GaAs infrared emitting diodes, fabricated in a liquid phase epitaxy process
- Good linearity ($I_e = f [I_F]$) at high currents
- High efficiency
- High reliability
- High pulse handling capability
- SFH 415: Same package as SFH 300, SFH 203
- Package
  - T1¾ (5mm)
  - Black epoxy resin lens
  - Solder tabs spacing .100 (2.54 mm)
  - Cathode marking: short lead

APPLICATIONS
- IR remote control of hi-fi and TV-sets, video tape recorders, dimmers
- Remote control of various equipment

DESCRIPTION
The SFH415/416 are T1¾ (5 mm) epoxy packaged infrared emitters with a peak wavelength of 950 nm. The unique chip used in these devices is GaAs with a GaAlAs "window." This construction allows for a low forward voltage while maintaining strong output power, efficiency, and linearity. Suitable for remote control for TV sets and similar consumer applications.

Maximum Ratings T_A=25°C

Operating/Storage
Temperature (T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t_p=10 µs, D=0 .... 3 A
Power Dissipation (P_{TOT}) .... 165 mW
Thermal Resistance (T_{THJA}) .... 450 K/W

Characteristics T_A=25°C

Parameter		Sym.	Value	Unit	Condition
Peak wavelength		λ	950	nm	I_F=100 mA, t_p=20 ms
Spectral Bandwidth, 50% of I_{REL}		Δλ	55		I_F=100 mA
Half Angle	SFH415	φ	±17	Deg.	
	SFH416		±28		
Active Chip Area		A	0.09	mm^2	
Active Chip Area Dimensions		L x W	0.3 x 0.3	mm	
Distance Chip Surface to Case Surface	SFH415	H	4.2 to 4.8		
	SFH416		3.4 to 4.0		
Switching Times I_e 10% to 90% or 90% to 10%		t_R, t_F	0.5	µs	I_F=100 mA
Capacitance		C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage		V_F	1.3 (≤1.5)	V	I_F=100 mA, t_p=20 ms
			2.3 (≤2.8)		I_F=1 A, t_p=100 µs
Reverse Current		I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux		$Φ_e$	22	mW	I_F=100 mA, t_p=20 ms
Temperature Coefficient, I_e or $Φ_e$		TC_I	–0.5	%/K	
Temperature Coefficient, V_F		TC_V	–2	mV/K	
Temperature Coefficient, λ		$TC_λ$	+0.3	nm/K	

Radiant Intensity Selections, I_E in axial direction at a steradian of Ω=0.01 sr

	Sym.	415	415-T	415-U	416-R	Unit
I_F=100 mA, t_p=20 ms	I_{Emin}	≥25	25	40	10	mW/sr
	I_{Emax}	—	50	—	—	
I_F=1 mA, t_p=100 µs	I_{Etyp}	—	380	600	150	

Figure 1. Radiation characteristics–SFH415 $I_{REL}=f(\varphi)$

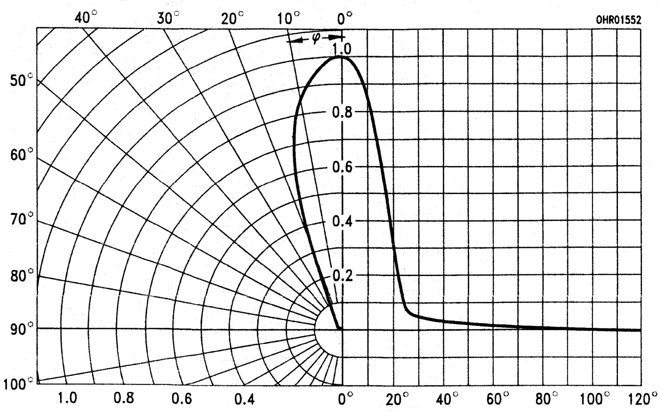


Figure 2. Radiation characteristics–SFH416 $I_{REL}=f(\varphi)$

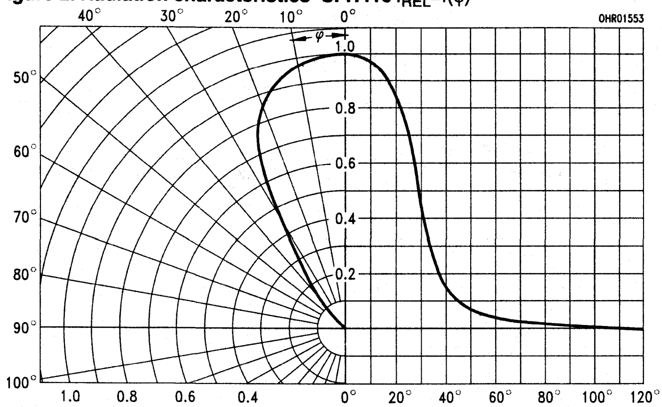


Figure 3. Relative spectral emission
$I_{REL}=f(\lambda)$

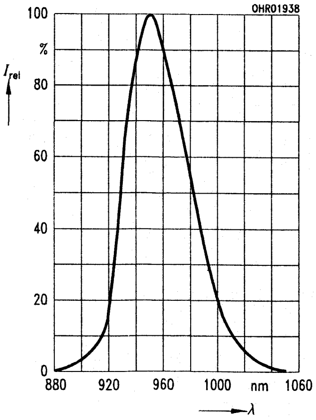


Figure 4. Radiant intensity
I_e/I_e 100 mA=f(I_F)

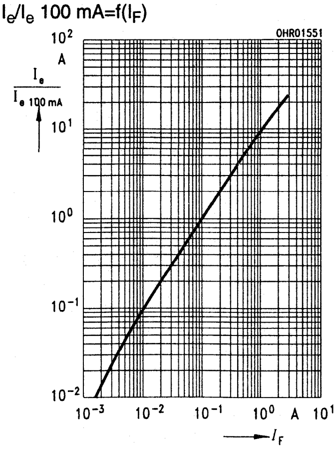


Figure 5. Maximum permissible forward current $I_F=f(T_A)$

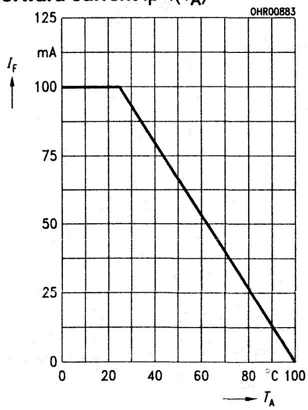


Figure 6. Forward current $I_F=f(V_F)$
Single pulse, τ=20 µs

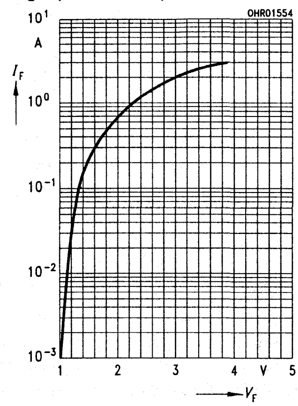
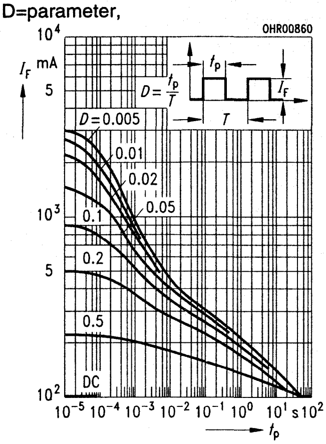


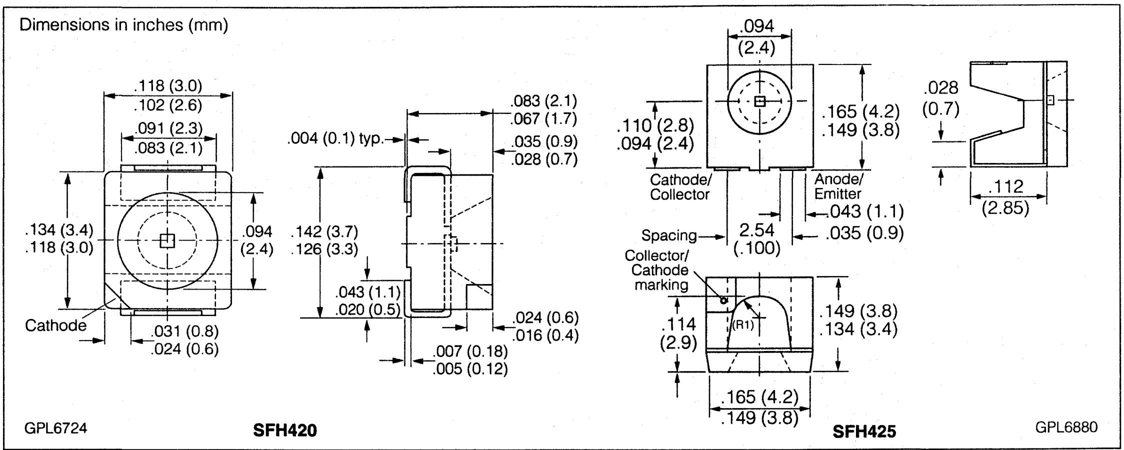
Figure 7. Permissible pulse handling capability $I_F=f(\tau)$, T_C=25°C, duty cycle D=parameter,



Infrared Emitters 10

SIEMENS

SMT TOPLED® SFH 420
SMT SIDELED® SFH 425
GaAs Infrared Emitter



FEATURES
- **Very high efficiency GaAlAs LED**
- **Good linearity [I_e = f (I_F)] at high currents**
- **DC (with modulation) or pulsed operations possible**
- **High reliability**
- **High pulse handling capability**
- **Suitable for surface mounting (SMT)**
- **On tape and reel**
- **SFH 420 same package as SFH 320/421**
  SFH 425 same package as SFH 325/426
- **SFH 425: Suitable only for IR-reflow soldering. Before dip soldering, contact us first**

APPLICATIONS
- **Miniature photointerrupters**
- **Industrial electronics**
- **For drive and control circuits**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})........................–55° to +100°C
Junction Temperature (T_J)............................ 100°C
Reverse Voltage (V_R).. 5 V
Forward Current (I_F) .... 100 mA
Pulse Current (I_{FSM}) τ=10 µs, D=0.................... 3 A
Power Dissipation (P_{TOT})T_A=25°C............. 160 mW
Thermal Resistance,
Junction to Ambient
Mounted on PC Board (R_{thJA})................450 K/W
Thermal Resistance,
Junction to Solder Point
Mounted on Metal Block (R_{thJS}) ....200 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	950	nm	I_F=100 mA, t_P=20 ms
Spectral Bandwidth, 50% I_{MAX}	Δλ	55		I_F=100 mA
Half Angle	φ	±60	Deg.	
Active Chip Area	A	0.09	mm^2	
Active Chip Area Dimensions	L x W	0.3 x 0.3	mm	
Switching Times, 10% to 90% and 90% to 10%	t_R, t_F	0.5	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.3 (≤1.5)	V	I_F=100 mA, t_P=20 ms
		2.3 (≤2.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Radiant Flux, Total	Φ_E	14	mW	I_F=100 mA, t_P=20 ms
Temp. Coefficient, I_E or Φ_E	TC_I	–0.5	%/K	I_F=100 mA
Temp. Coefficient, V_F	TC_V	–2	mV/K	
Temp. Coefficient, λ_{PEAK}	TC_λ	+0.3	nm/K	
Radiant Intensity	I_E	>2.5	mW/sr	I_F=100 mA, t_P=20 ms
Soldering Bath Temp.		260	°C	
Soldering Time, Max. Permissible		8	s	
Soldering Zone Temp. Preheating: 150°C		60 to 215	°C	

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

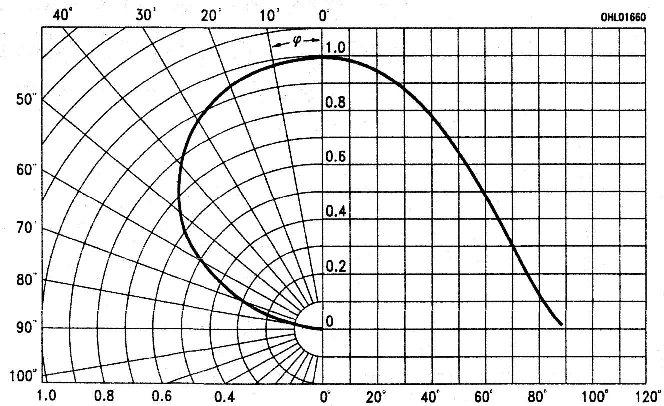


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, $T_C=25°C$, duty cycle D=Parameter

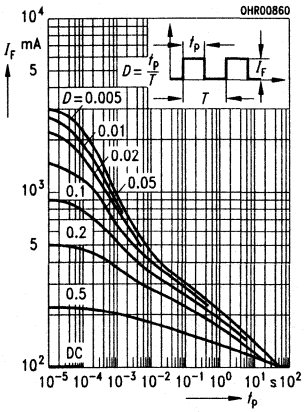


Figure 2. Relative spectral emission $I_{REL}=f(\lambda)$

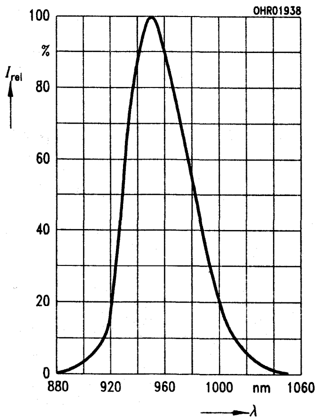


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

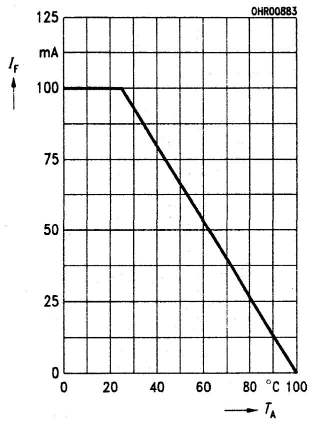


Figure 3. Radiant intensity $I_E/I_E100mA=f(I_F)$, Single pulse, $\tau=20\ \mu s$

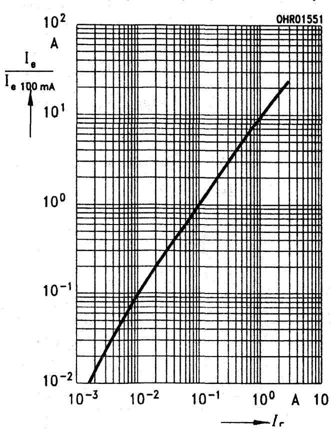
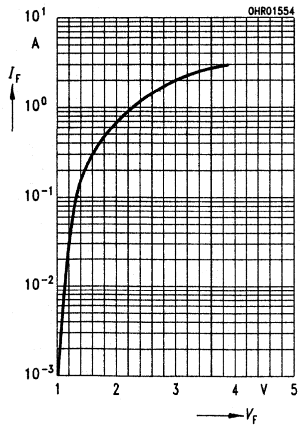
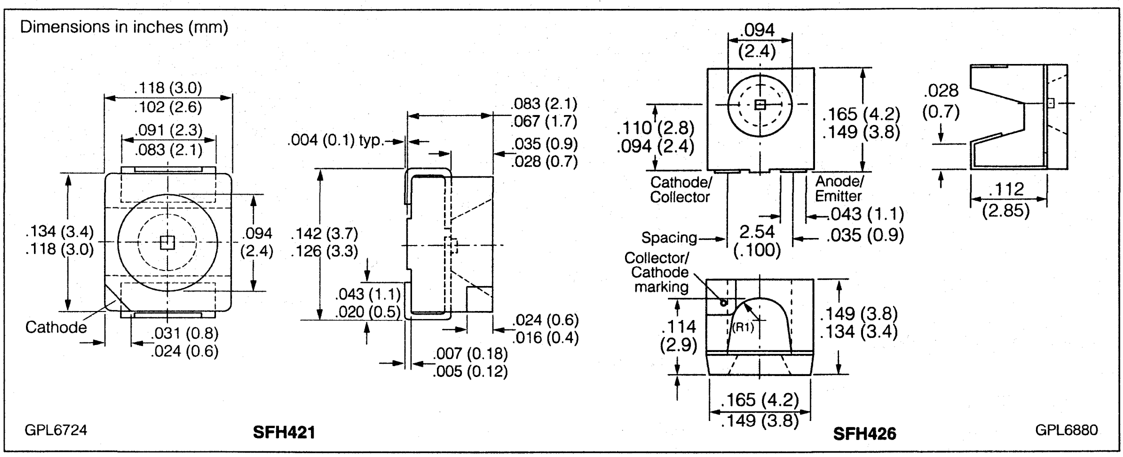


Figure 5. Forward current $I_F=f(V_F)$



SIEMENS

SMT TOPLED® SFH 421
SMT TOPLED® SFH 426
GaAlAs Infrared Emitter



FEATURES
- Very high efficiency GaAlAs LED
- Good linearity [$I_e = f(I_F)$] at high currents
- DC (with modulation) or pulsed operations possible
- High reliability
- High pulse handling capability
- Suitable for surface mounting (SMT)
- On tape and reel
- SFH 421 same package as SFH 320/420
  SFH 426 same package as SFH 325/425
- SFH 426: Suitable only for IR-reflow soldering. Before dip soldering, contact us first

APPLICATIONS
- Miniature photointerrupters
- Industrial electronics
- For drive and control circuits

Maximum Ratings T_A=25°C

Operating/Storage
Temperature (T_A, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) τ=10 ms, D=0 .... 2.5 A
Total Power Dissipation (P_{tot}) .... 180 mW
Thermal Resistance, Junction to Ambient
Mounted on PC Board (R_{thJA}) .... 450 K/W
Thermal Resistance, Junction to Solder
Point, Mounted on Metal Block .... ≈200 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{peak}	880	nm	I_F=100 mA, t_p=20 ms
Spectral Bandwidth, 50% of I_{MAK}	$\Delta\lambda$	80		I_F=100 mA
Half Angle	φ	±60	Deg.	
Active Chip Area	A	0.16	mm^2	
Active Chip Area Dimensions	L x W	0.4 x 0.4	mm	
Switching Time I_E 10% to 90%, 90% to 10%	t_r, t_f	0.5	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_p=20 ms
		3.0 (≤3.8)		I_F=1 A, t_p=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	Φ_e	23	mW	I_F=100 mA, t_p=20 ms
Temperature Coefficient, I_e or Φ_e	TC_I	–0.5	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	–2	mV/K	
Temperature Coefficient, λ	TC_λ	+0.25	nm/K	
Soldering Bath Temp.		260	°C	
Soldering Time, Max. Permissible		8	s	
Soldering Zone Temp. Preheating: 150°C		60 to 215	°C	
Transit Time, Max. approx. 1 min.		10 to 40	s	
Radiant Intensity I_E in Axial Direction measured at a Steradian of Ω=0.01 sr	I_E	≥4	mW/sr	I_F=100 mA, t_p=20 ms
	I_{Etyp}	48		I_F=1 A, t_p=100 µs

Figure 1. Radiation characteristics $I_{rel}=f(\varphi)$ $I_{rel}=f(\lambda)$

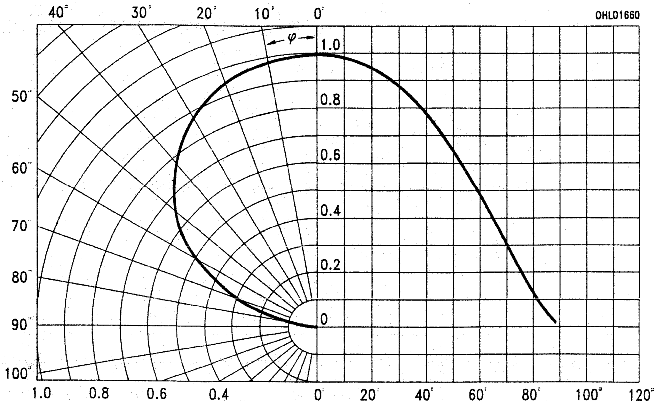


Figure 6. Permissible pulse handling capability Duty cycle D=Parameter, T_A=25°C

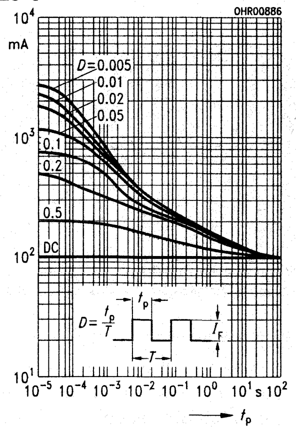


Figure 2. Relative spectral emission $I_{rel}=f(\lambda)$

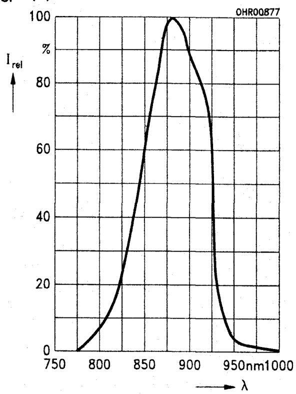


Figure 4. Max. permissible forward current $I_F=f(T_A)$

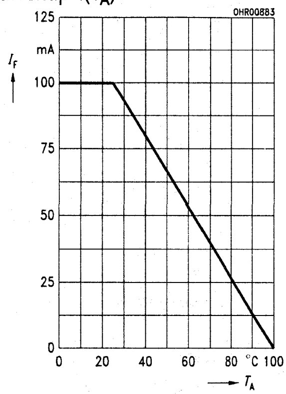


Figure 3. Relative radiant intensity I_e/I_e (100 mA)=f(I_F), one pulse, τ=20 µ

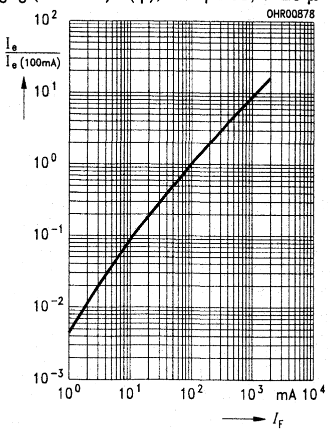
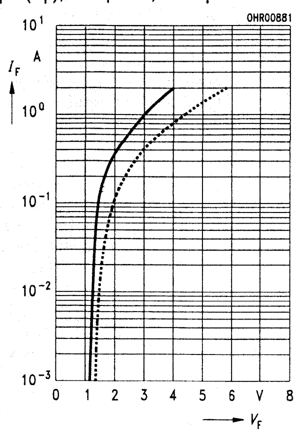


Figure 5. Forward current $I_F=f(V_F)$, one pulse, τ=20 µs

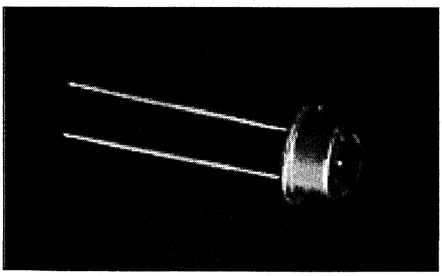


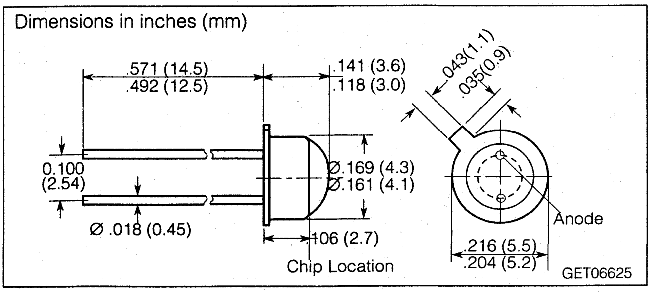
Infrared Emitters 10

SIEMENS

SFH464

GaAlAs Infrared Emitter





FEATURES

- **Radiation without IR in visible red range**
- **Cathode electrically connected to case**
- **Very high efficiency**
- **High reliability**
- **short switching time**
- **Same package as BP 103, LD 242**
- **DIN humidity category per DIN 40040 GQG**
- **Component subjected to aperture measurement (E 7800)**
- **Package**
  - **TO-18, 18 A3 DIN 870**
  - **Clear expoxy resin**
  - **Anode marking: projection at case bottom**

APPLICATIONS

- **Photointerrupter**
- **Fiber optic transmission**

Maximum Ratings T_A=25°C

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –40° to +80°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 3 V
Forward Current (I_F) .... 50 mA
Surge Current (I_{FSM})
t=10 µs, D=0 .... 1 A
Power Dissipation (P_{TOT}) .... 120 mW
Thermal Resistance (R_{thJA}) .... 450 K/W
(R_{thJC}) .... 160 K/W

Characteristics T_A=25°C

Parameter	**Symbol**	**Value**	**Unit**	**Condition**
Peak Wavelength	λ_{PEAK}	660	nm	I_F=50 mA t_p=20 ms
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	25		I_F=50 mA
Half Angle (1)	φ	±23	Deg.	
Active Chip Area	A	0.16	mm^2	
Active Chip Dimensions	L x W	0.325 x 0.325	mm	
Distance, Chip Front to Case Back	H	0.3 to 0.7		
Switching Times, I_E, 10% to 90% and 90% to 10%	t_R, t_F	100	ns	I_F=50 mA, R_L=50 Ω
Capacitance	C_0	30	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	2.1 (≤2.8)	V	I_F=50 mA, t_P=20 ms
Reverse Current	I_R	0.01 (≤10)	µA	V_R=3 V
Radiant Flux, Total	Φ_E	11	mW	I_F=50 mA, t_P=20 ms
Temp. Coefficient, I_E or Φ_E	TC_I	–0.4	%/K	I_F=50 mA
Temp. Coefficient, V_F	TC_V	-3	mV/K	
Temp. Coefficient, λ	TC_λ	0.16	nm/K	
Radiant Intensity (1) I_E in Axial Direction at a Steradian of Ω=0.01 sr	I_E	≥1	mW/sr	I_F=50 mA, t_P=20 ms

Notes:

1. An aperture is used in front of the component for measuring the radiant intensity and the half angle (diameter of the aperture: 1.1 mm; distance of aperture to case back side: 4 mm). This ensures that only the radiation in axial direction emitting directly from the chip surface will be evaluated during radiant intensity measurement. Radiation reflected by the bottom plate (stray radiation) will not be evaluated. These reflections impair the projection of the chip surface by additional optics (e.g. long-range light reflection switches). In respect of the application of the component, these reflections are generally suppressed by apertures well. This measuring procedure corresponding with the application provides more useful values. This measurement is denoted by "E7800" added to the part number.

2. Radiation characteristic $I_{REL}=f(\varphi)$

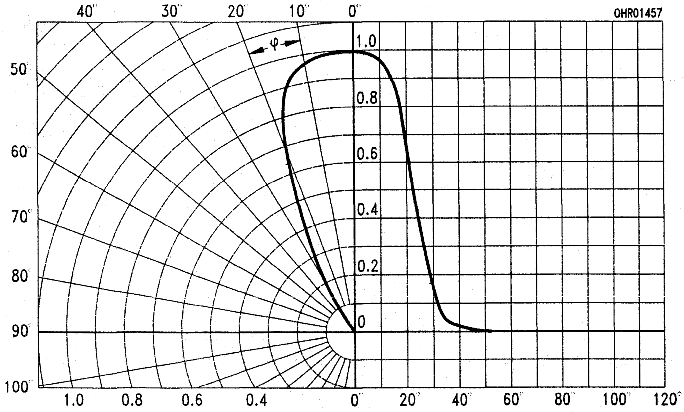


Figure 5. Permissible pulse handling capability $I_F=f(\tau)$, $T_A=25°C$, duty cycle D=Parameter

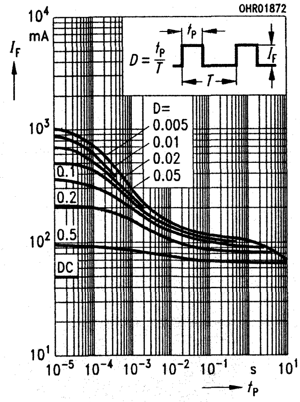


Figure 1. Relative spectral emission $I_{REL}=f(\lambda)$

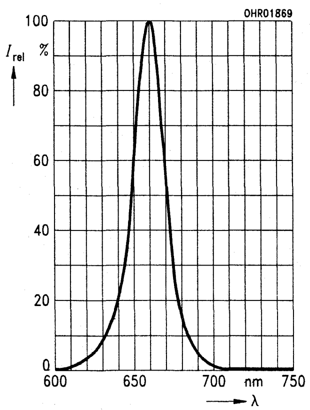


Figure 3. Maximum permissible forward current $I_F=f(T_A)$, $R_{THJC}=160$ K/W

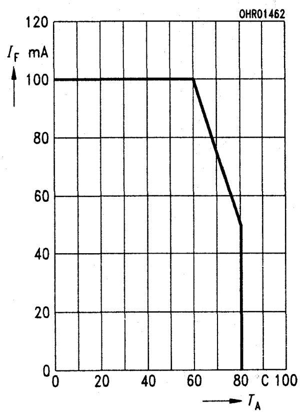


Figure 6. Maximum permissible forward current $I_F=f(T_A)$, $R_{THJC}=450$ K/W

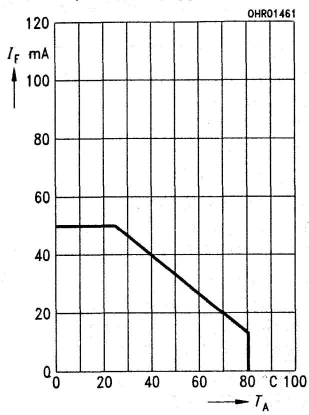


Figure 2. Radiant intensity $I_E/I_E100mA=f(I_F)$, Single pulse, $\tau=20$ µs

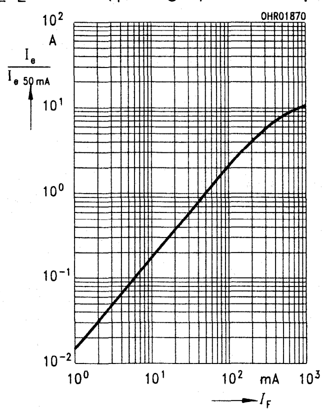
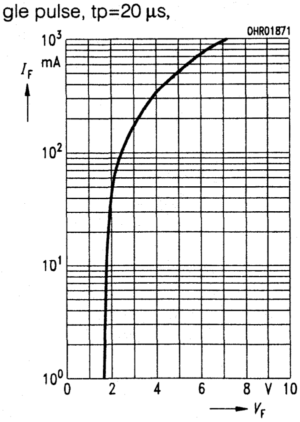
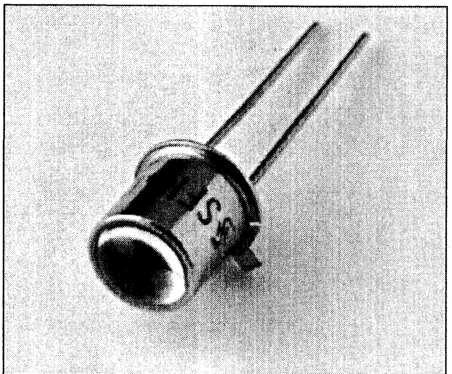


Figure 4. Forward current $I_F=f(V_F)$, single pulse, tp=20 µs,

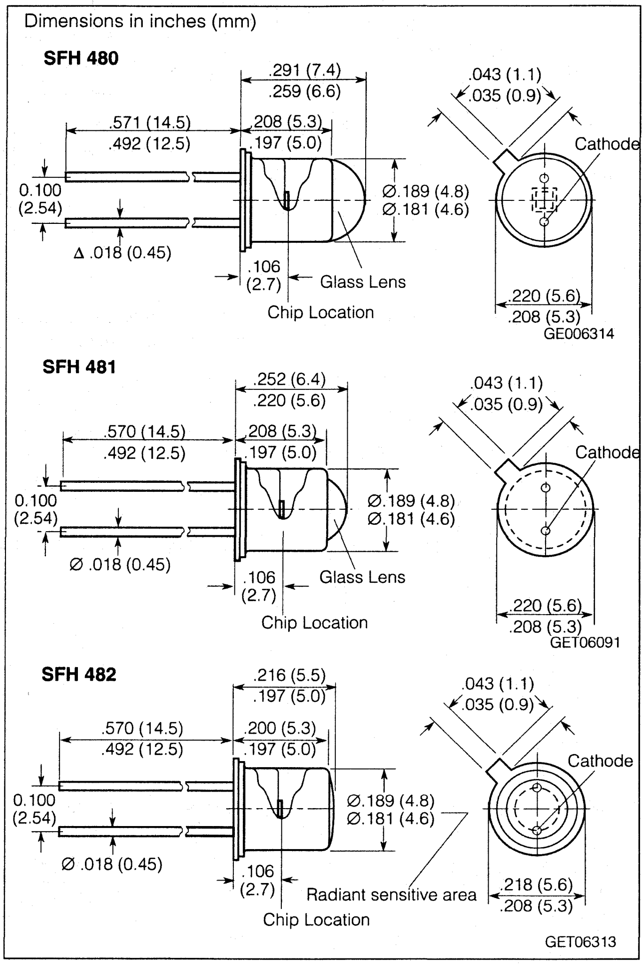


SIEMENS

SFH480
SFH481
SFH482
GaAlAs Infrared Emitter



SFH482



FEATURES
- **Half Angle**
  - **SFH 480, ±6°**
  - **SFH 481, ±15°**
  - **SFH 482, ±30°**
- **GaAlAs IR emitter, made in a liquid phase epitaxy process**
- **Anode electrically connected to case**
- **High reliability**
- **Matches all Si-photodetectors**
- **Hermetically sealed package**
- **SFH 480: Matches SFH216**
- **SFH 481: BPX43, BPY 63**
- **SFH 482: BPX38, BPX65**
- **Package**
  - **To-18, 18 A3 DIN 41876**
  - **Cathode marking: Projection at package**

Applications
- **Photointerrupters**
- **IR remote control of various equipment**

Maximum Ratings T_A=25°C

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55° + 100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 200 mA
Surge Current (I_{FSM}) t=10 µs, D=0 .... 2.5 A
Power Dissipation (P_{TOT}) .... 470 mW
Thermal Resistance (R_{thJA}) .... 450 K/W
(R_{thJC}) .... 160 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	880	nm	I_F=100 mA
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	80		
Half Angle SFH480 SFH481 SFH482	φ	 ±6 ±15 ±30	Deg.	
Active Chip Area	A	0.16	mm^2	
Active Chip Area Dimensions	L x W	0.4 x 0.4	mm	
Distance, Chip Front to Lens Top SFH480 SFH481 SFH482	H	 4.0 to 4.8 2.8 to 3.7 2.1 to 2.7		
Switching Times, I_E 10% to 90% and 90% to 10%	t_R, t_F	0.6/0.5	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3 (≤3.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Radiant Flux, Total	Φ_E	12	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	-0.5	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	-2	mV/K	
Temperature Coefficient, λ	TC_λ	0.25	nm/K	

Radiant Intensity Selections I_E in axial direction at steradian of Ω=0.01 sr

Symbol	SFH480		SFH481	SFH481		Unit	Condition
	–2	**–3**		**–1**	**–2**		
I_{Emin}	40	63	≥10	10	16	mW/sr	I_F=100 mA, t_P=20 ms
I_{Emax}	—	—	—	20	—		
I_{Etyp}	540	630	220	130	220		I_F=1 A, t_P=100 µs
Symbol	**SFH482**	**SFH482**				**Unit**	**Condition**
		–1	**–2**	**–3**	**E7800 (1)**		
I_{Emin}	≥3.15	3.15	5	8	1.6 to 3.2	mW/sr	I_F=100 mA, t_P=20 ms
I_{Emax}	—	6.3	10	—	—		
I_{Etyp}	—	40	65	80			I_F=1 A, t_P=100 µs

Notes:

1. An aperture is used in front of the component for measuring the radiant intensity and the half angle (diameter of the aperture: 2.0 mm; distance of aperture to case back side: 5.4 mm). This ensures that only the radiation in axial direction emitting directly from the chip surface will be evaluated during radiant intensity measurement. Radiation reflected by the bottom plate (stray radiation) will not be evaluated. These reflections impair the projection of the chip surface by additional optics (e.g. long-range light reflection switches). In respect of the application of the component. these reflections are generally suppressed by apertures as well. This measurement is denoted by "E7800" added to the part number.

Figure 1. Relative spectral emission
I_{REL}=f(λ)

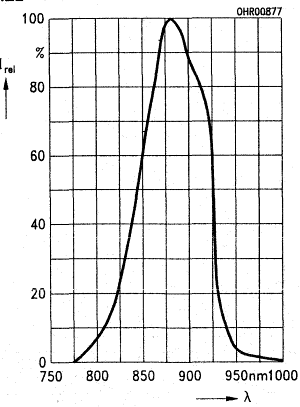


Figure 2. Radiant intensity
I_E/I_E 100mA=f(I_F), Single pulse, τ=20 µs

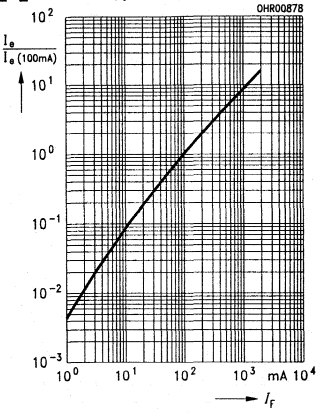
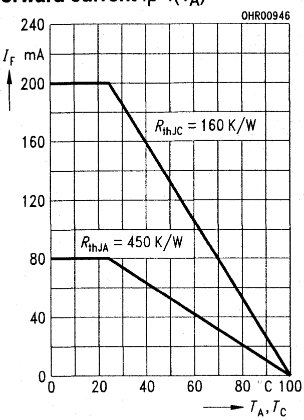


Figure 3. Maximum permissible forward current I_F=f(T_A)



Infrared Emitters
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Figure 4. Permissible pulse handling
Radiation characteristic—SFH480 $I_{REL}=f(\varphi)$

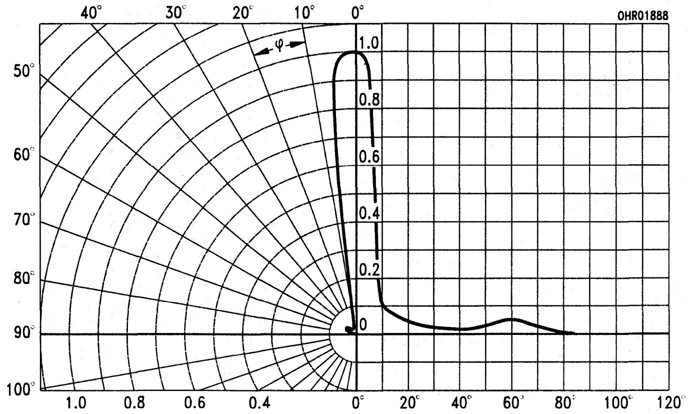


Figure 5. Radiation characteristic—SFH481 $I_{REL}=f(\varphi)$

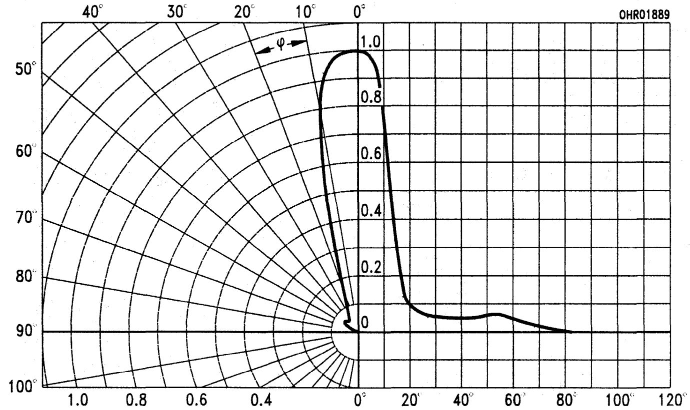


Figure 6. Radiation characteristic—SFH482 $I_{REL}=f(\varphi)$

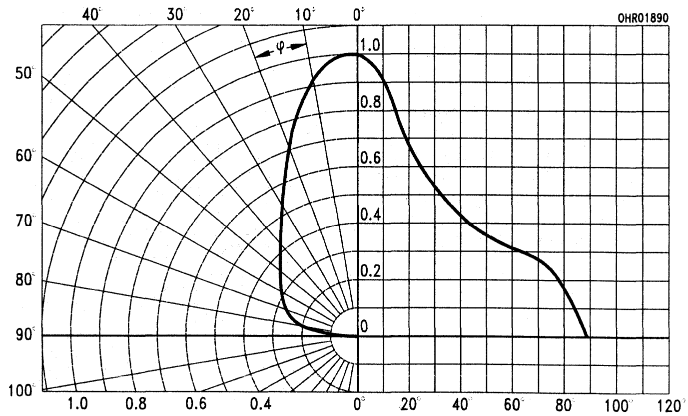


Figure 7. Forward current $I_F=f(V_F)$
Single pulse, τ=20 µs

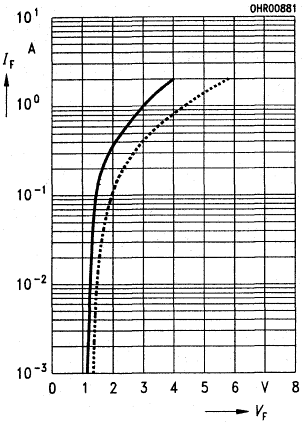
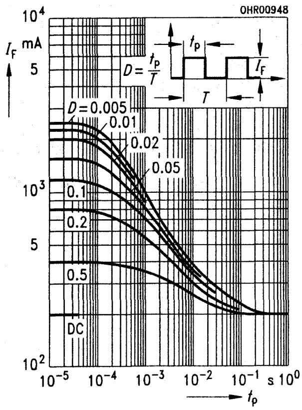


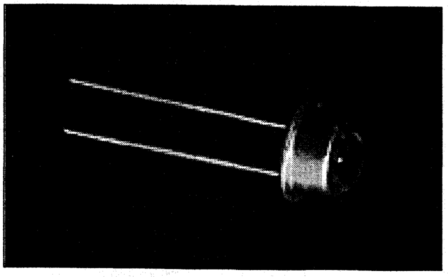
Figure 8. capability $I_F=f(\tau)$, T_C=25°C, duty cycle D=Parameter

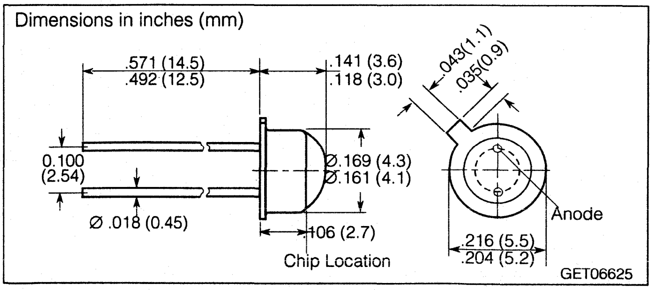


SIEMENS

SFH483

GaAlAs Infrared Emitter





FEATURES
- **Highly efficient GaAlAs LED**
- **Anode electrically connected to case**
- **High pulse power**
- **High reliability**
- **DIN humidity category per DIN 40040 GQG**
- **Matches BPX63, BP103, LD242, SFH464, photodetectors**
- **Package**
  - **TO-18, 18 A3 DIN 41870**
  - **Clear expoxy resin**

APPLICATIONS
- **I R Remote Controls and sound transmission,**
- **Photointerrupter**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –40° to +80°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) $T_C \leq 25°C$ .... 200 mA
Surge Current (I_{FSM})
t=10 µs, D=0, T_C=25°C .... 2.5 A
Power Dissipation (P_{TOT})T_C=25°C ....470 mW
Thermal Resistance (R_{thJA}) .... 450 K/W
(R_{thJC}) .... 160 K/W

Characteristics T_A=25°C

Parameter	**Symbol**	**Value**	**Unit**	**Condition**
Peak Wavelength	λ_{PEAK}	880	nm	I_F=100 mA
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	80		
Half Angle (1)	φ	±23	Deg.	
Active Chip Area	A	0.16	mm^2	
Active Chip Dimensions	L x W	0.4 x 0.4	mm	
Distance, Chip Front to Case Back	H	2.7 to 2.9		
Switching Times, I_E, 10% to 90% and 90% to 10%	t_R, t_F	0.6/0.5	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3.0 (≤3.8)		I_F=1A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Radiant Flux, Total	Φ_E	23	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.5	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	–2.5	mV/K	
Temperature Coefficient, λ	TC_λ	0.25	nm/K	
Radiant Intensity (1) I_E in Axial Direction at a Steradian of Ω=0.01 sr	I_{Emin}	1	mW/sr	I_F=100 mA, t_P=20 ms
	I_{Emax}	3.2	mW/sr	
	I_{Etyp}	20		I_F=1 A, t_P=100 µs

1. An aperture is used in front of the component for measuring the radiant intensity and the half angle (diameter of the aperture: 1.1 mm; distance of aperture to case back side: 4 mm). This ensures that only the radiation in axial direction emitting directly from the chip surface will be evaluated during radiant intensity measurement. Radiation reflected by the bottom plate (stray radiation) will not be evaluated. These reflections impair the projection of the chip surface by additional optics (e.g. long-range light reflection switches). In respect of the application of the component, these reflections are generally suppressed by apertures well. This measuring procedure corresponding with the application provides more useful values. This aperature measurement is denoted by "E7800" added to the part number.

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

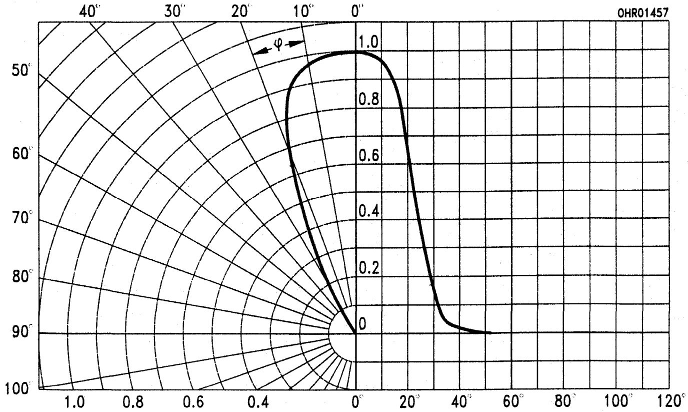


Figure 2. Relative spectral emission $I_{REL}=f(\lambda)$

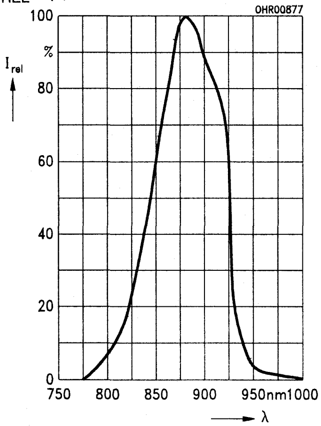


Figure 3. Radiant intensity I_E/I_E100mA=f(I_F), Single pulse, τ=20 µs

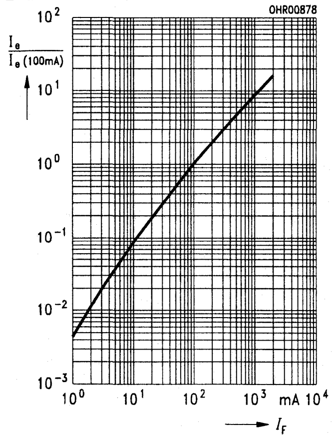


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

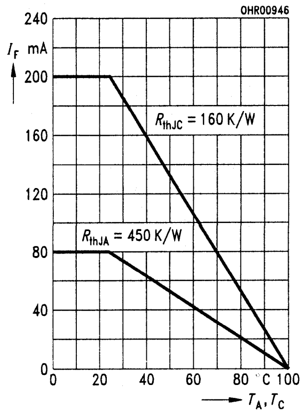


Figure 5. Forward current $I_F=f(V_F)$

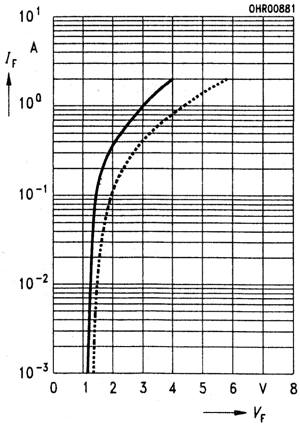
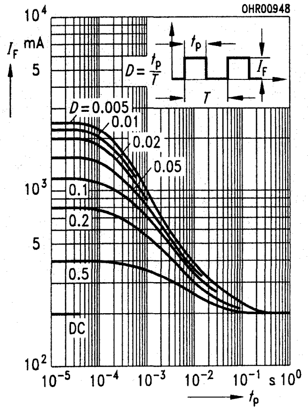


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, $T_C=25°C$, duty cycle D=Parameter

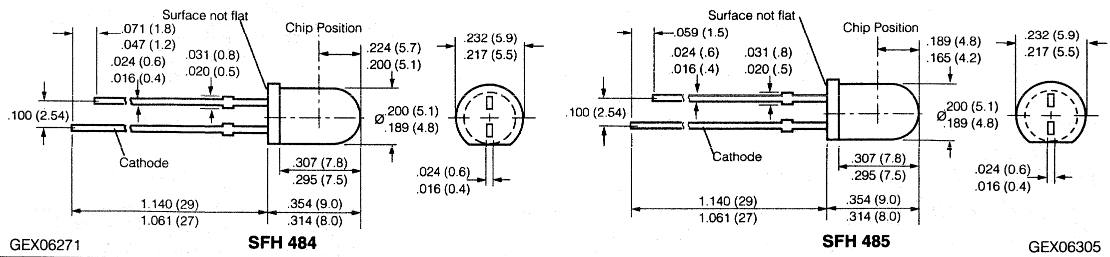


SIEMENS

SFH 484
SFH 485

GaAlAs Infrared Emitter 880 nm

Dimensions in inches (mm)



FEATURES

- **Made in a liquid phase epitaxy process**
- **High reliability**
- **Spectral match with silicon photodetectors**
- **SFH 484: LD274**
- **SFH 485: SFH 300, SFH 203**
- **Package**
  - **T1¾ (5 mm)**
  - **Violet epoxy resin**
  - **solder tabs lead spacing**
  - **Anode markong: Short lead**

APPLICATIONS

- **IR remote control of stereos, TVs, video tape recorders, dimmers**
- **Remote control for steady and varying intensity**

DESCRIPTION

SFH 484, an infrared emitting diode, emits radiation in the near infrared range (880 nm peak). The device comes in a T1¾ (5 mm) plastic package.

The SFH 485contains the same IR emitter chip as the SFH 484 but features a wider beam.

Maximum Ratings T_A=25°C

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t=10 µs, D=0 .... 2.5 A
Power Dissipation (P_{TOT}) .... 200 mW
Thermal Resistance (R_{thJA})
Lead Length between package bottom and PC board max. 10 mm .... 375 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	880	nm	I_F=100 mA
Spectral Bandwidth, 50% I_{REL}	$\Delta\lambda$	80		
Half Angle SFH 484 SFH 485	φ	 ±8 ±20	Deg.	
Active Chip Area	A	0.16	mm²	
Active Chip Area Dimensions	L x W	0.4 x 0.4	mm	
Distance chip front to lens top SFH 484 SFH 485	H	 5.1–5.7 4.2–4.8		
Switching Times, I_E, 10% to 90% and 90% to 10%	t_R, t_F	0.6/0.5	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_O	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3.0 (≤3.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	Φ_E	25	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.5	%/K	I_F=100mA
Temperature Coefficient, V_F	TC_V	–2	mV/K	
Temperature Coefficient, λ	TC_λ	0.25	nm/K	

Radiant Intensity I_E in Axial Direction

Symbol	Steradian of Ω=0.001 sr			Steradian of Ω=0.001 sr		Unit	Condition
	SFH 484	SFH 484-1	SFH 484-2	SFH 485	SFH 485-2		
I_{Emin}	50	50	80	16	25	mW/sr	I_F=100 mA, t_P=20 ms
I_{Emax}	160	100	160	80	—		
I_{Etyp}	800	700	900	300	340		I_F=1 A, t_P=100 µs

Infrared Emitters 10

Figure 1. Radiation characteristic—SFH484 $I_{REL}=f(\varphi)$

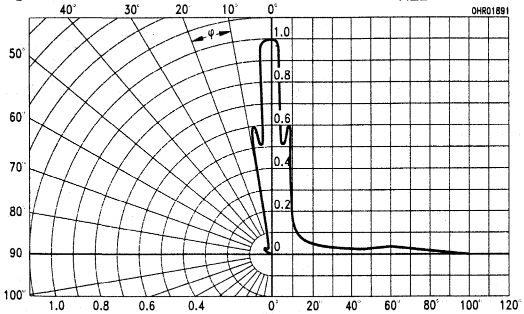


Figure 2. Radiation characteristic—SFH485 $I_{REL}=f(\varphi)$

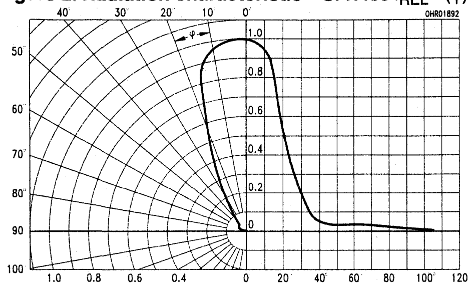


Figure 3. Relative spectral emisson
$I_{REL}=f(\lambda)$

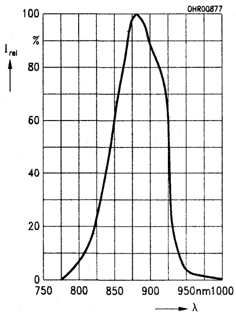


Figure 4. Radiant intensity
I_E/I_E 100mA=f(I_F), Single pulse, τ=20 µs

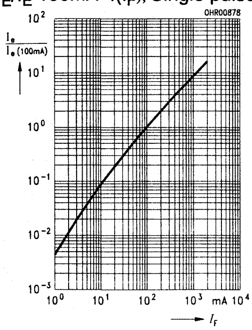


Figure 5. Maximum permissible forward current $I_F=f(T_A)$

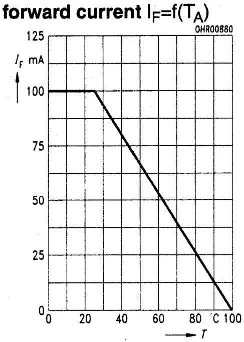


Figure 6. Forward current $I_F=f(V_F)$
Single pulse, τ=20 µs

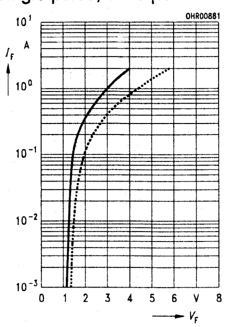


Figure 7. Permissible pulse handling capability $I_F=f(\tau)$, $T_A=25°C$, duty cycle D=Parameter

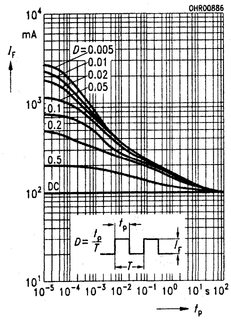
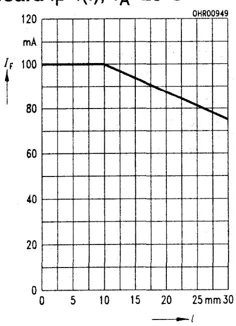


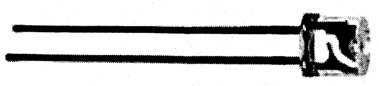
Figure 8. Maximum forward current vs. lead length, package bottom and PC board $I_F=f(l)$, $T_A=25°C$



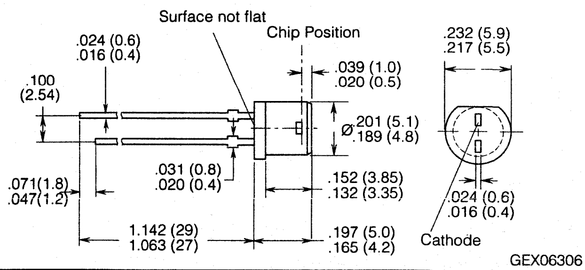
SIEMENS

SFH 485P

GaAlAs Infrared Emitter



Dimensions in inches (mm)



FEATURES

- **GaAlAs IR emitter made a liquid phase epitaxy process**
- **Small tolerance: Chip surface to case surface**
- **Good spectral match to silicon photodetectors**
- **Plane surface**
- **Matches SFH203P photodetector**
- **Package**
  - **T1³/₄ (5 mm)**
  - **Violet transparent epoxy resin**
  - **Solder tabs lead spacing**
  - **Anode marking: short lead**

APPLICATIONS

- **Light-reflection switches for steady and varying intensity (max. 500 kHz)**
- **Fiber optic transmission**

Maximum Ratings T_A=25°C

Operating/Storage Temperature
Range (T_{OP}, T_{STG})....................–55° to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t≤10 µs .... 2.5 A
Power Dissipation (P_{TOT}) .... 200 mW
Thermal Resistance (R_{thJA})
Lead length between package bottom and PC board max. 10 mm ....375 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	880	nm	I_F=100 mA
Spectral Bandwidth, 50% I_{REL}	$\Delta\lambda$	80		
Half Angle	φ	±40	Deg.	
Active Chip Area	A	0.16	mm²	
Active Chip Area Dimensions	L x W	0.4 x 0.4	mm	
Distance, Chip Front to Case Surface	D	0.5 to 1		
Switching Times, I_E 10% to 90% and 90% to 10%	t_R, t_F	0.6/0.5	µs	I_F=100 mA R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3.0 (≤3.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	Φ_E	25	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.5	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	–2	mV/K	
Temperature Coefficient, λ	TC_λ	0.25	nm/K	
Radiant Intensity I_E in Axial Direction at a Steradian of Ω=0.01 sr	I_E	≥3.15	mW/sr	I_F=100 mA, t_P=20 ms
	I_{Etyp}	48		I_F=1 A, t_P=100 µs

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

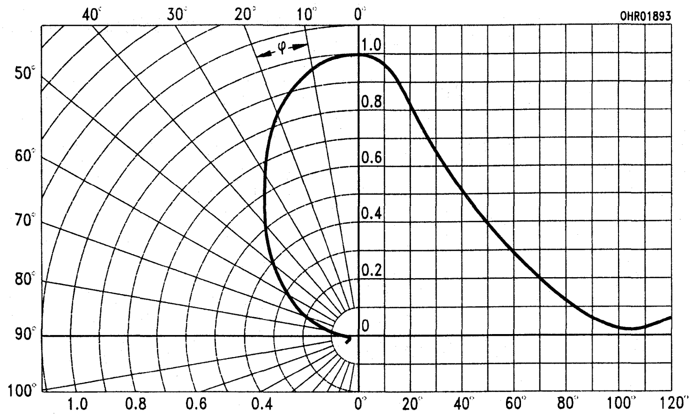


Figure 2. Relative spectral emission $I_{REL}=f(\lambda)$

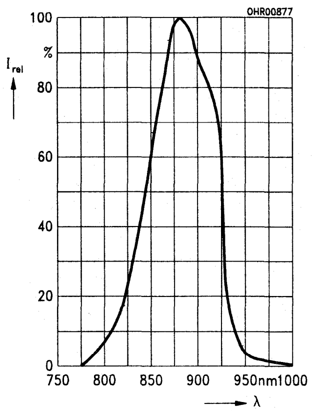


Figure 3. Radiant intensity $I_E/I_E100mA=f(I_F)$, Single pulse, τ=20 µs

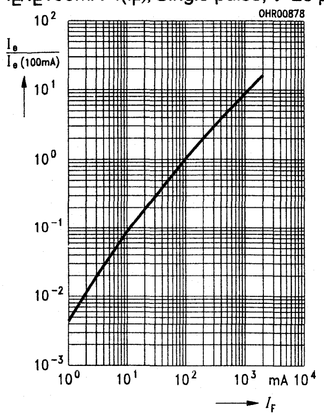


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

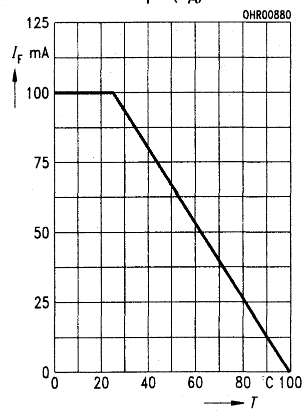


Figure 5. Forward current $I_F=f(V_F)$, Single pulse, τ=20 µs

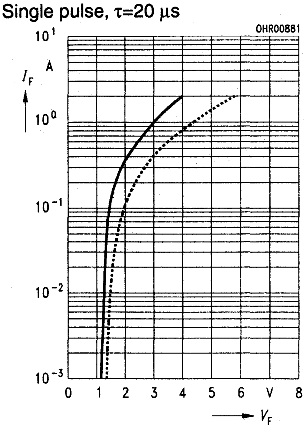


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, T_A=25°C, duty cycle D=Parameter

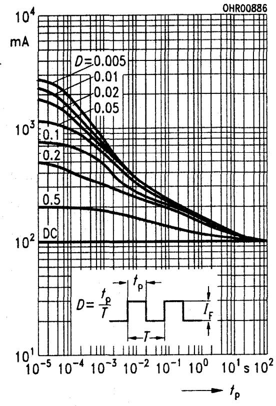
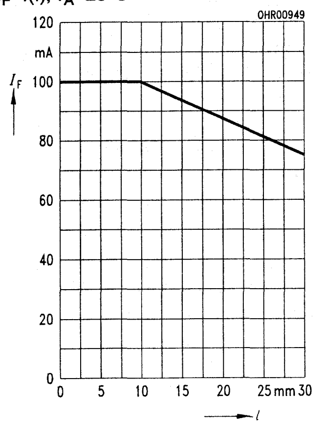


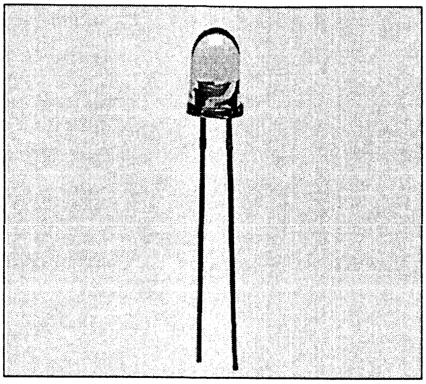
Figure 7. Forward current vs. lead length between package bottom and PC-board $I_F=f(l)$, T_A=25°C



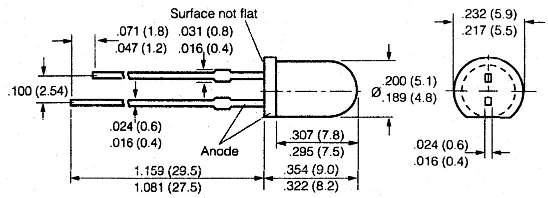
SIEMENS

SFH 486

GaAlAs Infrared Emitter 880 nm



Dimensions in inches (mm)



GEX06952

FEATURES
- **Made in a liquid phase epitaxyy process**
- **High reliability**
- **Spectral match with silicon photodetectors**

APPLICATIONS
- **IR remote control of stereos, TVs, video tape recorders, dimmers**
- **Remote control for steady and varying intensity**

Maximum Ratings T_A=25°C

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t=10 µs, D=0 .... 2.5 A
Power Dissipation (P_{TOT}) .... 200 mW
Thermal Resistance (R_{thJA}) .... 375 K/W

Characteristics T_A=25°C

Parameter	**Symbol**	**Value**	**Unit**	**Condition**
Peak Wavelength	λ_{PEAK}	880	nm	I_F=100 mA
Spectral Bandwidth, 50% I_{REL}	$\Delta\lambda$	80		
Half Angle	φ	±11	Deg.	
Active Chip Area	A	0.16	mm²	
Active Chip Area Dimensions	L x W	0.4 x 0.4	mm	
Distance Chip Front to Lens Top	H	5.1 to 5.7		
Switching Times, I_E, 10% to 90% and 90% to 10%	t_R, t_F	0.6/0.5	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3.0 (≤3.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	Φ_E	25	mW	I_F=100 A, t_P=20 ms
Temp. Coefficient, I_E or Φ_E	TC_I	–0.5	%/K	I_F=100mA
Temp. Coefficient, V_F	TC_V	–2	mV/K	
Temp. Coefficient, λ	TC_λ	0.25	nm/K	
Radiant Intensity Selections I_E in Axial Direction at a Steradian of Ω=0.001 sr	$I_{E40\ min}$	40	mW/sr	I_F=100 mA, t_P=20 ms
	$I_{E40\ max}$	typ. 60		
	$I_{E\ typ.}$	600		I_F=1 A, t_P=100 µs

Infrared Emitters 10

Figure 1. Radiation characteristic— I_{REL}=f(φ)

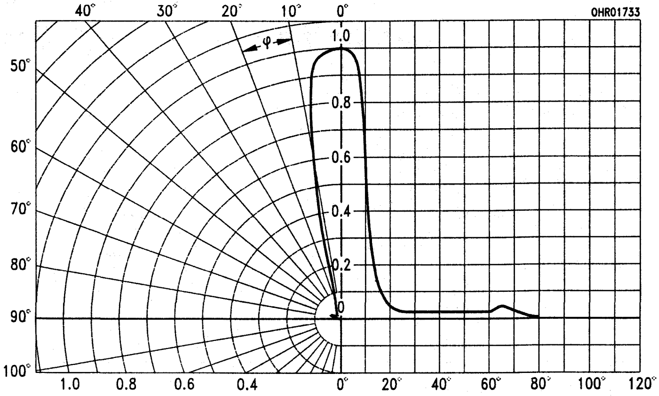


Figure 2. Relative spectral emisson
I_{REL}=f (λ)

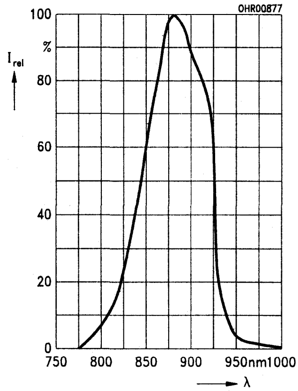


Figure 3. Radiant intensity
I_E/I_E 100mA=f(I_F), Single pulse, tp=20 µs

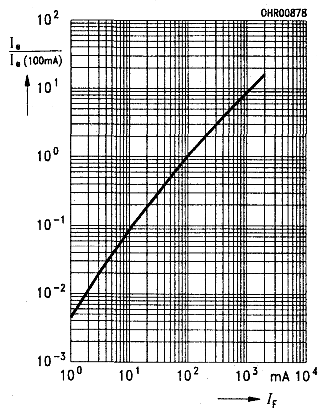


Figure 4. Maximum permissible forward current I_F=f(T_A)

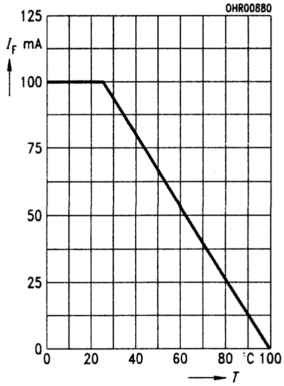


Figure 5. Forward current I_F=f(V_F)
Single pulse, tp=20 µs

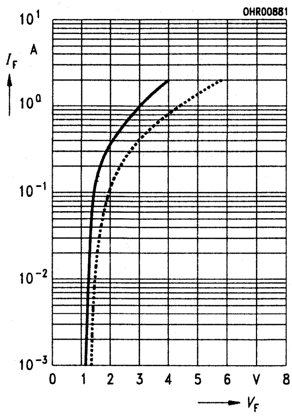


Figure 6. Permissible pulse handling capability I_F=f(τ), T_A=25°C, duty cycle D=Parameter

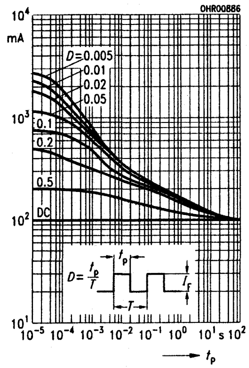
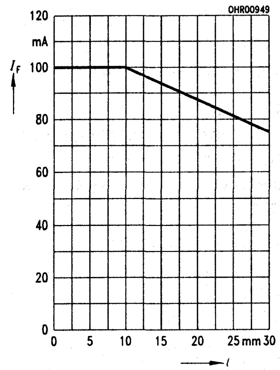


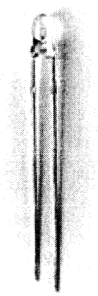
Figure 7. Maximum forward current vs. lead length, package bottom and PC board I_F=f(l), T_A=25°C

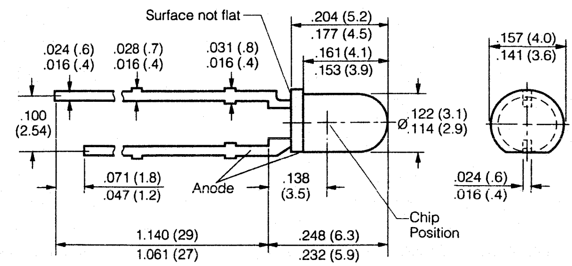


SIEMENS

SFH 487

GaAlAs Infrared Emitter 880 nm





FEATURES

- **Made in a liquid phase epitaxy process**
- **High reliability**
- **High pulse handing capability**
- **Good spectral match to silicon photodetectors**
- **Matches SFH309**
- **Package**
  - **T1 (3 mm)**
  - **Violet transparent epoxy resin**
  - **Solder tabs lead spacing**
  - **Anode marking: Short lead**

APPLICATIONS

- **IR remote control for stereos and TVs, video tape recorder, dimmers**
- **Light-reflection switches (max. 500 kHz)**

DESCRIPTION

SFH 487, an infrared emitting diode, emits radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current. screens.

Maximum Ratings T_A=25°C

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t≤10 µs .... 2.5 A
Power Dissipation (P_{TOT}) .... 200 mW
Thermal Resistance (R_{thJA})
Lead Length between package bottom and PC board max. 10 mm .... 375 K/W

Characteristics T_A=25°C

Parameter	**Symbol**	**Value**	**Unit**	**Condition**
Peak Wavelength	λ_{PEAK}	880	nm	I_F=100 mA
Spectral Bandwidth	$\Delta\lambda$	80		
Half Angle	φ	±20	Deg.	
Active Chip Area	A	0.16	mm²	
Active Chip Area Dimensions	L x W	0.4x0.4	mm	
Distance, Chip Front to Lens Top	D	2.6		
Switching Times, I_E 10% to 90% and 90% to 10%	t_R, t_F	0.6/0.5	µs	I_F=100 mA R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3.0 (≤3.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	Φ_E	25	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.5	%/K	
Temperature Coefficient, V_F	TC_V	–0.2	mV/K	
Temperature Coefficient, λ	TC_λ	0.25	nm/K	

Parameter	**Symbol**	**SFH 487**	**SFH 487-2**	**Unit**	**Condition**
Radiant Intensity I_E in Axial Direction at a Steradian of Ω=0.01 sr	I_E	≥12.5	≥20	mW/sr	I_F=100 mA, t_P=20 ms
		270			I_F=1 A, t_P=100 µs

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

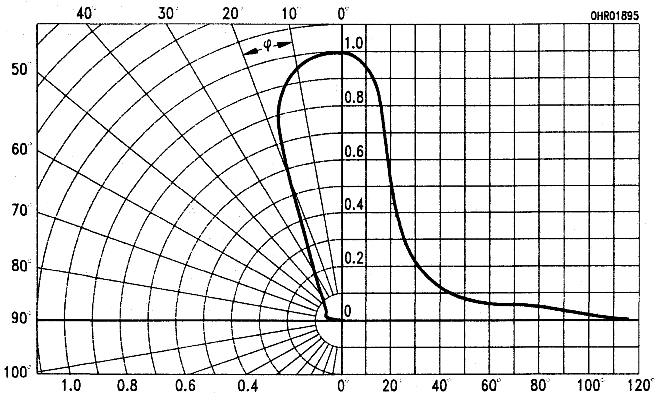


Figure 2. Relative spectral emission $I_{REL}=f(\lambda)$

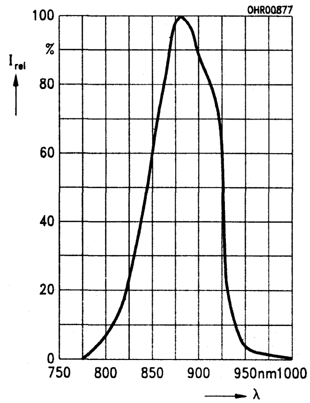


Figure 3. Radiant intensity I_E/I_E100mA=f(I_F), Single pulse, τ=20 µs

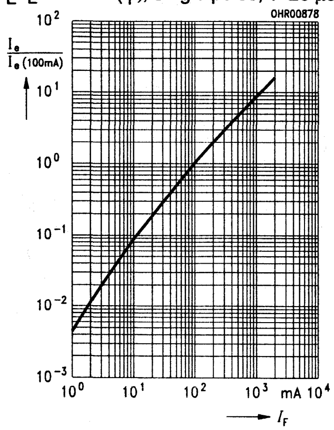


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

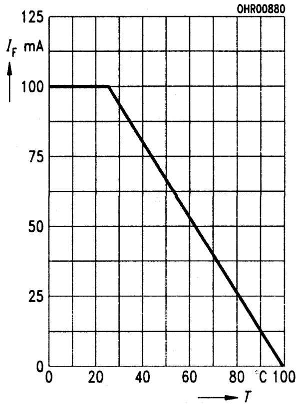


Figure 5. Forward current $I_F=f(V_F)$, Single pulse, τ=20 µs

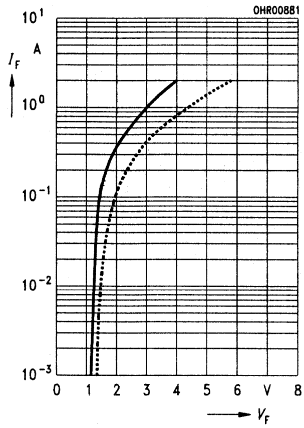


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, T_A=25°C, duty cycle D=Parameter

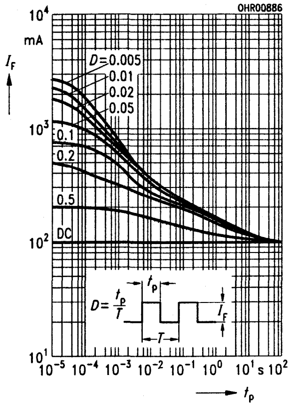
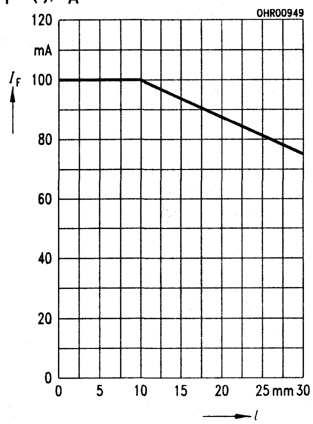


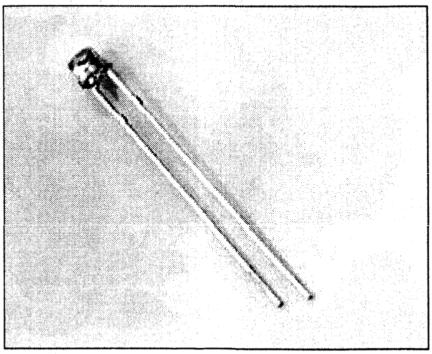
Figure 7. Forward current vs. lead length between package bottom and PC-board $I_F=f(l)$, T_A=25°C

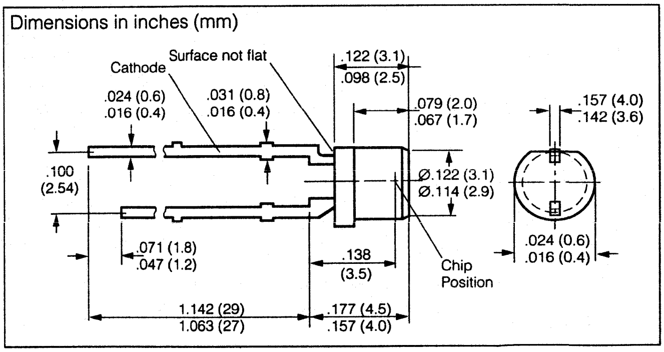


SIEMENS

SFH 487P

GaAIAs Infrared Emitter 880 nm





FEATURES

- **Made in a liquid phase epitaxy process**
- **High reliability**
- **High pulse handing capability**
- **Good spectral match to silicon photodetectors**
- **Matches SFH309**
- **Package**
  - **T1 (3 mm) flat lens**
  - **Violet transparent epoxy resin**
  - **Solder tabs lead spacing**
  - **Anode marking: Short lead**

APPLICATIONS

- **Ppotointerrupters**
- **Fiber optic transmission**

DESCRIPTION

SFH 487P, an infrared emitting diode, emits radiation in the near infrared range (880 nm peak). The emitted radiation, which can be modulated, is generated by forward flowing current.

Maximum Ratings T_A=25°C

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t≤10 µs .... 2.5 A
Power Dissipation (P_{TOT}) T=25°C............. 200 mW
Thermal Resistance (R_{thJA})
Lead Length between package bottom and PC board max. 10 mm .... 375 K/W

Characteristics T_A=25°C

Parameter	**Symbol**	**Value**	**Unit**	**Condition**
Peak Wavelength	λ_{PEAK}	880	nm	I_F=100 mA
Spectral Bandwidth	$\Delta\lambda$	80		
Half Angle	φ	±65	Deg.	
Active Chip Area	A	0.16	mm^2	
Active Chip Area Dimensions	L x W	0.4 x 0.4	mm	
Distance, Chip Front to Case Lans Top	D	0.4 to 0.8		
Switching Times, I_E 10% to 90% and 90% to 10%	t_R, t_F	0.6/0.5	µs	I_F=100 mA, R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3.0 (≤3.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	Φ_E typ.	25	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.5	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	–0.2	mV/K	
Temperature Coefficient, λ	TC_λ	0.25	nm/K	
Radiant Intensity I_E in Axial Direction at a Steradian of Ω=0.01 sr	I_E	>2	mW/sr	I_F=100 mA, t_P=20 ms
	I_E typ.	30		I_F=1 A, t_P=100 µs

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

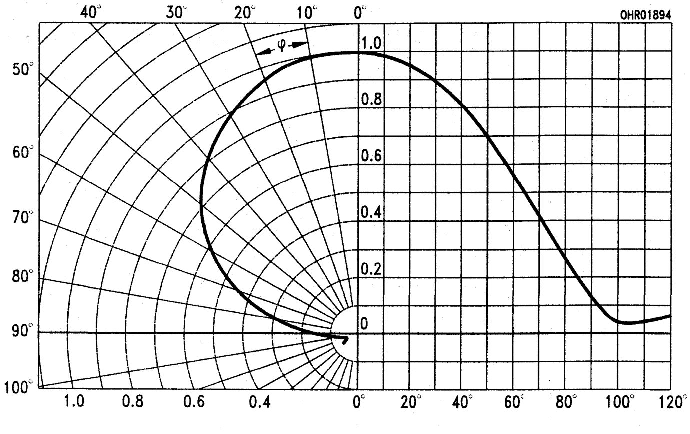


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, $T_C=25°C$, duty cycle D=Parameter

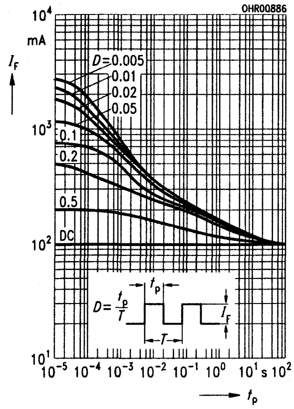


Figure 2. Relative spectral emission
$I_{REL}=f(\lambda)$

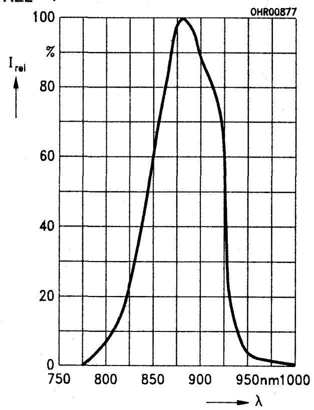


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

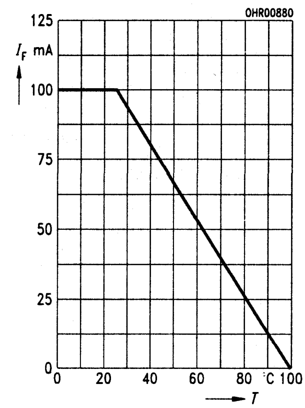


Figure 7. Forward current vs. lead length between package and PC-board $I_F=f(\tau)$, $T_A=25°C$

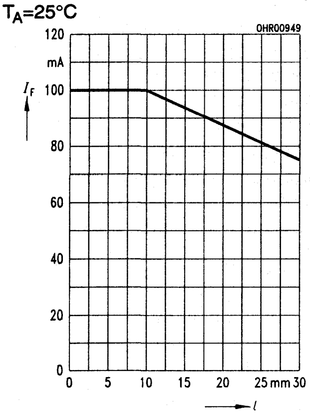


Figure 3. Radiant intensity
$I_E/I_E100mA=f(I_F)$, Single pulse, $\tau=20\ \mu s$

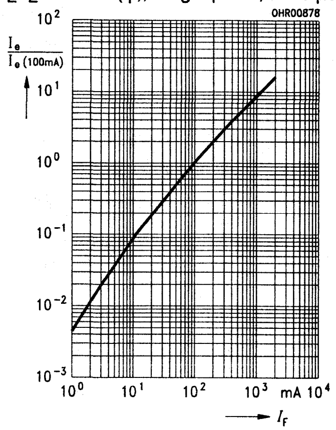
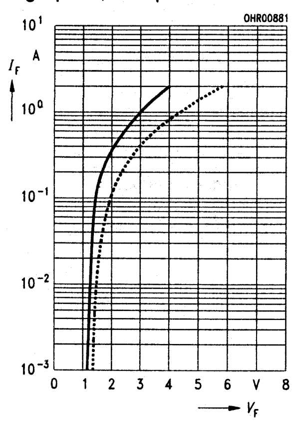


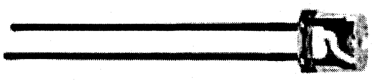
Figure 5. Forward current $I_F=f(V_F)$, Single pulse, $\tau=20\ \mu s$



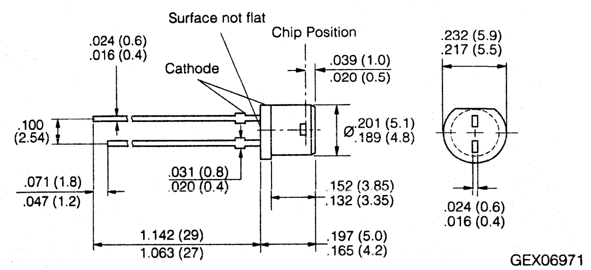
SIEMENS

SFH 495P

GaAlAs Infrared Emitter



Dimensions in inches (mm)



FEATURES
- **Stimulated emitter with high efficiency**
- **Laser diode in diffuse package**
- **Suitable esp. for pulse operation at high current**
- **High reliability**
- **Available on tape and reel**
- **Package similar to SFH 485P, SFH 217**
- **T1¾ (5 mm) package, flat, black**
- **Cathode marking: Short lead**

APPLICATIONS
- **INFRA link**
- **Remote controls**
- **For drive and control circuits**

Maximum Ratings T_A=25°C

Operating Temperature Range (T_{OP}) .... –40 to +80°C
Storage Temperature Range (TSTG) .... 0°C to +80°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 3 V
Surge Current (I_{FSM}) t≤10 µs, D=0 .... 1 A
Power Dissipation (P_{TOT}) .... 160 mW
Thermal Resistance (R_{thJA}) .... 450 K/W

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Peak Wavelength	λ_{PEAK}	945	nm	I_F=100 mA, t_P=20 mA
Spectral Bandwidth, 50% I_{MAX}	$\Delta\lambda$	4		I_F=100 mA
Half Angle	φ	±35/≠25	Deg.	
Switching Times, I_E 10% to 90% and 90% to 10%	t_R, t_F	7	ns	I_F=100 mA R_L=50 Ω
Capacitance	C_0	90	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	2.1	V	I_F=1 A, t_P=100 µs
Total Radiant Flux	Φ_E	700	mW	I_F=1 A, t_P=10 µs
Radiant Intensity	I_E	200	mW/sr	

Warning:

This data sheet refers to high power infrared emitting semiconductors. Depending on operating conditions (drive current, pulse duration optics, etc.), they may emit luminance/radiance levels considered harmful to the human eye, acc. to IEC 825.1

When operating powerful emitters, care should be taken to comply with IEC 825.1 to minimize any possible eye hazard:

- Use lowest possible drive level
- Use diffusing optics where possible
- Avoid staring into powerful emitters or connected fibers

Figure 1. Radiant intensity I_e=f (I_F)

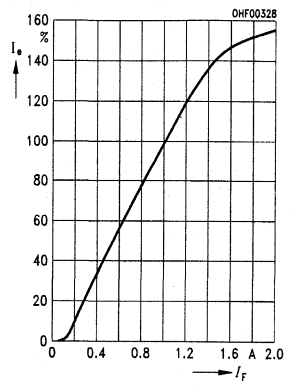


Figure 2. Forward current I_F=f(V_F)

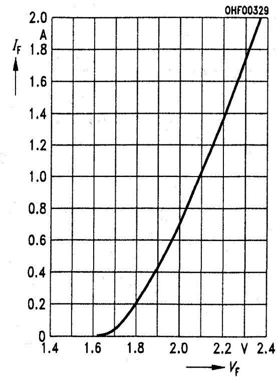
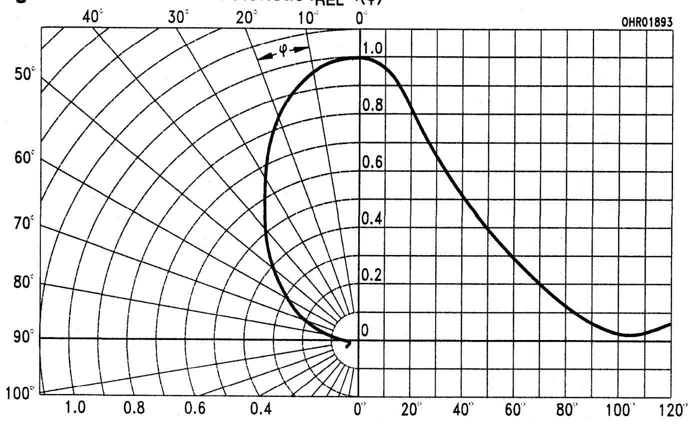


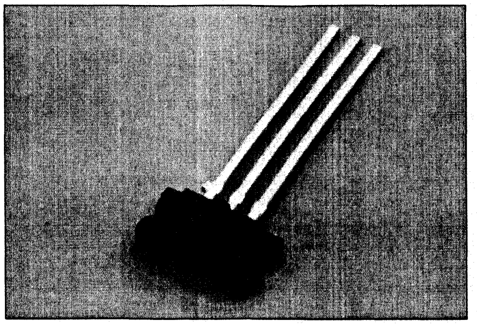
Figure 3. Radiation characteristic I_{REL}=f(φ)

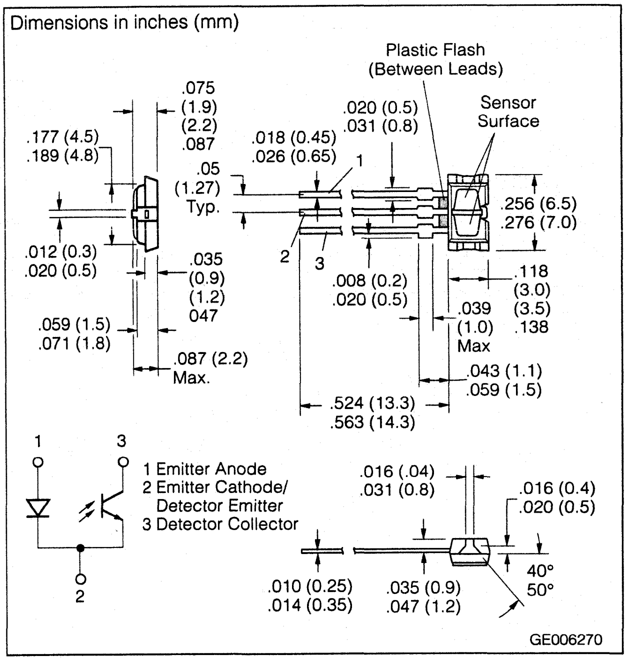


SIEMENS

SFH 900 SERIES

Miniature Light Reflection Emitter/Sensor





FEATURES

- **Designed for short distances up to 5 mm**
- **GaAs infrared emitter**
- **Silicon NPN phototransistor detector**
- **Flat plastic package**
- **Daylight filter against undesired light effects**
- **High collector-emitter current 0.25 to ≥ 1.0 mA**
- **Low saturation voltage**
- **No cross talk**

APPLICATIONS

- **Position reporting**
- **Devices and end position switches**
- **Speed monitoring**
- **Various types of motion transmitters**

DESCRIPTION

The SFH 900 is a light reflection switch which includes a GaAs IRLED transmitter and an NPN phototransistor with a high photosensitive receiver for short distances, operating in the infrared range. Both components are manufactured in modern strip-line technique and are mounted side-by-side in a plastic package. A daylight filter screens against undesired light effects.

The SFH 900 is designed for applications in industrial and entertainment electronics, e.g., as position reporting devices and end position switches, for speed monitoring or in general, as sensor elements in various types of motion transmitters.

For applications information see Appnote 26.

Maximum Ratings T_A=40°C

Emitter (GaAs Infrared Diode)

Reverse Voltage (V_R) .... 6 V
Forward DC Current (I_F) .... 50 mA
Surge Current (I_{FSM}) t_P≤10 µs .... 1.5 A
Total Power Dissipation (P_{TOT}) .... 80 mW

Detector (Silicon Phototransistor)

Collector Emitter Voltage (V_{CEO}) .... 30 V
Emitter Collector Voltage (V_{ECO}) 7V
Collector Current (I_C) .... 10 mA
Total Power Dissipation (P_{TOT}) .... 100 mW

Light Reflection Switch

Storage/Ambient Temperature Range (T_{STG}, T_A) .... –40° to +85°C
Junction Temperature (T_J) .... 100°C
Soldering Temperature (T_S)
(Dip soldering time t ≤ 3 s, ≥ 3 mm from package) .... 235°C
With Heat Sink between Case and Soldering (T_S) .... 260°C
Total Power Dissipation (P_{TOT}) .... 150 mW

Characteristics T_A=25°C

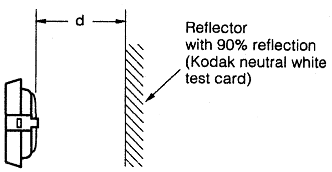
Parameter		Symbol	Value	Unit	Condition
Emitter (GaAs Infrared Diode)					
Forward Voltage		V_F	1.25 (≤1.65)	V	I_F=50 mA
Breakdown Voltage		V_{BR}	≥6		I_R=10 µA
Reverse Current		I_R	.01 (≤10)	µA	V_R=6 V
Capacitance		C_0	40	pF	V_R=0 V, f=1 MHz
Thermal Resistance		R_{thJA}	750	K/W	
Detector (Silicon Phototransistor)					
Capacitance		C_{CE}	11	pF	V_{CE}=5 V, f=1 MHz
Collector Emitter Leakage Current		C_{CEO}	20 (≤200)	nA	V_{CE}=10 V
Photourrent (outside light density)		I_P	3.5	mA	V_{CE}=5 V, E_V=1000 Lx
Thermal Resistance		R_{thJA}	600	K/W	
Light Reflection Switch					
Collector Emitter Current Kodak neutral white test card, 90% reflection	SFH 900	I_{CE}	> 0.25	mA	I_F=10 mA, V_{CE}=5 V, d=1 mm
	SFH 900-1(1)		.25 to .50		
	SFH 900-2		.40 to .80		
	SFH 900-3		.63 to 1.25		
	SFH 900-4(1)		≥1.0		
Collector Emitter Saturation Voltage Kodak neutral white test card, 90% reflection		VCE_{SAT}	0.2 (≤0.6)	V	I_F=10 mA; d=1 mm
I_C=85 µA	SFH 900				
I_C=85 µA	SFH 900-1(1)				
I_C=135 µA	SFH 900-2				
I_C=215 µA	SFH 900-3				
I_C=335 µA	SFH 900-4(1)				

1. Available only on request.

Switching Times T_A=25°C, V_{CC}=5 V, I_C=1 mA(1), R_L=1 KΩ

Description	Value	Unit
Turn-On Time (T_{ON})	65	µs
Rise Time (T_R)	50	
Turn-Off Time (T_{OFF})	55	
Fall Time (T_F)	50	

Note: I_C=1 mA



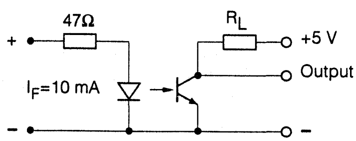


Figure 1. Output characteristics (typ.)
I_C=f(V_{CE}), spacing to reflector: d=1 mm, 90% reflection, T_A=25°C

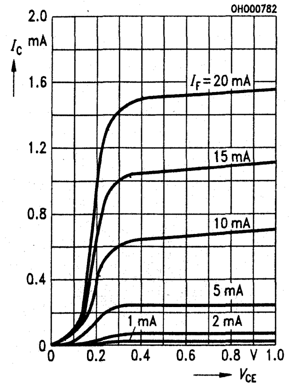


Figure 2. Trasistor capacitance (typ.)
C_{CE}=f(V_{CE}), T_A=25°C, f=1MHz

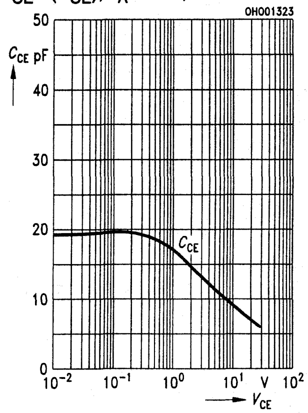


Figure 3. Collector current
$I_C/I_{C\ max}$=f(d)

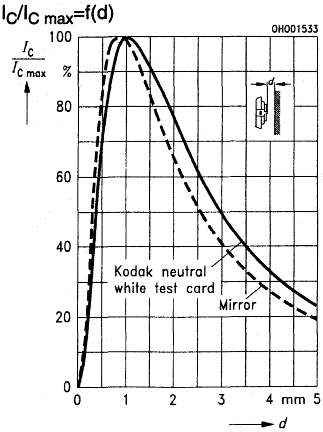


Figure 4. Diode forward voltage (typ.) $V_F=f(I_F)$

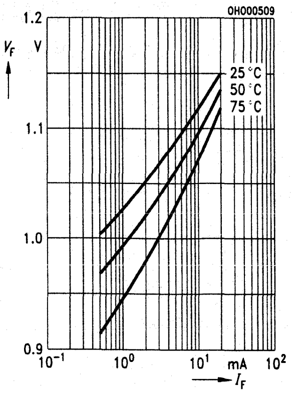


Figure 5. Max. permissible forward current $I_F=f(T_A)$

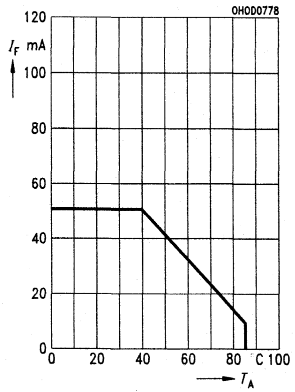


Figure 6. Permissible power dissipation, diode and transistor $P_{TOT}=f(T_A)$

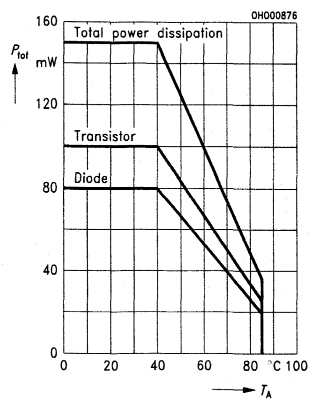


Figure 7. Permissible pulse handling capability $I_F=f(t_P)$, D=parameter, T_A=25°C

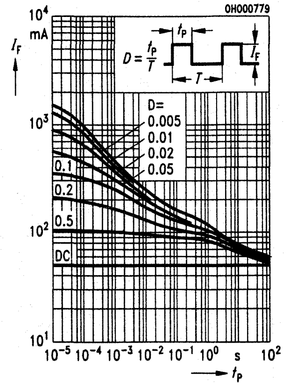


Figure 8. Switching characteristics $t=f(R_L)$, T_A=25°C, I_F=10 mA

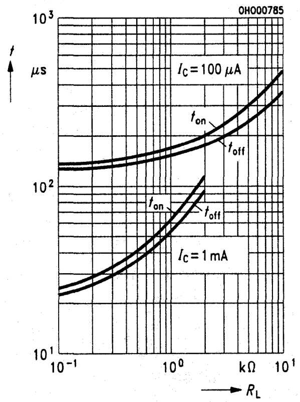


Figure 9. Rel. spectral characteristics, emitter (GaAs) and detector (Si) Emitter: $I_{REL}=f(\lambda)$, Detector: $S_{REL}=f(\lambda)$

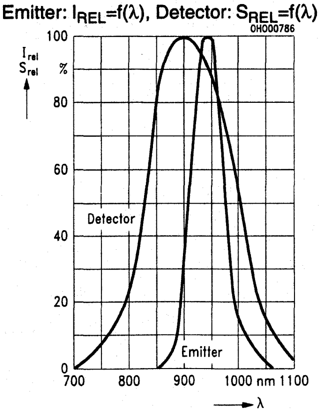


Figure 10. Collector current $I_C=f(I_F)$ Spacing d to reflector=1 mm, 90% reflection

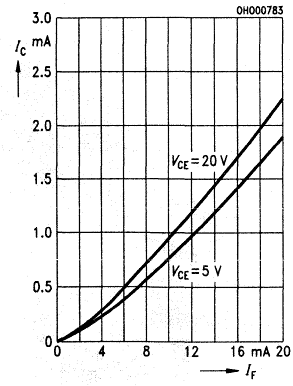
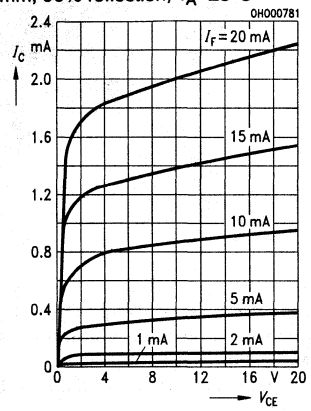


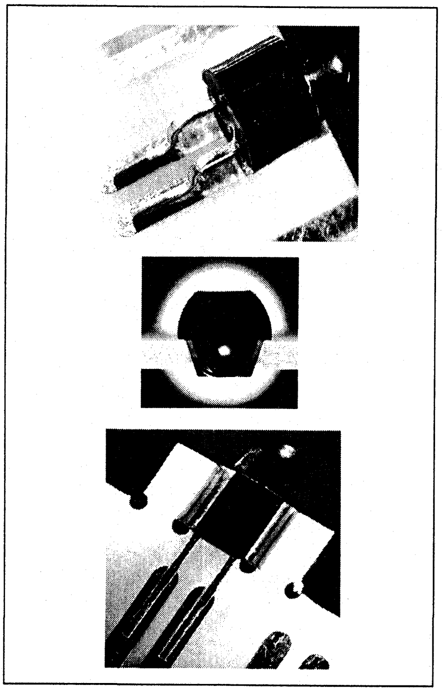
Figure 11. Output characteristics $I_C=f(V_{CE})$, spacing to reflector: d=1 mm, 90% reflection, T_A=25°C

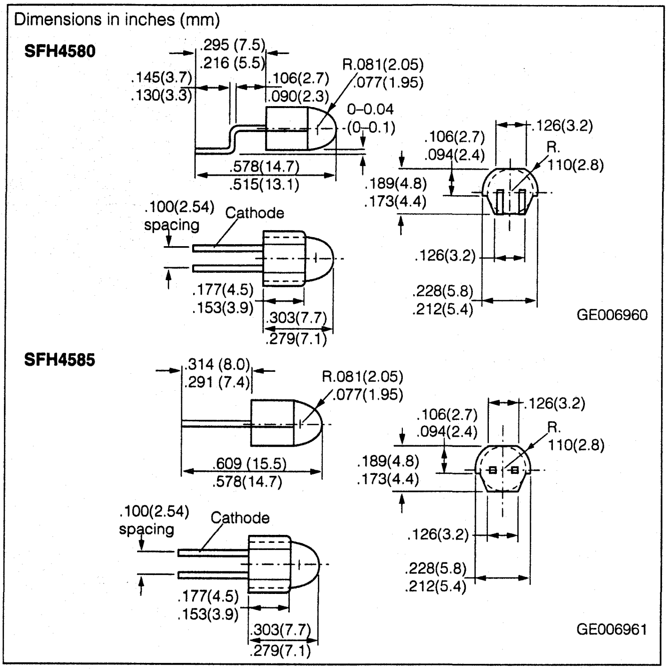


SIEMENS

SFH 4580
SFH 4585

GaAlAs Infrared Emitters (880 nm)





FEATURES
- **Fabricated in a liquid phase epitaxy process**
- **Suitable for surface mounting (SMT)**
- **Available on tape and reel**
- **Same package as photodiode SFH 2540/SFH 2545**
- **High reliability**
- **Spectral match with silicon photodetectors**

APPLICATIONS
- **IR remote control of stereos and TVs, video tape recorders, dimmers**
- **Remote control for steady and varying intensity**

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Junction Temperature (T_J) .... 100°C
Reverse Voltage (V_R) .... 5 V
Forward Current (I_F) .... 100 mA
Surge Current (I_{FSM}) t=10 µs, D=0 .... 2.5 A
Power Dissipation (P_{TOT}) .... 200 mW
Thermal Resistance, lead length between package bottom and PC-board max. 10mm (R_{thJA}) .... 375 K/W

Characteristics (T_A=25°C)

Parameter	Symbol	Value	Unit	Condition
Peak Emission Wavelength	λ_{PEAK}	880	nm	I_F=100 mA
Spectral Bandwidth, 50% I_{REL}	$\Delta\lambda$	80		
Half Angle	φ	±15	Deg.	
Active Chip Area	A	0.16	mm^2	
Active Chip Area Dimensions	L x W	0.4 x 0.4	mm	
Distance Chip Front to Lens Top	H	4.2 to 4.8		
Switching Times, I_E, 10% to 90% and 90% to 10%	t_R, t_F	0.6/0.5	µs	I_F=100 mA R_L=50 Ω
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3.0 (≤3.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤1)	µA	V_R=5 V
Total Radiant Flux	Φ_E	25	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient, I_E or Φ_E	TC_I	–0.5	%/K	I_F=100 mA
Temperature Coefficient, V_F	TC_V	–2	mV/K	
Temperature Coefficient, λ	TC_λ	0.25	nm/K	
Radiant Intensity	$I_{E\ MIN}$	≥25	mW/sr	I_F=100 mA, t_P=20 ms
Radiant Intensity	$I_{E\ TYP}$	225		I_F=1 A, t_P=100 µs

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

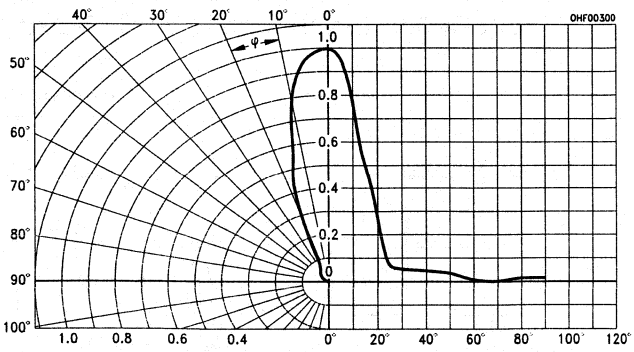


Figure 2. Relative spectral emisson
$I_{REL}=f(\lambda)$

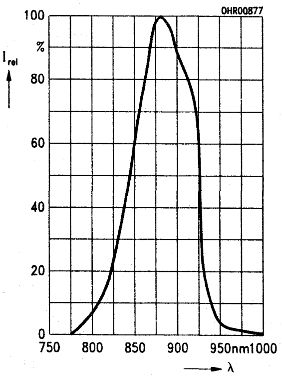


Figure 3. Radiant intensity
I_E/I_E 100mA=f(I_F), Single pulse, t=20 µs

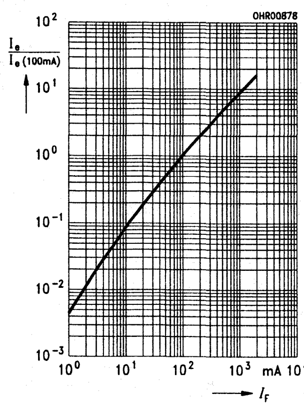


Figure 4. Maximum permissible forward current $I_F=f(T_A)$

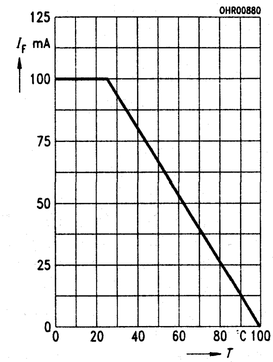


Figure 5. Forward current $I_F=f(V_F)$
Single pulse, tp=20 µs

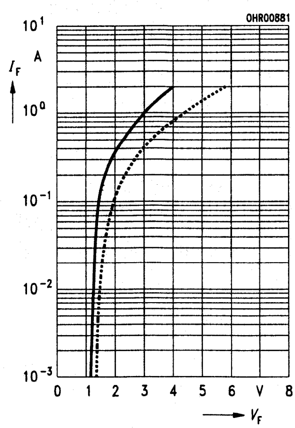


Figure 6. Permissible pulse handling capability $I_F=f(\tau)$, $T_A=25°C$, duty cycle D=Parameter

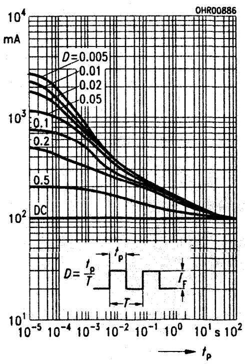
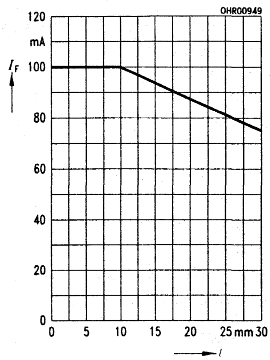


Figure 7. Forward current vs. lead length, package bottom and PC board
$I_F=f(l)$, $T_A=25°C$



Infrared Emitters

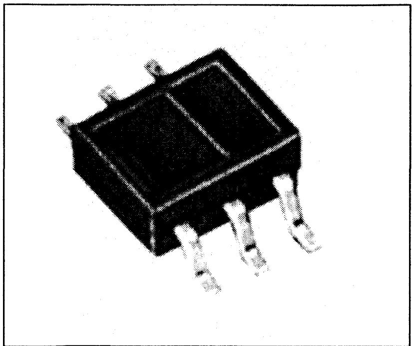
10

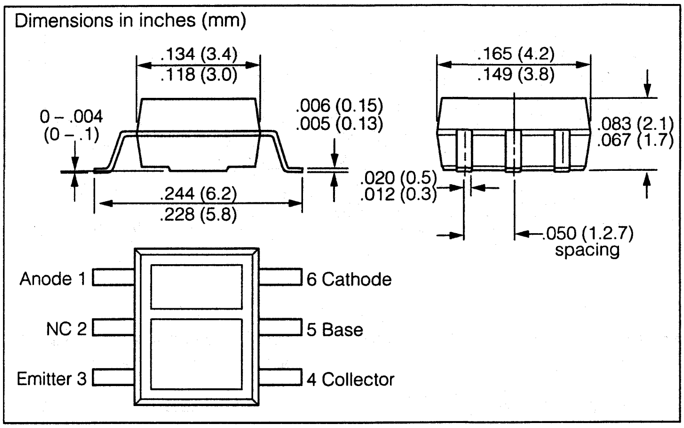
SIEMENS

SFH9101/9102

Light Reflection Switch in SMT Package

Preliminary Data





FEATURES

- **Light reflection switch for 1 mm to 5 mm operating distance**
- **IR GaAs emitter**
- **Silicon NPN phototransistor detector**
- **Daylight filter against undesired light effects**
- **Collector-emitter current 0.25 to ≥1.0 mA**
- **Low saturation voltage**
- **No cross-talk**
- **Emitter and detector electrically isolated**
- **Base connection brought out**

APPLICATIONS

- **Position reporting**
- **End position switch**
- **Speed monitoring and regulating**
- **Motion transmitter**

Maximum Ratings

Emitter (GaAs Diode)

Reverse Voltage (V_R) .... 6 V
Forward Current (I_F) .... 50 mA
Surge Current (I_{FSM}) t_P≤10µs .... 1.5 A
Power Dissipation (P_{TOT}) .... 80 mW

Detector (Silicon Phototrqnsistor)

Collector Emitter voltage (V_{CEO}) .... 30 V
Emitter Collector Boltage (V_{ECO}) .... 7 V
Collector Current (I_C) .... 10 mA
Power Dissipation (P_{TOT}) .... 100 mW

Light Reflection Switch

Storage and Ambient Temperature Range (T_{STG}, T_A) .... –40 to +85°C
Junction Temperature (T_J) .... 100°C

Soldering Conditions

Dip, Wave and Drag Soldering
Soldering Bath Temperature, T≤8s .... 260°C
Reflow SolderingTemperature of Soldering Zone,
t≤10s .... 260°C
t≤40s .... 215°C
Preheating t=approx. 1 min. .... 150°C

Observe handling guidelines for SMT devices.

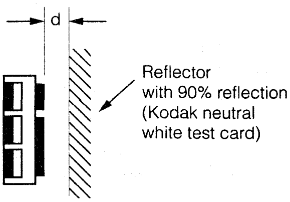
Characteristics T_A=25°C

Parameter	**Sym.**	**Value**	**Unit**	**Condition**
Emitter (IR-GaAs Infrared diode)				
Forward Voltage	V_F	1.25 (≤1.65)	V	I_F=50 mA
Breakdown Voltage	V_{BR}	≥6		I_R=10 µA
Reverse Current	I_R	0.01 (≤10)	µA	V_R=6 V
Capacitance	C_O	25	pF	V_R=0 V, f=1 MHz
Thermal Resistance(1)	R_{thJA}	500	K/W	

Characteristics (T_A=25°C)

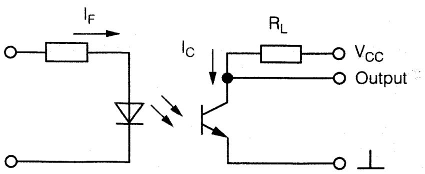
Parameter		Sym.	Value	Unit	Condition
Detector					
Capacitance	SFH9101	C_{CE}	11	pF	V_{CE}=5 V, f=1 MHz
	SFH9102		5		
Collector Emitter Leakage Current		I_{CEO}	20 (≤200)	nA	V_{CE}=10 V
Photocurrent (Outside Light Density)	SFH9101	I_P	3.5	mA	V_{CE}=5 V, E_V=1000 lx
	SFH9102		0.5		
Thermal Resistance[1]		R_{thJA}	500	K/W	
Light Reflection Switch					
Collector Emitter Current, Kodak Neutral White Test Card, 90% Reflection	SFH9101	I_{CEmin}	0.25	mA	I_F=10 mA, V_{CE}=5 V, d=1 mm
	SFH9102		63		
	SFH9101	I_{CEtyp}	0.7		
	SFH9102		200		
Collector Emitter Saturation Voltage, Kodak Neutral White Test Card, 90% Reflection	SFH9101	V_{CEsat}	0.2 (≤0.6)	V	I_F=10 mA, d=1 mm, I_C=85 µA
	SFH9102				I_F=10 mA, d=1 mm, I_C=13 µA

1. Mounting on PCB with >5 mm^2 pad size



Switching times

T_A=25°C, V_{CC}=5 V, I_C=1 mA[1], R_L=1 kΩ



Description	Sym.	SFH9101	SFH9102	Unit
Turn-on time	t_{ON}	65	40	µs
Rise time	t_R	50	30	
Turn-off time	t_{OFF}	55	45	
Fall time	t_F	50	40	

I_C as a function of the forward current of the emittimg diode, the degree of reflection and the distance between reflector and component (d)

Figure 1. Collector Current I_C/I_{Cmax}=f(d)

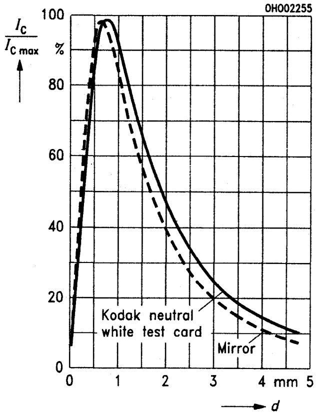


Figure 2. Permissible power dissipation for diode and transistor P_{tot}=f (T_A)

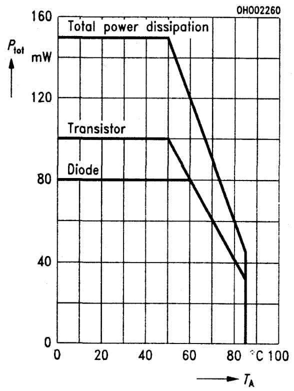


Figure 3A.Switching characteristics t=f (R_L) T_A=25°C, I_F=10 mA **SFH9101**

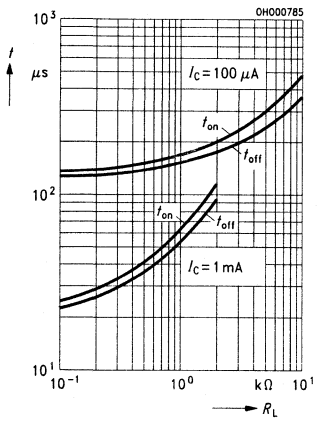


Figure3B. Switching characteristics t=f (R_L) T_A=25°C, I_F=10 mA **SFH9102**

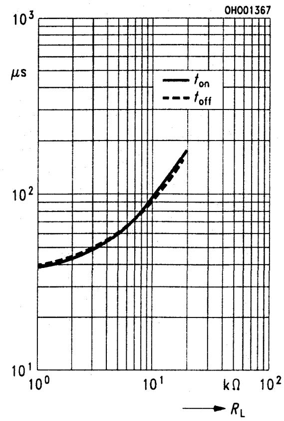


Figure 4. Maximum permiissible forward current I_F=f(T_A)

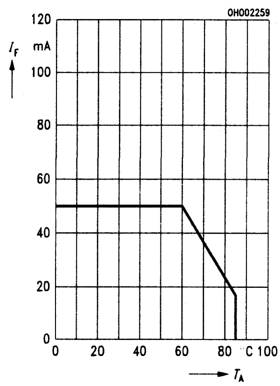


Figure 5. Permissible pulse handing capability I_F=f(tp), D=Parameter, T_A=25°C

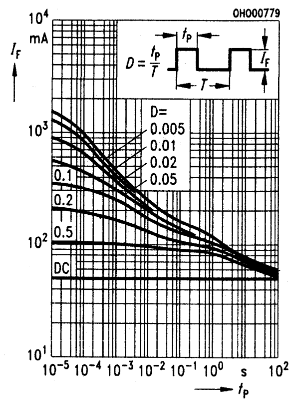


Figure 6A. Collector current I_C=f (I_F), spacing d to reflector=1 mm, 90% reflection **SFH9101**

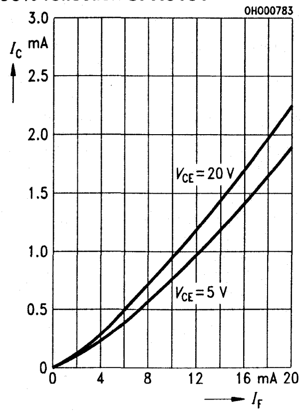


Figure 6B. Collector current I_C=f (I_F), spacing d to reflector=1 mm, 90% reflection **SFH9102**

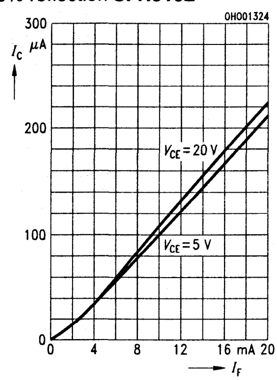


Figure 7. Diode forward voltage (typ.) V_F=f(T)

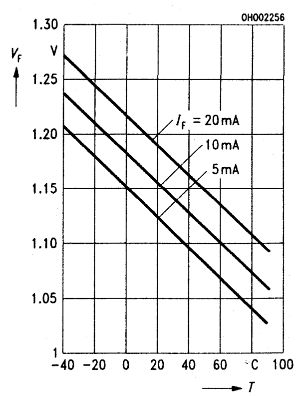


Figure 8. Relative spectral emission of emitter (GaAs) I_{REL}=f (λ) and detector (Si) S_{REL}=f (λ)

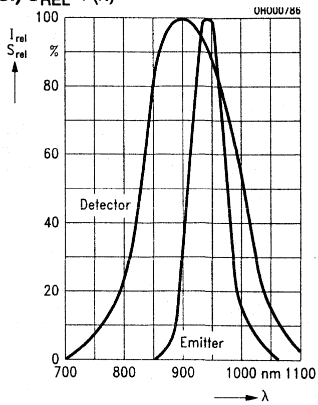


Figure 10. Transistor capacitance (typ.)
C_{CE}=f (V_{CE}), T_A=25°C, f=1 MHz

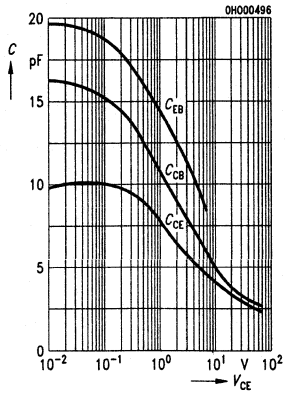


Figure 9A. Output characteristics
I_C=f(V_{CE}), spacing to reflector: d=1 mm, 90% reflection, T_A=25°C **SFH9101**

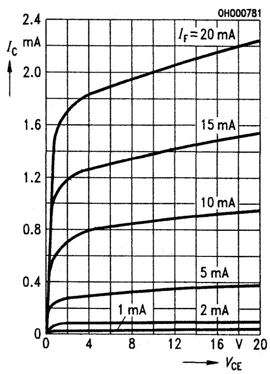


Figure 11A. Output characteristics
I_C=f(V_{CE}), spacing to reflector: d=1 mm, 90% reflection, T_A=25°C **SFH9101**

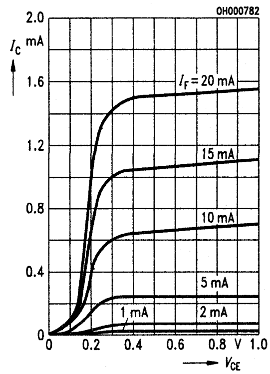


Figure 9B. Output characteristics
I_C=f(V_{CE}), spacingto reflector: d=1 mm, 90% reflection, T_A=25°C **SFH9102**

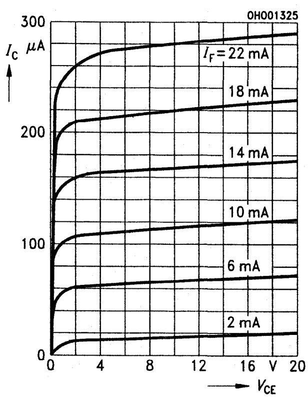
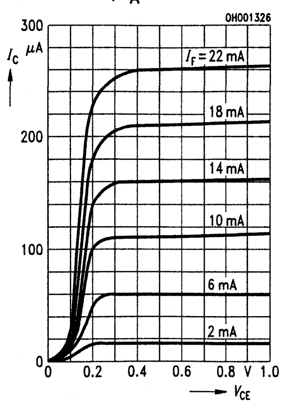
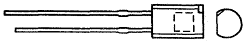
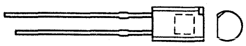
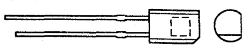
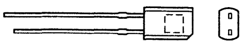
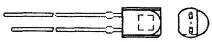
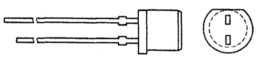
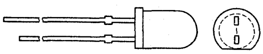
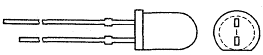


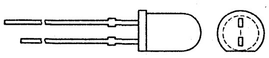
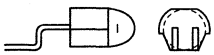
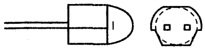
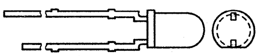
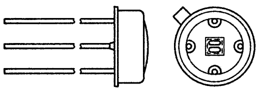
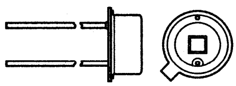
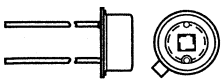
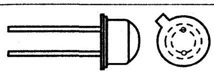
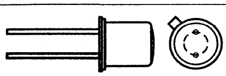
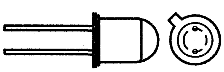
Figure 11B. Output characteristics
I_C=f(V_{CE}), spacing to reflector: d=1 mm, 90% reflection, T_A=25°C **SFH9102**



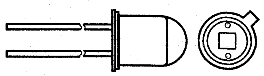
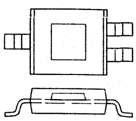
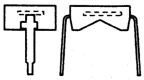
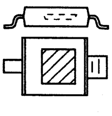
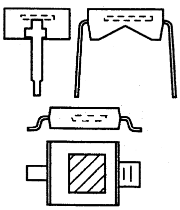
Photodiodes

Package Outline	Part Number	Package Type	Half Angle	Dark Current V_R=10 V nA	Spectral Sensitvity 1 mW/cm² µA	Radiant Sensitive Area mm²	Peak Wave-length nm	Features	Page
	SFH205F	Plastic, daylight filter, solder tabs	±60°	2 (≤30)	60(≥45)	7.00	950	PIN type. Short switching time (20 ns typ.).	11–47
	SFH205FA						900		
	SFH2910FA	TO-92, plastic, daylight filter.	±60°	≤1	46(≥36)	7.34	890	Applications in 880 nm range.	11–82
	SFH206K	Clear plastic, solder tabs	±60°	2 (≤30)	80(≥50) nA/lx (V_R=5 V)	7.00	850	PIN type. Short switching time (20 ns typ.).	11–49
	SFH225FA	Plastic, daylight-filter	±60°	2 (≤30)	17 (≥12.5)	4.84	900	PIN type. Short switching time (20 ns typ.).	11–59
	SFH235FA	Plastic, daylight filter	±65°	2 (≤30)	50(≥40) (λ=870 nm)	7	900	PIN type. Short switching time (20 ns typ.).	11–65
	SFH204F	T1³/4 (5 mm) daylight-filter	±60°	2 (≤30)	52 (≥43)	4.84	940	Applications in 880 nm range. Short switching time (20 ns typ.).	11–45
	SFH204FA						900		
	SFH203P	T1³/4 flat, clear plastic	±75°	1 (≤10) 20 V	9.5(≥5) nA/lx (V_R=5 V, etc.)	1	850	PIN type. Short switching time (5 ns typ.).	11–43
	SFH203PFA	T1³/4 flat, plastic, daylight-filter			6.2 (≥3.6)		900		
	SFH203	T1³/4 clear plastic	±20°	1 (≤5) 20 V	80(≥50) nA/lx (V_R=5 V, etc.)	1	850	PIN type. Short switching time (5 ns typ.).	11–41
	SFH203FA	T1³/4 plastic, daylight-filter			50(≥30)		900		
	SFH213	T1³/4 (5 mm) clear plastic	±10°	1 (≤5)	135 (≥100) (V_R=5 V, etc.)	1	850	PIN type. Short switching time (5 ns typ.).	11–51
	SFH213FA	T1³/4 (5 mm) daylight-filter			90(≥65)		900		

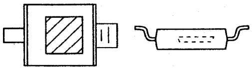
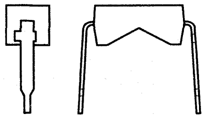
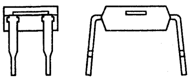
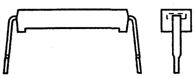
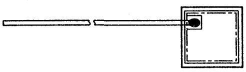
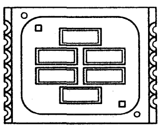
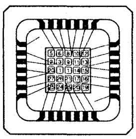
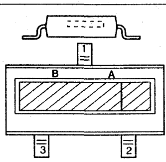
Photodiodes

Package Outline	Part Number	Package Type	Half Angle	Dark Current V_R=10 V nA	Spectral Sensitvity 1 mW/cm² µA		Radiant Sensitive Area mm²	Peak Wave-length nm	Features	Page
	SFH214	T1¾ clear plastic	±40°	1 (≤5) n A	45 (≥30) nA/lx	V_R=5 V, etc.	1	850	Short switching time (5 ns typ.)	11–53
	SFH214FA	T1¾ plastic, daylight-filter			25 (≥20)			900		
	SFH2500	T1¾ (5 mm), plastic,	±15°	1(≤5) nA	100 (>75)	V_R=5 V, etc.	1	850	Short switching time (5 ns typ.). Can be surface mounted.	11–79
	SFH2505FA				70 (>50)			950		
	SFH229	T1 clear plastic	±17°	50 pA	28 (≥18) nA/lx	V_R=5 V, etc.	0.3	860	PIN type. Short switching time (10 ns typ.)	11–61
	SFH229FA	T1 daylight filter			20 (≥10.8)			900		
	SFH221	TO-5 hermetic	±55°	10 (≤100)	24 (≥15) nA/lx	V_R=5 V	1.54	900	Short switching time. Double diode differential detector.	11–57
	SFH291	TO-5 hermetic	±55°	0.3 (≤1) 5 V	50 nA/lx	V_R=5 V	7.45	850	High photo sensitivity. UV range.	11–67
	BPW21	TO-5, hermetic	±55°	8(≤200) 5 V	10(≥5.5) nA/lx	V_R=5 V	7.34	550	High reliability, Vλ filter.	11–5
	BPX60		±55°	7(≤55)	70 nA/lx	V_R=5 V	7.45	850	High reliability. Enhanced blue sensitive.	11–21
	BPX61		±55°	2(≤30)	70(≥50) nA/lx		7.00	850	High reliability. PIN type.	11–23
	BPX63	TO-18, plastic lens	±75°	5(≤20) pA 1 V	10(≥8) nA/lx	V_R=5 V	0.97	800	Very low dark current. Low reverse current (5 pA typ.)	11–25
	BPX65	TO-18 hermetic	±40°	1(≤5) 20 V	10 (≥5.5) nA/lx	V_R=5 V	1	850	PIN type. High photosensitivity.	11–27
	SFH216	TO-18 hermetic	±12°	1(≤5) 20 V	50(≥35) nA/lx	V_R=5 V	1	850	Short switching time (5 ns typ.)	11–55

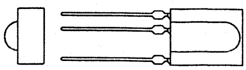
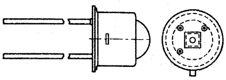
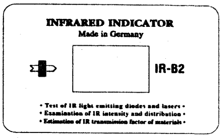
Photodiodes

Package Outline	Part Number	Package Type	Half Angle	Dark Current V_R=10 V nA	Spectral Sensitvity 1 mW/cm^2 µA		Radiant Sensitive Area mm^2	Peak Wave-length nm	Features	Page
	SFH231	TO-18 hermetic	±10°	10 (≤50) µA 1 V	13(≥8)	λ=1300 mn E_e=0.25mW/cm^2	1	1550	Germanium, PIN type. Short switching time (9 ns typ.)	11–63
	SFH2400	SMT plastic	±60°	0.1 (<5)	10 (>5.5)	V_R=5 V, etc.	1	850	PIN type. Short switching time (20 ns typ.)	11–77
	SFH2400FA	SMT daylight filter			6.2 (≥3.6)			900		
	BP104F	Plastic, solder tabs	±60°	2(≤30)	34 (≥25)		4.84	950	Daylight filter. PIN type. Short switching time (20 ns typ.)	11–1
	BP104FS	Surface mount								
	BP104S	Plastic, surface mount			55(≥40) nA/lx	V_R=5 V		850	PIN type. Short switching time (20 ns typ.)	11–3
 Surface Mount Package	BPW33	Clear plastic, solder tabs.	±60°	2(≤100) pA 1 V	75 (≥35) nA/lx	V_R=5 V	7.34	800	Low reverse current (20 pA typ.)	11–7
	BPW34	Clear plastic, solder tabs.	±60°	2(≤30)	80 (≥50) nA/lx	V_R=5 V	7.00	850	PIN type. Short switching time (20 ns typ.)	11–9
	BPW34S	Surface mount								
	BPW34B	Clear plastic.	±60°	2(≤30)	75 nA/lx	V_R=5 V	7.45	850	PIN type. Short switching time (25 ns typ.)	11–11
	BPW34F	Plastic, daylight filter.	±60°	2(≤30)	50 (≥40)		7.00	950	PIN type. Short switching time (20 ns typ.)	11–13
	BPW34FS	Surface mount								
	BPW34FA	Plastic, daylight filter.	±60°	2(≤30)	50(≥40)	λ=870 nm, V_R=5 V	7.00	880	PIN type. Short switching time (20 ns typ.)	11–15
	BPW34FAS	Surface mount								

Photodiodes

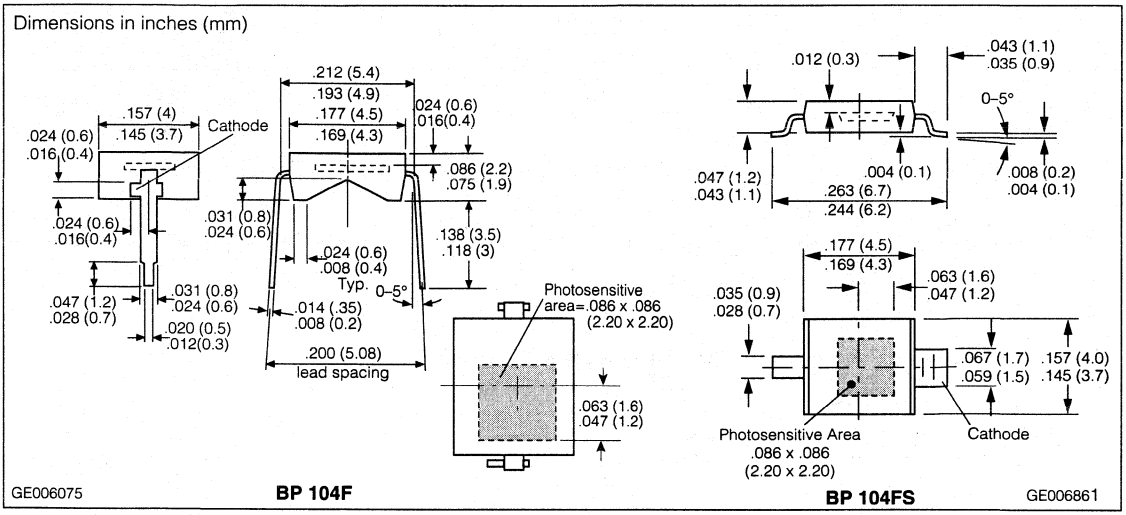
Package Outline	Part Number	Package Type	Half Angle	Dark Current V_R=10 V nA	Spectral Sensitvity 1 mW/cm^2 µA		Radiant Sensitive Area mm^2	Peak Wave-length nm	Features	Page
	BPW 34S (E9087)	Reverse gullwing surface mount	±60°	2 (≤30)	80 (≥50) nA/lx	V_R=5 V	7.00	850	PIN type. Short switching time (20 ns typ.)	11–17
	BPX90	Clear plastic, solder tabs.	±60°	5 (≤180)	45 (≥32) nA/lx	V_R=5 V	5.5	830	High sensitivity. applications 400 to 1100 nm (BPX 90), 950 nm (BPX90F)	11–29
	BPX90F	Plastic, daylight filter, sol-der tabs.			26(≥16)			950		
	BPX48	Clear plastic, solder tabs.	±60°	10 (≤100)	24(≥15) nA/lx	V_R=5 V, etc.	1.54	900	Differential type. High photosensitiv-ity. Double diode.	11–19
	BPX48F	Plastic, daylight filter, sol-der tabs.			7.5 (≥4.0)			920		
	SFH100	Clear plastic, solder tabs.	±60°	0.4 (≤10) 7 V	175 nA/ lx	V_R=5 V	21.2	850	Enhanced, blue sensitivity. Low reverse curent (400 pA typ.)	11–39
	BPY12	Chip with 2 leads.	±60°	10 (≤100)2 0 V	180 (≥100) nA/lx	V_R=5 V	20	920	High spectal sensitivity. Short switching time (25 ns typ.)	11–31
	KOM 2100B	6 chip array.	±60°	1(≤10)	9(≥7)		2.5	870	PIN type. Short switching time. (13 ns typ.) Available as photodiode w/ reverse voltage or photovoltaic cell.	11–33
	KOM 2100BF	6 chip array, daylight-filter.			8.5(≥6.6)					
	KOM 2108	5 x 5 Silicon photo-diode array.	±60°	0.05 (≤1)	1.1(≥0.8)		0.3	850	PIN type. Low noise. Short switch-ing time (10 ns typ.)	11–35
	KOM 2125	Clear plastic SMT.	±60°	A 5(≤30)	A 40(≥30) nA/lx	V_R=5 V	4	850	Two chips A and B. Short switching time. (25 ns typ.)	11–37
				B 10 (≤30)	B 100(≥75) nA/lx		10			

Photodiodes

Package Outline	Part Number	Package Type	Half Angle	Current Consumption mA	Peak Wave-length nm	Features	Page
	SFH506	Daylight filter	±55°C	0.5 pin 2	950	With hybrid IC. High immunity against ambient light	11–69
	SFH507	Daylight filter	±55°C	0.5 (<0.8) pin 2	950		11–72
Package Outline	**Part Number**	**Package Type**	**Supply current µA**	**Max. output current µA**	**Active Area**	**Features**	**Page**
	SFH 530	TO-5, hermetic	50–90	35–72	1	Hig UV sensitivity Low sensitivity visible and IR light,	11–75
	IR-B2	Infrared indicator card.	—	—	—	An application: check output of IR LEDs and IR laser diodes.	11–84

SIEMENS

BP 104F
SURFACE MOUNT BP 104FS
Daylight Filter Silicon NPN Photodiode



FEATURES
- **Especially suitable for applications of 950 nm**
- **Short switching time (typ. 20 ns)**
- **DIL plastic package with high packing density**
- **BP 104 FS: suitable for vapor-phase and IR-reflow soldering**
- **Package: black epoxy resin**
  - **BP104F: 0.200" (5.08 mm) lead spacing**
  - **BP104FS: surface mount package**

APPLICATIONS
- **IR remote control of stereos and TVs, video tape recorders, dimmers, various equipment**
- **Photointerrupters**

Maximum Ratings
Operating/Storage Temperature Range (T_{OP}, T_{STG})	–40° to +80°C
Reverse Voltage (V_R)	20 V
Power Dissipation (P_{TOT}) T_A=25°C	150 mW

Characteristics T_A=25°C, λ=950 nm

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	34 (≥25)	nm	V_R=5 V, E_E=1 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	950		
Spectral Sensitivity Range	λ	780 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	4.84	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.20x 2.20	mm	
Distance, Chip Surface to Case Surface, BP104F BP104FS	H	0.5 0.3		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.70	A/W	
Quantum Yield	η	0.90	electrons/photon	
Open Circuit Voltage	V_O	330 (≥250)	mV	E_e=0.5 mW/cm^2
Short Circuit Current	I_{SC}	17	μA	
Rise and Fall Time, Photocurrent	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 μA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	48	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O	TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	3.6 x 10^{-14}	W/√Hz	V_R=10 V
Detection Limit	D*	6.1 x 10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

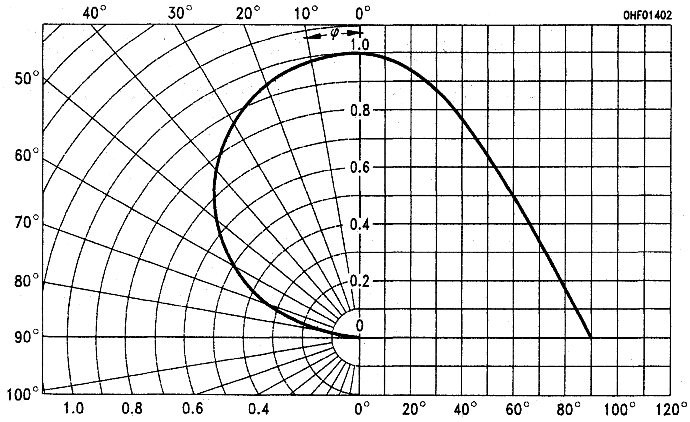


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

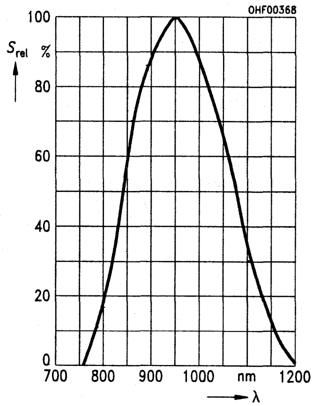


Figure 3. Photocurrent $I_P=f(E_e)$,
Open circuit voltage $V_O=f(E_e)$

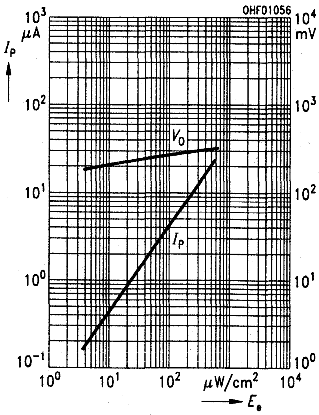


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

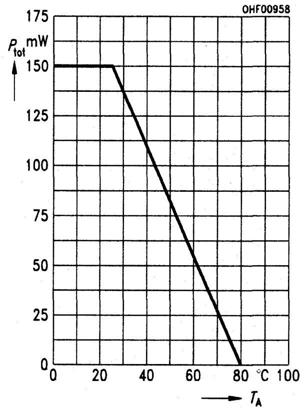


Figure 5. Dark current
$I_R=f(V_R)$, $T_A=25°C$, $E=0$

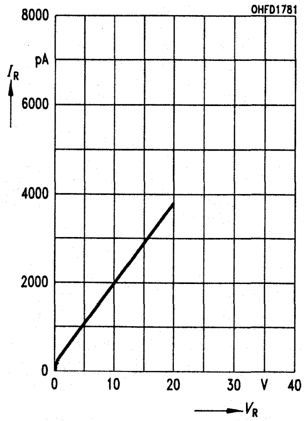


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

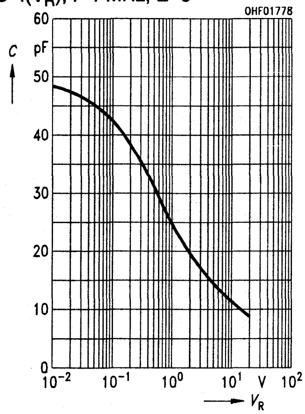
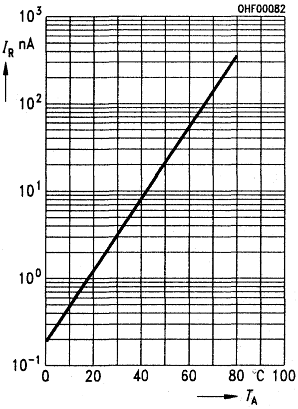


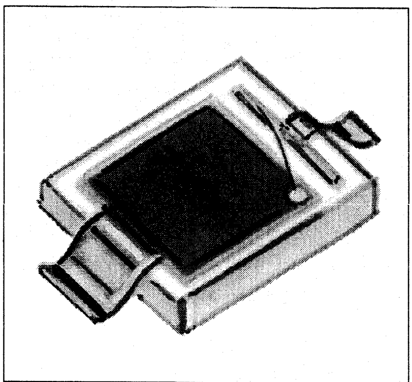
Figure 7. Dark current
$I_R=f(T_A)$, $V_R=10$, $E=0$

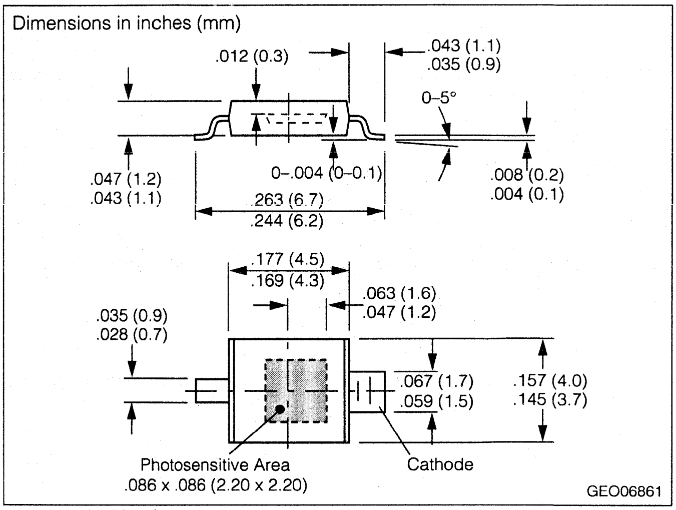


SIEMENS

BP 104S

Silicon PIN Photodiode





FEATURES

- **Especially suitable for applications from 400 nm to 1100 nm**
- **Short switching time (typ. 20 ns)**
- **Suitable for vapor-phase and IR-reflow soldering**
- **Suitable for SMT**

APPLICATIONS

- **Photointerrupters**
- **IR remote control**
- **Industrial electronics**
- **For control and drive circuits**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Reverse Voltage (V_R) .... 20 V
Power Dissipation (P_{TOT}) T_A=25°C .... 150 mW

Characteristics T_A=25°C, Standard light A, λ=950 nm

Parameter	Symbol	Value	Unit	Condition
Spectral Sensitivity	S	55 (≥40)	nA/lx	V_R=5 V,
Wavelength, Maximum Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	400 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	4.84	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.20x2.20	mm	
Distance, Chip Surface to Case Surface	H	0.3		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.62	A/W	
Quantum Yield	η	0.90	electrons / photon	
Open Circuit Voltage	V_O	360 (≥280)	mV	E_V=100lx
Short Circuit Current	I_{SC}	50	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	48	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O	TK_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TK_I	0.18	%/K	
Noise Equivalent Power	NEP	3.6×10^{-14}	W/√Hz	V_R=10 V λ=850 nm
Detection Limit	D*	6.1×10^{12}	cm•√Hz/W	

Photodiodes 11

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

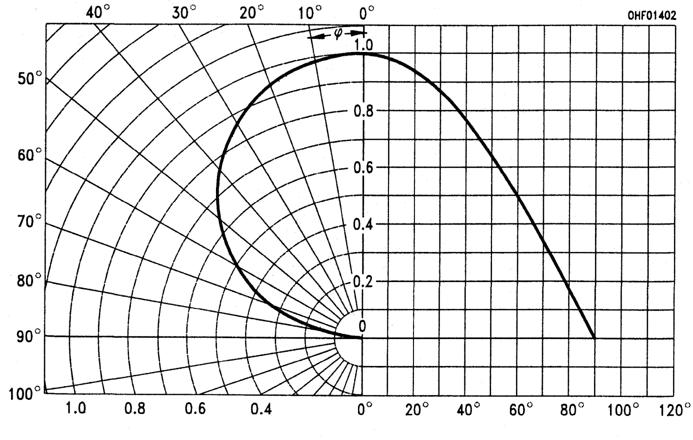


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

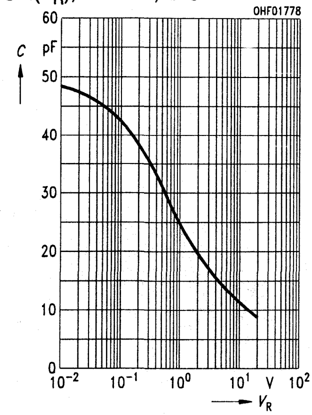


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

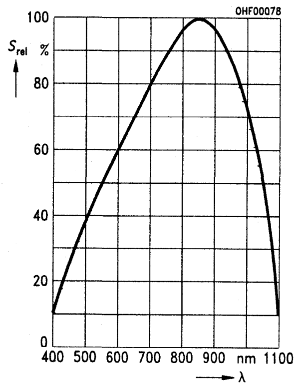


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

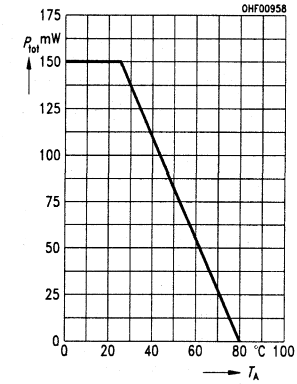


Figure 7. Dark current
$I_R=f(T_A)$, $V_R=10$, E=0

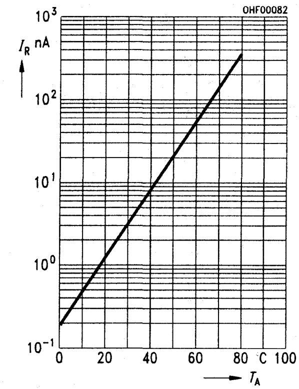


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

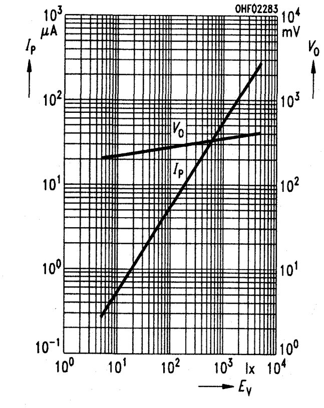
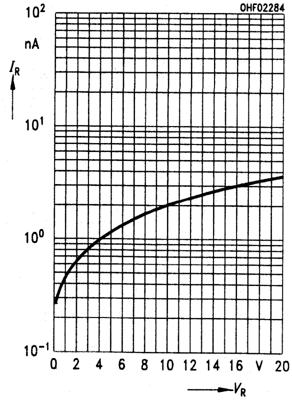
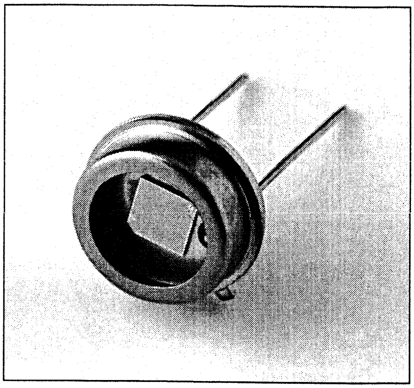


Figure 5. Dark current
$I_R=f(V_R)$, E=0

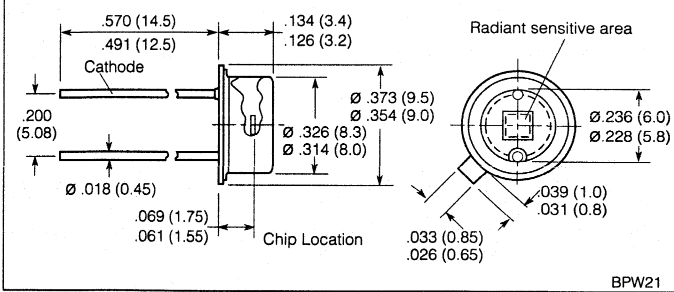


SIEMENS

Vλ FILTER BPW 21
Silicon Photodiode



Dimensions in inches (mm)



FEATURES
- **Especially suitable for applications from 350 nm to 820 nm**
- **Adapted to human eye sensitivity (Vλ)**
- **Hermetically sealed metal package (similar to TO-5), suitable up to 125°C[1]**

APPLICATIONS
- **Exposure meters for daylight**
- **For artificial light of high color temperature in photographic fields and color analysis**

1. For operating conditions of T_A>85°C please contact us.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Soldering Temperature (2 mm from case bottom) (T_s) t≤3 s .... 235°C
Reverse Voltage (V_R) .... 10 V
Power Dissipation (P_{TOT}) T_A=25°C .... 250 mW

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Symbol	Value	Unit	Condition
Spectral Sensitivity	S	10 (≥5.5)	nm	V_R=5 V
Wavelength, Max. Sensitivity	λ_{Smax}	550		
Spectral Sensitivity Range	λ	350 to 820		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.34	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.73x 2.73	mm	
Distance, Chip Surface to Case Surface	H	1.9 to 2.3		
Half Angle	φ	±55	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=5 V
		8 (≤200)	pA	V_R=10 mV
Spectral Sensitivity	S_λ	0.34	A/W	λ=550 nm
Quantum Yield	η	0.80	electrons / photon	
Open Circuit Voltage	V_O	400 (≥320)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	10	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	1.5	ns	R_L=1 K Ω, V_R=5 V, λ=550 nm, I_P=10 µA
Forward Voltage	V_F	1.2	V	I_F=100 mA, E_E=0
Capacitance	C_0	580	pF	V_R=0 V, f=1 MHz, E_V=0
Temperature Coefficient V_O	TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	–0.05	%/K	
Noise Equivalent Power	NEP	7.2 x 10^{-14}	W/√Hz	V_R=5 V, λ=550 nm
Detection Limit	D*	1 x 10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

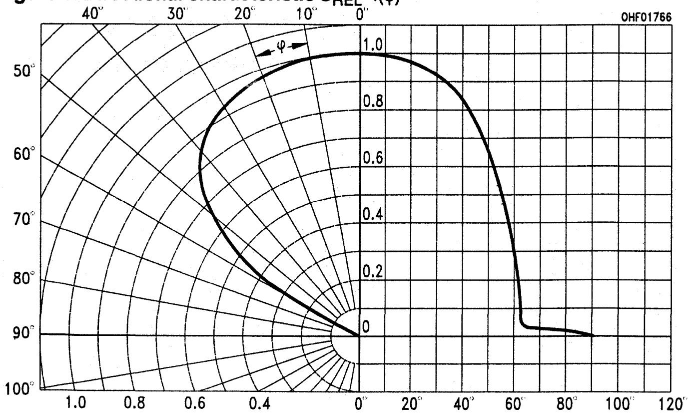


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

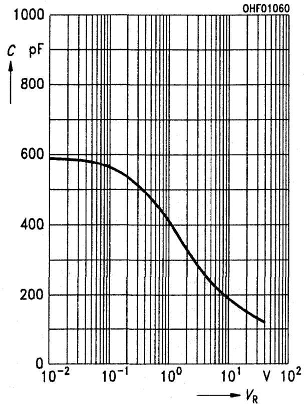


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

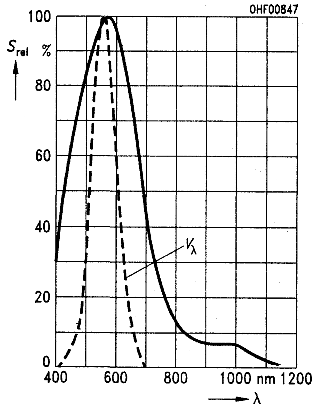


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

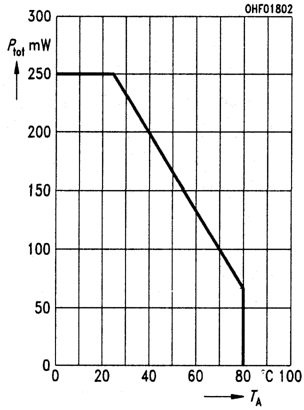


Figure 7. Dark current
$I_R=f(T_A)$, V_R=5 V, E=0

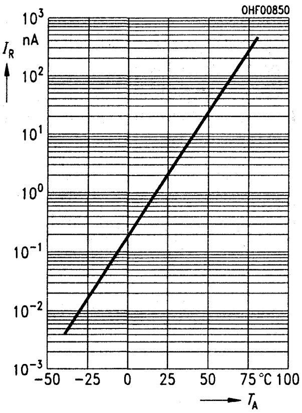


Figure 3. Photocurrent $I_P=f(E_V)$, V_R=5 V
Open circuit voltage $V_O=f(E_V)$

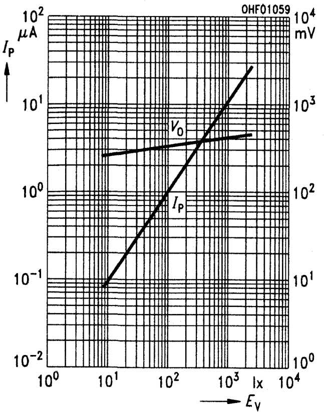
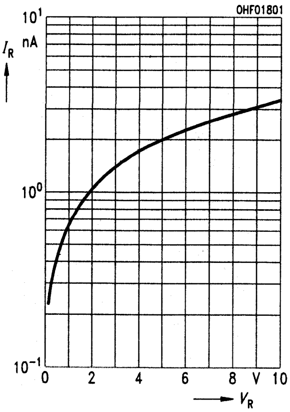


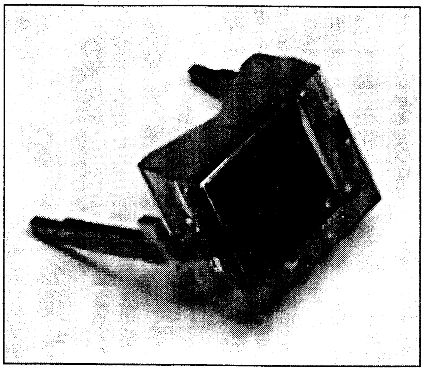
Figure 5. Dark current $I_R=f(V_R)$, E=0

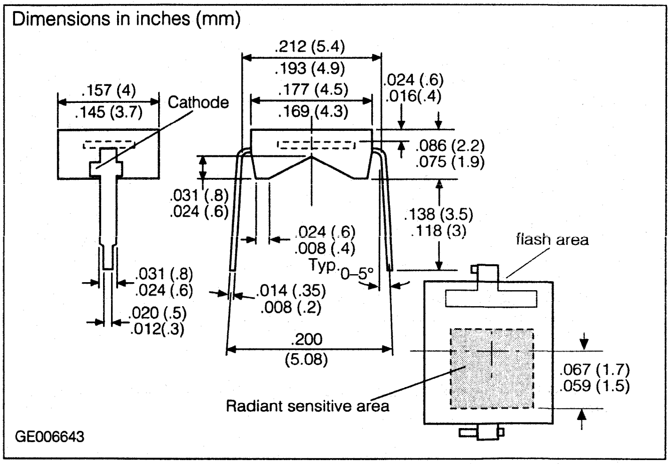


SIEMENS

BPW 33

Silicon Photodiode





FEATURES
- **Especially suitable for applications from 350 nm to 1100 nm**
- **Low reverse current (typ .20pA)**
- **DIL plastic package with high packing density**

APPLICATIONS
- **Exposure meters**
- **Color analysis**

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG})......................–40° to +80°C
Reverse Voltage (V_R)..................................... 7 V
Total Power Dissipation (P_{TOT}) T_A=25°C... 150 mW

Characteristics T_A=25°C, Standard Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	75 (≥35)	nA/lx	V_R=5 V
Wavelength, Maximum Sensitivity	λ_{Smax}	800	nm	
Spectral Sensitivity Range	λ	350 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.34	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.71x 2.71	mm	
Distance, Chip Surface to Case Surface	H	0.5		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	20 (≤100)	pA	V_R=1 V
Zero Cross Over	S_0	≤2.5	pA/mV	E=0
Spectral Sensitivity	S_λ	0.59	A/W	λ=850 nm
Quantum Yield	η	0.86	electrons/photon	
Open Circuit Voltage	V_O	440 (≥375)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	72	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	1.5	µs	R_L=1 KΩ, V_R=5 V, λ=850 nm, I_P=70 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	630	pF	V_R=0 V, E=0, f=1 MHz
Temperature Coefficient V_O	TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.2	%/K	
Noise Equivalent Power	NEP	4.3 x 10^{-15}	W/√Hz	V_R=1 V, λ=850 nm
Detection Limit	D*	6.3 x 10^{13}	cm•√Hz/W	

Photodiodes 11

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

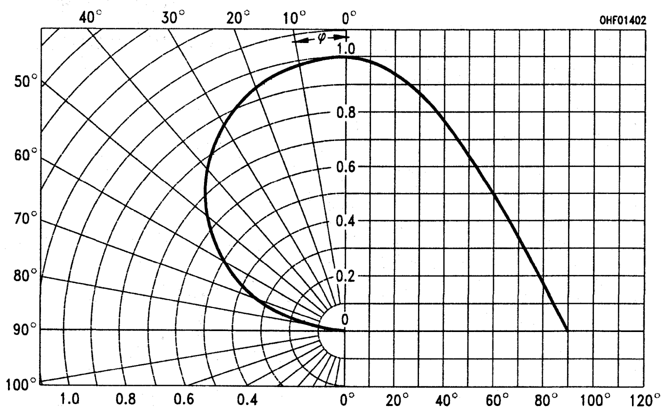


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

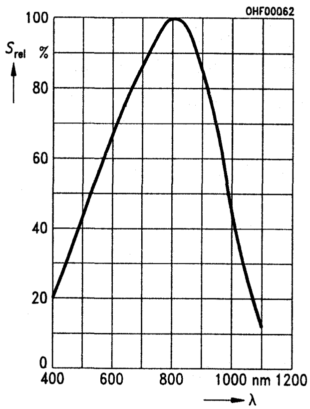


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

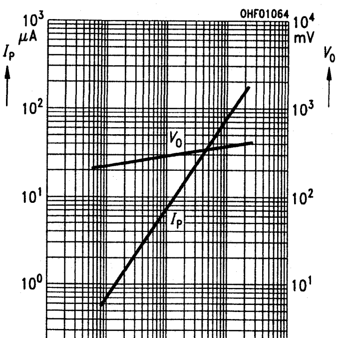


Figure 4. Power dissipation $P_{TOT}=f(T_A)$

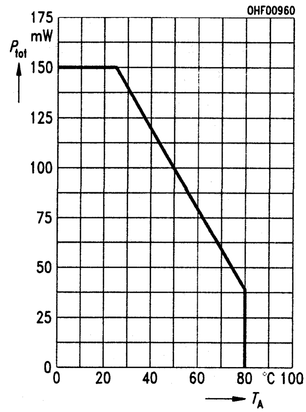


Figure 5. Dark current
$I_R=f(V_R)$, $T_A=25°C$, $E=0$

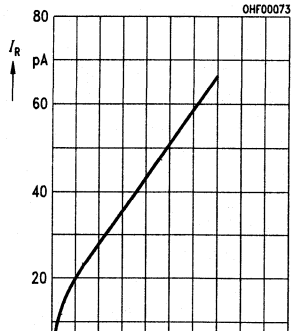


Figure 6. Capacitance
$C=f(V_R)$, $f=1$ MHz, $E=0$

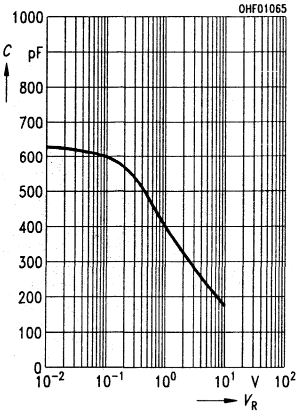
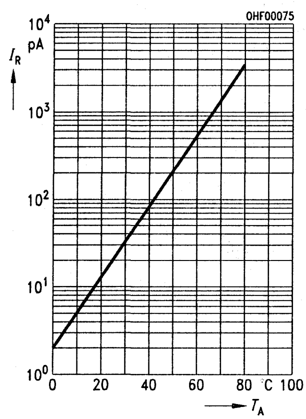
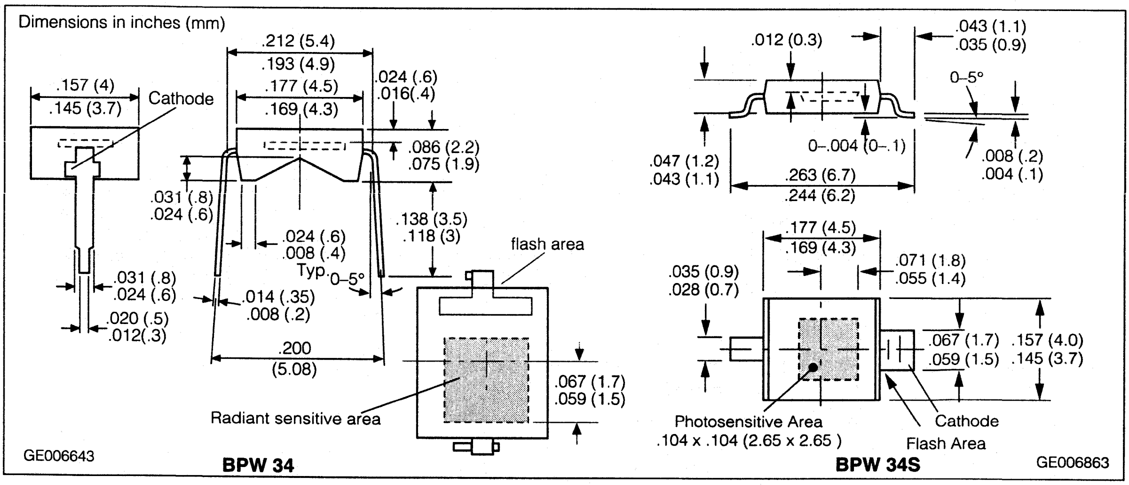


Figure 7. Dark current
$I_R=f(T_A)$, $V_R=1$, $E=0$



SIEMENS

BPW 34
SURFACE MOUNT BPW 34S
Silicon PIN Photodiode



FEATURES
- **Especially suitable for applications from 400 nm to 1100 nm**
- **Short switching time (typ. 20 ns)**
- **DIL plastic package with high packing density**
- **BPW 34 S: suitable for vapor-phase and IR-reflow soldering**

APPLICATIONS
- **Photointerrupters**
- **IR remote controls**
- **Industrial electronics**
- **For control and drive circuits**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})......................–40° to +80°C
Reverse Voltage (V_R)...................................32 V
Power Dissipation (P_{TOT}) T_A=25°C......... 150 mW

Characteristics T_A=25°C, Standard Light A, T=2856K

Parameter	Sym	Value	Unit	Condition
Photosensitivity[1]	S	80 (≥50)	nA/lx	V_R=5 V
Wavelength, Max. Photosensitivity	λ_{Smax}	850	nm	
Photosensitivity Spectral Range	λ	400 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.00	mm²	
Radiant Sensitive Area Dimensions	L x W	2.65x2.65	mm	
Distance, Chip Surface to Case Surface, BPW34 BPW34S	H	0.5 0.3		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Photosensitivity	S	0.62	A/W	λ=850 nm
Quantum Efficiency	η	0.90	electrons / photon	
Open Circuit Voltage[1]	V_O	365 (≥300)	mV	E_V=1000 lx
Short Circuit Current[1]	I_{SC}	80	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	72	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_O	TC_V	–2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	4.1×10^{-4}	W/√Hz	V_R=10 V, λ=850 nm
Detection Limit	D*	6.6×10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

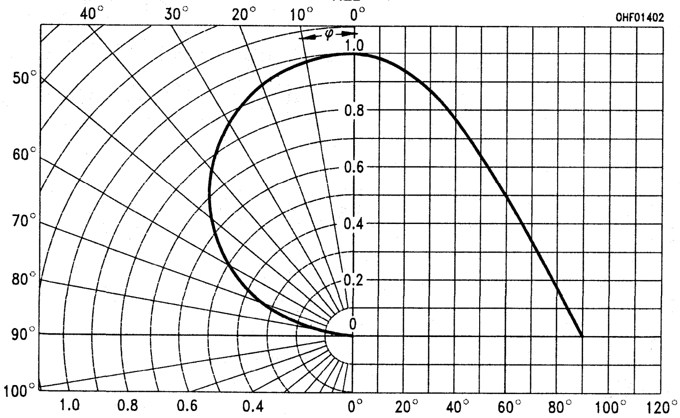


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

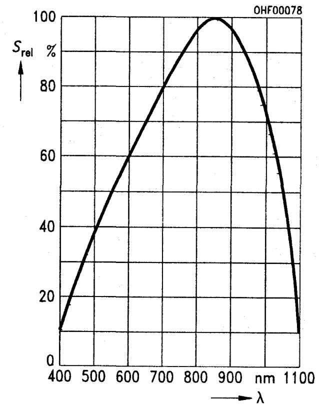


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5V$
Open circuit voltage $V_O=f(E_V)$

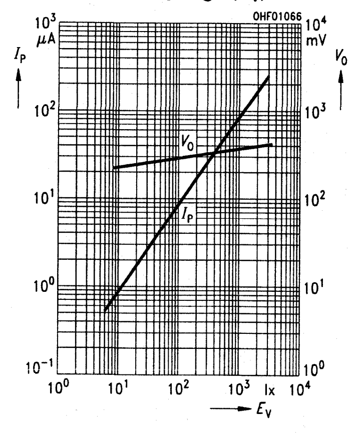


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

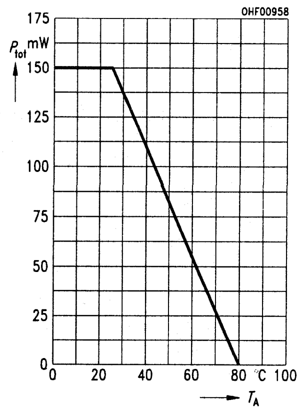


Figure 5. Dark current $I_R=f(V_R)$, E=0

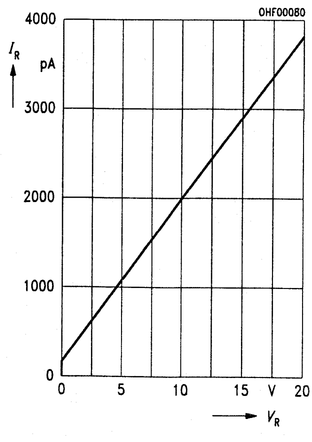


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

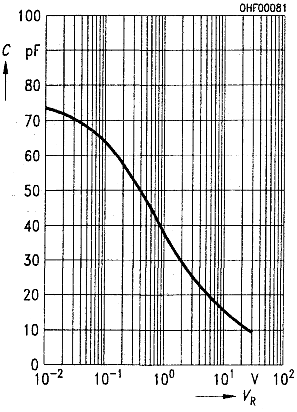
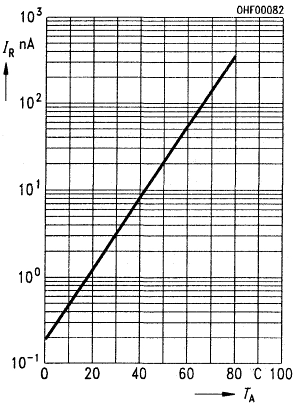


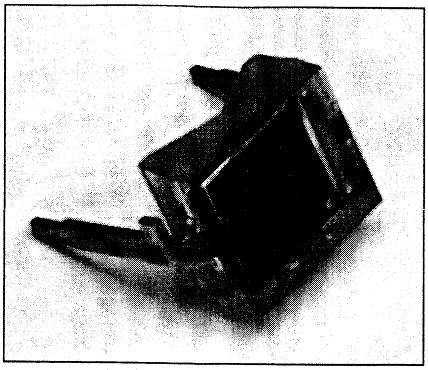
Figure 7. Dark current
$I_R=f(T_A)$, $V_R=10$, E=0

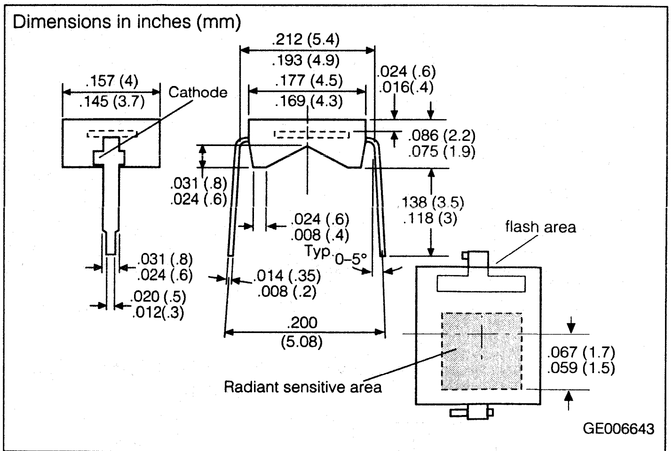


SIEMENS

BPW 34B

Silicon PIN Photodiode
Enhanced Blue Sensitivity





FEATURES

- **Especially suitable for applications from 350 nm to 1100 nm**
- **Short switching time (typ. 25 ns)**
- **DIL plastic package with high packing density**
- **SMT version on request**

APPLICATIONS

- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –40° to +80°C
Soldering Temperature
(2 mm from case bottom) (T_s) t≤3 s........ 230°C
Reverse Voltage (V_R) .... 32 V
Power Dissipation (P_{TOT}) T_A=25°C .... 150 mW

Characteristics T_A=25°C, Standard Light A, T=2856K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	75	nA/lx	V_R=5 V
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	350 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.45	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.73x2.73	mm	
Distance, Chip Surface to Case Surface	H	0.5		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.2	A/W	λ=400 nm
Quantum yield	η	0.62	electrons / photon	
Open Circuit Voltage	V_O	390	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	7.4 (≥5.4)	µA	E_e=0.5 mW/cm ^{2}, λ=400 nm
Rise and Fall Time, Photocurrent	t_R, t_F	25	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	72	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_O	TC_V	-2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	1.3 x 10^{-13}	W/√Hz	V_R=10 V, λ=400 nm
Detection Limit	D*	6.6 x 10^{12}	cm•√Hz/W	

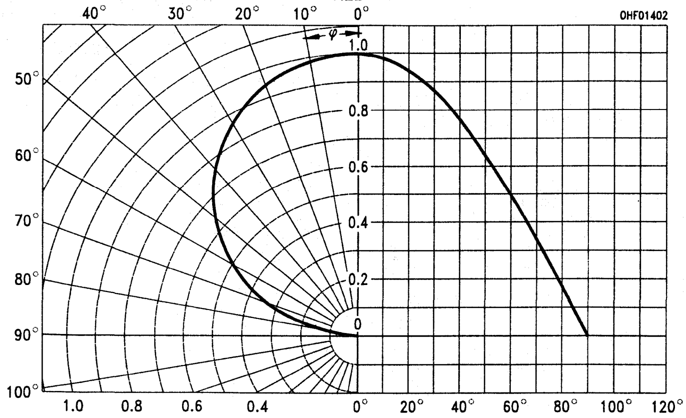


Figure 1. Directional characteristic S_{REL}=f(φ)

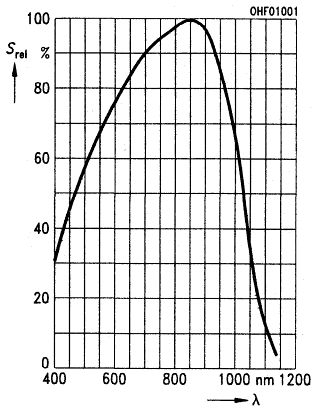


Figure 2. Relative spectral sensitivity
S_{REL}=f(λ)

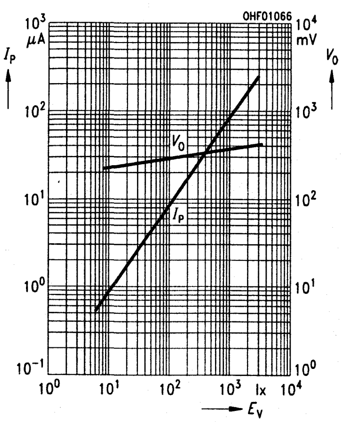


Figure 3. Photocurrent I_P=f(E_V), Open circuit voltage V_O=f(E_V)

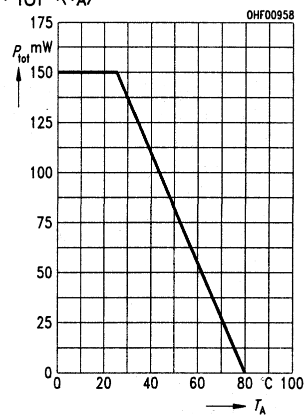


Figure 4. Total power dissipation
P_{TOT}=f(T_A)

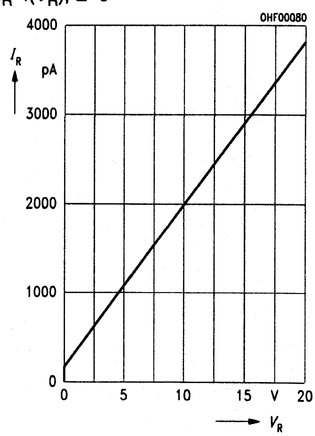


Figure 5. Dark current
I_R=f(V_R), E=0

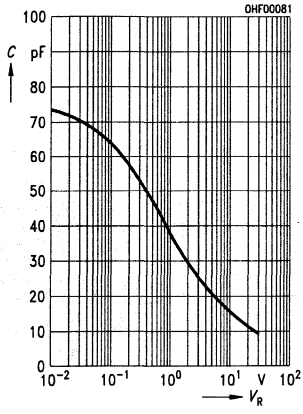


Figure 6. Capacitance
C=f(V_R), f=1 MHz, E=0

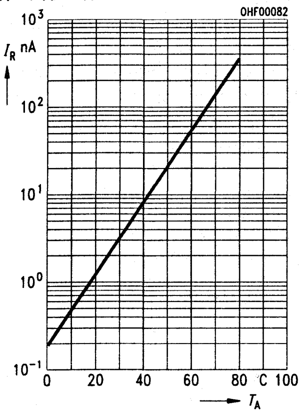
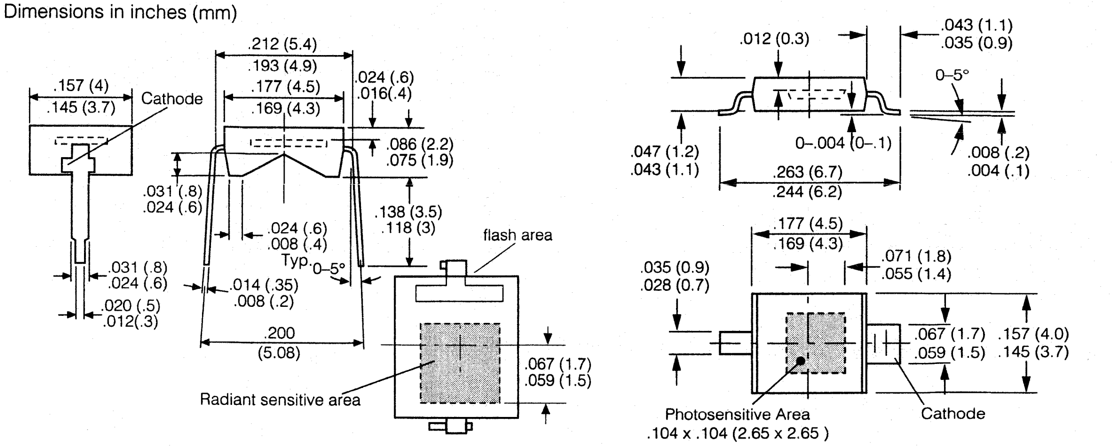


Figure 7. Dark current
I_R=f(T_A), V_R=10, E=0

SIEMENS

BPW 34F
SURFACE MOUNT BPW 34FS
Daylight Filter Silicon PIN Photodiode

Dimensions in inches (mm)



BPW34B.ge06643 **BPW 34F** **BPW 34FS** ge06863

FEATURES
- **Especially suitable for applications of 950 nm**
- **Short switching time (typ. 20 ns)**
- **DIL plastic package with high packing density**
- **BPW 34 FS: SMT version; replaces BP104 BS; suitable for vapor-phase and IR-reflow soldering**

APPLICATIONS
- **IR remote control of stereos, TVs, video tape recorders, various equipment**
- **Photointerrupters**

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG})......................–40° to +80°C
Reverse Voltage (V_R) .... 32 V
Power Dissipation (P_{TOT}) T_A=25°C .... 150 mW

Characteristics T_A=25°C, λ=950 nm

Parameter	Symbol	Value	Unit	Condition
Spectral Sensitivity	S	50 (≥40)	µA	V_R=5 V, E_E=1 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	950	nm	
Spectral Sensitivity Range	λ	780 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.00	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.65x 2.65	mm	
Distance, Chip Surface to Case Surface BPW 34F BPW 34FS	H	 0.5 0.3		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.59	A/W	
Quantum Yield	η	0.77	electrons / photon	
Open Circuit Voltage	V_O	330 (≥275)	mV	E_e=0.5 mW/cm^2
Short Circuit Current	I_{SC}	25	µA	
Rise and Fall Time, Photocurrent 10% to 90%, 90% to 10%	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_O	72	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient, V_O	TC_V	–2.6	mV/K	
Temp. Coefficient, I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	4.3 x 10^{-14}	W/√Hz	V_R=10 V
Detection Limit	D*	6.2 x 10^{12}	cm•√Hz/W	

Photodiodes 11

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

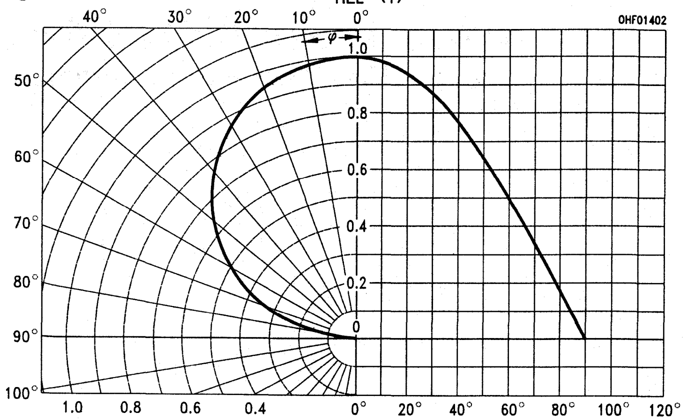


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

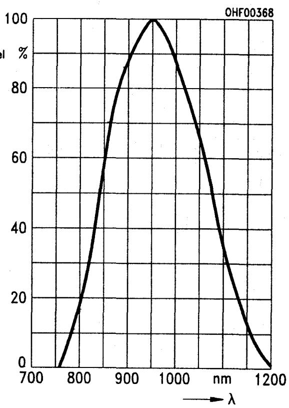


Figure 3. Photocurrent $I_P=f(E_V)$,
$V_R=5$ V **Open circuit voltage** $V_O=f(E_V)$

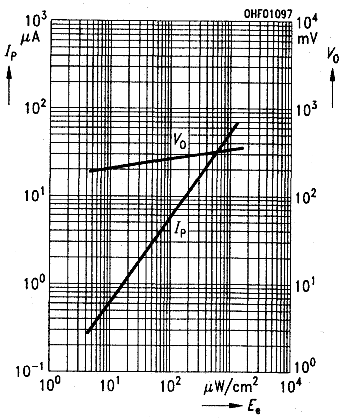


Figure 4. Power dissipation $P_{TOT}=f(T_A)$

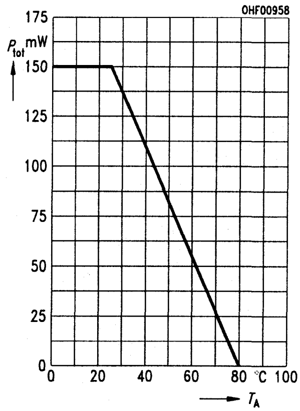


Figure 5. Dark current
$I_R=f(V_R)$, $T_A=25°C$, $E=0$

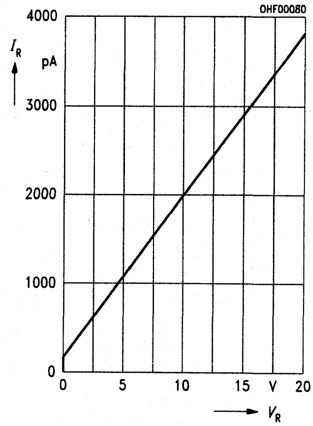


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

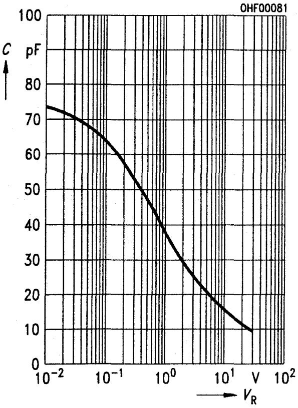
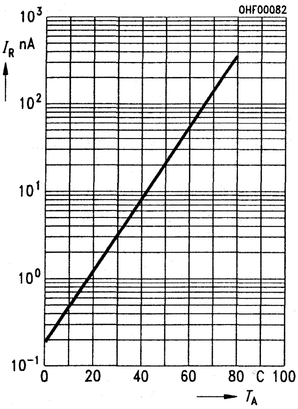
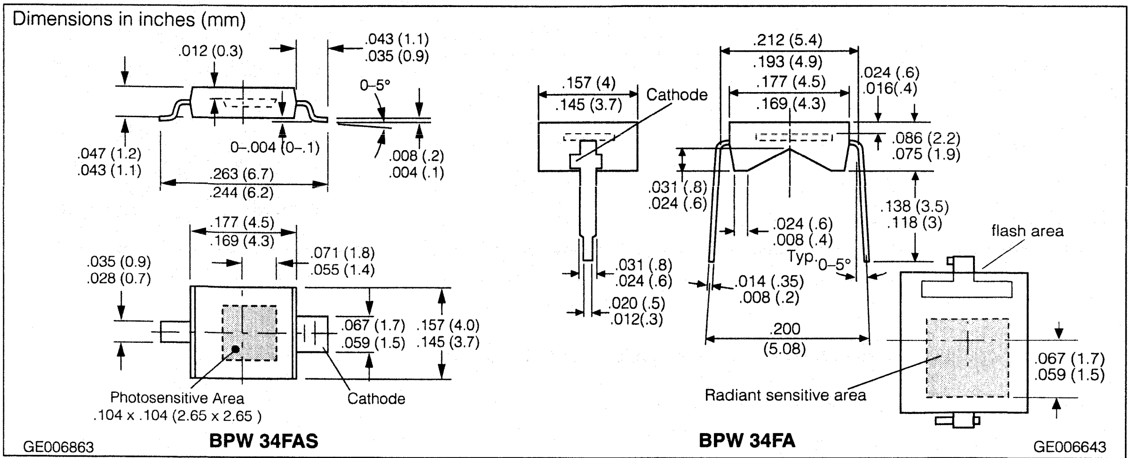


Figure 7. Dark current
$I_R=f(T_A)$, $V_R=10$, $E=0$



SIEMENS

BPW 34FA
SURFACE MOUNT BPW 34FAS
Silicon PIN Photodiode Daylight Filter, 830–880 nm Range



FEATURES
- **Especially suitable for 830 nm–880 nm wavelength range**
- **Short switching time (typ. 20 ns)**
- **DIL plastic package with high packing density**
- **BPW 34 FAS: Suitable for vapor phase and IR-reflow soldering**
- **Package: Black Epoxy Resin**
  BPW 34FA: .200 (5.08 mm) Lead Spacing
  BPW 34FAS: Surface Mount Package

DESCRIPTION
The BPW 34FA/FAS is a silicon planar PIN photodiode in a filtered plastic package with 0.200" (5.08 mm) lead spacing.

The spectral sensitivity is maximized in the 830 to 880 range making it an ideal match for GaAlAs IR emitters with λpeak at 880 nm (SFH 484, SFH 485, SFH 487).

The BPW34FA's high sensitivity, fast switching times, low capacitance, compact size, and lack of measurable degradation makes it suitable for diverse applications, such as TV and appliance remote control, IR sound transmission, video recorders, and measurement and control.

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –40° to +80°C
Reverse Voltage (V_R) .... 32 V
Power Dissipation (P_{TOT}) T_A=25°C .... 150 mW

Characteristics T_A=25°C, 870 nm

Parameter	Sym	Value	Unit	Condition
Spectral Sensitivity	S	50 (≥40)	µA	V_R=5 V, E_E=1 mW/cm^2
Wavelength, Maximum Sensitivity	λ_{Smax}	880	nm	
Spectral Sensitivity Range	λ	730 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.00	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.65x2.65	mm	
Distance, Chip Surface to Case Surface BPW34FA BPW34FAS	H	 0.5 0.3		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.65	A/W	
Quantum Yield	η	0.93	electrons / photon	
Open Circuit Voltage	V_O	320 (≥250)	mV	E_e=0.5 mW/cm^2
Short Circuit Current	I_{SC}	23	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	72	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_O	TC_V	–2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.1	%/K	
Noise Equivalent Power	NEP	3.9 x 10^{-14}	W/√Hz	V_R=10 V
Detection Limit	D*	6.8 x 10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

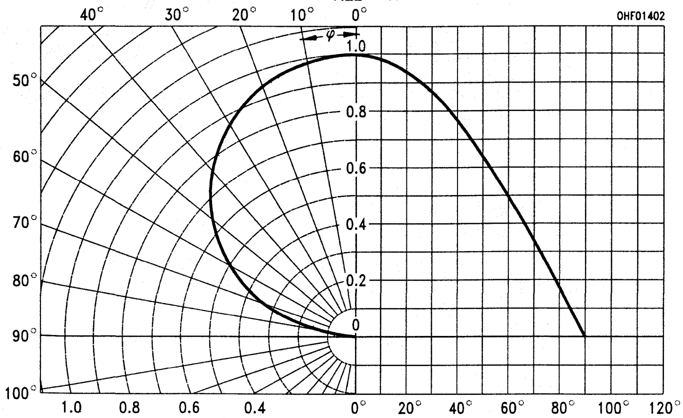


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

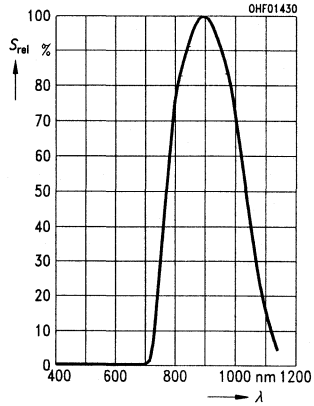


Figure 3. Photocurrent $I_P=f(E_V)$, V_R=5 V
Open circuit voltage $V_O=f(E_e)$

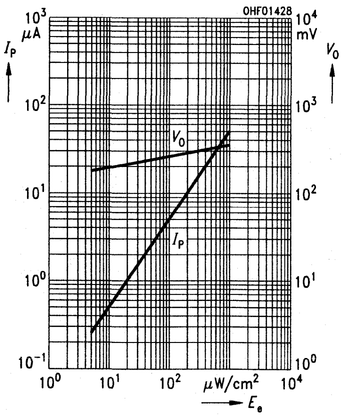


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

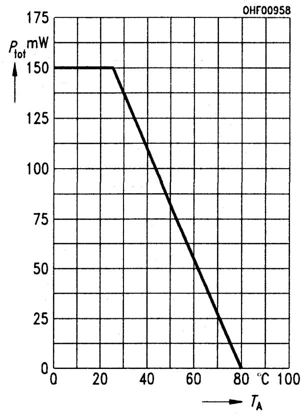


Figure 5. Dark current
$I_R=f(V_R)$, E=0

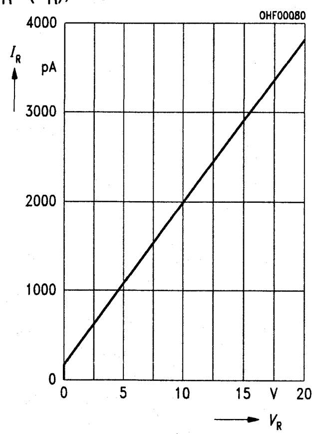


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

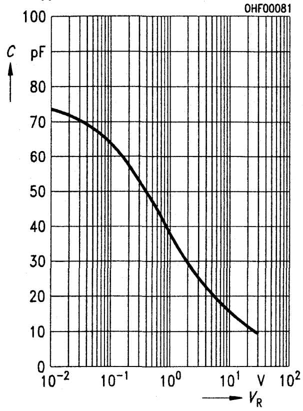
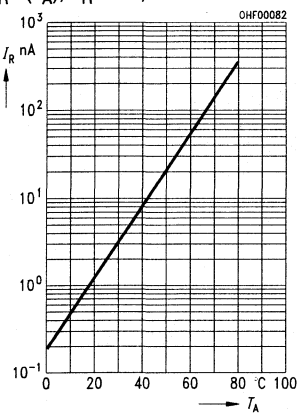


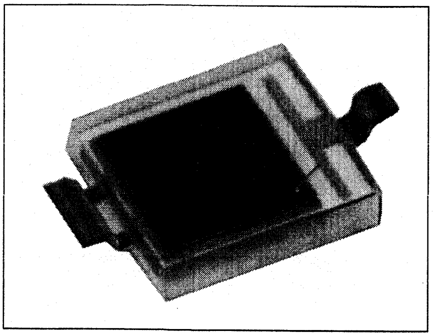
Figure 7. Dar k current
$I_R=f(T_A)$, V_R=10 V, E=0

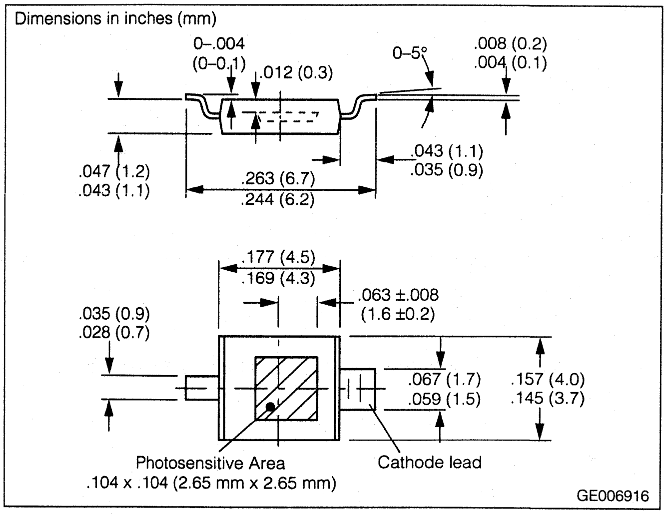


SIEMENS

BPW 34S (E9087)

Reverse Gullwing Surface Mount Silicon PIN Photodiode





FEATURES

- **Especially suitable for applicatons from 400 nm to 1100 nm**
- **Short switching time (typ. 20 ns)**
- **Suitable for vapor-phase and IR-reflow soldering**
- **Reverse gullwing**

APPLICATIONS

- **Photoinerupters**
- **IR remote controls**
- **Industrial electronics**
- **For control and drive circuits**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Reverse Voltage (V_R) .... 32 V
Power Dissipation (P_{TOT}) T_A=25°C .... 150 mW

Characteristics T_A=25°C, standard light A, T=2856k

Parameter	**Sym**	**Value**	**Unit**	**Condition**
Spectral Sensitivity	S	80 (≥50)	nA/lx	V_R=5 V
Wavelength, Maximum Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	400 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.00	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.65x2.65	mm	
Distance, Chip Surface to Case Surface	H	0.3		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.62	A/W	λ=850 nm
Quantum Yield	η	0.90	electrons / photon	
Open Circuit Voltage	V_O	365 (≥300)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	80	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	10	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	72	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O	TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	4.1 x 10^{-4}	W/√Hz	V_R=10 V, λ=850 nm
Detection Limit	D*	6.6 x 10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

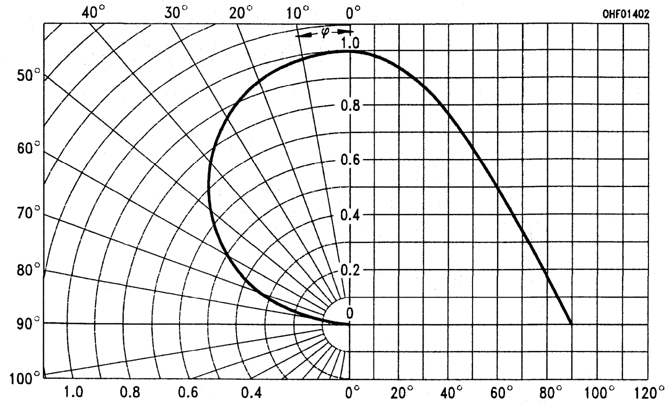


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

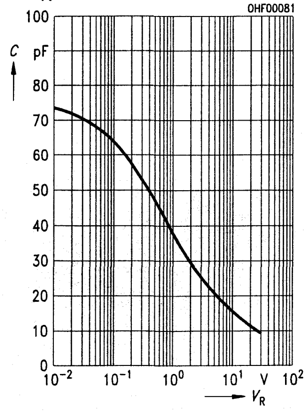


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

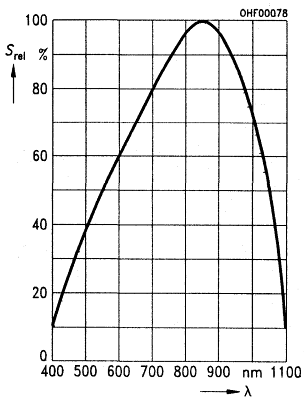


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

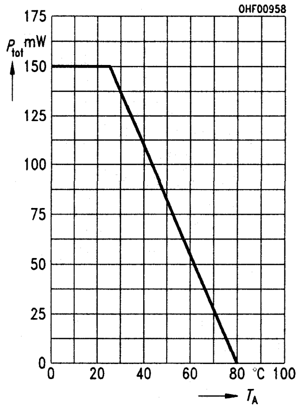


Figure 7. Dark current
$I_R=f(T_A)$, $V_R=10$, E=0

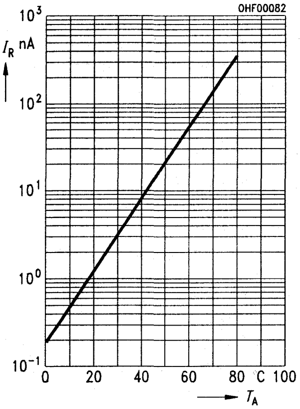


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

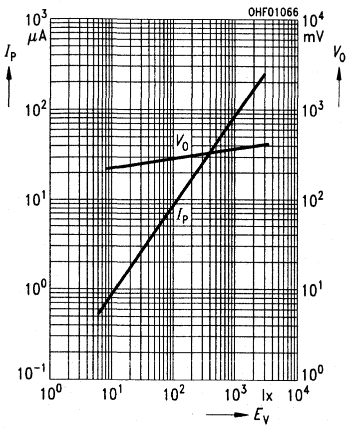
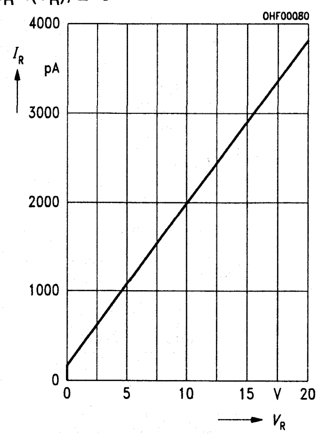
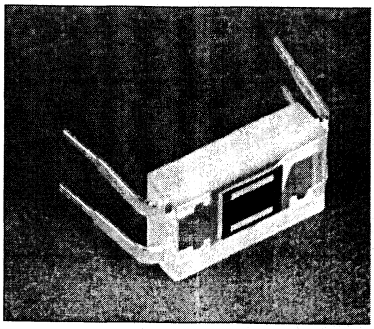


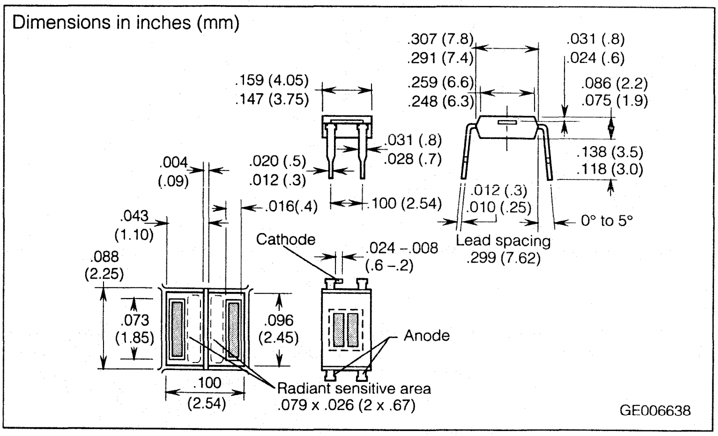
Figure 5. Dark current
$I_R=f(V_R)$, E=0



SIEMENS

BPX 48
DAYLIGHT FILTER BPX 48F
Silicon Differential Photodiode





FEATURES
- **Especially suitable for applications**
  - **BPX 48: 400 to 1100nm**
  - **BPX48F: 920 nm**
- **High photosensitivity**
- **DIL plastic package with high packing density**
- **Double diode with extremely high homogeneousness**

APPLICATIONS
- **Follow-up control**
- **Edge control**
- **Path and angle scanning**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION
The differential photodiode BPX 48 is designed for special industrial electronic applications, such as edge detection and path and angle scanning. The individual diodes are spaced 90 mm apart, resulting in a highly precise positional indication. Silicon planar ensures low dark current, low noise, and excellent signal-to-noise relationships.

Maximum Ratings
Operating/Storage Temperature Range (T_{OP}, T_{STG}) ....–40° to +80°C
Soldering Temperature (2 mm from case bottom) (T_s) t≤3 s......... 230°C
Reverse Voltage (V_R) .... 10 V
Power Dissipation (P_{TOT}) T_A=25°C .... 50 mW

Characteristics Single Diode T_A=25°C

Parameter		Sym	Value	Unit	Condition
Spectral Sensitivity	BPX48	S	24 (≥15)	nA/lx	V_R=5 V, Std.light A, T=2856 K
	BPX48F		7.5 (≥4.0)	µA	V_R=5 V, λ=950 nm, E_E=0.5 mW/cm²
Wavelength, Max. Photosensitivity	BPX48	λ_{Smax}	900	nm	
	BPX48F		920		
Spectral Sensitivity Range	BPX48	λ	400–1150		S=10% of S_{MAX}
	BPX48F		750–1150		
Radiant Sensitive Area		A	1.54	mm²	
Radiant Sensitive Area Dimensions		L x W	0.7 x 2.2	mm	
Distance, Chip Surface to Case Surface		H	0.5		
Half Angle		φ	±60	Deg.	
Dark Current		I_R	10 (≤100)	nA	V_R=10 V
Spectral Sensitivity	BPX48	S	0.55	A/W	λ=850 nm
	BPX48F		0.65		λ=950 nm
Max. Deviation, Systems Spectral Sensitivity from Average		ΔS	±5	%	
Quantum Yield	BPX48	η	0.8	electrons / photon	λ=850 nm
	BPX48F		0.95		λ=950 nm
Open Circuit Voltage	BPX48	V_O	330(≥280)	mV	E_V=1000 lx, Std.light A, T=2856 K
	BPX48F		300(≥280)		E_e=0.5 mW/cm², λ=950 nm
Short Circuit Current	BPX48	I_{SC}	24	µA	E_V=1000 lx Std.light A, T=2856 K
	BPX48F		7		E_e=0.5 mW/cm², λ=950 nm
Rise and Fall Time, Photocurrent		t_R, t_F	500	ns	R_L=1 KΩ, V_R=5 V, λ=850 nm, I_P=20 µA
Forward Voltage		V_F	1.3	V	I_F=40 mA, E=0
Capacitance		C_0	25	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_O		TC_V	–2.6	mV/K	
Temp. Coefficient I_{SC}	BPX48	TC_I	0.18	%/K	Std.light A
	BPX48F		0.2		λ=950 nm
Noise Equivalent Power		NEP	1.0×10^{-13}	W/√Hz	V_R=10 V,
Detection Limit		D*	1.2×10^{12}	cm•√Hz/W	λ=950 nm

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

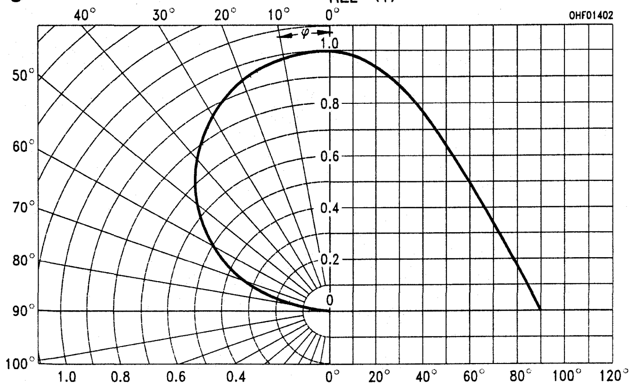


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **BPX48**

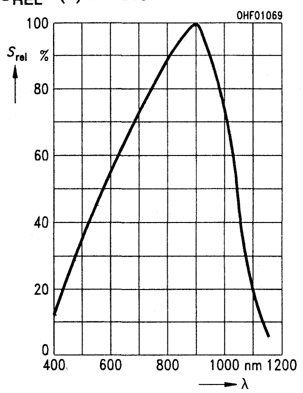


Figure 3. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **BPX48F**

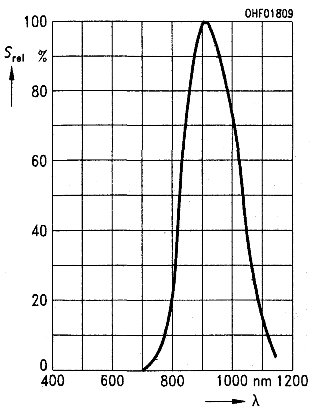


Figure 4. Photocurrent $I_P=f(E_V), V_R=5$ V **Open circuit voltage** $V_O=f(E_V)$ **BPX48**

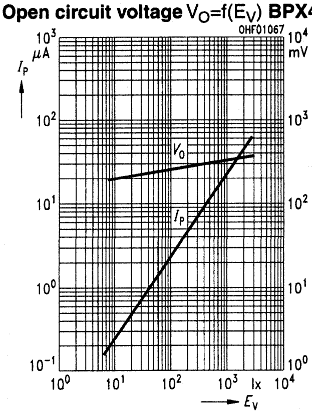


Figure 5. Photocurrent $I_P=f(E_V), V_R=5$ V **Open circuit voltage** $V_O=f(E_V)$ **BPX48F**

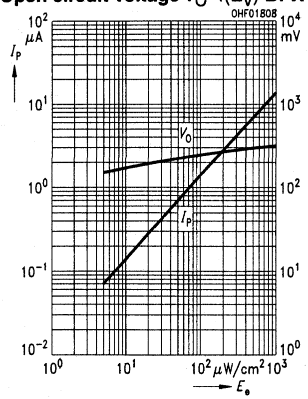


Figure 6. Power dissipation $P_{TOT}=f(T_A)$

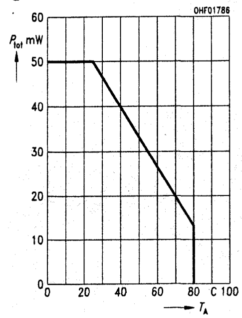


Figure 7. Dark current $I_R=f(V_R)$, E=0

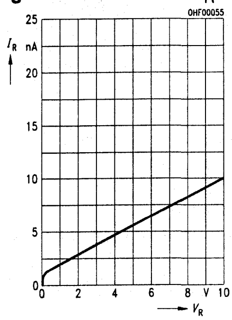


Figure 8. Capacitance $C=f(V_R)$, f=1 MHz, E=0

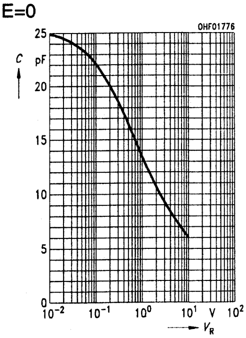
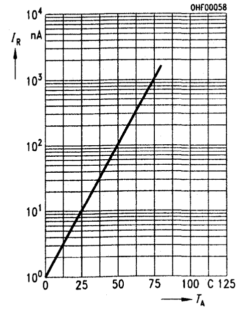
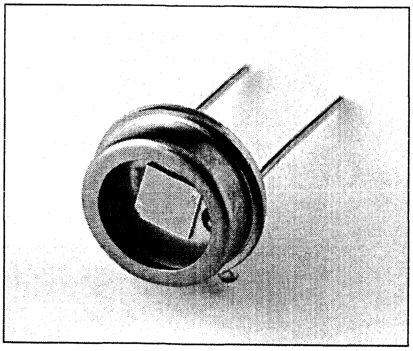


Figure 9. Dark current $I_R=f(T_A)$, $V_R=10$, E=0

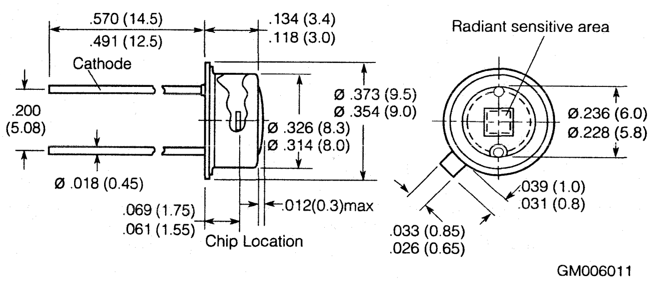


SIEMENS

BPX 60
Enhanced Blue Sensitivity Silicon Photodiode



Dimensions in inches (mm)



FEATURES
- **Especially suitable for applicatons from 350 nm to 1100 nm**
- **High photosensitivity**
- **Hermetically sealed metal package (similar to TO-5)**

APPLICATIONS
- **Photointerrupters**
- **Industrial electronics**
- **For control and circuits drive**

DESCRIPTION
The BPX 60 is a silicon planar photodiode. The hermetically sealed case—a TO-5 modification with a flat glass window—allows use at extreme operating conditions. The signal/noise ratio is favorable, even at low light levels. The open circuit voltage at low light levels is higher than with comparable mesa photovoltaic cells.

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –40° to +125°C
Soldering Temperature
(2 mm from case bottom) (T_s) t≤3 s..... 230°C
Reverse Voltage (V_R) .... 32 V
Power Dissipation (P_{TOT}) T_A=25°C ...... 250 mW

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	**Symbol**	**Value**	**Unit**	**Condition**
Spectral Sensitivity	S	70	nA/lx	V_R=5 V
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	350 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.45	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.73x2.73	mm	
Distance, Chip Surface to Case Surface	H	1.9 to 2.3		
Half Angle	φ	±55	Deg.	
Dark Current	I_R	7 (≤55)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.20	A/W	λ=400 nm
Quantum Yield	η	0.62	electrons / photon	
Open Circuit Voltage(1)	V_O	460	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	7.4 (≥5.4)	μA	E_e=0.5 mW/cm ^{2}, λ=400 nm
Rise and Fall Time, Photocurrent	t_R, t_F	3.0	ns	R_L=1 KΩ, V_R=5 V, λ=850 nm, I_P=70 μA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	580	pF	V_R=0 V, f=1 MHz, E_V=0
Temp. Coefficient V_O	TC_V	–2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	2.4 x 10^{-13}	W/√Hz	V_R=10 V, λ=400 nm
Detection Limit	D*	1.2 x 10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

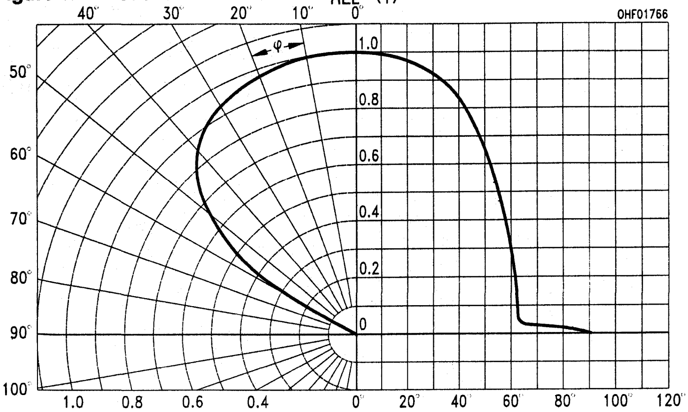


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

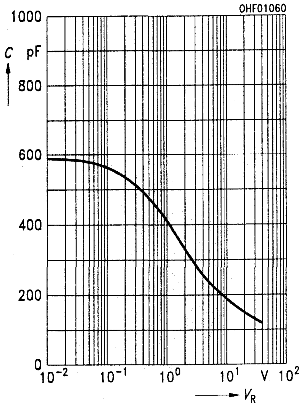


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

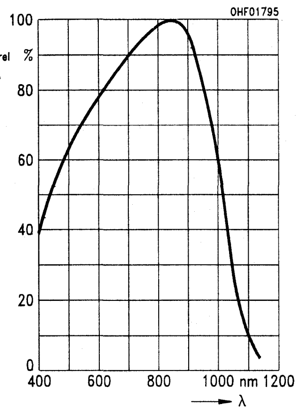


Figure 4. Power dissipation $P_{TOT}=f(T_A)$

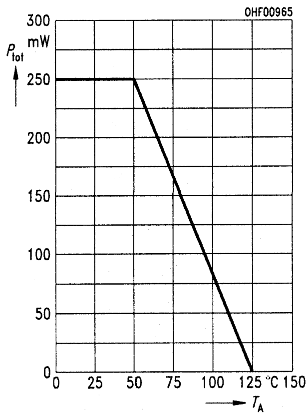


Figure 7. Dark current
$I_R=f(T_A)$, $V_R=10$ V

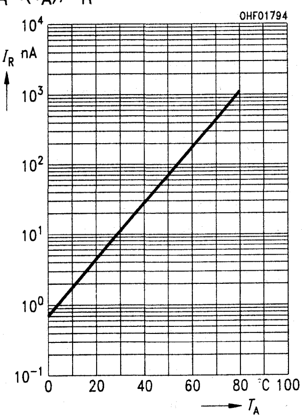


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

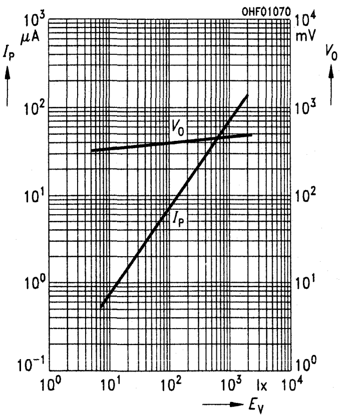
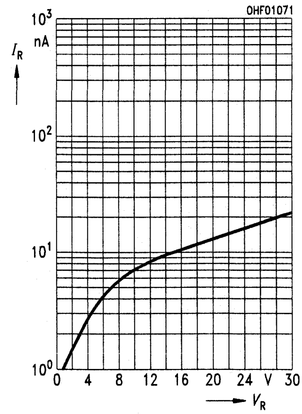


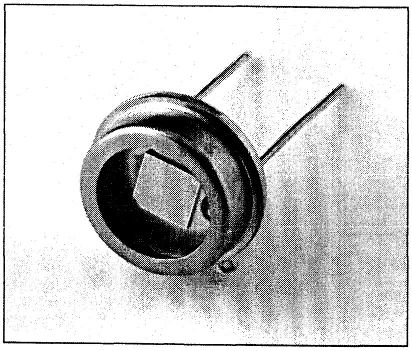
Figure 5. Dark current
$I_R=f(V_R)$, E=0



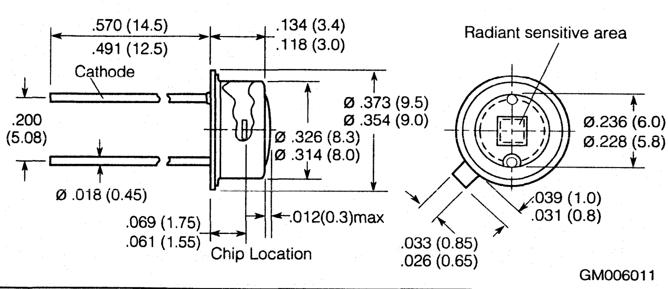
SIEMENS

BPX 61

Silicon Photodiode



Dimensions in inches (mm)



FEATURES

- **Especially suitable for applications from 400 nm to 1100 nm**
- **Short switching time (typ. 20 ns)**
- **Hermetically sealed metal package (similar to TO-5)**

APPLICATIONS

- **Photointerrupters**
- **IR-remote controls**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The BPX 61 is a silicon planar PIN photodiode with low reverse current. Its low capacitance permits use up to 10 MHz. The hermetically sealed package—a TO-5 modification with a flat glass window—allows use at extreme operating conditions. The signal/noise ratio is favorable, even at low light levels. The open circuit voltage at low light levels is higher than with comparable mesa photovoltaic cells. The PIN photodiode provides outstanding low junction capacitance, high cut-off frequency, and short switching times.

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –40° to +125°C
Soldering Temperature
(2 mm from case bottom) (T_s) t≤3 s......230°C
Reverse Voltage (V_R) ....32 V
Power Dissipation (P_{TOT}) T_A=25°C ....250 mW

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Sym	Value	Unit	Condition
Spectral Sensitivity	S	70 (≥50)	nA/lx	V_R=5 V
Wavelength, Maximum Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	400 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.00	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.65x2.65	mm	
Distance, Chip Surface to Case Surface	H	1.9 to 2.3		
Half Angle	φ	±55	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.62	A/W	λ=850 nm
Quantum Yield	η	0.90	electrons / photon	
Open Circuit Voltage	V_O	375 (≥320)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	70	μA	
Rise and Fall Time, Photocurrent	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 μA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E_E=0
Capacitance	C_0	72	pF	V_R=0 V, f=1 MHz, E_V=0 lx
Temp. Coefficient V_O	TC_V	-2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	4.1 x 10^{-14}	W/√Hz	V_R=10 V, λ=850 nm
Detection Limit	D*	6.6 x 10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

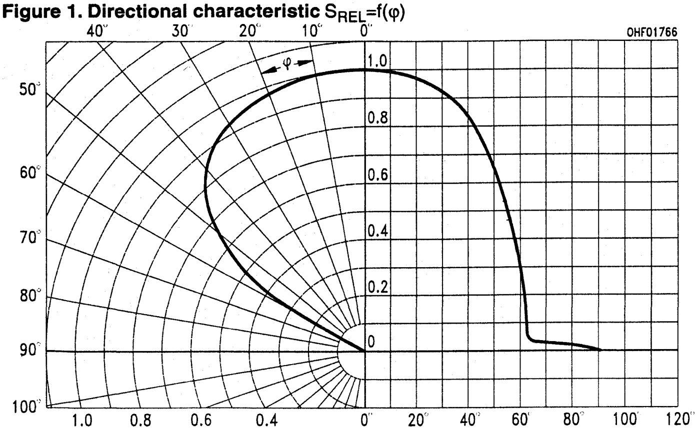


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

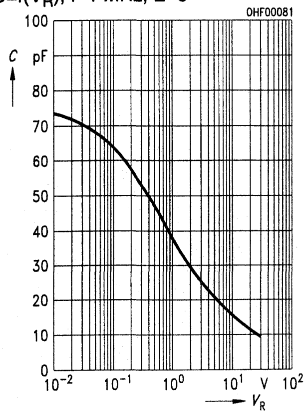


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

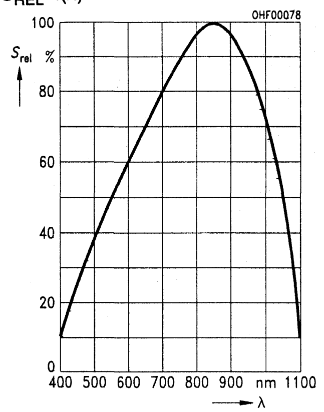


Figure 4. Power dissipation $P_{TOT}=f(T_A)$

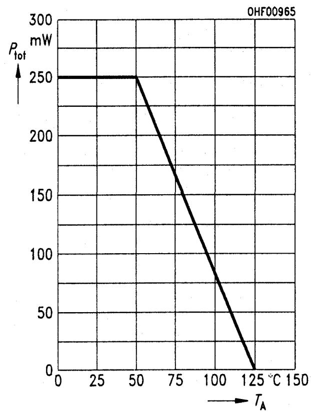


Figure 7. Dark current
$I_R=f(T_A)$, $V_R=10$ V, E=0

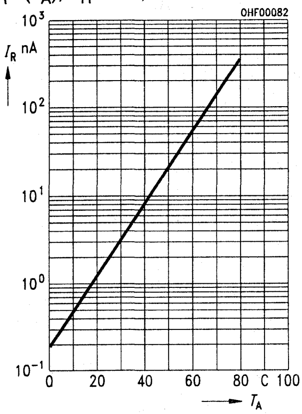


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

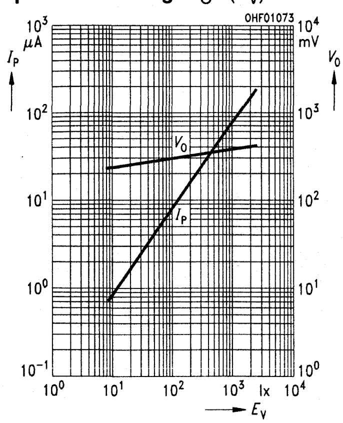
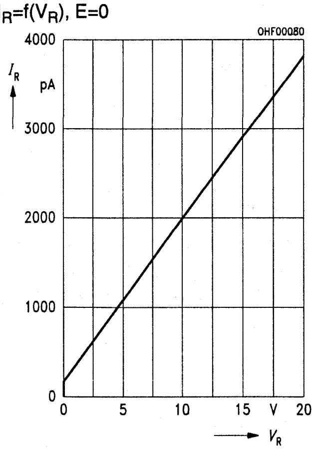


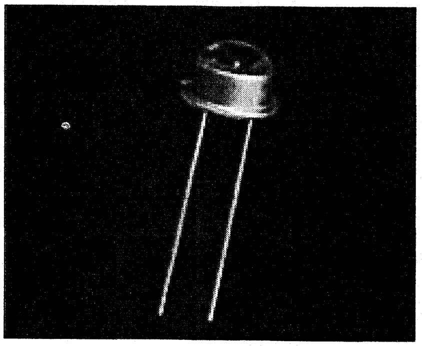
Figure 5. Dark current
$I_R=f(V_R)$, E=0

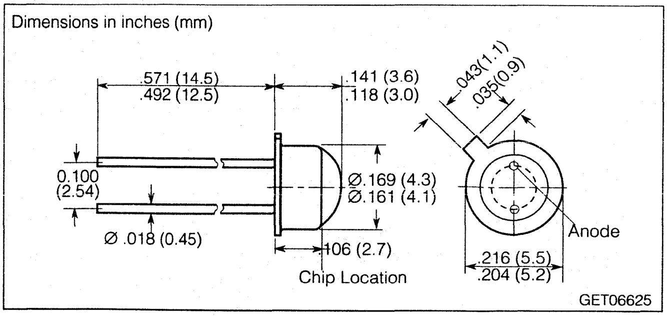


SIEMENS

BPX 63

Very Low Dark Current Silicon Photodiode





FEATURES

- **Especially suitable for applications from 350 nm to 1100 nm**
- **Low reverse current (typ. 5 pA)**
- **TO-18, base plate, transparent epoxy resin lens**

APPLICATION

- **Exposure meters, automatic exposure timers**

DESCRIPTION

The BPX 63 is a silicon planar photodiode, mounted on a TO18 base plate and covered with transparent plastic. The BPX 63 has been developed as a detector for low light levels. It is outstanding for low dark currents and, when used as a voltaic cell, for a high open circuit voltage at low light levels. The cathode of the BPX 63 is electrically connected to the package.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Soldering Temperature (2 mm from case bottom) (T_s) t≤3 s....... 230°C
Reverse Voltage (V_R) .... 7 V
Power Dissipation (P_{TOT}) T_A=25°C .... 200 mW

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	10 (≥8)	nA/lx	V_R=5 V
Wavelength, Max. Sensitivity	λ_{Smax}	800	nm	
Spectral Sensitivity Range	λ	350 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	0.97	mm²	
Radiant Sensitive Area Dimensions	L x W	0.985x0.985	mm	
Distance, Chip Surface to Case Surface	H	0.2 to 0.8		
Half Angle	φ	±75	Deg.	
Dark Current	I_R	5 (≤20)	nA	V_R=1 V
Zero Cross Over	S_0	≤0.4	pA/mV	E=0
Spectral Sensitivity	S_λ	0.50	A/W	λ=850 nm
Quantum yield	η	0.73	electrons/photon	
Open Circuit Voltage	V_O	450 (≥380)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	10	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	1.3	ns	R_L=1 KΩ, V_R=5 V, λ=850 nm, I_P=10 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	100	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O	TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.16	%/K	
Noise Equivalent Power	NEP	2.5×10^{-15}	W/√Hz	V_R=1 V, λ=850 nm
Detection Limit	D*	3.9×10^{13}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

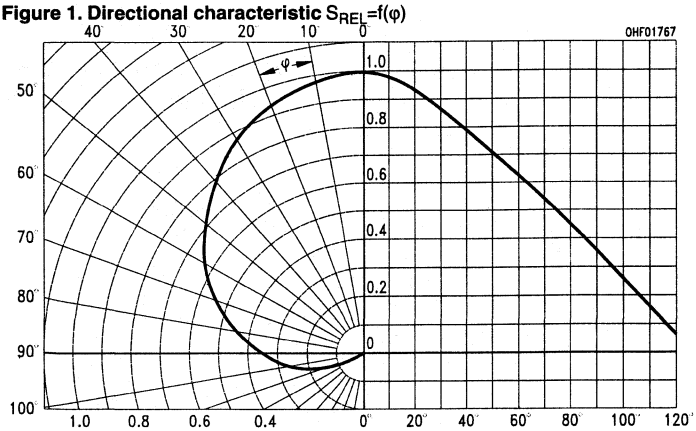


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

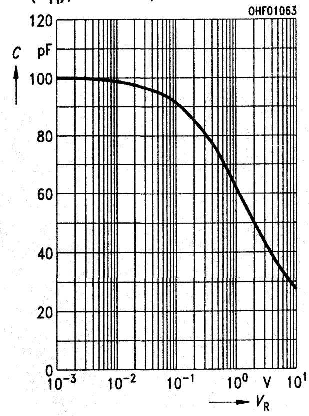


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

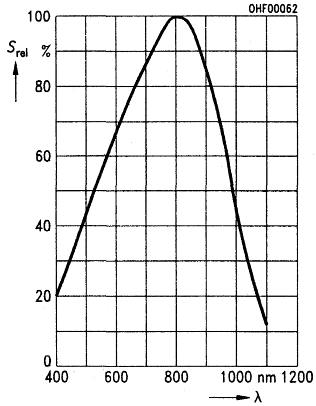


Figure 4. Power dissipation $P_{TOT}=f(T_A)$

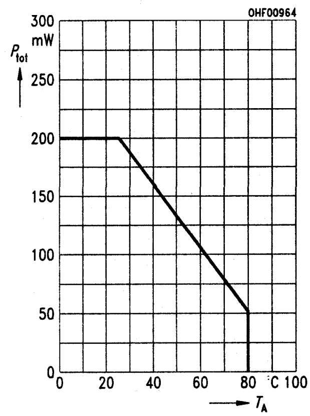


Figure 7. Dark current
$I_R=f(T_A)$, $E_V=0$, $V_R=1$ V

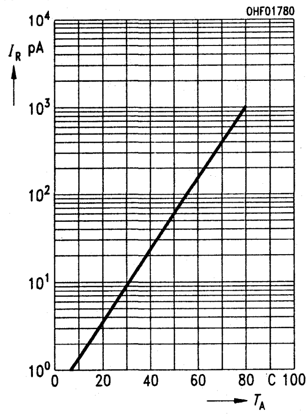


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

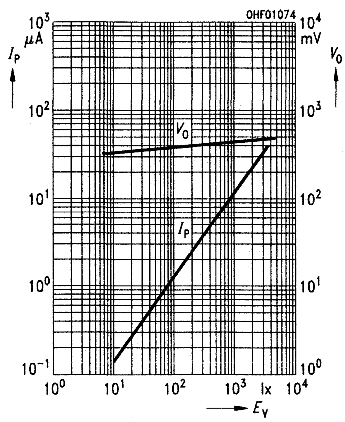
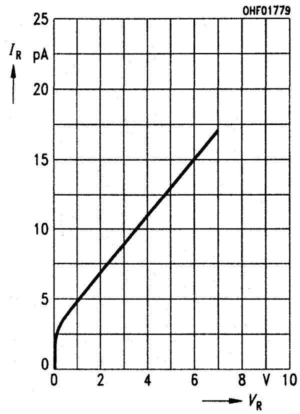
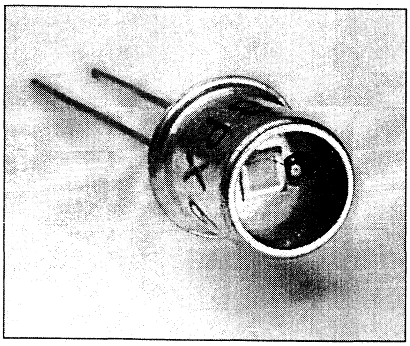


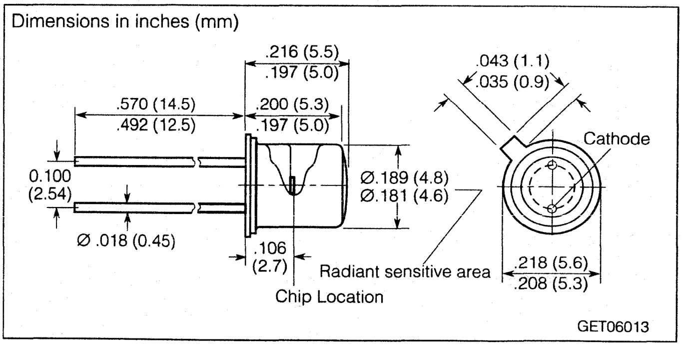
Figure 5. Dark current
$I_R=f(V_R)$, E=0



SIEMENS

BPX 65
Silicon Photodiode





FEATURES

- **Especially suitable for applications from 350 nm to 1100 nm**
- **High photosensitivity**
- **Hermetically sealed metal package (TO-18)**

APPLICATION

- **Fast optical sensor of high modulation bandwidth**

DESCRIPTION

The BPX 65 is a silicon planar PIN photodiode in an 18 A 2 DIN 41876 package (similar to TO18) with a flat window. The cathode is electrically connected to the package. The flat window has no affect on the beam path of optical lens systems. Because of its high cut-off frequency, this diode is well-suited for use as a high-modulation bandwidth optical sensor. The PIN photodiode provides low junction capacitance and short switching times.

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG})..................-40° to +125°C
Soldering Temperature
(2 mm from case bottom) (T_s) t≤3 s..... 230°C
Reverse Voltage (V_R)................................. 50 V
Power Dissipation (P_{TOT}) T_A=25°C....... 250 mW

Characteristics T_A=25°C, Standard Light A, T=2856 K

Parameter	**Sym.**	**Value**	**Unit**	**Condition**
Spectral Sensitivity	S	10 (≥5.5)	nA/lx	V_R=5 V
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	350 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	1.00	mm^2	
Radiant Sensitive Area Dimensions	L x W	1x1	mm	
Distance, Chip Surface to Case Surface	H	2.25 to 2.55		
Half Angle	φ	±40	Deg.	
Dark Current	I_R	1 (≤5)	nA	V_R=20 V
Spectral Sensitivity	S_λ	0.55	A/W	λ=850 nm
Quantum Yield	η	0.80	electrons / photon	
Open Circuit Voltage	V_O	320 (≥270)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	10	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	12	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	11	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O	TC_V	-2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.2	%/K	
Noise Equivalent Power	NEP	$3.3x10^{-14}$	W/√Hz	V_R=20 V, λ=850 nm
Detection Limit	D*	$3.1x10^{12}$	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

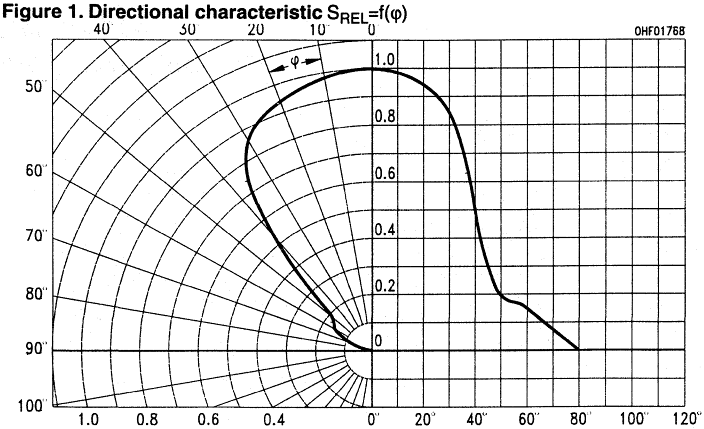


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

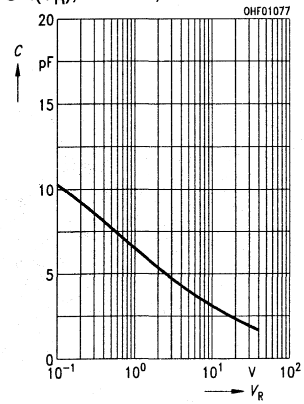


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

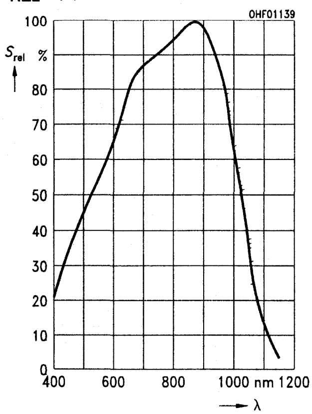


Figure 4. Power dissipation $P_{TOT}=f(T_A)$

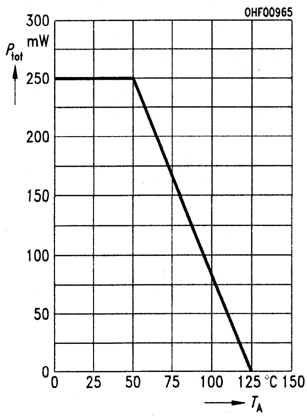


Figure 7. Dark current
$I_R=f(T_A)$, E=0, V_R=20 V

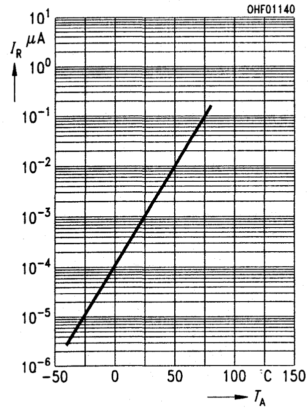


Figure 3. Photocurrent $I_P=f(E_V)$, V_R=5V
Open circuit voltage $V_O=f(E_V)$

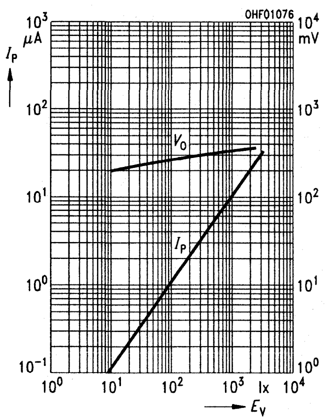
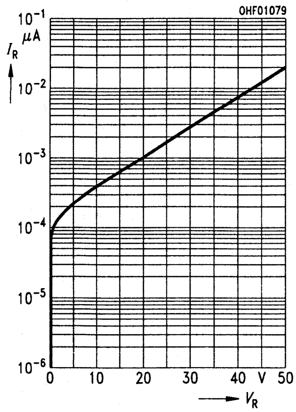
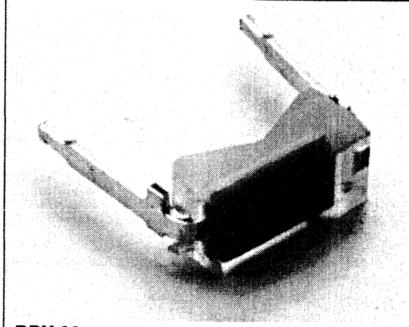


Figure 5. Dark current
$I_R=f(V_R)$, E=0

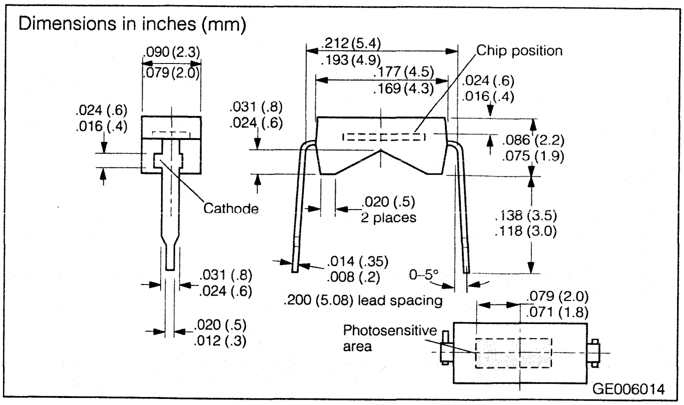


SIEMENS

BPX 90
DAYLIGHT FILTER BPX 90F
Silicon Planar Photodiode



BPX 90



FEATURES

- **Especially suitable for applications**
  - **BPX 90: 400nm to 1100 nm**
  - **BPX90 F: 950 nm**
- **High photosensitivity**
- **DIL plastic package with high packing density**

APPLICATIONS

- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The BPX 90 and BPX 90F are silicon planar photodiodes. The BPX 90 is in a transparent plastic package. The BPX 90F is in a black plastic package with IR filter. Its terminals are soldering tabs with 0.2" (5.08 mm) lead spacing.

This versatile photodetector is suitable for diode as well as voltaic cell operation, providing an excellent signal/noise ratio, even at low light levels. The open circuit voltage at low light levels is higher than with comparable mesa photovoltaic cells.

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Soldering Temperature (2 mm from case bottom) (T_S) t≤3 s ...... 230°C
Reverse Voltage (V_R) .... 32 V
Power Dissipation (P_{TOT}) T_A=25°C .... 100 mW

Characteristics T_A=25°C

Parameter		Sym.	Value	Unit	Condition
Spectral Sensitivity	BPX90	S	45 (≥32)	nA/lx	V_R=5 V, Std. Light A, T=2856 K
	BPX90F		26 (≥16)	μA	V_R=5 V, λ=950 nm, E_E=1 mW/cm^2
Wavelength, Max. Sensitivity	BPX90	λ_{Smax}	830	nm	
	BPX90F		950		
Spectral Sensitivity Range	BPX90	λ	400–1150		S=10% of S_{MAX}
	BPX90F		800–1150		
Radiant Sensitive Area		A	5.5	mm^2	
Radiant Sensitive Area Dimensions		L x W	1.75x3.15	mm	
Distance, Chip Surface to Case Surface		H	0.5		
Half Angle		φ	±60	Deg.	
Dark Current		I_R	5 (≤200)	nA	V_R=10 V
Spectral Sensitivity		S	0.48	A/W	λ=950 nm
Quantum Yield		η	0.62	electrons / photon	
Open Circuit Voltage	BPX90	V_O	450(≥380)	mV	E_V=1000 lx, Std. Light A, T=2856 K
Short Circuit Current		I_{SC}	45	μA	
Open Circuit Voltage	BPX90F	V_O	400(≥340)	mV	E_e=0.5 mW/cm^2, λ=950 nm
Short Circuit Current		I_{SC}	13	μA	
Rise and Fall Time, Photocurrent		t_R, t_F	1.3	ns	R_L=1 KΩ, V_R=5 V, λ=850 nm, I_P=30 μA
Forward Voltage		V_F		V	I_F=100 mA, E=0
Capacitance		C_0	430	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O		TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	BPX90	TC_I	0.18	%/K	
	BPX90F		0.2		
Noise Equivalent Power		NEP	8x10^{-14}	W/√Hz	V_R=10 V
Detection Limit		D*	2.9x10^{12}	cm•√Hz/W	

Figure 1. tDirectional characteristic $S_{REL}=f(\varphi)$

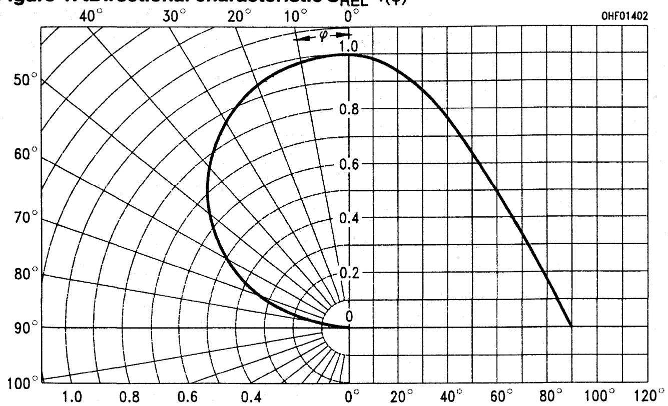


Figure 6. Total power dissipation $P_{TOT}=f(T_A)$

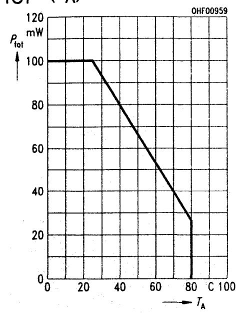


Figure 7. Dark current $I_R=f(V_R)$, E=0

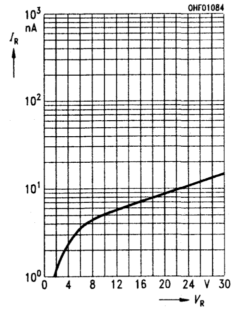


Figure 2. BPX90—Relative spectral sensitivity $S_{REL}=f(\lambda)$

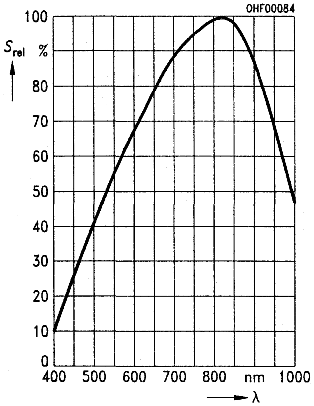


Figure 4. BPX90—Photocurrent $I_P=f(E_V)$, V_R=5V Open circuit voltage $V_O=f(E_V)$

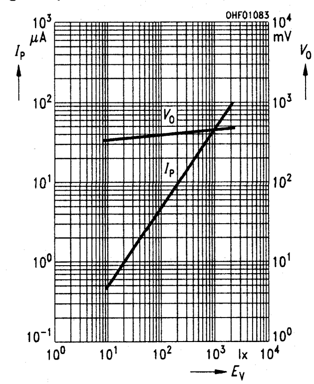


Figure 8. Capacitance $C=f(V_R)$, f=1 MHz, E=0

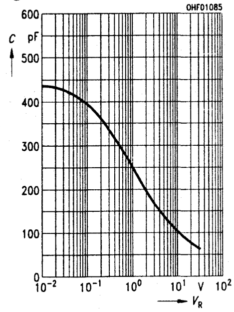


Figure 3. BPX90F—Relative spectral sensitivity $S_{REL}=f(\lambda)$

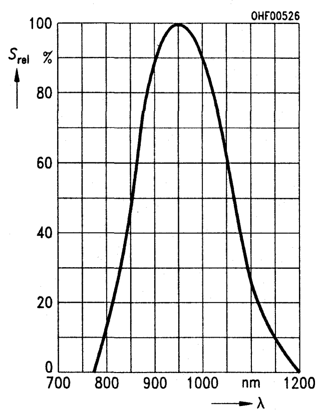


Figure 5. BPX90F—Photocurrent $I_P=f(E_V)$, V_R=5 V Open circuit voltage $V_O=f(E_V)$

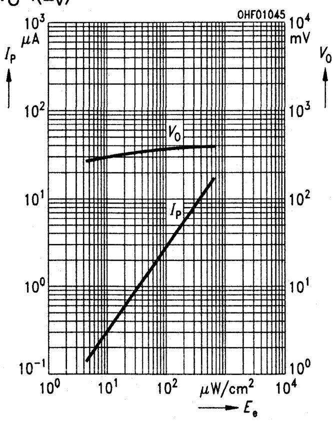
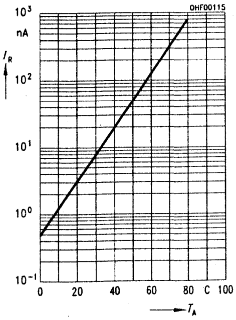


Figure 9. Dark current $I_R=f(T_A)$, V_R=10 V, E=0



SIEMENS

BPY 12

Silicon PIN Photodiode

FEATURES

- **Especially suitable for applications from 400 nm to 1100 nm**
- **Short switching time (typ. 25 ns)**

APPLICATIONS

- **Industrial electronics**
- **For control and drive circuits**

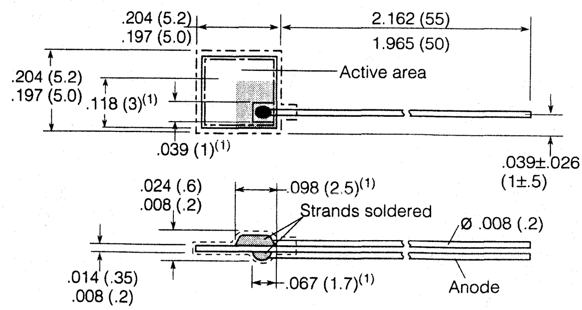
DESCRIPTION

The BPY 12 is a silicon planar PIN photodiode. N-Si material provides positive front and negative back contact. These photodetectors can operate as reverse voltage photodiodes or as photovoltaic cells.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})..................-55° to +100°C
Reverse Voltage (V_R)..................................20 V
Power Dissipation (P_{TOT}) T_A=25°C.........150 mW

Dimensions in inches (mm)



(1) Max. solder areas on front and back side GS006016

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Sym	Value	Unit	Condition
Spectral Sensitivity	S	180 (≥100)	nA/lx	V_R=5 V,
Wavelength, Maximum Sensitivity	λ_{Smax}	920	nm	
Spectral Sensitivity Range	λ	400 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	20	mm^2	
Radiant Sensitive Area Dimensions	L x W	4.47x4.47	mm	
Half Angle	φ	±60	Deg.	
Dark Current	I_R	10 (≤100)	nA	V_R=20 V
Spectral Sensitivity	S_λ	0.60	A/W	λ=850 nm
Quantum Yield	η	0.86	electrons / photon	
Open Circuit Voltage(1)	V_O	365 (≥310)	mV	E_V=1000 lx
Short Circuit Current(1)	I_{SC}	180	μA	
Rise and Fall Time, Photocurrent	t_R, t_F	25	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 μA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	140	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_O	TC_V	-2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.15	%/K	
Noise Equivalent Power	NEP	9.4×10^{-14}	W/√Hz	V_R=20 V, λ=850 nm
Detection Limit	D*	4.7×10^{12}	cm•√Hz/W	

Photodiodes 11

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

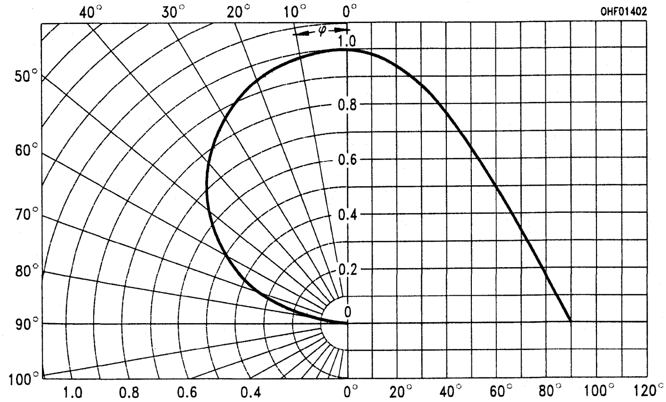


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

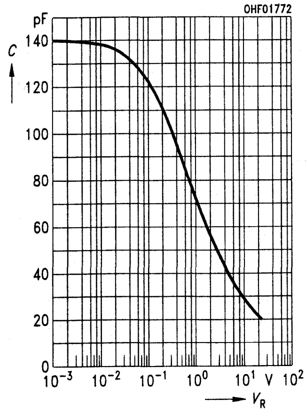


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

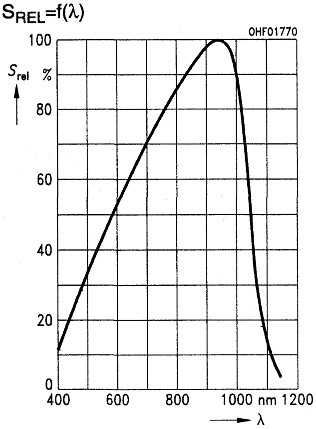


Figure 4. Power dissipation $P_{TOT}=f(T_A)$

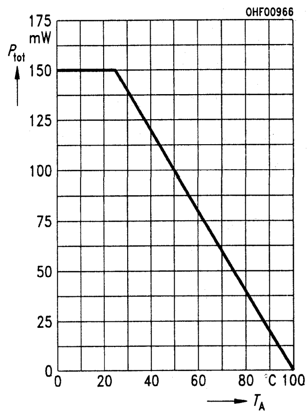


Figure 7. Dark current
$I_R=f(T_A)$, V_R=20 V, E=0

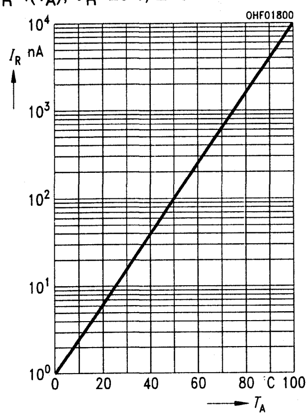


Figure 3. Photocurrent $I_P=f(E_V)$, V_R=5 V
Open circuit voltage $V_O=f(E_V)$

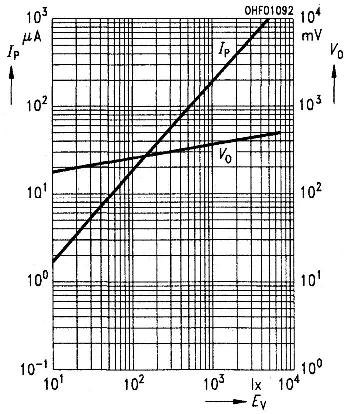
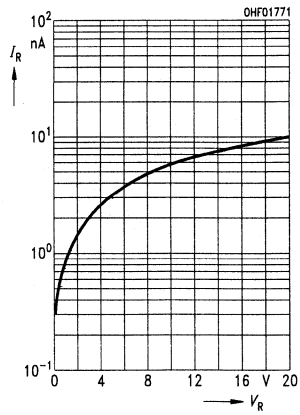
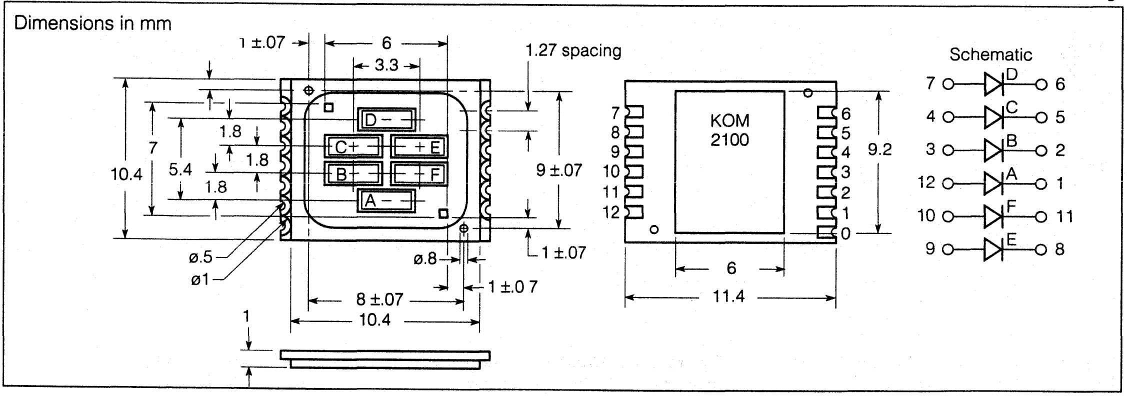


Figure 5. Dark current
$I_R=f(V_R)$, E=0



SIEMENS

KOM 2100 B
DAYLIGHT FILTER KOM 2100 BF
6-Chip Silicon PIN Photodiode Array



FEATURES
- **Especially suitable for applications**
  - **KOM 2100 B: 400 to 1100 nm**
  - **KOM 2100 BF: 880 nm**
- **Short switching time (typ. 13 ns)**
- **Cathode=back contact**
- **Available as photodiode with reverse voltage or photovoltaic cell**
- **Suitable for SMT**

APPLICATION
- **General-purpose, e.g. encoders**

DESCRIPTION
These devices are 6-chip photodiode arrays fabricated in planar technology with low reverse current. The N-Si material used results in a positive front and negative back contact. These photodetectors are suitable for diode operation (with reverse voltage) as well as for photo-element operation.

The package consists of a PC board with solder lugs and a clear epoxy seal. See drawing for cathode marking.

Maximum Ratings
Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Reverse Voltage (V_R) .... 20 V
Power Dissipation (P_{TOT}) T_A=25°C .... 150 mW

Characteristics T_A=25°C, λ=950 nm

Parameter		Sym.	Value	Unit	Condition
Spectral Sensitivity	2100B	S	9 (≥7)	μA	V_R=5 V, E_E=0.5 mW/cm^2
	2100BF		8.5 (≥6.6)		
Wavelength, Max. Sensitivity		λ_{Smax}	870	nm	
Spectral Sensitivity Range	2100B	λ	400 to 1100		S=10%, S_{max}
	2100BF		730 to 1100		
Radiant Sensitive Area		A	2.5	mm^2	
Radiant Sensitive Area Dimensions		L x W	1x2.5	mm	
Distance, Chip Surface to Seal Surface		H	0.4 to 0.6		
Half Angle		φ	±60	Deg.	
Dark Current		I_R	1 (≤10)	nA	V_R=10 V
Spectral Sensitivity	2100B	S_λ	0.68	A/W	
	2100BF		0.64		
Quantum Yield	2100B	η	0.9	electrons/photon	
	2100BF		0.85		
Max. Deviation, System Spectral Sensitivity from Average		ΔS	±10	%	
Short Circuit Current	2100B	I_{SC}	8.5	μA	E_e=0.5 mW/cm^2
	2100BF	I_{SC}	8		
Open Circuit Voltage		V_O	320 (≥250)	mV	
Rise and Fall Time, Photocurrent		t_R, t_F	13	ns	R_L=50 Ω, V_R=10 V, λ=850 nm, I_P=800 μA
Forward Voltage		V_F	1.2	V	I_F=100 mA, E=0
Capacitance		C_0	25	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O		TC_V	-2.6	mV/K	
Temperature Coefficient I_{SC}		TC_I	0.18	%/K	
Noise Equivalent Power	2100B	NEP	2.6×10^{-14}	W/√Hz	V_R=10 V
	2100BF		2.8×10^{-14}		
Detection Limit	2100B	D*	6.1×10^{12}	cm•√Hz/W	
	2100BF		5.7×10^{12}		

Photodiodes 11

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

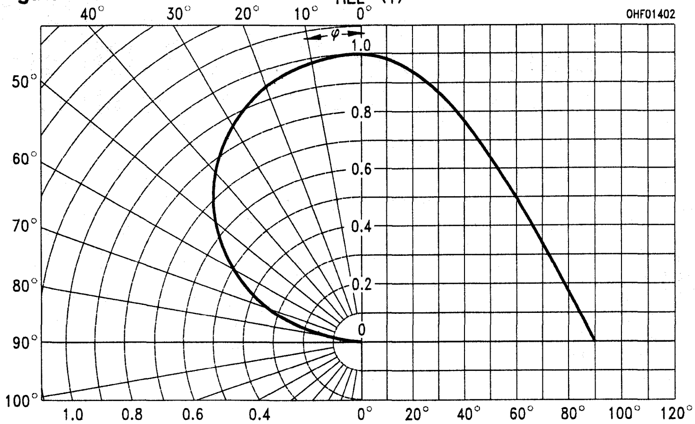


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$ **KOM 2100B**

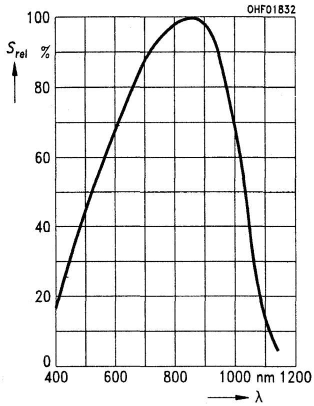


Figure 3. Relative spectral sensitivity
$S_{REL}=f(\lambda)$ **KOM 2100BF**

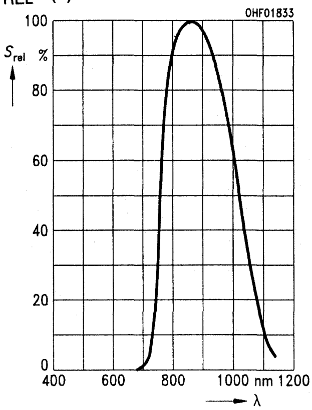


Figure 4. Photocurrent $I_P=f(E_E)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_E)$

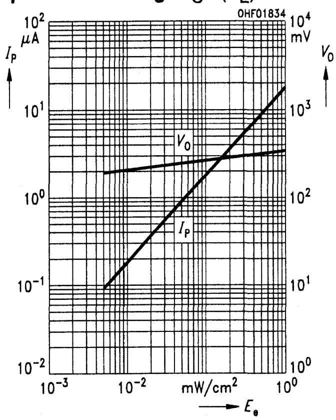


Figure 5. Power dissipation
$P_{TOT}=f(T_A)$

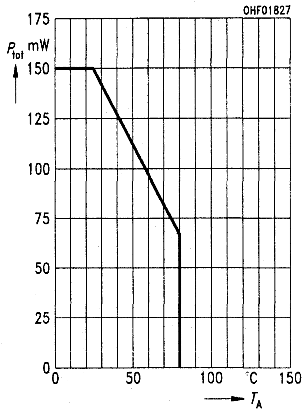


Figure 6. Dark current
$I_R=f(V_R)$, $T_A=25°C$, $E=0$

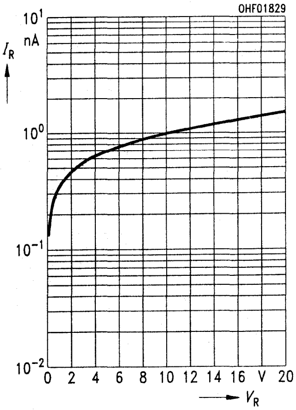


Figure 7. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

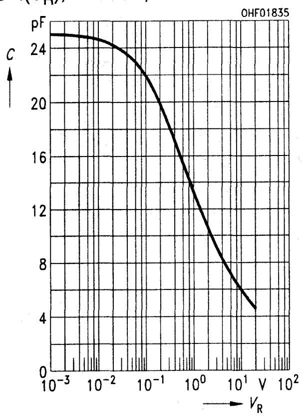
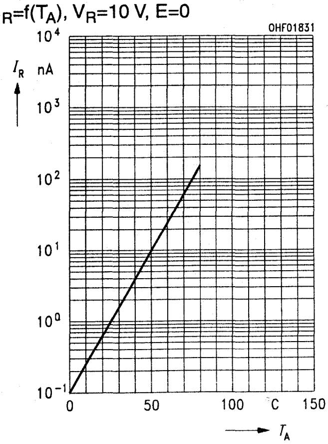


Figure 8. Dark current
$I_R=f(T_A)$, $V_R=10$ V, E=0



SIEMENS

KOM2108

5 x 5 Silicon PIN Photodiode Array

FEATURES

- **Suitable for use in the visible light and near infrared range**
- **Low noise**
- **Short switching time (typ. 10 ns)**
- **Every single diode can be activated**

APPLICATIONS

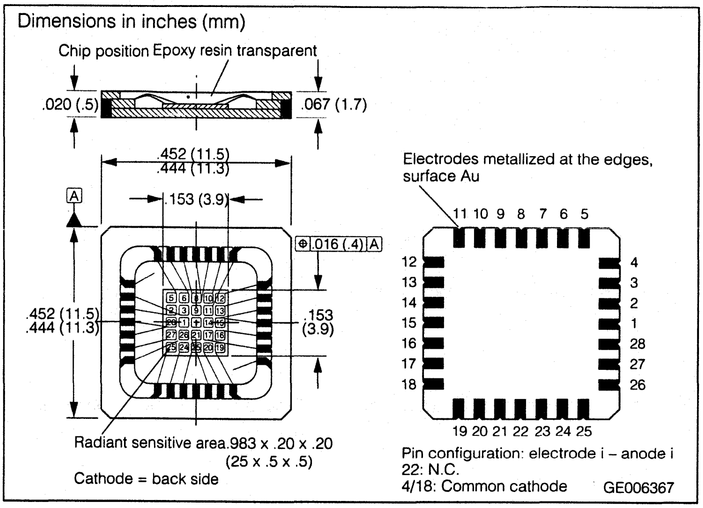
- **Universal pcb for two-dimensional resolution**
- **Follow-up controls**
- **Positioning**
- **Path and corner scanning**
- **Industrial electronics**
- **For drive and control circuits**

DESCRIPTION

Description text

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})................ –40 to +80°C
Reverse Voltage (V_R)............................ 20 V
Total Power Dissipation per Single
Diode (P_{TOT}) T_A=25°C.................... 30 mW



Characteristics T_A=25°C, λ=950 nm

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	1.1 (≥0.8)	µA	V_R=5 V, E_e=0.5 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	380 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	0.3	mm^2	
Radiant Sensitive Area, Dimension	L x W	0.56 x 0.56	mm	
Distance, Chip Front to Case Seal	H	0.6 to 0.9		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	0.05 (≤1)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.59	A/W	
Spectral Sensitivity, Max. Deviation from Average	ΔS	±10	%	
Quantum Yield	η	0.77	electrons / photon	
Open Circuit Voltage	V_L	360 (≥320)	mV	E_e=0.5 mW/cm^2
Short Circuit Current	I_{SC}	1	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	10	ns	R_L=50 Ω, V_R=10 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	13	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_L	TC_V	-2.6	mV/K	
Temp. Coefficient I_P	TC_I	0.2	%/K	
Noise Equivalent Power	NEP	6.5 x 10^{-15}	W/√Hz	V_R=10 V
Detection Limit	D*	8.4 x 10^{12}	cm•√Hz/W	

Figure 1. Directional characteristics $S_{REL}=f(\varphi)$

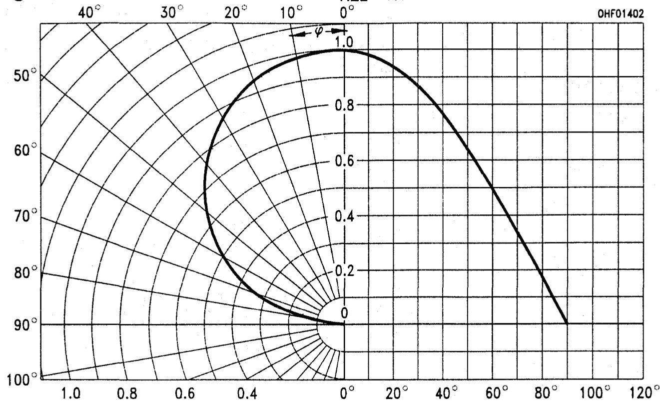


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

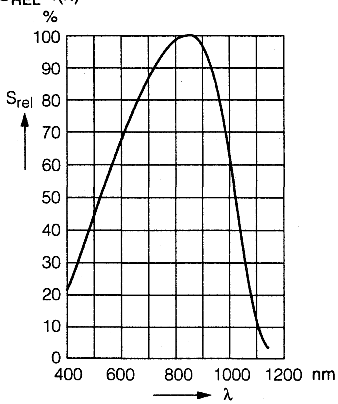


Figure 3. Photocurrent $I_P=f(E_E)$ $V_R=5$ V
Open circuit voltage $V_L=f(E_E)$

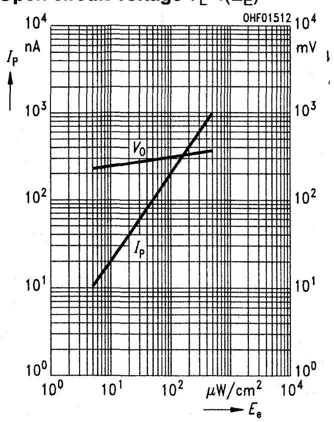


Figure 4. Total power dissipation $P_{tot}=f\ (T_A)$

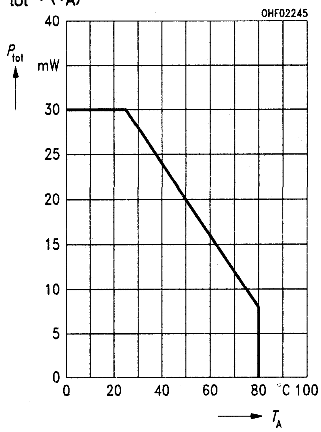


Figure 5. Dark current $I_R=f(V_R)$, E=0

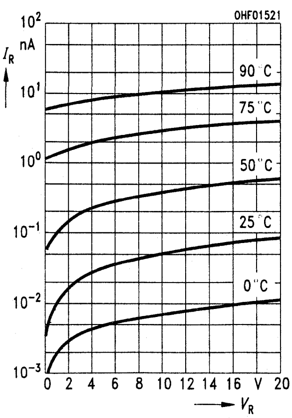


Figure 6. Capacitance $C=f(V_R)$, f=1 MHz, E=0

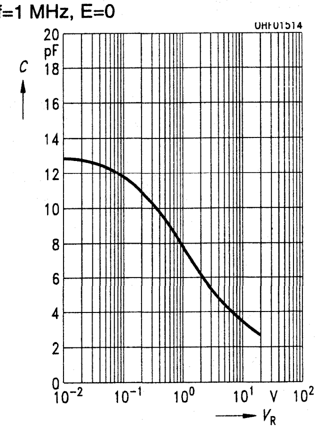
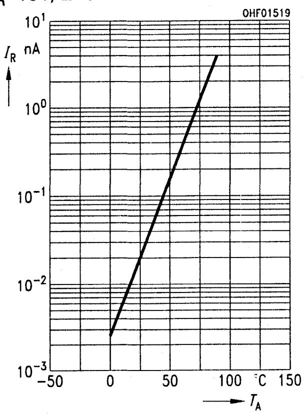


Figure 7. Dark current $I_R=f(T_R)$, $V_R=10V$, E=0



SIEMENS

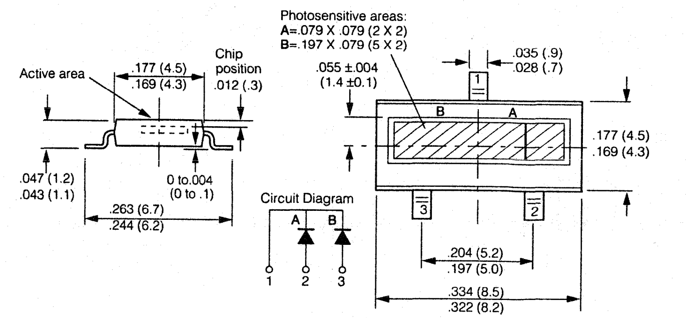
SURFACE MOUNT KOM2125
2-Chip Silicon PIN Photodiode

FEATURES
- **Especially suitable for applications from 400 nm to 1100 nm**
- **Short switching time (typ. 25 ns)**
- **Suitable for vapor phase and IR-reflow soldering**
- **Suitable for SMT**

APPLICATIONS
- **Follow-up controls**
- **Edge drives**
- **Industrial electronics**
- **Drive and control circuits**

Maximum Ratings
Operating and Storage Temperature
Range (T_{OP}, T_{STG})..............–40 to +80°C
Reverse Voltage (V_R)...........................60 V
Total Power
Dissipation (P_{TOT}) T_A=25°C........150 mW

Dimensions in inches (mm)



Characteristics T_A=25°C, Standard Light A, 2856 K

Parameter		Sym.	Value	Unit	Condition
Spectral Sensitivity	Diode A	S	40 (≥30)	nA/lx	V_R=5 V
	Diode B		100 (≥75)		
Wavelength, Maximum Sensitivity		λ_{Smax}	850	nm	
Spectral Sensitivity Range		λ	400 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	Diode A	A	4	mm^2	
	Diode B		10		
Radiant Sensitive Area, Dimension		L x W	2 x 2, 2 x 5	mm	
Distance, Chip Front to Case Seal		H	0.3	mm	
Half Angle		φ	±60	Deg.	
Dark Current	Diode A	I_R	5(≤30)	nA	V_R=10 V
	Diode B		10(≤30)		
Spectral Sensitivity		S_λ	0.62	A/W	
Quantum Yield		η	0.90	electrons / photon	
Open Circuit Voltage		V_L	350(≥300)	mV	E_V=1000 lx
Short Circuit Current	Diode A	I_{SC}	38	µA	
	Diode B		95		
Rise and Fall Time	Diode A	t_R, t_F	18	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
	Diode B		25		
Forward Voltage		V_F	1.0	V	I_F=100 mA, E=0
Capacitance	Diode A	C_0	40	pF	V_R=5 V, f=1 MHz, E=0
	Diode B		100		
Temperature Coefficient V_O		TC_V	–2.6	mV/K	
Temperature Coefficient I_P		TC_I	0.18	%/K	
Noise Equivalent Power	Diode A	NEP	6.4×10^{-14}	W/√Hz	V_R=10 V
	Diode B		9.1×10^{-14}		
Detection Limit	Diode A	D*	3.1×10^{12}	cm•√Hz/W	
	Diode B		3.5×10^{12}		

Figure 1. Directional characteristics $S_{REL}=f(\varphi)$

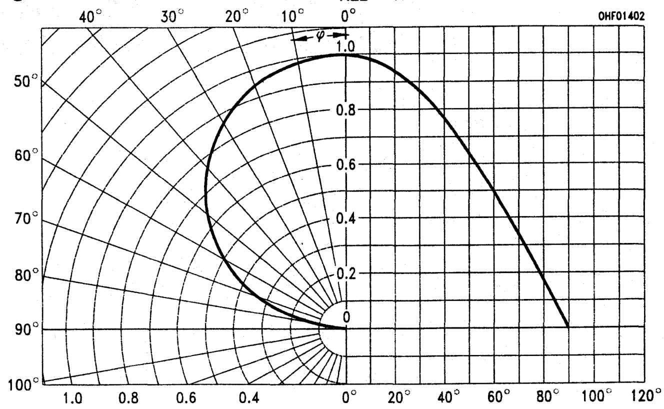


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

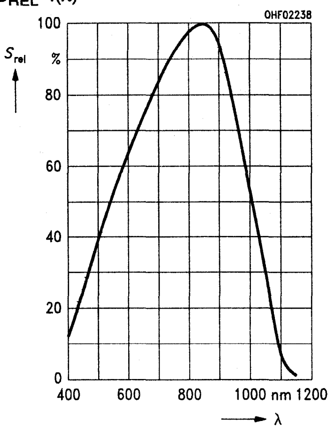


Figure 3. Photocurrent $I_P=f(E_E)$, $V_R=5$ V
Open circuit voltage $V_L=f(E_E)$

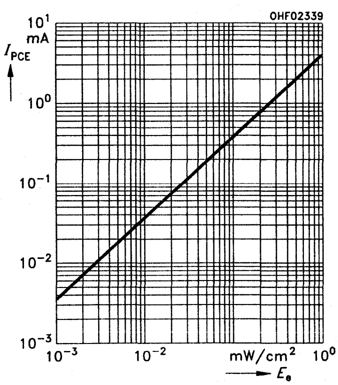


Figure 4. Total power dissipation $P_{tot}=f(T_A)$

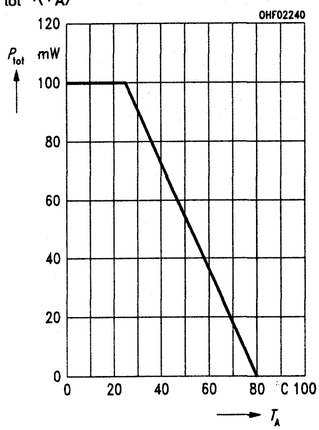


Figure 5. Dark current $I_R=f(V_R)$, E=0

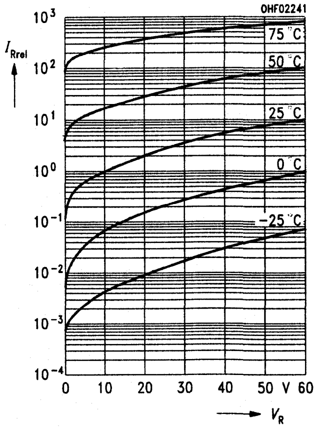


Figure 6. Capacitance $C=f(V_R)$, f=1 MHz, E=0

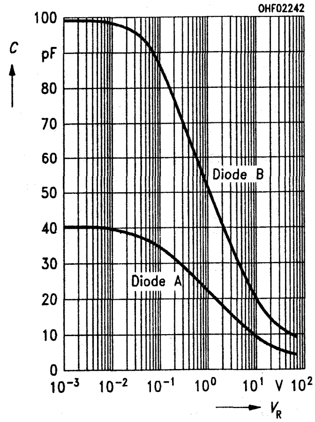
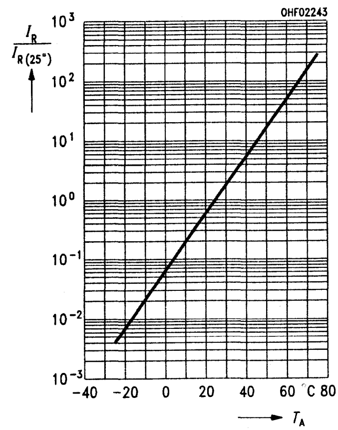
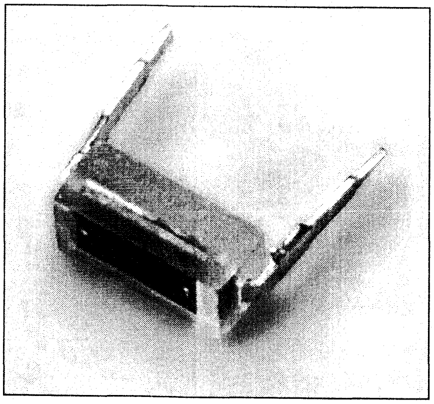


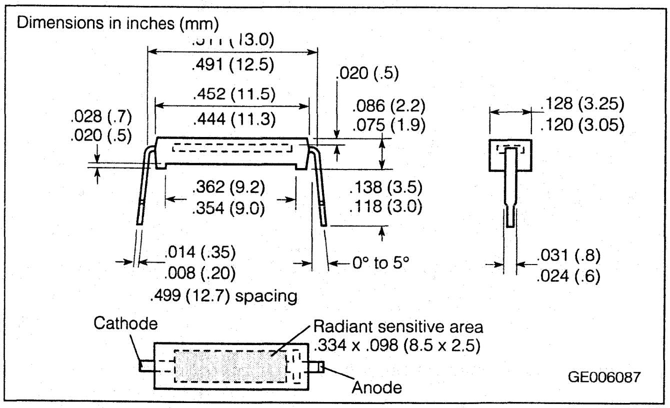
Figure 7. Dark current $I_R=f(T_A)$, $V_R=10$ V, E=0



SIEMENS

SFH 100
High Blue Sensitivity Silicon Photodiode





FEATURES
- **Especially suitable for applications from 350 nm to 1100 nm**
- **Low reverse current (typ. 400 pA)**
- **DIL plastic package with high packing density**

APPLICATIONS
- **Exposure meters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION
The SFH 100 silicon planar photodiode is suitable for universal applications, particularly with small reverse voltage (approximately 0.1 V) for detecting very limited light levels.

The component comes in a transparent plastic package with solder tabs spaced at 0.500" (12.7 mm).

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–40° to +80°C
Soldering Temperature
(≥2 mm from case bottom) (T_s) t≤3 s....... 230°C
Reverse Voltage (V_R)...................................... 7 V
Power Dissipation (P_{TOT}) T_A=25°C .... 100 mW

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Symbol	Value	Unit	Condition
Spectral Sensitivity	S	175	nA/lx	V_R=5 V
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	350 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	21.2	mm^2	
Radiant Sensitive Area Dimensions	L x W	8.5x2.5	mm	
Distance, Chip Surface to Case Surface	H	0.5		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	0.4 (≤10)	nA	V_R=7 V
Spectral Sensitivity	S_λ	0.2	A/W	λ=400 nm
Quantum Yield	η	0.62	electrons / photon	
Open Circuit Voltage	V_O	430	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	21 (≥15)	µA	E_e=0.5 mW/cm^2, λ=400 nm
Rise and Fall Time, Photocurrent	t_R, t_F	1.8	µs	R_L=1 KΩ, V_R=5 V, λ=850 nm, I_P=200 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_O	1000	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_O	TC_V	–2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.2	%/K	
Noise Equivalent Power	NEP	5.7x10^{-14}	W/√Hz	V_R=7 V, λ=400 nm
Detection Limit	D*	8.1x10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

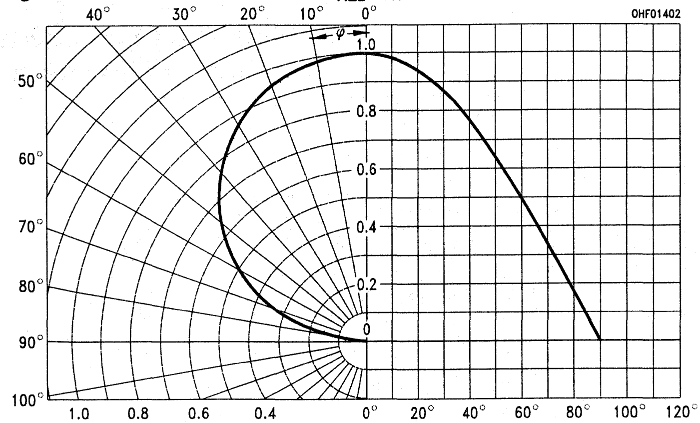


Figure 6. Dark current
$I_R=f(T_A)$, $V_R=7$ V, E=0

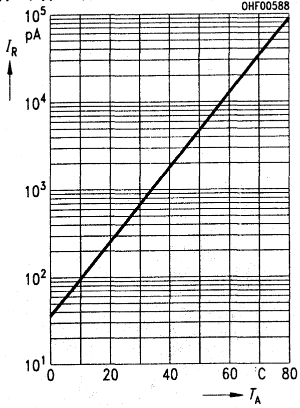


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

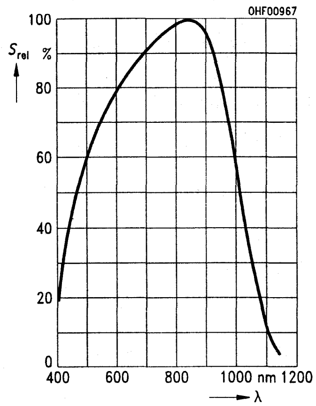


Figure 4. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

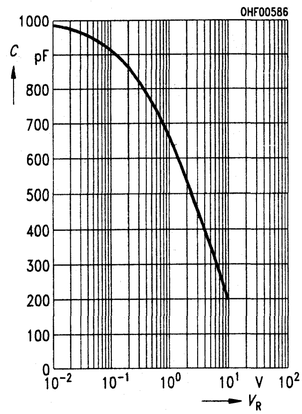


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

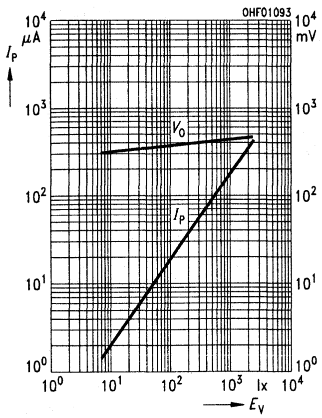
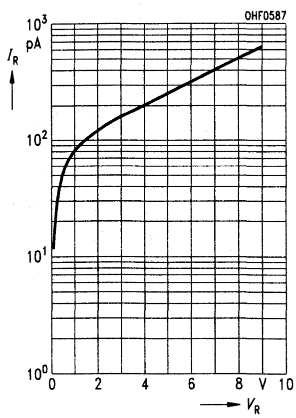
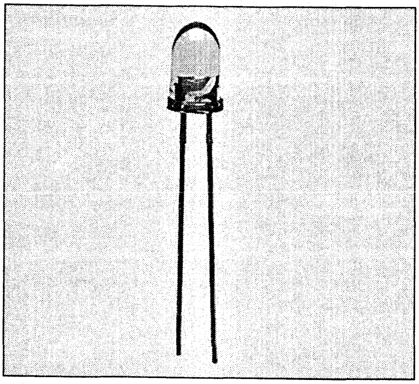


Figure 5. Dark current
$I_R=f(V_R)$, E=0

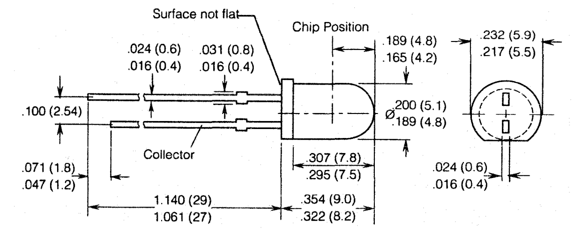


SIEMENS

SFH 203
DAYLIGHT FILTER SFH 203FA
Silicon PIN Photodiode



Dimensions in inches (mm)



FEATURES
- **Especially suitable for applications**
  - **SFH 203: 400 nm to 1100 nm**
  - **SFH 203 FA: 880 nm**
- **Short switching time (typ. 5 ns)**
- **T1 ¾ (5 mm) LED plastic package**
- **Also available on tape**

APPLICATIONS
- **Industrial electronics**
- **For control and drive circuits**
- **Photointerrupters**
- **Fiber optic transmission systems**

DESCRIPTION

SFH 203 and SFH 203FA are silicon planar PIN photodiodes in T1¾ packages. They can be used as photodiodes with reverse voltage, or as photovoltaic cells. The terminals are solder tabs with 0.1" (2.54 mm) lead spacing.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Soldering Temperature
(2 mm from case bottom) (T_s) t≤3 s....... 230°C
Reverse Voltage (V_R).................................. 50 V
Power Dissipation (P_{TOT})........................ 100 mW

Characteristics T_A=25°C

Parameter		Sym.	Value	Unit	Condition
Photosensitivity	203	S	80 (≥50)	nm	V_R=5 V, Std. Light A, T=2856K
	203FA		50 (≥30)		V_R=5 V, λ=950 nm, E_E=1 mW/cm²
Wavelength, Maximum Sensitivity	203	$λ_{Smax}$	850		
	203FA		900		
Spectral Sensitivity Range	203	λ	400 to 1100		S=10% of S_{MAX}
	203FA		800 to 1100		
Radiant Sensitive Area		A	1	mm²	
Radiant Sensitive Area Dimensions		L x W	1x1	mm	
Distance, Chip Surface to Case Surface		H	4.0 to 4.6		
Half Angle		φ	±20	Deg.	
Dark Current		I_R	1 (≤5)	nA	V_R=20 V
Spectral Sensitivity	203	$S_λ$	0.62	A/W	λ=850 nm
	203FA		0.59		
Quantum Yield	203	η	0.89	electrons / photon	
	203FA		0.86		
Open Circuit Voltage	203	V_O	420 (≥350)	mV	E_V=1000 lx, Std. Light A, T=2856 K
	203FA		370 (≥300)		E_e=0.5 mW/cm² λ=950 nm
Short Circuit Current	203	I_{SC}	80	μA	E_V=1000 lx(1)
	203FA		25		E_e=0.5 mW/cm² λ=950 nm
Rise and Fall Time, Photocurrent		t_R, t_F	5	ns	R_L=50 Ω, V_R=20 V, λ=850 nm, I_P=800 μA
Forward Voltage		V_F	1.3	V	I_F=80 mA, E_E=0
Capacitance		C_0	11	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O		TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	203	TC_I	0.18	%/K	Std. Light A
	203FA		0.2		λ=950 nm
Noise Equivalent Power		NEP	2.9 x 10^{-14}	W/√Hz	V_R=20 V, λ=850 nm
Detection Limit		D*	3.5 x 10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

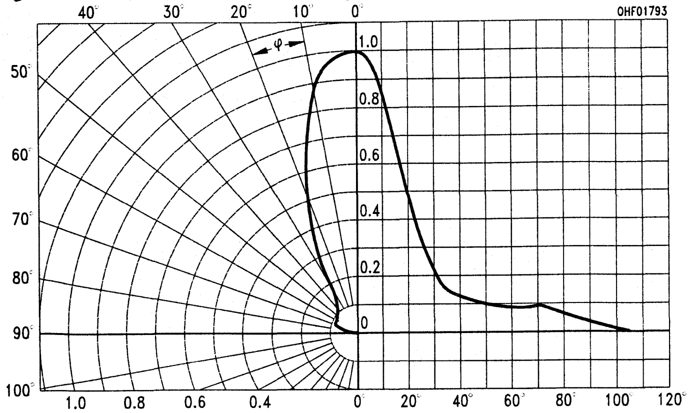


Figure 2. SFH 203—Relative spectral sensitivity $S_{REL}=f(\lambda)$

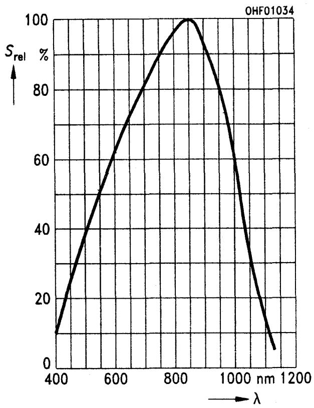


Figure 3. SFH 203FA—Relative spectral sensitivity $S_{REL}=f(\lambda)$

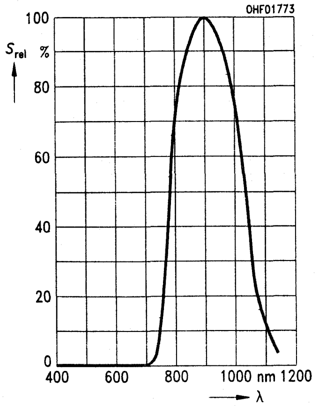


Figure 4. SFH203—Photocurrent $I_P=f(E_V)$, $V_R=5$ V Open circuit voltage $V_O=f(E_V)$

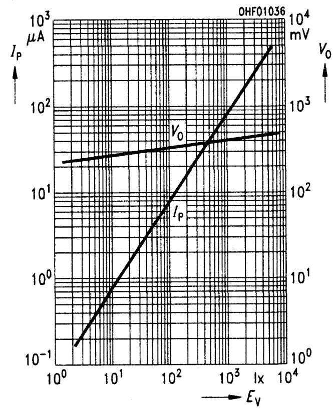


Figure 5. SFH203FA—Photocurrent $I_P=f(E_V)$, $V_R=5$ V Open circuit voltage $V_O=f(E_V)$

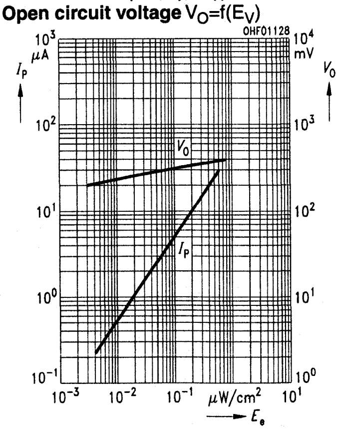


Figure 6. Power dissipation $P_{TOT}=f(T_A)$

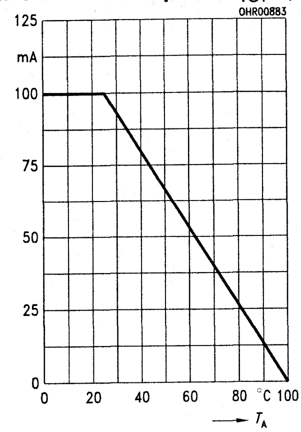
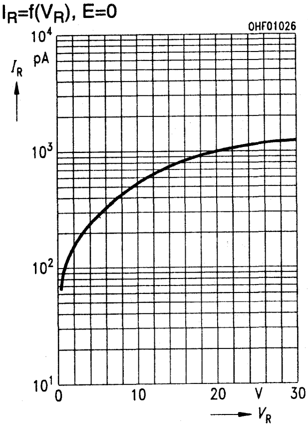
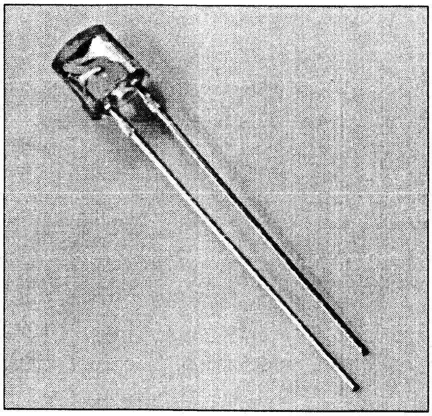


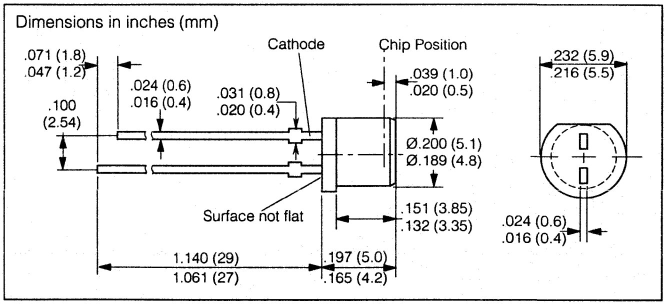
Figure 7. Dark current $I_R=f(V_R)$, E=0



SIEMENS

SFH 203P
DAYLIGHT FILTER SFH 203PFA
Silicon PIN Photodiode





FEATURES

- **Especially suitable for applications**
  - **SFH 203P: 400 to 1100 nm**
  - **SFH 203PFA: 880nm**
- **Shout switching time (typ. 5 ns)**
- **T1¾ (5 mm) LED plastic package**

APPLICATIONS

- **Industrial electronics**
- **Control and drive circuits**
- **Photointerrupters**
- **Fiber optic transmission systems**

DESCRIPTION

The SFH 203P and SFH 203PFA are planar PIN photodiodes in a plastic T1¾ package with a flat lens. This flat window has no affect on the beam path of optical lens systems. The cathode is denoted by a shorter lead.

Features include low junction capacitance and fast switching speeds.

Because of its high cutoff frequency, this diode is particularly well-suited for use as a high-modulation bandwidth optical sensor.

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG})....................–55° to +100°C
Soldering Temperature
(2 mm from case bottom) (T_s) t≤3 s ....300°C
Reverse Voltage (V_R).................................... 50 V
Power Dissipation (P_{TOT}) T_A=25°C.......... 100 mW

Characteristics T_A=25°C

Parameter		Sym.	Value	Unit	Condition
Spectral Sensitivity	203P	S	9.5 (≥5)	nA/lx	V_R=5 V, Std. Light A, T=2856 K
	203PFA		6.2 (≥3.6)	µA	V_R=5 V, λ=950 nm, E_E=1 mW/cm²
Wavelength, Max. Sensitivity	203P	λ_{Smax}	850	nm	
	203PFA		900		
Spectral Sensitivity Range	203P	λ	400 to 1100		S=10% of S_{MAX}
	203PFA		750 to 1100		
Radiant Sensitive Area		A	1	mm²	
Radiant Sensitive Area Dimensions		L x W	1x1	mm	
Distance, Chip Surface to Case Surface		H	0.4 to 0.7		
Half Angle		φ	±75	Deg.	
Dark Current		I_R	1 (≤10)	nA	V_R=20 V
Spectral Sensitivity	203P	S_λ	0.62	A/W	λ=850 nm
	203PFA		0.59		
Quantum Yield	203P	η	0.89	electrons/photon	λ=850 nm
	203PFA		0.86		
Open Circuit Voltage	203P	V_O	350 (≥300)	mV	E_V=1000 lx, Std. Light A, T=2856 K
Short Circuit Current	203P	I_{SC}	9.3	µA	
Open Circuit Voltage	203PFA	V_O	300 (≥250)	mV	E_e=0.5 mW/cm² λ=950 nm
Short Circuit Current	203PFA	I_{SC}	3.0	µA	
Rise and Fall Time, Photocurrent		t_R, t_F	5	ns	R_L=50 Ω, V_R=20 V, λ=850 nm, I_P=800 µA
Forward Voltage		V_F	1.3	V	I_F=80 mA, E=0
Capacitance		C_0	11	pF	V_R=0 V, f=1 MHz, E_V=0
Temperature Coefficient V_O		TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	203	TC_I	0.18	%/K	
	203FA		0.2		
Noise Equivalent Power		NEP	2.9×10^{-14}	W/√Hz	V_R=20 V, λ=850 nm
Detection Limit		D*	3.5×10^{12}	cm•√Hz/W	

Photodiodes 11

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

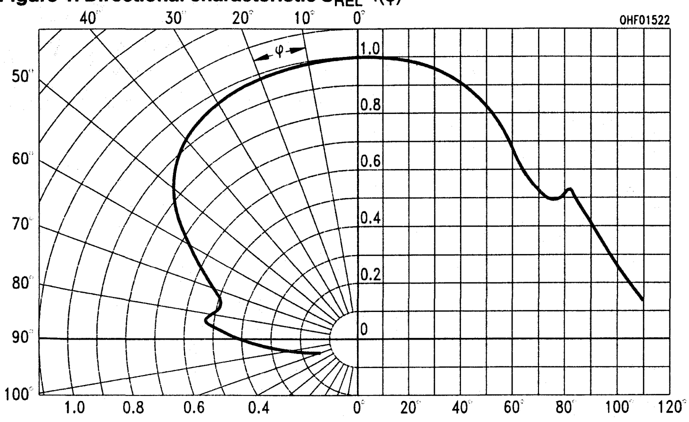


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **SFH 203P**

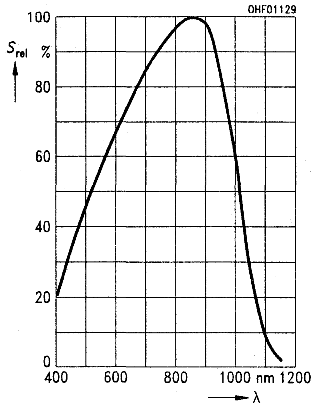


Figure 3. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **SFH 203PFA**

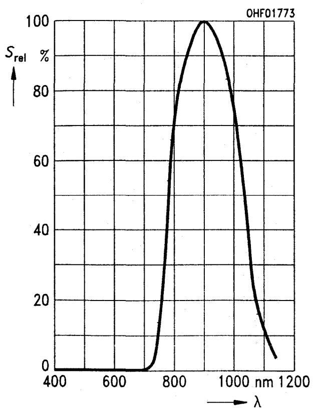


Figure 4. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$
SFH203PFA

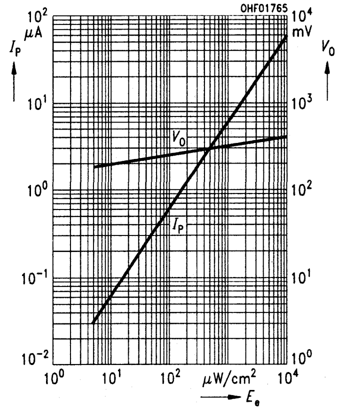


Figure 5. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$ **SFH203P**

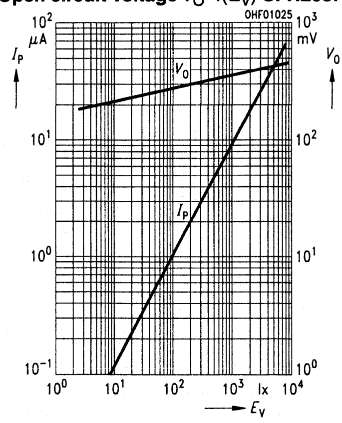


Figure 6. Power dissipation $P_{TOT}=f(T_A)$

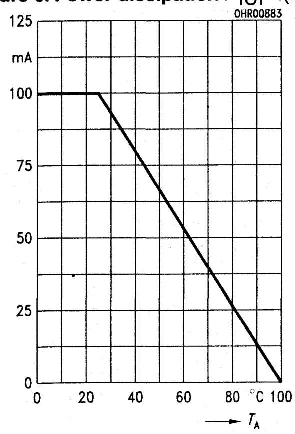


Figure 7. Capacitance $C=f(V_R)$,
f=1MHz, E=0

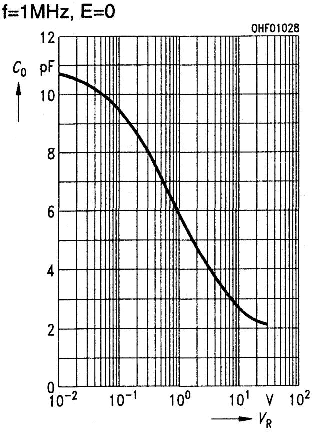
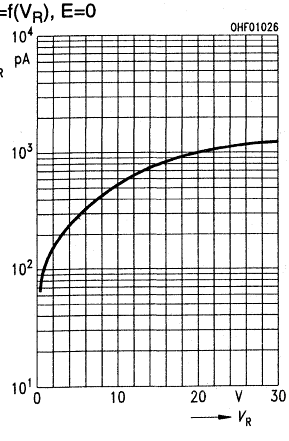


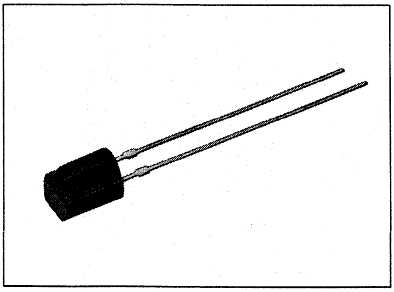
Figure 8. Dark current
$I_R=f(V_R)$, E=0

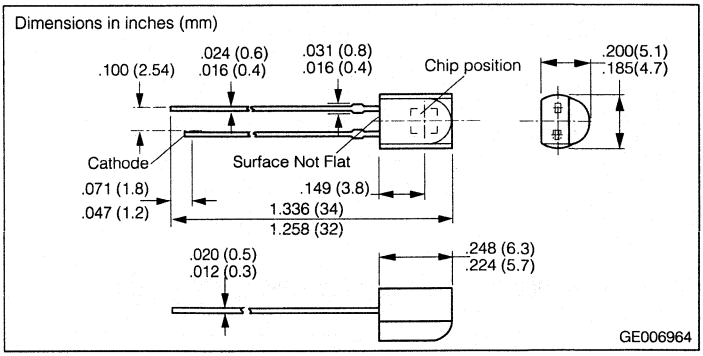


SIEMENS

SFH 204F/FA

Silicon PIN Photodiode with DayLight Filter





FEATURES

- **Especially suitable for applications of 880 nm**
- **Short switching time (typ. 20 ns)**
- **5 mm LED plastic package**
- **Also available on tape**

APPLICATIONS

- **IR-remote control of stereos and TVs, video tape recorders, dimmers, remote control of various equipment**
- **Photointerrupters**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})...............–55° to +100°C
Soldering Temperature
(≥2 mm from case bottom)
(T_s) t≤3 s.. 230°C
Reverse Voltage (V_R).............................. 20 V
Total Power Dissipation (P_{TOT})
T_A=25°C....................................... 150 mW

Characteristics T_A=25°C

Parameter	Sym.	204 F λ=950 nm	204 FA λ=870 nm	Unit	Condition
Spectral Sensitivity	S	52 (≥43)		nm	V_R=5 V, E_E=1 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	940	900		
Sensitivity, Spectral Range	λ	780 to 1120	740 to 1120		S=10% of S_{MAX}
Radiant Sensitive Area	A	4.84		mm^2	
Radiant Sensitive Area Dimensions	L x W	2.20x2.20		mm	
Distance, Chip Surface to Case Surface	H	1.9 to 2.4			
Half Angle horizontal	φ	±60		Deg.	
Dark Current	I_R	2 (≤30)		nA	V_R=10 mV
Spectral Sensitivity	S_λ	0.59	0.63	A/W	
Quantum Yield	η	0.77	0.90	electrons / photon	
Open Circuit Voltage	V_O	340 (≥270)		mV	E_E=0.5mW/cm^2
Short Circuit Current	I_{SC}	25		μA	
Rise and Fall Time, Photocurrent	t_R, t_F	20		ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 μA
Forward Voltage	V_F	1.3		V	I_F=100 mA, E=0
Capacitance	C_0	48		pF	V_R=0 V, f=1 MHz, E_V=0
Temp. Coefficient V_O	TC_V	–2.6		mV/K	
Temp. Coefficient I_{SC}	TC_I	0.18	0.1	%/K	
Noise Equivalent Power	NEP	3.6 x10^{14}		W/√Hz	V_R=10 V
Detection Limit	D*	6.1x10^{12}		cm•√Hz/W	

Figure 1. Directional characteristics—horizontal plane $S_{REL}=f(\lambda)$

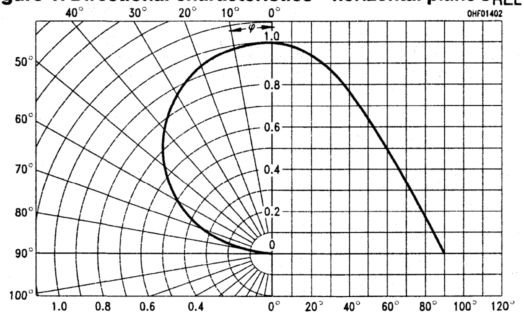


Figure 2. Directional characteristics—horizontal plane $S_{REL}=f(\lambda)$

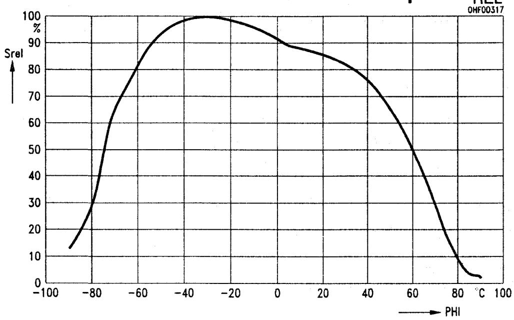


Figure 3. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **204 F**

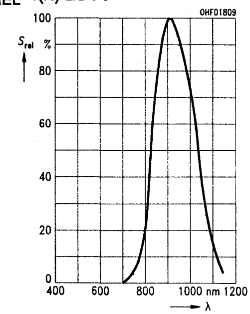


Figure 4. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **204 FA**

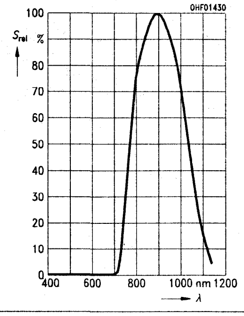


Figure 5. Photocurrent $I_P=f(E_E), V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

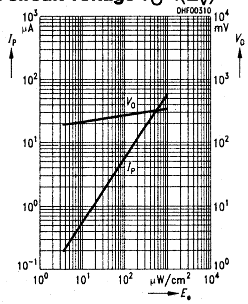


Figure 6. Dark current $I_R=f(T_A)$,
$V_R=10$ V, E=0

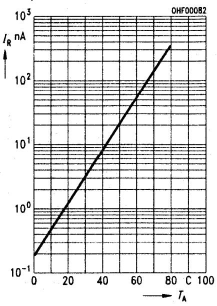


Figure 7. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

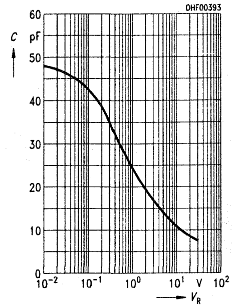


Figure 8. Dark current
$I_R=f(V_R)$, E=0

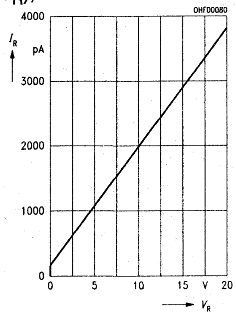
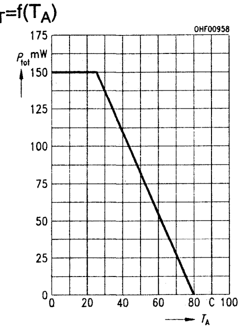


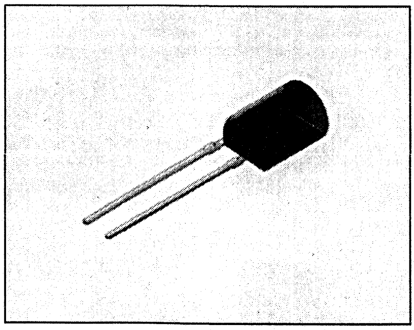
Figure 9. Total power dissipation
$P_{TOT}=f(T_A)$

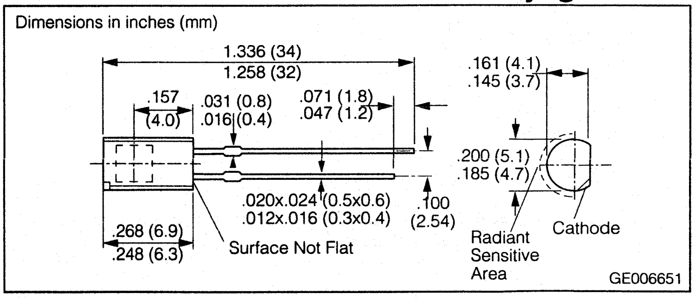


SIEMENS

SFH205F
SFH205FA

Silicon PIN Photodiode
Daylight Filter





FEATURES

- **Especially suitable for applications of 950 nm**
- **Short switching time (typ. 20 ns)**
- **Also available on tape**

APPLICATIONS

- **IR-remote control of stereos and TVs, video tape recorders, dimmers, various equipment**
- **Photointerrupters**

DESCRIPTION

The SFH 205F/205FA silicon planar PIN photodiode is housed in a plastic package that serves as both a filter and a window for infrared emission. Its terminals are solder tabs at 0.1" (2.54 mm) lead spacing. The cathode marking is stamped at the package edge.

Key features include low junction capacitance, high cut-off frequency, short switching times.

This versatile photodetector can be used as either a diode or as a voltaic cell.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55 to +100°C
Soldering Temperature
(2 mm from case bottom) (T_S) t≤3 s .... 230°C
Reverse Voltage (V_R) .... 32 V
Power Dissipation (P_{TOT}) T_A=25°C ...... 150 mW

Characteristics T_A=25°C, λ=950 nm

Parameter		Sym.	Value	Unit	Condition
Spectral Sensitivity		S	60 (≥45)	μA	V_R=5 V, E_E=1 mW/cm²
Wavelength, Maximum Sensitivity	SFH205F	λ_{Smax}	950	nm	
	SFH205FA		900		
Spectral Sensitivity Range	SFH205F	λ	800 to 1100		S=10% of S_{MAX}
	SFH205FA		740 to 1100		
Radiant Sensitive Area		A	7.00	mm²	
Radiant Sensitive Area Dimensions		L x W	2.65 x 2.65	mm	
Distance, Chip Surface to Case Surface		H	2.3 to 2.5		
Half Angle		φ	±60	Deg.	
Dark Current		I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	SFH205F	S_λ	0.59	A/W	
	SFH205FA		0.63		λ=870 nm
Quantum Yield	SFH205F	η	0.77	electrons / photon	
	SFH205FA		0.9		λ=870 nm
Open Circuit Voltage	SFH205F	V_O	330 (≥250)	mV	E_e=0.5 mW/cm²
	SFH205FA		350 (≥280)		E_e=1 mW/cm²
Short Circuit Current	SFH205F	I_{SC}	28	μA	E_e=0.5 mW/cm²
	SFH205FA		56		E_e=1 mW/cm²
Rise and Fall Time, Photocurrent		t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 μA
Forward Voltage		V_F	1.3	V	I_F=100 mA, E_E=0
Capacitance		C_0	72	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O		TC_V	-2.6	mV/K	
Temperature Coefficient I_{SC}	SFH205F	TC_I	0.18	%/K	
	SFH205FA		0.03		
Noise Equivalent Power	SFH205F	NEP	4.3 x 10^{-14}	W/√Hz	V_R=10 V
	SFH205FA				
Detection Limit	SFH205F	D*	6.2 x 10^{12}	cm•√Hz/W	V_R=10 V
	SFH205FA				

Photodiodes 11

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

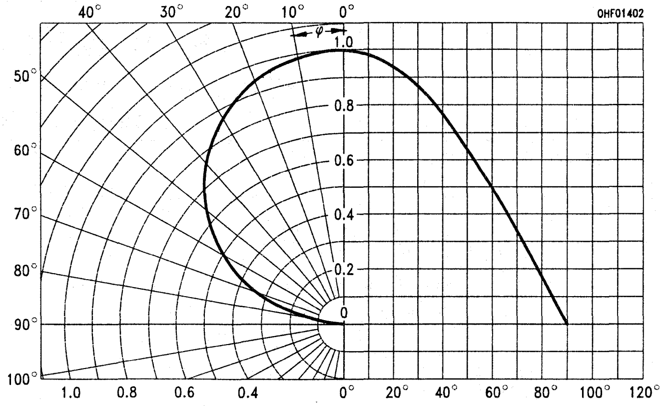


Figure 6. Dark current $I_R=f(V_R)$, E=0

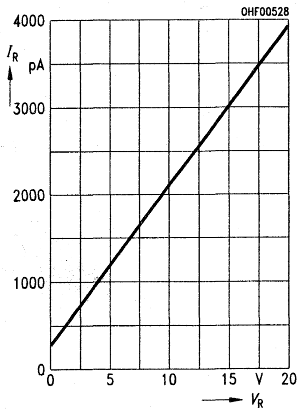


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **SFH205F**

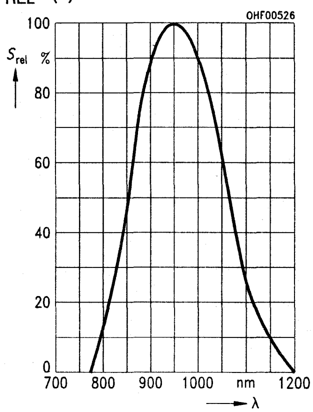


Figure 4. Photocurrent $I_P=f(E_E)$, V_R= 5 V **Photocurrent** $I_P=f(E_E)$, V_R= 5 V

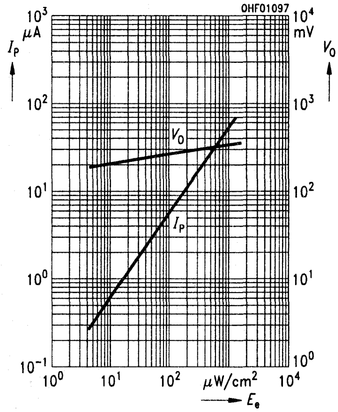


Figure 7. Capacitance $C=f(V_R)$, f=1 MHz, E=0

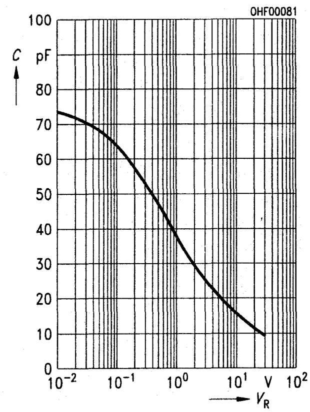


Figure 3. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **SFH205FA**

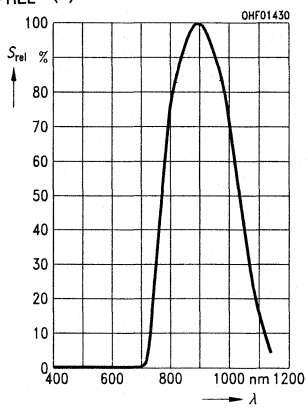


Figure 5. Total power dissipation $P_{TOT}=f(T_A)$

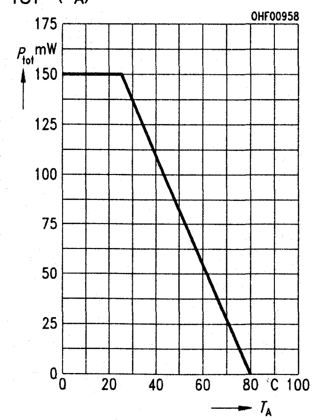
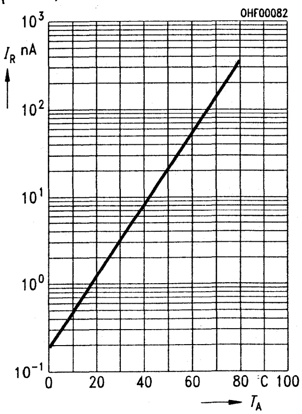


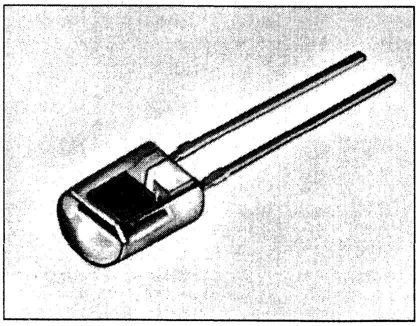
Figure 8. Dark current $I_R=f(T_A)$, V_R=10 V, E=0

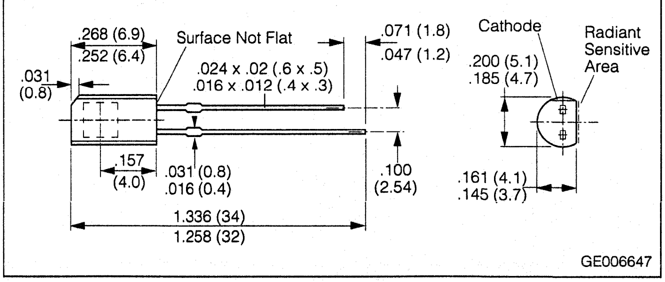


SIEMENS

SFH 206K

PIN Photodiode





FEATURES

- **Especially suitable for applications from 400 nm to 1100 nm**
- **Short switching time (typ. 20 ns)**
- **Also available on tape**

APPLICATIONS

- **Computer-controlled flashes**
- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The SFH 206K silicon planar PIN photodiode is housed in a colorless transparent plastic package. Its terminals are solder tabs at 0.1" (2.54 mm) lead spacing. The cathode marking is stamped at the package edge.

Key features include low junction capacitance, high cutoff frequency, short switching times.

This versatile photodetector can be used as either a diode or as a voltaic cell.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Soldering Temperature
(≥2 mm from case bottom) (T_s) t≤3 s.... 230°C
Reverse Voltage (V_R).................................. 32 V
Power Dissipation (P_{TOT}) T_A=25°C .... 150 mW

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	80 (≥50)	nm	V_R=5 V,
Wavelength, Max. Sensitivity	λ_{Smax}	850		
Spectral Sensitivity Range	λ	400 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.00	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.65x2.65	mm	
Distance, Chip Surface to Case Surface	H	1.2 to 1.4		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 mV
Spectral Sensitivity	S_λ	0.62	A/W	λ=850 nm
Quantum Yield	η	0.9	electrons / photon	
Open Circuit Voltage	V_O	365 (≥310)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	80	μA	
Rise and Fall Time, Photocurrent	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 μA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E_E=0
Capacitance	C_0	72	pF	V_R=0 V, f=1 MHz, E_V=0 lx
Temp. Coefficient V_O	TC_V	-2.6	mV/K	
Temp. Coefficient I_S	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	4.2 x10^{-14}	W/√Hz	V_R=10 V, λ=850 nm
Detection Limit	D*	6.3x10^{12}	cm•√Hz/W	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

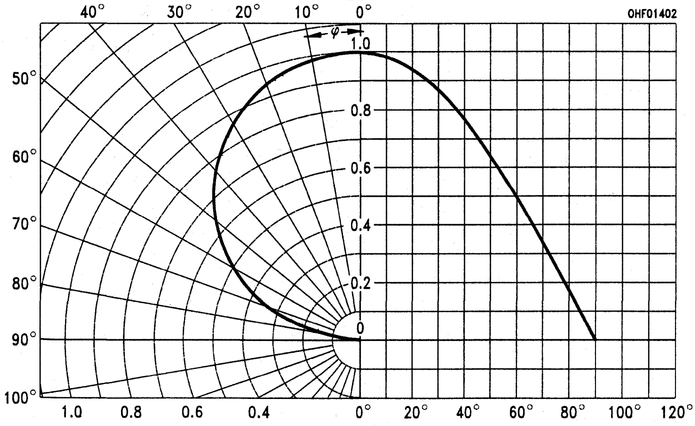


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

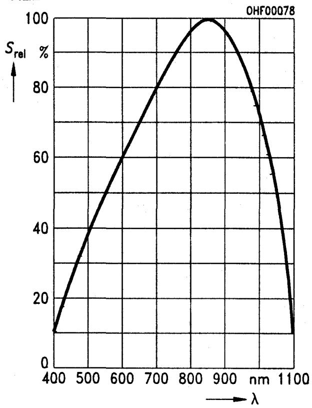


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

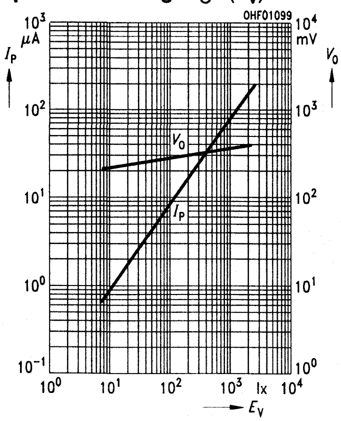


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

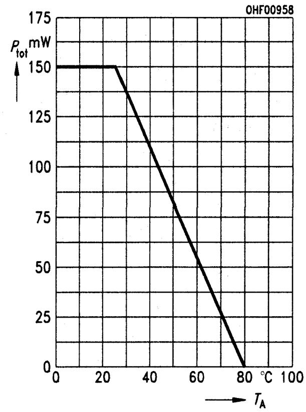


Figure 5. Dark current
$I_R=f(V_R)$, E=0

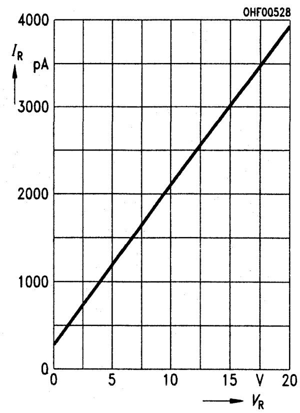


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

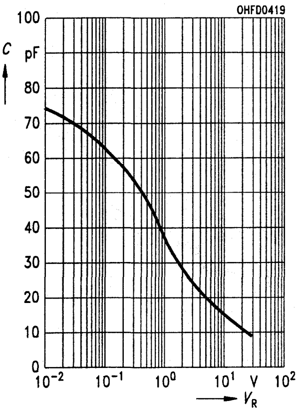
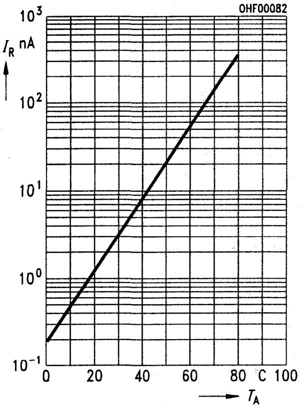
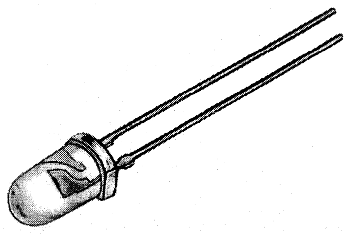


Figure 7. Dark current
$I_R=f(T_A)$, $V_R=10$, E=0



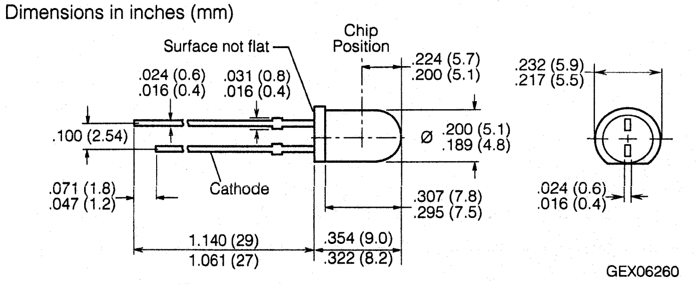
SIEMENS

SFH 213
DAYLIGHT FILTER SFH 213FA
Very Short Switching Time Silicon NPN Photodiode



SFH 213

Dimensions in inches (mm)



FEATURES

- **Especially suitable for applications**
  - **SFH 213: 400 nm to 1100 nm**
  - **SFH213FA: 880nm**
- **Short switching time (typ. 5 ns)**
- **T1¾ (5 mm) LED plastic package**
- **Also available on tape**

APPLICATIONS

- **Industrial electronics**
- **For control and drive circuits**
- **Photointerrupters**
- **Fiber optic transmission systems**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55° to +100°C
Soldering Temperature 2 mm from case bottom (T_s) t ≤3 s .... 300°C
Reverse Voltage (V_R) .... 50 V
Total Power Dissipation (P_{TOT}) ..... 100 mW

Characteristics T_A=25°C

Parameter	Sym.	213	213FA	Unit	Condition
Spectral Sensitivity	S	135 (≥100)		nA/x	V_R=5 V, Std. Light A, T=2856 K
			90(≥65)	µA	V_R=5 V, λ=870 nm, E_e=1 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	850	900	nm	
Spectral Sensitivity Range	λ	400–1100	750–1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	1		mm^2	
Radiant Sensitive Area Dimensions	L x W	1 x 1		mm	
Distance, Chip Surface to Case Surface	H	5.1–5.7			
Half Angle	φ	±10		Deg.	
Dark Current	I_R	1 (≤5)		nA	V_R=20 V
Spectral Sensitivity	S_λ	0.62	0.59	A/W	λ=850 nm
Quantum Yield	η	0.89	0.86	electrons/photon	
Open Circuit Voltage	V_O	430 (≥ 350)		mV	E_V=1000 lx, Std. Light A, T=2856 K
			380 (≥ 300)		E_e=0.5 mW/cm^2, λ=870 nm
Short Circuit Current	I_{SC}	125		µA	E_V=1000 lx, Std. Light A, T= 2856 K
			42		E_e=0.5 mW/cm^2, λ=870 nm
Rise and Fall Time, Photocurrent	t_R, t_F	5		ns	R_L=50 Ω, V_R=20 V, λ=850 nm, I_p=800 µA
Forward Voltage	V_F	1.3		V	I_F=80 mA, E=0
Capacitance	C_O	11		P_F	V_R =0 V, f=1 MHz, E=0
Temp. Coefficient, V_O	TC_V	-2.6		mV/K	
Temp. Coefficient, I_{SC}	TC_I	0.18		%/K	Std. Light A λ=870 nm
			0.2		
Noise Equivalent Power	NEP	2.9x10^{-14}		W/√Hz	V_R =10 V, λ=850 nm
Detection Limit	D*	3.5x10^{12}		cm.√Hz/W	

Figure 1. Directional characteristics $S_{rel}=f(\varphi)$

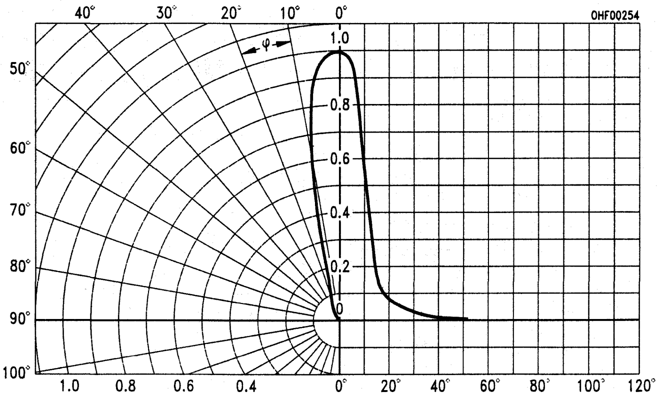


Figure 6. Total power dissipation $P_{TOT}=f(T_A)$

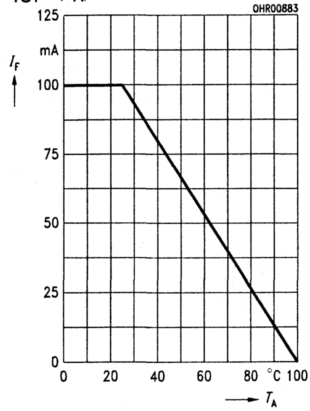


Figure 2. Relative spectral sensitivity, $S_{rel}=f(\lambda)$ SFH213

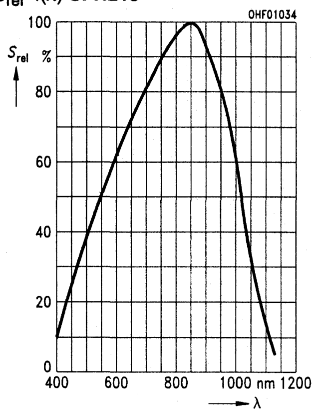


Figure 4. Photocurrent $I_P=f(E_V)$, $V_R=5$ V Open-circuit voltage $V_O=f(E_V)$, SFH 213

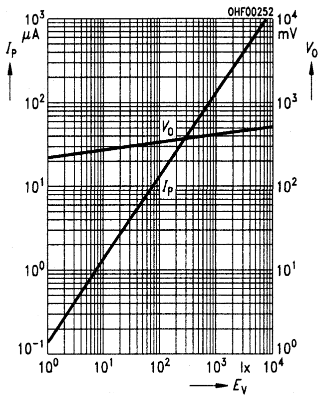


Figure 7. Dark current $I_R=f(V_R)$, E=0

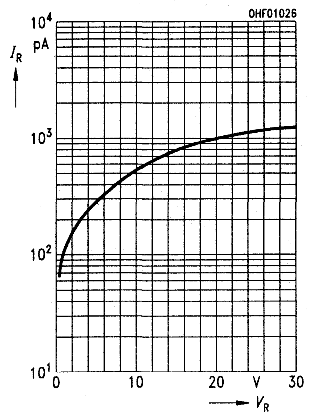


Figure 3. Relative spectral sensitivity, $S_{rel}=f(\lambda)$ SFH213FA

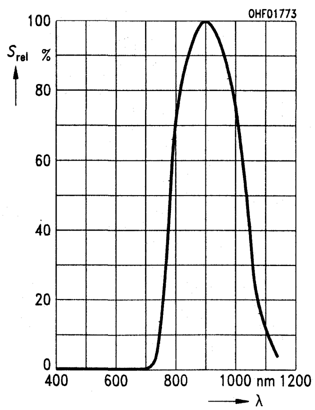
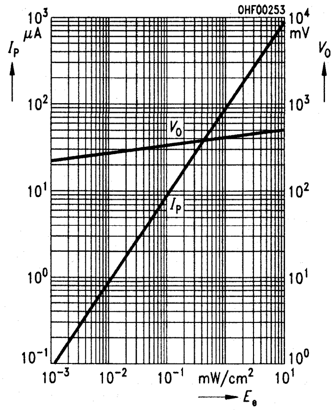


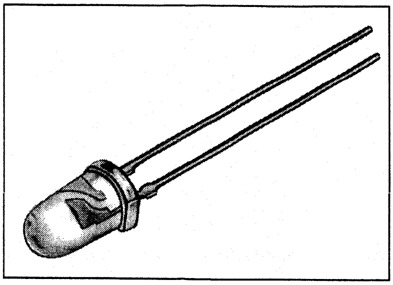
Figure 5. Photocurrent $I_P=f(E_e)$, $V_R=5$ V, Open-circuit voltage $V_O=f(E_e)$, SFH213FA



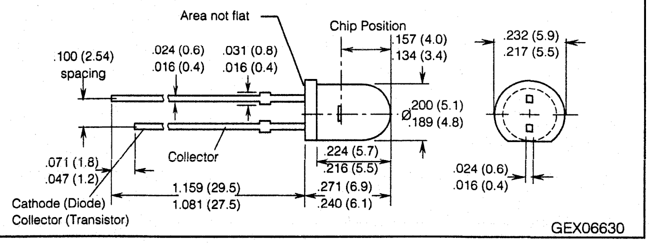
SIEMENS

SFH214
SFH214FA

Very Short Switching Time Silicon NPN Photodiode



Dimensions in inches (mm)



FEATURES
- **Especially suitable for applications**
  - **SFH 214: 440 nm to 1100 nm**
  - **SFH214FA: 880nm**
- **Short switching time (typ. 5 ns)**
- **Also available on tape**
- **LED plastic package: T1¾ (5 mm)**

APPLICATIONS
- **Industrial electronics**
- **For control and drive circuits**
- **Photointerrupters**
- **Fiber optic transmission systems**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG})........................ –55° to +100°C
Soldering Temperature, 2 mm from case bottom (T_s) t ≤3 s ....300°C
Reverse Voltage (V_R)..............................50 V
Total Power Dissipation (P_{TOT}) ....100 mW

Characteristics (T_A=25°C)

Parameter	Sym.	SFH214	SFH214FA	Unit	Condition
Spectral Sensitivity	S	45(≥30)		nA/x	V_R=5 V, Std. Light A, T=2856 K
			25(≥20)	µA	V_R=5V, λ=870 nm, E_e=1 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	850	900	nm	
Spectral Sensitivity Range	λ	400–1100	750–1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	1		mm^2	
Radiant Sensitive Area Dimensions	L x W	1 x 1		mm	
Distance, Chip Surface to Case Surface	H	3.4–4.0			
Half Angle	φ	±40		Deg.	
Dark Current	I_R	1 (≤5)		nA	V_R=20 V
Spectral Sensitivity	S_λ	0.62	0.59	A/W	λ=850 nm
Quantum Yield	η	0.89	0.86	electrons / photon	
Open Circuit Voltage	V_o	380 (≥ 300)		mV	E_V=1000 lx, Std. Light A, T = 2856 K
			340 (≥ 290)		E_e=0.5 mW/cm^2, λ=870 nm
Short Circuit Current	I_{SC}	42		µA	E_V=1000 lx, Std. Light A, T= 2856 K
			12		E_e=0.5 mW/cm^2, λ=870 nm
Rise and Fall Time, Photocurrent	t_R, t_F	5		ns	R_L=50 Ω, V_R=20 V, λ=850 nm, I_p=800 µA
Forward Voltage	V_F	1.3		V	I_F=80 mA, E=0
Capacitance	C_O	11		P_F	V_R =0 V, f=1 MHz, E=0
Temperature Coefficient, V_O	TC_V	-2.6		mV/K	
Temperature Coefficient, I_{SC}	TC_I	0.18		%/K	Normlicht/Std. Light A
			0.2		λ=850 nm
Noise Equivalent Power	NEP	2.9×10^{-14}		W/√Hz	V_R =0 V, λ=850 nm
Detection Limit	D*	3.5×10^{12}		cm.√Hz/W	V_R =20 V, λ=850 nm

Figure 1. Directional characteristics $S_{rel}=f(\varphi)$

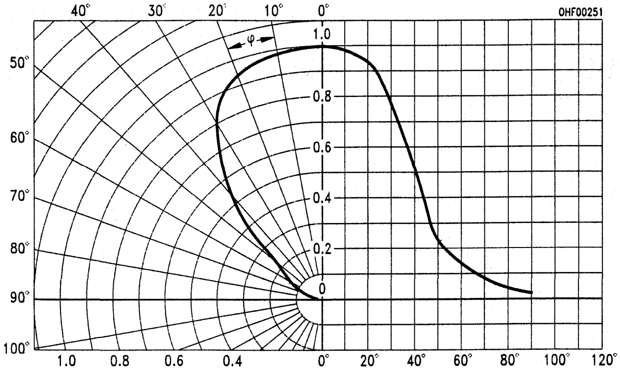


Figure 6. Total power dissipation $P_{TOT}=f(T_A)$

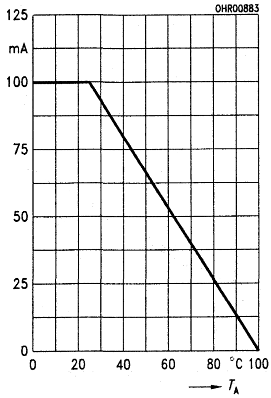


Figure 2. Relative spectral sensitivity, SFH214 $S_{rel}=f(\lambda)$

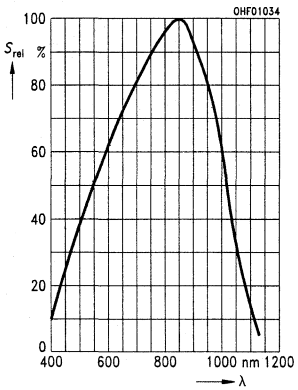


Figure 4. Photocurrent $I_P=f(E_V)$, $V_R=5$ V Open-circuit voltage $V_O=f(E_V)$, SFH 214

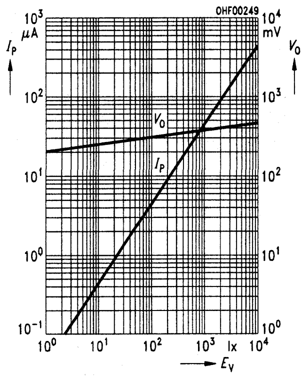


Figure 7. Dark current $I_R=f(V_R)$, E=0

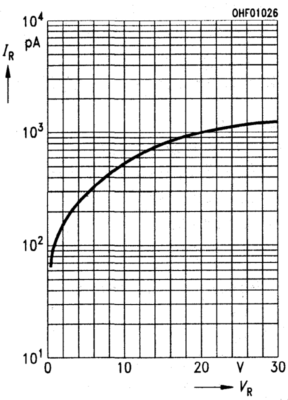


Figure 3. Relative spectral sensitivity, SFH214FA $S_{rel}=f(\lambda)$

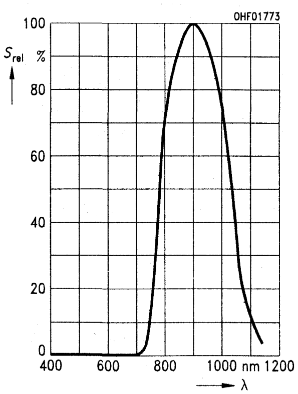
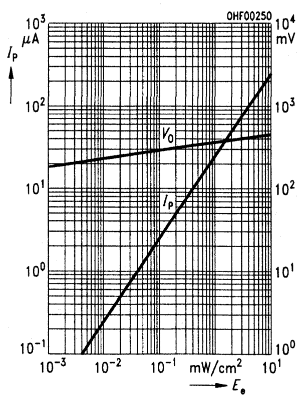
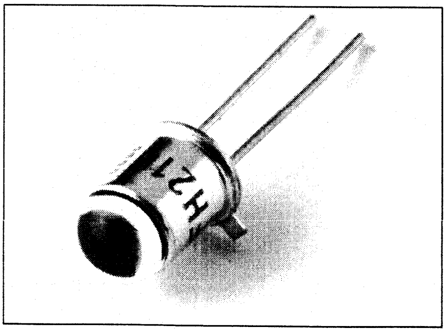


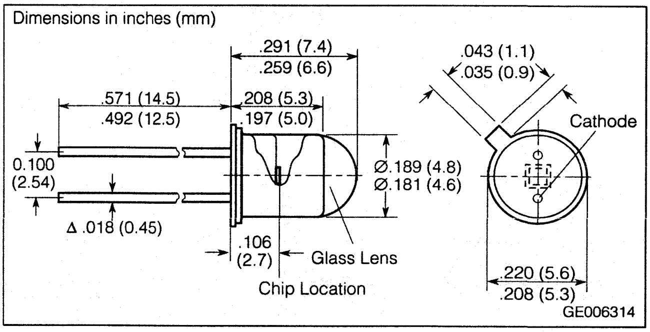
Figure 5. Photocurrent $I_P=f(E_e)$, $V_R=5$ V, Open-circuit voltage $V_O=f(E_e)$, SFH214FA



SIEMENS

SFH 216
Silicon PIN Photodiode





FEATURES
- **Especially suitable for applications from 350 nm to 1100 nm**
- **Short switching time (typ. 5 ns)**
- **Hermetically sealed metal package (TO-18)**

APPLICATION
- **Optical sensor of high modulation bandwidth for light pens**

DESCRIPTION
The SFH 216 silicon planar PIN photodiode includes N-Si material, which provides positive front and negative back contact. This photodetector can be used as either a diode with reverse voltage or as a voltaic cell.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})........................−40° to +125°C
Soldering Temperature
(2 mm from case bottom) (T_S) t≤3 s............230°C
Reverse Voltage (V_R).. 50 V
Power Dissipation (P_{TOT}) T_A=25°C............. 250 mW

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	50 (≥35)	nA/lx	V_R=5 V
Wavelength, Maximum Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	350 to 1150		S=10% S_{MAX}
Radiant Sensitive Area	A	1	mm^2	
Radiant Sensitive Area Dimensions	L x W	1 x 1	mm	
Distance, Chip Surface to Case Top Edge	D	4.2 to 5.0		
Half Angle	φ	±12	Deg.	
Dark Current	I_R	1 (≤5)	nA	V_R=20 V
Spectral Sensitivity	S_λ	0.55	A/W	λ=850 nm
Quantum Yield	η	0.80	electrons / photon	
Open Circuit Voltage(1)	V_O	410 (≥350)	mV	E_V=1000 lx
Short Circuit Current(1)	I_{SC}	50	µA	
Rise and Fall Time of Photocurrent	t_R, t_F	5	ns	R_L=50 Ω, V_R=20 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	11	pF	V_R=1 V, f=1 MHz, E=0
Temp. Coefficient V_O	TC_V	-2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.2	%/K	
Noise Equivalent Power	NEP	3.3 x 10^{-14}	W/√Hz	V_R=20 V, λ=850 nm
Detection Limit	D*	3.1 x 10^{12}	cm•√Hz/W	

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

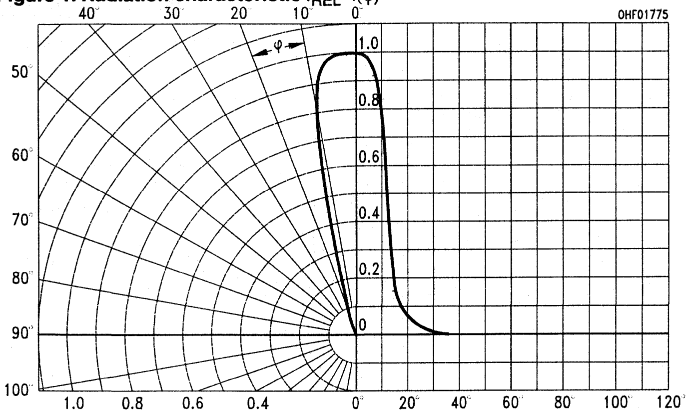


Figure 2. Relative spectral emission
$S_{REL}=f(\lambda)$

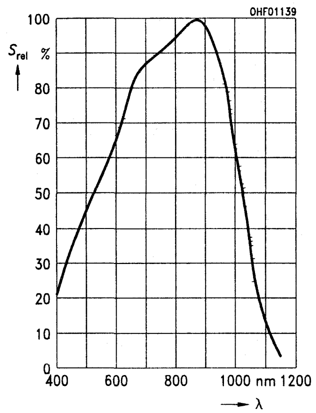


Figure 3. Photo current $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

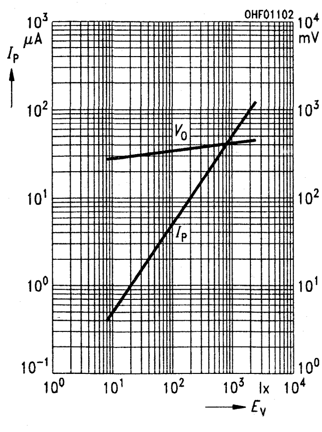


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

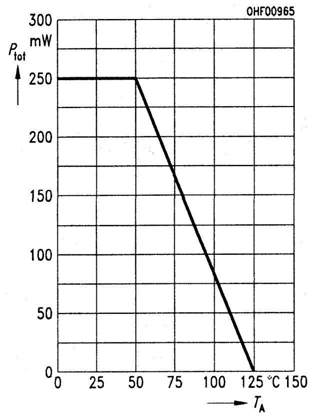


Figure 5. Dark current $I_R=f(V_R)$, E=0

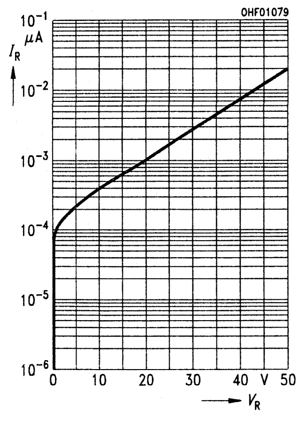


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

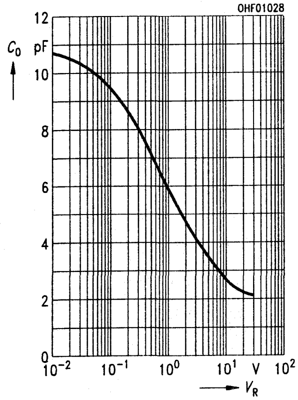
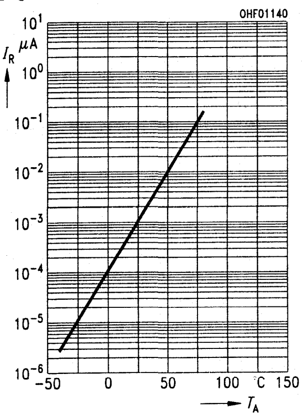


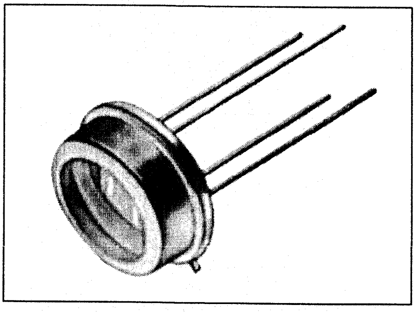
Figure 7. Dark current $I_R=f(T_A)$, $V_R=20$ V, E=0

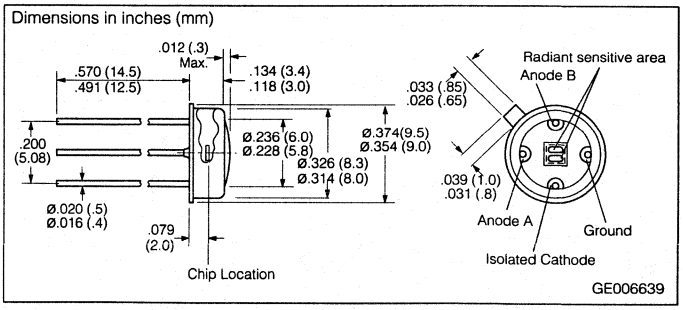


SIEMENS

SFH 221

Silicon Differential Photodiode





FEATURES

- **Especially suitable for applications from 400 nm to 1100 nm**
- **High photosensitivity**
- **Hermetically sealed metal package (similar to TO-5)**
- **Double diode with extremely high homogeneousness**

APPLICATIONS

- **Follow-up controls**
- **Edge drives**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The SFH 221 is a silicon planar photodiode that can be operated as a photodiode with reverse voltage or as a photovoltaic cell. N-Si material provides positive front and negative back contacts.

Applications include follow-up controls, edge drives, path and corner scanning, industrial electronics, and measurement and control.

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +125°C
Soldering Temperature (1.5 mm from case bottom) (T_S) t≤3 s .... 230°C
Reverse Voltage (V_R) .... 10 V
Power Dissipation (P_{TOT}) T_A=25°C .... 50 mV
Insulation Voltage Versus Package (V_{IS}) .... 100 V

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	24 (≥15)	nA/lx	V_R=5 V
Wavelength, Maximum Sensitivity	λ_{Smax}	900	nm	
Spectral Sensitivity Range	λ	400 to 1100		S=10% S_{MAX}
Radiant Sensitive Area	A	1.54	mm²	
Radiant Sensitive Area Dimensions	L x W	0.7 x 2.2	mm	
Distance, Chip Surface to Case Top	H	1.1 to 1.6		
Half Angle	φ	±55	Deg.	
Dark Current	I_R	10 (≤100)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.55	A/W	λ=850 nm
Maximum Deviation, Spectral Sensitivity System from Average	Δ_S	±5	%	
Quantum Yield	η	0.80	electrons / photon	λ=850 nm
Open Circuit Voltage	V_O	330 (≥280)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	24	µA	
Insulation Current	I_{IS}	0.1 (≤1)	nA	V_{IS}=100 V
Rise and Fall Time of Photocurrent 10% to 90% and 90% to 10%	t_R, t_F	500	ns	R_L=1 kΩ, V_R=5 V, λ=850 nm, I_P=25 µA
Forward Voltage	V_F	1.0	V	I_F=40 mA, E=0
Capacitance	C_0	25	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O	TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	1.0×10^{-13}	W/√Hz	V_R=10 V, λ=850 nm
Detection Limit	D*	1.2×10^{12}	cm•√Hz/W	

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

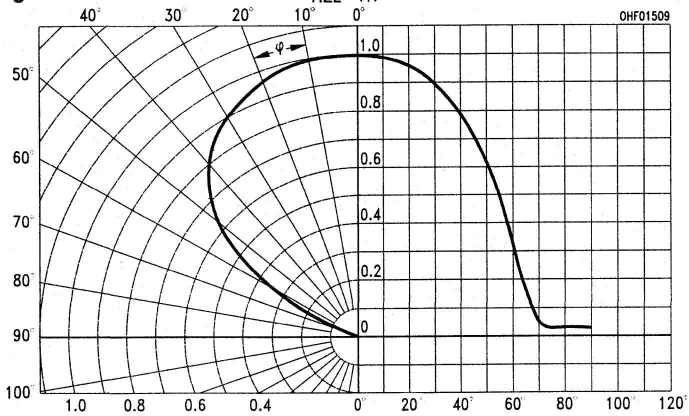


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

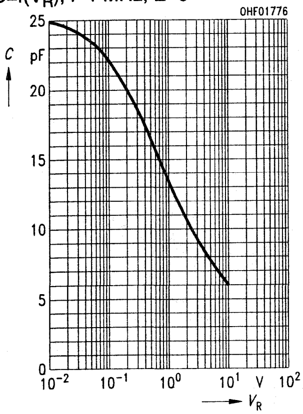


Figure 2. Relative spectral emission
$S_{REL}=f(\lambda)$

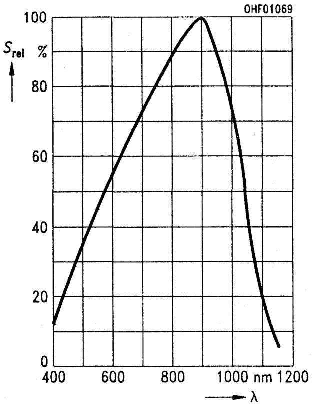


Figure 4. Power dissipation
$P_{TOT}=f(T_A)$

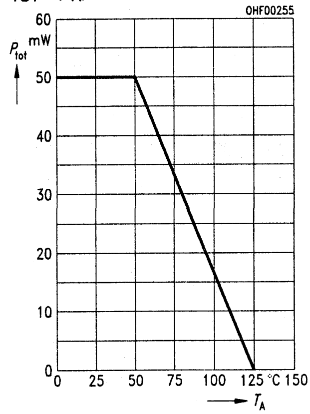


Figure 7. Dark current $I_R=f(T_A)$,
$V_R=10$ V, E=0

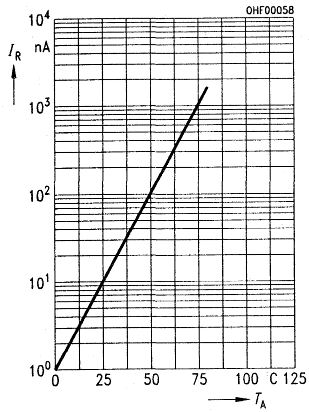


Figure 3. Photocurrent $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

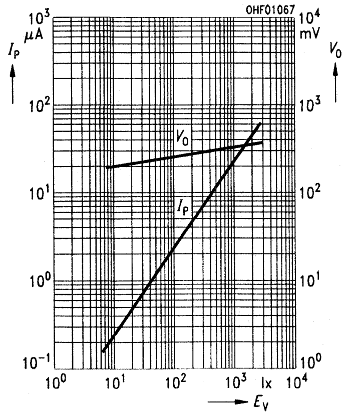
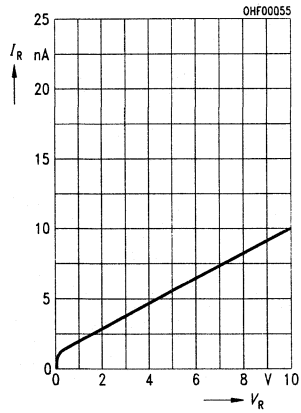


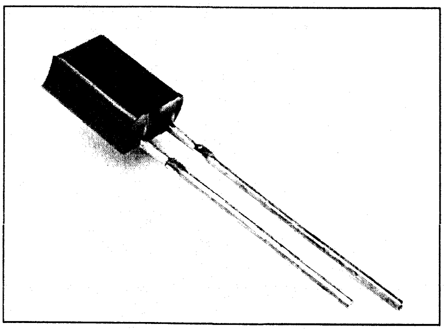
Figure 5. Dark current $I_R=f(V_R)$, E=0

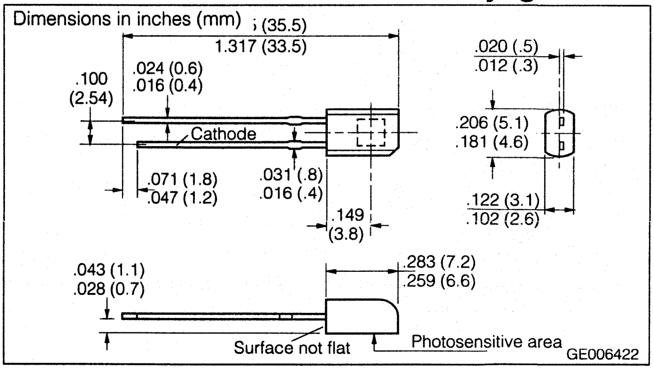


SIEMENS

SFH 225FA

Silicon PIN Photodiode Daylight Filter





FEATURES

- **Especially suitable for applications of 880 nm**
- **Short-switching time (typ. 20 ns)**
- **Also available on tape**

APPLICATIONS

- **IR-remote control of stereos and TVs, video tape recorders, dimmers, various equipment**
- **Photointerrupters**

DESCRIPTION

The SFH 225FA is a silicon planar PIN photodiode housed in a black epoxy package that acts as a daylight rejection filter. It can be operated as a photodiode with reverse voltage or as a photovoltaic cell.

Features include low junction capacitance, short switching times, and a high cutoff frequency. Its small package and 0.1" (2.54 mm) lead spacing make it suitable for high density packaging. Due to its low signal/noise ratio and IR filter, it is also effective at low light levels.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –40° to +80°C
Soldering Temperature (2 mm from case bottom) (T_S) t≤3 s........... 230°C
Reverse Voltage (V_R) .... 20 V
Power Dissipation (P_{TOT}) .... 150 mW

Characteristics T_A=25°C, λ=870

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	34 (≥25)	µA	V_R=5 V, E_E=1 mW/cm^2
Wavelength, Maximum Sensitivity	λ_{Smax}	900	nm	
Spectral Sensitivity Range	λ	740 to 1120		S=10% S_{MAX}
Radiant Sensitive Area	A	4.84	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.20 x 2.20	mm	
Distance, Chip Surface to Case Surface	H	0.6 to 0.8		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	2 (≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.63	A/W	
Quantum Yield	η	0.90	electrons / photon	
Open Circuit Voltage	V_O	330 (≥250)	mA	E_e=0.5 mW/cm^2
Short Circuit Current	I_{SC}	17	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_0	48	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_O	TC_V	-2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.18	%/K	
Noise Equivalent Power	NEP	3.6 x 10^{-14}	W/√Hz	V_R=10 V
Detection Limit	D*	6.1 x 10^{12}	cm•√Hz/W	

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

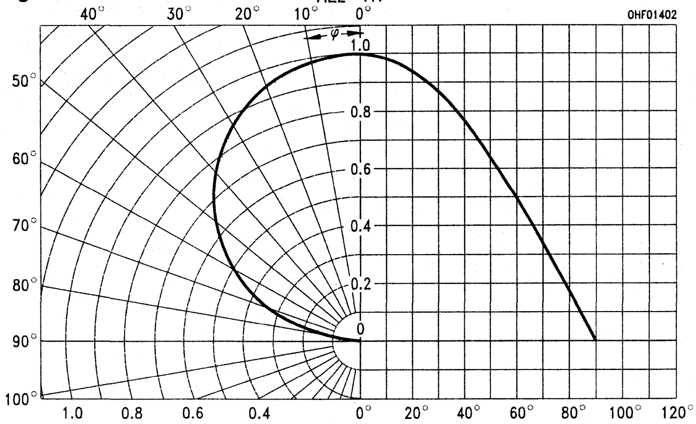


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

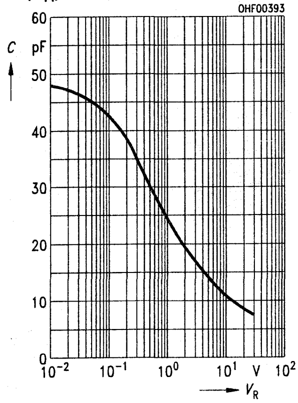


Figure 2. Relative spectral emission
$S_{REL}=f(\lambda)$

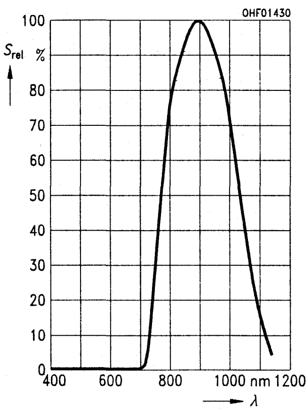


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

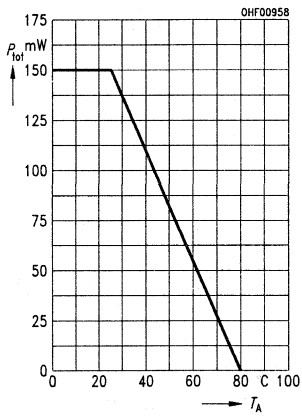


Figure 7. Dark current $I_R=f(T_A)$,
V_R=10 V, E=0

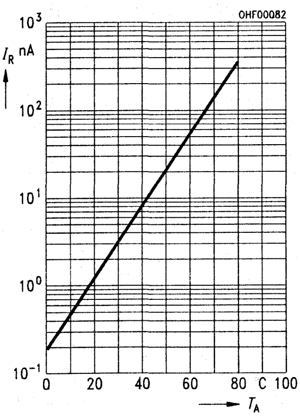


Figure 3. Photocurrent $I_P=f(E_V)$, V_R=5 V
Open circuit voltage $V_O=f(E_V)$

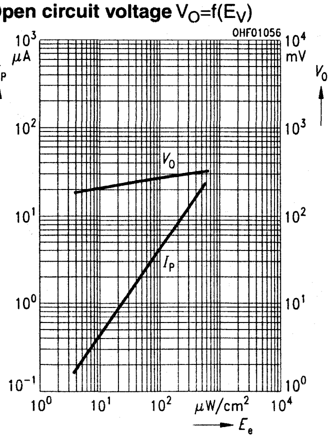
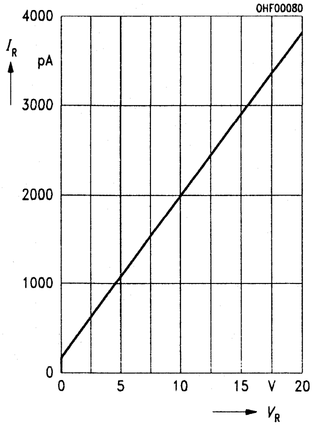
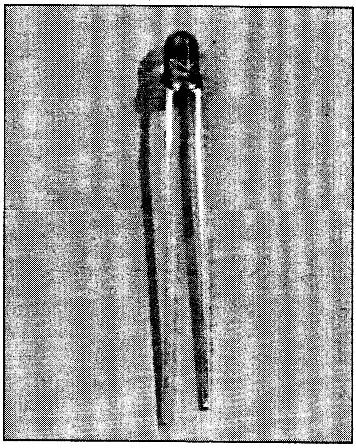


Figure 5. Dark current $I_R=f(V_R)$, E=0

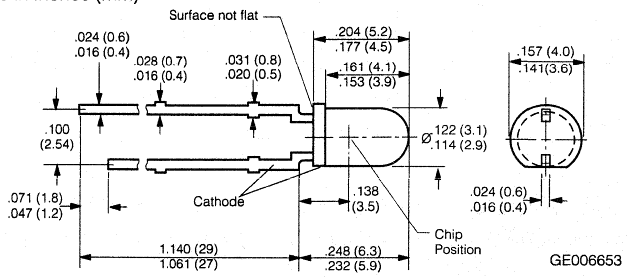


SIEMENS

SFH229
DAYLIGHT FILTER SFH229FA
Silicon PIN Photodiode



Dimensions in inches (mm)



FEATURES
- **Especially suitable for applications**
  - **SFH 229: 380 nm to 1100 nm**
  - **SFH 229 FA: 880 nm**
- **Short switching time (typ. 10 ns)**
- **T1 (3 mm) LED plastic package**
- **Also available on tape**

APPLICATIONS
- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) ...... –55 to +100°C

Soldering Temperature (≥2 mm from case bottom) (T_S) t≤3 s .... 230°C

Reverse Voltage (V_R)...................... 20 V

Total Power Dissipation (P_{TOT}) .... 150 mW

Characteristics T_A=25°C

Parameter		Sym.	Value	Unit	Condition
Spectral Sensitivity	SFH229	S	28 (≥18)	nA/lx	V_R=5 V, Std. light A, T=2856 K
	SFH229FA		20 (≥10.8)	µA	V_R=5 V, λ=950 nm, E_e=0.5 mW/cm^2
Wavelength, Max. Sensitivity	SFH229	λ_{Smax}	860	nm	
	SFH229FA		900		
Spectral Sensitivity Range	SFH229	λ	380 to 1100		S=10%, S_{max}
	SFH229FA		730 to 1100		
Radiant Sensitive Area		A	0.3	mm^2	
Radiant Sensitive Area Dimensions		L x W	0.56 x 0.56	mm	
Distance, Chip Surface to Case Surface		H	2.4 to 2.8		
Half Angle		φ	±17	Deg.	
Dark Current		I_R	50 (≤5000)	pA	V_R=10 V
Spectral Photosensitivity	SFH229	S_λ	0.62	A/W	λ=850 nm
	SFH229FA		0.60		
Quantum Yield	SFH229	η	0.90	electrons / photon	λ=850 nm
	SFH229FA		0.88		
Open Circuit Voltage	SFH229	V_O	450 (≥400)	mV	E_V=1000 lx, Std. Light A, T=2856 K
	SFH229FA		420 (≥370)		E_e=0.5 mW/cm^2, λ=950 nm
Short Circuit Current	SFH229	I_{SC}	27	µA	E_V=1000 lx, Std. Light A, T=2856 K
	SFH229FA		9		E_e=0.5 mW/cm^2, λ=950 nm
Rise and Fall Time, Photocurrent		t_R, t_F	10	ns	R_L=50 Ω, V_R=10 V, λ=850 nm I_P=800 µA
Forward Voltage		V_F	1.3	V	I_F=100 mA, E=0
Capacitance		C_0	13	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient V_O		TC_V	-2.6	mV/K	
Temperature Coefficient I_{SC}	SFH229	TC_I	0.18	%/K	Std. Light A,
	SFH229FA		0.2		λ=950 nm
Noise Equivalent Power		NEP	6.5 x 10^{-15}	W/√Hz	V_R=10 V, λ=850 nm
Detection Limit		D*	8.4 x 10^{12}	cm•√Hz/W	

Photodiodes 11

Figure 1. Directional characteristic $S_{RES}=f(\varphi)$

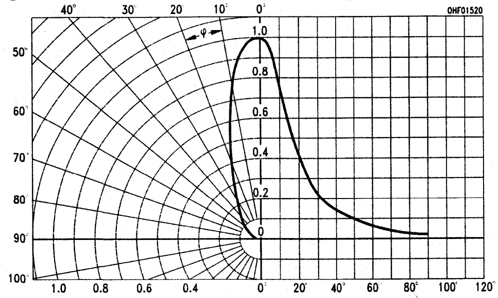


Figure 2A. Relative spectral sensitivity $S_{rel}=f(\lambda)$ **SFH229**

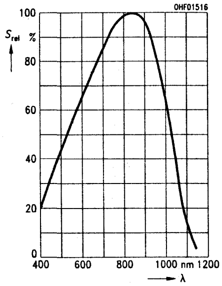
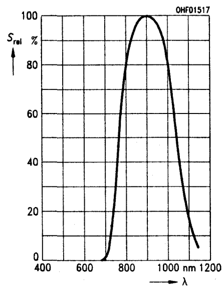


Figure 2B. Relative spectral sensitivity $S_{rel}=f(\lambda)$ **SFH229FA**



igure 3A. Photocurrent, $I_P=f(E_V)$, $V_R=5$ V **Open circuit voltage** $V_L=f(E_V)$ **SFH229**

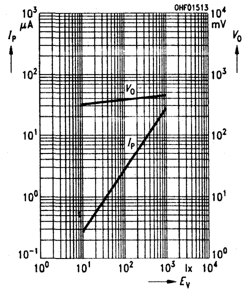


Figure 3B. Photocurrent, $I_P=f(E_V)$, $V_R=5$ V **Open circuit voltage** $V_L=f(E_V)$ **SFH229FA**

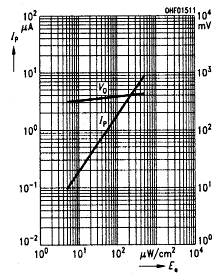


Figure 4. Total power dissipation $P_{TOT}=f(T_A)$

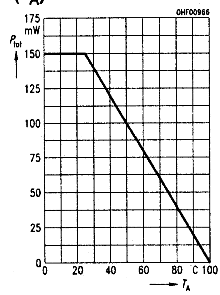


Figure 5. Dark current $I_R=f(V_R)$, E=0

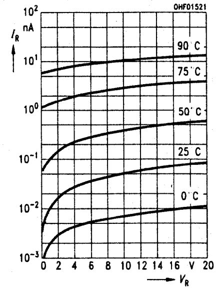


Figure 6. Capacitance $C=f(V_R)$, f=1 MHz, E=0

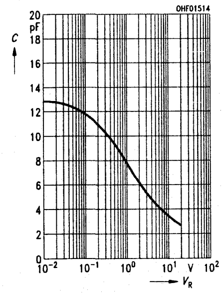
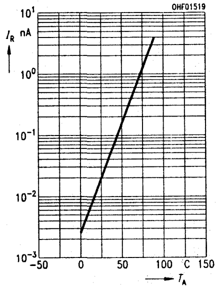


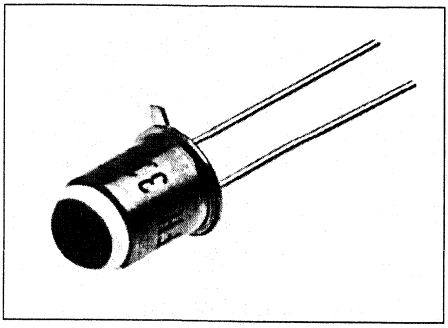
Figure 7. Dark current $I_R=(T_A)$, $V_R=10$ V, E=0

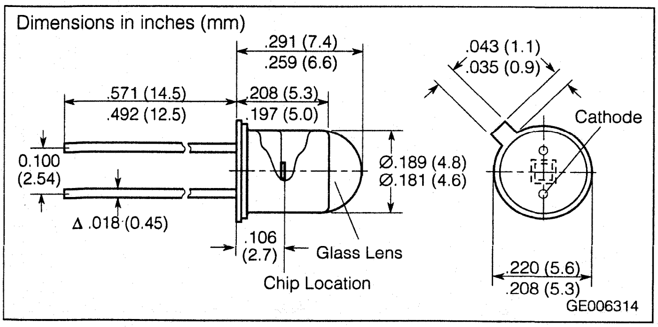


SIEMENS

SFH 231

Germanium PIN Photodiode





FEATURES

- **Especially suitable for applications from 600 nm to 1800 nm**
- **short switching time (typ. 9 ns)**
- **Hermetically sealed metal package (similiar to TO-18)**

APPLICATIONS

- **For control and drive circuits**
- **Spectrophotometers**
- **IR laser detector systems**
- **IR destance measuring equipment**
- **Optical information transmission and measuring instruments**

DESCRIPTION

The SFH 231 is a germanium planar PIN photodiode, designed for the 1100 to 1700 nm wavelength range. It can be used as a diode with reverse voltage or for element operation. N-Ge material provides positive front and negative back contacts.

Maximum Ratings

Operating/Storage Temperature Range
(T_{OP}, T_{STG}) .... –40° to +80°C
Reverse Voltage (V_R) .... 15 V
Power Dissipation (P_{TOT}) T_A=25°C .... 150 mW
Thermal Resistance (R_{THJA}) .... 450 K/W

Characteristics T_A=25°C, λ=1300 nm

Parameter	Sym.	Value	Unit	Condition
Photosensitivity	S_V	130	nA/lx	V_R=0 V, Std. Light A, T=2856 K
	S_E	13 (≥8)		V_R=0 V, E_e=0.25 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	1550	nm	
Spectral Sensitivity Range	λ	600 to 1800		S=10% S_{MAX}
Radiant Sensitive Area	A	1	mm^2	
Radiant Sensitive Area Dimensions	L x W	1 x 1	mm	
Distance, Chip Surface to Case Surface	H	4.2 to 5		
Half Angle	φ	±10	Deg.	
Dark Current	I_R	10 (≤50)	μA	V_R=1 V, E=0
Spectral Sensitivity	S_λ	0.68	A/W	
Quantum Yield	η	0.65	electrons / photon	
Short Circuit Current	I_{SC}	13 (≥8)	μA	E_e=0.25 mW/cm^2
Rise and Fall Time, Photocurrent	t_R, t_F	9	ns	R_L=50 Ω, V_R=1 V, I_P=100 μA
Forward Voltage	V_F	1	V	I_F=100 mA, E=0
Capacitance	C_0	62	pF	V_R=1 V, f=1 MHz, E=0
Noise Equivalent Power	NEP	2.6 x 10^{-12}	W/√Hz	V_R=1 V
Detection Limit	D*	3.8 x 10^{10}	cm•√Hz/W	

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

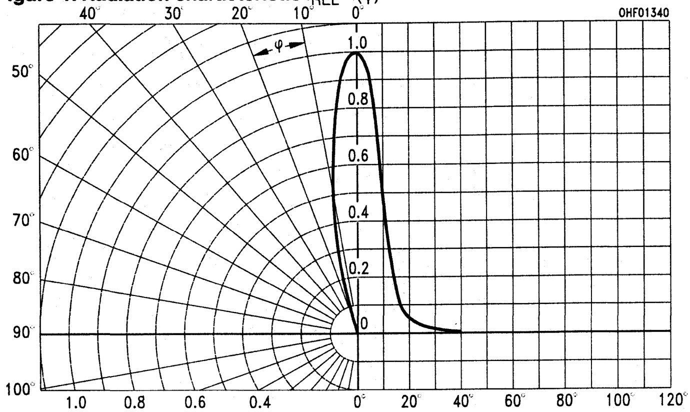


Figure 6. Switching times
$t_R/t_F=f(V_R)$, $R_L=50\ \Omega$

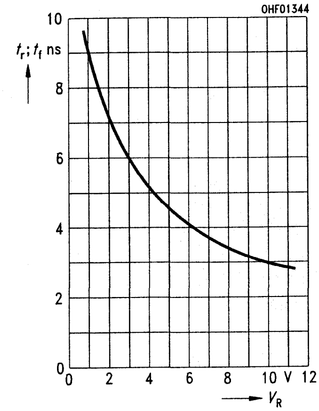


Figure 2. Relative spectral emission
$S_{REL}=f(\lambda)$

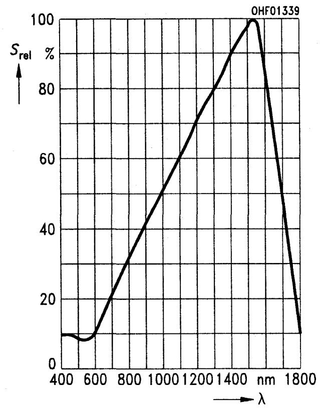


Figure 4. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

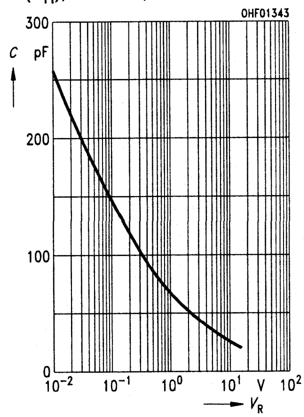


Figure 3. Dark current $I_R=f(V_R)$, E=0

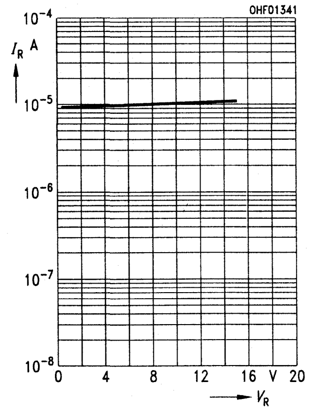
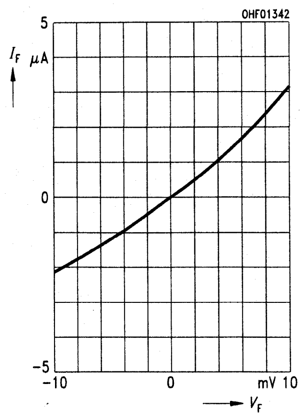


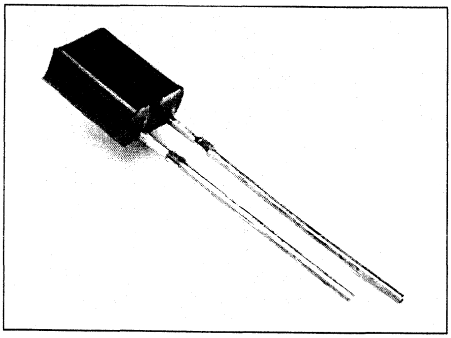
Figure 5. Zero crossover $I_F=f(V_R)$, E=0

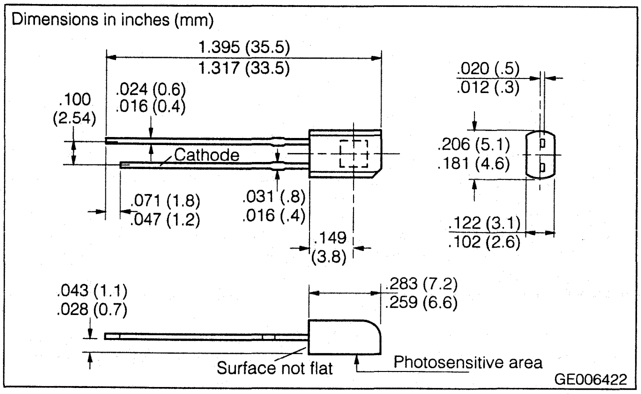


SIEMENS

SFH 235FA

Silicon PIN Photodiode Daylight Filter





FEATURES
- **Especially suitable for applications of 880 nm**
- **Short switching time (typ. 20 ns)**
- **T1¾ (5 mm) LED plastic package**
- **Also available on tape**

APPLICATIONS
- **IR-Remote control of stereos and TVs, video tape recorders, dimmers, various equipment**
- **Photointerrupters**

Maximum Ratings

Operating/Storage
Temperature (T_{OP}, T_{STG}) .... –40°C to +80°C
Soldering Temperature
(2 mm from case bottom) (T_S) t≤3 s .... 230°C
Reverse Voltage (V_R) .... 32 V
Total Power Dissipation (P_{TOT})
T_A=25°C .... 150 mV

Characteristics T_A=25°C, λ=870 nm

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	I_P	50 (≥40)	µA	V_R=5 V E_e=1 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	900	nm	
Spectral Sensitivity Range	λ	740 to 1120		S=10% of S_{MAX}
Radiant Sensitive Area	A	7	mm^2	
Radiant Sensitive Area Dimension	L x W	2.65x2.65	mm	
Distance Chip Surface to Case Surface	H	0.6 to 0.8		
Half Angle	φ	±65	Deg.	
Dark Current	I_R	2(≤30)	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.63	A/W	
Quantum Yield	η	0.9	electrons/photon	
Open Circuit Voltage	V_O	320 (≥250)	mV	E_e=0.5 mW/cm^2
Short Circuit Current	I_{SC}	22	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	20	ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_P=800 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_O	72	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient, V_L	TC_V	-2.6	mV/K	
Temp. Coefficient, I_{SC}	TC_I	0.03	%/K	
Noise Equivalent Power	NEP	4.0x10^{-14}	W/√Hz	V_R=10 V
Detection Limit	D*	6.6x10^{12}	cm•√Hz/W	

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

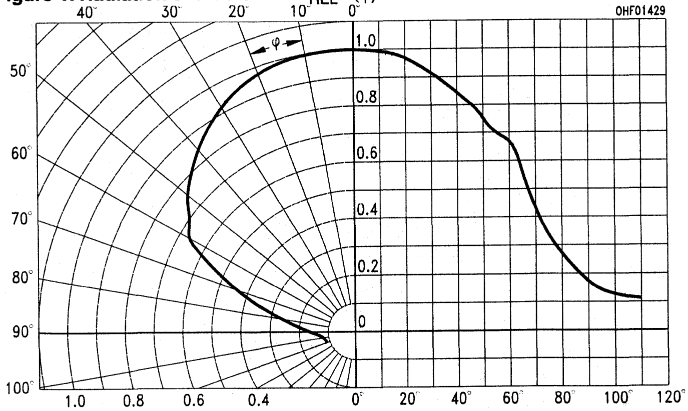


Figure 6. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

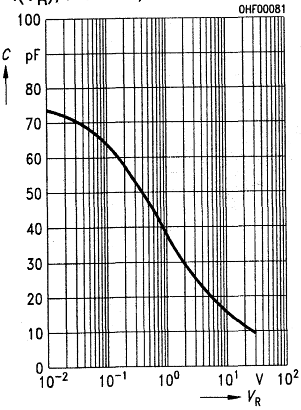


Figure 2. Relative spectral emission
$S_{REL}=f(\lambda)$

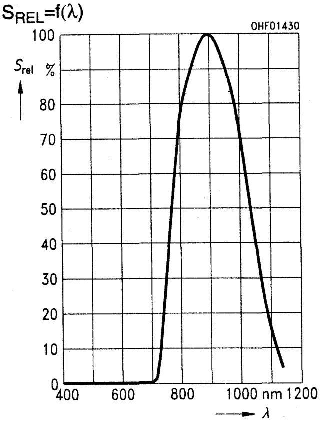


Figure 4. Power dissipation $P_{TOT}=f(T_A)$

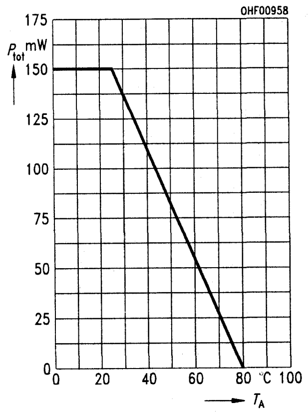


Figure 7. Dark current $I_R=f(T_A)$, V_R=10 V, E=0

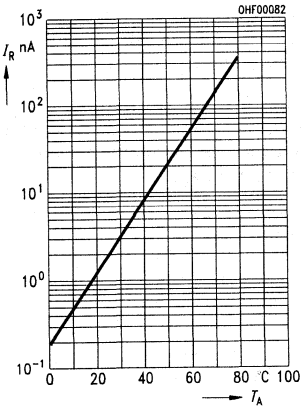


Figure 3. Photo current $I_P=f(E_V)$, V_R=5 V
Open circuit voltage $V_O=f(E_V)$

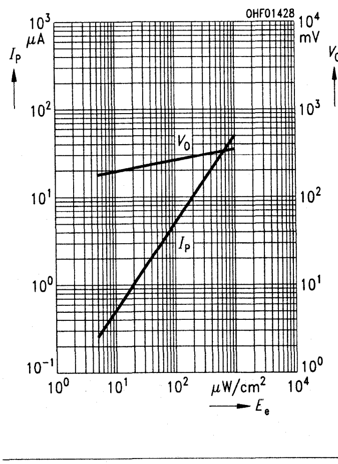
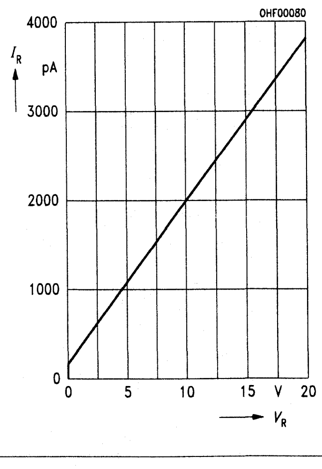


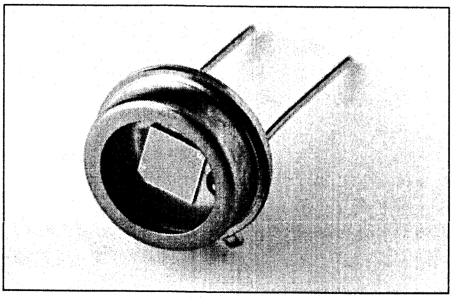
Figure 5. Dark current $I_R=f(V_R)$, E=0



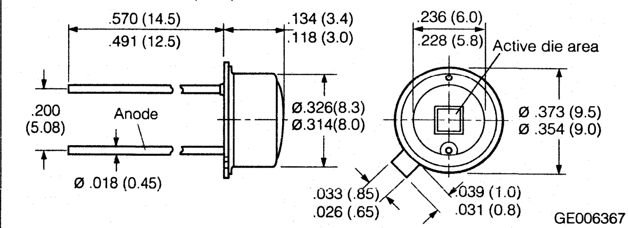
SIEMENS

SFH 291

High UV Sensitivity Silicon Photodiode



Dimensions in inches (mm)



FEATURES

- **Especially suitable for applications from 230 nm to 1100 nm**
- **High photosensitivity in the UV range**
- **Hermetically sealed metal package (similiar to TO-5)**

APPLICATIONS

- **Industrial electronics**
- **For control and drive circuits**
- **Spectrophotometers**
- **Controlling UV radiation in A and B ranges in solariums and/or in ERPOM eraser instru-ments**
- **Flame monitoring in gas and fuel combustion**
- **UV water purification facilities**
- **UV lasers**

DESCRIPTION

The SFH 291 is a silicon planar photodiode that can be used as a diode with reverse voltage or for ele-ment operation. N-Si material provides positive front and negative back contacts.

Maximum Ratings

Operating/Storage
Temperature (T_{OP}, T_{STG})...............–40°C to +80°C
Soldering Temperature
(2 mm from case bottom) (T_S) t≤3 s ....230°C
Reverse Voltage (V_R)..10 V
Power Dissipation (P_{TOT})..............................250 mV

Characteristics T_A=25°C, Std. Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Photosensitivity	S_V	50	nA/lx	V_R=5 V, Standard Light A, T=2856 K
Maximum Photosensi-tivity Wavelength	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	230 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.45	mm^2	
Radiant Sensitive Area Dimensions	L x W	2.73x2.73	mm	
Distance, Chip Surface to Case Surface	H	1.9 to 2.3		
Half Angle	φ	±55	Deg.	
Dark Current	I_R	0.3 (≤1)	nA	V_R=5 V, E=0
Spectral Sensitivity	S_λ	0.15	A/W	λ=350 nm
Quantum Yield	η	0.55	electrons / photon	
Open-Circuit Voltage(1)	V_O	420	mV	E_V=1000 lx
Short-Circuit Current	I_{SC}	1 (≥0.6)	µA	E_e=0.1 mW/cm², λ=350 nm
		50		E_V=1000 lx(1)
Rise and Fall Time, Photocurrent	t_R, t_F	3	µs	R_L=1 kΩ, V_R=5 V, λ=850 nm, I_P=50 µA
Forward Voltage	V_F	1.2	V	I_F=100 mA, E=0
Capacitance	C_O	600	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient, V_O	TC_O	–2.6	mV/K	Standard Light A
Temperature Coefficient, I_{SC}	TC_S	0.2	%/K	
Noise Equivalent Power	NEP	4.9×10^{-14}	W/√Hz	V_R=5 V, λ=350 nm
Detection Limit	D*	5.6×10^{12}	cm•√Hz/W	

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

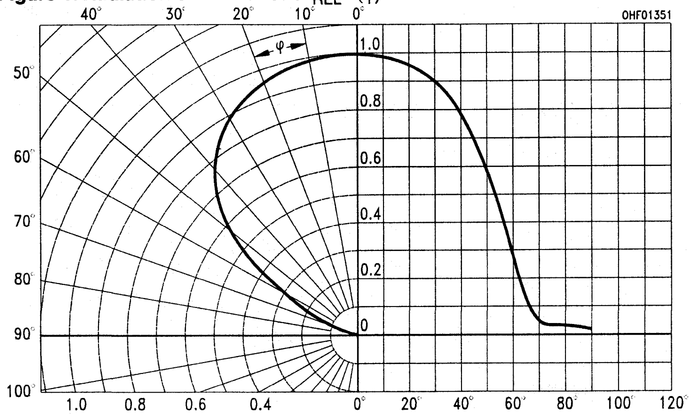


Figure 2. Relative spectral emission
$S_{REL}=f(\lambda)$

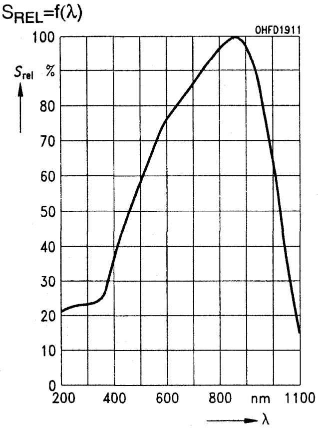


Figure 3. Photo current $I_P=f(E_V)$, $V_R=5$ V
Open circuit voltage $V_O=f(E_V)$

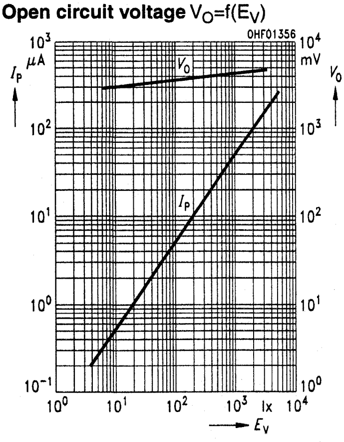


Figure 4. Dark current $I_R=f(V_R)$, E=0

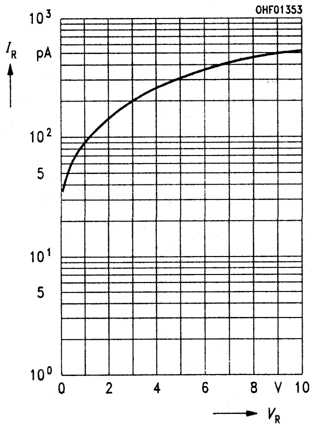


Figure 5. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

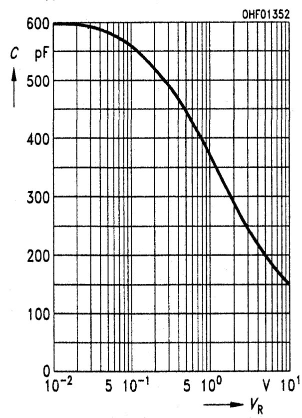
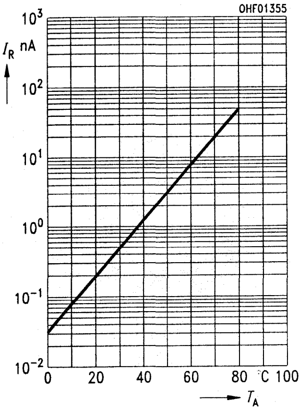


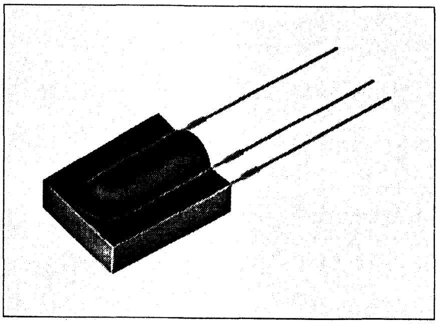
Figure 6. Dark current $I_R=f(T_A)$, $V_R=20$ V, E=0



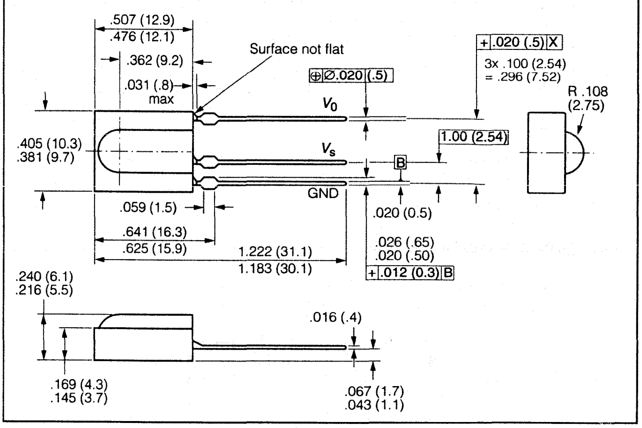
SIEMENS

SFH506

IR Receiver/Demodulator Device



Dimensions in inches (mm)



FEATURES

- **Photodiode with hybrid integrated circuit**
- **Several carrier frequencies**
- **Black epoxy resin with daylight filter optimized for 950 nm**
- **High immunity against ambient light**
- **Low power consumption**
- **5 V supply voltage**
- **High sensitivity (internal shield case)**
- **TTL and CMOS compatibility**
- **Continuous transmission possible ($t_{pi}/T \le 0.4$)**

APPLICATION

- **IR remote control preamplifier module**

DESCRIPTION

The SFH506 is a family of miniaturized receivers for infrared remote control systems. The demodulated output signal can be directly decoded by a microprocessor.

Maximum Ratings

Operating/Storage Temperature
Range (T_A, T_{STG}) .... –25° to +85°C
Junction Temperature (T_J) ....+100°C
Soldering Temperature (solder joint ≥2 mm from package)
Soldering Time, t ≤5 s ....+260°C
Supply Voltage, Pin 2 (V_{CC}).............–0.3 to +6.0 V
Supply Current, Pin 2 (I_{CC})...........................5 mA
Output Voltage, Pin 3 (V_Q)...............–0.3 to +6.0 V
Output Current, Pin 3 (I_Q).............................5 mA
Power Dissipation (P_{TOT}) T_A≤85°C ....50 mW

Characteristics T_A=25°C

Parameter	Symbol	Value	Unit	Condition
Threshold Irradiance, $t_{po}=t_{pi}\pm160$ µs (test signal, see Fig. 3)	E_{emin}(1)	0.35 typ. 0.5 max.	mW/m²	
	E_{emax}(1)	20	W/m²	
Wavelength, Max. Sensitivity	λ_{Smax}	950	nm	
Spectral Sensitivity Range	$\Delta\lambda$	830 to 1100		S=10% of S_{MAX}
Half Angle	φ	±55	Deg.	
Current Consumption, Pin 2	I_{CC}	0.5	mA	V_S=5 V, E_V=0
		1.0		V_S=5 V, E_V=4000 lx, Sunlight
Output Voltage, Pin 3	V_{Qlow}	<250	mV	I_Q=0.5 A, E_e=0.5 mW/m², f=f_0, T_p/T=0.4

Part Number	Carrier Frequency, kHz
SFH506-30	30
SFH506-33	33
SFH506-36	36
SFH506-38	38
SFH506-40	40
SFH506-56	56

Note

1. An arrival distance of 35 m is possible when used with IRED SFH415 when I_F=1.5 A

Figure 1. Block diagram

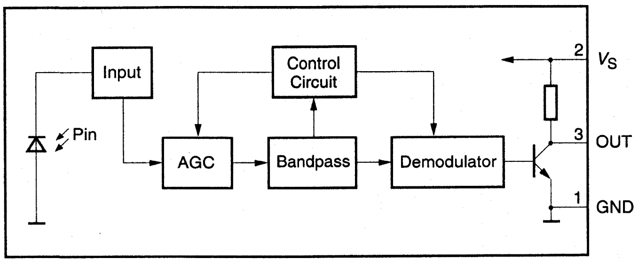
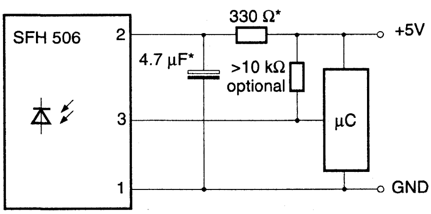


Figure 2. External circuit



* only necessary to suppress power supply disturbances

Figure 3. Test signal

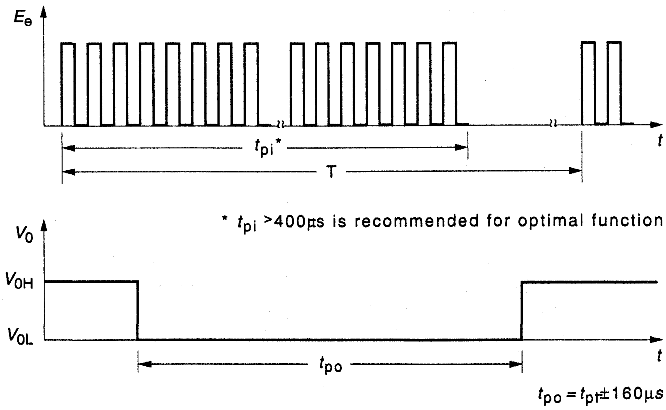


Figure 6. Directional characteristic $_{rel}$=f(φ)

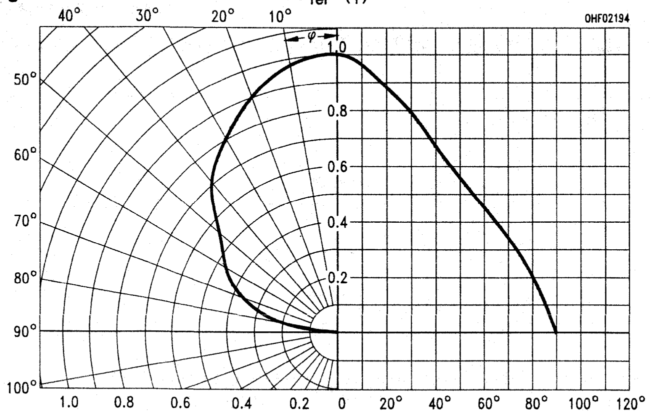


Figure 9. Sensitivity vs. duty cycle
E_e=f(t_p/T)

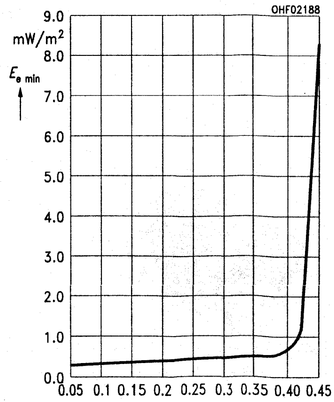


Figure 4. Relative sensitivity
E_{emin}/E_e=f(f/f_0)

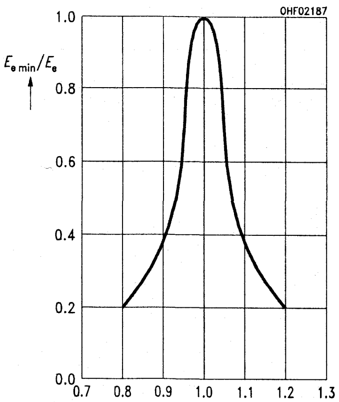


Figure 7. Relative luminous intensity
S_{rel}=f(λ), T_A=25°C

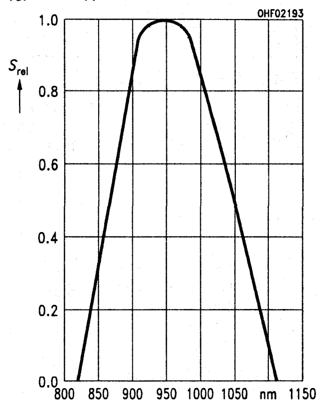


Figure 10. Sensitivity vs. bright ambient
E_{emin}=f(E), λ=950 nm, ambient

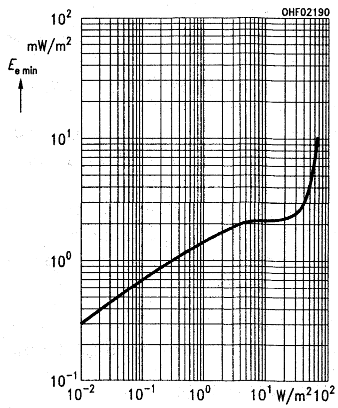


Figure 5. Sensitivity vs. electric field disturbance E_{emin}=f(E), disturbance field strength, f=f_0

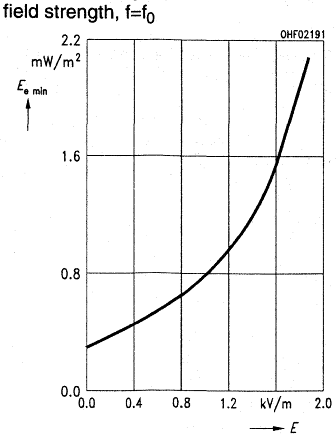


Figure 8. Sensitivity vs. dark ambient
T_{pout}=f(E_e), λ=950 nm, optical test signal

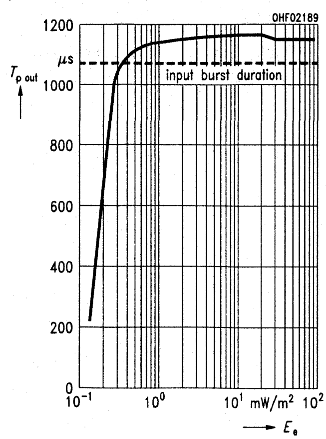
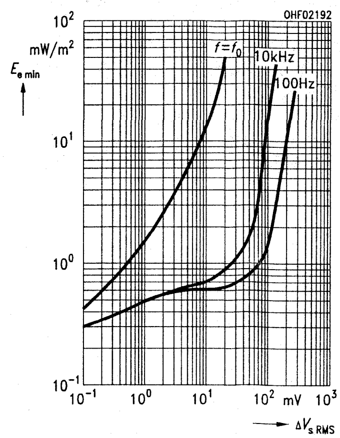


Figure 11. Sensitivity vs. supply voltage disturbance E_{emin}=f(ΔV_{SRMS})

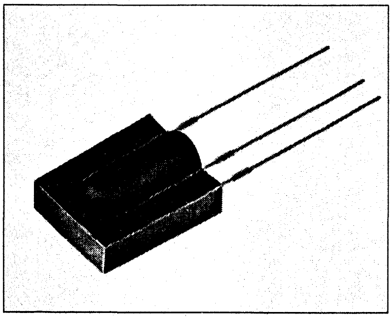


11 Photodiodes

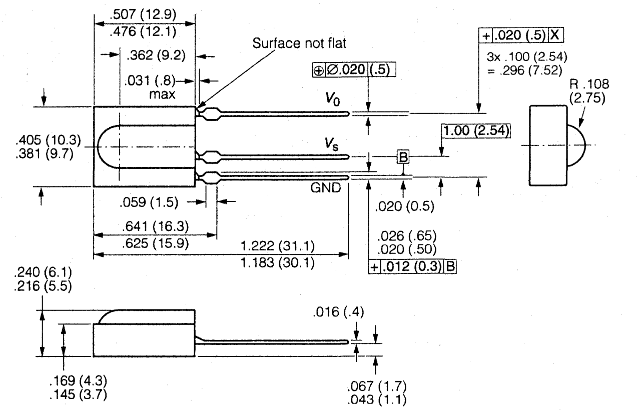
SIEMENS

SFH507

IR Receiver for Remote Control Systems (for short burst)



Dimensions in inches (mm)



FEATURES

- **Receiver module for transmission codes with short bursts (N≥ 6 pulses per bit)**
- **Photodiode with hybrid integrated circuit**
- **Black epoxy resin: daylight filter optimized for 950 nm**
- **High immunity against ambient light**
- **Low power consumption (0.5 mA typ.)**
- **5 V supply voltage**
- **High sensitivity (internal shield case)**
- **TTL and CMOS compatibility**
- **2.4 kbit/s data transmission possible (N=6, f_o=56 kHz)**

APPLICATION

- **IR remote control preamplifier module**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})................ –25° to +85°C
Junction Temperature (T_J).................... 100°C
Soldering Temperature (solder joint ≥1 mm from package)
Soldering Time, t ≤10 s..................... 260°C
Supply Voltage, Pin 2 (V_{CC})..... –0.3 to +6.0 V
Supply Current, Pin 2 (I_{CC}).................... 5 mA
Output Voltage, Pin 3 (V_Q)....... –0.3 to +6.0 V
Output Current, Pin 3 (I_Q)...................... 5 mA
Power Dissipation (P_{tot}) T_A≤85°C ....50 mW

Characteristics T_A=25°C

Parameter	**Symbol**	**Value**	**Unit**	**Condition**
Threshold Irradiance, (test signal, see Figure 3)	$E_{emin(30–40\ kHz)}$ (1)	0.4 (<0.6) typ.	mW/m^2	
	$E_{emin(56\ kHz)}$ (1)	0.45 (<0.7) typ.		
	E_{emax}	20	W/m^2	
Wavelength, Maximum Sensitivity	λ_{Smax}	950	nm	
Half Angle	φ	±55	Deg.	
Current Consumption, Pin 2	I_{CC}	0.5(<0.8)	mA	V_S=5 V, E_V=0
		1.0		V_S=5 V, E_V=40klx, Sunlight
Output Voltage, Pin 3 Test Signal, see Fig. 2	V_{Qlow}	<250	mV	I_Q=0.5 A, E_e=0.7 mW/m^2,

Part Number	**Carrier Frequency, kHz**	**Part Number**	**Carrier Frequency, kHz**
SFH 507-30	30	SFH 507-38	38
SFH 507-33	33	SFH 507-40	40
SFH 507-36	36	SFH 507-56	56

Note

1. Used with IRED SFH415 (operating condition of I_F=1.5A) distunce of 32m is possible.

Figure 1. Block diagram

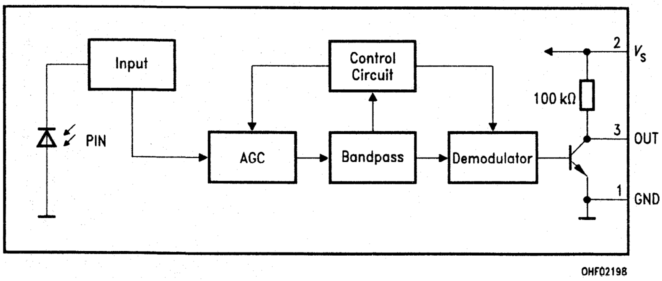
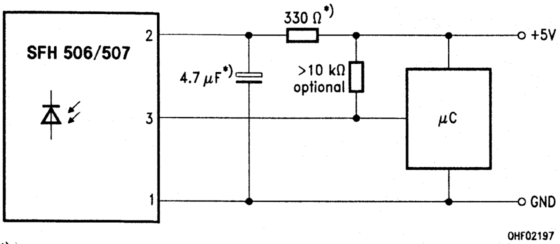
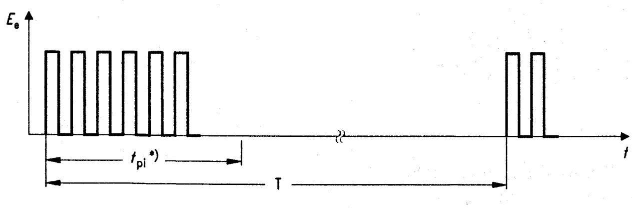


Figure 2. External circuit



*) only necessary to suppress power supply disturbances

Figure 3. Timing diagram



*) N ≥ 6 Pulses is recommended for optimal function

1) $4/f_o < t_d < 10/f_o$

2) $t_{pi} - 3/f_o < t_{po} < t_{pi} + 6/f_o$

Figure 4. Relative sensitivity
$E_{emin}/E_e = f(f/f_0)$

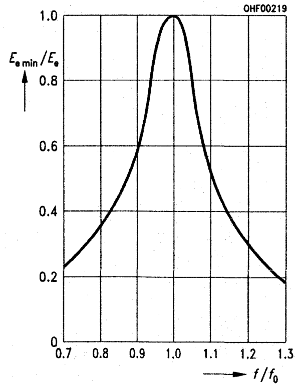


Figure 5. Sensitivity vs. dark ambient
$T_{pout} = f(E_e)$

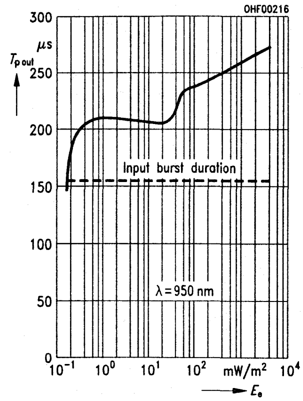
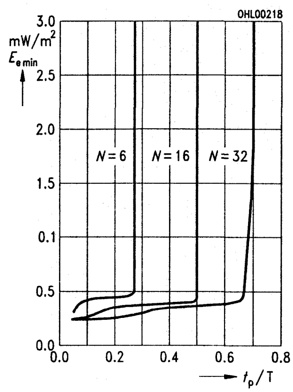


Figure 6. Sensitivity vs. duty cycle
$E_e = f(t_p/T)$



Photodiodes 11

Figure 7. Sensitivity vs. electric field disturbance E_{emin}=f(E), disturbance field strength, f=f_0

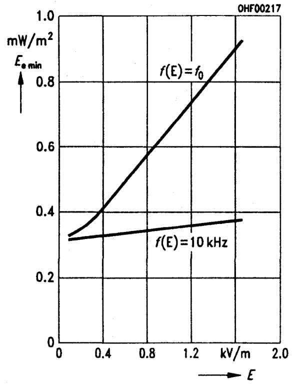


Figure 10. Relative luminous sensitivity S_{REL}=f(λ), T_A=25°C

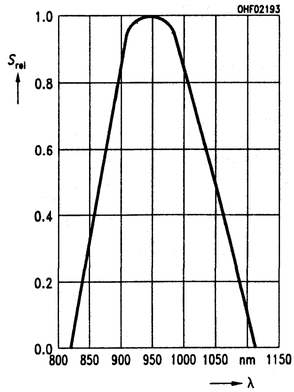


Figure13. Output pulse T_{ON}, T_{OFF}=f(E_e)

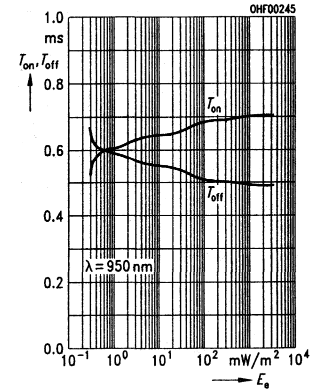


Figure 8. Vertical directivity φy

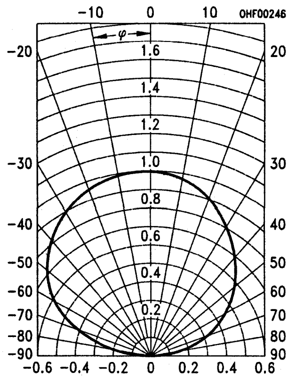


Figure 11. Horizontal directivity φx

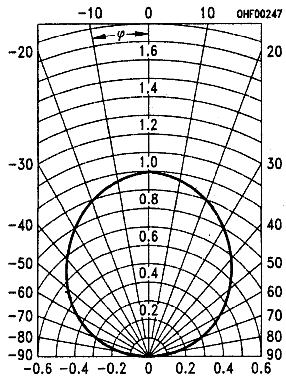


Figure 9. Sensitivity vs. bright ambient E_{emin}=f(E)t

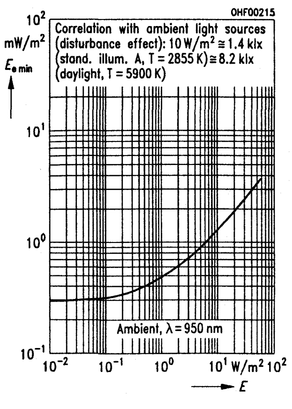
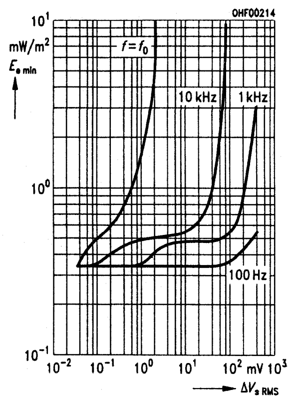


Figure 12. Sensitivity vs. supply volt. disturbance E_{emin}=f(ΔV_{SRMS})



SIEMENS

SFH530

Ultraviolet Selective Sensor

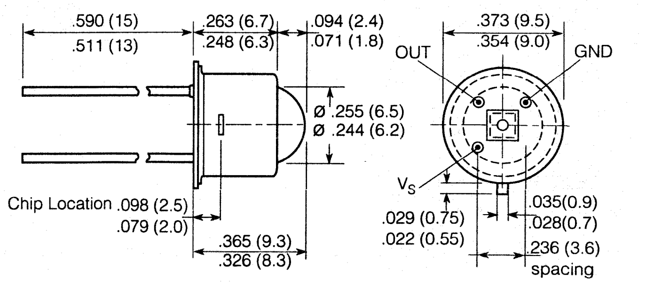
FEATURES
- **High UV sensitivity**
- **Suitable for applications at 310 nm**
- **Low sensitivity for visible and infrared light**
- **Single supply voltage**
- **Low current consumption**
- **Hermetically sealed metal package (TO-5)**

APPLICATIONS
- **Flame detector**
- **Chemical and biomedical analysis**
- **Photometry**
- **Excimer laser control and monitoring**
- **Environment mapping**
- **Skin irradiation studies**
- **Monitoring of UV sterilizing equipment**
- **Medical diagnostic**
- **Welding monitoring**

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG})..........–20 to +80°C
Supply Voltage (V_S)............................8 V

DESCRIPTION
The SFH 530, an ultraviolet (UV) selective optical sensor has been specially developed for the exacting requirements placed on flame monitoring in oil burners and can be used for many other important measuring tasks in the UV detection area. The photodiode and the amplifier circuit (amplification of the photocurrent, conversion to a voltage signal) are housed in a hermetically sealed TO-5 package with three terminal pins (GND, V_S: operating voltage, OUT: output voltage). The package is specially protected against electromagnetic interference and moisture over the entire operating temperature range of –20°C to + 80°C.

Dimensions in inches (mm)



GE006954

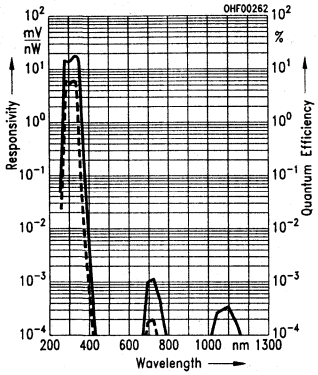
Characteristics T_A=25°C, 5V, 20°C no load unless otherwise noted

Description		Sym.	Value			Unit
			min.	typ.	max.	
Supply Current		I_S	50	65	90	µA
Max. Output Current Saturation, 1.4 kΩ Load		I_{OUT}	35	51	72	
Output swing	Saturation		2.1	2.6	3.1	V
	Dark		0	0.2	1	mV
PSRR (50 to 100 Hz)			40		62	dB
Offset Voltage	25 °C	V_{OFF}	-5	0	1	mV
	60 °C		–10	–2	0	
	80 °C		-60	–10	–1	
Cut-Off Frequency (3 dB)		f_G		16		Hz
NEP at 310 nm		NEP		7×10^{-14}		$W/\sqrt{Hz}$
Detection Limit, λ=310 nm		D*		5×10^{11}		$m \cdot \sqrt{Hz}/W$
Active Area (1)		A	10	11	12	mm^2
Responsivity at 310 nm			160			$mV \times mm^2/nW$
Selectivity (2)					10^{-4}	
Responsivity to a 2856 K Quartz-Halogen Lamp without UV (Glass Filter GG400)					0.4	mV/lx
Transimpedance			1.1	1.3	1.5	GΩ

(1) Due to the light concentration of the lens.

(2) Selectivity = $\frac{\max \{\text{Responsivity in the range of 400...1200 nm}\}}{\text{Responsivity at 310 nm}}$

Figure 1. Typ. spectr. response of UV sensor



Optical Characteristics

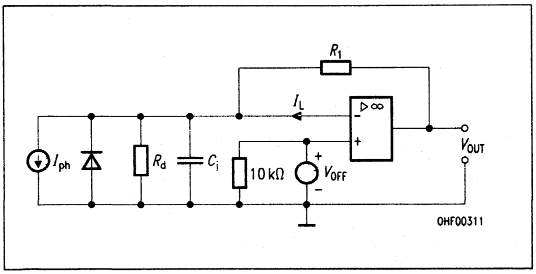
The optical behavior of the SFH 530 is determined by the combination of a UV-permeable focusing lens, a UV filter glass and a Si photodiode with high selectivity for UV radiation. The selectivity in the wavelength range 290 to 350 nm is achieved by means of a defined doping of the photodiode and a vapor-deposited interference filter. This heavily suppresses the effect of visible and infrared radiation on the signal. The sensitivity to wavelengths ≥400 nm is always less than one ten-thousandth of the maximum sensitivity at approximately 310 nm.

Electrical Characteristics

- Operated from a single supply voltage.
- The photocurrent of the UV diode is typically I_{ph}=100 pA. For a high output signal the value of the feedback resistor R1 in the amplifier circuit must be very high typ.1 GΩ.

The main electrical functions of the UV sensor are shown in the equivalent circuit diagram (**Figure 2**).

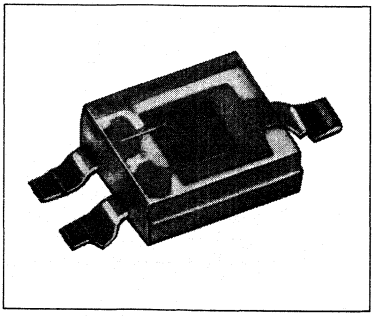
Figure 2

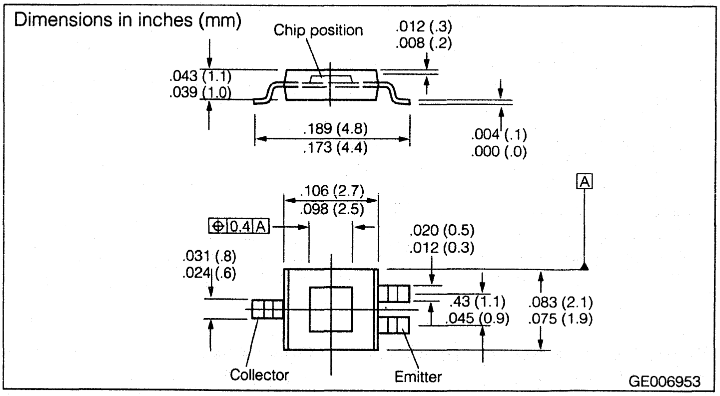


- $V_{OUT}=(I_{ph}-I_L)\ R_K+V_{OFF}\ (1+R_1/R_d)$
- For oscillating illuminances the circuit constitutes a first-order lowpass filter with a cutoff frequency of typically 100 Hz.
  Temperature behavior:
  I_L: is typically<1 pA at room temperature and doubles every 12°C
  R_d: is typically>10 GΩ (at room temperature, consisting of the parallel connection of the corresponding resistances of the
  – recombination current (doubles every 12°C)
  – diffusion current (doubles every 5.6°C)
- The temperature behavior shows the marked effect on the sensor's output signal. The ASIC is so designed that it exhibits a 0 to −1 mV offset and a negative temperature coefficient at room temperature. Even any leakage currents present would only reduce the wanted signal (the leakage current is always subtractive with respect to the output signal).

SIEMENS

SFH 2400
DAYLIGHT FILTER SFH 2400FA
Very Short Switching Time Silicon NPN Photodiode





- **FEATURES**
- **Especially suitable for applications**
  - **SFH 2400: 400 nm to 1100 nm**
  - **SFH 2400FA: 880 nm**
- **Short switching time (typ. 5 ns)**
- **SMT package, suitable for vapor phase and IR reflow soldering**
- **Available on tape and reel**

APPLICATIONS
- **Industrial electronics**
- **For control and drive circuits**
- **Photointerrupters**
- **Fiber optic transmission systems**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55° to +100°C
Reverse Voltage (V_R) .... 50 V
Total Power Dissipation (P_{TOT}) ...... 100 mW
Thermal Resistance for Mounting on PCB (R_{THJA}) .... 450 K/W

Characteristics T_A=25°C

Parameter		Sym.	Value	Unit	Condition
Spectral Sensibivity	SFH2400	S	10(>5.5)	nA/lx	V_R=5 V, Std. Light A, T=2856 K
	SFH2400FA		6.2(≥3.6)	μA	V_R=5 V, λ=950 nm, E_e=1mW/cm^2
Wavelength, Max. Sensitivity	SFH2400	λ_{Smax}	850	nm	
	SFH2400FA		900		
Spectral Sensi-tivity Range	SFH2400	λ	400 to 1100		S=10% of S_{MAX}
	SFH2400FA		750 to 1100		
Radiant Sensitive Area		A	1	mm^2	
Radiant Sensitive Area Dimensions		L x W	1x 1	mm	
Half Angle		φ	±60	Deg.	
Dark Current		I_R	0.1 (<5)	nA	V_R=20 V
Spectral Sensitivity	SFH2400	S_λ	0.62	A/W	λ=850 nm
	SFH2400FA		0.59		
Quantum Yield	SFH2400	η	0.89	electrons / photon	
	SFH2400FA		0.86		
Open Circuit Voltage	SFH2400	V_O	320	mV	E_V=1000 lx, Std. Light A, T=2856 K
	SFH2400FA				E_e=0.5mW/cm^2, λ=950 nm
Short Circuit Current	SFH2400	I_{SC}	10	μA	E_V=1000 lx, Std. Light A, T=2856 K
	SFH2400FA		3		E_e=0.5mW/cm^2, λ=950 nm
Rise and Fall Time, Photocurrent		t_R, t_F	5	ns	R_L=50 Ω, V_R=20 V, λ=850 nm, I_P=800 μA
Forward Voltage		V_F	1.3	V	I_F=80 mA, E=0
Capacitance		C_0	36	pF	V_R=0 V, f=1 MHz, E=0
Temp. Coefficient V_O		TC_V	-2.6	mV/K	
Temp. Coeffi-cient I_{SC}	SFH2400	TC_I	0.18	%/K	Std. Light A, λ=950 nm
	SFH2400FA		0.2		
Noise Equivalent Power		NEP	2.9 x10^{-14}	W/√Hz	V_R=20 V, λ=850 nm
Detection Limit		D*	3.5x10^{12}	cm•√Hz/W	

Photodiodes 11

Figure 1. Directional characteristics $S_{rel}=f(\varphi)$

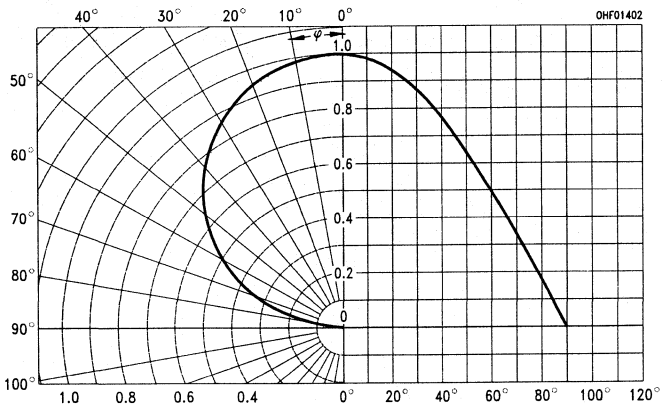


Figure 6. Total power dissipation $P_{TOT}=f(T_A)$

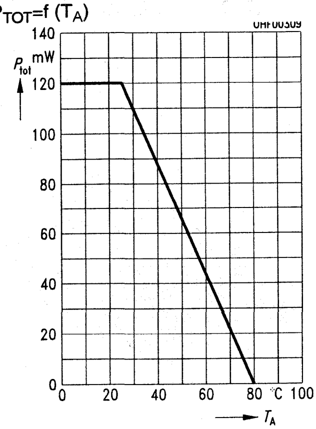


Figure 2. Relative spectral sensitivity $S_{rel}=f(\lambda)$ **SFH 2400**

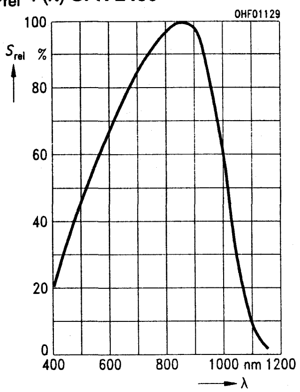


Figure 4. Relative spectr. sensitivity $S_{rel}=f(\lambda)$ **SFH 2400 FA**

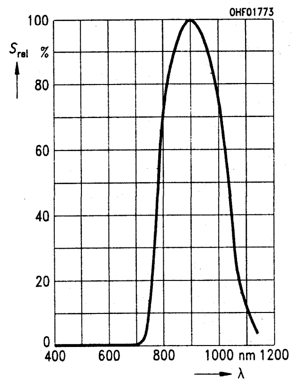


Figure 7. Dark current $I_R=f(V_R)$, E=0

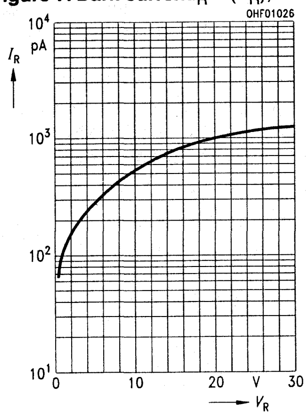


Figure 3. Photocurrent $I_P=f(E_v)$, $V_R=5$ V
Open-circuit voltage $V_O=f(E_v)$
SFH 2400

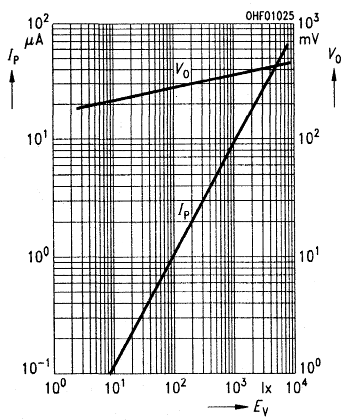


Figure 5. Photocurrent $I_P=f(E_e)$, $V_R=5$ V
Open-circuit voltage $V_O=f(E_e)$
SFH 2400 FA

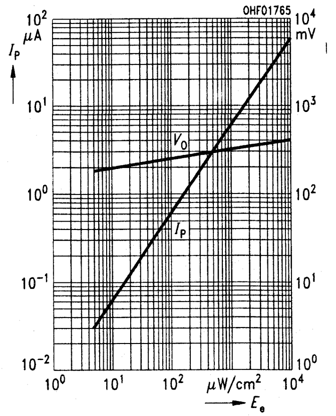
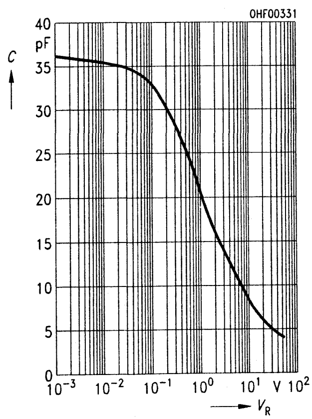
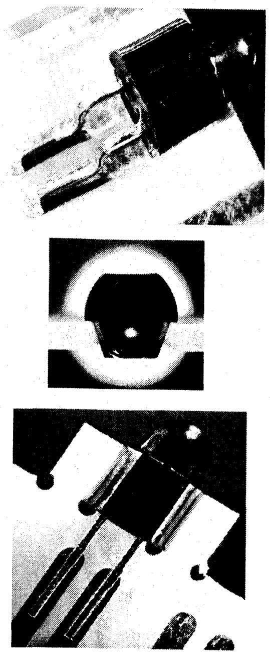


Figure 8. Capacitance $C=f(V_R)$,
f =1 MHz, E=0



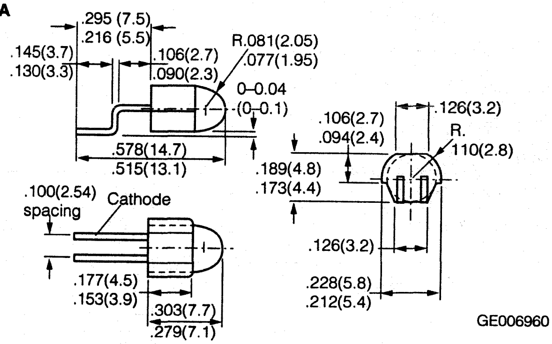
SIEMENS

SFH 2500/FA
SFH 2505/FA
Very Short Switching Time Silicon PIN Photodiode

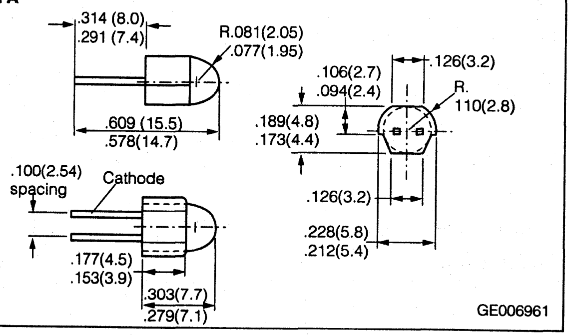


Dimensions in inches (mm)

SFH2500/FA



SFH2505/FA



FEATURES
- **Especially suitable for applications**
  - **SFH 2500/2505: 400 nm to 1100 nm**
  - **SFH 2500 FA/2505 FA880 nm**
- **Short switching time (typ. 5 ns)**
- **5 mm LED plastic package**
- **Also available on tape**
- **Suitable for surface mounting**

APPLICATIONS
- **Industrial electronics**
- **For control and drive circuits**
- **Photointerrupters**

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) ....–55° to +100°C
Soldering temperature (2 mm distance from case bottom)
$t \leq 3$ s (T_S) .... 230°C
Reverse Voltage (V_R).. 50 V
Total Power Dissipation (P_{TOT}) .... 100 mW

Characteristics T_A=25°C

Parameter	Sym.	SFH 2500 SFH 2505	SFH 2500 FA SFH2505 FA	Unit	Condition
Spectral Sensitivity	S	100 (>75)	—	nA/lx	V_R=5 V, Std. Light A, T=2856 K
		—	70 (>50)	μA	V_R=5 V, λ=870 nm, E_e=1 mW/cm^2
Wavelength, Max. Sensitivity	λ_{Smax}	850	900	nm	
Spectral Sensitivity Range	λ	400 to 1100	750 to 1100		S=10% of S_{max}
Radiant Sensitive Area	A	1		mm^2	
Dimensions of Radiant Sensitive Area	LxW	1x1		mmxmm	
Distance Chip Front to Lens Top	H	3.9 to 4.4		mm	
Half Angle	φ	±15		Deg.	
Dark Current	I_R	1 (≤5)		nA	V_R=10 V
Spectral Sensitivity	S_λ	0.62	0.59	A/W	λ=850 nm
Quantum Yield	h	0.89	0.86	electrons / photons	
Open-circuit Voltage	V_O	430 (> 360)	—	mV	E_V=1000 lx, Std. Light A, T=2856 K
		—	390 (> 320)		E_e=0.5 mW/cm^2, λ=870 nm
Short-Circuit Current	I_{SC}	100	—	μA	E_V=1000 lx, Std. Light A, T=2856 K
		—	35		E_e=0.5 mW/cm^2, λ=870 nm
Rise and Fall Time, Photocurrent	t_R, t_F	5		ns	R_L=50 Ω, V_R=5 V, λ=850 nm, I_p=800 μA
Capacitance	C_O	11		pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient, V_O	TC_V	-2.6		mV/K	
Temperature Coefficient, I_{SC}	TC_I	0.18	—	%/K	Std Light A
		—	0.1		λ=870 nm
Noise Equivalent Power	NEP	2.9×10^{-14}		W/√Hz	V_R=**20 V**, λ=850 nm
Detection Limit	D*	3.5×10^{12}		cm·√Hz/W	

Figure 1. Radiation characteristic I_{REL}=f(φ)

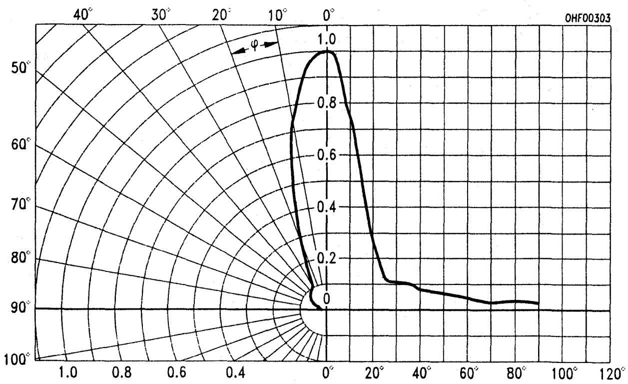


Figure 2A. Relative spectral sensitivity S_{REL}=f (λ) **SFH 2500/2505**

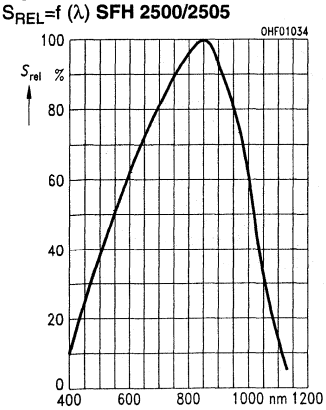


Figure 2B. Relative spectral sensitivity S_{REL}=f (λ) SFH 2500FA/2505FA

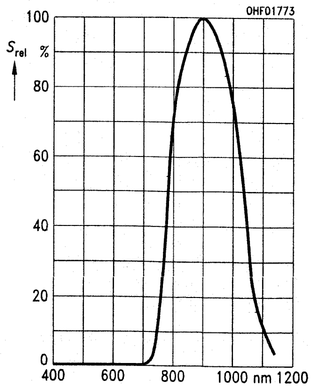


Figure 4. Total power dissipation P_{tot}=f(T_A)

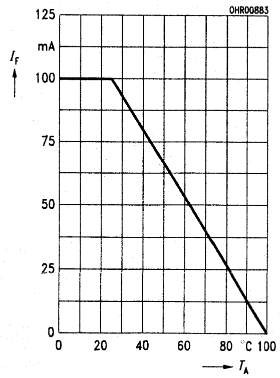


Figure 3A. Photocurrent I_P=f(E_V), V_R=5 V **Open-circuit Voltage** V_O=f(E_V) **SFH 2500/2505**

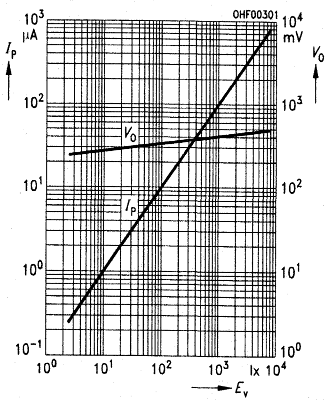


Figure 5. Dark current I_R=f(V_R), E=0

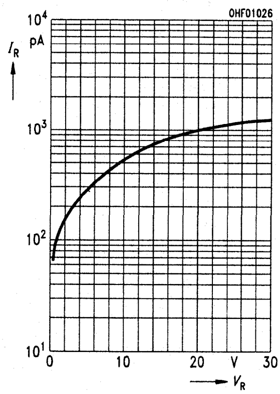
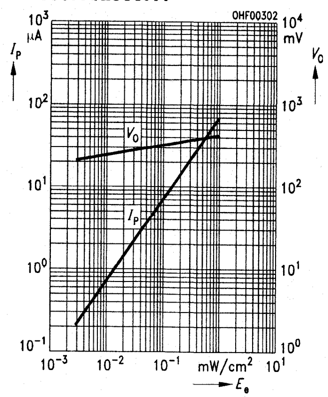


Figure 3B. Photocurrent I_P=f(E_V), V_R=5 V **Open-circuit Voltage** V_O=f(E_V) **SFH 2500FA/2505FA**

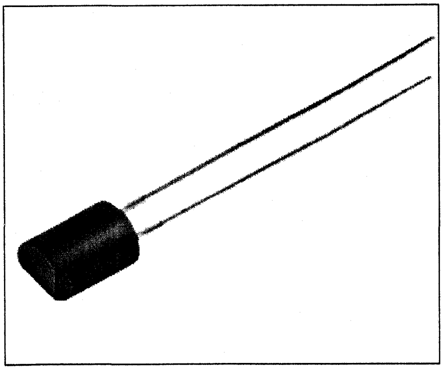


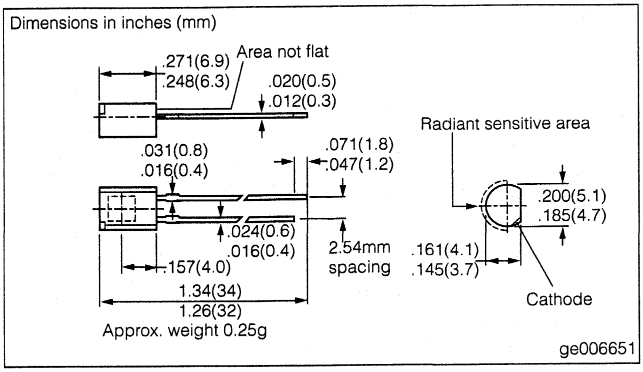
Photodiodes 11

SIEMENS

SFH 2910 FA

Silicon Photodiode





FEATURES

- **Especially suitable for applications in 880 nm range**
- **TO-92 plastic package**
- **Also available on tape**

Maximum Ratings

Operating/Storage
Temperature (T_{OP}, T_{STG}) .... –40°C to +100°C
Reverse Voltage (V_R) .... 7 V
Total Power Dissipation (P_{TOT})
T_A=25°C .... 150 mV

Characteristics (T_A=25°C, λ=870 nm)

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	46 (≥36)	µA	V_R=5 V E_e=1 mW/cm^2
Wavelength, Maximum Sensitivity	λ_{Smax}	890	nm	
Spectral Sensitivity Range	λ	750 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.34	mm^2	
Radiant Sensitive Area Dimension	L x W	2.71x2.71	mm	
Distance Chip Surface to Case Surface	H	2.3 to 2.5		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	≤1	nA	V_R=10 V
Spectral Sensitivity	S_λ	0.59	A/W	
Quantum Yield	η	0.86	electrons / photon	
Open-Circuit Voltage	V_O	440 (≥375)	mV	E_e=0.5 mW/cm^2
Short-Circuit Current	I_{SC}	42	µA	
Rise and Fall Time, Photocurrent	t_R, t_F	1.5	ns	R_L=1 kΩ, V_R=5 V, λ=850 nm, I_P=70 µA
Forward Voltage	V_F	1.3	V	I_F=100 mA, E=0
Capacitance	C_O	630	pF	V_R=0 V, f=1 MHz, E=0
Temperature Coefficient, V_L	TC_V	–2.6	mV/K	
Temperature Coefficient, I_{SC}	TC_I	0.1	%/K	
Noise Equivalent Power	NEP	4.3x10^{-15}	W/√Hz	V_R=1 V
Detection Limit	D*	6.3x10^{13}	cm•√Hz/W	

Figure 1. Radiation characteristic $I_{REL}=f(\varphi)$

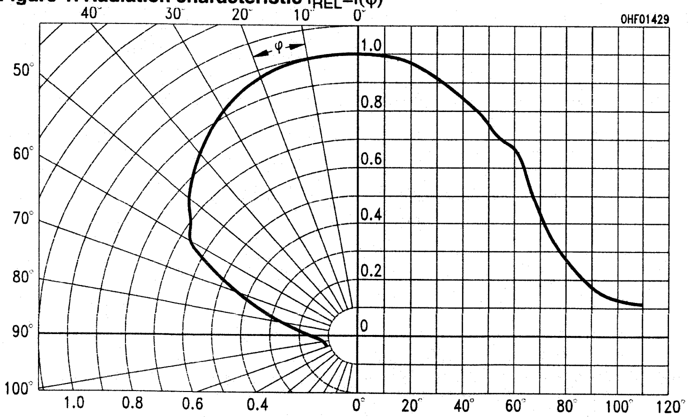


Figure 2. Dark current $I_R=f(V_R)$, E=0

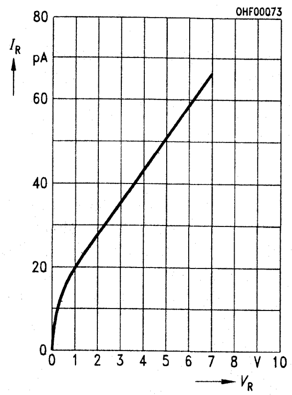


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

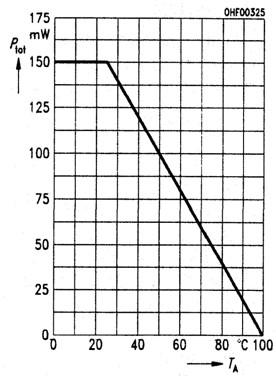


Figure 3. Capacitance
$C=f(V_R)$, f=1 MHz, E=0

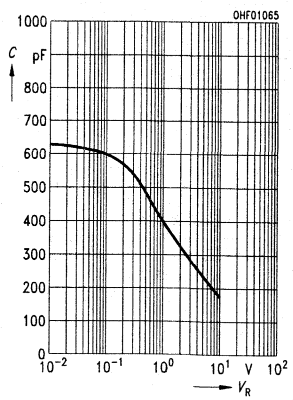
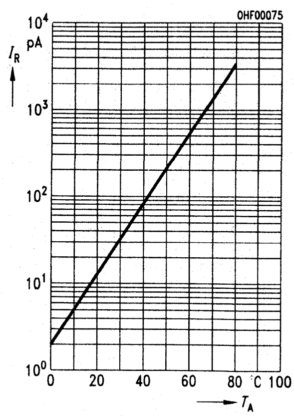


Figure 5. Dark current $I_R=f(T_A)$, V_R=1 V, E=0



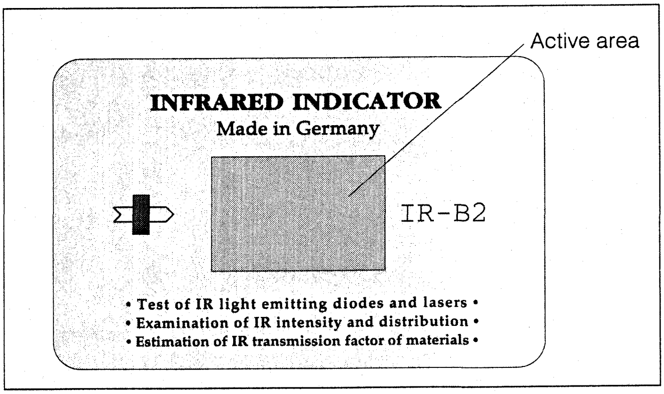
SIEMENS

IR-B2

Infrared Indicator Card

APPLICATIONS

- **Check output of IR LEDs and IR laser diodes**
- **In test Set-ups, remote control devices, tone transmitters, light reflection switches, light pens, optical fiber systems, etc.**
- **Evaluate IR radiant intensity and radiation pattern**
- **Evaluate IR transmissiveness of materials**



Operating principle

The active luminous area of the IR-B2 infrared indicator card consists of fine crystalline semiconductor material doped with rare-earth metals, Europium and Samarium. This material is capable of being charged (stimulated) with light and responds best to blue light. When subjected to IR stimulation, this material emits visible light. The brightness of this emitted light is directly proportional to the intensity of the IR stimulation.

Charging

The charging time depends on the intensity of the light source used. A few seconds are sufficient when charging with sunlight, several minutes, however, may be necessary in case of dim light. One should be careful in charging with an incandescent source, as the IR segment of this light source serves to elicit emission, even as the card is excited. So, IR-free light is best and can be obtained by using an IR filter such as a 'SCHOTT' BG39.

Indicator Operation

The indicator card is charged with IR light and emits visible light. The emitted light will be proportional to the intensity ot the IR light. The intensity of the emitted light, however, is not constant but declines over time with each stimulation. The rise and fall time for emission is in the microsecond range. Filters such as RG780 through RG1000 from SCHOTT can be used to isolate specific segments of the IR light to be tested.

Self-Discharge

Like any other energy storing device, the infrared indicator card IR-B2 tends to a self-discharge, resulting in an extremely low emission. An (almost) complete self-discharge takes several months; the saturation charge is stored for about ten minutes.

Service Life

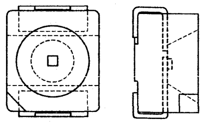
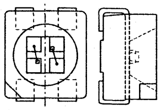
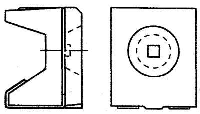
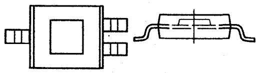
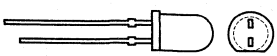
The charge/discharge cycles and full discharge cause no perceptible aging. Overloading is not possible. Strong, steady UV radiation will cause an i rreversible decline in sensitivity. The sudden, abrupt failure of the card is impossible.

Further Notes on Use

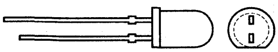
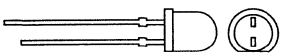
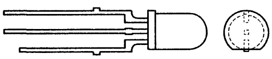
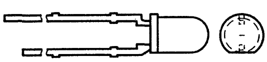
The card has to be charged with daylight or fluorescent light. In case of self-discharge or decline in sensitivity after IR stimulation, the card must be recharged. If the IR source is weak, shield the card from ambient light. The card is humidity resistant and can be used in transmissive or reflective mode. The use of an IR-blocking filter is recommended if using an incandescent source (e. g. SCHOTT BG39).

Parameter	Value	Unit
Peak λ for max. charge (excitation)	approx. 480 (blue)	nm
Indication λ (under fluourescent light)	400 to 700nm (visible light)	
Low-end λ of sensitivity to IR (stimulation) ,10% of max. sensitivity	approx. 700 (medium IR)	
High-end λ of sensitivity to IR (stimulation), 10% of max. sensitivity	approx. 1300 (medium IR)	
Peak λ for IR sensitivity	approx. 1020 (near IR)	
Active area	30 x 20	mm
Outside dimensions (credit-card size)	85.5 x 54.0 x 0.8	
Temperature range	–30 to 70 short-term usage: 100	°C

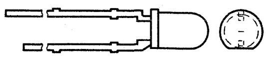
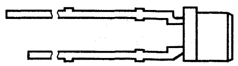
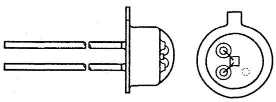
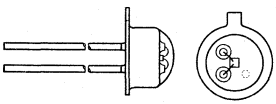
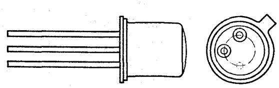
Phototransistors

Package Outline	Part Number	Package Type	Half Angle	Photocurrent λ=950 nm E_E=0.5 mW/cm² V_{CE}=5 V mA		Collector Emitter Voltage V	Radiant Sensitive Area mm²	Features	Page
	SFH320-2	SMT TOP-LED	±60°	≥16	E_E=0.1 mW/cm²	35	0.045	λSmax 860 nm (SFH320), 900 nm (SFH320FA). PL-CC-2 package. Matches IR emitter SFH420.	12–34
	SFH320-3			25–50 μA					
	SFH320-4			≥40 μA					
	SFH320FA-2	SMT SIDE-LED, day-light filter		≥16					
	SFH320FA-3			≥25–50 μA					
	SFH320FA-4			≥40 μA					
	SFH331	SMT Multi TOPLED	±60°	≥16 μA	E_E=0.1 mW/cm²	35	0.045	Emitter/ Transistor	12–38
	SFH7221	SMT Multi TOPLED	±60°	≥16 μA		35	0.045		12–44
	SFH325-2	SMT SIDE-LED	±60°	≥16	E_E=0.1 mW/cm²	35	0.045	λSmax 860 nm (SFH325), 900 nm (SFH325FA). PL-CC-2 package.	12–36
	SFH325-3			25–50 μA					
	SFH325-4			≥40 μA					
	SFH325FA-2	SMT SIDE-LED, day-light filter		≥16					
	SFH325FA-3			25–50 μA					
	SFH325FA-4			≥40 μA					
	SFH3400-1	SMT, 3 leads	±60°	63–125 μA		70	0.55	850 nm	12–42
	SFH3400-2			100–200 μA					
	SFH3400-3			160–320 μA					
	SFH300	T1 3/4 (5 mm) clear plastic	±25°	≥0.63		35	0.12	λSmax 850 nm (SFH300), 870 nm (SFH300FA), High linearity.	12–16
	SFH300-2			0.63–1.25					
	SFH300-3			1.0–2.0					
	SFH300-4			≥0.63					
	SFH300FA	T1 3/4 (5 mm) daylight filter		≥0.63					
	SFH300FA-2			0.63–1.25					
	SFH300FA-3			1.0–2.0					
	SFH300FA-4			≥1.6					

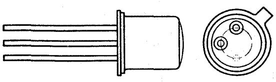
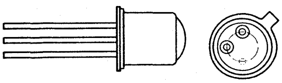
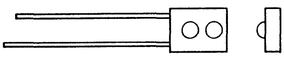
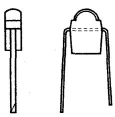
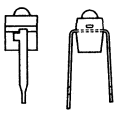
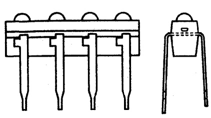
Phototransistors

Package Outline	Part Number	Package Type	Half Angle	Photocurrent λ=950 nm E_E=0.5 mW/cm^2 V_{CE}=5 V mA	Collector Emitter Voltage V	Radiant Sensitive Area mm^2	Features	Page
	SFH313	T1 3/4 (5 mm) clear plastic	±10°	≥2.5	70	0.55	λSmax 850 nm (SFH313), 870 nm (SFH313FA) Applications from 460 to 1080 nm (SFH313) and 880 nm (SFH313FA)	12–36
	SFH313-2			4–8				
	SFH313-3			6.3–12.5				
	SFH313FA	T1 3/4 (5 mm) plastic, daylight filter		≥2.5				
	SFH313FA-2			4–8				
	SFH313FA-3			6.3–12.5				
	SFH314	T1 3/4 (5 mm) clear plastic	±40°	≥0.63	70	0.55	λSmax 850 nm (SFH314), 870 nm (SFH314FA) Applications from 460 to 1080 nm (SFH314) and 880 nm (SFH314FA).	12–32
	SFH314–2			1–2				
	SFH314–3			1.6–3.2				
	SFH314FA	T1 3/4 (5 mm) plastic, daylight filter		≥0.63				
	SFH314FA–2			1–2				
	SFH314FA–3			1.6–3.2				
	SFH303	T1 3/4 (5 mm) clear plastic	±20°	≥1.0	50	0.2	λSmax 850 nm (SFH303), 870 nm (SFH303FA) Applications from 450 to 1100 nm (SFH303) and 880 nm (SFH303FA).	12–20
	SFH303-2			1.0–2.0				
	SFH303-3			1.6–3.2				
	SFH303-4			≥2.5				
	SFH303FA	T1 3/4 (5 mm) plastic, daylight filter		≥1.0				
	SFH303FA-2			1.0–2.0				
	SFH303FA-3			1.6–3.2				
	SFH303FA-4			≥2.5				
	SFH309	T1 (3 mm) clear plastic	±12°	≥0.4	35	0.2	λSmax 860 nm (SFH309), 900 nm (SFH309FA) Applications from 380 to 1180 nm (SFH309) and 880 nm (SFH309FA). Matches IR emitter SFH409.	12–24
	SFH309-2			0.4–0.8				
	SFH309-3			0.63–1.25				
	SFH309-4			1.0–2.0				
	SFH309-5			1.6–3.2				
	SFH309FA			≥0.4				
	SFH309FA-2			0.4–0.8				
	SFH309FA-3			0.63–1.25				
	SFH309FA-4			1.0–2.0				
	SFH309FA-5			1.6–3.2				

Phototransistors

Package Outline	Part Number	Package Type	Half Angle	Photocurrent λ=950 nm E_E=0.5 mW/cm² V_{CE}=5 V mA	Collector Emitter Voltage V	Radiant Sensitive Area mm²	Features	Page
	SFH310	T1 (3 mm) plastic	±25°	≥0.4	70	0.19	λ_{Smax} 780 nm (SFH310), 980 nm (SFH310FA). Applications from 400 to 1100 nm (SFH310) and 880 nm (SFH310FA).	12–28
	SFH310-2			0.63–1.25				
	SFH310-3			1.0–2.0				
	SFH310FA	T1 (3 mm) plastic, daylight filter		≥0.4				
	SFH310FA-2			0.63–1.25				
	SFH310FA-3			1.0–2.0				
	SFH309P	T1 (3 mm) clear plastic	±75°	420 µA	35	0.045	λ_{Smax} 860 nm (SFH309P), 900 nm (SFH309FA). High linearity.	12–26
	SFH309PFA	T1 (3 mm) plastic , daylight filter		≥63 E_V=1000lx, std. light A, V_{CE}=5V				
	BP103	Similar to TO-18, clear plastic lens	±55°	≥0.08	50	0.12	IR remote control. λ_{Smax} 850 nm. Matches IR emitter LD242.	12–1
	BP103-2			0.08–0.16				
	BP103-3			0.125–0.25				
	BP103-4			0.2–0.4				
	BP103-5			≥0.32				
	SFH302	Hermetic TO-18 with base plate	±50°	≥0.4	50	0.675	λ_{Smax} 860 nm. Applications from 450 nm to 1100 nm:	12–18
	SFH302-2			0.4–0.8				
	SFH302-3			0.63–1.25				
	SFH302-4			1–2				
	SFH302-5			1.6–3.2				
	SFH302-6			≥2.5				
	BPX38	TO-18 hermetic package, flat glass lens	±40°	≥0.2	50	0.675	λ_{smax} 880 nm. Applications from 450 to 1120 nm. Matches IR emitter SFH402.	12–4
	BPX38-2			0.2–0.4				
	BPX38-3			0.32.–0.63				
	BPX38-4			0.5–1.0				
	BPX38-5			≥0.8				

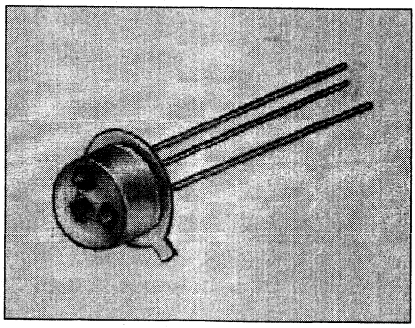
Phototransistors

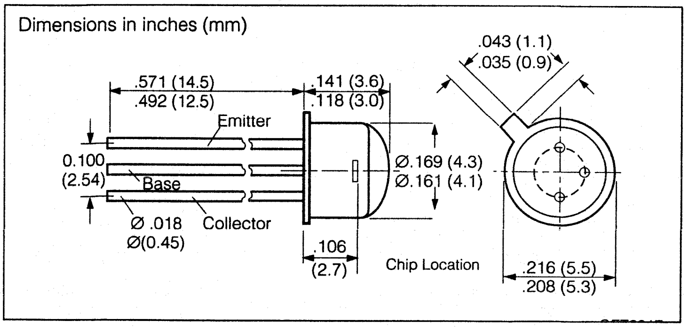
Package Outline	Part Number	Package Type	Half Angle	Photocurrent λ=950 nm E_E=0.5 mW/cm² V_{CE}=5 V mA	Collector Emitter Voltage V	Radiant Sensitive Area mm²	Features	Page
	BPX43	TO-18 hermetic package, glass lens	±15°	≥0.8	50	0.675	λsmax 880 nm. Applications from 450 to 1100 nm. Matches IR emitter SFH401.	12–7
	BPX43-2			0.8–1.6				
	BPX43-3			1.25–2.5				
	BPX43-4			2.0–4.0				
	BPX43-5			≥3.2				
	BPY62-2	TO-18 hermetic package, glass lens	±8°	0.5–1.0	50	0.12	λsmax 850 nm. Applications from 420 to 1130 nm. Matches IR emitter SFH400.	12–12
	BPY62-3			0.8–1.6				
	BPY62-4			1.25–2.5				
	BPY62-5			≥2.0				
	LPT-80A	Rectangular clear plastic, side facing	±40°	≥0.2	30	—	λsmax 870 nm. Matches IR emitters IRL80A/81A.	12–15
	SFH305	Minitature-clear plastic, axial leads		≥0.25	32	0.17	λsmax 850 nm. Matches IR emitter SFH405.	12–22
	SFH305-2		±16°	0.25–0.5				
	SFH305-3			0.4–0.8				
	BPX81	1 transistor	±18°	≥0.25	32	0.17	Axial leads. λsmax 850 nm. BPX81–matches IR emitter LD261. BPX82-89, BPX80–matches IR emitters LD262–9, LD260.	12–10
	BPX81-2			0.25–0.5				
	BPX81-3			0.4–0.8				
	BPX81-4			≥0.63				
	BPX82	2 transistors		≥0.32		0.17 per transistor		
	BPX83	3 transistors						
	BPX84	4 transistors						
	BPX85	5 transistors						
	BPX86	6 transistors						
	BPX87	7 transistors						
	BPX88	8 transistors						
	BPX89	9 transistors						
	BPX80	10 transistors						

SIEMENS

BP103

Silicon NPN Phototransistor





FEATURES

- **Especially suitable for applications from 420 nm to 1130 nm**
- **High linearity**
- **TO-18, base plate, transparent epoxy resin lens, with base connection**
- **Spectral sensitivity selections**

APPLOCATIONS

- **Computer-controlled flashes**
- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The BP103 is an epitaxial NPN silicon planar phototransistor in a modified TO18 (18 A 3 DIN 41876) package with a clear plastic lens. The lens provides a wide angle for incident light.

The emitter lead is marked by a tab on the case bottom. The collector is electrically connected to the metallic case.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –40° to +80°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (T_s) t≤5 s ....260°C
Iron Soldering (T_s) t≤3 s ....300°C
Collector Emitter Voltage (V_{CEO})................ 50 V
Collector Current (I_C) .... 100 mA
Collector Surge Current (I_{CS}) t<10 µs... 200 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_A=25°C ...... 150 mW
Thermal Resistance (R_{THJA})500 K/W

Characteristics T_A=25°C

Parameter	Sym.	Value	Unit	Condition
Wavelength, Maximum Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	420 to 1130		
Radiant Sensitive Area	A	0.12	mm²	
Die Area Dimensions	L x W	0.5 x 0.5	mm	
Distance, Chip Surface to Case Surface	H	0.2 to 0.8		
Half Angle	φ	±55	Deg.	
Photocurrent, Collector Base Photo-diode	I_{PCB}	0.9	µA	E=0.5 mW/cm², V_{CB}=5 V
		2.7		E_V=1000 lx, Std. Light A, V_{CB}=5 V
Capacitance	C_{CE}	8	pF	V_{CE}=0 V, f=1 MHz, E=0
	C_{CB}	11		V_{CB}=0 V, f=1 MHz, E=0
	C_{EB}	19		V_{EB}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	5 (≤100)	nA	V_{CEO}=35 V, E=0
Saturation Voltage(1), Collector Emitter	V_{CEsat}	150	mV	$I_C=I_{PCEmin}$x 0.3, E_E=0.5 mW/cm²

Parameter	Sym.	–2	–3	–4	–5	Unit	Condition
Photocurrent λ=950 nm	I_{PCE}	80 to160	125 to 250	200 to 400	≥320	µA	E_e=0.5 mW/cm², V_{CE}=5 V
		0.38	0.6	0.95	1.4	mA	E_V=1000 lx, std. light A, V_{CE}=5 V
Rise/Fall Time	t_R,t_F	5	7	9	12	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Current Gain	I_{PCE}/ I_{PCB}	140	210	340	530		E_E=0.5 mW/cm², V_{CE}=5 V

Note

1. I_{PCE}min is the min. photocurrent of the specified dash number.

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

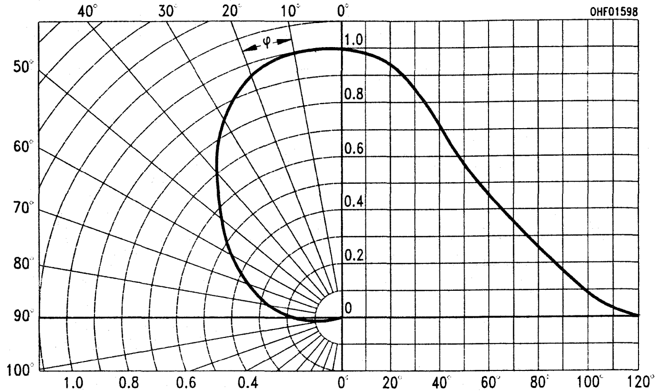


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

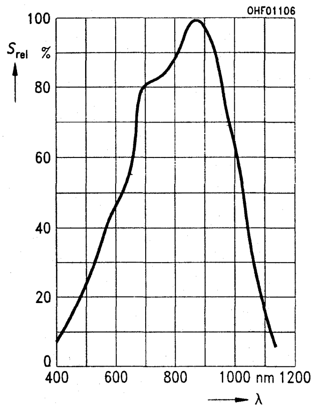


Figure 3. Photocurrent $I_{PCE}=f(E_e)$, V_{CE}=5 V

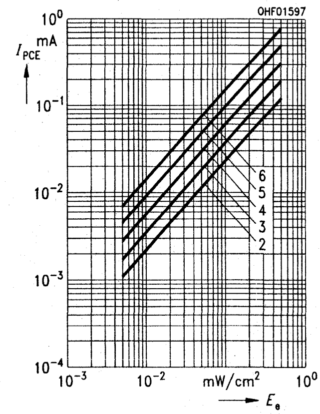


Figure 4. Total power dissipation $P_{TOT}=f(T_A)$

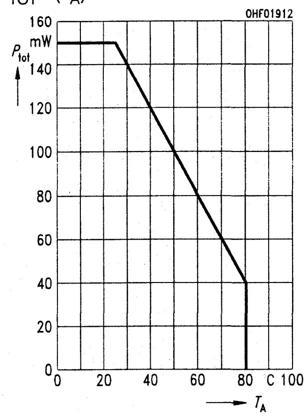


Figure 5. Output characteristics $I_C=f(V_{CE})$, I_B=Parameter

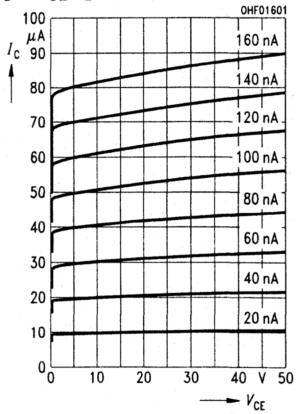


Figure 6. Output characteristics $I_C=f(V_{CE})$, I_B=Parameter

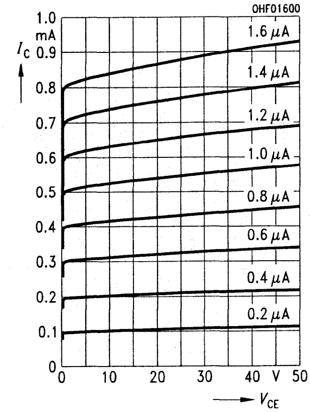


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

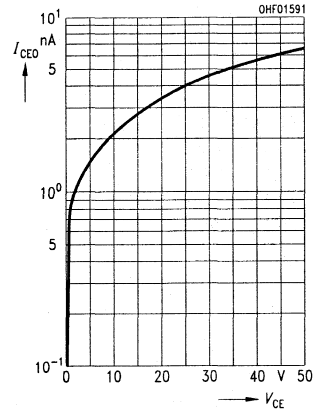


Figure 8. Photocurrent $I_{PCE}/I_{PCE25°}=f(T_A)$, V_{CE}=5 V

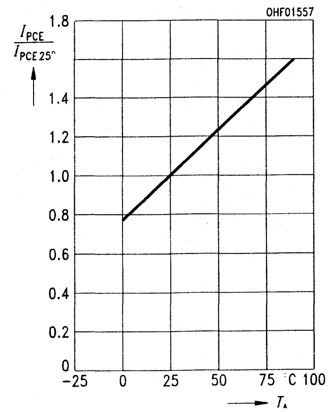


Figure 9. Dark current

$I_{CEO}/I_{CEO25°}=f(T_A)$, $V_{CE}=25$ V, E=0

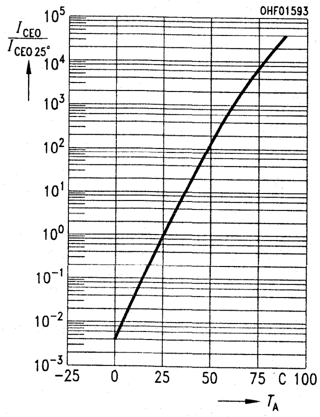


Figure 10. Collector emitter capacitance

$C_{CE}=f(V_{CE})$, f=1 MHz, E=0

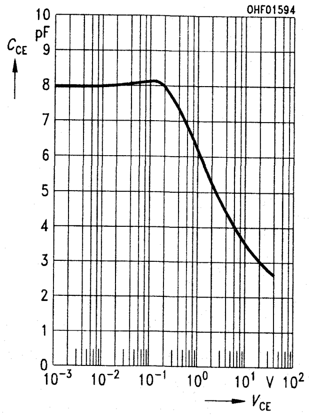


Figure 11. Collector base capacitance

$C_{CB}=f(V_{CB})$, f=1 MHz, E=0

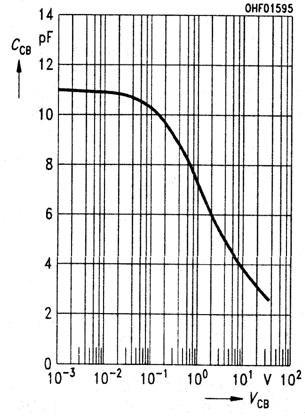
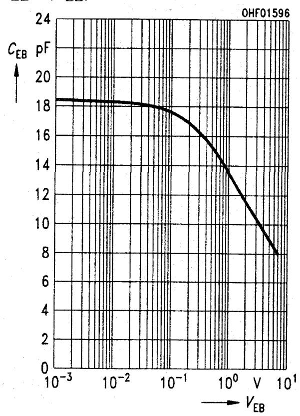


Figure 12. Emitter base capacitance

$C_{EB}=f(V_{EB})$, f=1 MHz, E=0

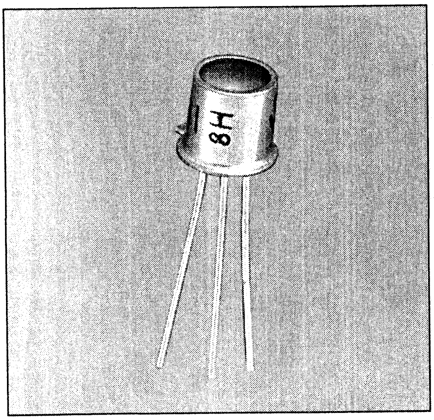


Phototransistors 12

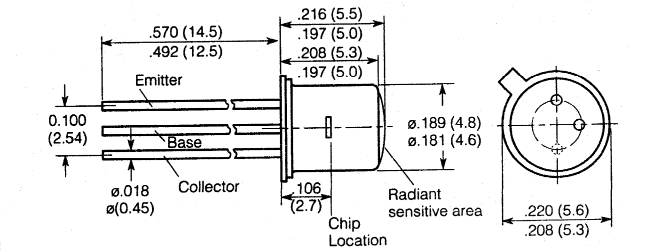
SIEMENS

BPX38

Silicon NPN Phototransistor



Dimensions in inches (mm)



FEATURES

- **Expecially suitable for applications from 450 nm to 1120 nm**
- **High linearity**
- **Hermetically sealed metal package (TO-18), base connection, suitable up to 125°C**
- **SPectral sensitivity**
- **Selections**

APPLICATIONS

- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The BPX38 is an high-sensitivity epitaxial NPN silicon planar phototransistor in a TO18 (18 A 3 DIN 41876) package with a flat lens. The collector is electrically connected to the metallic case.

Maximum Ratings

Operating/Storage Temperature Range
(T_{OP}, T_{STG})................................–55° to +125°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (T_s) t≤5 s .... 260°C
Iron Soldering (T_s) t≤3 s .... 300°C
Collector Emitter Voltage (V_{CEO}).................... 50 V
Collector Current (I_C) .... 50 mA
Collector Surge Current (I_{CS}) τ<10 µs ...... 200 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_A=25°C .... 220 mW
Thermal Resistance (R_{THJA})..................... 450 K/W

Characteristics T_A=25°C

Parameter	Sym	Value	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	880	nm	
Spectral Sensitivity Range	λ	450 to 1120		
Radiant Sensitive Area	A	0.675	mm^2	
Radiant Sensitive Area Dimensions	L x W	1 x 1	mm	
Distance, Chip Surface to Case Surface	H	2.05 to 2.35		
Half Angle	φ	±40	Deg.	
Photocurrent, Collector–Base Photoiode	I_{PCB}	1.8	µA	E_e=0.5 mW/cm², V_{CB}=5 V
		5.5		E_V=1000 lx, Std Light A, V_{CB}=5B
Capacitance	C_{CE}	23	pF	V_{CE}=0 V, f=1 MHz, E=0
	C_{CB}	39		V_{CB}=0 V, f=1 MHz, E=0
	C_{EB}	47		V_{EB}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	20 (≤300)	nA	V_{CE}=25 V, E=0
Saturation Voltage(1), Collector Emitter	V_{CEsat}	200	mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm²

Parameter	Sym	–2	–3	–4	–5(2)	Unit	Condition
Photocurrent, λ=950 nm	I_{PCE}	.2 to .4	.32 to .63	.5 to 1.0	≥.8	mA	E_e=0.5 mW/cm², V_{CE}=5 V
		0.95	1.5	2.3	3.6	mA	E_V=1000 lx, std. light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	9	12	15	18	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Current Gain	I_{PCE}/ I_{PCE}	170	280	420	650		E_e=0.5 mW/cm², V_{CE}=5 V

Note: 1. I_{PCEmin} is the min. photocurrent of the specified group.
2. Availability subject to yield.

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

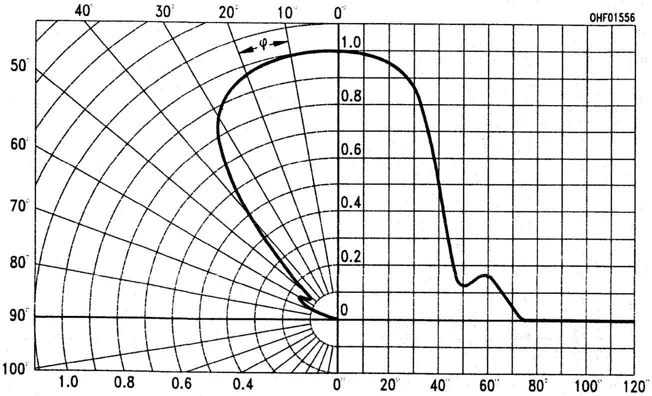


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

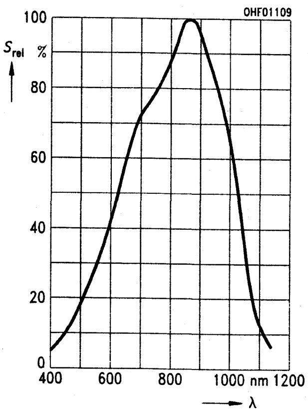


Figure 3. Photocurrent $I_{PCE}=f(E_e)$, $V_{CE}=5$ V

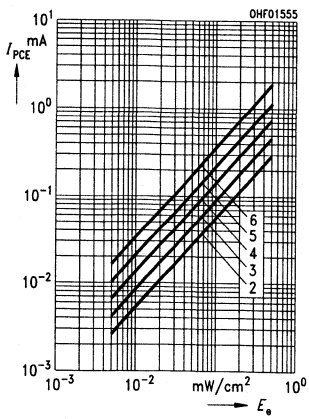


Figure 4. Total power dissipation $P_{TOT}=f(T_A)$

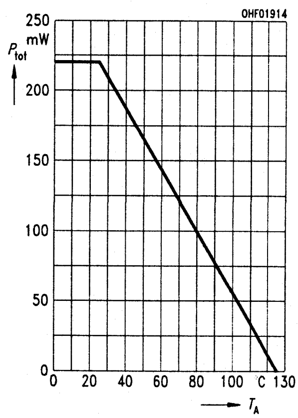


Figure 5. Output characteristics $I_C=f(V_{CE})$, I_B=Parameter

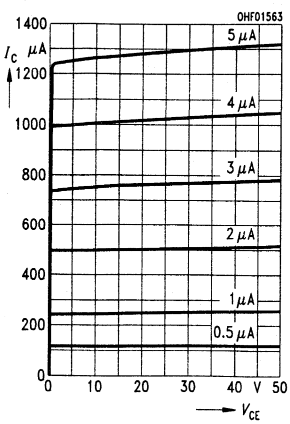


Figure 6. Output characteristics $I_C=f(V_{CE})$, I_B=Parameter

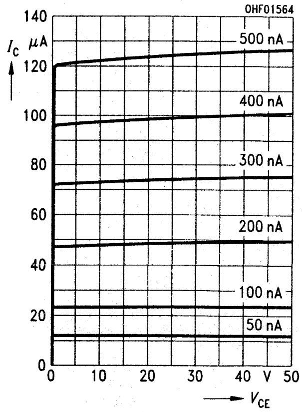


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

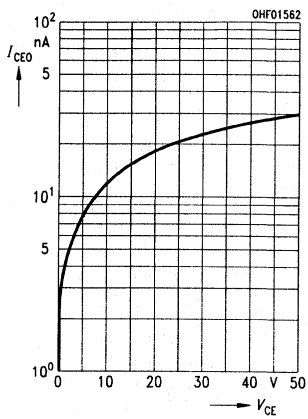
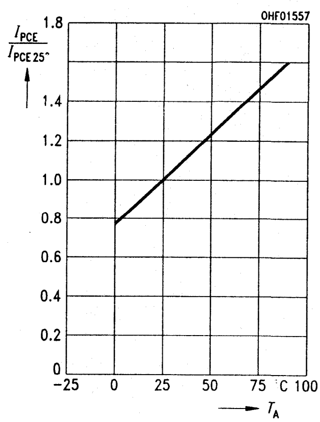


Figure 8. Photocurrent $I_{PCE}/I_{PCE25°}=f(T_A)$, $V_{CE}=5$ V



Phototransistors 12

Figure 9. Dark current
$I_{CEO}/I_{CEO25°}=f(T_A)$, $V_{CE}=25$ V, E=0

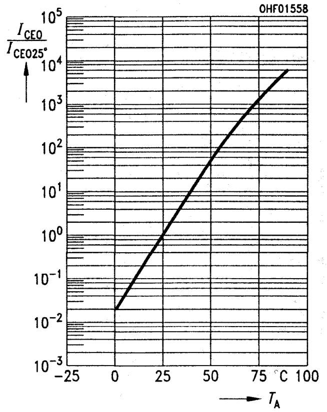


Figure 10. Collector emitter capacitance
$C_{CE}=f(V_{CE})$, f=1 MHz, E=0

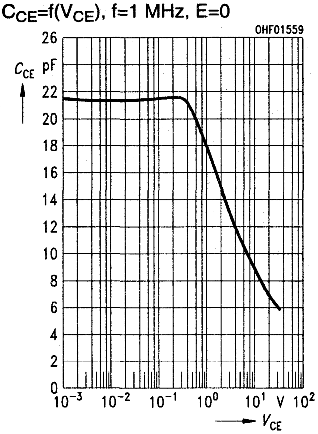


Figure 11. Collector base capacitance
$C_{CB}=f(V_{CB})$, f=1 MHz, E=0

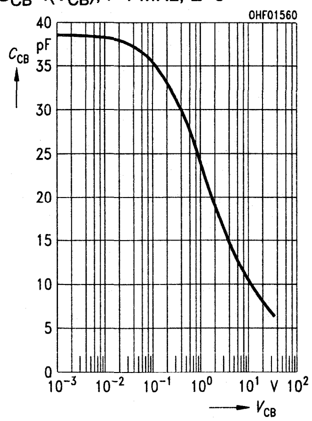
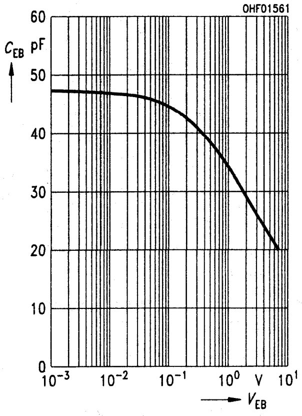


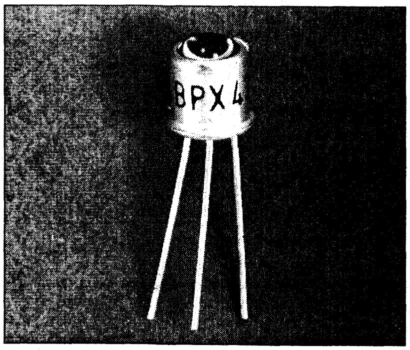
Figure 12. Capacitance
$C_{EB}=f(V_{EB})$, f=1 MHz, E=0

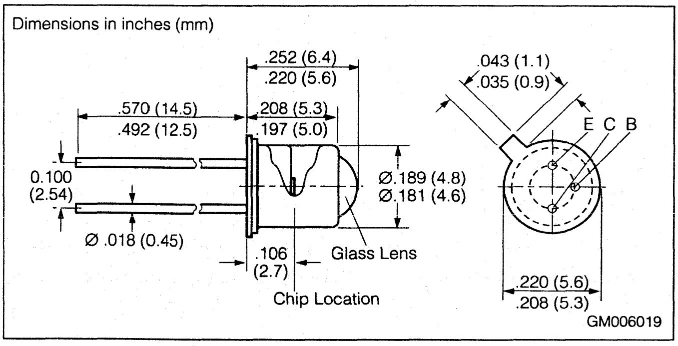


SIEMENS

BPX43

Silicon NPN Phototransistor





FEATURES

- **Especially suitable for applications from 450 nm to 1100 nm**
- **High linearity**
- **Hermetically sealed metal package (TO-18) with base connection suitable up to 125°C**
- **Spectral sensitivity selections**

APPLICATIONS

- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The BPX43 is an epitaxial NPN silicon planar phototransistor in a TO18 (18 A 3 DIN 41876) package with a glass lens. The collector is electrically connected to the metallic case.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–55° to +125°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (T_s) t≤5 s .... 260°C
Iron Soldering (T_s) t≤3 s .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 50 V
Collector Current (I_C) .... 50 mA
Collector Peak Current (I_{CS}) t<10 µs ..... 200 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_A=25°C ...... 220 mW
Thermal Resistance (R_{THJA}) .... 450 K/W

Note:

1. I_{PCE}min is the min. photocurrent of the specified dash number.

Characteristics T_A=25°C

Parameter	Sym.	Value	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	880	nm	
Spectral Sensitivity Range	λ	450 to 1100		
Radiant Sensitive Area	A	0.675	mm^2	
Die Area Dimensions	L x W	1 x 1	mm	
Distance, Chip Surface to Case Surface	H	2.4 to 3.0		
Half Angle	φ	±15	Deg.	
Photocurrent, Collector-Base Photodiode	I_{PCB}	11	µA	E_e=0.5 mW/cm², V_{CB}=5 V
		35		E_V=1000 lx, Std. Light A, V_{CB}=5 V
Capacitance (f=1 MHz, E=0)	C_{CE}	23	pF	V_{CE}=0 V
	C_{CB}	39		V_{CB}=0 V
	C_{EB}	47		V_{EB}=0 V
Dark Current	I_{CEO}	20 (≤300)	nA	V_{CEO}=25 V, E=0

Parameter	Sym.	–2	–3	–4	–5 (1)	Unit	Condition
Photocurrent, λ=950 nm	I_{PCE}	.8 to 1.6	1.25 to 2.5	2 to 4	≥3.2	mA	E_e=0.5 mW/cm², V_{CE}=5 V
		3.8	6.0	9.5	15.0	mA	E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	9	12	15	18	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Saturation Voltage(1), Collector Emitter	V_{CEsat}	200	220	240	260	mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm²
Current Gain	I_{PCE} / I_{PCB}	110	170	270	430	640	E_e=0.5 mW/cm², V_{CE}=5 V

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

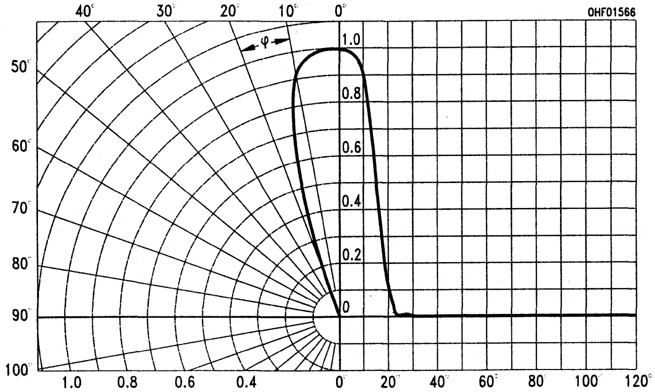


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

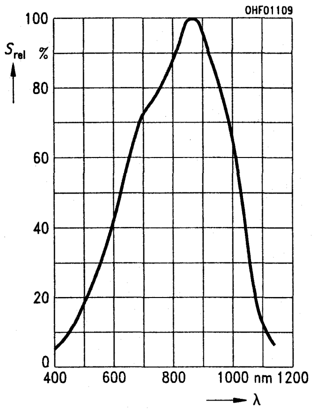


Figure 3. Photocurrent $I_{PCE}=f(E_e)$

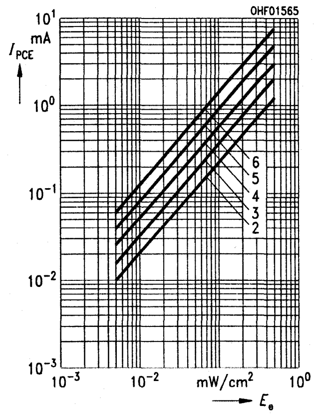


Figure 4. Total power dissipation $P_{TOT}=f(T_A)$

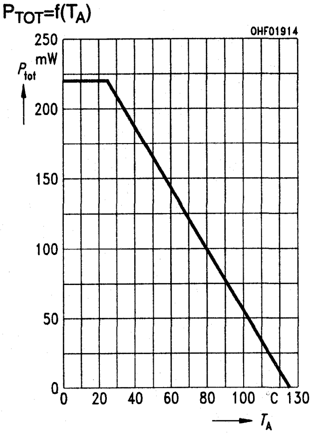


Figure 5. Output characteristics $I_C=f(V_{CE})$, I_B=Parameter

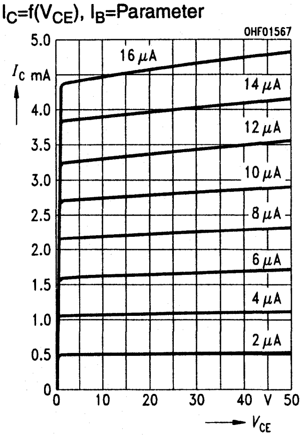


Figure 6. Output characteristics $I_C=f(V_{CE})$, I_B=Parameter

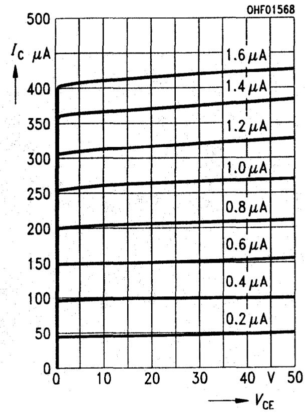


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

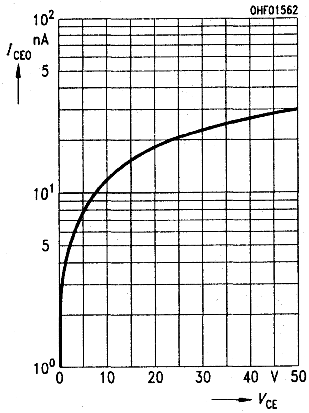


Figure 8. Photocurrent $I_{PCE}/I_{PCE25}=f(T_A)$, V_{CE}=5V

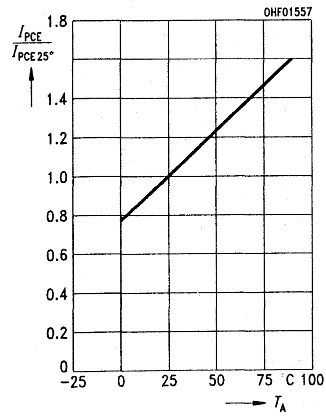


Figure 9. Dark current I_{CEO}/ I_{CEO25}=f(T_A), V_{CE}=25 V, E=0

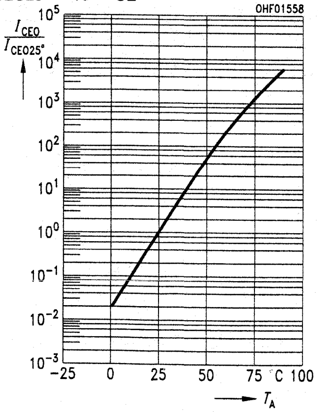


Figure 11. Collector base capacitance C_{CB}=f(V_{CB}), f=1 MHz, E=0

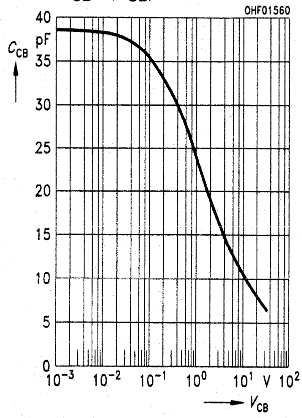


Figure 10. Collector emitter capacitance C_{CE}=f(V_{CE}), f=1 MHz, E=0

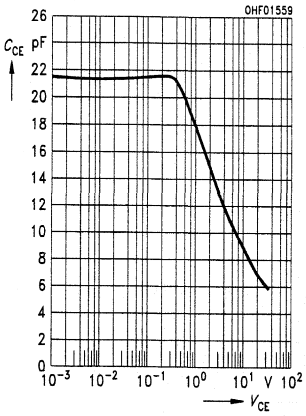
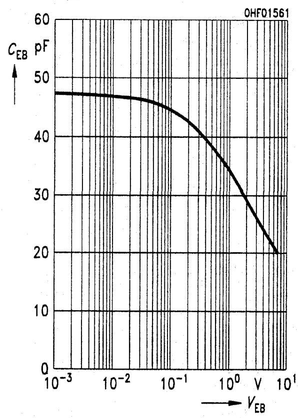


Figure 12. Emitter base capacitance C_{EB}=f(V_{EB}), f=1 MHz, E=0



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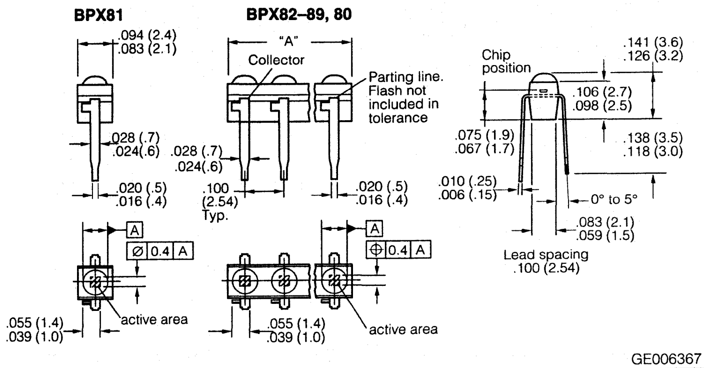
SIEMENS

SINGLE TRANSISTOR BPX81
2–10 TRANSISTOR ARRAYS BPX82–89, 80
Silicon NPN Phototransistor

Dimensions in inches (mm)

Part No.	Dimension "A".			
	Min.		Max.	
BPX 82	.177	(4.5)	.193	(4.9)
BPX 83	.275	(7.0)	.291	(7.4)
BPX 84	.377	(9.6)	.393	(10)
BPX 85	.476	(12.1)	.491	(12.5)
BPX 86	.574	(14.6)	.590	(15)
BPX 87	.676	(17.2)	.692	(17.6)
BPX 88	.774	(19.7)	.790	(20.1)
BPX 89	.876	(22.3)	.892	(22.7)
BPX 80	.975	(24.8)	.990	(25.2)



FEATURES
- **Especially suitable for applications from 440 nm to 1070 nm**
- **High linearity**
- **Multiple-digit array package of transparent epoxy**
- **Spectral sensitivity selections***

APPLICATIONS
- **Miniature photointerrupters**
- **Punched tape reading**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The BPX81 is a single transistor plastic encapsulated phototransistor; the BPX82 to BPX89, BPX80 are arrays. These silicon NPN epitaxial planar photo- transistors have standard lead spacing of 0.100" (2.54 mm).

The small angle of the lens-shaped window avoids optical "cross modulation" from an adjacent system. The collector leads are marked by tabs.

*The components are marked –A, –B, –C. Due to differing yields, not possible to order a definite dash number.

Note: 1. I_{PCEmin} is the min. photocurrent of the specified dash number.

Maximum Ratings

Operating and Storage Temperature Range (T_{OP}, T_{STG}) ....–40° to +80°C
Soldering Temperature (≥2 mm from case bottom)
Dip Soldering Time (T_s) t≤3 s .... 230°C
Iron Soldering Time (T_s) t≤5 s .... 300°C
Collector Emitter Voltage (V_{CE}) .... 32 V
Collector Current (I_C) .... 50 mA
Collector Surge Current (I_{CS}) τ<10 µs .... 200 mA
Power Dissipation (P_{TOT}) T_A=25°C .... 90 mW
Thermal Resistance (R_{THJA}) .... 750 K/W

Characteristics (T_A=25°C)

Parameter	Sym.	Value	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	440 to 1070		
Radiant Sensitive Area	A	0.17	mm²	
Chip Area Dimensions	L x W	0.6 x 0.6	mm	
Distance, Chip to Case	H	1.3 to 1.9	mm	
Half Angle	φ	±18	Deg.	
Capacitance	C_{CE}	6	pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	25 (≤200)	nA	V_{CEO}=25 V, E=0
Saturation Voltage, Collector Emitter(1)		150	mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm²

Parameter	Symbol	–A	–B	–C	Unit	Condition
Photocurrent, λ=950 nm	I_{PCE}	.32 to .63	.40 to .80	≥.5	mA	E_e=0.5 mW/cm², V_{CE}=5 V
		1.7	2.2	2.7		E_V=1000 lx, Std. Light A, V_{CE}=5 V

Parameter	Symbol	BPX81-2	BPX81-3	BPX81-4	Unit	Condition
Photocurrent, λ=950 nm	I_{PCE}	.2 to .5	≥.63	≥.63	mA	E_e=0.5 mW/cm², V_{CE}=5 V
		1.4	2.2	3.4		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	5.5	6	8	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

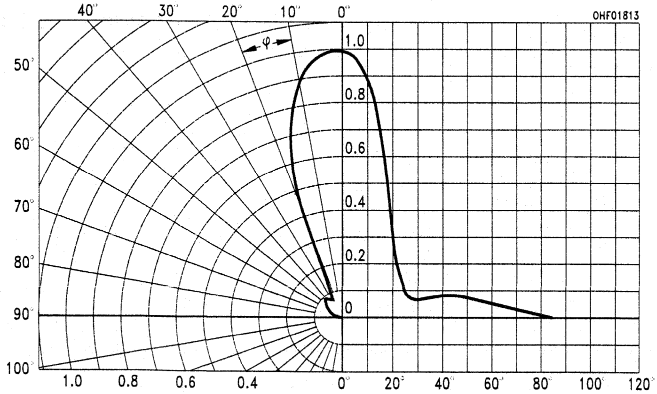


Figure 6. Collector emitter capacitance $C_{CE}=f(V_{CE})$, f=1 MHz, E=0

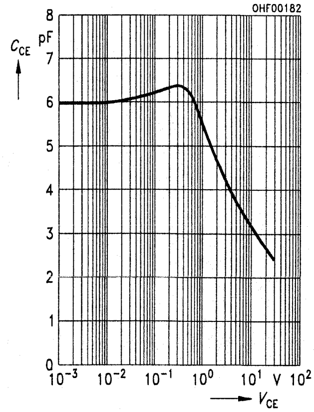


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

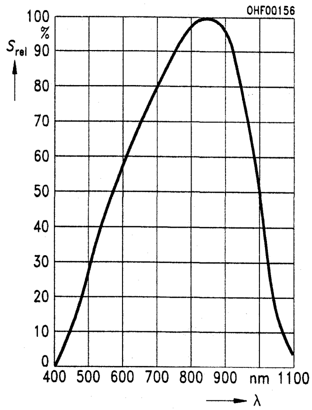


Figure 4. Total power dissipation $P_{TOT}=f(T_A)$

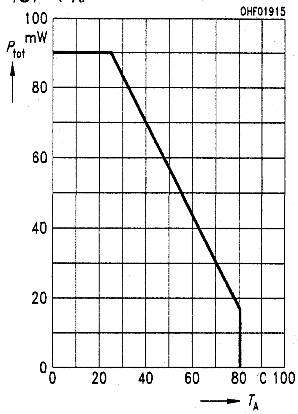


Figure 3. Photocurrent $I_{PCE}=f(E_e)$, V_{CE}=5V

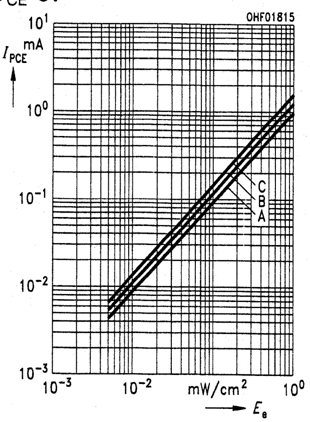
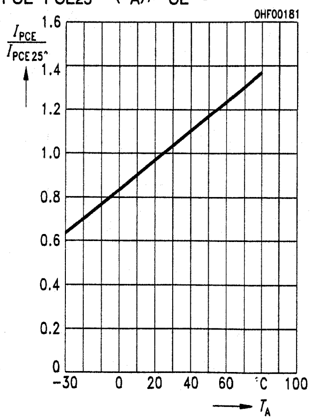


Figure 5. Photocurrent $I_{PCE}/I_{PCE25°}=f(T_A)$, V_{CE}=5 V

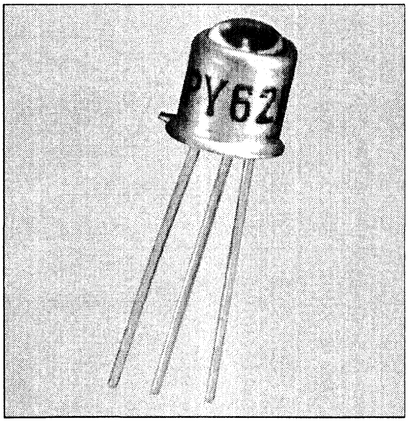


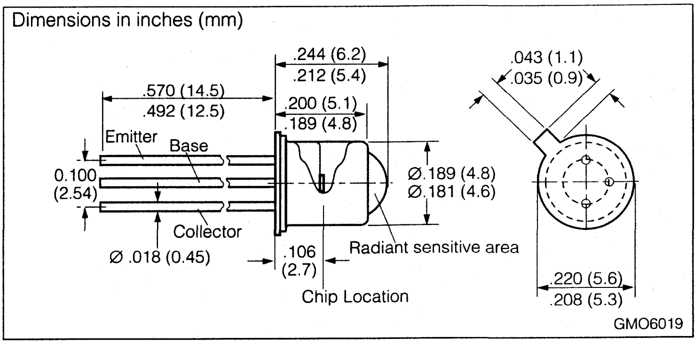
Phototransistors 12

SIEMENS

BPY62

Silicon NPN Phototransistor





FEATURES

- **Especially suitable for applications from 420 nm to 1130 nm**
- **High linearity**
- **Hermetically sealed metal package (TO-18) with base connection suitable up to 125°C**
- **Spectral sensitivity selections**

APPLICATIONS

- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The BPY62 is an epitaxial NPN silicon planar phototransistor in a TO18 (18 A 3 DIN 41876) package with a glass lens.

There is an external base connection. The emitter is marked by a tab on the case bottom. The collector is electrically connected to the metallic case.

The BPY62 is suitable for use with filament lamp light where sensitive photoelectric detectors are required.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +125°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (T_s) t≤5 s .... 260°C
Iron Soldering (T_s) t≤3 s .... 300°C
Collector Emitter Voltage (V_{CEO})................50 V
Collector Current (I_C) .... 100 mA
Collector Surge Current (I_{CS}) t<10 µs...200 mA
Emitter Base Voltage (V_{EB}) .... 7 V
Power Dissipation (P_{TOT}) T_A=25°C......200 mW
Thermal Resistance (R_{THJA}) ....500 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter	**Sym.**	**Value**	**Unit**	**Condition**
Wavelength, Maximum Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	420 to 1130		
Radiant Sensitive Area	A	0.12	mm^2	
Chip Area Dimensions	L x W	0.5 x 0.5	mm	
Distance, Chip Surface to Case Surface	H	2.4 to 3.0		
Half Angle	φ	±8	Deg.	
Photocurrent, Collector–Base Photodiode	I_{PCB}	4.5	µA	E=0.5 mW/cm², V_{CB}=5 V
		17		E_V=1000 lx, Std. Light A, V_{CB}=5 V
Capacitance f=1MHz, E=0	C_{CE}	8	pF	V_{CE}=0 V
	C_{CB}	11		V_{CB}=0 V
	C_{EB}	19		V_{EB}=0 V
Dark Current	I_{CEO}	5 (≤100)	nA	V_{CE}=35 V, E=0

Parameter	**Sym.**	**–2**	**–3**	**–4**	**–5**	**Unit**	**Condition**
Photocurrent, λ=950 nm	I_{PCE}	.5 to 1	.8 to 1.6	1.25 to 2.5	≥2	mA	E_e=0.5 mW/cm², V_{CE}=5 V
		3.0	4.6	7.2	11.4		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	5	7	9	12	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Saturation Voltage[(1)], Collector Emitter	V_{CEsat}	150	150	160	180	mV	I_C=I_{PCE}min x 0.3, E_e=0.5 mW/cm²
Current Gain,	I_{PCE} / I_{PCB}	170	270	420	670		E_e=0.5 mW/cm², V_{CE}=5 V

Note: 1. I_{PCEmin} is the min. photocurrent of the specified group.

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

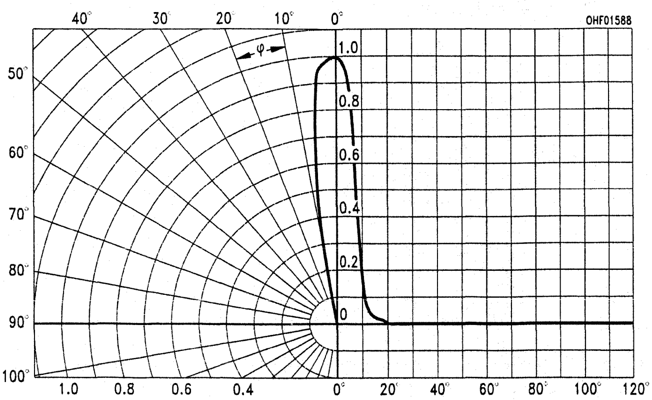


Figure 6. Output characteristics
$I_C=f(V_{CE})$, I_B=Parameter

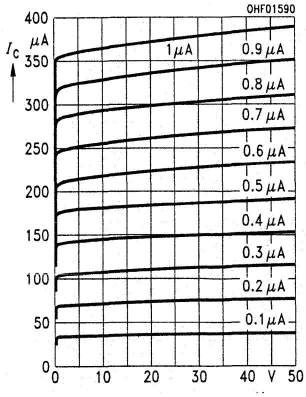


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

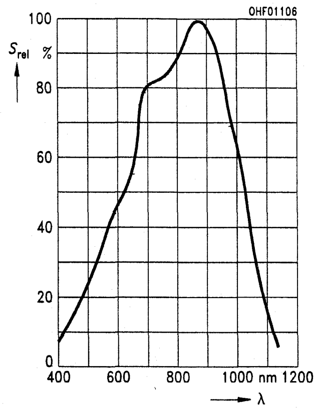


Figure 4. Total power dissipation $P_{TOT}=f(T_A)$

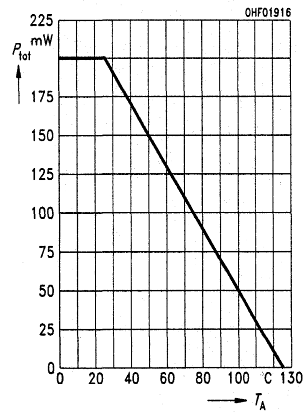


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

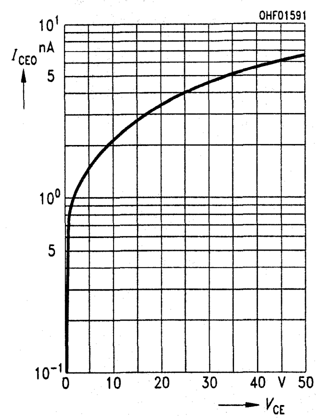


Figure 3. Photocurrent $I_{PCE}=f(E_e)$, V_{CE}=5 V

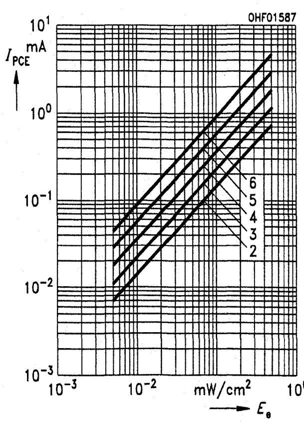


Figure 5. Output characteristics
$I_C=f(V_{CE})$, I_B=Parameter

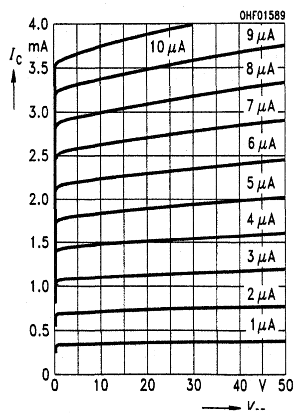
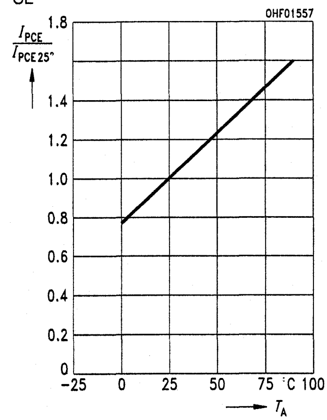


Figure 8. Photocurrent $I_{PCE}/I_{PCE25}=f(T_A)$, V_{CE}=5V



Phototransistors 12

Figure 9. Dark current
$I_{CEO}/I_{CEO25°}=f(T_A)$, $V_{CE}=25$ V, E=0

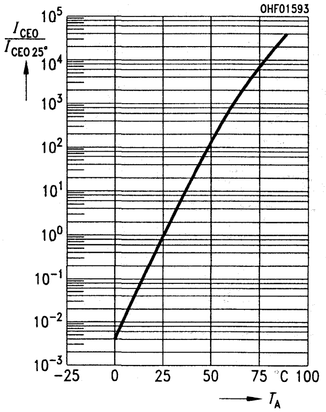


Figure 10. Collector emitter capacitance $C_{CE}=f(V_{CE})$, f=1 MHz, E=0

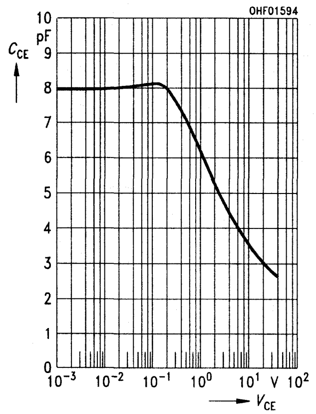


Figure 11. Collector base capacitance $C_{CB}=f(V_{CB})$, f=1 MHz, E=0

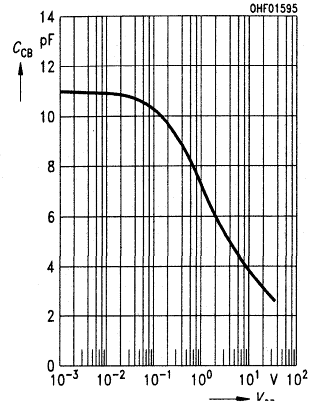
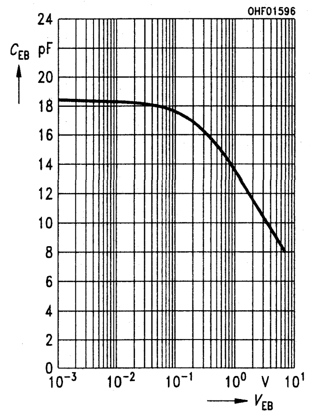


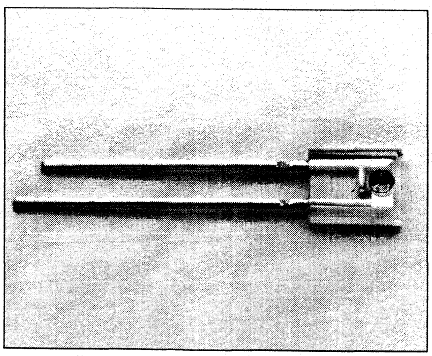
Figure 12. Emitter base capacitance
$C_{EB}=f(V_{EB})$, f=1 MHz, E=0

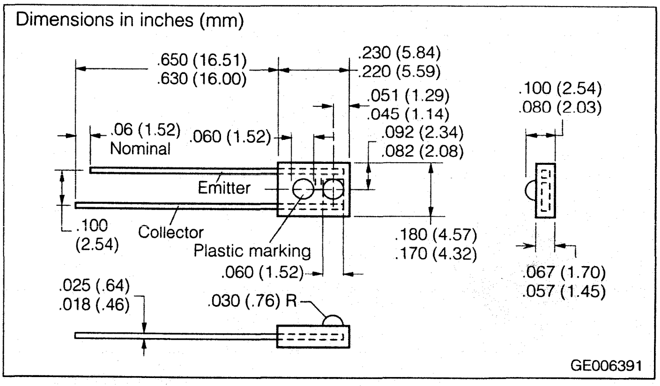


SIEMENS

LPT-80A

Silicon NPN Phototransistor





FEATURES
- **Low cost plastic package**
- **Sidelooker**
- **High sensitivity**
- **Matches infrared emitter IRL 80A, IRL 81A**

APPLICATIONS
- **Photointerrupters**

DESCRIPTION

The LPT-80A is a plastic, NPN phototransistor. It comes in a lensed, clear plastic, side-facing, miniature package. The lens accepts light from very wide angles, ±40°.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) ....–40° to +100°C
Dip Soldering Temperature, 2 mm from case bottom, t≤5 sec .... 240°C
Collector Emitter Voltage (V_{CEO}) .... 30 V
Collector Current (I_C)..................................50 mA
Collector Surge Current (I_{CS}) τ=1 ms........100 mA
Total Power Dissipation (P_{TOT}) T_A=25°C .. 100 mW
Thermal Resistance.................................750 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter	Symbol	Value	Unit	Condition
Wavelength, Maximum Sensitivity		870	nm	
Half Angle	φ	±40	Deg.	
Photocurrent(1)	I_P	≥200	µA	V_{CE}=5 V, E_e=0.5 mW/cm²
Dark Current	I_{CEO}	≤100	nA	V_{CE}=15 V, E=0
Collector Emitter Reverse Voltage	V_{CEO}	≥30	V	I_C=100 µA
		≥5		
Saturation Voltage	V_{CEsat}	0.15 (≤0.4)		I_C=250 µA, E_e=0.5 mW/cm²

Note
1. The light source is a tungsten filament bulb used with a 950 ±30 nm filter. The mechanical axis is aligned with the light source.

Figure 1. Relative spectral emission S_{REL}=f (λ)

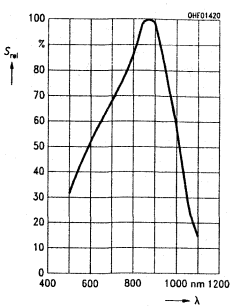


Figure 2. Radiation characteristics S_{REL}=f ((φ)

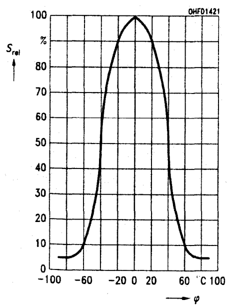


Figure 3. Forward current I_{PCE}=f (E_e), V_{CE}=5 (λ)

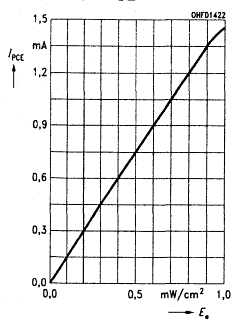
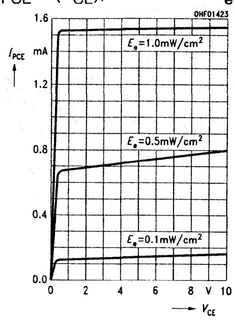
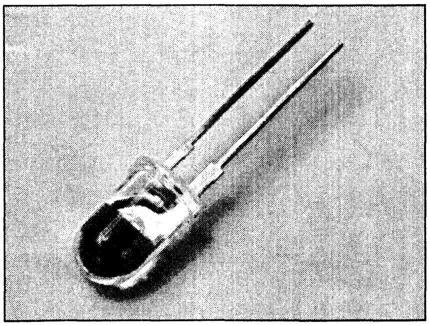


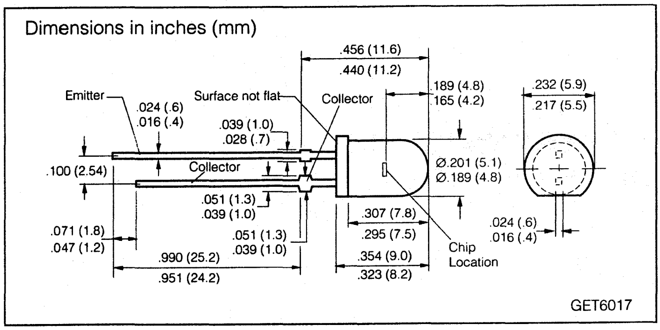
Figure 4. Forward current I_{PCE}=f (V_{CE}), Parameter=E_e (λ)



SIEMENS

SFH300
DAYLIGHT FILTER SFH300FA
Silicon NPN Phototransistor





FEATURES
- **Especially suitable for applications**
  - **SFH300: 420 to 1130 nm**
  - **SFH300FA: 880nm**
- **High linearity**
- **T1¾ (5 mm) LED plastic package**
- **Spectral sensitivity selections**

APPLICATIONS
- **Computer-controlled flashes**
- **Photointerrupters**
- **Industrial electronics**
- **Control and drive circuits**

DESCRIPTION
The SFH300 and SFH300FA are high-sensitivity epitaxial NPN silicon planar phototransistors. They are enclosed in a T1¾ (5 mm) clear plastic package.

Maximum Ratings

Operating/Storage Temperature Range (T_{OP}, T_{STG}) .... –55° to +100°C
Soldering Temperature (≥2 mm from case bottom)
Dip Soldering (T_s) t ≤5 s .... 260°C
Iron Soldering (T_s) t ≤3 s .... 300°C
Collector Emitter Voltage (V_{CE}) .... 35 V
Collector Current (I_C) .... 50 mA
Collector Surge Current (I_{CS}) t<10 µs .... 100 mA
Emitter Collector Voltage (V_{EC}) .... 7 V
Power Dissipation (P_{TOT}) T_A=25°C .... 200 mW
Thermal Resistance (R_{thJA}) .... 375 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter	Sym.	Value SFH300	Value SFH300FA	Unit	Condition
Wavelength, Maximum Sensitivity	λ_{Smax}	850	870	nm	
Spectral Sensitivity Range	λ	420 – 1130	730 –1120		
Radiant Sensitive Area	A	0.12		mm^2	
Chip Area Dimensions	L x W	0.5 x 0.5		mm	
Distance, Chip Surface to Case Surface	H	4.1 – 4.7			
Half Angle	φ	±25		Deg.	
Capacitance	C_{CE}	6.5		pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	5 (≤100)		nA	V_{CE}=35 V, E=0

Parameter	Sym.	–2	–3	–4[1]	Unit	Condition
Photocurrent, λ=950 nm	I_{PCE}	.63 – 1.25	1 – 2	≥1.6	mA	E_e=0.5 mW/cm², V_{CE}=5 V
		3.4	5.4	8.6		E_V=1000 lx, Std. Light V_{CE}=5 V
Rise/Fall Time	t_R, t_F	7.5	10	10	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Saturation Voltage[2] Collector Emitter	V_{CEsat}	130	140	150	mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm²

1. Subject to yield. Reserve right to deliver al substitute dash number.
2. I_{PCEmin} is the minimum photocurrent of the specified group

Figure 1. Directional characteristics $S_{REL}=f(\varphi)$

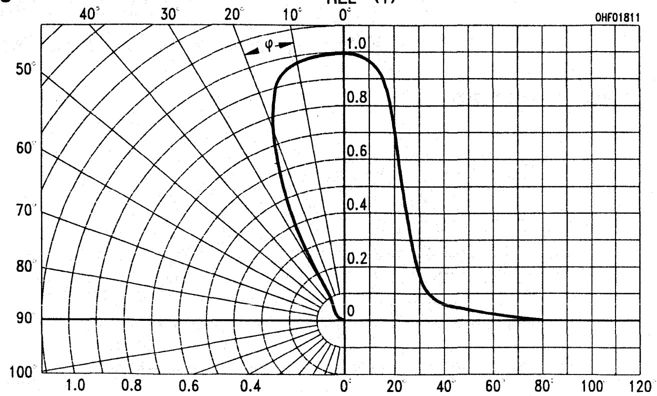


Figure 2. Relative spectral sensitivity SFH300 $S_{REL}=f(\lambda)$

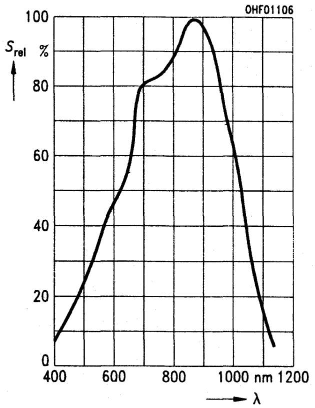


Figure 3. Relative spectral sensitivity SFH300FA $S_{REL}=f(\lambda)$

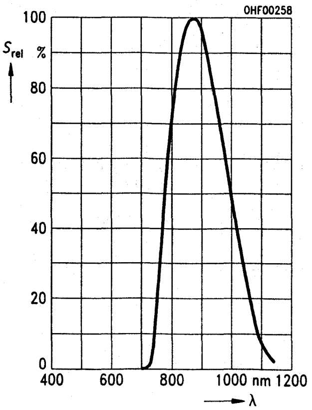


Figure 4. Photocurrent $I_{PCE}/I_{PCE\ 25°}=f$ (T_A), $V_{CE}=5$ V

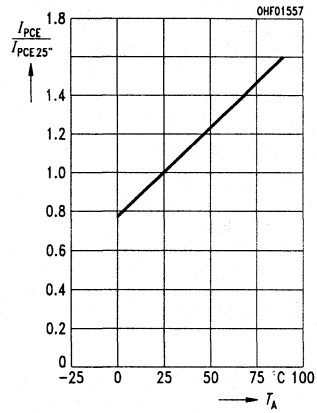


Figure 5. Photocurrent $I_{PCE}=f(E_e)$, $V_{CE}=5$ V

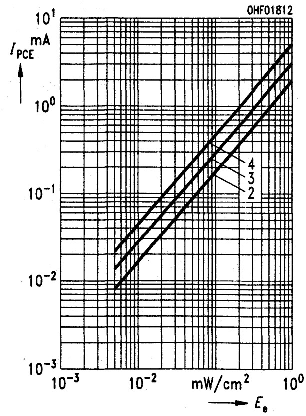


Figure 6. Dark current $I_{CEO}/I_{CEO\ 25°}=f$ (T_A), $V_{CE}=25$V, E=0

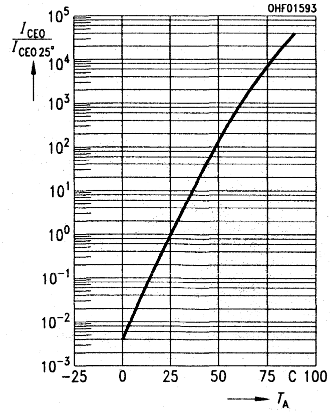


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

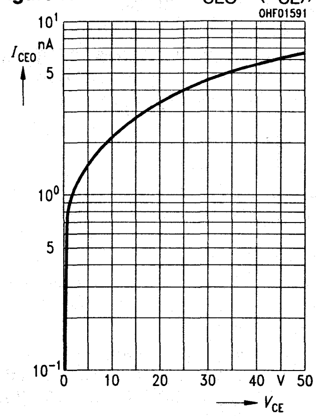
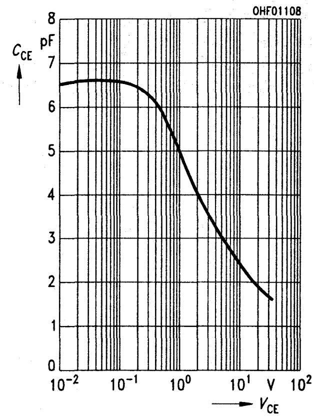


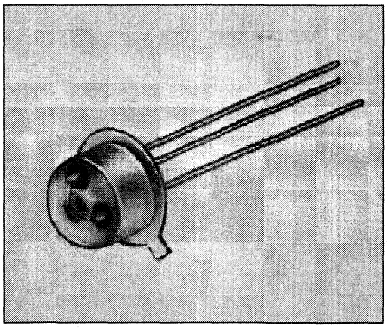
Figure 8. Collector emitter capacitance $C_{CE}=f(V_{CE})$, f=1 MHz, E=0

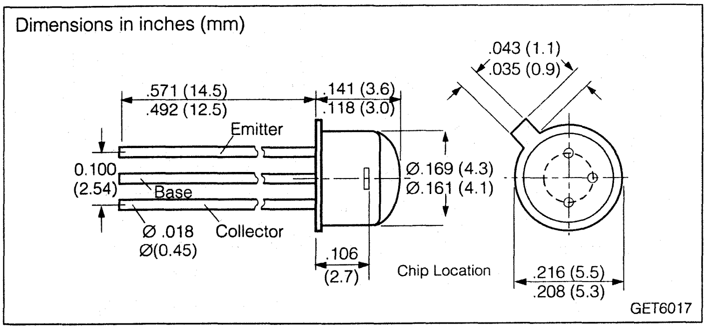


SIEMENS

SFH302

Silicon NPN Phototransistor





FEATURES

- **Especially suitable for applications from 450 nm to 1100 nm**
- **High linearity**
- **TO-18, base plate, transparent epoxy resin lens, with base connection**
- **Spectral sensitivity selections**

APPLOCATIONS

- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

Maximum Ratings

Operating/Storage Temperature Range
(T_{OP}, T_{STG})..........................–40° to +80°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (T_s) t≤5 s .... 260°C
Iron Soldering (T_s) t≤3 s .... 300°C
Collector Emitter Voltage (V_{CE}) ....50 V
Collector Current (I_C)..........................50 mA
Collector Surge Current
(I_{CS}) τ<10 µs.................................200 mA
Emitter Base Voltage (V_{EB})......................7 V
Total Power Dissipation
(P_{TOT}) T_A=25°C .... 150 mW
Thermal Resistance (R_{thJA}) ....450 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter	Sym.	Value	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	880	nm	
Spectral Sensitivity Range	λ	450 to 1100		S=10% of S_{max}
Radiant Sensitive Area	A	0.675	mm^2	
Radiant Sensitive Area Dimensions	L x W	1 x 1	mm	
Distance, Chip Surface to Case Surface	H	0.2 to 0.8		
Half Angle	φ	±50	Deg.	
Photocurrent, Collector–Base Photodiode	I_{PCB}	4.2	µA	E_e=0.5 mW/cm², V_{CB}=5 V
		12.5		E_V=1000 lx, Std. Light A, V_{CB}=5 V
Capacitance	C_{CE}	23	pF	V_{CE}=0 V, f=1 MHz, E=0
	C_{CB}	39		V_{CB}=0 V, f=1 MHz, E=0
	C_{EB}	47		V_{EB}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	20 (≤200)	nA	V_{CE}=10 V, E=0
Saturation Voltage(1), Collector Emitter	V_{CEsat}	200	mV	I_C=I_{PCEmin}x 0.3, E_e=0.5 mW/cm²

Parameter	Sym.	–2	–3	–4	–5	–6	Unit	
Photocurrent	I_{PCE}	0.4–0.8	0.63–1.25	1–2	1.6–3.2	≥2.5	mA	E_e=0.5 mW/cm², V_{CE}=5 V
		1.75	2.8	4.5	7.1	9.5		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	9	11	14	17	20	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Current Gain	I_{PCE} / I_{PCB}	140	230	360	570	750		E_e=0.5 mW/cm², V_{CE}=5 V

Note:
1. I_{PCEmin} is the minimum photocurrent of the specified dash number.

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

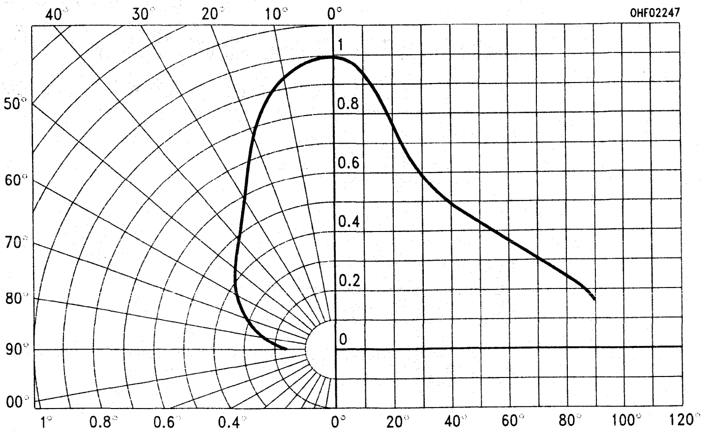


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

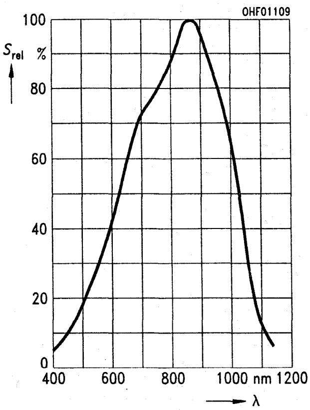


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

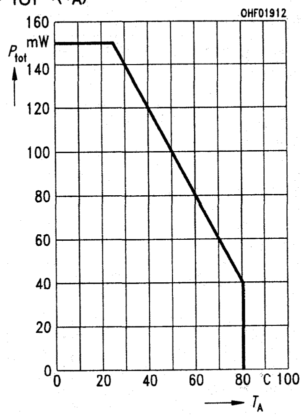


Figure 3. Photocurrent
$I_{PCE}=f(E_e)$, V_{CE}=5 V

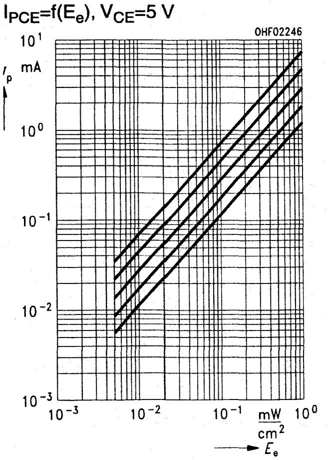
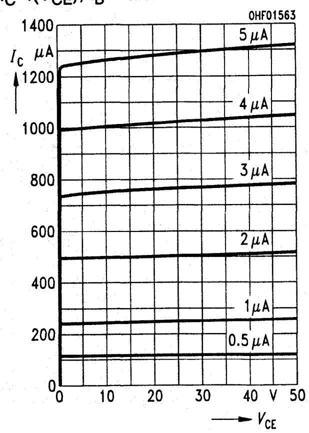
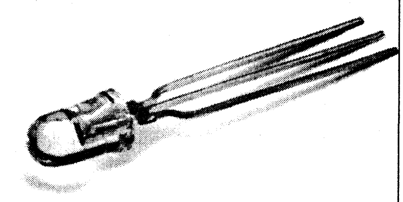


Figure 5. Output characteristics
$I_C=f(V_{CE})$, I_B=Parameter



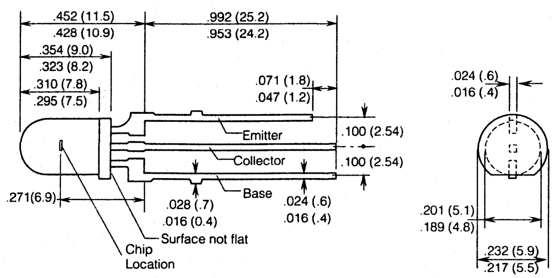
SIEMENS

SFH303
DAYLIGHT FILTER SFH303FA
Silicon NPN Phototransistor



SFH 303

Dimensions in inches (mm)



GE006351

FEATURES
- **Especially suitable for applications**
  - **SFH 303: 450 nm to 1100 nm**
  - **SFH 303 FA: 880 nm**
- **High linearity**
- **T1¾ (5 mm) LED plastic package**
- **Also available on tape**
- **Spectral sensitivify selections**

APPLICATIONS
- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION
The SFH303/303FA are silicon phototransistors with external base connections. The SFH303 comes in a standard T1¾ (5 mm) water-clear plastic package. The SFH303FA has a black daylight filter.

The emitter lead is the short lead; the collector lead is the middle lead.

Maximum Ratings
Operating/Storage Temperature Range (T_{OP}, T_{STG}) ....–55° to +100°C

Soldering Temperature (≥2 mm from case bottom)

Dip Soldering (T_S) t≤5 s .... 260°C

Iron Soldering (T_S) t≤3 s .... 300°C

Collector Emitter Voltage (V_{CE}) .... 50 V

Emitter Base Voltage (V_{EB}).......................... 7 V

Collector Current (I_C)............................. 50 mA

Collector Surge Current (I_{CS}) τ<10 µs.. 100 mA

Total Power Dissipation (P_{TOT}) T_A=25°C................................ 200 mW

Thermal Resistance (R_{THJA}) ....375 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter		Sym.	Value	Unit	Condition
Wavelength, Max. Sensitivity	SFH303	λ_{Smax}	850	nm	
	SFH303FA		870		
Spectral Sensitivity Range	SFH303	λ	450 to 1000		S=10% of S_{max}
	SFH303FA		720 to 1100		
Radiant Sensitive Area		A	0.20	mm^2	
Radiant Sensitive Area Dimensions		L x W	0.65 x 0.65	mm	
Distance Chip Surface to Case Surface		H	4.0 to 4.6		
Half Angle		φ	±20	Deg.	
Photocurrent, Collector Base Photodiode	SFH303	I_{PCB}	15.8	µA	E_V=1000 lx, Std. Light A, V_{CB}=5 V
	SFH303FA		4.5		E_e=0.5 mW/cm², V_{CB}=5 V
Capacitance, f=1 MHz, E=0		C_{CE}	10	pF	V_{CE}=0 V
		C_{CB}	15		V_{CB}=0 V
		C_{EB}	21		V_{EB}=0 V
Saturation Voltage(1), Collector Emitter		V_{CEsat}	150	mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm²

Parameter	Sym.	–2	–3	–4	Unit	Condition
Photocurrent, λ=950 nm	I_{PCE}	1.0 to 2.0	1.6 to 3.2	≥2.5	mA	E_e=0.5 mW/cm², V_{CE}=5 V
Photocurrent, λ=950 nm, **SFH303**		5.2	8.4	13.1		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	11	13	15	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Current Gain	I_{PCE}/ I_{PCB}	330	530	830		E_e=0.5 mW/cm², V_{CE}=5 V

Notes: 1. I_{PCEmin} is the minimum photocurrent of the specified dash number.

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

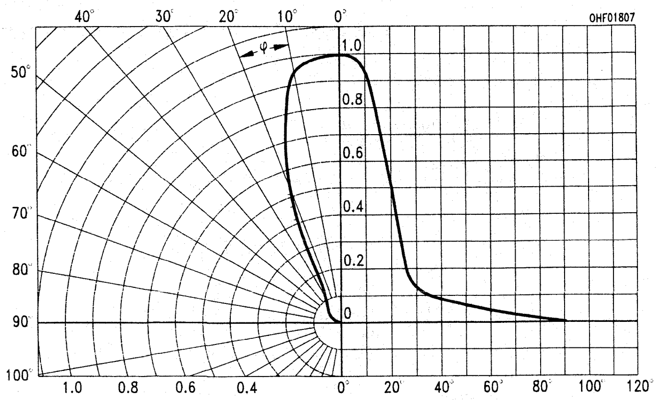


Figure 2. Relative spectral sensitivity —SFH303 $S_{REL}=f(\lambda)$

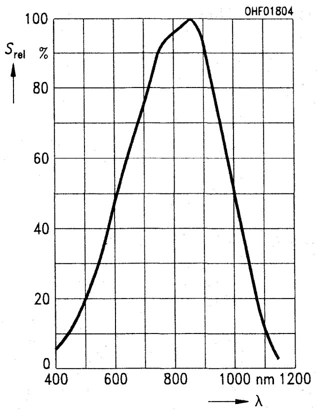


Figure 3. Relative spectral sensitivity —SFH303FA $S_{REL}=f(\lambda)$

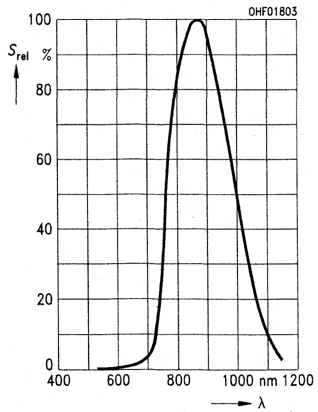


Figure 4. Photocurrent
$I_{PCE}=f(E_e)$, $V_{CE}=5$ V

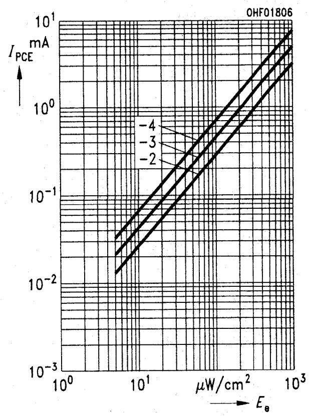


Figure 5. Output characteristics
$I_C=f(V_{CE})$, I_B=Parameter

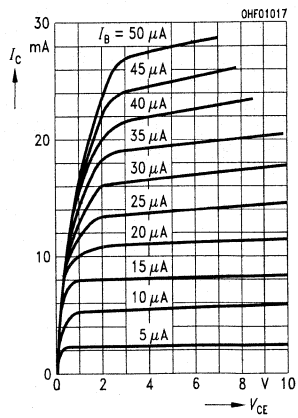


Figure 6. Dark Current $I_{CEO}=f(V_{CE})$, E=0

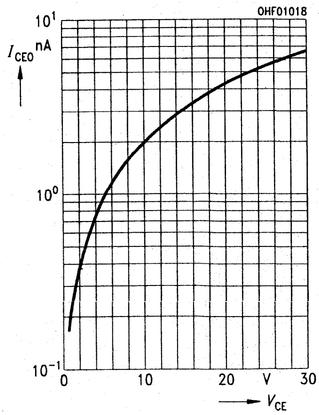
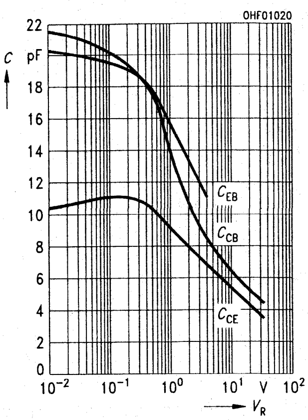


Figure 7. Capacitance
C=f(V), f=1 MHZ, E=0

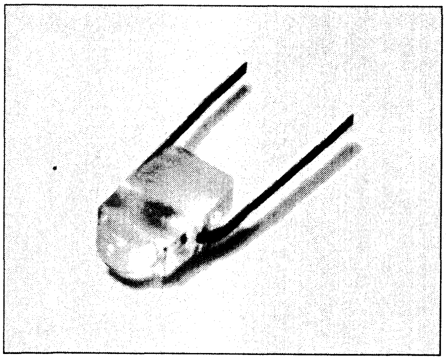


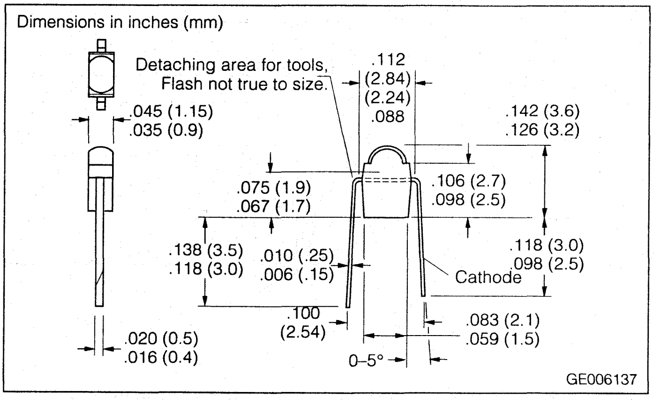
Phototransistors 12

SIEMENS

SFH305

Silicon NPN Phototransistor





FEATURES

- **Especially suitable for applications from 460 nm to 1060 nm**
- **High linearity**
- **Mini-package**
- **Spectral sensitivity selections**

APPLICATIONS

- **Miniature photointerrupters**
- **Punched tape reading**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The SFH305 is a NPN silicon planar phototransistor in clear plastic encapsulation with solder terminals and a marked collector. There are two photosensitivity ranges.

The SFH305 can be used as a detector with IR emitter SFH405 as a miniature light barrier with close spacing between emitter and detector.

Maximum Ratings

Operating/Storage Temperature Range
(T_{OP}, T_{STG}) .... –40° to +80°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (Ts) t≤5 s .... 230°C
Iron Soldering (Ts) t≤3 s .... 300°C
Collector Emitter Voltage (V_{CEO}) .... 32 V
Collector Current (I_C)..................................... 50 mA
Collector Surge Current (I_{CS}) τ<10 µs......... 100 mA
Total Power Dissipation (P_{TOT}) T_A=25°C ...... 70 mW
Thermal Resistance (R_{THJA})...................... 950 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter	Sym	Value	Unit	Condition
Wavelength, Maximum Sensitivity	λ_{Smax}	850	nm	
Photosensitivity Spectral Range	λ	440 to 1070		S=10% of S_{max}
Radiant Sensitive Area	A	0.17	mm^2	
Radiant Sensitive Area Dimensions	L x W	0.6 x 0.6	mm	
Distance Chip Surface to Case Surface	H	1.3 to 1.9		
Half Angle	φ	±16	Deg.	
Capacitance	C_{CE}	5.5	pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	3(≤20)	nA	V_{CE}=25 V, E=0

Parameter	Sym.	–2	–3	Unit	Condition
Photocurrent λ=950 nm	I_{PCE}	.25 to .5	.4 to .8	mA	E_e=0.5 mW/cm², V_{CE}=5 V
		1.4	2.2		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	5.5	6	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Saturation Voltage[(1)], Collector Emitter	V_{CEsat}	150	150	mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm²

Note:1. I_{PCEmin} is the minimum photocurrent of the specified group

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

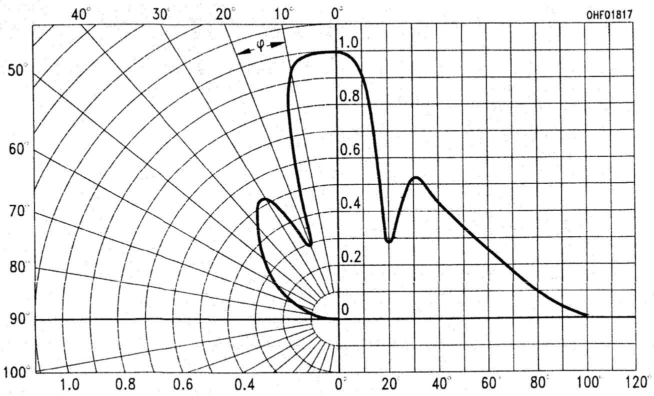


Figure 6. Collector emitter capacitance
$C=f(V_R)$, f=1 MHz, E=0

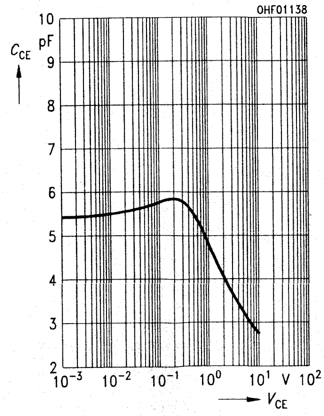


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

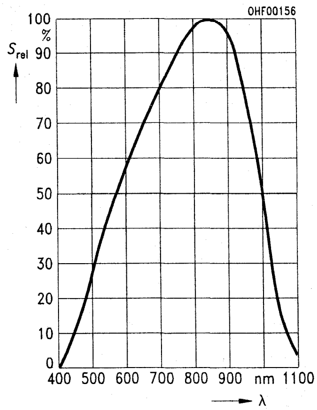


Figure 4. Total power dissipation
$P_{TOT}=f(T_A)$

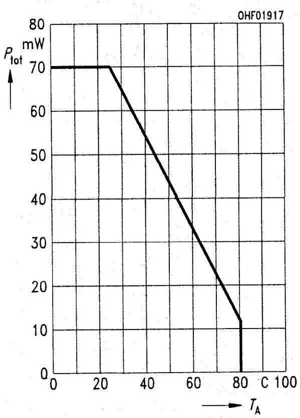


Figure 7. Dark current
$I_{CEO}=f(T_A)$, V_{CE}=25 V, E=0

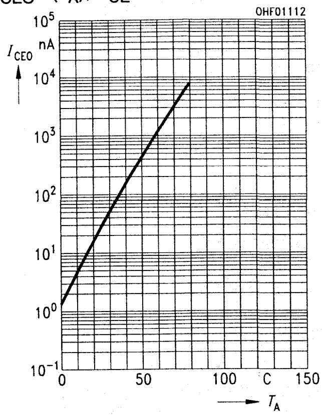


Figure 3. Photocurrent
$I_{PCE}=f(E_e)$, V_{CE}=5 V

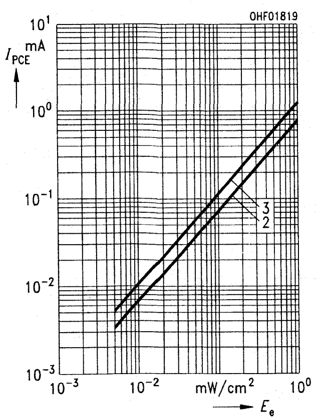
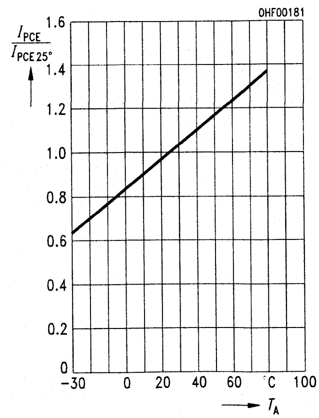
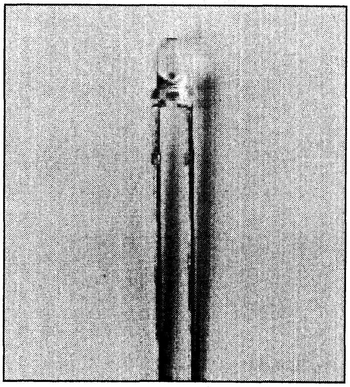


Figure 5. Photocurrent
$I_{PCE}/I_{PCE25°}=f(T_A)$, V_{CE}=5 V

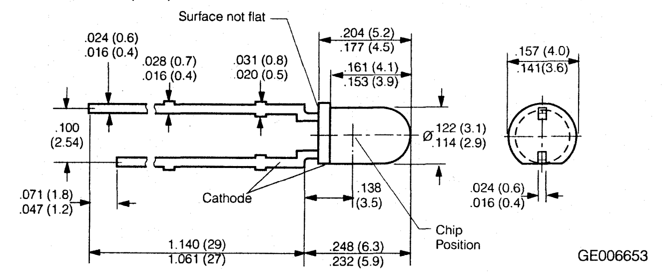


SIEMENS

SFH309
DAYLIGHT FILTER SFH309FA
Silicon NPN Phototransistor



Dimensions in inches (mm)



FEATURES
- **Especially suitable for applications**
  - **SFH 309: 380 to 1180 nm**
  - **SFH309 FA: 880 nm**
- **High linearty**
- **3 mm LED plastic package**
- **Avilable in groups**

APPLICATIONS
- **Photointerupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION
The SFH309/309FA are silicon NPN phototransistors in a standard T1 (3 mm) plastic package. The SFH309F has a black daylight filter.

The devices can be used in a variety of low-cost, high-volume applications such as IR remote control and other consumer and entertainment products.

Maximum Ratings
Operating/Storage Temperature Range (T_{OP}, T_{STG})................................–55° to +100°C
Soldering Temperature (≥2 mm from case bottom)
  Dip Soldering Time (T_S) t≤5 s .... 260°C
  Iron Soldering Time (T_S) t≤3 s .... 300°C
Collector Emitter Voltage (V_{CEO}).. 35 V
Collector Current (I_C) .... 15 mA
Collector Peak Current (I_{PK}) t<10 µs .... 75 mA
Total Power Dissipation (P_{TOT}) T_A=25°C .... 165 mW
Thermal Resistance (R_{THJA})..450 K/W

Characteristics (T_A=25°C)

Parameter		Symbol	Value	Unit	Condition
Wavelength, Maximum Sensitivity	SFH309	λ_{Smax}	860	nm	
	SFH309FA		900		
Spectral Sensitivity Range	SFH309	λ	380 to 1150		
	SFH309FA		730 to 1120		
Radiant Sensitive Area		A	0.2	mm	
Chip Area Dimensions		LxW	.45x.45		
Distance, Chip Surface and Lens		H	2.4 to 2.8		
Half Angle		φ	±12	Deg.	
Capacitance		C_{CE}	5.0	pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current		I_{CEO}	1 (≤200)	nA	V_{CE}=25 V, E=0
Saturation Voltage[1], Collector Emitter		V_{CEsa}	200	mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm^2

Parameter	Sym.	–2	–3	–4	–5	–6[2]	Unit	Condition
Photocurrent, λ=950 nm	I_{PCE}	.4 to .8	.63 to1.25	1.0 to 2.0	1.6 to 3.2	≥2.5	mA	E_e=0.5 mW/cm^2, V_{CE}=5 V
Photocurrent, λ=950 nm,SFH309		1.5	2.8	4.5	7.2	10.0		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R,t_F	5	6	7	8	9	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ

Notes
1. I_{PCEmin} is the minimum photocurrent of the specified group.
2. Availability subject to yield.

Figure 1. Directional characteristics $S_{REL}=f(\varphi)$

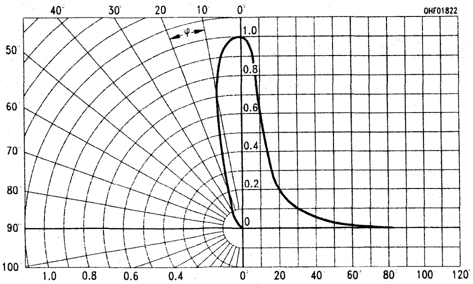


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **SFH309**

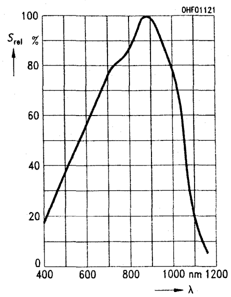


Figure 3. Relative spectral sensitivity $S_{REL}=f(\lambda)$ **SFH309FA**

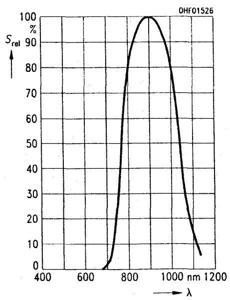


Figure 4. Photocurrent $I_{PCE}=f(Ee)$, $V_{CE}=5$ V

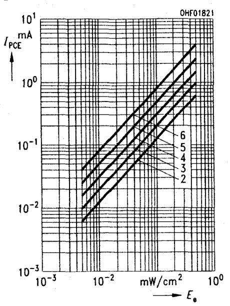


Figure 5. Total power dissipation $P_{TOT}=f(T_A)$

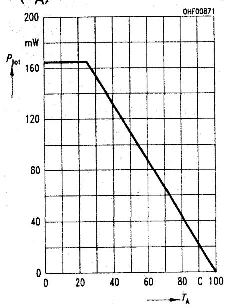


Figure 6. Photocurrent $I_{PCE}=f(V_{CE})$, E_e=Parameter

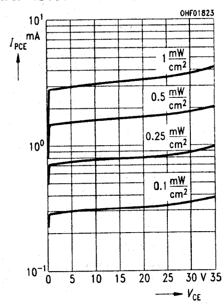


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

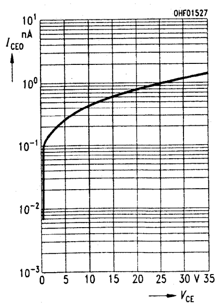


Figure 8. Dark current $I_{CEO}=f(T_A)$, $V_{CE}=25$V, E=0

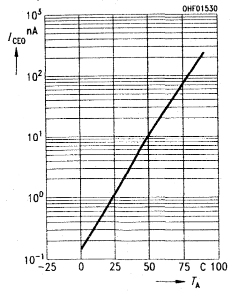


Figure 9. Capacitance $C_{CE}=f(V_{CE})$, f=1 MHz, E=0

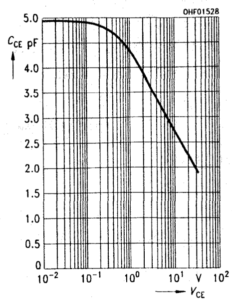
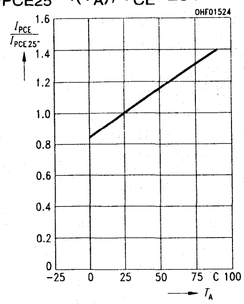
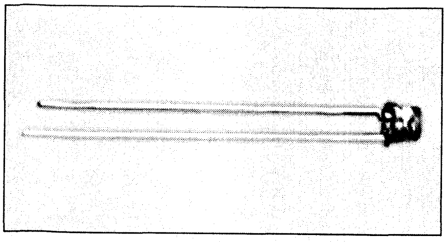


Figure 10. Dark current $I_{PCE}/I_{PCE25°}=f(T_A)$, $V_{CE}=25$V

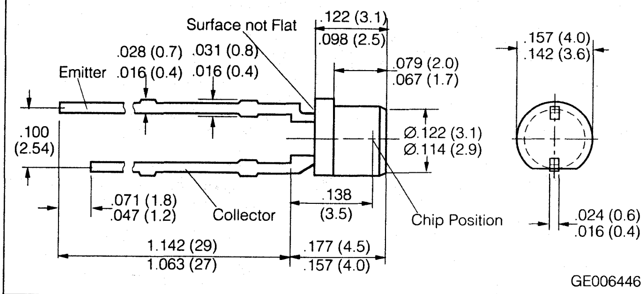


SIEMENS

SFH309P
DAYLIGHT FILTER SFH309PFA
Silicon NPN Phototransistor



Dimensions in inches (mm)



FEATURES

- **Especially suitable for applications**
  - **SFH 309P: 380 to 1180 nm**
  - **SFH 309P FA: 880 nm**
- **High linearty**
- **T1 (3 mm) LED plastic package**

APPLICATIONS

- **Photointerupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The SFH309P/309PFA are silicon NPN phototransistors in a standard T1 (3 mm) plastic package. The SFH309PFA has a black daylight filter.

Maximum Ratings

Rating	Value
Operating and Storage Temperature (T_{OP}, T_{STG})	–55°C to +100°C
Soldering Temperature (≥2 mm from case bottom)	
Dip Soldering Time (T_{ST}) t ≤ 5 sec.	260°C
Iron Soldering Time (T_{SK}) t ≤ 3 sec.	300°C
Collector Emitter Voltage (V_{CE})	35 V
Collector Current (I_C)	15 mA
Collector Surge Current (I_{CS}) τ<10 µs	75 mA
Power Dissipation (P_{TOT}) T_A=25°C	165 mW
Thermal Resistance (R_{thJA})	450 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter		Sym.	Value	Unit	Condition
Wavelength, Max. Sensitivity	SFH309P	λ_{Smax}	860	nm	
	SFH309PFA		900		
Photosensitivity Spectral Range	SFH309P	λ	380–1150	nm	S=10% of S_{MAX}
	SFH309PFA		730–1120		
Radiant Sensitive Area		A	0.045	mm^2	
Radiant Sensitive Area Dimensions		L x W	.45 x .45	mm	
Distance, Chip Surface to Case Surface		H	0.4 to 0.8		
Half Angle		φ	±75	Deg.	
Capacitance		C_{CE}	5.0	pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current		I_{CEO}	1(≤200)	nA	V_{CEO}=25 V, E=0
Photocurrent		I_{PCE}	≥63	µA	E_e=0.5 mW/cm^2, V_{CE}=5 V
Photocurrent **SFH309P**			420		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time		t_R, t_F	≥6	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Saturation Voltage, Collector Emitter		V_{CEsat}	150	mV	I_C=20 µA, E_e=0.5 mW/cm^2

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

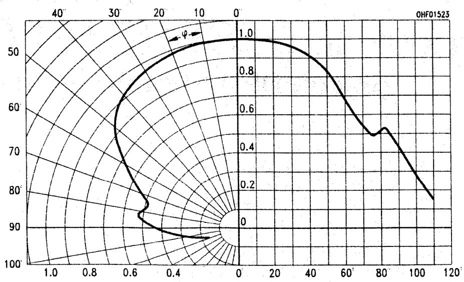


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$ SFH309P

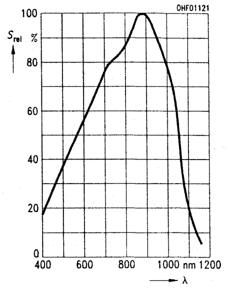


Figure 3. Relative spectral sensitivity $S_{REL}=f(\lambda)$ SFH309PFA

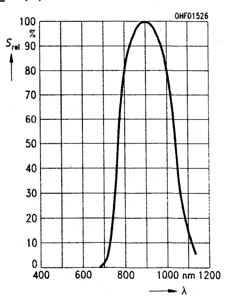


Figure 4. Photocurrent $I_{PCE}=f(E_e).V_{CE}=5$ V, $\lambda=950$ nm

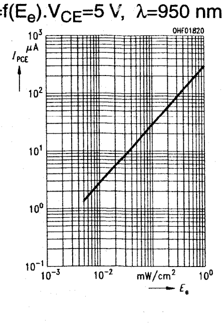


Figure 5. Total power dissipation $P_{TOT}=f(T_A)$

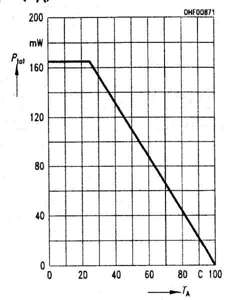


Figure 6. Photocurrent $I_{PCE}=f(V_{CE})$, E_e=Parameter

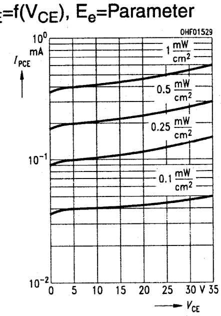


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

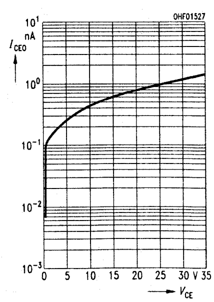


Figure 8. Dark current $I_{CEO}=f(T_A)$, $V_{CE}=25$ V, E=0

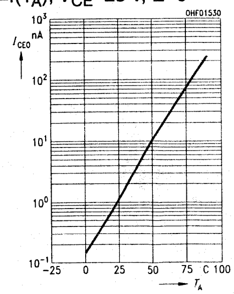


Figure 9. Capacitance $C_{CE}=f(V_{CE})$, f=1 MHz, E=0

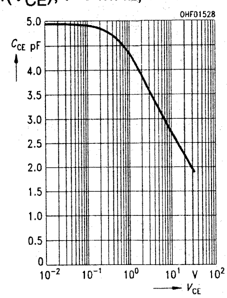
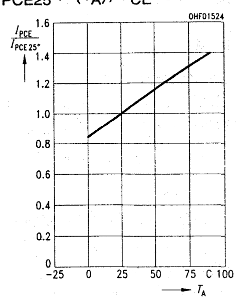


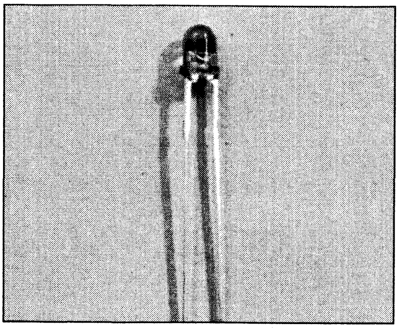
Figure 10. Photocurrent $I_{PCE}/I_{PCE25°}f=(T_A)$, $V_{CE}=5$ V



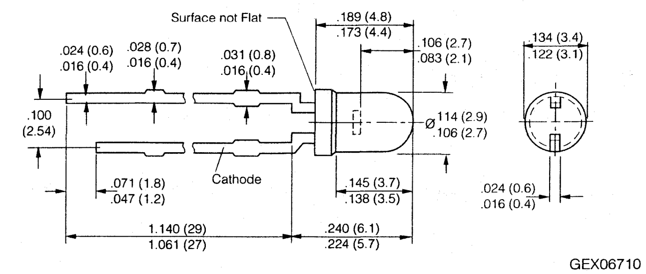
Phototransistors 12

SIEMENS

SFH310
DAYLIGHT FILTER SFH310FA
Silicon NPN Phototransistor



Dimensions in inches (mm)



FEATURES
- **Especially suitable for applications**
  - **SFH 310: 400 to 1100 nm**
  - **SFH 310 FA: 880 nm**
- **High linearity**
- **T1 (3 mm) plastic package**
- **Spectral sensitivity selections**

APPLOCATIONS
- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION
The SFH310 and SFH310FA are NPN silicon planar phototransistors. They are enclosed in a T1 (3 mm) clear plastic package.

The collector is denoted by the shorter lead.

Maximum Ratings
Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (T_s) t ≤5 s .... 260°C
Iron Soldering (T_s) t ≤3 s .... 300°C
Collector Emitter Voltage (V_{CE}) .... 70 V
Collector Current (I_C)............................ 50 mA
Collector Surge Current (I_{CS})
τ=10 µs .... 100 mA
Total Power Dissipation (P_{TOT})
T_A=25°C .... 165 mW
Thermal Resistance (R_{thJA}) .... 450 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter	Symbol	Value		Unit	Condition
		SFH310	**SFH310FA**		
Wavelength, Maximum Sensitivity	λ_{Smax}	780	880	nm	
Spectral Sensitivity Range	λ	470 – 1070	740 –1070		S=10% of Smax
Radiant Sensitive Area	A	0.19		mm^2	
Chip Area Dimensions	L x W	0.65 x 0.65		mm	
Distance, Chip Surface to Case Surface	H	2.1 – 2.7			
Half Angle	φ	±25		Deg.	
Capacitance	C_{CE}	10		pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	5 (≤100)		nA	V_{CE}=10 V, E=0
Photocurrent	I_{PCE}	≥0.4		mA	E_e=0.5 mW/cm², V_{CE}=5 V
		4	—		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	7		µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Saturation Voltage(1), Collector Emitter	V_{CEsat}	150		mV	I_C=1.2 mA, E_e=0.5 mW/cm²

Parameter	Sym.	–2	–3	Unit	Condition
Photocurrent λ=950 nm	I_{PCE}	0.63 to 1.25	1 to 2	mA	E_e=0.5 mW/cm², V_{CE}=5 V
Photocurrent λ=950 nm **SFH 310**		3.4	5.4		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R,t_F	7	8	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ

T_A=25°C, λ=950 nm

Figure 1. Directional characterristics $S_{rel}=f(\varphi)$

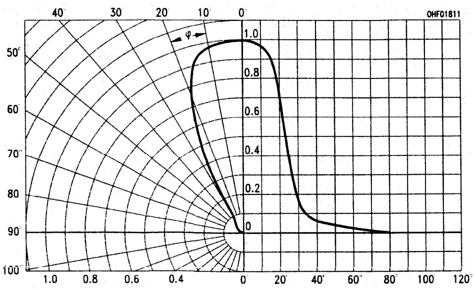


Figure 2. Relative spectral sensitivity, SFH310 $S_{rel}=f(\lambda)$

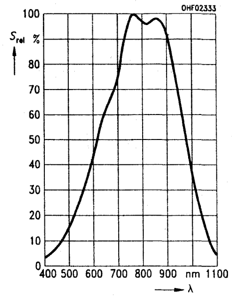


Figure 3. Relative spectral sensitivity, SFH310FA $S_{rel}=f(\lambda)$

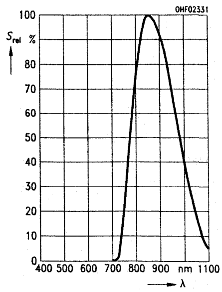


Figure 4. Photocurrent $I_{PCE}=f(E_e)$**,** V_{CE}=5V

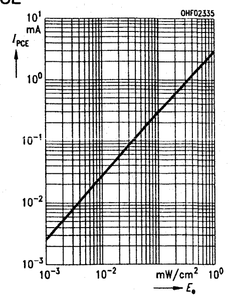


Figure 5. Total power dissipation $P_{tot}=f(T_A)$

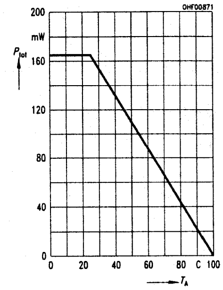


Figure 6. Photocurrent $I_{PCE}=f(V_{CE})$, E_e=Parameter

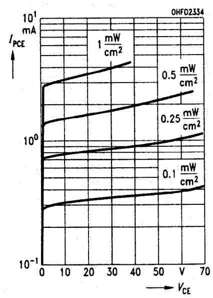


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

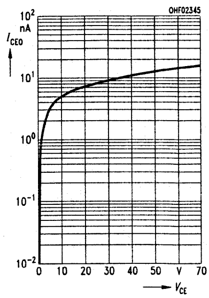


Figure 8. Dark current $I_{CEO}=f(T_A)$, V_{CE}=10 V, E=0

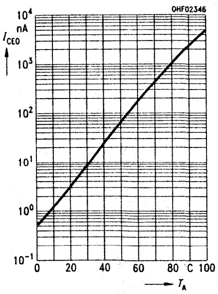


Figure 9. Capacitance $I_{CE}=f(V_{CE})$, f=1 MHz

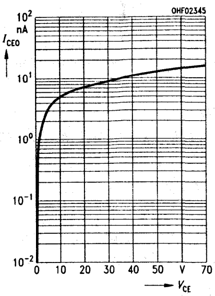
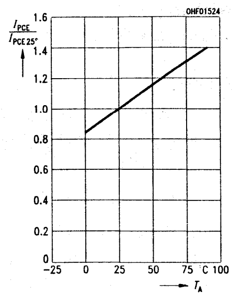
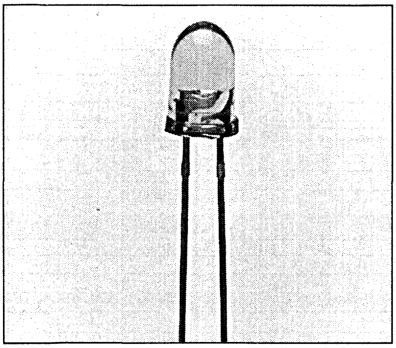


Figure 10. Photocurrent $I_{PCE}=f(T_A)$ V_{CE}**=5 V, normalized to 25°C**

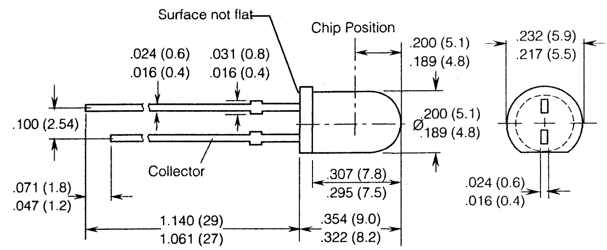


SIEMENS

SFH313
DAYLIGHT FILTER SFH313FA
Silicon NPN Phototransistor



Dimensions in inches (mm)



FEATURES
- **Especially suitable for applications**
- **SFH313: 460 nm to 1080 nm**
- **SFH313FA: 880 nm**
- **High Linearity**
- **T1¾ (5 mm) plastic package**
- **Spectral sensitivity selections**

APPLICATIONS
- **Computer-controlled flashes**
- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION
The SFH313 and SFH313FA are NPN silicon planar phototransistors. They are enclosed in a T1¾ (5 mm) package.

The collector is the shorter lead.

Maximum Ratings
Operating/Storage Temperature Range
(T_{OP}, T_{STG}) .... –55° to +100°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (T_s) t ≤5 s ....260°C
Iron Soldering (T_s) t ≤3 s ....300°C
Collector Emitter Voltage (V_{CE}) ....70 V
Collector Current (I_C)........................... 50 mA
Collector Surge Current (I_{CS}) .... 100 mA
Emitter Collector Voltage (V_{EC}) ....7 V
Total Power Dissipation (P_{TOT})
T_A=25°C...200 mW
Thermal Resistance (R_{thJA}).............. 375 K/W

Characteristics T_A=25°C

Parameter	Sym.	Value		Unit	Condition
		SFH313	SFH313FA		
Wavelength, Max. Sensitivity	λ_{Smax}	850	870	nm	
Spectral Sensitivity Range	λ	460–1080	740–1080		
Radiant Sensitive Area	A	0.55		mm^2	
Chip Area Dimensions	L x W	1 x 1		mm	
Distance, Chip Surface to Case Surface	H	5.1–5.7			
Half Angle	φ	±10		Deg.	
Capacitance	C_{CE}	15		pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	10 (≤200)		nA	V_{CE}=10 V, E=0
Photocurrent	I_{PCE}	≥4.0		mA	E_e=0.5 mW/cm², V_{CE}=5 V
		30	—		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	t_R, t_F	12		µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Saturation Voltage[(1)], Collector Emitter	V_{CEsat}	150		mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm²

Parameter	Sym.	–2	–3	Condition
Photo Current λ=950 nm	I_{PCE}	4 to 8	6.3 to 12.5	E_E=0.5 mW/cm², V_{CE}=5 V
Rise and Fall Time	t_R, t_F	10	12	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ

1. I_{PCEmin} is the mine photocurrent of the specified dash number.

Figure 1. Directional characterristics $S_{rel}=f(\varphi)$

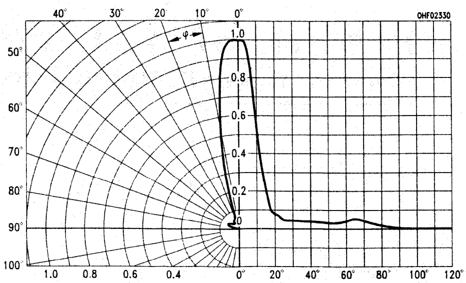


Figure 2. Relative spectral sensitivity $S_{rel}=f(\lambda)$ **SFH313**

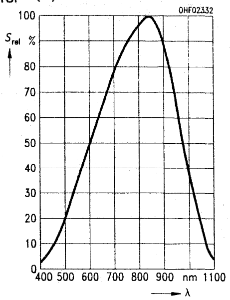


Figure 3. Relative spectral sensitivity $S_{rel}=f(\lambda)$ **SFH313FA**

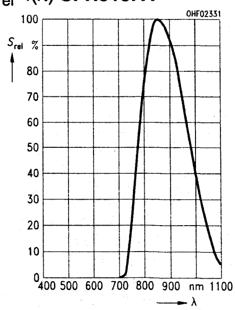


Figure 4. Dark current $I_{CEO}=f(V_{CE})$, E=0

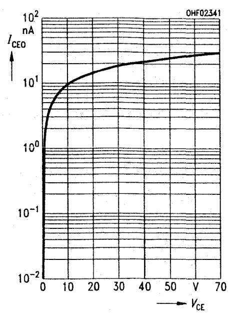


Figure 5. Photocurrent $I_{PCE}=f(T_A)$, V_{CE}=5 V, normalized to 25°C

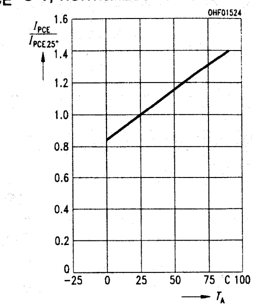


Figure 6. Photocurrent $I_{PCE}=f(E_e)$, V_{CE}=5 V

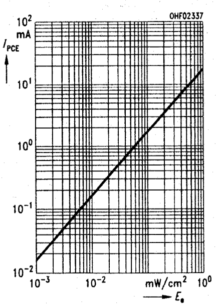


Figure 7. Collector-emitter capacitance $C_{CE}=f(V_{CE})$, f=1 MHz

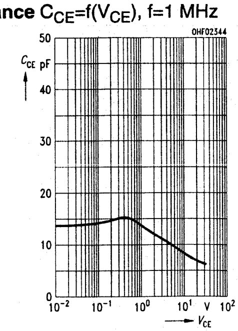


Figure 8. Photocurrent $I_{pCE}=f(V_{CE})$, E=parameter

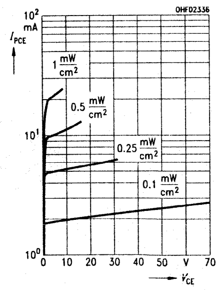


Figure 9. Dark current $I_{CE}=f(T_A)$, V_{CE}=10 V, E=0

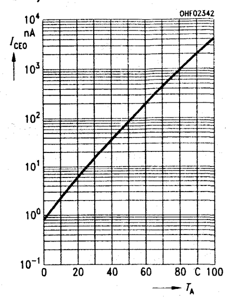
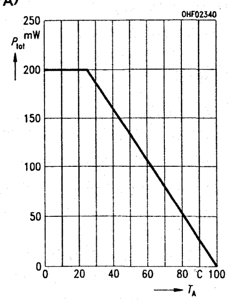


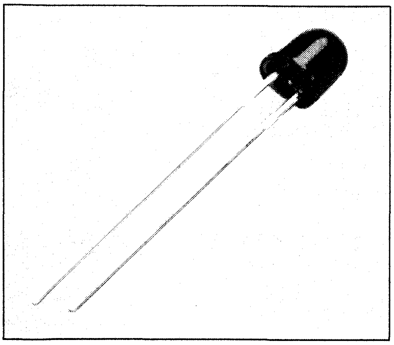
Figure 10. Total power dissipation $P_{tot}=f(T_A)$

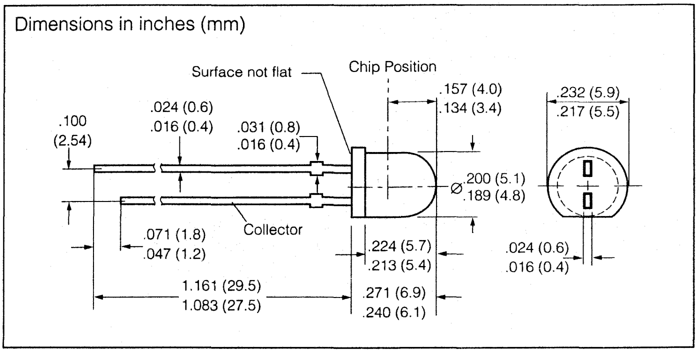


Phototransistors 12

SIEMENS

SFH314
DAYLIGHT FILTER SFH314FA
Silicon NPN Phototransistor





FEATURES
- **Especially suitable for applications**
  - **SFH314 : 460 nm to 1080 nm**
  - **SFH314FA : 880 nm**
- **High linearity**
- **T1¾ (5 mm) plastic package**
- **Spectral sensitirity selections**

APPLICATIONS
- **Computer-controlled flashes**
- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The SFH314 and SFH314FA are NPN silicon planar phototransistors. They are enclosed in a T1¾ (5 mm) clear plastic package.

The collector is denoted by the shorter lead.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Soldering Temperature
(≥2 mm from case bottom)
Dip Soldering (T_s) t ≤5 s .... 260°C
Iron Soldering (T_s) t ≤3 s .... 300°C
Collector Emitter Voltage (V_{CE}) .... 70 V
Collector Current (I_C) .... 50 mA
Collector Surge Current (I_{CS})
τ<10µs .... 100 mA
Emitter Collector Voltage (V_{EC}) .... 7 V
Total Power Dissipation (P_{TOT})
T_A=25°C .... 200 mW
Thermal Resistance (R_{thJA}) .... 375 K/W

Characteristics T_A=25°C

Parameter	**Sym.**	**Value**		**Unit**	**Condition**
		SFH313	**SFH313FA**		
Wavelength, Maximum Sensitivity	λ_{Smax}	850	870	nm	
Spectral Sensitivity Range	λ	460–1080	740–1080		S=10%S_{max}
Radiant Sensitive Area	A	0.55		mm^2	
Chip Area Dimensions	L x W	1 x 1		mm	
Distance, Chip Surface to Case Surface	H	3.4–4.0			
Half Angle	φ	±40		Deg.	
Capacitance	C_{CE}	15		pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	10 (≤200)		nA	V_{CE}=10 V, E=0
Photocurrent	I_{PCE}	≥0.63		mA	E_e=0.5 mW/cm^2, V_{CE}=5 V
		7	—		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise/Fall Time	$t_R t_F$	12		µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Saturation Voltage(1), Collector Emitter	V_{CEsat}	150		mV	I_C=I_{PCEmin}x.3, E_e=0.5 mW/cm^2

Parameter	**Sym.**	**–2**	**–3**	**Condition**
Photocurrent λ=950 nm	I_{PCE}	1 to 2	1.6 to 3.2	E_E=0.5 mW/cm^2, V_{CE}=5 V
Photocurrent λ=950 nm **SFH 314**		5.4	8.6	E_V=1000 lx, Std. Light A , V_{CE}=5 V
Rise and Fall Time	t_R, t_F	10	12	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ

Figure 1. Directional characterristics $S_{rel}=f(\varphi)$

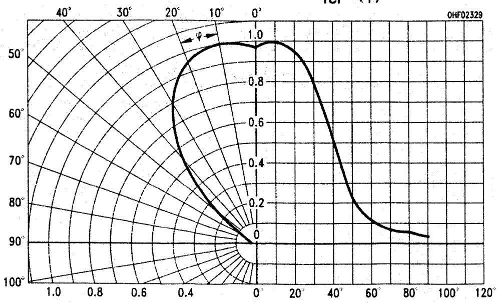


Figure 2. Relative spectral sensitivity $S_{rel}=f(\lambda)$ SFH314

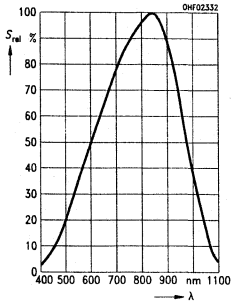


Figure 3. Relative spectral sensitivity $S_{rel}=f(\lambda)$ SFH314FA

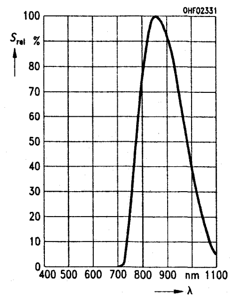


Figure 4. Dark current $I_{CEO}=f(V_{CE})$, E=0

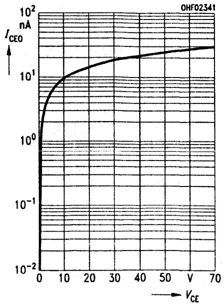


Figure 5. Photocurrent $I_{PCE}=f(T_A)$, $V_{CE}=5$ V, normalized to 25°C

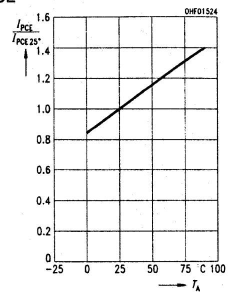


Figure 6. Photocurrent $I_{PCE}=f(E_e)$, $V_{CE}=5$ V

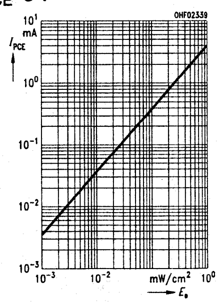


Figure 7. Collector-emitter capacitance $C_{CE}=f(V_{CE})$, f=1 MHz

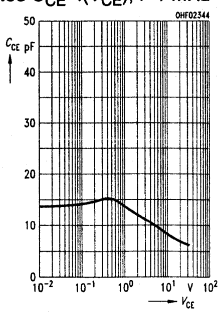


Figure 8. Photocurrent $I_{PCE}=f(V_{CE})$, E=parameter

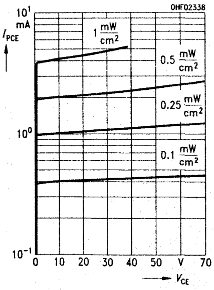


Figure 9. Total power dissipation $P_{tot}=f(T_A)$

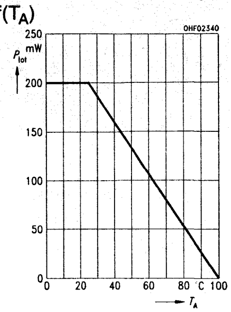
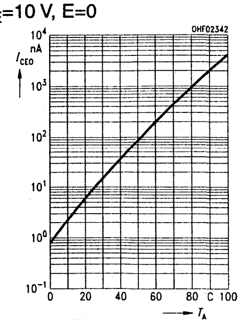
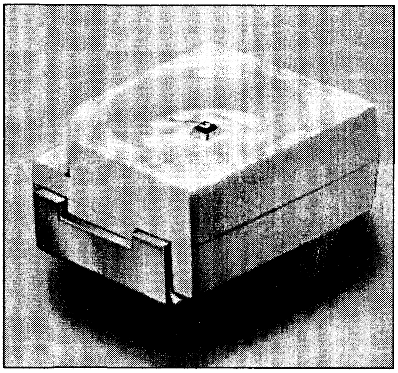


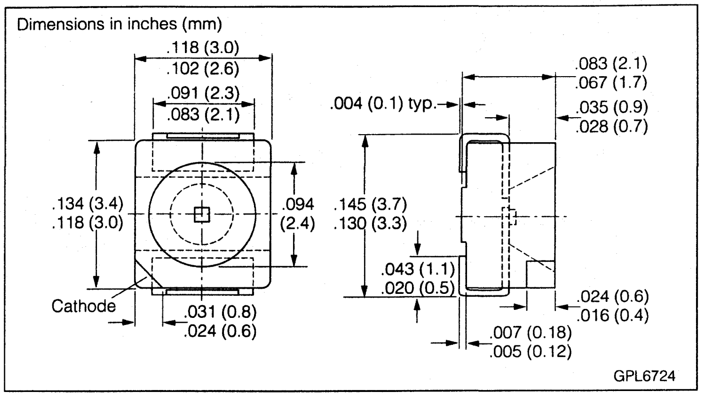
Figure 10. Dark current $_{CE}=f(T_A)$, $V_{CE}=10$ V, E=0



SIEMENS

SFH320
DAYLIGHT FILTER SFH320FA
Silicon NPN Phototransistor
SMT TOPLED®





FEATURES
- **Especially suitable for applications**
  - **SFH 320: 380 to 1150 nm**
  - **SFH 320FA: 880nm**
- **High linearity**
- **P-LCC-2 package**
- **Spectral sensitivity selections**
- **Suitable for all soldering methods**

APPLOCATIONS
- **Miniature photointerrupters**
- **Punched tape readers**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION

The SFH320/320FA are high-sensitivity NPN silicon phototransistors in a compact surface-mountable package. Available with or without a daylight filter, they are compatible with automatic placement equipment and can withstand IR reflow, vapor phase reflow, and wave solder processes.

Maximum Ratings

Operating/Storage Temperature
(T_{OP}, T_{STG}) .... –55 to +100°C
Collector-Emitter Voltage (V_{CE}) .... 35 V
Collector Current (I_C) .... 15 mA
Collector Surge Current
(I_{CS}) τ<10 µs .... 75 mA
Power Dissipation (P_{tot}) T_A=25°C ..... 165 mW
Thermal Resistance, Mounting on
PC Board (R_{thJA}) .... 450 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter	Sym.	SFH320	SFH320FA	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	860	900	nm	
Spectral Sensitivity, Range	λ	380 to 1150	730 to 1120		S=10% of S_{MAX}
Radiant Sensitive Area	A	0.045		mm^2	
Radiant Sensitive Area Dimensions	L x W	0.45 x 0.45		mm	
Distance, Chip Surface to Case Surface	H	0.5 to 0.7			
Half Angle	φ	±60		Deg.	
Capacitance	C_{CE}	5.0		pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	1 (≤200)		nA	V_{CE}=25 V, E=0
Saturation Voltage(1), Collector Emitter	V_{CEsat}	150		mV	I_C=I_{PCEmin}x 0.3, E_e=0.1 mW/cm^2

Parameter	Sym.	320/FA	–2	–3	–4	Unit	Condition
Photocurrent λ=950 nm	I_{PCE}	≥16	16–32	25–50	≥40	µA	E_e=0.1 mW/cm^2, V_{CE}=5 V
Photocurrent λ=950 nm **SFH320**		—	420	650	1000		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise Time/Fall Time	t_R, t_F	7	6	7	8	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ

Note: 1. I_{PCEmin} is the minimum photocurrent for each dash number.

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

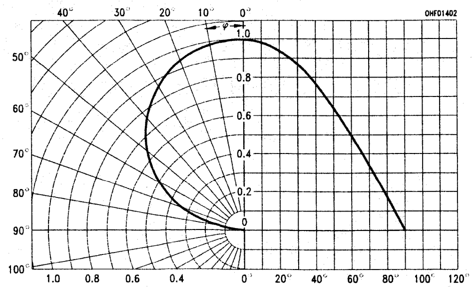


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$ SFH320

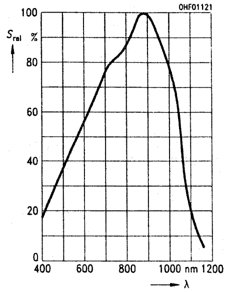


Figure 3. Relative spectral sensitivity $S_{REL}=f(\lambda)$ SFH320FA

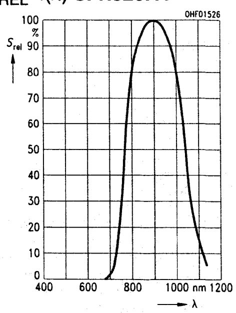


Figure 4. Photocurrent $I_{PCE}=f(E_e)$, $V_{CE}=5$ V$=f(E_V)$

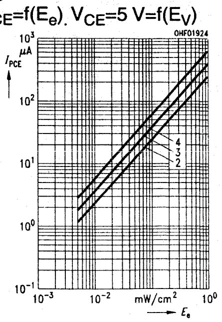


Figure 5. Total power dissipation $P_{TOT}=f(T_A)$

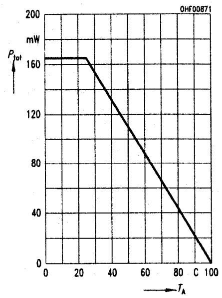


Figure 6. Photocurrent $I_{PCE}=f(V_{CE})$, E_e=Parameter

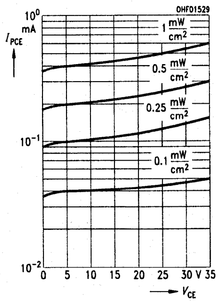


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

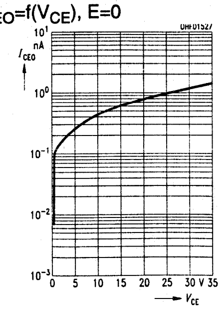


Figure 8. Dark current $I_{CEO}=f(T_A)$, $V_{CE}=25$ V, E=0

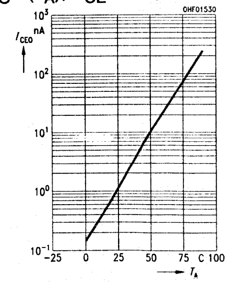


Figure 9. Capacitance $C_{CE}=f(V)$, f=1 MHz, E=0

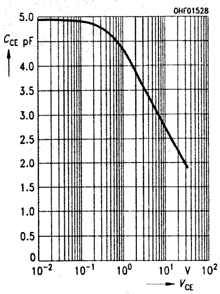
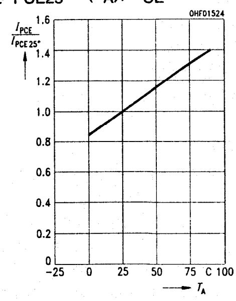
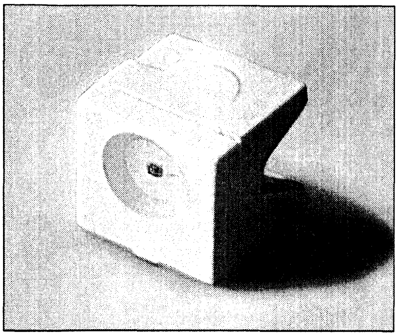


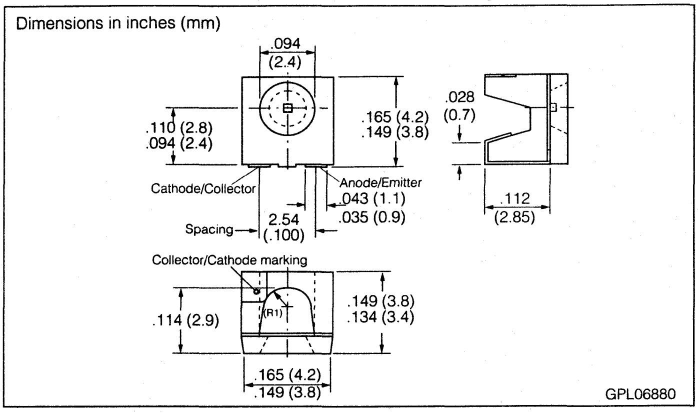
Figure 10. Photocurrent $I_{PCE}/I_{PCE25°}=f(T_A)$, $V_{CE}=5$ V



SIEMENS

SFH325
DAYLIGHT FILTER SFH325FA
Silicon NPN Phototransistor
SMT SIDELED®





FEATURES
- **Especially suitable for applications**
  - **SFH 325: 380 to 1150 nm**
  - **SFH 325FA: 880nm**
- **High linearity**
- **P-LCC-2 package**
- **Spectral sensitivity selections**
- **Suitable only for reflow IR soldering. For dip soldering, contact factory.**

APPLICATIONS
- **Miniature photointerrupters**
- **Punched tape readers**
- **Industrial electronics**
- **For control and drive circuits**

DESCRIPTION
The SFH325/325FA are high-sensitivity NPN silicon phototransistors in a compact surface-mountable right angle package. Available with or without a daylight filter, they are compatible with automatic placement equipment and can withstand IR reflow and vapor phase reflow solder processes. Their small size makes them suitable for dense packaging in array applications

Maximum Ratings
Operating/Storage Temperature
(T_{OP}, T_{STG}) .... –55 to +100°C
Collector-Emitter Voltage (V_{CE}) .... 35 V
Collector Current (I_C) .... 15 mA
Collector Surge Current
(I_{CS}) τ<10 µs .... 75 mA
Power Dissipation (P_{tot}) T_A=25°C ..... 165 mW
Thermal Resistance, Mounting on
PC Board (R_{thJA}) .... 450 K/W

Characteristics T_A=25°C, λ=950 nm

Parameter	Sym.	SFH325	SFH325FA	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	860	900	nm	
Spectral Sensitivity Range	λ	380 to 1150	730 to 1120		S=10% of S_{MAX}
Radiant Sensitive Area	A	0.045		mm^2	
Radiant Sensitive Area Dimensions	L x W	0.45x0.45		mm	
Distance, Chip Surface to Case Surface	H	0.5 to 0.7			
Half Angle	φ	±60		Deg.	
Capacitance	C_{CE}	5.0		pF	V_{CE}=0 V, f=1 MHz, E=0
Dark Current	I_{CEO}	1 (≤200)		nA	V_{CEO}=25 V, E=0
Saturation Voltage[(1)], Collector Emitter	V_{CEsat}	150		mV	I_{PCE}=I_{PCEmin} x 0.3, E_e=0.1 mW/cm^2

Parameter	Sym.	325/FA	–2	–3	–4[(1)]	Unit	Condition
Photocurrent λ=950 nm	I_{PCE}	≥16	16 to 32	25 to 50	≥40	µA	E_e=0.1 mW/cm^2, V_{CE}=5 V
Photocurrent λ=950 nm **SFH325**		—	420	650	1000		E_V=1000 lx, Std. Light A, V_{CE}=5 V
Rise Time/ Fall Time	t_R, t_F	7	6	7	8	µs	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ

Note: 1. I_{PCEmin} is the minimum photocurrent for each dash number.

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

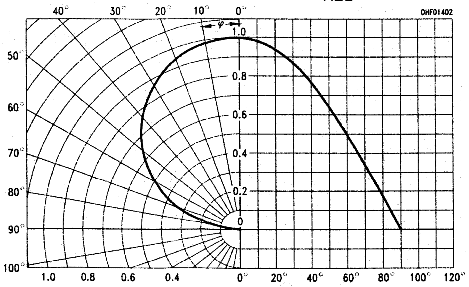


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$ SFH325

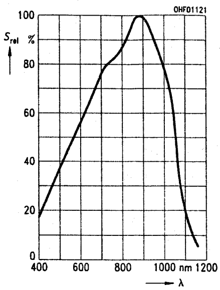


Figure 3. Relative spectral sensitivity $S_{REL}=f(\lambda)$SFH325F

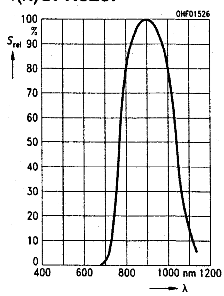


Figure 4. Photocurrent $I_{PCE}=f(E_e)$, $V_{CE}=5$ V

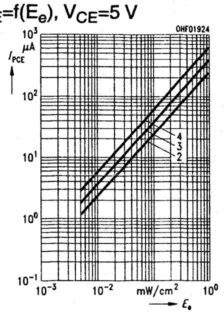


Figure 5. Total power dissipation $P_{TOT}=f(T_A)$

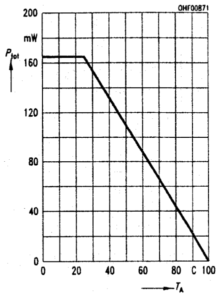


Figure 6. Photocurrent $I_{PCE}=f(V_{CE})$, E_e=Parameter

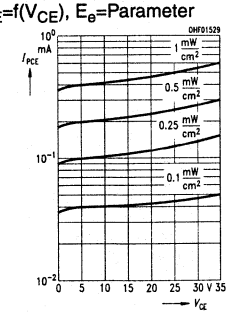


Figure 7. Dark current $I_{CEO}=f(V_{CE})$, E=0

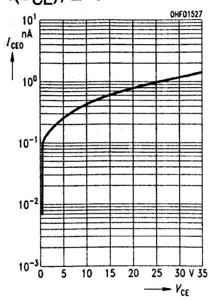


Figure 8. Dark current $I_{CEO}=f(T_A)$, $V_{CE}=5$ V, E=0

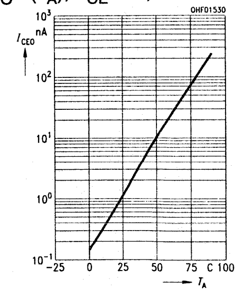


Figure 9. Capacitance $C_{CE}=f(V)$, f=1 MHz, E=0

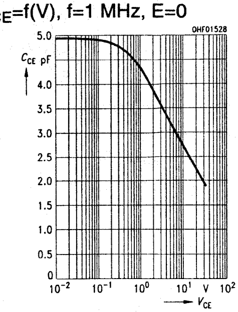
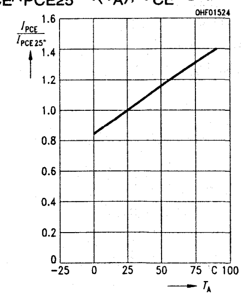


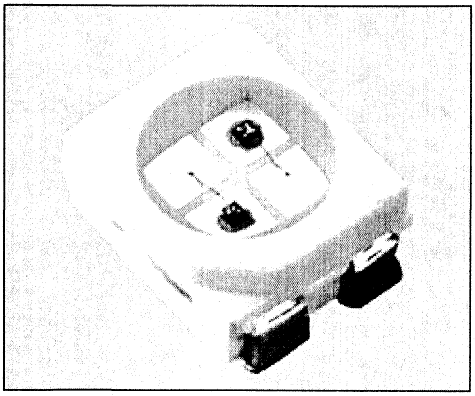
Figure 10. Photocurrent $I_{PCE}/I_{PCE25°}=f(T_A)$, $V_{CE}=5$ V



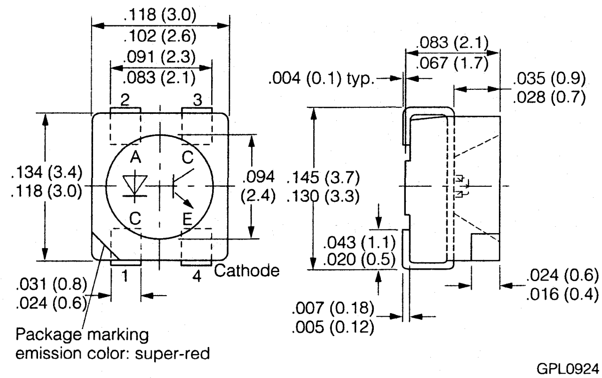
SIEMENS

SFH 331

Emitter/Transistor SMT Multi TOPLED®



Dimensions in Inches (mm)



Maximum Ratings

Emitter and Transistor

Operating/Storage Temperature Range
(T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C

Emitter

Forward Current (I_F) .... 30 mA
Surge Current, t≤10 ms, D=0.005 (I_{FM}) .... 500 mA
Reverse Voltage (V_R) .... 5 V
Total Power Dissipation (P_{TOT}) .... 100 mW
Thermal Resistance Junction/
Ambient, mounted on PCB*
(pad size≥16 mm2) (R_{THJA}) .... 450 K/W
Junction/Soldering Joint (R_{THJS}) 350K/W

Transistor

Collector Current (I_F) .... 15 mA
Surge Current, t≤10 mS, D=0.005 (I_{FM}) .... 75 mA
Collector-Emitter Voltage (V_R) .... 35 V
Total Power Dissipation (P_{TOT}) .... 165 mW
Thermal Resistance Junction/
Ambient, mounted on PCB*
(pad size≥16 mm^2) (R_{THJA}) 450K/W

*PC-board: G30/FR4

The stated maximum ratings refer to other specified chip regardless of the operating status of the other one.

Emitter Characteristics T_A=25°C (Values typical unless specified)

Parameter		Symbol	Value	Unit	Condition
Peak Wavelength		λ_{PEAK}	635	nm	I_F=10 mA
Dominant Wavelength		λ_{DOM}	628		
Spectral Bandwidth, 50% I_{relmax}		$\Delta\lambda$	45		
Viewing Angle, 50% I_V		2φ	120	Deg.	
Forward Voltage		V_F	2.0 (≤2.6)	V	I_F=10 mA
Reverse Current		I_R	0.01 (≤10)	µA	V_R=5 V
Capacitance		C_0	12	pF	V_R=0 V, f=1 MHz
Switching Times, I_V	10% to 90%	t_R, t_F	300	ns	I_F =100 mA, tp=10 µs R_L=50 Ω
	90% to 10%		150		
Radiant Intensity (Group JK)		I_e	6 (4.0–12.5)	mcd	I_F=10 mA

Phototransistor Characteristics T_A=25°C, λ=950 nm

Parameter	Sym.	Value	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	860	nm	
Spectral Sensitivity Range	λ	380 to 1150		S=10% S_{max}
Radiant Sensitive Area (Ø 240 µm)	A	0.045	mm^2	
Dimensions, Chip Area	LxB	0.45x0.45	mmxmm	
Distance, Chip Front to Case Surface	H	0.5 to 0.7	mm	
Half Angle	φ	±60	Deg.	
Capacitance	C_{CE}	5.0	pF	V_{CE}=0 V , f=1 MHz, E=0
Dark Current	I_{CEO}	1 (≤200)	nA	V_{CE}=25 V, E=0
Photocurrent	I_{PCE}	≥16	µA	E_E=0.1 mW/cm², V_{CE}=5 V
Rise Time/Fall time	t_R, t_F	7	µs	I_C=1 mA, V_{CC}=5 V R_L=1 KΩ
Saturation Voltage, Collector Emitter	V_{CEsat}	150	mW	I_C=5 µA, E_E=0.1 mW/cm²

Figure 1. LED radiation characteristics I_{REL}=f(φ)
Phototransistor directional characteristics S_{REL}=f(φ)

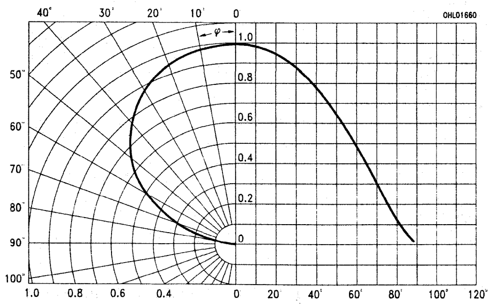


Figure 2. LED relative spectral emission I_{REL}=f(λ), T_A=25°C, I_F=20 mA
V(l)=Standard eye response curve

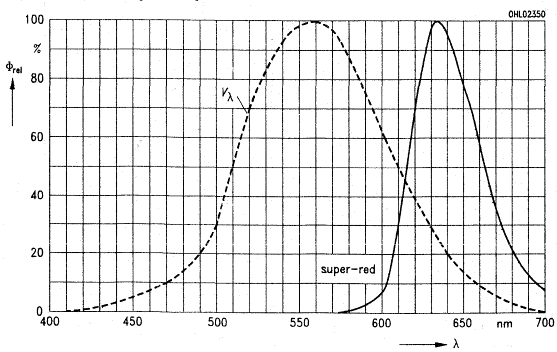


Figure 3. Forward current I_F=f(V_F), T_A=25°C

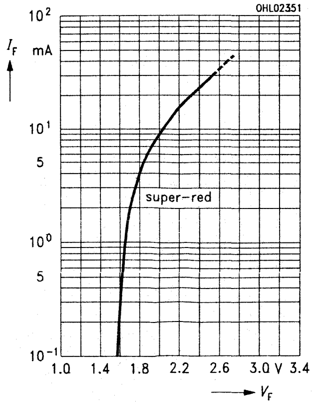


Figure 4. Relative luminous intensity I_V=$I_{V(10\ mA)}$=f (I_F), T_A=25°C

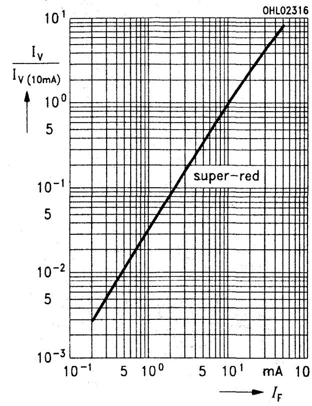


Figure 5. Perm. pulse handling capability I_F=f(t_p), Duty cyclce D=parameter, T_A=25°C

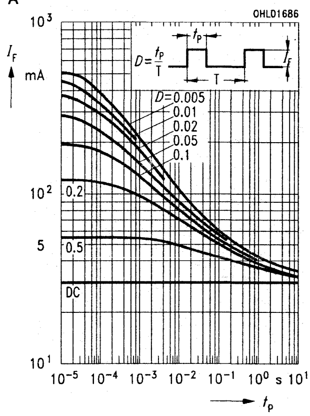


Figure 6. Maximum permissible forward current I_F=f(T_A)

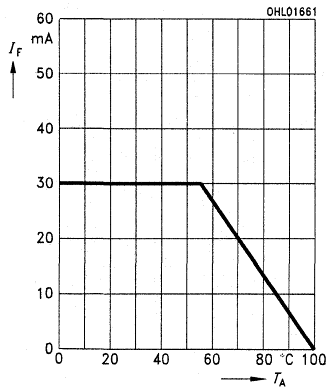


Figure 7. Peak wavelength
λ_{PEAK}=f(T_A), I_F=20 mA

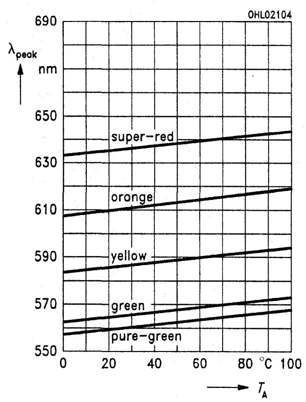


Figure 8. Dominant wavelength
λ_{DOM}=f(T_A), I_F=20 mA

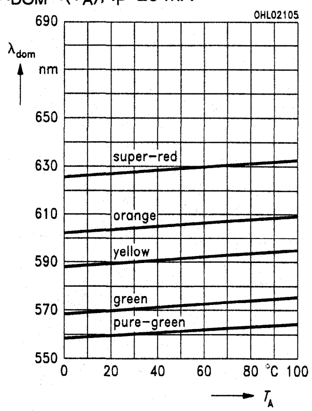


Figure 9. Forward current
V_F=f(T_A), I_F=10 mA

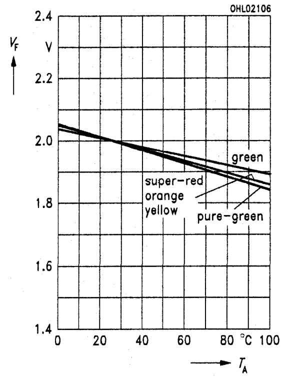
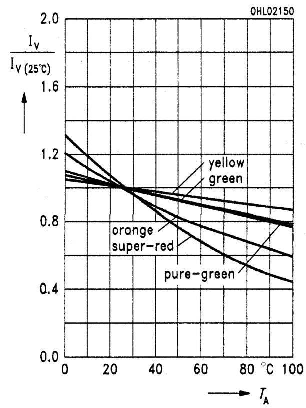


Figure 10. Rel. luminous intensity
I_V=$I_{V(25°C)}$=f (T_A), I_F=10 mA



PHOTOTRANSISTOR

Figure 11. Rel. spectral sensitivity
S_{REL}=f(λ)

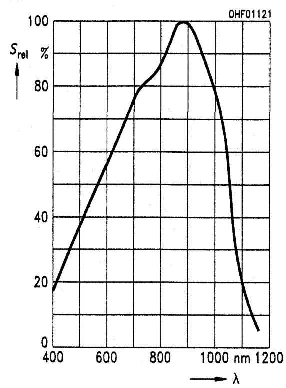


Figure 12. Photocurrent
I_{PCE}=f(V_{CE}). E_e=Parameter

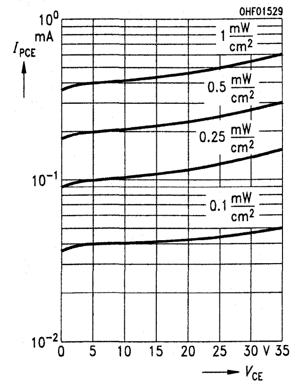


Figure 13. Dark current
I_{CEO}=f(V_{CE}), E=0

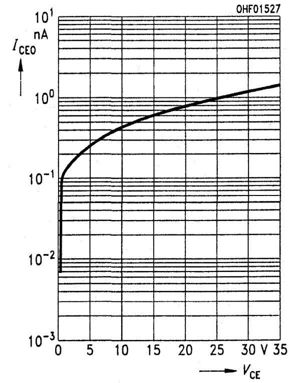


Figure 14. Total power dissipation
P_{tot}=f (T_A)

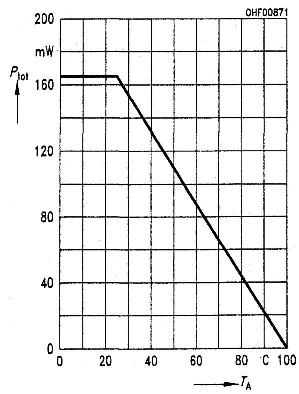


Figure 15. Capacitance $C_{CE}=f(V_{CE})$, f=1 MHz, E=0

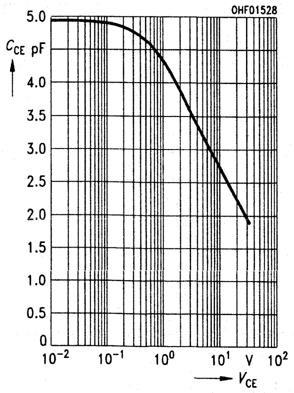


Figure 16. Photocurrent
$I_{PCE}/I_{PCE25°}=f(T_A)$, V_{CE}=5 V

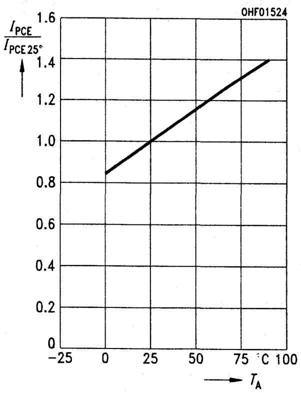


Figure 17. Dark current $I_{CEO}=f(T_A)$, V_{CE}=5 V, E=0

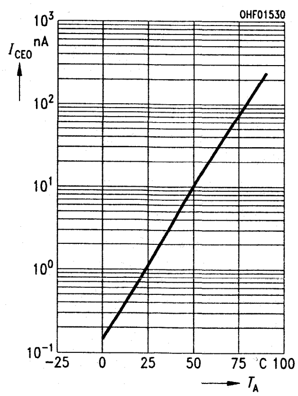
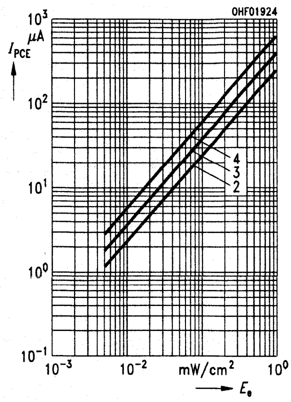


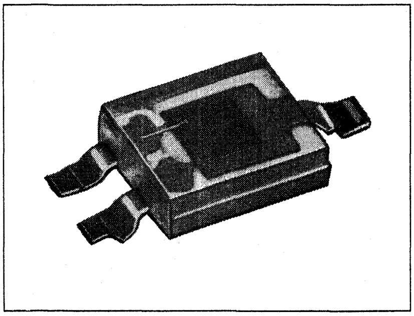
Figure 18. Photocurrent
$I_{PCE}=f(E_E)$, V_{CE}=5 V

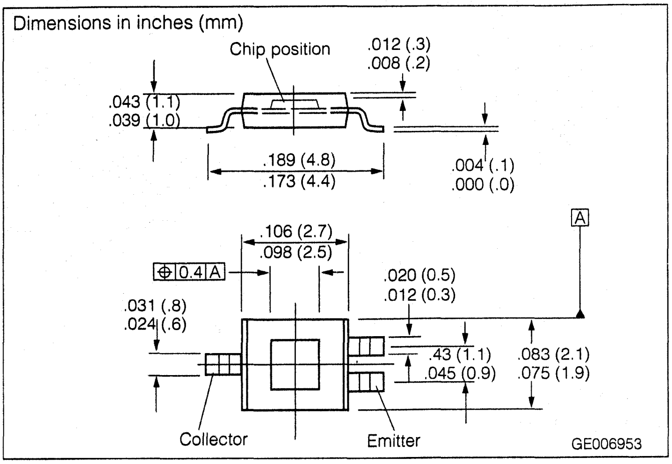


SIEMENS

SFH 3400

Silicon NPN Phototransistor





- **FEATURES**
- **Especially suitable for applications from 460 nm to 1080 nm**
- **High linearity**
- **SMT package without base connection, suitable for vapor phase and IR reflow soldering**
- **Available on tape and reel**

APPLICATIONS

- **Ambient light detector**
- **Photointerrupters**
- **Industrial electronics**
- **For control and drive circuits**

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –40° to +85°C
Collector-Emitter Voltage (V_{CE}) ....70 V
Collector Current (I_C) .... 50 mA
Collector Surge Current (I_{CS}) .... 100 mA
Emitter-Collector Voltage (V_{EC}) ....7 V
Power Dissipation (P_{TOT}) T_A=25°C ....120 mW
Thermal Resistance for Mounting on
PCB (R_{THJA}) .... 450 K/W

Characteristics T_A=25°C

Parameter	Sym.	Value	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Spectral Sensitivity Range	λ	460 to 1080		S=10% of S_{MAX}
Radiant Sensitive Area	A	0.55	mm^2	
Radiant Sensitive Area Dimensions	L x W	1x 1	mm	
Distance, Chip Surface to Case Surface	H	0.2 to 0.3		
Half Angle	φ	±60	Deg.	
Capacitance	C_{CE}	15	pF	C_{CE}=0V, f=1MHz, E=0
Dark Current	I_{CEO}	10 (≤200)	nA	V_R=1 V
Photocurrent, Collector Base Photodiode	I_{PCB}	1.4	µA	E_e=0.5mW/cm2, V_{CB}=5V
		4.8		E_V=1000lx, Std Light A, V_{CB}=5V
Saturation Voltage(1), Collector Emitter(1)	V_{CEsat}	170	mV	I_C=I_{PCEmin} x 0.3, E_e=0.5 mW/cm^2

Spectral Sensitivity selections by dash number

Description	Sym..	Value			Unit	Condition
		–1	–2	–3		
Photocurrent, λ = 950 nm	I_{PCE}	63 to 125	100 to 200	160 to 320	µA	E_e=0.5 mW/cm^2, V_{CE}=5 V
		1.65	2.6	4.2	mA	E_V=1000 lx, Std Light A, V_{CE}=5 V
Rise and fall time	t_r, t_f	10	12	14	ms	I_C=1 mA, V_{CC}=5 V, R_L=1 kΩ
Current gain	$\frac{I_{PCE}}{I_{PCB}}$	270	430	670		E_e=0.5 mW/cm^2, V_{CE}=5 V

1. I_{PCEmin} is the min. photocurrent of the specified group

Figure 1. Directional characteristic S_{REL}=f(φ)

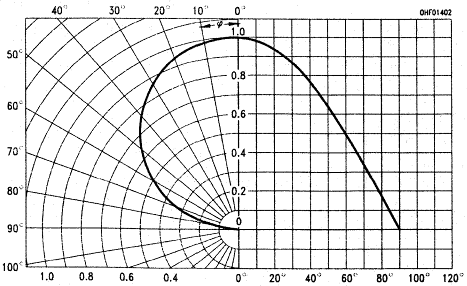


Figure 8. Output characteristics
I_C=f(V_{CE}), I_B=parameter

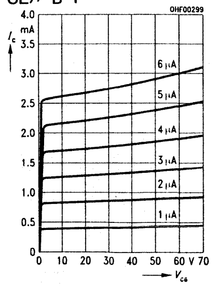


Figure 2. Relative spectral sensitivity
S_{REL}=f(λ) T_A=25°C, λ=950 nm,

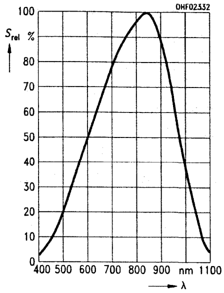


Figure 5. Photocurrent I_{PCE}=f (T_A), V_{CE}=5 V, nomalized to 25°C

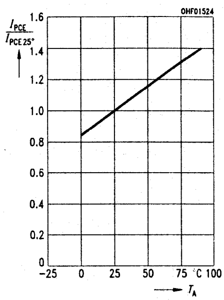


Figure 9. Dark current
I_{CEO}=f(V_{CE}), E=0

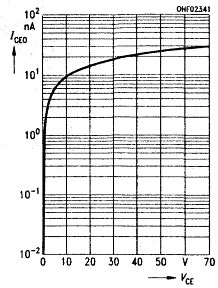


Figure 3. Photocurrent I_{PCE}=f(E_e), V_{CE}=5 V

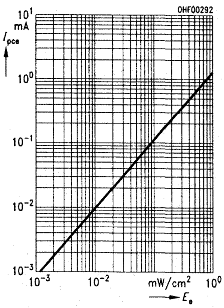


Figure 6. Dark current
I_{CEO}=f(T_A), V_{CE}=10 V, E=0

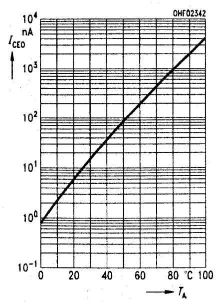


Figure 4. Collector-emitter capacitance C_{CE}=f(V_{CE}), f=1MHz

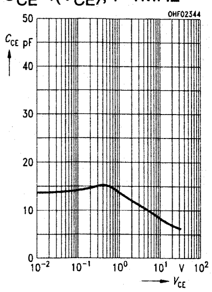
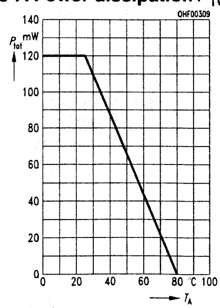


Figure 7. Power dissipation P_{TOT}=f(T_A)

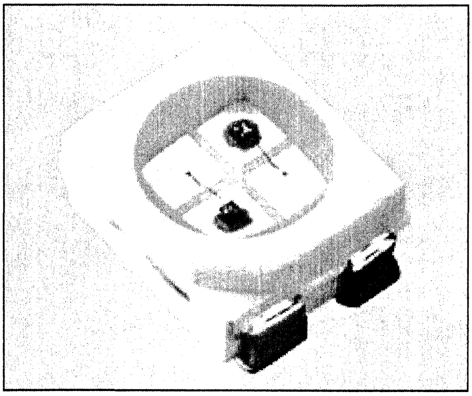


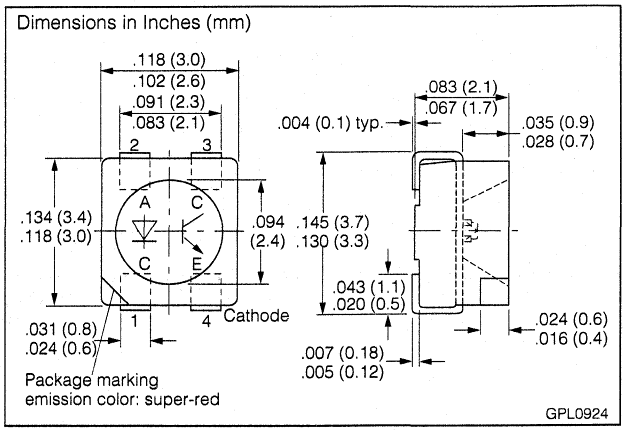
Phototransistors 12

SIEMENS

SFH 7221

Emitter/Transistor SMT Multi TOPLED®





Maximum Ratings

Operating/Storage Temperature Range
(T_{OP}, T_{STG}) .... –55 to +100°C
Junction Temperature (T_J) .... +100°C

Emitter

Forward Current (I_F)... 100 mA
Surge Current, t≤10 ms, D=0.005 (I_{FM}) .... 2500 mA
Reverse Voltage (V_R) .... 5 V
Total Power Dissipation (P_{TOT})......................... 180 mW
Thermal Resistance Junction/
Ambient, mounted on PCB*
(pad size≥16 mm^2) (R_{THJA}).........................500 K/W
Junction/Soldering Joint (R_{THJS}) 400K/W

Transistor

Collector Current (I_F)... 15 mA
Surge Current, t≤10 mS, D=0.005 (I_{FM})............. 75 mA
Collector-Emitter Voltage (V_R)............................... 35 V
Total Power Dissipation (P_{TOT})......................... 165 mW
Thermal Resistance Junction/
Ambient, mounted on PCB*
(pad size≥16 mm^2) (R_{THJA})...........................450K/W

*PC-board: G30/FR4

The stated maximum ratings refer to one chip.

Emitter Characteristics T_A=25°C

Parameter	Sym.	Value	Unit	Condition
Wavelength, Radiation	λ_{PEAK}	880	nm	I_F=100 mA, tp=20 ms
Spectral Bandwidth, 50% I_{relmax}	$\Delta\lambda$	80		
Viewing Angle	φ	±60	Deg	
Active Chip Area	A	0.16	mm^2	
Dimensions, Active Chip Area	LxW	0.4x0.4	mm	
Switching Times, I_e 10% to 90% and 90% to 10%	t_R, t_F	0.5	µs	I_F =100 mA, R_L=50 Ω
Forward Voltage	V_F	1.5 (≤1.8)	V	I_F=100 mA, t_P=20 ms
		3.0 (≤3.8)		I_F=1 A, t_P=100 µs
Reverse Current	I_R	0.01 (≤10)	µA	V_R=5 V
Total Radiant Flux	Φ_E	23	mW	I_F=100 mA, t_P=20 ms
Temperature Coefficient — I_E or Φ_E	TC_I	–0.5	%/K	I_F=100 mA
Temperature Coefficient — V_F	TC_V	–2	mV/K	
Temperature Coefficient — λ	TC_λ	+0.25	nm/K	
Radiant Intensity I_e in axial direction at a steradian of Ω=0.01 sr	I_e	>4	mW/sr	I_F=100 mA, t_P=20 ms
	$I_{e\ typ.}$	48		I_F=1 A, t_P=100 µs

Phototransistor Characteristics T_A=25°C, λ=880 nm

Parameter	Sym.	Value	Unit	Condition
Wavelength, Max. Sensitivity	λ_{Smax}	860	nm	
Sensitivity, Spectral Range	λ	380 to 1150		S=10% S_{max}
Radiant Sensitive Area (Ø 240 µm)	A	0.045	mm^2	
Dimensions, Chip Area	LxB	0.45x0.45	mmxmm	
Distance, Chip Front to Case Surface	H	0.5 to 0.7	mm	
Half Angle	φ	±60	Deg.	
Capacitance	C_{CE}	5	pF	V_{CE}=0 V , f=1 MHz, E=0
Dark Current	I_{CEO}	1 (≤200)	nA	V_{CE}=25 V, E=0
Photocurrent	I_{PCE}	≥16	µA	E_E=0.1 mW/cm², V_{CE}=5 V
Rise Time/Fall time	t_R, t_F	7	µs	I_C=1 mA, V_{CC}=5 V R_L=1 KΩ
Saturation Voltage, Collector Emitter	V_{CEsat}	150	mW	I_C=5 µA, E_E=0.1 mW/cm²

Figure 1. EMITTER: Radiation characteristic I_{REL}=f(φ)
PHOTOTRANSISTOR: Directional characteristic S_{REL}=f(φ)

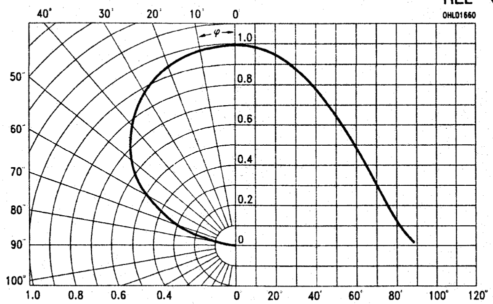


Figure 4. Permissible pulse handling capability I_F=f(T_P), duty cycle D=Parameter, T_A=25°C

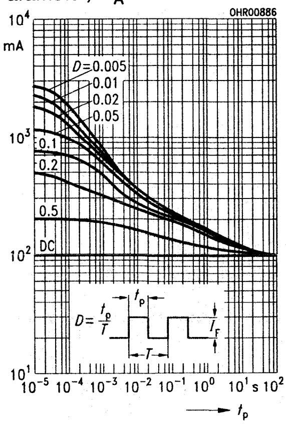
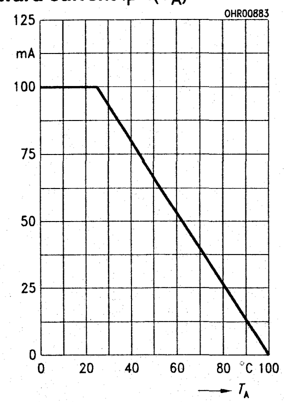


Figure 5. Maximum permissible forward current I_F=f(T_A)



EMITTER

Figure 2. Forward current I_F=f(V_F), T_A=25°C

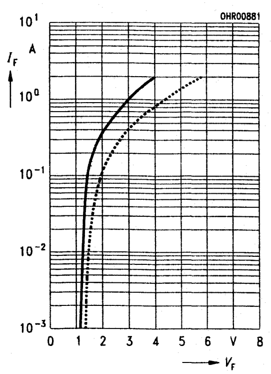


Figure 3. Rel luminous intensity I_V/I_V(10 mA)=f(I_F) T_A=25°C

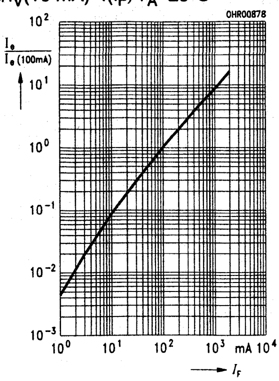
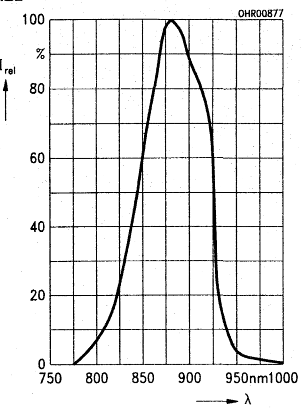


Figure 6. Relative spectral emission I_{REL}=f(λ)



Phototransistors 12

PHOTOTRANSISTOR

Figure 7. Relative spectral sensitivity $S_{REL}=f(\lambda)$

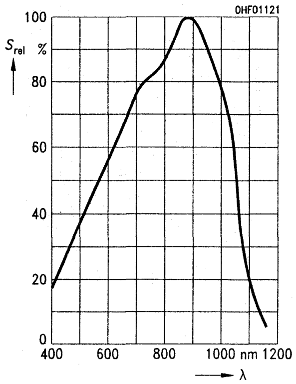


Figure 8. Photocurrent
$I_{PCE}=f(V_{CE})$, E_e=Parameter

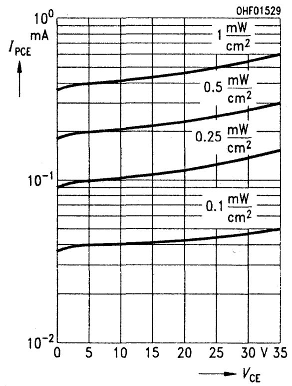


Figure 9. Dark current
$I_{CEO}=f(V_{CE})$, E=0

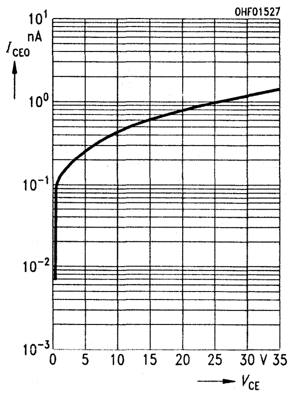


Figure 10. Total power dissipation
$P_{TOT}=f(T_A)$

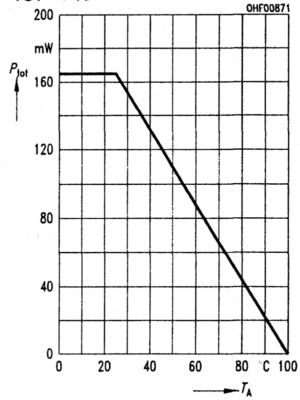


Figure 11. Capacitance
$C_{CE}=f(V)$, f=1 MHz, E=0

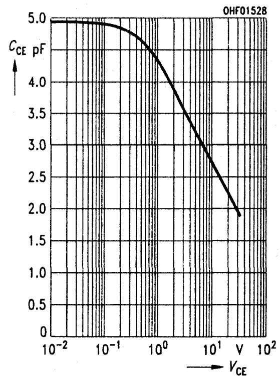


Figure 12. Photocurrent
$I_{PCE}/I_{PCE25°}=f(T_A)$, V_{CE}=5 V

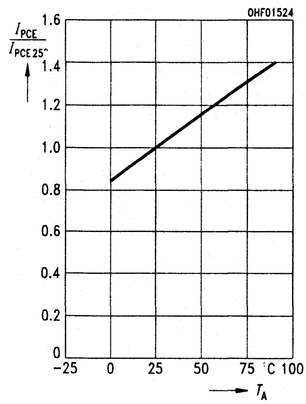


Figure 13. Dark current
$I_{CEO}=f(T_A)$, V_{CE}=25 V, E=0

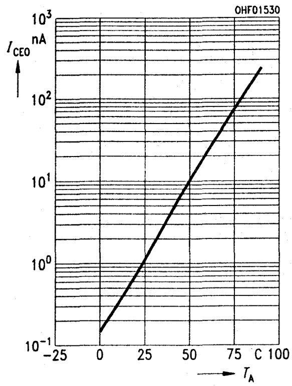
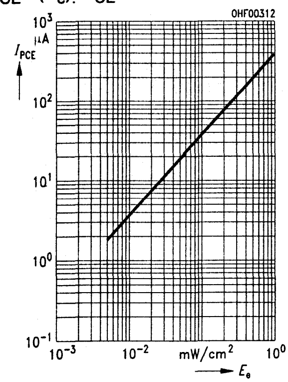
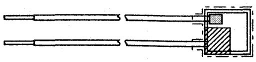
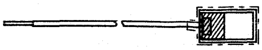
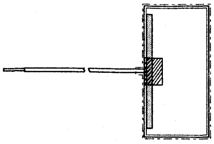
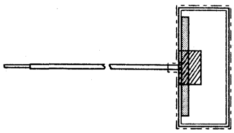
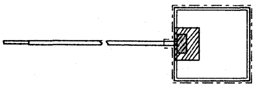
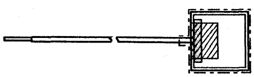
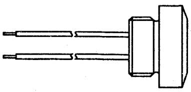
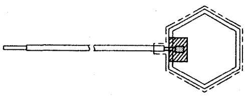


Figure 14. Photocurrent
$I_{PCE}=f(E_e)$, V_{CE}=5 V



Photovoltaic Cells

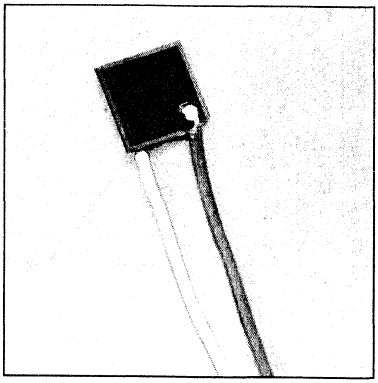
Package Outline	Part Number	Package Type	Half Angle	Sensitivity (μA/lx)	Dark Current V_R=1V, E=0, μA	Radiant Sensitive Area mm²	Peak Wave-length	Capacitance V_R=0 V, E=0 nF	Page
	BPX79	Chip with wires.	±60°	170 nA/lx	0.3 (≤50)	20	800	2.5	13–1
	BPY11P	Chip with wires.	±60°	60 (≥56) nA/lx	1 (≤10)	7.6	850	0.8	13–3
	BPY47P	Chip with wires.	±60°	1.4 (≥0.9)	25 (≤400)	190	850	16	13–5
	BPY48P	Chip with wires.	±60°	0.5 (≥0.35)	10 (≤180)	70	850	6	13–7
	BPY63P	Chip with wires.	±60°	0.65 (≥0.45)	10 (≤60)	94	830	8	13–9
	BPY64P	Chip with wires.	±60°	0.25 (≥0.18)	4 (≤80)	36	850	3	13–11
	TP60P	Plastic, threaded.Anode marked by red lead.	±60°	1 (≥0.7)	0.1 (≤2)	1300	900	11	13–13
	TP61P	Chip with wires. Anode marked by red lead.							

Photovoltaic Cells 13

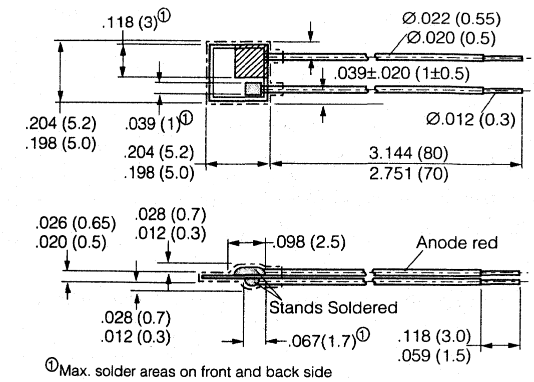
SIEMENS

BPX79

Enhanced Blue Sensitivity Silicon Photovoltaic Cell



Dimensions in inches (mm)



GS006631

FEATURES

- **For applications from 350 nm to 1100 nm**
- **Cathode=back contact**
- **Coated with humidity-proof protective layer**
- **Wide temperature range**

APPLICATIONS

- **For control and drive circuits**
- **Light pulse scanning**
- **Quantitative light measurements in near infrared and visible light range**

DESCRIPTION

The BPX79 is a silicon planar photovoltaic cell. Its high sensitivity with shorter wavelengths makes it suitable for applications with high-blue light sources. The BPX79 is nitride-passivated and has an anti-reflection coating for a λ=450 nm wavelength.

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Reverse Voltage (V_R) .... 1 V

Characteristics T_A=25°C, Standard. Light, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	170	nA/lx	V_R=0 V
Wavelength, Max. Sensitivity	λ_{Smax}	800	nm	
Sensitivity, Spectral Range	λ	350 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	20	mm^2	
Radiant Sensitive Area Dimensions	L x W	4.47 x 4.47	mm	
Half Angle	φ	±60	Deg.	
Dark Current	I_R	0.3(≤50)	µA	V_R=1 V, E=0
Spectral Sensitivity	S_λ	0.19	A/W	λ=400 nm
Quantum Yield	η	0.60	electrons / photon	
Open Circuit Voltage	V_O	450 (≥250)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	19(≥14)	µA	E_e=0.5 mW/cm^2, λ=400 nm
Rise and Fall Time, Photocurrent	t_R, t_F	6	µs	R_L=1 kΩ, V_R=1 V, λ=850 nm, I_P=150 µA
Capacitance	C_O	2500	pF	V_R=0 V, f=1 MHz, E_V=0 lx
Temperature Coefficient V_O	TC_V	-2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.2	%/K	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

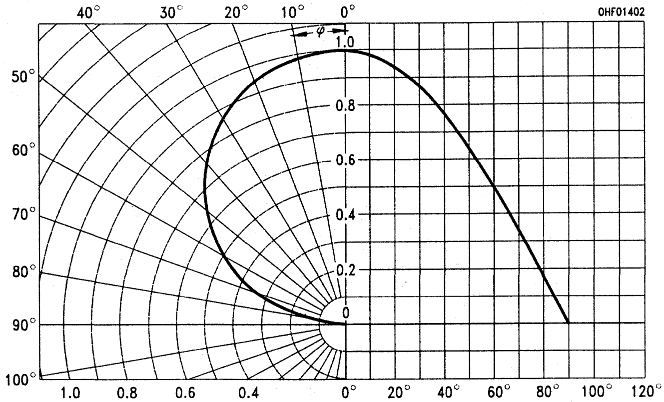


Figure 6. Power dissipation $P_{TOT}=f(T_A)$

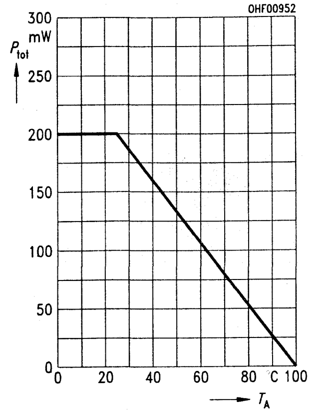


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

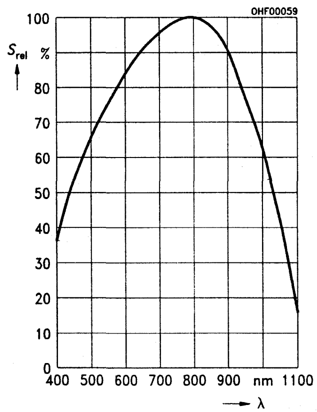


Figure 4. Capacitance $C=f(V_R)$, f=1 HM, E=0

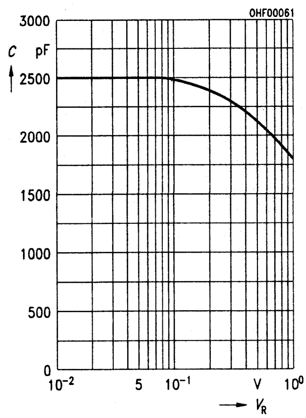


Figure 3. Open circuit voltage $V_O=f(E_V)$
Short circuit voltage $V_{SC}=f(E_V)$

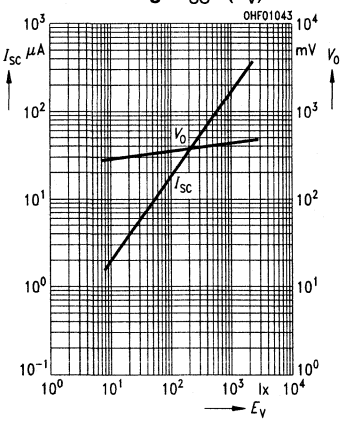
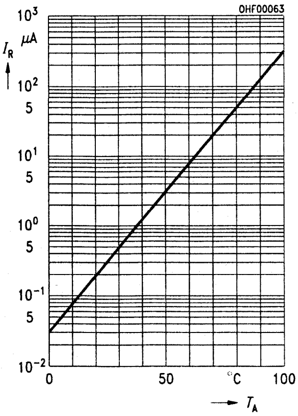


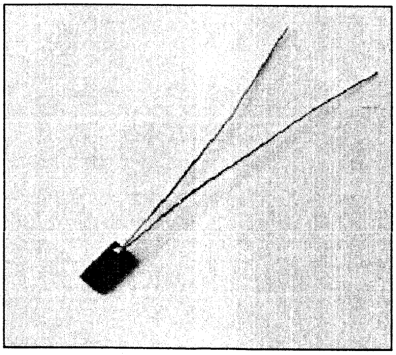
Figure 5. Dark current $I_R=f(V_R)$, V_R=1 V, E=0



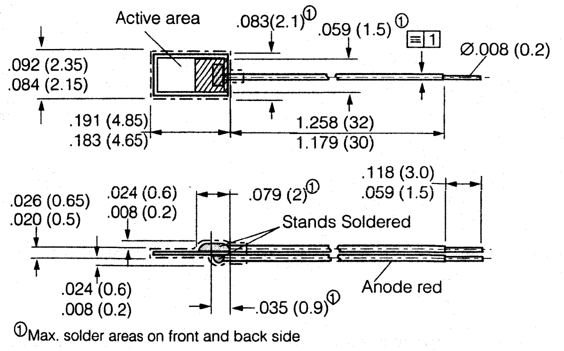
SIEMENS

BPY11P

Silicon Photovoltaic Cell



Dimensions in inches (mm)



FEATURES

- **For applications from 420 nm to 1060 nm**
- **Cathode=back contact**
- **Coated with humidity-proof protective layer**

APPLICATIONS

- **For control and drive circuits**
- **Light pulse scanning**
- **Quantitative light measurements in near infrared and visible light range**

DESCRIPTION

The BPY11P is a silicon planar photovoltaic cell, which can be used in control and drive circuits, for light pulse scanning, and for quantitative light measurements. Its rapid response, small dimensions, and high permissible operating temperature enable universal application.

Since this cell is not encased, it can be used for the assembly of high-efficiency scanning systems by cementing the cells closely together on suitable mounting assemblies.

Maximum Ratings

Operating and Storage Temperature
Range (T_{OP}, T_{STG})...............–55° to +100°C
Reverse Voltage (V_R)................................ 1 V

Characteristics T_A=25°C, Standard Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	60(≥56)	nA/lx	V_R=0V
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Sensitivity Spectral Range	λ	420 to 1060		S=10% of S_{MAX}
Radiant Sensitive Area	A	7.6	mm^2	
Radiant Sensitive Area Dimensions	L x W	1.95 x 4.45	mm	
Half Angle	φ	±60	Deg.	
Dark Current	I_R	1(≤10)	μA	V_R=1 V, E=0
Spectral Photosensitivity	S_λ	0.55	A/W	λ=850 nm
Quantum Efficiency	η	0.80	electrons/photon	
Open Circuit Voltage	V_O	440(≥260)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	60(≥47)	μA	
Rise and Fall Time, Photocurrent	t_R, t_F	3	μs	R_L=1 kΩ, V_R=1 V, λ=850 nm, I_P=50 μA
Capacitance	C_O	0.8	nF	V_R=0 V, f=1 MHz, E_V=0 lx
Temp. Coefficient V_O	TC_V	-2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.2	%/K	
Spectral Sensitivity	I_{SC}	≥56	μA	E_V=1000 lx,

Figure 1. Directional characteristic HM, E=0

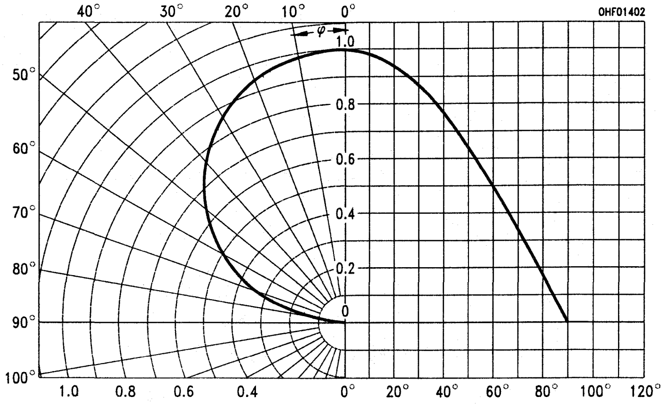


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

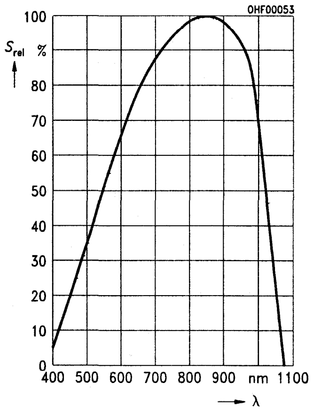


Figure 3. Open circuit voltage $V_O=f(E_V)$
Short circuit voltage $V_{SC}=f(E_V)$

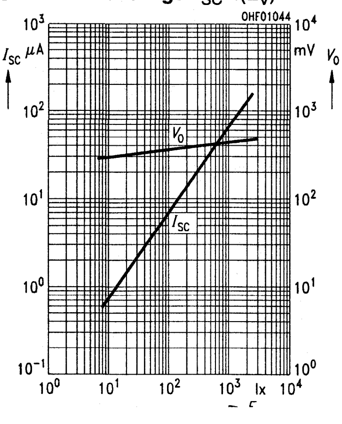


Figure 4. Capacitance $S_{REL}=f(\varphi)$
$C=f(V_R)$, f=1

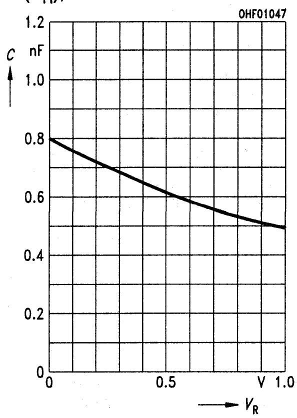


Figure 5. Dark current $I_R=f(V_R)$, E=0

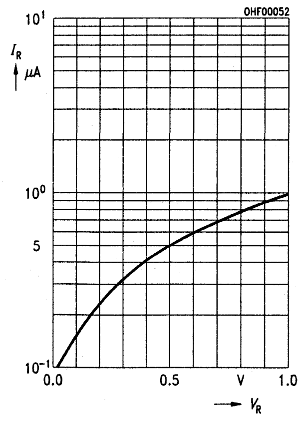
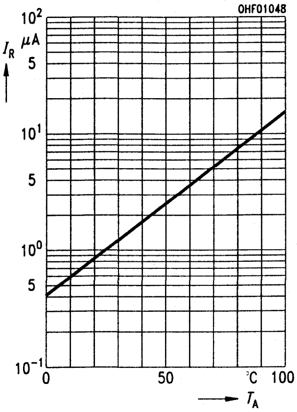


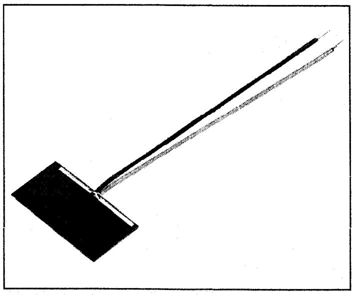
Figure 6. Dark current $I_R=f(T_A)$, V_R=1 V, E=0



SIEMENS

BPY47P

Silicon Photovoltaic Cell



Features

- **For applications from 420 nm to 1060 nm**
- **Cathode=back contact**
- **Coated with humidity-proof protective layer**
- **Wide temperature range**

APPLICATIONS

- **For control and drive circuits**
- **Light pulse scanning**
- **Quantitative light measurements in near infrared and visible light range**

DESCRIPTION

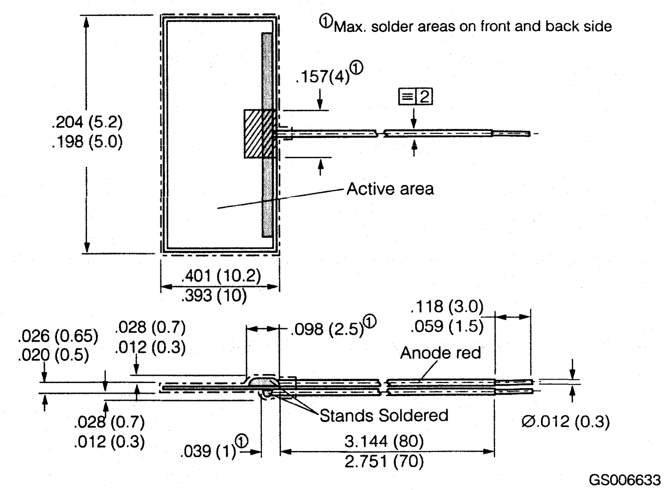
The BPY47P is a silicon planar photovoltaic cell with N-Si material providing positive front and negative back contacts. The Si chip has two leads and is coated with a humidity-proof protective layer.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}).......–55° to +100°C

Reverse Voltage (V_R)......................... 1 V

Dimensions in inches (mm)



Characteristics T_A=25°C, Standard Light A, T=2856 K

Parameter	Symbol	Value	Unit	Condition
Spectral Sensitivity	S	1.4 (≥0.9)	µA/lx	V_R=0 V
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Sensitivity, Spectral Range	λ	420 to 1060		S=10% of S_{max}
Radiant Sensitive Area	A	190	mm^2	
Radiant Sensitive Area Dimensions	L x W	9.58 x 19.58	mm	
Half Angle	φ	±60	Deg.	
Dark Current	I_R	25 (≤400)	µA	V_R=1 V, E=0
Spectral Sensitivity	S_λ	0.51	A/W	λ=850 nm
Quantum Yield	η	0.73	electrons / photon	
Open Circuit Voltage	V_O	450 (≥280)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	1.4 (≥0.9)	mA	
Rise and Fall Time, Photocurrent	t_R, t_F	23	µs	R_L=1 kΩ, V_R=1 V, λ=850 nm, I_P=50 µA
Capacitance	C_O	16	nF	V_R=0 V, f=1 MHz, E_V=0 lx
Temperature Coefficient V_O	TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.2	%/K	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

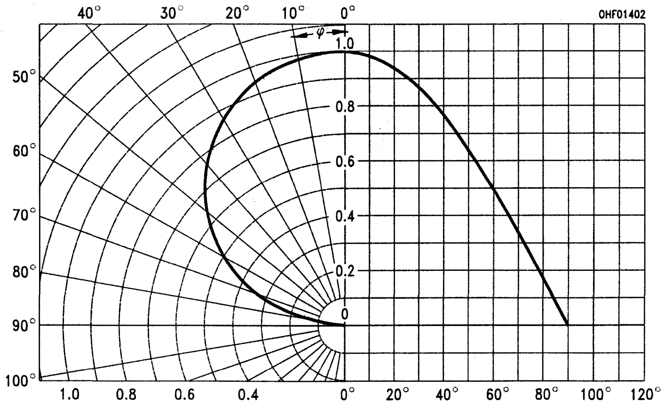


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

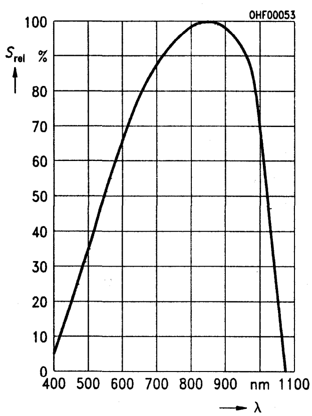


Figure 4. Capacitance $C=f(V_R)$, f=1 MH, E=0

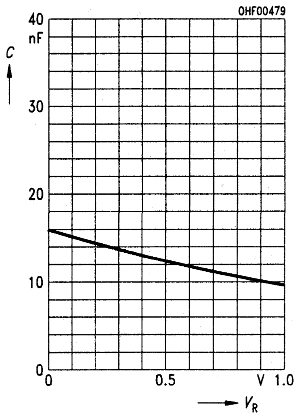
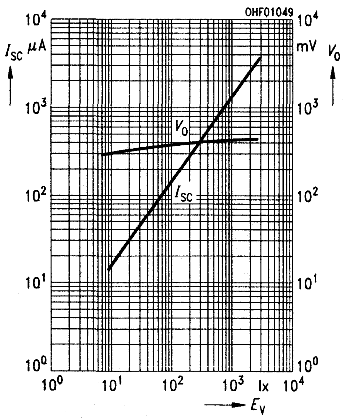


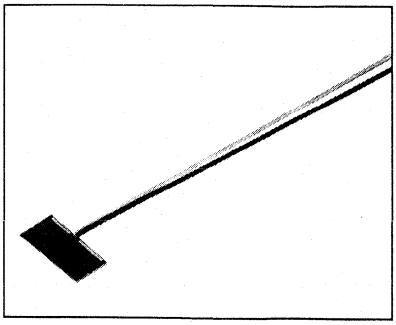
Figure 3. Open circuit voltage $V_o=f(E_V)$
Short circuit voltage $V_{sc}=f(E_V)$



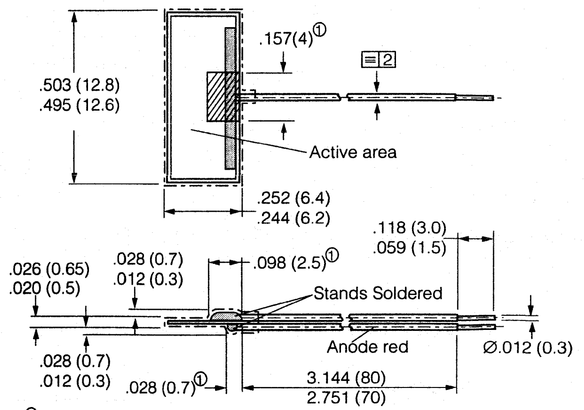
SIEMENS

BPY48P

Silicon Photovoltaic Cell



Dimensions in inches (mm)



FEATURES

- **For applications from 420 nm to 1060 nm**
- **Cathode=back contact**
- **Coated with humidity-proof protective layer**
- **Wide temperature range**

APPLICATIONS

- **For control and drive circuits**
- **Light pulse scanning**
- **Quantitative light measurements in near infrared and visible light range**

DESCRIPTION

The BPY48P is a silicon planar photovoltaic cell, with N-Si material providing positive front and negative back contacts. The Si chip has two leads and is coated with a humidity-proof protective layer..

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–55° to +100°C
Reverse Voltage (V_R)................................ 1 V

Characteristics T_A=25°C, Standard Light A, T=2856 K

Parameter	**Symbol**	**Value**	**Unit**	**Condition**
Spectral Sensitivity	S	0.5 (≥0.35)	µA/lx	V_R=0 V
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Sensitivity Spectral Range	λ	420 to 1060		S=10% of S_{MAX}
Radiant Sensitive Area	A	70	mm²	
Radiant Sensitive Area Dimensions	L x W	5.78 x 12.18	mm	
Half Angle	φ	±60	Deg.	
Dark Current	I_R	10 (≤180)	µA	V_R=1 V, E=0
Spectral Sensitivity	S_λ	0.55	A/W	λ=850 nm
Quantum Yield	η	0.80	electrons/photon	
Open Circuit Voltage	V_O	460 (≥280)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	0.5 (≥0.35)	mA	
Rise and Fall Time, Photocurrent	t_R, t_F	10	µs	R_L=1 kΩ, V_R=1 V, λ=850 nm, I_P=50 µA
Capacitance	C_O	6	nF	V_R=0 V, f=1 MHz, E_V=0 lx
Temp. Coefficient V_O	TC_V	–2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.2	%/K	

Figure 1. Directional characteristic S_{REL}=f(φ)

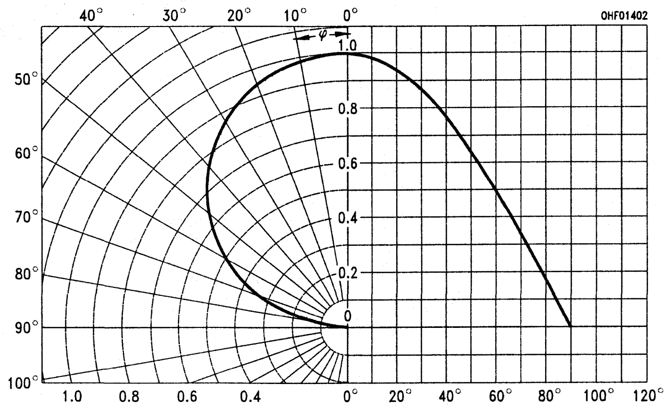


Figure 2. Relative spectral sensitivity S_{REL}=f(λ)

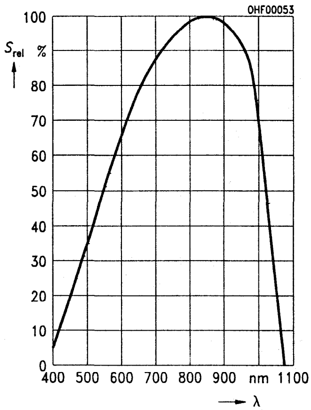


Figure 4. Capacitance C=f(V_R), f=1 HM, E=0

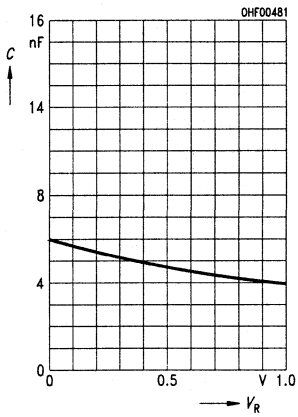
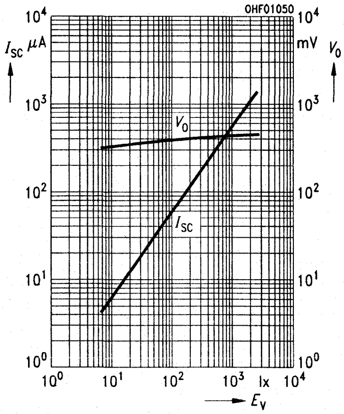


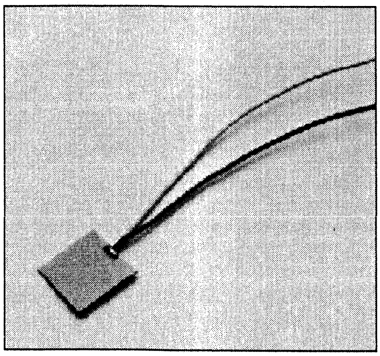
Figure 3. Open circuit voltage V_O=f(E_V)
Short circuit voltage V_{SC}=f(E_V)

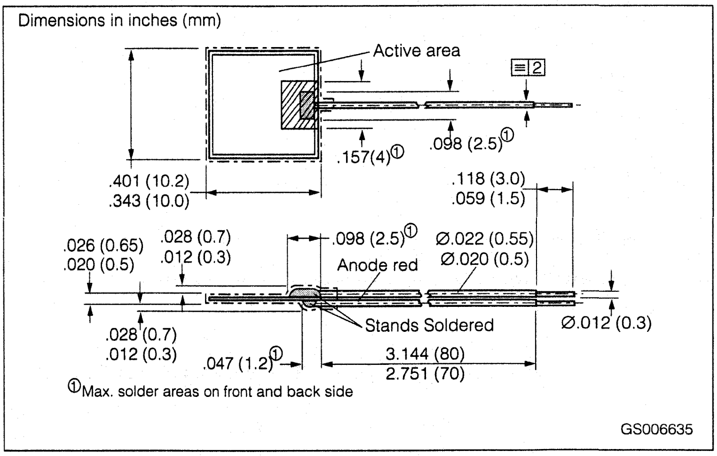


SIEMENS

BPY63P

Silicon Photovoltaic Cell





FEATURES

- For applications from 400 nm to 1100 nm
- Cathode=back contact
- Coated with humidity-proof protective layer
- Wide temperature range

APPLICATIONS

- For control and drive circuits
- Light pulse scanning
- Quantitative light measurements in near infrared and visible light range

DESCRIPTION

The BPY63P is a silicon planar photovoltaic cell with two leads and a hydro-protective outer layer. The BPY63P can be used in control and regulation circuits and as a photoelement to detect incandescent light and daylight.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG})...........–55° to +100°C
Reverse Voltage (V_R)............................ 1 V

Characteristics T_A=25°C, Standard Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	0.65(≥0.45)	µA/lx	V_R=0 V
Wavelength, Max. Sensitivity	λ_{Smax}	830	nm	
Sensitivity, Spectral Range	λ	400 to 1100		S=10% of S_{MAX}
Radiant Sensitive Area	A	94	mm²	
Radiant Sensitive Area Dimensions	L x W	9.69 x 9.69	mm	
Half Angle	φ	±60	Deg.	
Dark Current	I_R	10(≤60)	µA	V_R=1 V, E=0
Spectral Sensitivity	S_I	0.5	A/W	λ=850 nm
Quantum Yield	η	0.72	electrons / photon	
Open Circuit Voltage	V_O	430(≥280)	mV	E_V=1000 lx,
Short Circuit Current	I_{SC}	0.65(≥0.45)	mA	E_V=1000 lx,
Rise and Fall Time, Photocurrent	t_R, t_F	11	µs	R_L=1 kΩ, V_R=1 V, λ=850 nm, I_P=50 µA
Capacitance	C_O	8	nF	V_R=0 V, f=1 MHz, E_V=0 lx
Temp. Coefficient V_O	C_V	-2.6	mV/K	
Temp. Coefficient I_{SC}	TC_I	0.2	%/K	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

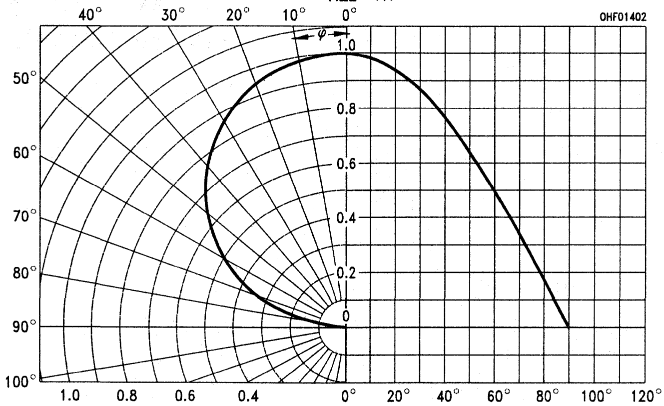


Figure 6. Dark current $I_R=f(T_A)$, $V_R=1$ V, E=0

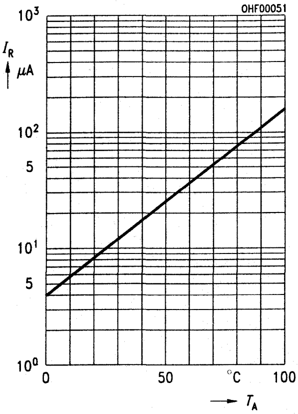


Figure 2. Relative spectral sensitivity $S_{REL}=f(\lambda)$

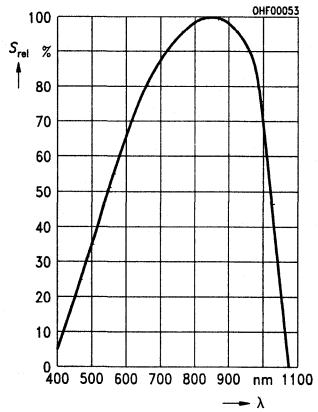


Figure 4. Capacitance $C=f(V_R)$, f=1 MH, E=0

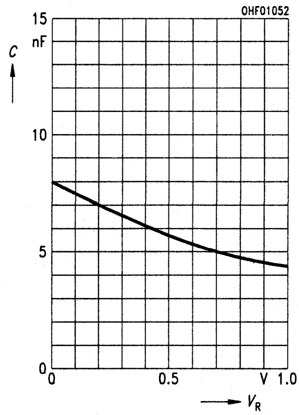


Figure 3. Open circuit voltage $V_O=f(E_V)$
Short circuit voltage $V_{SC}=f(E_V)$

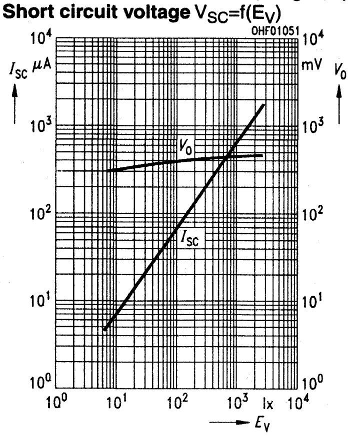
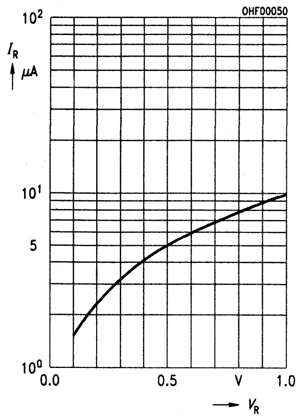


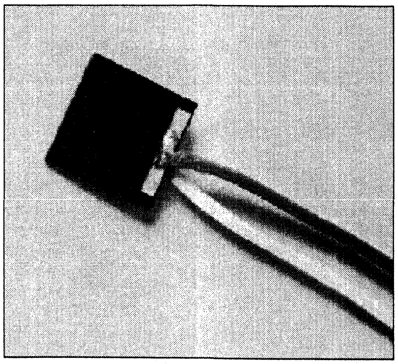
Figure 5. Dark current $I_R=f(V_R)$, E=0

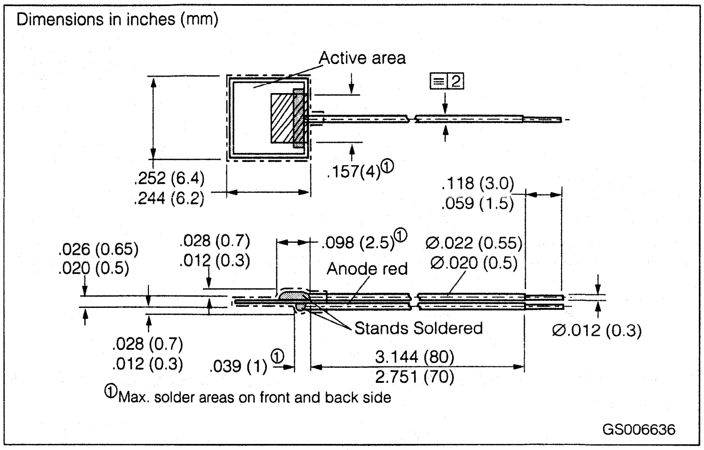


SIEMENS

BPY64P

Silicon Photovoltaic Cell





FEATURES

- **For applications from 420 nm to 1060 nm**
- **Cathode=back contact**
- **Coated with humidity-proof protective layer**
- **Wide temperature range**

APPLICATIONS

- **For control and drive circuits**
- **Light pulse scanning**
- **Quantitative light measurements in near infrared and visible light range**

DESCRIPTION

The BPY64P is a silicon photovoltaic cell. It can be used in control and drive circuits and as a detector for light of filament lamps or daylight.

Maximum Ratings

Operating/Storage Temperature
Range (T_{OP}, T_{STG}) ....–55° to +100°C
Reverse Voltage (V_R)................................ 1 V

Characteristics T_A=25°C, Standard Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Photosensitivity	S	0.25(≥0.18)	µA/lx	V_R=0 V
Wavelength, Max. Sensitivity	λ_{Smax}	850	nm	
Sensitivity, Spectral Range	λ	420 to1060		S=10% of S_{MAX}
Radiant Sensitive Area	A	0.36	cm^2	
Radiant Sensitive Area Dimensions	L x W	5.98x5.98	mm	
Half Angle	φ	±60	Deg.	
Dark Current	I_R	4(≤80)	µA	V_R=1 V, E=0
Spectral Sensitivity	S_λ	0.5	A/W	λ=850 nm
Quantum Yield	η	0.72	electrons / photon	
Open Circuit Voltage	V_O	450(≥280)	mV	E_V=1000 lx
Short Circuit Current	I_{SC}	0.25(≥0.18)	mA	
Rise and Fall Time, Photocurrent	t_R, t_F	5	µs	R_L=1 kΩ, V_R=1 V, λ=840 nm, I_P=250 µA
Capacitance	C_0	3	nF	V_R=0 V, f=1 MHz, E_V=0 lx
Temperature Coefficient V_O	TC_V	-2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.2	%/K	

Figure 1. Directional characteristic
S_{REL}=f(φ)

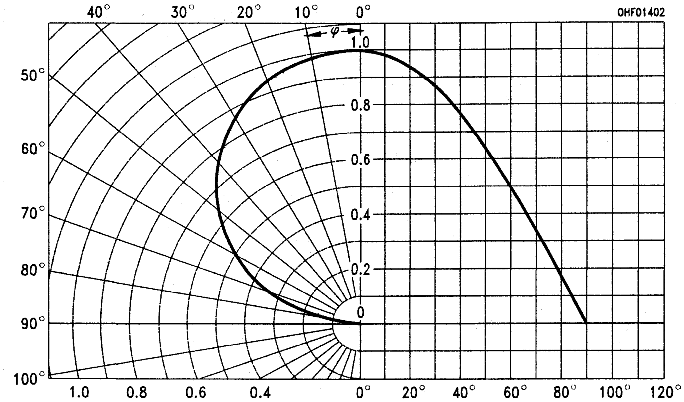


Figure 2. Relative spectral sensitivity
S_{REL}=f(λ)

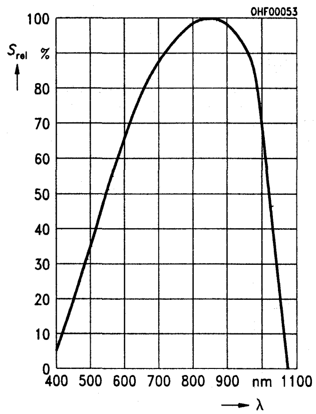


Figure 4. Capacitance C=f(V_R), f=1 HM, E=0

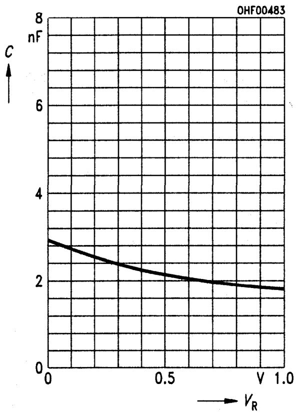
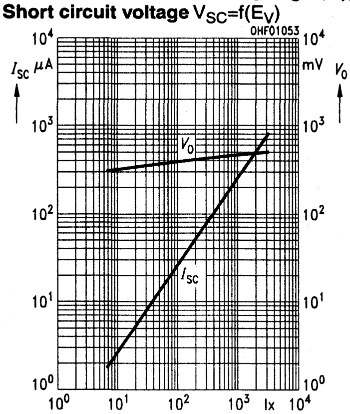
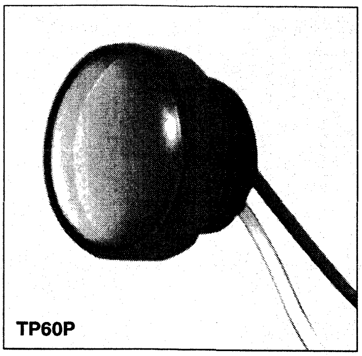


Figure 3. Open circuit voltage V_O=f(E_V)
Short circuit voltage V_{SC}=f(E_V)



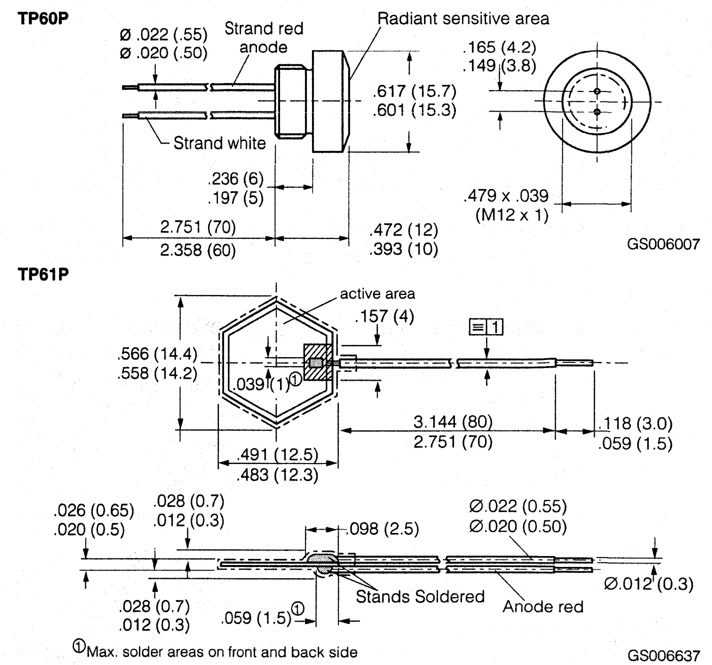
SIEMENS

TP60P
TP61P
Silicon Photovoltaic Cell



TP60P

Dimensions in inches (mm)



FEATURES
- **For applications from 420 nm to 1120 nm**
- **Cathode=back contact**
- **Mounting by bolt/nut**

APPLICATIONS
- **For control and drive circuits**
- **Light pulse scanning**
- **Quantitative light measurements in near infrared and visible light range**

DESCRIPTION
The TP60/61P are silicon photovoltaic cells with the same electrical characteristics; they differ only in packaging. The anode (positive pole of the cell) is denoted by a red lead.

Maximum Ratings
Operating/Storage Temperature
Range (T_{OP}, T_{STG}) .... –55° to +100°C
Reverse Voltage (V_R).......................... 1 V

Characteristics T_A=25°C, Standard Light A, T=2856 K

Parameter	Sym.	Value	Unit	Condition
Spectral Sensitivity	S	1(≥0.7)	µA/lx	V_R=0 V
Wavelength, Max. Sensitivity	λ_{Smax}	900	nm	
Sensitivity, Spectral Range	λ	400 to 1120		S=10% of S_{MAX}
Radiant Sensitive Area	A	1.3	cm²	
Radiant Sensitive Shape		Sechseck hexagon		
Half Angle	φ	±60	Deg.	
Dark Current	I_R	0.1(≤2)	µA	V_R=1 V, E=0
Spectral Sensitivity	S_λ	0.55	A/W	λ=850 nm
Quantum Yield	η	0.80	electrons / photon	
Open Circuit Voltage	V_O	450(≥270)	mV	E_V=1000 lx
		430		E_E=0.5 mW/cm², λ=850 nm
Short Circuit Current	I_{SC}	1(≥0.7)	mA	E_V=1000 lx
Rise and Fall Time, Photocurrent	t_R, t_F	18	µs	R_L=1 kΩ, V_R=1 V, λ=850 nm, I_P=50 µA
Capacitance	C_0	11	nF	V_R=0 V, f=1 MHz, E_V=0 lx
Temperature Coefficient V_O	TC_V	–2.6	mV/K	
Temperature Coefficient I_{SC}	TC_I	0.12	%/K	

Figure 1. Directional characteristic $S_{REL}=f(\varphi)$

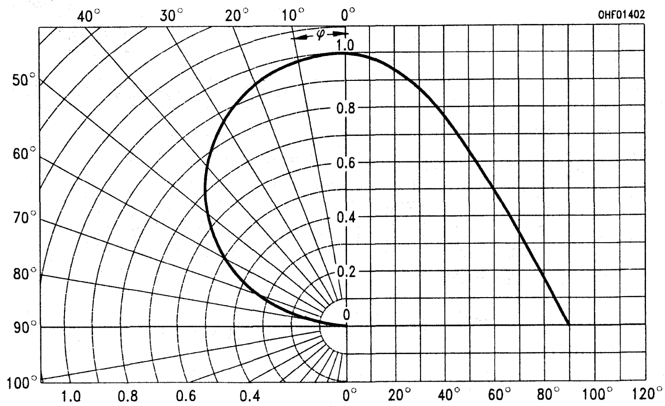


Figure 6. Dark current $I_R=f(V_R)$, E=0

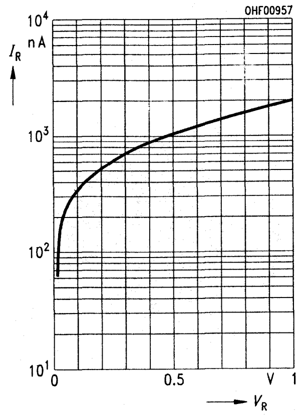


Figure 2. Relative spectral sensitivity
$S_{REL}=f(\lambda)$

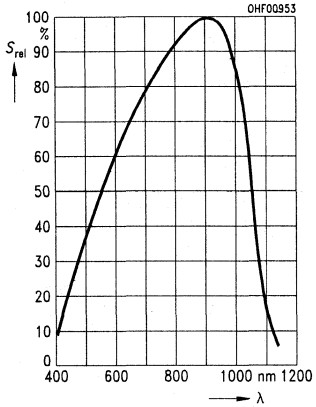


Figure 4. Open circuit voltage—TP61P
$V_O=f(E_V)$ Short circuit voltage $V_{SC}=f(E_V)$

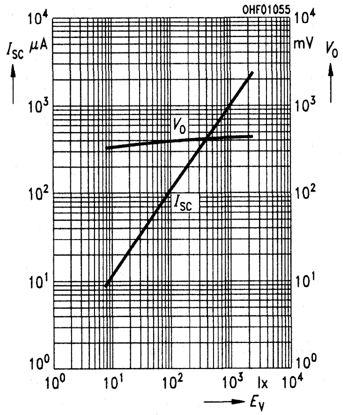


Figure 3. Open circuit voltage—TP60P
$V_O=f(E_V)$ Short circuit voltage $V_{SC}=f(E_V)$

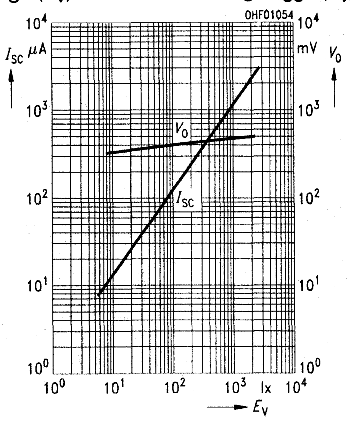
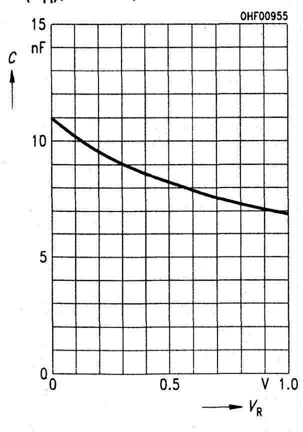


Figure 5. Capacitance
$C=f(V_R)$, f=1 HM, E=0



Application Notes by Product Group

Application Notes Numerical Order

LEDs and Photometry Appnote 1

by George Smith

The observed spectrum of electromagnetic radiations, extends from a few Hz to beyond 10^{24} Hz, covering some 80 octaves. The narrow channel from 430 THz to 750 THz would be entirely negligible, except that more information is communicated to human beings in this channel than from the rest of the spectrum. This radiation has a wavelength ranging from 400 nm to 700 nm and is detectable by the sensory mechanisms of the human eye. Radiation observable by the human eye is commonly called light.

Measurements of the physical properties of light and light sources can be described in the same terms as any other form of electromagnetic energy. Such measurements are commonly called radiometric measurements.

Measurements of the psychophysical attributes of the electromagnetic radiation we call light are in units, other than radiometric units. Those attributes which relate to the luminosity (sometimes called visibility) of light and light sources are called photometric quantities. The measurement of these aspects is the subject of *photometry.*

Electronics engineers who are starting to apply light emitting diodes and other optoelectronic devices to perform useful tasks will find the subject of photometry to be a confused mass of strange units, confusing names for photometric quantities, and general disagreement about the important requirements are for his/her application.

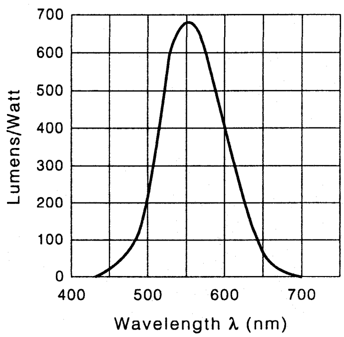
The photometric quantities are related to the corresponding radiometric quantities by the C.I.E. Standard Luminosity Function (Figure 1) or colloquially, the standard eyeball. We can think of the luminosity function as the transfer function of a filter which approximates the behavior of the average human eye under good lighting conditions.

Figure 1. Relationship between radiometric units and photometric units

The eye responds to the rate at which radiant energy falls on the retina, i.e., on the radiant flux density expressed as Watts/m^2. The corresponding photometric quantity is Lumens/m^2. Therefore the standard luminosity function is a plot of Lumens/Watt as a function of wavelength.

The function has a maximum value of 680 Lumens/Watt at 555 nm and the half power points occur at 510 nm and 610 nm (Figure 2).

Figure 2. CIE standard photopic luminosity function

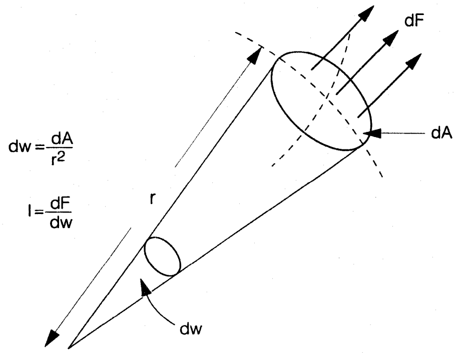


The lumen is the unit of luminous flux and corresponds to the watt as the unit of radiant flux.

Thus the total luminous flux emitted by a light source in all directions is measured in lumens, and can be traced back to the power consumed by the source to obtain an efficiency number.

Since it is generally not practical to collect all the flux from a light source and direct it in some desired direction, it is desirable to know how the flux is distributed spatially about the source. If we treat the source as a point (far field measurement), we can divide the space around the source into elements of solid angle (dω), and inquire as to the luminous flux (dF) contained in each element of solid angle (df/dω). The resulting quantity is Lumens/Steradian and is called *luminous intensity* (I), Figure 3. The unit of luminous intensity is called the *candela*, sometimes loosely called the candle, or candle power.

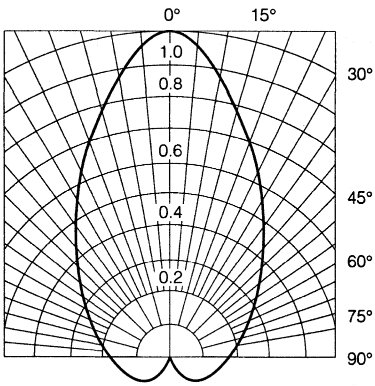
Figure 3. Solid angles and luminous intensity



Since the space surrounding a point contains 4 π steradians, it is apparent that an isotropic radiator of one candela intensity emits a total luminous flux of 4 π Lumens.

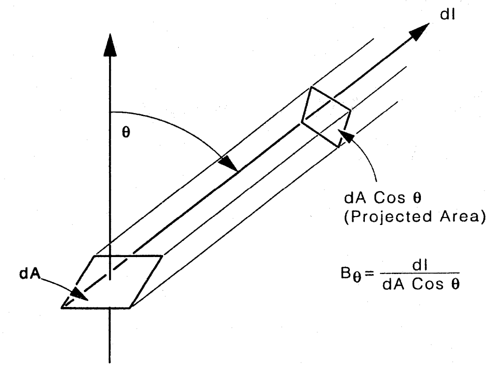
No real light source is isotropic, so it is quite common to show a plot of luminous intensity versus angle off the axis (Figure 4). If the source has no axis of symmetry, a more complex diagram is required.

Figure 4. Spatial distribution pattern



For an extended radiating surface, (such as an LED chip), each element of area contributes to the luminous intensity of the source in any given direction. The luminous intensity contribution in the given direction divided by the projected area of the surface element in that direction is called the *luminance* (B) of the source (in that direction), Figure 5. The quantity is sometimes called photometric brightness, or simply brightness. Using the term brightness on its own should be discouraged as brightness involves various subjective properties such as texture, color, sparkle, apparent size, etc., that have psychological implications.

Figure 5. Definition of luminance



The fundamental quantitative standard of the photometric system of units is the standard of luminance.

The luminance of a black body radiator at the temperature of freezing platinum (2043.8°K) is 60 candela per square centimeter. A blackbody radiator is a perfect absorber of all electromagnetic energy incident on it. In thermal equilibrium at a given temperature, it emits radiation, spectrally distributed according to Planck's Formula.

$$W\lambda = \frac{C_1 \lambda^{-5}}{exp\left(\frac{C_2}{\lambda}\right) - 1}$$

The units of luminance in present use are an engineering nightmare.

1 candela/cm^2 is called a *Stilb*
1/π candela/cm^2 is called a *Lambert*
1 candela/m^2 is called a *Nit*
1/π candela/m^2 is called an *Apostilb*
1/π candela/ft^2 is called a *foot-Lambert*

The foot Lambert is the most commonly used unit in the U.S.

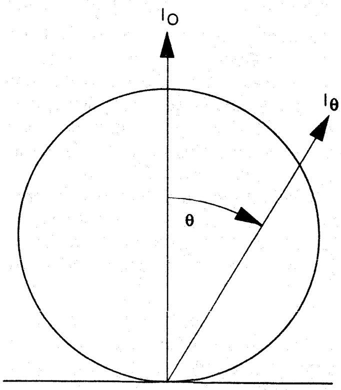
Of particular interest is a source whose angular distribution pattern is a circle (Figure 6). For such a source we have $I\ \theta = I_o \cos\theta$, the luminance of such a source in a given direction q, is then given by:

$$B\theta = \frac{dI\theta}{dA\cos\theta} = \frac{dI_o Cos\theta}{dACos\theta} = \frac{dI_o}{dA}$$

The luminance is seen to be the same in all directions. Such a source is called a *lambertian source.* It can be shown that a perfectly diffusing surface behaves in this fashion. The formula governing a diffusing surface $I\theta = I_O \cos\theta$ is called Lambert's Cosine Law.

It can be shown that a flat LED chip is a very good approximation to a Lambertiian Source.

Figure 6. Lambertian radiation pattern



If we now take a surface element (dA) and determine the intensity contribution in each direction we can determine the total flux (dF) emitted by the surface element. The resultant ratio (dF/dA) Lumens/m^2 is called the *luminous emittance* (L). For a flat surface we may calculate L from:

$$L = 2\pi \int_0^{\frac{\pi}{2}} B_{(\theta)} Sin\,\theta Cos\,\theta d\theta$$

The corresponding radiant emittance in watts/m^2 is of considerable interest for GaAs infrared LEDs where total output power is an important parameter.

The total luminous flux emitted by a light source can then be calculated from $F_{total} = \int L dA$.

These photometric quantities are sufficient to describe the properties of light sources such as light emitting diodes.

When light falls on a receiving surface, it is either partially reflected in the case of a purely passive surface, or partly converted into some other form of energy by what we may describe as an active surface (such as a phototransistor or photomultiplier cathode). In either case we are interested in how much flux falls on each element of the surface; Lumens/m^2 in the case of a passive surface which we wish to illuminate, or the eye; and Watts/m^2 in the case of other active surfaces. The quantity Lumens/m^2 in this case is called the *illuminance* sometimes loosely referred to as the illumination. The unit of illuminance is the *lux* also referred to as the metercandle. Another commonly used unit of illuminance, in the U.S. is the *foot candle*, equal to one lumen per square foot. One lumen per square cm is called a *phot*.

Many of these photometric quantities and units are in common use in the field of illumination engineering. While English units are the most common in the U.S., a mixed system of units is involved in common usage.

Application to Light Emitting Diodes

The above description of photometric quantities should indicate that there are many ways in which the photometric properties of LEDs can be stated. There is no general agreement among LED makers and users as to the best way to specify LED performance leading to much confusion and misunderstanding.

Many factors must be taken into account when evaluating LED specifications for a particular application, and electronic engineers will need to develop a knowledge of these factors to use LEDs effectively in new designs.

Presently available light emitting diodes are made from III-V, II-VI, and IV semiconductors, with Gallium Arsenide Phosphide and Gallium Phosphide being the major materials. Gallium Aluminum Arsenide is also used but is less common. Gallium Arsenide is commonly included in this group, but GaAs emits only infrared radiation around 900 nm which is not visible to the eye and can't properly be called light. All specifications of non-visible emitters must be in radiametric units.

GaP emits green light between 520 and 570 nm peaking at 550 nm, very close to the peak eye sensitivity. It also can emit red light between 630 and 790 nm peaking at 690 nm.

$GaAs_{(1-x)} P_X$ emits light over a broad range from green to infrared depending on the percentage of phosphorus in the material (x). For x in the 0.4 region, red light between 640 and 700 nm peaking at 660 nm is obtained. For x=0.5, amber light peaking around 610 nm is obtained.

$Ga_{(1-x)} Al_X AS$ as presently available emits red light between 650 and 700 nm peaking at 670 nm and also emits into the infrared range.

The efficiency of these materials is very dependent on the emitted wavelength, with drastic fall off in efficiency as the wavelength gets shorter. Fortunately the standard eyeball filter favors the shorter wavelength (down to 555 nm) and gives some measure of compensation. Some typical efficiencies reported by device makers, and the resulting overall luminous efficiency (Lumens/electrical watt) are as follows:

GaP.red .72% at 20 Lum/Watt=14 Lum/Watt overall

$GaAs_6P_4$ red .3% at 50 Lum/Watt=.15 Lum/Watt overall

GaAlAs red 1.5% at 40 Lum/Watt=.024 Lum/Watt overall

GaP green .006% at 675 Lum/Watt=.04 Lum/Watt overall

$GaAs_5P_5$ amber .0044% at 340 Lum/Watt=.015 Lum/Watt overall

For simple status indicator applications, front panel lamps and similar applications, several factors must be considered:

1. Color—LED lamps and displays are available in a variety of standardized colors of emitted light: red, high efficiency red, soft orange, yellow, green and blue—although not every component is available in every color.

2. Apparent source size—Various combinations of chip size and optical systems are available so that apparent source sizes from about 5 mils to about 300 mils diameter are available as standard products. Other things being equal, a larger source size is more visible.

3. Angular distribution. GaAsP diode chips are nearly Lambertian, but GaP are nearly isotropic. With suitable optical design, the angular distribution pattern can be changed from very broad to quite narrow. By placing the chip at the focus of the lens system a narrow high intensity beam is obtained. The off axis visibility is drastically reduced. By using diffusing lens materials, a large area source with good off axis visibility is obtained but the luminance is reduced.

4. Luminous intensity. This will govern the visibility under optimum background contrast conditions, when viewed at normal distances. 1 millicandela is typical for red lamps of either GaAsP or GaP at normal operating conditions.

5. Luminance. When it is not possible to provide a dark contrasting background, or when the source is viewed at very close distances, the luminance becomes important. Values from 100 ft-L to 5000 ft-L are typical.

These factors are all related to the design of the device and the user should understand the trade offs. High luminance values in excess of 10,000 ft-L are easily obtained by running very high current densities in the LED chip but can lead to shortened life if carried too far.

For a given drive current the luminous intensity of two different chips will be similar, while the luminance will be inversely proportional to the active area of the chip.

If the designer can use filter screens or circularly polarizing filters in front of the light source, excellent protection from background illumination can be obtained. In this case a diffusive lens giving a large apparent source with lower luminance, is more visible than a high luminance point source.

When a LED is used with an optical system to activate a remote sensor such as a cadmium sulphide or cadmium selenide cell (red light), or a GaAs IR emitter is used with a silicon photo detector, the performance requirements are somewhat different. It can be shown that for a given optical arrangement the irradiance of the detector determines the detected signal and this is proportional to the radiance of the source, which is comparable to the luminance (brightness) of the source. The intensity of the source will not be a factor unless the detector active area is larger than the incident beam.

When average power consumption must be minimized but good visibility is required, or detection at a considerable distance is required, pulsed operation can be used. With GaAs and GaAsP emitters using low duty cycle short pulses, very high peak intensity levels can be reached permitting communication over considerable distances. This technique is not useful with GaP diodes since they do not exhibit a linear relationship between optical output and instantaneous forward current, becoming saturated at moderate current levels. GaPalso has a 50% higher rate of fall off in light output with temperature increase, than GaAsP which further inhibits high power applications.

Using LEDs to give a "heads up" projected display, such as for an automobile speedometer readout, or aircraft cockpit application places severe requirements on the display luminance. For easy visibility, the projected image must be sufficiently contrasted with the ambient illumination. This requires very high luminance values for the LEDs together with the use of photochromic windshields and probably polarizing screens.

The foregoing is a necessarily simplified description of a very complex subject. For more information read the standard textbook literature on these subjects.

References:

R. Kingslake, *Applied Optics & Optical Engineering Committee on Colorimetry of the O.S.A., The Science of Color.*
Warren J. Smith, *Modern Optical Engineering*

SIEMENS

Applications of Optocouplers Appnote 2

The IL1 is the first in a family of optocouplers. These products are also called photon coupled isolators, photocouplers, photo-coupled pairs and optically coupled pairs. All of the characteristics of the IL1 are electrical: it has no external optical properties. Hence optoisolators are not *optoelectronic devices*; they are in fact one of the simplest of all *electro-optical systems.*

The IL1 consists of a Gallium Arsenide infrared emitting diode, and a silicon phototransistor mounted together in a DIP package.

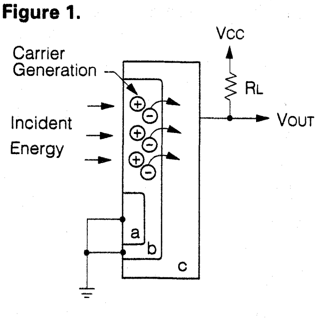
When forward current (I_F) is passed through the Gallium Arsenide diode, it emits infrared radiation peaking at about 900 nm wavelength. This radiant energy is transmitted through an optical coupling medium and falls on the surface of the NPN phototransistor.

Phototransistors are designed to have large base areas, and hence a large base-collector junction area, and a small emitter area. Some fraction of the photons that strike the base area cause the formation of electron-hole pairs in the base region. This fraction is called the *quantum efficiency* of the photodetector.

If we ground the base and emitter, and apply a positive voltage to the collector of the phototransistor, the device operates as a photo diode.

The high field across the collector base junction quickly draws the electrons across into the collector region. The holes drift towards the base terminal attracting electrons from the terminal.

Figure 1.



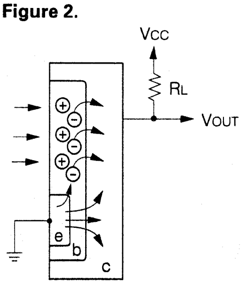
Thus a current flows from collector to base, causing a voltage drop across the load resistance (R_L).

The high junction capacitance, C_{cb}, results in an output circuit time constant R_LC_{cb}, with a corresponding output voltage rise time.

The output current in this configuration is quite small and hence this connection is not normally used.

The commonest circuit configuration is to leave the base connection open. With this connection, the holes generated in the base region cause the base potential to rise, forward biasing the base-emitter junction. Electrons are then injected into the base from the emitter, to try to neutralize the excess holes. Because of the close proximity of the collector junction, the probability of an electron recombining with a hole is small and most of the injected electrons are immediately swept into the collector region. As a result, the total collector current is much higher than the photogenerated current, and is in fact β times as great.

Figure 2.



The total collector current is then several hundred times greater than for the previous connection.

This gain comes with a penalty of much slower operation. Any drop in collector voltage is coupled to the base via the collector-base capacitance tending to turn off the injected current. The only current available to charge this junction capacitance is the original photocurrent. Thus, the rate of change of the output voltage is the same for both the diode and transistor connections. In the latter case, the voltage swing is β times as great, so the total rise time is β times as great as for the diode connection. Thus the effective output time constant is $\beta\ R_LC_{cb}$.

For the IL1 a typical 2 µs rise time for 100 Ω results.

The ratio of the output current from the phototransistor (I_C or I_E), to the input current in the Gallium Arsenide diode is called the Current Transfer Ratio (CTR). For the IL1, CTR is specified at 20% minimum with 35% being typical at I_F=10 mA.* Thus for 10 mA input current the minimum output current is 2 mA. Other important parameters are V_F typically 1.25V at 60mA I_F.

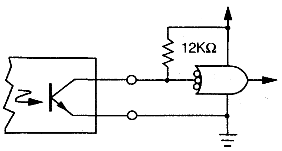
Digital Interfaces

Output Sensing Circuits

The output of the phototransistor can directly drive the input of standard logic circuits such as the 7400 TTL families. The worst case input current for the 74 series gate is –1.6 mA for V_{IN}=0.4 Volts. This can be easily supplied by the IL1, with 10 mA input to the infrared diode.

TTL Active Level Low (7400)

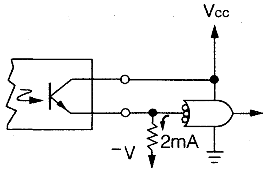
Figure 3.



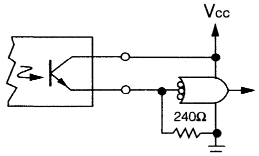
Note: Use smaller pull up resistor for higher speed.

It is more difficult to operate into TTL gates in the active level high configuration. Some possible methods are as follows:

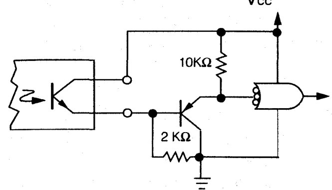
Figure 4.



Note: Best method if negative supply is available.

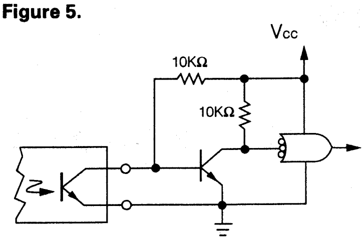


Note: Requires 10 mA from transistor and sacrifices noise margin.



Note: High sensitivity but sacrifices noise margin. Needs extra parts.

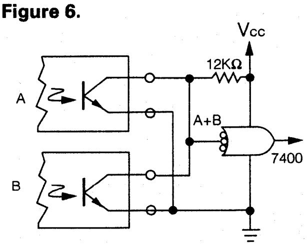
Figure 5.



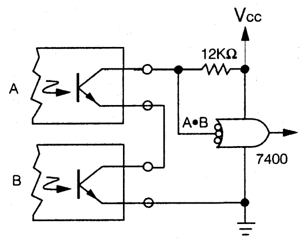
Note: Extra parts cost but high sensitivity.

Obviously, several optocoupler output transistors can be connected to perform logical functions.

Figure 6.



Note: Logical OR connection.

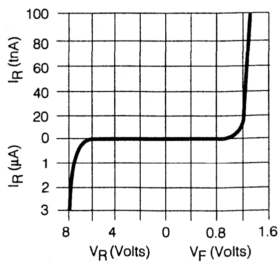


Note: Logical AND connection.

Input Driving Circuits

The input side of the IL1 has a diode characteristic as shown.

Figure 7.

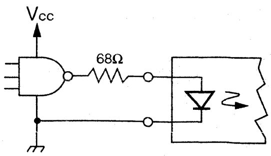


The forward current must be controlled to provide the desired operating condition.

The input can be conveniently driven by integrated circuit logic elements in a number of different ways.

TTL Active Level High (7400 Series)

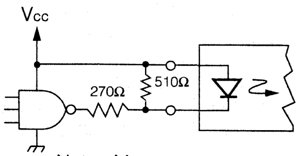
Figure 8.



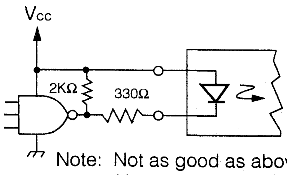
Note: Can omit resistor for about 15 mA into diode.

TTL Active Level Low (7400 Series)

Figure 9.



Note: More parts required than above.



Note: Not as good as above circuit. Not recommended.

There are obviously many other ways to drive the device with logic signals, but the commonest needs can be met with the above circuits. All provide 10 mA into the LED giving 2 mA minimum out of the phototransistor. The 1 Volt diode knee and its high capacitance (typically 100 pF), provides good noise immunity. The rise time and propagation delay can be reduced by biasing the diode on to perhaps 1 mA forward current, but the noise performance will be worse.

All previous configurations show medium speed digital interfaces. These circuits have various advantages over other ways of doing the task.

(1) They can replace relays and reed relays, giving much faster switching speeds, no contact bounce, better reliability, and usually better electrical isolation except for special configurations. However relays have high current capability, higher output voltage, lower on resistance and offset voltage and higher off resistance.

(2) They can replace pulse transformers in many floating applications. Opto-isolators can transmit DC signal components and low frequency AC, whereas pulse transformers couple only the high frequency components, and a latch is required to restore the DC information. Pulse transformers have faster rise time than phototransistor optocouplers.

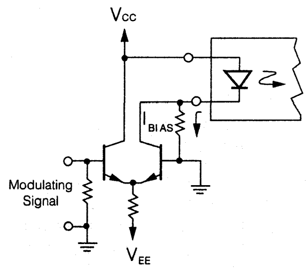
(3) Integrated circuit line drivers and receivers are used to transmit digital information over long lines in the presence of common mode noise. The maximum common mode noise voltage permissible is usually in the 30 Volt range. There are many practical situations where common mode noise voltages of several hundred Volts can be induced in long lines. For these applications, optocouplers provide protection against several thousand volts.

Linear Applications

The curve of input current versus output current for the IL1 is somewhat non-linear, because of the variation of β with current for the phototransistor, and the variation of infrared radiation out versus forward current in the GaAs diode. The useful range of input current is about 1 mA to 100 mA, but higher currents may be used for short duty cycles.

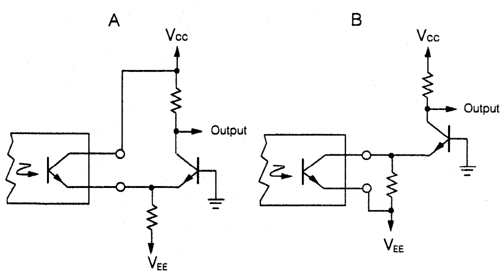
For linear applications the LED must be forward biased to some suitable current (usually 5 mA to 20 mA). Modulating signals can then be impressed on this DC bias. A differential amplifier is a good way to accomplish this.

Figure 10.



Sensing in linear applications can be done in several ways depending on the requirements. For high frequency performance, the phototransistor should be operated into a low impedance input current amplifier. The simplest such scheme is a grounded base amplifier.

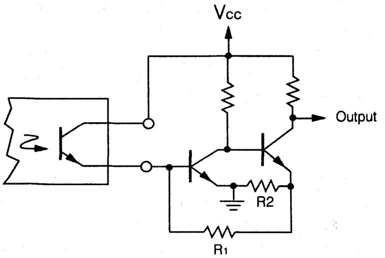
Figure 11.



The circuit will work equally well either way, with a phase inversion between the two. Obviously a PNP transistor would work as well.

A feedback amplifier could also be used to get a low impedance input.

Figure 12.



The current gain is

$$\left(1+\frac{R_1}{R_2}\right)$$

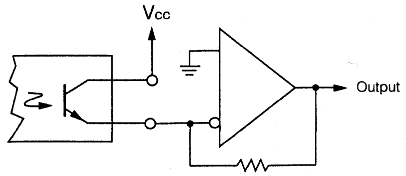
The input impedance is approximately

$$\left(\frac{R_1}{1+\frac{V_{CC}-2V_{BE}}{0.026}}\right)$$

For example if R1=900 Ω, R2=100 Ω, V_{CC}=5 V, we would have a current gain of 10 and an input impedance of about 6.3 Ω. This would give a considerable speed improvement over a 100 Ω load.

A high speed operational amplifier could be used to give excellent performance.

Figure 13.



Note that in all cases the output can be taken from either the collector or the emitter of the phototransistor depending on the polarity desired. The operating speed is the same in either case.

Conclusion

This appnote covers the most commonly used ways of applying phototransistor optocouplers. The design engineer will see many ways to expand on these circuits to achieve his end goals. The devices are extremely versatile, and can provide better solutions to many systems problems than other competing components. Special designs are possible to optimize certain parameters such as coupling capacitance, or transfer ratio.

Table 1. Properties of signal coupling devices

Device	Advantages	Disadvantages
Optocoupler	Economical Solid state reliability Medium to high speed signal transmission DC & low frequency transmission High voltage isolation High isolation impedance Small size DIP Package No contact bounce Low power operation	Finite ON Resistance Finite OFF Resistance Limited ON state current Limited OFF state voltage Low transmission efficiency (Low CTR)
Relays	High power capability Low ON resistance DC transmission High voltage isolation	High cost High power consumption Unreliable Very slow operation Physically large
Pulse Transformers	High speed signal transmission Moderate size Good transmission efficiency	No DC or low frequency transmission Expensive for high isolation impedance or voltage
Differential Line Drivers and Receivers	Solid state reliability Small size DIP package High speed transmission DC transmission Low cost	Very low breakdown voltage Low isolation impedance

SIEMENS

Multiplexing LED Displays Appnote 3

by George Smith

In digital displays, such as would be used in a D.V.M. or counter of conventional design, all digits are operated in parallel, with a separate decoder-driver for each digit operated from data generally stored in a quad latch.

In many cases, a reduction in cost can be effected by operating the display in a time division multiplexed mode. The question of cost effectiveness depends on the particular application. As a general rule, the greater the number of digits in the display, the more advantageous the multiplex system becomes from the cost standpoint. Because of the great variety of situations possible, it is difficult to say at what number of digits the change should be made. In some circumstances, non-multiplexed operation of less than 8 digits is more economical. On the other hand, there are circumstances where multiplexing is used for three and four digit displays at a cost saving. This application note attempts to show some of the many ways of multiplexing digits. The designer can decide whether his/her own system application would be lower in cost by using a multiplex scheme.

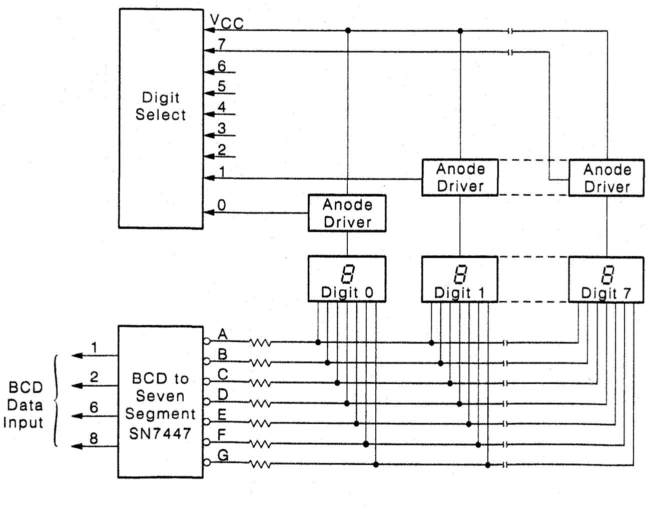
The properties of light emitting diodes (LED) make them particulary suitable for multiplexed operation, and hence it is the preferred method to use, if a scheme can be designed which is cost competitive with non-multiplexed operation.

It will be generally assumed that we are talking of a system using TTL type logic families, with MSI functions being used where applicable. In most production situations this will be the most economical approach. There will be some cases where discrete gates and flip-flops may yield a lower cost. There are also cases where a single MOS chip contains all the necessary logic functions and only interface driver circuits are required.

The seven segment numeric displays with a common anode connection made by Siemens provide compatibility with the most widely available decoder-drivers, which are active level low outputs. The commonest device is SN7447 or similar. Any of these is suitable for driving displays: HD107XX, HD110XX or HD1131XX series. For common cathode displays, such as the Siemens DL330M, DL340M, DL430M, or DL440M, a SN7448 decoder can be used, and anode drivers become cathode drivers.

In a multiplex system, the corresponding cathodes of each digit are bussed together and driven from one seven segment decoder-driver via the usual current limiting resistors. The display data is presented serially by digit to the decoder-driver, together with an enable signal to the appropriate digit anode (Figure 1).

Figure 1.



Each digit anode is driven by a switch, capable of passing the full current of all segments. The simplest switch would be a PNP high current switch or amplifier transistor, such as a core driver type.

In operation, the anode switches are activated one at a time, in the desired sequence, while the appropriate digital data is presented at the input to the decoder driver. The amount of circuitry required in Figure 1 is much less than that used in the non-multiplexed scheme. The question of overall economy depends on the amount of circuitry required to sequence the anodes and present the data at the decoder input. Let us consider some typical situations.

Case 1

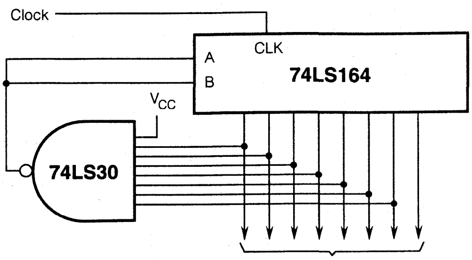
An 8-digit counter-timer display with the data stored in multiple latch circuits is the most common situation present in a counter-timer of conventional design. A quad latch (SN7475) is used to store each digit, and this data is periodically updated. To scan this data, a 4 pole 8 position switch is required (SN74151). To select the appropriate digit, an octal counter (SN7493) and a BCD decoder (SN7442) are required. The complete circuit is shown in Figure 2.

The total package count is about half the same for this arrangement, as for non-multiplexed operation, but most of the packages are lower cost than the seven segment decoder. The scheme shown is a 20% cost reduction over non-multiplexed operation, based on O.E.M. prices for the components. For less than eight digits, it would be difficult to compete with non-multiplexed operation using this scheme.

Case 2

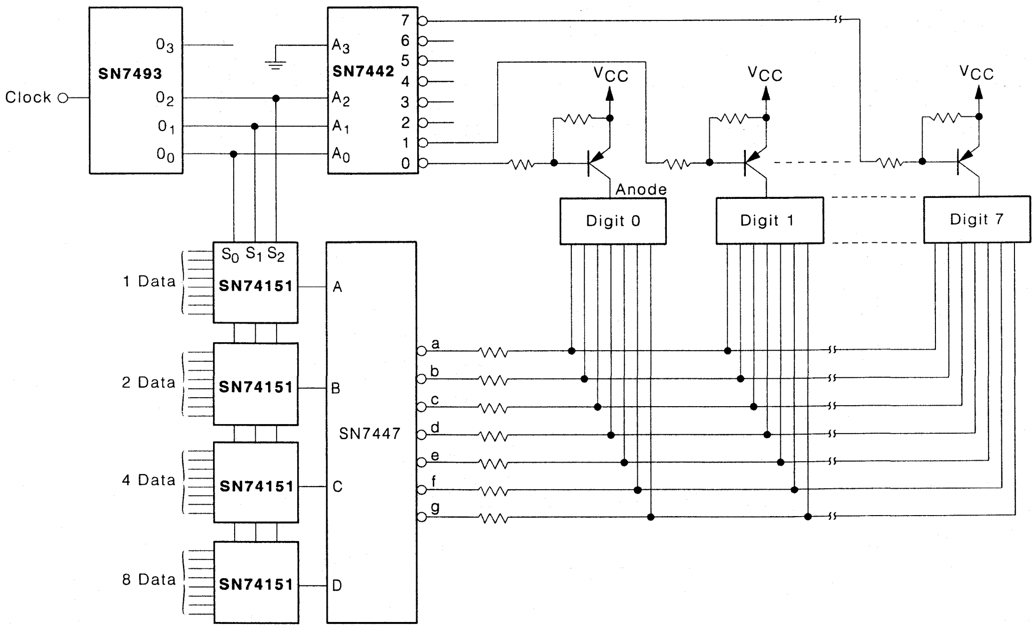
Multiplexing becomes more attractive when the data is stored in a shift register, rather than in latches. In this case the data is circulated around the register at some suitable rate and is sequentially presented at the input of the seven-segment decoder-driver. The anode drive can be obtained from a counter and decoder as in Figure 2, or from a parallel output shift register, Figure 3.

Figure 3.



This circuit, which can be expanded to any number of digits, circulates a single zero, and can directly drive the PNP anode switches. Systems using recirculating memories generally require this digit timing circuitry for other reasons, so it is generally already available in the system.

Figure 2.



For displays of eight digits; a very common number in counter-timer instruments, the 741648 bit shift register makes a very good circulating shift register.

The scheme can be extended to more digits by adding a four bit shift register, such as the 7494; the extra shift bits are inserted at the points marked ⊗ in Figure 4. The same circuit can be used for less than eight digits, if a 12½% duty cycle is satisfactory.

The preceding schemes demonstrate that systems containing recirculating data are very effectively coupled to multiplexed LED displays. Many multi-digit systems such as calculating machines use L.S.I. MOS circuits to provide their logic, and these naturally lend themselves to recirculating data. It is now practical to use microprocessors in instruments, which work well with Siemens Intelligent Display devices.

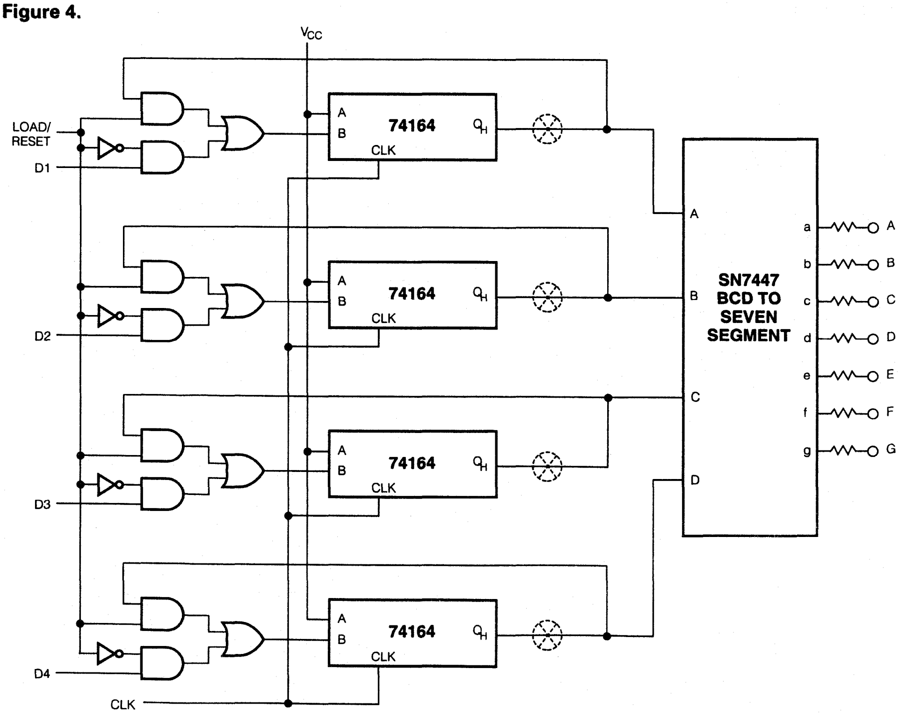
Apart from the strictly logical problems involved in a multiplexed display, the designer must choose suitable operating conditions for the LEDs. Peak forward current, current pulse width, duty cycle and repetition rate are all factors which the designer must determine.

The luminous intensity, or the luminance of GaAsP LEDs, is essentially proportional to forward current over a wide range, but certain phenomena modify this condition. At low currents, the presence of nonradiative recombination processes results in less light output than the linear relationship would predict. This effect is noticeable just below 5 mA per segment (for ¼ inch characters). The result is that noticeable difference in luminance from segment to segment can occur at low currents. At high currents, the power dissipation in the chip causes substantial temperature rise, and this reduces the dissipation efficiency of the chip. As a result, the light output versus forward current curve falls below the straight line, at high currents (Figure 5). It should be emphasized that this latter effect is entirely due to self heating. If the power dissipation is limited, by running short pulses at low duty cycle, the output follows the straight line up to very high current densities. Whereas 100 A/cm^2 may be used in DC operation, as much as 10^4 A/cm^2 can be used under pulsed conditions, with a proportionate increase in peak intensity. (If this did not occur, GaAsP lasers could not be built.) Gallium Phosphide, however, has an inherent saturation mechanism that causes a drastic reduction in efficiency at high current densities even if the junction temperature remains constant. This effect is due to competing non-radiative recombination mechanisms at high current density.

As a first approximation the brightness of a pulsed LED will be similar to being operated at a DC forward current equal to the average pulsed current. For example, for 40 mA peak current at 25% duty cycle, the brightness will be similar to DC operation at 10 mA. The actual brightness comparison will depend on the actual pulsing conditions. Under most legitimate conditions the brightness will be greater for pulsed operation.

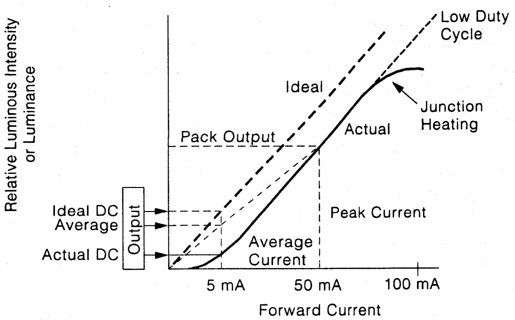
Figure 5 shows how the actual light output at 5 mA DC is substantially less than expected from the ideal curve, because of the "foot" on the curve at low currents. Operation at 50 mA peak current and 10% duty cycle yields a high peak output as shown, and an integrated average output that is much closer to the ideal value. It should be obvious that variations in the "foot" from segment to segment cause a significant variation in light output at a low DC current, but a much smaller variation in the average output when operated in a pulsed mode. As well

Figure 4.



as an increase in luminance, or luminous intensity due to pulsing, there is an increase in brightness because of the behavior of the eye. The eye does not behave as an integrating photometer, but as a partially integrating and partially peak reading photometer. As a result, the eye perceives a brightness that is somewhere between the peak and the average brightness

Figure 5.



The net result is that a low duty cycle high intensity pulse of light looks brighter than a DC signal equal to the average of the pulsed signal. Therefore the practical benefit of multiplexed operation is an improvement in display visibility for a given average power consumption besides the lower cost. The brightness variation from segment to segment and digit to digit is also reduced by time-sharing. The gain in brightness over DC operation can be as much as a factor of 5 at low duty cycles of 1 or 2 percent, and peak currents of 50 to 100 mA.

A number of factors must be considered when deciding on the design of a multiplexed display. Besides the optical output, thermal considerations are very Important.

Most 1/4" size LED numerics are rated at 30 mA DC maximum per segment. Under pulsed operation, higher currents can be used provided several thermal considerations are taken into account.

(1) The average power dissipation must not exceed the maximum rated power.

(2) The power pulse width must be short enough to prevent the junction from overheating during the pulse. This implies that the pulse width must get shorter as the amplitude increases.

Present experience indicates that for pulses of 10 µs, the amplitude should be limited to 100 mA maximum. Shorter pulses of higher amplitude may be used but the circuit problems become severe if the pulse width is very short.

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Driving High-Level Loads With Optocouplers Appnote 4

Frequently a load to be driven by an optocoupler requires more current, voltage, or both, than an optocoupler can provide at its output.

Available optocoupler output current is found by multiplying input (LED section) current by the "CTR" or current transfer ratio. For worst-case design, the minimum specified value would be used. The minimum CTR of the IL1 is 20%. Temperature derating is not usually necessary over the 0°C to +60°C range because the LED light output and transistor beta have approximately compensating coefficients.

Multiplying the minimum CTR by 0.9 would ensure a safe design over this temperature range. Over a wide range, more margin would be required.

The LED source current is limited by its rated power dissipation. Table 1 shows maximum allowable I_F versus maximum ambient temperature.

Values for Table 1 are based on a 1.33 mW/°C derate from the 100 mW at 25°C power rating.

Table 1.

Maximum Temperature	I_F Maximum
40°C	50 mA
60°C	35 mA
80°C	17 mA

Obviously, one can increase the available output current either by choosing a higher CTR-rated optocoupler or by providing more current, or both. Table 2 shows the minimum available output current for the IL1, at T_A=60°C (from Table 1) and a 10 percent margin for temperature effects.

Table 2.

P/N	I_{CE} (min) mA
IL1	6.3

If the IL1 is being operated from logic with 5 volt driving transistor and 0.2 volt V_{CE} saturation is assumed for the driving transistor; a 75 ohm R_{IF} resistor will provide the 48 mA. The forward voltage of the IR-emitting LED is about 1.2 volts. Figures 1 and Figure 2 show two such drive circuits.

Figure 1. NPN driver

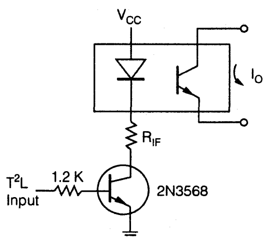
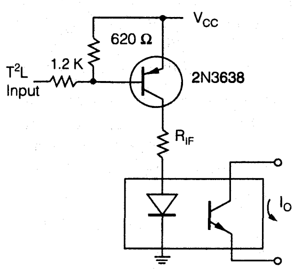
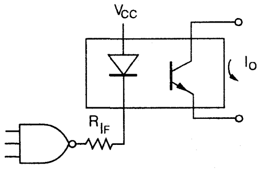


Figure 2. PNP driver



A "buffer-gate," such as the SN7440 provides a very good alternative to discrete transistor drivers. Figure 3 shows how this is done. Note that the gate is used in the "current-sinking" rather than the "current-sourcing" mode. In other words, conventional current flows into the buffer-gate to turn on the LED. This makes use of the fact that a T^2L gate will sink more current than it will source. The SN7440 is specified to drive thirty 1.6 mA loads or 48 mA. Changing R_{IF} from 75 to 68 ohms adjusts for the higher saturation voltage of the monolithic device.

Figure 3. Buffer-gate drive



1/2 SN7440

More Current

For load currents greater than 6.3 mA, a current amplifier is required. Figure 4 and Figure 5 show two simple one-transistor current amplifier circuits.

Figure 4. NPN current booster

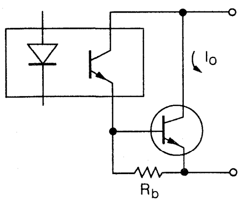
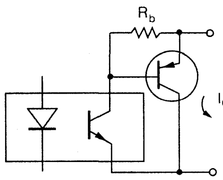


Figure 5. PNP current booster



Since the transistor in the optocoupler is treated as a two-terminal device, no operational difference exists between the NPN and the PNP circuits. R_b provides a return path for I_{CBO} of the output transistor. Its value is: $R_b = 400$ mV/I_{CBO} (T) where I_{CBO}(T) is found for the highest *junction* temperature expected.

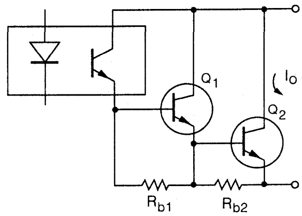
Assume that leakage currents double every ten degrees. Use the maximum dissipated power, the specified maximum junction-to-ambient thermal resistance, and the maximum design ambient temperature in conjunction with the specified maximum 25° I_{CBO} to calculate I_{CBO}(T)

As an example, suppose a 2N3568 is used to provide a 100 mA load current. Also assume a maximum steady-state transistor power dissipation of 100 mW and a 60°C maximum ambient. The transistor junction-to-ambient thermal resistance is 333°C/watt, so a maximum junction temperature of 60 + 33 or 93°C is expected. This is about 7 decades above 25°C. Therefore, I_{CBO}(T)=I_{CBO}(max) x 27=50 nA x 128=6.5 µA. A safe value for R_b is 400 mV/6.5 µA=62 kilohms.

Working backwards, maximum base current under load will be I_O/h_{FE}(min)=100 mA/100=1 mA. Current in R_b is V_{BE}/R_b= 600 mV/60 k=10 µA, which is negligible. An IL1 with a 9 mA drive would operate effectively.

If the load requires more current than can be obtained with the highest beta transistor available, then more than one transistor must be used in cascade. For example, suppose 3 amperes load current and 10 watt dissipation are needed. A Motorola MJE3055 might be used for the output transistor, driven by a MJE205 as shown in Figure 6. Using a 5°/watt heat sink and the rated MJE3055 junction-to-case thermal resistance of 1.4°/watt, we find that junction temperature rise is 6.4 x 10, or 64°. Therefore maximum junction temperature is 124°C. This is 10 decades above 25°C making I_{CBO}(T)= 2^{10} I_{CBO}(max)=10^3 I_{CBO}(max).

Figure 6. Two NPN current boosters



I_{CBO}(max) at 30 volts or less is not given, but I_{CEO} is. Using (for safety) a value of 20 for the minimum low current h_{FE} of the device, I_{CBO} could be as large as I_{CEO}/20=35 µA. Then I_{CBO}(T) is 35 mA and R_{b2}=400 mV/35 mA=11 ohms. For I_b use I_O/h_{FE} (min at 4 A)=3 A/20=150 mA. I_{Rb2}=600 mV/10 ohms=60 mA, so $I_{e(Q1)}$=210 mA.

Maximum power in Q_1 will be about 1/14 the power in Q_2 since its current is lower by that ratio and the two collector-to-emitter voltages are nearly the same. This means Q_1 must dissipate 700 mW.

Assuming a small "flag" heat sink having 50°/watt thermal resistance, we find the junction at about 95°C. The 150°C case temperature I_{CBO} rating for this device is 2 mA, so one can work backwards and assume about 1/30 of this value, or 70 µA. On the other hand, the 25° rated I_{CBO} is 100 µA. Choosing the larger of these contradictory specifications, R_{b1}=400 mV/0.1 mA=4 k≈3.9 k. Q_1 base current is $I_{E(Q1)}/h_{FE(Q1\text{-}min)}$=210 mA/50*=4.2 mA. Total current is $I_{b(Q1)}$ + I_{Rb1}=4.2 + 0.24=4.5 mA. Table 2 shows that an IL1 could be used here.

* Minimum hFE is obtained using the specification at I_{CE}=2 A and the "Normalized DC Current Gain" graph given in Motorola's "Semiconductor Data Book", 5th edition, pp. 7–232 and 7–233.

More Load Voltages

All of the current-gain circuits shown so far have one common feature: load voltage is limited by the 30 volt rating of the IL1 not by the voltage or power rating of the transistor(s).

Figure 7 shows a method of overcoming this limitation. This circuit will stand off BV_{CEO} of Q_1. The voltage rating of the phototransistor is irrelevant since its maximum collector-emitter voltage is the base emitter voltage of Q_1 (about 0.7 volts).

Figure 7. NPN HV booster

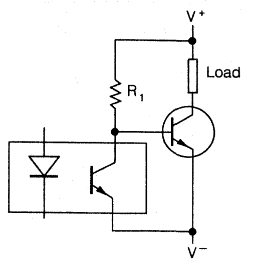
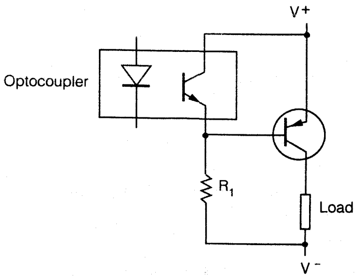


Figure 8. PNP HV booster



Unlike the "Darlington" configurations shown previously, this circuit operates "normally-ON." When no current flows in the LED the phototransistor, being OFF, allows R_2 current to flow into the base of Q_1, turning Q_1 ON. When the optocoupler is energized, its phototransistor "shorts out" the R_2 current turning Q_1 OFF.

The value of R_1 depends only on the load-supply voltage $V^+ - V^-$, and the maximum required Q_1 base current. This is derived from the minimum beta Of Q_1 at minimum temperature and the load current. The required current-drive capability is the same as I_{R1}, since I_{R1} changes negligibly when the circuit goes between its "ON" and "OFF" states.

In some applications either more current gain will be required than one transistor can provide or the power dissipated in R_1 will be objectionable. In these cases, simply use the Darlington high-voltage boosters shown in Figure 9.

If more than one load is being driven and their negative terminals must be in common, use the PNP circuit (Figure 10). Otherwise, the NPN is better because the transistors cost less. Performance characteristics of the NPN and PNP versions are identical if the device parameters are also the same.

Figure 9. NPN Darlington HV booster

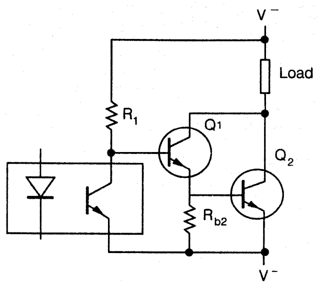
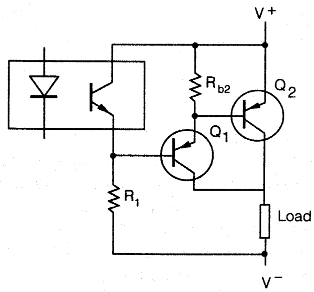


Figure 10. PNP Darlington HV booster



Applications

Optocoupler isolated circuits are useful wherever ground loop problems exist in systems, or where dc voltage level translations are needed. In many systems so-called interpose relays are used between a logic circuit section (which may be a minicomputer) and the devices being controlled. Sometimes *two levels* of interpose relays are used in cascade either because of the load power level or because of extreme difficulties with EMI. Optocouplers aided by booster circuits such as those described can replace many of the relays in these systems.

The reed relays, typically used as the first level of interpose and mounted on the interface logic cards in the electronic part of the system, are almost always replaceable by optocouplers since their load is just the coil of a larger relay. This relay may have a coil power of 1/2 to 5 watts and operate on 12, 24 or 48 volts dc.

Assuming worst-case design techniques are carefully followed, system reliability should improve in proportion to the number of relays replaced.

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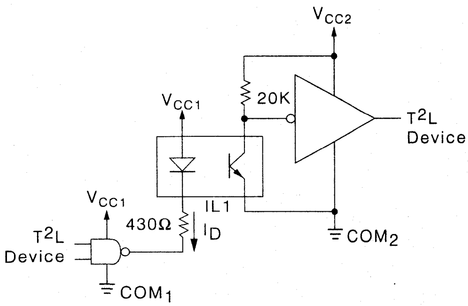
More Speed from Optocouplers Appnote 5

by David M. Barton

Figure 1 shows a typical circuit employing an optocoupler to transmit logic signals between electrically isolated parts of a system. In the circuit shown, the optocoupler must "sink" the current from one T^2L load plus a pull-up resistor to V_{CC}. The resistor in series with the LED half of the optocoupler must supply the worst case load current divided by the "current transfer ratio" or CTR of the optocoupler. If an IL1 optocoupler is used, having a minimum CTR of 0.2, and 80 percent variation in the load is allowed, 8.1 mA is required. This is supplied by the 430 Ω resistor.

Figure 1.

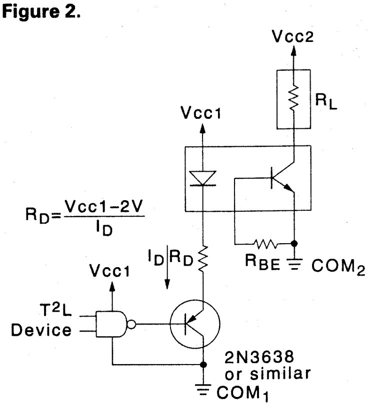


The maximum repetition rate at which this circuit will operate is only about 8 kHz. The severe speed limitation is due entirely to the characteristics of the phototransistor half of the optocoupler. This device has a large base-collector junction area and a very thick base region in order to make it sensitive to light. C_{ob} is typically 25 pF. This capacitance is, in the circuit of Figure 1, effectively multiplied by a large factor due to the "Miller effect." Also, because the base region volume is large, so is base storage time.

A very simple method of reducing both of these effects is to add a resistor between the base and emitter as shown in Figure 2. This resistor helps by reducing the time constant due to C_{ob} and by removing stored charge from the base region faster than recombination can. When a base-emitter resistor is used, of course, the required LED drive is increased since much of the photo-current generated in the base-collector junction is now deliberately "dumped."

Using this method does not usually result in a large power supply current drain since average repetition rate is low in most applications.

Figure 2.



As drive is increased and R_{BE} reduced, turn-on time and turn-off time both decrease. The total amount of charge stored can also be reduced by decreasing the LED drive pulse duration. Also, as higher drive levels are used, the load resistance, R_L can be reduced to further enhance the speed of the circuit. These parameters are related to each other such that all should be changed together for best results.

One important generalization can be made concerning their interdependence. The LED drive pulse duration, T_{in} output fall time (t_f) output rise time (t_r) and propagation delay (tp) should occur in a 1.5:1:1:1 ratio, approximately. If this relationship does not occur, the circuit will not operate at as high a repetition rate as it could at the same drive level. T_{out} equals T_{in} at low currents but stretches out at high currents.

Figure 3 is a graph relating the important parameters for a typical IL1 whose CTR is 0.25. The optimum values of T_{in}, R_{BE}, and R_L are shown versus LED pulse current as are the resultant output pulse width and maximum full-swing frequency. Rise, fall and propagation time can be read as $^2/_3$ of T_{in}.

Figure 3. Parameters versus LED pulse current

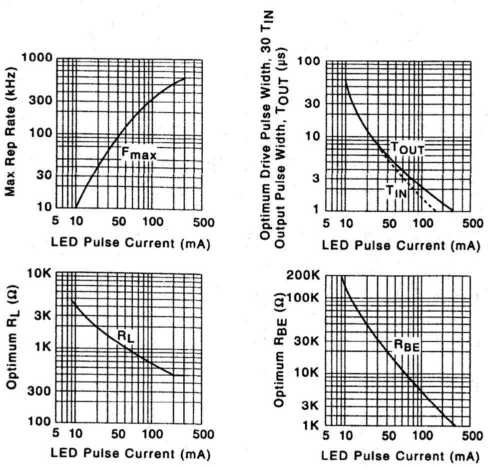
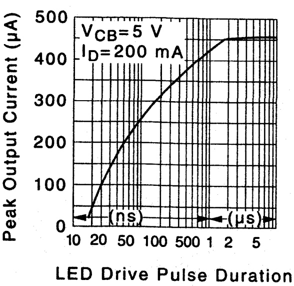


Figure 3 shows that increasing drive to 200 mA and using optimum R_{BE} and R_L will increase the maximum repetition rate from 3 kHz to 500 kHz, a 167:1 improvement.

Lower grade optocouplers will behave similarly if the LED drive level is scaled appropriately to allow for a lower CTR.

Another method of increasing speed is to operate the phototransistor as a photodiode. In this method, bias voltage is supplied between the collector and base terminal, the emitter being unused. Operation to at least 1.0 MHz is possible this way, but the price is the need for external amplification. Figure 4 is a graph showing peak output current versus drive pulse duration for 200 mA peak drive current.

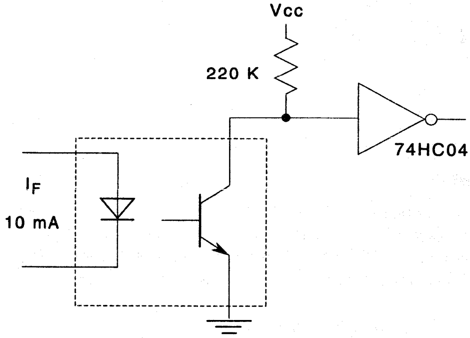
Figure 4. Diode mode output current versus drive pulse duration



Since output current is small, some type of widebandwidth amplifier must be employed in order to drive T^2L loads.

One simple solution for intermediate speed operation is the use of MOS inverter (1/6 74HC04), Figure 5.

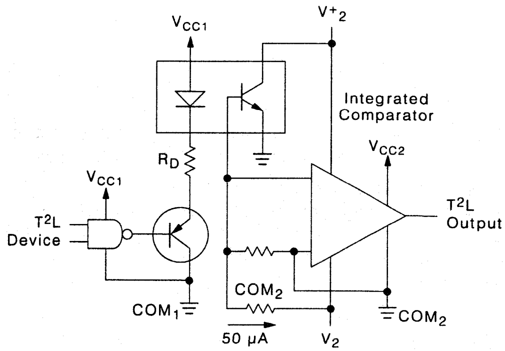
Figure 5.



Another device which will provide a good interface is an integrated comparator amplifier. The phototransistor collector goes to V_{CC}. Its base has a 200 Ω load resistor to ground and goes to one input of the comparator. Also, a resistor goes from this node to the minus supply. This resistor is chosen to supply 50 µA. The other comparator input is grounded. The voltage at the comparator input will switch from –10 mV to +10 mV or more when the diode turns on and the output will drive the T^2L loads.

Of course discrete component amplifiers could be used and may be best in some applications.

Figure 6.



Conclusion

For operation to 500 kHz, the addition of a base-emitter resistor and a high-current driver is probably the best method of increasing optocoupler speed. Above 500 kHz one must revert to photodiode mode and use an external amplifier to drive most loads, particularly T^2L.

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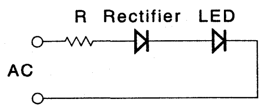
Operating LEDs on AC Power Appnote 6

by David M. Barton

Introduction

Frequently it is desirable to operate LEDs on AC power rather than DC. Typically, the power source is 120 VRMS 60 Hz. The most obvious method is to rectify this power with a series diode and use a resistor to limit LED current as shown in Figure 1.

Figure 1. Power Resistor Method



This method, though sound, results in very high power dissipation in the resistor since the LED operates on only 1.6 volts.

The Method

Figure 2. Capacitor method

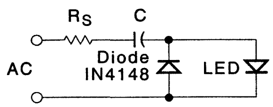


Figure 2 shows a better method—using a capacitor to control LED current and a shunt silicon diode provides rectification.

Since, for current in either direction, voltage drop across the LED or rectifier is a negligible part of the supply voltage, current in the capacitor is almost exactly equal to the AC supply voltage divided by the reactance of the capacitor. Average capacitor current is then:

1. $I_C\ (AV) = .9 \times VRMS/X_C$

   and average half-cycle LED or rectifier current is:

2. $I_{LED\ (AV)} = \frac{1}{2}\ I_D\ (AV) = .45\ VRMS/X_C$

   or, for 120 VRMS, 60 Hz operation,

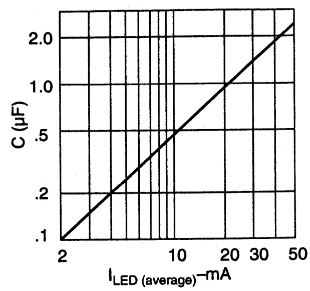
3. $I_{LED\ (AV)} = 20\ mA \times C\mu F$

   or $C\mu F = \dfrac{I_{LED\ (AV)}}{20\ mA}$

Figure 3 shows the value of the series capacitor needed for a range of average LED currents assuming 60 Hz, 120 volt power.

A resistor is necessary in series with the capacitor to limit turn-on transient currents. A value of 100 ohms will be adequate in most cases.

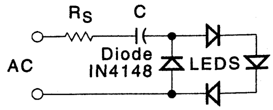
Figure 3. Series capacitor value versus average LED current for 120 VRMS 60 Hz



The current in the LED, of course, flows almost exactly in quadrature with the line voltage. For this reason, power dissipation is low, being limited to the expected LED and rectifier power loss, the loss in series resistor and to losses in the capacitor. The latter term will be extremely low if high quality capacitors are used. Although power consumption of a circuit may not be of much significance in terms of the cost of the power, it certainly can be important to reduce heat generation within an enclosure.

If more than one LED is to be operated from the same source, simply put the LEDs in series in the same circuit, as shown in Figure 4. For small numbers of LEDs the current will be, for practical purposes, the same as for one.

Figure 4. LEDs in series



Conclusion

Cost of the series capacitor (mylar) will be similar to the cost of a series power resistor. The shunt diode, a IN4148 or similar, will cost about two cents; much less than a series rectifier which must have a several hundred volt PIV rating.

So the capacitor method is both lower in cost and lower in heat generation and power consumption than the resistor method.

Mounting Considerations for LED Lamps and Displays Appnote 11

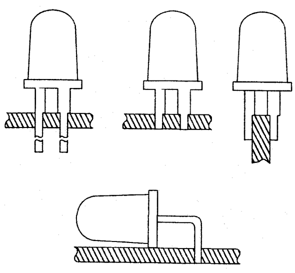
by Dave Takagishi

There are numerous ways to mount an LED lamp into a panel or a piece of equipment and this application note is written as an aid to designers and engineers when using LED lamps and displays.

Mounting Techniques

There are several ways to mount LED lamps such as the Siemens LS 5420 by soldering directly into PCBs, plugging into sockets, or panel mounting with or without clips. Bending leads is allowed keeping the following guidelines in mind. Leads must not be bent closer than 0.065 inches from the base of case when leads are not in excess of 0.020 inches in diameter. Leads should be clamped next to the case when lead bending to relieve stresses. Under no circumstances must any mechanical force be applied to the case while bending the leads. Also, incorrectly spaced holes in the printed circuit board will place mechanical stress on the plastic case which can cause failure during soldering.

Figure 1.



Displays of the HD11XXX type can be soldered directly into a printed circuit board or be plugged into sockets. Many displays can be end-stacked (butted end-to-end) to obtain longer displays with more digits. This usually causes no break in digit spacing. In applications using screw-down mounting, a flexible washer should be used to avoid strain from misalignment or board warpage.

Figure 2.

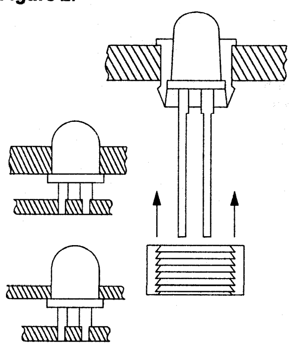


Table 1. Connector/socket suppliers (partial list)

Aries	Frenchtown, NJ
Augat	Attleboro, MA
Berg	New Cumberland, PA
EMC	Woonsocket, RI
Robinson Nugent	New Albany, IN
Precision Concept, Inc.	Bohemia, NY

Thermal Considerations

Most LED failures can be traced to excess thermal stress. A typical LED chip is mounted on a substrate or lead frame with a wire bond from the top of the chip to a metallized trace on the substrate and is encapsulated in epoxy. Temperature changes cause these various materials to expand and contract at different rates. Extreme low temperatures are most likely to cause structural failure. High temperatures usually cause reduced lifetime rather than immediate failures.

The internal LED junction temperature depends on ambient temperature, power applied to the LED, and the thermal resistance, LED chip-to-ambient.

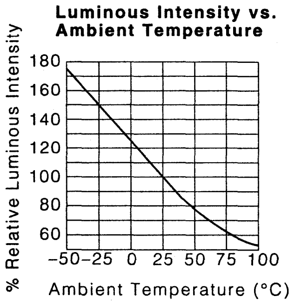
Long-term degradation of LED chips, causing reduced light output, will occur if junction temperature exceeds 125°C. Also the epoxy material overcoating the LED chips may gradually become opaque if it is subjected to temperatures above 125°C.

For these reasons, all Siemens LED products carry derating specifications designed to limit LED junction temperature to 100°C.

Particular care is needed in designing multiplexed systems. Increased forward voltage and the effects of the thermal time constant, chip to ambient (about 10 mS typical) can cause "thermal ripple" peak excursions above 100°C while calculated average temperature is much lower.

Another reason for keeping LED chip temperature down is the reduced light output (see graph). One can reach a point of diminishing returns, particularly in multiplexed systems, in which an increase in current reduces reliability while actually resulting in little or no increase in display visibility. In such cases, one would be well advised to use a higher brightness-grade displays.

Figure 3.



A well-designed display system, especially if high power levels or multiplexed operations are involved, should:

1. Allow for convection airflow around the display.
2. Place other heat-generating components (i.e., display current-control resistors) either away from or above, but never below the display.
3. Take the increased forward voltage and "thermal ripple" peaks into account, in multiplexed systems, and not allow peak temperature to exceed 100°C.

In common with many semiconductor products, LED displays offer the user the most reliable and longest lifetime product available. These good properties do depend, however, on proper usage. Semiconductor products are well-known to be rather unforgiving of abuse when compared to the older technologies. LEDs are not different; they are, in fact, hybrid integrated circuits.

Soldering Considerations

Take care not to overheat LEDs when soldering. Effectiveness and safety in soldering are related to three basic parameters: temperature, time, and distance. In general, soldering time should not exceed 3 seconds at $^1/_{16}$ inch from the case at 260°C. Some packages allow greater latitude, as indicated on individual data sheets.

Optical Considerations

Siemens recommends the use of a contrast enhancing filter in front of LED displays. These filters will increase the contrast ratio of digit to surrounding area and help remove reflected light and glare from the PCB and components around the display. In setting the display to reduce direct ambient light on the display should also be considered.

Rohm & Haas red Plexiglass #2423 makes a good general purpose filter for the 640-660 nm peak emission wavelength of red LEDs. A $^1/_{16}$ inch thick sheet of this inexpensive material is quite effective. Additional information on this and other filter materials may be obtained by contacting the following suppliers.

Table 2. Filter Manufacturers

Rohm & Haas	Philadelphia, PA
Homalite	Wilmington, DE
Panelgraphic	West Caldwell, NJ
3M	St. Paul, MN
Polaroid	Cambridge, MA

Table 3. Filters

For Red LEDs	
Rohm & Haas	Plexiglass 2423
Homalite	1670, 1605
Panelgraphic	Red 60, Red 63, Red 65, Purple 90
Polaroid	HRCP
For Green LEDs	
Rohm & Haas	Plexiglass 38168
Panelgraphic	Green 48
Homalite	1425, 1440
For Yellow LEDs	
Panelgraphic	Yellow 25, Amber 23
Homalite	1720, 1726
Neutral Density Filter	
Homalite	Neutral Gray 10

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Displaying Message Systems Without a Microprocessor Appnote 13

by Dave Takagishi

Any Siemens 4 digit, alphanumeric Intelligent Display device has on board memory, decoder and drive circuitry which makes these displays particularly well suited to connect directly to a microprocessor. However, small multi-message systems of 4, 8, 12, 16 character length need not have a microprocessor to drive the Intelligent Display. With the aid of PROM, Intelligent Display devices can combine lighted indicators, status displays, annunciator messages or symbols, or a "canned message" into a single display.

Annunciator Displays

An automobile, for example, has several switches each lighting its own status or annunciator indicator. A single Intelligent Display could easily display messages alternately upon interrogation of the appropriate switches.

Figures 1, 2, and 3 show a DLX1414 but any of our Intelligent Display devices can be substituted. The circuit shown in Figure 1 will display four character messages sequentially for each open switch and continue to display until switches are returned to their normally closed positions. The Counters U4 and U5 address the PROM U6 and select switches on U1. The Data Selector (U1) sequentially selects one of eight switches (oil, temperature, catalytic, generator, brake, door, belt, and null). The eighth switch or null state can display a blank for a normal or off condition. The output of U1 enables the display's CE. When this signal goes high, the Monostable (U2) will fire and inhibit the Oscillator U3 for approximately a two second display time. The PROM, U6, generates the ASCII code data for each word. Expansion of the display can easily be achieved by adding a PROM for each additional display.

Another annunciator type display is shown in Figure 2. This display has a message of up to 16 characters and will continue to display the same line until the 6 bit input code changes state. With this scheme, it can be seen that the 16 character X64 line message PROM easily can be adapted for other message and character length combinations.

Figure 1.

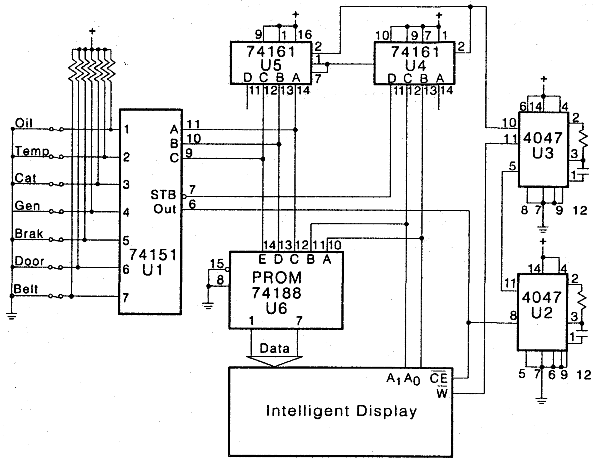
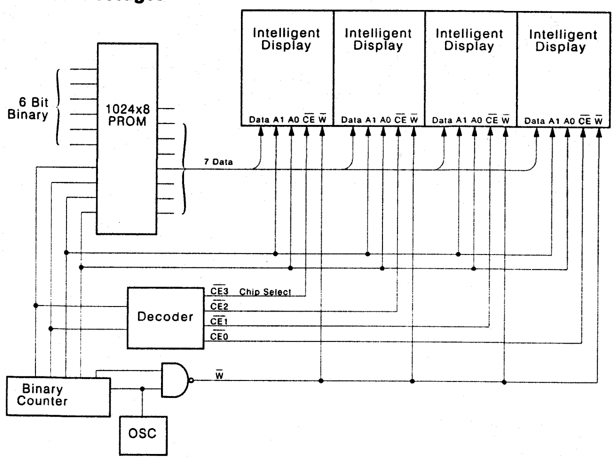


Figure 2. Typical circuit for 64 messages–16 characters long canned messages



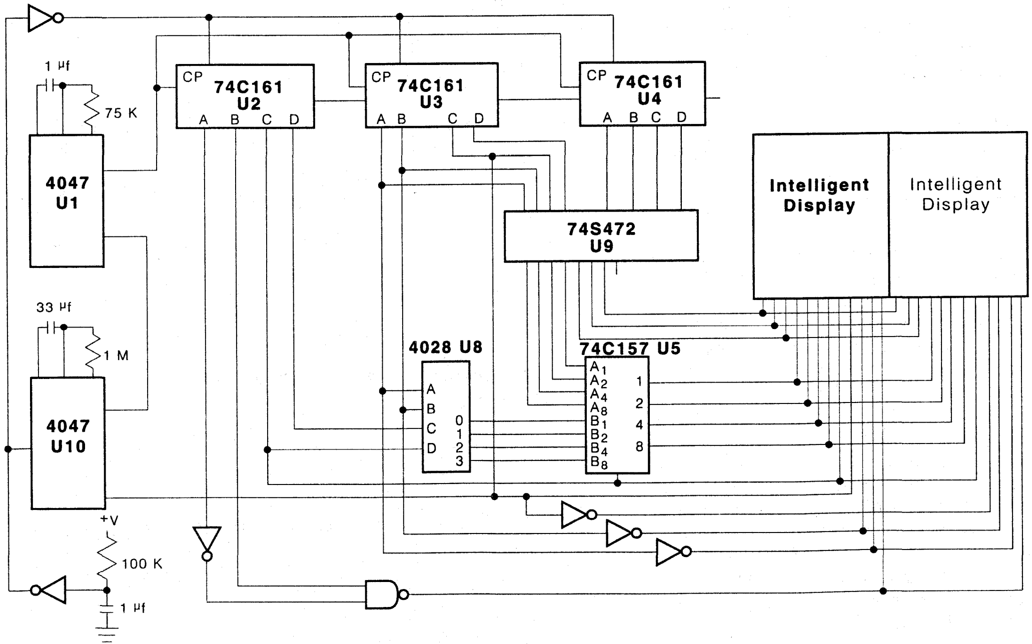
Canned Messages

The canned message type display can be an ideal sales marketing or instructional aid. The message can be altered by replacing the PROM.

The technique for this display would be to sequentially display a word or group of words, depending on the character length of the display, through the entire message. The system could either continue to repeat itself or could go through the complete sequence once each time a switch is operated.

Figure 3 is the schematic for a sales demo box for the DLX1414. A 256X8 PROM was used to display an 8 digit-32 word message. The oscillator (U1) increments the counters U2, U3, U4 providing the address for the DL1416s and PROM U9. After eight counts the monostable U10 is fired, inhibiting the oscillator for a two second display time. Devices U5 and U8 were added for cursor control. Decoder U8 will alternately enable or disable a data bit for a cursor to proceed writing new data into each digit. The multiplexer U5 will select the character data or the cursor data for the D0–D3 data lines. Inverters on the address lines cause data entry to occur from the left rather than from the right.

Figure 3. Schematic–sales demo box



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Applying the DLX2416 Intelligent Display® Device Appnote 14

by Dave Takagishi

This application note is intended to serve as a design and application guide for the DLX2416 alphanumeric Intelligent Displays. The information presented covers device electrical description and operation, considerations for general circuit design, and interfacing the DLX2416 to microprocessors. Refer to the specific data sheet and other Siemens Appnotes for more details.

Electrical & Mechanical Description

The internal electronics in these Intelligent Displays eliminates all the traditional difficulties of using multi-digit light emitting displays (segment decoding, drivers, and multiplexing). The Intelligent Display also provides internal memory for the four digits. This approach allows the user to asynchronously address one of four digits, and load new data without regard to the LED multiplex timing.

Figure1 is a block diagram of the DLX2416. The unit consists of 4 (5x7) LEDs and a single CMOS integrated chip. The IC chip contains the column drivers and row drivers, 128 character ROM, four word x7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, cursor memory, address decoder, and miscellaneous control logic.

Figure 1. Block diagram–DLX2416

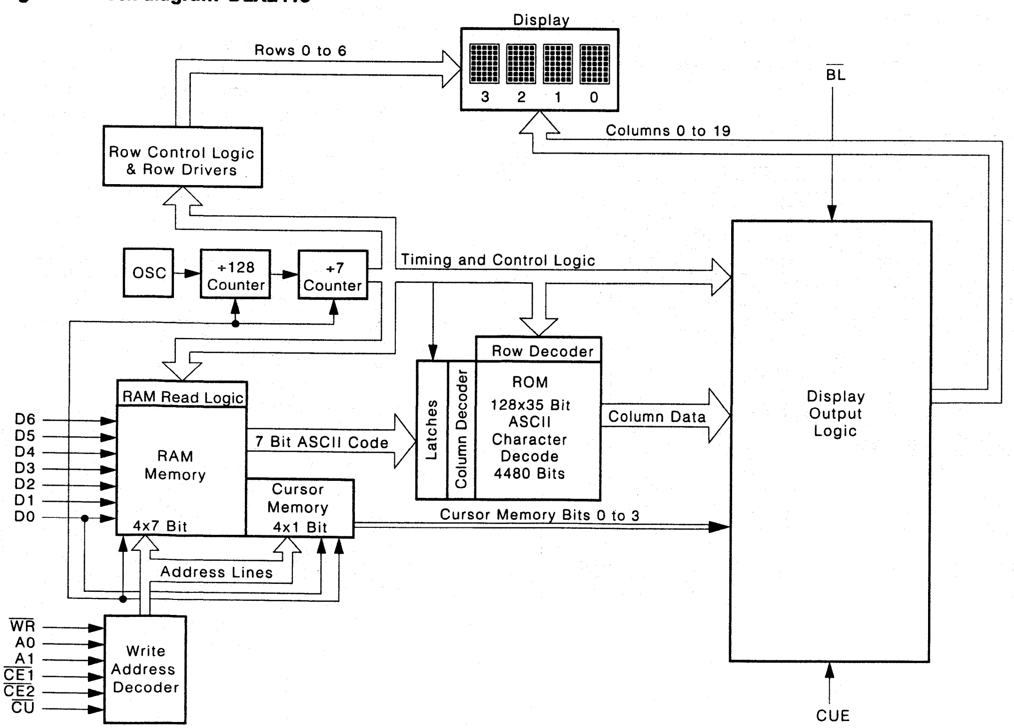
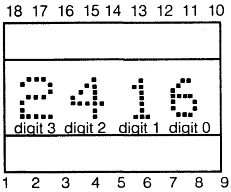


Figure 2. Top view and pin outs



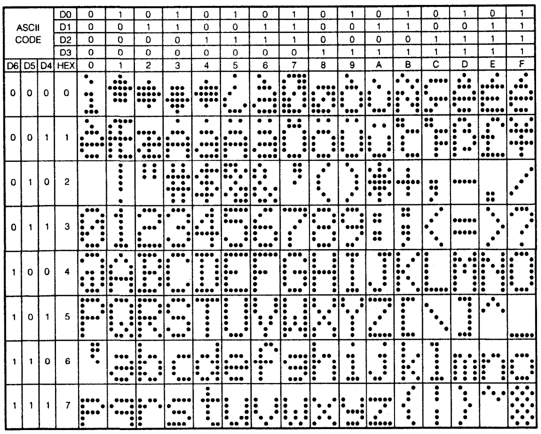
Pin	Function	Pin	Function
1	$\overline{CE1}$ Chip Enable	10	GND
2	$\overline{CE2}$ Chip Enable	11	D0 Data Input
3	$\overline{CLR}$ Clear	12	D1 Data Input
4	CUE Cursor Enable	13	D2 Data Input
5	$\overline{CU}$ Cursor Select	14	D3 Data Input
6	$\overline{WR}$ Write	15	D6 Data Input
7	A1 Digit Select	16	D5 Data Input
8	A0 Digit Select	17	D4 Data Input

Packaging

Packaging consists of a nylon lens which also serves as an "encapsulation shell" since it covers five of the six "faces." The assembled and tested substrate is placed within the shell and the entire assembly is then filled with a water-clear IC-grade epoxy.

This yields a very rugged part, which is quite impervious to moisture, shock and vibration, Although not "hermetic", the device will easily withstand total immersion in water/detergent solutions.

Figure 3. Character set–DLX2416



1. High=1 level. 2. Low=0 level. 3. Upon power up, device will initialize in a random state.

Clear Memory

Clearing of the entire internal four-digit memory may be accomplished by holding the clear line ($\overline{CLR}$) low for one complete internal display multiplex cycle, 1 mS; less time may leave some data uncleared. $\overline{CLR}$ also clears the cursor memory.

Display Blanking

Blanking the display may be accomplished by loading a blank, space into each digit of the display or by using the ($\overline{BL}$) display blank input. Setting the ($\overline{BL}$) input low does not affect the contents of either data or cursor memory. A flashing display can be realized by pulsing ($\overline{BL}$).

Table 1. Electrical inputs to the DLX2416

V_{CC}	Positive supply +5 V
GND	Ground
D0–D6	Data lines The seven data input lines are designed to accept the first 128 ASCII characters. See Figure 3 for character set.
A0, A1	Address Lines The address determines the digit position to which the data will be written. Address order is right to left for positive-true logic.
$\overline{WR}$	Write (Active Low) Data and address to be loaded must be present and stable before and after the trailing edge of write. (See data sheet for timing information).
$\overline{CE1}$, $\overline{CE2}$	Chip Enable (Active Low) This determines which device in an array will actually accept data. When either or both chip enable is in the high state, all inputs are inhibited.
$\overline{CLR}$	Clear (Active Low) The data RAM and cursor RAM will be cleared when held low for a minimum of 1 mS.
CUE	Cursor Enable. Activates Cursor function. Cursor will not be displayed regardless of cursor memory contents when cue is Low.
$\overline{CU}$	Cursor Select (Active Low) This input must be held high to store data in data memory and low to store data into the cursor memory.
$\overline{BL}$	Display Blank (Active Low) Blanking the entire display may be accomplished by holding the $\overline{BL}$ input low. This is not a stored function, however. When $\overline{BL}$ is released, the stored characters are again displayed. BL can be used for flashing or dimming.

Operation

Multiplexed display systems sequentially read and display data from a memory device. In synchronous systems, control circuitry must compare the location of data to be read to the location or position of new data to be stored or displayed, i.e., synchronize before a Write can be done. This can be slow and cumbersome.

Data entry in "intelligent displays" is asynchronous and may be done in any random order. Loading data is similar to writing into a RAM. Each digit has its own memory location and will display until replaced by another code.

The waveforms of Figure 4 demonstrate the relationships of the signals required to generate a write cycle. (Check individual data sheet for minimum values). As can be seen from the waveforms, all signals are referenced from the rising or trailing edge of write.

Cursor

The cursor function causes all dots to light at 50% brightness. The cursor can be used to indicate the position in the display of the next character to be entered. The cursor isnot a character but overrides the display of a stored character. Upon removal of the cursor, the display will again show the character stored in memory.

The cursor can be written into any digit position by setting the cursor enable (CUE) high, setting the digit address (A1, A0), enabling Chip Enable, ($\overline{CE1}$, $\overline{CE2}$), cursor select ($\overline{CU}$), Write ($\overline{WR}$) and Data (D0). A high on data line D0 will place a cursor into the position set by the address A0 and A1. Conversely, a low on D0 will remove the cursor. The cursor will remain displayed after the cursor ($\overline{CU}$) and write ($\overline{WR}$) signals have been removed. During the cursor-write sequence, data lines D1 through D6 are ignored.

If the user does not wish to use the cursor function, the cursor enable (CUE) can be tied low to disable the cursor function. For a flashing cursor, simply pulse the CUE line after cursor data has been stored.

General Design Considerations

Using Positive true logic, address order is from right to left. For left to right address order, use the "ones complement" or simple inversion of the addresses.

A "display test" or "lamp test" function can be realized by simply storing a cursor into all digits.

Because of the random state of the cursor RAM after power up, if the cursor function is to be used, it will be necessary to clear cursors initially to assure that all cursor memories contain its zero state. This is easily accomplished with the $\overline{CLR}$ input.

Figure 4. Write cycle waveforms

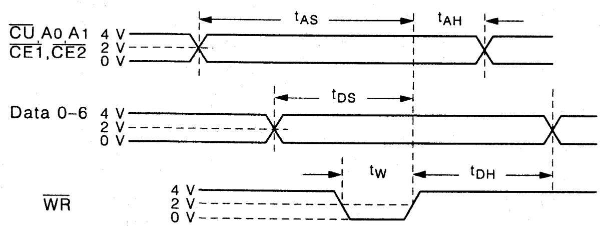


Figure 5. Tables—loading data and loading cursor

Loading Data

$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	Digit 3	Digit 2	Digit 1	Digit 0
L	X	X	X	H	X	H	X	X	X	X	X	X	X	X	X	Blank			
H	H	X	L	H	X	H	X	X	X	X	X	X	X	X	X	Previous Characters			
H	X	H	L	H	X	H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
H	X	X	L	H	H	H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
H	L	L	L	H	L	H	L	L	H	L	L	L	L	L	H	NC	NC	NC	A
H	L	L	L	H	L	H	L	H	H	L	L	L	L	H	L	NC	NC	B	A
H	L	L	L	H	L	H	H	L	H	L	L	L	L	H	H	NC	C	B	NC
H	L	L	L	H	L	H	H	H	H	L	L	L	H	L	L	D	C	NC	A
H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	D	C	B	E
H	L	L	L	H	L	H	H	L	H	L	L	H	L	H	H	D	K	B	E
H	L	L	L	H	L	H	–	–	–	–	–	–	–	–	–	See Character Set			

Loading Cursor

$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A1	A0	D6	D5	D4	D3	D2	D1	D0	Digit 3	Digit 2	Digit 1	Digit 0
H	L	L	L	H	X	H	X	X	X	X	X	X	X	X	X	Normal Data Entry			
H	L	L	H	H	H	H	X	X	X	X	X	X	X	X	X	Enable Previous Stored Cursors			
H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	NC	NC	NC	■
H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	NC	NC	■	■
H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	NC	■	■	■
H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	■	■	■	■
H	L	L	L	H	H	H	X	X	X	X	X	X	X	X	X	D	K	B	E
H	L	L	L	L	L	H	L	L	X	X	X	X	X	X	L	D	K	B	E
H	L	L	H	H	H	H	X	X	X	X	X	X	X	X	X	■	■	■	E

X=Don't care
NC=No change from previously displayed characters

■=all dots/segments on at half brightness

When using the DLX2416 on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all inputs. This is most easily achieved with Hex non-inverting buffers such as the 74365. The object is to prevent transient current in the protection diodes. The buffers should be located on the display board near the displays.

Local power supply bypass capacitors are also needed in many cases. These should be 6 or 10 volt, tantalum type having 10 µF or greater capacitance. Low internal resistance is important due to current steps which result from the internal multiplexing of the displays.

If small wire cables are used, it is good engineering practice to calculate the wire resistance of the ground plus the +5 volt wires. More than 0.1 volt drop, (at 25 mA per digit worst case) should be avoided, since this loss is in addition to any inaccuracies or load regulation limitations of the power supply.

Figure 6. General interface circuit

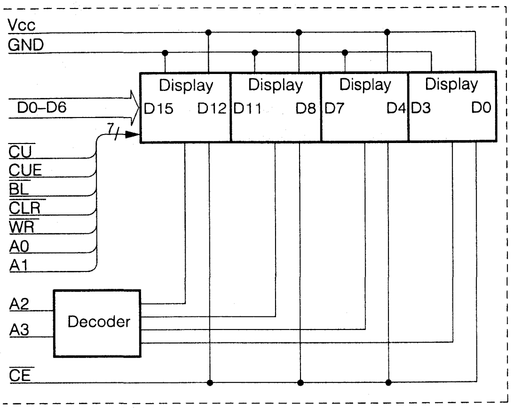
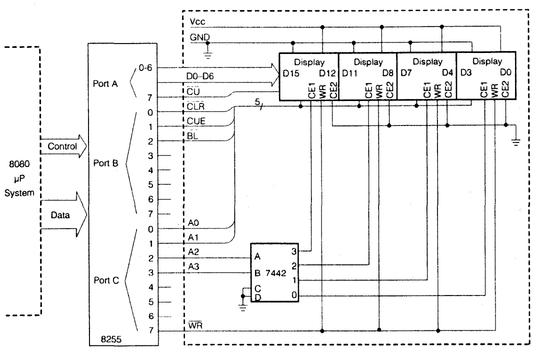


Figure 7. 16-digit parallel I/O system



The 5-volt power supply for the displays should be the same one supplying V_{CC} to all logic devices which drive the display devices. If a separate supply must be used, then local buffers using hex non-inverting gates should be used on all displays inputs and these buffers should be powered from the display power supply. This precaution is to avoid logic inputs higher than display V_{CC} during power up or line transients.

Program for 16-Character Message

INT:	MVI A,80H OUT CONTROL	;CONTROL DATA MODE ;LOAD CONTROL REGISTER
CUSR:	MVI A,00H OUT PORT A MVI B, 0FH	;CLEAR CURSOR DATA ;LOAD DATA PORT ;SET CHARACTER COUNTER
CUSRI:	MOV A, B CALL DSPWT DCR B JNZ CUSRI MOV A, B CALL DSPWT MVI A, FFH OUT PORT B	; ;WRITE SUBROUTINE ;DECREMENT COUNTER ;DIGIT 0? ; ; ;SET DATA FOR CONTROL ;LOAD CONTROL LINES
DISP:	LXI H, TABLE	;SET TABLE ADDRESS

DISP1:	MOV A, M
	
	OUT PORT A
	MOV A, B
	CALL DSPWT
	
	INX H
	
	INR B
	MVI A, 10H
	CMP B
	JNZ DISP1
	HALT
		;MOVE TABLE DATA INTO ACCUMULATOR
		;LOAD DATA PORT
		;
		;LOAD ADDRESS AND CONTROL
		;INCREMENT TABLE ADDRESS
		;INCREMENT COUNTER
		;SET # OF DIGITS
		;
		;16 CHARACTERS?
		;END OF PROGRAM

DSPWT:	ORI F0H OUT PORT C ANI 7FH OUT PORT C ORI F0H OUT PORT C RET	;SET CONTROL BITS OFF ;LOAD CONTROL ;SET WRITE BIT ON ;LOAD WRITE ;SET WRITE BIT OFF ;LOAD CONTROL
TABLE:	DB	;0C3H ;0C9H ;0D4H ;0D3H ;0C1H ;0D4H ;0CEH ;0C1H ;0C6H ;0A0H ;0D3H ;0D4H ;0C8H ;0C7H ;0C9H ;0CCH

Interfacing the DLX2416

A general and straightforward interface circuit is shown in Figure 6. This scheme can easily interface to μP systems or any other systems which can provide the seven data lines, appropriate address and control lines

Parallel I/O

The parallel I/O device of a microprocessor can easily be connected to the circuit in Figure 6. One eight bit output port can provide the seven input data bits and the cursor ($\overline{CU}$). Another eight bit output port can contain the address and chip enable information and the other control signals.

Figure 7 illustrates a 16-character display with an 8080 system using the 8255 programmable peripheral interface I/O device. The following program will display a simple 16-character message using this interface.

I/O or Memory Mapped Addressing

Some designers may wish to avoid the additional cost of a parallel I/O in their system. Structuring the addressing architecture for the DLX2416 to look like a set of peripheral or output devices (I/O mapped) or RAM's and ROM's (memory mapped) is very easy. Figure 8 shows the simplicity of interfacing to microprocessors, such as 8080, Z80 and 6502 as examples.

The interface with the 6800 microprocessor in Figure 9 illustrates the need for designers to check the timing requirements of the DLX2416 and the μP. The typical data output hold time is only 30 ns for DBE=Ø2 timing; two inverters in the DBE line are added to increase the data output hold time for compatibility with the 50 nS minimum spec of the DLX2416.

Conclusion

Although other manufacturers' products are used in examples, this application note does not imply specific endorsement, or recommendation or warranty of other manufacturers' products by Siemens.

The interface schemes shown demonstrate the simplicity of using the DLX2416 with microprocessors. The slight differences encountered with various microprocessors to interface with the DLX2416 are similar to those encountered when using different RAMs. The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

Figure 8. Mapped interface

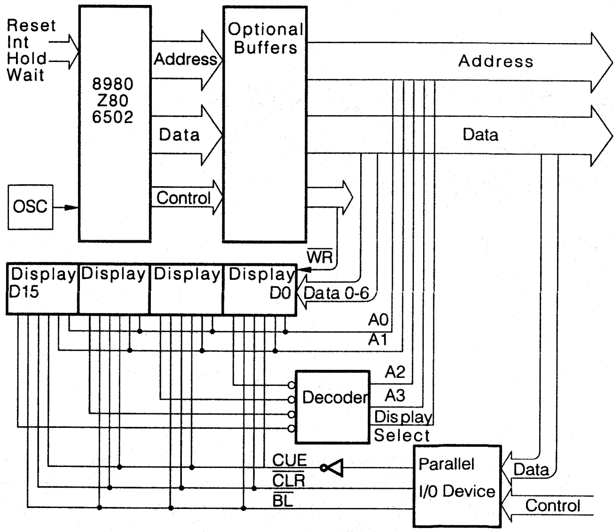
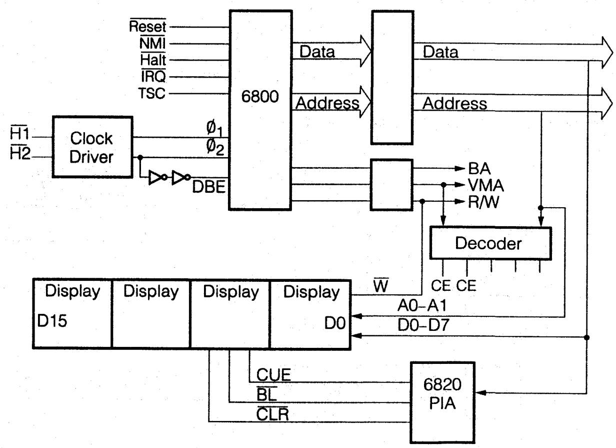


Figure 9. 6800 microprocessor interface



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Applying the DLX1414 Intelligent Display® Device Appnote 15

by Dave Takagishi

This application note is intended to serve as a design and application guide for users of the DLX1414 alphanumeric Intelligent Display. The information presented covers device electrical description and operation, considerations for general circuit design, and interfacing the DLX1414 to microprocessors.

Electrical & Mechanical Description

The internal electronics of the Intelligent Display eliminates all the traditional difficulties of using multi-digit light emitting displays (decoding, drivers and multiplexing). The Intelligent Display also provides internal memory for the four digits. With this approach the user can asynchronously address one of four digits and load new data without regard to the LED multiplex timing.

Figure 1 is a block diagram of the DLX1414. The device consists of four (5x7) LED arrays and a single CMOS integrated chip. The IC chip contains the column drivers and row drivers, 128 character ROM, four word x7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, cursor memory, address decoder, and miscellaneous control logic.

Figure 1. Block Diagram–DLX1414

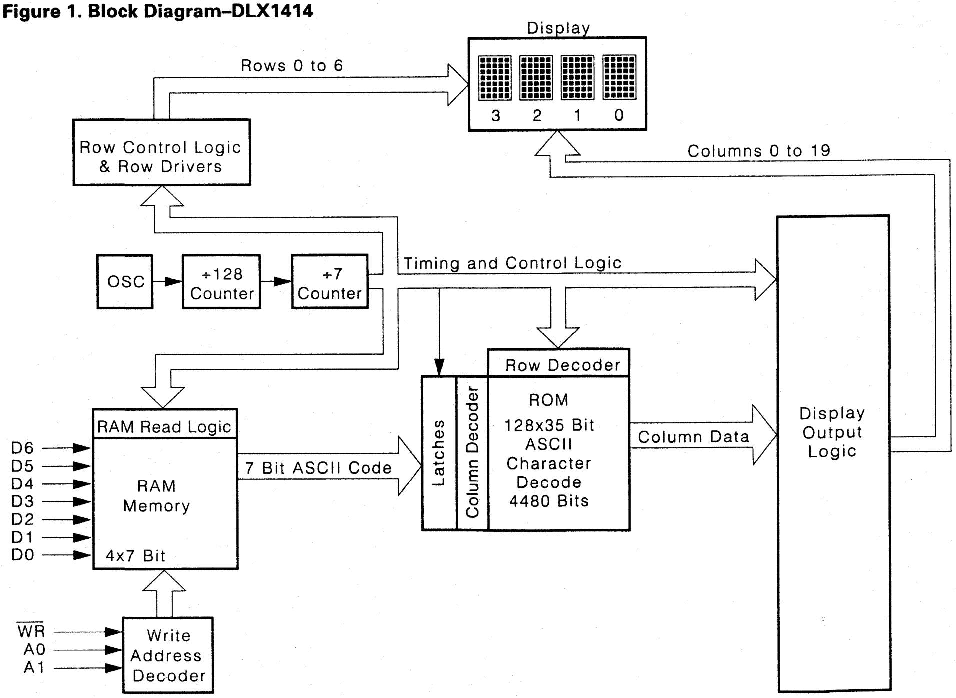
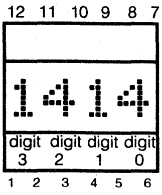


Figure 2. Top view and pin outs



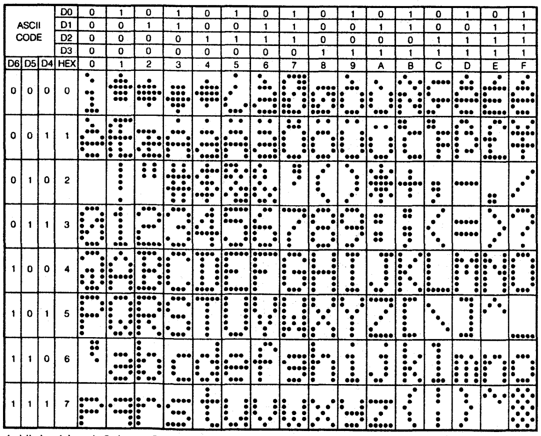
Pin	Function	Pin	Function
1	D5 Data Input	7	GND
2	D4 Data Input	8	D0 Data Input (LSB)
3	$\overline{WR}$ Write	9	D1 Data Input
4	A1 Digit Select	10	D2 Data Input
5	A0 Digit Select	11	D3 Data Input
6	V_{CC}	12	D6 Data Input (MSB)

Packaging

Packaging consists of an injection-molded plastic lens which covers five of the six "faces." The assembled and tested substrate is placed within the shell and the entire assembly is then filled with a waterclear IC-grade epoxy.

This yields a very rugged part which is quite impervious to moisture, shock and vibration. Although not "hermetic, the device will easily withstand total immersion in water/detergent solutions.

Figure 3. Character set-DLX1414



1. High=1 level. 2. Low=0 level. 3. Upon power up, device will initialize in a random state.

Table 1. Electrical inputs to the DLX1414

V_{CC}	Positive supply +5 V
GND	Ground
D0–D6	Data lines The seven data input lines are designed to accept the first 128 ASCII characters. See Figure 3 for the character set.
A0, A1	Address Lines The address determines the digit position to which the data will be written. Address order is right to left for positive-true logic.
$\overline{WR}$	Write (Active Low) Data and address to be loaded must be present and stable before and after the trailing edge of write. (See data sheet for timing info).

Operation

Multiplexed display systems sequentially read and display data from a memory device. In synchronous systems, control circuitry must compare the location of data to be read to the location or position of new data to be stored or displayed, i.e., synchronize before a Write can be done. This can be slow and cumbersome.

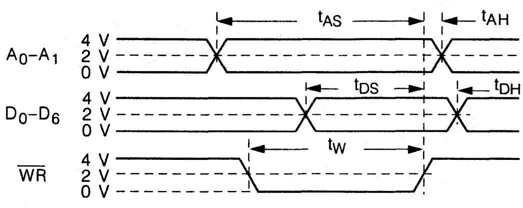
Data entry in Intelligent Displays is asynchronous and may be done in any random order. Loading data is similar to writing into a RAM. Each digit has its own memory location and will display until replaced by another code.

The waveforms in Figure 4 demonstrate the relationships of the signals required to generate a Write cycle. (Check individual data sheet for minimum values.) As can be seen from the waveforms, all signals are referenced from the rising or trailing edge of Write.

General Design Considerations

Using positive true logic, address order is from right to left. For left to right address order, use the ones complement or simple inversion of the addresses.

Figure 4. Write cycle waveform



When using the DLX1414 on a separate display board with more than 6 inches of cable length, it may be necessary to buffer all inputs. This is most easily achieved with Hex non-inverting buffers such as the 74365. The object is to prevent transient current in the protection diodes. The buffers should be located on the display board near the displays.

Local power supply bypass capacitors are also needed in many cases. These should be 6 or 10 volt, tantalum type with10 µF or greater capacitance. Low internal resistance is important due to current steps which result from the internal multiplexing of the displays.

If small wire cables are used, good engineering practice is to calculate the wire resistance of the ground plus the +5 volt wires. More than 0.1 volt drop, (at 25 mA per digit worst case) should be avoided, since this loss is in addition to any inaccuracies or load regulation limitations of the power supply.

The 5-volt power supply for the displays should be the same one supplying V_{CC} to all logic devices which drive the display devices. If a separate supply must be used, then local buffers using hex, non-inverting gates should be used on all inputs and these buffers should be powered from the display power supply. This precaution is to avoid logic inputs higher than display V_{CC} during power up or line transients.

Interfacing the DLX1414

A general and straightforward interface circuit is shown in Figure 6. This scheme can easily interface to LP systems or any other systems which can provide the seven data lines, appropriate address and control lines.

The DLX1414 does not have a chip enable input; therefore each display in a system requires its Write pulse be gated with appropriate address signals. Figure 7a shows the use of a 74154 decoder (4 lines to 16 lines) for up to a 64 character display. Using the G1 input for display select (address select in a memory mapped system) and the G2 input to gate the Write signal. Another approach (Figure 7b and 7c) which minimizes logic for a 16 or 32 digit display takes advantage of decoding scheme of the 7442 decoder.

Parallel I/O

The parallel I/O device of a microprocessor can be connected easily to the circuit in Figure 6. One eight bit output port can provide the seven input data bits. Another eight bit output port can contain the address and control signals.

Figure 5. Data loading table

$\overline{WR}$	Address A1	Address A0	Data Input D6	D5	D4	D3	D2	D1	D0	Digit 3	Digit 2	Digit 1	Digit 0
H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
L	L	L	H	L	L	L	L	L	H	NC	NC	NC	A
L	L	H	H	L	L	L	L	H	L	NC	L	B	A
L	H	L	H	L	L	L	L	H	H	NC	C	B	A
L	H	H	H	L	L	L	H	L	L	D	C	B	A
L	L	L	H	L	L	L	H	L	H	D	C	B	E
L	H	L	H	L	L	H	L	H	H	D	K	B	E
L	–	–	–	–	–	–	–	–	–	See Character Set			

X=Don't care NC=No change

Figure 6. General interface circuit

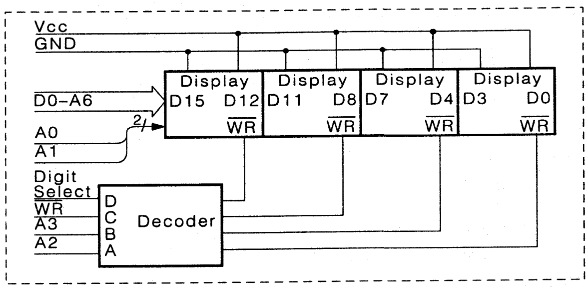


Figure 7. Gating the write pulse

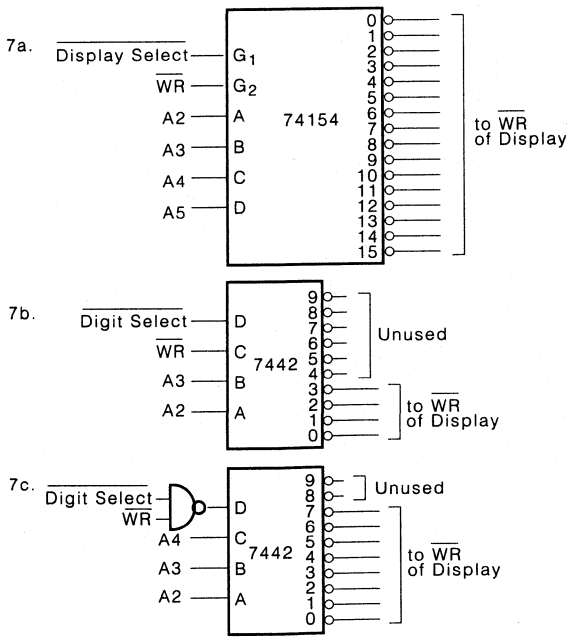


Figure 8. 16-digit parallel I/O

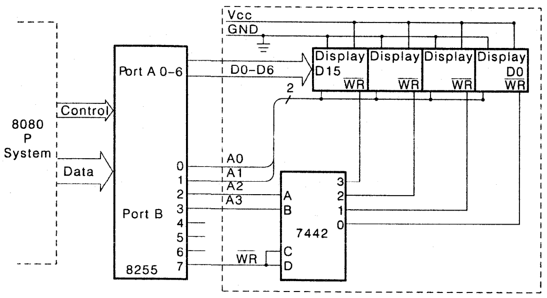


Figure 8 illustrates a 16-character display with an 8080 system using the 8255 programmable peripheral interface I/O device. The following program will display a simple 16 character message using this interface.

Program for 16-Character Message

INT:	MVI A,80H	;CONTROL DATA MODE 0
	OUT CON-	;LOAD CONTROL REGISTER
	TROLMVI B,00H	;SET COUNTER =0
DISP:	LXI H, TABLE	;SET TABLE ADDRESS
DISP1:	MOV A,M	;MOVE TABLE DATA TO ACCUMULATOR
	OUT PORTA	;LOAD DATA PORT
	MOV A, B	
	CALL DSPWT	;LOAD ADDRESS AND CONTROL
	INX H	;INCREMENT TABLE ADDRESS
	INR B	;INCREMENT COUNTER
	MVI A, 10H	;SET # OF DIGITS
	CMP B	
	JNZ DISP1	;16 CHARACTERS ?
	HALT	;END OF PROGRAM
DSPWT:	ORI F0H	;SET CONTROL BITS OFF
	OUT PORTB	;LOAD CONTROL
	ANI 7FH	;SET WRITE BIT ON
	OUT PORTB	;LOAD WRITE
	ORI F0H	;SET WRITE BIT OFF
	OUT PORTB	;LOAD CONTROL
	RET	
TABLE:	DL	;0C3H
	DB	;0C9H
	DB	;0D4H
	DB	;0D3H
	DB	;0C1H
	DB	;0D4H
	DB	;0CEH
	DB	;0C1H
	DB	;0C6H
	DB	;0A0H
	DB	;0D3H
	DB	;0D4H
	DB	;0C8H
	DB	;0C7H
	DB	;0C9H
	DB	;0CCH

I/O or Memory Mapped Addressing

Some designers may wish to avoid the additional cost of a parallel I/O in their system. Structuring the addressing architecture for the DLX1414 to look like a set of peripheral or output devices (I/O mapped) or RAMs and ROMs (memory mapped), is very easy. Figure 9 shows the simplicity of interfacing to microprocessors, such as 8080, Z80 and 6502 as examples.

The interface with the 6800 microprocessor in Figure 10 illustrates the need for designers to check the timing requirements of the DLX1414 and the LP. The typical data output hold time is only 30 ns for DBE=02 timing; two inverters in the DBE line are added to increase the data output hold time for compatibility with the 50 ns minimum spec of the DLX1414.

Figure 9. Mapped interface

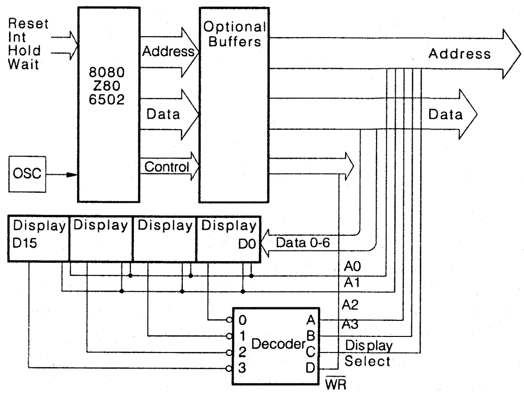
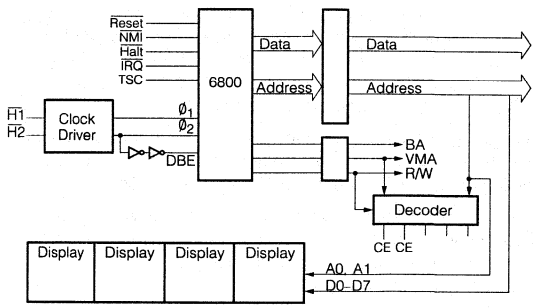


Figure 10. Gating the write pulse



Conclusion

Although other manufacturers' products are used in examples, this application note does not imply specific endorsement, or recommendation or warranty of other manufacturer's products by Siemens.

The interface schemes shown demonstrate the simplicity of using the DLX1414 with microprocessors. The slight differences encountered with different microprocessors to interface with the DLX1414 are similar to those encountered when using different RAMs The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

SIEMENS

Silicon Photovoltaic Cells, Silicon Photodiodes and Phototransistors Appnote 16

Optoelectronic components are increasingly used in modern electronics. The main fields of application are light barriers for production control and safety devices, light control and regulating equipment like twilight switches, fire detectors and facilities for optical heat supervision, scanning punched cards and perforated tapes, positioning of machine tools (for measuring length, angle and position), of optical apparatus and ignition processes, for signal transmission at electrically separated input and output, as well as conversion of light into electrical energy.

Other applications for optoelectronic components are in the photographic industry for exposure and aperture control and for automatic electronic flashes. IR sound transmission and IR remote control are new modes in the radio industry. Computer diagnosis and LED displays in instrument panels are possible applications in the automotive industry.

Depending upon the application either photovoltaic cells or photodiodes can be used. Photodiodes are preferred wherever amplifiers with high input impedance are required.

Phototransistors are predominantly used in connection with transistor circuits or to drive integrated circuits, whereas photovoltaic cells are preferred to scan large surfaces if a strictly linear relation between light and signal level or optimum reliability is required.

Photovoltaic Cells

Photovoltaic cells are active two poles with a comparably low resistance that has its cause in the voltage of the voltaic cell, which may only be some tenth of a volt. For practical application, this characteristic requires special attention.

The open circuit voltage (V_L) rises almost logarithmically as a function of the illuminance, and particularly with planar photovoltaic cells, reaches high values already at very low illuminances. It is independent of the size of the photovoltaic cell.

The short circuit current (I_K) increases linearly with the illuminance and is proportional to the size of the exposed photosensitive area at uniform illuminance.

The maximum energy of the photovoltaic cell is yielded in a load resistance (R_L) of approximately V_L/I_K.

Practical short circuit operation and thus proportionality between optical and electrical signal is given at load resistance up to $V_L/2\ I_K$. This relation can be applied to an open circuit voltage of ≥100 mV.

In any type of application the highest value of I_K has to be used. A simple way to determine the load resistance required is to measure V_L and I_K at given illumination conditions, irrespective of the radiation source.

If the voltage yielded by the photovoltaic cell is insufficient, it can also be used in diode operation at reverse voltages up to 1 volt, however, the flowing dark current has to be taken into consideration.

The rise time of a signal voltage delivered to a load resistor by the voltaic cell primarily depends on the operating conditions. There are two distinctive borderline cases:

1. Load resistor smaller than the matching resistor (tendency toward short circuit operation).
2. Load resistor larger than the matching resistor (tendency to open circuit operation).

In case #1 the photovoltage rise is analogous to the charging of a capacitor via a resistor from a constant voltage source. In photovoltaic cells the junction capacitance Cj must be charged. The rise occurs by the time constant $r = R_L \cdot C_j$, R_L being the load resistor (the low ohmic resistance of the photovoltaic cell is considered negligible).

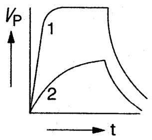
In case #2 the photovoltage rise is similar to the charging of a capacitor by a constant current mode. The rise time, t, of the photovoltage follows the equation:

$$T_r = \frac{V_P \times V_J}{I_K}$$

I_K is the short circuit current under given illumination conditions. This relation only holds true for values of V_P less than 80% of the final value of the open circuit voltage.

The principal characteristic of the rise time of photovoltaic cells is shown in Figure 1.

Figure 1. Rise time of photovoltaic cell



Case #1: Rise time according to the equation

$$V_P = I_K \cdot R_L \cdot \left(1 - e^{-\frac{t}{R_L \cdot C_J}}\right)$$

Time constant $r = R_L \cdot C_j$

Case #2: Rise time

$$t_r = \frac{V_P \cdot C_j}{I_K}$$

Fall time in both cases $\tau = R_L \cdot C_j$

Modulation transients can, under certain conditions, lead to a modification of the above diagram.

E.g. At very low time constants (particularly in short circuit operation) the actual pulse shape of the short circuit current that deviates from an ideal square pulse has to be noted. See diagram.

Figure 2. Pulse shapes of short circuit current

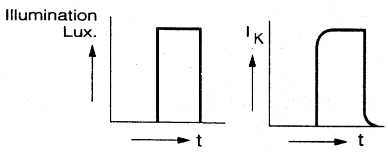
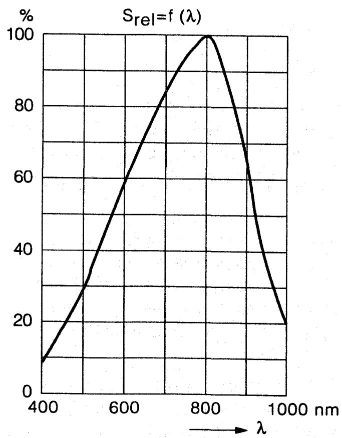


Figure 3. Relative spectral sensitivity



Silicon Photodiodes

These photodiodes have a PN junction poled by a reversed bias. The capacitance which decreases with a growing reverse voltage reduces the switching times. The PN junction is of easy access to the light. Without illumination a very small reverse current flows, the so-called darl current. Light falling onto the surrounding of the PN junction generates charge carrier pairs there that lead to an increase of the reverse current. This photocurrent is proportional to the illuminance. Therefore, photodiodes are particularly well suited for quantitative light measurements. The planar technique has 2 essential advantages: The dark currents are considerably smaller than for comparable photo electric components in non-planar technique. This leads to a reduction of the current noise and thus to a decisive improvement of the signal/noise ratio.

Figure 4. Photons of different wavelengths (blue, red, infrared)

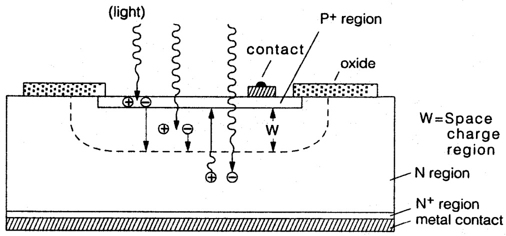


Figure 4 shows the basic design of a photodiode. The limit of the space charge region is indicated by a dashed line.

Without illumination only a small dark current (I_D) flows through the PN junction as a result of thermally generated carriers.

With light, additional charge carrier pairs (hole electron pairs) are generated in the P and N region by the radiation quantum (internal photo effect). Carriers originating in the space charge region are immediately extracted because of the electrical field present there, i.e. the holes in the P and the electrons in the N direction. Carriers from the remaining field must first diffuse into the space charge region in order to be separated there. If holes and electrons recombine before, they do not contribute to the photocurrent. Thus, the photocurrent (I_P) is a combination of the drift current of the space charge region and the diffusion current of the P and N area.

I_P is proportional to the incident radiation intensity. Since I_D is very small for diodes, it can be neglected in the equation $I_P = I_P + I_D$. Subsequently one gets a linear correlation between I_P and the incident radiation intensity over a very wide range.

Diodes with a small space charge width are termed PN diodes; diodes with a large space charge width, PIN diodes.

PN diodes have the diffusion current as the dominating part of the photocurrent; for PIN diodes, it is the drift current.

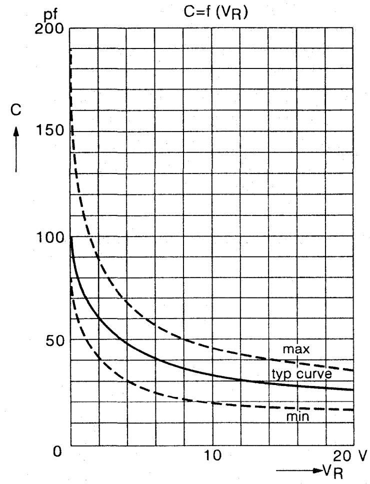
As the capacitance of the space charge width (W) is inversely proportional, the PIN diode is characterized by a smaller capacitance than a PN diode of identical surface. The capacitance of (most of) the diodes reads:

$$C_D \sim \sqrt{\frac{N}{D}}$$

The less the doping N of the basic material and the higher the applied voltage V, the lower the capacitance.

Figure 5 shows the capacitance as function of the voltage for a PIN diode, e.g. BPY 12.

Figure 5. Junction capacitance versus reverse voltage



Silicon Phototransistors

The introduction of the planar technique allows to produce phototransistors of small dimensions. They are used as photoelectric detectors in control and regulating devices. The photoelectric transistors are excellently suited as receivers for incandescent lamp light, as their maximal photosensitivity lies near the infrared limit of the light wave spectrum.

In its mode of operation a photoelectric transistor corresponds to that of a photodiode with built-in amplifier. It has a 100 to 500 times higher photosensitivity than a comparable photoelectric diode.

The photoelectric transistor is preferably operated in an emitter circuit and acts similar to an AF transistor.

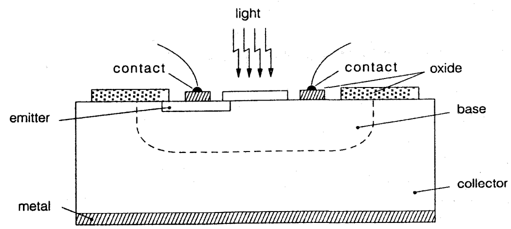
Unilluminated, only a small collector-emitter leakage current flows. It amounts to approximately $I_d = B \cdot I_{CBO}$, B standing for the current amplification and I_{CBO} for the reverse current of the base diode.

At illumination the reverse current of the base diode (I_{CBO}) increases by the photocurrent I_P'. Thus, one receives for the photocurrent $I_P \sim B\,(I_{CBO} + I_P')$.

Consequently, the photocurrent of a transistor is a function of the photocurrent I_P' of the base diode and the current amplification B. As B cannot be increased indefinitely, try for as high as possible photosensitivity of the base diode.

Figure 6 shows the design of a phototransistor. The emitter and base leads are affixed laterally to make the base diode most easily accessible to light. The large collector zone ensures that the most possible radiation quanta are absorbed there and will contribute to the photocurrent.

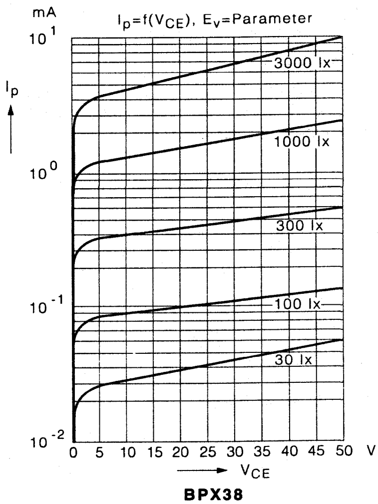
Figure 6. Phototransistor design



Contrary to a photodiode, a linear interconnection between the incident radiation intensity and the photocurrent (I_P) exists only in a small region, since the current gain B depends on the current. Figure 7 shows typical current voltage characteristics of a phototransistor.

Since the reverse current (I_{CBO}) of the base diode is amplified in the same way as the photocurrent (I_P), the signal/noise ratio of the phototransistor is the same as that of the photodiode.

Figure 7. Photocurrent versus collector-emitter voltage



For versatile applications, special type phototransistors are available. BPY 62, BPX 43, BP 101 and BP 102 requiring no lens on the receiver side are suitable for general applications.

BPY 62 is outstanding for a higher cut off frequency, BPX 43 for a higher photosensitivity.

For an application requiring a lens on the detector side use the BPX 38. The flat window of the BPX 38 makes a precise reproduction of the focal spot on the photosensitive surface of a transmitter system possible. Because of the larger system surface, the adjustment and alignment of the transistor case to the light emitter causes less difficulties.

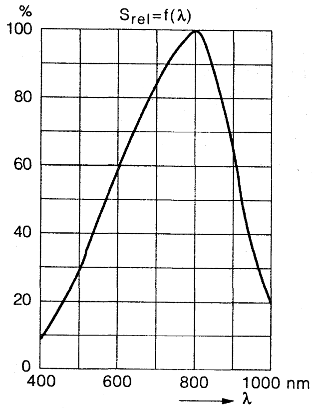
Of the types mentioned, the user may preset the operating point of the phototransistor by wiring the base leads. The rapidity of response may thus be increased and the photosensitivity reduced. A fixed bias can reverse the phototransistor. Coincidence circuits can be achieved by scanning this bias.

The phototransistor BPY 61 meets the requirement for high packing density. It is enclosed in a miniature glass case of 13 mm x 2.1 mm Ø and its photosensitivity is by the factor 500 to 1000 higher than small surface silicon photovoltaic cells. Also the BPX 62 in a micro ceramic case can be used on PC boards at minimum space requirements. The tolerance range of light sensitivity is subdivided into four sensitivity groups. There is no base contact. Light is the controlling element which produces a correspondingly high collector current via the emitter-base path of the transmitter system, multiplied by the factor of the current gain. The rise and fall times depend on the illuminance and decrease with rising intensity.

Main applications are scanning of binary coded discs, films and punched cards.

Under limited mounting conditions the following amplifier must often be connected by relatively long leads. There is only little danger of interference pickup since a sufficiently large signal to noise ratio is ensured by high photoelectric currents.

Figure 8. Relative spectral sensitivity



Mounting Instructions for Silicon Voltaic Cells and Photodiodes, Open Design without Casing

As silicon is an inherently brittle material, the photoelectronic component should be shielded from pressure or tension. Contact points are particularly vulnerable. Should tension come to bear on the solid wire leads, which for technological reasons are alloyed to a very thin P layer, it should only be parallel to the surface and must not exceed 200 p (pond). Leads may only be bent 3 mm off the outer edge of the photoelectric component. Photoelectric components can be cemented onto metallic or plastic supports but the expansion coefficient of the material has to be considered to prevent mechanical strain between support and photoelectric component at change of temperature. An epoxy resin is to be used to cement or encapsulate the photoelectric component. It has to be colorless and should not grow darker with time. After curing, the epoxy resin must not have any gas occlusions (filter effect).

The epoxy resin EPICOTE 162[1] together with the hardener LAROMIN-C 60[2] are well suited encapsulating photoelectric components. 100 weight parts EPICOTE 162, 38 weight parts LAROMIN-C 260 are to be mixed well and remain workable for about 30 minutes. After 30 minutes the epoxy becomes viscid. All material to be encapsulated has to be dry, dust-free and grease-free. Should bubbles form after the encapsulation it is advisable to raise the curing process temperature to 100°C for a short time. Raising the temperature makes the bubbles come to the surface and burst. The normal curing temperature lies between 60 and 80°C. The curing time is one hour, it lessens with higher temperature. When working with epoxy great care should be taken that neither the resin nor the hardener touches the skin. The quick binding glue SICOMET 85[3] proves adequate to cement open-design Si diodes or photovoltaic cells. The light sensitive surface of photovoltaic cells are coated with a protective lacquer and should not be contaminated while cementing.

[1] Registered trademark (Shell Chemical)

[2] Registered trademark (BASF)

[3] Registered trademark (Sichel-Werke, Hannover)

SIEMENS

Applying the DLX3416* Intelligent Display® Device Appnote 17

by Dave Takagishi

This application note is intended to serve as a design and application guide for users of the DLX3416 (referred to as 3416 hereafter) alphanumeric Intelligent Displays. This appnote also covers device electrical description and operation, considerations for general circuit design, and interfacing the 3416 to microprocessors. Refer to the specific data sheet and other Siemens Appnotes for more details.

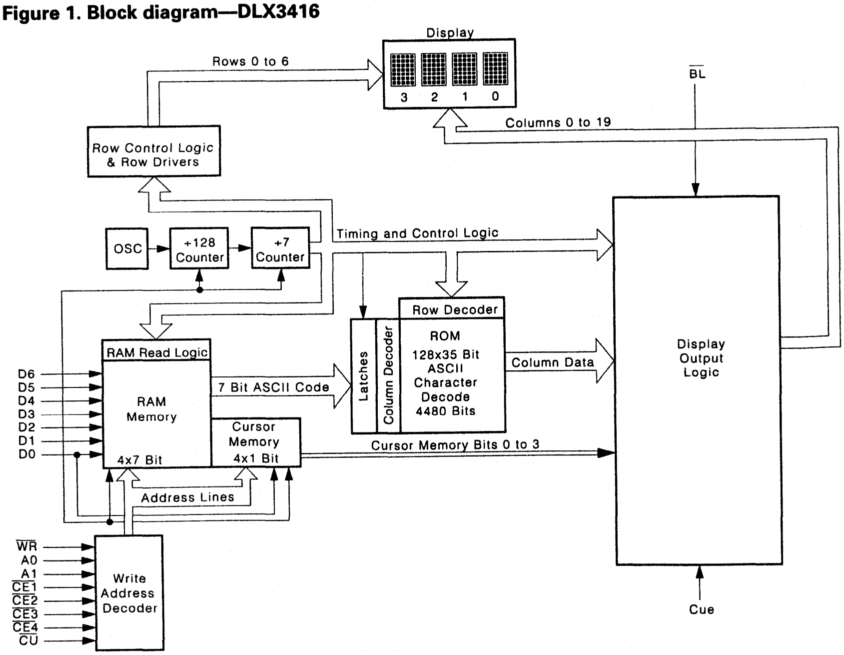
Electrical & Mechanical Description

The internal electronics in these Intelligent Displays eliminates all the traditional difficulties of using multi-digit light emitting displays (segment decoding, drivers, and multiplexing).

An Intelligent Display also provides internal memory for the four digits. This approach allows the user to asynchronously address one of four digits, and load new data without regard to the LED multiplex timing.

Figure 1 is a block diagram of the DLX3416. The unit consists of four (5x7) LED arrays and a single CMOS integrated chip. The IC chip contains the column and row drivers, 128 character ROM, four word x7 bit Random Access Memory, oscillator for multiplexing, multiplex counter/decoder, cursor memory, address decoder, and miscellaneous control logic.

Figure 1. Block diagram—DLX3416



Packaging

Packaging consists of a transfer molded nylon lens which also serves as an "encapsulation shell" since it covers five of the six "faces." The assembled and tested substrate ("PTF" multi-layer), is placed within the shell and the entire assembly is then filled with a water clear IC grade epoxy.

This yields a very rugged part, which is quite impervious to moisture, shock and vibration. Although not "hermetic," the device will easily withstand total immersion in water/detergent solutions.

Figure 2. Top view

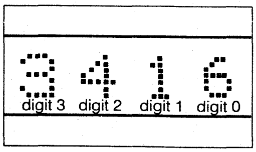


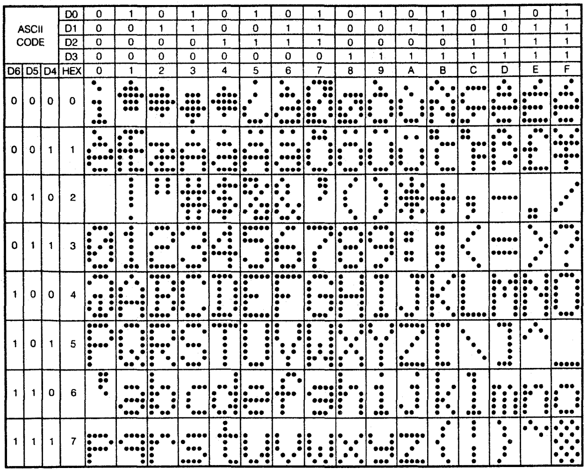
Table 1. Pin outs

Pin	Function	Pin	Function
1	$\overline{\text{CE1}}$ Chip Enable	10	GND
2	$\overline{\text{CE2}}$ Chip Enable	11	D0 Data Input
3	$\overline{\text{CLR}}$ Clear	12	D1 Data Input
4	CUE Cursor Enable	13	D2 Data Input
5	$\overline{\text{CU}}$ Cursor Select	14	D3 Data Input
6	$\overline{\text{WR}}$ Write	15	D6 Data Input
7	A1 Digit Select	16	D5 Data Input
8	A0 Digit Select	17	D4 Data Input
9	V_{CC}	18	$\overline{\text{BL}}$ Display Blank

Table 2. Electrical inputs to the 3416

V_{CC}	Positive supply +5 volts
GND	Ground
D0-D6	Data Lines The seven data input lines are designed to accept the first 64 ASCII characters. See Figure 3 for DL3416 character set (The DL3416 interprets all undefined codes as a blank). See Figure 3 for DLX3416 character set.
A0, A1	Address Lines The address determines the digit position to which the data will be written. Address order is right to left for positive-true logic.
$\overline{\text{WR}}$	Write (Active Low) Data and address to be loaded must be present and stable before and after the trailing edge of write. (See DL3416, DLX3416 data sheets for timing information).
$\overline{\text{CE1}}$, $\overline{\text{CE2}}$	Chip Enable (Active High)
$\overline{\text{CE3}}$, $\overline{\text{CE4}}$	Chip Enable (Active Low) Determines which device in an array will actually accept data. When either or both chip enable is in the high state, all inputs are inhibited.
$\overline{\text{CLR}}$	Clear (Active Low) The data RAM and cursor RAM of the DL 3416 will be cleared when held low for 15 mS. The minimum for the $\overline{\text{CLR}}$ is 1 mS for the DLX3416.
CUE	Cursor Enable Activates Cursor function. Cursor will not be displayed regardless of cursor memory contents when cue is Low.
$\overline{\text{CU}}$	Cursor Select (Active Low) This input must be held high to store data in data memory and low to store data into the cursor memory.
$\overline{\text{BL}}$	Display Blank (Active Low) Blanking the entire display may be accomplished by holding the $\overline{\text{BL}}$ input low—not a stored function. When $\overline{\text{BL}}$ is released, the stored characters are again displayed. $\overline{\text{BL}}$ can be used for flashing or dimming.

Figure 3. Character set—DLX3416



Notes: 1. High = 1 level.
2. Low = 0 level.
3. Upon power up, the device will initialize in a random state.

Clear Memory

Clearing of the entire internal four digit memory may be accomplished by holding the clear line (CLR) low for one complete internal display multiplex cycle, 15 mS minimum for DL 3416, 1 mS for DLX3416. Less time may leave some data uncleared. CLR also clears the cursor memory.

Display Blanking

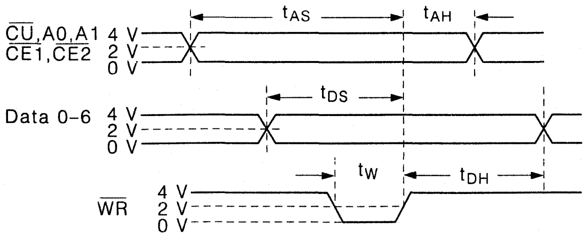
Blanking the display may be accomplished by loading a blank, space or illegal code into each digit of the display or by using the (BL) display blank input. Setting the (BL) input low does not affect the contents of either data or cursor memory. A flashing display can be realized by pulsing (BL).

Operation

Multiplexed display systems sequentially read and display data from a memory device. In synchronous systems, control circuitry must compare the location of data to be read to the location or position of new data to be stored or displayed, i.e., synchronize before a Write can be done. This can be slow and cumbersome.

Data entry in Intelligent Displays is asynchronous and may be done in any random order. Loading data is similar to writing into a RAM. Each digit has its own memory location and will display until replaced by another code.

Figure 4. Write cycle waveforms



The waveforms of Figure 4 demonstrate the relationships of the signals required to generate a write cycle. (Check individual data sheet for minimum values). As can be seen from the waveforms, all signals are referenced from the rising or trailing edge of write.

Cursor

The DLX3416 cursor function causes all dots to light at 50% brightness. The cursor can be used to indicate the position in the display of the next character to be entered. The cursor is not a character but overrides the display of a stored character. Upon removal of the cursor, the display will again show the character stored in memory.

The cursor can be written into any digit position by setting the cursor enable (CUE) high, setting the digit address (A1, A0), enabling Chip Enable, (CE1, CE2), cursor select (CU), Write (WR) and Data (D0). A high on data line D0 will place a cursor into the position set by the address A0 and A1. Conversely, a low on D0 will remove the cursor. The cursor will remain displayed after the cursor (CU) and write (WR) signals have been removed. During the cursor-write sequence, data lines D1 through D6 are ignored by the 3416.

If the user does not wish to utilize the cursor function, the cursor enable (CUE) can be tied low to disable the cursor function. A flashing cursor can be realized by simply pulsing the CUE line after cursor data has been stored.

General Design Considerations

Using Positive true logic, address order is from right to left. For left to right address order, use the "ones complement" or simple inversion of the addresses.

For systems with only a 6 bit (abbreviated ASCII) code format, Data Line D6 cannot be left open. Data D6 must be the complement of Data Line D5.

A "display test" or "lamp test" function can be achieved by simply storing a cursor into all digits.

Because of the random state of the cursor RAM after power up, if the cursor function is to be used, it will be necessary to clear cursors initially to assure that all cursor memories contain its zero state. This is easily accomplished with the CLR input.

When using the 3416 on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all inputs. This is most easily achieved with Hex non-inverting buffers such as the 74365. The object is to prevent transient current in the protection diodes. The buffers should be located on the display board near the displays.

Local power supply bypass capacitors are also needed in many cases. These should be 6 or 10 volt, tantalum type with 10 µF or greater capacitance. Low internal resistance is important due to current steps which result from the internal multiplexing of the displays.

If small wire cables are used, it is good engineering practice to calculate the wire resistance of the ground plus the +5 volt wires. More than 0.1 volt drop, (at 25 mA per digit worst cast) should be avoided, since this loss is in addition to any inaccuracies or load regulation limitations of the power supply.

The 5 volt power supply for the displays should be the same one supplying V_{CC} to all logic devices which drive the display devices. If a separate supply must be used, then local buffers using hex non-inverting gates should be used on all inputs and these buffers should be powered from the display power supply. This precaution is to avoid logic inputs higher than display V_{CC} during power up or line transients.

Figure 5.

Loading Data

$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A_1	A_0	D6	D5	D4	D3	D2	D1	D0	Digit 3	Digit 2	Digit 1	Digit 0
L	X	X	X	H	X	H	X	X	X	X	X	X	X	X	X	Blank			
H	H	X	L	H	X	H	X	X	X	X	X	X	X	X	X	Previous Characters			
H	X	H	L	H	X	H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
H	X	X	L	H	H	H	X	X	X	X	X	X	X	X	X	NC	NC	NC	NC
H	L	L	L	H	L	H	L	L	H	L	L	L	L	L	H	NC	NC	NC	A
H	L	L	L	H	L	H	L	H	H	L	L	L	L	H	L	NC	NC	B	A
H	L	L	L	H	L	H	H	L	H	L	L	L	L	H	H	NC	C	B	NC
H	L	L	L	H	L	H	H	H	H	L	L	L	H	L	L	D	C	NC	A
H	L	L	L	H	L	H	L	L	H	L	L	L	H	L	H	D	C	B	E
H	L	L	L	H	L	H	H	L	H	L	L	H	L	H	H	D	K	B	E
H	L	L	L	H	L	H	–	–	–	–	–	–	–	–	–	See Character Set			

Loading Cursor

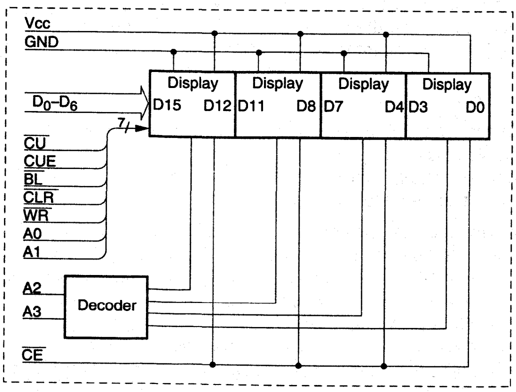
$\overline{BL}$	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	$\overline{CLR}$	A_1	A_0	D6	D5	D4	D3	D2	D1	D0	Digit 3	Digit 2	Digit 1	Digit 0
H	L	L	L	H	X	H	X	X	X	X	X	X	X	X	X	Normal Data Entry			
H	L	L	H	H	H	H	X	X	X	X	X	X	X	X	X	Enable Previous Stored Cursors			
H	L	L	H	L	L	H	L	L	X	X	X	X	X	X	H	NC	NC	NC	■
H	L	L	H	L	L	H	L	H	X	X	X	X	X	X	H	NC	NC	■	■
H	L	L	H	L	L	H	H	L	X	X	X	X	X	X	H	NC	■	■	■
H	L	L	H	L	L	H	H	H	X	X	X	X	X	X	H	■	■	■	■
H	L	L	L	H	H	H	X	X	X	X	X	X	X	X	X	D	K	B	E
H	L	L	L	L	L	H	L	L	X	X	X	X	X	X	L	D	K	B	E
H	L	L	H	H	H	H	X	X	X	X	X	X	X	X	X	■	■	■	E

X = Don't care
NC = No change from previously displayed characters
■ = all dots/segments on at half brightness

Interfacing the 3416

A general and straightforward interface circuit is shown in Figure 6. This scheme can easily interface to µP systems or any other systems which can provide the seven data lines, appropriate address, and control lines.

Figure 6. General interface circuit



Parallel I/O

The parallel I/O device of a microprocessor can easily be connected to the circuit in Figure 6. One eight bit output port can provide the seven input data bits and the cursor (CU). Another eight bit output port can contain the address and chip enable information and the other control signals.

INIT:	MVI A,80H OUT CONTROL	;CONTROL DATA MODE 0 ;LOAD CONTROL REGISTER
CUSR:	MVI A,00H OUT PORT A MVI B, 0FH	;CLEAR CURSOR DATA ;LOAD DATA PORT ;SET CHARACTER COUNTER
CUSRI	:MOV A, B CALL DSPWT DCR B JNZ CUSRI MOV A, B CALL DSPWT MVI A, FFH OUT PORT B	; ;WRITE SUBROUTINE ;DECREMENT COUNTER ;DIGIT 0? ; ; ;SET DATA FOR CONTROL ;LOAD CONTROL LINES
DISP:	LXI H, TABLE	;SET TABLE ADDRESS

DISP1	MOV A, M
	
	OUT PORT A
	MOV A, B
	CALL DSPWT
	
	INX H
	
	INR B
	MVI A, 10H
	CMP B
	JNZ DISP1
	HALT
		;MOVE TABLE DATA INTO ACCUMULATOR
		;LOAD DATA PORT
		;
		;LOAD ADDRESS AND CONTROL
		;INCREMENT TABLE ADDRESS
		;INCREMENT COUNTER
		SET # OF DIGITS
		;
		;16 CHARACTERS?
		;END OF PROGRAM

DSPWT	:ORI F0H OUT PORT C ANI 7FH OUT PORT C ORI F0H OUT PORT C RET	;SET CONTROL BITS OFF ;LOAD CONTROL ;SET WRITE BIT ON ;LOAD WRITE ORI F0H ;LOAD CONTROL
TABLE:	DB DB DB DB DB DB DB DB DB DB DB DB DB DB DB DB	;0C3H ;0C9H ;0D4H ;0D3H ;0C1H ;0D4H ;0CEH ;0C1H ;0C6H ;0A0H ;0D3H ;0D4H ;0C8H ;0C7H ;0C9H ;0CCH

Figure 7. 16-digit parallel I/O system

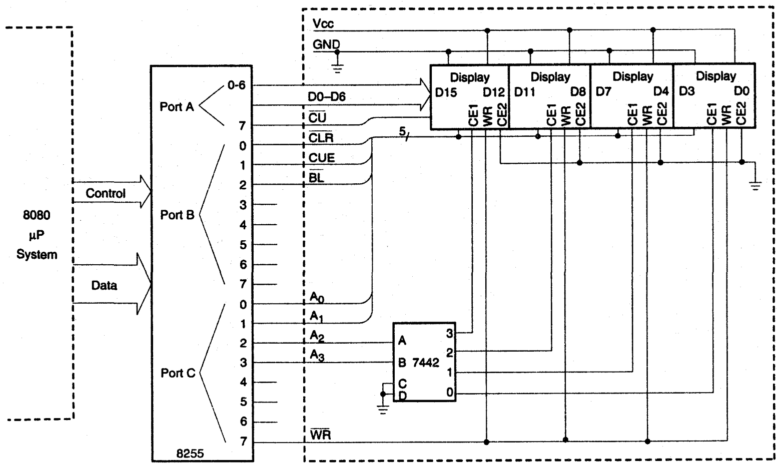


Figure 8. Mapped interface.

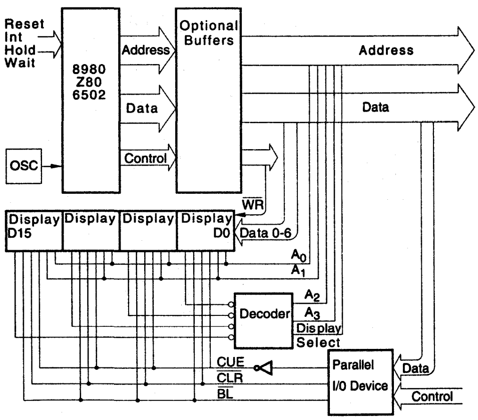


Figure 9. Interface with 6800 microprocessor

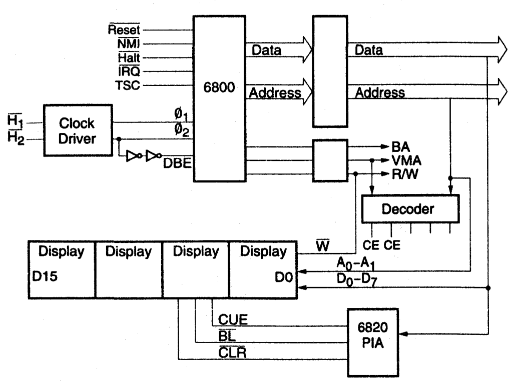


Figure 7 illustrates a 16 character display with an 8080 system using the 8255 programmable peripheral interface I/O device. The following program will display a simple 16 character message using this interface.

I/O or Memory Mapped Addressing

Some designers may wish to avoid the additional cost of a parallel I/O in their system. Structuring the addressing architecture for the 3416 to look like a set of peripheral or output devices (I/O mapped) or RAM's and ROM's (memory mapped) is very easy. Figure 8 shows the simplicity of interfacing to microprocessors, such as 8080, Z80 and 6502 as examples.

The interface with the 6800 microprocessor in Figure 9 illustrates the need for designers to check the timing requirements of the 3416 and the μP. The typical data output hold time is only 30 ns for DBE=Ø2 timing; two inverters in the DBE line are added to increase the data output hold time for compatibility with the 50 nS minimum spec of the 3416.

Conclusion

Note that although other manufacturers' products are used in examples, this application note does not imply specific endorsement, or recommendation or warranty of other manufacturer's products by Siemens.

The interface schemes shown demonstrate the simplicity of using the 3416 with microprocessors. The slight differences encountered with various microprocessors to interface with the 3416 are similar to those encountered when using different RAMs. The techniques used in the examples were shown for their generality, and any display of this family are interchangeable in these examples. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

SIEMENS

Guidelines for Handling and Using Intelligent Display® Devices Appnote 18

by Malcolm Howard and Dave Takagishi

IMPORTANT!

This appnote contains vital information for optimum design and performance of Intelligent Displays Devices.

Siemens Optoelectronics Intelligent Displays Devices and Programmable Displays are one, four, eight, or ten digit LED display modules with dot matrix and on-board CMOS integrated circuits. The CMOS chip provides dot or segment decoding, drivers, multiplexing and memory for easy interfacing to most microprocessors.

This application note is a guide for the design and handling considerations of Intelligent and Programmable Displays.

System Design Consideration

In the practical circuit (i.e., design of PCB, etc.) the voltage to any input must never exceed the power inputs (i.e., $GND<V_{IN}<V_{CC}$). If these conditions are not met, then malfunction, or at worst, device destruction can occur. The most common cause of these conditions is circuit noise on the inputs and transient power supply changes.

Good Circuit Layout

The principles of good circuit layout are identical to any logic circuitry, but the deviation tolerance of MOS devices is much less than that of bipolar logic. Keeping the signal path lengths as short as possible is important to reduce the coupling effect between signals.

Buffering

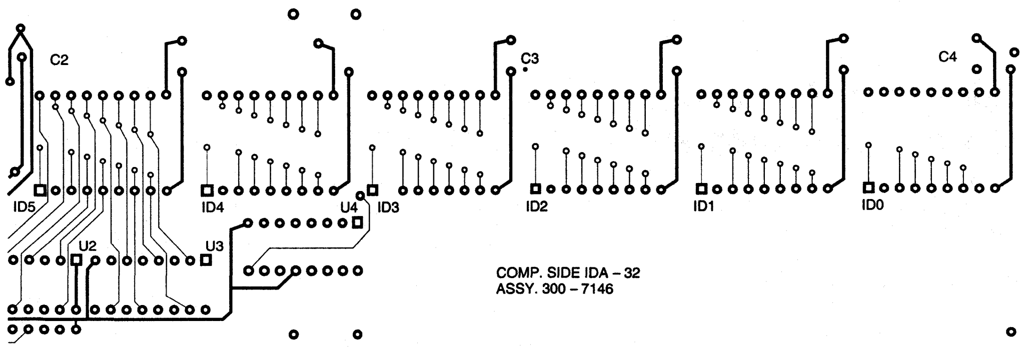
Although the use of parallel tracking is usually considered good design practice, avoid PCB designs which allow an interconnection track to run parallel to another. This is particularly true if one of the tracks is a high power bus when the fluctuations of power supply current can cause inductive or capacitive coupled charge onto an adjacent input signal.

Possibly the worst example of parallel tracking is the ribbon cable. While physically neat and convenient, ribbon cables can be electrically destructive for MOS circuits. It is often necessary, because of the very nature of Intelligent Displays Devices, to use a ribbon cable from the CPU board to the display assembly board. In those circumstances for PCB trace lengths plus cable lengths over 15.5 cm (6 inches), use a buffer for each input. This is especially true for noisy systems which have motors, relays, etc. The buffers should be physically as close as possible to the displays, maintaining a minimum distance between their outputs and the display inputs. Long cables can be poor transmission lines for speed pulses. Line drivers, line receivers, or Schmitt trigger gates may be required to shape pulses.

Voltage Transients

It has become common practice to provide 0.01 µf bypass capacitors liberally in digital systems. For Intelligent Displays Devices, the emphasis is on adequate decoupling. Like other CMOS circuitry, the Intelligent Display controller chip has a very low power consumption and the usual 0.01 µf capacitor would be adequate were it not for the LEDs. The module can, in some conditions (depending on the displayed characters), use up to 500 mA pk (average, multiplexed). To prevent power supply transients, use capacitors with low inductance and high capacitance at high frequencies, i.e., a solid tantalum or ceramic disc for high frequency bypass. For longer display lengths, distribute the bypass capacitors evenly keeping capacitors as close to display power pins as possible. Do not rely on onboard decoupling; use a 10 µf and a 0.01 µf capacitor for every three or four Intelligent Displays Devices to decouple the displays themselves, at the displays. See Figure 1.

Figure 1. PCB layout of a line DLX2416 Intelligent Displays Devices



Capacitors are spaced evenly and close to the displays with room for additional capacitors if required.

Functional Limitations

Several parameters of an Intelligent/Progammable Display which may affect your design are listed below. While some parameters may not be destructive, some may affect reliability and/or functional operation. (Check latest data sheets.)

1. No more than 20 LEDs/character may be lit for HDSP200XLP, Serial Input Displays.
2. The timing parameters at 25°C will increase (slower) with increased temperature.
3. The timing parameters will decrease (faster) with increased V_{CC}.

Manufacturing Considerations
Handling

The static voltages generated by friction with synthetic materials (i.e., carpets, clothing, device carriers, etc.) are often measured in thousands of volts. Although these static charges usually have little energy, it is sufficient to cause destruction to CMOS circuitry if applied to circuit inputs. Our CMOS circuits have input protection diodes which can minimize their vulnerability to these static voltages, but there is a limit to their protection capabilities. Under certain conditions, static charges can exceed that limit. The most effective protection is to avoid generation of static charges. When static charges are unavoidable, prevent that charge from coming into contact with the device pins.

1. ***Avoid touching the pins; handle the body only.***
2. ***Keep the devices in anti-static tubes or conductive material when transporting.***
3. ***Use conductive and grounded working area*** (conductive flooring, conductive workbench tops, conductive individual wrist straps, etc.).

Intensity Brightness Codes

Display uniformity is a concern when two or more displays are in a system. Siemens has adopted a letter code (indicating a brightness range) to maintain a uniform display. We recommend a single letter code be used per system. Because this may be difficult to always achieve due to yield and delivery, adjacent codes (i.e., D with E or E with F) can be used with minimal problems. Jumping over a code (i.e., D with F) may be noticeable.

Soldering

Because of the plastic housing of the Intelligent Displays Devices, it is necessary to control the solder temperature, soldering time, and soldering distance. Refer to data sheet for maximum limits. An additional requirement during wave soldering: the temperature of the plastic package should not exceed the maximum rated storage temperature of the device type.

In general, Intelligent Displays cannot be reflowed as an SMT component.

Cleaning

Refer to Appnote 19, "Cleaning LED Opto Products."

SIEMENS

Cleaning LED Optoelectronic Products Appnote 19

by Jonathan Wafer

Now that you have selected the proper optoelectronic device for your application and designed the circuitry, the next step is to install the devices. This application note is a cleaning guide for Siemens Optoelectronic products.

Purpose of Cleaning

Removing both flux rosin or resin along with ionic residues after soldering is essential for good product and overall system performance and reliability. Optoelectronic components require special packaging materials with transmissive or reflective optical properties, therefore they must be treated differently than conventional semiconductor devices with respect to cleaning.

Cleaning Processes

Component cleaning or defluxing processes fall into four categories: aqueous, semiaqueous, solvent, and no clean. Both in-line and batch cleaning equipment employ one of the above processes. A brief description of each process, along with approved cleaning solutions from each group, is summarized below. Table 1 lists several cleaning solution suppliers.

Aqueous Cleaning

Siemens Optoelectronics components are compatible with most aqueous cleaning agents. These solutions are usually high pH alkyl amine-based products that also contain surfactants, saponifiers, buffers, and inhibitors. The solution reduces organics to form soaps, followed by a deionized water rinse. In its simplest form, aqueous processing using a deionized water rinse is useful for removing water-soluble flux residues. The following are approved aqueous cleaning agents and their suppliers:

Indusco Chemicals	WL 1000 Aqua Flux Strip
Altos Group	AQ 1534

Semiaqueous Cleaning

Semiaqueous cleaning uses hydrocarbon or citrus extract solutions to solubilize residues followed by a deionized water rinse and dry cycle. Semiaqueous cleaning agents compatible with Siemens Opto products are listed in Table 2 on the following page.

Solvent Cleaning

The most common solvent cleaning technique, vapor degreasing, involves placing parts within a vaporized solvent chamber—condensing the vapor into a liquid solvent and dissolving the soil. Many popular solvents used in this application are CFC 113 azeotropes that face regulation and eventual ban per the 1990 Clean Air Act. Compatibility of these and other solvents with Siemens Opto components is also listed in Table 2.

Conclusion

The list of solvents and cleaning solutions in Table 2 represents a small group of all the available cleaning agents on the market. Others may be compatible, but more likely, most will be incompatible. Usage of non-ozone depleting chemicals (ODCs) is highly recommended for environmental and long term safety reasons.

Siemens does not assume any responsibility for damage caused to products by use of the cleaning agents mentioned above. This application note is only a guide to products that have been found satisfactory when tested under our controlled lab conditions. We recommend that components be evaluated under client specific conditions before committing to use on a production basis.

Table 1. Cleaning solution suppliers

Supplier	Product
Allied Signal Inc. Engineered Solvent Systems	Genesolv CFC 113 Azeotropes
E I DuPont de Nemours	Freon CFC 113 Azeotropes Axarel Semiaqueous Cleaners
Petroferm Inc.	BioAct EC7R Terpene Semiaqueous Cleaners
Kyzen Corp.	Ionox Semiaqueous Cleaners

Table 2. Compatbility of various cleaning solutions with Siemens Optoelectronics products

Product Type	Cleaning Agents												
	CFC*					Non-CFC			Semiaqueous				
											Ionox		
	TF	TE	TES	TA	TMS	Ace-tone	IPA	111 TCA	Axarel 38	EC7R	HC	LC	MC
Visible Lamps	S	S	N	N	S	N	S	N	S	S	S	S	S
IR	S	S	N	N	S	N	S	N	S	S	S	S	S
Optocouplers	S	S	N	N	S	N	S	N	S	S	S	S	S
Displays Group 1 HD XXXX DLX413X DLX573X DLX713X PD443X	S	S	N	N	S	N	S	N	S	S	N	S	S
Displays Group 2 DL 3XXM/4XXM DLX1414 HDSP2000XLP DLX2416 PDSP211X DLX3416 SLX2016 PD243X PD353X SCD558X SCD5510X	S	S	N	S	N	S	N	N	S	S	N	S	S

S – Suitable for use
N – Not suitable for use
* – Denotes ozone-depleting substance. May be regulated by 1990 Clean Air Act.

SIEMENS

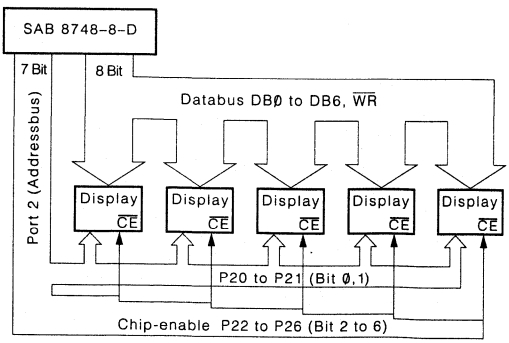
Moving Messages Using Intelligent Display® Devices and 8748 Microprocessor Appnote 20

Reprinted from Siemens Design Examples of Integrated Circuits Edition 1980/81

Output and display of texts including an important operator information are not only limited to devices of data processing systems but they are more and more applied in other fields of electronics, e.g. in industrial and consumer as well as control engineering. If data of different kinds (e.g. program results, error indications, decision criteria, test results, etc.) are displayed as moving news, they have a striking effect calling the operator's attention.

The text can easily be read when each character remains for 0.25 s on the display. A special advantage of a moving news panel being controlled by a microcomputer is in that the information can immediately be modified. The described circuit of Figure 1 operates with SAB 8748. Its program memory capacity (EPROM) is 1 KByte and up to 900 characters can be stored. If the microcomputer is replaced by another one incorporating a different program, the information which is to be displayed is also exchanged.

Figure 1.



The described circuit offers the advantage in requiring a minimum of components. The single chip microcomputer SAB 8748 operates in conjunction with an alphanumeric 16 segment LED display DL2416. It incorporates memory decoder and driver.

Hardware

The ASCII coded data is transferred from the SAB 8748 to the display ICs via the bus port (DB0 to DB6) and via the $\overline{WR}$-output (strobe). The information at pins P20 and P21 addresses the specific digits of the display IC DL2416. The signals at P22 to P26 select the individual ICs via the chip enable input $\overline{CE1}$. When one pin of port 1 is connected to ground, the microcomputer supplies the corresponding text. An output of 4 different texts is possible.

The text may have any length as long as the memory capacity of 900 bytes is not exceeded. There are no additional components required than indicated in the circuit of Figure 2.

Software

The first 100 bytes of the EPROM are reserved for the program. As the program counter can only be read as data memory within 256 bytes, additional instructions are necessary (see listing). At the beginning of the program, port 1 is read. If a signal with low level is available at one of the pins, the starting address of the corresponding text is loaded to register 2 (low address) and 3 (high address). Now output registers 20H to 32H have to be filled with blanks. Then the first letter is transferred from text memory to data memory. Now the microprocessor operates in a waiting loop, determining the speed of the moving news. At an oscillator frequency of 3 MHz the timer has an overflow after $^{1}/_{3} \times 10^{-6}$ µs x 15 x 32 x 256 = 40.96 ms. The moving news text is stepping four times per second after 6 overflows have occurred; that means the 900 characters need in total 3 $^{3}/_{4}$ minutes. If the 8 bit word zero (figure 0, not the ASCII character for O) is read as character, the text end is recognized by the program. Therefore a counting is not necessary; that means all characters have been transferred. Now the program returns to read port 1.

The flowchart is shown in Figure 3.

Components for Circuit 2

1	8 bit single chip microcomputer (1 KByte EPROM, 3 MHz version)	SAB 8748-8-D
5	4 digit alphanumeric LED displays with memory, decoder and driver, (4 mm character height, 16 segments)	DL2416
1	Crystal	3 MHz
4	Push buttons for PC board mounting,	
2	break-make contacts, lateral operation	

Figure 2.

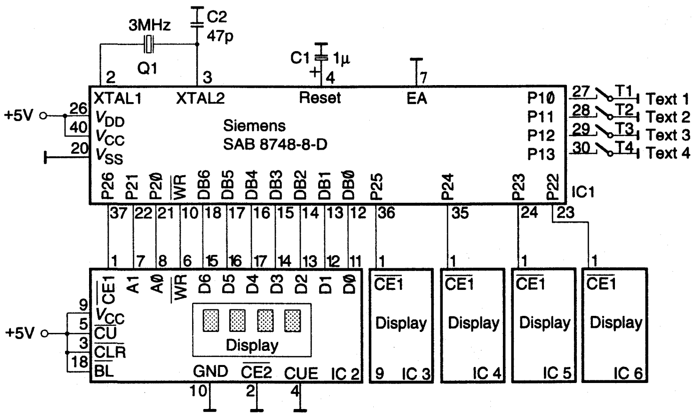
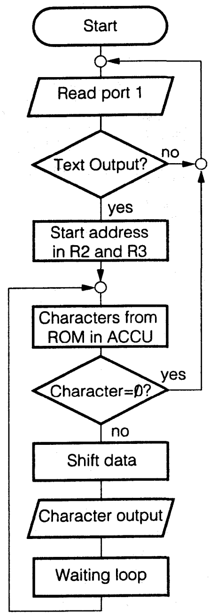


Figure 3. Flowchart



SIEMENS

Silver Plated Tarnished Leads Appnote 21

by Dave Takagishi

This application note will discuss silver tarnish and solderability. Silver plating, as an alternative to gold plating, has excellent electrical conductivity, LED die attach, and wire bonding properties. But tarnished leads can cause soldering difficulties.

Effects of Tarnish

Solderability means the metals or surfaces to be soldered must be types that will go into solution with tin-lead alloys. When exposed to the atmosphere, all metals form oxides or tarnish of varying degree which reduce the ability of solder alloys to adhere to the metals. Silver tarnish is formed when silver chemically reacts with sulfur to form silver sulfide (A_2S). This tarnish is the reason for poor solderability of silver plated products. However, the amount of tarnish and the kind of solder flux used actually determine the solderability. As the tarnish increases, a more active flux must be used to penetrate and remove the tarnish.

Prevention and Handling

Prevention is the best method for inhibiting the formation of tarnish and insuring good solderability of silver plated devices. To inhibit silver tarnish, do not expose the silver plating to sulfur and sulfur compounds. One source of sulfur is free air. Another is paper products such as bags and cardboard. Listed below are a few suggestions for storing silver plated products.

1. Store the unused devices in polyethylene sheet to keep out free air.
2. Loose devices may be stored in zip-lock or sealed plastic bags.
3. For long term storage, place petroleum napthalene (mothballs) with product inside plastic packages to help keep out free air.
4. The silver leads may be wrapped in "Silver Saver" paper for protection. "Silver Saver" is manufactured by:

   Daubert Coated Products,1200 Jorie Drive
   Oak Brook, IL 60521, phone (312) 582-1000
5. Tapes such as adhesive, electrical, and masking should not be used because the adhesive may leave a film and will need to be removed before soldering.

The best defense against tarnish formation is to keep silver plated devices in protective packaging until just prior to soldering.

Fluxes

Depending on the amount of tarnish, different types of flux may be required. Below is a list of flux in order of increasing strength.

Type RMA: Mildly Activated Rosin Flux
A WW rosin flux with a small amount of activating agent. Flux and its residue are non-conductive and non-corrosive.

Type RA: Activated Rosin Flux
Similar to RMA flux but with greater amounts of activating agents. Flux and its residue are non-conductive & non-corrosive.

Types AC: Organic Acid Flux
A fully active organic flux with greater flux ability than a rosin flux. Due to its organic nature, the flux residues decompose at soldering temperatures but must be removed to prevent conductive and corrosive aftereffects.

Recommended flux types with respect to the various tarnish amount:

1. Tarnish free: solder with Alpha 100, Kester 135, or equivalent Type R flux (Identified by a bright surface).
2. Minor tarnish: use Alpha 611, Kester 197, or equivalent Type RMA flux (Identified by a medium bright surface).
3. Mild tarnish: use Alpha 711, Kester 1544, or equivalent Type RA flux (Identified by a light tint surface).
4. Moderate tarnish: use Alpha 830, Kester 1429, or equivalent Type AC flux (Identified by a light tan color surface).
5. If severe tarnish, identified by a dark tan to black color, is present a cleaner/surface conditioner Alpha 140, Kester 5560, or equivalent must be used. A few seconds at room temperature is all that is required. These conditioners are acidic, so wash and rinse thoroughly. Immerse only the leads and not the body because optical properties can be damaged.

Soldering

To obtain reliable circuit operation, good soldering is necessary. For wave soldering, Sn60 is the most commonly used solder for electronic components. Two alternatives are Sn63 and Sn62 solder. A high quality rosin core flux is recommended for hand solder operations. Typically the core is an RMA type flux. Two major soldering suppliers are:

Alpha Metals
600 Rt. 440
Jersey City, NJ 07304, phone (201) 434-6778

Kester Solder
4201 Wrightwood Ave.
Chicago,11160639, phone (312) 235-1600

Regardless of the flux and solder technique used, take care to assure the optical properties of the optoelectronic product are not degraded in any manner.

Siemens does not assume any responsibility for damage caused by products mentioned above.

SIEMENS

Socket Selection Guide
Appnote 22

by Dave Takagishi

This application note is a guide to locate a suitable socket for various Siemens products. The selection of a socket is first based on the number of pins and the pin spacing required. Sockets for displays require an orientation and sometimes stackability. Other requirements may be:

- Contact type (i.e., side vs. edge)
- Plating type (i.e., tin vs. gold)
- PCB mounting (i.e., solder vs. wirewrap)
- Height of socket

To use this guide:
1. Find Siemens product part number in Table 1;
2. Note number of pins;
3. Note spacing and orientation: Example 300 H;
4. Go to Table 2, find number of pins with corresponding spacing/orientation and follow to suggested socket.

The purpose of this application note is to guide you to possible vendors and suggest one out of many possible socket choices. Use the given vendor's part numbers as a starting point for choosing a socket. The part number will depend on your requirement and application.

This guide is not intended to imply specific endorsement or warranty of other manufacturer's products by Siemens.

Table 1.

Part Number	No. of Pins	Spacing
DL04135/4137	16	.300 H
DLX1414	12	.600 H
DLX2416	18	.600 H
DL3X0/4X0M	12	.300 H
DLX3416	22	.600 H
DLX573X	12	.300 H
DLX7135/7137	14	.600 H
HD107XX	10	(SPC)
HD110XX	10	.300 V
HD113XO	10	.300 H
HD113XX	10	.600 H
HDN107XO	10	(SPC)
HDN113XO	10	.600 H
HDSP200XLP	12	.300 H
HDSP211XS	28	.600 H
IPD254XA	20	(SPC)
IPD 213XTXVB	32	.300 H
254XA TXVB	20	(SPC)
ISD201X	12	.300 H
ISD231X/235X	12	(SPC)
PD243X, PD353X, PD443X	20	.600 H
PDSP188X	30	.300 H
PDSP211X	28	.600 H
PLCD558X	28	.600 H
SCD5510X, SCD558X	24	.300 H
SCDV554X	14	.300 V
SCE578X	26	.300 H
SCF574X	22	.600 H
SLX2016	14	.300 H
Optocouplers: 6 pin	6	.300 B
8 pin	8	.300 B
6pin	16	.300 B
Arrays	2–20	.100 B

Table 2.

Number of Pins	Row-Row Spacing	Aries	Garry Mfg.	Robinson-Nugent	Samtec
12	.300 H	12-513-10	(2) 102-06-X	(2)ICN-063-X	
14	.300 H	14-511-10	102-14-X-X-X	ICL-143-S6-X	ICC-314-T
18	.600 V	18-6511-10	300-18-X-X-X		IC-618-X
22	.600 V	24-6513-10	300-22-XX-X		ICC-624-X
22	SPC	—	—	—	—
13	SPC	—	—	—	—
12	.300 V	12-513-10			
14	.300 V	14-511-10	102-14-X-X-X	ICL-143-S6-X	ICC-314
14	.600 V	14-6511-10	300-14-X-X-X		IC-614-X
20	.300 H	20-511-10	102-20-CC-X-X	ICL-203-S6-X	ICC-320
10	SPC	—	—	—	—
10	.300 V				IC310-X
10	.600 V	10-6511-10			IC610-X
18	.300 V	18-511-10	102-18-X-X-X		ICC-318
6	.300 B	6-513-10	102-06-X	ICN-063-S3-X	IC-306-X
8	.300 B	8-511-10	102-8-X-X-X	ICN-083-S3-X	IC-308
16	.300 B				
2–20	.100 B	PIN-LINE SERIES	SERIES 200 SERIES 2002	SB-25-100X	SSA-1XX-X SERIES ICK-1XX-X SERIES
Others		Yes	Yes	Yes	

Notes:
1. All sockets are 0.100 pin-to-pin spacing.
2. Products listed are generally tin plated PCB solder type. Contact vendor for other types.
3. Row-row spacing of pins:
   (H)-pins are horizontal with respect to viewing of display;
   (V)-pins are vertical with respect to viewing of display;
   (B)-pins can be either horizontal or vertical;
   (SPC)-pins not standard 0.100 or row-row spacing.
4. Others—Special sockets for display such as right angle, etc. Contact vendor for details.
5. Consult vendor for stackability.
6. Strip in-line sockets may be used (cut to length required).
7. Vendor may have other products also suitable for your application.

List of Possible Vendors

Aries Electronics Co.
P.O. Box 130
Frenchtown, NJ 08825
201-996-6841

Garry Manufacturing
1010 Jersey Ave.
New Brunswick, NJ 08902
201-545-2424

Robinson-Nugent
800 E. Eighth St.
New Albany, IN 47150
812-945-0211

Samtec
810 Progress Blvd.
New Albany, IN 47150
812-944-6733

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LED Filter Selection Guide Appnote 23

By Dave Takagishi

The most important design consideration for a piece of equipment using LED products is the ability to display information to an observer clearly. This information must be easily and accurately recognized in various ambient light conditions. This application note will discuss the design considerations and recommendations for filtering.

Since the quality of readability is very subjective, the best judge of the performance of a product is the human eye and in the user's conditions. To improve the readability of a display, use techniques such as contrast enhancement, wavelength filtering, special filtering, and mounting.

Contrast Enhancement

The objective of contrast enhancement is to maximize the contrast between the display segments "ON" and "OFF" states. This is done by reducing the ambient light reflected from the surface of the display and allowing as much of the emitted light to reach the observer. This can be accomplished by painting the front surface of the display to match as *close* as possible the color of an "OFF" segment. This reduces the distracting areas around the display and therefore enhances the "ON" segments.

Contrast enhancement may be improved further by using selected wavelength filters. Under bright ambient conditions, contrast enhancement is more difficult and additional techniques such as louvered filters and/or shading may be necessary.

Filters

The majority of display applications use plastic filter material for their low cost and ease of assembly. The filter requirements for different ambient lighting conditions and different color displays make it necessary to become familiar with the various relative transmittance characteristics. Most filter manufacturers will provide transmittance curves for their products.

When selecting a filter, the shape of the transmittance curve versus wavelength should be considered in relationship to the LED radiated spectrum to obtain maximum contrast enhancement. For standard red displays, a long wavelength pass filter having a sharp cutoff in the 600 nm to 620 nm range is ideal. The same applies for high efficiency red displays with a long wavelength pass filter in the 570 nm to 590 nm range.Yellow and green displays are more difficult to filter effectively. The most effective filter for yellow displays is a yellow-orange or amber filter. Yellow only filters are very poor for contrast enhancement. Green displays will require a band-pass yellow-green filter which peaks at 565 nm.

Choose among available filters on the basis of which filter and LED combination is most effective, but experiment with each choice to choose the most esthetic combination.

Effectiveness of Wavelength Filters with Different Lighting

Contrast is very dependent upon ambient lighting. If the ambient light is outside the spectrum of the LED, then it is very easy to reduce the reflected light. This is the case for a red LED display in fluorescent lighting or a green LED in incandescent lighting. Bright sunlight has a flat spectral distribution curve and when it is directly incident upon a display the background may meet or exceed the light output of the display. It should be obvious that a wavelength filter alone is not sufficient in daylight ambient conditions.

Other Techniques

An acceptable contrast is difficult to achieve if high ambient light is parallel to the viewing axis (the incident light is perpendicular to the face of the display). If the incident light is not parallel to the viewing axis, the use of louvered filters or shading and recessing is recommended. It is the shading of louvered filters that reduces the incident light to allow for more contrast. The drawback to this filter is the restricted viewing angle.

Circular polarizing filters are effective in reducing the reflected light from the highly reflective (glossy) surfaces of bubble lensed products, such as some Intelligent Displays.

Glare can still be present from the surface of filters, therefore, an anti-reflection surface is recommended. This can be incorporated into the filter. The trade-off is that both ambient and display light are diffused and the display may appear fuzzy if not mounted close enough to the filter.

Take care when designing the printed circuit board to keep all reflective surfaces away from display area or display side of the board or consider a dark coating on the reflective surfaces.

Mounting Considerations

The designer should consider recessing the display and bezel assembly to add some shading effect. Shading will reduce indirect lighting for better contrast.

It is essential to design the unit to allow sufficient air flow for circulation and to mount current limiting resistors on another board or any heat generating components away from the displays.

Filter Recommendations

Table 1. Visible filters

Manufacturer	Red	HER	Yellow	Green	Specials
Homalite	1605	1670	1720 1726	1425 1440	
Panelgraphic	Red 60 Red 63	Red 65	Yellow 25 Amber 23	Green 48	Gray 10
Rohm & Haas	2423	2444			2412
3-M					Louvered Filters
Polaroid					Circular Polarizing

Table 2. Near IR filter

Manufacturer	Red
Rohm & Haas	Red 2711

Table 3.

U.S. Filter Manufacturers		European Filter Manufacturers
Filter Material Manufacturers	**Bezel and Filter Assembly Manufacturers**	
Panelgraphic Corporation 10 Henderson Drive West Caldwell, NJ 07006 201-227-1500	R.M.F. Products P.O. Box 413 Batavia, IL 60510 312-879-0020	3M Deutschland GmbH D-4040 NEUSS1, Box 100422 Carl Schurz-Straße 1 ☎ (02101) 140, TLX 8517511
SGL Homalite 11 Brookside Drive Wilmington, DE 19804 302-652-3686	Nobex Components Nobex Division Griffith Plastic Corp. 1027 California Dr. Burlingame, CA 94010 415-342-8170	CHEQUERS (U.K.) Limited 1-4 Christina Street LONDON, EC2A 4PA ☎ 01-739/6964-5, TLX 291673
3M Company Visual Products Division 3M Center, Bldg. 220-10W St. Paul, MN 55101 612-733-0128	Photo Chemical Products of California 1715 Berkeley St. Santa Monica, CA 90404 213-828-9561	RÖHM GmbH D-6000 DARMSTADT Kirschenallee ☎ (06151) 181
Rohm and Haas Independence Mall West Philadelphia, PA 19105 215-592-3000	I.E.E.-Atlas Industrial Electronic Engrs. Inc. 7740 Lemona Avenue Van Nuys, CA 91405 213-787-0311	POLARIZERS TECHNICAL PRODUCTS 1800 AL ALKMAAR P.O. BOX 489 Oude Gracht 90, The Netherlands ☎ 072-121553, TLX 57571
Polaroid Corporation Polarizer Division 549 Technology Square Cambridge, MA 02139 617-864-6000		BAYER AG, Geschäftsbereich KU D 5000 KÖLN 1 Konrad Adenauer Ufer 41 ☎ (0221) 16471
Dontech Inc. P.O. Box 889 Doylestown, PA 18901 215-348-5010		A1037 WIEN 3, Box 124 % (0222) 732551 CH 8045 ZÜRICH, P.O. Box ☎ (01) 4658111
ESCO Products Inc. 171 Oak Ridge Road Oak Ridge, NJ 07438 201-697-3700		

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Drivers For Light Emitting Displays Appnote 24

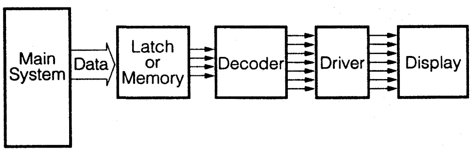
by Dave Takagishi

The purpose of this application note is to provide some information on the integrated circuits presently available to drive Light Emitting Diodes (LED) displays and how to interface them to the various displays.

Background

LED displays come in various sizes (0.1" to 0.8"), colors (red, high-efficiency red, green, yellow and blue), fonts (7/9/14/16 segment, dot-matrix, or bargraph), and types (common anode, common cathode, multi-digit). The brightness is essentially proportional to the current through an LED and each element within a display should have the same current or a brightness variation may be apparent. A display subsystem can be made up from several elements.

Figure 1. Display system



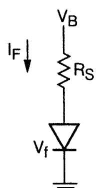
The partitioning of these elements are dependent on the drivers used; therefore the display driver chosen is dependent on the specifications of the display and the application. Also some types of displays require using a multiplexing technique because of the internal interconnections. This is only applicable for multi-digit displays.

Typical Circuits

Figure 2 shows a very basic circuit for driving an LED. The series resistance can be easily calculated from the following formula.

$$Rs = \frac{Vb - Vf}{If}$$

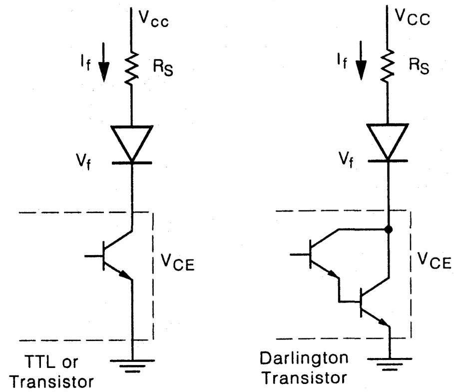
Figure 2. Basic circuit to drive an LED



For circuits using TTL logic or transistors, see Figure 3.

$$Rs = \frac{Vcc - Vce - Vf}{If}$$

Figure 3. Circuits for TTL or transistor and darlington transistor



It can be seen that Vce (saturation voltage) for the driver is going to be a factor in determining the series limiting resistor. Therefore a darlington versus a single output transistor will have different current limiting resistor values to maintain a constant current through the LED.

Figure 4. Common cathode display

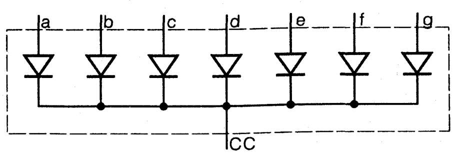


Figure 5. Common anode display

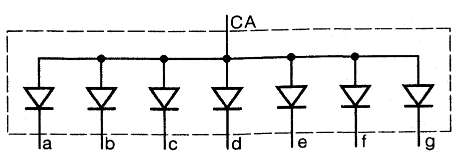


Figure 6. Common cathode display with driver

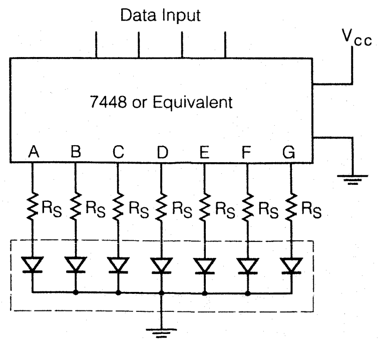


Figure 7. Common anode display with driver

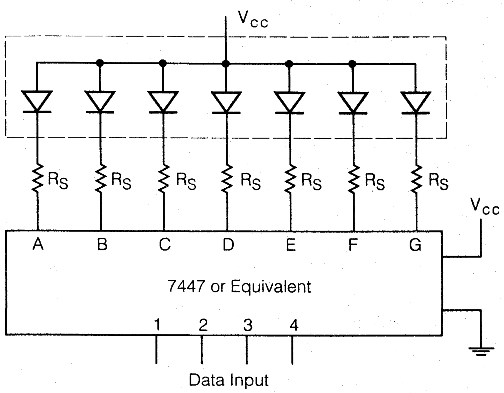


Figure 8. Open collector type driver with common anode display

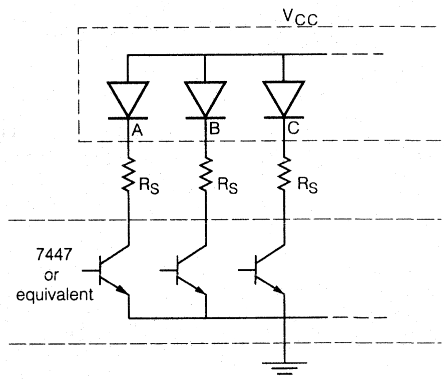
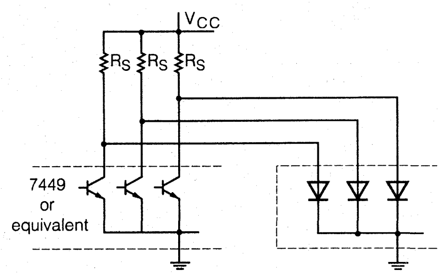


Figure 9. Open collector type driver with common cathode display



Selection

One factor in choosing the display and/or driver will be whether the display is a common cathode or common anode type display.

Another factor is that different drivers go low or high or can be wired into different configurations.

From Figures 6/7/8/9, it may appear obvious to combine the seven series resistors (Rs) into one common resistor in the common line. However this should not be done because of the possible variation in Vf from segment to segment. Variation in Vf can cause a variation in current, resulting in segment brightness differences.

Table 1 is list of some of the most common LED drivers available. Besides having different current drive capabilities, one product may have a feature which may make them easier to use in a particular application:

— Serial versus parallel input data
— Data latching type drivers
— Blanking
— Drive ripple blanking input (rbo) with pulse width modulation to vary brightness
— Multi-digit drivers
— Constant current drivers
— Advantage of a constant current driver as Vf may not affect brightness, important with different color LEDs.

Multiplexing

In a multiplex system, the corresponding segment of each digit is bussed together and driven from one segment drive via the usual current limiting resistors. The display data is presented serially by digit to the decoder driver together with the appropriate digit signal (Figure 10). For more information multiplexing, see Appnote 3 (Multiplexing LED Displays).

One way to simplify the design procedure for alphanumeric displays would be to consider Siemens Intelligent Displays. This device family incorporates all necessary interface control with drivers and memory built-in with the display. This means the designer need not be concerned about the memory, multiplex circuitry, character generator, or drivers for these are provided inside a modular unit. More information on these products is available in Siemens Optoelectronics Data Book.

Circuits shown in this Appnote are for reference only and are not the responsibility of Siemens Optoelectronics. Products are continually being improved by vendors and/or are obsoleted; therefore consult the factory.

Figure 10. Block diagram—4 digit multiplexed display

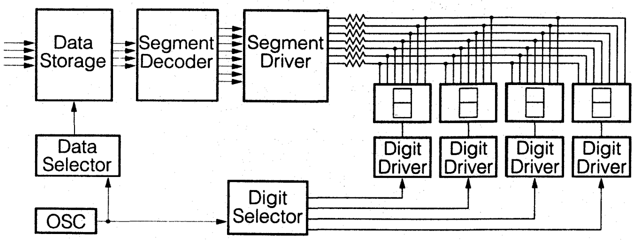


Table 1.

Single Digit Decoder/Drivers				
Part Number	**Manufacturer**	**If/Segment**	**Type**	**Comments**
7447 74247 7446	Fairchild Hitachi Motorola National Signetics Teledyne TI	40 mA	CA	BCD-to-7 segment, open coll, ripple blnkng
7448 74248	Fairchild Hitachi Motorola National Signetics TI	6 mA	CC	BCD-to-7 segment, int pull-up, ripple blnkng
7449 74249	Fairchild Hitachi Motorola National Signetics TI	8 mA	CC	BCD-to-7 segment, open coll, ripple blnkng
DS8857	National	60 mA	CA	BCD-to-7 segment, decoder, ripple blnkng
DS8858	National	50 mA	CC	BCD-to-7 segment, decoder, ripple blnkng
CD4511 4511 B MC14511	Fairchild National Motorola	25 mA	CC	BCD-to-7-segment, latched, blnkng
DS8647 DS8648	National	10 mA	CC	9 segment drivers
NE587	Signetics	50 mA	CA	BCD-to-7-segment, latched, blnkng, vari current
NE589	Signetics	50 mA	CC	BCD-to-7-segment, latched, blnkng, vari current
CA3161E	RCA	25 mA	CA	BCD-to-7-segment, constant current drivers
9368	Fairchild	20 mA	CC	BCD-to-7-segment, ripple blnkng
9374	Fairchild	15 mA	CA	BCD-to-7-segment, ripple blnkng

Table 1. (continued)

Multi-Digit Display Drivers				
Part Number	**Manufacturer**	**If/Segment**	**Type**	**Comments**
SDA2014	Siemens	12 mA	CC	2 or 4 digit, serial bcd input
SDA2131	Siemens	20 mA	CA	16 element serial input
MM5450	National	25 mA	CA	34 segment serial input, brightness control
MM5451	National	25 mA	CA	35 segment serial input, brightness control
MM74C912	National	100 mA	CC	6 digit, 7 segment+decimal, BCD decoder, output enble
MM74C911	National	100 mA	CC	4 digit, 8 segments controller/segment/driver
MM74917	National	100 mA	CC	6 digit, 7 segments+decimal, Hex decoder, output enble
DS8669	National	25 mA	CA	Dual BCD-to-7 segment decoder/driver
CA3168E	RCA	25 mA	CA	Dual BCD-to-7 segment decoder/driver
ICM7212 ICM7212A ICM7212M ICM7212AM	Intersil	8 mA	CA	4 digit, latched, 28 segment drivers, brightness cntl
ICM7218A	Intersil	20 mA	CA	8 digit, 8 segment (decoded/spcl), w/mem/drivers
ICM7218B	Intersil	10 mA	CC	8 digit, 8 segment (decoded/spcl), w/mem/drivers
ICM7218C	Intersil	20 mA	CA	8 digit, 8 segment (hex/bcd), w/mem/drivers
ICM7218D	Intersil	10 mA	CC	8 digit, 8 segment (hex/bcd), w/mem/drivers
ICM7218E	Intersil	20 mA	CA	8 digit, 8 segment (decoded/spcl), w/mem/drivers, cntls avble
TSC700A	Teledyne	11 mA	CA	4 digit decoder/driver, parallel output, brightness cntl
TSC7212A	Teledyne	5 mA	CA	4 digit decoder/driver, parallel output, brightness cntl
SAA1060	Signetics	40 mA	CA	16 element serial in/parallel out driver
Other Drivers				
XR-2000	Exar	400 mA	sink	5 darlington transistors, MOS-to-LED
XR-2201 XR-2202 XR-2203 XR-2204	Exar	500 mA	sink	7 darlington transistors, open collector w/diodes, TTL-to-LED, compatible to Sprague (ULN-xxxx)
CA3081	RCA	100 mA	sink	7 common emitter transistor array
CA3082	RCA	100 mA	source	7 common emitter transistor array
9665 9667	Fairchild	250 mA	sink	7 common emitter darlington transistor array
Bar Graph Drivers				
UAA180	Siemens	10 mA	n.a.	12 element bar driver
LM3914	National	2–20 mA	n.a.	10 element dot/bar linear output driver
LM3915	National	1–30 mA	n.a.	10 element dot/bar linear output driver

SIEMENS

The DLX713X, 5x7 Dot Matrix Intelligent Display® Device Appnote 25

By Dave Takagishi

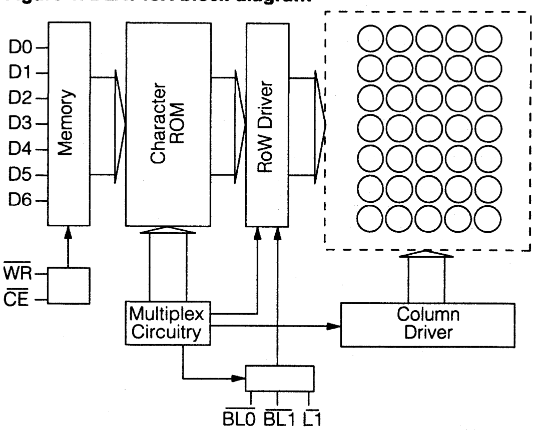
This application note is intended to serve as a design and application guide for users of the DLO7135 and DLG7137 Siemens Intelligent Displays. This appnote covers device electrical description, operation, general circuit design considerations and interfacing to microprocessors.

Electrical Description

The DLX713X intelligent alphanumeric 5x7 dot matrix display contains memory, character generator, multiplexing circuits, and drivers built into a single package.

Figure 1 is a block diagram of the DLX713X. The unit consists of 35 LED die arranged in a 5x7 pattern and a single CMOS integrated circuit chip. The IC chip contains the column drivers, row drivers, 128 character generator ROM, memory, multiplex and blanking circuitry.

Figure 1. DLX713X block diagram



Package

Thirty-five dots form a 0.48 x 0.68 inch overall character size in a 0.700 x 0.800 inch dual-in-line package. The ±50 degree wide viewing angle complements the large display and is the ideal display for industrial control applications. Display construction is filled reflector type with the intregrated circuit in the back also filled with IC-grade epoxy. This results in a very rugged part which is resistant to moisture, shock, and vibration.

Figure 2. Physical dimensions in inches (mm)

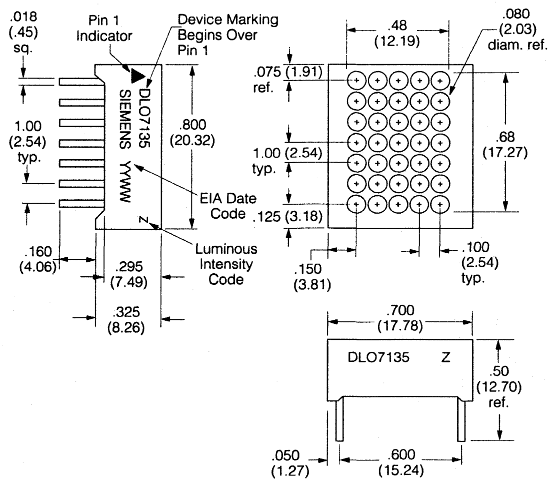


Table 1. Electrical inputs

Pin	Name	Pin	Name
1	V_{CC}	14	D6 data input (MSD)
2	$\overline{LT}$ lamp test	13	D5 data input
3	$\overline{CE}$ chip enable	12	D4 data input
4	$\overline{WR}$ write	11	D3 data input
5	$\overline{BL1}$ brightness	10	D2 data input
6	$\overline{BL0}$ brightness	9	D1 data input
7	GND	8	D0 data input (LSD)

Table 2. Pin description

V_{CC}	Positive Supply +5 V
GND	Ground
D0–D6	Data Lines, see Figure 3 (Character set)
$\overline{CE}$	Chip Enable (active low) Determines which device in an array will accept data
$\overline{WR}$	Write (active low) Data and chip enable must be present and stable before and after the write pulse (see DLX713X data sheet for timing)
$\overline{BL0}$, $\overline{BL1}$	Blanking Control Input (active low) Used to control level of display brightness
$\overline{LT}$	Lamp Test (active low) Causes all dots to light at 1/2 brightness

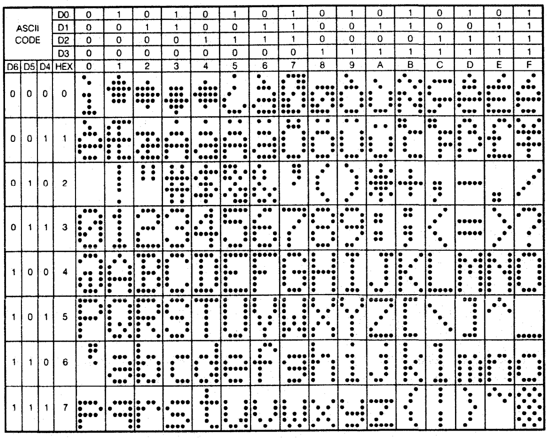
Operation

In a dot matrix display system, it is advantageous to use a multiplexed approach with 12 drivers (5 digit plus 7 segments) rather than 35 segment drivers, reducing the number of drives and interconnections required. A multiplexed system must be a synchronous system or the digits or elements may have different on (lit) times and therefore varying brightness.

The DLX713X is an internally multiplexed display but the data entry is asynchronous. Loading data is similar to writing into a RAM. Present the data, select the chip, and give a write signal. For a multidigit system, each digit has its own unique location and will display its contents until replaced by another code.

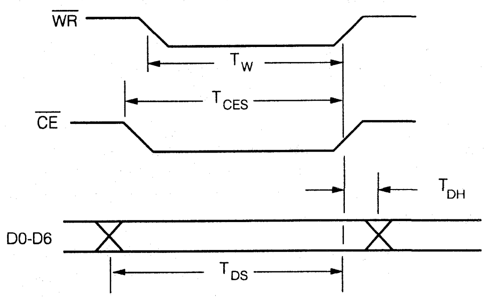
The waveforms of Figure 4 demonstrates the relationship of the signals required to generate a write cycle. Check the data sheet for minimum values required for each signal.

Figure 3. Character set



1. High=1 level. 2. Low=0 level.

Figure 4. Timing characteristics



Display Blanking and Dimming

The DLX713x Intelligent Display has the capability of three levels of brightness plus blank. Figure 5 shows the combination of $\overline{BL0}$ and $\overline{BL1}$ for the different levels of brightness. The $\overline{BL0}$ and $\overline{BL1}$ inputs are independent of write and chip enable and does not affect the contents of the internal memory. A flashing display can be achieved by pulsing the blanking pins at a 1–2 hertz rate. Either $\overline{BL0}$ or $\overline{BL1}$ should be held high to light up the display.

Table 3. Dimming and blanking control

Brightness Level	$\overline{BL1}$	$\overline{BL0}$
Blank	0	0
1/7 brightness	0	1
1/2 brightness	1	0
full brightness	1	1

Lamp Test

The lamp test when activated causes all dots on the display to be illuminated at 1/7 brightness. It does not destroy any previously stored characters. The lamp test function is independent of chip enable, write, and the settings of the blanking inputs.

This convenient test gives a visual indication that all dots are functioning properly. Because lamp test does not affect the display memory, it can be used as a cursor or pointer in a line of displays.

General Design Considerations

When using the DLX713X on a separate display board having more than six inches of cable length, it may be necessary to buffer all of the input lines. A non-inverting 74LS244 buffer can be used. The object is to prevent transient current into the DLX713x protection diodes. The buffers should be located on the display board and as close to the displays as possible.

Because of high switching currents caused by the multiplexing, local power supply bypass capacitors are also needed in many cases. These should be 10 volt, tantalum type having 10 uf capacitance. The capacitors may only be required every 2 displays depending on the line regulation and other noise generators.

Decoupling capacitors should also be used across V_{CC} and ground of each display. Typical value of these capacitors is 0.01 mF/10 V.

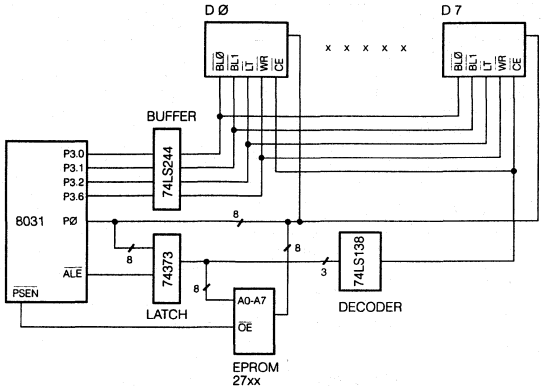
If small wire cables are used it is good engineering practice to calculate the wire resistance of the ground and the +5 volt wires. More than 0.2 volt drop (at 100 ma per digit) should be avoided, since this loss is in addition to any inaccuracies or load regulation of the power supply.

The 5 volt power supply for the DLX713X should be the same one supplying the V_{CC} to all logic devices. If a separate supply must be used then local buffers should be used on all the inputs and these buffers should be powered from the display power supply. This precaution is to avoid line transients or any logic signals to be higher than V_{CC} during power up.

Interfacing

For an eight digit display using the DLX713X, interfacing to a single chip microprocessor is easy and straight forward.

Figure 5. Block diagram of the Intel 8031 controller



Conclusion

Note that although other manufacturers' products are used in the examples, this application note does not imply specific endorsement, or warranty of other manufacturers' products by Siemens. The interface schemes shown demonstrate the simplicity of using the DLX713X dot matrix Intelligent Display. Slight timing differences may be encountered for various microprocessors, but can be resolved similar to those encountered when using different RAM's. The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

Program Listing

```
                                ; BY DAN WATSON
                                ; TO DO LAMP TEST,SET 100% BRIGHTNESS
                                ; AND WRITE 'SIEMENS*'

                                ; P3.0 = BLO\
                                ; P3.1 = BL1\
                                ; P3.2 = LT\
                                ; P3.6 = WR\

                                ; RO = DIGIT ADDRESS ( CHIP ENABLES – CE\ )
                                ; R1 = DIGIT COUNTER
                                ; R7 = R6 = R5 = WAIT REGISTERS

0000                            .ORG 00H
0000  02 00 03                      INIT:JMP BEGIN
0003  12 00 24                      BEGIN:CALL WAIT1         ; DELAY FOR uC TO STABILIZE
0006  75 B0 00                          MOV P3,#00H          ; LAMP TEST
0009  12 00 24                          CALL WAIT1           ; DISPLAY LT\ FOR A WHILE
000C  75 B0 07                          MOV P3,#07H          ; SET ALL 8 DISPLAYS TO 100% BRT
000F  00                                NOP
0010  00                                NOP
0011  78 00                             MOV R0,#00H          ; DIGIT 7 ADDRESS
0013  79 08                             MOV R1,#08H          ; 8 DIGIT COUNTER
0015  74 00                             MOV A,#00H           ; CLEAR ACC.
0017  90 00 37                          MOV DPTR,#TEXT       ; ADDRESS OF THE MESSAGE
001A  93                            WRT:MOVC A,@A+DPTR       ; LOAD FIRST CHAR. INTO THE ACC.
001B  F2                                MOVX @R0,A           ; DIGIT ADDRESS AND DATA WRITE
001C  A3                                INC DPTR             ; NEXT CHARACTER ADDRESS
001D  08                                INC R0               ; NEXT DIGIT (6) ADDRESS
001E  E4                                CLR A
001F  D9 F9                             DJNZ R1,WRT          ; WRITE ALL 8 CHAR.
0021  00                            GO:NOP
0022  01 21                             JMP GO               ; MESSAGE ALWAYS ON
0024
0024
0024  7F 88                         WAIT1:MOV R7,#88H        ; DELAY LOOPS
0026  00                                NOP
0027  7E FF                         WAIT2:MOV R6,#FFH
0029  00                                NOP
002A  7D FF                         WAIT3:MOV R5,#FFH
002C  00                                NOP
002D  DD FE                             DJNZ R5,$
002F  00                                NOP
0030  DE F8                             DJNZ R6,WAIT3
0032  00                                NOP
0033  DF F2                             DJNZ R7,WAIT2
0035  00                                NOP
0036  22                                RET

0037  53 49 45 4D 45                TEXT:DB 'SIEMENS*'
003C  4E 53 2A
003F
003F                            .END
```

SIEMENS

SFH900—A Low-Cost Miniature Reflex Optical Sensor®
Appnote 26

Whether for an industrial plant or a hobbyist's drilling machine, an electric drive will hardly be acceptable nowadays without speed control. Incremental bar patterns simply applied to rotating shafts can be detected by the new Siemens reflex optical sensor, the SFH900. The information can be processed with a minimum of circuitry, whether for a high rate of black-to-white transitions or just single, slow transitions.

Construction

The SFH900 optical sensor is a remarkable component even by virtue of its shape alone. Its maximum height of 2.2 mm is in the trend of today's electronics, of putting a large number of functions into a very small space. The small dimensions allow it to be used where ordinary optical sensors run into space or other problems. Figure 1 is an enlarged picture of the device. Dimensions and pin configuration are shown in Figure 2.

Fabricated by lead frame technique in a thermoplastic package, the sensor uses a GaAs infrared diode as a radiation emitter and a large area phototransistor as the detector. High sensitivity is ensured by a 1 mm^2 radiation sensitive area and a current gain of almost 1000. The effect of unwanted ambient light is almost screened out by a filter.

Figure 1. SFH900 reflex optical sensor, front and back view

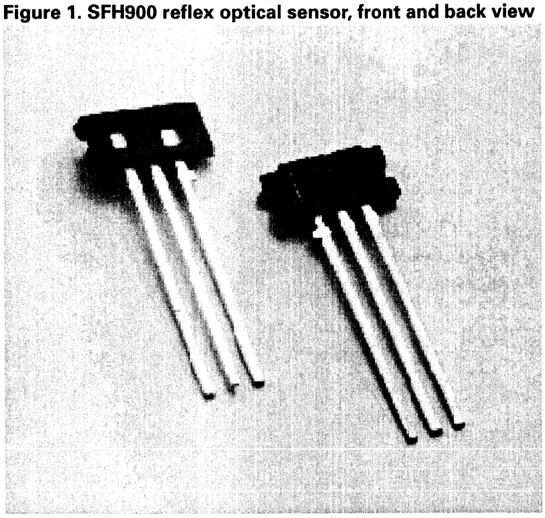
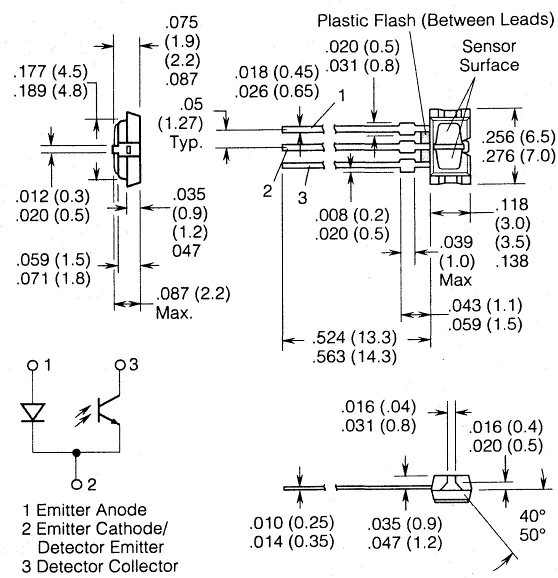
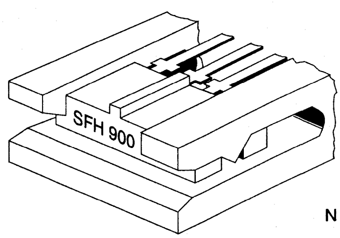


Figure 2. SFH900 outline dimensions and pin connections



Two fixing notches are a help in mounting the device. Lead frame technology accurately locates the optically active areas relative to these notches and thus to the component body. Figure 3 is an example of one form of mounting.

Figure 3. Suggestion for mounting the SFH900



Projections N in the flexible plastic clamp locate in corresponding notches in the body of the optical sensor

Characteristics

Main technical data are given in the Table 1. Turn-on and turn-off times are also important. These depend essentially on the collector current I_C and the load resistance R_L. Typical switching times for I_C=1 mA and R_L=1 kΩ are 50 to 70 μs.

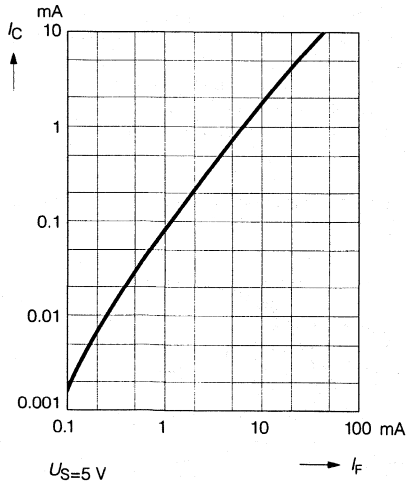
The user will be mainly concerned with the following points:

- What collector current (I_C) can be expected under given static conditions?
- What are the signal amplitudes when scanning bar patterns of different pitches?
- What is the temperature dependence of the collector current and what is the repeatability of the measured values?

Collector Current

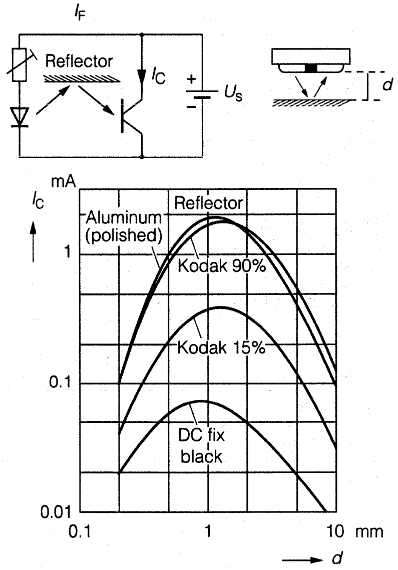
Dependence of collector current on emitter diode forward current (I_F) is almost linear at forward currents above 10 mA (Figure 4). At currents below 1 mA the dependency shows almost a square law. The measurement was made with a standard reflector (Kodak neutral white test card, r=90%) at a distance of 1 mm. Figure 5 shows I_C characteristics for distances of 0.2 to 10 mm at a constant forward current of 10 mA. The curves are for four different reflecting materials: two standard Kodak reflectors with 15% and 90% reflection, polished aluminum and a strongly absorbing foil. DC-fix adhesive tapes and other tapes commonly used for printed circuit layouts proved particularly suitable. It should be mentioned that the curve for polished aluminum in Figure 5 is very similar to the Kodak reflector response with r=90%, in spite of the reflection being mirrored by the metal and diffused by the standard reflector, as a result of the wide directional characteristics of the emitter and detector.

Figure 4. SFH900 collector current (I_C) versus forward current (I_F) with 90% diffuse reflection at distance d=1 mm and with U_S=5 V



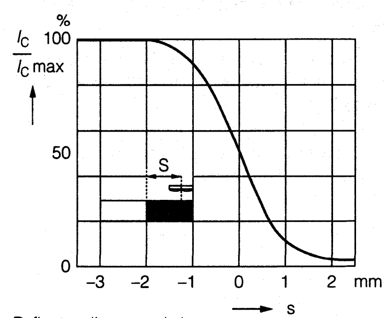
At short distances (e.g., d=0.25 mm) very large changes of current per unit distance are obtained. Because of these steep edges, which can only be used dynamically, the SFH900 may also be utilized as a microphone.

Figure 5. SFH900 collector current I_C versus reflector distance d with different reflector material



Forward current I_F=10 mA
Operating voltage U_S = 5 V

Figure 6. Resolution of a black to white transition. Relative collector current versus sensor position "s"



Reflector distance d=1 mm
Emitter diode current I_F=10 mA

Table 1. Selective characteristics of SFH900

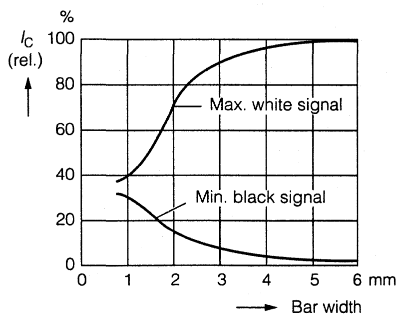
Emitter (GaAs infrared diode)				
Reverse Voltage		U_R	6	V
Forward dc Current		I_F	50	mA
Surge Current (t≤10 µs)		i_{FSM}	1.5	A
Power Dissipation (T_{amb}=40°C)		P_{tot}	80	mW
Thermal Resistance		R_{thJU}	750	K/W
Detector (Silicon Phototransistor)				
Collector-emitter Voltage		U_{CEO}	30	V
Emitter-collector Voltage		U_{ECO}	7	V
Collector Current		I_C	10	mA
Total Power Dissipation (T_{amb}=40°C)		P_{tot}	100	mW
Collector-emitter Leakage Current (U_{CE} =10 V)		I_{CEO}	20(≤200)	nA
Photocurrent Under Ambient Light (U_{CE}=5 V)				
E_E=0.5 mW/cm^2		I_F	≤3	mA
Reflex Optical Sensor				
Storage Temperature Range		T_S	–40 to +85	°C
Ambient Temperature Range		T_U	–40 to +85	°C
Junction Temperature		T_j	100	°C
Total Power Dissipation (T_{amb}=40°C)		P_{tot}	150	mW
Collector Current (I_F=10 mA; U_{CE}=5 V; d=1 mm)	SFH900-1 SFH900-2	I_{CE} I_{CE}	≥0.3 ≥0.5	mA mA

Resolution of Black and White Patterns

As can be seen from Figure 5, strongly reflecting and badly reflecting materials give collector currents differing by a factor of about 25. Strongly reflecting means >>white<< badly reflecting >>black<<.

If a black to white transition is scanned, the displacement distance between the >>fully white<< signal and the >>fully black<< signal is 4 to 5 mm (Figure 6).

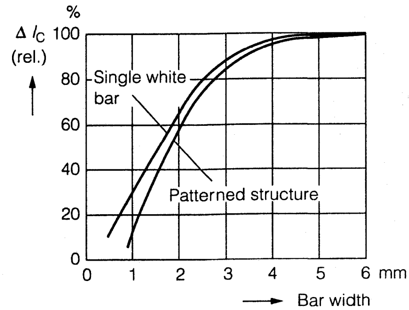
Figure 7. Maximum and minimum collector current when scanning a black white pattern



If, in contrast, a regular bar pattern is scanned, the signal amplitude becomes smaller the smaller the bar width. Figure 7 shows clearly how the excursion is affected: the maximum white signal becomes smaller with decreasing bar width, while the minimum black signal becomes larger. Figure 8 shows the signal excursion itself, to make it clearer. Here a regular pattern and a single white bar are compared. The excursion is referred to a single black to white transition corresponding to a 100% signal excursion.

Figure 8. Relative signal excursion versus white bar width

I_F = 10mA, d = 1 mm



A bar width of 3 mm can thus be detected without significant loss of sensitivity. The signal excursion, however, drops to as low as 10% using a grid of 1 mm bar width. An apparently higher signal excursion is obtained when a single 1 mm wide white bar on a black background is scanned. The result is then about 30%, as shown in Figure 8.

The optical sensor can be used for scanning in any position, regardless of whether the emitter-detector axis is at right-angles to the scanning direction. Tests have shown that the device sensitivity is independent of direction. If a white spot on a black background (or vice versa) is to be detected without loss of sensitivity, this should have a minimum area of 5x5 mm. From this we can conclude that a pattern bar must not be larger than 5 mm.

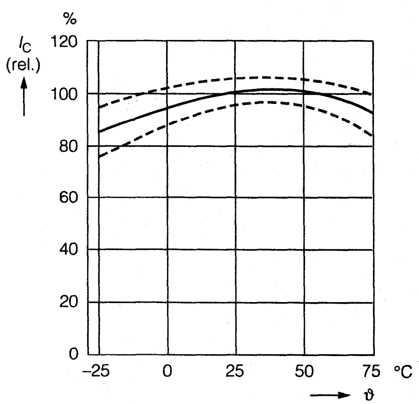
Thus the resolution capability of the SFH900 seems to be limited to bar widths of 1 to 2 mm minimum. In fact, however, considerably higher resolutions can be obtained when gratings are used. An example is given below.

Temperature Dependence

The temperature dependence of the output signal is shown in Figure 9. This fortunately very small dependence results from the combination of the temperature dependent diode emission (approximately –0.55%/K) with the temperature dependent current gain of the phototransistor (approximately +0.9%/K). As these two parameters partly compensate for each other the temperature dependence of the output signal is fairly small.

There is a spread of characteristics in the different devices but they remain within the specified tolerance range, allowing for aging, with a probability of at least 95%.

Figure 9. Relative collector current versus temperature



U_S = 5 V d = 1 mm
I_F = 10 mA r = 90%
——— typical response
- - - - spread of characteristics (including long-term effects)

Applications

Speed Control for dc Motors

A simple speed regulator circuit for small dc motors can be designed using the TCA955 device. Figure 10 is an example. The teeth of a toothed wheel on the motor shaft serve as reflectors (40 teeth on a wheel of approximately 60 mm diameter). Pulses from the optical sensor are converted by the TCA955 into a dc voltage proportional to speed. The pulse signal is first amplified, then frequency doubled, then fed to a monostable which produces a square wave with a constant pulse duration determined by the R_1 C_1 product. The mean value of this pulse train is determined by capacitor C2 and an 8.7 kΩ internal resistor.

The voltage present at C2, still with a slight triangular modulation, is compared with an internal set value. The difference is amplified and determines the duty cycle in the subsequent mark-to-space ratio converter. The motor is connected to the operating voltage via a BD675 switching stage, which runs to the rhythm of the duty cycle. A larger mark-to-space ratio causes the speed to increase. The desired frequency can be set by P1 over a wide range.

Speed Control for ac Motors

This is mainly intended for use in the consumer field, in such things as kitchen appliances and drilling machines. It is important that the speed indicator should have a very low current consumption as it is supplied from a simple line rectifier circuit using a series resistor. The specimen circuit in Figure 11 has an emitter diode current of only 2 mA. Signal processing and triac triggering are done by the new TLB3101 phase control I_C. Total current needed for control is around 7 mA, including the SFH900.

Pulses from the optical sensor are first amplified, then converted by a monostable to constant pulse width and finally filtered to give a mean value. By comparison with a sawtooth voltage the gate trigger time for the triac is fixed. A soft start is given by transistor T1.

The range of speed regulation is 5000 to 15,000 rpm. The reflector is a disc mounted on the motor shaft, and at its periphery this disc has, as an example, 5 pairs of black and white segments.

Figure 10. Speed regulator using SFH900 and TCA955 integrated speed control

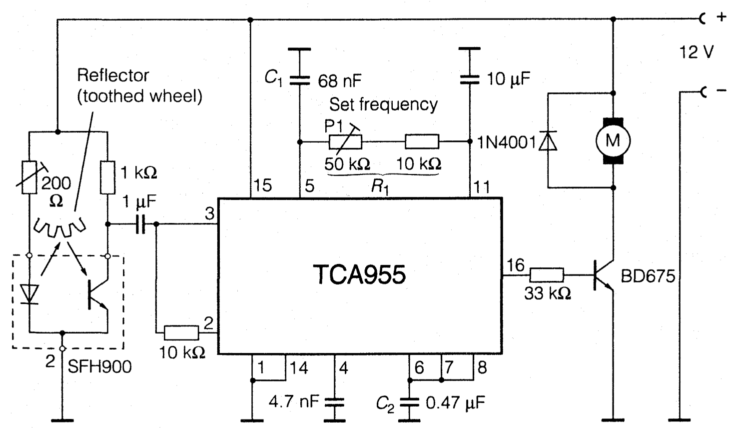
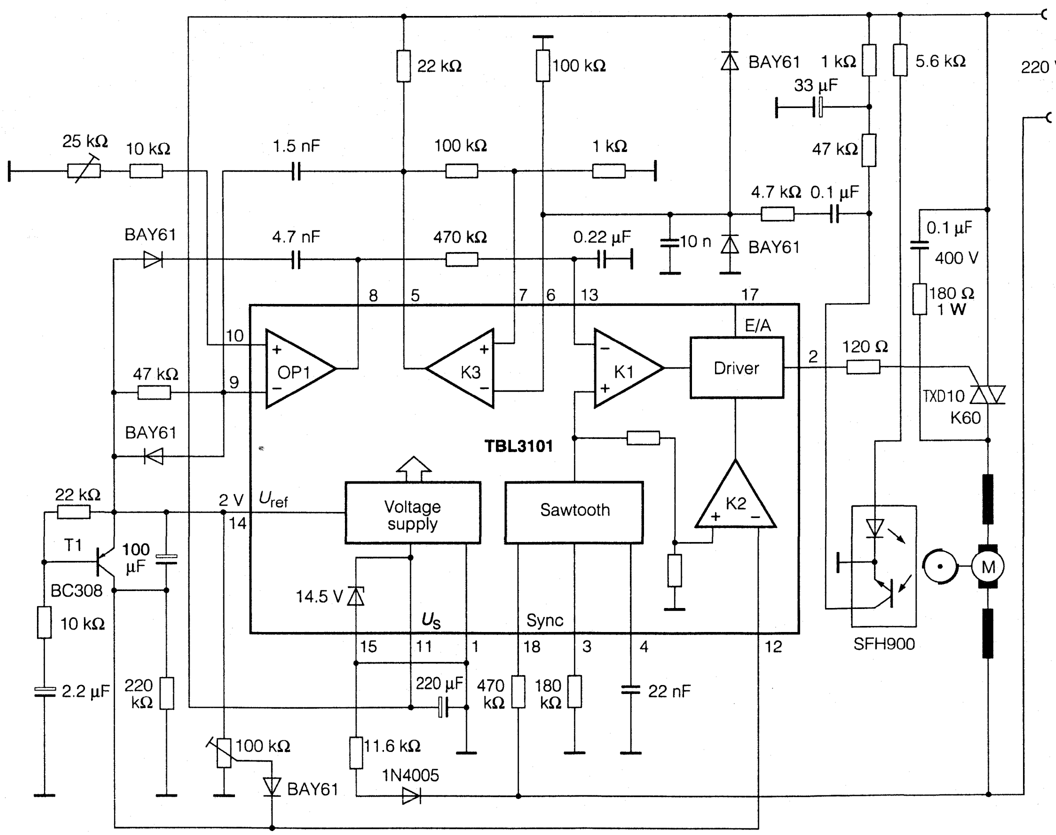


Figure 11. Speed regulator for an ac motor using SFH900 and TLB3101



Shaft Encoder with Direction Sensing

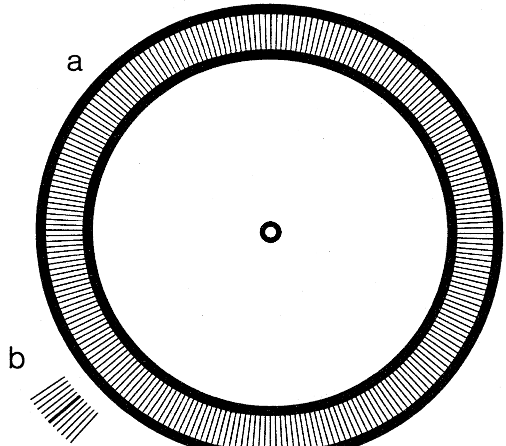
This example shows how gratings can be used to give a considerable increase in resolution. A transparent disc of about 130 mm diameter has an array of 200 opaque bars at its periphery (Figure 12a). The bar width is thus about 1 mm. A second grating with reflecting white bars is placed under the disc. If the disc pattern and the grating beneath are set gap to gap, the detector >>sees<< 100% black. If the bars of the two gratings are on top of each other the image appears as 50% white. So, when the disc is rotating the useful amplitude is therefore about 50% of the full black-to-white excursion.

The grating pattern is constructed so that one half is displaced by 90° of a grid period with respect to the other half. If a reflex optical sensor is assigned to each half, on rotation of the disc the output signals will be roughly sinusoidal and displaced by 90° from each other. This means that patterns of half bar width can be successfully resolved.

In further processing both sinewave voltages are converted into square waveforms, also phase-shifted by 90° (Figure 13).

The rising edge of on square-wave (signal 1) is used for counting: It triggers a monoflop which generates a pulse of short duration relative to the square-wave period. The other, 90° shifted, square-wave controls the direction of the counter (Low=forward, High=backward).

Figure 12. Example—patterned disc (a) and counting grid (b)



According to the direction command, the conditions in Figure 13 come into effect. The active clock edge coincides with either the low level or the high level of signal 2. Counting therefore takes place in accordance with forward or backward rotation of the shaft. Figure 14 gives the detailed circuit diagram of the shaft encoder. The counter used has a range of two decades and gives the BCD separately for each digit.

A 7-segment decoder-driver follows this for each of the two LED displays. The number of digits can be increased by cascading several stages.

For the purposes of explanation any bar in the pattern can be considered as the starting point and the counter reset to zero using the reset key. If now the disc is turned at any speed in either direction with respect to the stationary mark, the counter indicates the bar number difference with respect to the starting point. As only dc voltage coupling is used the rotational speed may have any arbitrary minimum value.

Figure 13. Waveforms—shaft encoder operation with direction sensing

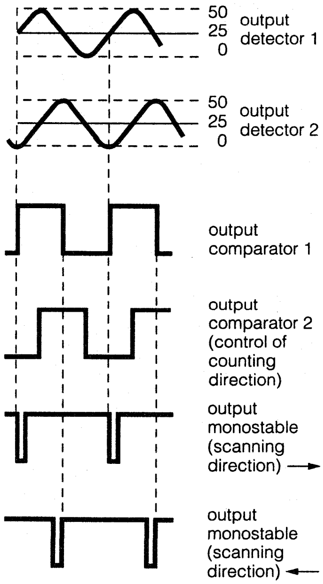
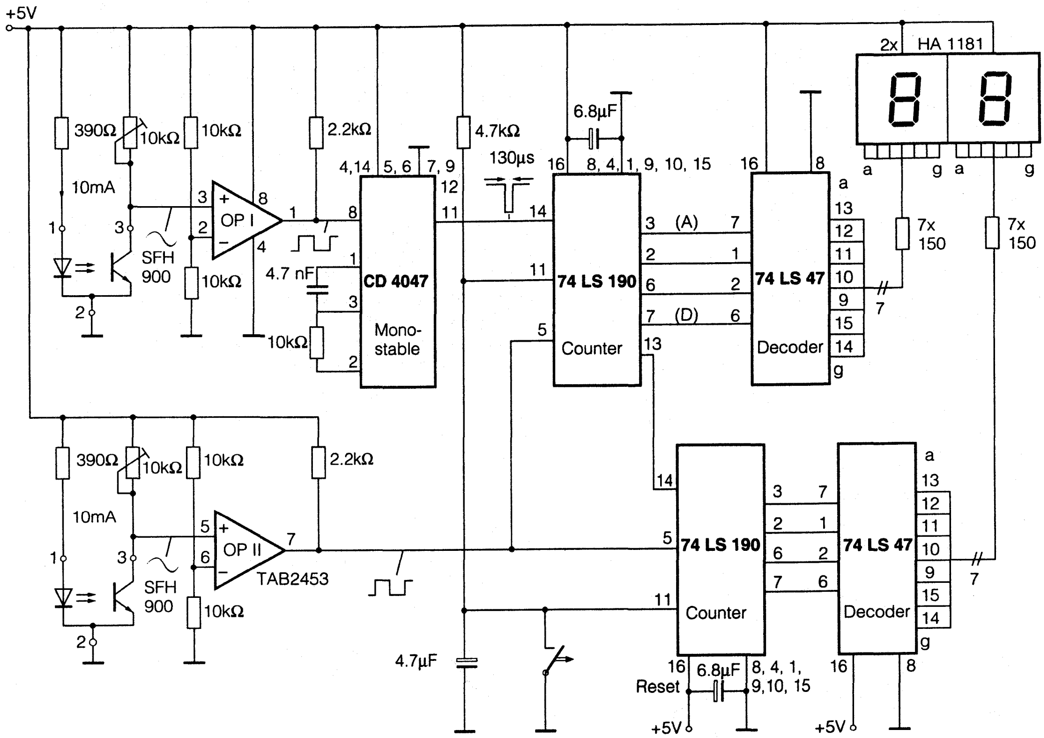


Figure 14. SFH900 circuit for shaft encoder with direction sensing



SIEMENS

The DLO4135/DLG4137 5x7 Dot Matrix Intelligent Display®
Appnote 28

by Dave Takagishi

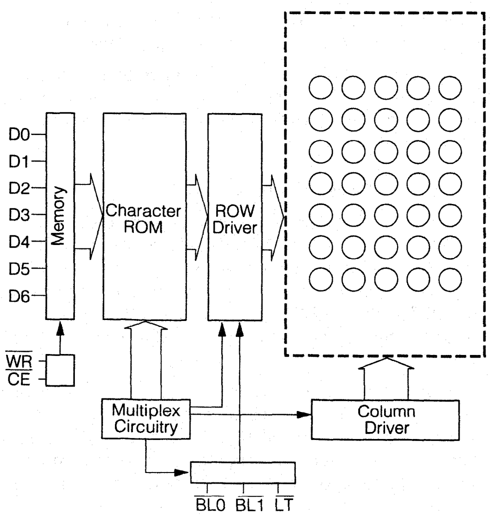
This application note is intended to serve as a design and application guide for users of the DLO4135 and DLG4137 Siemens Intelligent Displays. This appnote covers device electrical description, operation, general circuit design considerations, and interfacing to microprocessors.

Electrical Description

The DLO4135/DLG4137 Intelligent Alphanumeric 5x7 Dot Matrix Display contains memory, character generator, multiplexing circuits, and drivers built into a single package.

Figure 1 is a block diagram of DLO4135/DLG4137. The unit consists of 35 LED die arranged in a 5x7 pattern and a single CMOS integrated circuit chip. The IC chip contains the column drivers, row drivers, 128 character generator ROM, memory, multiplex and blanking circuitry.

Figure 1. DLO4135/DLG4137 block diagram



Thirty-five dots form a 0.30 x 0.43 inch overall character size in a.500 x 1.00 inch dual-in-line package. The ±50 degree wide viewing angle complements the display and is the ideal display for industrial control applications. Display construction is filled reflector type with the integrated circuit in the back also filled with IC-grade epoxy. This results in a very rugged part which is resistant to moisture, shock and vibration.

Figure 2. Physical dimensions in inches (mm)

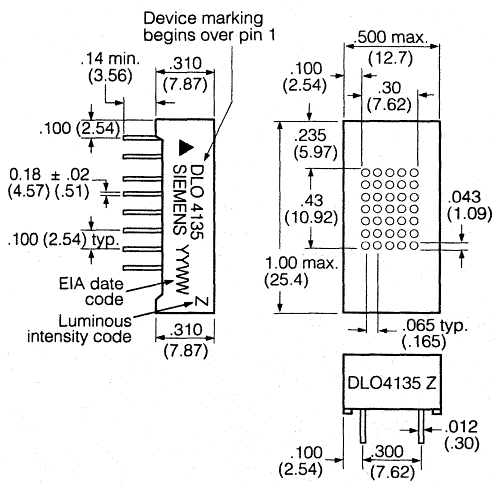


Table 1. DLO4135/DLG4137 pin functions

Pin	Function	Pin	Function
1	$\overline{LT}$ Lamp Test	9	D0 data LSB
2	$\overline{WR}$ Write	10	D1 data
3	$\overline{BL1}$ Brightness	11	D2 data
4	$\overline{BL0}$ Brightness	12	D3 data
5	No Pin	13	D4 data
6	No Pin	14	D5 data
7	$\overline{CE}$ Chip Enable	15	D6 data MSB
8	GND	16	$+V_{CC}$

Table 2. Pin description

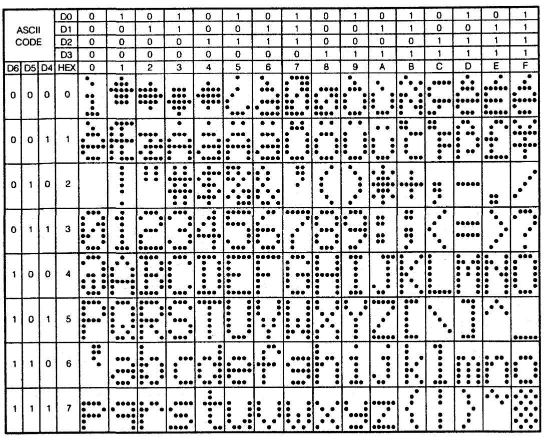
V_{CC}	Positive Supply +5 volts
GND	Ground
D0-D6	Data Lines, see Figure 3 (Character set)
$\overline{CE}$	Chip Enable (active low) This determines which device in an array will accept data
$\overline{WR}$	Write (active low) Data and chip enable must be present and stable before and after the write pulse (see data sheet for timing)
$\overline{BL0}$, $\overline{BL1}$	Blanking Control Input (active low) Used to control the level of display brightness
$\overline{LT}$	Lamp Test (active low) Causes all dots to light at 1/2 brightness

Operation

In a dot matrix display system, it is advantageous to use a multiplexed approach with 12 drivers (5 digit plus 7 segments) rather than 35 segment drivers. This obviously reduces the number of drivers and interconnections required. A multiplexed system must be a synchronous system, or the digits or elements may have different on (lit) times and therefore varying brightness.

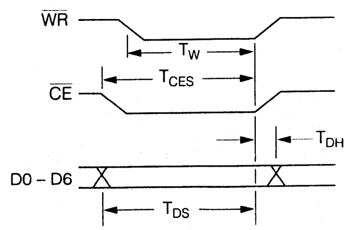
The DLO4135/DLG4137 is an internally multiplexed display, but the data entry is asynchronous. Loading data is similar to writing into a RAM. Present the data, select the chip, and give a write signal. For a multi digit system, each digit has its own unique address location and will display its contents until replaced by another code. The waveforms of Figure 4 shows the relationship of the signals required to generate a write cycle. Check the data sheet for minimum values required for each signal.

Figure 3. Character set



1. High=1 level. 2. Low=0 level.

Figure 4. Timing characteristics



Display Blanking and Dimming

The DLO4135/DLG4137 Intelligent Display has the capability of three levels of brightness plus blank. Figure 5 shows the combination of $\overline{BL0}$ and $\overline{BL1}$ for the different levels of brightness. The $\overline{BL0}$ and $\overline{BL1}$ inputs are independent of write and chip enable and does not affect the contents of the internal memory. A flashing display can be achieved by pulsing the blanking pins at a 1–2 hertz rate. Either $\overline{BL0}$ or $\overline{BL1}$ should be held high to light up the display.

Table 3. Dimming and blanking control

Brightness Level	$\overline{BL1}$	$\overline{BL0}$
Blank	0	0
1/7 brightness	0	1
1/2 brightness	1	0
full brightness	1	1

Lamp Test

The lamp test when activated causes all dots on the display to be illuminated at 1/7 brightness. It does not destroy any previously stored characters. The lamp test function is independent of chip enable, write, and the settings of the blanking inputs.

This convenient test gives a visual indication that all dots are functioning properly. The lamp test can be used as a cursor or pointer in a line of displays because it does not affect the display memory.

General Design Considerations

When using the DLO4135/DLG4137 on a separate display board having more than 6 inches of cable length, it may be necessary to buffer all of the input lines. A non-inverting 74LS244 buffer can be used. The object is to prevent current transient into the DLO4135/DLG4137 protection diodes. The buffers should be located on the display board and as close to the displays as possible.

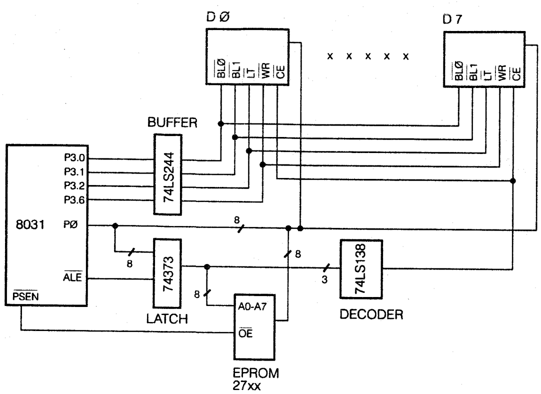
Because of high switching currents caused by the multiplexing, local power supply by-pass-capacitors are also needed in many cases. These should be 10 volt, tantalum type having 10 uf capacitance. The capacitors may only be required every 2 displays depending on the line regulation and other noise generators.

Decoupling capacitors should also be used across V_{CC} and ground of each display. Typical value of these capacitors is 0.01 mF/10 V.

If small wire cables are used, good engineering practice is to calculate the wire resistance of the ground and the +5 volt wires. More than 0.2 volt drop (at 100 ma per digit) should be avoided, since this loss is in addition to any inaccuracies or load regulation of the power supply.

The 5 volt power supply for the DLO4135/DLG4137 should be the same one supplying the V_{CC} to all logic devices. If a separate power supply must be used, then local buffers should be used on all the inputs. These buffers should be powered from the display power supply. This precaution is to avoid line transients or any logic signals to be higher than V_{CC} during power up.

Figure 5. Block diagram of the Intel 8031 controller



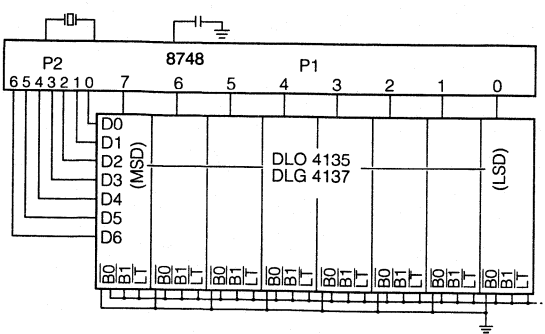
Interfacing

For an eight digit display using the DLO4135/DLG4137, interfacing to a single chip microprocessor such as the 8748, is easy and straight forward. One approach may be to dedicate one port for the seven data signals and another 8-bit port for the write signals. The schematic is shown in Figure 6.

I/O or Memory Mapped System

For a memory mapped system using a processor such as the 8080 or 8085, the interfacing is also straight-forward. Each display is treated as a memory location with its own address, like another I/O or RAM location. See Figure 7.

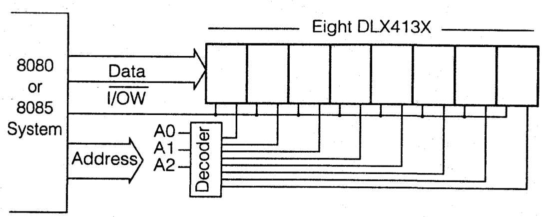
Figure 6. DLO4135/DLG4137 with 8748



Subroutine to Load an 8-digit Display using the DLO4135/DLG4137

```
                          ; DATA IN RAM 10H-17H
                            (MSD-LSD)
INIT    ORL   P1,#0FFH    ; PORT 1 ALL HIGH (WRITE)
        ORL   P2,#00H     ; PORT 2 ALL LOW (DATA)
        MOV   R1,#OFH     ; RAM ADDRESS—1
        MOV   R2,#0FEH    ; WRITE PULSE
        MOV   R3,#08H     ; COUNTER
START:  INC   R1          ; INCREMENT RAM POINTER
DATA:   MOV   A,@R1       ; FETCH DATA FROM RAM
        OUTL  P2,A        ; LOAD PORT 2
        MOV   A,R2        ; RECALL WRITE
        RR    A           ; SHIFT A TO NEXT WRITE
        MOV   R2,A        ; SAVE WRITE
WRITE:  OUTL  P1,A        ; SEND WRITE PULSE
        MOV   A,#OFFH     ; WAIT
        OUTL  P1,A        ; RESET WRITE PULSE
        DJNZ  R3,START    ; LOAD COMPLETE?
        RET               ; RETURN TO MAIN PROGRAM
```

Figure 7. Block diagram for 8-digit DLO4135/DLG4137



Routine for an 8-Digit Display using the DLO4135/DLG4137 and 8085 or 8080 Microprocessor

```
                        ; DATA TO BE DISPLAYED IS IN
                        ; A0 (LSD) THRU A7 (MSD)
                        ;
                        ; DISPLAY ADDRESS C00X
                        ; LSD IS RIGHT MOST DIGIT
                        ;
                        ; DOES NOT SAVE REG A,B,H,L,D,E
                        ;
DADD    EQU   0A000H    ; DATA ADDRESS LOCATION
DPAD    EQU   0C000H    ; DISPLAY ADDRESS
                          LOCATION
LEN     EQU   08H       ; DISPLAY LENGTH
                        ;
ORG     100H
                        ;
DISP:   LXI   H,DADD    ; LOAD DATA ADDRESS
        LXI   D,DPAD    ; LOAD DISPLAY ADDRESS
        MVI   B,LEN     ; LOAD DISPLAY LENGTH
DISP1:  MOV   A,M       ; GET DATA
        XCHG            ; XCHG H/L & D/E
        MOV   M,A       ; LOAD DISPLAY FROM REG A
        XCHG            ; RESTORE H/L & D/E
        INX   D         ; INCREMENT DISPLAY ADDRESS
        INX   H         ; INCREMENT DATA ADDRESS
        DCR   B         ; DECREMENT LENGTH COUNTER
        JNZ   DISP1     ; END OF DISPLAY?
        RET             ; RETURN TO MAIN PROGRAM
```

Conclusion

Note that although other manufacturers' products are used in the examples, this application note does not imply specific endorsement, or warranty of other manufacturer's products by Siemens. The interface schemes shown demonstrate the simplicity of using the DLO4135/DLG4137 dot matrix Intelligent Display. Slight timing differences may be encountered for various microprocessors, but can be resolved using similar methods as those used when using interfacing microprocessors with various RAMs. The techniques used in the examples were shown for their generality. The user will undoubtedly invent other schemes to optimize his particular system to its requirements.

Program Listing

```
                              ; BY DAN WATSON
                              ; TO DO LAMP TEST, SET 100% BRIGHTNESS
                              ; AND WRITE 'SIEMENS*'

                              ; P3.0 = BLO\
                              ; P3.1 = BL1\
                              ; P3.2 = LT\
                              ; P3.6 = WR\

                              ; RO = DIGIT ADDRESS ( CHIP ENABLES – CE\ )
                              ; R1 = DIGIT COUNTER
                              ; R7 = R6 = R5 = WAIT REGISTERS

0000                          .ORG 00H
0000  02 00 03                    INIT:JMP BEGIN
0003  12 00 24                    BEGIN:CALL WAIT1       ; DELAY FOR uC TO STABILIZE
0006  75 B0 00                        MOV P3,#00H        ; LAMP TEST
0009  12 00 24                        CALL WAIT1         ; DISPLAY LT\ FOR A WHILE
000C  75 B0 07                        MOV P3,#07H        ; SET ALL 8 DISPLAYS TO 100% BRT
000F  00                              NOP
0010  00                              NOP
0011  78 00                           MOV R0,#00H        ; DIGIT 7 ADDRESS
0013  79 08                           MOV R1,#08H        ; 8 DIGIT COUNTER
0015  74 00                           MOV A,#00H         ; CLEAR ACC.
0017  90 00 37                        MOV DPTR,#TEXT     ; ADDRESS OF THE MESSAGE
001A  93                          WRT:MOVC A,@A+DPTR     ; LOAD FIRST CHAR. INTO THE ACC.
001B  F2                              MOVX @R0,A         ; DIGIT ADDRESS AND DATA WRITE
001C  A3                              INC DPTR           ; NEXT CHARACTER ADDRESS
001D  08                              INC R0             ; NEXT DIGIT (6) ADDRESS
001E  E4                              CLR A
001F  D9 F9                           DJNZ R1,WRT        ; WRITE ALL 8 CHAR.
0021  00                          GO:NOP
0022  01 21                           JMP GO             ; MESSAGE ALWAYS ON
0024
0024
0024  7F 88                       WAIT1:MOV R7,#88H      ; DELAY LOOPS
0026  00                              NOP
0027  7E FF                       WAIT2:MOV R6,#FFH
0029  00                              NOP
002A  7D FF                       WAIT3:MOV R5,#FFH
002C  00                              NOP
002D  DD FE                           DJNZ R5,$
002F  00                              NOP
0030  DE F8                           DJNZ R6,WAIT3
0032  00                              NOP
0033  DF F2                           DJNZ R7,WAIT2
0035  00                              NOP
0036  22                              RET

0037  53 49 45 4D 45              TEXT:DB 'SIEMENS*'
003C  4E 53 2A
003F
003F                          .END
```

SIEMENS

Serial Intelligent Display® Device Appnote 29

by Dave Takagishi

This application note describes a method of obtaining a serial input display with a selected number of digits using an 8051/8031 microprocessor and DL2416 Intelligent Displays. The DL2416 has been used only as an example for this Appnote; other Intelligent Displays can be used instead.

Introduction

A parallel bus configuration is frequently used to transfer data to a microprocessor when it is used on a single card system. However, if the system is not physically small in number of chips or has multiple cards, data handling becomes cumbersome and costly. For long distances, serial communications over a two or four wire links is desirable and is economically attractive. However, the trade-off between cost and speed has to be considered by the designer.

Description

The DL2416 Intelligent Display is a 0.160" four character, 17 segment, LED display module with on-board memory, character generator, multiplexer and display drivers integrated into a custom integrated circuit. This eliminates the necessity to design external circuitry normally required to drive a multiplexed display. Using these important attributes of the Intelligent Display, the designer now only has to provide for interfacing, which is a seven-bit ASCII parallel code, a two-bit address, and a write signal. The procedure for writing these commands is similar to those used for an external Random Access Memory.

The serial/parallel and parallel/serial conversion is normally accomplished by using a UART (Universal Asynchronous Receiver/Transmitter) or a USART (Universal Synchronous/Asynchronous Receiver/Transmitter). The 8031 is a very attractive microcontroller to use in this application because it has an integral UART. This integral UART provides the designer with the means for controlling the conversion of serial into parallel information or vice-versa. The 8031 has more RAM than the popular 8048, but the operation and instruction sets are very similar. Refer to a 8031 data sheet for a complete description of the product.

Circuit Description

The block diagrams of the 8031 (Figure1) and the DL2416 (Figure 2) show the internal structure of these devices. By combining the DL2416, an easy to use peripheral device in a parallel system, and the 8031 results in a low cost, simple serial display system. A 32-digit system can be built using an 8031 microprocessor, an 8212 or equivalent latch, a 2716 EPROM, and a 75189 IC for interfacing to 20 mA or RS232 input lines. Buffers were added to minimize the long cable noise spikes and interface loading on the bus. See Figure 3 for system schematic.

Software Considerations

This system, as described, is set up to receive data only at 100 baud rate. Additional software is required for transmit routine. For a given data rate and (data format is start bit, 9-data bits and a stop bit) three sections of software and possibly a special crystal oscillator frequency may be required for a given transmit rate. On power-up or reset, the serial port and timer control words must be initialized.

Special control functions have been included in this program as follows:

- Power Up
- Return
- Backspace
- Line Feed

See Program Listing on last page of appnote.

Conclusion

This Application Note has introduced the ease of interfacing the DL2416 to any microprocessor. By combining the DL2416 and the 8031, difficulties usually associated with serial conversion using software and its attendant timing problems can be easily overcome.

Siemens Optoelectronic Division does not endorse or guarantee other manufacturer's products used in this Application Note.

Figure 1. 8031 block diagram

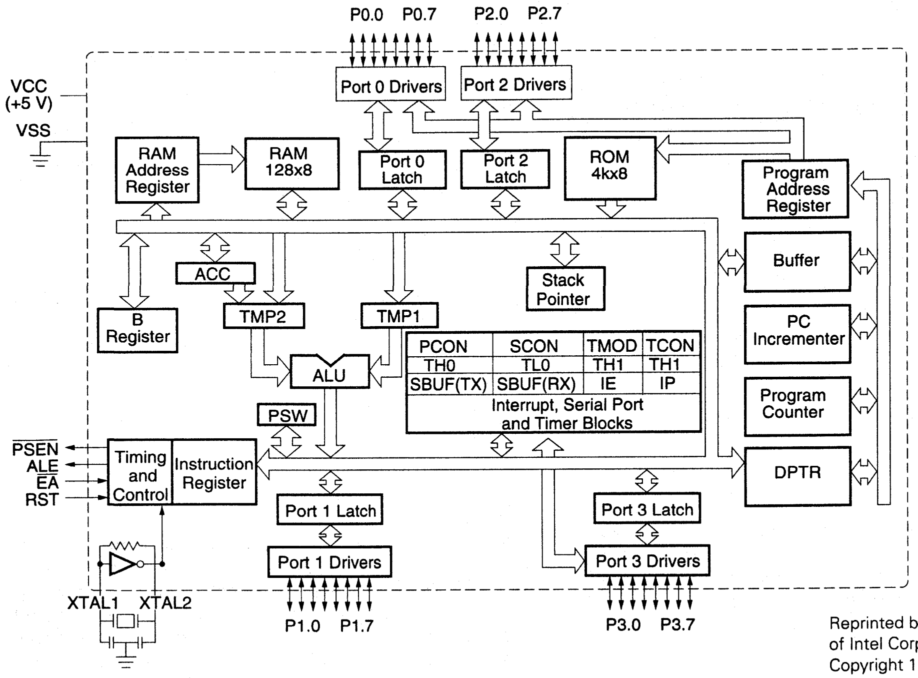


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Figure 2. DL2416 internal block diagram

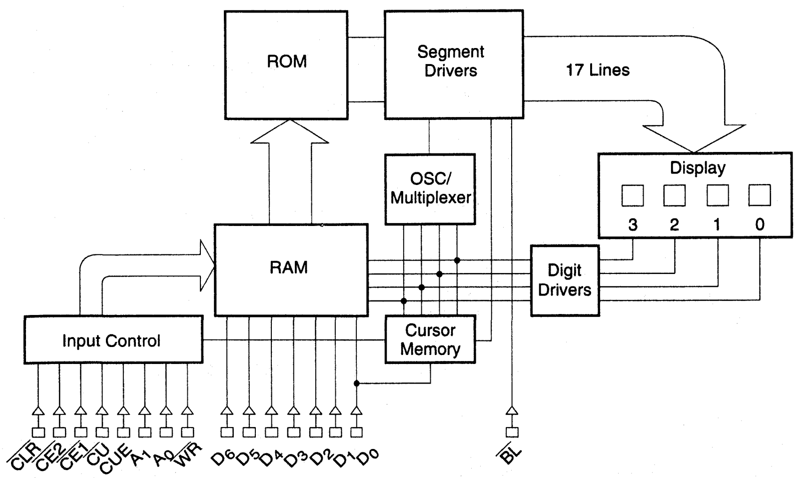


Figure 3. System schematic

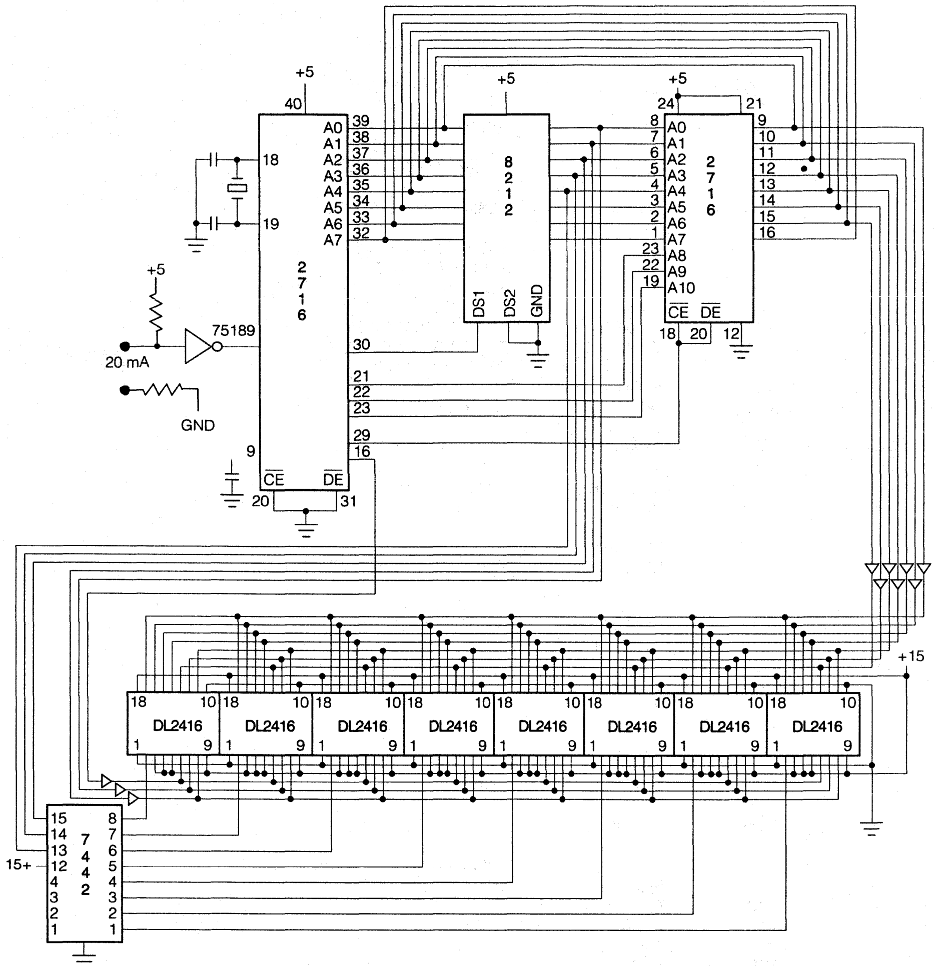
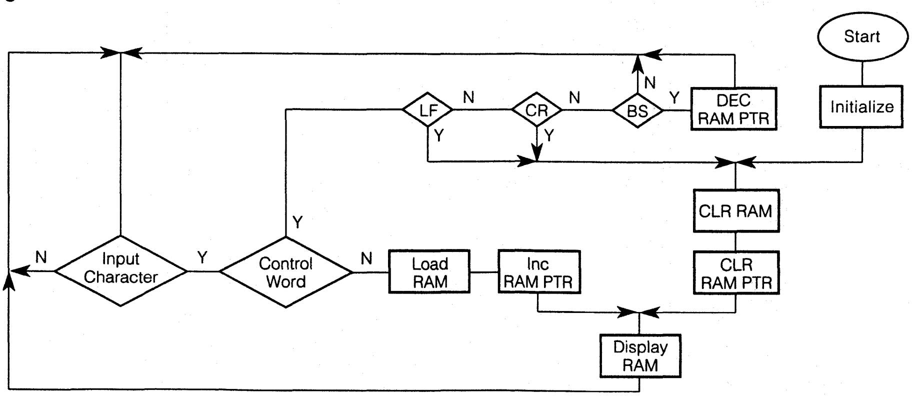


Figure 4. Serial IDA flow chart



```
                                              ;SERIAL IDA USING 8031 UP
                                              ;AND IEA2416-32
                           ORG     0000H
0000   020040              LJMP    INIT
                           ORG     0003H      ;EXTERNAL INTERRUPT 0
0003   32                  RTI
                           ORG     000BH      ;TIMER 0 OVERFLOW
000B   32                  RTI                                     INTERRUPTS
                           ORG     0013H      ;EXTERNAL INTERRUPT 1  NOT USED
0013   32                  RTI
                           ORG     001BH      ;TIMER 1 OVERFLOW
001B   32                  RTI
                           ORG     0023H      ;SERIAL I/O INTERRUPT
0023   32                  RTI
                                              ;SETUP SERIAL PORT
                                              ;9 BIT UART MODE 3
                                              ;SET TIMER
                           ORG     0040H
0040   75A800    INIT:     MOV     IE,#00H    ;ENABLE INTERRUPTS
0043   758922              MOV     TMODE,#22H ;TIMER 0 & 1 AUTO RELOAD     INITIALIZE
0046   758D72              MOV     TH1,#72H   ;RELOAD FOR 110              803 1 µP
0049   759870              MOV     SCON,#70H  ;MODE 3 RCV
004C   D28E                SETB    #8EH       ;TIMER 1 ON

004E   7920      CLRAM:    MOV     R1,#RAM    ;RAM INITIAL ADDRESS
0050   E4                  CLR     A                                   CLR RAM
0051   7B20                MOV     R3,#CNTR   ;LOAD # OF DIGITS
0053   F7        CLR1:     MOV     @R1,A      ;LOAD RAM
0054   09                  INC     R1
0055   DBFC                DJNZ    R3,CLR1
0057   7820                MOV     R0,#RAM    ;SET RAM INPUT PNTR TO INITIAL   CLR RAM PTR

0059   7B20      DISPRM:   MOV     R3,#CNTR   ;R3=COUNTER
005B   900000              MOV     DPTR,#DSPTR ;DPTR=DISPLAY POINTER       DISPLAY
005E   793F                MOV     R1,#RAM    ;R1=RAM DISPLAY POINTER+LENGTH  RAM
0060   E7        DISP1:    MOV     A,@R1      ;FETCH DATA FROM RAM
0061   F0                  MOVX    @DPTR,A    ;LOAD DISPLAY
0062   19                  DEC     R1
0063   A3                  INC     DPTR
0064   DBFA                DJNZ    R3,DISP1

0066   3098FD    SERIN:    JNB     RI,SERIN   ;WAIT UNTIL AN INPUT         INPUT CHAR
0069   C298                CLR     RI
006B   E599                MOV     A,SBUF

                                              ;CHECK FOR CONTROL WORDS
006D   FC        CNTLWD:   MOV     R4,A       ;SAVE A
006E   2460                ADD     A,#060H
0070   4013                JC      LDATA      ;JUMP IF DATA
0072   EC                  MOV     A,R4
0073   2473                ADD     A,#073H
0075   40D7      JC:       CLRAM   ;CR
0077   EC                  MOV     A,R4                                DATA=CR
0078   2476                ADD     A,#076H
007A   40D2                JC      CLRAM      ;LF                      DATA=LF
007C   EC                  MOV     A,R4
007D   2478                ADD     A,#078H                             DATA=BS
007F   50E5                JNC     SERIN      ;OTHER CONTROL
0081   18                  DEC     R0         ;BS
0082   020066              AJMP    SERIN

0085   EC        LDATA:    MOV     A,R4
0086   F6                  MOV     @R0,A      ;LOAD RAM
0087   08                  INC     R0                                  LOAD
0088   E8                  MOV     A,R0                                DATA
0089   24C0                ADD     A,#0C0H                             INTO
008B   5002                JNC     LDAT1                               RAM
008D   7820                MOV     R0,#RAM
008F   020059    LDAT1:    AJMP    DISPRM

END
```

SIEMENS

Blue Light Emitting Silicon-Carbide Diodes—Materials, Technology, Characteristics Appnote 31

by Dr. Claus Wyrich
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Introduction

Light-emitting diodes (LEDs) are widely used in the field of electronics as indicator lamps and seven-segment displays because of their excellent characteristics such as high mechanical stability, low operating voltage. compatibility with semiconductor drive circuits, low operating temperature and long service life. LEDs are now mass produced in colors: red, superred, yellow and green. The semiconductor materials that are used are III-V compounds such as gallium arsenide phosphide ($GaAs_{1-X}P_X$) gallium phosphide (GaP) and recently, also gallium aluminum arsenide ($Ga_{1-X}A1_XAs$). An extension of the color of LEDs into the blue region of the spectrum has been wished by many users. The materials that are suitable for blue-light diodes are discussed here, followed by a survey of the technology and characteristics of blue-light diodes based on silicon carbide (SiC), the material that is preferred for this application by the Siemens company.

Semiconductor Materials for Blue-light Emitting Diodes

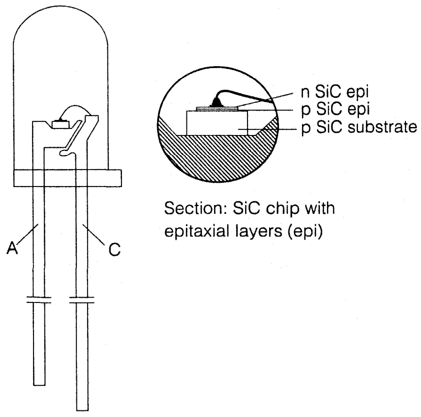
For emission in the blue region of the spectrum $GaAs_{1-X}P_X$ or GaP is out of the question because the band gap is too small, limiting the wavelength of the emitted radiation towards the lower end. But there are other semiconducting compounds such as gallium nitride (GaN), zinc sulfide (ZnS), zinc selenide (ZnSe) and silicon carbide (SiC). GaN was investigated quite intensively for the purpose of creating blue-light LEDs at the beginning of the 70s. With but one exception however, industrial research into this semiconductor material was then discontinued. The major drawback is the fact that GaN cannot be p-doped with sufficiently low resistance. Thus the light in this semiconductor is not produced by the radiative recombination of injected charge carriers at the pn junction as with the other III-V materials, but by highly accelerated electrons that are generated in the very high-resistance i layer of a metal-i-GaN-n-GaN layer by collision-ionization processes and thus lead to the emission of light. The efficiency of this mechanism, which results in higher operating voltages of the device, decreases with increasing current density (and thus luminous intensity of the diode). The situation is similar in the case of blue-light diodes using ZnS and ZnSe materials, in which likewise no low-resistance pn junction can be produced. The result of this is that with all the materials mentioned, despite the direct band-gap structure that is favorable for the generation of light and which leads to very efficient photoluminescence or cathodoluminescence for instance, the efficiency of the internal conversion of electrical energy into light is lower in comparison. SiC is the only material that allows reproducible p and n doping and possesses a suitable band gap for the emission of light in the blue region of the spectrum. The advantage of a device that can easily be controlled in all its physical characteristics more than makes up for the fact that SiC has an indirect band-gap structure, which is less favorable for generating light.

Groundwork on SiC blue-emitting LEDs has been performed in Great Britain, the USSR, Japan and in Germany at Hannover Technical University. Proceeding from the work done in Hannover, the development of SiC blue-emitting LEDs was pursued in the Siemens research laboratories and diodes were created with the highest efficiencies known to date. Siemens is one of the first semiconductor manufacturers to have successfully produced such diodes in the laboratory.

Technology and Design of SiC LEDs

An essential feature of SiC is its appearance in several modifications with different band gaps. For the production of blue-light LEDs the hexagonal modification 6H (αSiC) is the most favorable. As with all known LEDs, with SiC LEDs too the active light zone consists of epitaxial, monocrystalline material deposited on a p-type substrate crystal. The layer is grown from an Si melt saturated with carbon (liquid-phase epitaxy) at temperatures between 1600 and 1700°C, the p-type layer being doped with aluminum and the n-type layer additionally with nitrogen. The contacting and the diode structure are produced using the technologies already familiar with LEDs. The structure of an SiC lamp is shown in Figure 1.

Figure 1. Schematic of an SiC LED (dia. 5 mm)

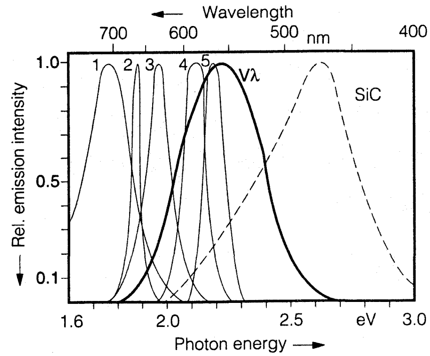


In addition to the high process temperatures, the major problem in SiC LED technology, compared to other semiconductor materials, is the lack of large-area substrate crystals—an absolute necessity where low manufacturing costs are concerned. Up to now it has been necessary to make do by preparing small crystal wafers of the appropriate modification from the kind of crystal clusters that appear as a by-product in the large scale industrial synthesis of SiC for producing grinding powder, but their diameter is no more than 10 to 14 mm. The big disadvantage of this is that the yield of suitable substrate crystals is only very small. At Siemens a substantial step towards a solution has now been taken. By means of a newly devised process, involving sublimation followed by condensation, monocrystals with a diameter of 15 mm and a length of 25 mm—that makes about 30 substrate wafers—were produced on a nucleus. This technology is, admittedly, considerably more elaborate than the technology of III-V semiconductors, so one cannot expect the price of blue-emitting diodes from SiC to fall to the level of more common LEDs; on the other hand though, an appreciable step towards mass production has thus been taken.

Characteristics of SiC LEDs

The emission spectrum of SiC LEDs and the dependence of the light current on diode current are illustrated in Figures 2 and 3 in comparison with other LEDs. Figure 4 shows the color locations of different LEDs on a standard color diagram. Whereas the red, yellow and green emitting diodes lie practically on the spectrum locus, the blue emitting SiC diodes exhibit two peculiarities. Their color location is not on the spectrum locus, and the dominant wavelength experienced by the observer shifts slightly with increasing diode current towards shorter wavelengths. Associated with this is a decrease in the rise and decay time of the luminescence from typically 0.9 µs (90-10%) at 5 mA to typically 0.5 µs at 50 mA. For a diode current of 20 mA the diodes have a luminous intensity of typically 4 mcd, the luminous efficiency being approximately 10^{-2} lm/V. A typical current/voltage characteristic is shown in Figure 5.

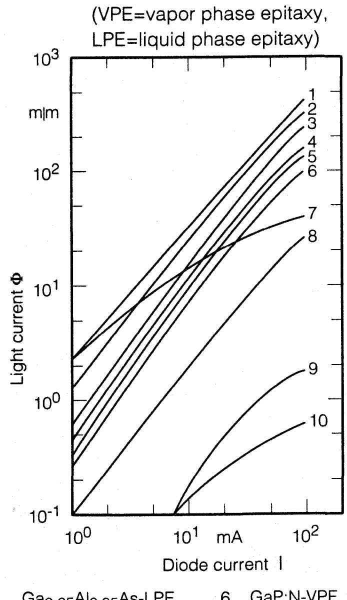
Figure 2. Photopic luminosity (normal vision) V, and emission spectra of different light-emitting diodes



1 GaP:Zn,O
2 $GaAs_{0.6}P_{0.4}$ and $Ga_{0.65}Al_{0.35}As$
3 $GaAs_{0.35}P_{0.65}$:N
4 $GaAs_{0.15}P_{0.85}$:N
5 GaP:N

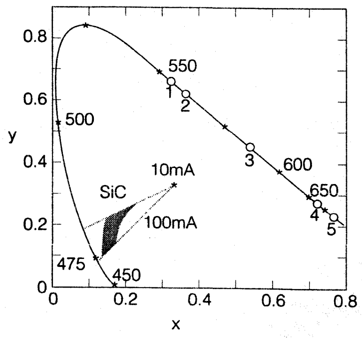
Based on $GaAs_{1-X}P_X$, GaP, $Ga_{1-X}Al_XAs$ and SiC in the visible spectral range

Figure 3. Light current/diode current characteristics Φ (I) of different LEDs



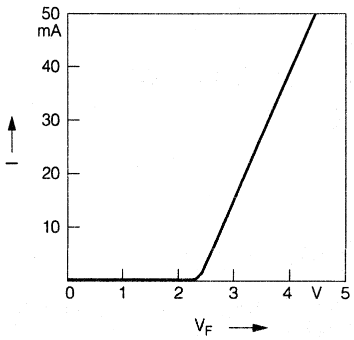
1 $Ga_{0.65}Al_{0.35}As$-LPE
2 GaP:N-LPE
3 $GaAs_{0.35}P_{0.65}$:N-VPE
4 GaP:X-LPE
5 $GaAs_{0.15}P_{0.85}$:N-VPE
6 GaP:N-VPE
7 GaP:NZn,O-LPE
8 $GaAs_{0.6}P_{0.4}$-VPE
9 SiC:Al,N-LPE
10 GaN-MiS-VPE

Figure 4. Color location of SiC LEDs (dotted) compared to other LEDs



1 GaP:X
2 GaP:N
3 $GaAs_{0.15}P_{0.85}$:N
4 GaP:Zn,O and $GaAs_{0.35}P_{0.65}$:N
5 $GaAs_{0.6}P_{0.4}$ and $Ga_{0.65}Al_{0.35}As$

Figure 5. Current/voltage characteristic I (V_F) of a typical SiC LED



Applications and Prospects

The possible applications for SiC LEDs are all those in which small light emitters are required that are capable of emitting in the blue spectral range and are suitable for fast modulation (up to 500 kHz), in the scientific and technical field as a calibration light source for photomultipliers for example, in TV-camera engineering and photography, and as a radiation source in spectroscopy, biophysics and medicine.

It will no doubt be possible to make this technology cheaper through continuing development of the individual process steps that are involved. It should be emphasized once more, however, that the fundamental problems of SiC technology are such that the prices of conventional LEDs are not likely to be approached. This does not only apply to SiC, incidentally, but also to the other materials being considered for blue-light emitting diodes.

SIEMENS

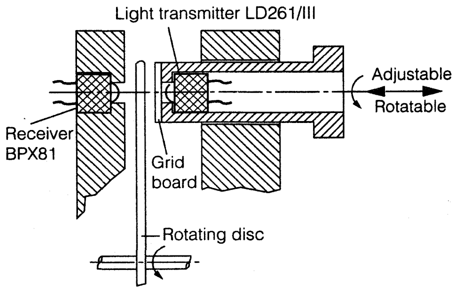
Light Activated Switches Appnote 33

Miniature Light Barrier for a Shaft Position Encoder or a Revolution Counter

Miniature light barriers are required for shaft position encoders, since light transmitters and receivers face each other by a distance of only a few millimeters. For this application a practical combination is achieved by using the light emitting diode LD261 and the phototransistor BPX81. Both components have the same epoxy case with an edge length of 2.2 mm. The LED operates in the infrared range at about 950 nm, since the efficiency is essentially higher than that of the visible radiation. The circuit described in the following converts interruptions of a light beam into electrical pulses for counting.

The construction of a shaft position encoder is shown in Figure 1. The distance between the transmitting and the receiving components is about 3 to 5 mm. Both are inserted in a hole with a diameter of 3 mm, whereby the opening is diminished to 1.4 mm at its front ends. A plastic disc carrying a line pattern at its circumference (Figure 2) is rotating between transmitter and receiver. A pervious section follows a non-pervious one and the angle position of the disc is determined by counting the quantity of sections having passed.

Figure 1.



Assuming that the rotating disc with a diameter of about 50 mm has a pattern of 600 lines, the distance between two lines is about 0.25 mm. To increase the light-to-dark ratio at the receiver side a plate with the same grid structure is mounted in front of the transmitter-hole (Figure 3). If the position of the grid on the rotating disc coincides with the one of the plate, the phototransistor receives a maximum of light. If both grid patterns are displaced with half the distance of two lines, the received light becomes a minimum. As the transmitter is rotatable and adjustable in its position an efficiency maximum can be achieved.

Figure 2.

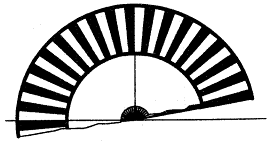
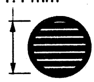


Figure 3.



The circuit is shown in Figure 4. The emitting diode LD261 operated at a current of about 20 mA

Figure 4.

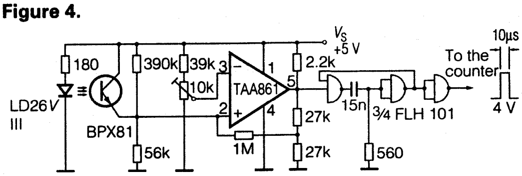


Table 1. Technical data

Supply voltage V_S	5 V
Supply current (total) I_S	35 mA
Wavelength of the transmitted light	950 nm
Maximum counting frequency	40 kHz
Duration of the output pulses	10 µs
Amplitude of the output pulses	4 V

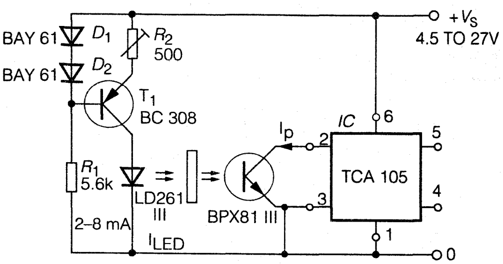
The collector current of the potentiometer varies between about 3 µA (minimum) and about 12 µA (maximum) when the disc is rotating. Since the minimum value is to be kept constant, strong ambient light influences have to be eliminated.

The current variation is sufficient to safely trigger the op amp TAA 861, which serves as a Schmitt-trigger. The following NAND-gates (FLH101) operating as monostable multivibrator produce a definite square pulse with a duration of about 10 µs, for each line passing the light barrier. The circuit operates up to a frequency of 40 kHz, which corresponds to about 4000 r.p.m. of the disc.

Light Barrier Using TCA105

The light barrier shown in Figure 5 consists of a GaAs lightemitting diode LD261, phototransistor BPX81 and the integrated threshold switch TCA105. The LED is operated at a constant current to meet the total range of the power supply voltage being between 4.5 V and 27 V. The IC itself is specified for a wider range. The constant current source is realized by the transistor T_1, the diodes D_1 and D_2 as well as the two resistors R_1 and R_2. By the two diodes an independent, nearly constant voltage is achieved at the base of T_1. The constant current of the transistor can be adjusted by the potentiometer R_2.

Figure 5.



Parameter changes of the components created by temperature and aging effects are compensated for if the photocurrent of the phototransistor is chosen four times higher than the required input threshold current of the TCA105, i.e., about 200 μA. The output signal is available at the two antivalent outputs of the IC (pins 4 and 5).

Adjustment

The light barrier is adjusted by setting the LED-current. If the IC is operated in the test circuit as shown in Figure 6, the current of the LED has to be set in such a way that a voltage of 400 mV is available between pins 1 and 2 of the TCA105.

Figure 6.

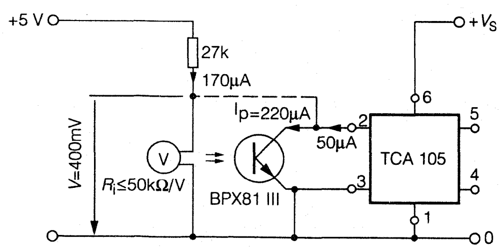


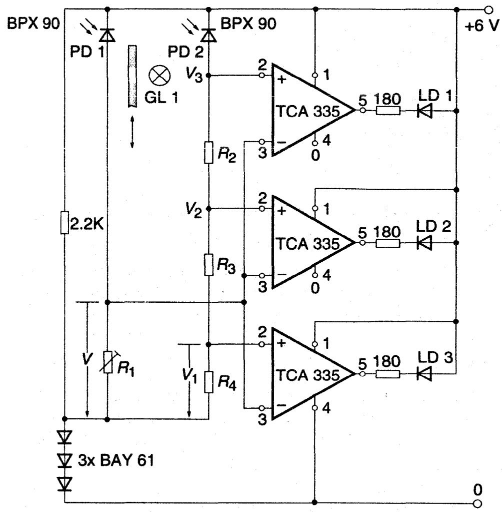
Table 2. Technical data

Supply voltage	4.5 to 27 V
Supply current	3.5 to 11.3 mA
LED current	2 to 8 mA
Supply current of the IC	3.3 mA
Ambient temperature range	–25°C to + 70°C

Optical Weight-Quantizer for Large Scales

The optoelectronic circuit described in Figure 7 facilitates the weight quantization of large scales, whereby a 3-stage LED display indicates the difference of the adjustment.

Figure 7.



The incandescent lamp Gl_1 illuminates the two photodiodes PD_1 and PD_2. The first is covered by a slot diaphragm, which is moved up and down by the balance arm of the scale with a stroke of 4.5 mm, corresponding to the balance difference. A voltage, being proportional to the balance difference, drops across the resistor R_1 and is supplied to the three op amps TCA335 operating as threshold switches. The reference voltages V_1, V_2 and V_3 are produced by the photocurrent of the photodiode PD_2 and drop across the resistors R_2, R_3 and R_4. They are supplied to the non-inverted inputs of the TCA335. If the voltage across the resistor R_1 exceeds the reference value then the corresponding LEDs LD_1, LD_2 and LD_3 are switched on. An inverse function can be achieved by interchanging inputs 2 and 3 of the op amps. Since both photodiodes are illuminated by the same incandescent lamp, brightness changes created by aging or supply voltage variations are ineffective.

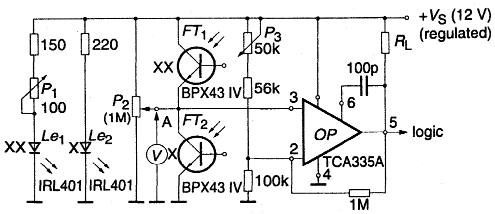
The common mode voltage necessary for operating the op amps drops across the diodes D_1, D_2 and D_3.

Optically Code Reading on Different Kinds of Papers and Different Reflection Coefficients

When identifying stroke markings placed on different kinds of papers, the uncertainty exists that the code is erroneously read due to different reflection coefficients.

The circuit described in the following and shown in Figure 8 avoids this difficulty by means of an additional compensation track. The two phototransistors FT_1 and FT_2 being connected in series serve as a voltage divider, the center tap of which is joined to the inverted input of the amplifier OP. An LED belongs to each phototransistor.

Figure 8.



P_3 threshold adjustment
P_1 P_2 zero adjustment
X reading track
XX compensation track

Both are connected in parallel, whereby the pair consisting of Le_1 and FT_1 serves for the compensation track and the one incorporating Le_2 and FT_2 functions for the reading track.

Therefore, the influence of a reflection coefficient of the paper is eliminated and the reading result is determined only by the different reflection of the strokes.

Adjustment Procedure

First, the potentiometer P_2 is adjusted so that a level of $0.5 \times V_S$ is measured at point A. During this procedure the phototransistors have to be completely covered. Then a paper of any kind without stroke markings is inserted into the readchannel and P_1 is adjusted in such a way that point A has a level of $0.5 \times V_S$. The threshold for the stroke markings is determined by the potentiometer P_3.

Light Barrier Indicating the Interruption Direction

It is generally important to know not only that a light barrier has been passed but also from which direction the passing occurred. These requirements can be met by using the window discriminator TCA965 with RS memory function. Two receiver diodes are necessary to indicate the passing direction (see Figure 9).

The LED IRL400 operates as a transmitter diode. It is supplied with short current pulses of approx. 1 A peak value and a repetition period of 30 ms. These pulses are generated by the programmable unijunction transistor BRY56. The emitted light pulses are received by the diodes BP104. They are connected to two transistors operating as emitter followers. The transistors are connected to a differential amplifier via a 15 nF-capacitor each. The output signal of the TCA971 is supplied to pin 8 of the window discriminator.

No signal is available from the differential amplifier if both receiver diodes are covered and when both receive light. If the diode A is not met by the light beam, the voltage V_8 at pin 8 is greater than that at pin 7. If the diode B is not met by the light-beam, V_8 is lower than V_6 (see Figure 10).

Figure 10.

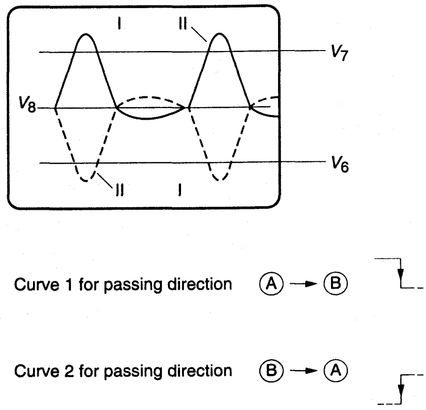
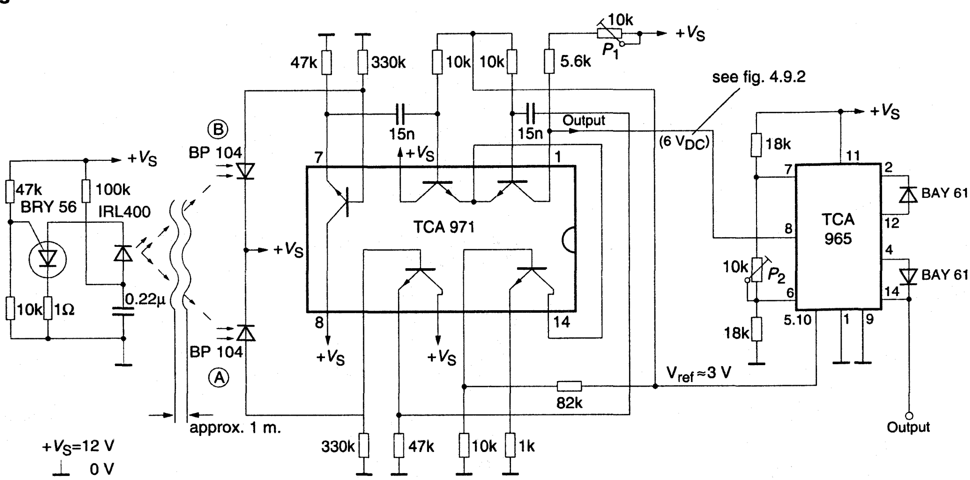


Figure 9.



If the light barrier is passed from A to B, an L-level is available at pin 14 (curve I). But if it is passed from B to A, pin 14 shows an H-level (curve II).

The sensitivity of the circuit is adjustable by potentiometer P_2 Potentiometer P_1 sets the dc level of the output symmetrically to V_6 and V_7. The five transistors are combined in the transistor-array TCA971.

Thus, a very good temperature behavior of the differential amplifier is obtained. The reference voltage V_{10} at pin 10 of the TCA965 is also utilized by the constant-current source of the TCA971.

Intrared Reflex-Light Barrier with IRL400 and TDA4050

The transmitter of this circuit is an IR-LED, type IRL400, emitting a strongly focused light beam. TDA4050B is used as receiving preamplifier. When using a triplet mirror with an area of about 20 cm^2 as reflector, the maximum distance is at least 10 m. The allowed interfering light in lens axis is up to 200 lux (incandescent lamp light). This corresponds to a white surface illuminated at 50 klx over the whole irradiation of the receiver. Emitter and receiver can be placed in the same housing. The circuit is particularly suited for decoding fast changing codes (e.g. running bar patterns) and as a light barrier.

Contrary to IR remote controls, IR reflex-light barriers require only very narrow emitting and receiving characteristics. Because of the short reaction time required, a continuous emitter signal is also needed. Therefore, the pulse currents cannot be as high as with remote controls as this operation would exceed the admissible power dissipation.

Transmitter

A circuit consisting of 2 CMOS-NAND-gates (Figure 11) generates a square-wave oscillation with a frequency of approximately 30 kHz. The pulse duty factor is fixed at 4:1. According to experience, a good efficiency is achieved herewith. To obtain the desired ratio between pulse duration and pulse space, the discharging resistor is partially bypassed by a diode. The 30 kHz-carrier is 1 kHz-modulated by a second pair of gates. When decoding running bar patterns, this modulation is not necessary as the object itself will be the source for the modulation.

A Darlington stage with BC875 drives the transmitter diode with peak currents of 200 to 250 mA, resulting in a mean diode current of around 25 mA. Without modulation, the mean diode current would reach twice this value.

Receiver

The IR signal received by the photodiode BP104 (Figure 12) is amplified through a transistor stage by 20 dB. The gain is determined by the collector resistance of 4.7 kΩ as well as by the 1.8 kΩ-input impedance of TDA4050B. The coupling capacitance of 22 nF and the RC circuit of the emitter reduce drastically low frequency-signals, especially the 50 and 100 Hz-components mainly present in artificial light.

The integrated circuit TDA4050B has a gain of about 60 dB between input and output. In order to limit the bandwidth, an active filter consisting of a double-T-section is connected between pins 4 and 5. Thus, the bandwidth is limited to approximately10 kHz. The gain of the TDA4050B depends on the potential at the control input (pin 2). Normally only a capacitor, being charged to a level of 1 V without signal, is connected to this terminal. In the circuit in Figure 12, a bias of 1.85 V is set via a voltage divider and the gain is reduced by approximately 20 dB therewith. This is necessary as otherwise, with the increased gain at the output, short-time peaks could result from the control action and would disturb the function. Notwithstanding the adjustment of the basic gain at pin 2, the automatic control is preserved, avoiding an overdrive of the receiver. Due to different charging and discharging resistors of the TDA4050B, downward control is very fast but upward control is relatively slow. The controlling time-constant is determined by the capacitor connected to pin 2.

When the input signal at the photodiode exceeds a signal current of 5 nA_{pp}, the output at pin 3 becomes negative.

Acoustic Indication and Evaluation

Should the incoming signal be acoustically indicated, pin 3 has to be connected to an evaluation circuit. It consists, for example, of a loudspeaker with a transistor BC309. Besides that, with this circuit the limit range can be easily defined as the tone becomes undefined when the maximum range is exceeded.

Figure 11.

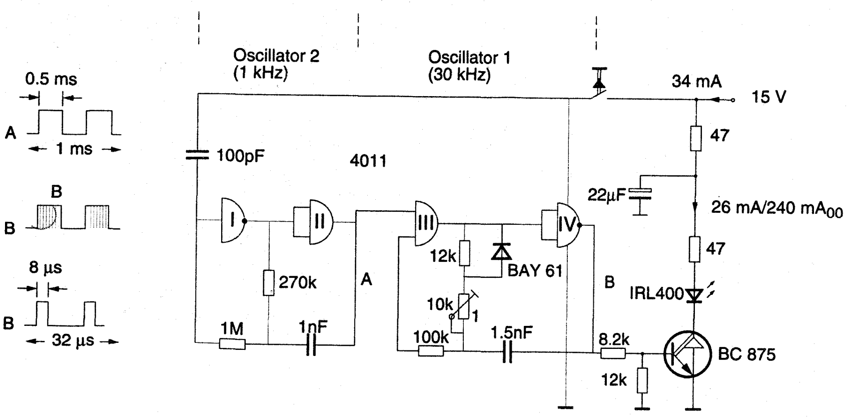


Figure 12.

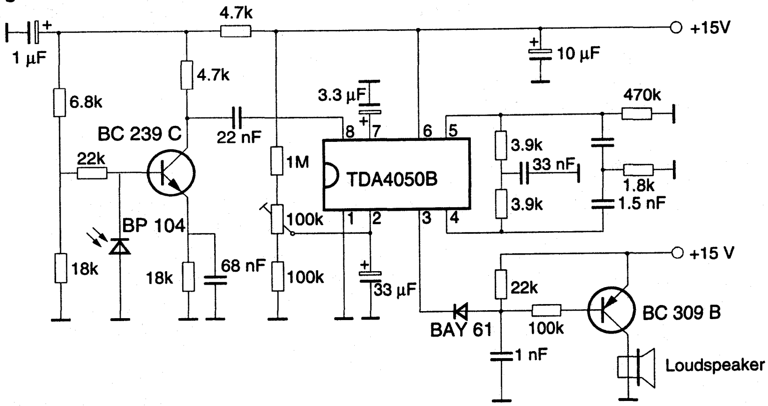


Table 3. Technical data

Transmitter	
Supply current at V_S=15 V Unmodulated 1 kHz-modulation, duty cycle 0.5	 60 mA 34 mA
Carrier frequency (square wave oscillation)	30 kHz
Duty cycle of carrier	0.25
Carrier-pulse-peak radiant intensity	100 mW/sr
Opt. wavelength	950 nm
Cone of radiation (half-angle)	6°
Receiver	
Supply current at V_S=15 V Without load (loudspeaker) load (loudspeaker) only	 10 mA 18 mA
Angle of irradiation with lens	±3°
Intermediate frequency	30 kHz
Bandwidth (3 d B)	10 kHz
Min. pulse-peak-radiant-power to diode BP104	10 nW
Max. modulation frequency Standard sensitivity Reduced sensitivity	 5 kHz 10 kHz
Dynamic range	60 dB
Max. interfering light (incandescent lamp light in lens axis)	200 lux
Total circuit	
Supply current at V_S=15 V	max. 70 mA[1)]
Range with simple triplet mirrors as reflector Seize of reflector 20 cm^2 Seize of reflector 1000 cm^2	 approx. 12 m approx. 80 m
Range with top-quality pentaprism as reflector seize of reflector 25 cm^2	approx. 20 m

[1)] Without modulation and load (loudspeaker)

Optics

For the receiver, a collecting lens with a diameter of 15 mm and a focal length of 30 mm is used. Thus an effective receiver area 30 times larger than with photodiode BP104 is achieved. At the same time the angle of irradiation is restricted to ±3°. With an increase of the lens diameter the range increases proportionally. But an increase of the focal length at the same time will limit the angle of irradiation.

For the transmitter, no additional optic is used, but the parasitic radiation remainder outside the cone becomes inoperative by means of a blackened tubus.

Electrical Features

The transmitter must be well shielded against the receiver so that the highly-sensitive receiver input cannot be disturbed. The electrical separation of the lines signals is sufficiently obtained by the filter circuits mentioned.

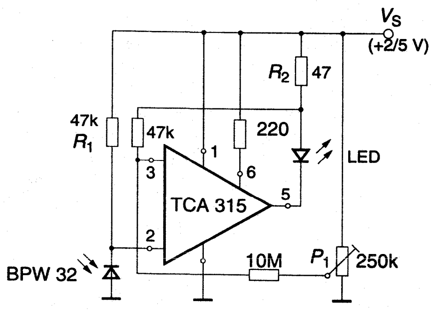
Current Control of LEDs as a Function of Ambient Light

A brightness control of LEDs is required especially when the ambient light intensity varies within a wide range. Figure 13 shows a circuit for this application. It operates sufficiently even at a supply voltage of only 2.5 V. In complete darkness the LED is driven with a current of 100 µA. If the intensity of the ambient light rises, the current, i.e., the brightness of the LED, increases accordingly. At daylight the LED is operated by an impressed current of 5 mA/100 lux.

The ambient light intensity is sensed by the Silicon photodiode BPW32. The signal is amplified through the Darlington operational amplifier TCA315. The sensitivity of the circuit is determined by the resistances of R_1 and R_2. The LED current exceeds the one of the photodiode by a factor of 1000 with the exception of in darkness, where the LED-current is 100 µA, as described above.

The current referring to a complete darkness is adjusted by the potentiometer P_1. The total supply current is 200 µA plus the LED current (at V_S=2.5 V).

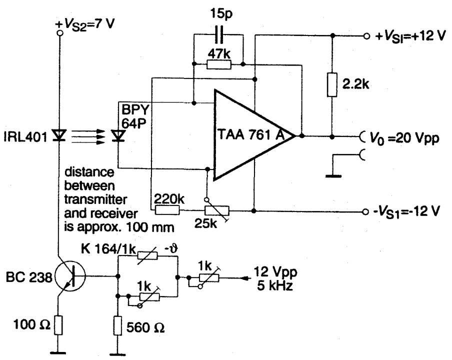
Figure 13.



Temperature-Response Compensation of LED IRL401

Figure 14 shows a circuit which is especially favored for compensating temperature effects of the LED IRL401. It is used in a light barrier operating with modulated light. The maximum diode current is rated to 50 mA_{pp} and the temperature range is +10°C to +55°C.

Figure 14.



The NTC-resistor K 164 has been connected to the base of the transistor BC238 and not directly to the LED as usually practiced. This measure reduces the self-heating of the thermistor. The control characteristic is adjustable by the two 1-kΩ potentiometers. To obtain a temperature drift of only 2.5% for the complete circuit in the mentioned temperature range, the resistance of the potentiometers should be set to a value of approximately 500 Ω each.

It should be mentioned for comparison purposes that the output voltage shifts about 20% when the circuit has no compensation.

The photovoltaic cell BPY64P operates as a detector in conjunction with an amplifier circuit. For processing a square-wave voltage with a frequency of 6 kHz, it is recommended to drive the photovoltaic cell BPY64P in a short-circuit operation. This will advantageously be realized by using the operational amplifier TAA761A operating with an impressed input current.

Reflection Light Barrier

This circuit is applicable for realizing a reflection light barrier. If, however, there are no requirements for improved sensitivity and reduced immunity against undesired influence of ambient light, this circuit can be simplified.

The circuit described in the following reacts within a range of 1 m, regardless as to whether the light is reflected from the human skin or from textiles.

Transmitter

The pulse generator of the transmitter circuit shown in Figure 15 operates with a CMOS-gate, type HEF4011[1)], and produces pulses with a duration of 10 µs and a repetition frequency of 100 Hz. The peak current of 1.5 A required by the LED, type LD27, is supplied by the Darlington stage consisting of T_1 and T_2. The electrolytic capacitor C_1 operates as a buffer. The pulse duration is adjustable by potentiometer P_2 and the repetition frequency is set by potentiometer P_1. Under the assumption of a duty cycle 1000:1, an average current of 1.7 mA is required for the complete transmitter circuit.

[1)] HEF4011 refers to RCACD4011

Figure 15.

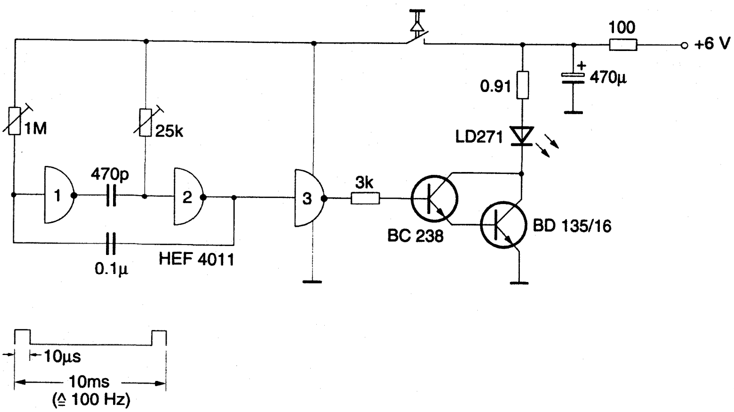


Table 4. Characteristics

Supply voltage	6 V
Supply current	1.7 mA at V_S=6 V
Pulse interval	10 ms
Pulse duration	10 µs
Half angle of radiation cone	35°

Receiver

The broadband receiver circuit shown in Figure 16 is applicable if the ambient light is less than 500 lx. For realizing the infrared filter in front of the photodiode BPW34 a nonexposed but developed color film, type CT18 (Agfa) is used. The signal supplied from the BPW34 is amplified by the transistors T_1 to T_5 and is available at the output with an amplitude of 6 V_{pp}. The gain is about 20,000. The operating point of T_5 is adjusted by the potentiometer P_2, setting a dc-level of 3 V to the base of T_5. The output signal is symmetrized by potentiometer P_1 which determines the operating point of the transistor T_2.

Figure 16.

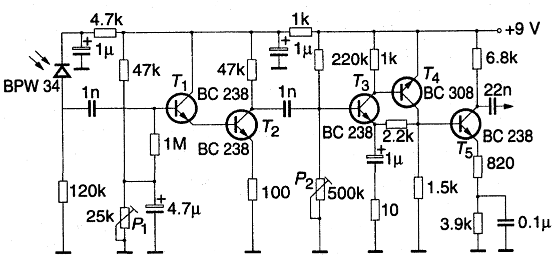


Table 5. Characteristics

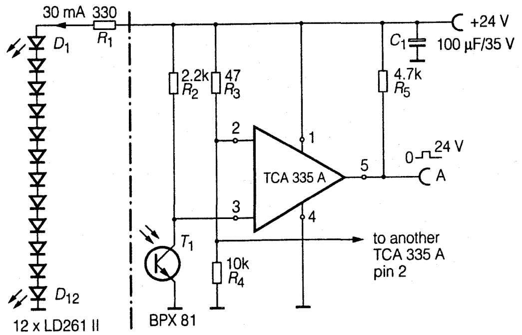
Supply voltage	9 V
Supply current	5 mA at V_S=9 V
Gain	20,000
Output voltage	6 V_{pp}
Noise (without ambient light)	approx. 0.5 V
Operating range in conjuction with the above described transmitter, reflection from skin or textiles	max. 1 m

Optoelectronic Steel Tape Reader

Under more adverse conditions steel tape is often used instead of normal punched tape for reading control data into numerically controlled machine tools. The circuit proposed here is based on a configuration with 12 bit parallel read-in. The LEDs associated with the 12 bit are connected in series and supplied through the resistor R_1 from the 24 V supply. Each bit is allocated a phototransistor BPX81 and operational amplifier TCA335A. The phototransistor is connected to the inverting input of its associated operational amplifier, so with incident light (hole in the tape) the voltage at pin 3 of the TCA335A drops. A positive pulse then appears at the output.

Up to an ambient temperature of 40°C the LEDs require no additional cooling. Compared with tape readers employing light bulbs, the LED configuration is more robust, requires less maintenance and its power consumption is a factor of 10 lower. Reader errors cannot occur in practice because if a LED goes open circuit, all 12 are without current and the fault is immediately apparent.

Figure 17.



SIEMENS

Remote Control Appnote 34

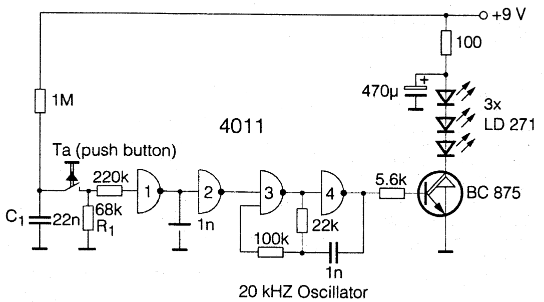
1. Simple Infrared Remote Control with Low Current Consumption

For remote-controlled switch operation only a very simple circuit is needed. The infrared signal consists of a 20 kHz burst with a duration of approximately 1 ms. To reduce the interference by ambient light and flashes, an integrating circuit is connected to the receiver which will only supply a trigger pulse after having been applied by a series of pulses.

Transmitter

A 20 kHz oscillator consisting of two CMOS-NAND gates (Figure 1) is used. As long as gate 2 has L-level, the oscillation is interrupted. After pressing key T, H-potential is applied to the input of gate 1 as well as to the output of gate 2 and the oscillator starts operating. After a certain time, determined by the time constant of the R_1C_1 circuit, the voltage at the input of

Figure 1.



gate 1 drops below the minimum H-level threshold and thus the oscillation is interrupted. The time constant of R_1C_1-circuit is dimensioned for a burst length of 1 ms. The 1 nF capacitor, connected to output of gate 1, suppresses pulse spikes during turn-on.

Due to the oscillation at the output of G_4, the Darlington transistor BC875 is periodically conductive. The transmitter diodes, type LD271 are operated at peak currents of up to 1 A. The energy is supplied during 1 ms by the 470 µF capacitor. Its voltage drops by a value of 1 V during the burst.

Receiver

The photodiode BP104 with integrated IR filter is used as a load with a resistance of 56 kΩ (Figure 2). At normal ambient light this resistance is low enough not to generate a voltage drop. The next stage is an emitter follower with an input impedance of approximately 1 MΩ. In conjunction with the second stage a gain of 100 is achieved. The dc operating point is controlled by means of an inverse feedback. By the next two stages, being also part of the inverse feedback circuit, the signal is further amplified by a factor of approximately 100.

The input signal, amplified totally by a factor of 10,000 is supplied to an integrated rectifier circuit. At each pulse the 10 nF capacitor is charged by a voltage that depends on the ratio of the capacitors (680 pF and 10 nF). As soon as the threshold of the transistor being connected to the rectifying circuit is reached, a pulse with a positive switching edge is generated. It is steepened by means of four inverters. This edge triggers the following JK-flip-flop 4027 operating as a monoflop. At its output a defined pulse is available for triggering the following flip-flop 4027. In this case antivalent outputs are used to drive a red or a green LED.

Figure 2.

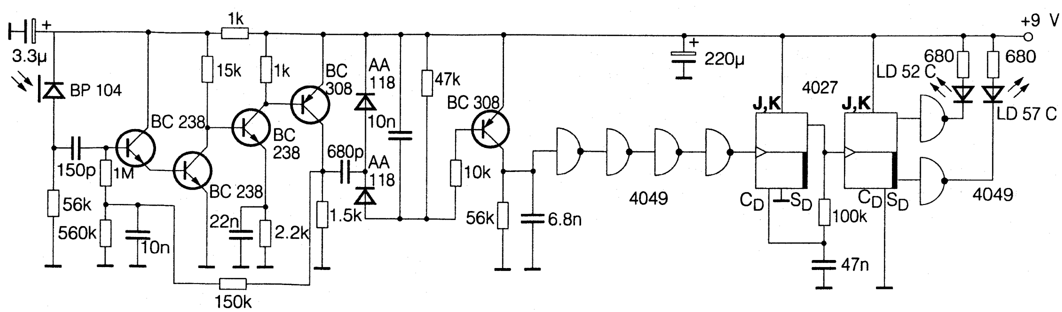


Table 1. Technical Data

Transmitter	
Supply voltage	9 V
Pulse width (single pulse)	1 ms approx.
Carrier frequency	20 kHz approx.
Peak current	1 A approx.
Receiver	
Supply voltage	9 V
Supply current (without LED)	2 mA
Intermediate frequency	20 kHz approx.
Gain	80 dB approx.
Range	≥ 15 m

2. Power Saving Infrared Transmission—One Channel

With the transmitter receiver combination described in the following it is possible to transmit simple instructions, e.g. on-off, over a distance of about 20 m by using the light emitting diode LD271 and the receiving photodiode BPW34. Therefore this device is favored for remote control operations of electrical equipment, e.g. dimmers, motors, switches, model railways or even installations carrying high tensions. Besides that it can be advantageously used to realize light barriers, since the high carrier frequency guarantees a high interference immunity against continuous and low frequency modulated light. If an optical system is used for the transmitter as well as for the receiver, much greater distances than the above mentioned can be covered.

An extension to more than one channel is possible, but the current consumption will increase by the number of channels. Thus this operating principle is also applicable for remote control of TV receivers and of other devices demanding higher requirements. If the number of channels is n, $2^{n}-1$ different instructions can be transmitted.

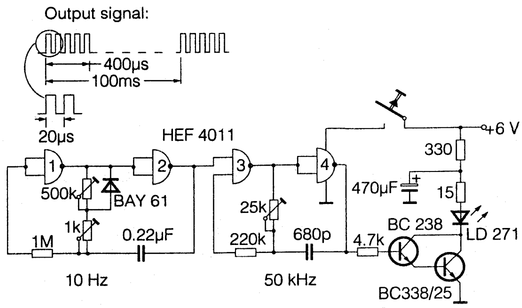
Since the information is only transmitted for a short period, the average power dissipation is reduced by a factor of 500 in comparison to the peak power. In the described application the repetition frequency is 10 Hz, i.e. the interval between two instructions is 100 ms.

By the ambient light a noise voltage is generated in the photodiode BPW34. Therefore, the input circuit of the receiver operates with a narrow band filter, keeping the noise influence low. Each instruction consists of a pulse train with constant pulse interval (e.g. 50 kHz). The number of pulses per train required for processing a statement depends on the amplifier. Therefore, it has to be considered that a narrow band amplifier has transient response which is not to be negligible. For instance, a resonant circuit with a determined quality factor Q needs pulses in a quantity of (Q/3) in order to reach 50% of the maximum resonant amplitude. Assuming a carrier frequency of 50 kHz, a quality factor of 16 and a bandwidth of 3 kHz, 5 pulses are required to obtain a value, which is 50% of the maximum resonant-circuit voltage. In the described circuit the interval for the total pulse train was chosen with 400 µs which refers to 20 pulses.

Transmitter

Only one CMOS-IC, type HEF4011 (RCA CD4011) has been utilized to realize the two oscillating circuits of the transmitter, operating at 10 Hz resp. 50 kHz (see Figure 3). The 10 Hz oscillator has a duty cycle of 250:1.

Figure 3.



These different intervals are obtained through bypassing the charging capacitor by means of the diode BAY61. The 50 kHz oscillator is modulated by 10 Hz, i.e. it operates only during a time of 400 µs. The LD27, emitting infrared light, is square-wave modulated by a Darlington stage with reference to the rhythm of the output signal. If the peak current is a 1 A, the average value is only 2 mA. As this peak current is not available from the battery, it is supplied from a 470 µF capacitor, the voltage of which decreases by a value of 0.5 V for the duration of the pulse train. The diode current being higher at the start positively effects the resonant circuit of the receiver.

Table 2. Characteristics

Supply voltage	6 V
Supply current	2 mA at 6 V
Subcarrier frequency	50 kHz
Duration of pulse train to train repetition period	400 µs:100 ms
Emitted peak power	80 mW/sr
Half angle of the radiation cone	35°

Receiver

The receiver shown in Figure 4 operates with the photodiode BPW34 which is matched to an input impedance of approximately 80 kΩ at 50 kHz. The dc diode current should not exceed a value of 20 μA. For the infrared filter placed in front of the photodiode, a non-exposed but developed color film, type CT18 (Agfa) has been used. In the following circuit the pulses are amplified, clipped, rectified and applied to a monostable multivibrator, which covers the space between two pulse trains. Therefore a dc voltage is available at the output of the receiver as long as the push button of the transmitter is operated. Thus the required function can be realized.

The amplifier consisting of transistors T_1 to T_5 offers a gain of 20,000. T_1 operates as an impedance former. The band- width is adjusted to a value of 3 kHz by a selective feed- back between T_3 and T_4. T_6 operates as the threshold switch and limiter. The signal is integrated by the capacitor C_S and delayed, so that after the start of the pulse train three to four 50 kHz-oscillations pass before the following monostable multivibrator is triggered. Thus it is guaranteed that short pulse interferences do not trigger the monovibrator consisting of two NAND-gates, type HEF4011 (RCA CD4011). The duration of the monovibrator pulse is 100 ms. Thus it is assured that the steady state is obtained after a period of 100 ms, if the following pulse train is not emitted from the LED.

Table 3. Characteristics

Supply voltage	9 V
Required current (without output circuit)	10 mA, V_S=9 V
Receiving bandwidth	3 kHz
Center frequency	50 kHz
Admissible ambient light day light incandescent light fluorescent lamp light	 4,000 lux max. 500 lux max. 10,000 lux max.
IR filter, cut off wavelength	870 nm

3. IR Preamplifier with IC TCA440 for Infrared Remote Control Systems

Preamplifiers for IR remote control systems with pulse code modulation must meet additional overdrive requirements compared with frequency coded systems.

Receiver overdrive in conjunction with tuned circuits results in falsification of the envelope pulse duration. However, the receiver can only process such pulse "distortion" to a certain degree. As the input signals can differ by a factor of more than 10^5, a control loop must be introduced to prevent overdrive. The control circuit must act fast enough to assure correct transmission of the first bit. This is especially important for the transmission of single instructions. The requirements are less critical for repetition instructions; here it suffices when the correct control state condition is achieved by the time transmission of the second instruction begins.

With single instructions, the signal AGC circuit must act within a fraction of the bit duration. This necessitates a response time of less than 100 μs. The dwell time in the control state must, however, be much longer, ideally more than 100 ms so that for repetition instructions a more or less steady control state condition already exists for the second instruction

In addition to this control loop driven by the useful signal for single instructions, a control circuit dependent on light level is also advisable. This assures maximum sensitivity under low ambient light conditions and reduces the amplification with increasing light level to maintain the light noise just below its disturbing level.

In practice, the operator can bring the transmitter very close to the receiver. When this form of overdrive occurs it must be assured that correct recognition of the signal is not prevented. For guidance purposes, a minimum separation of 5 cm can be assumed. The resulting level differences of more than 100 dB generally can not be fully handled by the internal control circuit of the IC; additional measures such as peak level limiting are therefore required to hold pulse distortion within the admissible limits.

Figure 4.

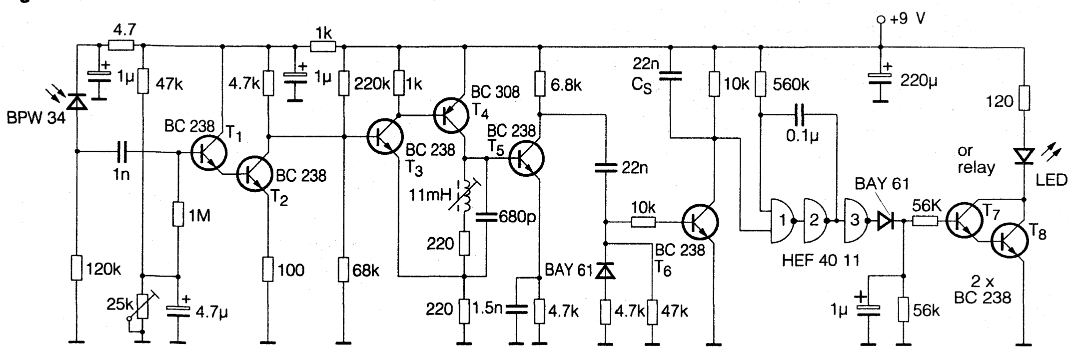
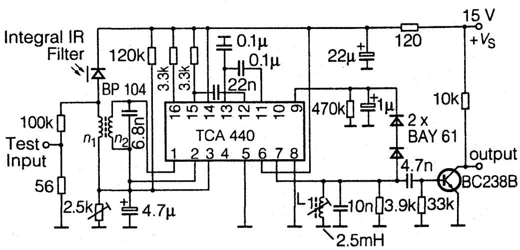


Figure 5 shows a circuit incorporating the IC TCA440 which essentially meets all the above requirements.

Figure 5.



It is assumed that the transmitter radiates an IR signal with a carrier of approximately 30 kHz modulated with information as 7 bit instructions in biphase code. The bit length should be about 1 ms; the repetition frequency, if present, about 10 Hz.

In series with the IR diode BP104, which is similar to the photodiode BPW34 but with integral IR filter, is a resonant circuit tuned to 31.25 kHz and having a resonant impedance of 50 kΩ. Damping is provided by the 100 kΩ resistor and transformed input impedance of the TCA440. With a transformation ratio of 5:1, the TCA input impedance of about 4 kΩ appears as 100 kΩ on the primary side. The bandwidth of 10 to 12 kHz is relatively large, but this makes the input circuit design uncritical and assures short rise and fall times. The capacitive loading is mainly on the secondary side, only the BP104 junction capacitance loads the primary side. The bandwidth can be halved if required by removing the 100 kΩ resistor.

In the TCA440 the preamplifier stage with inputs 1, 2 and output 15 and the controlled IF amplifier with input 12 and output 7 are utilized. The latter requires a resonant circuit at the output, otherwise the output voltage is too low. The AGC starts to operate through pin 9 when the output circuit voltage exceeds 2.5 V_{pp}.

Under high ambient light conditions, the input amplifier gain can also be controlled. The DC output current of the BP104 causes a small voltage drop at the bottom end of the primary winding which is utilized for gain control. Input 3 is current biased such that the AGC already acts at relatively low photocurrent levels.

The output circuit bandwidth is about 4 kHz and contributes decisively to the receiver sensitivity. The output voltage is limited by the TCA440 to about 4 to 5 V_{pp}. When designing this circuit, care should be taken to prevent inductive feed- back from the circuit inductance L_1 to the input transformer.

Table 4. Technical Data

Input IR irradiance (λ=950±30 nm) Minimum Maximum	 1 nW/mm^2 $5 \cdot 10^5$ nW/mm^2
Range a) without wall influence (free room) Angle 0° Angle 30° b) with wall influence (corridor) Corridor 2 m wide x 2.5 m high Angle 0° Under the following conditions: – Transmitter peak power 160 mW (i e. 2 lower limit LD 271 with 1 A peak current) – Low outside light (Max. illumination 500 Lux, caused by daylight or fluorescent lamp)	 >12 m >8 m >20 m
Outside light influence With incandescent light E=1000 Lux Range reduction	 <50%
Admissible variation in pulse group length (rated value 500 or 1000 µs)	 ±10%
AGC time constants Gain reduction Gain increase	 <100 µs >100 ms
Center frequency	31.25 kHz
Bandwidth for small signals (AGC not operating) referred to output 7	3 kHz approx.
Output signal	15 V_{pp} modulated
Supply voltage Admissible ripple Input transformer: B65531-L0250-A028 Pot core 11 x 7, A_L=250 nH n_1 =565 turns, 0.07 dia. n_2 = 111 turns, 0.07 dia. Primary inductance approx. 85 mH L_1: B65517-A0250-A028 Pot core 9 x 5, A_L=250 nH n=100 turns, 0.1 dia.	15 V + 3 V, –5 V <2%

4. Single Channel IR Receiver with High Interference Resistance

Figure 6 shows an IR receiver circuit which is especially suitable for light barriers or simple IR transmission systems. It features increased resistance to extraneous light interference, for example the switch-on pulses of fluorescent lamps.

The pulse groups emitted by the transmitter (f_0=40 kHz, t=1 ms, T=100 ms) are received and amplified by approximately 60 dB on OP 1. P_3 sets the switching threshold for the following threshold switch OP 2, at the output of which the pulses are again available at TTL level. The first pulse received by the diode triggers MF1 which produces a pulse of duration t_1 (see Figure 7). This in turn releases after approximately 90 ms a pulse of duration t_2 (G_1 and G_2). The second transmitted pulse can only pass G_4 during the period t_2. The output signal A (continuous signal) is delivered by MF3, a post-triggered monoflop with t_3>T.

The circuit is therefore insensitive to incoming interference pulses for a time T–t_2 and only responds when at least two pulse groups are received with a spacing T.

It is possible to replace the TTL ICs MF1 to MF3 by CMOS monoflops (4047). This reduces the power requirements and permits the use of a higher supply voltage, for example from a 9 V battery. The Zener voltage of diode D_1 must in this case be about half the supply voltage.

Table 5. Technical Data (TTL Version)

Supply voltage	5 V
Supply current	55 mA
Carrier center frequency f_0	40 kHz
Input circuit bandwidth	4 kHz
Pulse group duration t	1 ms
Pulse group repetition frequency 1/T	10 Hz
Response threshold (max sensitivity) referenced to photodiode useful current	3 nA approx.
Range measured with a transmitter with 3 x LD271, I_P=1 A	>12 m

Figure 6.

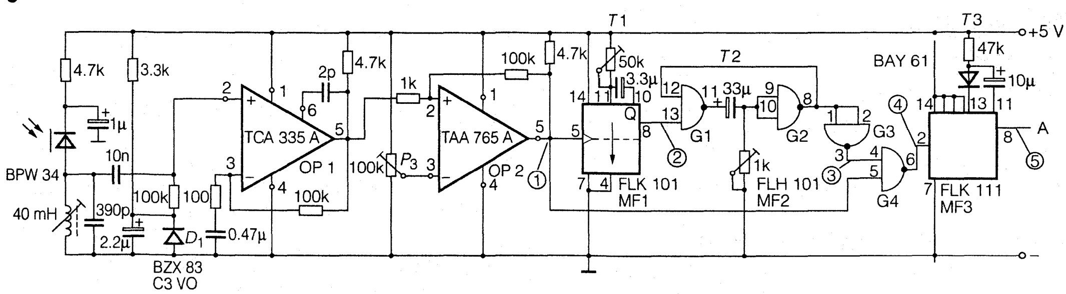
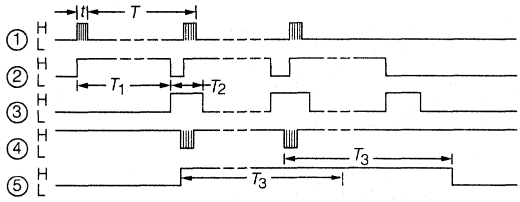


Figure 7.



5. Simple Battery-Operated IR Remote Control Transmitter for Single Instructions

The IR transmitter circuit is shown in Figure 8. The capacity of a normal 9 V battery (240 mAh) suffices for about 30,000 switching operations; thus it is not the switching rate which normally determines the battery life but its storage capacity.

Figure 8.

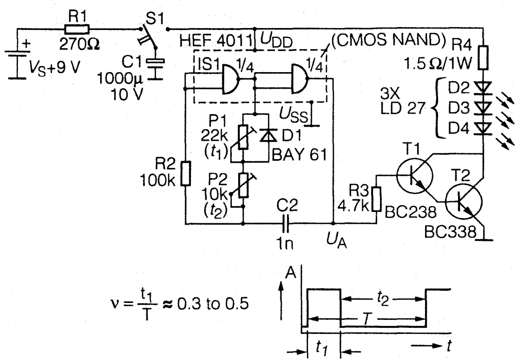
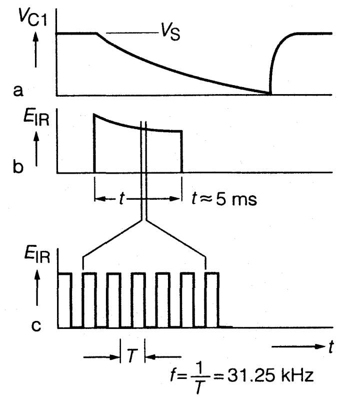


Figure 9.



When the switch S_1 is operated, the transmitter radiates a single IR pulse of about 5 ms duration modulated with 31.25 kHz (see Figure 9). After demodulation of the signal, 5 ms square wave pulses corresponding to the envelope of the modulated pulses emitted by the transmitter appear at the receiver output. These can be used for various purposes, for example to change over a flip-flop state for switching equipment off or on, to drive counter circuits that actuate different switching processes, etc. The modulating frequency of 31.25 kHz is generated by a stable multivibrator incorporating CMOS NAND gates to minimize the power consumption. The multivibrator supplies the driver stage T_1, T_2 for the GaAs LEDs (IR radiators) D_2, D_3 and D_4. With S_1 in its rest position C_1 charges up through R_1. When S_1 is pushed, C_1 is connected as a voltage source to the transmitter circuit which then starts to oscillate. The current consumption of the circuit and the value of C_1 determine the duration of transmission.

The center frequency of 31.25 kHz is determined by P_1 and P_2: P_1 affects the pulse duration t_1 and P_2 the interval t_2.

The duty cycle $v = t_1/T$ should be between 0.3 and 0.5. This gives the longest range for minimum power consumption. Because of resistance tolerances within the CMOS circuit, the frequency can only be calculated roughly:

$$f = \frac{1}{T} \approx \frac{1}{1.1(P_1 + 2P_2) \cdot C_2}$$

Table 6. Technical Data

DC supply voltage	9 V
Center frequency (adjustable)	31.25 kHz
Transmission duration per single pulse (C_1=1000 µF)	5 ms
Energy consumption per switching operation	25 mWs

6. Preamplifier for IR Remote Control Systems

Infrared remote control receivers with MOS-ICs usually require a digital input signal with TTL-levels. Therefore a preamplifier has to be connected between the photodiode and the MOS-circuit. Such a preamplifier has already been described (see Part 3). A description of a circuit using the IC DA4050 follows. The TDA4050 was especially developed for applications of IR remote control systems. It comprises a controlled prestage, an amplifier and a threshold amplifier. This IC offers excellent large-signal characteristics, an output with short-circuit protection and a simple driver circuit for active band-pass filters. Although solutions without coils are cheaper, an LC-network is connected to the input of the circuit shown in Figure 10 to obtain a higher selectivity. The photodiode SFH205 is connected directly to the resonant circuit. It is reversely operated and biased with 11 to 14 volts. The signal from the resonant circuit is supplied to the input of the IC via transistor BC414C. Thus, the signal-to-noise ratio is improved. An active filter is connected to pins 4 and 5. It is part of the reverse feedback circuit of the operational amplifier. The output signal is available at pin 3, offering a protection against short-circuits to ground (R_i=10 kΩ). At L-level, the output has a low impedance.

Figure 10.

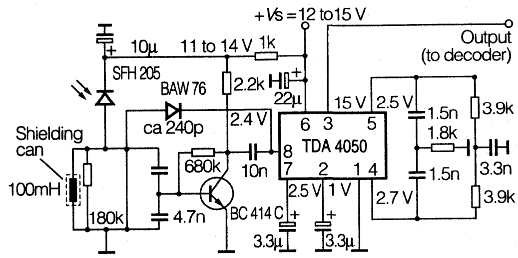
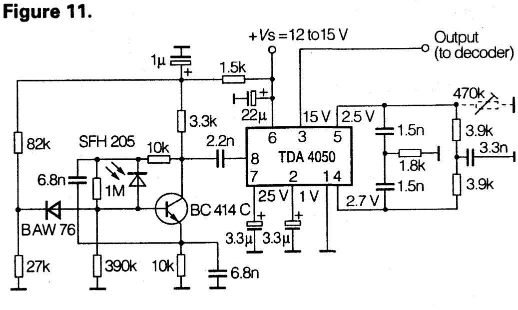


Figure 11 shows a circuit without coils. The large signal characteristics and noise immunity are improved by a network consisting of resistors and diodes.

Figure 11.



Both circuits should advantageously be mounted in a double-screened case.

Without any influence of extraneous light, a distance of 25 to 30 m between transmitter and receiver can be easily realized, whereas the distance is much higher if the circuit with LC-network is used.

The described preamplifier circuit is also applicable for IR remote control systems used in TV sets. In this case, only a range of 15 to 18 m is covered because of the wire-netting protection and the stray influences of the TV deflection coils.

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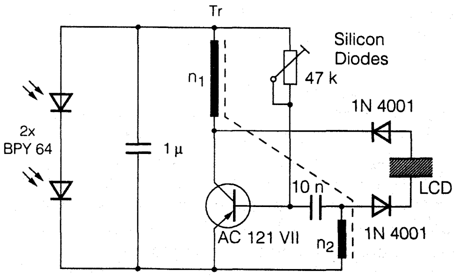
Photographic Aperture, Exposure Controls, and Electronic Flash Appnote 35

Solar Cell Generator for Exposure Control in Cameras without Moving Parts

Exposure meters normally work with a moving coil instrument. With a field effect liquid crystal display and a solar generator with two photovoltaic cells, type BPY64 a fully electronic light control without mechanical moving parts can be realized. The reversal point of the indicator is reached at an illumination of 100 lux (color temperature of 2850 K). Thus exposure-time display for low-priced cameras is possible.

Circuit Description

Figure 1.



Coil Pot Core 14 x 8 n_1 = 666 turns
Material N30 n_2 = 333 turns
0.07 ECu
L = 1.84

A basic requirement is an oscillator which starts oscillating at a voltage below 100 mV. Two photovoltaic cells, type BPY64, feed a blocking oscillator with transistor AC121 VII as shown in Figure 1. Because of the low photoelectric voltage available at low illuminations a germanium transistor with a low threshold voltage has to be used. In operation, the transistor is at first conductive so that a magnetic field can be built up in the primary winding of the transformer Tr. Through the secondary winding, a reverse voltage is induced to the base circuit which turns off the transistor. At this moment the magnetic field of the coil collapses. The potential difference between collector and base is momentarily approximately 5 V at the breakdown point of the liquid crystal display. To avoid a too strong damping of the base circuit by the capacitor of the display, two diodes are connected in series to the LCD. The pulse duration of the blocking oscillator signal is mainly defined by the self-inductance and self-capacitance of the coil, while the repeating frequency depends on the time constant of the base circuit. The optimum output voltage is achieved at a repeating frequency of approximately 3 kHz. The oscillations start at a collector voltage V_{CE} of –60 mV and a mean current I_C of 30 µA.

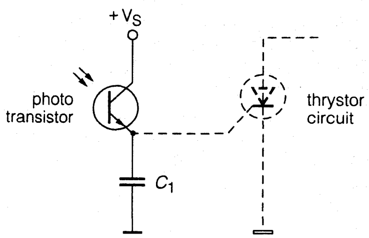
Phototransistor Used In a Computerized Photoflash Unit

A new circuit has been designed for the receiving part of the computerized photoflash unit. It offers the advantage in that it essentially compensates all the undesired influences produced by exposure time errors, ambient light, temperature, and tolerances of the photosensitivity. A phototransistor in conjunction with an integrating capacitor connected to the emitter serves as a photodetector.

A computerized photoflash unit differs from a standard one in that the duration of the photoflash is determined by a photodetector. Therefore, the exposure time for a camera film is constant and does not depend on the intensity of the reflected light, i.e. the flash is interrupted sooner or later in dependence on the quantity of reflected light. Figure 2 shows on principle the control circuit of a computerized photoflash unit. The photocurrent of the phototransistor charges the capacitor C_1 and thus the turnoff thyristor shown in the figure with broken lines is triggered.

A trial was conducted to find out how far exposure time errors of photoflash devices using the circuit of Figure 2 depend on the sensitivity of the phototransistor. It has been experienced that the sensitivity changes by about 25% in a distance between 0.9 m to 4.0 m. This variation is generated through the change of the current gain depending on the collector current.

Figure 2.

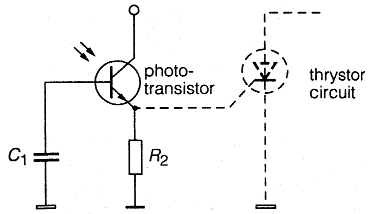


The compensation of the linearity error of a phototransistor is only partially possible because of its unavoidable characteristic tolerance. Therefore it is more convenient to use a circuit in which the value of the current gain does not essentially influence the exposure time of a computerized photoflash unit.

The base collector current dependence on the luminous intensity is completely linear whereas this is contrary to the one of the emitter collector current because the base-collector-junction serves as a photodiode. Therefore, a special circuit has been designed. The current generated through the light is integrated by capacitance not being connected to the emitter of the phototransistor but to its base as shown in Figure 1. At the beginning of the exposure the capacitor is not charged, i.e. the base-emitter-junction is not conductive. If the phototransistor is illuminated, charge carriers are generated. A hole moves to the base terminal and positively charges the capacitor C_1 with reference to ground potential. When the capacitor is charged so that the base-collector-junction becomes conductive, the phototransistor starts to amplify, i.e. the emitter current increases. The amplified photocurrent produces a voltage drop across the load resistor R_2 and thus the following turnoff thyristor is triggered.

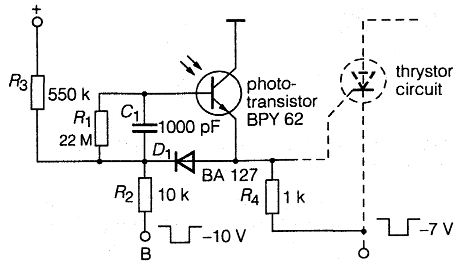
The disadvantage of the circuit shown in Figure 2 is that the signal slewing rate is not fast enough, because the capacitance of the integrating capacitor, C_1 is increased by the gain of the phototransistor at that instant when the base-emitter-junction becomes conductive, i.e. when there is an amplification effect. In order to improve the signal slewing rate the circuit shown in Figure 3 is recommended. Here the capacitor C_1 is connected to the base and emitter. If the voltage across the load resistor R_4 increases, the level at the capacitors low end also rises with nearly the same amount as at the high end of C_1 connected to the base. Therefore, the capacitor C_1 usually requires no charge.

Figure 3.



The circuit according to Figure 4 assures that at the beginning of each photoflash the capacitor C_1 always has the same charge impedance of the illumination which previously occurred. The resistors R_2 and R_3 serve as voltage divider, at which a positive voltage of 1 V referred to the level of the phototransistor emitter is disposable before the photoflash is started. The diode D_1 is turned off. Its voltage difference effects that a current flows via the resistor R_1 into the base of the phototransistor. At its base-emitter-junctions a voltage drop, not being essentially increased by the external illumination is produced. At the beginning of the photoflash, a negative pulse is applied via terminal B to the resistor R_2. By the current flowing through R_2 the diode D_1 becomes conductive and its level changes from +1 V to –0.7 V. This potential difference is fully transmitted via the integrating capacitor C_1 to the base of the phototransistor, which is therefore reversibly biased by this voltage. Thereafter, this bias is compensated by the photocurrent. The negative voltage pulse required at the beginning of the photoflash can be derived from the same voltage source, which generates the collector-emitter-voltage at the beginning of the photoflashing. The voltage at terminal A is taken from a divider being in parallel to the photoflash capacitor, i.e. also available before the photoflashing occurs.

Figure 4.



The advantages of the circuit shown in Figure 4 compared to the one of a conventionally computerized photoflash unit are as follows:

a. Exposure time failures are nearly not detectable presuming an objective lux meter (<5%).

b. The phototransistors must not be selected according to their photosensitivity since their base-collector-junction is utilized and there is no difference in sensitivity among the phototransistors.

c. No neutral absorber is required, since the internal base-collector-diode of the phototransistor operates linearly. Therefore, the photodetector is able to receive more light, i.e. signals with a higher amplitude are produced and the operation is trouble-free. The gate current of the thyristor does not influence the exposure time control. The total temperature coefficient is low (about 0.3% K^{-1}). If necessary the TC can be additionally decreased by applying at terminal B a pulse with a high amplitude. The charging of the integrating capacitor is extremely low when the supply voltage is suddenly applied to the phototransistor.

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General Photoelectric Applications Circuits Appnote 36

1. Suppression of DC Component in Photocurrent of Phototransistors

In many applications, phototransistors are intended to transmit only intensity-modulated light signals. Non-modulated light intensity interferes; the dc component caused by it must be suppressed.

Two circuits are described here in which the dc component remains ineffective. In the first circuit the direct current is kept constant through an automatic control system, in the second an active, frequency-dependent external resistance is used which is much smaller at low frequencies than at high ones.

Phototransistors are particularly suitable as light detectors for many applications since they are economical, and due to their amplification, offer a larger output signal than photodiodes. Thus they are less sensitive to external interferences.

In optoelectronics, a number of applications are used in which an intensity-modulated signal is superimposed upon a non-modulated signal, e.g. in optical flame control, in light barriers involving moving objects, and in computerized flashlight equipment as well as slave flashlight equipment in which the primary illumination can cause interference. In many instances the suppression of the dc component is required because of the danger of overdriving through unmodulated light intensity.

Using phototransistors, the dc component of the photocurrent cannot be suppressed by a coupling capacitor.

Circuit for Phototransistors with Base Terminal

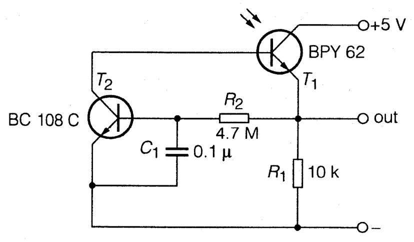
In Figure 1 phototransistor T_1 and transistor T_2 form an automatic control system which regulates the voltage drop at resistor R_1, maintaining it at a constant value, independent of the unmodulated light intensity at phototransistor T_1. When the light intensity rises, a larger photocurrent I_p flows through T_1, and the voltage drop at resistor R_1 becomes greater. As a result, a larger current flows to the base of T_2 photocurrent of T_2 keeps reducing the primary photocurrent of T_2 until the voltage drop at resistor R_1 reached its original value.

Due to the by-passing of the base-emitter junction of T_2 by capacitor C_1, this control mechanism is ineffective during rapid changes. The cut-off frequency above, at which the control becomes ineffective, is determined by capacitor C_1 and resistor R_2.

Resistor R_1 determines the quiescent current. R_2 should be as large as possible to permit small values for C_1. However, when resistance of R_2 becomes too large, the drive of T_2 is too weak. As a result the maximum light intensity at which the control still works is reduced. The maximum light intensity is also limited by the power supply voltage, because the voltage drop at R_1 must not exceed a fixed maximum value.

For the dimensioning given in Figure 1, the maximum light intensity can be 25,000 lx; the voltage drop at R_1 must not exceed the value VR_1=4 V. The photosensitivity of phototransistor BPY62 is 2 mA/1000 lx. The dark current of the circuit is smaller than the dark current/CEO of the simple phototransistor, because part of the dark current is split as residual current from T_2. The lower cut-off frequency of the circuit in the above dimensioning is f_{gu}=16Hz, the upper frequency f_{go}=2.5 kHz. If an increase in the upper cut-off frequency f_{go} is required, resistance of R_1 must become smaller.

Figure 1.



To exclude interference signals, the connection between the collector of T_2 and the base of phototransistor T_1 must be held as short as possible.

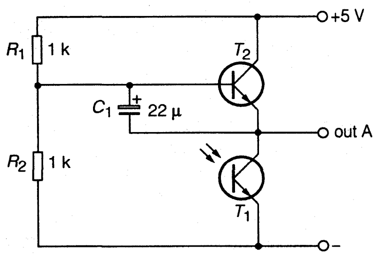
Circuit for Phototransistors Without Base Connection

The circuit shown in Figure 2 is intended for phototransistors without base connection. At low frequencies the base voltage of transistor T_2 remains constant and is determined by the voltage divider of resistors R_1 and R_2. The collector resistance of phototransistor T_1 is determined by the relatively low diffusion resistance of the base-emitter junction of transistor T_2. A large collector current can flow without resulting in a substantial decrease of the collector voltage of phototransistor T_1. For the diffusion resistance it applies that

$$R_D = \frac{k \times T}{e \times I}$$

k standing for Boltzmann constant (1.38×10^{-23} Wsk^{-1}; T for absolute temperature of phototransistor T_1, in Kelvin; e for elementary charge (1.6×10^{-19} As); and I for emitter current of transistor T_2 Ampere.

Figure 2.



At high frequencies the base-emitter junction is short-circuited by capacitor C_1. As a result the considerably larger differential resistance of the emitter-collector junction of transistors T_2 functions as external resistance. Parallel to it there is the series circuit consisting of capacitor C_1 and the resistors R_1 and R_2, parallel-connected through the power supply. In the circuit shown in Figure 2, the maximum light intensity for the given dimensions can amount to 20,000 lx.

The sensitivity of phototransistor BPX81, used in the experimental circuit, is 2.5 mA/1000 lx. The lower cut-off frequency is f_{gu}=80 Hz, the upper frequency is f_{go}=40kHz. The ac voltage at point A can be raised by increasing the resistance of R_1 and R_2. For a maximum light intensity of 20,000 lx, resistances of up to 10k are permissible.

Capacitors Used in the Circuit 1

1 pc Ceramic Capacitor 0.1 mF/63V

Capacitors Used in the Circuit 2

1 pc Electrolytic Capacitor 22 µF/40 V

2. Power Supply Using Photovoltaic Cell BPY64P for Low-Consumption-Devices

In the following, a circuit using the photovoltaic cell BPY64P and a blocking oscillator is described. The circuit supplies energy to small electronic devices of low power consumption, e.g., transmitter of infrared remote control systems. Generally a buffer accumulator is connected in parallel to this circuit and thus an operation without any batteries of other power suppliers is realized.

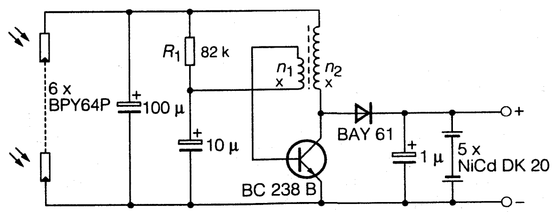
On sunny days, transmitted energy of approximately 1 mWh can be generated by a Silicon-diode area of 2 cm^2 (corresponding to 6 x BPY64P) even in standard-size living rooms. But on cloudy or winter days, a maximum value of only 0.2 mWh can be expected.

Assuming a current of 10 mA for the short operation period of an IR remote control transmitter, a power of 60 mW at battery voltage of 6 V is necessary. As the sum of all operations for remote control of a TV set does not exceed one minute per day, an electric energy of 1 mWh per day is required.

Under ideal conditions (i.e. power matching $R_i = R_o$, meeting exactly the color temperature for the sensitivity maximum) the photovoltaic cell BPY64P supplies approximately 60 µW at 1000 lx and at a color temperature of 2856 K. In practice, however, an average power generation between 15 and 16 µW can be obtained at diffused daylight and cloudy sky (E=1000 lx).

Six photovoltaic cells, type BPY64P, connected in series as shown in Figure 3 guarantee a safe starting of the blocking oscillator even at a low illuminance of 100 lx (daylight). The oscillator operates at 10 kHz. Its frequency strongly depends on the illuminance and the load. The basic current is adjusted by resistor R_1. A value of 82 kΩ can be considered as a good compromise especially at a low illuminance. The resistance of R_1, should be lower for higher illuminance values.

Figure 3.



The circuit offers an efficiency of approximately 60 to 65%.

FiveNiCd-cells (20DK, Varta, ordering number 3910020001) can be suitably utilized as buffer accumulators. They supply an open-circuit voltage of approximately 6.2 V at a 100% charge. The capacity is 20 mAh.

Figure 4 shows the accumulator current as a function of illuminance at an open-circuit voltage of 5.8 V and at a charge without load. The two curves show the dependence on incandescent lighting (60 W-bulb, matt, with white reflector) and on daylight (diffuse, near the window).

Figure 4.

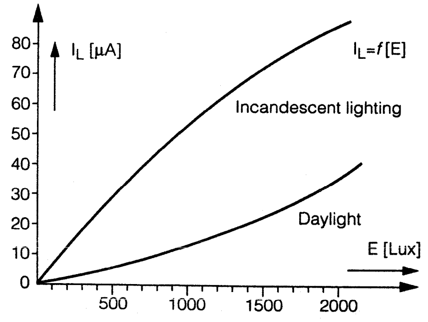
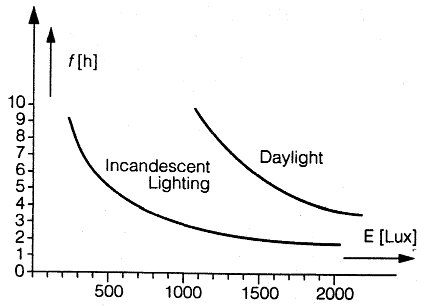


Figure 5 shows the time necessary per day as a function of the illuminance. As reference an energy of 1000 μWh is assumed. This is required by the accumulator if the remote control transmitter is operated 60 times per day for a period of 1 s.

Figure 5.



Coil Data

n_1: 15 turns 0.07 enamelled copper wire

n_2: 340 turns 0.07 enamelled copper wire

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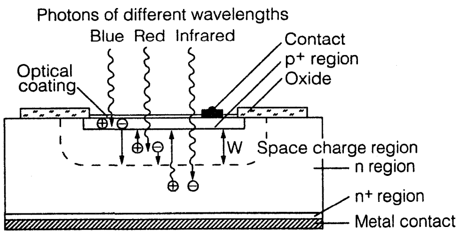
General IR and Photodetector Information Appnote 37

1. Detectors (Radiation-sensitive Components)

Charge Carrier Generation in a Photodiode

Figure 1 shows the basic design of a planar silicon photo-diode with an abrupt pn transition. Due to the differing carrier concentrations, a field region free of mobile carriers, the space charge region, builds up between the p^+ and n region, which only reaches into the n region if there is an abrupt p^+ n transition. The following applies to the width of the space charge region:

Figure 1. Planar silicon photodiode (schematic)



$$w \sim \sqrt{\frac{V_D + V}{n_D}} \qquad (1)$$

In this case, V_D is the diffusion voltage, V is the external voltage and n_D is the donor concentration on the n side. For the junction capacitance $C_j \sim 1/w$ with w from equation (1) the g is obtained:

$$C_j \sim \sqrt{\frac{n_D}{V_D + V}} \qquad (2)$$

If photons with an energy $h\nu \geq E_g$ penetrate into the diode, electron hole pairs are generated on both sides of the pn junction. The energy difference $(h\nu - E_g)$ is dissipated to the grid in the form of heat. The electrical field in the space charge region repels the majority carriers and attracts the minority carriers on the other respective side (thus, holes from the n side to the p side and, vice versa, electrons from the p side to the n side). In this way, the charge carrier pairs are separated and a photocurrent flows through an external circuit, also without an additional voltage (photovoltaic effect). Carriers occurring in the space charge region are immediately sucked off due to the field prevailing in this layer. The carriers from the other regions must first of all diffuse into the space charge region in order to be separated. If they recombine beforehand, they are lost with respect to the photocurrent. Thus, the photocurrent I_p consists of a drift current I_{drift} of the space charge region and of a diffusion current I_D from the remaining regions.

Should the p^+ region be far thinner than the penetration depth $1/\alpha_\lambda$ (α_λ = absorption coefficient) of the radiation, the photocurrent from the p^+ region can be neglected and the following relationship can be derived for the photocurrent I_p.

$$I_p = q\Phi_O\left[1 - \frac{e^{-\alpha_\lambda w}}{1 + \alpha_\lambda L_P}\right] \qquad (3)$$

L_O is the diffusion length of the holes in the n region, q is the elementary charge and Φ_O the radiant flux. The absorption coefficient α_λ is the only variable in the equation which depends on the wavelength. It predominantly determines the spectral characteristic of the diode's photosensitivity. In accordance with equation (1), the space charge region width w depends on the voltage and the doping which, in addition to the crystal quality, also influences L_D. High sensitivity is achieved with high values for w and/or L_D.

With respect to the electrical mode of operation, we differentiate between diode mode (with bias voltage) and cell mode (without bias voltage). In cell mode, the diode acts as a current generator which converts the radiant energy into electrical energy. If the photodiode is considered as a current source with the photocurrent I_p and a diode of equal polarity is connected in parallel to the load resistance R_{LE} (idealized equivalent circuit diagram), the relationship between the current and voltage can be expressed as follows:

$$I = I_S\left[e^{\frac{V}{n \cdot V_T}} - 1\right] - I_p \qquad (4)$$

In this case, I_p is the photocurrent, I_{sat} the saturation current, V the voltage between the p and n contact, V_T the voltage equivalent of the temperature and n is the diode factor. In the case of I_p=0, equation (4) is reduced to a normal diode equation and describes the dark characteristic (E_V=0). When subjected to light, the characteristic is shifted downwards corresponding to the illuminance. The open-circuit voltage

$$V_L = nV_T ln\left[1 + \frac{I_p}{I_S}\right] \qquad (5)$$

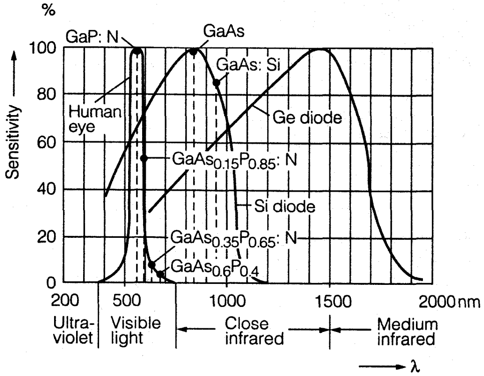
belongs to I=0 ($R_{LE}=\infty$) and the short-circuit current $I_S=-I_p$ belongs to V=0 (R_{LE}=0).

There is a linear relationship, depending on the diode type, between the illuminance E_V and the photocurrent I_p, which covers several powers of ten (eight and more). However, due to $I_p \sim E_V$ and $I_p > I_S$, a logarithmic relationship prevails between the open-circuit voltage V_L and the illuminance E_V. The forward current I_F belonging to the open-circuit voltage V_L is equal to the impressed photocurrent. In diode mode, the photocurrent of one or the other diode type may slightly change together with the applied voltage. This is due to the voltage dependence of the space charge region. In silicon photodiodes, the dark current [first term in equation (4)] once again only plays a role with extremely low illuminances (in the millilux range).

Spectral Sensitivity

Figure 2 shows the graph of the spectral sensitivity of a silicon and a germanium photodiode. The positions of the emission maxima of the most important light emitting diodes and the sensitivity of the human eye are also shown.

Figure 2. Relative sensitivity of a silicon and a germanium diode



The two photodiodes cover the wavelength band from approximately 300 to 1800 nm. In this case, the silicon diode is of greater significance; it covers the visible range and, with its maximum sensitivity in the near infrared area, is well matched to the GaAs infrared emitting diode, whose best known field of application covers IR remote controls and light barriers.

The sensitivity limit of semiconductor detectors in the long wave spectral wave band λ_g is determined by the energy gap E_g.

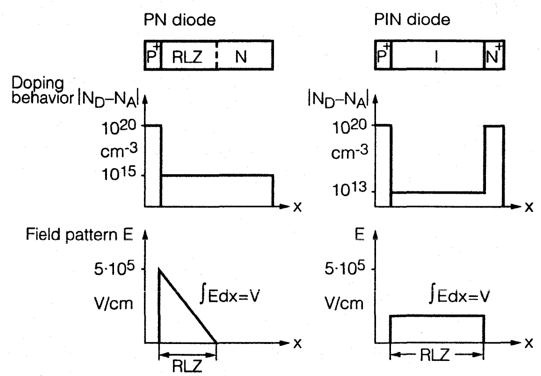
$$\lambda_g[nm] = \frac{h \cdot c}{E_g} = \frac{1.24}{E_g[eV]}$$

The run of the spectral sensitivity curve in the remaining wave band is determined by the absorption coefficient α_λ and the recombination relationships in the interior and on the surface of the semiconductor (carrier loss). The drop in the curve towards shorter wavelengths is due to the higher absorption for shortwave radiation; for this reason, carrier pairs are only generated in the regions near the surface but, due to the high prevalent recombination rate, are mostly lost with respect to the photocurrent.

Photodiodes (PN and PIN Diodes)

Photodiodes can optimally be matched to the desired appli- cation by choosing the correct mode of operation and by means of a suitable internal structure. In addition to the schematic structure of each individual diode type, Figure 3 shows the doping

Figure 3. Doping behavior and field pattern of photodiodes



behavior and the field pattern as well as the region in which the avalanche effect takes place at a sufficiently high voltage (ionization region).

PN photodiode radiation which, as a rule, enters the p^+ region vertically, is absorbed in the mainly quasi-neutral p and n regions due to the narrow space charge region; thus, the photocurrent predominantly consists of the diffusion current. As the characters are diffused relatively slowly, PN diodes are frequently used in applications in which the stress is placed rather more on low dark currents than on high speed. (For complete diffusion of a 5 µm thick p layer, an electron needs 3 ns, and a hole needs 15 ns for the same distance in the n region). Therefore, silicon PN diodes can be found in exposure meters which still operate perfectly under starlight; this presupposes dark currents of less than approximately 10^{-11} A/mm^2. Solar cells also belong to the group of PN photodiodes.

Contrary to the PN diode, most of the light for PIN photodiodes is absorbed in the space charge region. These photodiodes are mostly used in applications requiring high speeds. If possible, in order to achieve a large space charge region, according to equation (2), the semiconductor material must be intrinsic (intrinsic I) (mostly weak n or weak p doped) into which a p^+ region is diffused on the one side and an n^+ region is diffused on the other side.

A $P^+ IN^+$ structure ("sandwich" structure) is obtained. Per equation (3), the junction capacitance C_j is low due to the large space charge region of the PIN diode. C_j values are used between a few picofarad and a few tenths of a picofarad. The product from C_j and R_L (load resistance) is the time constant of the measurement circuit.

To achieve PIN diodes which are as "fast" as possible, the voltage is increased to such an extent that the carriers drift through the space charge region at saturation speed V_{sat}. In silicon and germanium, a saturation speed V_{sat} from 5 x 10^6 to 1 x 10^7 cm/sec is achieved with fields of approximately 2 x 10^4 V/cm. Accordingly, a carrier requires approximately 50 ps to completely drift through a 5 µm thick region.

Photovoltaic Cells

Voltaic cells are active dipole components which convert optical energy into electrical energy without requiring an external voltage source.

The properties of a voltaic cell are essentially characterized by the open-circuit voltage and the short-circuit current. In the case of a short circuit (V=0), the current I_S is a linear function of the illuminance and thus also proportional to the area subjected to radiation. The open-circuit voltage V_O initially increases logarithmically with the luminous intensity.

This is independent of the size of the cell and amounts to approximately 0.5 V at 1000 lx. In order to extract the maximum amount of energy from a voltaic cell, the load resistance R_L must lie in the order of magnitude of $R_i = \sqrt{V_O/I_S}$. The internal resistance R_i of a voltaic cell should be as low as possible in order to prevent unnecessary loss.

In order to measure the luminous intensity, the proportional relationship between the optical and electrical signals is important, and in practice, this applies up to a load resistance of $R_i \sim V_O/2I_S$.

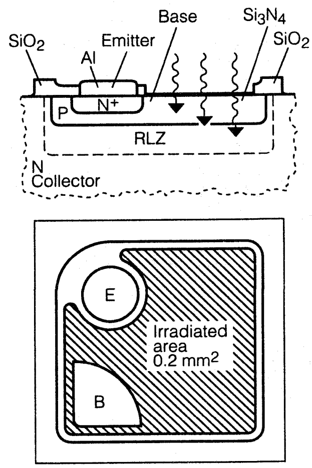
In principle, voltaic cells can also be operated in diode mode by applying a voltage in reverse direction. Obviously, this voltage must not exceed the maximum reverse voltage.

Phototransistors

In principle, a phototransistor corresponds to a photodiode (collector-base diode) with a series-connected transistor as amplifier. The phototransistor is the simplest integrated photoelectric component. Figure 4 shows one of the practical designs of a bipolar phototransistor (cross-section and view) with emitter (n^+), base (p) and collector (n); the latter is mostly subdivided into a weakly doped n and a highly doped n^+ region. As the diffusion length L_D of the holes in the n^+ region is low due to the high amount of doping, only the p and n regions provide the maximum amount to the primary photocurrent I_{CB} of the collector-base diode. This is due to the low photosensitivity (also in comparison with photodiodes) of epitaxial transistors in the long wave band. A large part of the long-wave radiation is absorbed in the n^+ region as the n region is mostly extreme thin (10 to 20 µm) as a result of the requirement for extremely low conductor resistances. The view of the transistor shows a base with a large area in which the emitter and also the base connection are attached to the side; in this way, as uniform as possible a surface sensitivity is achieved. The gain of phototransistors normally lies between 100 and 1000. Gain deviations from the linearity and thus from the linear relationship between the illuminance and the photocurrent amount to (over approximately four powers of ten of the photocurrent I_p, from some 100 nA to some mA) less than 20% and mostly less than 10%. With regard to dynamic behavior, phototransistors are less favorable than photodiodes as, in addition to the collecting and charging processes in photodiodes, there is also a delay due to the amplification mechanism (Miller effect). In addition to the rise and fall times t_r and t_f, the transistor also has the delay time t_d. This is the time required until the photocurrent has reached 10% of its final value after activation of an optical square-wave pulse. For the rise and fall times of a phototransistor, the following relationship applies:

$$t_{r \cdot f} = \sqrt{\left(\frac{1}{2 f_T}\right)^2 + a(R \cdot C_{CB} \cdot V)^2}$$

Figure 4. Bipolar phototransistor



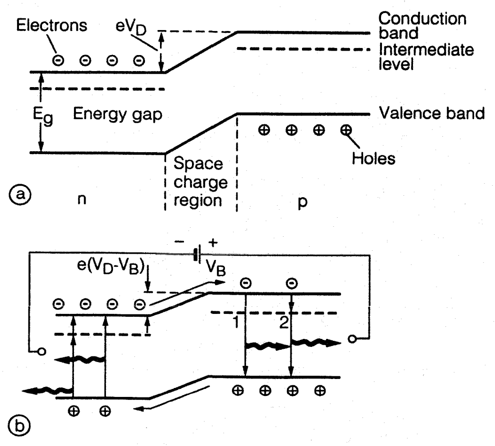
In this case, f_T is the transition frequency, R is the load resistance, C_{CB} is the collector-base capacitance, G is the gain, a is a constant whose value lies between four and five. The rise and fall times of usual phototransistors range from 1 to approximately 30 µs with 1 kOhm load resistance. Therefore, they are particularly suitable for utilization within a frequency range up to some 100 kHz, which suffices for important applications such as light barriers, punch tapes, and punch card readers.

2. Emitters (Radiation Emitting Components)
Principle of Operation and Materials

Light emitting diodes operate in accordance with the principle of injection luminescence. Through a pn junction operated in forward direction, n-type charge carriers are injected into the neutral n and p region where they partially recombine for emission, sending out a photon with the energy $h\nu = hc/\lambda \le E_g$ (h = Planck's constant, v = frequency, c = speed of light, λ = wavelength, E_g = energy gap). This is shown in Figure 5, an energy diagram for a pn junction.

The probability of radiant recombination essentially depends on the band structure type of the corresponding semiconductor material. In the case of direct semiconductors with GaAs as the most important representative, an electron can directly fall from the conduction band into a free state in the valence band (hole), in which case the released energy is given off as a photon (cp Figure 6, left). In the case of the so-called indirect semiconductors with Si, Ge, and GaP as the most important representatives, however, this transition is linked with a pulse change of the electron. Recombination is then only possible with the participation of third partners, for example, phonons or impurities. These must ensure pulse compensation. The energy released during the transition is mainly dissipated as heat to the grid. In indirect semiconductors, this leads to the probability of radiant recombination being less by orders of magnitude than in direct semiconductors. Nevertheless, effective radiant recombination can be generated in some indirect semiconductors. This is achieved by doping with isoelectronic impurities.

Figure 5. The pn junction of a light emitting diode



(a) without external voltage
(b) with externally applied voltage. Diode operated in forward direction (1 ≙ direct recombination. 2 ≙ indirect recombination)

The two most efficient isoelectronic impurities in GaP are the nitrogen atom and the zinc-oxygen pair. Radiant recombination is then achieved by way of the decay of an electron hole pair (exciton) bonded to the isoelectronic impurity (cp Figure 6, right).

A high degree of crystal perfection is a precondition for the creation of effectively radiant recombination as crystal defects act as centers for non-radiating recombination. For this reason, the active layers of light emitting diodes are produced epitaxially at temperatures far below the melting point of the semiconductor material.

III-V compound semiconductors and mixtures of these can be used as materials for light emitting diodes as their energy gaps cover wide spectrum and the band structure, contrary to the classical semiconductors Si and Ge, enable the creation of effective radiant recombination. Above all, the semiconductors GaAs, GaP, and the terniary mixtures Ga (As, P) and (Ga, Al) As have practical significance.

Infrared Emitters (IR LEDs)

IR emitters are based on GaAs which has an energy gap of approximately 1.43 eV, corresponding to emission of approximately 900 nm. Higher external quantum efficiencies can be achieved with these diodes than with light emitting diodes for the visible wave band. The left-hand side of Figure 7 shows the schematic of the diode body of a silicon-doped GaAs IRED. By means of liquid phase epitaxy (LPE), the active layer with a high crystal perfection can be grown onto a GaAs substrate. Due to the amphoteric characteristic of the silicon impurity, the pn junction forms automatically during the process of epitaxy. Due to the silicon doping, the emission lies at 950 nm and is thus so far underneath the band edge that the radiation created in the diode body is only absorbed to a slight extent. Part of the radiation leaves the diode body on a direct path through the near surface. However, radiation emitted in the direction of the substrate is also useful. For this purpose, the rear of the diode body is mirrored and serves as a reflection surface.

GaAs-IREDs are fitted in plastic packages or in hermetically sealed glass-metal housings.

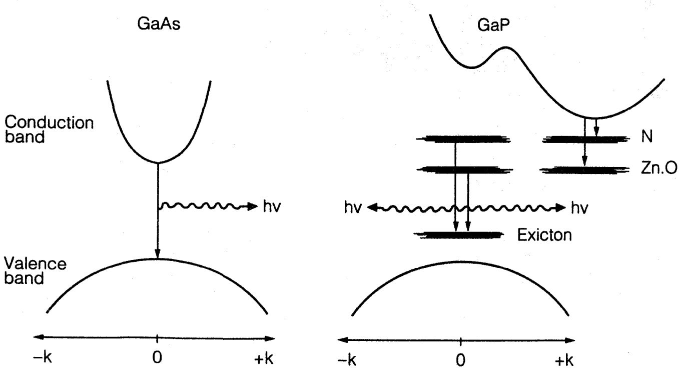
An essential piece of information for the user is the radiation characteristic. If the light emitting diodes are used in an arrangement without optical lenses, for example, in a punch tape reading head, the radiation should have a small half angle. This is the case with LD260 to 269 and CQY77.

In conjunction with optical lens systems, designs are preferred in which the radiation leaves the component through a flat window (CQY78, SFH402).

Array designs are suitable for a wide range of applications as they can be rowed up in any configuration.

Further developments in the field of silicon-doped liquid phase epitaxial IREDs is aimed at expanding the wave band. The amphoteric character of the silicon doping is retained in the terniary mixed crystal (GaAl) As in that the energy gap can be var-

Figure 6. Dependence of energy states on wave number vector k in direct (GaAs) and indirect (GaP) semiconductors



ied by means of the amount of Al. In this way, it is possible to produce emission wave bands between 850 and 900 nm and to tune the emitter diodes to the maximum detector sensitivity. With selectively sensitive detectors, it would be possible to create transmission systems with two (or more) optically separate channels.

Electrical and Optical Characteristics of IR LEDs

Figure 8 shows the emission spectrum of the most important LEDs and the relative spectral contact sensitivity Vλ. With respect to the emission spectrum of the IRED relative to the sensitivity curve of the silicon photodiode (Figure 1).

The emission spectrum of the GaP diode ranges from the yellow to the green wave band. By dying the plastic seal, the emission band can be limited in such a way that the emitted light appears yellow (λ_p = 575 nm) or green (λ_p = 560 nm) to the viewer.

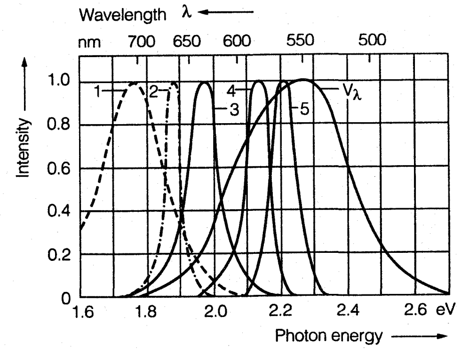
In the case of GaAs diodes and the red $GaAs_{0.6}P_{0.4}$ diode, the emitted radiation (or luminous intensity, respectively) of IREDs and LEDs changes in the normal operating range in a linear relationship with the forward current while, in the case of TSN diodes and GaP diodes, it rises slightly over proportionally (Figure 9).

If the forward current is very high, the curve asymptotically approaches a threshold value. This is caused by a strong heating of the semiconductor system. The linearity range can be widened by switching from static to pulse operation. Non-linearity also turns up at small forward currents. It is caused by excess current not contributing to the radiation and cannot be influenced by the customer. Figure 10 shows the radiant power versus the forward current.

At constant current, the radiant intensity or luminous intensity, respectively, decreases with rising temperature. The temperature coefficient is –0.7% per degree for GaAs, –0.8% per degree for GaAsP, and –0.3% per degree for GaP. This is negligible for many applications. If the temperature dependence proves disturbing, it can widely be eliminated by compensation circuits.

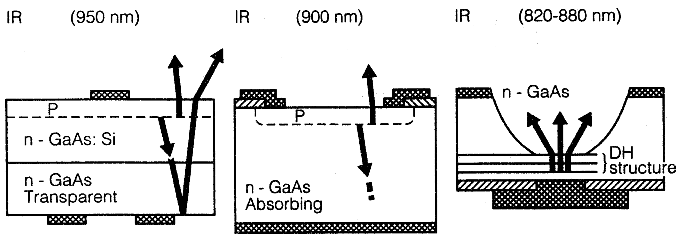
The radiant power emitted by LEDs declines with increasing length of operation ("aging"). A "life" of components was introduced to describe the degree of degradation. It is defined as the time after which the radiant power has fallen to half the value. In the case of IREDs, for example, the average life dependent on the operating current and ambient temperature is approximately 10^5 h (extrapolated from continuous tests). Refer to Figure 11.

Figure 8. Emission spectra of the most important LEDs



1: GaP: Zn.O — Red
2: $GaAs_{0.6}P_{0.4}$ — Red
3: $GaAs_{0.35}P_{0.65}$: N — TSN - Red
4: $GaAs_{0.15}P_{0.85}$: N — TSN - Yellow
5: GaP: N — GaP - Green/yellow
Vλ: Spectral contact sensitivity curve

Figure 7. Structure of the diode body of an IRED



Epitaxy	LPE	—	LPE (Hetero)
pn junction	LPE	Diffusion	LPE (Hetero)
Technology	GaAs-IRED	Diffused GaAs IRED	Burrus type
Switching time (typical)	1000 ns	50 ns	15 ns

Semiconductor — Contact — Contact

LPE = liquid phase epitaxy

Figure 9. Light current - diode current characteristic

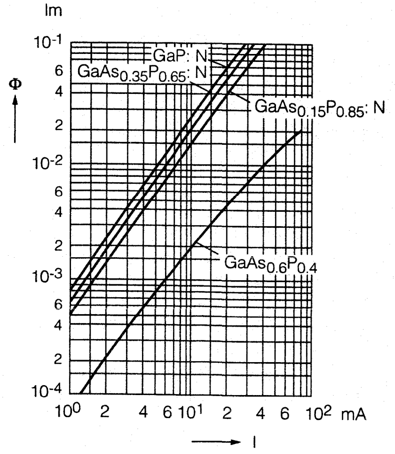
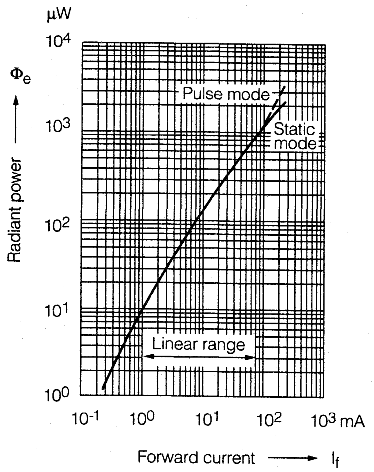


Figure 10. Radiant power versus forward current

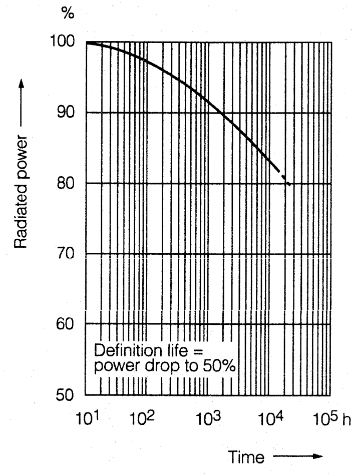


3. Measuring Technique

Detectors (Radiation Sensitive Components)

Radiation-sensitive semiconductor devices serve to convert radiation energy into an electrical one. Radiation energy can be offered to the component in manifold forms, depending on the source of radiation. For measuring purposes only such radiation sources can be taken into consideration which, in their spectral energy distribution, can easily be covered and are reproducible, i.e. thermic radiation sources like the tungsten filament lamp, which at least in the wavelength range here of interest comes very close to the black body and monochromatic light sources that means those emitting radiation of only one wavelength or at least of a very narrow wavelength range, above all light emitting diodes and a combination of whatever emitters with narrow band filters. Especially for applications with infrared emitting diodes (IREDs), this measurement of the spectral photosensitivity is increasingly gaining significance and is taking

Figure 11. Radiated power versus operating life



the place of integral measurement with standard light A. Because of its high energy, the tungsten filament lamp is mainly used for measuring the radiation sensitivity when set to a "color temperature" of 2856 K, corresponding to standard light A as per IEC306-1 part 1 and DIN5033 while light emitting diodes are primarily employed for cut-off frequency and switching time measurements as they can be modulated or pulsed up to high frequencies. At this instance, we want to draw your attention to the following. The definition "color temperature" is limited in its use for the optoelectronic measuring technique, quasi only as auxiliary. But unfortunately the term has come to stay. In practice the lamps are not calibrated to color temperature but to "relative temperature in the visible range", mostly to a green-red relation. An extension to a red-green-infrared relation and thus an approach to the, for our measuring technique solely correct, "distribution temperature" in the wavelength range 350 to 1200 nm, or even better 300 to 1800 nm, is worth aspiring after. This still meets with objections on the part of lamp manufacturers to extend their calibration equipment and the relatively small quantity of lamps required.

The tungsten filament lamps used for measuring purposes have to be set to a relative spectral energy distribution that corresponds to that of the black body at a temperature of normally 2856 K at least in the wavelength range 350 to 1200 nm, and have to be operated under very stable conditions. It is necessary to have the lamp operated with constant current, the deviation from the rated value must be kept less than ±0.1%. This requirement seems to be very high, but one has to consider that a deviation of the lamp current by 0.1% brings about a change of the radiant intensity by 0.7% and, of the color temperature, by 2 K. Naturally, the lamp can also be operated with constant voltage but this is hard to realize in practice because of the inevitable and varying contact resistances in the lamp socket, therefore an operation with constant current is to be preferred.

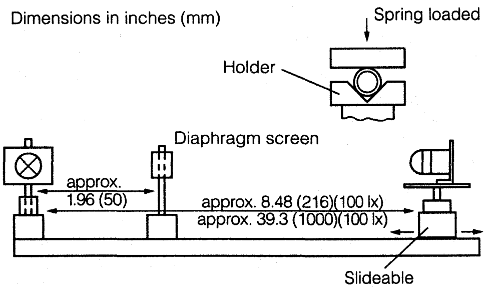
A lamp voltage check at the same time permits a control of the lamp with regard to a change in its characteristics, for example, by evaporating of coiled filament material which would point to the fact that the lamp is no longer suitable for measuring purposes and has either to be replaced or calibrated anew. This check is mainly recommended for the "standard lamps" which are standard for color temperature, radiant and/or luminous intensity.

For general measuring purposes, serial measurements in particular, the standard lamps gauged by the PTB or the manufacturer are usually not used because of the calibration costs. Therefore, the service lamps are set to the given ratings by a comparison with these standard lamps.

Photosensitivity

For photosensitivity measurements (photocurrent or photovoltage) the components to be measured are placed at the position predetermined for the specific irradiance and there they are held in such a way that the radiant sensitive surface of the semiconductor chip is vertical to the direction of light. Cylindric components such as in TO18, TO5 or similar plastic packages are put up so that the package axis coincide with the direction of radiation. This is of prime importance for components with a highly focusing lens. A holder with a sliding socket for the terminal wires proved useful (see Figure 12).

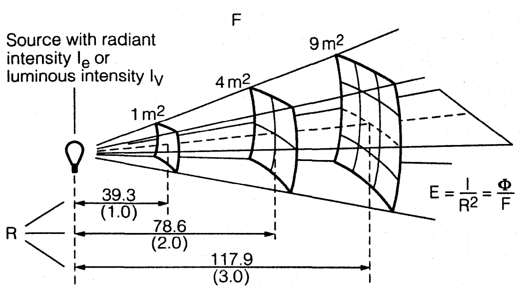
Figure 12. Ip test set-up for photoelectric devices



Solid Angle

The solid angle is a part of space. It is limited by all the beams which radiate conically from one point (radiation source) and which end on a closed curve in the space. If this closed curve lies on the unitary sphere (radius R = 1 m) and envelopes an area of 1 m^2, and if all rays originate from the center point of the unitary sphere, the solid angle has one sterad (sr).

Figure 13. Solid angle (1 sterad)



Short-circuit Current

When measuring the short-circuit current I_S of photovoltaic cells care has to be taken that the internal resistance of the measuring instrument used is small enough compared to the internal resistance of the photovoltaic cell. The same applies to measuring the open circuit, the internal resistance of the measuring instrument is large compared to the internal resistance of the photovoltaic cell.

Switching Times

The switching times are measured oscillographically by a setup as shown in the circuit diagram below (Figure 15) by means of a pulsed infrared emitting GaAs diode as a measuring source and a double-beam oscillograph. The switching times of the GaAs must, of course, be small compared to the switching times of the component to be measured.

Figure 14. I or V versus load resistance for photovoltaic cell BPY11

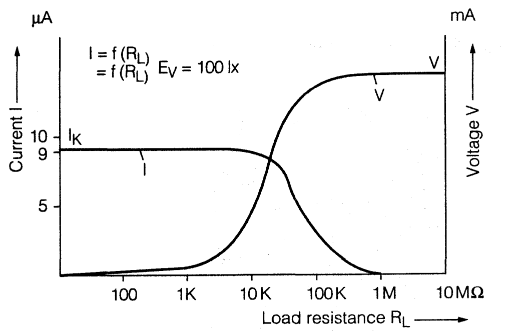
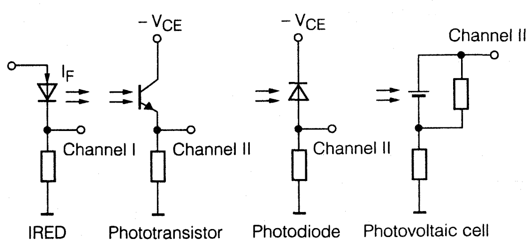


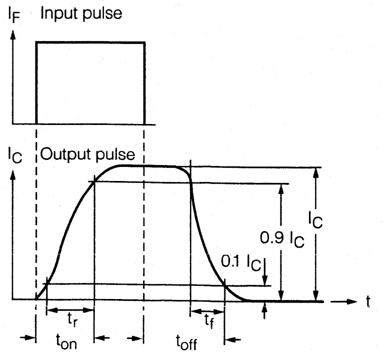
Figure 15. "Measuring the switching times of detectors"



Radiation in the Infrared Range

The radiant intensity I_e in the direction of the case axis should be measured by a wavelength independent detector (thermocouple element) but low sensitivity, inertia, and temperature sensitivity cause difficulties. For this reason, one usually measures with a correspondingly calibrated photovoltaic cell. In such case, the spectral sensitivity curve of the photovoltaic cell has to be considered and the measuring result corrected with regard to the deviations in the emitted wavelength of the radiator to be measured (for example IRED with different production

Figure 16. Switching time definitions



Turn-on time t_{on}:
The time in which the collector current I_C rises to 90% of its maximum value after activation of the drive current I_F.

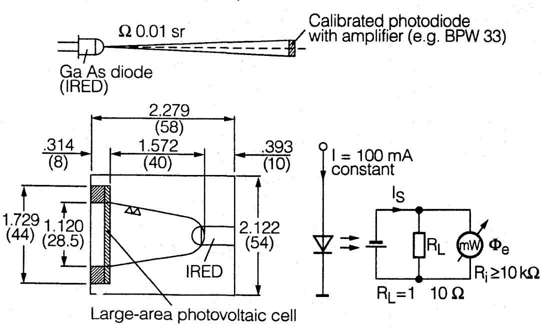
Rise time t_r:
The time in which the collector current I_C rises from 10% to 90% of its final value.

Turn-off time t_{off}:
The time in which the collector current I_C drops to 10% of its maximum value after deactivation of the drive current I_F.

Fall time t_f:
The time in which the collector current I_C drops from 90% to 10% of its maximum value.

Figure 17. Calibrated photodiode with amplifier (for example BPW33)

Dimensions in inches (mm)

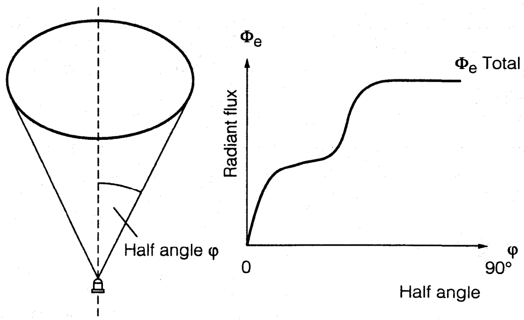


technology). If the total radiation of the component shall be measured, the IRED has to be fitted in a parabolic like reflector to ensure that all radiation emitted by the component reaches the photovoltaic cell that forms the end of the parabola.

Figure 17 shows the outline of such a measuring parabola. As for the rest, the same requirements apply as for radiant intensity measurements.

In cases where IRED emitting diodes are used in connection with mirrors or lenses, for example in light barriers, it can prove useful to state the radiant power (radiation capacity) Φ_e defined in a cone with the half angle φ, or the curve $\Phi_e = f(\varphi)$, respectively (see Figure 18).

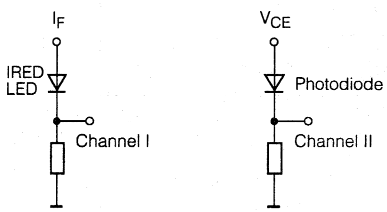
Figure 18. Radiation cone and radiant flux Φ_e versus half angle



Switching Times

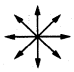
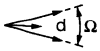
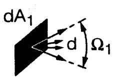
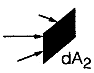
For measuring the switching times the same applies as to the radiant sensitive components except that now a photodiode serves as detector and its switching time must be small compared to that of the IRED or LED to be measured.

Figure 19.

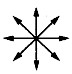
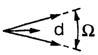
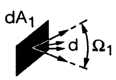
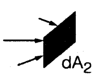


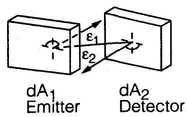
4. Terms and Definitions

Radiation and Light Measurement

	Radiometric terms				
No.	Term	Symbol	Unit	Relation	Simplified definition
1 	Radiant power	Φ_e, P	W		Radiant power is the total power given in the form of radiation
	Emitter				
2 	Radiant intensity	I_e	$\frac{W}{sr}$	$I_e = \frac{d\Phi_e}{d\Omega_1}$	Radiant intensity is radiant power per solid angle
3 	Radiance	L_e	$\frac{W}{m^2\,sr}$	$L_e = \frac{d^2\Phi_e}{dA_1 \cdot d\Omega_1}$	Radiance is radiant power per area and solid angle
	Sensor				
4 	Irradiance	E_e	$\frac{W}{m^2}$	$E_e = \frac{d\Phi_e}{dA_2}$	Irradiance is incident radiant power per (sensor) surface

Indices "e" (= energetic) and "v" (= visual) may be omitted unless danger of confusion
DIN 1301, DIN 1304, DIN 5031, DIN 5496
International Dictionary of Light Engineering, 3rd Ed. publ. by CIE and IEC

	Spectral Radiometric terms			**Photometric terms**		
No.	Term	Symbol	Unit	Term	Symbol	Unit
1 	Spectral radiant power distribution	$\Phi_{e\lambda}$	$\frac{W}{nm}$	Luminous flux	Φ_v	lm Lumen
	Emitter					
2 	Spectral radiant intensity distribution	$I_{e\lambda}$	$\frac{W}{sr\,nm}$	Luminous intensity	I_v	$\frac{lm}{sr} = cd$ Candela
3 	Spectral radiance distribution	$L_{e\lambda}$	$\frac{W}{cm^2 sr\,nm}$	Luminance	L_v	$\frac{cd}{cm^2} = sb$ Stilb
	Sensor					
4 	Spectral irradiance distribution	$E_{e\lambda}$	$\frac{W}{m^2 nm}$	Illuminance	E_v	$\frac{lm}{m^2} = lx$ Lux



dA_1 = element of area of emitter
dA_2 = element of area of detector
ε_1 = angle of radiation

Photometric Basic Law

$$d^2\Phi = L\frac{dA_1 \cdot \cos\varepsilon_1 \cdot dA_2 \cdot \cos\varepsilon_2}{R^2}\,\Omega_0$$

Inverse Square Law

$$E = \frac{I}{R^2}\cos\varepsilon_1\,\Omega_0$$

(r should be 10 times the max. spacing of emitter-detector to keep error below 1%)

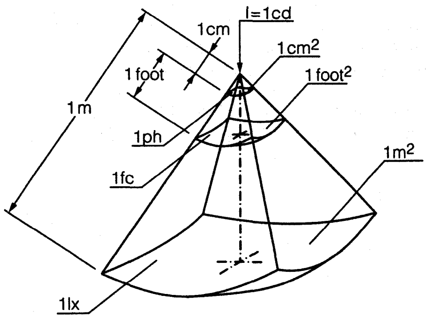
ε_2 = angle of irradiation
R = spacing emitter-detector
Ω_0 = sr

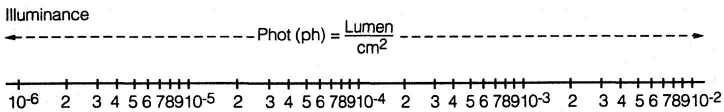
Radiation Characteristic

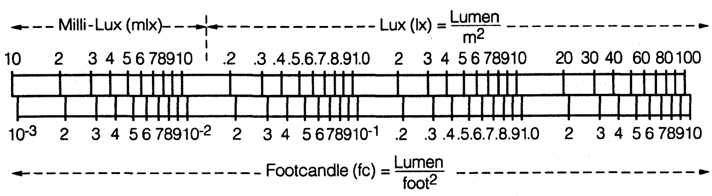
Designation	Symbol	Meas. quant.	Abbr.	Definition
Quantity of radiation	Q	Joule Wattsecond	J Ws	Quantity of radiation through a surface
Radiant power	Φ	Watt	W	Quantity of radiation Q per second through a surface
Point source of radiation	–	–	–	...is a source viewed from such a great distance R that all rays seem to emanate from one point. The max. linear expansion of the source must be substantially smaller than the distance R (example: sun for observer on earth).
Solid Angle	Ω	Sterad	sr	$\Omega = \frac{A_1}{R_1^2} = \frac{A_2}{R_2^2} = \frac{A_3}{R_3^2} = \frac{A}{R^2}$ the radiant power F[*W*] of a point source is constant in solid angle. (Prerequisite: homogenous, undamping medium.) $\Omega = 1$ is $A = R^2$ so that $\Omega_{hemisphere} = \Omega_{\triangle} = 2\pi\ sr$, $\Omega_{full\ sphere} = \Omega_{\ominus} = 4\pi\ sr$
Radiant intensity	I	$\frac{\text{Watt}}{\text{sterad}}$	$\frac{W}{sr}$	...is the solid angle density of the radiant power $\left(\frac{d\Phi}{d\Omega}\right)$ I of one source generally varies depending upon viewing direction. I only defined when $R \rightarrow \infty$
Total radiant power of a source	Φ_{tot}	Watt	W	$\Phi_{tot} = \int_0^{4.7} I d\Omega$
Irradiance	E	$\frac{\text{Watt}}{\text{meter}^2}$	$\frac{W}{m^2}$	...is the surface density of the radiant power (spherical surface) for a point source. $E = \frac{d\Phi}{dA}$; $dA = R^2 d\Omega$ $E = \frac{d\Phi}{d\Omega R^2} = \frac{I}{R^2}$; $I = ER^2$
Radiance	L	$\frac{\text{Watt}}{\text{m}^2\text{sterad}}$	$\frac{W}{m^2 sr}$	...is the radiant intensity referred to the radiant surface viewed by the observer. (Surface projection $A_p = \cos\varepsilon$, when ε is the angle by which the radiant surface is rotated against the connecting line to viewer. $L = \frac{I}{A_p} = \frac{I}{A\cos\varepsilon}$) Important optical quantity 1) In an undamped beam path L is maintained and cannot be increased by any optical measure 2) The human eye sees differences in radiance as differences in brightness
Sensitivity of detector	$S = \frac{I}{E}$	$\frac{\text{Ampere}}{\text{irradiance}}$	$\frac{A \cdot m^2}{W}$	Electrical quantity (current, voltage or resistance) in relation to irradiance

Illuminance (units and conversion factors)

		lx	mlx	ph	fc
1 Lux = lx	=	1	10^{-3}	10^{-4}	9.29×10^{-2}
1 Millilux = mlx	=	10^{-3}	1	10^{-7}	9.29×10^{-5}
1 Phot =ph	=	10^{4}	10^{7}	1	929
1 Footcandle = fc[1])	=	10.76	10760	1.076×10^{-3}	1







1) equivalent footcandle / apparent footcandle } footlambert (Luminous density) ≙ footcandle (illuminance).

Figure 21. Conversion of illuminance E_v into irradiance E_e (Planck's black body)

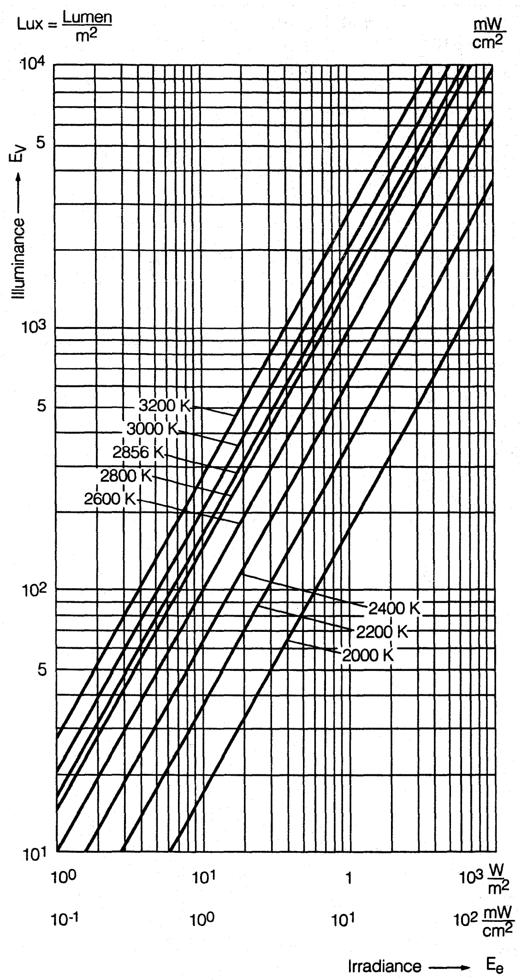
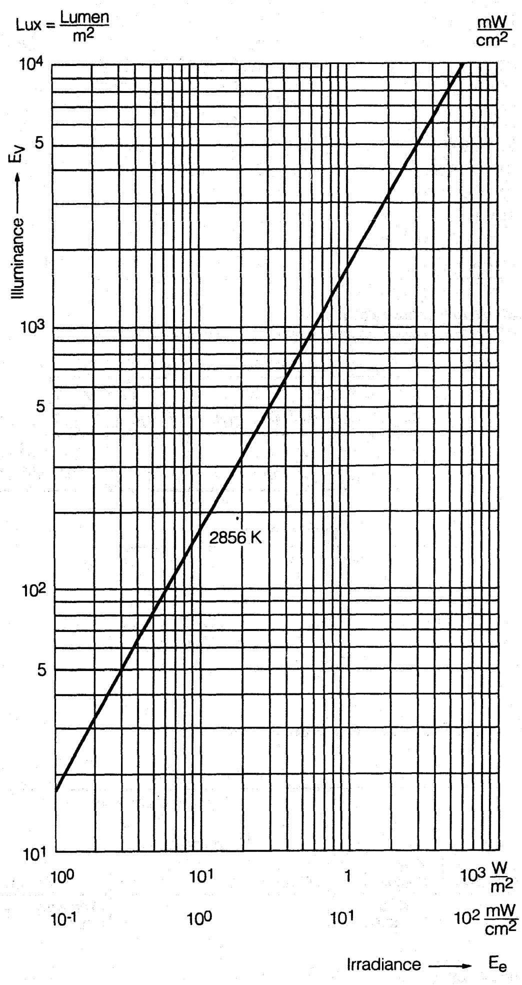


Figure 22. Conversion of illuminance E_v into irradiance E_e at 2856 K (Planck's black body)



Luminous density (units and conversion factors)

Units		sb	cd/m²	cd/ft²	cd/in²	asb	L	Lm	ftL
1 Stilb = cd/cm² = sb	=	1	10^4	929	6.45	31400	3.14	3140	2920
1 cd/m² = Nit = nt	=	10^{-4}	1	9.29×10^{-2}	6.45×10^{-4}	3.14	3.14×10^{-4}	0.314	0.292
1 cd/ft²	=	1.076×10^{-3}	10.76	1	6.94×10^{-3}	33.8	3.38×10^{-3}	3.38	3.14
1 cd/in²	=	0.155	1550	144	1	4870	0.487	487	452
1 Apostilb = asb	=	3.18×10^{-5}	0.318	2.96×10^{-2}	2.05×10^{-4}	1	10^{-4}	0.1	9.29×10^{-2}
1 Lambert = L or la	=	0.318	3183	296	2.05	10^4	1	10^3	929
1 mL or mla	=	3.18×10^{-4}	3.18	0.296	2.05×10^{-3}	10	10^{-3}	1	0.929
1 footlambert	=								
1 equivalent footcandle	=								
1 apparent footcandle ftL or ftla	=	3.43×10^{-4}	3.43	0.318	2.21×10^{-3}	10.76	1.076×10^{-3}	1.076	1

Electromagnetic radiation

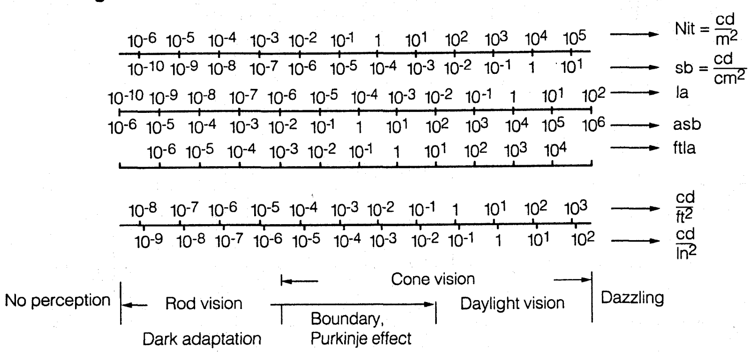


Figure 23. Frequency and wave bands

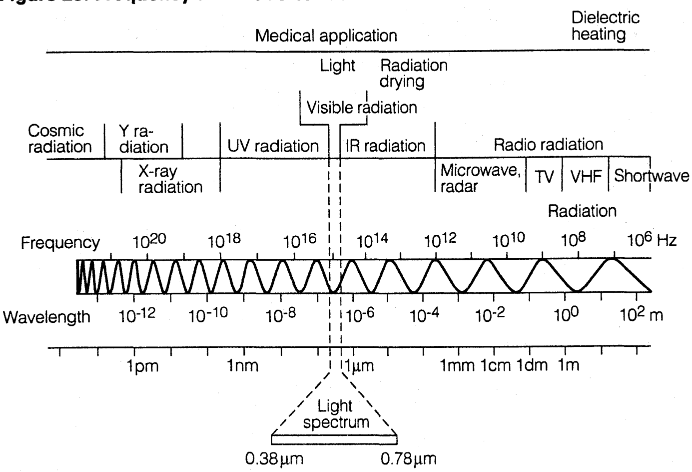


Figure 24. Relative sensitivity of different light-sensitive detectors

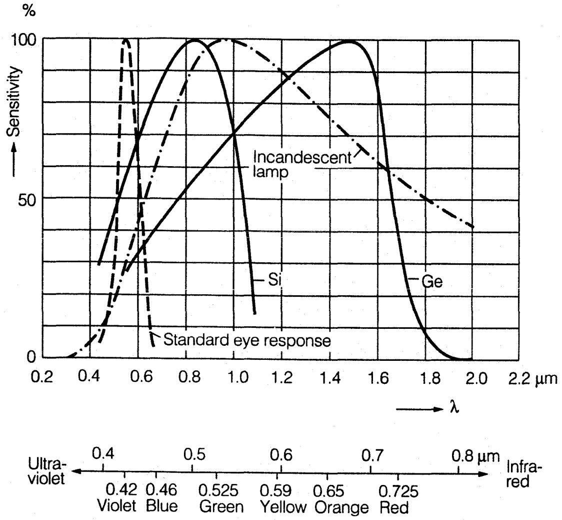


Figure 25. Nomogram for electromagnetic radiation

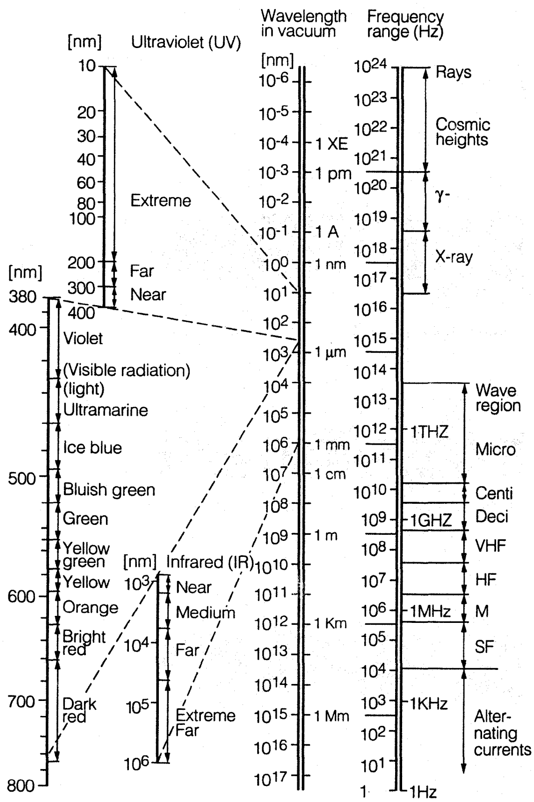
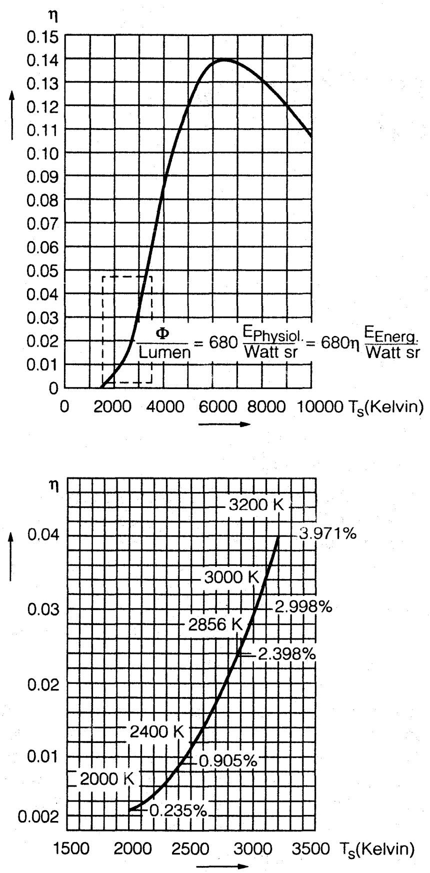


Figure 26. Visual efficiency µ of the total radiation of a black body versus temperature



SIEMENS

Surface Mounting
Appnote 38

1. What is Surface Mounting?

In conventional board assembly technology the component leads are inserted into holes through the PC board and connected to the solder pads by wave soldering on the reverse side (through-hole assembly). In hybrid circuits (thick and thin film circuits) "chips", i.e. leadless components, are reflow soldered (see paragraph 7.2) onto the ceramic or glass substrate in addition to the components already integrated on the substrate. Surface mounting evolved from these two techniques (Figure 1).

In through-hole technology the components are placed on one PCB side (component side) and soldered on the other (solder side) (Figure 1, top), whereas in surface mount technology the components can be assembled on both sides of the board (Figure 1, bottom). The components are attached to the PCB by solder paste or non-conductive glue and then soldered.

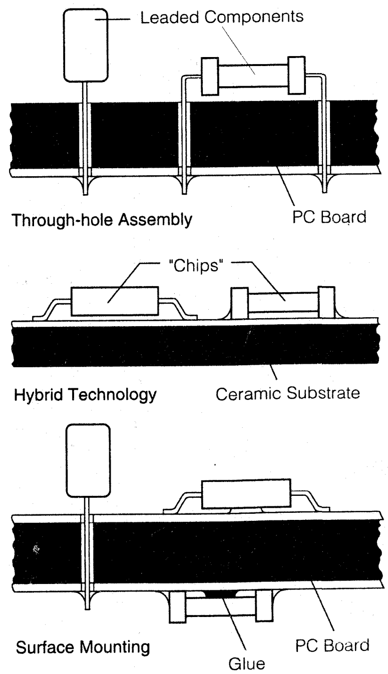
In the near future mixed assemblies, i.e. a combination of leaded and surface mounted components, will prevail, since not yet all component types are available as surface mount version.

Automatic assembly machines are a must for an expedient production; there are systems for simultaneous and for sequential assembly.

The following explanations point out what is new in surface mounting:

- Up to now connecting materials with large differences in the thermal coefficient of expansion, such as plastic boards and ceramic components, by rigid soldering has been regarded as a serious problem. Practice has shown, however, that this is feasible owing to the elasticity of board and solder; of course, component size and thermal stress are subject to certain restrictions (see section 4).
- Components for surface mounting have to withstand high thermal stress during the soldering procedure. Not all component types meet these requirements; therefore new components suitable for surface mounting are constantly developed (see section 4).
- In some cases the components are non-conductively glued to the PCB before soldering.
- As compared to through-hole technology there is a closer interrelation between the individual steps in design and production.
- Automatic assembly gains prior importance.

Figure 1. Through-hole assembly—hybrid technology—surface mounting



2. What are SMDs?

The abbreviation SMD* for **S**urface **M**ounted **D**evice is the most common designation for this new component. SMDs are designed with soldering pads or short leads and are much smaller than comparable leaded components. In contrast to conventional components, the leads of which must be inserted into holes, SMDs are directly attached to the surface of the PCB and then soldered. In Figure 2 and the section below the various SMD types are summarized. Surface mountable components include "chips"** with cubic dimensions, cylindrical SMDs, plastic packages with solder pins (SOT, SO, VSO package), chip carrier packages, miniature IC packages (Quad Flat Pack, Flat Pack), TAB components and special SMDs such as inductors, trimmers, quartz crystals, switches, plugs, relays, etc.

* Other terms used: SMC (**S**urface **M**ounted **C**omponent), SMT (**S**urface **M**ount **T**echnology), SMA (**S**urface **M**ount **A**ssembly).

** "Chip" should only be used when confusion with semiconductor chip as used in semiconductor technology can be excluded.

SMD Types:

Cubic components ("chips")
Preference types 0805,1206,1210,1812, 2220, etc.

Cylindrical components
MELF[1], MINIMELF, MIKROMELF
TUBULAR (e.g. tubular capacitors)
SOD 80 (MELF-similar diodes)

SOT 23,143, 89,192

SO[2] 4 to 28 pins (SOIC)

VSO[3] 40 pins

CHIP CARRIER
Plastic case (PLCC[4])
Ceramic case (LCCC[5])

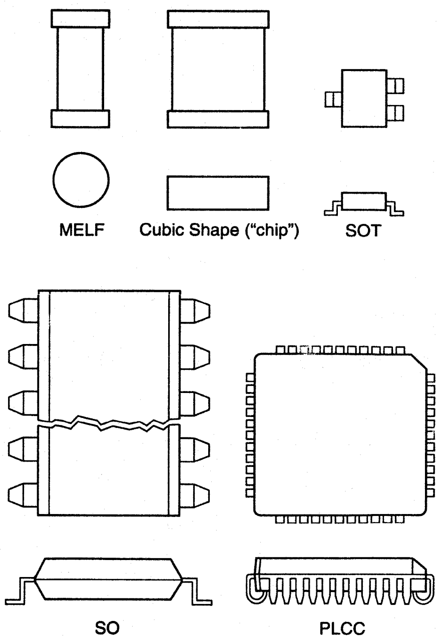
ICs with gull-wing leads
Flat Pack
Quad Flat Pack

MIKROPACK TAB[6]

Special packages for:
Inductors, SAWs[7], trimmers,
quartz crystals, switches, plugs, relays, etc.

[1] **M**etal **E**lectrode **F**ace Bonding
[2] **S**mall **O**utline
[3] **V**ery **S**mall Outline
[4] **P**lastic **L**eaded **C**hip **C**arrier
[5] **L**eadless **C**eramic **C**hip **C**arrier
[6] **T**ape **A**utomated **B**onding
[7] **S**urface **A**coustic **W**ave Filter

Figure 2. SMD types



Most of these components are suitable for dip soldering; chip carriers, TAB (MIKROPACK) and some special versions require other soldering methods.

Resistors, ceramic capacitors and discrete semiconductors represent at 80% the largest part of the SMD spectrum. In the range of SMDs the cubic shape prevails over cylindrical versions, as the latter can only have two pins thus being exclusively suitable for resistors, capacitors and diodes.

If development of a special SMD package is not advisable for electric or economic reasons, the DIP package can be converted into a surface mountable version by bending the leads.

An important factor for automatic assembly is the components' adequate and uniform geometry. Some packages are already standardized (IEC) or are proposed for standardization (JEDEC Recommendation).

For more than ten years Siemens has offered its customers SMDs and thus has gained considerable experience in the field of SMD production through continual modernization and development. The spectrum of active and passive components available covers ICs, transistors, diodes, ceramic multilayer capacitors, NTC thermistors, as well as SIFERRIT miniature ferrites, and the product menu is growing larger almost daily.

Table 1. SMD dimensions

Package	Dimensions (mm)	Standard
0805	2.0 x 1.25	IEC
1206	3.2 x 1.6	IEC
1210	3.2 x 2.5	IEC
1812	4.5 x 3.2	IEC
2220	5.7 x 5.0	IEC
MELF	5.9 x 2.2 ∅	
MINIMELF	3.6 x 1.4 ∅	
MIKROMELF	2.0 x 1.27 ∅	
SOD 80	3.5 x 1.6 ∅	
SOT 23	3.0 x 1.3	DIN 23 A 3 JEDEC TO-236
SOT 143	3.0 x 1.3	DIN 23 A 3
SOT 89	4.5 x 1.5	JEDEC TO-243
SOT 192	4.5 x 4.0	
SO 4 to 28[1)]	spacing 1.27	JEDEC MO-046...
VSO (SOT 158)[2)]	spacing 0.76	
PLCC	spacing 1.27	JEDEC MO-04...
LCCC	spacing 1.27	JEDEC MO-04...

1) SO 6 3.9 x 4.0 or 3.9 x 6.2 (incl. pins)
SO 8 5.2 x 4.0 or 5.2 x 6.2 (incl. pins)
SO 14 8.8 x 4.0 or 8.8 x 6.2 (incl. pins)
SO 20 L 12.8 x 7.6 or 12.8 x 10.7 (incl. pins)

2) VSO 15.5 x 7.6 or 15.5 x 12.8 (incl. pins)

3. Advantages of Surface Mounting

The three major benefits of surface mounting

- rationalization
- miniaturization
- reliability

are discussed in the following.

A consistent concept as regards components, board layout, assembly machines, processing and testing is essential for an efficient application of surface mount technology; in other words, the aim should be an optimized overall concept. The component price, for example, should not be seen isolated, but with regard to the total cost including placement, soldering and testing which may already be considerably lower than with conventional board assembly technology.

In the following the advantages of surface mounting are analyzed as to component, PC board, automatic assembly, reliability and rework.

3.1 Components

- SMDs are much smaller than leaded components, thus enabling smaller board size, higher packing density, reduced storage space and finally smaller equipment to be obtained.
- Light weight makes them ideal for mobile appliances.
- No leads means high resistance to shock and vibration.
- Cutting and bending of leads are eliminated.
- Parasitic inductance and capacitance due to leads are substantially lowered making SMDs particularly suitable for RF applications.
- Automatic assembly machines ensure accurate placement.
- MIKROPACKs, PLCCs and similar packages permit a considerably higher number of pins.
- Closer capacitance tolerances can easily be obtained for capacitors with low capacitance values.
- The growing demand for SMDs results in lower production costs, so that further cost reductions can be anticipated. The surface mount version of ceramic multilayer capacitors, for example, is even today cheaper than the leaded version.

3.2 Printed Circuit Board

- Surface mount technology makes PC boards smaller. When using SMDs on both sides of the board, size can be reduced by more than 50 per cent. On the other hand, maintaining the PCB size implies reduced packing density and thus higher yields and higher reliability.
- In many cases the printed circuits can be shortened and reduced in number. Owing to the compact "leadless" construction the electrical characteristics can easily be reproduced, thus cutting the cost for adjusting RF circuits.
- Surface mount technology does not require a special PCB material; standard materials such as phenolic resin laminated paper and glass-fiber laminated epoxy material are quite suitable, but of course, special materials, e.g. for RF circuits, can be used, too. For normal packing density the printed circuit precision should meet current requirements.
- The elimination of through-holes entails a further cost reduction. This is quite an important factor, as the cost for the drilling of holes can amount up to 10% of the total PCB cost.
- Mixed assembly with leaded components is possible. The reason for using this assembly variation was explained in the beginning.

3.3 Assembly

The average cost per component for automatic assembly can be considerably cut by surface mounting, because the smaller number of assembly machines entails less capital investment, maintenance, servicing and factory space.

- A major advantage of surface mounting are the high component placement rates attained by automatic placers. Fast machines can place several hundred thousand components on the PCBs per hour.
- Automatic placement systems for SMDs feature high placement reliability. Failure rates of less than or equal to 20 ppm (parts per million) can be obtained by machines capable of identity checking and defective recognition. This means that out of a million placed components only max. 20 are not at all or incorrectly assembled.
- In mixed assembly any ratio of SMDs and leaded components is possible, thus facilitating transition to the new technology.
- Some automatic placement systems can handle a wide range of different components.

3.4 Reliability

The demands on quality and reliability of PCB assemblies increase steadily. In this respect SMDs have at least to meet the standard set by conventional through-hole technology.

As surface mount technology is a relatively new development, sufficient proven information on quality and reliability is not yet available. However, the following general statements can be made:

- The failure rate of SMDs does not exceed that of leaded components. Omission of leads means one point of contact less. Owing to their small size and light weight SMD assemblies feature a higher resistance to mechanical stress (vibration, shock) than the corresponding assemblies with leaded components.
- A quality approval for SMDs used in hybrid circuits can be usually applied to surface mounting, as well.
- High requirements are placed on the solderability of SMDs. The specifications for wetting, leaching and storage have to be observed (see section 7).
- In many cases the soldering methods are the same as with other mounting methods. The known advantages and disadvantages apply to surface mount technology as well. One should bear in mind, however, that the criteria for judging solder joints are different for wave soldering and reflow soldering (see section 7.2). For example, the filling of through-holes with solder is only possible with the wave soldering method, with reflow soldering the amount of solder is too small.
- If components have to be replaced because of incorrect assembly, reliability of the board—although correctly assembled then—is diminished. Hence, automatic placement systems with their high degree of placement reliability enhance board reliability.

3.5 Rework

Elimination of component preparation, high placement reliability provided by automated systems, and careful planning of each step of the design and production process considerably reduce expensive rework of PCB assemblies with SMDs.

[1] At present three assembly machines are usually required for leaded components:
1) Insertion machine for radial-leaded components
2) Insertion machine for axial-leaded components
3) Insertion machine for DIPs.

4. Restrictions and Special Features of Surface Mounting

Maximum packing density—one of the primary goals in surface mount technology—requires the use of miniature components, i.e. certain IC packages (e.g. VSO or MIKROPACK). This involves problems, not necessarily resulting from surface mount technology as such, but from miniaturization in general.

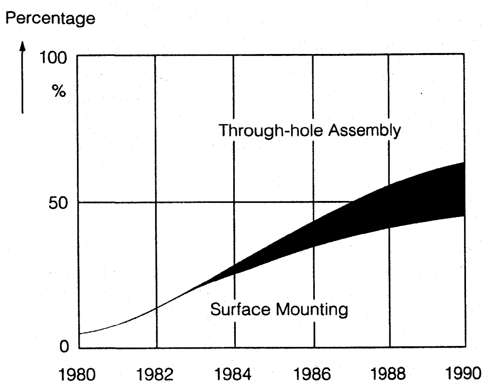
- The use of high-pin-count ICs may require new PCB design (fine etching and super-fine etching) and an increased number of layers (multilayer) because the space between the IC pins is too narrow for printed circuits.
- Due regard must be paid to heat dissipation. The high packing density may cause thermal problems. Special PCBs with good thermal conductivity can aid heat removal, if necessary.
- Using ceramic components is restricted. Due to the different thermal expansion coefficient of ceramic and PCB material, ceramic SMDs with edges longer than 6 mm should not be used on phenolic resin laminated paper and epoxy glass fiber boards.
- Not all SMDs are suitable for dip or wave soldering. This has to be considered when designing a PC board.
- Some components are not yet available as SMD version. Not all SMDs available are standardized.
- High voltages naturally require certain minimum spacings.
- Visual inspection of solder joints becomes difficult if the leads are partially beneath the component body. Therefore, soldering methods should be optimized so that visual inspection will become unnecessary.

- Test methods have to be adjusted to SMD assemblies. Development of new adapters may be required.
- Repair of SMD assemblies may be more costly as compared with conventional PCB assemblies.

5. Market Forecast for SMD Applications

Figure 3 shows the increasing share of surface mount technology in the market.

Figure 3. Trends in mounting techniques



6. Fixing SMDs by Glue

New in surface mounting is the gluing procedure required for fixing the components when the PC board is to be turned upside down for soldering. The glue has to meet numerous requirements. It must provide reliable fixing of the components (also of heavy ones) on all kinds of PC boards. Furthermore, it should feature uniform viscosity to ensure easy handling; a pot life of at least several days is advisable. The glue should feature short curing time at low temperature. After curing the glue must not show chemical reactions in order not to impair board or components. On the one hand the adhesive is required to withstand high thermal stress, and on the other hand it must permit removal of SMDs from the assembled board in case of repair. For repairs the component body is heated, so that the adhesive becomes soft and allows the component to be removed without damaging the printed circuit below it. The glue has to be non-toxic, as odorless as possible, and free of solvents. Besides, it should feature good heat conductivity. Development of new adhesives is under way.

The component outline should be such that the adhesive can easily be applied, i.e. the distance between component body and board must be closely tolerated (Figure 4).

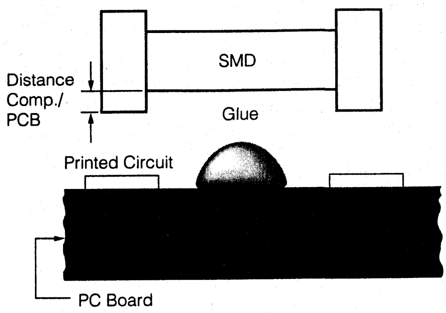
There are three methods of dispensing the glue:
1) by applicator
2) by pin transfer
3) by screen printing.

Not all adhesives are equally suitable for all methods.

Siemens pick-and-place machine (see chapter 12.3) dispenses the glue by an applicator simultaneously with the placement process.

Component and glue dot have to be shaped such that the component is reliably wetted while the contact area remains free of glue.

Figure 4. Form of the glue dot and component outline



7. Soldering Techniques

An appropriate soldering method is particularly important for obtaining good electrical contact and inhibiting short circuits. The choice of the soldering procedure depends on the PCB design (single or double-clad, multilayer, etc.), the components supplied, and the production facilities. While many SMDs are suitable for all soldering methods, the soldering technique for ICs, for example, has to be chosen very carefully. Besides manual soldering, which should only be used for repair purposes, there are several automated soldering methods such as bath soldering (wave and dip soldering) and reflow soldering.

With bath soldering the solder is applied during the soldering process itself, whereas with reflow soldering the solder is applied before. For this reason the preconditions for bath soldering, e.g. component orientation and configuration are quite different from those for reflow soldering. The reflow method is particularly advisable for soldering certain ICs.

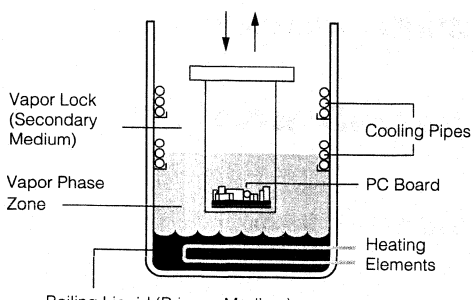
7.1 Wave Soldering

Wave soldering is the most popular automated soldering process in the production of PCB assemblies. The solder bath temperature lies between 240 and 260°C and the dwell time is 1 to 3 seconds. Before soldering the flux is applied.

High packing density on the PCB side to be wave soldered involves the problem of solder bridges and shadows (not completely wetted leads and pads). Therefore, PCB layout, i.e. component configuration, should match the soldering method used.

Dual-wave soldering best meets requirements of surface mounting. The first turbulent wave sends up a jet of solder to ensure good wetting of all metallization areas, while the second more laminar wave removes the excess solder (solder accumulations and bridges).

Figure 5. Principle of vapor phase soldering



7.2 Reflow Soldering

In reflow soldering a specific amount of solder, in the form of solder paste, is applied to the PC board. After attaching the SMDs the reflow process is performed by one of the following methods:

- vapor phase soldering
- hot gas soldering
- heat collet soldering
- infrared soldering.

The latest reflow technique is vapor phase soldering, where the entire PC board is uniformly heated until a defined temperature is reached; there is no possibility of overheating. The defined temperature (e.g. 215°C) in a saturated vapor zone is obtained by heating an inert (neutral) fluid to the boiling point. A vapor lock above this primary vapor zone prevents the expensive primary medium from escaping (Figure 5).

When the assembled PC board is immersed in the vapor zone the vapor condenses at the cold parts and transfers its heat to the workpiece. Adequate heating control ensures continuous vapor supply. Summing up, vapor phase soldering is a very gentle method that excludes overheating. At present it is the best reflow soldering method, if components with different thermal capacity are densely positioned or if adequate heating cannot be provided otherwise.

Other methods are hot gas and infrared soldering in continuous-type furnace. As compared to vapor phase soldering these methods have the disadvantage of poor heat transfer and non-uniform heating effect on components with different thermal capacity.

For heat collet or pulse soldering a collet or a soldering iron is used to transfer the heat to the component leads. It is important to force the leads into reliable contact with the solder pads before and during the soldering process. This method is preferably used for MIKROPACK and Flat Pack packages.

7.3 Iron Soldering

Manual soldering with temperature-controlled miniature iron should only be used in exceptional cases (repair, etc.), because this method is not only uneconomic, but can also damage components or PC board.

7.4 Fluxes, Cleaning Agents

Wave soldering requires no other fluxes than those used for conventional techniques (e.g. collophony F-SW32 per DIN 8511).

Most of the solder pastes required for reflow soldering, however, contain aggressive fluxes the residues of which must be removed by a cleaning process.

Figure 6. Variations of PCB assemblies

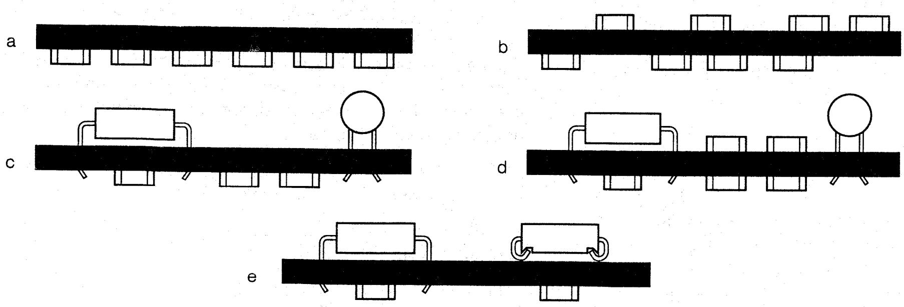


Figure 7. Mixed assembly of SMDs and leaded components (variant 1)

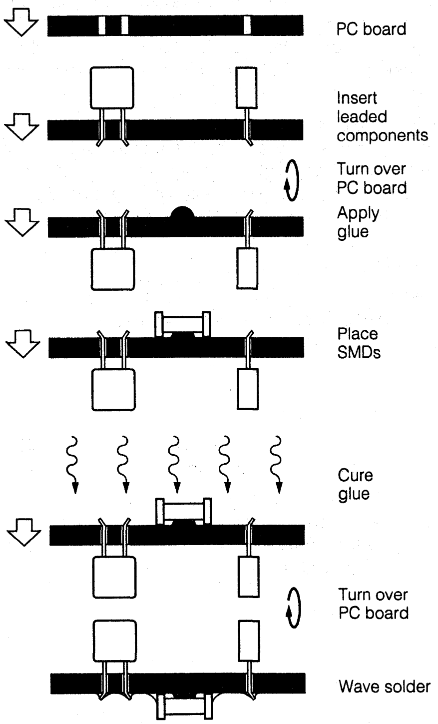
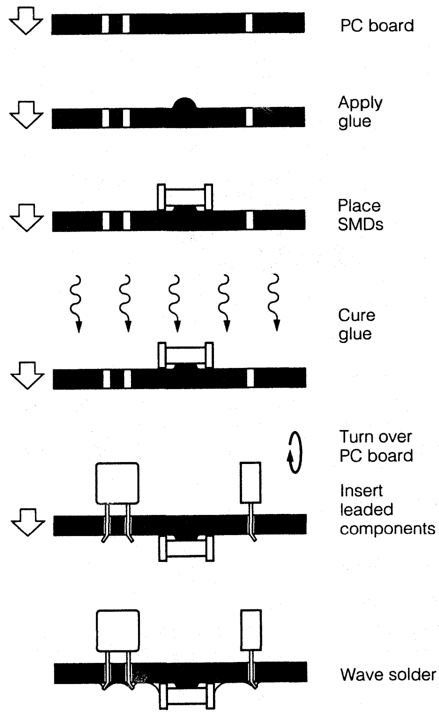


Figure 8. Mixed assembly of SMDs and leaded components (variant 2)



7.5 Conductive Adhesion

Conductive adhesion is not a soldering process, but shall be described here for the sake of completeness. It is not very often used since most conventional PC boards with a surface of tin or solder tin are not suitable for gluing. If components or PC board permit gluing, silver-filled mixed epoxy resin adhesives can be recommended. These can be spread by an applicator, screen printing, or by pin transfer.

The times required for curing are between 1 min and 12 h depending on the temperature. The thermal stress imposed on the components is less than with soldering, but the adhesion process must be performed separately after soldering the other components.

8. Assembly Variations

Figure 6 shows the PCB assembly variations possible with SMDs: Assemblies exclusively with SMDs in the top row (Figure 6a and 6b), mixed assemblies, i.e. SMDs combined with leaded components in the middle (Figure 6c and 6d), and mixed assembly consisting of dip solderable components (on solder side) and non-dip-solderable components (on component side) in the last row (Figure 6e). The versions illustrated in Figures 6b, d, e require double-clad PC boards.

In mixed assemblies with SMDs and leaded components (Figure 6c and 7) the leaded components are usually placed first, then the board is turned over and the glue applied. Subsequently the SMDs are placed, the glue is cured and after a renewed turn over the board is wave soldered.

The second variant shown in Figure 8 differs from the first in so far as the glue is applied by screen printing at first; the following production steps are executed as illustrated in Figure 8. This procedure has the advantage that the glue can be applied by screen printing, however, it has to be taken into account that because of the already mounted SMDs vacant board space is required for the mounting tools of the insertion machines, which are needed for cutting and bending the leads of conventional components.

The procedure for double-sided SMD mounting is as follows:

- Screen printing of solder paste
- SMD placement
- Reflow soldering
- Insertion of leaded components
- PCB turn over

- Application of glue
- Placement of SMDs on the reverse side
- Curing of the glue
- PCB turn over
- Mounting of components requiring special handling
- Fluxing, wave soldering

Here both reflow and wave soldering are used. Assemblies including leaded components always require wave soldering.

The aim is a uniform mounting procedure with the exclusive use of SMDs. Figure 9 shows examples for totally surface mounted assemblies with reflow soldering (top) and wave soldering (bottom).

Figure 10 is a flow chart for the various assembly and exclusive use of SMDs.

Figure 9. PC board exclusively with SMDs, reflow soldered or wave soldered

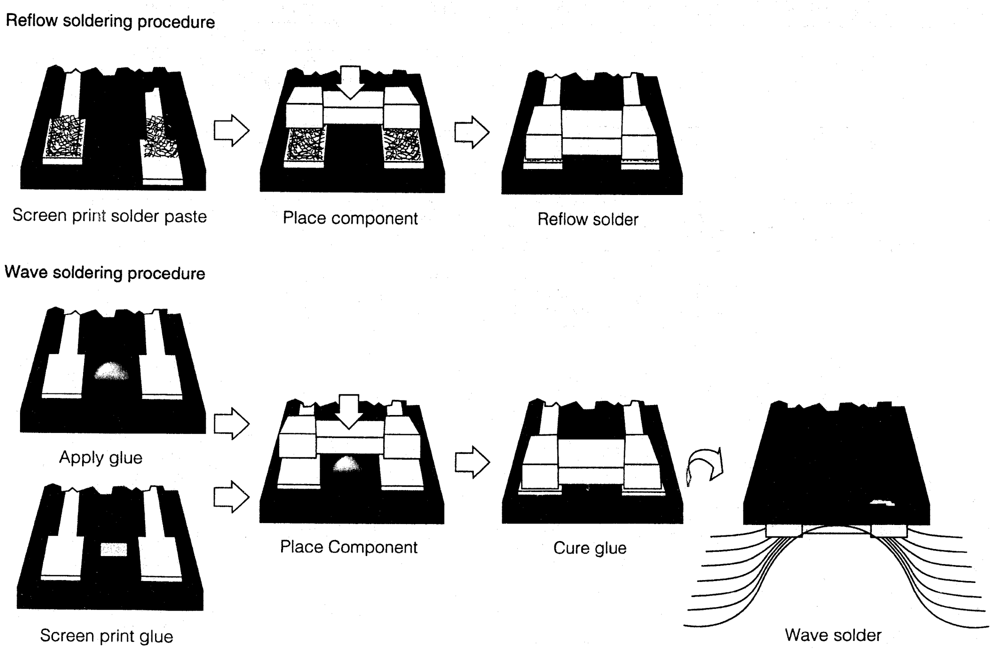
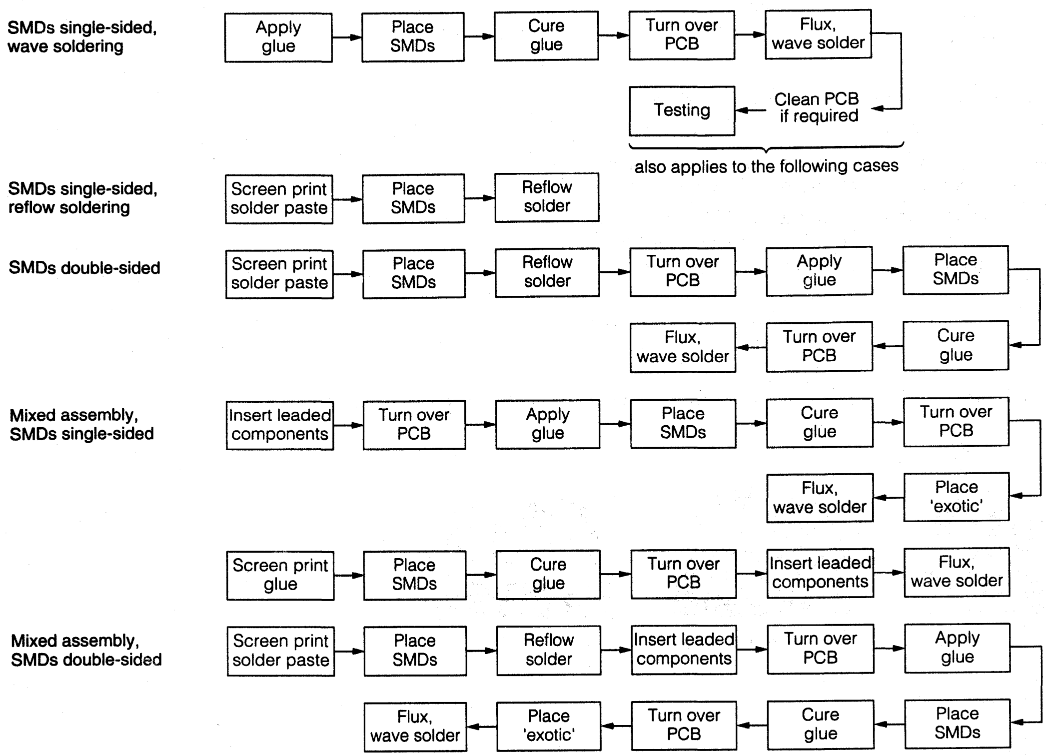
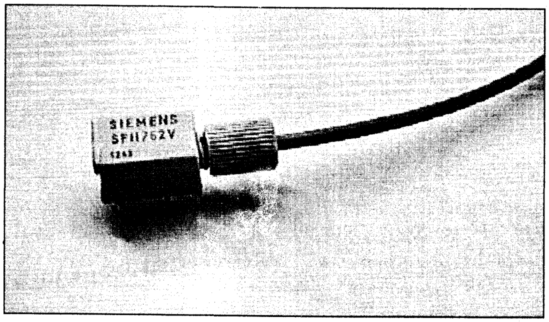


Figure 10. Possible assembly procedures for SMDs and leaded components



SIEMENS

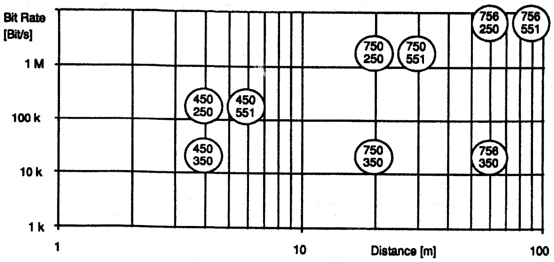
Plastic Fiber Components (PFC): A Cost Effective Solution for Optical Signal Transmission Appnote 40



Optical communications offer important advantages over electrical transmission links. The following characteristics make the technology particularly attractive for a wide range of applications:

- Insensitivity to electromagnetic interference
- Voltage decoupling between emitter and detector
- Security against tapping
- No sparking at fiber ends or breaks
- No ground loops

Figure 1.1 Bit rate versus transmission span



Yet despite the many potential application areas arising from these advantages, the use of optical glass fiber is restricted due to its relatively high cost. Where demands are for medium bit rates and distances, by far the more cost effective solution today is offered by Plastic Optical Fiber (POF) in combination with Siemens Plastic Fiber Components (PFC) emitters and detectors. These low cost components permit the use of plastic fibers even in the most cost-sensitive applications, such as:

- Industrial and medical networks
- Motor controls, links between power and control units
- Replacement of connections with copper wire and opto coupler (within cabinets)
- High voltage opto couplers
- Automotive bus applications
- Building information and control systems

The Siemens PFC product range consists of three different emitter diodes (SFH450, SFH750, and SFH756) and three optodetectors (SFH250, SFH350 and SFH551/1). Whatever the system requirements, a combination of Siemens PFCs may be selected to provide the optimal solution. The characteristics of various combinations of PFC emitters and detectors are shown in Figure 1.1.

1. Optical–mechanical Design

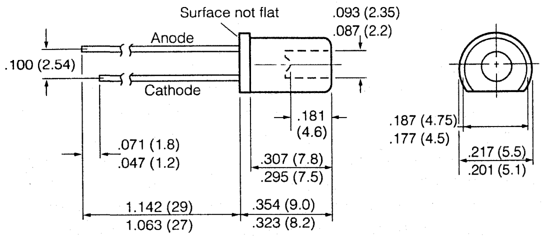
The product range builds upon proven fabrication technology 5 mm LEDs. The task of coupling the device to the fiber is given over to the housing, the design is shown in Figure 1.2 a.

A particular advantage of the Siemens PFCs is the housing aperture into which a standard plastic fiber (external diameter of 2.2 mm) may be introduced without having to remove the cladding. This has the additional benefit of automatically aligning the fiber on the chip.

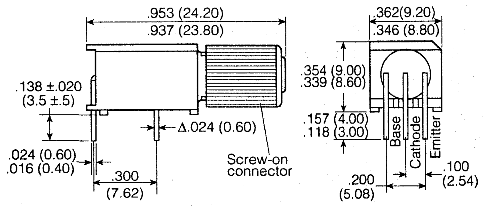
Sticking the component and the fiber together results in a permanent connection, which not only saves on space but also is very cost effective. Should a temporary connection be required, the PFCs are also available in a housing with a mounting screw (see Figure 1.2 b). This option has numerous advantages:

- The cladding need not be removed
- A connector on the fiber is not necessary
- The plastic fiber is connected by a simple turn of the screw cap
- The screw cap cannot be removed (loss-proof)
- The component is suitable for automatic board assembly
- The fiber itself does not turn when the cap is screwed tight
- Every plastic fiber with an external diameter of 2.2 mm and an internal diameter of 1 mm can be used
- Small housing dimensions
- The housing protects photodetectors from external light sources

Figure 1.2 Design of the PFC housing



a. SFH250, SFH750, SFH450



b. SFH350V

Table 2.1 Parameters of the PFC emitters

Part	SFH450	SFH750	SFH756	Unit
Wavelength	950	660	660	nm
Typ. Pin (I_F=10 mA)	90	9	200	µW
t_r 10%/90%	1000	120	80	ns
t_f 90%/10%	1000	50	80	ns

The emitters are mounted in grey housing and the detectors in a black one. Two mounting pins are provided on the housing for firm attachment to boards.

2. Electrical and Optical Characteristics of PFCs

Both the emitters and detectors display the same electrical characteristics of standard optoelectronic devices. They may be operated in a temperature range of –40°C to +85°C.

2.1 Characteristics of the Emitter Diodes

Different technologies employed in chip fabrication lead to significant variation in parameters for the various emitter diodes. All the emitters distinguish themselves in offering high output power coupled into the plastic fiber, low fiber attenuation and long lifetimes. Table 2.1 gives a summary of the most important device parameters, where Pin is the output power coupled into the fiber, t_r and t_f are the rise and fall switching times for the optical signal.

SFH450 emits in the infrared range, whereas SFH750 and SFH756 emit visible light in the red range, namely at 660 nm, which is optimal for plastic fiber. The choice of emitter for a particular application is dealt with in section 3, where system issues are discussed.

The output power coupled into the fiber is measured using a standard plastic fiber of numerical aperture 0.47 and length approximately 30 cm, for a forward current of 10 mA. It should be noted that this power is not transmitted over long distances. As a consequence the first few meters of a long length of fiber appear to have higher attenuation (see section 3.2).

The optical power does not rise linearly over the entire operating range. At low currents the optical power rises more than proportionately with the current; at higher currents, saturation sets in.

As regards the effect of device temperature, all emitter diodes have negative temperature coefficients. As a result the output power coupled into the fiber decreases at higher temperatures.

2.2 Characteristics of the Photodetectors

Within the PFC range, three photodetectors are available: a fast PIN-Photodiode (SFH250), a phototransistor (SFH350) and an integrated photodetector with TTL-output (SFH551/1).

The main parameters of the photodetectors are summarized in Table 2.2.

2.2.1 Phototransistor SFH350

The phototransistor SFH350 is a very cost effective photodetector. In operation it yields a high output current even at low optical input power. Its performance is limited by low switching speeds. The external base connector on the SFH350 may be used to divert current using a base-emitter resistor, with the following advantages:

Table 2.2 Parameters of PFC photodetectors

	SFH250 PIN-Photodiode	SFH350 Phototransistor	SFH551/1 Integrated Photodetector	Unit
Sensitivity 660 nm (950 nm)	0.25 (0.3)	80 (120)		A/W
Switching level			6	µW

- Reduction of the collector-emitter cut-off current
- Reduction of the switch off time
- Suppression of noise signals and signals with low power

As the temperature coefficient is positive for phototransistors, this in some measure compensates for the negative coefficient of the emitter diodes, assuming that the ambient temperature of the emitter and receiver are the same.

2.2.2 Photodiode SFH250

The photodiode SFH250 has a switching time of 10 ns (with 50 Ω for P_{opt}=50 μW), which makes it the fastest available detector. When driving a load of greater than 200 Ω, the capacitance of the diode also determines the switching time.

Temperature dependence of I_P is less than that for a phototransistor. The photodiode SFH250 has lower, negative temperature coefficients for wavelengths of 565 or 500 nm. At 950 nm wavelength, the coefficient becomes positive.

2.2.3 Digital Receiver SFH551/1

A simple design of the electronic circuitry is an essential step for the implementation of low cost optical links. In many cases optical emitters can be directly driven by logic gates through a resistor for adjusting the current. On the receiver side, however, a special low-noise amplifier is required due to the small photocurrent. Thus, receivers with integrated preamplifiers have succeeded to realize simple and low cost transmission links.

Figure 2.1 Optical transmission line with integrated optical receiver

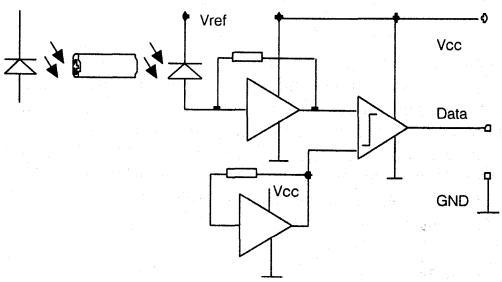
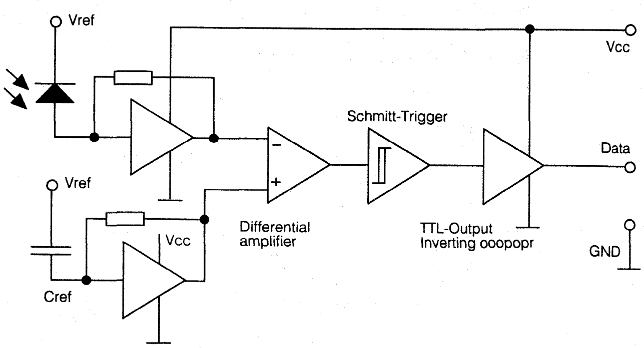


Figure 2.2 Circuitry of the SFH551/1 with built in Schmitt trigger



For this purpose SIEMENS offered the SFH551 (not for new design), which stood the test in many applications. Now this receiver is substituted by the upgrade version SFH551/1 which is compatible in pinning and identical in most of its properties. It was the goal of the SFH551/1 development to improve its performance with respect to noise and dynamics. The features of the SFH551/1 are now discussed in detail.

Principle of the digital receiver

An integrated optical receiver in an optical transmission system (Figure 2.1) comprises the following units:

Using a built-in lens, the light leaving the plastic fiber is focused onto the photodiode of the IC. The photodiode integrated in the device converts the received light into photocurrent.

The preamplifier converts the photocurrent into voltage. Usually, a transimpedance-amplifier is applied. A resistor in the amplifiers feed-back loop determines the current/voltage conversion. To avoid pulse disturbance, the amplifier has to offer a linear performance over the entire power-range of the received light.

The comparator following the signal path works digital. Here, the preamplifiers output voltage is compared to a reference voltage and the decision to set the output high or low is made. As the signal may be noisy, a (small) undefined voltage range occurs around the reference level. Typical input signals go through this range very fast and no degradation of the output signal can be observed. However, if the signal slowly increases towards the decision threshold, the output can run into undefined states. Thus, noise peaks may occur with amplitudes reaching the switching threshold of the following stages.

To remove this effect, the SFH551/1 is equipped with a Schmitt trigger which works with different thresholds: If the output is 'off' a high signal level is required for switching to the on-state, whereas a lower level has to be reached to switch back to the off-state. Therefore, the probability is greatly reduced that small noise signals cannot cause unwanted switching errors.

How the DC-coupled receiver with a fixed threshold works

The form of the signal that is internally delivered from the transimpedance amplifier to the decision circuit considerably determines the performance of the receiver. This form itself is determined by the optical receiver signal and its processing in the preamplifier.

The received optical signal is determined by the following items:

- bias light caused by scattering or residual emission of the transmitter in the switched off state
- rise and fall times depending on the transmitters control signal, the transmitter's speed and possibly effects from the transmission link
- pulse amplitude depending on emission power and the loss of the optical transmission link.

The preamplifier integrated in the SFH551/1 is designed for wide bandwidth. Consequently no considerable disturbance occurs within its linear working range.

Depending where the fixed decision threshold crosses...

If the input signal is too small and does not reach the decision threshold, the decision circuit does not change its output state. A short peak exceeding the threshold results in a correspondingly short output pulse.

If the level of the input signal is very high this results in early transition to the on- and a delayed transition to the off-state. Consequently, the delay of the electrical signal caused by the falling edge of the optical signal is longer than the delay of the rising edge (optical signal).

If the transmitter signal is dc-biased (at logical zero) or additional light hits the receiver, the noise signal is shifted to the decision threshold. In the case of the SFH551 (without Schmitt trigger) unwanted pulses may occur at the output. Using a SFH551/1 its built-in Schmitt trigger eliminates this problem.

Highly biased signals (at logical zero) cause permanent switching to the on-state and therefore prohibit data transmission for both the SFH551 (not for new design) and the SFH551/1.

The effects described above demonstrate, that the performance of the optical receiver can only fully be described if level and form of the optical input signal are taken into account.

Limits of the receiver operation

Dynamic range:

An important figure for the application of an optical receiver is the dynamic range, defining the range between smallest and highest signal level in which perfect operation is assured.

To define this range we have a look at the performance close to the limits:

SFH551 (not for new design): minimal optical power

As described above noise pulses can occur at the receiver output:

- if no light is received (negative peaks on high level)
- if the input power is close to or below the specified limit of 4 µW (positive peaks on low level)

As these noise pulses occur on random, they are hard to detect requiring a modern storage oscilloscope.

The measurement has shown, that the receiver switches at an input level as low as 2 µW. In order to avoid noise as described above, a switching level of 4 µW for nearly error free operation has been specified in the data sheet.

SFH551/1: minimal light power

As described above, the SFH551/1 contains a Schmitt trigger. To ensure safe operation, the limit of the switching-threshold was shifted to 5 W. Compared to the SFH551 this appears as a lower sensitivity, but taking the very low bit error rate into account the transmission system can be reliably operated with less system margin. Due to possible coupling losses, a value of 6 W is specified in the datasheet.

On request a low cost option (SFH551/1-2) with switching level < 10 W is available.

SFH551/1: maximal light power

The SFH551/1 offers a considerably increased dynamic range. Using conventional plastic fiber transmitter diodes overdriving is practically impossible. Depending on the system application a limit is given by pulse disturbances in time depending on the pulse form and increasing with the input level at high input power. It is recommended not to exceed a signal level of 400 W. For higher levels the pulse form has to be checked in the customers circuit individually.

Hints for the application in an electronic circuit

- power supply

For print board mounting it has to be taken into account that the SFH551 and SFH551/1 are fast electronic circuits. A blocking capacitor (100 nF) is obligatory for the SFH551 (not for new design) and recommended for the SFH551/1. As both circuits can be operated at 5 V voltage, a noisy power supply can be connected via a resistor building a low pass filter together with the capacitor. Despite this means, the full output level can be reached, if the pull up resistor is connected to Vcc.

- how to dimension the pull-up resistor

To keep the current consumption low, a high value within the possible range is usually chosen. For very fast systems it might be important to work with the minimal value. The calculation of the minimal value, however, should not be performed with the maximal output current. For the SFH551 (not for new design) the minimal value is 330 Ω (Vcc = 5 V). The SFH551/1 can also be operated with this value, although 390 Ω are recommended here.

Signal delay

The redesign of the receiver has resulted in a little increase of the delay times. This becomes clear, if the pulse form of the SFH551/1 is taken into account: The rising edge is fast; the delay time increases only for a very small light power.

Figure 2.3 Definition of the delay times

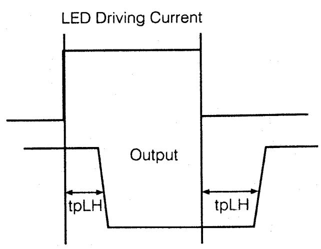
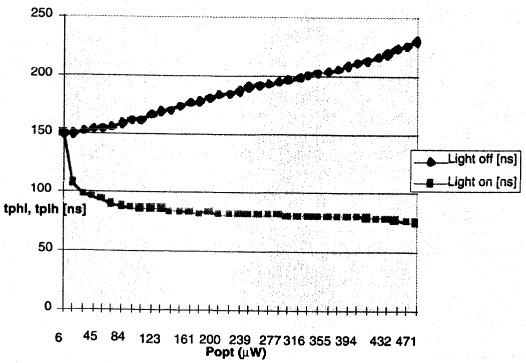


Figure 2.4 shows that the delay of the electrical signal caused by the falling edge of the optical signal is longer than the delay of the rising edge (optical signal).

Figure 2.4 Measured Signal delay depending on the level of received light using SFH756 on the transmitter side



3. Systems with PFC Diodes

3.1 Plastic Optical Fiber (POF)

The most common type of fiber consists of a polymethylmethacrylate (PMMA) core approximately 970 μm thick with 30 μm thick cladding made of fluoride-containing carbon polymer. Given the refractive indices of the core and cladding are 1.492 and 1.417 respectively, the numerical aperture is 0.47 and the fiber acceptance angle 56°. With a PVC or PE protecting sheath the POF has a total diameter of 2.2 mm.

These fibers are obtainable from many manufacturers. The CUPOFLEX fibers, data for which is given in the appendix, are typical of the POFs available.

The appendix also gives the typical attenuation as a function of wavelength. Of the two attenuation minima in the visible spectrum, the one in the red region with = 650 nm is suitable for distances up to 100 m. Due to the low quantum efficiency of the green emitter, the attenuation minimum at = 570 nm is unsuitable for communications applications. Moreover the switching times of the red emitters are significantly lower and the degradation is less than for green emitters. In spite of the high attenuation of POF in the IR-spectrum (4 dB/m) infrared emitters (SFH450) can still produce sufficient power levels at the fiber end over a few meters to be of practical use.

Plastic optical fiber made of PMMA can be used in ambient temperatures of –20° up to +85°C. For lower temperatures (down to –50°C) the constraint of mechanical flexibility has to be taken into account. Fibers for higher temperatures up to 100°C, such as those necessary for automotive applications, are in development.

When using POF, the bend radius should not be less than 20 mm, as otherwise the fiber attenuation increases. Smaller radii are possible using fibers with higher numerical aperture.

Treatment of Fiber Ends

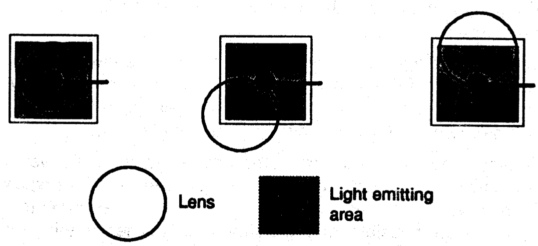
Due to the thick diameter of POF it is easier to handle than glass fiber. Thus for very short distances where plenty of allowance has been made for attenuation, it is possible to cleave the fiber using a sharp edged blade. For longer stretches wet polishing the fiber end with 600 grain sandpaper yields greatly improved results. To achieve very flat surfaces at the fiber ends, the fiber should be cut with a blade heated to 160-180°C or the clean cut fiber end may be pressed for 2-4 seconds on to a plate heated to 100-140°C. Alternatively it is suggested to refer to the manufacturer's recommendations.

3.2 Connecting the PFCs to the Fiber Emitter

When current flows in the forward direction the emitter diode emits optical radiation. The task of the housing is to bundle the output radiation so that the greater portion of it is coupled into the fiber. The components are intended for use with plastic fibers and thus the data regarding optical coupling into and out of the fiber refers to standard plastic fiber with a core diameter of 1 mm and a numerical aperture (NA) of 0.47. So that as much as possible of the radiation emitted within this angle falls upon the fiber, the radiation is concentrated on the fiber using a built-in reflector and a lens.

The chip in the SFH756 is a large area radiating chip with the bonding ball in the centre. Therefore not only one position between chip and fiber core (indicated by the lens) is possible for optimum coupling as shown in Figure 3.1.

Figure 3.1 Lens position in the transmitter



In section 2.1 it was already pointed out that the optical power which can be coupled into the fiber is measured using a standard plastic fiber with a numerical aperture of 0.47 and of length approx. 30 cm. The power defined in this way is not transmitted along large lengths (> 3 m) of fiber. For long stretches of fiber the first meters therefore apparently exhibit a higher level of attenuation. This can be taken into account by adding 2 dB to the attenuation incurred due to the length of the fiber itself.

Detector

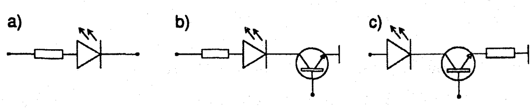
Due to the lens of the detector's housing, virtually all the input radiation is focused on to the chip.

3.3 Dimensioning the Emitter Driver and the Detector

3.3.1 The Emitter Driver

The emitter is stimulated into emission by current flowing in the forward direction. There are several possibilities for the design of the driver circuit, which has the task of adjusting and stabilizing the current flow. In Figure 3.2 the basic types of driver circuits are given.

Figure 3.2 Types of emitter diode driver circuits



In the simplest example (Figure 3.2 a) the emitter diode is connected in series with a resistance R_S to the supply voltage V_S. The current I_f is dependent of the forward voltage V_f of the diode:

$I_f = (V_S - V_f) / R_S$

The diode may also be driven using the output transistor of a TTL gate or a separate driver transistor (Figure 3.2 b), in which case the collector-emitter voltage should be taken into account. In this configuration the current let through by the transistor is given as:

$I_f = (V_S - V_f - V_{ce}) / R_S$

In order to keep the current and thus the optical power constant, it is preferable to control the current flow (Figure 3.2 c). For this example as with the others, it is necessary to ensure than sufficient voltage is provided.

One of the diagrams in the emitter data sheet shows the dependency of the forward voltage Vf on the current. Since V_f may reach 3 V for currents of 300 mA for example, the maximum duty cycle may be limited by the supply voltage.

Another important parameter when dimensioning the driver is the permissible pulse load. It is clear from the relevant diagram in the data sheet, that in regard to power loss, peak currents of up to 1 A are possible for short duty cycles. Whether this peak current can be used, depends on the available supply voltage.

3.3.2 Detector

When dimensioning the detector it is necessary to establish the dynamic range, ie. the relation between the minimum current required and the maximum permissible current.

3.4 System Planning

In order to demonstrate the process of system planning, an example of the design of an optical transmission system over a long distance using the SFH551/1 detector will be discussed.

According to the data sheet, the SFH551/1 detector has a dynamic range of around 18 dB. This range must be attributed to the various levels of attenuation along the fiber and the tolerance of the emitter power.

Attenuation in plastic fiber over long distances for light of wavelength 660 nm is of the order 0,3 dB/m. However the first section of fiber exhibits higher attenuation (around 2 dB additional to the regular losses in the first meters). Since the emitter power is measured and specified using a short length of fiber, the effect needs to be taken into account (see section 3.2).

The following example demonstrates how a PFC system with a length of 50 m should be driven:

Table 3.1 Planning of a transmission line

Detector power	22.0	dBm
50 m distance at 0.3 dB/m	15.0	dB
Additional attenuation of first few meters	2.0	dB
Needed emitter power without tolerances	5.0	dBm
Further effects which contribute to the reduction of the operating range:		
Temperature (–20 to 45°C)	1.0	dB
Aging	2.0	dB
Range of emitter power distribution	1.5	dB
Emitter power	0.5	dBm

Thus the configuration in this example requires at minimum an emitter 890 µW output power achievable with SFH756 driven by 50 mA peak current.

For easy planning SFH551/1 with SFH756 the following table for recommended drive current in SFH756 may be used:

Table 3.2 Easy planning of a transmission line SFH551/1 with SFH756

Maximum length	10 m	20 m	30 m	40 m	50 m
Needed peak current	5 mA	10 mA	20 mA	30 mA	40 mA

4. Recommendations for Mounting

When soldering it should be ensured that the components is not overheated. Given a distance of 2 mm between the component and the soldering point, when using a soldering iron the maximum permissible temperature is 300°C for at most 3 s. In the case of flow and dip soldering the maximum temperature is 260°C for up to a 5 s period.

When soldering particular care should be taken so that the component is not subject to any mechanical stress. When bending the connection pins, the packaging should not be loaded in any way.

The soldered components may be cleaned using organic solvents, with an alcohol base, a base of certain fluorohydrocarbons or a mix of the two. Under no circumstance should solvents or solvent mixtures be used which contain chorohydrocarbons or ketones, since these can attack or dissolve the housing.

5. Reliability

5.1 Degradation

For optoelectronic emitters, the emitted radiation power reduces over the component's lifetime. This effect is known as ageing. It is dependent on the technology of the diode system, the load current If and the ambient temperature TA.

If one defines the failure criteria as a 50% (–3 dB) fall in output power relative to the start value, the lifetime of all PFC emitter is more than 105 hours.

5.2 Emitter Diode Permissible Current Load

When the emitter diode is in operation most of the electrical input power ($U_f \times I_f$) is converted into heat. The temperature of the semiconductor chip and the packaging rises as a consequence. On grounds of reliability, the chip should not be heated above the maximum permitted for the depletion layer. This in turn yields a maximum power loss, dependent on the ambient temperature, which cannot be exceeded (cf. relevant data sheets). These values are valid for dc operation.

Significantly better operation conditions are possible using the emitter diodes in pulse operation, as the average power decreases inversely proportional to the duty cycle. However this means that the maximum forward current I_f can be increased for shorter pulse widths and/or longer duty cycles, as shown in the Permissible Pulse Load plot in the data sheets. These plots give the maximum permissible forward current dependent on the pulse width for an ambient temperature TA of 25°C. The duty cycle parameter D (ratio of pulse width to cycle period) given as $D = \tau/T$. For very short pulse widths (10 s) and small duty factor (1:200) a current up to 20 times greater than the maximum direct current is permissible for PFC emitter diodes. Even in the range of 100-milliseconds and a duty cycle of 1:5 a doubling of the forward current may be reached, thereby raising the power coupled into the fiber by a factor 2 with the SFH450 and a factor 2.5 with the SFH750 in comparison with dc operation.

5.3 Permissible Mechanical Load

The fiber optic components SFH250, SFH350, SFH450, SFH 750, SFH756 and SFH551/1 are designed in such a way, that they can cope with a heavy mechanical load, as required for instance in automotive applications. The following tests have been successfully conducted on all the above components:

Oscillation test (according to DIN IEC Teil 2 - 6, Test Fc)

Schock test (according to IEC 68-2-27, Test Ea)

In these tests diodes were employed into which a fiber of length approx. 5 cm had been stuck. They were soldered to a board and subjected to oscillations and schocks (single impulses) in the three orthogonal axes. The oscillation frequency was varied between 10 and 500 Hz with an acceleration of 49 m^{-2} (ie. five times the acceleration due to gravity).

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Light-Link Components Control High-Frequency Switched-Mode Power Supplies Appnote 41

by Reinhard Blöckl

Operating frequencies of 100 kHz are common practice in modern switched-mode power supplies. And the trend continues towards even higher frequencies. The reason for this is that they allow the development of power supplies of smaller size and improved dynamic control characteristics. The necessary feedback is done by Siemens light-link components which permit reliable control of SMPS with working frequencies in the MHz range.

Feedback of control information in switched-mode power supplies is mainly handled by integrated analog optocouplers (e.g. CNY 17 and SFH 600). The limited bandwidth of these couplers allows SMPS to be controlled at working frequencies below 100 kHz.

Use of the light-link components, SFH 450 and SFH 750 (emitters) and SFH 250 (detector), greatly extends the range of optical signal transmission.
The circuits described here for analog signal transmission are characterized by:

- suitability for SMPS with high and very high working frequencies,
- minimizing parasitic coupling capacitance between emitter and detector,
- no electromagnetic interference in the transmission line (plastic fiber).

Using the new light-link components in SMPS results in a higher efficiency and a reduction of screening. The savings achieved largely compensate for the extra costs of light-link components and mounting them relative to integrated optocouplers.

Low-cost optoelectronic coupling elements can be used in SMPS with higher working frequencies (above 100 kHz). This has so far been the domain of sophisticated transformer techniques.

Electrical isolation of the SMPS is provided by a power transformer with primary and secondary windings isolated from each other. Figure 1 is a block diagram of such an arrangement.

Figure 1. Block diagram of a pulsewidth-modulation controlled switched-mode power supply

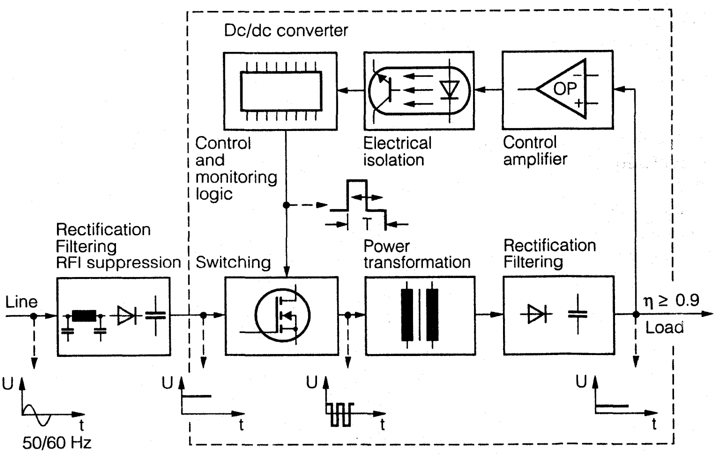


Figure 2. Typical frequency characteristics in the control of switched-mode power supplies

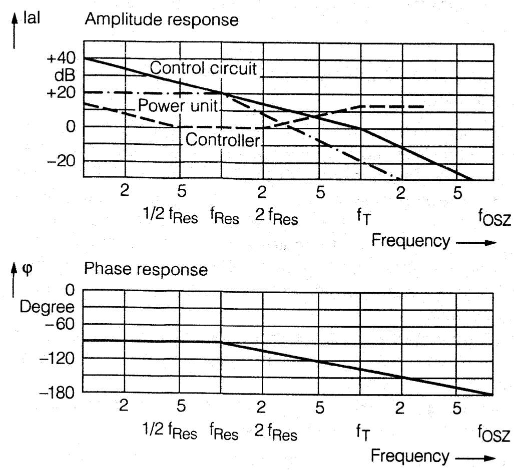
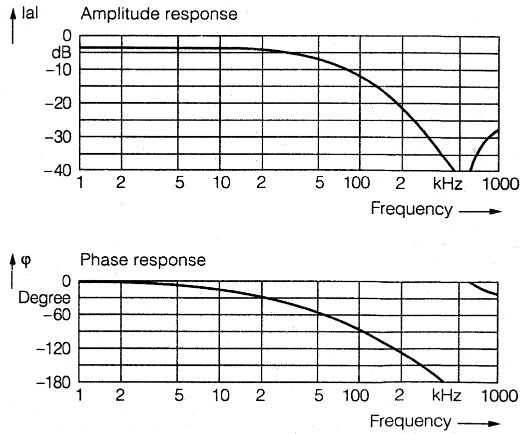


Figure 3. Frequency characteristics of CNY 17-1 coupler



With the control and monitoring circuit on the primary side of the SMPS, as shown in Figure 1, the closed-loop voltage control therefore bridges the isolation between the primary and secondary sides.

To maintain electrical isolation, the control feedback path must include an isolated linear transmission device.
This device is governed by the same VDE regulations as the power transformer in terms of isolation voltage, air and creepage paths.

Two methods are currently employed in isolated signal transmission:

- transformer signal transmission,
- optical signal transmission.

Relative to the technically valuable but expensive transformer solution, optocouplers are less costly. But this method does have some engineering restrictions.

Design of SMPS Control Circuits

Forward-converter SMPS operating in the »voltage mode«, normally use a controller with PIDT1-characteristic (proportional–integral–derivative 1st order action) whereas SMPS in the »current mode« use controllers with a PIT1 characteristic. Frequency response is compensated to maintain the widest possible bandwidth with sufficient stability.

The SFH 600, and CNY 17 optocouplers have a limited achievable bandwidth.

The new broadband light-link components are linear transmission elements which allow for a control bandwidth depending only on the chosen working frequency of the SMPS. Hence an improved SMPS dynamic control characteristic (the most important reason for increasing the working frequency) can be implemented in practice. Figure 2 shows the Bode diagram of a »voltage mode« forward converter power unit (chain line).

The LC output filter has a transfer function with two poles at the resonance point. This implies a –180° phase shift at higher frequencies. The circuitry for frequency response compensation is designed so that the control amplifier has the desired PIDT1 type frequency response, as shown in Figure 2 (broken lines). From this the frequency response (solid line) of the complete control circuit is obtained.

Time constant T1 has been chosen so that the associated corner frequency corresponds to the transition frequency f_T of the system

$f_T = 1/(2 \cdot \pi \cdot T1)$

This serves for the bandwidth limiting necessary to suppress the switching frequency.

Sufficient attenuation is guaranteed by making the transition frequency one decade below the switching frequency.

A parameter of control stability is the phase shift of the separated control circuit at the transition frequency (gain at transit frequency is 0 dB). A maximum phase angle of –150° (this means a –30° phase margin) is still considered sufficiently stable.

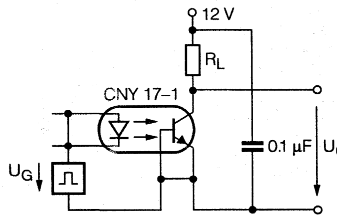
So far we have neglected the optocoupler's frequency response. We started from the assumption that the control op-amp would not cause any significant phase shift of the given transition frequency.

A phase shift of –135° results from Figure 2 for the transition frequency.
Consequently, the additional phase shift of the optocoupler at transition frequency may be a maximum of –15° to maintain a minimum phase margin of 30°.

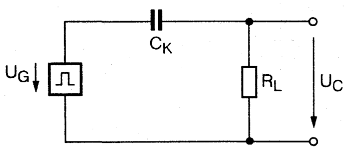
As a rule of thumb the working frequency of a switched-mode power supply should exceed the frequency at which the optocoupler produces a –15° phase shift by a factor of ten.

Although a higher switching frequency is possible, it will not improve the dynamic control characteristics as the transition frequency cannot be raised appropriately for reasons of stability.

Figure 4. Common-mode transmission through coupling capacitance C_K



Measuring circuit to determine the coupling capacitance



Equivalent circuit footman-mode transmission

Properties of Integrated Optocouplers in Linear Operation

Obvious benefits of optocouplers are their compact size and low price.
Against these, however, are some drawbacks:

- low cut-off frequency
- coupling capacitance between emitter and detector.
- air and creepage paths between external connections are likely to fall short of requirements after pc board mounting.

Frequency Response of Integrated Optocouplers

When a high cut-off frequency is required, the optocoupler should be used in a low impedance circuit. For example, the data sheet specifications for the limit frequency for the SFH 600 optocoupler is 250 kHz with a load resistance of R_L=7 Ω. The permissible component current limits the reduction of resistance values. To assess the possibilities of using optocouplers as part of a control circuit, the frequency response characteristic method (Bode diagram) is very useful. Figure 3 shows the measured frequency response characteristics of the CNY 17 standard optocoupler for a load resistance R_L=1 kΩ.
The amplitude characteristic lal here has a logarithmic current transfer ratio.

$$|a| = 20 \cdot \log (I_C/I_F)$$

The phase response shows the phase angle between the light emitting diode current I_F and the detector transistor current I_C. From the frequency response characteristic it can be seen that

- the phase angle of –15° lies at about 10 kHz
- a zero occurs at about 550 kHz in the amplitude response.

From the first, it can be concluded that the integrated optocoupler is suitable for working at frequencies up to 100 kHz. The second observation points to the effect of the parasitic coupling capacitance. By superimposing both signal transfer paths, opto-electrical and capacitive, which produce phase displacements with opposite signs, the output signal may be partially erased. This gives the observed non-uniformity of the frequency response.

Common-mode Suppression with Integrated Optocoupler

The undesired transmission of common-mode signals through optocouplers is caused by the parasitic coupling capacitance C_K between the input and the output of the optocoupler. Figure 4 shows a measurement circuit to find the coupling capacitance and obtain the high-frequency equivalent circuit. As can be seen from the equivalent circuit the transmission of common-mode signals corresponds to an RC first-order high pass filter consisting of parasitic coupling capacitance C_K and the external load resistance R_L.
The common-mode signal transmission produces spiked interference waveforms in the output voltage U_C from the square-wave input voltage U_G.
The appropriate signal characteristics are shown in Figure 5. The measured load resistance R_L was 10 kΩ.

With the switched-mode power supply described common-mode transfer action is most disturbing as capacitively coupled in (e.g. transformer winding capacitance) common-mode signals of high amplitude are likely to occur at regular intervals because of the clock-pulse mode of operation.

Insufficient common-mode suppression may cause these interference waveforms to be transmitted through the optocoupler to the pulsewidth-modulation control circuit.

This often leads to incorrect operation of the PWM. Here an additional interference suppression in the form of a screen inside the power transformer is required.

Useful Features of Light-link Components

Unlike integrated optocouplers, light-link components consist of separate emitter and detector units optically coupled through an optical fiber (for example plastic fiber) over any desired distance.

This technology brings some major benefits:

- The coupling capacitance is negligible because of the spacing between emitter and detector,
- the required air and creepage paths and isolation voltages are easily provided because of the spacing between emitter and detector,
- optical fiber links can neither emit nor receive electromagnetic interference in the radio frequency band,
- using a PIN photodiode as the detector provides very broad bandwidths.

A technical description of available emitter and detector devices and amplifier circuits is given in [1].

This article deals with applications in linear transmission, especially in the control feedback paths of SMPS. Suitable circuits are discussed.

To determine the limit values of the individual circuits, their frequency response characteristics were measured and plotted as Bode diagrams.

Figure 5. Common-mode interference at the output of Figure 4 circuit with R_L=10 kΩ

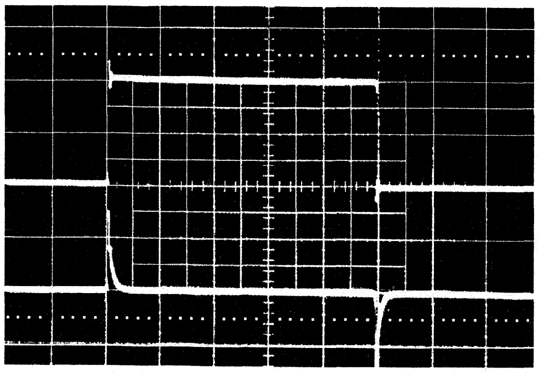


Figure 7. Frequency characteristics of Figure 6 circuit

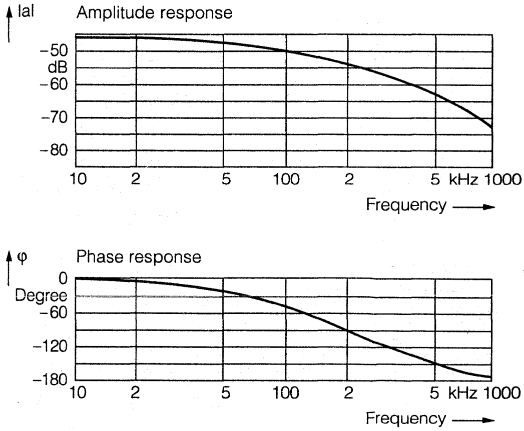


Figure 6. Optical signal transmission circuit with single-stage amplifier

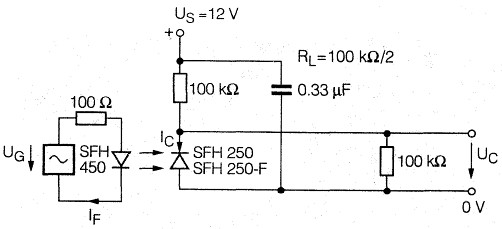
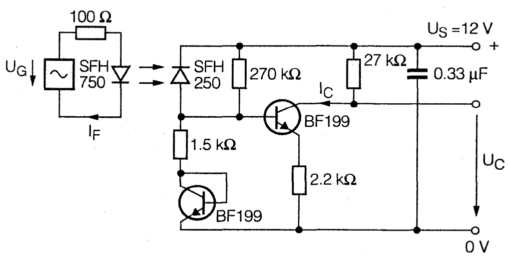


Figure 8. Optical signal transmission circuit with single-stage amplifier



Circuits for Linear Optical Signal Transmission Interface Requirements

The design of optical signal transmission circuits is based on the following assumptions:

- for driving the photodiode (emitter) a current I_F between 0 and 50 mA is available,
- a voltage U_C of about 5 V is provided at the detector circuit output,
- with LED control current I_F=0 A, the output voltage is $U_C \geq 5$ V,
- the complete circuit is inverted–in other words–the output voltage U_C drops with rising control current I_F

These interface conditions are so chosen that the optoelectronic circuits can be driven by standard amplifiers and there is compatibility with the TDA 47xx and TDA 49xx SMPS control IC series. The optical signal transmission circuit can be incorporated into the SMPS concept of Figure 1.

Three optical transmission circuits are described which meet the increasing demands for transmissible frequencies.

Optical Signal Transmission Circuits without Amplifiers for Frequencies up to 450 kHz

The circuit shown in Figure 6 is built from just a few components. As the current transfer ratio I_C/I_F of the combination SFH 450 (IR emitter diode) and SFH 250 (photodiode) is sufficient, the output signal can be obtained at the load resistor R_L without any additional amplification after the photodiode.

As the 1-µs switching time of the SFH 450 is rather long, a wide bandwidth cannot be achieved with this simple circuit.

The SFH 250 F infra-red light-transmitting filter detector diode can be used with the same results as protection against daylight in Figure 6 circuit. The associated Bode diagram is given in Figure 7.

From this it can be seen that at about 45 kHz a phase shift of −15° occurs. With these parameters the circuit is suitable for switched-mode power supplies operating at frequencies up to 450 kHz. Technical data are summarized in Table 1.

Figure 9. Frequency characteristics of Figure 8 circuit

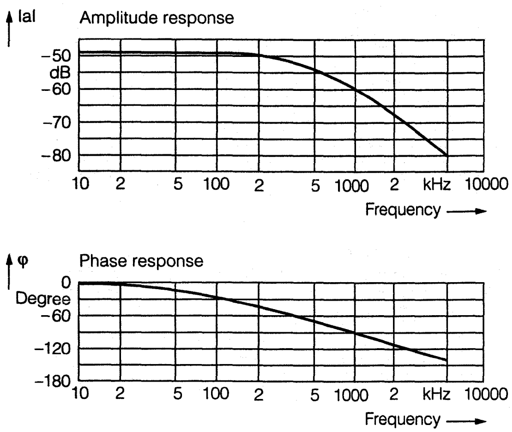
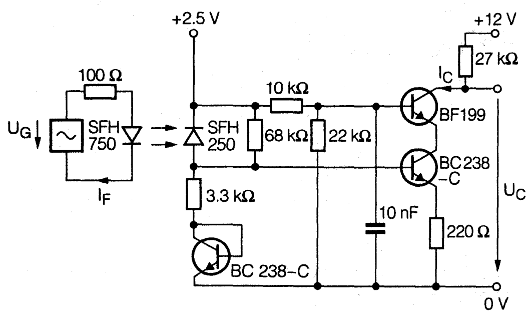


Figure 10. Optical signal transmission circuit with amplifier in cascade arrangement



Circuits with Single-stage Amplifier for Frequencies up to 650 kHz

The limit frequency can be increased when the SFH 450 IR LED is replaced by the SFH 750 emitter diode operating in the red spectral range. Switching times are reduced by a factor of 10. The radiant power coupled into the optical fiber from this LED is, however, much smaller. An amplifier stage is required to produce the necessary output voltage. Figure 8 is the block diagram.

The BF 199 transistor is used as common-emitter amplifier. The base-emitter diode of another transistor provides temperature compensation.

To allow for the manufacturing tolerances of the transistor, it may become necessary to trim the 270-kΩ resistor. The Bode diagram of this arrangement is shown in Figure 9.

The frequency at which the phase is shifted by –15° lies at 65 kHz. The transmission circuit is suitable for SMPS with working frequencies up to 10 times higher than this. Table 1 gives the technical data on this circuit.

Figure 11. Frequency characteristics of Figure 10 circuit

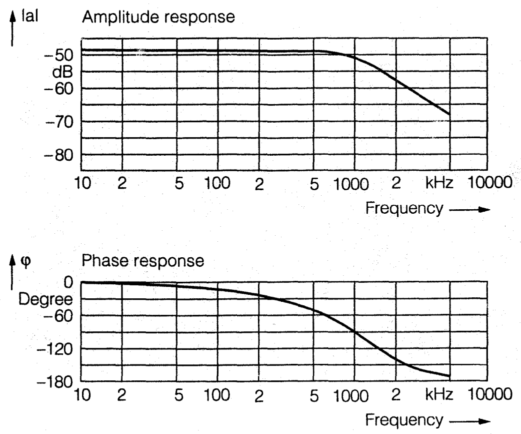
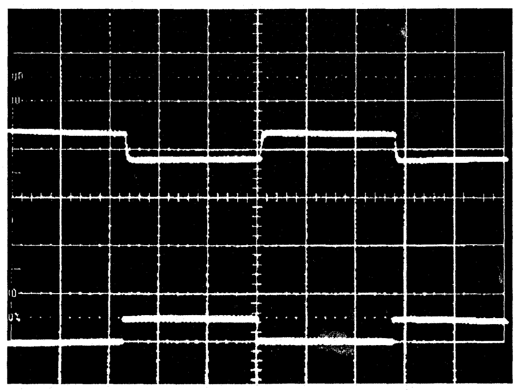


Figure 12. Optical signal transmission circuit with amplifier in cascade arrangement



Circuits Using Cascade Amplifier for Frequencies up to 1600 kHz

The cascade circuit is characterized by an excellent high-frequency performance. The Figure 10 arrangement requires a stabilized 2.5-V source and 12-V supply voltage, which are already provided when TDA 47xx or TDA 49xx SMPS control IC_S are used.

The cascade circuit uses one BC238-C and one BF 199 transistor.

The operating point of the BF I99 transistor is set by a voltage divider supplied from the 2.5-V source. The base-emitter diode of the third transistor provides temperature compensation. To allow for the transistor manufacturing tolerances, it may be necessary to trim the 68-kΩ resistor. The Bode diagram of this arrangement is shown in Figure 11. The frequency at which the phase is shifted by –15° lies at 160 kHz. Consequently, the highest possible working frequency for a SMPS using this circuit is about 1.6 MHz.

Figure 12 shows the behavior of the circuit with time. The emitter diode is driven with a square-wave current I_F of 5-mA amplitude. The amplitude of the output signal U_C is 0.6 V. Technical data are given in Table 1.

Conclusion

Switched-mode power supplies using light-link components in the control feedback path provide broadband control characteristics which depend on the chosen switching frequency. Stability and excellent dynamic control characteristics are obtained. The small coupling capacitance between emitter and detector in the optical transmission path (large spacing) eliminates the need for a screen in the power transformer.

The possibility of obtaining higher working frequencies with simpler and thus lower-cost configurations of SMPS will be an impetus towards further increases of frequency in power supply design.

Table 1. Technical data on three transmission circuits using light-link components to control switched-mode power supplies with different working frequencies

Description	Symbol	Circuit to Fig. 6 typical values	Fig. 8	Fig. 10	Unit
Operating point (U_S =12 V)	I_F	10	10	12	mA
	U_C	4.2	5.5	5	V
DC transmission performance	$\frac{\Delta U_C}{\Delta I_F}$	0.24	0.1	0.1	$\frac{V}{mA}$
3-dB limit frequency	f_{3dB}	100	250	700	kHz
Dependency of output voltage on U_S	$\frac{\Delta U_C}{\Delta U_S}$	0.5	–0.53	–	–
Dependency of output voltage on 2.5-V supply voltage	$\frac{\Delta U_C}{\Delta 2.5\ V}$	–	–	9.5	–
Temperature coefficient of output voltage (in the range 0°C ≤ ϑ ≤ 60°C) I_F =15mA	$\frac{\Delta U_C}{\Delta \vartheta}$	9	2	~0	$\frac{mV}{K}$

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FREDFET Power Half-Bridge: Short-Circuit Proof through Light-Link Components Appnote 43

by Walter Schumbrutzki

With higher clock frequencies in power switches inverse-capable MOS power transistors (FREDFET) are going to replace bipolar devices. In the low power range (≤ 2 kW) MOS half-bridges are already being designed which are far superior to those using bipolar transistors.

The most important requirements to be met by bridge circuits are:

- minimum forward and switching losses,
- duty factor of 0 to 100%,
- current limiting (if necessary, short-circuit and leakage protection),
- low control power,
- separate drive of individual transistors,
- electrical isolation of control and output circuits.

Driving of »high side« transistors is made somewhat difficult because of the switched source potential (floating). Apart from providing a solution to this problem, the circuit described in this article fulfills all the above requirements.

Transformer Coupled SIPMOS Halfbridge (Figure 1) Pulse Transmission of Input Signal Using a Ring Core

Though transformer coupling permits fast switching times, the effects of magnetic saturation generally confine the duty factor to about 50%. Magnetic saturation also limits the time a transformer can hold a MOSFET in the on-state. To overcome this problem the transformer in the circuit described is fed with a high-frequency pulse train (burst of 1 MHz) for the duration of the input pulse.

The FET is operated as long as the burst is present. Thus turn-on times are freely selectable. An auxiliary power supply on the secondary side is not necessary. Driving the half-bridge entails two opposed square-wave signals with some delay of the positive edge (around 500 ns) and a 2-MHz clock signal. These signals can be derived from a pulse-width modulation circuit. The 2-MHz clock can be obtained from the drive circuit via the ALE line of a microcomputer. The drive signal (active high) goes to a turn-off logic circuit which blocks the input signal when the current threshold is reached. Then, with active low on pins R and S of the data flipflop 4013, complementary 1-MHz bursts are delivered to the push-pull stage and the ring core transformer (R 10/N 30) is energized. Both windings are put on face to face to minimize their capacitance. The primary has 10 turns, the secondary 12.

As the carrier current flowing through the capacitance between primary and secondary circuits is rectified and may cause spurious turn-on of the FREDFET, special attention has to be given to the design of the transformer.

Common-mode rejection of more than 100 V/µs is achieved by simply using a thin coaxial cable for the secondary winding. One end of the outer shield (not both) has to be connected to the appropriate FREDFET source.

On the secondary side the burst is rectified via a diode bridge and a positive gate signal is produced which simultaneously switches on the load and the current measuring MOSFETs. Figure 2 shows the transmission of an input pulse of 1.5 µs duration. When switched on the MOSFET gates are discharged via the BC 327/25 pnp transistor. Discharge time is determined by the time constant of the base resistance (1 kΩ) and smoothing capacitance (220 pF). The FREDFET is operated as long as the 1-MHz carrier is available, that is, when the control input (R, S) is low.

Low-loss Use of the Signal for Current Measurement (Figure 3)

Current measurement resistance in the load circuit means high additional losses. For current measurement the drain-source voltage of the load transistor in the on-state is taken out via a small-signal transistor (BSS 125). In the on-state it can be measured by the BSS 125 source resistance as the gates and drains of the two transistors are connected. This drain voltage is a direct measure for the flowing current ($U_{DS} = I_{DS} \cdot R_{DS\,(on)}$) and can be used to turn off the transistor via a threshold switch.

Transmission of Current Measurement Signals via Light-link Components

The main problem in transmitting the turn-off pulse is the du/dt sensitivity of commercially available fast optocouplers. Their high coupling capacitance prevents the transmission of steep signal edges. For this reason, a diode coupler is used here as a transfer device. It is made up from one special light-link transmitting diode and one receiving diode and a plastic fiber

Figure 1. Circuit diagram of SIPMOS half-bridge

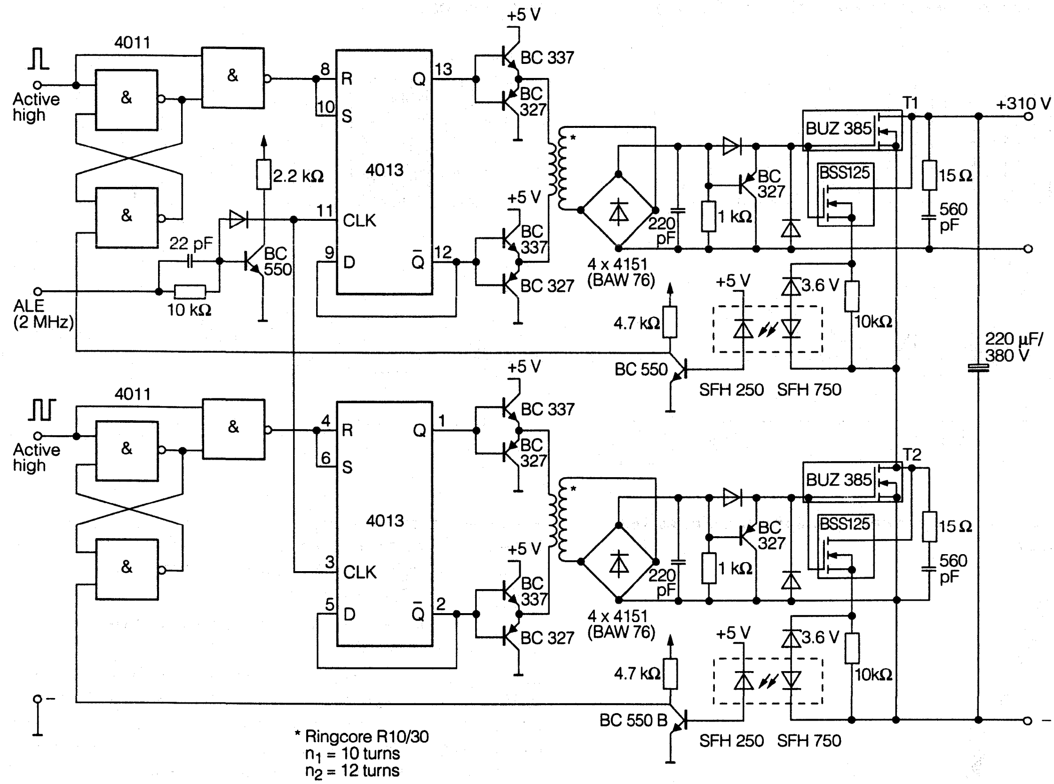


Figure 2. Waveform in the driver stage

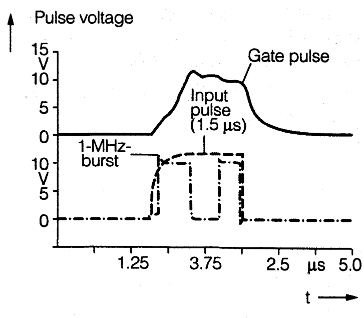
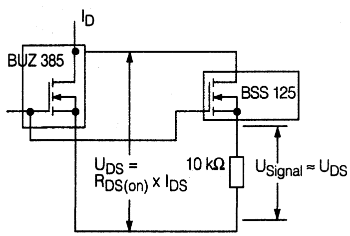


Figure 3. Circuit (extract) for low-loss capture of the signal for current measurement



about 4-cm long. A shrink sleeve supports the function between the diodes and the fiber and protects the assembly against extraneous light (Figure 5).

Coupling capacitance can be neglected in this case, which, in turn leads to excellent du/dt immunity. Here the signal voltage is taken from the source circuit of the small signal transistor.

The transmitting diode of the light-link device is connected in series with the Z-diode.

With a certain signal voltage (limit current drop) sufficient current flows through the transmitting diode to cause information to be sent through the plastic fiber to the detecting diode in the drive circuit. An amplifier transistor then actuates the flipflop which turns off the output stage.

Figure 4. Overcurrent behavior of the Figure 1 circuit with a load switched in abruptly via T2 (77 µH, 186 mΩ)

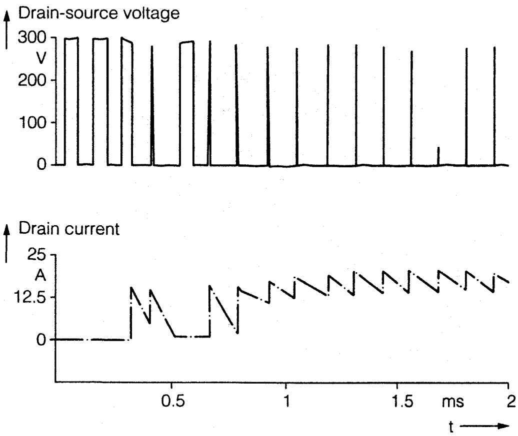


Figure 6. Current and voltage waveforms in the FREDFET with overload

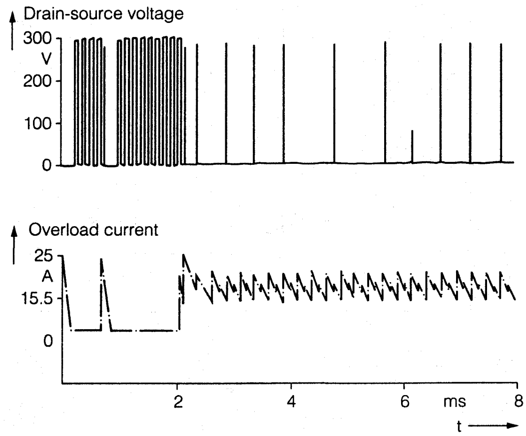


Figure 5. Diode coupler built from light-link diodes and plastic fiber

The turn-off circuit is incorporated on the low-voltage side because any short-circuit would seriously load the transformer and the risk of coupling in capacitive interference currents if the turn-of circuit would occur.

The current transfer ratio of the diode coupler is very low with this system configuration.

Unambiguous pulse transmission requires a diode current of 50 to 60 mA. The on-resistance of the BSS 125 transistor is a crucial factor in this current, so that the Z-diode voltage should be fairly small for a trigger current of 10 A. The actual turn-off current (after 2 µs) is about 18 A with a test overload of 77 µH and 186 mΩ, see Figure 4.

The circuit is so designed as to reset the flipflop immediately after the overload current has been turned off. If the overload is not eliminated the remaining input control pulses will initiate another turn-off operation. This constant repetition results in load current limiting, as can be seen in Figure 6.

Refer to Appnote 40 "Low Cost, Fiber Optic Systems Using Siemens Light-Link Emitters and Detectors."

SIEMENS

Designing with the Small AlphaNumeric Display Appnote 44

By Bob Krause and Dave Takagishi

Introduction

The Siemens Small AlphaNumeric (SAN) Display family is one of the most versatile and flexible LED readout systems available today. Its four 5x7 characters are dot addressable permitting alphanumeric, graphics, and special symbols to be easily programmed in four colors (red, high efficiency red, yellow, green). SANs are available in 0.15≤ or 0.20≤ character heights, which are efficiently assembled in row and column stackable plastic or ceramic DIP packages. These packages allow environmental operation from commercial to the most demanding industrial and military requirements. Table 1 lists the SAN model numbers and their principle characteristics.

The internal CMOS row drivers and memory reduce power consumption and support electronics. Blanking Control makes night vision to sunlight ambient intensity control easy.

This appnote covers the SAN family capabilities which include: display operation, intensity control, thermal and optical management, and an 8051 MPU interface.

Display Operation

As compared to Siemens Intelligent and Programmable Displays, SANs require dot decoded serial data rather than parallel ASCII to operate. Figure 1 block diagram shows that the display with its four 5x7 LED characters and two CMOS 14 bit serial-in, parallel-out (SIPO) shift registers. Each LED matrix is a 5x7 diode array organized with the anode of each column tied in common and the cathodes of each character tied in common. The seven row cathode commons of each character are connected to the constant current sinking outputs of the seven successive stages of the shift register. The like columns of the four characters are tied together and brought to a single column pin (i.e., column one of all four digits is connected to pin one, etc.). So that any diode of any character may be addressed by shifting data to the appropriate shift register location and supplying current to the appropriate column.

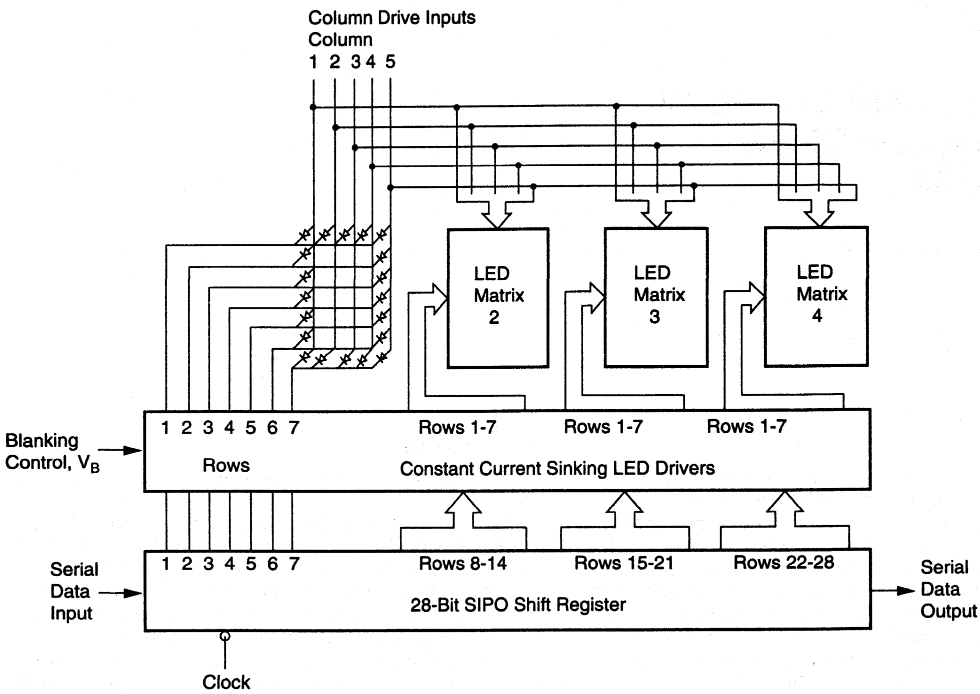
The SIPO shift register has constant current sinking outputs associated with each shift register stage. A FET current mirror supplies a reference signal to all of the 28 constant current

Table 1. SAN display principal characteristics

Part No.	Color	Character Height	Power Dissipation*	Temperature Range	Package Type
HDSP2000LP HDSP2001LP HDSP2002LP HDSP2003LP	Red Yellow HER Green	0.15 in.	0.40 W	–40°C to +85°C	Plastic
ISD2010 ISD2011 ISD2012 ISD2013	Red Yellow HER Green	0.15 in.	0.40 W	–55°C to +100°C	Ceramic
ISD2310 ISD2311 ISD2312 ISD2313	Red Yellow HER Green	0.20 in.	0.52 W	–55°C to +100°C	Ceramic
ISD2351 ISD2352 ISD2353	Yellow HER Green	0.20 in.	0.74 W	–55°C to +100°C	Ceramic

*15 LEDs ON per character/4 characters per package

Figure 1. Block diagram



shift register out (logic 1) and is ANDed with this reference source to turn on the output drivers. Data is loaded serially into the shift register when the clock goes from High to low and the data is stable for a minimum hold time and will be latched on the LOW to HIGH signal of the clock.

The Data Output (pin 7) is a TTL buffer interface from the 28th bit of the shift register (i.e., the 7th row of character four in each package). The Data Output directly interconnects to the Data Input (pin 12) on a succeeding SAN display. The data, clock and Vb inputs are all buffered to allow direct interface to any TTL logic family.

Theory of Operation

Dot matrix alphanumeric display systems generally are organized logically so that any character can be generated either as a combination of five subsets of seven bits each or seven subsets of five bits each. This technique reduces from 35 to five or seven the number of outputs required from the character generator. To display a complete character, these subsets of data appear sequentially in the appropriate locations of the display matrix. Repeating this process a minimum of 100 times per second insures that each of the appropriate matrix locations is re-energized, the eye will perceive a continuous image of the entire character. The apparent intensity of each of the display elements will be equal to the intensity of that element during the "ON" period multiplied by the ratio of the "ON" time to refresh period. This ratio is referred to as the display duty factor and the technique, "strobing."

Each character of SANs is made up of five subsets of seven bits. For a four character display, 28 bits representing the first subset of each of the four characters are loaded serially into the on-board SIPO shift register. The first column is energized for a period of time, T. This process is repeated for columns two through five. If the time required to load the 28 bits into the SIPO shift register is t, the duty factor is: $DF = t/5\,(t+T)$, and the term 5(t+T), the refresh period. For a satisfactory display, the refresh frequency should be ≥100Hz, which means:

$$5(t+T) = 10\ ms$$

$$(t+T) = 2\ ms$$

Therefore, two milliseconds is the maximum time period which should be allowed for loading and displaying of each column.

Interfacing

A display system using the SAN display requires inter-facing with a character generator and refresh memory electronics. The system in Figure 2 is a single four digit display, therefore the 1/N counter becomes a 1/4 counter where N equals the number of characters in the string. The refresh memory stores the information to be displayed. Information can be coded in any one of several different standard data codes, such as ASCII or EBDIC; or a customized code and display font using a custom coded ROM. The only requirement being that the output data be generated as five subsets of seven bits each.

The character generator receives data from the refresh memory and outputs seven displaying data bits that correspond to the character and the column select data input. This data is converted to serial format in the parallel to serial shift register. In a typical system the right most character to be displayed is selected first, and the data corresponding to the ON and OFF display elements in the first column is clocked into the first seven shift register locations of the SAN.

In a similar manner, column one data for characters three, two and one is selected by the 1/N counter, decoded and shifted into the display shift register. After 28 clock counts, data for each character is located in the SAN shift register locations which are associated with the seven rows of the appropriate LED matrix. The 1/N counter overflows, triggering the display time counter enabling the output of the 1/5 column select decoder, and disabling the clock input to the display. The information now in the shift registers will be displayed for a period, T. The divide by five counter which provides column select data for both the SAN and the character generator is incremented one count and column data is loaded and displayed in the same manner as column one.

This process is repeated for each of the five columns which comprise the five subsets of data necessary to display the desired characters. After the fifth count, the 1/5 decoder automatically resets to one and the sequence is repeated. The only changes required to extend this interface to character strings of more than four digits are to increase the size of the refresh memory and to change the divide one by four counter to a module equal to the number of digits in the desired string.

Since data is loaded for all of the like columns in the display string and these columns are enabled simultaneously, only five columns are enabled simultaneously. Only five column transistors are required regardless of the number of characters in the string. The column switch transistors should be selected to handle approximately 110 mA per character in the display string. The collector voltage saturation voltage characteristics and column voltage supply should be chosen to provide a 2.6 V≤Vcol >Vcc. To save power supply costs and improve efficiency, this supply may be a full rectified unregulated DC voltage as long as the PEAK value doesn't exceed the Vcc and the minimum value doesn't drop below 2.6 volts. Since large current transients can occur if a column line is enabled during data shifting operations, the most satisfactory operations will be achieved if the columns current is switched off before clocking begins.

Interface Design

A logical "1" in the display shift register turns a corresponding LED "ON." Clocking occurs on the high to low transition of the clock input. A character generator which produces seven bit "column" data can be used. The internal shift register is 28 bits in length. The right hand digit is loaded first. Each column should be refreshed at a minimum rate of 100 Hz.

The following program uses a single chip microprocessor to control a SAN display (i.e., the 8051 microprocessor and a Sprague UCN5890A driver). See Figure 3.

The processing speed of a microprocessor is so high that the refresh rate of 1/5 can't be comprehended, therefore this program repeats itself 255 times before continuing to another line of data (similar to the scanning technique of a television screen).

Figure 2. Block diagram

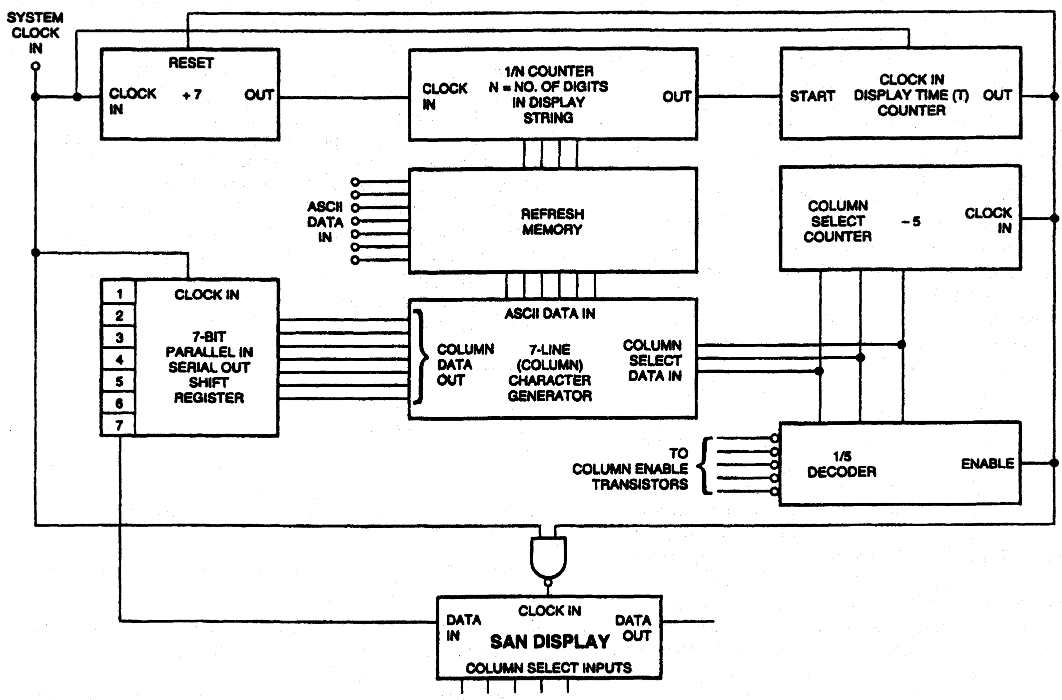
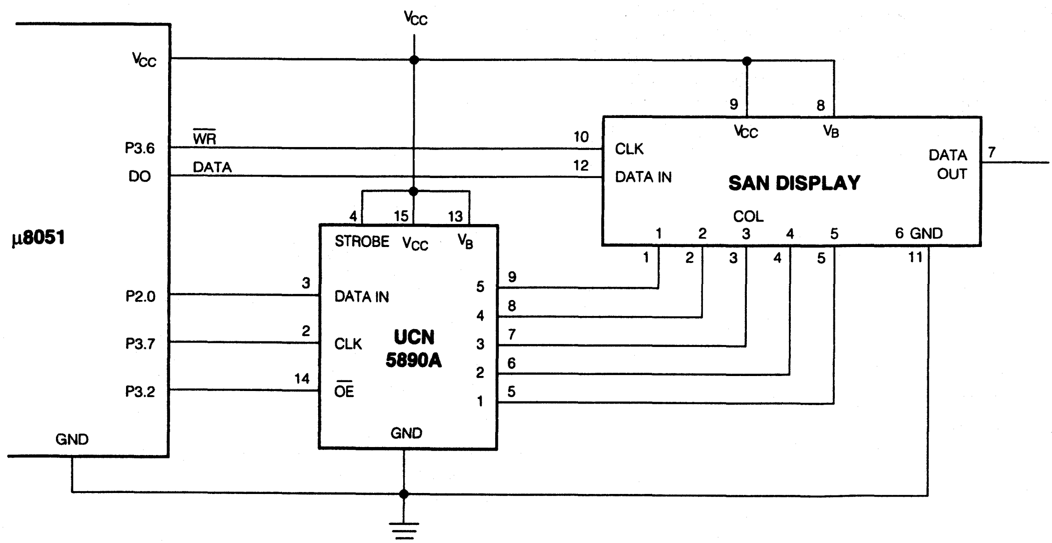


Figure 3. Shematic for SAN display and UCN5890A



Program to Drive One SAN Display with the 8051 and the UCN5890A as the Column Driver

This program assumes that the data memory address is loaded into DPTR prior to entering this subroutine:

```
                                ;R0 = # REPEATS
                                ;R1 = DISPLAY ADDRESS
                                ;R2 = WAIT
                                ;R3 = # COL
                                ;R4 = ROW COUNTER
                                ;R5 = BIT/COL
                                ;R6 = DIGIT COUNTER
                                ;R7 = UNUSED

REG 30H   EQU DPRTL                       ;DPTR MEM LOW REGISTER
REG 31H   EQU DPTRH                       ;DPTR MEM HIGH REGISTER

HDSP:     MOV     R0, #0FFH               ;# OF REPEAT CYCLES
BEGIN:    MOV     DPTRL, DPL              ;SAVE DPTR LOW
          MOV     DPTRH, DPH              ;SAVE DPTR HIGH
          SETB    P3.2                    ;TURN OFF COLUMN
          SETB    P2.0                    ;DATA 1st COLUMN
          MOV     R3, #5H                 ;# OF COL
START:    CLR     P3.7                    ;COL CLK
          SETB    P3.7                    ;COL CLK
          MOV     R4, #7H                 ;# ROWS
NXCOL:    MOV     R6, #4H                 ;4 DIGITS
NWYT:     MOV     R5, #7H                 ;7 BIT/COL
          CLR     A
          MOVC    A, @A+DPTR              ;GET DATA
          INC     DPTR                    ;INC DATA ADDRESS
NXBT:     MOVX    @R1, A                  ;OUTPUT D0 & CLK
          RR      A                       ;SHIFT TO NEXT BIT
          DJNZ    R5, NXBT                ;DO 7 TIMES
          DJNZ    R6, NWBYT               ;DO 4 CHARS
          CLR     P3.2                    ;TURN ON COL
          MOV     R2, #77H                ;WAIT TIME
          DJNZ    R2, $                   ;WAIT
          MOV     R2, #77H
          DJNZ    R2, $                   ;WAIT
          SETB    P3.2                    ;TURN OFF COL
          MOV     P2, #00H                ;SET COL DRVR DATA
          DJNZ    R3, START               ;NEXT COL
          MOV     DPH, DPTRH              ;RESTORE DPTR HIGH
          MOV     DPL, DPTRL              ;RESTORE DPTR LOW
          DJNZ    R0, BEGIN               ;REPEATS?
          RET                             ;RETURN FOR ANOTHER LINE
```

Table 2. SAN display optical characteristics

Part No.	LED PK I_V	Average LED I_V	Character* I_V	Peak I_F	Average I_F	η_v	Average Sterance L_V LED	
	μcd	μcd	mcd	mA	mA	μcd/mA	cd/m^2	ft candle
HDSP200LP	200	40	0.60	12.0	2.4	17	717	67
HDSP201LP	750	150	2.25	12.0	2.4	63	1923	179
HDSP202LP	1430	286	4.30	12.0	2.4	119	3667	340
HDSP203LP	1550	310	4.65	12.0	2.4	129	3974	369
ISD2010	200	40	0.60	12.0	2.4	17	717	67
ISD2011	750	150	2.25	12.0	2.4	63	1923	179
ISD2012	1430	286	4.30	12.0	2.4	119	3667	340
ISD2013	1550	310	4.65	12.0	2.4	129	3974	369
ISD2310	300	60	0.90	13.6	2.7	22	1075	100
ISD2311	1140	228	3.42	13.6	2.7	84	2923	271
ISD2312	1632	326	4.89	13.6	2.7	120	4179	388
ISD2313	2410	482	7.23	13.6	2.7	177	6179	573
ISD2351	3400	680	10.20	13.6	3.2	212	8718	810
ISD2352	2850	570	8.55	13.6	3.2	178	7308	679
ISD2353	3000	600	9.00	13.6	3.2	187	7692	714

* 15 LEDs ON per character, DF=20%

Optical Considerations

Luminous Intensity Control

The luminous intensity of the Small Alphanumeric display can be easily adjusted from sunlight viewability through night vision requirements (ISD 235X only).

The light output of the SAN display depends on a number of variables. These include the absolute efficiency of the LED material, the average current through the LED, and the LED's junction temperature. The readability of the display's light output depends upon the luminous and chrominous contrast of the LED diode to the package and ambient lighting environment.

Table 2 lists the luminous intensity per LED for the SAN family. The average character brightness is based on 15 LEDs per character with a 20% duty factor. The time averaged LED current for the SAN is in the range of 2.4–3.2 mA/LED (DF=20%). The Blanking Control (VB) can be used to change the duty factor ON time, resulting in a lower LED intensity. Figure 4 shows a 74LS122 timer whose pulse width can be manually adjusted for a 1000:1 intensity control.

Optical Filtering

Having a bright display does not guarantee readability in a given lighting ambient. The readability of the SAN depends on the contrast of the LED to the ambient light. The human eye measures contrast in both brightness (luminance) and color (chrominance) perception.

There are three contrast ratios that describe the optimum readability for the display. The first is ratio between the ON LED to an OFF LED and should be much greater than one. The second ratio deals with the ON LED to the color and brightness of the surrounding package and also is much greater than one. The third ratio is equal to OFF LED to the brightness and color of the surrounding package. This ratio should be equal to one, meaning no color or brightness difference between the OFF LED and the package.

Using proper package design and optical filter selection insures high contrast ratios. In dim ambients high optical transmission long wave and bandpass filters are the best choice. However, in high light ambients low transmission neutral density (grey) filters give the best contrast ratios of the OFF LED and ON LED to the package background, improving the true readability of the display. For sunlight readability, the SAN's glass window permits the use of glass or plastic circularly polarized filters. These filters greatly minimize the incident light that falls on the surface of the OFF LEDs and the package background. Table 3 is a guide for filter selection.

Figure 4. Brightness control using a one shot multi-vibrator

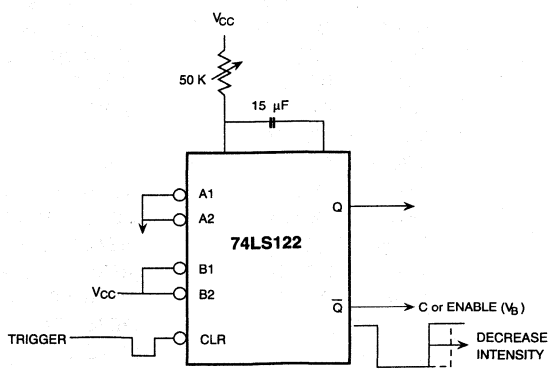


Table 3. Contrast enhancement filters

Display Color [2] **Part No.**	**Ambient Light**		
	Dim	**Moderate**	**Bright**
Red HDSP2000LP	Panelgraphic Dark Red 63 Panelgraphic Ruby Red 60 Chequers Red 118 Plexiglass 2423	Polaroid HNCP37	
Yellow HDSP2001LP	Panalgraphic Yellow 27	3M Light Control Film Panelgraphic Gray 10	Polaroid HNCP 10-Glass Marks Polarized MPC 30-25C
HER HDSP2002LP	Panelgrphic Ruby Red 60 Chequers Red 112	Chequers Gray 105	[1] Polaroid HNCP 10-Glass Marks Polarized MPC 20-15C
Bright Green HDSP2003LP	Panelgraphic Green 48 Chequers Green 107		Polaroic HNCP 10-Glass Marks Polarized MPC 50-12C
Display Color **Part No.**	**Filter Color**	**Marks Polarized Corp.** **Filter Series**	**Optical Characteristics** **of Filter (Circular Polarizer)**
Red, HER ISD 2010, 2012, 2310, 2312, 2352	Red	MPC 20-15C	25% at 635 nm
Yellow ISD 2011, 2311, 2351	Amber	MPC 30-25C	25% at 583 nm
Green ISD 2013, 2313, 2353	Yello/Green	MPC 50-22C	22% at 568 nm
Multiple Colors High Ambient Light	Neutral Gray	MPC 80-10C	10% Neutral
Multiple Colors	Neutral Gray	MPC 80-37C	37% Neutral

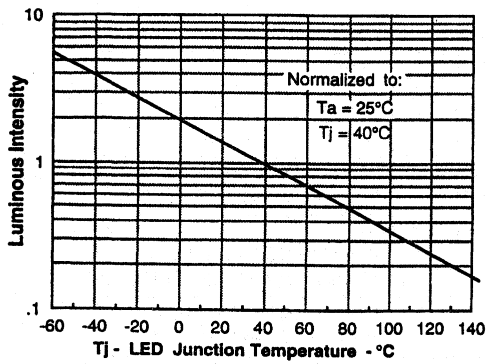
Note:
[1] Optically coated circular polarized filters, such as Polaroid HNCP10.
[2] For multiple colors use Marks Polarized Corporation filters, MPC 80-10C or MPC 80-37C.

Polaroid Corporation
1 Upland Road, Bldg. #2
Norwood, MA 02062
☎ (800) 225-2770

Marks Polarized Corporation
25-B Jefryn Blvd. W.
Deer Park, NY 11729
☎ (516) 242-1300
Fax (516) 242-1347

Marks Polarized Corp. manufactures to MIL-I-45208 inspection system.

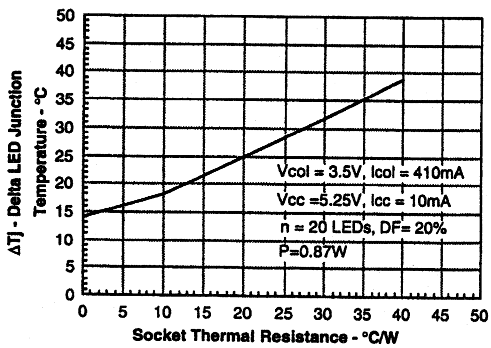
Figure 5. Normalized luminous intensity vs. junction temperature



The light output of the LEDs is inversely related to the LED diodes junction temperature as shown in Figure 5. For optimum light output, keep thermal resistance of the socket of PC board as low as possible.

For example, when the HDSP200XLP is mounted in a 10°C/W socket and operated at Absolute Maximum Electrical conditions, the LED junction will rise 17°C above ambient. If T_A=40°C, then the LED's T_J will be 57°C. Under these conditions Figure 5 shows that the I_V will be 75% of its 25°C value.

Figure 6. Maximum LED junction temperature vs. socket thermal resistance



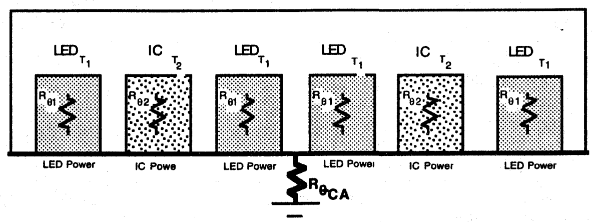
Thermal Consideration

Optimum reliability and optical performance will result when the junction temperature of the LEDs and CMOS ICs are kept as low as possible. The plastic HDSP200XLP should operate to a maximum ambient temperature of 85°C, while maintaining a maximum junction temperature of ≤100°C. The ceramic and glass SANs (ISD2XXX) may operate up to 100°C as long as the junction temperature of the IC is maintained at less then 125°C.

Table 4.

Model Number	V_F		
	Min.	**Typ.**	**Max.**
HDSP2000LP	1.6	1.7	2.0
HDSP2001/2/3LP	1.9	2.2	3.0

Figure 7. Thermal model



Thermal Modeling

For a thermal model of the display, see Figure 7 which shows junction self heating + the case temperature rise + ambient temperature = junction temperature of the semiconductor. Equation 1 shows this relationship.

Equation 1.

$$T_{J(LED)} = P_{LED}\,Z_{\theta JC} + P_{CASE}\,(R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(LED)} = [(I_{COL}/28)\,V_{F(LED)}\,Z_{\theta JC}] + [(n/35)\,I_{COL}\,DF\,(5V_{COL}) + V_{CC}\,I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

The junction rise within the LED equals the thermal impedance of an individual LED (37 °C/W, DF 20%, F=200 Hz) times the forward voltage, $V_{F(LED)}$, and forward current, $I_{F(LED)}$, of 13–14.5 mA. This rise averages $T_{J(LED)}$=1°C. Table 4 shows the $V_{F(LED)}$ for respective displays.

The junction rise within the LED driver IC is the combination of the power dissipated by the IC quiescent current and the 28 row driver current sinks. The IC junction rise is given in Equation 2. A thermal resistance of 28°C/W results in a typical junction rise of 6°C.

Equation 2.

$$T_{J(IC)} = P_{COL}(R_{\theta JC} + R_{\theta CA}) + T_A$$

$$T_{J(IC)} = [5(V_{COL} - V_{F(LED)}) \cdot (I_{COL}/2) \cdot (n/35)\,DF + V_{CC} \cdot I_{CC}] \cdot [R_{\theta JC} + R_{\theta CA}] + T_A$$

For easier calculations, the maximum allowable electrical operating condition is dependent on the aggregate thermal resistance of the LED matrixes and the two driver ICs. The parallel combination of these two networks is 15°C/W. All of the thermal management calculations are based on this number. The maximum allowable power dissipation is given in Equation 3.

Equation 3.

$$P_{DISPLAY} = \frac{T_{J(MAX)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

$$P_{DISPLAY} = 5V_{COL}\,I_{COL}\,(n/35)\,DF + V_{CC}\,I_{CC}$$

Key to equation symbols

DF	Duty factor
I_{CC}	Quiescent IC current
I_{COL}	Column current
n	Number of LEDs on in a 5x7 array
P_{CASE}	Package power dissipation excluding LED under consideration
P_{COL}	Power dissipation of a column
$P_{DISPLAY}$	Power dissipation of the display
P_{LED}	Power dissipation of a LED
$R_{\theta CA}$	Thermal resistance case to ambient
$R_{\theta JC}$	Thermal resistance junction to case
T_A	Ambient temperature
$T_{J(IC)}$	Junction temperature of an IC
$T_{J(LED)}$	Junction temperature of a LED
$T_{J(MAX)}$	Maximum junction temperature
V_{CC}	IC voltage
V_{COL}	Column voltage
$V_{F(LED)}$	Forward voltage of LED
$Z_{\theta JC}$	Thermal impedance junction to case

SIEMENS

How to Use Optocoupler Normalized Curves Appnote 45

by Bob Krause

An optocoupler provides insulation safety, electrical noise isolation, and signal transfer between its input and output. The insulation and noise rejection characteristics of the optocoupler are provided by the mechanical package design and insulating materials.

A phototransistor optocoupler provides signal transfer between an isolated input and output via an infrared LED and a silicon NPN phototransistor.

When current is forced through the LED diode, infrared light is generated that irradiates the photosensitive base-collector junction of the phototransistor. The base-collector junction converts the optical energy into a photocurrent which is amplified by the current gain (HFE) of the transistor.

The gain of the optocoupler is expressed as a Current Transfer Ratio (CTR), which is the ratio of the phototransistor collector current to the LED forward current. The current gain (HFE) of the transistor is dependent upon the voltage between its collector and emitter. Two separate CTRs are often needed to complete the interface design. The first CTR, the non-saturated or linear operation of the transistor, is the most common specification of a phototransistor optocoupler and has a Vce of 10 volts. The second is the saturated or switching CTR of the coupler with a Vce of 0.4 volts. Figures 1 and 2 illustrate the Normalized CTR_{CE} for the linear and switching operation of the phototransistor. Figure 1 shows the Normalized Non-Saturated CTR_{CE} operation of the coupler as a function of LED current and ambient temperature when the transistor is operated in the linear mode. Normalized $CTR_{CE(SAT)}$ is illustrated in Figure 2. The saturated gain is lower with LED drive greater than 10 mA.

Figure 1. Normalized CTR versus I_F and T_{amb}

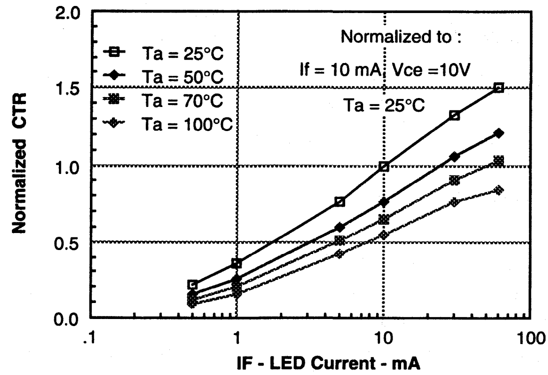
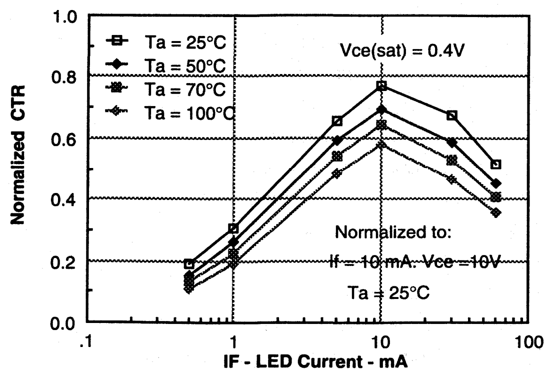


Figure 2. Normalized saturated CTR

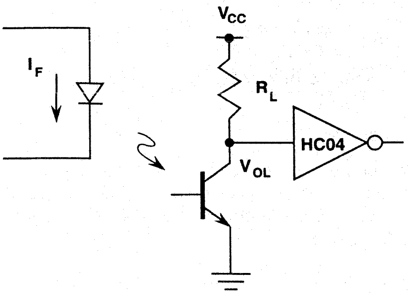


The following design example illustrates how normalized curves can be used to calculate the appropriate load resistors.

Problem 1.

Using an IL1 optocoupler in a common emitter amplifier (Figure 3) determine the worst case load resistor under the following operation conditions:

Figure 3. IL1 to 74HC04 interface



T_{amb}=70°C, I_F =2 mA, V_{OL}=0.4 V, Logic load =74HC04

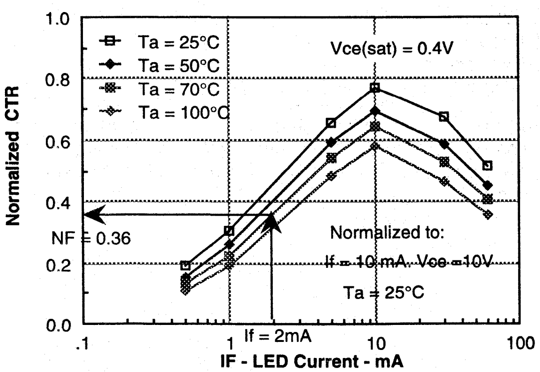
IL1 Characteristics:

$CTR_{CE(NON\ SAT)}$=20% Min. at T_{amb}=25°C, I_F=10 mA, V_{CE}=10 V

Solution

Step 1. Determine $CTR_{CE(SAT)}$ using the normalization factor ($NF_{CE(SAT)}$) found in Figure 2.

Figure 4. Normalized saturated CTR



$$CTR_{CE(SAT)} = CTR_{CE(NON\ SAT)}\ NF_{CE(SAT)} \qquad (1)$$

$$CTR_{CE(SAT)} = 20\% \ * \ 0.36$$

$$CTR_{CE(SAT)} = 7.2\%$$

Step 2. Select the minimum load resistor using the following equation:

$$R_{L(MIN)} = \frac{V_{CC} - V_{OL}}{\frac{CTR_{CE(SAT)} I_F}{100\%} - I_L} \qquad (2)$$

$$R_{L(MIN)} = \frac{5\,V - 0.4\,V}{\frac{(0.072)\,2\,mA}{100\%} - 50\,\mu A}$$

$R_{L(MIN)}$=48.94 KΩ, select 51 KΩ ±5%

The switching speed of the optocoupler can be greatly improved through the use of a resistor between the base and emitter of the output transistor. This is shown in Figure 5. This resistor assists in discharging the charge stored in the base to emitter and collector to base junction capacitances. When such a speed-up technique is used the selection of the collector load resistor and the base-emitter resistor requires the determination of the photocurrent and the HFE of the optocoupler.

The photocurrent generated by the LED is described by the CTR_{CB} of the coupler. This relationship is shown in Equations 3 and 4. Equation 5 shows that CTR_{CE} is the product of the CTR_{CB} and the HFE. The HFE of the transistor is easily determined by evaluating Equation 4, once the $CTR_{CE(SAT)}$ and CTR_{CB} are known. The Normalized CTR_{CB} is shown in Figure 6. Equations 5, 6, and 7 describe the solution for determining the R_{BE} that will permit reliable operation.

Figure 5. Optocoupler/logic interface with R_{BE} resistor

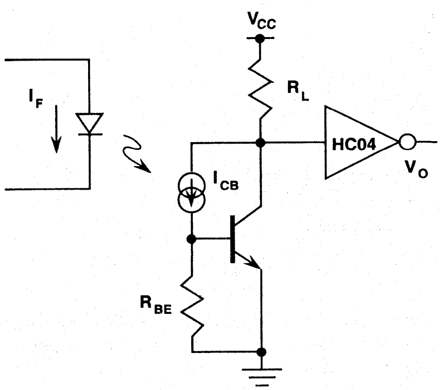
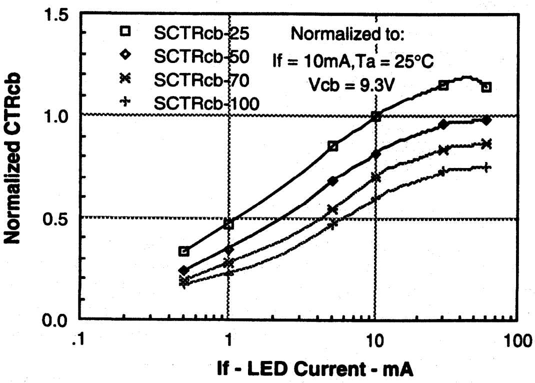


Figure 6. Normalized CTR_{CB} versus LED current



$$CT_{CB} = \frac{I_{CB}}{I_F}100\% \quad (3)$$

$$I_{CB} = I_F \frac{CTR_{CB}}{100\%} \quad (4)$$

$$CTR_{CE(SAT)} = CTR_{CB} HFE_{(SAT)} \quad (5)$$

$$HFE_{(SAT)} = \frac{CTR_{CE(SAT)}}{CTR_{CB}} \quad (6)$$

$$R_{BE} = \frac{V_{be}}{I_{CB} - I_{BE}} \quad (7)$$

$$R_{BE} = \frac{V_{BE} HFE_{(SAT)} R_L}{I_{CB} HFE_{(SAT)} R_L - [V_{CC} - V_{CE(SAT)}]} \quad (8)$$

$$R_{BE} = \frac{V_{BE} \frac{CTR_{CE} NF_{CE(SAT)}}{CTR_{CB} NF_{CB}} R_L}{\frac{I_F CTR_{CE} NF_{CE(SAT)} R_L}{100\%} - [V_{CC} - V_{CE(SAT)}]} \quad (9)$$

Problem 2.

Using an IL2 optocoupler in the circuit shown in Figure 6, determine the value of the collector load and base-emitter resistor, given the following operational conditions:

T_{amb}=70°C, I_F=5 mA, V_{OL}=0.4 V, Logic load =74HC04

IL2 Characteristics:

CTR_{CE}=100% at T_{amb}=25°C, V_{CE}=10 V, I_F=10 mA

CTR_{CB}= 0.24% at T_{amb}=25°C, V_{CB}=9.3 V, I_F=10 mA

Solution

Step 1. Determine $CTR_{CE(SAT)}$, and CTR_{CB}.

From Figure 2 the $CTR_{CE(SAT)}$=55%, [$NF_{CE(SAT)}$=0.55]

From Figure 6 the CTR_{CB}=0.132%, [NF_{CB}=0.55]

Step 2. Determine R_L.

From Equation 2 R_L=1.7 KΩ

Select R_L= 3.3 KΩ

Step 3. Determine R_{BE}, using Equation 9.

$$R_{BE} = \frac{0.65V\frac{(100\%)(0.55)}{(0.24\%)(0.55)}3.3K\Omega}{\frac{(5mA)(100\%)(0.55)(3.3K\Omega)}{(100\%)} - [5V - 0.4V]} \quad (10)$$

R_{BE}=199 KΩ, select 220 KΩ

Using a 3.3 kΩ collector and a 220 KΩ base-emitter resistor greatly minimize the turn-off propagation delay time and pulse distortion. The following table illustrates the effect the R_{BE} has on the circuit performance.

	I_F=5 mA, V_{CC}=5 V	
	R_L=3.3 KΩ R_{BE}=∞ Ω	R_L=3.3 KΩ R_{BE}=220 KΩ
t_{delay}	1 µs	2 µs
t_{rise}	4 µs	5 µs
$t_{storage}$	17 µs	10 µs
t_{fall}	5 µs	12 µs
t_{phl}	3.5 µs	7 µs
t_{plh}	22 µs	12 µs
Pulse Distortion 50 µs pulse	37%	10%

Not only does this circuit offer less pulse distortion, but it also improves high temperature switching and lower static DC power dissipation and improved common mode transient rejection.

SIEMENS

Sunlight Readability Contrast Measurements for the ISD2351 and ISD2353 Serial Input Small Alphanumeric Display Appnote 47

by Bob Krause

Introduction

Light emitting diode alphanumeric displays have had a long and successful relationship with military and avionic equipment. Applications with very high light ambients now are possible because of advances in the efficiency of LEDs. Polarized filters enhance the readability of LEDs by eliminating much of the ambient reflection from the LED die and the surrounding package.

Readability Criteria

An observer's ability to perceive the information from an alphanumeric display depends on two factors. These include font and size of the message in relationship to the viewing position and the optical contrast of the message to the surrounding environment.

Optical contrast is the comparison of the brightness or sterance (L) of the On/Off/LED to the brightness of the surrounding environment. High readability results by optimizing the following contrast ratios. The first ratio, C_1, involves the OnLED stearance, L_{LEDon}, and the background stearance, L_B, is optimized when the OnLED is brighter than the surrounding area. Thus C_1 will be much greater than unity (1).

The next ratio, C_2, involves the sterance ratio of the On, L_{LEDon}, and Off, L_{LEDoff}, LED. C_2 is optimized when the L_{LEDon} is much greater than the L_{LEDoff}, resulting in being much greater than unity (1).

The optimal ratio of C3, involving OffLED to the background, is achieved when the ratio is near zero. The OffLED should have minimal contrast with the background.

The equations for these three ratios are given below.

The U.S. military has established contrast ratios limits to satisfy sunlight readability criteria. These criteria are published in, "*Night Vision Goggle Lighting Specification.*" The specifications are shown below:

C1—OnLED to Background	≥ 2.0:1 Minimum
C2—OnLED to OffLED	≥ 2.0:1 Minimum
C3—OffLED to Background	≤ 0.25:1 Maximum

Optical Filtering

An LED, regardless of its brightness, has a difficult time competing with the sterance of the sun. An LED display's readability can be greatly improved by using contrast enhancement filters. The filter of choice is one that eliminates the interference of the sun with the background of the display. A number of filter vendors offer anti-reflection coated, circular polarized (AR/CP), optically tinted bandpass and neutral density filters which have proven very helpful in satisfying the sunlight readability contrast requirements.

The display front surface and the areas surrounding the LEDs have specular reflector characteristics. This reflective property allows optimum contrast when used with a circular polarized filter with anti-reflective coating. See Table 1 for Filter Selection Guide.

Ratio Equations

1) C_1—OnLED to Background

$$C_1 = \frac{L_{LEDon} - L_B}{L_B}$$

2) C_2—OnLED to OffLED

$$C_2 = \frac{L_{LEDon} - L_{LEDoff}}{L_{LEDoff}}$$

3) C_3—OffLED to Background

$$C_3 = \frac{|L_{LEDoff} - L_B|}{L_B}$$

Table 1. Contrast enhancement filter selection guide

Display P/N or Condition	Display Color	Transmission	Filter Color	Filter Model No. Filter Manufacturer
ISD2010 ISD2012 ISD2352* ISD2310 ISD2312	Red/ Hi Eff. Red	25% at 635 nm	Red	MPC 20-15C Marks
ISD2011 ISD2351* ISD2311	Yellow	25% at 585 nm	Amber	MPC 30-25C Marks
ISD2013 ISD2353* ISD2313	Hi Eff. Green	22% at 565 nm	Yellow/Green	MPC 50-22C Marks
High Ambient Light	All Colors	10% Neutral	Neutral Gray	MPC 80-10C Marks
High Ambient Light	All Colors	37% Neutral	Neutral Gray	MPC 80-37C Marks
ISD2010 ISD2012 ISD2352* ISD2310 ISD2312	Red/ Hi Eff. Red	14%	Reddish Orange	HLF-608-5R Hoya
ISD2011 ISD2351* ISD2311	Yellow	14%	Yellowish Orange	HLF-608-3Y Hoya
ISD2013 ISD2353* ISD2313	Hi Eff. Green	14%	Yellow/Green	HLF-608-1G Hoya
High Ambient Light	All Colors	10% Neutral	Neutral Gray	HNCP10 Polaroid

* Sunlight viewable displays. All other part numbers represent all the standard Military Small Alphanumeric Displays.

Manufacturers

Marks Polarized Corporation
25B Jefryn Blvd. West
Deer Park, NY 1179-5715
(516) 242-1300

HOYA Optics, Inc.
3400 Edison Way
Fremont, CA 94538-6138
(415) 490-1880

Polaroid Corp.
Polarizer Division
1Upland Road
Norwood, MA 02062
(617) 577-2000

Contrast Measurements

The ability to read a display in direct sunlight used to be determined by using a series of standard observers and irradiating the display with one sun. Recent technical studies have established contrast criteria permitting laboratory measurements that verify sunlight readability.

A yellow ISD2351 and a high efficiency green ISD2353 Small Alphanumeric Display were evaluated for sunlight readability under a simulated sun with an incident of 4200 fc. These two displays were tested with both pass-band and neutral density AR/CP filters. The measurement technique and results follow.

Contrast Measurement Setup

Contrast measurements require the use of a spot photometer, which measures the luminance of the surface within a specific spot size. A Photo Research Spectra Pritchard spot photometer Model 1980B with a Macro Spectar MS-80 Lens was calibrated and set to read out in foot Lamberts, fL. The display and filter were mounted on a micro adjustable X/Y/Z stage. This stage, the spot photometer, and a 500 W Unimat LX80 light source were mounted on a optical bench. The light source was oriented 30° from the normal of the display. See Figure 1.

Figure 1. Sunlight readability contrast measurement setup

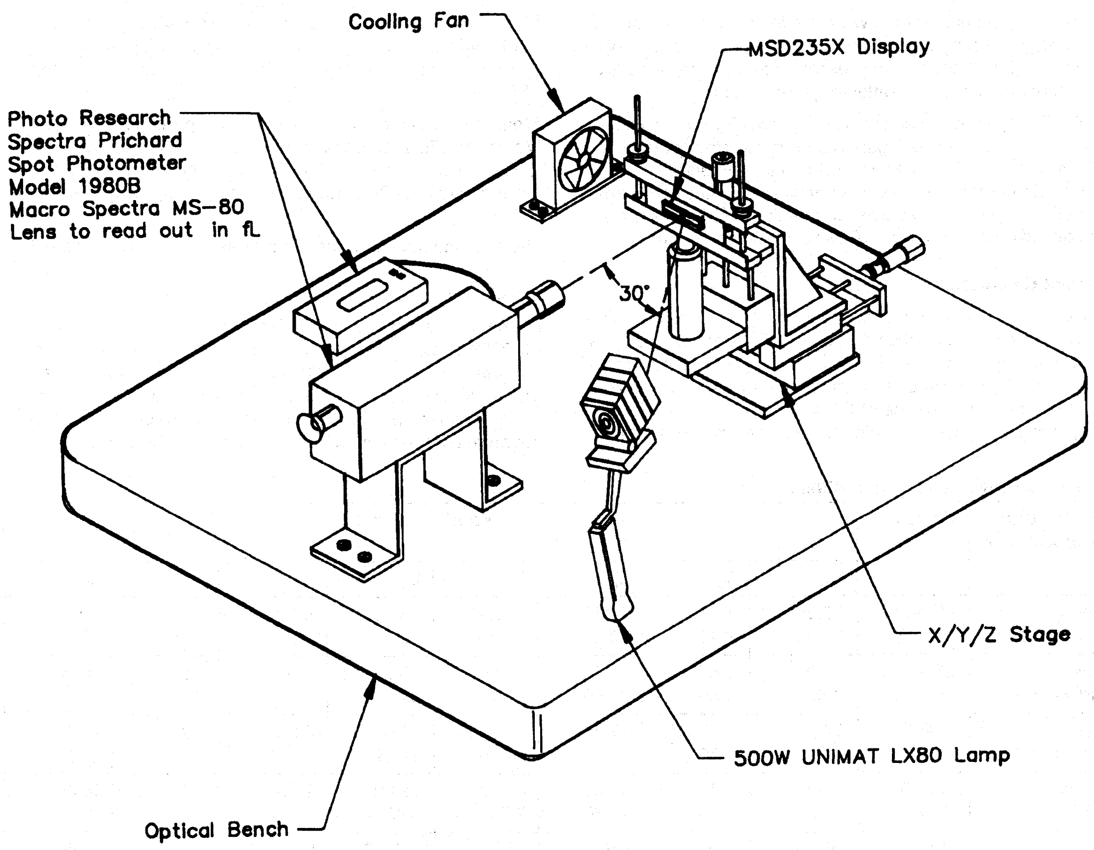


Figure 2. LEDs selected for measurement

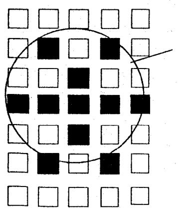
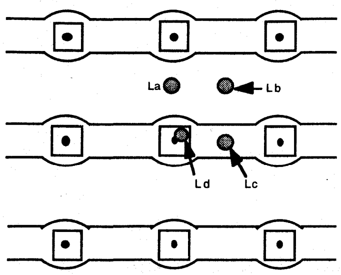


Figure 3. Points for luminous stearance measurement



The sterance measurements were made using the photometer with an angle setting of 2 minutes resulting in a spot size of .004 in. The incidence flux was determined by using a Kodak 6080 standard lambertian reflector painted slide.

The X/Y/Z stage supported the display, the AR/CP filter, and the display drive electronics. Figure 3 shows the asterisk (*) programmed on the display. Each LED had a duty factor of ON 17.6%. The center of the asterisk was used as the measurement LED. The stage was used to position the display at the four contrast measurement points as shown in Figure 2.

Contrast Calculations

The data derived from the spot photometer was used to calculate the three contrast ratios, C_1, C_2, C_3. For best accuracy, L_B was the average of three spot locations. Figure 3 shows these as L_a, L_b, L_c. L_a is the substrate sterance between two LED die, L_b is the substrate sterance of the area between four LED die; and L_c is the sterance of a gold trace connecting the LEDs.

Measurements were made using a yellow ISD2351 and a Marks MPC80-10C neutral density gray filter. This display had a typical intensity of 2450 µcd/LED with an average wavelength of 585 nm.

Measurements were also made using a green ISD2353 with a Marks MPC50-22C yellow/green bandpass filter and a Marks MPC80-10C neutral density gray filter. This display had a typical intensity of 3470 µcd/LED with an average wavelength of 572 nm.

The data and results of the experiment are shown in Table 2.

Conclusion

From the data, the most readable combination is the green ISD2353 display and a green bandpass AR/CP filter, followed by the green display and the 10% transmissive neutral density gray AR/CP filter. In both cases these combinations exceeded the military limit by almost 2.5 times. The yellow display has optimum contrast with a neutral density AR/CP gray filter.

Table 2. Luminous contrast at 4200 fc

Display Color Filter Model #	Status	Footlamberts							
		L_a	L_b	L_c	L_d	L_B	C_1	C_2	C_3
Green MPC50-22C	LED-On LED-Off	12.00 11.00	10.20 9.40	27.10 20.60	101.60 12.60	16.43 13.67	5.18	7.06	0.08
Green MPC80-10C	LED-On LED-Off	9.70 8.80	8.60 8.60	17.80 11.40	69.80 10.10	12.03 9.60	4.80	5.91	0.05
Green MPC50-22C	LED-On LED-Off	12.60 11.10	11.30 9.80	37.30 17.70	111.00 14.40	15.30 12.87	6.25	6.71	0.12
Yellow MPC80-10C	LED-On LED-Off	9.30 7.80	8.20 7.20	19.40 10.30	46.50 7.70	12.30 8.43	2.78	5.04	0.09
Yellow No Filter	LED-On LED-Off	208.00 198.00	198.00 171.00	650.00 853.00	480.00 171.00	352.00 407.33	0.36	1.81	0.58

Optocouplers for Safe Electrical Isolation to VDE 0884 Appnote 48

by Gerhard Kaiser

Because of their high reliability and long life, optocouplers are used in applications requiring safe electrical isolation of two circuits, such as in switched-mode power supplies (SMPS). Optocouplers have to comply with the relevant VDE standards and/or international standards like IEC when used for protecting systems against electrical damage.

Currently the tendency is to incorporate international standards (e.g. IEC) into the German VDE regulations. On the other hand, the goal is to make a national VDE standard (such as one that has proved to increase safety) into an internationally recognized IEC standard. For example, a new VDE standard, VDE 0884, has just been introduced in Germany and also is being reviewed in various international standardization committees.

German VDE standards are divided into three main groups:

- Basic VDE standards, such as VDE 0110 which describes air and creepage path requirements in general
- VDE standards governing components, such as the recently expired VDE 0883 standard for optocouplers
- VDE standards governing systems and equipment, such as VDE 0805/0806 for office machines and EDP systems

Optocouplers used in a switched mode power supply of a computer have to satisfy the requirements of VDE 0883 and VDE 0805/0806.

Thickness of solid insulation between conducting parts, the isolation test voltage and the air and creepage paths are crucial in applications requiring reliable electrical isolation. Depending on the sensitivity of the application, different values are given in the VDE standards.

For example, an electrical control cabinet will probably be opened and operated infrequently and only by skilled staff. However, it's not unusual for a cup of coffee to be spilled accidentally over the keyboard of an electric typewriter. Thus the requirements to be met in the two cases are very different.

The latest findings in high-voltage technology have questioned two parameters thickness of solid insulation and isolation test voltage. Dielectric strength does increase with the thickness of the insulating material, but only when the insulating material is homogeneous and free of impurities or air-pockets. A high-quality thin insulation can be better than a thick layer with impurities or air-bubbles. The trend is clearly towards reducing insulation thickness (about 0.3 to 0.5 mm) for more economical manufacturing and technologically advanced optocoupler functions.

To test the breakdown strength, isolation test voltage normally lasts 60 seconds in qualification tests and up to one second in 100% inspection (depending on the particular VDE standard). However, no determination is made whether any partial discharge occurs in the insulation material during testing. This requires measurement equipment of extreme sensitivity and has been introduced on the market only recently.

Studies in high-voltage technology have shown that a single partial discharge will probably not be extinguished at low voltages and that permanent partial discharge may degrade and damage the insulating material. So that even under normal operating conditions partial discharge may occur when operating voltage is applied. A high-voltage breakdown is likely to occur after a certain time of operation.

The new standard for optocouplers, VDE 0884, used for safe electrical isolation addresses the two drawbacks mentioned earlier. Suitable dielectric strength is now determined by the presence of partial discharges at a defined test voltage. Partial discharges occur with impurities or air-bubbles in the insulating material or insufficient thickness of solid insulation.

The conventional breakdown test (isolation test voltage) may risk causing initial damage to the optocoupler which is not detectable. This test has been replaced in VDE 0884 by the partial discharge test which detects any partial discharge. The absence of partial discharge during the test reliably proves the isolation capability without any undesirable initial damage to the insulation material.

Partial discharge measurement method per VDE 0884

Two measurement methods, as described in VDE 0884, have proved to be reliable and suitable for optocouplers.

- Measurement method A—a destructive test to qualify optocouplers and for sample testing in manufacture.
- Measurement method B—a non-destructive test of every component (100% inspection).
- Figures 1 and 2 show two typical voltage time curves (AC voltage peak-to-peak values) for Siemens optocoupler testing per VDE 0884.

Figure 1. Measurement method A of VDE 0884

A destructive test for the qualification of optocouplers and sample testing in manufacture. This time-test voltage diagram can be used with SFH601 and CNY17 couplers.

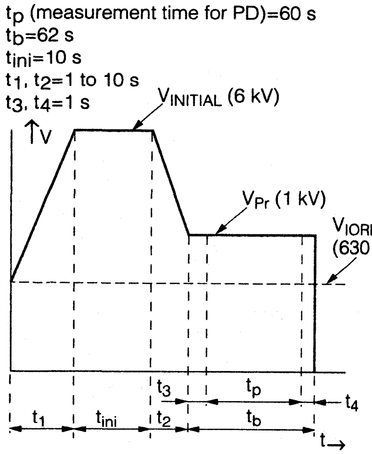
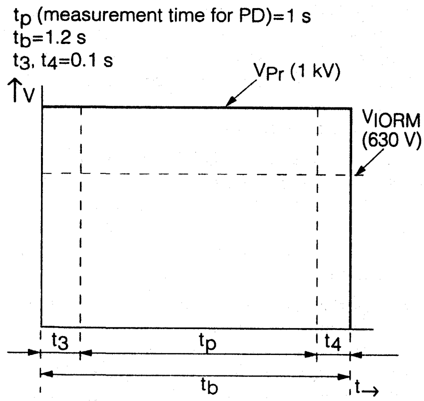


Figure 2. Measurement method B

A non-destructive test of every component (100% inspection)



More VDE 0884 test criteria for safe electrical isolation by optocouplers

In addition to the partial discharge test, VDE 0884 has further requirements to improve optocoupler reliability. For example, data on reliability limits such as limit current, temperature, and/or power dissipation must be given for every approved and qualified component. Figure 3 shows the reliability limit values for SFH601 and CNY17 optocouplers.

Limit values are generally higher than the maximum ratings. They indicate whether and if additional components are required in the circuit to ensure safe electrical isolation in case of failure in the surrounding circuitry.

In the qualification test (destructive test) the optocoupler is exposed to numerous tests in rough environments such as humidity cycles or temperature shocks. The optocouplers are then stressed to the limit values for 72 hours. Finally, they are tested partial discharge. Absence of partial discharge (PD) currently means a value below 5 picocoulombs.

Importance of VDE 0884 standard for the future

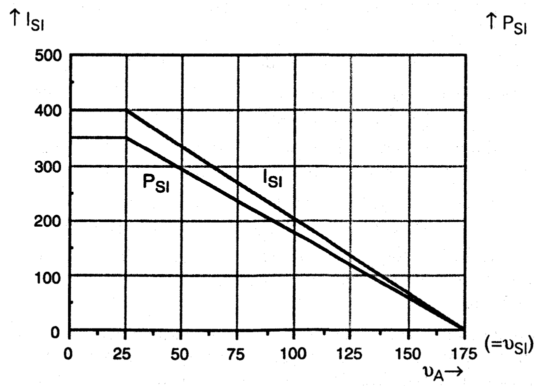
Optocouplers used in applications for safe electrical isolation are tested for freedom from partial discharge to give improved reliability and useful information on the long term stability of insulating materials. VDE 0884 is only a first step in this direction. Partial discharge measurements probably will become applicable to transformers, capacitors, and other components. VDE 0883 is no longer the standard since December 1988. However, until the end of 1991 approvals to VDE 0883 were accepted in the marketplace.

From 1992 optocouplers must have VDE 0884 approval. New designs of PC boards or systems using optocouplers which have to fulfil the requirements of safe electrical isolation, must use only optocouplers with VDE 0884 approval.

Siemens already offers the SFH601 and CNY17 optocouplers with VDE 0884 approval under option 1. Other types, especially DIP-4 series, have been approved and are available.

Figure 3. Dependency of reliability maximum ratings on ambient temperature for SFH601, CNY17

For every optocoupler type approved to VDE 0884, reliability limit values such as limit temperature, current and power dissipation must be given.



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Interfacing the PD243X Alphanumeric Programmable Display™ with the SAB80515/SAB80535 Microcontroller

To Produce a Bidirectional, Speed Regulated Moving Message Display by Using the SAB80515/SAB80535's Timer 2 & 8-Bit Converter

Appnote 49

by Ashutosh Ahluwalia

This application note introduces the user to one of the features of Timer 2 and A/D converter of the SAB 80515/535. Included in this application note is a description of both the software and hardware implementations of the SAS 80515/535 to use its Timer 2 and 8-bit A/D converter for the bidirectional, speed regulated moving message display. The program listing demonstrates how the Timer 2 and the 8-bit A/D converter of the SAB 80515/535 can be combined to generate time delays controlled by analog levels. The hardware circuitry shows an interface of the SAP 80515/535 with a simulated analog input, a 2 kbyte EPROM, and intelligent display chips of Siemens used in memory mapped 1/0 scheme.

The SAB 80515/535 microcontroller with on-chip A/D converter and a 16-bit Timer (Timer 2) with reload capability offers a solution which can be applied to a wide range of industrial applications. These applications vary from analog controlled digital delays to controlled frequency converters for pulse width modulation.

In the present application example, the above features of the SAB 80515/535 are used in conjunction to generate the software delays. The software delay results in varying the voltage level of the analog signal applied to the A/D converter of the SAB 80515/535.

A/D Converter

The SAB 80515/535 provides an 8-bit A/D converter with eight multiplexed analog input channels on-chip. In addition, the A/D converter has a sample and hold circuit and offers the feature of software programmable reference voltages. For the conversion, the method of successive approximation with a capacitor network is used.

Figure 1 shows a block diagram of the A/D converter. There are three user-accessible special function registers:

—ADCON (A/D converter control register)
—ADDAT (A/D converter data register)
—DAPR (D/A converter program register) for the programmable reference voltages.

Special function register ADCON is used to select one of the eight analog input channels to be converted, to specify a single or continuous conversion, and to check the status bit BSY which signals whether a conversion is in progress or not.

The special function register ADDAT holds the converted digital 8-bit data result. The data remains in ADDAT until it is overwritten by the next converted data. The new converted value will appear in ADDAT in the 15th machine cycle after a conversion has been started. ADDAT can be read and written to under software control. If the A/D converter of the SAB 80515/535 is not used, register ADDAT can be used as an additional general-purpose register.

The special function register DAPR is provided for programming the internal reference voltages IVAREF and IVAGND. In the present application DAPR holds a value of 00H. For this value of DAPR, IVAREF and IVAGND are the same as VAREF and VAGND respectively.

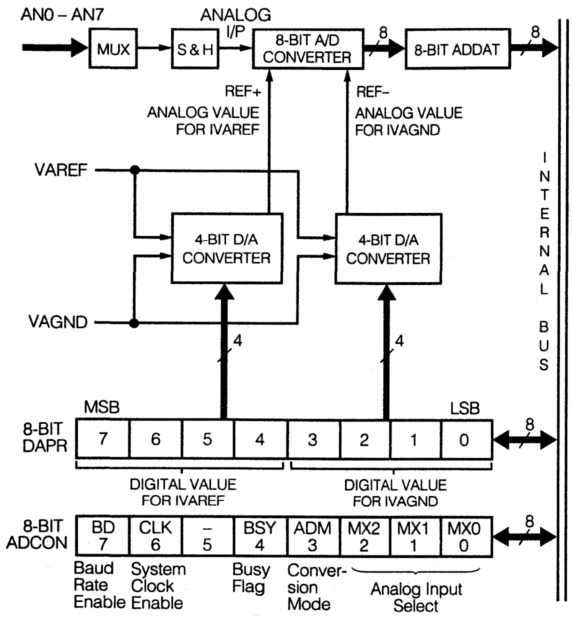
A/D Conversion

A conversion is started by writing to the special function register DAPR. A "Write-to-DAPR" will start a new conversion even if a conversion is currently in progress. The conversion begins with the next machine cycle. The busy flag BSY will be set in the same machine cycle as the "write-to-DAPR" operation occurs. If the value written to DAPR is 00H, meaning that no adjustment of the internal reference voltages is desired, the conversion needs 15 machine cycles to be completed. Thus, the conversion time is 15 µs for 12 MHz oscillator frequency.

After a conversion has been started by writing into the special function register DAPR, the analog voltage at the selected input channel is sampled for 5 machine cycles (5 µs at 12 MHz oscillator frequency), which will then be held at the sampled level for the rest of the conversion time.

The external analog source must be strong enough to source the current in order to load the sample & hold capacitance, being 25 pF, within those 5 machine cycles.

Figure 1. Block diagram of A/D converter

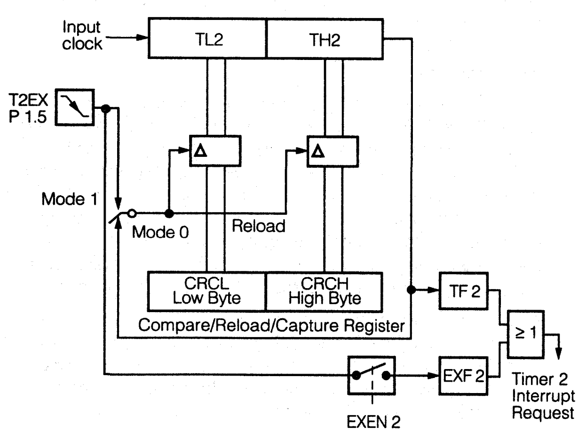


Conversion of the sampled analog voltage takes place between the 6th and 15th machine cycle after sampling has been completed. In the 15th machine cycle the converted result is moved to ADDAT.

Timer 2

The SAB 80515 has three 16-bit Timer/Counters: Timer 0, Timer 1 and Timer 2. These Timers can be configured to operate either as

Figure 2. Functional diagram of Timer 2 in reload mode



timers or event counters. Timer 2 is the time base of the programmable Timer/Counter Register Array (PTRA) unit. In addition to the operational modes "Timer" or "counter", Timer 2, being the time base for the PTRA unit, provides the features of:

—16-bit reload

—16-bit compare

—16-bit capture

The reload mode of Timer 2 is used in this application to generate software delays. For explanation of the other modes please refer to the users' manual.

Reload

The reload mode for Timer 2 is selected by bits T2R0 and T2R1 in special function register T2CON as illustrated in Table 1. In mode 0, when Timer 2 rolls over from all 1s to all 0s, it not only sets TF2 but also causes the Timer 2 registers to be loaded with the 16-bit value in the CRC (compare/reload/capture) register which is preset by software. The reload will happen in the same machine cycle in which TF2 is set, thus overwriting the count value 0000H.

Table 1. Timer 2 reload mode selection

T2RI	T2R0	Mode
0	X	Reload Disabled
1	0	Mode 0: Auto-Reload upon Timer 2 Overflow (TF2)
1	1	Mode 1: Reload upon Falling Edge at Pin T2EX/P1.5

PD2435

The PD2435 is a CMOS 4-character 5x7 dot matrix alphanumeric programmable display with ROM to decode 128 ASCII alphanumeric characters and enough RAM to store the display's complete four digit ASCII message with software programmable attributes. The CMOS IC incorporates special interface control circuitry to allow the user to control the module as a fully supported microprocessor peripheral.

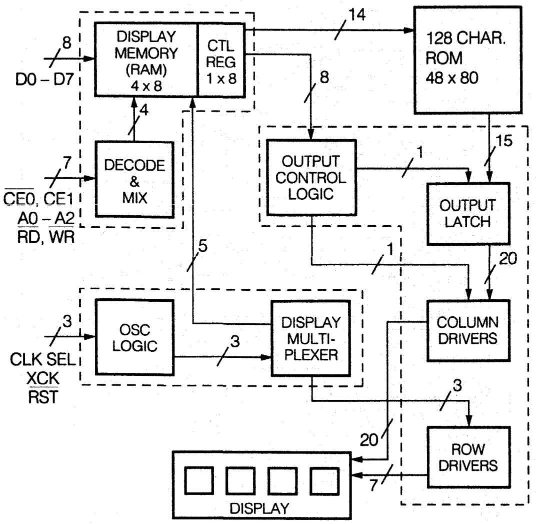
Microprocessor Interface

The interface to the microprocessor is through the address lines (A0-A2), the data bus (D0-D7), two chip select lines ($\overline{CE0}$, CE1), and ($\overline{RD}$) and ($\overline{WR}$) lines. The $\overline{CE0}$ should be held low and CE1 held high when executing a read or write to a specific PD243X device. The read and write lines are both active low. A valid write will enable the data as input lines.

Programming the PD2435

There are five registers within the PD2435. Four of the registers are used to hold the ASCII code of the four display characters. The fifth register is the Control Word, which is used to blink, blank, clear or dim the entire display to change the presentation (attributes) of individual characters.

Figure 3. PD2435 block diagram showing the major blocks and internal registers



Application

The speed regulated moving message display is an example where a digitized value of the controlling analog signal is used to compute a reload value for the Timer 2. The Timer 2 is operated in mode 0 where this reload value becomes a starting point for the Timer to count up. On overflow the Timer automatically takes the restart value for counting from reload register CRC. While the Timer is counting up, a new reload value is computed using the present A/D value.

Hardware

The circuit used in this application has the advantage of requiring a minimum of components. The single chip microcomputer SAB 80535 operates in conjunction with four alphanumeric programmable display chips PD 2435 to form a 16-digit long display.

The ASCII-coded data is transferred from the SAB 80535 to the display ICs via the data port P0 and using the control signal WR (P3.6) of the SAB 80535. The address pins from the ports P0 and P2 of the SAB 80535 are used to address the EPROM as well as the display chips in a memory-mapped I/O scheme. The display chips are addressed as memory locations with the following addresses.

Display Chip	Control Register Address	Digits Address
1	1000H	1004H-1007H
2	2000H	2004H-2007H
3	4000H	4004H-4007H
4	8000H	8004H-8007H

A push button is interfaced to port P3.2 of the SAB 80535 to provide an external interrupt to the microcontroller.

Firmware Description

Besides controlling speed of the moving message, there is a provision to interrupt the moving message and roll it backwards to the beginning of the message. The microcontroller reads the code and the message to display from an EPROM 2716A interfaced to the ports P0 and P2 of the SAB 80535. A virtual image of the message is created in the internal RAM of the SAB 80535. Four display chips PD2435 are interfaced to the SAB 80535 in a memory-mapped scheme and can be addressed as external memory to the SAB 80535. The virtual image of the message in internal RAM of the SAB 80535 is used to manipulate data to be displayed on the display chips. The internal RAM used for the display can be viewed as an area divided into two portions:

1. For active display
2. As a data buffer

The active display area is the replica of the data being displayed on the display chips. In this case the 16-digit display would need 16 RAM locations which correspond to 16 digits currently being displayed. The data buffer contains the rest of the message which is not being displayed. The message is shifted character by character in the RAM area. When the message on the display moves from right to left, the RAM buffer acts in "First In First Out" mode, and when the message on the display moves from left to right, the data to the display from the microcontroller RAM buffer is supplied in the "Last In First Out" scheme.

Between display of every character there is a software delay which depends upon the level of the analog signal supplied to the AN0 pin of the SAB 80535. The external interrupt 0 (at port P3.2) is used to interrupt the microcontroller to inform it that the message needs to be scrolled backwards. On getting this interrupt the software sets the flag bit 0 which remains set until the message is scrolled back to the beginning of the message.

List of Components

Name	Number
SAB 80535	1
271 6A	1
PD2435	4
12 MHz Crystal	1
74LS373	1
22 pF Capacitors	2
100 nF Capacitor	1
4.7 µf Capacitor	1
1 k Resistor	1
10 k Pot	1

Reference Material for ICs

1. SAB 80515/80535 User's Manual.
2. PD2435 Data-Sheet or Optoelectronic Data Book (1990).

Figure 4. Interface circuit

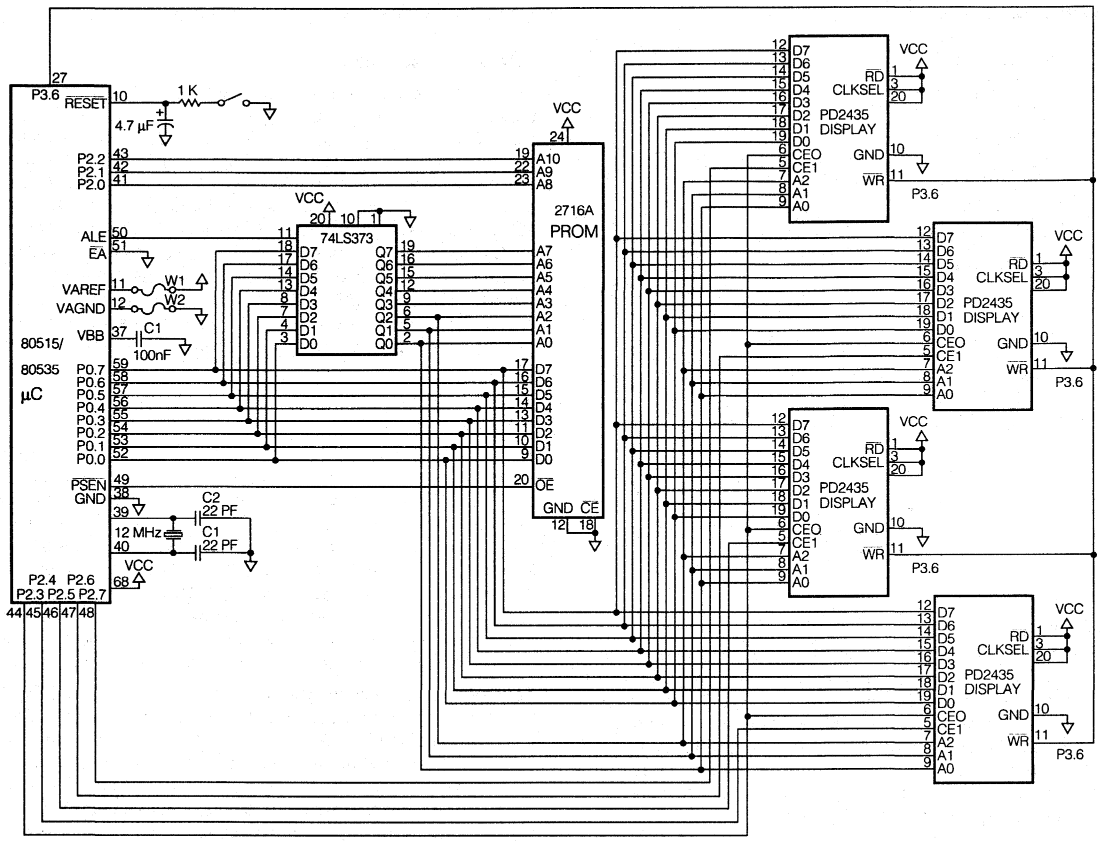
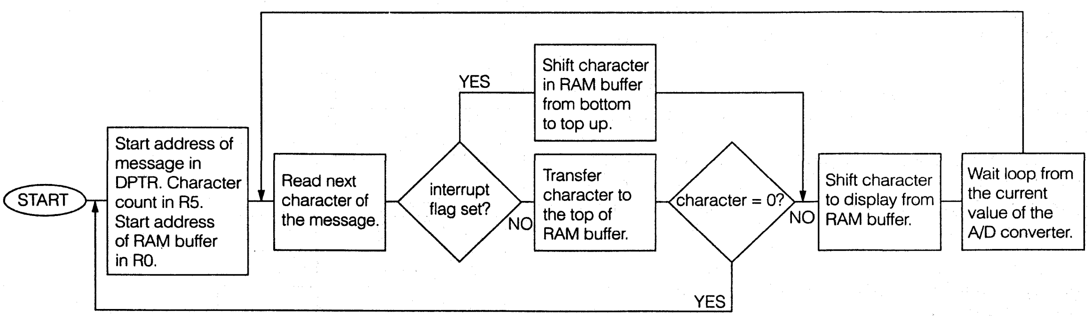


Figure 5. Program flow chart



Program listing

UDISP 'PD 2435 Display PROGRAM'

```
                   $TITLE ('PD 2435 DISPLAY PROGRAM')
                   $MOD515
                   $NOSYMBOLS
....               CSEG
                   $DEBUG
0000                                ORG     00H
0000 02000C                         LJMP    BEGIN            ;Jump on reset
                                    ;
                                    ;  ____________________________________________________________
                                    ;  This is the interrupt subroutine for INTO. This is used to set a flag
                                    ;  which then indicates that the message needs to be rolled back.
                                    ;  ____________________________________________________________
                                    ;
0003                                ORG     03H
0003 C0E0                           PUSH    ACC
0005 D2D5                           SETB    F0               ;Set flag for external interrupt
0007 D0E0                           POP     ACC
0009 C289                           CLR     IE0
000B 32                             RETI
                                    ;  ____________________________________________________________
                                    ;  MAIN PROGRAM
                                    ;  ____________________________________________________________
                                    ;
000C D282          BEGIN:           SETB    P3.2             ;Set bit for INT0
000E 758110                         MOV     SP,#10H
0011 75D800                         MOV     ADCON, #00H      ;Select analog channel 0
0014 C2D5          OPTS:            CLR     F0               ;Clear flag 0
0016 7800                           MOV     R3,#00H          ;Character pointer in the message
0018 79FF                           MOV     R1,#0FFH         ;R1 used as a flag
001A 90F000                         MOV     DPTR,#0F000H     ;Control register of all displays
001D 7403                           MOV     A,#03H           ;Control word for display
001F F0                             MOVX    @DPTR,A
0020 9000C2                         MOV     DPTR,#(TEXT-1)   ;Beginning of the text
0023 7820                           MOV     R0,#20H          ;Internal RAM location
0025 7D65                           MOV     R5,#101          ;A count for 101 characters
0027 7420                           MOV     A,#20H           ;ASCII for space
0029 F6            BLANK:           MOV     @R0,A            ;Fill all locations with blank
002A 08                             INC     R0
002B DDFC                           DJNZ    R5, BLANK
002D 12006C        SHIF:            CALL    NEXTC            ;Read the next character
0030 20D501                         JB      F0,TEMP          ;Check if the interrupt was raised
0033 0B                             INC     R3               ;If no interrupt
0034 7D65          TEMP:            MOV     R5,#101          ;Character count in message
0036 7820                           MOV     R0,#20H          ;RAM location 20H
0038 20D506                         JB      F0,REV0
003B C6            SHFT:            XCH     A,@R0            ;If no interrupt
003C 08                             INC     R0               ;Add the character
003D DDFC                           DJNZ    R5,SHFT          ;To the top of the RAM buffer
003F 0158                           AJMP    CONT0
0041 7421          REV0:            MOV     A,#21H           ;If there is no interrupt
0043 2B                             ADD     A,R3             ;Offset for the RAM buffer
```

```
0044 F8                      MOV    R0,A            ;Pointer in the RAM buffer
0045 7600                    MOV    @R0,#00H        ;Displayed so far
0047 7820                    MOV    R0,#20H         ;Beginning of the RAM buffer
0049 E6                      MOV    A,@R0           ;Read the character
004A C0E0                    PUSH   ACC             ;Save it
004C 08          AGAIN:      INC    R0              ;Next location in RAM buffer
004D E6                      MOV    A,@R0           ;Read the next character
004E 18                      DEC    R0              ;Back to first character
004F F6                      MOV    @R0,A           ;Replace with second character
0050 08                      INC    R0              ;Process repeats
0051 DDF9                    DJNZ   R5,AGAIN        ;Moving character backwards
0053 08                      INC    R0
0054 7600                    MOV    @R0,#00H        ;End of character buffer
0056 D0E0                    POP    ACC             ;Restore character
0058 7820        CONT0:      MOV    R0,#20H         ;Beginning of character buffer
005A E9                      MOV    A,R1            ;Check if end of character buffer
005B 6087                    JZ     OPTS
005D 120071                  CALL   OUTC
0060 C2AF                    CLR    IEN0.7          ;Disable interrupt
0062 1200A4                  CALL   WAITA           ;Before delay
0065 75A881                  MOV    IEN0,#81H       ;Enable interrupt
0068 D288                    SETB   IT0             ;INT0 control bit
006A 012D                    AJMP   SHIF

                             ;
                             ;  The routine moves a character of the message to ACC.
                             ;

006C A3          NEXTC:      INC    DPTR
006D 7400                    MOV    A,#0
006F 93                      MOVC   A,@A+DPTR       ;Move the character to Acc.
0070 22                      RET

                             ;
                             ;
                             ;  This routine displays and moves a character over the four digits of
                             ;  the PD2435 and then repeats for the next display chip and so on.
                             ;
                             ;

0071 C0E0        OUTC:       PUSH   ACC
0073 C082                    PUSH   DPL
0075 C083                    PUSH   DPH
0077 7A04                    MOV    R2,#4           ;For four digits (0 to 3) in a chip
0079 901004                  MOV    DPTR,#1004H     ;Digit 0 in first display chip
007C 120098                  CALL   OUTC0
007F 902004                  MOV    DPTR,#2004H     ;Digit 0 in second display chip
0082 120098                  CALL   OUTC0
0085 904004                  MOV    DPTR,#4004H     ;Digit 0 in third display chip
0088 120098                  CALL   OUTC0
008B 908004                  MOV    DPTR,#8004H     ;Digit 0 in fourth display chip
008E 120098                  CALL   OUTCO
0091 D083                    POP    DPH
0093 0082                    POP    DPL
0095 D0E0                    POP    ACC
0097 22                      RET

                             ;
                             ;
                             ;  This is a nested subroutine. It moves a nonzero hex value (ASCII)
                             ;  from left to right of the four digit display.
                             ;
                             ;

0098 E6          OUTC0:      MOV    A,@R0
```

```
0099 6007                   JZ      FIN
0098 F0                     MOVX    @DPTR,A
009C 08                     INC     R0
009D A3                     INC     DPTR
009E DAF8                   DJNZ    R2,OUTC0
00A0 7A04                   MOV     R2,#4
00A2 F9          FIN:       MOV     R1,A
00A3 22                     RET

                            ;
                            ;   ____________________________________________________
                            ;   This subroutine generates the software delay. The delay is
                            ;   generated by the timer 2. The start count of the timer 2 is
                            ;   computed from the present value of the A/D converter.
                            ;   ____________________________________________________
                            ;

00A4 7E03        WAITA:     MOV     R6,#03H
00A6 7D10        WAITB:     MOV     R5,#10H
00A8 75DA00      WAITC:     MOV     DAPR,#00H
00AB E5D9                   MOV     A,ADDAT
00AD 75F0FF                 MOV     B,#255          ;For computing reload value
00B0 A4                     MUL     AB              ;Reload value is computed
00B1 F5CA                   MOV     CRCL,A          ;Load the reload value low
00B3 85F0C8                 MOV     CRCH,B          ;Load the reload value high
00B6 75C811                 MOV     T2CON,#11H
00B9 10C602      WAITD:     JBC     TF2,WAITE
00BC 01B9                   AJMP    WAITD
00BE DDE8        WAITE:     DJNZ    R5,WAITC
00C0 DEE4                   DJNZ    R6,WAITB
00C2 22                     RET

                            ;   ____________________________________________________
                            ;   MESSAGE
                            ;   ____________________________________________________

00C3 20202020    TEXT:      DB      '                '
00C7 20202020
00CB 20202020
00CF 20202020
00D3 5349454D               DB      'SIEMENS MICROCONTROLLER SAB 80515/535'
00D7 454E5320
00D8 4D494352
00DF 4F434F4E
00E3 54524F4C
00E7 4C455220
00EB 53414220
00EF 38303531
00F3 352F3533
00F7 35
00F8 20202020               DB      '      SAB 80515/535          ',0
00FC 20202020
0100 20202020
0104 53414220
0108 38303531
010C 352F3533
0110 35202020
0114 20202020
0118 20202020
011C 20202020
0120 00
                            END

ASSEMBLY COMPLETE, 0 ERRORS FOUND
```

SIEMENS

Designing Linear Amplifiers Using the IL300 Optocoupler Appnote 50

by Bob Krause

Introduction

This application note presents isolation amplifier circuit designs useful in industrial, instrumentation, medical, and communication systems. It covers the IL300's coupling specifications, and circuit topologies for photovoltaic and photoconductive amplifier design. Specific designs include unipolar and bipolar responding amplifiers. Both single ended and differential amplifier configurations are discussed. Also included is a brief tutorial on the operation of photodetectors and their characteristics.

Galvanic isolation is desirable and often essential in many measurement systems. Applications requiring galvanic isolation include: industrial sensors, medical transducers, and mains powered switch mode power supplies. Operator safety and signal quality are insured with isolated interconnections. These isolated interconnections commonly use isolation amplifiers.

Industrial sensors include thermocouples, strain gauges, and pressure transducers. They provide monitoring signals to a process control system. Their low level DC and AC signal must be accurately measured in the presence of high common mode noise. The IL300's 130 dB common mode rejection (CMR), ±50 ppm/°C stability and ±0.01% linearity provide a quality link from the sensor to the controller input.

Safety is an important factor in instrumentation for medical patient monitoring. EEG, ECG, and similar systems demand high insulation safety for the patient under evaluation. The IL300's 7500 V Withstand Test Voltage (WTV) insulation, DC response, and high CMR are features which assure safety for the patient and accuracy of the transducer signals.

The aforementioned applications require isolated signal processing. Current designs rely on A to D or V to F converters to provide input/output insulation and noise isolation. Such designs use transformers or high speed optocouplers which often result in complicated and costly solutions. The IL300 eliminates the complexity of these isolated amplifier designs without sacrificing accuracy or stability.

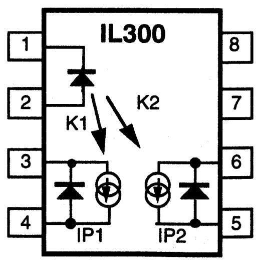
The IL300's 200 KHz bandwidth and gain stability make it an excellent candidate for subscriber and data phone interfaces. Present OEM switch mode power supplies are approaching 1 MHz switching frequencies. Such supplies need output monitoring feedback networks with wide bandwidth and flat phase response. The IL300 satisfies these needs with simple support circuits.

Operation of the IL300

The IL300 consists of a high efficiency AlGaAs LED emitter coupled to two independent PIN photodiodes. The servo (pins 3, 4) photodiode provides a feedback signal which controls the current to the LED emitter (pins 1, 2). This photodiode provides a photocurrent, I_P1, that is directly proportional to the LED's incident flux. This servo operation linearizes the LED's output flux and eliminates the LED's time and temperature. The galvanic isolation between the input and the output is provided by a second PIN photodiode (pins 5, 6) located on the output side of the coupler. The output current, I_P2, from this photodiode accurately tracks the photocurrent generated by the servo photodiode.

Figure 1 shows the package footprint and electrical schematic of the IL300. The following sections discuss the key operating characteristics of the IL300. The IL300 performance characteristics are specified with the photodiodes operating in the photoconductive mode.

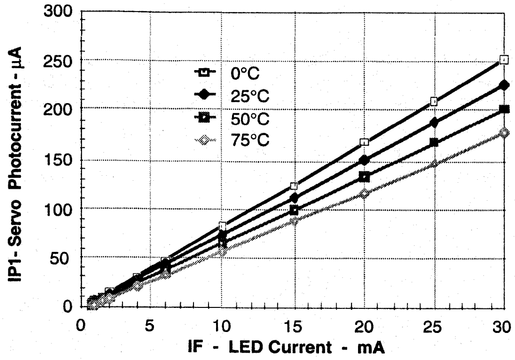
Figure 1. IL300 schematic



Servo Gain—K1

The typical servo photocurrent, I_P1, as a function of LED current, is shown in Figure 2. This graph shows the typical non-servo LED-photodiode linearity is ±1% over an LED drive current range of 1 to 30 mA. This curve also shows that the non-servo photocurrent is affected by ambient temperature. The photocurrent typically decreases by −0.5% per °C. The LED's nonlinearity and temperature characteristics are minimized when the IL300 is used as a servo linear amplifier.

Figure 2. Servo photocurrent vs. LED current

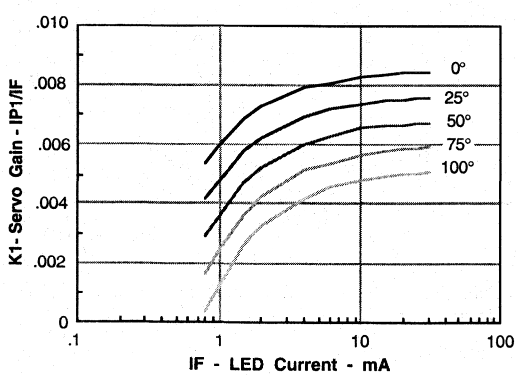


The servo gain is defined as the ratio of the servo photocurrent, I_P1, to the LED drive current, I_F. It is called K1, and is described in Equation 1.

$$K1 = I_P1 / I_F \quad (1)$$

The IL300 is specified with an I_F=10 mA, T_A=25°C, and Vd=−15 V. This condition generates a typical servo photocurrent of I_P1=70 µA. This results in a typical K1=0.007. The relationship of K1 and LED drive current is shown in Figure 3.

Figure 3. Servo gain vs. LED current



The servo gain, K1, is guaranteed to be between 0.005 minimum to 0.011 maximum of an I_F=10 mA, T_A=25°C, and VD=−15 V.

Figure 4. Normalized servo gain vs. LED current

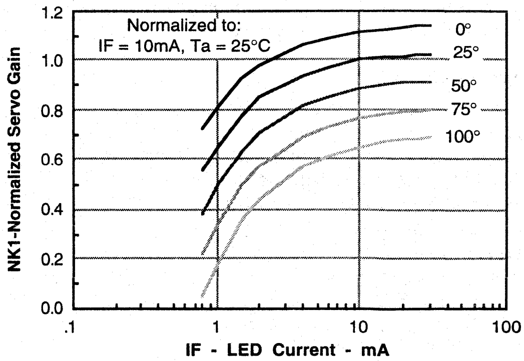


Figure 4 presents the Normalized servo gain, NK1(I_F, T_A), as a function of LED current and temperature. It can be used to determine the minimum or maximum servo photocurrent, I_P1, given LED current and ambient temperature. The actual servo gain can be determined from Equation 2.

$$K1(I_F, T_A) = K1(data\ sheet\ limit) \cdot NK1(I_F, T_A) \quad (2)$$

The minimum servo photocurrent under specific use conditions can be determined by using the minimum value for K1 (0.005) and the normalization factor from Figure 4. The example is to determine I_P1 (min) for the condition of K1 at T_A=75°C, and I_F=6 mA.

$$NK1(I_F = 6\,mA, T_A = 75°C) = 0.72 \cdot NK1(I_F, T_A) \quad (3)$$

$$K1\,MIN(I_F, T_A) = K1\,MIN(0.005) \cdot NK1(0.72) \quad (4)$$

$$K1\,MIN(I_F, T_A) = 0.0036 \quad (5)$$

Using K1(I_F, T_A)=0.0036 in Equation 1 the minimum I_P1 can be determined.

$$I_P1\,MIN = K1\,MIN(I_F, T_A) \cdot I_F \quad (6)$$

$$I_P1\,MIN = 0.0036 \cdot 6\,mA \quad (7)$$

$$I_P1\,MIN(I_F = 6mA, T_A = 75°C) = 21.6\,\mu A \quad (8)$$

The minimum value I_P1 is useful for determining the maximum required LED current needed to servo the input stage of the isolation amplifier.

Output Forward Gain—K2

Figure 1 shows that the LED's optical flux is also received by a PIN photodiode located on the output side (pins 5, 6) of the coupler package. This detector is surrounded by an optically transparent high voltage insulation material. The coupler construction spaces the LED 0.4 mm from the output PIN photodiode. The package construction and the insulation material guarantee the coupler to have a Withstand Test Voltage of 7500 V peak.

K2, the output (forward) gain is defined as the ratio of the output photodiode current, I_P2, to the LED current, I_F. K2 is shown in Equation 9.

$$K2 = I_P2 / I_F \quad (9)$$

The forward gain, K2, has the same characteristics of the servo gain, K1. The normalized current and temperature performance of each detector is identical. This results from using matched PIN photodiodes in the IL300's construction.

Transfer Gain—K3

The current gain, or CTR, of the standard phototransistor optocoupler is set by the LED efficiency, transistor gain, and optical coupling. Variation in ambient temperature alters the LED efficiency and phototransistor gain and result in CTR drift. Isolation amplifiers constructed with standard phototransistor optocouplers suffer from gain drift due to changing CTR.

Isolation amplifiers using the IL300 are not plagued with the drift problems associated with standard phototransistors. The following analysis will show how the servo operation of the IL300 eliminates the influence of LED efficiency on the amplifier gain.

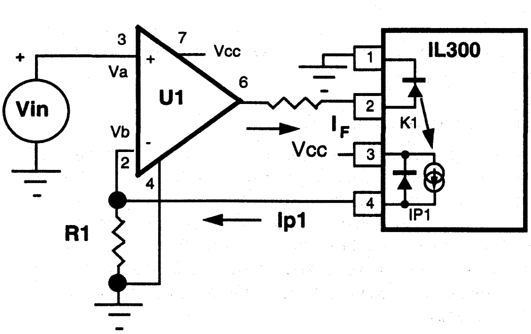
The input-output gain of the IL300 is termed transfer gain, K3. Transfer gain is defined as the output (forward) gain, K2, divided by servo gain, K1, as shown in Equation 10.

$$K3 = K2/K1 \tag{10}$$

The first step in the analysis is to review the simple optical servo feedback amplifier shown in Figure 5.

The circuit consists of an operational amplifier, U1, a feedback resistor R1, and the input section of the IL300. The servo photodiode is operating in the photoconductive mode. The initial conditions are: $Va = Vb = 0$. Initially, a positive voltage is applied to the noninverting input (Va) of the opamp. At that time the output of the opamp will swing toward the positive Vcc rail, and forward bias the LED. As the LED current, I_F, starts to flow, an optical flux will be generated. The optical flux will irradiate the servo photodiode causing it to generate a photocurrent, I_P1. This photocurrent will flow through R1 and develop a positive voltage at the inverting input (Vb) of the operational amplifier. The amplifier output will start to swing toward the negative supply rail, –Vcc. When the magnitude of the Vb is equal to that of Va, the LED drive current will cease to increase. This condition forces the circuit into a stable closed loop condition.

Figure 5. Optical servo amplifier



When Vin is modulated, Vb will track Vin. For this to happen the photocurrent through R1 must also track the change in Va. Recall that the photocurrent results from the change in LED current times the servo gain, K1. The following equations can be written to describe this activity.

$$Va = Vb = Vin = 0 \tag{11}$$

$$I_P1 = I_F \cdot K1 \qquad (12)$$

$$Vb = I_P1 \cdot R1 \qquad (12)$$

The relationship of LED drive to input voltage is shown by combining Equations 11, 12, and 13.

$$Va = I_P1 \cdot R1 \tag{14}$$

$$Vin = I_F \cdot K1 \cdot R1 \tag{15}$$

$$I_F = Vin/(K1 \cdot R1) \tag{16}$$

Equation 16 shows that the LED current is related to the input voltage Vin. A changing Va causes a modulation in the LED flux. The LED flux will change to a level that generates the necessary servo photocurrent to stabilize the optical feedback loop. The LED flux will be a linear representation of the input voltage, Va. The servo photodiode's linearity controls the linearity of the isolation amplifier.

The next step in the analysis is to evaluate the output transresistance amplifier. The common inverting transresistance amplifier is shown in Figure 6. The output photodiode is operated in the photoconductive mode. The photocurrent, I_P2, is derived from the same LED that irradiates the servo photodetector. The output signal, Vout, is proportional to the output photocurrent, I_P2, times the transresistance, R2.

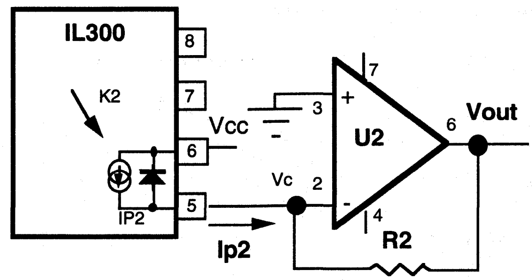
$$Vout = -I_P1 \cdot R2 \tag{17}$$

$$I_P2 = K2 \cdot I_F \tag{18}$$

Combining Equations 17 and 18 and solving for I_F is shown in Equation 19.

$$I_F = -Vout/(K2 \cdot R2) \tag{19}$$

Figure 6. Output transresistance amplifier



The input-output gain of the isolation amplifier is determined by combining Equations 16 and 19.

$$I_F = Vin/(K1 \cdot R1) \qquad (16)$$

$$I_F = -Vout/(K2 \cdot R2) \qquad (19)$$

$$Vin/(K1 \cdot R1) = -Vout/(K2 \cdot R2) \tag{20}$$

Equation 21 gives the solution for the input-output gain.

$$Vout/Vin = -(K2 \cdot R2)/(K1 \cdot R1) \quad (21)$$

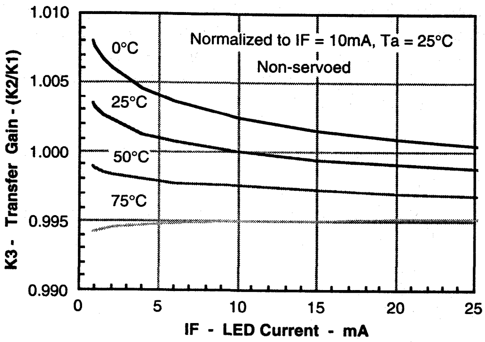
Note that the LED current, I_F, is factored out of Equation 21. This is possible because the servo and output photodiode currents are generated by the same LED source. This equation can be simplified further by replacing the K2/K1 ratio with IL300's transfer gain, K3.

$$Vout/Vin = -K3 \cdot (R2/R1) \quad (22)$$

The IL300 isolation amplifier gain stability and offset drift depends on the transfer gain characteristics. Figure 7 shows the consistency of the normalized K3 as a function of LED current and ambient temperature. The transfer gain drift as a function of temperature is ±0.005%/°C over a 0°C to 75°C range.

Figure 8 shows the composite isolation amplifier including the input servo amplifier and the output transresistance amplifier. This circuit offers the insulation of an optocoupler and the gain stability of a feedback amplifier.

Figure 7. Normalized servo transfer gain



An instrumentation engineer often seeks to design an isolation amplifier with unity gain: *Vout / Vin=1.0*. The IL300's transfer gain is targeted for unity gain: K3=1.0. Package assembly variations result in a range of K3. Because of the importance of K3, Siemens offers the transfer gain sorted into ±5% bins. The bin designator is listed on the IL300 package. The K3 bin limits are shown in Table 1.

This table is useful when selecting the specific resistor values needed to set the isolation amplifier transfer gain.

Table 1. K3 transfer gain bins

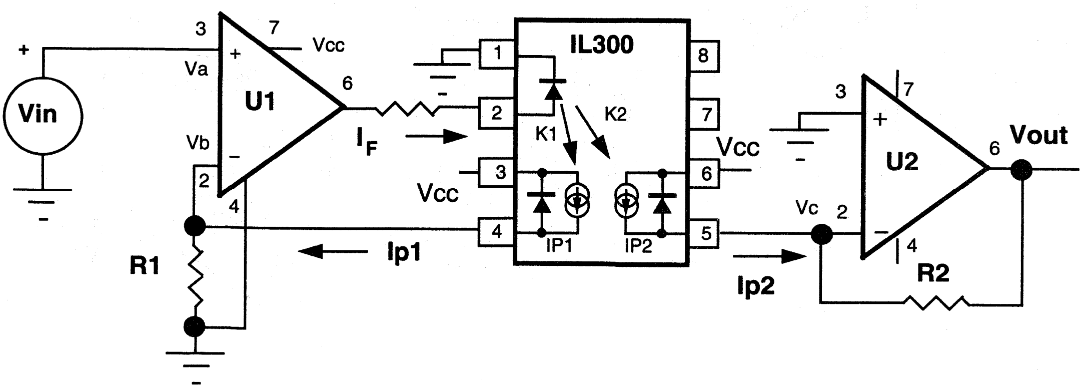
BIN	Typ.	Min.	Max.
A	0.59	0.56	0.623
B	0.66	0.623	0.693
C	0.73	0.693	0.769
D	0.81	0.769	0.855
E	0.93	0.855	0.95
F	1.0	0.95	1.056
G	1.11	1.056	1.175
H	1.24	1.175	1.304
I	1.37	1.304	1.449
J	1.53	1.449	1/61

Isolation Amplifier Design Techniques

The previous section discussed the operation of an isolation amplifier using the optical servo technique. The following section will describe the design philosophy used in developing isolation amplifiers optimized for input voltage range, linearity, and noise rejection.

The IL300 can be configured as either a photovoltaic or photoconductive isolation amplifier. The photovoltaic topology offers the best linearity, lowest noise, and drift performance. Isolation amplifiers using these circuit configurations meet or exceed 12 bit AD performance. Photoconductive photodiode operation provides the largest coupled frequency bandwidth. The photoconductive configuration has linearity and drift characteristics comparable to a 8-9 bit AD converter.

Figure 8. Composite amplifier



Photovoltaic Isolation Amplifier

The transfer characteristics of this amplifier are shown in Figure 9.

When low offset drift and greater than 12 bit linearity is desired, photovoltaic amplifier designs should be considered. The schematic of a typical positive unipolar photovoltaic isolation amplifier is shown in Figure 10.

The input stage consists of a servo amplifier, U1, which controls the LED drive current. The servo photodiode is operated with zero voltage bias. This is accomplished by connecting the photodiodes anode and cathode directly to U1's inverting and non-inverting inputs. The characteristics of the servo amplifier operation are presented in Figure 9a and Figure 9b. The servo photocurrent is linearly proportional to the input voltage, $I_P1 = Vin/R1$. Figure 9b shows the LED current is inversely proportional to the servo transfer gain, $I_F = I_P1/K1$. The servo photocurrent, resulting from the LED emission, keeps the voltage at the inverting input of U1 equal to zero. The output photocurrent, I_P2, results from the incident flux supplied by the LED. Figure 9c shows that the magnitude of the output current is determined by the output transfer gain, K2. The output voltage, as shown in Figure 9d, is proportional to the output photocurrent I_P2. The output voltage equals the product of the output photocurrent times the output amplifier's transresistance, R2.

The composite amplifier transfer gain (Vo/Vin) is the ratio of two products. The first is the output transfer gain, K2 · R2.

The second is the servo transfer gain, K1 · R1. The amplifier gain is the first divided by the second. See Equation 23.

Figure 9. Positive unipolar photovoltaic isolation amplifier transfer characteristics

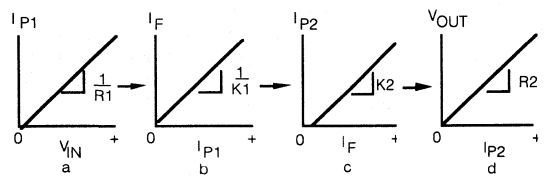
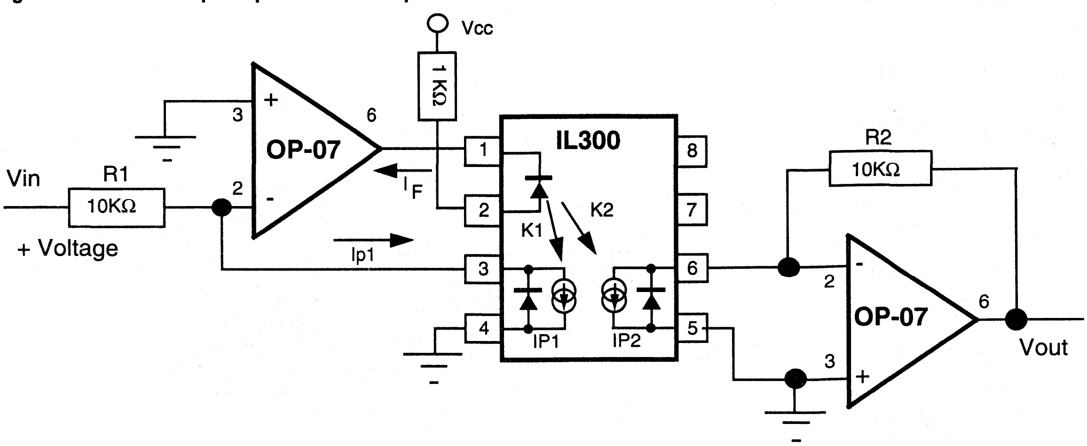


Figure 10. Positive unipolar photovoltaic amplifier



$$\frac{Vo}{Vin} = \frac{K2 \cdot R1}{K1 \cdot R1} \qquad (23)$$

Equation 23 shows that the composite amplifier transfer gain is independent of the LED forward current. The K2/K1 ratio reduces to IL300 transfer gain, K3. This relationship is included in Equation 24. This equation shows that the composite amplifier gain is equal to the product of the IL300 gain, K3, times the ratio of the output to input resistors.

$$\frac{Vo}{Vin} = \frac{K3 \cdot R2}{R1} \qquad (24)$$

Designing this amplifier is a three step process. First, given the input signal span and U1's output current handling capability, the input resistor R1 can be determined by using the circuit found in Figure 9 and the following typical characteristics:

OP-07	Iout = ±15 mA
IL300	K1 = 0.007
	K2 = 0.007
	K3 = 1.0
Vin	0 ≥ +1.0 V

The second step is to determine servo photocurrent, I_P1, resulting from the peak input signal swing. This current is the product of the LED drive current, I_F, times the servo transfer gain, K1. For this example the I_{outmax} is equal to the largest LED current signal swing, i.e., $I_F = I_{outmax}$.

$I_P1 = K1 \cdot I_{outmax}$
$I_P1 = 0.007 \cdot 15\ mA$
$I_P1 = 105\ \mu A$

The input resistor, R1, is set by the input voltage range and the peak servo photocurrent, I_P1. Thus R1 is equal to:

$R1 = Vin / I_P1$
$R1 = 1.0 / 105\ \mu A$
$R1 = 9.524\ K\Omega$

R1 is rounded to 10 KΩ.

Figure 11. Photovoltaic amplifier transfer gain

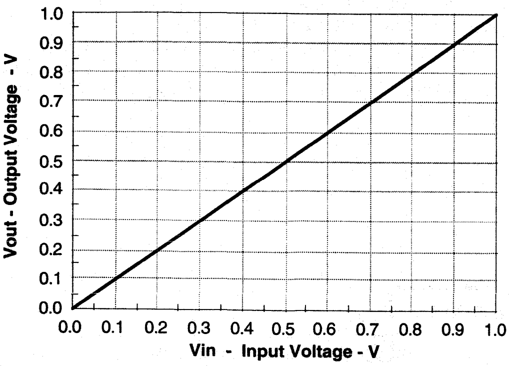
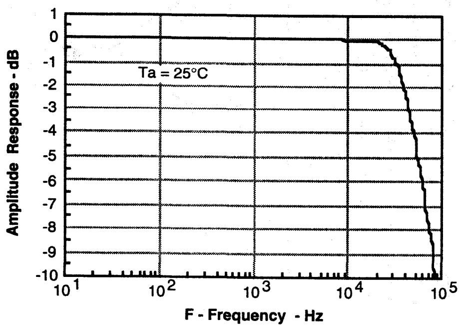


Figure 12. Photovoltaic amplifier frequency response



The third step in this design is determining the value of the trans resistance, R2, of the output amplifier. R2 is set by the composite voltage gain desired, and the IL300's transfer gain, K3. Given K3 = 1.0 and a required *Vout/Vin = G = 1.0*, the value of R2 can be determined.

$$R2 = (R1 \cdot G)/K3$$
$$R2 = (10\ K\Omega \cdot 1.0)/1.0$$
$$R2 = 10\ K\Omega$$

When the amplifier in Figure 9 is constructed with OP-07 operational amplifiers it will have the characteristics shown in Figure 11 and Figure 12.

The frequency response is shown in Figure 12. This amplifier has a small signal bandwidth of 45 KHz.

The amplifier in Figure 9 responds to positive polarity input signals. This circuit can be modified to respond to negative polarity signals. The modifications of the input amplifier include reversing the polarity of the servo photodiode at U1's input and connecting the LED so that it sinks current from U1's output. The noninverting isolation amplifier response is maintained by reversing the IL300's output photodiodes connection to the input of the transresistance amplifier. The modified circuit is shown in Figure 13.

The negative unipolar photovoltaic isolation amplifier transfer characteristics are shown in Figure 14. This amplifier, as shown in Figure 13, responds to signals in only one quadrant. If a positive signal is applied to the input of this amplifier, it will forward bias the photodiode, causing U1 to reverse bias the LED. No damage will occur, and the amplifier will be cut off under this condition. This operation is verified by the transfer characteristics shown in Figure 14.

Figure 13. Negative unipolar photovoltaic isolation amplifier

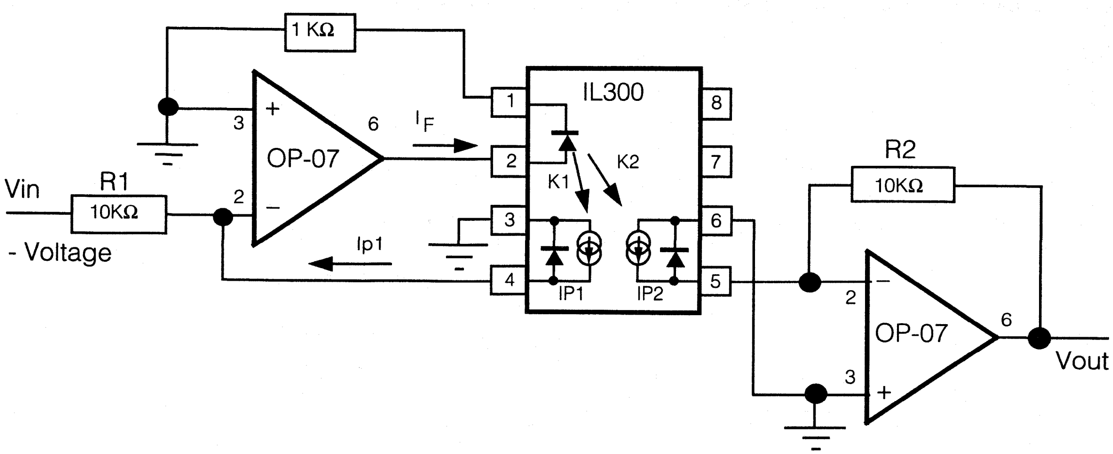
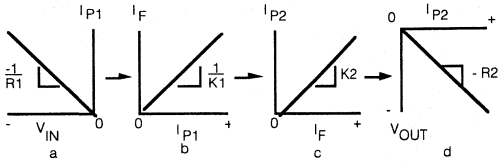


Figure 14. Negative unipolar photovoltaic isolation amplifier transfer characteristics



A bipolar responding photovoltaic amplifier can be constructed by combining a positive and negative unipolar amplifier into one circuit. This is shown in Figure 15. This amplifier uses two IL300s with each detector and LED connected in antiparallel. The IL300a responds to positive signals while the IL300b is active for the negative signals. The operation of the IL300s and the U1 and U2 is shown in the transfer characteristics given in Figure 16.

Figure 15. Bipolar input photovoltaic isolation amplifier

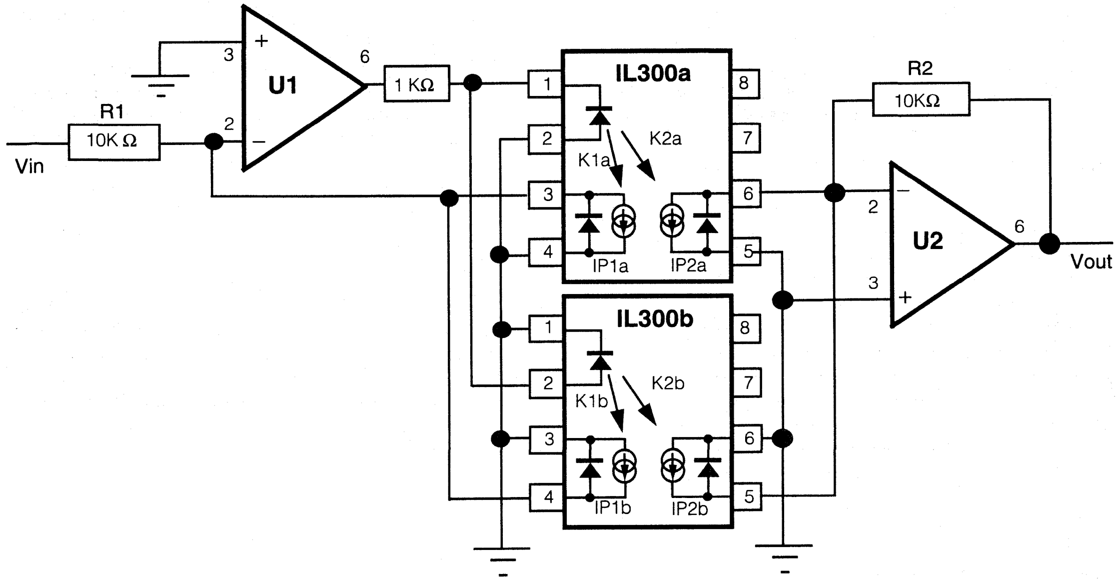
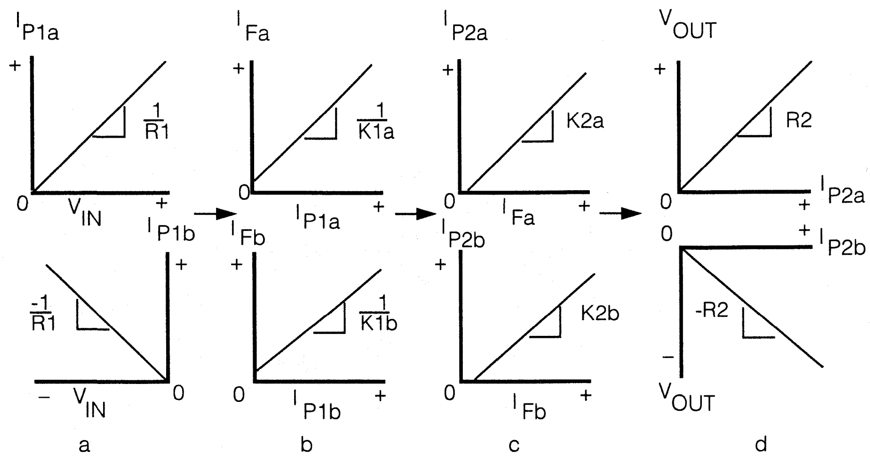


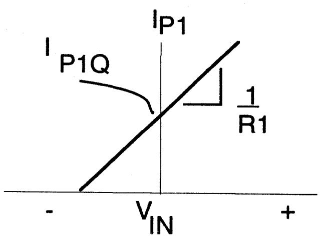
Figure 16. Bipolar input photovoltaic isolation amplifier transfer characteristics



The operational analysis of this amplifier is similar to the positive and negative unipolar isolation amplifier. This simple circuit provides a very low offset drift and exceedingly good linearity. The circuit's useful bandwidth is limited by crossover distortion resulting from the photodiode stored charge. With a bipolar signal referenced to ground and using a 5% distortion limit, the typical bandwidth is under 1 KHz. Using matched K3s, the composite amplifier gain for positive and negative voltage will be equal.

Whenever the need to couple bipolar signals arises a prebiased photovoltaic isolation amplifier is a good solution. By prebiasing the input amplifier the LED and photodetector will operate from a selected quiescent operating point. The relationship between the servo photocurrent and the input voltage is shown in Figure 17.

Figure 17. Transfer characteristic prebiased photovoltaic bipolar amplifier



The quiescent operation point, I_P1Q, is determined by the dynamic range of the input signal. This establishes maximum LED current requirements. The output current capability of the OP-07 is extended by including a buffer transistor between the output of U1 and the LED. The buffer transistor minimizes thermal drift by reducing the OP-07 internal power dissipation if it were to drive the LED directly. This is shown in Figure 18.

The bias is introduced into the inverting input of the servoamplifier, U1. The bias forces the LED to provide photocurrent, I_P1, to servo the input back to a zero volt equilibrium. The bias source can be as simple as a series resistor connected to Vcc. Best stability and minimum offset drift is achieved when a good quality current source is used. Figure 20 shows the amplifier found in Figure 18 including two modified Howland current sources. The first source prebiases the servo amplifier, and the second source is connected to U2's inverting input which matches the input prebias.

Figure 19. Prebiased photovoltaic isolation amplifier transfer characteristics

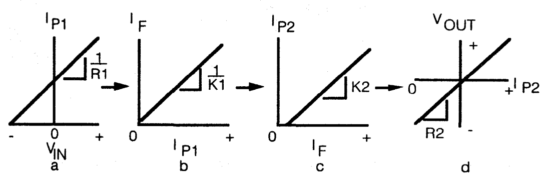


Figure 18. Prebiased photovoltaic isolation amplifier

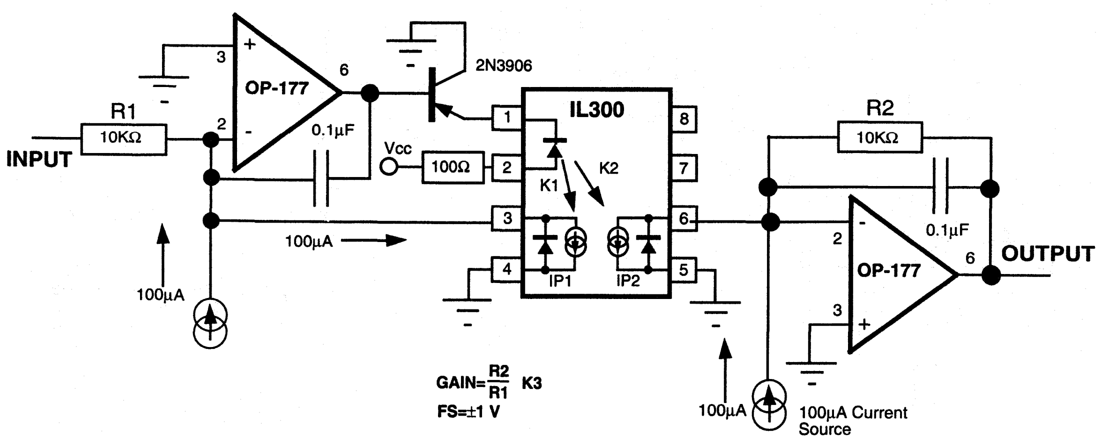


Figure 20. Prebiased photovoltaic isolation amplifier

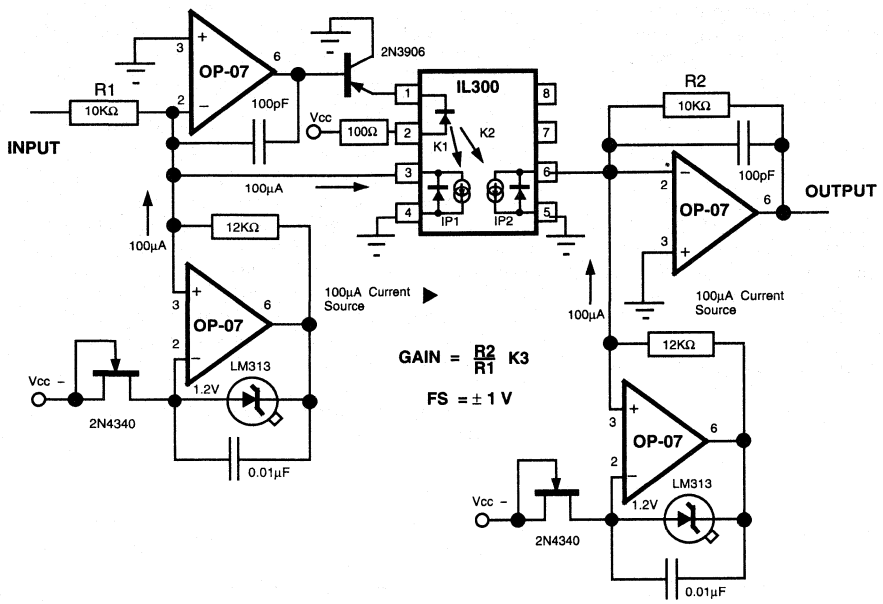
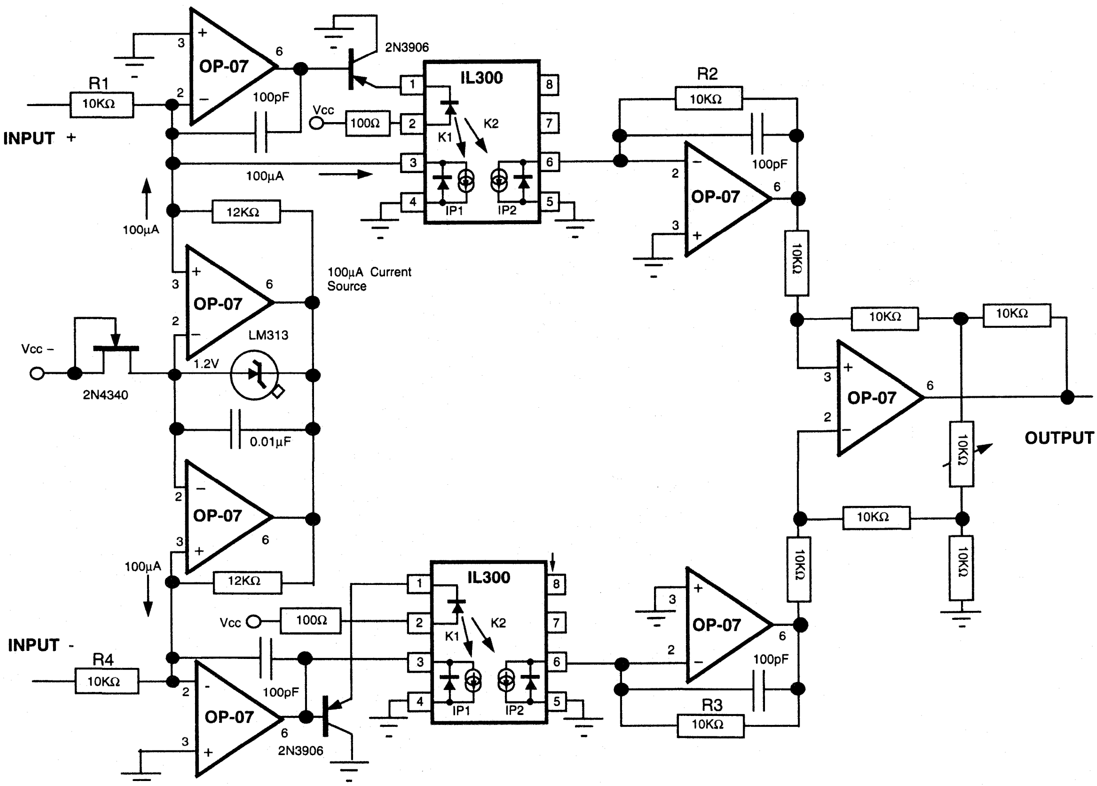


Figure 21. Differential prebiased photovoltaic isolation amplifier



The previous circuit offers a DC/AC coupled bipolar isolation amplifier. The output will be zero volts for an input of zero volts. This circuit exhibits exceptional stability and linearity. This circuit has demonstrated compatibility with12 bit A/D converter systems. The circuit's common mode rejection is determined by CMR of the IL300. When higher common mode rejection is desired one can consider the differential amplifier shown in Figure 21.

This amplifier is more complex than the circuit shown in Figure 20. The complexity adds a number of advantages. First the CMR of this isolation amplifier is the product of the IL300 and that of the summing differential amplifier found in the output section. Note also that the need for an offsetting bias source at the output is no longer needed. This is due to differential configuration of the two IL300 couplers. This amplifier is also compatible with instrumentation amplifier designs. It offers a bandwidth of 50KHz, and an extremely good CMR of 140 dB at 10 KHz.

Photoconductive Isolation Amplifier

The photoconductive isolation amplifier operates the photodiodes with a reverse bias. The operation of the input network is covered in the discussion of K3 and as such will not be repeated here. The photoconductive isolation amplifier is recommended when maximum signal bandwidth is desired.

Unipolar Isolation Amplifier

The circuit shown in Figure 22 is a unipolar photoconductive amplifier and responds to positive input signals. The gain of this amplifier follows the familiar form of $Vo/Vin = G = K3 \cdot (R2/R1)$. R1 sets the input signal range in conjunction with the servo gain and the maximum output current, Io, which U1 can source. Given this, $Io_{max} = I_{Fmax}$. R1 can be determined from Equation 28.

$$R1 = Vin_{max}/(K1 \cdot Io_{max}) \quad (28)$$

The output section of the amplifier is a voltage follower. The output voltage is equal to the voltage created by the output photocurrent times the photodiode load resistor, R2. This resistor is used to set the composite gain of the amplifier as shown in Equation 29.

$$R2 = (R1 \cdot G)/K3 \quad (29)$$

This amplifier is conditionally stable for given values of R1. As R1 is increased beyond 10 KΩ, it may become necessary to frequency compensate U1. This is done by placing a small capacitor from U1's output to its inverting input. This circuit uses 741 op-amps and will easily provide 100 KHz or greater bandwidth.

Figure 22. Unipolar photoconductive isolation amplifier

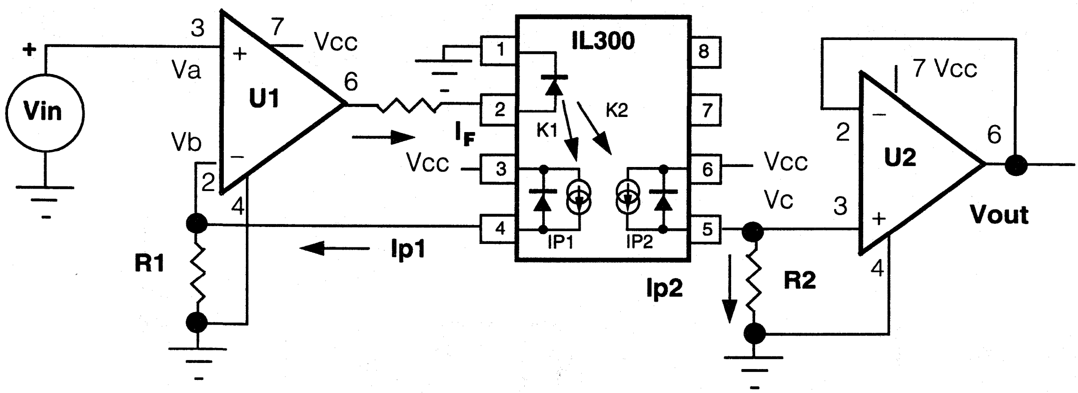
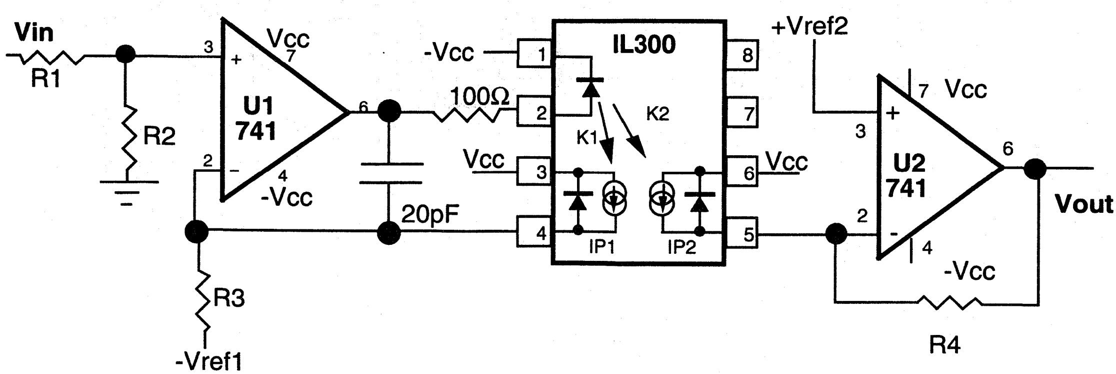


Figure 23. Bipolar photoconductive isolation amplifier



Bipolar Isolation Amplifier

Many applications require the isolation amplifier to respond to bipolar signals. The generic inverting isolation amplifier shown in Figure 23 will satisfy this requirement. Bipolar signal operation is realized by prebiasing the servo loop. The prebias signal, Vref1, is applied to the inverting input through R3. U1 forces sufficient LED current to generate a voltage across R3 which satisfies U1's differential input requirements. The output amplifier, U2, is biased as a transresistance amplifier. The bias or offset, Vref2, is provided to compensate for bias introduced in the servo amplifier.

Much like the unipolar amplifier, selecting R3 is the first step in the design. The specific resistor value is set by the input voltage range, reference voltage, and the maximum output current, Io, of the op-amp. This resistor value also affects the bandwidth and stability of the servo amplifier.

The input network of R1 and R2 form a voltage divider. U2 is configured as a inverting amplifier. This bipolar photoconductive isolation amplifier has a transfer gain given in Equation 30.

$$\frac{Vout}{Vin} = \frac{K3 \cdot R4 \cdot R2}{R3(R1 + R2)} \qquad (30)$$

Equation 31 shows the relationship of the Vref1 to Vref2.

$$Vref2 = (Vref1 \cdot R4)/R3 \qquad (31)$$

Another bipolar photoconductive isolation amplifier is shown in Figure 24. It is designed to accept an input signal of ±1 V and uses inexpensive signal diodes as reference sources. The input signal is attenuated by 50% by a voltage divider formed with R1 and R2. The solution for R3 is given in Equation 32.

$$R3 = (0.5\, Vin_{max} + Vref1)/(I_F \cdot K1) \qquad (32)$$

For this design R3 equals 30 KΩ.

The output transresistance is selected to satisfy the gain requirement of the composite isolation amplifier. With K3 = 1, and a goal of unity transfer gain, the value of R4 is determined by Equation 33.

$$R4 = [R3 \cdot G \cdot (R1 + R2)]/(K3 \cdot R2) \qquad (33)$$

R4 = 60 KΩ

From Equation 31, Vref2 is shown to be twice Vref1. Vref2 is easily generated by using two 1N914 diodes in series.

This amplifier is simple and relatively stable. When better output voltage temperature stability is desired, consider the isolation amplifier configuration shown in Figure 25. This amplifier is very similar in circuit configuration except that the bias is provided by a high quality LM313 band gap reference source.

This circuit forms a unity gain non-inverting photoconductive isolation amplifier. Along with the LM113 references and low offset OP-07 amplifiers the circuit replaces the 741 opamps. A 2N2222 buffer transistor is used to increase the OP-07's LED drive capability. The gain stability is set by K3, and the output offset is set by the stability of OP-07s and the reference sources.

Figure 26 shows a novel circuit that minimizes much of the offset drift introduced by using two separate reference sources. This is accomplished by using an optically coupled tracking reference technique. The amplifier consists of two optically coupled signal paths. One IL300 couples the input to the output. The second IL300 couples a reference voltage generated on the output side to the input servo amplifier. This isolation amplifier uses dual opamps to minimize parts count. Figure 26 shows the output reference being supplied by a voltage divider connected to Vcc. The offset drift can be reduced by using a band gap reference source to replace the voltage divider.

Figure 24. Bipolar photoconductive isolation amplifier

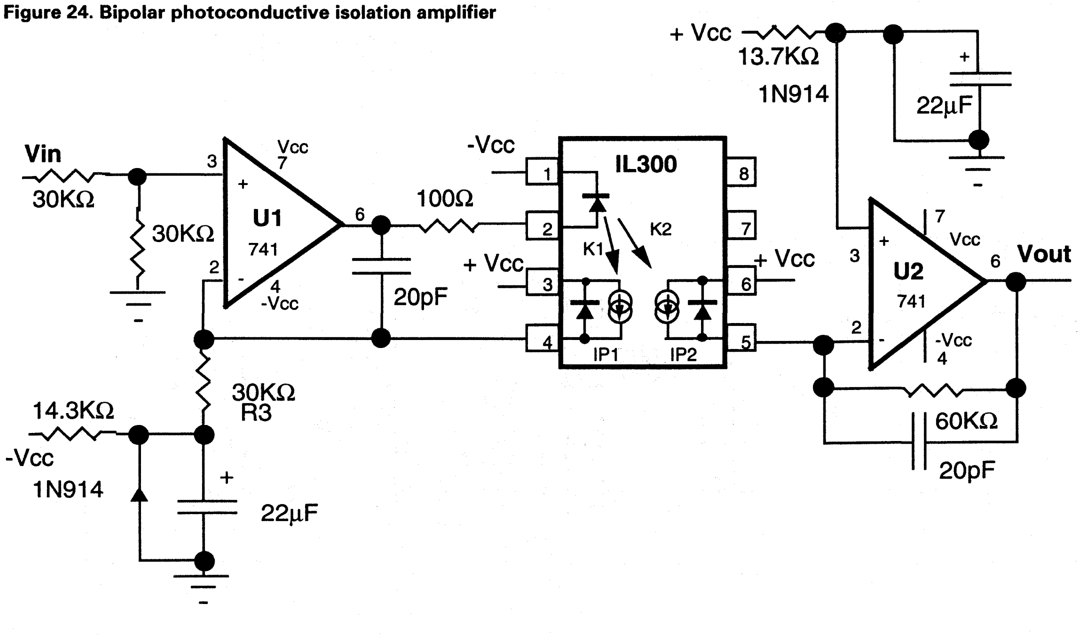


Figure 25. High stability bipolar photoconductive isolation amplifier

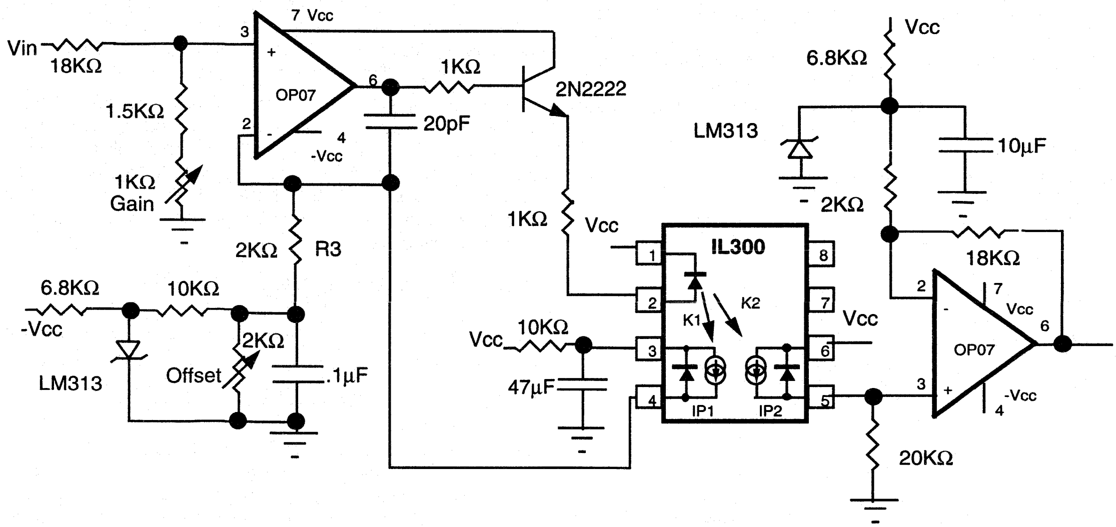
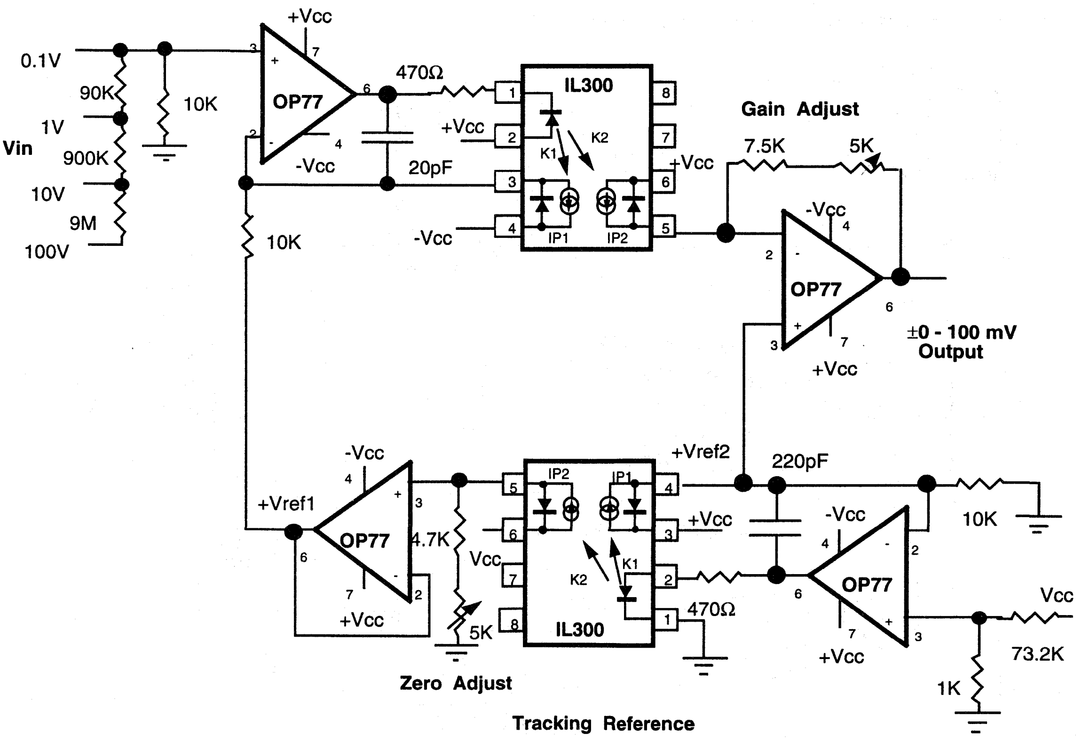


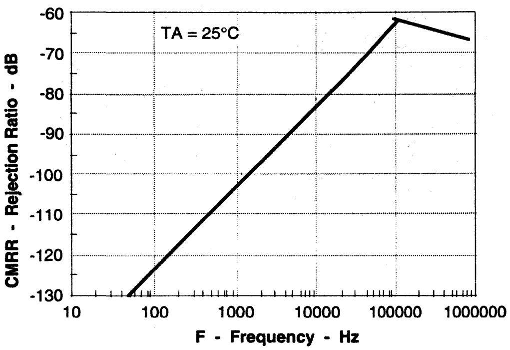
Figure 26. Bipolar photoconductive isolation amplifier with tracking reference



Differential Photoconductive Isolation Amplifier

One of the principal reasons to use an isolation amplifier is to reject electrical noise. The circuits presented thus far are of a single ended design. The common mode rejection, CMRR, of these circuits is set by the CMRR of the coupler and the bandwidth of the output amplifier. The typical common mode rejection for the IL300 is shown in Figure 27.

Figure 27. Common mode rejection



The CMRR of the isolation amplifier can be greatly enhanced by using the CMRR of the output stage to its fullest extent. This is accomplished by using a differential amplifier at the output that combines optically coupled differential signals. The circuit shown in Figure 28 illustrates the circuit.

Opamps U1 and U5 form a differential input network. U4 creates a 100 µA, I_S, current sink which is shared by each of the servo amplifiers. This bias current is divided evenly between these two servo amplifiers when the input voltage is equal to zero. This division of current creates a differential signal at the output photodiodes of U2 and U6. The transfer gain, Vout/ Vin, for this amplifier is given in Equation 34.

$$\frac{Vout}{Vin} = \frac{R4 \cdot R2 \cdot K3(U5) + R3 \cdot R1 \cdot K3(U2)}{2 \cdot R1 \cdot R2} \quad (34)$$

The offset independent of the operational amplifiers is given in Equation 35.

$$Voffset = \frac{Is \cdot [R1 \cdot R3 \cdot K3(U2) - R2 \cdot R4 \cdot K3(U5)]}{R1 + R2} \quad (35)$$

Equation 35 shows that the resistors, when selected to produce equal differential gain, will minimize the offset voltage, Voffset. Figure 29 illustrates the voltage transfer characteristics of the prototype amplifier. The data indicates the offset at the output is –500 µV when using 1 KΩ 1% resistors.

Figure 28. Differential photoconductive isolation amplifier

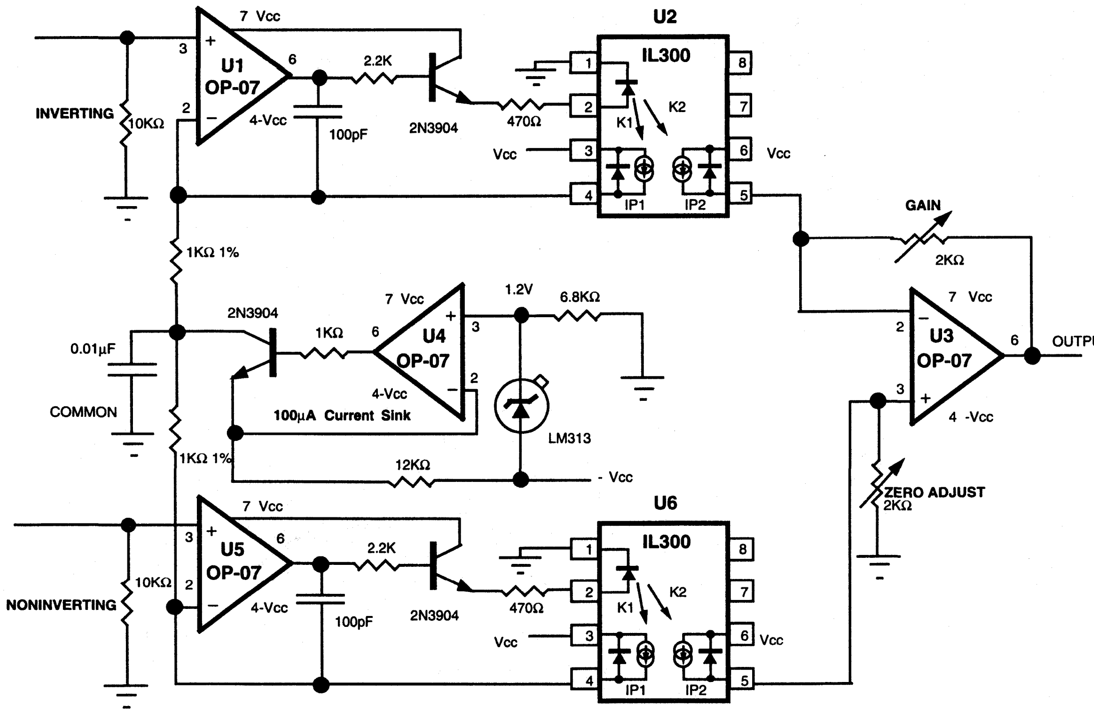


Figure 29. Differential photoconductive isolation amplifier transfer characteristics

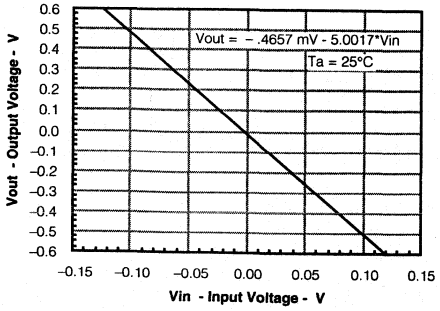


Figure 30. Transistor unipolar photoconductive isolation amplifier transfer characteristics

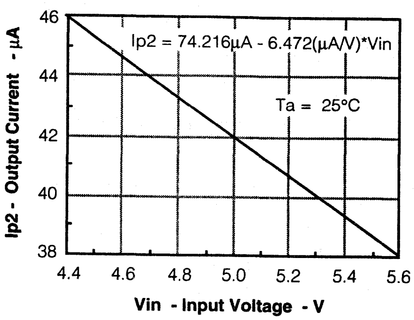
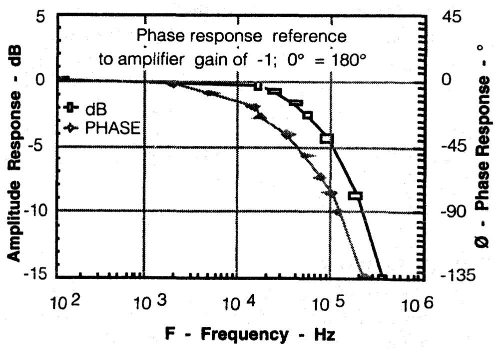


Figure 31. Transistor unipolar photoconductive isolation amplifier frequency and phase response



Discrete Isolation Amplifier

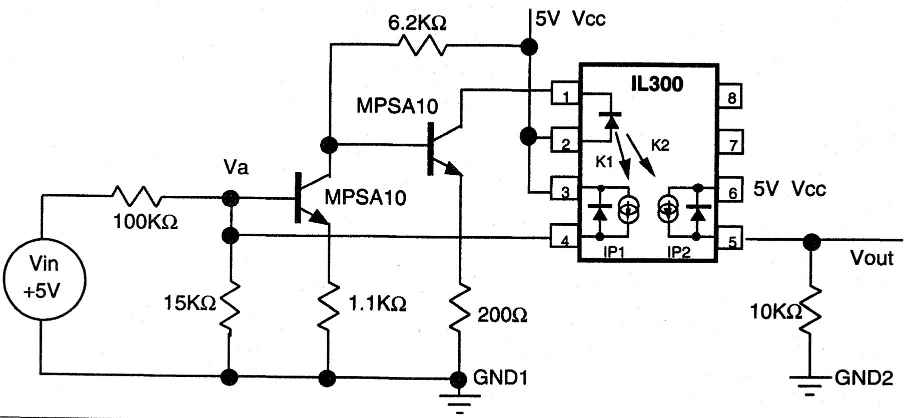
A unipolar photoconductive isolation amplifier can be constructed using two discrete transistors. Figure 32 shows such a circuit. The servo node, Va, sums the current from the photodiode and the input signal source. This control loop keeps Va constant. This amplifier was designed as a feedback control element for a DC power supply. The DC and AC transfer characteristics of this amplifier are shown in Figures 30 and 31.

Conclusion

The analog design engineer now has a new circuit element that will make the design of isolation amplifiers easier. The preceding circuits and analysis illustrate the variety of isolation amplifiers that can be designed. As a guide, when highest stability of gain and offset is needed, consider the photovoltaic amplifier. Widest bandwidth is achieved with the photoconductive amplifier. Lastly, the overall performance of the isolation amplifier is greatly influenced by the operational amplifier selected. Noise and drift are directly dependent on the servo amplifier.

The IL300 also can be used in the digital environment. The pulse response of the IL300 is constant over time and temperature. In digital designs where LED degradation and pulse distortion can cause system failure, the IL300 will eliminate this failure mode.

Figure 32. Unipolar photoconductive isolation amplifier with discrete transistors



Supplemental Information
Photodetector Operation Tutorial
Photodiode Operation and Characteristics

The photodiodes in the IL300 are PIN (**P**-material - **I**ntrinsic material - **N**-material) diodes. These photodiodes convert the LED's incident optical flux into a photocurrent. The magnitude of the photocurrent is linearly proportional to the incident flux. The photocurrent is the product of the diode's responsivity, S_I, (A/W), the incident flux, E_e (W/mm^2), and the detector area A_D, (mm^2). This relationship is shown below:

$$I_P = S_I \cdot E_e \cdot A_D \qquad (1a)$$

Photodiode I/V Characteristics

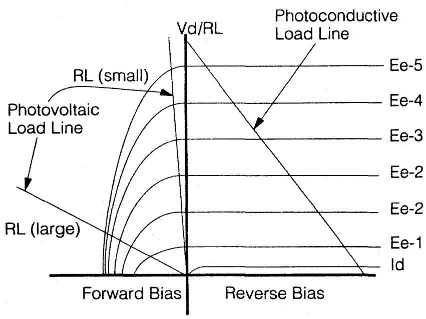
Reviewing the photodiode's current/voltage characteristics aids in understanding the operation of the photodiode, when connected to an external load. The I-V characteristics are shown in Figure 33. The graph shows that the photodiode will generate photocurrent in either forward biased (photovoltaic), or reversed biased (photoconductive) mode.

In the forward biased mode the device functions as a photovoltaic, voltage generator. If the device is connected to a small resistance, corresponding to the vertical load line, the current output is linear with increases in incident flux. As R_L increases, operation becomes nonlinear until the open circuit (load line horizontal) condition is obtained. At this point the open circuit voltage is proportional to the logarithm of the incident flux.

In the reverse biased (photoconductive mode), the photodiode generates a current that is linearly proportional to the incident flux. Figure 33 illustrates this point with the equally spaced current lines resulting from linear increase of E_e.

The photocurrent is converted to a voltage by the load resistor R_L. Figure 33 also shows that when the incident flux is zero (E=0), a small leakage current, or dark current (I_D) will flow.

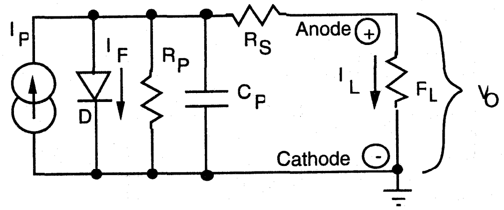
Figure 33. Photodiode I/V characteristics



Photovoltaic Operation

Photodiodes, operated in the photovoltaic mode, generate a load voltage determined by the load resistor, R_L, and the photocurrent, I_P. The equivalent circuit for the photovoltaic operation is shown in Figure 34. The photodiode includes a current source (I_P), a shunt diode (D), a shunt resistor (R_P), a series resistor (R_S), and a parallel capacitor (C_P). The intrinsic region of the PIN diode offers a high shunt resistance resulting in a low dark current, and reverse leakage current.

Figure 34. Equivalent circuit—photovoltaic mode

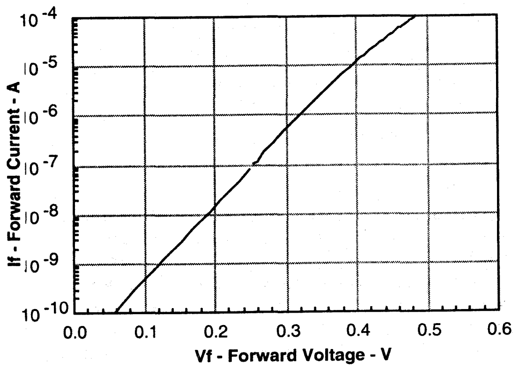


The output voltage, Vo, can be determined through nodal analysis. The circuit contains two nodes. The first node, V_F, includes the photocurrent generator, I_P, the shunt diode, D, shunt resistor (R_P), and parallel capacitance, C_P. The second node, V_O, includes: the series resistor, R_S, and the load resistor, R_L. The diode, D, in the V_F node is responsible for the circuit's nonlinearity. The diode's current voltage relationship is given in Equation 2a.

$$I_F = I_S \cdot [EXP(V_F/K) - 1] \qquad (2a)$$

This graphical solution of 2a for the IL300 is shown in Figure 35.

Figure 35. Photodiode forward voltage vs. forward current



Inserting the diode Equation 2a, into the two nodal equations gives the following DC solution for the photovoltaic operation (Equation 3a):

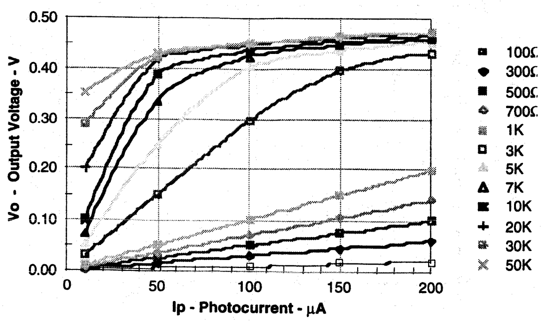
$$0 = I_P - I_S \cdot \{EXP[V_O(R_S + R_L)/K \cdot R_L] - 1\} - V_O[(R_S + R_L + R_P)/(R_P \cdot R_L)] \qquad (3a)$$

Typical IL300 values:

I_S = 13.94 · 10^-12
R_S = 50 Ω
R_P = 15 GΩ
K = 0.0288

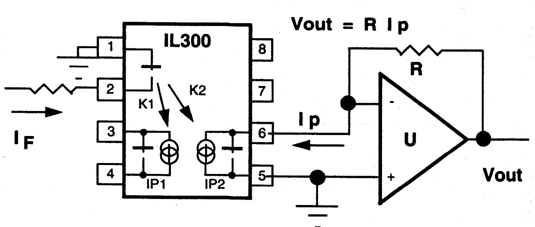
By inspection, as R_L approaches zero ohms the diode voltage, V_F, also drops. This indicates a small diode current. All of the photocurrent will flow through the diode series resistor and the external load resistor. Equation 3a was solved with a computer program designed to deal with nonlinear transcendental equations. Figure 36 illustrates the solution.

Figure 36. Photovoltaic output vs. load resistance and photocurrent



This curve shows a series of load lines, and the output voltage, Vo, caused by the photocurrent. Optimum linearity is obtained when the load is zero ohms. Reasonable linearity is obtained with load resistors up to 1000 ohms. For load resistances greater than 1000 Ω, the output voltage will respond logarithmically to the photocurrent. This response is due to the nonlinear characteristics of the intrinsic diode, D. Photovoltaic operation with a zero ohm load resistor offers the best linearity and the lowest dark current, I_D. This operating mode also results in the lowest circuit noise. A zero load resistance can be created by connecting the photodiode between the inverting and non-inverting input of a transresistance operational amplifier, as shown in Figure 37.

Figure 37. Photovoltaic amplifier configuration



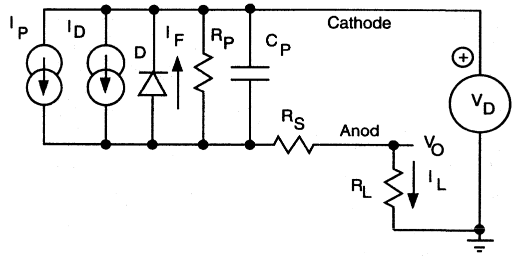
Photoconductive Operation Mode

Isolation amplifier circuit architectures often load the photodiode with resistance greater than zero ohms. With non-zero loads, the best linearity is obtained by using the photodiode in the photoconductive or reverse bias mode. Figure 38 shows the photodiode operating in the photoconductive mode. The output voltage, Vo, is the product of the photocurrent times the load resistor.

The reverse bias voltage causes a small leakage or dark current, I_D, to flow through the diode. The output photocurrent and the dark current, sum the load resistor. This is shown in Equation 4a.

$$V_L = R_L \cdot (I_P + I_D) \qquad (4a)$$

Figure 38. Photoconductive photodiode model



The dark current depends on the diode construction, reverse bias voltage and junction temperature. The dark current can double every 10°C. The IL300 uses matched PIN photodiodes that offer extremely small dark currents, typically a few picoamps. The dark current will usually track one another, and their effect will cancel each other when a servo amplifier architecture is used. The typical dark current as a function of temperature and reverse voltage is shown in Figure 39.

The responsivity, S, of the photodiode is influenced by the potential of the reverse bias voltage. Figure 40 shows the responsivity percentage change versus bias voltage. This graph is normalized to the performance at a reverse bias of 15 volts. The responsivity is reduced by 4% when the bias is reduced to 5 volts.

Figure 39. Dark current vs. reverse bias

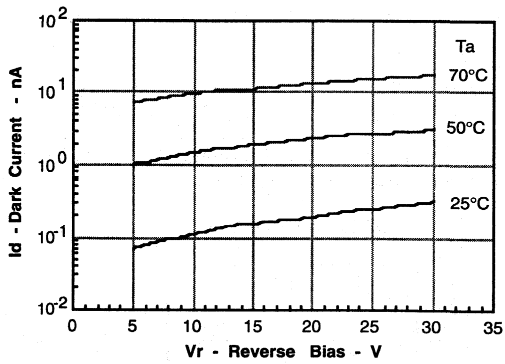
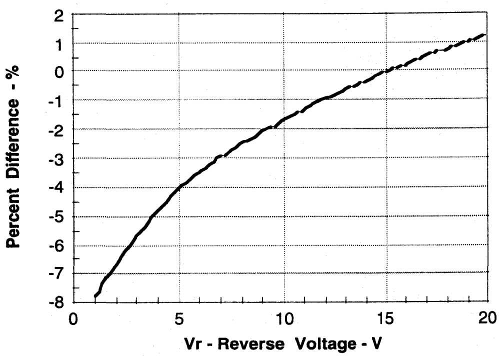


Figure 40. Photoconductive responsivity vs. bias voltage



The photodiode operated in the photoconductive mode is easily connected to an operational amplifier. Figure 41 shows the diode connected to a transresistance amplifier. The transfer function of this circuit is given in Equation 5a.

$$V_{out} = R \cdot (I_P \cdot I_d) \qquad (5a)$$

Bandwidth Considerations

PIN photodiodes can respond very quickly to changes in incident flux. The IL300 detectors respond in tens of nanoseconds. The slew rate of the output current is related to the diodes junction capacitance, C_j, and the load resistor, R. The product of these two elements set the photo-response time constant.

$$\tau = R \cdot Cj \qquad (6a)$$

This time constant can be minimized by reducing the load resistor, R, or the photodiode capacitance. This capacitance is reduced by depleting the photodiode's intrinsic region, I, by applying a reverse bias. Figure 42 illustrates the effect of photodiode reverse bias on junction capacitance.

Figure 41. Photoconductive amplifier

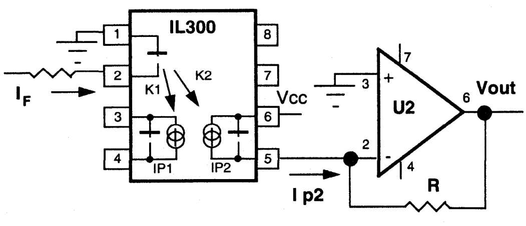
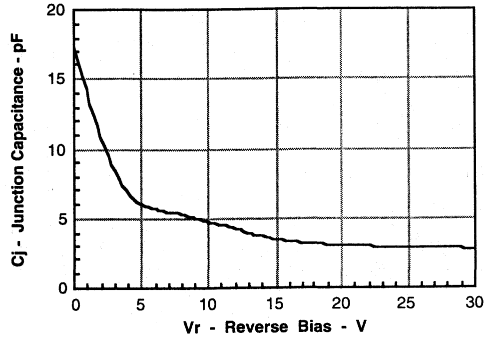
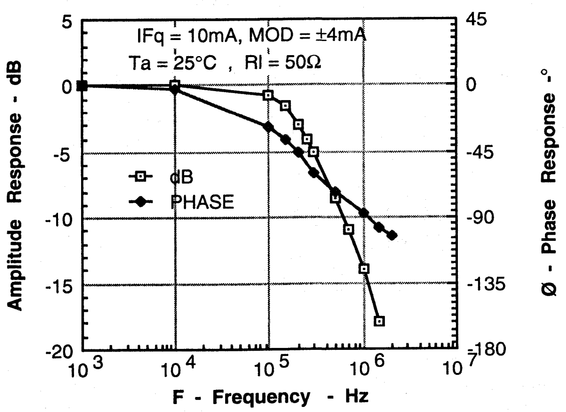


Figure 42. Photodiode junction capacitance vs. reverse voltage



The zero biased photovoltaic amplifier offers a 50 KHz-60 KHz usable bandwidth. When the detector is reverse biased to −15 V, the typical isolation amplifier response increases to 100-150 KHz. The phase and frequency response for the IL300 is presented in Figure 43. When maximum system bandwidth is desired, the reverse biased photoconductive amplifier configuration should be considered.

Figure 43. Phase and frequency response



SIEMENS

Applications of Surface Mount LEDs Appnote 51

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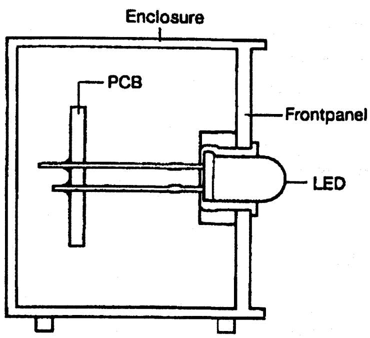
Siemens AG, Semiconductor Group, Munich, Germany

SMT Replaces Through Hole Technology

The use of SMT-TOPLED™ varies greatly from the use of traditional through hole LEDs. Historically through hole LEDs have been incorporated directly into front panels using the leads as a stand off (Figure 1).

Figure 1. Typical through hole LED mounting



Due to the automated nature of SMT assembly, and the size constraints of SMT component and assemblies, SMT-TOPLED™ applications are different from through hole applications. For SMT applications the LED is often 10 mm or more from the front panel (Figure 2). Employing light pipes can create the optimum display to the final viewer. Because of the size and radiation pattern of the Siemens/Hewlett-Packard SMT-TOPLED™ the final light emitting surfaces can be created in almost any shape. Lenses can also be combined with SMT-TOPLED™. Because of the uniform repeatable radiation pattern, the lens design can be matched to the exact customer requirements. Additional applications include backlighting of symbols and liquid crystal displays.

Applications

Of course the simplest way of using the new SMT-TOPLED™ is in a direct view application. Efficient optical design ensures that further optics are not required. Direct view applications include simple displays and moving message boards. Figure 3 and Figure 4 show these examples.

Figure 2. SMT-TOPLED™ with light pipe to front panel

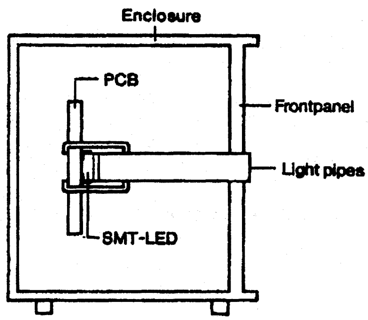


Figure 3. Direct view application of SMT-TOPLED™

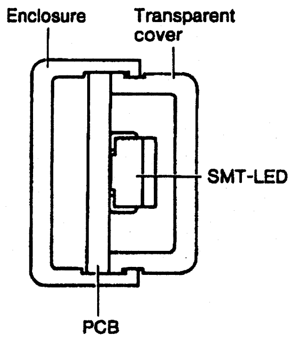
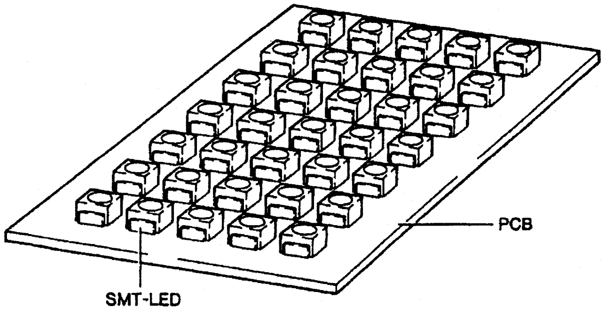


Figure 4. Moving message board with SMT-TOPLED™



In direct view applications, the following features are of particular advantage:

- Defined, rounded light emitting area
- Uniform illumination
- Large, uniform radiation pattern
- Due to the optical and package design, the performance of the package is very robust
- Misplacement and tilting will not adversely affect the optical performance.

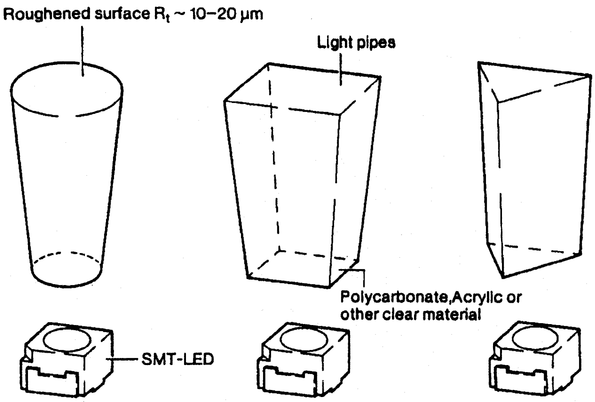
All these applications are addressed with the same SMT-TOPLED™ design. For the user this means simplified design and standardized assembly. This improved optical design freedom is an additional benefit of the new SMT-TOPLED™.

Light Pipes

A major application of the new SMT-TOPLED™ will be with light pipes. Figure 5 shows some possible designs.

By using light pipes, the distances between boards and front panels can be bridged and almost any luminous area or picture can be produced. The light emitted from a light pipe does not need to be directly above the SMT-TOPLED™. By making use of the critical angle of an

Figure 5. Light pipes used in conjunction with SMT-TOPLED™



optical system, (based on total internal reflection), or with mirrored reflectors, the light can be deflected to any angle with only minimal losses. Figure 6 illustrates one example.

Multi Color Light Pipes

By coupling LEDs of different wavelengths (colors) into the same light pipe it is possible to have either multi-color capability, or new colors formed by the combination of the existing colors (Figure 7).

Bridging the distance between PC boards and front panels by an electrically non conducting light pipe automatically produces protection for electronics against ESD or for users against high voltage.

Figure 6. Right angle light pipe

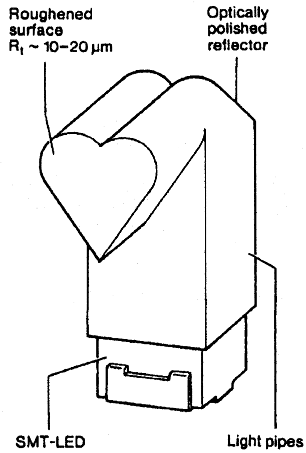
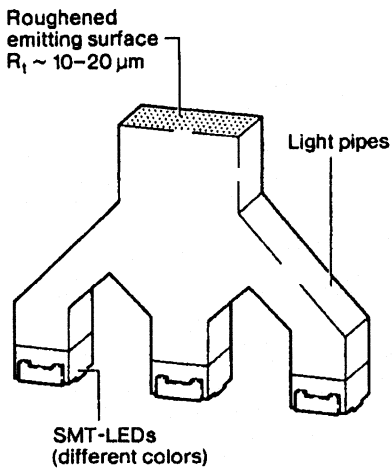


Figure 7. Light pipe used to form a multicolor indicator



Backlighting

Backlighting of legends and LCDs is a major application possibility for this new SMT-TOPLED™ design. There are three ways of getting the light from the LED to the backlighting area.

- Direct use of SMT-TOPLED™
- Incorporating reflectors
- Incorporating large area light pipes

Direct use is appropriate for low total height applications such as membrane keyboards. Because of the uniform, wide emission angle, surfaces with heights of 2 to 3 mm can be illuminated uniformly without any additional measures (Figure 8).

Figure 8. LED behind membrane keypad

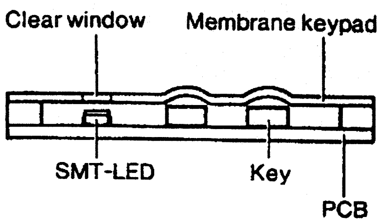
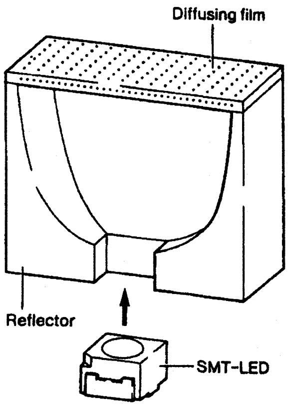


Figure 9. SMT-TOPLED™ illuminating a reflecting cavity



If more height is available or required and larger surfaces are to be illuminated, such as car dashboards, the SMT-TOPLED™ can be combined with external reflectors. In this way both single legends (Figure 9) and surfaces of any size can be backlit brightly and uniformly (Figure 10). A reflector/SMT-TOPLED™ combination is advantageous for backlighting positive and negative LCDs as sufficient brightness is produced with only a few LEDs.

If the assembly does not leave space for an external reflector, legends and LCDs can be backlit with flat light pipes. In this way it is possible to produce backlighted units of only a few mm height. Figure 11 illustrates backlighting for a LCD display where the LCD is at a right angle to the LED board.

Figure 10. SMT-TOPLED™ illuminating a large area

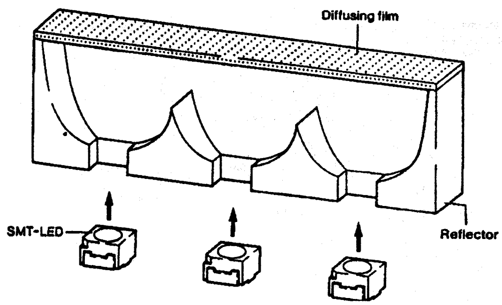


Figure 11. LEDs backlighting an LCD display with a right angle light pipe

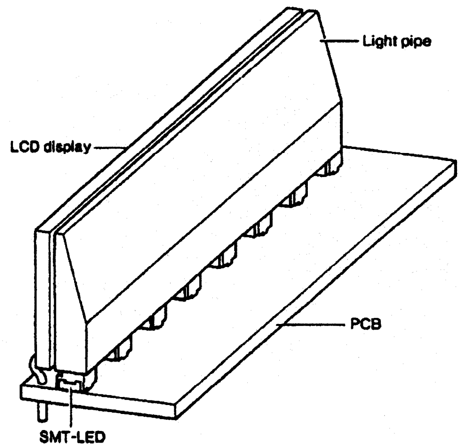


Figure 12 and Figure 13 outline locations in which the LCD is parallel to the LEDs. In Figure 13 the light couples into the light pipe on both sides to increase brightness or illuminate a large area.

Lenses

The common through hole LED standards of 3 mm and 5 mm diameter emit light through a lens integrated into the package. Different radiation patterns are produced depending on the die and lens spacing and the shape of the lens. With straight forward design lenses can be produced to couple with the SMT-TOPLED™ to emit light at any required angle or pattern (Figure 14).

Figure 12. LCD backlighting configuration

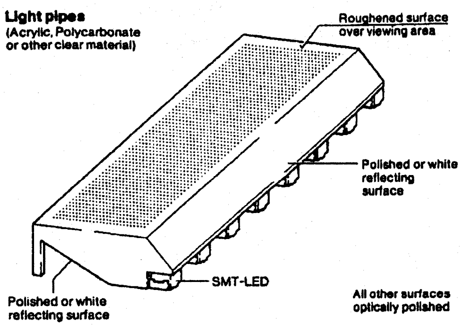
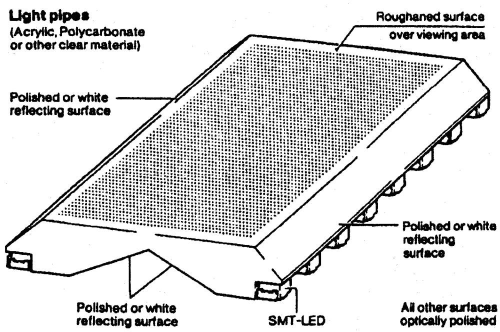


Figure 13. Improved brightness for LCD backlighting



Using an external lens can change both the on axis intensity and the viewing angle. For example, it is possible to change the typical light output from an Iv of 6 mcd and a viewing angle to 120 degrees to an Iv of 18 mcd and a viewing angle of 60 degrees, or even to an Iv of 40 mcd with a viewing angle of 30 degrees (Figure 15 and Figure 16).

Exercise proper care in the design of the light pipes for optimum coupling of the light emitted by the SMT-TOPLED™ to the final viewer. Tests have shown that with proper design and care more than 90% of the light can be transmitted by the light pipe. The design guidelines for light pipes are effectively covered by existing application notes, common literature associated with fiber optics as well as most texts covering optics. Both Hewlett-Packard and Siemens have advanced ray tracing programs and services.

HP and Siemens will give application support for design and manufacturing of boards incorporating SMT-TOPLED™. Clarification of the optical and electrical needs for each application are the first step in the support process.

Figure 14. LED with lens

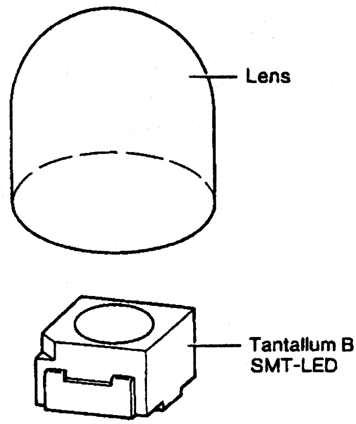


Figure 15. Different light pipe configurations

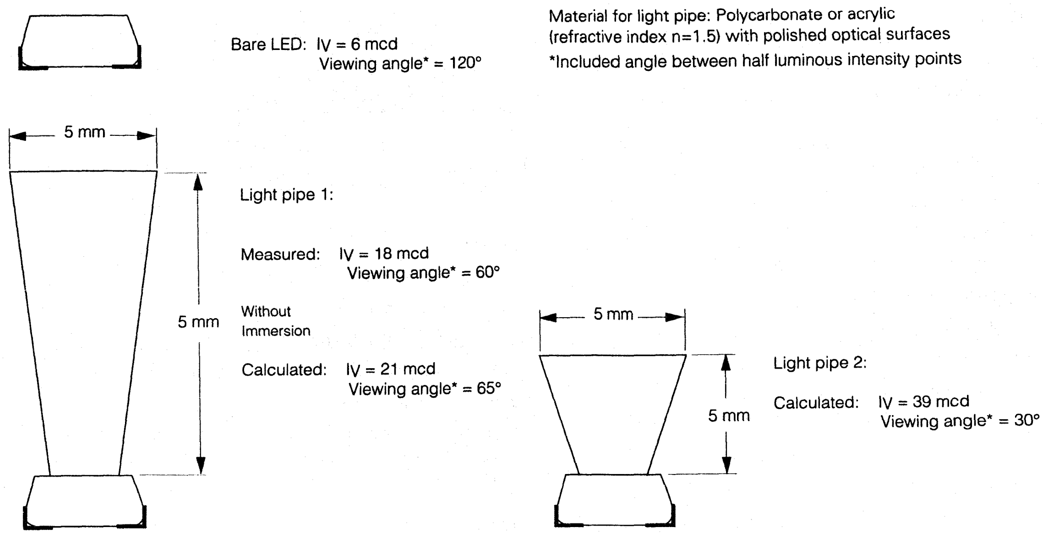
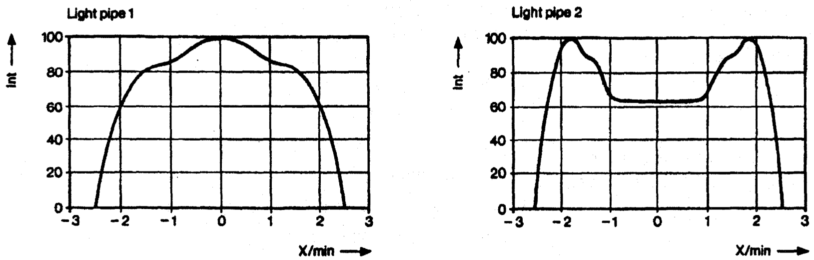


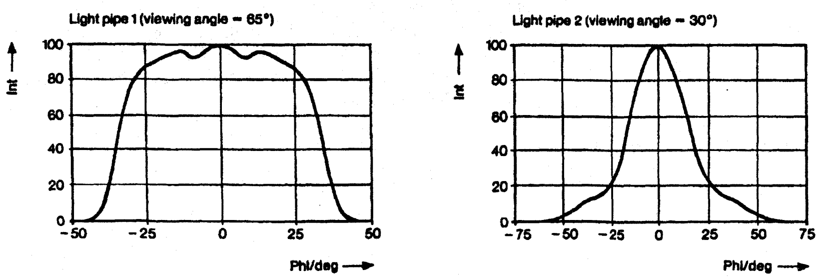
Figure 16. Computer simulation of radiation patterns of SMT-TOPLED™ with light pipes

Radiation pattern of SMT LED, with light pipes viewing angle
Computer simulation (Figure 19)

Near field radiation pattern (at the surface of the light pipe)



Far field radiation pattern (20 cm from the light pipe)



Designing with Surface Mount LEDs

The evolution from through hole technology to SMT demands surface mount optoelectronic components. HP and Siemens have addressed this need by creating a SMT standard for LEDs. The advantages to the user of using SMT-TOPLED™ are many:

- Lower PC board costs: reduced area, less drilling, fewer plated through holes
- Quality, time and cost improvement through automatic placement
- Components packaged in standard tape and reel
- Standard package allows for ease of landing pad design
- Low component height compared to through hole
- Uniformly placed components
- Uniform soldering techniques
- Improvement in reliability
- More flexibility during assembly
- Assembly processes compatible with active and passive components

SMT LED Design

Figure 17 shows a cross sectional view of the SMT-TOPLED™. High temperature thermoplastic is insert molded around a continuously stamped lead frame. Selection criteria for the plastic material included mechanical and thermal characteristics, and its high value of diffuse reflectance (90% efficient). Optical characteristics were achieved by reflector cavity geometry and the material features. The light output intensity is a factor of 2 greater than the SOT-23 LED with a more usable radiation pattern. A semiconductor die is placed in the prefabricated leadframe/molding assembly. An epoxy resin is used to improve the light output coupling, and seals the reflector cavity for environmental protection. The resin and the package materials were carefully matched to minimize mechanical and thermal stresses during soldering.

SMT Compatibility

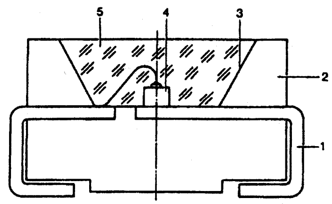
Due to the specific and standardized assembly techniques that evolved in SMT, the following list of requirements are essential for a true SMT-TOPLED™.

Pick and Place

- Flat surfaces on LED package
- Tight package tolerances
- Standard dimensions for automation
- Standard tape and reel sizes
- Standard lead bends and finishes

Traditional through hole LEDs lack many if not all of these features. Careful engineering and cooperation with standards setting organizations assures that all of these requirements are met.

Figure 17. SMT-TOPLED™ cross section



Soldering

- Infrared Reflow (IR)
- Vapor Phase Reflow (VP)
- Through the Wave Soldering
- (TTW) Solder finished leads for soldering processes
- Standard Landing Pads

Characterization of these processes insured an LED designed to withstand the specific mechanical, thermal, and chemical extremes of each.

Cleaning

- Ethyl Alcohol
- Isopropyl Alcohol
- Aqueous Cleaning solutions
- Solvent Cleaning solutions

Aqueous and organic solvents containing alcohol are suitable for cleaning soldered components to remove the remaining soldering flux. Due to environmental concerns and possible negative effects on the LED package do not use chlorinated hydrocarbons, fluoridated hydrocarbons, and ketones.

Optics

- Rounded emitting area
- High on axis intensity
- Wide viewing angle
- Compatible with external optical systems
- Compatible with light pipes
- Suitable for backlighting: legends or LCDs

Siemens has produced LEDs in a SOT-23 package for a number or years. Similarly HP has produced gull wing and yoke lead LEDs for SMT. Experience with these designs formed the foundation for developing a new SMT-TOPLED™. A major objective was improvement of the optical performance with respect to intended SMT applications.

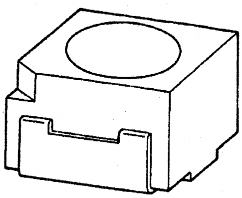
Reliability

Incoming inspection of SMT-TOPLED™ supplied in tape and reel format is difficult for the user. This means that high quality must be assured at incoming inspection in the low parts per million (PPM) defective range. To ensure this the quality departments of the user and the supplier must have effective communication to monitor quality levels and concerns. Working together it is possible to achieve incoming quality levels of better than 10 PPM.

HP and Siemens SMT-TOPLED™ Solution

Figure 18 shows the design of the new SMT-TOPLED™ in a form that matches the Tantalum B molded capacitor. This is from the IEC publication 286 part 3, and from EIA standard IS28. Refer to Table 1 of the last page of this appnote for optical characteristics.

Figure 18. Package drawing of SMT-TOPLED™



Features

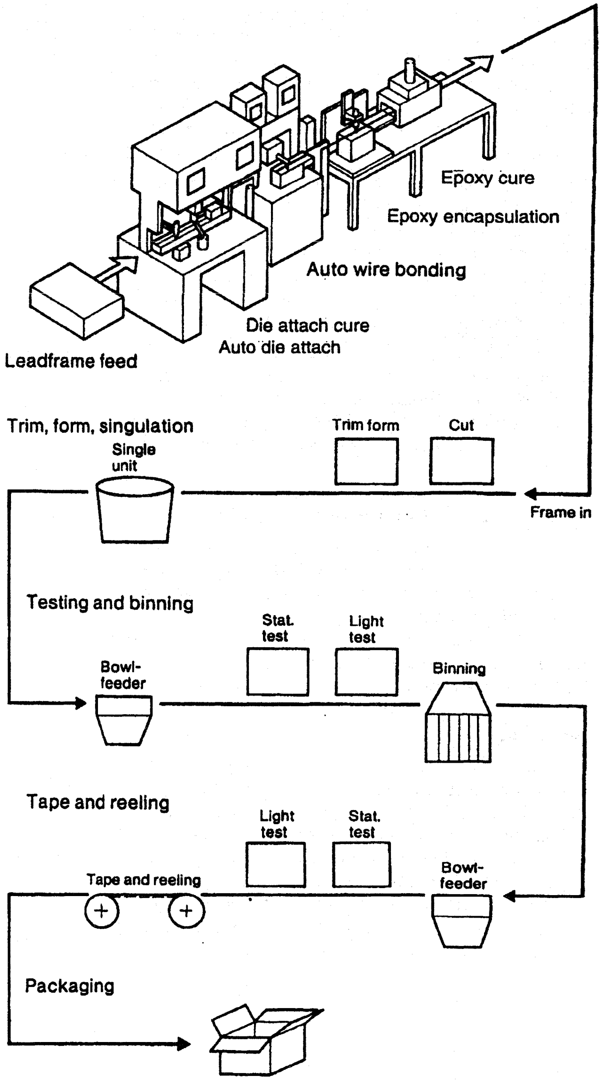
- EIA and IEC Standard Package
- Standard Lead Bend and Footprint
- Cathode Identification
- Flat top and sides for Pick and Place Compatibility
- High Temperature Thermoplastic Housing for SMT Soldering
- Nonimaging Optical Design for High Intensity Light Output

Close cooperation between Siemens and Hewlett-Packard's Optoelectronic Divisions carried out the development of the SMT-TOPLED™. These two worldwide leaders in optoelectronic components have agreed upon this package standard.

SMT-TOPLED™ Manufacturing

A stable, controlled manufacturing line helps to assure quality (Figure 19). The SMT-TOPLED™ manufacturing line incorporates the latest semiconductor assembly equipment in a "hands off" environment for process quality and repeatability. Decisions which affect quality are made based on statistical data and process capability data. The use of extensive automation eliminates the possibility of random uncontrolled failures in the process. From leadframe manufacturing to final bagging, the SMT-TOPLED™ is never handled by human hands.

Figure 19. Manufacturing process flow



Quality and Reliability

With SMT comes a heightened need for quality and reliability. Cost and complexity of boards demand high yields in SMT assembly. To meet these yields effectively, the components must exhibit outstanding initial quality and long term reliability. Performing stringent qualification testing by the component manufacturer ensures adherence to customers' strict requirements.

Reliability qualification of the SMT-TOPLED™ includes preconditioning of the LEDs before testing. This consists of screen printing adhesive to the test boards, pick and placing the LEDs, and soldering the board through the intended soldering process. On completing preconditioning, the boards' reliability testing may begin. Figure 20 illustrates the qualification tests done on the SMT-TOPLED™.

These tests simulate and accelerate actual user environments. Demanding qualification criteria used in testing assures LED users a guarantee for a product that will function after soldering and long into the future in the field.

SMT-TOPLED™ Performance

Table 1 highlights the important optical and electrical data for the new SMT design. Of special note is the combination of the high on axis intensity (I_V), and the large, uniform radiation pattern characterized by $2\,\Theta\,{}^1/_2$ (Figure 21). The uniformity and repeatability of the radiation pattern assure uniform viewing of multiple LEDs in both direct view or through secondary optics.

Conclusion

Through joint design efforts Hewlett-Packard and Siemens have assured true second sourcing of a high quality SMT-TOPLED™ that meets the manufacturabilty and illumination needs of the industry. Work is already under way on IR and detector implementations. It can be expected that further optoelectronic devices such as seven segment displays, light bars, multicolor emitters and sideways emitting LEDs will be standardized in this or a similar technology.

Figure 20. SMT-TOPLED™ qualification tests

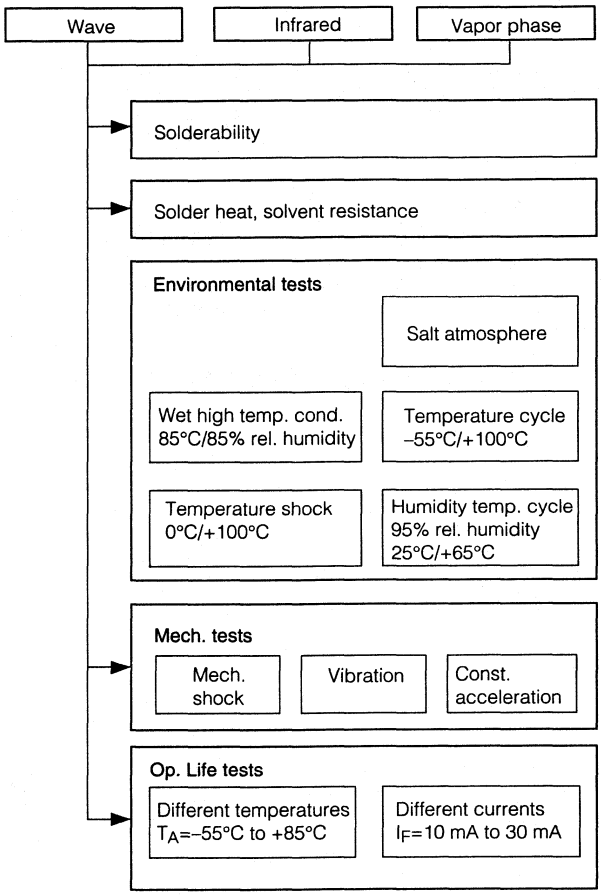


Figure 21. SMT-TOPLED™ radiation patterns

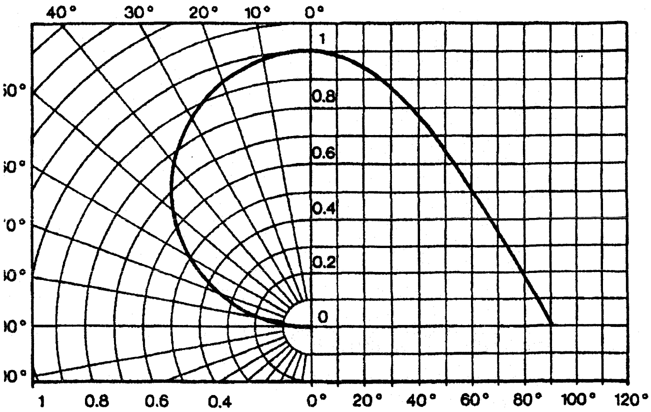


Table 1. SMT LED typical data

Parameter	Symbol	AlGaAs	Red	Orange	Yellow	Green	Unit
Luminous Intensity (I_F=10 mA)	I_V	14	6	5	5	8	mcd
Dominant Wavelength (I_F=10 mA)	I_{DOM}	641	627	605	588	570	nm
Forward Voltage (I_F=10 mA)	V_F	1.8	1.9	1.9	1.9	2.0	V
Viewing Angle $2\Theta^{1}/_{2}$	$2\Theta^{1}/_{2}$	120	120	120	120	120	Degrees
HP Part No.		HSMA-T400	HSMS-T400	HSMD-T400	HSMY-T400	HSMG-T400	
Siemens Part No.		LH T674	LS T670	LO T670	LY T670	LG T670	

SIEMENS

Visible and IR LEDs in SMT-TOPLED™ Package—Tape and Reel Packaging Data Appnote 52

Applicable Part Numbers—A Sampling

Visible LEDs

LS T670	High Efficiency Red
LY T670	Yellow
LG T670	Green
LO T670	Orange

IR Emitters/Detectors

SFH320 .... Phototransistor
SFH320F .... Phototransistor with daylight filter
SFH420 .... GaAs 950 nm IRED

For Automatic Placement

These parts come packaged on 18 cm diameter spools with 1500 pieces/spool. 33 cm spools (7500 pieces) are also available. The tape is compartmentalized and sealed with a foil cover.

Spool/Tape Characteristics

Maximum Storage Temperature .... 40° +5°
C/R-H=95%/240 hrs.
Tape Tear Resistance (max.) .... ≥10 N
(at right angle to direction of unreeling)
Cover Foil Pull Force .... 0.2 to 1.0 N
(pull speed=300 mm/min.)

Polarity and Orientation

- Mounting surface (bottom) on bottom of tape compartment
- All devices are oriented in one direction

Reel Marking

All reels are marked with manufacturer's name, part number, date code, and order number.

Parameter	Symbol	Dimensions (mm)	Notes
Tape Width	W	8 ±0.3	
Carrier Tape Thickness	t	0.3 max.	
Sprocket Hole Pitch	P_0	4 ±0.1	Cumulative pitch error, ±0.5 mm pitches
Sprocket Hole Diameter	D_0	1.5 +0.1	
Sprocket Hole Distance	E	1.75 ±0.1	
Component Position	F	3.5 ±0.05	Center hole to center compartment
	P_2	2 ±0.05	
Component to Component Position	P3	4	
Compartment Dimensions	K	3 max.	See individual components for exact dimensions
	OL	15° max.	
	R_1, R_2	0.5 max.	
	H_0	0.3 +0.1/–0.05	Between inner side or the compartment bottom and the reference level for measuring A_0, B_0
	A_0		Tolerances chosen so that the components can change their orientation, but can easily be removed from the tape
	B_0		
Hole in Compartment	D_1	1 +0.2	Tolerance to the center or sprocket hole: ±0.1 mm
Fixing Tape Width Device Tilt in Compartment	W_1 d	5.5 typ. 0.1 max. 15° max.	Fixing tape not to cover sprocket holes, nor protrude beyond carrier tape so not to exceed max. tape width
Bending Radius	R	25 min.	

SIEMENS

Optocouplers Isolate Modem Data Access Arrangement Appnote 53

by Bob Krause

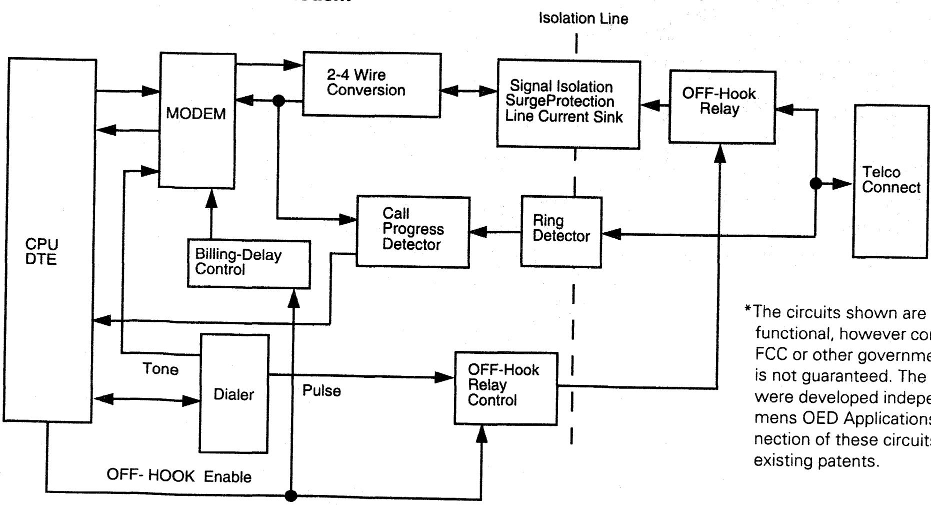
Lap Top, Palm Top, and Pen Based computer modem manufactures are seeking ways to accommodate the small form factor of the PCMCIA peripheral cards. They are looking for devices to replace the bulky magnetic and electromechanical components normally found in the modem's telco line interconnection. Modem supplier have found that optocouplers satisfy both the space and performance needs of a PCMCIA format Fax/Modem product.

This application note describes various DAA circuit architectures*. It shows how the Linear Optocoupler, IL350, is used to isolate the modem signal, provide ring detection, and OFF/Hook operation. The IL350 offers the PCMCIA modem designer a small package with wide signal bandwidth and high insulation and isolation.

Data Access Arrangement–DAA

Figure 1 shows the block diagram of the Data-Access Arrangement (DAA) direct connect modem. The line interconnect section consists of the OFF/Hook relay, Ring Detector, Signal Isolation, Line Current Sink, and Surge Protection. An optically coupled FET switch, such as the LH1056, is commonly used for OFF/Hook switching. Ringer signal sensing is done by phototransistor optocouplers such as 4N35 or ILD255.

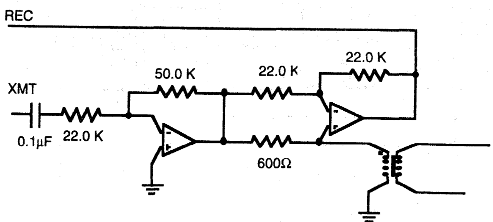
Figure 1. DAA–direct connect modem



Optical 2-4 Wire Hybrid

Replacing the 600 Ω transformer is the most obvious application of the IL350. When a single baud rate modem is being designed, the IL350 can provide line isolation and also can function as the 2-4 wire hybrid.

Figure 2. 2-4 wire electronic hybrid



A typical transformer coupled 2-4 wire electronic hybrid is shown in Figure 2. This circuit provides transmitted tone cancellation, while supplying a –3 dBm transmit level, and receiver sensitivity for a –42 dBm signal. It offers a 600 Ω termination impedance to the telco transformer in both transmit and receive function. The hybrid function is provided by U2. When a telco signal is being received the transformer sees a 600 Ω

*The circuits shown are believed to be functional, however compliance to telco, FCC or other government specifications is not guaranteed. The following circuits were developed independently by Siemens OED Applications. The interconnection of these circuits may infringe on existing patents.

load, R3, terminated to virtual ground. U2 amplifies the receive signal across R3 with a gain specified by the values of R1 and R4. The modem's transmit signal is canceled by U2's differential amplifier action. The amplifier inverting gain is set so that the feedback signal is equal and 180° out of phase to the transmit signal level arriving at U2's non-inverting input. R1 is selected to set U2's gain. The magnitude of transmit tone cancellation is described in the following equation. Optimum tone cancellation is achieved when R3=R2 and R1=R4.

$$\text{Transmit suppression } (dB) = 20Log\left\{Abs\left[\frac{R1+R4}{R1}\left(\left(\frac{R3}{R1+R3}\right)-\left(\frac{R4}{R1+R4}\right)\right)\right]\right\}$$

Figure 3 is a block diagram of an optical transformer connected between the output U1 and the non-inverting input U2. By introducing two unity gain isolation amplifiers in this path, it is possible to isolate the 600 Ω line termination resistor while preserving the hybrid's tone cancellation feature. Figure 4 is a detail of Figure 3.

Figure 3. DDA/2

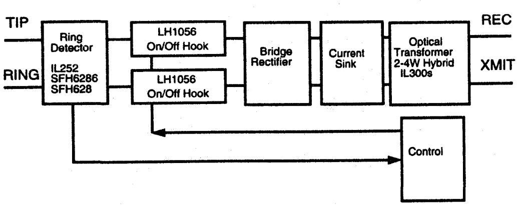
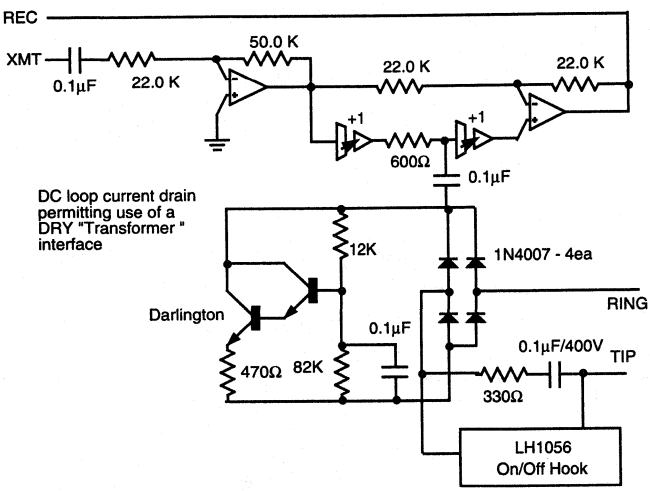


Figure 4. 2-4 wire hybrid optically isolated transformer



Application of the optical transformer results in a "Dry Transformer" type line termination. A dry transformer requires a separate central office battery current return path, which is usually a current sink constructed with discrete components. This example shows a Darlington transistor current sink providing this path.

Various optical transformer 2-4 hybrid circuits were investigated. One circuit used single supply Thevenin style differential operational amplifiers in the isolated section of the interface. The results were less than acceptable. These circuits had difficulty driving reactive low impedance (600 Ω) loads.

Figure 5 shows a better performing design that uses Norton or current input operation amplifiers (LM3900) in the isolated telco line and standard Thevenin Dual supply operational amplifiers (LM324) within the subscriber unit. The LM3900, U6, easily drives the IL350's LED, and a non-inverting photodiode amplifier requires a minimum of components, U5. Note that U3, LM324, requires a buffer transistor (2N3906) to adequately drive the LED. U4 is used as a transresistance amplifier, converting the receive IL350's photocurrent into a voltage that is compatible with the cancellation requirements of U2. The R3, R4, C1 forms the lag compensation network to compensate for the delay in the isolated path between U1's output and U2's input.

A lower component count circuit is shown in Figure 5. This interface uses Norton amplifiers exclusively for both the telco line and subscriber instrument sections. The transmit and receive sections are identical to those in Figure 4. The transmit suppression is accomplished in the current differential amplifier, U2. R4, R5, C2 form the lag network to compensate for the delay introduced by U3, U4, U5, U6, and U7.

Figure 5. 2-4 wire optically coupled hybrid Norton/Thevenin amplifier configuration

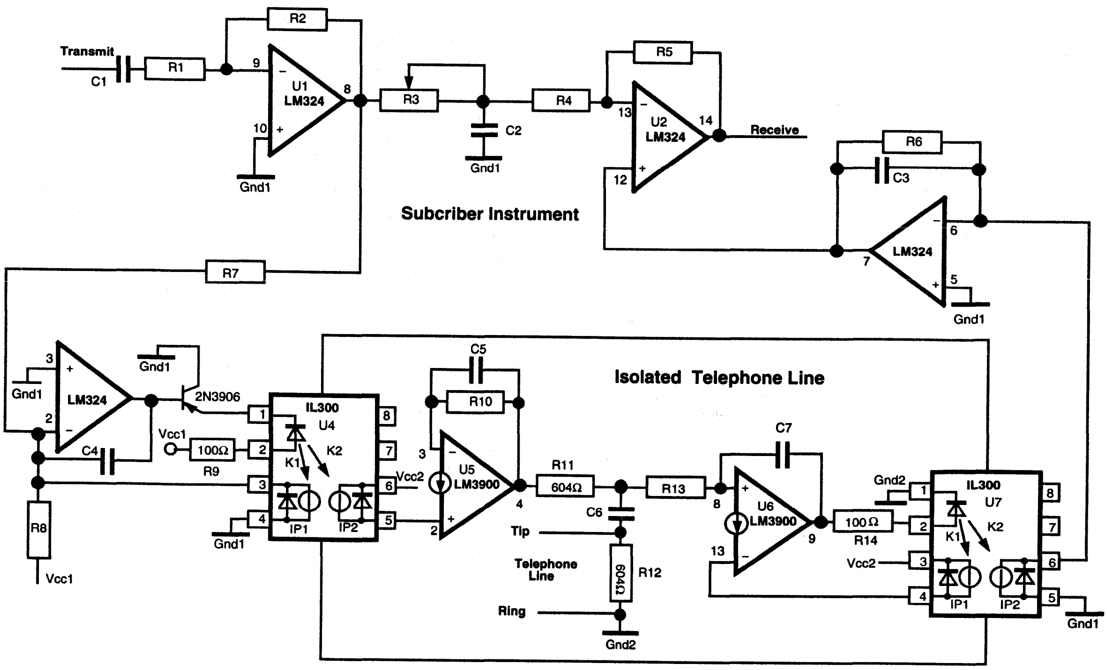


Figure 6. 2-4 wire optically coupled hybrid Norton amplifier configuration

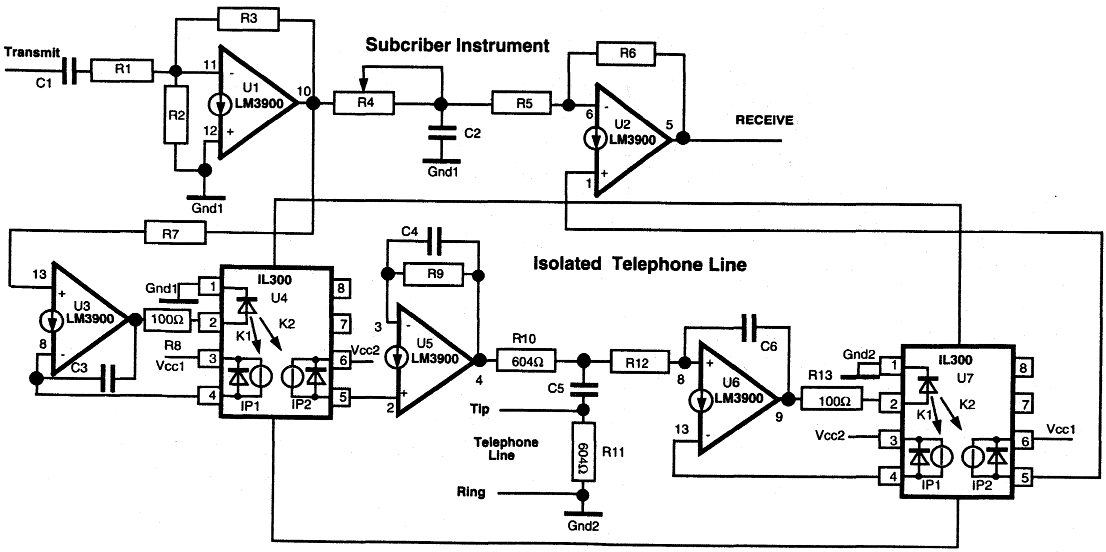


Figure 7.

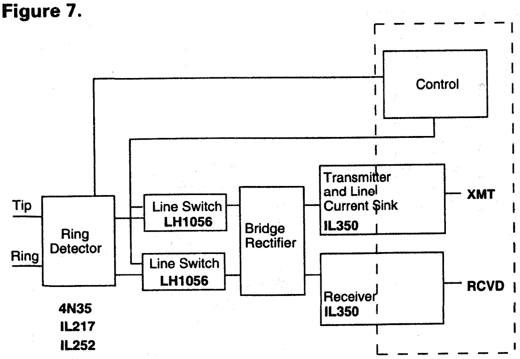


Figure 8.

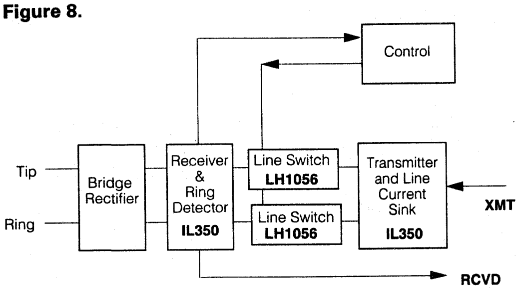
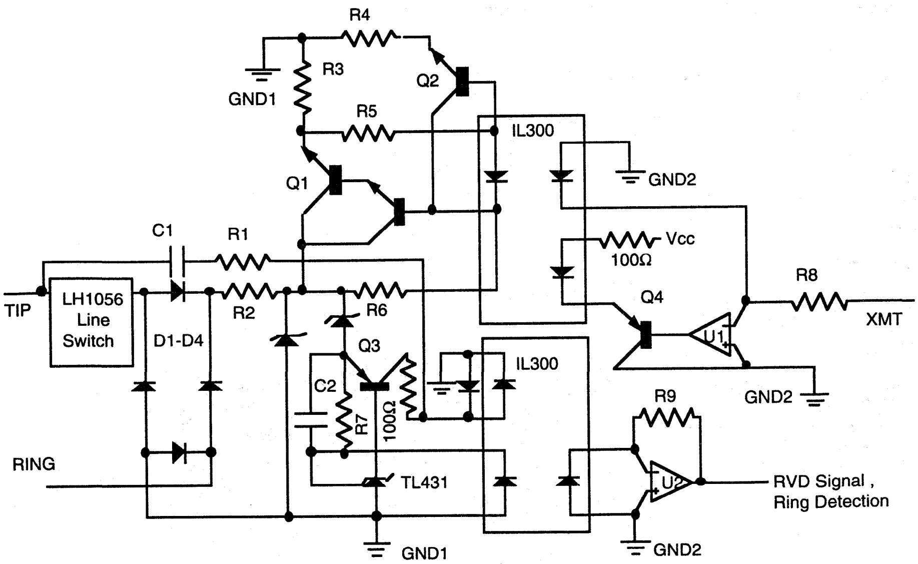


Figure 9.



A 1 KHz transmit signal suppression of –36 dB was measured on the bench. Both of these optical hybrids derive their power from the telco line through a voltage dropping network connected after the OFF/Hook switch. The circuits were evaluated with 5-9 V supply voltages.

Non Hybrid DAA Architectures

The previous circuits may not be suitable for multiple baud rate applications. This results from the frequency dependency of the lag network found in the hybrid. This situation leads to a series of architectures that use digital transmit suppression techniques. When such techniques are possible then standard IL350 interface circuits can be used.

Figure 7 shows a design with a phototransistor coupler as the ring detector and one or more LH1056 FET switches for OFF/Hook control.

This design can be simplified by having ring detection performed by the IL350 receiver, using one LH1056 OFF/Hook switch and combining the transmitter and line current into one circuit function. The block diagram for this approach is shown in Figure 8, the schematic in Figure 9.

The circuit operation is as follows. Line OFF/Hook control is performed by one LH1056 FET switch. Ring detection is accomplished by the signal path of C1, R1 and the LED of the IL350 coupler. These values are selected to provide a 1-2 mA LED ringing current.

Once the ringing signal is detected the OFF/Hook control closes the LH1056, and the IL350 receiver amplifier is energized from power supplied by the central office battery via the bridge rectifier D1-D4. The zener diode ZD2 is used to supply +15 V. The IL350 servo amplifier is constructed with Q3 and a shunt regulator, TL431. R7 is used to set a prebias current for the servo operation. The optical servo current can range from 50 μA to 100 μA depending on the K1 servo gain of the IL350. This photo bias current will result in a LED current of 5 mA to 10 mA. C2 provides a low impedance received signal path into the input of the TL431. The received signal is converted to an output photocurrent based upon the transfer gain, K3, of the IL350. This output photocurrent is then amplified by the transresistance amplifier, U2.

Figure 10. Switchless DAA interconnection

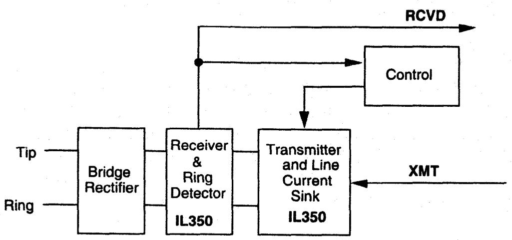
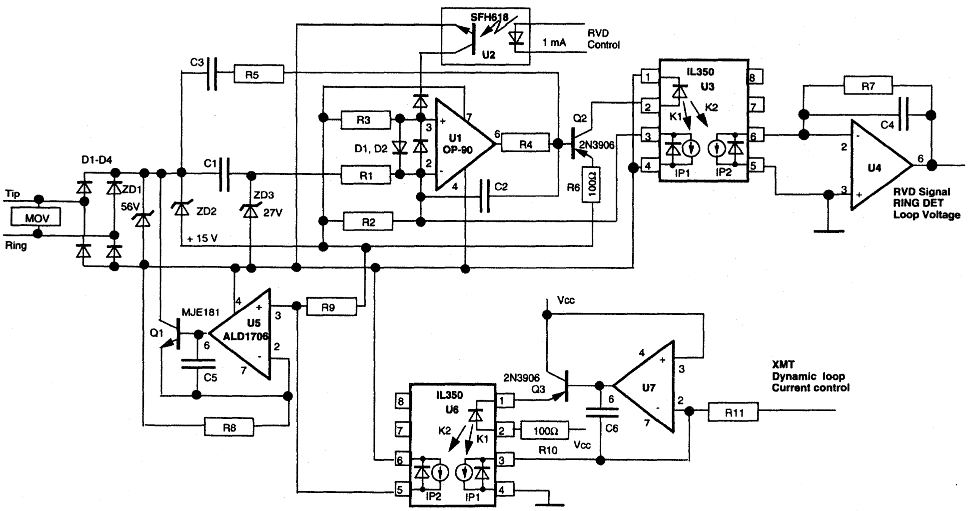


Figure 11. Switchless DAA interconnection



The transmit function and central office battery current sink is provided by the transmit amplifier. This circuit consists of Q1, Q2, R2, R4, R5, and R6. Under transmit operation the transmit signal XMT consists of a DC and AC component. The DC component prebiases the transmit amplifier. This prebias sets the supplemental line current to be sunk. Recall that the receiver amplifier will require a 5–10 mA operating current, therefore the transmit current sink will handle any additional current required by the central office switch. The central office line current is typically 20-30 mA. The AC component of the transmit signal is set to a level that satisfies the –3 dBm line transmit level. This circuit was designed to use the smallest and the fewest number of components as possible.

See Figure 10 for a circuit design that further minimizes board space by eliminating the OFF/Hook optocouplers. The schematic of this design is shown in Figure 11.

The circuit operation for this design is as follows. Ring detection is performed by a network consisting of C3, R5, Q2, and the LED of the IL350. This ringer offers a higher impedance than previous designs. This was done to reduce the value and physical size of C3. During ringing, Q2 functions as a ringer amplifier for the LED. Once the ringing signal has been recognized by the modem, the receiver amplifier is activated by turning ON the SFH618 optocoupler, U2. When U2 is OFF, it disables a bias network which also disables the micro-power opamp, U1. Under this condition this amplifier requires only a 20 μA supply current, equivalent to an OFF/Hook resistance of 2.5 MΩ. When the U2 is ON, it provides a current return for the photo bias current supplied by R2 and R3. This bias network is selected to set an LED quiescent current of 5-10 mA.

The received signal is supplied to U1 via C1 and R1. These values are selected to satisfy the bandwidth and signal to noise requirement of the modem. The received signal generates a modulated LED current that is optically coupled through U3 to the modem receive transresistance amplifier consisting of U4, C4, and R4.

The transmit and central office battery current sink is provided by the transmit amplifier. The transmit amplifier and current sink are connected across the telco line. The transmit signal consists of a DC and AC component. When not transmitting, the transmit signal will have a DC level that forces the LED current of transmit IL350, U6, to zero. Under this condition the output photocurrent, IP2, of U6 will also be zero, disabling the transmit amplifier U5 and Q1. When disabled, the transmit amplifier requires a supply current of less that 10 μA, giving the line an OFF/Hook resistance of 5 MΩ.

When the modem is transmitting, the transmit signal, XMT, will have a DC component sufficient to force Q1 to sink any additional central office line current not required by the activated receive amplifier. U5 and Q1 function as a current to current amplifier. The transconductance of the amplifier is set by R8, and R11. The transmit AC signal level at U7 is set to provide a –3 dBm signal to the telco line. R9 provides the output photodiode bias return path. The bandwidth of the transmit circuit is set by amplifier selection, with the values of R11, R8, and C6. Signal bandwidths in excess of 20 KHz are possible with proper component selection.

Conclusion

The circuit designs shown in this application note are provided as a starting point for the design of PCMCIA compatible modem. By using the special lead formed IL350, SOT23, SOT223 transistors, surface mount ICs and passive components, a DAA interface that will fit the 5 mm height form factor of the PCMCIA standard can be constructed.

SIEMENS

Isolated Industrial Current Loop Using the IL300 Linear Optocoupler Appnote 54

by Bob Krause

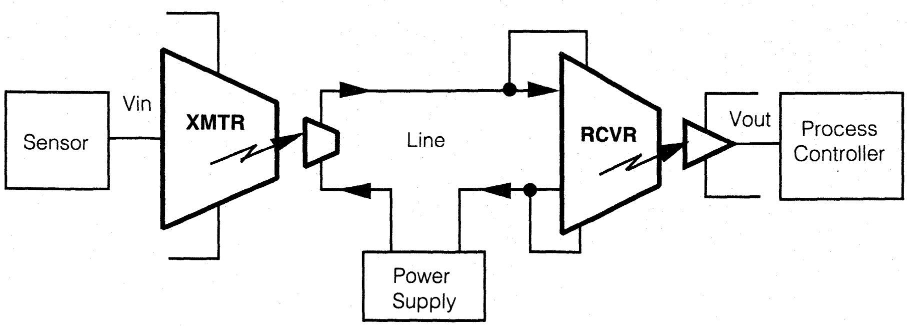
Introduction

Programmable Logic Controllers (PLC) were once only found in large manufacturing firms but now are used in small to medium manufacturing firms. PLCs are being retrofitted into manufacturing environments where temperature, pressure, and level sensor control signals are exposed to harsh electrical noise. The connection between these sensors and the controller requires the use of high noise immunity communication technology.

One solution to this communication problem is the analog current loop. A current loop is an interface technique that converts a process sensor's output to a DC current signal. When compared to voltage control techniques, a current loop receiver's low input resistance offers higher noise immunity. Current loops have the added advantage of better accuracy, because they eliminate sensor signal errors introduced by communication line resistance.

Electrical noise can be reduced further by providing isolation between the current loop receiver or transmitter and the process controller. An isolated receiver and transmitter can be constructed using the IL300, linear optocoupler. This application note will describe how to design a line powered isolated current loop receiver and transmitter. It will discuss the design process and show circuit variations compatible with common current loop pseudo-standards.

Figure 1. Isolated transmitter and receiver current loop



Current Loop Elements

A current loop typically consists of a transmitter, a receiver, and a DC power supply. The highest insulation and noise immunity is achieved when an isolated transmitter and an isolated receiver are used as shown in Figure 1. However there are many situations where only one end of the loop can be isolated. Figures 2 and 3 illustrate combinations of isolated and non-isolated current loop elements.

Isolated current loop transmitters and receivers commonly require separate isolated power supplies in addition to the standard loop voltage supply. The designs in this application note derive their power from the DC supply found in the loop. Commonly the loop power supply is an isolated voltage supply whose output voltage will range from 10 to 24 volts. Thus only a single isolated power supply is needed to power the loop.

Current Loop Conventions

The 4–20 mA current loop is the most common pseudo-standard. This convention defines a 4 mA loop current as the sensor's zero reference. The full scale of the sensor output corresponds to a 20 mA loop current, representing a minimum to maximum current ratio of 1:5. The sensor's signal output commonly has a zero reference of +1 volt and a full scale of +5 volts which also corresponds to a 1:5 signal ratio and a +4 volt

Figure 2. Isolated transmitter and non-isolated receiver current loop

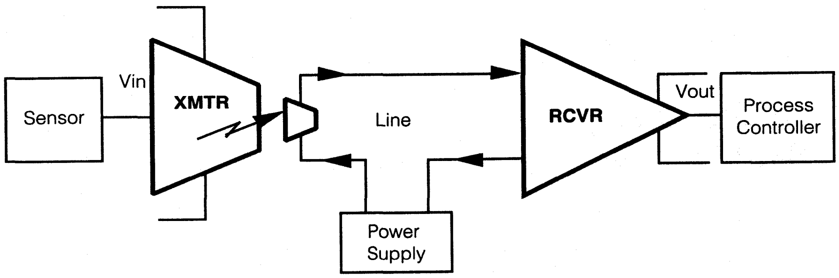
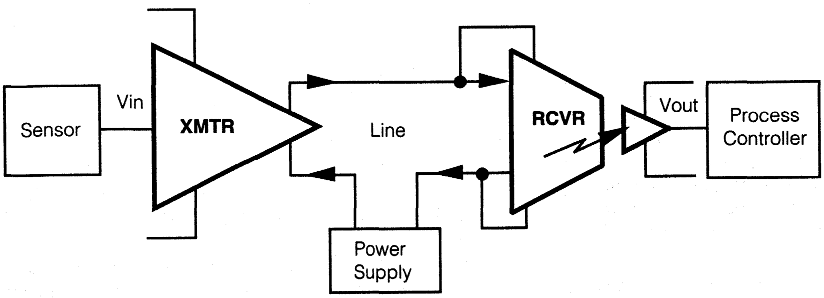


Figure 3. Non-isolated transmitter and isolated receiver



span. Figure 4 shows the transmitter's output loop current as a function of input sensor voltage. Other conventions include sensor signal spans of 5 volts, where the sensor's zero reference is 0 V, and full scale is +5 volts (Figure 5).

Figures 4 and 5 show the transmitter transfer function. The loop current (IL) is the product of the sensor voltage (Vin) times the transmitter transconductance, milli-Siemens. The receiver in Figure 4 has a transresistance of 250 Ω, while for Figure 5 it is 312.5 Ω

Figure 4. 1–5 V to 4–20 mA current loop transfer

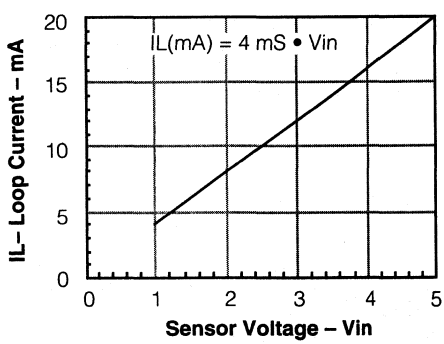
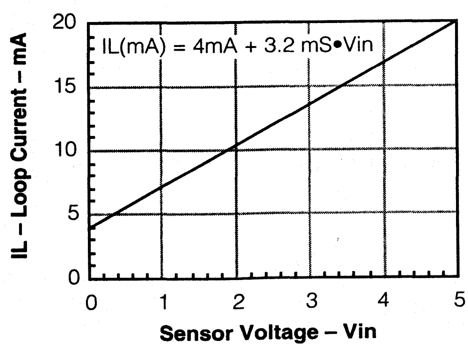


Figure 5. 0–5 V to 4–20 mA current loop transfer



Current Loop Transmitter

Figure 6 shows an isolated current loop transmitter with a 1–5 V input and a 4–20 mA output. The sensor section consists of an optical feedback amplifier (U1, IL300) that converts the sensor voltage (Vin) to an output photocurrent (IP2). The output amplifier, U2, operates as a current controlled current sink. The equation for the line current (IL) as a function of the output photocurrent (IP2) is given below:

$$Io = \frac{IP2 \cdot R3}{R4} \quad (1)$$

The equation for the output photocurrent, IP2, as a function of the sensor voltage is given below:

$$IP2 = \frac{Vin \cdot K3}{R1} \quad (2)$$

Combining Equations 1 and 2 results in the complete transmitter DC transfer relationship with K3 the IL300's transfer gain.

$$\frac{Io}{Vin} = \frac{K3 \cdot R3}{R1 \cdot R4} \quad (3)$$

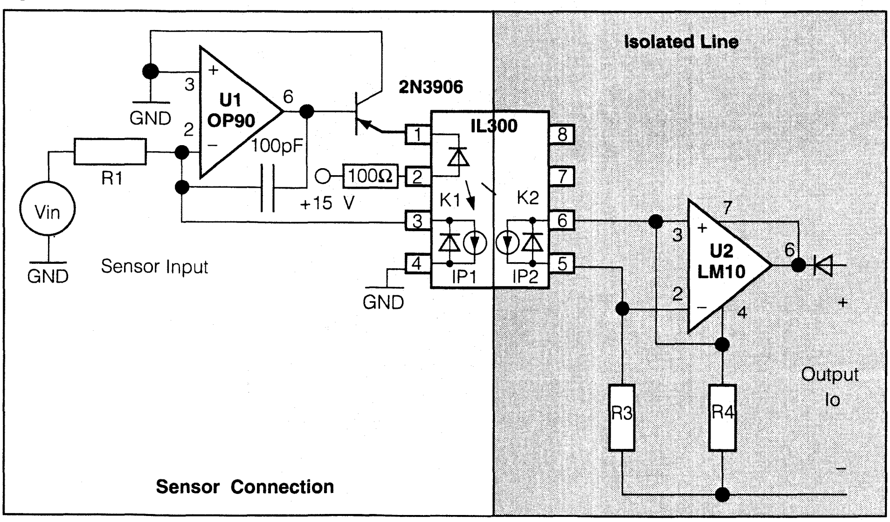
1–5 V to 4–20 mA Transmitter Design

The design of the 1–5 V input, 4–20 mA output isolated current loop transmitter starts with analyzing the isolated current to current converter. This amplifier (U2), a National Semiconductor LM10 operational amplifier, was chosen for its high output current and ability to operate from a single supply. The input sensor amplifier controls the output photocurrent (IP2). IP2 develops a voltage across R3 at the inverting input of U2, forcing a loop current to flow through R4. Thus Io times R4 is equal to the voltage developed across R3 times IP2 (Equation 4). Equation 5 shows that resistors R3 and R4 set U2's current gain.

$$IP2 \cdot R3 = Io \cdot R4 \quad (4)$$

$$Current\ Gain = \frac{R3}{R4} \quad (5)$$

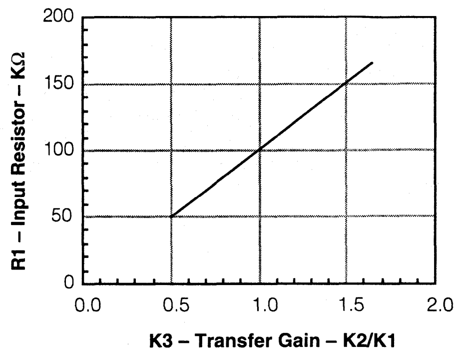
Figure 6. Isolated 1–5 V, 4–20 mA transmitter



A current gain of 400 is selected, with R4 equal to 50 Ω. From Equation 5, R3 is 20 KΩ. Equation 1 shows that a loop current of 4-2 mA requires an output photocurrent (IP2) of 10–50 μA.

The last design step is to determine the input resistor (R1) by rearranging Equation 3. The transconductance, Io/Vin of Figure 6, is 4 milli-Siemens (mS). The remaining variable is the IL300's transfer gain, K3. The part to part variation of the transfer gain offers a range of 0.56 to 1.53. With K3=1, R1 is calculated to be 100 KΩ from Equation 6. See Figure 7 for the spread of R1 versus the guaranteed range of K3. Thus a 200 KΩ, 10 turn potentiometer will compensate for the full distribution of K3.

Figure 7. R1 versus K3 for isolated 1–5 V, 4–20 mA transmitter



$$R1 = \frac{K3 \cdot 20\,K\Omega}{6\,mS \cdot 50\,K\Omega}$$

$$R1 = 100\,K\Omega \quad for\ K3 = 1.0$$

0–5 V to 4–20 mA Transmitter Design

A current loop transmitter conforming to the pseudo-standard of 0-5 V input to 4–20 mA output can be designed using the general circuit topology in Figure 6. With the addition of a bias source (Vref) 4 mA of line current will flow when Vin=0 V. The LM10 offers an integrated 200 mV band gap reference source with voltage follower buffer amplifier. The LM10's voltage reference and differential amplifier make it uniquely qualified as the output current amplifier. Figure 8 shows the schematic of a current transmitter including a bias source, U3.

By inspection and using Equation 4, the transmitter current transfer function can be determined. The transfer function for Figure 8 is given in Equation 7.

$$Io = \frac{Vin \cdot K3 \cdot R3}{R1 \cdot R4} + \frac{Vref \cdot R3}{R2 \cdot R4} \qquad (7)$$

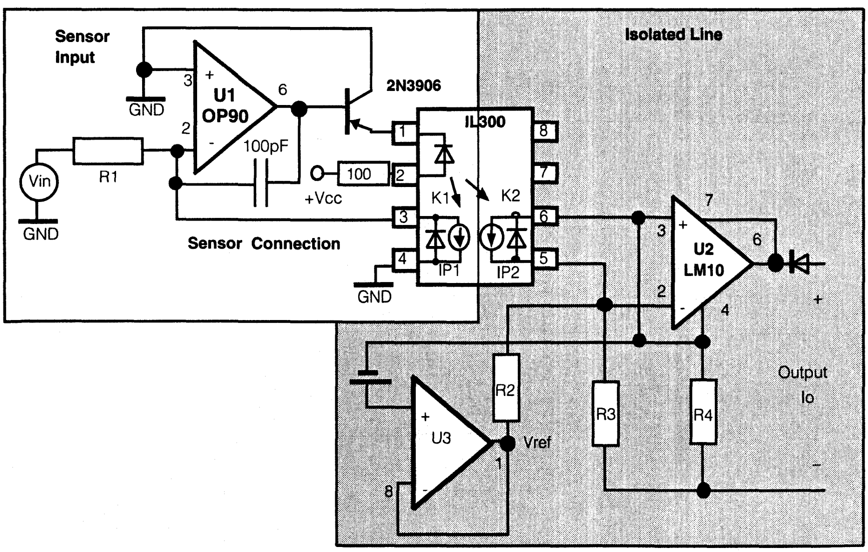
This equation shows that the loop current is the sum of the sensor controlled signal (Vin) and current provided by the bias source (Vref). The bias source consists of a voltage follower (U3) that buffers a 200 mV band gap reference. This voltage reference is converted to a current source by the R2 resistor. The value of R2 can be calculated from Equation 8, when Vin=0 V, and Io=4 mA.

$$Iref = \frac{Vref}{R2}$$

$$Io = \frac{Vref}{R2} \cdot \frac{R3}{R4} \text{ when } Vin = 0\ V$$

$$R2 = \frac{Vref \cdot R3}{Io \cdot R4} \qquad (8)$$

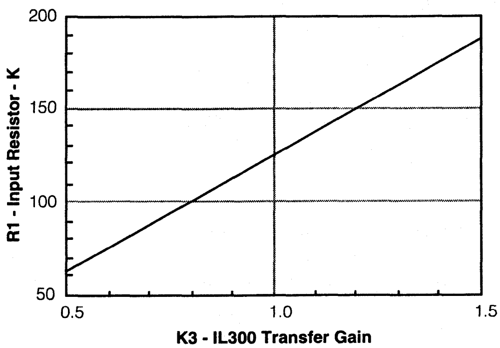
Figure 8. Isolated 0–5 V, 4–20 mA transmitter



Given the current gain, R3/R4=400, Vin=0 V, and Io=4 mA, R2 is calculated to be 20 KΩ.

The input resistor (R1) sets the transconductance (ΔIP2/ΔVin) of the input amplifier. The current transmitter's transconductance equals the transconductance of the input amplifier times the current gain of the output amplifier. The transmitter incremental transconductance is calculated given a ΔVin of 5 V, (0 V–5 V), and ΔIo of 16 mA (4 mA–20 mA). A transmitter transconductance 3.2 milli-Siemens results.

Figure 9. R1 versus K3 for isolated 0–5 V, 4–20 mA transmitter



$$\frac{\Delta IP2}{\Delta Vin} = \frac{K3}{R1}$$

$$\frac{\Delta Io}{\Delta Vin} = \frac{K3}{R1} \cdot \frac{R3}{R4} \quad (9)$$

$$\frac{R1}{\Delta Io} = \frac{\Delta Vin \cdot K3 \cdot R3}{R4} \quad (10)$$

Given a output amplifier current gain of 400 (R3=20KΩ, R4=50Ω), a typical K3=1, and a transmitter transconductance of 3.2 mS. Substituting R3, R4, and K3 into Equation 10, R1 can be determined.

$$R1 = \frac{1.0 \cdot 20\,K\Omega}{3.2\,mS \cdot 50\,\Omega} \quad (11)$$

$$R1 = 125\,K\Omega$$

Figure 11 shows the relationship of R1 as a function K3.

See Table 1 for the component values for each design.

Table 1. Isolated transmitter resistor values, K3=1

	0–5 V to 4–20 mA	1–5 V to 4–20 mA
R1	125 KΩ	100 KΩ
R2	20 KΩ	INF
R3	20 KΩ	20 KΩ
R4	50 KΩ	50 Ω

1–5 V to 4–20 mA Transmitter Performance

The transmitter described in Figure 6 was constructed and evaluated for accuracy and linearity as a function of input sensor voltage and ambient temperature. The transmitter was calibrated by adjusting R1 for 12.000 mA loop current with an input voltage of 3.000 V at T_A=23°C. Figure 10 shows the percent error deviation from the expected loop current. This circuit offers a typical accuracy of ±0.2% over a temperature range of 0°C to 75°C. Note that the temperature performance appears to follow a parabolic contour.

Figure 10. Percent error versus input sensor voltage 1–5 V to 4–20 mA transmitter

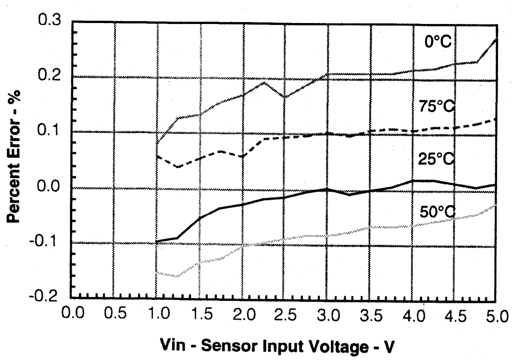
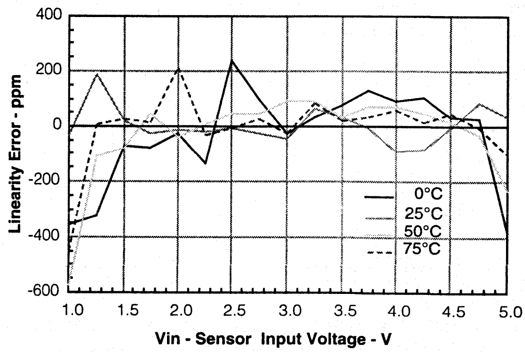


Figure 11. Linearity error versus input sensor voltage 1–5 V to 4–20 mA transmitter



Many industrial controllers have calibration techniques that can compensate for temperature imposed accuracy errors. These techniques are only valid if the transmitter exhibits a high degree of linearity. Figure 11 shows the linearity error for the transmitter. The linearity error is expressed as a deviation in parts per million (ppm) from a best fit linear regression at each temperature. Figure 11 shows a typical linearity of +200 ppm to –600 ppm over a 0°C to 75°C temperature range.

0–5 V to 4–20 mA Transmitter Performance

The transmitter in Figure 8 was constructed and evaluated for accuracy and linearity as a function of input sensor voltage and ambient temperature. The transmitter was calibrated by adjusting R2 for 4.000 mA loop current with an input voltage of zero volts (0.000 V). The R1 resistor is then adjusted for 12.000 mA loop current with an input voltage of 2.5 V at T_A=23°C. Figure 12 shows the percent error deviation from the expected loop current. This circuit offers a typical accuracy of +0.4% over a temperature range of 0°C to 75°C. Note that the temperature performance appears to follow a parabolic contour.

Figure 12. Percent error versus input sensor voltage 0–5 V to 4–20 mA transmitter

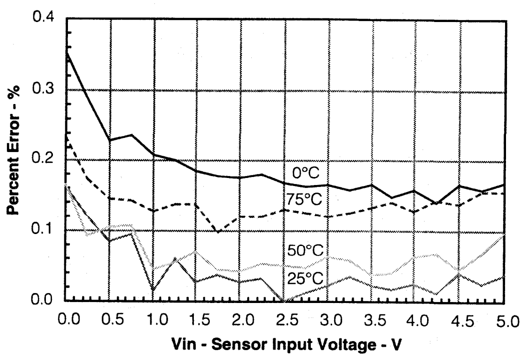
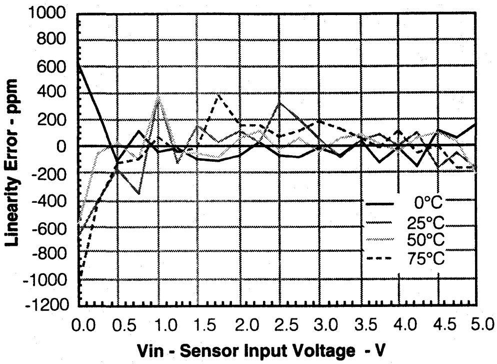


Figure 13 shows the linearity error for the transmitter. The linearity error is expressed as a deviation in parts per million (ppm) from a best fit linear regression at each temperature. Figure 13 shows a typical linearity of +600 ppm to –1000 ppm over a 0°C to 75°C temperature range.

Figure 13. Percent error versus input sensor voltage 0–5 V to 4–20 mA transmitter



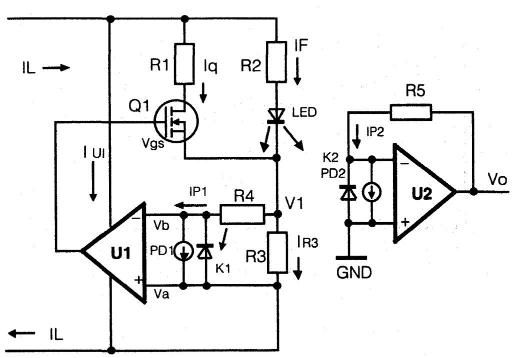
Current Loop Receiver

The sensor controlled, current loop signal is converted to a voltage by the current loop receiver. The receiver's conversion gain and output voltage span is determined by the adopted current loop standard. A 4–20 mA loop current is commonly converted to a 1 to 5 V output signal. The receiver design in this section conforms to this standard. Signal conversion and isolation are provided by an IL300, linear optocoupler. The circuit is loop current powered. The isolation feature and the receiver's low operating voltage drop permits multiple receivers within the loop.

Receiver Operation

The isolated current loop receiver consists of two sections. They include a loop current to photocurrent current amplifier, U1, and an output transresistance amplifier, U2. Figure 14 shows a simplified schematic. The receiver's linearity and stability are insured by using optical feedback within the loop current to photocurrent amplifier.

Figure 14. Isolated current loop receiver

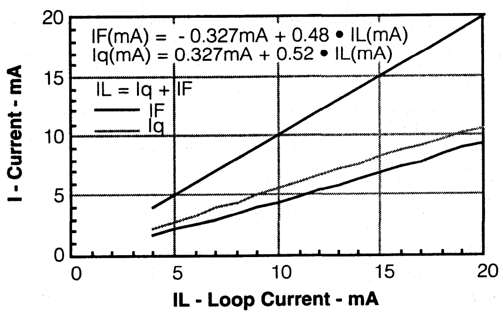


The optical feedback amplifier provides precise control of the LED's output flux. A bifurcated optical signal path within the IL300 provides an equally well controlled photocurrent for the output transresistance amplifier.

The loop current to photocurrent current amplifier consists of a single supply micro-powered differential control amplifier, U1, and an LED current shunt regulator, Q1. Shunt control of the LED current was chosen to accommodate the receiver's need for a low supply voltage operation.

The current loop receiver circuit functions as follows. The loop current (IL) flows into the junction of U1's Vcc (R1 and R2). U1's supply current (IU1) is substantially smaller than the loop current and will be omitted in the analysis. The loop current is divided at the juncture of R1 and R2. The sum of the currents flowing in each leg is equal to the loop current. The individual currents (Iq and IF) are determined by the required LED current to generate the needed photocurrent (IP1) connected to the control network at U1. Figure 15 shows the Iq and IF relationships for the receiver.

Figure 15. LED current shunt control



The total loop current flows into the junction, V1. This current, IR3, develops a voltage across R3. Under initial conditions, this positive voltage appearing at the inverting input of U1 will force U1's output towards the negative rail. This Vgs forces Q1 into cut-off. Under this condition the LED current (IF) equals the loop current (IL). This rise in LED current generates an optical flux which falls on the feedback photodiode (PD1) and generates a photocurrent (IP1). This photocurrent will rise to a value where voltage developed across R4 equals the voltage across R3. This satisfies the differential amplifier requirement of Va=Vb. U1's output provides the control signal for Q1's gate, forcing it into conduction and shunting excess loop current away from the LED current path. The feedback control relationship is shown in Equation 12.

$IP1 \cdot R4 = IR3 \cdot R3 \ ; \quad IR3 \sim IL$

$IP1 \cdot R4 \ IL \cdot R3$ (12)

The control relation shown in equation can be used to develop the current to current gain ratio. Recall the following IL300 gain equations.

$IP1 = K1 \cdot IF$ (13)

$IP2 = K2 \cdot IF$ (14)

$IP2 = IP1 \cdot K3$ (15)

Where: IP1 = feedback photocurrent
K1 = feedback gain
IP2 = output photocurrent
K2 = output gain
K3 = transfer gain (K2/K1)

With Equations 12, and 15, solve for IP2.

$$IP2 = \frac{R3}{R4} \cdot IL \cdot K3 \qquad (16)$$

The transfer gain can be written from Equation 16.

$$\frac{IP2}{IL} = \frac{R3}{R4} \cdot K3 \qquad (17)$$

The output current, IP2, is converted to a voltage by the transresistance amplifier U2. The output voltage gain equation is shown below.

$$Vo = IP2 \cdot R5 \qquad (18)$$

Combining Equations 18 and 17 results in the current loop transfer gain solution, Vo/IL (Equation 19).

$$\frac{Vo}{IL} = \frac{R3}{R4} \cdot R5 \cdot K3 \qquad (19)$$

LED Current Shunt Operation

The differential amplifier, U1, provides the control signal to the LED current shunt regulator. U1's output is connected to the gate of an N-Channel FET, Q1. This transistor is the control element of the LED current shunt regulator. The regulator consists of a network made up of the series connection of the FET and R1, in parallel with the series connection of the IL300's LED and R2.

The amplifier's output signal controls the FET's drain to source resistance, Rq. As the gate voltage is increased, the FET resistance will decrease causing a larger percentage of the loop current to be diverted away from the LED signal path. Thus a rising control voltage, Vgs, causes the LED current to decrease. A Siliconix TN0201L low enhancement voltage FET was selected as the control device for two reasons. First, with $Iq \le 20$ mA, the FET's gate voltage should be less than 3 volts. The TN0201L control characteristics as a function of loop current are shown in Figure 16. Second, the FET's dynamic resistance should be in the same order of magnitude as the IL300's LED dynamic resistance. The dynamic resistance of both the LED and FET are shown in Figure 17.

Figure 16. TN0201L gate voltage versus drain current

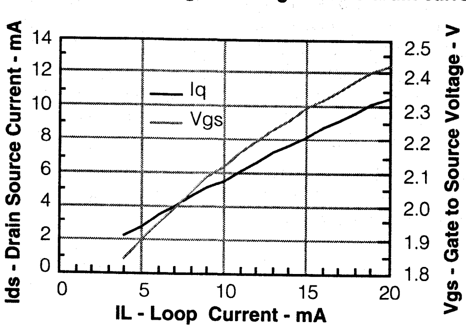
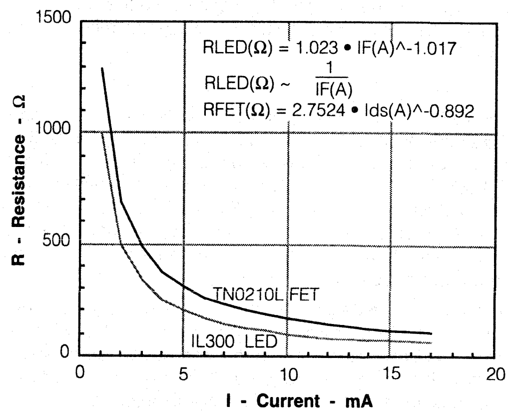


Figure 17. Dynamic resistance versus current



The shunt regulator includes a series resistor in each leg of the network. These resistors are included in the design for two reasons. First, to provide a measure of current overload protection for the LED and FET, and second to set the initial control conditions for the network.

The design equations are given below:

$$L = Iq + IF \qquad (20)$$

$$Vn = Iq\,(R_{FET} + R1) \qquad (21)$$

$$Vn = IF\,(R_{LED} + R2) \qquad (22)$$

Where: IL = loop current
Iq = Q1 drain current
IF = LED forward current
R_{FET} = Q1 dynamic resistance
R_{LED} = LED dynamic resistance
Vn = Voltage across the control network

Combining Equations 20, 21, and 22:

$$Iq\,(R_{FET} + R1) = IF\,(R_{LED} + R2) \qquad (23)$$

Replacing Iq in terms of IF and setting to zero gives Equation 24

$$0 = R_{FET} - R_{LED} + R1 - R2 \qquad (24)$$

The LED and FET dynamic resistance equations are substituted into EQ 24.

$$0 = (2.7524 \cdot (IL - IF)\wedge - 0.892) - (1/IF) + R1 - R2 \qquad (25)$$

This transcendental equation is best solved by iterative techniques.

Current Loop Receiver Design

The current loop receiver design is divided into two sections. The first is the shunt regulator and second, is control the amplifier. The shunt regulator design relies on Equation 25 and intuitive selection of an LED operating point. The LED forward current is bounded by the loop current range which is 4 mA to 20 mA. The selection of R1 and R2 is determined by solving Equation 25 when the LED current, IF=10 mA, for a loop current equal to 20 mA. This point is selected to provide sufficient

FET current control range given the initial value range of K1 and its temperature dependence. Under the IF and IL conditions selected, Equation 25 will provide the resistance range for R1 and R2.

$$R2 - R1 = 67\,\Omega \qquad (26)$$

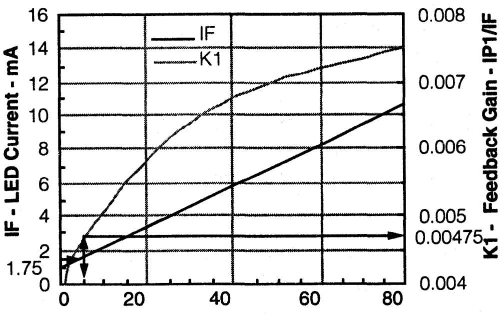
Equation 26 shows that R2 is greater than R1, and the recommended difference is 67 Ω. Given this guidance, a 100 Ω resistor is selected for R2. A larger value than the recommended 33 Ω is selected for R1. A 47 Ω resistor is used providing for greater LED current limiting. Given R1=47 Ω and R2=100 Ω, the LED current is calculated equation 25 at loop current extremes. At IL=4 mA, the LED current (IF) is equal to 1.735 mA, while for a loop current of 20 mA, IF=9.42 mA.

The next part of the design selecting the resistors, R3 and R4, surrounding the feedback control amplifier. Recall that R3 is the loop current sense resistor and should be valued less than 100 Ω. For this design example, R3=20 Ω. Equation 27 shows the relationship of R4 in terms of circuit variables.

$$R4 = \frac{R3 \cdot IL}{IF \cdot K1} \qquad (27)$$

Figure 18 shows the nonlinear nature of the feedback gain, K1, for the IL300. The worst case condition occurs when the loop current is at its minimum, IL=4 mA. Under this condition IF=1.75 mA. Figure 14 can be used to determine K1 under these conditions. The figure shows that at IF=1.75 mA, K1 equals 0.00475.

Figure 18. LED current and feedback gain versus feedback photocurrent



Substituting these values into Equation 27, R4 can be determined.

$$R4 = \frac{20\,\Omega \cdot 4\,mA}{1.75\,mA \cdot 0.00475} \qquad (28)$$

R4 = 9.62 kΩ, a 10 KΩ resistor is selected.

The final section of the design centers on the selection of the transresistance of the output amplifier shown in Figure 19. The feedback resistor (R5) combined with the operation of the output amplifier (U2) converts the IL300's output photocurrent (IP2) into the output voltage (Vo). The output voltage span (ΔVo) will be 1 V to 5 V, given a loop current span (ΔIL) of 16 mA. This relationship substituted into Equation 19 can be used to solve for R5.

$$R5 = \frac{\Delta Vo \cdot R4}{\Delta IL \cdot K3 \cdot R3} \qquad (29)$$

$$\Delta Vo = Vo_{MAX} - Vo_{MIN} \qquad (30)$$

$$\Delta IL = IL_{MAX} - IL_{MIN}$$

$$R5 = \frac{(Vo_{MAX} - Vo_{MIN}) \cdot R4}{(IL_{MAX} - IL_{MIN}) \cdot K3 \cdot R3} \qquad (31)$$

$$R5 = \frac{(5V - 1V) \cdot 10\,K\Omega}{(20\,mA - 4\,mA) \cdot 1.0 \cdot 20\,\Omega} \qquad (32)$$

$$R5 = 125\,K\Omega$$

The final circuit of the isolated current loop receiver is shown in Figure 19.

The circuit is completed by adding two diodes placed in series with the loop. The diode, D2, is a protection device which will block current flow if the receiver's loop voltage source is improperly connected. The diode, D1, performs two functions: (1) a visual indicator of loop current flow, (2) functions as a 2 V drop in the loop. This voltage drop is needed to provide supply head room for the control of the shunt regulator FET.

Receiver Performance 4–20 mA Loop Current, 1–5 Volt Output

The receiver in Figure 19 was constructed and evaluated for accuracy and linearity as a function of input loop current and ambient temperature. The receiver was calibrated by adjusting R6 for 3.00 V output with a loop current of 12.00 mA at T_A=23°C. Figure 20 shows the percent error deviation from the expected output voltage. This circuit offers a typical accuracy of +0.8% to –0.5% over a temperature range of 0°C to 75°C. Note that the temperature performance appears to follow a linear temperature characteristic. Figure 18 shows a typical temperature coefficient of 175 ppm/°C.

Many industrial controllers have calibration techniques that can compensate for temperature imposed accuracy errors. These techniques are only valid if the receiver exhibits a high degree of linearity. Figure 21 shows the receiver's linearity error as a deviation in parts per million (ppm) from a best fit linear regression at each temperature. Figure 21 shows a typical linearity of +300 ppm to –1000 ppm over a 0°C to 75°C temperature range.

Conclusion

Isolated current loops offer the industrial control designer the peace of mind that electrical noise and grounding problems will not influence the sensor signal. This application note has shown the design technique and results to construct a line powered 4–20 mA current loop receiver. It also presented two isolated current loop transmitters, one conforming to the 1–5 V input and a second to the 0–5 V input standard.

The performance data in this application note shows that the receiver and transmitter easily conform to a 8-bit operation over a 0–75°C operating range.

Figure 19. Isolated current loop receiver

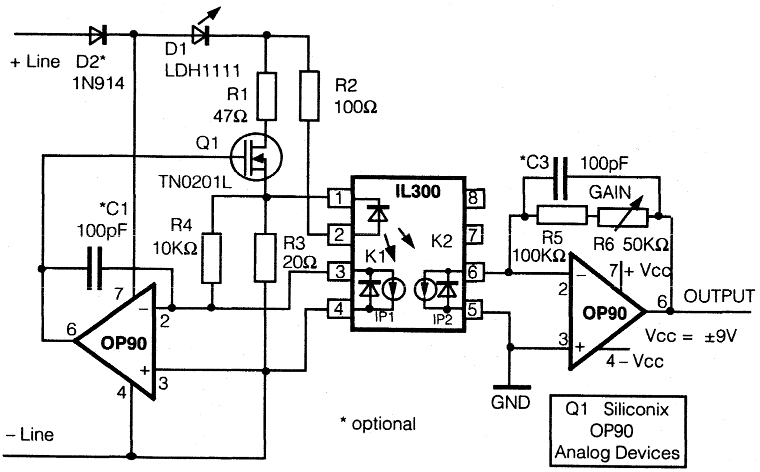


Figure 20. Percent error versus loop current 4–20 mA receiver

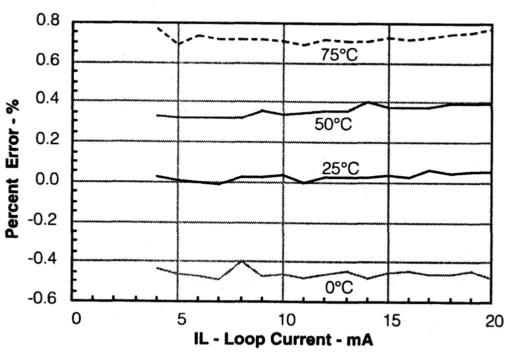
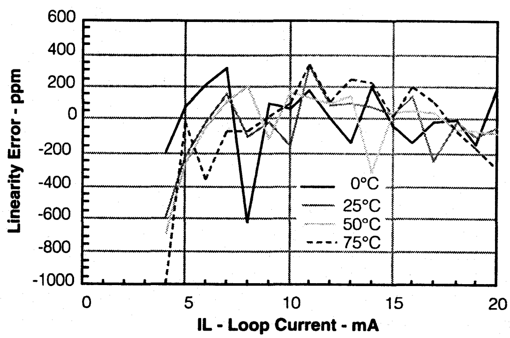


Figure 21. Linearity error versus loop current 4–20 mA receiver



SIEMENS

Optoelectronic Feedback Control Techniques for Linear and Switch Mode Power Supplies Appnote 55

by Bob Krause
Applications Engineering Manager

Introduction

The power supply designer is continually being pressured to provide units which have higher efficiency, better regulation, less EMI & RFI, smaller size and weight, all at a lower cost. The solution to this problem is a combination of circuit topology, layout, and supply control. This appnote will address output control techniques for linear and Switch Mode Power Supplies (SMPS). Specifically it will cover control techniques using standard phototransistors and a new family of linear optocouplers.

Isolated Regulation

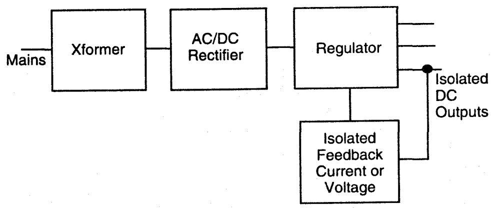
National and international safety agencies require a supply's output to be isolated and insulated from the AC mains. Many supply manufacturers have elected to offer power supplies that satisfy all national and international safety insulation criteria by selecting power transformers and feedback devices that meet a 3750 Vac withstand tests voltage. Feedback systems that use optocouplers easily comply with this insulation criteria. Optocouplers also offer a high degree of noise rejection or isolation combined with its insulation characteristics.

Linear Power Supply Feedback

Linear power supplies comply with the main insulation and isolation safety requirements by virtue of the primary/secondary insulation of the power transformer. There are numerous circumstances where isolated feedback in a linear power supply is needed. Requirements such as monitoring high voltage power supplies, current measurement in the high side of the supply, or monitoring multiple isolated outputs. Figure 1 shows a typical block diagram.

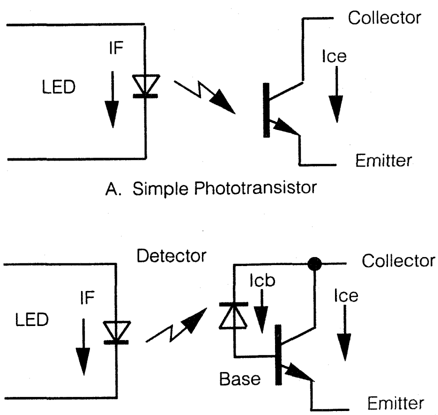
The feedback system for a linear power supply should be DC transparent and continuous. A standard phototransistor coupler when properly specified can perform the feedback function. To properly specify the phototransistor it is important to review the elements that contribute to a coupler's operation. Figure 2 shows the phototransistor optocoupler schematic.

Figure 1. Linear power supply phototransistor model



Originally presented at the PCIM®/Power Quality®, 1993 Conference, Irvine, CA, U.S.A.

Figure 2. Phototransistor coupler schematic



A. Simple Phototransistor

B. Expanded Simple Phototransistor

Phototransistor optocouplers are current amplifiers. These couplers include an infrared light emitting diode, LED, and an NPN silicon phototransistor. Figure 2A shows the common schematic of a standard phototransistor optocoupler. Figure 2B is an expanded schematic that includes a collector-base photodetector. An input LED current, IF, creates an optical flux, which is detected by the photodiode. The photodiode develops a photocurrent, Icb, which is amplified by the phototransistor. The phototransistor supplies a collector-emitter current, Ice. The current gain of the device is defined as a Current Transfer Ratio (CTR) and expressed as a percentage. The CTR relationship is given in Equation 1.

$$CTR = \frac{Ice}{IF \times 100}\% \qquad (1)$$

The relationship of the LED forward current flux creation and the generation of photocurrent is called Current Transfer Ratio Collector-Base (CTRcb). See Equation 2.

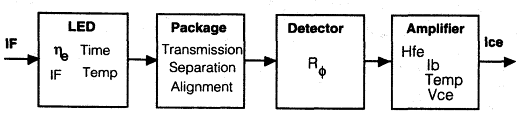
$$CTRcb = \frac{Icb}{IF \times 100}\% \qquad (2)$$

Combining Equation 2 with the transistor current gain, Hfe, provides a more complete optocoupler gain equation.

$$CTR = \frac{Icb}{IF \times Hfe \times 100}\% \qquad (3)$$

The relationship given in Equation 3 can be shown in a block diagram of the four elements that make up the DC transfer function of the phototransistor coupler. These elements are shown in Figure 3.

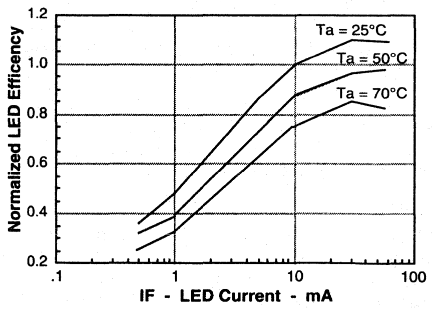
Figure 3. Phototransistor block diagram



The LED, package, detector, and transistor components have independent variables contributing to the optocoupler transfer function. The performance of the LED is influenced by four variables. These include the LED's external quantum efficiency, η_e, the forward current, I_F, junction temperature, T_J, and the total operation time.

The LED's external quantum efficiency, η_e, specifies the electrical to optical conversion factor. The optimum efficiency is determined by LED construction, for example, a GaAs LED has an η_e of approximately 10%, while the η_e for a AlGaAs LED may be as high as 30%. The operational LED efficiency is determined by the three remaining variable. The two most important are junction temperature and LED current. The LED's, η_e has a negative temperature coefficient, typically –1%/°C. Figure 4 shows the temperature dependence. This figure shows that when the LED junction experiences a 50°C temperature change, for example, from 25°C to 75°C. The output of the LED may be reduced by as much as 50%. The temperature characteristic is more pronounced at a lower LED drive current. As the LED current is increased this coefficient may fall to –0.5%/°C.

Figure 4. Normalized LED efficiency



The influence of forward current on LED efficiency is also shown in Figure 4. Note that a standard GaAs LED efficiency will be reduced by 50% when the LED current is changed from 10 mA to 2 mA. One can conclude that in DC circuit design the LED introduces large variations as a function of forward current and junction temperature.

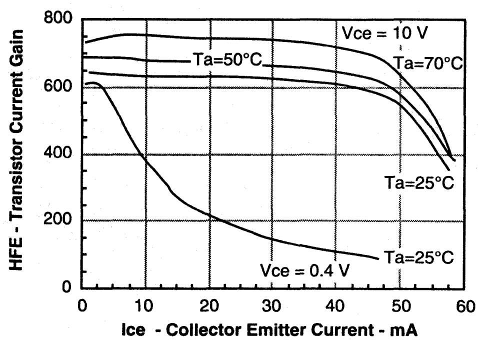
Today's LED processing techniques have all but eliminated efficiency reduction as function of time. LED efficiency reduction is commonly called CTR degradation. Typical degradation is less than 10% at 10 K hour and increases at a logarithmic rate.

The second element is the optical coupling (K_ϕ) within the package. Numerous assembly techniques exist for creating the LED-photodiode coupling path. However manufacturing variations introduce coupling deviations, such as, optical transmission media, emitter-detector separation distance, and alignment. K_ϕ is set at the time of manufacturing and is constant as a function of time and temperature.

The third element is the phototransistor's collector-base photodetector responsivity. This factor is the most consistent and linear element of the coupler. Process variations introduce worst case responsivity, R_ϕ, variations of less than 25%. The nonlinearity of the detector, over the designed photocurrent range, is less than ±0.1%.

The fourth element is the phototransistor current gain, HFE. The typical DC current gain showing the temperature, collector current, and V_{CE} influence on DC current gain is illustrated in Figure 5. Note that Siemens phototransistors do not exhibit the

Figure 5. Phototransistor HFE versus Ice and temperature



typical beta peak found at low (<1 mA) collector currents. It shows a typical HFE temperature coefficient of +0.5%/°C. The most noticeable is the influence that V_{CE} has on current gain. Figure 5 shows that the saturated gain (V_{CE} < 0.4V) is reduced by 30% for an LED current of 10 mA.

These four elements optocoupler elements create a linear DC transfer function, implying that a change in any one of these elements creates a factored change at the output. Functionally the relationship is shown in Equation 4.

$$I_{CE} = I_F \cdot (\eta_e\,(I_F, T_J, time) \cdot K_\phi(T,A,S) \cdot R_\phi \cdot HFE(Ib, T_J, V_{CE}) \quad (4)$$

This section has presented the basic DC model and resulting transfer equation of the standard phototransistor. The goal was to illustrate factors that effect the DC current gain. The designer is encouraged to review the characteristics of the optocoupler being considered and be aware of the temperature and LED current influences on the current transfer ratio of a simple phototransistor.

Most designers compensate for these variations by selecting narrow binned CTR optocouplers. Designer often compensate for gain variations by introducing negative feedback within a control loop. Equation 4 illustrates that typical voltage or current feedback techniques are not possible if insulation or noise isolation is to be maintained.

Optical Feedback Control Technique

The factors that influence the DC current gain of the optocoupler can be compensated by introducing optical feedback within the LED or input side of the coupler. This technique consists of including an optical detector or photodiode on the input that monitors the LED's output flux which is possible now with the introduction of Siemens family of linear optocouplers.

A DC coupler optical isolation amplifier using the new IL300 linear optocoupler is shown in Figure 6.

This optical isolation amplifier uses an operational amplifier (U1) as an electro-optical servo amplifier that controls the LED current. The servo photodiode is operated in the photovoltaic mode and is zero biased from its connection to U1's inverting and non-inverting inputs.

This circuit responds to positive unipolar voltages, as found at the voltage output of the power supply. Initially when the power supply is energized, Vin=0 V, IF and IP1 are also zero. As the input voltage rises, U1 forces a voltage across the LED causing it to emit light. The LED's optical flux generates a servo photocurrent (IP1) which is proportional to the input voltage, *IP1=Vin/R1*. The LED's current increases until sufficient servo photocurrent is generated to keep the difference between U1's inverting-noninverting inputs equal to zero volts.

The servo photocurrent is proportional to the LED's current. This relationship is defined as servo gain, *K1=IP1/IF.* Combining the two equations describes the LED's current dependence on input voltage,

$$IF = \frac{Vin}{K1 \times R1} \quad (6)$$

The isolated output circuit consists of a zero biased photodiode transresistance amplifier. This output amplifier is configured to generate an output voltage proportional to IP2 and the transresistance R2. The output photocurrent, IP2, is determined by the output transfer gain, K2=IP2/IF. The output gain equation is Vo=IP2•R2. Solving for LED current by combing the preceding equations results in:

$$IF = \frac{Vo}{K2 \times R2} \quad (7)$$

The composite DC transfer function of the input and output amplifiers can be determined when the equations 6 and 7 are combined resulting in the voltage gain equation.

$$\frac{Vo}{Vin} = \left(\frac{K2}{K1}\right) \times \frac{R2}{R1} \quad (8)$$

For simplicity the ratio of K2/K1 is defined as the transfer gain, K3. The transfer gain can rewritten as:

$$\frac{Vo}{Vin} = K3 \times \frac{R2}{R1} \quad (9)$$

The coupler's transfer gain (K3) is determined by the bifurcation of the LED's optical path within the coupler package. The time, temperature, and LED current have little effect on the transfer gain (Figure 7).

Figure 6. Optical feedback amplifier

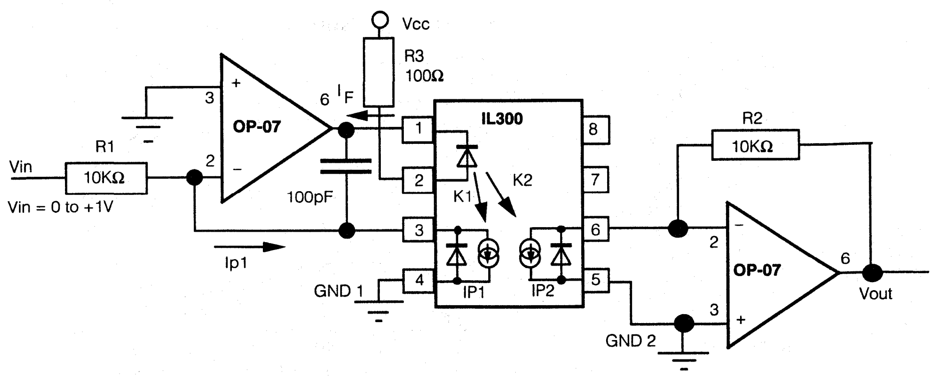


Figure 7. IL300 transfer gain, K3

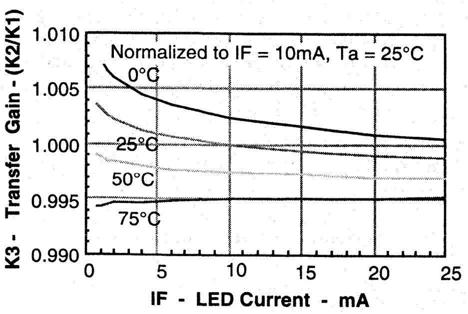


Figure 8. IL300 frequency and phase response

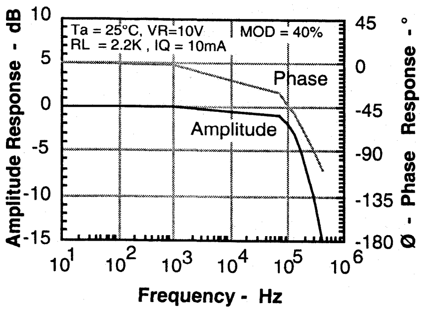


Figure 9. SMPS block diagram

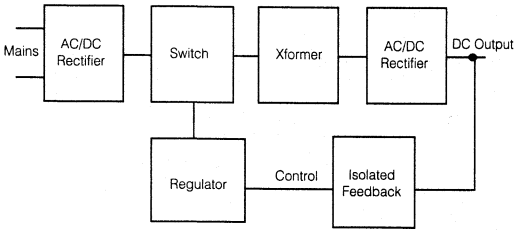


Figure 10. +5 V isolated feedback amplifier

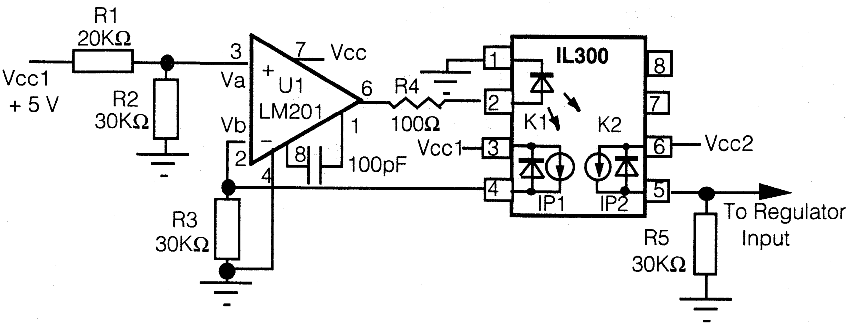


Figure 7 shows that the IL300's gain typically varies by only ±0.2% over an LED current range of 5 to 20 mA and has a temperature stability of ±50 ppm/°C.

Figure 8 shows the frequency and phase response curve that shows the –3 dB point and a phase shift of 45° occurs at a frequency in excess of 100 KHz.

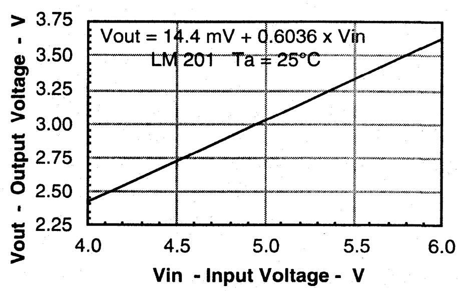
The optical feedback technique greatly improves the main characteristic needed for a feedback amplifier used in a linear power supply.

Mains Isolated Switching Power Supply

Today's mains connected switch mode power supplies require an insulated and isolated output voltage control method. Standard phototransistor optocoupler are one of the various techniques used to effect this regulation. With the goal of high switching frequencies the use phototransistor is being pushed to its frequency response limits. Most power supply designers have found that gain and phase flatness can only be assured to operating frequencies of ≤10 KHz. Given these limitations designers are considering the optical feedback optocoupler.

Figure 9 shows a block diagram of a typical SMPS. The isolated feedback section can be viewed as an isolated piece of wire connecting the DC output to the control pin of the switch mode regulator. A simple design using a LM201 low cost differential op-amp is shown in Figure 10. R1 and R2 function as a voltage divider, dividing the +5 V supply output to 3 V. The servo/feedback photodiode sources a feedback current (IP1) to R1 (30 KΩ). This resistor will develop 3 V when 100 µA flows through it. With K3 =1 a similar value of 100 µA will flow through R5 (30 KΩ).

Figure 11. LM201 DC transfer gain



Thus IP2 of 100 μA will develop the 3 V DC signal needed by the control pin of the regulator. Figure 11 shows the DC response of this amplifier. Figure 12 shows the phase and frequency response.

This feedback circuit offers linearity and gain accuracy of ±0.02% over a 4.0 V to 6.0 V input, Figure 13.

The previous examples used differential amplifiers as the summing device. It is possible to configure a single input DC amplifier that will perform the sample optical servo control. One such design is shown in Figure 14.

Figure 14 shows a DC coupled current feedback amplifier. Q1 and Q2 form the gain stages. The feedback photocurrent, IP is supplied to the summing network at Va. By inspection the nodal equation indicates that the photocurrent will be that necessary to create a 2 Vbe drop across R1. The input resistor is also sourcing current to this node. Thus as the input voltage rises the photocurrent will drop, for this reason this amplifier functions as an inverting amplifier. The frequency response and phase response for Figure 14 is shown in Figure 15.

Given this circuit's simplicity, gain accuracy and linearity are not compromised. The linearity error for this amplifier is ±0.015% as shown in Figure 16.

Figure 12. LM201 phase and frequency response

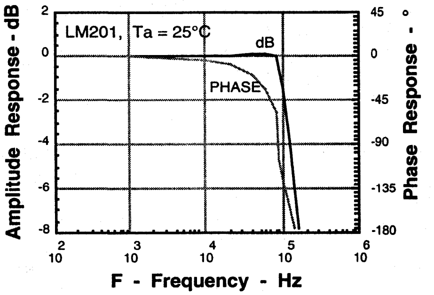


Figure 13. LM201 linearity error

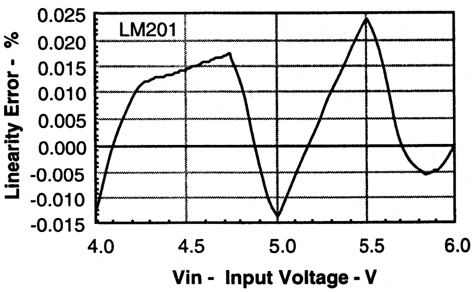


Figure 15. Discrete isolation phase and frequency response

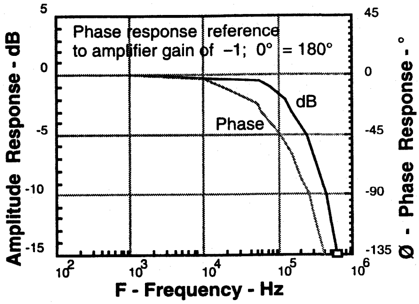


Figure 16. Discrete isolation linearity error

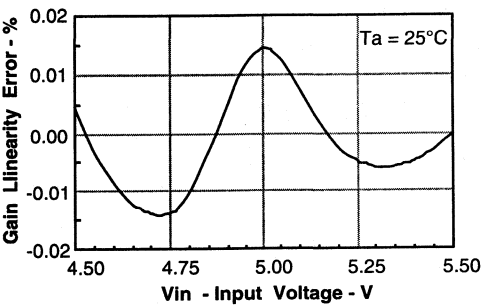


Figure 14. Discrete isolation amplifier

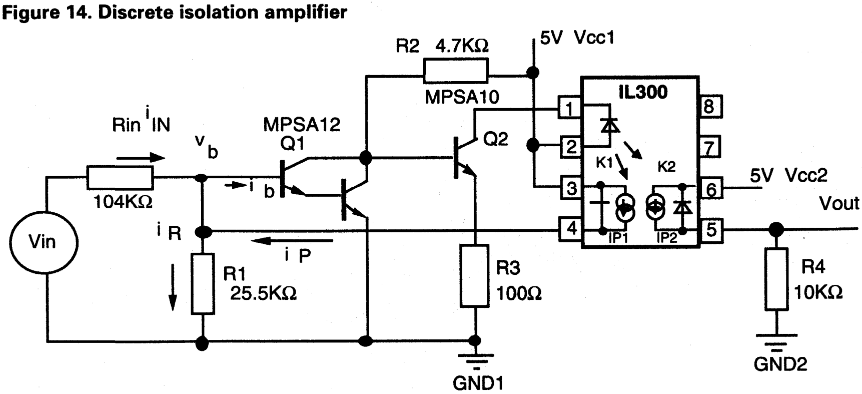
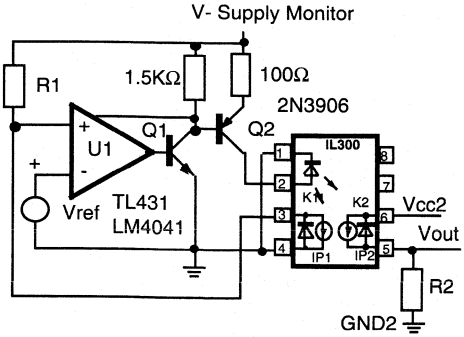


Figure 17. Shunt voltage regulator



Most power supply designers are familiar with TL431 and LM4041 precision adjustable zener diode. When you look more closely at the internal operation of this device you will find that it too can function as a optical feedback amplifier for the IL300, Figure 17.

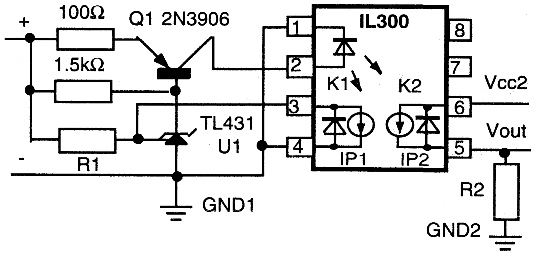
The three terminal regulators includes U1, Q1, and the precision reference, Vref. The linear coupler will supply sufficient photocurrent to develop a difference voltage across R1. The transfer equation for this amplifier is given in Equation 10.

$$\frac{Vo}{Vmon - Vref} = \frac{R2}{R1} \times K3 \qquad (10)$$

The precision voltage reference (Vref) is 2.5 volts for the TL43. When lower voltage supplies, i.e., 3.3 volts are to be regulated, the new LM4041 with a reference of 1.225 volts can be used.

The designer may be more familiar with the circuit schematic shown in Figure 18.

Figure 18. Shunt voltage regulator isolation amplifier



Conclusion

This appnote was a generic presentation of the DC model of the standard phototransistor. Most designers have overcome many of standard phototransistor's temperature and initial gain variations by selecting well specified couplers such as the CNY17-X family.

When wider bandwidth and greater gain stability is required power supply designers are using the new optical feedback linear optocouplers. The circuits provided and their performance characteristic will satisfy even the most demanding high frequency SMPS applications.

SIEMENS

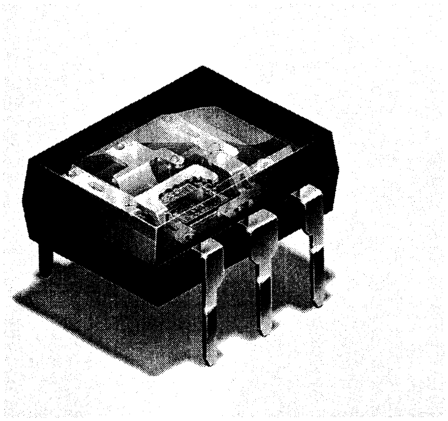
Solid State Relays
Appnote 56

Introduction

Siemens offers a full line of miniature MOSFET solid state relays (SSRs) for use in telecommunication, industrial control, security, and instrumentation applications.

MOSFET SSRs have an optocoupler construction, but have a pair of MOSFETs on the output instead of a phototransistor. A pair of source-coupled MOSFETs emulate an electromechanical relay by providing bidirectional switch capability and a linear contact. No output power supply is required.

Figure 1. SSR internal view



The advantages of the MOSFET contacts are solid state reliability and long life as well as very low thermal switch offset, extremely high off-resistance, and lack of contact bounce. Thermal switch offset is actually a misnomer for SSRs. Any contact offset voltage is photo induced. This photo-induced voltage is extremely low and typically runs about 0.1 μV. These attributes make SSRs a significant contender in applications historically served by reed relays.

In some designs, however, the user must consider the contact on-resistance and capacitance. Because MOSFET on-resistance is dominated by the bulk resistivity in the n-drift region and there is no bipolar junction, no diode offset exists in the MOSFET SSR I-V characteristics and the on-resistance is extremely linear. The contact capacitance of a MOSFET SSR is higher than an open contact of an electromechanical relay. This precludes traditional SSRs from a number of high-frequency applications, making them more suitable for dc, power, and audio frequency applications. Switch capacitance is a function of the MOSFET's overall size. For a given voltage, the lower the MOSFET's on resistance, the higher the capacitance.

An internal view of a Siemens SSR shows the LED input and a monolithic switch output (Figure 1). The switch is built using a Smart Power BiCMOS technology. Individual components are fabricated in dielectrically isolated tubs. A fully integrated die has many advantages. Higher reliability is achieved due to a reduction in the amount of wire bonds. Finer control over circuit operating parameters is realized and higher-performance circuits like current limiting and make-before-break operation are easily integrated.

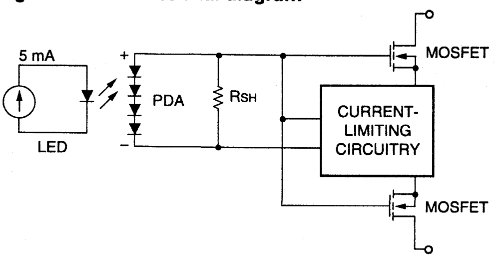
These miniature SSRs are offered in 6-pin packages, DIP or surface mount, with single pole, normally open (1 Form A) or normally closed (1 Form B) contacts. They also come in 8-pin DIP or surface-mount packages with two normally open (dual or 2 Form A) or normally closed (dual Form B) contacts. Single-pole, double-throw (1 Form C) contacts are also available in 6- or 8-pin packages. Some SSRs are also available in a low-profile, small-outline package (SOP).

Functional Description

The infrared light emitted by a gallium-aluminum-arsenide (GaAlAs) LED within the relay, controls the switch output. The LED is placed over the output-control switch, directing light downward onto a stack of photodiodes. This is called an over-under design. Both input and output silicon are fully encapsulated in a translucent inner-mold compound that passes light while providing a reliable, sustaining dielectric barrier in the thousands of volts. A dark outer mold compound, with a matched thermal expansion coefficient to the inner-mold compound, is then applied creating a doubled-molded package.

In a basic schematic for an optically coupled MOSFET SSR, the photodiode array acts as a floating power source for the MOSFET switches (Figure 2). Each diode is fabricated in its own dieletrically isolated tub. Current-transfer ratios are small, and dielectric isolation provides optimum light reception with no leakage to the substrate. Each diode acts as a 0.6 V battery when illuminated by the LED. With 20 to 30 diodes, ample voltage is generated to turn on the MOSFET pair, even at high operating temperatures where LED and photodiode output drop.

Figure 2. SSR functional diagram



To turn the relay, current is applied to the LED. The LED emits light, illuminating the inner mold and the photodiode array. The amount of light emitted is dependent upon the amount of forward current applied. For high temperature or high load current operation, more LED current is required. The photodiode voltage biases the normally open, enhancement-mode MOSFET gates positive with respect to their sources. For a normally closed depletion-mode MOSFET, the photodiode array would be wired to bias the gates negative with respect to their sources.

Figure 2 portrays a current-limiting circuit. This circuit is a unique feature on many of Siemens Form A SSRs. When current through the MOSFETs becomes greater than the SSR's rated value, the integrated current-limit circuit is activated. This circuit increases the impedance of the MOSFET switches thereby regulating the amount of current flowing through the SSR. When LED current is removed, the gate-to-source shunt resistance (R_{SH}) turns the MOSFET switches off by providing a discharge path for the gate charge. Siemens SSRs use either a JFET or MOS circuit for the gate-to-source shunt resistance in order to achieve fast turn-off. This control circuitry ensures a smooth "clickfree" turn-on and a slower turn-on than turn-off. This feature can sometimes be used to achieve break-before-make operation when using multiple relays. Most of Siemens Form C relays have the break-before-make feature built in.

Output Operation

Figure 3 shows the bidirectional or ac/dc I-V characteristics of a current-limited SSR. Figure 4 shows the bidirectional I-V characteristics of an SSR without current limiting. In operation, the SSR is exceptionally linear up to the knee current (I_K). This linearity provides a distortion-free contact, making it ideal for small-signal applications such as V.34 modems. Beyond I_K, the incremental resistance decreases, by approximately 35%, thereby minimizing internal power dissipation.

For SSRs with current limiting, overload currents are clamped at I_{LMT} by internal circuitry. The current-limiting circuitry exhibits a negative temperature coefficient, thereby reducing the current-limit value when relay temperature is increased. An extended clamp condition, which increases relay temperature, decreases the current-limit value, resulting in a current-foldback characteristic. When the overload current is removed, the relay immediately resumes its normal I-V characteristics.

Most 6-pin SSRs can be used in a unidirectional or dc mode. In this mode, ON-resistance is reduced by 75% and load currents are doubled. For unidirectional applications, pins 4 and 6 become the positive output of the relay and pin 5 becomes the negative output of the relay. Only the LH1510 provides current limiting in this configuration.

Figure 5 shows the unidirectional I-V characteristics of the LH1510 SSR. Figure 6 shows the unidirectional characteristics of the SSRs without dc current limiting. Here the SSRs are exceptionally linear up to and beyond their rated load current.

Figure 3. Typical ac/dc ON-characteristics of a current limited SSR

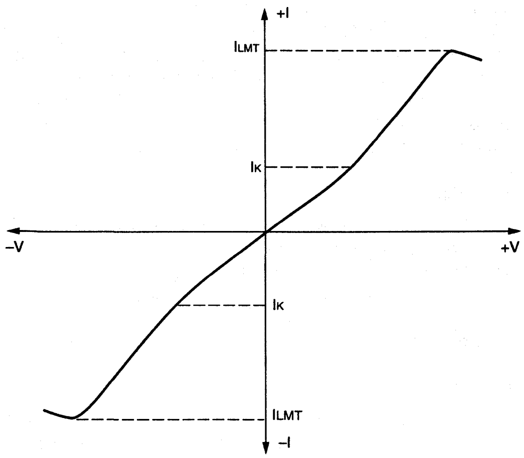


Figure 4. Typical ac/dc ON-characteristics of a SSR without current limiting

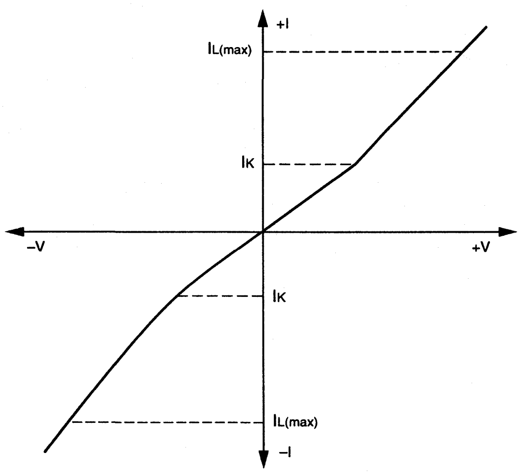


Figure 5. Typical dc characteristics of the LH1510, pins 4 and 6 shorted'

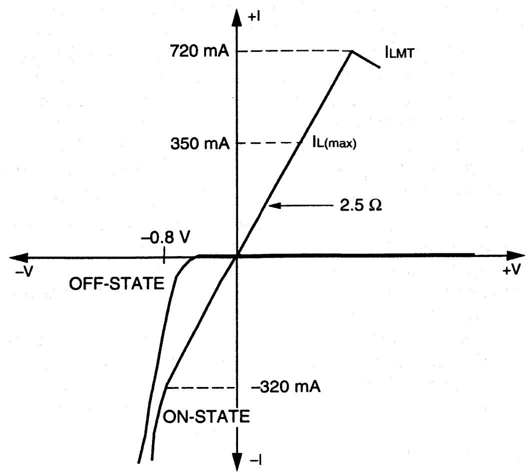
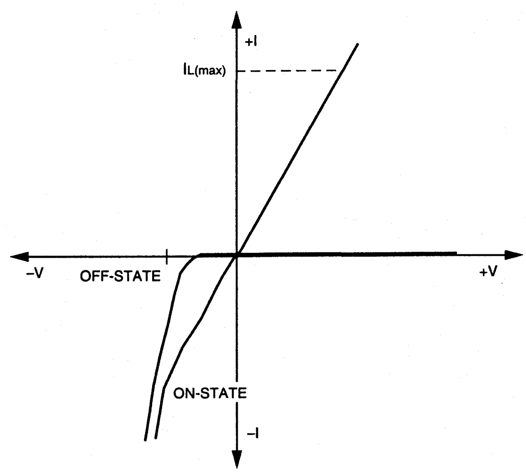


Figure 6. Typical dc characteristics of an SSR without dc current limiting, pins 4 and 6 shorted



SIEMENS

SSR Overvoltage Protection Appnote 57

Introduction

Since their inception, solid state relays (SSRs) have relied on overvoltage suppression devices such as metal oxide varistors (MOVs) to protect their outputs from voltage extremes such as overvoltage transients. Any voltage that exceeds the SSR's dc or peak ac load voltage, as specified in the absolute maximum ratings of the data sheet, could potentially damage the SSR. If overvoltage conditions are likely to occur (e.g., lightning or power-cross inductions from telephone lines, voltage spikes from turning off inductive loads like motors and transformers, or even surges from raw utility power), the outputs of the SSRs require an overvoltage suppression device. This application note explores the various types of protection devices and provides suggested recommendations on their selection and use with Siemens SSRs. Table 1 lists some suppression devices that are suitable for protecting Siemens SSRs.

Suppression Devices

There is a myriad of overvoltage suppressors with many different names. Most of these suppressors can be categorized into one of the following four groups.

Zener Diodes: These devices clamp voltages at their reverse avalanche breakdown value. They can be used back-to-back for bidirectional clamping.

Metal Oxide Varistors (MOVs): The MOV is a voltage-dependent variable resistor. Its structure consists of metal oxide grains with boundaries between the grains acting as PN junctions. The MOVs behave in a similar manner to the back-to-back zener diodes.

Gas Discharge Tubes: The miniature microgap gas tube clips voltage and then crowbars energy after their spark-over threshold is exceeded.

Semiconductor Suppressors: These devices are monolithic transient suppressors integrating SCR type thyristor and zener functions. These solid state suppressors clip voltage and then crowbar energy after their zener threshold voltage is achieved.

When choosing a suppression device, trade-offs between voltage overshoot, current handling capability, capacitance, leakage current, physical size, surface-mount capability, failure mode, and price need to be considered.

Attributes of Common Suppression Devices

Zener Diodes: Low-voltage overshoot, small size, surface-mount versions available, short-circuit failure mode.

MOVs: Capable of handling large surge currents, surface-mount versions available, short-circuit failure mode, inexpensive.

Gas Discharge Tubes: Capable of handling large surge currents, low capacitance, low leakage current.

Semiconductor Suppressors: Low-voltage overshoot, capable of handling large surge currents, low capacitance, low leakage current, short-circuit failure mode.

Suppression Techniques

There are various techniques available to protect an SSR and load from an overvoltage condition. Figure 1A shows an SSR wired in its dc configuration controlling an inductive load. To protect the relay from inductive flyback energy, a diode is placed across the load. When the relay turns the load off, flyback energy is shunted across the coil by the diode, thus eliminating extreme voltage potentials. However, this diode will not protect the relay from transients generated from other sources.

To fully protect the SSR, a zener diode placed across the contacts of the SSR is highly recommended. The zener diode will protect the SSR from any positive voltage transients when the SSR is off, while diodes, intrinsic to the MOSFET switch, will protect the SSR from any negative voltage transients. These transients should not exceed the SSR's peak load current value (approximately 400 mA per MOSFET). If larger currents are anticipated, use a discrete suppressor to provide an external shunt path. Figure 1B shows a similar application using an ac source with an SSR wired in its ac/dc configuration. Here MOVs are utilized for bidirectional protection. A third MOV (not shown) could be added, shunting both the load and the SSR.

This MOV would keep excessive ac source surge currents away from the load and SSR. This technique is commonly used in industrial and telecom applications. A variety of other techniques can be used where lightning surges are prevalent.

Figure 2 shows a basic data access arrangement (DAA) consisting of a telephone loop terminated into a transformer primary wet circuit, an SSR for on/off-hook control, and transient voltage suppression (TVS). Placing suppression devices across the SSR and the load is the safest approach to circuit protection. In this configuration, both suppressors need to be sized accordingly to handle surge currents.

An improvement of the circuit in Figure 2 is shown in Figure 3. Here the suppression device across the load is relocated and placed across both the load and the SSR. This suppressor will take the brunt of the surge current. The suppression device across the SSR has now reduced its role to solely protecting the SSR against inductive kicks from the load. Therefore, a suppression device with lower current handling capability can now be used. If the load is not inductive, the circuit can be further simplified by eliminating the protector across the relay as shown in Figure 4.

Another protection scenario is portrayed in Figure 5. If the load is capable of handling surge currents, then a suppression device placed directly across the SSR is adequate.

The most common protection technique is depicted in Figure 6. A TVS placed directly across the telephone loop bounds the transient voltage to a value lower than the SSR's load voltage value. A second suppressor device, usually a zener diode residing in the dc termination loop holding circuit, free wheels on inductive flyback from this dry transformer DAA circuit.

Suppression Device Selection

The first selection criteria is whether to use a suppression device that clamps (zeners) an overvoltage or one that clips the overvoltage and then crowbars the energy.

A crowbar device is necessary when the desired operating voltage approaches the SSR's maximum load voltage rating. At threshold voltage, crowbar protectors pull the transient voltage low keeping the voltage overshoot to a minimum. In contrast, the voltage across an MOV will rise as current through it increases.

Another important difference between a clamp and a crowbar suppressor when placed directly across an SSR is impressed voltage. A crowbar protector minimizes power dissipated in the SSR when a fault occurs by becoming a low impedance. If a crowbar protector is placed directly across the SSR's outputs, only a few volts will be across the SSR, thus keeping current flow through the SSR to a minimum. A clamp suppressor, on the other hand, allows its full clamp voltage across the SSR output. This could potentially damage an SSR if precautions are not taken. Siemens SSRs with current limiting minimize current flow through the SSR when high clamp voltage is exposed to it. These SSRs allow the designer to use an inexpensive MOV clamp suppressor without concern of damaging the SSR.

The main electrical parameters to consider when selecting a suppression device are clamping voltage and current capacity. The clamping voltage or breakover voltage should never exceed the SSR breakdown voltage. Determine the worst-case clamping voltage at peak pulsed current. MOVs have the highest voltage clamping ratio. For these devices, a large differential exists between voltages experienced under normal circuit operation and peak transient voltage. Whatever suppressor is used, size the device appropriately to absorb the worst-case fault current.

Other electrical considerations are suppressor capacitance, leakage, effects on circuit performance, and, if using a semiconductor suppressor, holding current. A semiconductor suppressor is a gated SCR-thyristor structure. Turn-on current is supplied to the gate of the SCR by a zener diode structure. The zener diode sets the threshold voltage of the suppressor. Once triggered, the SCR conducts current until the source current drops below a certain value. This value is referred to as holding current. It is important to select a suppressor that exhibits a holding current value higher than the circuit's highest operating current. In selecting a holding current value, note that the holding current will decrease with increased temperature and load impedance. Proper holding current selection will prevent the suppressor from remaining on after the overvoltage condition has passed.

Figure 1. SSR overvoltage protection

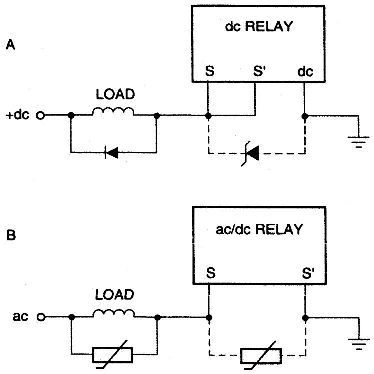


Figure 2. Basic DAA protection

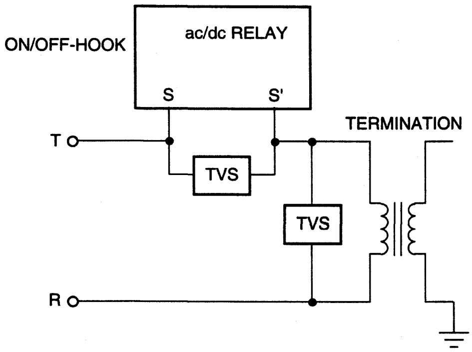


Figure 3. Basic DAA with lower current TVS across the SSR

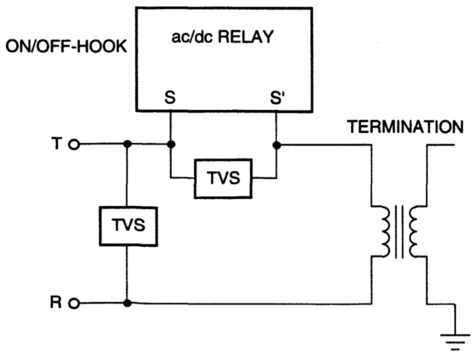


Figure 4. Basic DAA with resistor termination

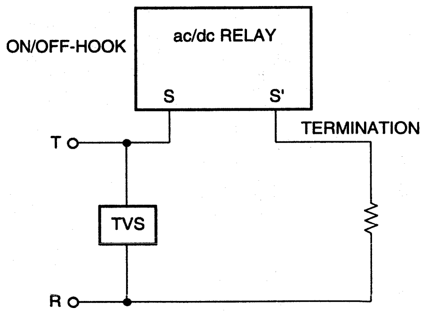


Figure 5. Basic DAA with load current capable of handling surge current

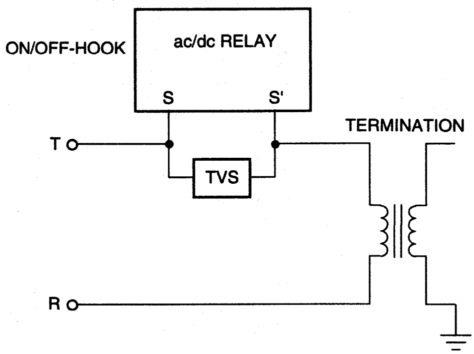


Figure 6. Typical DAA protection

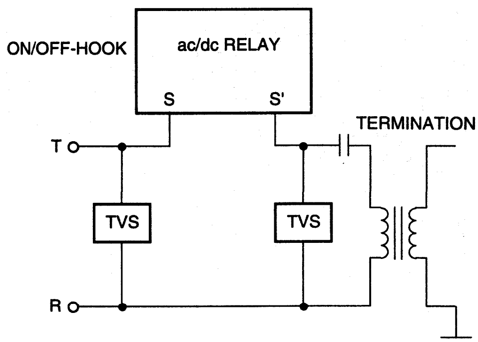


Table 1. Overvoltage protection device selection guide

Device Type	Manufacturer	Suppression Method	Package Type	Current Capability		Siemens SSR Load Voltage (V) 150	200	250	280	350	400	440
MOV	Siemens	Clamp	Disc Radial	2 J—90 J, 2 ms	Part # dc Op V	SxxK50 65	SxxK75 100	SxxK95 125	S14K115 150	SxxK130 170	SxxK150 200	SxxK175 225
MOV	Siemens	Clamp	Surface Mount	4 J—11 J, 2 ms	Part # dc Op V	CU4032K50G 65	CU4032K75G 100	CU4032K95G 125	CU4032K95G 125	CU4032K130G 170	CU4032K150G 200	CU4032K150G 200
MOV	Harris	Clamp	Disc Radial	6 J—80 J, 10x1000 µs	Part # dc Op V	V82ZA12 66	V120ZA1 102	V150ZA1 127	V150ZA8 127	V130LAxx 175	V150LAxx 200	V175LA10A 225
Trisil	SGS-Thompson	Crowbar	Axial	30 A, 20 ms	Part # dc Op V	TPA100A 100	TPA150A 150	TPA200B 200	TPA220B 220	TPA240A 240	TPA270A 270	TPA270A 270
Trisil	SGS-Thompson	Crowbar	Axial	50 A, 20 ms	Part # dc Op V	TPB100A 100	TPB150A 150	TPB200B 200	TPB220B 220	TPB240A 240	TPB270A 270	TPB270A 270
Gas Discharge	Mitsubishi	Crowbar	Radial		Part # dc Op V							DSS-301L 250
Sidactor	TECCOR	Crowbar	TO-92/ TO-220	50 A, 10x1000 µs	Part # dc Op V	P1300EA70 120	P1500EA70 135	P2400AA61 220	P2500AA61 240	P3000AA61/ P3100EA70	P3300AA61 300	P3300AA61 300
Surgector	G. E.	Crowbar	TO-220	100 A, 10x1000 µs	Part # dc Op V			SGT23B13 230	SGT27B13 270	SGT27B13 270	SGT27B13 270	SGT27B13 270

Note:
All suppressors are bidirectional

SIEMENS

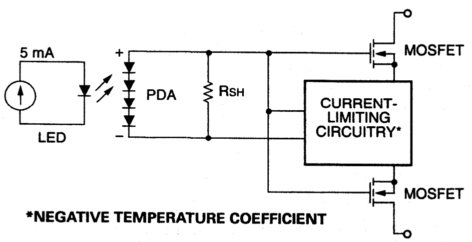
Solid State Relay
Current Limit Performance
Appnote 58

Description

Most Siemens Form A solid state relays (SSRs) have built-in, active, current-limit circuitry. This feature protects not only SSRs, but can also protect the circuitry beyond the SSRs from fault conditions. These SSRs limit current through the device at a prescribed value. Current-limit trip and reset is automatic, smooth, fast and precise.

Refer to Figure 1. In operation, current through the input LED produces light for the photodiode array (PDA). The PDA develops a voltage that is directly applied to the gates of the MOSFET switches. If excessive current flows through the MOSFETs, the current-limiting circuitry activates and pulls down on the PDA, robbing current and dropping the voltage available for the gates of the MOSFET switches. Lower gate voltage increases switch resistance and thereby limits the current through the switches.

Figure 1. Current-limit SSR schematic



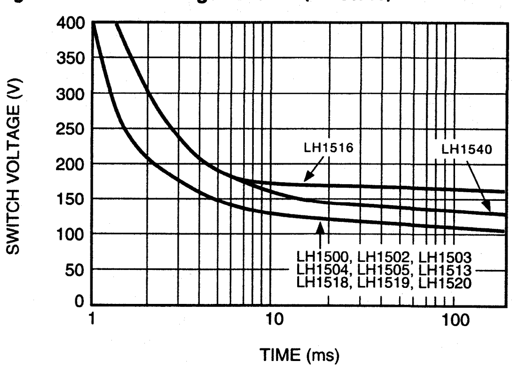
The current-limit circuit has a negative temperature coefficient, thereby limiting power dissipation to safe levels during extended high on-voltage conditions. When the excessive current is removed, the SSR immediately resumes normal operation.

How an SSR performs in current limiting depends on how it is driven into current limiting. A dc current allows the SSR to gradually heat up, slowly decreasing the current limit value which minimizes SSR power dissipation. With dc current faults, assuming the overall power applied to the relay contact is reasonable (use Figure 2 as a guide) the SSRs will reach thermal equilibrium at a current-limit value and power dissipation that is safe for SSR integrity.

Figure 2 shows a voltage versus time curve that illustrates the SSR's safe operating region in the on-state. Curves for a number of SSRs are presented. In normal operation, the voltage drop across the SSR is typically less than 3 V. During a fault condition, excessive current through the SSR increases the voltage drop. When the current limit activates, SSR resistance dramatically increases, thereby noticeably increasing SSR voltage drop, possibly into the hundreds of volts. A potential of this magnitude imposed on the SSR creates significant power dissipation! Not all SSRs will survive. Figure 2 shows the maximum allowable voltage drop some specific SSRs can tolerate before power dissipation becomes undesirable.

Although not plotted, clamping for longer durations is sometimes acceptable. Hard operation into current limiting basically becomes a reliability experiment for the relay. The SSR package exceeds its maximum continuous power dissipation when in current limiting, and die temperature will increase at a rate of 100°C/W. It is this increase in temperature that emulates a reliability experiment. For occasional short duration faults or even light duty operation into current limiting, reliability is not an issue. But current limiting and clamping for minutes, hours, or even days, could statistically become an issue if every relay in a given system were subjected to such conditions. If only a small percentage of the relay population ever sees an extended clamp condition, then once again statistically reliability is not an issue. The SSRs have exhibited excellent reliability results even in applications where the parts are routinely driven into current limit.

Figure 2. Switch voltage vs. time (on-state)



Note:

DPST SSR poles were alternately stressed.

Relay Protection

For the SSRs to withstand transients, some form of voltage-limit protection is required. This protection limits the voltage across the SSR's outputs to the values shown in Figure 2 when the SSR is in the on-state and absorbs some of the power dissipated during a fault condition. The voltage protection also limits the voltage below the SSR's maximum load voltage when the SSR is in the off-state.

Current-Limit Performance During Fast Transients or Lightning

When a transient occurs and the SSR is off, the voltage across the poles of the SSR rises to the trip voltage of the protection device being used. The SSR remains off without leaking current.

When a fast transient occurs and the SSR is on, current through the SSR reacts as follows:

First, the SSR exhibits a time delay before current limiting trips. The time required to trip depends on the current through the SSR. The amount of current conducted during this initial rise and the current-limit trip time is dependent upon the specific SSR, the rise time of the fault, and the series resistance in the conduction path between the transient voltage and the SSR. Currents range from 0.5 A to 4 A and trip times from 200 ns to 10 µs, for an 800 V, 10 x 560 µs impulse waveform.

Next, current limiting trips and the SSR turns off. The voltage rises to an amplitude bounded by the protection device across the SSR. The SSR remains in this state for the duration of the SSR's specified turn-on time.

Lastly, the SSR turns back on and limits the transient current to the SSR's specified current-limit value. In current limiting, the SSR presents a high impedance to the fault. The SSR can dissipate a substantial amount of power while in this state. However, SSR characteristics and the protection device both assist in limiting the power dissipation of the SSR. The SSR's current-limit circuit exhibits a negative temperature coefficient.

As the SSR heats up from current limiting, its impedance increases, reducing current flow through the SSR, thereby reducing its power dissipation. If a crowbar protection device is used, it will have already shunted current flow (assuming the transient was of sufficient potential to break over the crowbar device), thereby relieving the SSR from any power dissipation during this state. If an MOV protection device is used, it sets the maximum voltage that is imposed on the SSR and shunts some of the current around the SSR when its zener voltage is exceeded. The SSR remains in this state until the transient subsides. At this time, the SSR immediately resumes its normal operating characteristics.

Current-Limit Performance During Power Cross

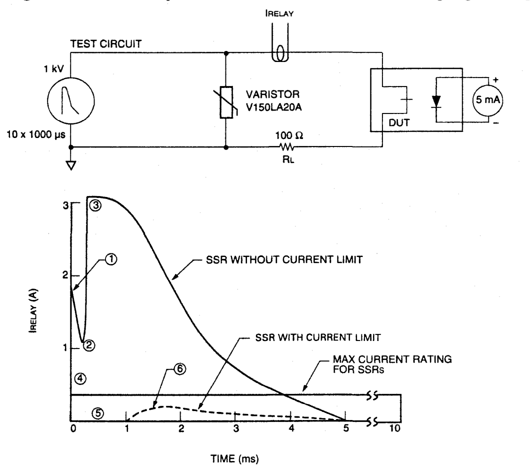
Power cross is an ac fault condition where 50 Hz/60 Hz power waves are induced on telephone lines. This condition can produce a fault as high as 600 Vrms and 40 A, as specified in UL1459 50A. The primary design criteria for components exposed to power-cross overvoltage conditions is that they must not present a risk of fire. The mold compound used in the construction of the LH1500 series of SSRs carries a stringent flammability rating of UL94 V-0.

Depending on the applications circuitry, the protection components, and the extent of the power-cross fault, the SSRs can survive some power-cross stresses. Refer to Figure 2 for the acceptable operating region of the Siemens SSRs under transient conditions.

If an MOV that clamps overvoltages to a specified value is used to limit voltage across an SSR, the MOV voltage should be limited to 125 V to 175 V in order for the SSRs to survive power-cross stress.

A desirable feature of the current-limited SSRs is the tendency of the SSR to thermally shutdown under high power and extreme temperature. The SSRs will actually shutdown at Tj above 150°C if LED drive currents are kept relatively low. At high temperatures, both the LED light output diminishes and the photodiode array output current decreases, lowering MOSFET switch gate voltage to below threshold and turning the SSR off. The SSR turns back on when the temperature subsides.

Figure 3. Anatomy of a current-limit SSR during lightning



SSR Without Current Limit:

1. An SSR draws substantial current due to application of an impulse waveform. The current is limited only by any series and load resistance in the circuit and the ON-resistance of the SSR itself.
2. The SSR is overcome by localized heating due to severe power dissipation and goes into secondary breakdown.
3. In secondary breakdown, the SSR draws excessive current until the fault subsides.

Siemens SSR With Current Limit:

1. The current-limit SSR draws a short pulse of current, indistinguishable on this millisecond scale.
2. The current-limit SSR turns itself off during the worst part of the impulse wave dissipating no power.
3. The current-limit SSR turns itself back on into current limiting and remains in current limit until the fault subsides.

SIEMENS

Solid State Relay Input Resistor Selection Appnote 59

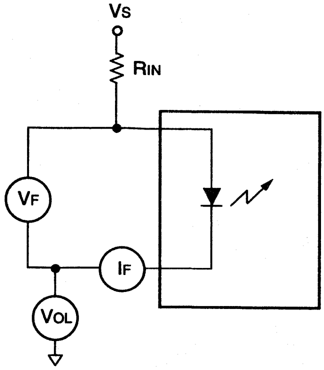
Description

Solid state relays are commonly driven by TTL or buffered CMOS logic gates. These gates, when used to sink current, provide adequate drive for SSRs. An open-collector output is not required to drive the SSRs, but it can be useful to perform a logic OR function.

When using logic drive, an input resistor is usually required to limit current through the control LED to a recommended value. The recommended operating current for most SSRs is between 1 mA and 20 mA depending upon the application. LED current below the recommended value can inhibit relay operation should temperature increase, while higher currents can manifest reliability problems. The following discussion helps in the selection of the proper resistor for specific applications.

A quick recommendation for 5 V power supply operation of most SSRs is to use a 560 Ω resistor. This combination provides an LED current range of 5 mA to 9 mA, thereby optimizing LED current, surge capability, and turn-on/off times. This calculation has taken into consideration power supply variations, temperature variations from −40°C to +85°C, and manufacturing variations and uses a 10% tolerance, 300 ppm/°C input resistor. Likewise, for operation to only 70°C, a 680 Ω resistor would suffice.

Figure 1. Input resistor diagram



The formula for resistor selection is:

$$Rin = [V_S-(V_F+V_{OL})]/I_F \quad (1)$$

Where:
Rin is the input resistor.
V_S is the power source used.
V_F is the forward voltage outdrop of the LED.
V_{OL} is the low-level output of the driving logic gate or the collector-emitter voltage of the driving logic transistor.
I_F is the forward current through the LED.

In choosing appropriate input resistors for a design, parameter variations must be considered. For the power source, consider power supply variations and tolerance. For LED voltage drop, manufacturing variations affecting V_F and V_F temperature variations must be considered. V_F ranges from 1.15 V to 1.45 V at 10 mA I_F and 25°C, because of manufacturing variations. V_F decreases an additional 1.4 mV/°C with higher temperature and increases proportionally with a lower temperature. For the input resistor itself, consider the resistor tolerance and resistor temperature coefficient.

To determine the maximum value for the input resistor in a specific application, obtain the following values:

I_F (min), the lowest desired LED current.
V_S (min), minimum voltage of power source.
V_F (max), obtain from Figure 2. Select the value at the coldest anticipated operating temperature and the lowest desired I_F operating current. Extrapolate desired temperatures in between given temperatures.
V_{OL}(max), maximum low-level output voltage at desired I_F value.

Use the following formula to calculate the maximum value for the input resistor.

$$Rin(max) = [V_S(min) - (V_F(max) + V_{OL}(max))]/I_F(min) \quad (2)$$

To determine the minimum value for the input resistor in a specific application, obtain the following values:

I_F (max), highest desired LED current.
V_S (max), maximum voltage of power source.
V_F (min), obtain from Figure 2. Select the value at the hottest anticipated operating temperature and the highest desired I_F operating current. Extrapolate desired temperatures in between given temperatures.
V_{OL} (min), minimum low-level output voltage at desired I_F value.

Use the following formula to calculate the minimum value for the input resistor.

$$Rin(min) = [V_S(max) - (V_F(min) + V_{OL}(min))]/I_F(max) \quad (3)$$

Select a value of resistance between the minimum and maximum values. If the minimum calculated value for the input resistor exceeds the maximum calculated value, the maximum calculated value should be used. Remember to consider resistor tolerance and temperature coefficients when choosing the resistor.

It is often desirable to operate at the lowest possible LED current.

Example:

For operation between –40°C and +85°C, using a power source of 5 V, what input resistor would provide an LED current of 4 mA?

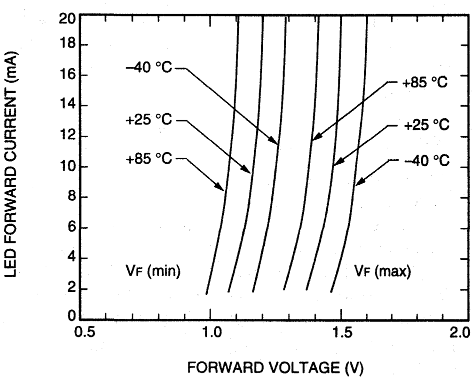
To solve this problem, simply determine the maximum input resistor value. This will set up the lowest LED forward current.

Determine the maximum input resistor value.

I_F (min)=0.004
V_S (min)=4.5
V_F (max)=1.5
V_{OL} (max)=0.25
Rin (max)=4.5–[1.5 + 0.25])/.004=688 Ω

Select a resistor with a value below 688 Ω so that with resistor tolerance and temperature variations, the maximum input resistor value is not exceeded.

Figure 2. LED current and voltage vs. temperature



Faster Turn-On/Off Times

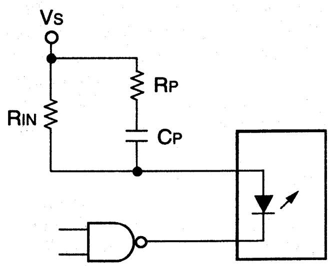
Improved turn-on times for Form A SSRs and improved turn-off times for Form B SSRs can be realized by using a current peaking circuit on the input of the SSR. A simple RC network placed in parallel with the LED current-limiting resistor will provide a current spike to the LED. This current spike, if of proper amplitude and duration, will speed-up the turn-on or turn-off times equivalent to those shown in the parameter curves for higher LED drive current values. Wherein, all SSRs will improve their turn-on or turn-off characteristics by using the peaking circuit, certain SSRs that have a Vbe multiplier circuit built in will benefit greatly. For instance, turn-on time for the LH1530 can be reduced to <100 µs. The SSRs with Vbe multipliers are the LH1516, LH1517, LH1519, LH1525, LH1530, LH1531, LH1533, and LH1550 Form A and all Form B SSRs.

Figure 3 shows a simple RC peaking circuit. Turn-on and turn-off times are dependent upon the SSR type, V_S, the control driver, the RC network values, and the value of Rin. Within the RC network, Rp limits the peak amplitude current through the LED and Cp sets the pulse time constant. For adequate pulse duration, try Cp values between 0.3 µF and 3.0 µF. For adequate peak pulse current, try Rp values from 10 Ω to 200 Ω.

$$Rp = V_S - V_F / Ipeak \quad (4)$$

Limit the pulsed current through the LED to 300 mA.

Figure 3. RC peaking circuit



SIEMENS

Stacking Our Solid State Relays for Higher Switching Voltages Appnote 60

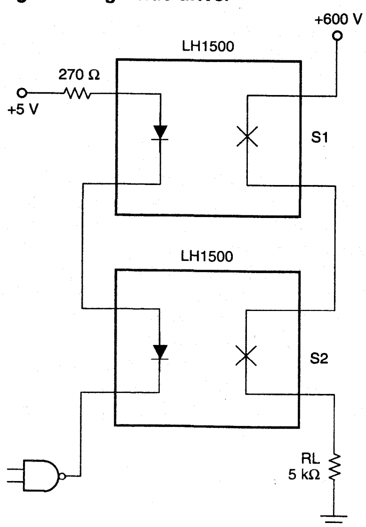
Introduction

Siemens solid state relays (SSR) provide high-voltage switching capability (presently up to 400 V) in packages as small as a 6-pin DIP. Higher switching voltages can be achieved when relays are wired in series (stacked). By adhering to the following recommendations, SSRs can easily be stacked to achieve switching capabilities into the thousands of volts range.

Stacking Relays

Electrical parameters that must be considered when stacking relays are ON-resistance, load voltage, and load current. ON-resistance of the stacked relay becomes the sum of the individual ON-resistance of each relay. Likewise, total load voltage or standoff voltage becomes the sum of the individual load voltages. It is usually more prudent to choose relays with equivalent load voltages because the relays will equally block the applied voltage. Maximum load current becomes the lowest rated load current of the stacked relays. The primary design concern with stacked relays is maintaining load voltage during switching.

Figure 1. High-side driver

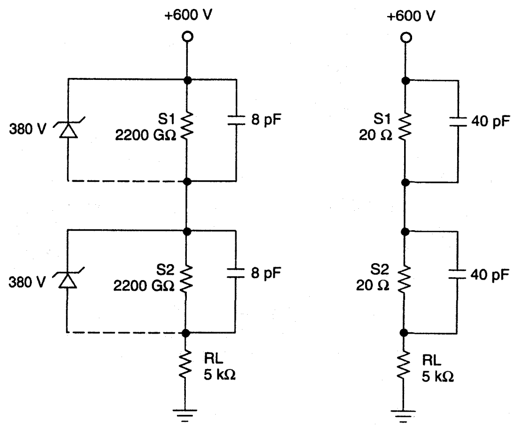


Voltage Sharing

Figure 1 shows two LH1500 relays in a high-side driver configuration. The input LEDs are wired in series to obtain simultaneous control from the logic gate. The LH1500 relay has a rated load voltage of 350 V, and when two are stacked, they have the potential of switching 700 V.

Figure 2 (A) depicts a simple electrical model of the relays in the off-state condition. The 380 V zener diodes represent the avalanche breakdown value of the switches. Compared to the G Ω impedances of the off MOSFET switches, the voltage drop across RL is insignificant and each switch will equally standoff 300 V. Figure 2 (B) shows a simple electrical model with both relays on. Each relay drops 2.4 V, and the remaining 595.2 V is passed on to the load.

Figure 2. Simple output model of high-side driver



A. Off-State

B. On-State

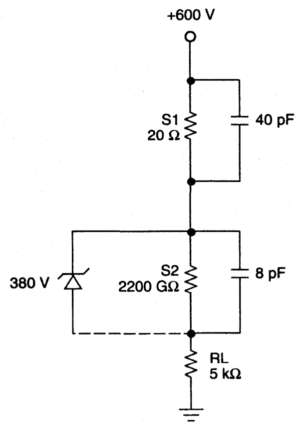
Switching

The stacked relay models in Figure 3 will function properly if switches S1 and S2 turn on and off simultaneously; in actuality, this would be an optimum case. Even though Siemens SSRs exhibit a tight t_{ON} and t_{OFF} distribution, individual SSRs and even the two poles of a DPST (2 Form A) will still exhibit distinct t_{ON}/t_{OFF} times that need to be considered. Differences in t_{ON} and t_{OFF} can be minimized (but not entirely eliminated) by increasing LED drive current to 10 mA or 20 mA.

An extreme case of t_{ON} or t_{OFF} mismatch would be where S1 actually turns on before S2 (Figure 3). If this occurs, the full 600 V of power source is applied directly across S2 driving it into avalanche breakdown.

In this instance, an avalanche current of 120 mA could flow, possibly destroying the switch if applied for any lengthy duration. In practice, the delta of turn-on and turn-off times will fall somewhere between the optimum and extreme cases mandating some form of external conditioning.

Figure 3. Simple output model of high-side driver with mismatched t_{ON}



RC Snubber

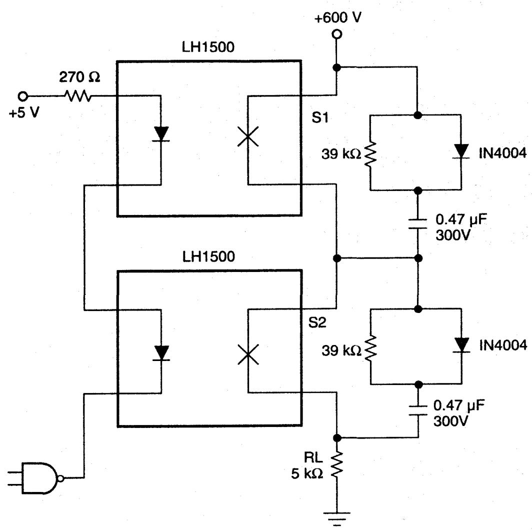
One way to keep SSRs from avalanching during switching is to place a simple RC snubber across each switch output (Figure 4). The RC snubber network will provide dynamic voltage sharing during switching.

During relay turn off, a charging path is set up from the power source through the two diodes and capacitors and returning through the load. The minimum RC snubber capacitance is governed by the equation:

$$C(min) = I_L tf / 2V_L \qquad (1)$$

Where I_L is the load current determined by the power source and the load, tf is the time it takes for the load voltage to drop from power source potential to ground (assumes the fall times for both relays are nearly equivalent), and V_L is the load voltage of one relay (assumes two relays with equal load voltage rating). If the fall times are not equivalent, another factor should be added to the equation:

Figure 4. High-side driver with RC snubber



$$C(min) = I_L tf + 2I_L \Delta t_{OFF} / 2V_L \qquad (2)$$

This equation assumes that one relay turns off before the other, thus allowing twice the charging current to that relay's snubber capacitor until the other relay turns off.

During relay turn on, the capacitor discharges through the relay and the snubber resistor. The load voltage pulse shape can be manipulated by the snubber resistor value.

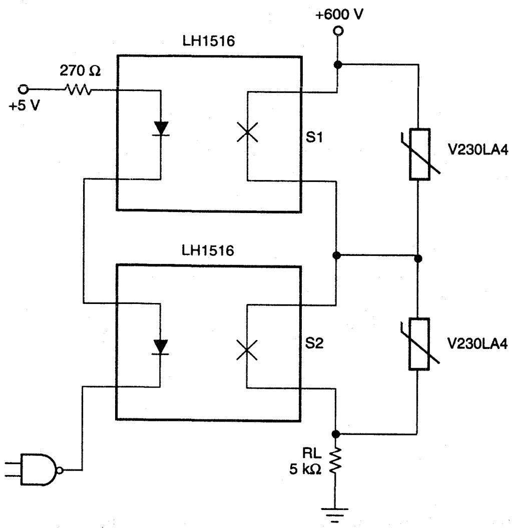
A snubber solution is tailored for specific switching conditions, and capacitor values can be selected to operate SSRs up to their maximum load voltage rating. In the event of a high-voltage transient from another source, the SSRs would still be in jeopardy of avalanche breakdown. Also note that the load will be subjected to positive transients that feed through the snubber network capacitance. Component sizing is also a consideration; with the relatively slow switching speeds of the SSR, snubber capacitance values become fairly large. These high values coupled with high-working voltage equate to a rather substantial capacitor.

Voltage Suppression

Another method in preventing the SSRs from avalanching is to place a metal oxide varistor (MOV) across the outputs of the relay. A properly selected MOV suppression device will keep the relay from ever exceeding avalanche breakdown. MOV selection is very critical. The maximum standoff voltage of the stacked relay now becomes the sum of the MOV's maximum continuous voltage rating. If the MOV continuous rating is exceeded, the MOVs could conduct substantial current when the stacked relay is supposed to be off, creating an undesirable leaky operation and eventual MOV destruction. Also be sure that under worst-case conditions the SSR load voltage is not compromised.

Referring to Figure 5, to achieve the original 600 V target, each MOV must be rated for 300 V dc continuous voltage or greater. A V230LA4 MOV (Harris Corp or equivalent) meets these qualifications. Its varistor voltage at 1 mA ranges from 324 V to 396 V. To use this MOV, the load voltage of the individual relays needs to increase to 400 V. Notice the LH1500 relays that were originally used with a 350 V load voltage rating have been replaced with the LH1516 relays that are rated at 400 V.

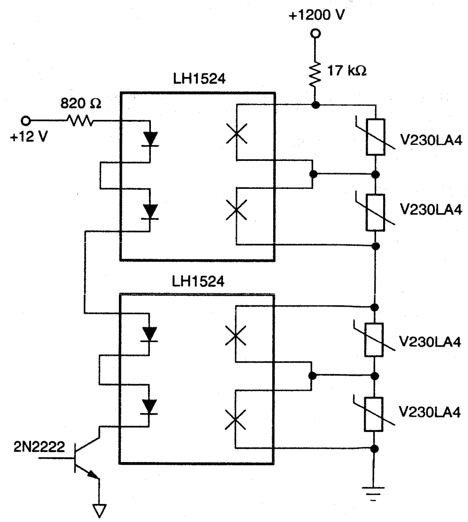
Figure 5. High-side driver with MOV protection



To protect against high-current transients that could drive the MOV to even higher varistor clamp voltages, a third SSR may be required. In this case, perhaps a more attractive alternative would be to use a solid state suppression device. Solid state suppression devices exhibit lower clamp voltage ratio values than MOVs. The P3300AA61 *SIDACtor* from TECCOR Corp. has a breakover voltage of 330 V. This part allows 300 V continuous voltage without exceeding the 350 V load voltage rating of the LH1500, even under high-surge current conditions.

Applying this information, it is very easy to see how a 1200 V relay can be constructed using two LH1524 400 V relays. By stacking the outputs of these two relays and using four V230LA4 MOVs (capable of dc operation up to 300 V) for dynamic voltage sharing and protection, we achieve a relay capable of switching 1200 V and 70 mA (See Figure 6). Similarly, even higher voltage and current relays can be created by stacking the desired type and appropriate number of relays.

Figure 6. A 1200 V low-side driver



Reference:

Switching Very High Values of Blocking Voltage,
Miro Glogolja and John Kerr, Siemens Components.

SIEMENS

Solid State Relay Parallel and DC Operation Appnote 61

Description

Siemens Solid State Relay (SSR) outputs can be wired in parallel enabling the user to benefit from lower ON-resistance and higher load current for ac/dc switching applications. This technique is also useful to compensate for load current derating with increased ambient temperature, to minimize heat from output power dissipation, and for circuits that require redundancy. Also, many of Siemens SPST SSRs provide a center tap so that internal MOSFET switches can be paralleled for dc only switching applications.

Static Current Sharing

MOSFET switches operate as positive temperature coefficient resistors when VGS is large. The control circuit of Siemens SSRs supply ample gate bias to the MOSFET switches to ensure positive temperature coefficient RDSon operation even with LED input currents as low as 2 mA. Therefore, with parallel MOSFET operation, if one MOSFET switch draws more than average current, its resistance will increase thereby counteracting the increased current. This intrinsic mechanism ensures that thermal equilibrium and stable current sharing is maintained.

To determine the maximum dc operating current from a set of paralleled SSRs, simply use the formula:

$$It = \sqrt{Pt/Rt} \qquad (1)$$

Where It is the maximum dc operating current for all paralleled SSRs; Pt is the sum of the power dissipation for all paralleled SSRs; and Rt is the parallel combination of all R_{ON}s for a given operating temperature.*

Note:

* For ac/dc operation, SSR R_{ON} at high current can be less than the value stated in the Electrical Specifications section. This phenomena is due to a parasitic diode in the reverse conducting MOSFET. To take advantage of this lower R_{ON}, review the SSR's I-V characteristics, and then decrease the maximum electrical R_{ON} specification by approximately 10%.

Observe the load current derating curves given in the Recommended Operating Conditions section of the appropriate data sheet or use a ΘJA of 100°C/W and try not to exceed 125°C for Tj, where for a given SSR:

$$Tj = P\,\Theta JA + TA \qquad (2)$$

Caveat

For operation at or near full rated current, if two SSRs with identical, R_{ON} electrical specifications are placed in parallel, one would expect the dc operating current to be double their rated load. R_{ON} is specified within a given range; if R_{ON} of the individuals SSRs is not matched, one of the SSRs will draw more than half the current.

A better solution is to use a Siemens 2 Form A relay where the mismatch is minimal. These switches are fabricated on the same die, thereby providing optimum R_{ON} matching by virtue of the close proximity of one MOSFET switch to another. The single die construction also provides excellent thermal stability since all the switches now reside on the same paddle. Furthermore, R_{ON} matching is a specification on Siemens 2 Form A SSRs and is 100% factory tested.

Dynamic Current Sharing

Current sharing during switching is rarely a problem. Turn-on and turn-off times typically vary by a couple of hundred of microseconds for a given part number SSR. Switching slew rates are slow (~1 ms for t_{ON}), in effect keeping SSRs that are first to turn on in a high-impedance state until other paralleled SSRs have had time to turn on.

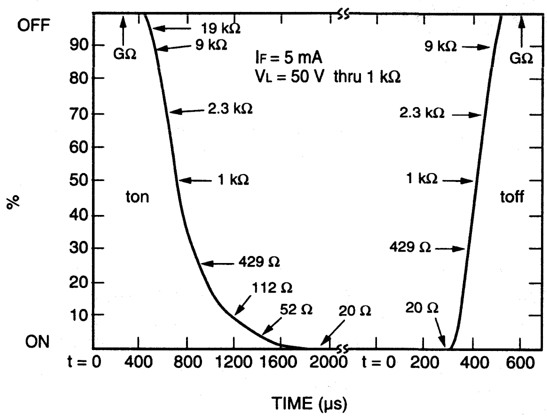
Figure 1 shows the typical dynamic switching resistance of the LH1500 SSR. If two LH1500 SSRs in parallel differed in turn-on time by 200 µs, when the faster LH1500 is fully on at 20 Ω, the slower LH1500 would have an ON-resistance of 36 Ω. Therefore, the faster SSR would have to source only 64% of the load current for 200 µs. If the slew rates were fast, the faster SSR would have to source 100% of the load current for 200 µs.

With different part number SSRs, turn-on time deltas can become more pronounced and here dissimilar turn-on times could momentarily subject the fastest SSR to the full load current of the overall circuit. If many relays are paralleled to obtain a high-current operation, this current could potentially damage the SSRs. Most Siemens Form A SSRs employ integrated current-limiting circuitry that will protect the relay from high-current transient conditions. Dynamic current sharing can be ignored when current-limited SSRs are used. For SSRs without current limiting, be sure that the overall load current does not exceed the absolute maximum pulsed peak current specification of the respective SSRs.

dc Operation

Similarly, most of the 6-pin Siemens SSRs can be wired for dc only operation. In this configuration, pins 4 and 6 are usually tied together, thereby paralleling the two internal MOSFET switches. Pins 4 and 6 become the positive output of the SSR, and pin 5 becomes the negative output. Here too, the MOSFET switches reside on the same die and static and dynamic current sharing are not an issue.

Figure 1. Dynamic switching resistance



SIEMENS

LH1502 Form A/B, C Solid State Relay Break-Before-Make Functionality Appnote 62

Description

The Siemens LH1502 Solid State Relay (SSR) combines the functionality of a normally open Form A SSR switch and a normally closed Form B SSR switch into a single 8-pin package. These SSR switches can be used independently, or when tied together, provide the function of a break-before-make Form C transfer relay.

An electromechanical relay, by virtue of its mechanics, breaks one contact in a Form C relay before making the other contact. For an SSR, unless otherwise conditioned, the respective contacts will attempt to break and make at the same time. SSR manufacturers have traditionally left the break-before-make conditioning to the user. By having individual access to both the Form A and Form B SSR control inputs, the user can create a break-before-make operation with the use of additional circuitry. Siemens eliminates the need for this additional circuitry by integrating break-before-make circuitry into their SSRs.

Break-Before-Make Circuitry and Timing

Siemens uses a Smart Power BiCMOS technology to integrate not only the photodiode array and switches, but also the switch control circuitry into a single piece of output silicon. By using integrated circuit technology, break-before-make functionality can easily be built into Siemens SSRs. To obtain break-before-make functionality, Siemens controls the turn-on and turn-off times of the Form A and Form B switches. To use this feature, simply wire both LEDs of the LH1502 in series. Figure 1 illustrates a typical break-before-make test circuit, and Figure 2 portrays the break-before-make operational waveforms.

When an LED current is applied, the normally closed switch begins to turn off. The turn-on time of the normally open switch is delayed by the internal control circuitry. This allows adequate time for the normally closed switch to turn off first. Next, LED current is removed. Now the normally open switch starts to turn off. Here the normally closed switch's turn-on time is delayed to ensure that the normally open switch has adequate time to turn off.

Figure 1. Break-before-make test circuit

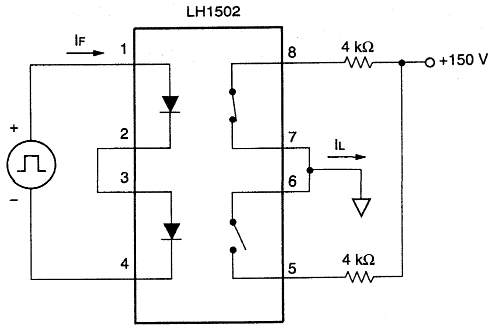
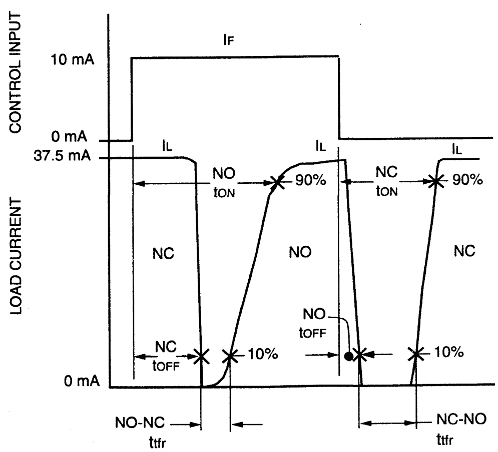


Figure 2. Break-before-make waveforms



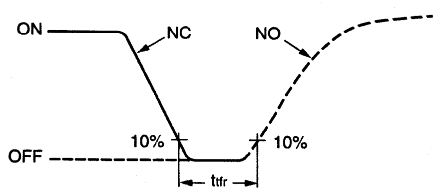
Break-Before-Make Testing

Figure 3 highlights the timing during the switch transfer function. The time between switching where both switches are off (open) is called transfer-off time. This parameter is the period of time measured from the 10% level of the switch turning off to the 10% level of the switch turning on. This is a conservative measurement. At the 10% level, the ON-resistance of the switches is very high. In most applications, more waveform overlap would be tolerated.

Siemens tests 100% of the LH1502 product for transfer-off time. The test is performed using a load voltage of 150 V and with load resistors of 4 kΩ. A relatively high load voltage is used in production test to ensure suitable operation in the more common lower voltage applications. Transfer-off time is reduced at higher load voltages.

Note that when switching a capacitive load, turn-on and turn-off slew rates could be dominated by capacitive charging and discharging effects. In these applications, transfer-off time cannot be guaranteed.

Figure 3. Transfer-off time timing diagram



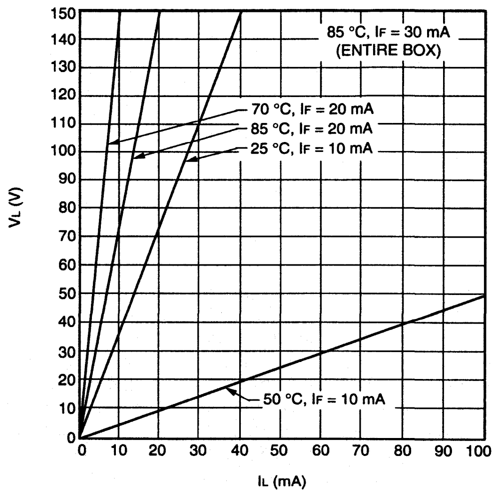
Transfer-Off Time vs. Temperature

To explore break-before-make variation with temperature, the two transfer periods must be considered separately. For the sake of discussion, period one is that time when the Form A switch turns off and the Form B switch turns on. Period two is that time when the Form B switch turns off and the Form A switch turns on. For period one, both the normally open t_{OFF} characteristic and the normally closed t_{ON} characteristic exhibit similar negative temperature coefficients.

Therefore, when the temperature rises, the transfer time remains relatively constant. Period two is not as accommodating; here the normally closed t_{OFF} temperature coefficient is positive and the normally open t_{ON} temperature coefficient is negative. Both of these characteristics move in the wrong direction for the transfer-off time parameter, making it harder to provide break-before-make operation at elevated temperatures.

Figure 4 portrays an operating window for break-before-make operation plotting load voltage and load current versus different ambient temperatures and LED forward currents. For optimum break-before-make performance, operate below or to the right of the respective lines. As shown, increased LED forward drive allows break-before-make operation at elevated temperatures. With 30 mA LED drive, break-before-make operation can be achieved even at temperatures of 85°C. Of course some applications are not conducive to this amount of LED power dissipation. A simple RC peaking network applied to the input control can provide a 30 mA initial current pulse while drawing only a meager quiescent current. For a more detailed explanation on the RC peaking network, see the *Input Resistor Selection* Application Note.

Figure 4. Break-before-make operating window



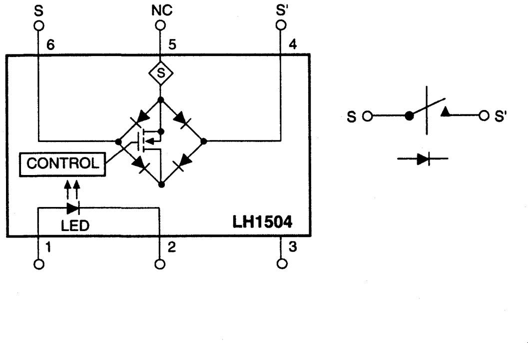
SIEMENS

Using the LH1504 Solid State Relay Appnote 63

Introduction

Most of the relays in Siemens portfolio of solid state relays (SSRs) utilize a pair of source-coupled MOSFETs in the output stage of the circuit. This popular topology provides an exceptionally linear, bidirectional characteristic in the on state, and bidirectional blocking in the off state. This is necessary for relays used in dc and ac applications. However, there is another circuit topology which will also perform well in dc and ac applications, and may reduce costs. By surrounding a single MOSFET by a diode bridge, a new relay can be realized which also provides bidirectional conduction and blocking. The RxA product (resistance x area) of a PN diode is usually much lower than that of a MOSFET with similar breakdown voltage. Thus, the die area consumed by such a circuit topology can be made much smaller than that of a source-coupled pair MOSFET relay with similar ON-resistance. This translates to lower cost, and was the driving force behind the development of the AT&T LH1504 SSR, shown in Figure 1.

Figure 1. Functional diagram



Output Offset Voltage

As can be seen in Figure 1, when the relay is in the off state, the full blocking voltage is developed across the drain to source of the MOSFET (less two forward-biased diode drops), regardless of the polarity of voltage applied to the output terminals. Similarly, when the relay is in the on state, the conduction path is always through the series combination of two forward-biased diodes and the MOSFET.

This results in an interesting I-V characteristic, as illustrated in Figure 2. Before the relay will begin to conduct current, a small voltage must be applied to the output terminals to forward-bias the two diodes. Once the diodes are turned on, the relay enters its linear region of operation, similar to that of a source-coupled MOSFET SSR, but offset by the small voltage. For the LH1504 SSR, this offset voltage is approximately 1.4 V. This offset must be accounted for in a circuit design utilizing such a relay, as will be discussed in the following sections.

Output ON-Resistance

For the purpose of discussion, we will describe the ON-resistance (R_{ON}) of an SSR in two ways: static R_{ON} and dynamic R_{ON}. The static R_{ON} describes the dc output resistance of the relay at a single operating point. Static R_{ON} can be calculated by simply dividing the voltage dropped across the output terminals by the current flowing through the terminals. As illustrated in Figure 3, we can calculate the static R_{ON} for the LH1504 SSR using values provided in the designer's guide (V_{ON} @ 1 mA=1.4 V typical, and V_{ON} @ 90 mA=3.6 V typical).

The low current data yields,

$$R_{ON} = \frac{1.4\ V}{1\ mA} = 1400\ \Omega \quad (1)$$

The high current data yields,

$$R_{ON} = \frac{3.6\ V}{90\ mA} = 40\ \Omega \quad (2)$$

Thus, the static or dc ON-resistance varies considerably over the usable operating range of the LH1504 SSR.

The dynamic R_{ON}, describing the ac output resistance of the relay, is in response to a signal which is varying over a range of currents within the linear region of operation. It can be calculated by dividing the change in voltage by the change in current between two operating points. This is also illustrated in Figure 3. The linear region of operation for the LH1504 SSR is from approximately 10 mA up to the maximum load current of 95 mA. The designer's guide lists the dynamic R_{ON} measured between two points within this region (20 mA and 50 mA) and reports a typical value of 23 Ω. Thus, the dynamic or ac ON-resistance is constant for operation anywhere within the LH1504 SSR linear region. As shown in Figure 2, a source-coupled MOSFET SSR has a linear region which extends through the origin, so the static and dynamic ON-resistances are identical.

Calculating the overall operating point of the LH1504 SSR in a circuit requires consideration of both the static and dynamic ON-resistances, and the offset voltage. The offset in the I-V characteristic results in a somewhat higher voltage drop across the SSR (and thus, higher power dissipation) than for a source-coupled MOSFET SSR. For instance, the typical voltage drop across the output terminals of an LH1504 SSR at a load current of 50 mA is determined to be,

$$V_{ON} = (50\ mA \cdot 23\ \Omega) + 1.4\ V = 2.55\ V \quad (3)$$

The power dissipation of the SSR is also increased due to the offset voltage and is determined to be,

$$P_{DISS} = 50\ mA \cdot 2.55\ V = 128\ mW \quad (4)$$

As with most of Siemens SSRs, the LH1504 R_{ON}, V_{ON}, and thus P_{DISS}, have a positive temperature coefficient. When operating the relay at ambient temperatures above 25°C, care must be taken to not exceed the maximum recommended power dissipation requirement. See the Electrical Specifications section on the LH1504 for more details.

Output Linearity

As was mentioned above, an SSR with a source-coupled MOSFET output stage exhibits an exceptionally linear I-V characteristic, as long as the transistors are operated in their linear region. Linearity is especially important in applications requiring the switching of audio or high-speed data signals, since nonlinearity contributes to harmonic distortion. A diode-offset SSR such as the LH1504 uses "nonlinear" diodes (actually, the characteristic is exponential) in the signal path. However, for small ac signal excursions around a dc operating point, even a diode can exhibit a quite linear characteristic. Couple this with the fact that the diode ON-resistance is only 10% to 15% of the total dynamic R_{ON}, and it becomes feasible to use the LH1504 SSR in applications requiring high linearity. Obviously, such applications require a detailed spectral analysis of the LH1504 performance.

Figure 2. SSR I-V characteristics

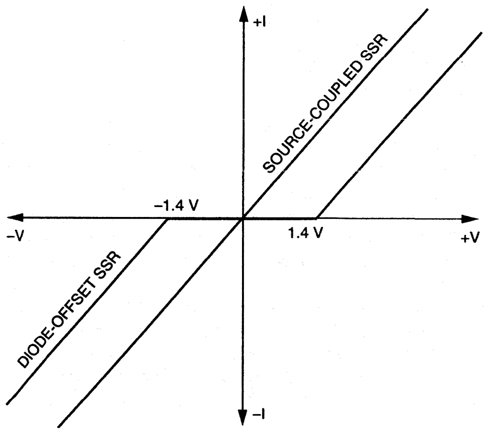
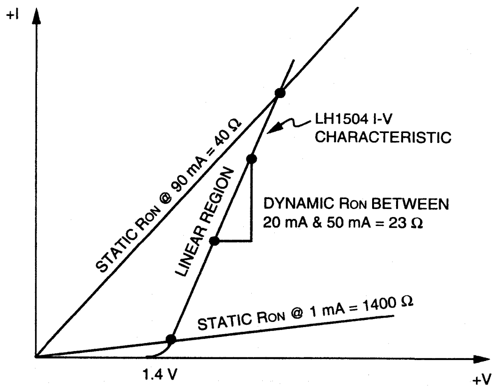


Figure 3. LH1504 output ON-resistance



Applications

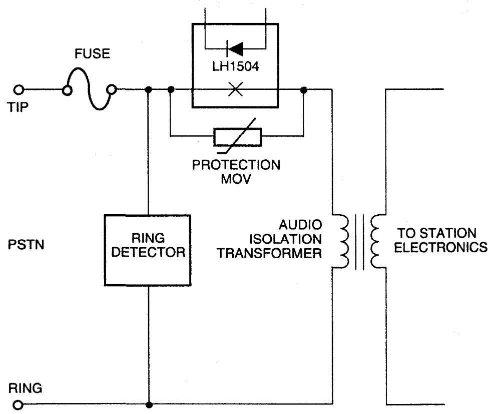
The information presented so far allows discussion of applications for diode-offset SSRs such as the Siemens LH1504. These applications can be divided into three general categories:

1. dc switching applications.
2. Large signal ac applications (signal passes through the origin) not requiring a high degree of linearity.
3. Small signal, high linearity ac applications, provided that a dc current is present to ensure operation is confined to the SSR's linear region.

A wide variety of low-power dc and large-signal ac (i.e., 120 V ac line) switching applications exist including consumer electronics, programmable controllers, industrial controls, instrumentation, and computer peripherals. A very common small-signal ac application for the LH1504 SSR is in telecommunications. In many cases, the switchhook relay function in answering machines, FAX machines, and modems can be provided by the LH1504. This is because the public switched telephone network (PSTN) typically provides a minimum loop current of approximately 20 mA, which is adequate to confine operation to the linear region of the relay.

An issue of concern when using a diode-offset SSR in telecommunications applications is that of dc ON-resistance. In order to ensure that the central office can seize the telephone line when the equipment goes off-hook, there are requirements for maximum dc off-hook resistance on equipment connected to the PSTN (in the U.S., a rule of thumb is 200 Ω, maximum). Thus, care must be taken when determining the relay operating point, as discussed above. For instance, the typical static or dc R_{ON} of the LH1504 SSR at a loop current of 20 mA is 93 Ω (see equations 3 and 4), nearly half of the maximum requirement. An example of a typical switchhook application in a DAA (data access arrangement), which is the PSTN interface for answering machines, FAX machines, and Modems, is shown in Figure 4.

Figure 4. Typical DAA interfaces



Summary

What has been discussed in this application note is essentially the differences between the characteristics of a diode-offset SSR and the more common source-coupled MOSFET SSR. However, in most other respects, the two types of relays operate very similarly. As with most of Siemens LH1500 series of SSRs, the LH1504 provides reliable 3750 Vrms I/O isolation, uses integral current-limiting circuitry to survive FCC Part 68 lightning surges, and requires very low input current to operate. These features are discussed in detail in numerous other Siemens solid state relay publications.

The Siemens LH1504 Solid State Relay provides a low-cost, high-performance solution for a wide range of today's switching applications.

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Using the LH1525 Solid State Relay Appnote 64

Description

The LH1525 solid state relay (SSR) combines the latest high-voltage integrated circuit technology with an intelligent circuit design to provide an extremely versatile SSR. The LH1525 is able to achieve this versatility by combining low turn-on current with fast switching speed. With standard SSRs, low turn-on current provides slow switching speed. Likewise, high switching speed requires substantial LED drive current. The LH1525 provides a fast switching speed at a much lower drive current. For applications where minimal power dissipation is critical, the LH1525 provides the lowest turn-on current available in an optically coupled solid state relay.

The LH1525 can be used to minimize power dissipation in battery powered applications or in applications where power management is a concern. It can be used in instrumentation applications where fast switching speed is critical. Or it can be used in telecom applications where its robust current-limit circuitry will protect the relay from lightning and other fault conditions commonly present on telephone lines.

Minimizing Power Dissipation

Figure 1 plots switch load current versus ambient temperature. The amount of LED forward current (I_F) required for switch operation is based on these parameters. If power dissipation is the only concern, select the lowest LED drive current curve that encompasses your load current and ambient operating temperature design window. A given LED forward current will support the operating area below and to the left of the curves. Extrapolate forward current values between 300 μA and 1 mA as required. If switching speed is also a concern, refer to the next section.

LED Drive Current vs. Switching Speed

The LH1525 can provide switching speeds from as slow as 3 ms to as fast as 100 μs. Switching speed performance is dependent upon the magnitude of LED drive current used. This application note addresses three areas of operation of turn-on speed and turn-on current. Turn-on speed is the time it takes for the contact to close after current is applied to the LED. Turn-on current is the amount of current required through the LED to sustain a given load current.

The graph in Figure 2 plots LED drive current versus turn-on speed. It has been segmented into these three areas of operation. Very low turn-on current, slow speed performance is desirable for some battery powered applications and also telecom applications. Low turn-on current, moderate speed performance is suitable for a variety of applications where both speed and power consumption are critical. In instrumentation applications where every microsecond counts, high-speed performance using high turn-on current would be a logical choice.

Very Low Turn-On Current, Slow Switching Speed

LED drive currents between 0.3 mA to 1.5 mA are required to keep switching speeds at 1 ms or more. This slow speed operation is desirable in telecom applications due to the way the relay's current limit circuitry responds to a lightning surge. The LH1525, like many other Siemens Form A SSRs, has integrated current-limiting circuitry. When an SSR is directly connected to a telephone line (e.g., switchhook or ring/test access in a PBX or central office) and high current transients occur from lightning, the current-limit circuit will operate to protect the relay. For a large transient, as those specified by various regulatory agencies, the current-limit circuit will shut down the relay with submicrosecond speed. While the relay is off the power from the lightning dissipates in a transient voltage suppressor. The relay remains off for the duration of one turn-on period. It is important that this off period be long enough to allow the lightning wave to subside. An off period of 1 ms or greater provides the most robust solution. To achieve 1 ms or slower at room temperature, 1.0 mA to 1.5 mA of LED forward current should be used. Refer to Figure 1 to obtain an adequate LED current value for elevated temperature operation.

Another advantage that SSRs bring to this solution is noise-free operation. SSRs will not be a source of acoustical noise and will not generate transients during closure.

Low Turn-On Current, Moderate Switching Speed

LED drive currents between 3.0 mA to 5.0 mA provide nominal switching speeds better than 500 µs. This fast switching speed is desirable in many data acquisition or instrumentation systems where scanning time needs to be minimized. Most optically coupled MOSFET relays require 5 mA to 10 mA of LED drive for operation at elevated temperatures. The lower drive currents required for the LH1525 minimizes power consumption of the relays. This is very desirable in battery-powered equipment or in large multiplexed relay systems where power management is a concern. Of course another advantage the SSR brings to these applications is that no extra settling time is required since there is no contact bounce.

High Turn-On Current, High Switching Speed

LED drive currents above 8 mA provides typical switching speeds below 200 µs. This current can be provided as a steady-state current or as a current pulse from an RC peaking network. Note that with high LED drive currents the turn-off time will actually exceed the turn-on time. Depending on temperature, turn-off time will run between 200 µs to 300 µs with LED drive currents above 8 mA.

Testing and Temperature Variation

The previous discussions referred to typical LH1525 speed performance and 25°C ambient operation. The LH1525 is tested for a maximum turn-on time of 800 µs with 5 mA of LED drive and a turn-off time of 400 µs. If maximum speed is critical to a design, these worst-case test limits must be used. Figures 3 and 4 provide LED drive current versus speed graphs for the extreme temperatures as well as room ambient. Use this data to estimate performance at extreme temperatures.

Input Control

If you're familiar with our parts and commonly evaluate their performance using a curve tracer (step generator sourcing current to LED, relay outputs tied to collector and emitter) you may notice that the part is difficult to turn off. Using the 1 mA scale from the step generator may still source microamps of leakage current even when the dial is turned to zero. You'll need to select a lower range like the 50 µA range to fully turn the relay off.

You will not experience any difficulty in actual use, however, if your logic circuit provides an adequate pull-up voltage.

The LH1525 is designed with highly sensitive photo-detection circuits which will detect even the most minute currents flowing through the LED. The relay typically turns on with only 120 µA of LED drive at room temperature. At elevated temperatures only 1 mA or 2 mA of LED drive is required to turn the relay on. Leakage current must be considered when designing a circuit to turn on and off these relays.

Figure 5 shows a typical logic circuit for providing LED drive current. R1 is the input resistor which limits the amount of current flowing through the LED. For 5 V operation, a 2700 Ω resistor will limit the drive current to about 1.4 mA. Where high-speed actuation is desirable, use a lower value resistor for R1.

R2 is an optional pull-up resistor which pulls the logic level high output (V_{OH}) up towards the V_S potential. The pull-up resistance is set at a high value to minimize the overall current drawn from V_S. The primary purpose of this resistor is to keep the differential voltage across the LED below its turn-on threshold. LED dropout voltage is graphed versus temperature in the Typical Performance Characteristics section of the designer's guide. Many applications will operate satisfactorily without this pull-up resistor. In the logic circuit of Figure 5, the only path for current to flow is back into the logic gate. Logic leakage is usually negligible. Each application should be evaluated, however, over the full operating temperature range to make sure that leakage current through the input control LED is kept to a value less then the minimum LED forward current for switch turn-off specification.

Figure 1. SSR recommended operating conditions

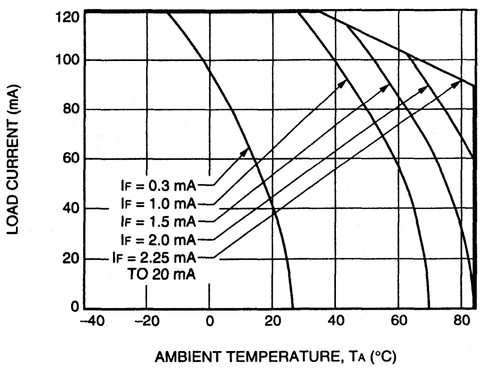


Figure 2. Turn-on time vs. LED current

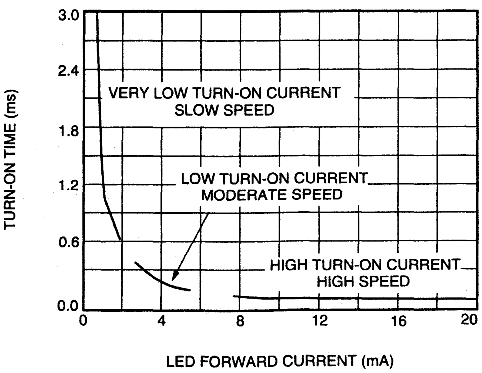


Figure 3. Typical turn-on time vs. LED current

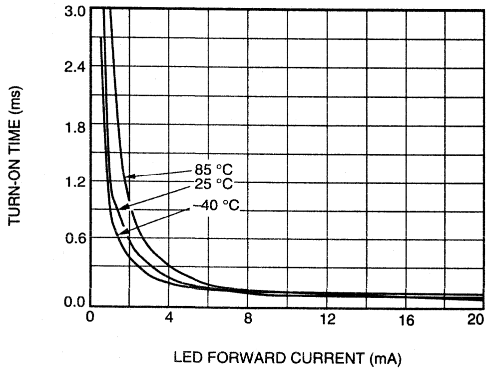


Figure 4. Typical turn-off time vs. LED current

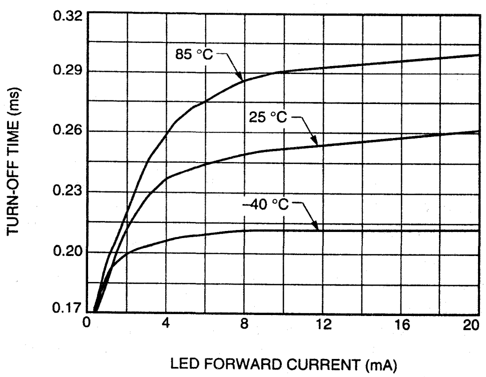
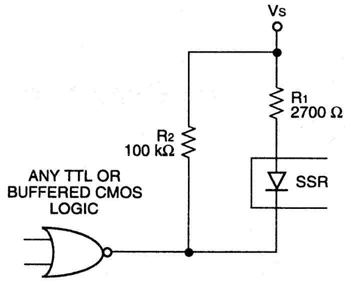


Figure 5. Input control circuit



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LH1529/49 Telecom Switches Appnote 65

Introduction

As a companion to this document, please refer to the respective telecom switch data sheets for more information.

The LH1529 and LH1549 Telecom Switches consist of an optically isolated solid state relay (SSR) and autopolarity optocoupler in a single 8-pin package. The LH1529 and LH1549 differ on three parameters, SSR load voltage, SSR ON-resistance, and optocoupler LED continuous forward current. The following table illustrates the differences between the two devices:

Device	SSR V_L (V)	SSR R_{ON} (Ω) Max	Optocoupler I_F (mA) Max
LH1529	350	25	50
LH1549	400	33	120

Within the telecom switch, the SSR is ideal for performing on/off-hook control and dial pulse switching. The optocoupler is ideal for ring detection and loop current sensing functions. Both the SSR and the optocoupler provide better than 3750 Vrms of input-to-output isolation to satisfy worldwide telecom safety requirements.

Figure 1 shows the LH1529 SSR being used for on/off-hook control and dial pulsing, and the optocoupler being used for ring detection in a modem circuit. A discussion of this application follows.

On/Off-Hook Control

For on/off-hook control, the function of the SSR is that of a switchhook, to make a connection to the telephone loop. The SSR has a 1 Form A contact (SPST-NO) between pins 7 and 8, which is actuated by an LED between pins 1 and 2. An appropriate LED drive current (I_{FON}) can be derived from Figure 2. Drive current is dependent upon ambient and junction temperature.

Elevated ambient temperatures and electrical self-heating from high-load currents mandate a higher LED drive current. Figure 2 utilizes a worst-case parameter analysis and takes into account manufacturing tolerances in order to ensure SSR turn-on.

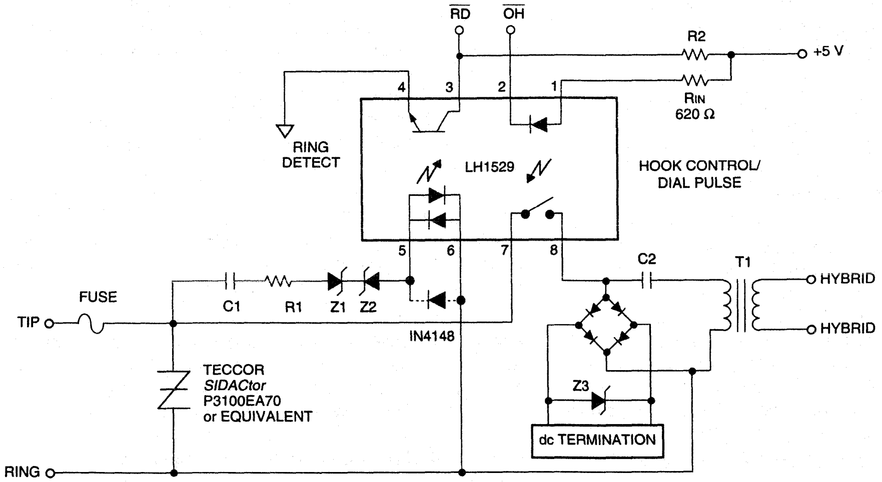
For the circuit in Figure 1, a minimum of 5 mA drive current is provided. This drive current can easily be sinked from TTL logic or sourced or sinked from modem chip set CMOS. The 5 mA was selected from Figure 2 as a value that guarantees hook control up to 85°C ambient temperature with loop current potentials better than 80 mA. The input resistor value (R_{IN}) was calculated assuming a minimum supply voltage of 4.75 V and a maximum LED voltage drop of 1.45 V at 0°C.

$$\frac{Vcc(min) - V_F(max)}{I_F(min)} = R_{IN}(max)$$

Where Vcc(min) is the minimum supply voltage, V_F(max) is the maximum forward voltage drop of the LED at the coldest ambient temperature, and I_F(min) is the minimum desired LED forward current. The maximum value for R_{IN} equates to 660 Ω. The next lowest common resistor value of 620 Ω is used. For a more in-depth discussion, refer to the *Input Resistor Selection* Application Note.

The output of the SSR is a source-coupled MOSFET switch pair (Figure 1 of the data sheet), which functions as the relay's contact. In its off-state (on-hook), a typical SSR provides an extremely high off-resistance (5000 GΩ). The SSRs are tested for an off-resistance minimum of 500 MΩ at 100 Vdc. This far exceeds worldwide on-hook dc impedance requirements. For instance, the U.S. requires 5 MΩ, and Canada 2 MΩ off-resistance at 100 V. Japan requires 1 MΩ at 250 V, and the U.S., 30 kΩ at 200 V [1]. Test minimums of 350 MΩ at 350 V for the LH1529 and 400 MΩ at 400 V for the LH1549 guarantee these requirements.

Figure 1. Telecom switch modem application



Some countries also specify a minimum on-hook ac impedance. The ac impedance of the SSR is dependent upon the contact capacitance, which is a function of the applied voltage. For these requirements, the SSR provides 32 MΩ of capacitance reactance at 500 Hz. Canada requires that the ac impedance be greater than16 kΩ at 500 Hz.

Most countries also specify impedance from Tip and Ring to ground. The telecom switch provides a minimum of 450 MΩ from input to output tested at 4500 Vrms. Here again, this far exceeds typical on-hook regulatory requirements of 5 MΩ or less. It also easily complies with FCC 68.304 leakage current limitations (>100 kΩ at 1000 Vdc).

Off-hook impedance for the SSR is in the 12 Ω to 33 Ω region depending on the telecom switch selected. Overall dc off-hook impedance requirements of less than 200 Ω or 300 Ω are easily achieved using the SSR and a transformer or dc loop holding circuit. For off-hook return loss and longitudinal balance requirements, the contribution of a typical SSR at room temperature is a flat 0.28 dB for an LH1529 or 0.35 dB for an LH1549 across the entire frequency range.

The final consideration with the on/off-hook control SSR is contact protection under fault conditions. Built-in current-limiting circuitry to the SSR protects the contacts from repetitive off-hook transients or ac over-current stresses. Overvoltage protection is required to prevent the SSR from going into avalanche breakdown during on-hook faults. Quite often, the same protector that is used to protect voltage-sensitive components in the ring-detect circuit or dc loop holding circuit will serve as adequate protection for the telecom switch.

There are many performance and safety requirements that specify longitudinal and metallic lightning surges. There are also documents like UL 1459 which specify power line inductions. For any longitudinal requirement, the I/O isolation of the telecom switch is 100% tested to ensure a minimum sustaining voltage at 3750 Vrms for 1 minute. For metallic requirements, a transient voltage suppressor is required.

The circuit of Figure 1 uses a solid state *SIDACtor** to limit the potential between Tip and Ring to 350 V. If a metal oxide varistor (MOV) is used in lieu of the crowbar *SIDACtor* device, use the LH1549 Telecom Switch. The SSR in the LH1549 provides a load voltage of 400 V which provides additional margin for the MOV's clamp voltage during lightning surges. In addition, the dc termination zener (Z3) protects an off-hook SSR from transformer inductive flyback by freewheeling when the SSR current-limit circuitry interrupts current during a transient. For a more in-depth discussion of SSR overvoltage protection and current-limit performance during transient operation, refer to the appropriate application notes.

Dial Pulsing

The SSR in the circuit of Figure 1 can also be used for dial pulsing in the U.S. and other countries. For countries that specify pulse dial rise and fall times like the U.K., an additional SSR should be used. A separate relay for dial pulse eliminates electronic inductor interaction in dry transformer designs by placing a direct short across the telephone loop for a dial pulse make period.

For dial pulsing, EIA/TIA-496-A specifies a minimum ac on-hook impedance with 1 Vrms to 10 Vrms across the device. The worst-case capacitance of the SSR would be at the lower 1 Vrms requirement. The ac impedance of the SSR under this condition is in the hundreds of megohms, well above the kilohms specification. On-hook and off-hook impedance to ground requirements are also compliant as described previously. EIA/TIA-496-A allows 3 ms for contact bounce. The SSR will switch cleanly, well within 2.5 ms without any contact bounce when driven with at least 5 mA of LED drive current.

Note:

*SIDACtor is a registered trademark of TECCOR Electronics Inc

Ring Detection

The optoisolator portion of the telecom switch is used for ring detection in Figure 1. With proper selection of an external zener and RC network, isolated ring detection can be implemented.

Capacitor C1 blocks dc loop current from entering the ring detection path. The value of C1 must be low enough to pass the lowest-frequency ring signal. The upper value limit is set by Telco impedance regulations like FCC Part 68.312 (generally 1600 Ω to 40 kΩ). Values between 0.33 µF to 0.56 µF are common for ringer equivalence numbers (REN) less than 1.

The working voltage of C1 should be higher than the breakover voltage of the transient voltage suppressor. Resistor R1 limits the ring current flowing through the ring detect path. R1 and C1 values set up the overall ring-detect impedance and REN value. This impedance value will dictate the current transfer ratio (CTR) of the optoisolator and select the sensitivity of the ring-detect network. Values from 7.2 kΩ through 22 kΩ are common for R1. The power rating should be between 0.5 W and 1 W, chosen to safely dissipate the worst-case ring signal (example, 150 Vrms, 68 Hz).

The back-to-back zener diodes, Z1 and Z2, set the minimum amplitude threshold for the incoming ring signal. The value of the zener depends on the combined impedance of (R1+C1) in the range of 15.3 Hz to 68 Hz together with the V-I specifications of the LED of the optoisolator.

The optoisolator crosses the dielectric barrier and therefore is subject to the on-hook impedance tests. Like the SSR, the optoisolator provides 450 MΩ of isolation resistance tested at 4500 Vrms. This exceeds worldwide on-hook impedance requirements [1]. The optoisolator contains two antiparallel LEDs. For ring detection, the antiparallel LEDs provide symmetry by conducting on both halves of the ac ring signal. The forward-biased LED also protects the other LED from exceeding its reverse breakdown voltage. Upon ring detection, the phototransistor outputs a full-wave rectified ring signal. For half-wave rectification, place a 1N4148 diode across the internal diodes as shown with the dotted lines in Figure 1. This will clamp the voltage to 0.7 V, keeping the forward-biased parallel diode from conducting during its half of the ring waveform.

R2 is the collector pull-up resistor. The value of R2 is dependent upon REN, CTR, dark current leakage, and trickle current leakage parameters. REN determines how much current will be flowing through the LEDs. CTR determines how much of that current will be coupled to the optotransistor. From dark current leakage (I_{CEO}), one can determine how resistive the optotransistor will be with 5 V across it and no LED input. Figure 3 provides I_{CEO} versus temperature information. Trickle current leakage specifies collector current when a small amount of current is flowing through the LED input. For a given Vcc, the phototransistor must swing down to a logic level low when the lowest LED current is sourced. For a given REN, a range of LED currents can be determined. The optoisolator collector currents can then be determined from the CTR (allow some design margin). With known collector currents, a range of values for R2 can be determined.

There are drawbacks to extreme values on either side of such range. If R2 is chosen close to the lower limit, logic and phototransistor leakage current are more tolerable but the saturation voltage of the logic low state increases. If R2 is chosen close to the upper limit, a low REN can be realized but sensitivity to line disturbances and leakage current fluctuations becomes more of a concern. Values of R2 between 10 kΩ to 20 kΩ are common.

Having considered parameter interactions, manufacturing tolerances, and temperature variations (up to 50°C), component values for a U.S. ring-detect circuit implementation are shown in Figure 4. Vary these values accordingly when designing for other countries or to achieve better performance.

In any design, remember to consider parameter shifts with temperature. Zener voltage increases with elevated temperature, while capacitance and CTR decreases. CTR of the telecom switch varies by approximately –0.4%/°C with an increase in temperature. The average CTR value runs about 150%.

Figure 2. SSR recommended operating conditions

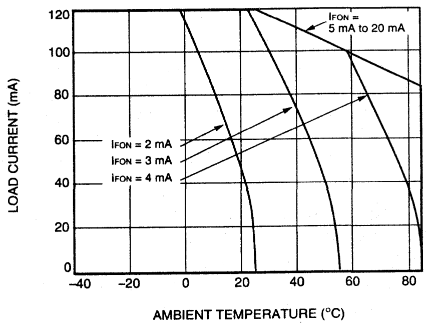


Figure 3. Typical ICEO vs. temperature

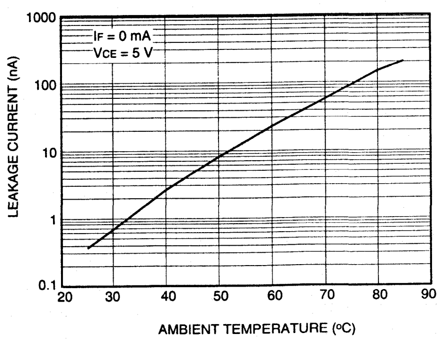
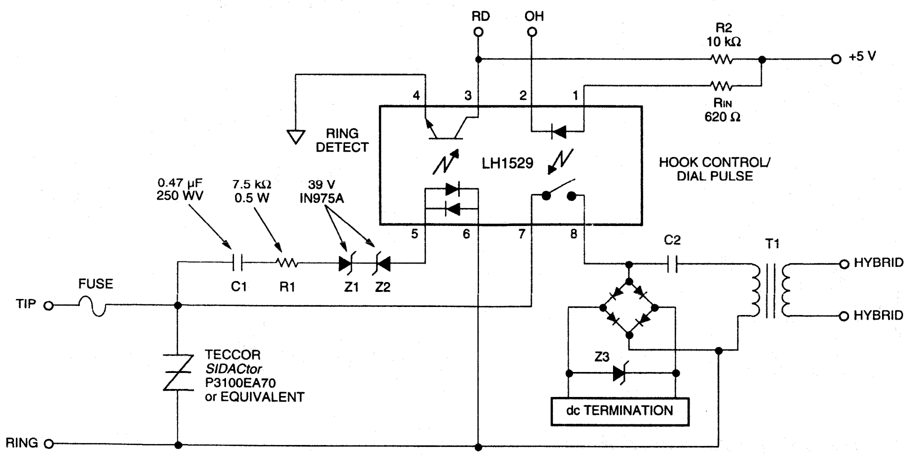


Figure 4. Typical telecom switch modem application



Loop Current Detection

Another application for the telecom switch is loop current detection. The optoisolator in the telecom switch can be placed in series with a telephone line to detect presence of loop current. The autopolarity input allows current detection even under polarity reversal conditions.

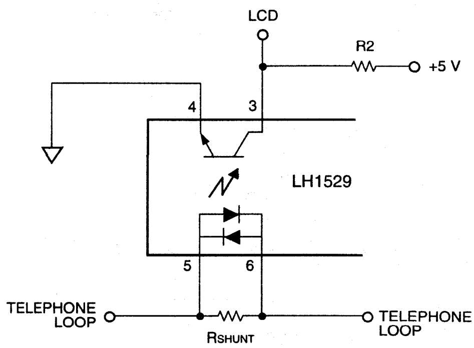
Loop current detection can be used for a variety of reasons. One common application is in FAX machines and answering machines. If the far-end party hangs up after a call has been established, many central offices will momentarily interrupt the loop current to the local end of the connection. If this disconnect signal can be detected, the FAX or answering machine can immediately go on-hook, rather than waiting 20 seconds or more to detect that the far-end party is no longer on the line. This prevents the FAX or answering machine from tying up the phone line unnecessarily.

To set up a threshold trip current, a resistor shunt can be used as shown in Figure 5. To trip at a given threshold current, simply divide the lowest anticipated LED forward voltage by the desired threshold current to determine the resistor shunt value.

To determine the lowest LED forward voltage, start with the manufacturing minimum value of 0.9 V @ 10 mA and vary it accordingly to compensate for threshold current and temperature using Figure 6 as a guide. For selecting the value of R2, the same considerations as those discussed in the Ring Detection section apply. Of course here, loop current would take the place of REN.

Another consideration is LED protection against lightning. Here, the current-limited SSR can be beneficial if used in series with the loop current detector. For circuits where this is not possible, a set of external shunting diodes and another sense resistor may be required to protect the antiparallel LEDs from excessive current (see Figure 7).

Figure 5. Loop current detection



An alternative loop current detector circuit is shown in Figure 8. This circuit senses loop current as it flows through the dc termination circuit. Positive and negative connections are derived from the dc termination's diode bridge. The forward-biased diode of the telecom switch supplies base current to Q1. Q1 shunts excess loop current around the telecom switch. Loop threshold current is set by the value of R1. In this circuit, lightning protection is provided by the zener protecting the electronic inductor.

In loop current detection applications, potentially high-loop currents can flow through the telecom switch LEDs which can degrade an LED's light output over time. The LH1529 Telecom Switch can reliably handle up to 50 mA of loop current. The LH1549 has larger LEDs in the optocoupler which can reliably handle 120 mA. Be leery of products that do not use an adequately sized LED to handle higher currents.

Figure 6. Typical LED forward voltage vs. temperature

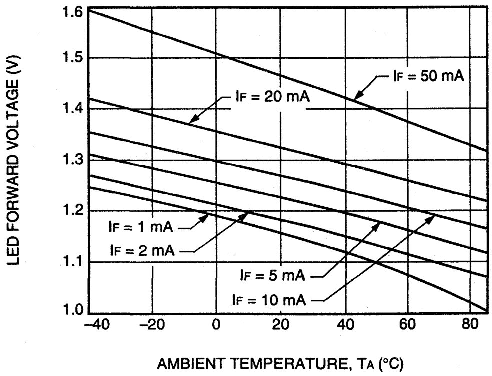


Figure 7. Loop current detection with parallel protection network

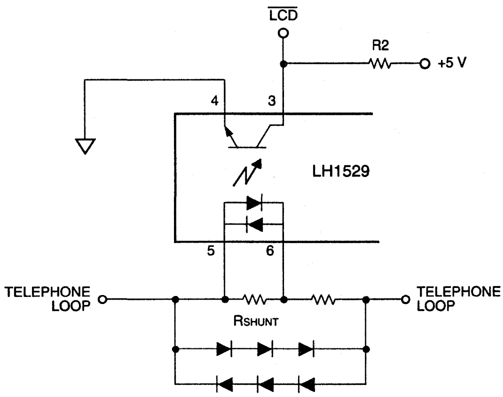
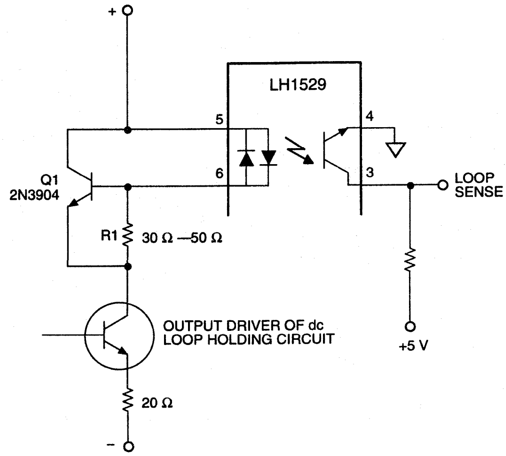


Figure 8. Loop current detection within the electronic inductor of a dc loop holding circuit



References:

1. *Trade and Telecom: Direct Connection Overseas*, by Glen Dash, Compliance Engineering, page 278, 1988.
2. *TIA Telecommunications Systems Bulletin No.31, Part 68 Rationale and Measurement Guidelines*, by EIA/TIA TR-41 Committee on Telephone Terminals, Washington D.C. 1990.

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Modem Line Interface Solutions Appnote 66

Introduction

This application note shows how Siemens solid state relays (SSRs) can be used to implement telephone line interface functions for Europe and North America.

The term "Data Access Arrangement" (DAA) is commonly used to describe the interface circuitry that connects voice and or data signalling circuits to the telephone line. This function is required in computer modems of all types (internal, external, and PCMCIA), FAX machines, answering machines, and certain types of special feature telephones.

Typical DAA functions include high-voltage isolation, on-/off-hook control, pulse dialing, line transfer, ring detection, loop-current detection, and caller ID detection.

On-/Off-Hook Control and Pulse Dialing

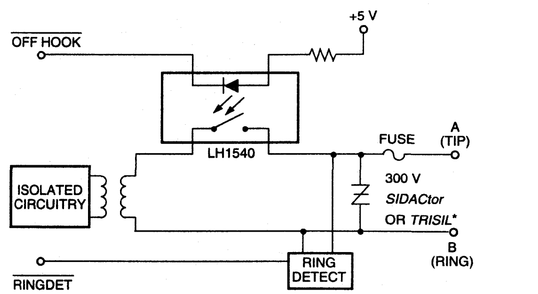
In the simplest circuit, (Figure 1) where a single relay is used to provide on-/off-hook control as well as pulse dialing, an SSR provides several advantages over a mechanical relay: 1, the SSR is considerably smaller. 2, the current required to operate the SSR is only 5 mA at operating temperatures up to 85°C. 3, the SSR does not require large external components across the switch to protect the contacts from arcing during pulse dialing.

In contrast to other SSRs, Siemens devices are available with current limiting. This feature allows the SSRs to survive repeated lightning strikes even when in the "on" condition, by rapidly turning the SSR off thereby shunting the current through an external protection device.This current-limiting feature can also be useful for meeting safety requirements such as the UL 1459 overvoltage test. Siemens SSRs can limit the fault current through the load, thereby greatly reducing overheating and the subsequent risk of fire.

Ring Detection and On-/Off-Hook Control

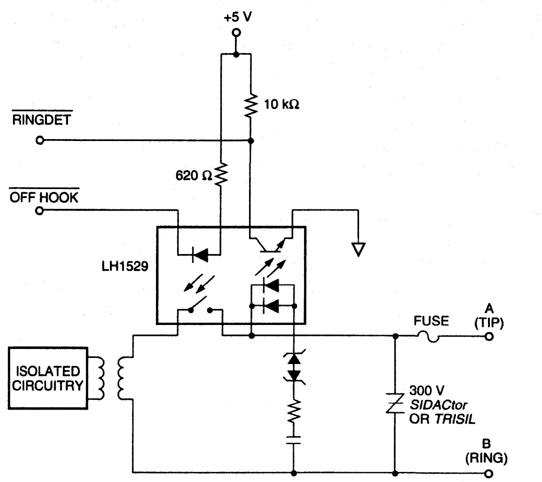
The LH1529 Telecom Switch utilizes two common line interface functions in the same package. A solid state relay for on-/off-hook control and an optoisolator in the same package provide a simple method for implementing a ring detector (Figure 2).

Figure 1. On-/off-hook control and pulse dialing



* Trisil is a registered trademark of SGS–Thompson Microelectronics S. A.

Figure 2. Typical ring detection application



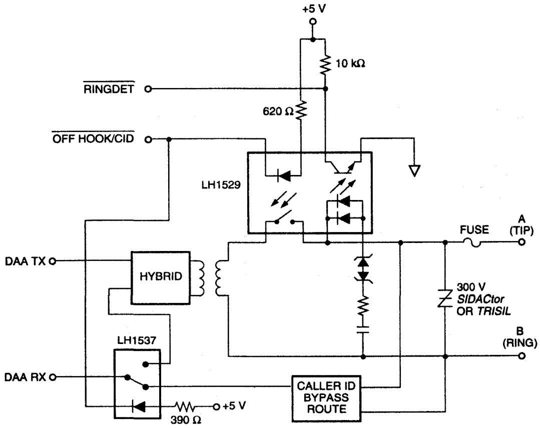
Caller ID, Ring Detection, and On-/Off-Hook Control

Caller ID is a feature that is available in the United States and is now being considered in several other countries.

In the United States, the central office transmits an FSK modulated signal during the silent interval between the first and second ring cycles. The modulated signal contains the telephone number of the calling party. This information can be used for a variety of purposes, such as ignoring unwanted calls or identifying priority callers.

The circuit shown in Figure 3 uses a 1 Form C SSR (LH1537) as a switching function for the caller ID signal decoding in a modem. When the modem is in the on-hook state, the caller ID signaler is directed to the receive input of the modem. When the modem is in the off-hook state, the hybrid circuit is connected to the receive input of the modem.

Figure 3. Caller ID application

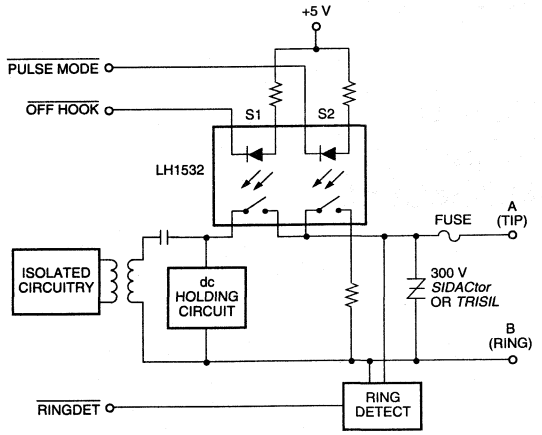


Pulse Dialing with Pulsing Termination

In some applications, the transient response or voltage drop of the load presented by the line interface makes it unsuitable as a termination for pulse dialing. This is often the case for so called dry transformer circuits, where the dc loop current flows though a solid state holding circuit.

To provide a suitable termination for the loop during pulse dialing, an additional solid state switch (S2) can be used as shown in Figure 4. To enter the pulse dialing mode, the pulsing relays (S2) is closed, and the switchhook relay (S1) is opened. Pulse dialing is then performed by opening and closing S2. At the conclusion of pulse dialing, S1 is closed and S2 is opened. This returns the circuit to the normal off-hook state. Siemens SSR LH1532 provides both S1 and S2 in a single package. In some cases, the resistance of S2 will provide a sufficient pulsing termination, thus eliminating the need for a series resistor.

Figure 4. Pulse dialing with pulsing termination application



Pulse Dialing with Ringer Shunt

In some countries, pulse dialing is performed in conjunction with a shunt wire. During pulse dialing, the shunt wire is connected to the A side of the phone line. The shunt wire is needed for certain types of equipment in France and the United Kingdom.

Figure 5 shows how the Siemens LH1532 SSR can be used to perform the ringer shunt function. Connecting the shunt wire to the A lead has the effect of shorting out the ringers of all parallel-connected terminal equipment. This prevents the ringers from responding to the transients caused by pulse dialing. Such false triggering is often referred to as bell tinkle.

Figure 5. Pulse dialing with ringer shunt

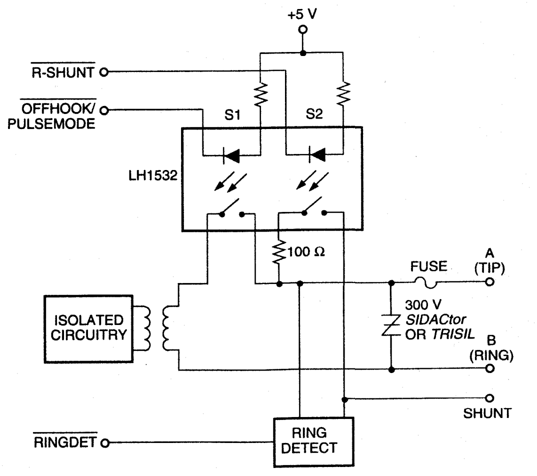
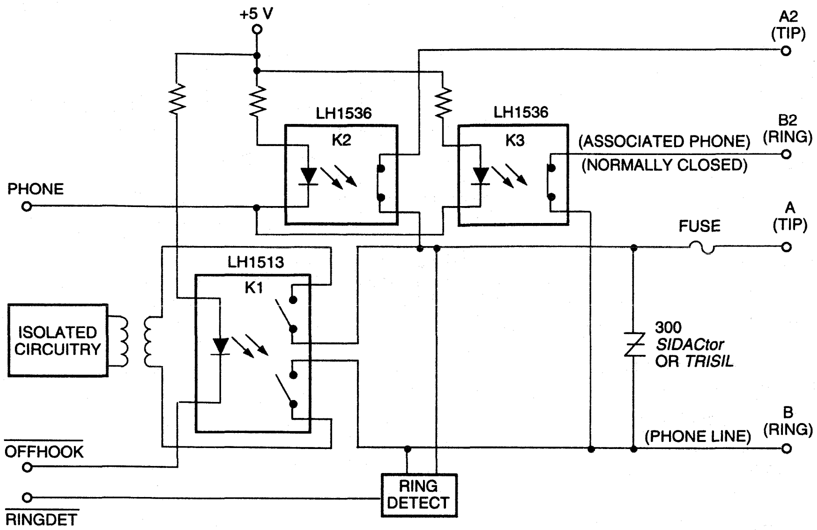


Figure 6. Typical talk/data switch application



Talk/Data Switch

In some types of equipment, such as FAX machines and modems, provisions are made for connecting an associated telephone. If the associated telephone were simply connected in parallel with the FAX or modem, any data transmission in progress could be corrupted by taking the associated telephone off-hook.

To prevent such problems, a switching function can be accomplished by using the Siemens relays as shown in Figure 6. Relay K1 (LH1513) is used for on-/off-hook control for the fax or modem. Relays K2 and K3 (LH1536) allow the associated telephone to be disconnected under software control.

When the FAX or modem is idle or not powered up, relay K1 is open and relays K2 and K3 are closed. This allows the associated telephone to operate normally. When the FAX or modem are in operation, the relay K1 closes (goes off-hook) and relays K2 and K3 are now opened. This prevents the associated telephone from corrupting the transmitted data.Under appropriate software control, the telephone line can be connected to either the fax or modem or to the associated telephone. This configuration allows what is commonly referred to as talk/data switching.

The talk/data switching function shown in Figure 6 is suitable for use in Germany, where this function is generally used in FAX, modem, and answering machines. In Germany, the series resistance between the A/B leads and the A2/B2 leads must not exceed 25 Ω. In addition, relay K1 should be used to disconnect the A and B leads when the associated telephone is enabled. For applications in Germany, it may be possible to use a simpler circuit with fewer relay poles and/or higher series resistance.

Loop Current Sensing

Figure 7 shows how an optoisolator contained in the LH1529 Telecom Switch can be used for detecting loop current.

Loop-current detection can be used for a variety of reasons. The most common reason is in FAX and answering machines. If the far end hangs up after a call has been established, many central offices will momentarily interrupt the loop current to the local end connection. If this disconnect signal can be detected, the FAX or answering machine can immediately go on-hook, rather than waiting 20 seconds or more to detect that the far-end party is no longer on the line. This prevents the FAX or answering machine from tying up the telephone line unnecessarily.

The circuit in Figure 7 shows such a loop current detector. The 47 Ω resistor, in conjunction with the six 1N4001 diodes, prevents excessive current from flowing through the LEDs in the LH1529 SSR. This protects the LEDs from damage due to high loop current or lightning. For long-term reliability, the current through the LEDs should be limited to under 50 mA. The 68 Ω resistor sets the threshold detection.

An alternative solution for loop current detection is shown in Figure 8. This circuit senses loop current as it flows through the dc termination circuit that is typically used with dry transformers. Positive and negative connections are derived from the dc termination diode bridge. Z1 shunts excess loop current around the telecom switch.

Figure 7. Loop current detection

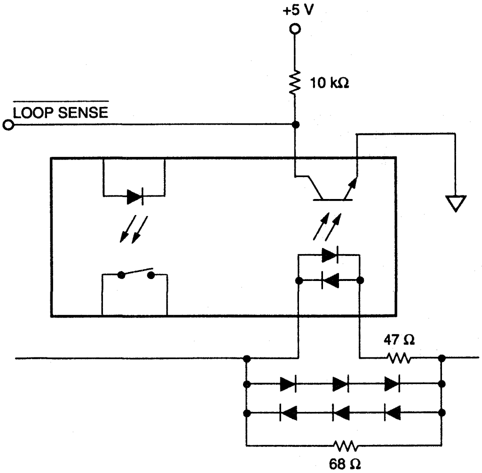
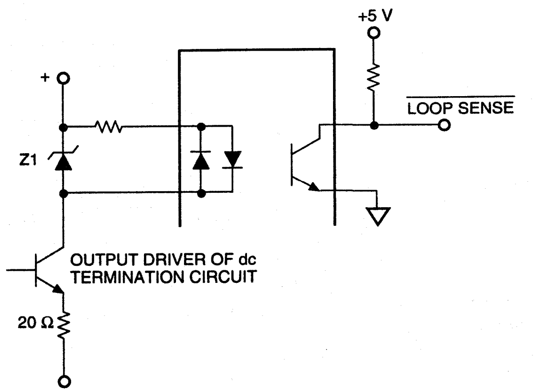


Figure 8. Loop current detection with dc termination circuit



The LEDs in the optoisolator of the LH1549 have a current rating of 120 mA. Using the LH1549 in place of the LH1529 simplifies the circuit in Figure 7 by eliminating the need of the six 1N4001 diodes and the 47 Ω resistor. In Figure 8, by using the LH1549, the zener diode and LED series resistor can be eliminated. However, it should be noted that some form of lightning surge current limiting is still required in both circuits. One way to provide this protection is to use the current-limiting function that is available in many of the SSRs in the LH1500 family.

SIEMENS

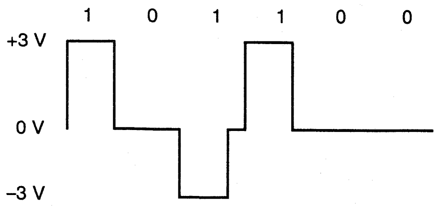
T1 Switching with the LH1514 Solid State Relay Appnote 67

Introduction

The T1 carrier enjoys wide application. As a transmission standard developed in the early sixties, it has survived over three decades of network growth. It is a four-wire transmission medium (two transmit, two receive) consisting of twisted-pair transmission lines, typically using 22-gauge wire, and often bundled with one common shield for all carriers. Its primary application is at the DS1 data rate of 1.544 Mbits/s, where 100 Ω characteristic impedance line is employed. In Europe, there is a related data rate at 2.048 Mbits/s (DS1A). Data rates of 3.152 Mbits/s (DS1C), 6.312 Mbits/s (DS2), 44.736 Mbits/s (DS3), 139.264 Mbits/s (DS4NA), and 155.520 Mbits/s (STS-3) are also common in North America [1].

DS1 signaling on a T1 line typically follows an alternate mark inversion (AMI) format which is illustrated in Figure 1.

Figure 1. Bit patterns for a T1 signal.



Description

When the DS1 signal emerges from a T1 interface device, it passes through a transformer and is injected onto the T1 line with alternating pulses whose amplitudes typically alternate between +3 V and –3 V about midway down the T1 line. The rising and falling edge slew rate can be as fast as 0.6 V/ns at the driving end.

Applications for T1 lines are quite varied. Within a telecom switch, the T1 line is a popular low-cost transmission medium for wiring from the switch fabric to the outer switch boundary. As a transmission medium on a digital loop carrier (DLC), a T1 line can connect 24 customers on a subscriber loop to a main telecom switch installation, thus saving a bundle of tip/ring pairs. In an ISDN application, a T1 line can carry 23 bearer channels and one data channel to implement the ISDN primary rate interface (PRI), i.e., 23 B+1D.

In a telecom switch installation, there is often the need to switch T1 lines. One such application includes T1 sparing, such as found in protection switching. Until now, this switching was done with large, bulky, electromechanical relays, which were susceptible to shock, vibration, contact wear, contact bounce, sticking, and long-term reliability failures. Also, in switching, an electromechanical relay creates substantial contact noise and relay coil kickback. Furthermore, these relays tend to require significant amounts of coil current, neighboring in the mid tens of milliamps. Since they require full coil voltage to operate, no sharing of coil currents is possible for multiple-switching situations, unless one chooses to run the coils from a central office battery voltage. More importantly, modern equipment installations are migrating to full surface-mount manufacturing, for which these large relays are unsuitable.

The LH1514 solid state relay overcomes the above limitations of electromechanical relays in an 8-pin, surface-mount DPST configuration (it is also available in a through-hole DIP). The LH1514 is rugged, very small, and offers superior reliability at 20 FITs (failures in 10^9 device-hours). It offers smooth, quiet switching and 8 mA guaranteed control over the entire temperature range, and, perhaps best of all, it is available in a surface-mount package for reduced manufacturing costs. Additionally, the LED turn-on voltage is less than 1.5 V, allowing ganged switches to share control currents by placing the LEDs in series. This saves substantial power in dense T1 relay matrices.

The LH1514 is targeted primarily for DS1 switching applications, being optimized for low on-resistance (5 Ω, typical) and good off-state blocking. For a slew-rate of 0.6 V/ns, the LH1514 will allow no more than 100 mV of signal bleed-through. The useful frequency range of the LH1514 is not limited by data rate but by the slew rate of the signal being blocked in the off-state. DS1A, DS1C, and DS2 data rates could be switched by the LH1514 if the off-state bleed-through of 100 mV max at 0.6 V/ns is adequately low.

In this document, the LH1514 T1 Relay from Siemens will be described. Next, a typical application will be presented, including extensive design information. Basic T1 transmission principles, as they relate to the LH1514, will be discussed, including the following:

- Off-state Bleed-through
- Transmission Line Matching
- Return Loss Minimization
- Impact of Mismatch on Meeting the DS1 Template
- Lightning Survival
- Interoffice Application of the LH1514

Main Characteristics of the LH1514 [3]

The LH1514 is manufactured in High-Voltage BCDMOS process, using optical coupling to achieve 3750 V isolation from input to output. BCDMOS features dielectric isolation (DI) in order to achieve the ultimate in component isolation. The DI is essential for optically coupled devices, such as a solid state relay. The relay chip is activated by an infrared LED mounted in close proximity. DI prevents unwanted device interaction between light-sensitive devices and the active output circuitry. The BCDMOS process has been in production since 1984 and is presently in its third generation.

Figure 2 illustrates the pinout for the LH1514.

The LH1514 consists of two normally off poles (2 form A, DPST). With no LED current, both poles are off. When the LED is activated with sufficient forward current, the two poles will turn-on so that they meet the on-state specifications. The key specifications for the LH1514 are given in the Absolute Maximum Ratings and Electrical Characteristics sections.

Because the ON-resistance of the solid state relay cannot be made ideally zero, some care must be taken to ensure proper line matching on the receiving end of the T1 line when the LH1514 is employed.

The off-state bleed-through is a critical specification. That and the ON-resistance are the most important parameters. ON-resistance and off-state blocking will be discussed in the following sections.

Figure 2. Pinout for the LH1514

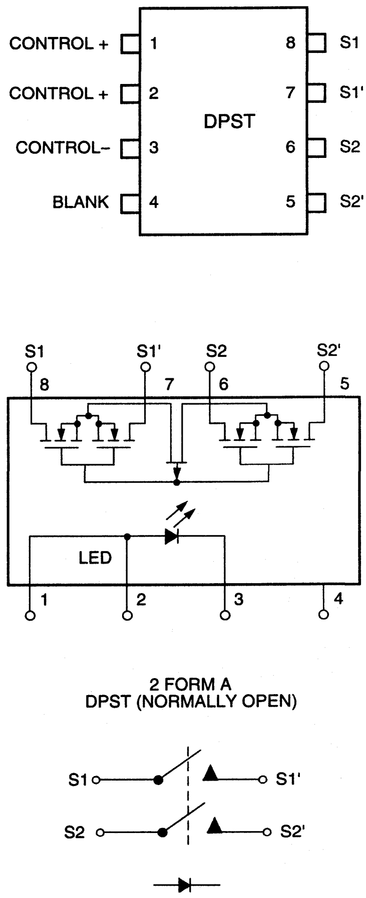


Table 1. Absolute maximum ratings

Parameter	Symbol	Value	Unit
Ambient Temperature Range	T_A	–40 to +85	°C
Input/Output Isolation Voltage	V_{ISO}	3750	Vrms
LED Continuous Forward Current	I_F	50	mA
dc or Peak ac Load Voltage	V_L	15	V
Continuous dc Load Current	I_L	150	mA
Power Dissipation	Pdiss	600	mW

Table 2. General electrical characteristics

Parameter	Min	Typ	Max	Units
LED Forward Current Required for Turn-on: T=25°C T=85°C	 — —	 2.5 5.0	 4.0 8.0	 mA mA
R_{ON} (25°C)	3.0	5.0	8.0	Ω
TC(R_{ON}) (–25°C to +85°C)	—	–0.0936	—	%/°C
Vmax (breakdown voltage @ 50 μa)	15	25	—	V
$T_{ON/OFF}$	—	0.5	1.0	ms
Off-state Bleed-through, 1.5 MHz Square Wave, 3 V_{pp}, T_{RISE}=5 ns, 50 Ω Load (See Figure 3)	—	70	100	mV pk

Figure 3. Off-state bleed-through for the LH1514

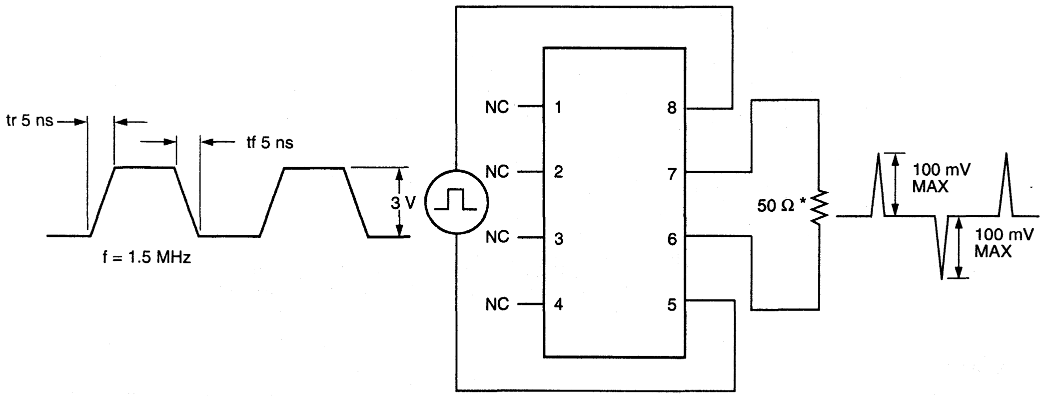
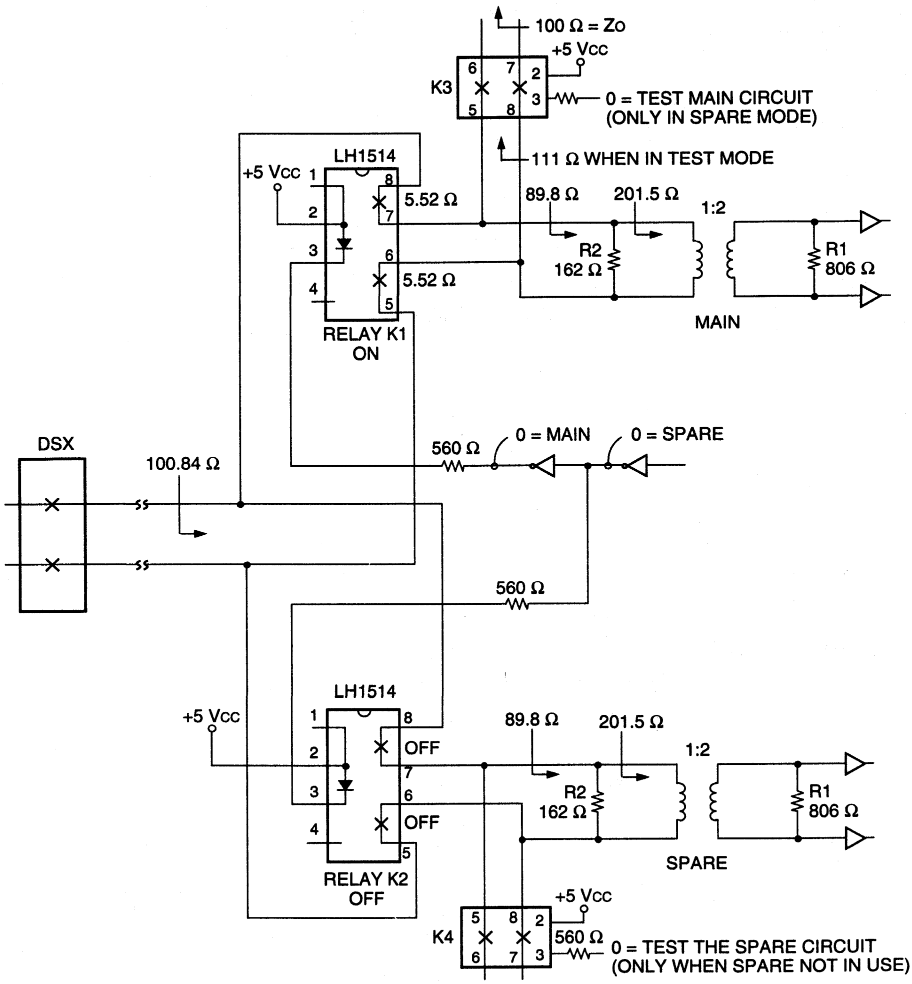


Figure 4. Typical T1 relay application



A T1 Relay Application

Figure 4 illustrates a typical application for the LH1514. It is a T1 sparing application where a T1 line could connect to one of two receiving-end circuits. This application is often known as **protection switching**.

As illustrated in Figure 4, the upper relay, K1, is on, while the lower relay, K2, is off. When K1 is off and K2 is activated, the network is said to be in a **protection switching** mode. In this mode, the main receiving circuitry is placed under testing while the signal is routed to a spare receiver. When not in a **protection switching** mode, the spare receiver is under test. The LED current, provided through a TTL inverter, is set at 8 mA to ensure full operation over the temperature range of 0°C to 75°C for this example.

The signal comes from a digital cross connect (DSX). The DSX is that place in a system where T1 lines are hardwired together. It also serves as a good place to measure and characterize signals. The DSX is typically midway between the source and load points, which, in turn, are typically several hundred feet from one another.

The transmission line is typically 22-gauge twisted pair, offering about 0.47 dB of attenuation per every 100 ft. at 1 MHz. At 2 MHz, 3 MHz, and 4 MHz, the attenuation is about 0.66 dB, 0.82 dB, and 0.94 dB per 100 ft., respectively [1,4].

The 100 Ω transmission line arrives at the load through an LH1514. The signal then arrives at a padding resistor, R2, continues across a step-up isolation transformer, and finally crosses a load resistor, R1, before it arrives at the receiving-end circuitry.

At room temperature, the R_{ON} of the LH1514 is typically 5 Ω per pole. But over temperature, the minimum R_{ON} would be 2.86 Ω at 75°C. (TC(R_{ON})=–0.0936%/°C). Thus, the R_{ON} ranges from 2.86 Ω (min, hot) to 8.19 Ω (max, cold), having a midrange value of 5.52 Ω ±2.67 Ω for this set of conditions. The loading on the receive end of the relay is purposely made a little lower than 100 Ω. R1 and R2 are selected to work with the R_{ON} of the relay, in order to provide nominal 100 Ω matching to the transmission line. The terminating impedance seen by the transmission line is given by:

$$ZT = 2 \cdot R_{ON} + (R2 // (R1 / N^{**}2)) \qquad (1)$$

where:

R_{ON} is the R_{ON} of one relay pole, nominally 5.52 Ω for this case. R1 is chosen to be nominally 806 Ω (using standard 1% values). R2 is chosen to be nominally 162 Ω. N is the effective transformer turns ratio, 2 for this case, and ZT is the terminating impedance seen by the transmission line, which turns out to be 100.84 Ω for this set of component values. This provides nearly perfect 100 Ω matching for the transmission line.

The off-state blocking becomes important in the protection switching mode. Here, the main receiver under test cannot be corrupted by the signal now going to the spare. Likewise, the signal going to the spare cannot corrupt the main receiver now under test. It is important to prevent false triggering of the digital circuitry on the receiving end. The LH1514 has been designed to provide no more than 100 mV of false signaling on the transformer primary due to off-state bleed-through.

The worst-case signal dv/dt (i.e., slew-rate) has been estimated at 0.6 V/ns. This dv/dt will try to induce signal current to jump across the off-state relay contacts due to their off-state capacitance. To the off-state relay, there is 49.6 Ω of loading. This consists of the 89.8 Ω loading, looking into the transformer, in parallel with the T1 line coming in through the test path when relay K3 is on. The impedance looking into K3 when it is on is 111 Ω. This path includes the 100 Ω transmission line impedance, plus the 5.52 Ω midrange on-resistance per pole of the LH1514. The resultant 49.6 Ω loading to the off-state relay is where the 50 Ω load in Figure 3 comes from.

An important feature of the LH1514 is its inherent ability to prevent off-state bleed-through. Figure 2 shows a JFET suspended between the midpoints of the two relay contacts. This patent pending technique uses the JFET to absorb unwanted signals that want to jump across the off-state relay contacts. Conceptually, it is a balanced version of the T-switch topology. When the relay contacts are on, the JFET is deactivated.

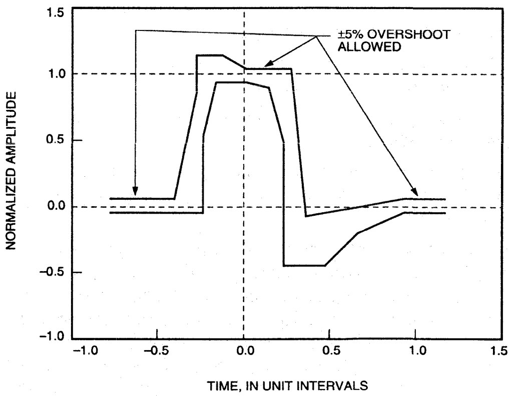
Note:

It is very important to use the same relay package to switch both leads in a twisted pair in order to minimize crosstalk and to take best advantage of this low bleed-through feature. Relay contacts should not be mixed and matched indiscriminately with different signals in the same package.

As stated above, the loading network on the receive end forms 100.84 Ω matching in conjunction with the two 5.5 Ω poles. This suppresses unwanted reflections from arriving back at the DSX. There is good reason for this.

Bellcore has published requirements for T1 lines [1]. Hard requirements for things like load mismatch and return loss are not well defined in reference [1], due to lack of industry convergence. While many important spec are listed as typical, the allowable waveform distortion at the DSX is very well defined. This specification is referred to as the DSX template. Load mismatch and return loss can be inferred from it. The template for DS1 waveforms is illustrated in Figure 5.

Figure 5. Conformance requirements for the DS1 waveform [1]



Minimum Curve	
Time in Unit Intervals	**Normalized Amplitude**
–0.77	–0.05
–0.23	–0.05
–0.23	0.5
–0.15	0.95
0.0	0.95
0.15	0.9
0.23	0.5
0.23	–0.45
0.46	–0.45
0.66	–0.2
0.93	–0.05
1.15	–0.05

Maximum Curve	
Time in Unit Intervals	**Normalized Amplitude**
–0.77	0.05
–0.39	0.05
–0.27	0.8
–0.27	1.15
–0.12	1.15
0.0	1.05
0.27	1.05
0.35	–0.07
00.93	0.05
1.16	0.05

It is customary for a system engineer to use an oscilloscope probe at the DSX to analyze the waveform. A transparency-photocopy of the DSX template is often taped to the screen of an oscilloscope to check for conformance. Because the boundaries of the DSX template are based on relative values, any reasonable manipulation can be done on the screen to bring the waveform into the template. This includes varying the horizontal time/division and vertical volts/division. Inverting the pattern of the screen is also used for negative pulses. One purpose of the template is to ensure that there is no crosstalk between bundled T1 lines.

This works on two bases:

- A pulse conforming to the waveform will not have so much overshoot that it causes crosstalk.
- If a signal conforms to the template, it is ensured that whatever crosstalk is present, it will not cause false triggering of the digital detection circuitry on the receiving end. Fortunately, crosstalk is usually very, very low.

Two (2) portions of the template require variation of less than 5% of peak value in the pulse shape:

- The baseline trace just before the rising edge and after the falling edge undershoot window.
- The flattened portion of the template, at the top, just past the overshoot window.

For a 3 V peak amplitude, this allows for only 150 mV of variation, which will consist of line reflections, crosstalk, and other secondary phenomena.

The shape of the template provides some insight into what to expect in T1 transmission medium. Over the distance of the transmission line, some attenuation of high-frequency components in the squared pulse is to be expected. This will result in rounding of the corners on the waveform. In order to maintain signal integrity, the rising and falling edges of the pulse are typically predistorted with some overshoot, with the intent of providing a more squared pulse at the receiving end. The driving-end circuitry often include some amplitude and wave shape programming to account for varying line lengths. One technique for tailoring the line drive is to use L-C equalization networks to create the desired predistortion. Integrated devices such as the T7289[2] form Siemens provide programmable equalization to accommodate long lines and overshoot predistortion simultaneously.

Relating the Template to Line Matching

In this section, it will be shown that use of the LH1514 allows for conformance to the DSX template, even though this relay has a nonzero R_{ON}.

The following analysis should be performed for any T1 transmission system, regardless of whether or not a solid state relay is used. The following analysis may seem complicated at first, but it is actually quite easy and gives enormous insight into the performance of your system.

The worst-case 5% waveform variation allowed by the DSX template, as mentioned above, relates directly to return-loss and line matching. Return loss is simply a measure of how much signal is lost in return from the load side of a line back to the driving side. It is a figure of merit for matching the load to the transmission line. For example, infinite return loss implies that matching is perfect; the transmitted energy is fully absorbed by the load, and no reflection occurs. The definition of return loss is:

$$RL = 20 \cdot log l (ZT + Z0)/(ZT - Z) \qquad (2)$$

where:

RL is return loss in dB.
Z0 is the transmission line characteristic impedance.
ZT is the terminating impedance.

If, for example, Z0 is 100 Ω and ZT is 95 Ω, the return loss will be 31.8 dB. RL specs of 26 dB minimum are common.

Note that if Z0=ZT, perfect transmission line matching occurs, and there is no reflection back to the load. The result is infinite return loss.

However, if ZT equals zero or infinity, the return loss is zero, and the energy impinging on the receiving end will be fully reflected back into the direction of the driver.

For the circuit in Figure 4, the return loss is nominally 47.57 dB, which is quite good. We will soon analyze how this varies with normal component tolerances.

(Transmission line matching is not to be confused with maximum power transfer matching. In maximum power transfer matching, it is desirable to have ZT as the complex conjugate of the transmission line impedance, perceived at the load, in order to maximize the power transferred to the load. In transmission line matching, it is desirable to have ZT be precisely equal to Z0, in order to reduce reflections. Since Z0 in this case has a real component of 100 Ω, matching is greatly simplified.)

The reflected voltage is related to return loss and is given by:

$$Vr = [(ZT - Z0)/(ZT + Z0)] \cdot Vpulse \qquad (3)$$

where:

Vr is the peak amplitude reflected signal.
Vpulse is the amplitude of the incoming signal.

If, for example, Z0 is 100 Ω and ZT is 95 Ω, the amount of signal reflection is 2.56% of Vpulse. This means that from a 3 V pulse, 77 mV will be reflected back into the direction of the source. If this 77 mV peak happens to appear at the DSX, the waveform observed there will have this 77 mV blip riding on top of the desired signal. It is a harmless phenomena, but it shows up nevertheless.

An excellent estimate of signal reflection can be made as follows: the percentage of reflected signal is approximately half the percentage of load mismatch. In this example, a 5% mismatch caused approximately a 2.5% reflection.

If this reflection nudges a portion of the waveform out of the DSX template, a system technician can observe it in the field. Even though this reflected signal has absolutely no impact on system performance, the technician can take note of it. In most cases, such phenomena are not a concern. But every reasonable effort should be made to provide good matching at the receiving end of the T1 line.

When analyzing the case of the solid state relay in the sparing application, the SSR ON-resistance must be counted as part of the load. Based on equation (3), the reflection coefficient, G, is given by:

$$Vr/Vpulse = G = (\mathbf{A} - 1)/(\mathbf{A} + 1) \qquad (4)$$

where:

G is the reflection coefficient

and

$$\mathbf{A} = ZT/Z0 \qquad (5)$$

Perfect matching would make G equal to zero and **A** equal to unity. For the circuit in Figure 4, **A** is 1.0084 and G is 4.18e–3. It is desirable to keep the absolute value of G under 0.05, based on the DSX template requirement discussed above. This means that **A**, the ratio of ZT to Z0, must be kept in the following range:

$$0.9047 < \mathbf{A} < 1.1053 \qquad (6)$$

As long as **A** is kept in this range, |G| will be 0.05 or less and the DSX template requirements will be met.

In this analysis, we will carefully look at all the variables which contribute to **A** and confirm that the DSX template requirements are fulfilled. It is important to note that this analysis should be done for every T1 application, regardless of whether a solid state relay is used.

When more than two variables are present, it is more realistic to use a statistical rms approach to the worstcase analysis, rather than lay all of the possible worstcase extremes end-to-end. This is a more reasonable approach to the worst-case problem because of the statistical nature of the variations being dealt with. It is highly unlikely that all of the worst-case conditions would precisely combine in the worst of all ways. In this type of analysis, the variational contributions to **A** are individually squared and added, and then the square root of the sum is taken to yield the final variation.

First we find **A** as a function of all the component values in Figure 4.

Combining equations (1) with (5):

$$\mathbf{A} = \frac{R1 \cdot R2 + 2 \cdot R1 \cdot R_{ON} + 2 \cdot R_{ON} \cdot R2 \cdot N^2}{Z0 \cdot (R1 + R2 \cdot N^2)} \qquad (7)$$

Since **A** is not a linear function of Z0, Z1, Z2, N, and R_{ON}, and because the variations under consideration are small compared to Z0, the calculus will be used to find the variation of **A** as a function of these variables. Once this is done, the following deviations from nominal **A** are found:

$$d(\mathbf{A}) = \frac{-\mathbf{A}}{Z0} \cdot dZ0 \qquad (8)$$

$$d(\mathbf{A}) = \frac{(R2 \cdot N)^2}{Z0 \cdot H^2} \cdot dR1 \qquad (9)$$

$$d(\mathbf{A}) = \frac{R1^2}{Z0 \cdot H^2} \cdot dR2 \qquad (10)$$

$$d(\mathbf{A}) = \frac{2}{Z0} \cdot dR_{ON} \qquad (11)$$

$$d(\mathbf{A}) = \frac{-2 \cdot N \cdot R1 \cdot R2^2}{Z0 \cdot H^2} \cdot dN \qquad (12)$$

where:

$$H = R1 + R2 \cdot N^2 \qquad (13)$$

and:

d(**A**) is the variation in **A**.
dZ0 is a variation in Z0.
dR1 is a variation in R1.
dR2 is a variation in R2.
dR_{ON} is a variation in R_{ON}.
dN is a variation in the effective turns ratio, N.

It is interesting in the above expressions to note the minus signs in front of a few of them. These give indication as to how the variables interact. For instance, an increase in Z0 would cause **A** to decrease, but an increase in R_{ON} will tend to cancel that effect.

To find the worst-case variation using an rms analysis, every term for d(**A**) given above is squared and then the sum of these squares is raised to the 1/2 power.

Obtaining values for equations (8) – (13) is rather straightforward. Most parameters are assigned their nominal value. Transmission line impedance is typically controlled within 5%. The midrange value for R of 5.52 Ω is used. Variation in R1 and R2 is taken to be 2.5% of nominal value. This comes from the fact that end-of-life limits for a 1% resistor can go as far as 2.5% from center over device lifetime. The effective turns ratio can be very well controlled, typically 2%.

The following values are used in quantifying equations (8) –13):

Z0 = 100 Ω
dZ0 = ±5 Ω, max

R1 = 806 Ω
dR1 = ±20.15 Ω, max

R2 = 162 Ω
dR2 = ±4.05 Ω, max

R_{ON} = 5.52 Ω
dR_{ON} = ±2.67 Ω, max

N = 2
dN = ±0.04, max

Based on the above, the individual variations in d(**A**) are as follows:

d(**A**)[dZ0] = ±5.042e–2
d(**A**)[dR1] = ±1.00054e–2
d(**A**)[dR2] = ±1.2445e–2
d(**A**)[dR_{ON}] = ±5.34e–2
d(**A**)[dN] = ±1.60087e–2

By squaring the above terms, adding their squares, and taking the root of that, the worst-case variation in **A** is the following:

d(**A**)max = ±7.684e–2

So, **A**, which is typically 1.0084, varies between 0.9316 and 1.0852, which conforms to the limits defined in equation (6).

Based on equation (4), the nominal reflection coefficient, G, is 4.18e–3. This means the return loss is typically 47.57 dB, which is very good. Based on the variation in **A**, G varies between –3.54e–2 and +4.09e–2. This means the return loss will range to as low as 27.77 dB.

Considering these results, the worst-case wiggle in the waveform at the DSX, due to mismatch reflections, will be 4.09%, against a specification of 5%. Other contributors to this number might be identified, but their contribution is believed to be less than that of the parameters discussed, so their contribution to the rms total would be slight.

There is one factor which provides free margin against the template with regard to load reflections. The line attenuation per foot will reduce the pulse as it travels from the DSX to the load. So, the reflected signal is a small replica of an attenuated DSX pulse. Furthermore, by the time it arrives back to the DSX as a reflection, it is attenuated even further. Assuming that the distance from DSX to load is about 100 ft., the attenuation at 1 MHz is 0.47 dB/100 ft. x 200 ft., or 0.94 dB. So for this 100 ft. situation, the worst-case wiggle at the DSX due to mismatch reflections is just 89.7% of what was calculated above, or just 3.67% against a specification of 5%.

This analysis is easier than it might look at first. It has been found, interestingly, that many existing installations have never been analyzed from the standpoint of worst-case mismatch and its impact on the template requirements. Regardless of whether or not you use a solid state relay, an analysis similar to the one described above should be done for your system at all points where there is a receiving-end load to be designed. If you are using the LH1514, you will find that the benefits of using a solid state relay will make the analysis time well worth the effort, in addition to gaining insight into your design.

A final concern might be how the system can function properly if the ON-resistance of the solid state relay will provide some attenuation of the incoming signal. In the example just illustrated, the worst-case attenuation would be about 2 dB, and is typically 1 dB (i.e., [89.8/[100.84]=1.0 dB). It turns out that T1 driving circuitry usually has substantial signal punch in excess of that required. Furthermore, the receiving end is usually quite sensitive. Using a commercially available transformer [2] provides a minimum of a 2.4 V peak at the DSX when programmed for a 665 ft. stretch to the DSX. That signal continues down the T1 line, and then is stepped up 1:2 at the receiver end. The receiver sensitivity is at least 0.85 V peak. Assuming the distance from the DSX to the receiver is another 665 ft., the line attenuation will be 665 ft. x 0.47 dB/100 ft.= 3.1 dB. The excess drive under worst-case is then:

Excess Drive = 20 x log [2.4 x 2/.85] – 3.1 dB
Excess Drive = 11.94 dB

This will more than compensate for the 1 dB–2 dB loss due to the solid state relay ON-resistance.

Impact of On-State Pole-to-Pole Capacitance on Line Matching

The 50 pF on-state pole-to-pole capacitance of the LH1514 should be considered when analyzing the load match to the transmission line. In practice, the 50 pF of pole-to-pole capacitance will present a capacitive reactive element in parallel with the 100 Ω load. This will cause mismatch reflections at the higher-frequency components of the incoming pulse.

Computer simulation has shown that the reflection will appear as a very narrow spike traveling back to the generating end. Yet in a system installation, no such reflection can be observed. According to computer simulation, for a 50 pF of pole-to-pole capacitance, and a 0.3 V/ns dv/dt, this spike will be about 15 ns wide and about 1.5 V tall, riding on top of a 3 V DS1 pulse. But it does not show up in a practical DS1 application because it is swallowed up by losses and reactive characteristics of the transmission line at high frequencies (characteristics which are not modelled by most SPICE simulators).

For example, this 15 ns wide spike may be viewed for the moment as correlating to 66 MHz signal. The highest frequency at which T1 line losses are published is 10 MHz. There the losses are 16 dB for 1000 ft.[1]. Beyond 9 MHz the loss/1000 ft. increases dramatically and is difficult to extrapolate. A conservative extrapolation would yield a loss of at least 60 dB at 60 MHz. Thus, what would be a 1.5 V, 15 ns spike reflected back on a lossless line will show up in practice as something in the tens of millivolts range for 22-gauge twisted-pair. This will have no impact on the template requirements for DS1 and DS1A applications. At higher data rates such as DS2 (6.312 Mbits/s), the 50 pF should be considered more closely as the reactance of the 50 pF at this frequency approaches the value of Z0.

Lightning Survival

In this section, it will be shown that the LH1514 survives lightning quite well.

The first point to remember about lightning is that no one expects a data line in a telecom switch to survive a direct lightning hit. The destructive force of a lightning hit is just too great to be handled by mere circuit techniques. Besides, if a direct lightning strike is experienced, fire and structural damage to the premises will be a much bigger problem than the digital system damage.

A more practical concern is the energy induced onto a data line by means of a nearby lightning strike. There are two applicable situations: in-building wiring and out-of-building wiring.

For in-building wiring, the following sequence of events occurs (this sequence is illustrate in Figure 6):

1. Lightning strikes on or near the building.
2. Massive current surges are momentarily induced in the metallic elements of the building (pipes steel I-beams in the frame, etc.).
3. These, in turn, reradiate their energy onto twisted-pair data line running point-to-point within the system.

US-ISDN-BRI, ANSI T1.605 describes the requirements for in-building data lines which run up to 1 km (3286 ft.) in length. It is interpreted in another document for the benefit of end-users. *North American ISDN Users Forum, Document ICOT-90-40.* The key requirement for this discussion center around a lightning surge which must be applied to all lines longitudinally (i.e, all lines simultaneously, or common-mode). The applied surge follows the shape given is Figure 7.

Figure 7 describes a voltage ramp climbing to 1000 V in 1 ms and decaying to 500 V in 50 µs. The source is limited with a 31.6 Ω resistor in series with every line. Thus, the maximum current allowable during the surge is 31.6 A.

For out-of-building lines, the duration of the surge is longer. The lightning strikes near the twisted pair and induces energy right onto it. Out-of-building lightning would be a concern, for example, in a digital loop carrier (DLC) application where T1 lines bring telephone service to a remote community. Even though the T1 bundle is typically shielded, induced lightning is still a concern.

Figure 6. Qualitative model for lightning surges on data lines confined within premises

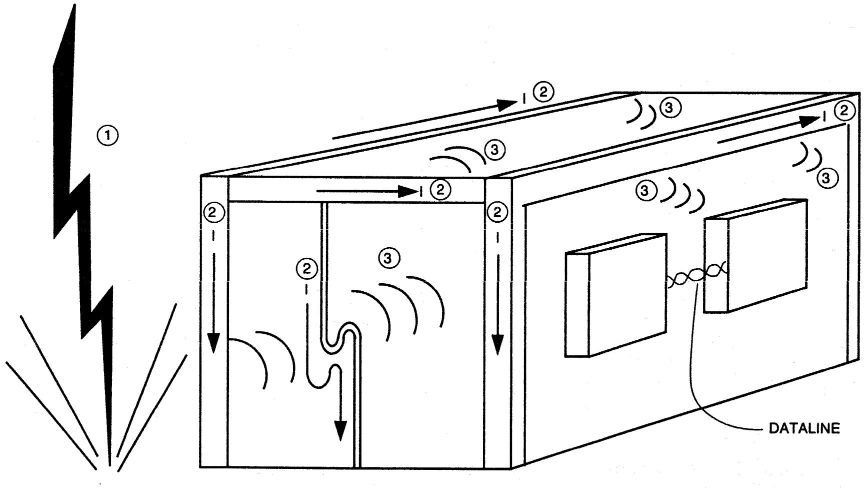


Figure 7. ANSI longitudinal surge for in-premises wiring

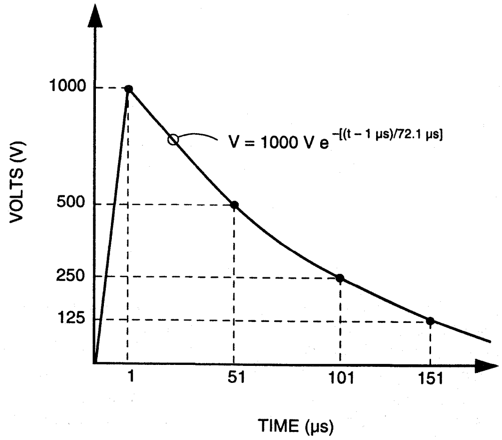
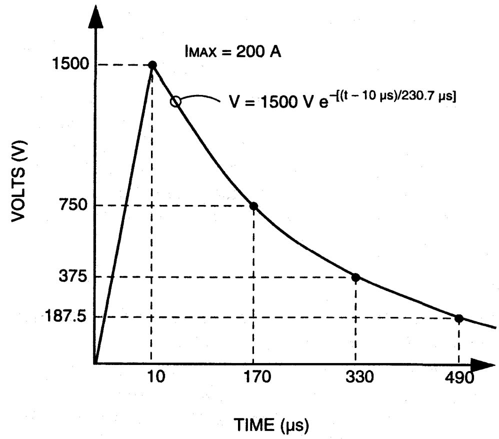


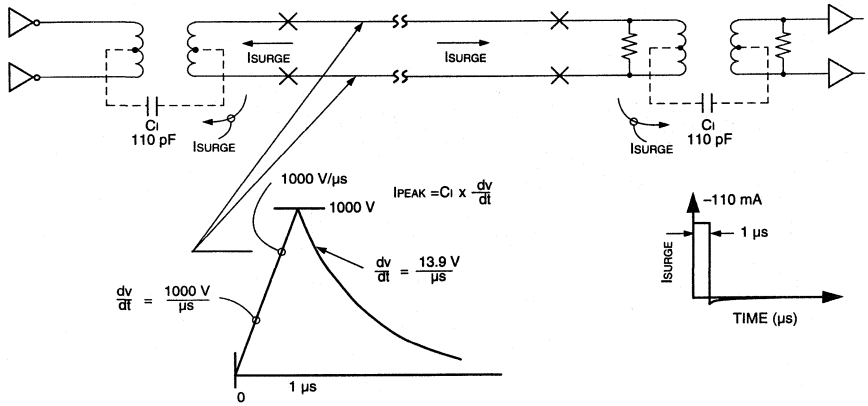
Figure 8. FCC 68.302 longitudinal surge for out-of-building lines, "10x160"



Surge requirements for out-of-building wiring is described in FCC part 68.302. These lightning surge models were originally developed with tip/ring pairs in mind. It would stand to reason that since tip/ring conductors are in close proximity to one another, the induced voltage would be identical for both of them, and, thus, there should be no need for metallic (differential) surge testing. But in practice, tip/ring lines are very often surge protected with crowbar devices such as SCRs and gas discharge tubes. In the event that one protector fires before the other (or perhaps one protector does not fire at all), there will be a perceived metallic surge on the tip/ring pair. This series of events will never occur, however for most T1 lines. T1 lines have no lightning protection circuitry on them, except for isolation transformers provided on both the receiving and transmitting ends.

Thus, metallic surges have no bearing on the lightning survival issue for T1 out-of-building wiring, unless they are required by regulatory agencies or if active protection devices are used on the line, as discussed above. In this case, the metallic surges would be applicable, and the LH1514 would not be recommended. However, even without a solid state relay, it would be catastrophic for most T1 installations to be subjected to a metallic surge.

Figure 9. Lightning model for a T1 line under surge (typical application circuit)



Therefore, in most cases, it is sufficient for T1 lines to be evaluated under longitudinal surges. The out-of-building longitudinal surge from FCC 68.302 is illustrated in Figure 8.

In Figure 8, the expression "10x160" refers to the 10 µs rise time of the surge, and the 160 µs fall time it takes for the voltage to reach half of its peak value.

Figure 9 illustrates the circuit dynamics of an induced lightning strike. Note the absence of any protection devices on the balanced transmission line, except for the isolation transformers.

Referring to Figure 9, the surge comes upon the T1 relay in the following way. First, a surge is induced onto the data line. The induced energy has no dc return path to ground, thanks to the isolation transformers. The interwinding capacitance provides a 110 pF transient path to ground through the transmit and receive devices. The worst-case surge current is given by:

$$Isurge = Ci^{*}\, dv/dt \qquad (14)$$

where:

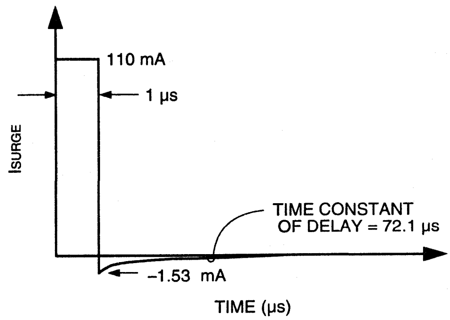
Ci is the interwinding capacitance of the isolation transformer, dv/dt is the slop of the incoming surge.

A commercially available transformer with an interwinding capacitance of approximately 110 pF was chosen for this example because it has the highest interwinding capacitance of any T1 transformer. They typically range from 5 pF to 90 pF. The worst-case dv/dt is from the ANSI-BRI spec, which from Figure 7 is 1000 V/µs. The out-of-building FCC surge does not present a worst-case dv/dt. Therefore, we have used the ANSI-BRI surge for this analysis. Thus, the maximum possible surge is 110 mA. It would follow the shape shown in Figure 10.

The LH1514 can handle this 110 mA peak surge with no problems whatsoever. If the LH1514 is in breakdown (i.e., in the off-state), it can easily handle 300 mA steady state. Typical devices will degrade at about 500 mA of breakdown. In the on-state, the LH1514 is even more rugged.

This means that the LH1514 can be used with confidence both for in-building and out-of-building applications, as long as transformer isolation is used.

Figure 10. Surge current for the circuit of figure 9



Conclusion

The LH1514 solid state relay for T1 signals has been presented, with extensive design information. Recent trends towards improved reliability and ease of manufacture make the LH1514 attractive for both new designs and redesigns. It offers clean, bounce-free switching, ruggedness, and high reliability in a small, surface-mount package, lending itself well to improved performance and reduced manufacturing costs. A careful analysis of load matching, and its impact on the DSX template, has been presented. An analysis such as this is called for regardless of whether or not an SSR is used. Lightning survival was reviewed illustrating that T1 lines are normally susceptible only to longitudinal surges. The T1 driver/receiver circuitry is protected by isolation transformers, which also help protect the LH1514 by eliminating any return path to ground.

The growing T1 equipment market will benefit from the features of this new device.

SIEMENS

Solid State Relay Metallic On-Stage Surge Performance

Appnote 69

Introduction

Whether designing telephones, modems, PBX or central office equipment, protecting telecom equipment from lightning surges is a prime consideration. Siemens designs their solid state relays (SSRs) to survive repeated lightning surges by building current-limit circuitry into most of their Form A SSRs. A current-limited SSR restricts surge current flow thereby preserving SSR integrity even after repetitive exposure to lightning fault conditions. Current limiting in Form A SSRs is ideal for protection against surge conditions; however, many Form B or Form C configurations are used in telecom applications as well. This technical note presents a comprehensive evaluation of the metallic on-state surge capability of the entire LH1500 family of SSR devices.

Surge Capability

Surge capability is a function of the SSR's switch silicon area, current-limit value, and turn-on speed. SSRs with larger DMOS switches and lower current-limit values will surge the best. Turn-on speed is also important because the current-limit circuit shuts the SSR off during the first part of the lightning wave where the impulse power is the greatest. Siemens designs slow turn-on times into their SSRs so that the SSRs remain off during the worst part of the impulse wave. Turn-on speed is dependent upon the LED forward current value. A large LED drive current will turn the SSR on faster than desired for lightning surge conditions. We recommend no more than 4 mA to 5 mA of LED forward drive current for large applications.

Surge Waveforms

Two surge waveforms were evaluated. An 800 V, 10 x 560 µs waveform is specified in the United States by the FCC. A 10 x 560 µs pulse refers to a double-exponential unipolar impulse wave that rises to full-rated voltage in 10 µs and decays to half of the rated voltage in 560 µs. A 1000 V, 10 x 1000 µs waveform is called out by the REA and Bellcore for central office equipment in the United States and by the CSA for telecom equipment in Canada. The surge results from the 10 x 1000 waveform could also be applied to the European 1000 V, 10 x 700 µs CCITT standard.

Surge Configurations

Eleven surge configurations were evaluated. For subscriber telephone equipment, four wiring configurations were explored. The first uses a solid-state crowbar type protector directly across tip and ring to protect the equipment from voltage transients. This provides the best protection because the crowbar action shunts metallic surge currents between tip and ring sparing the station equipment.

The second configuration places an MOV directly across the SSR contacts. In this configuration, a properly selected MOV ensures that the transient voltage across the SSR never exceeds its breakdown voltage. This is an important consideration when using an inductive load. An inductor can generate a voltage spike under surge conditions that could potentially damage the SSR. The third configuration uses a resistive load. Here an MOV placed between tip and ring would be adequate.

The last configuration places the MOV between the tip and ring and uses an inductive load. This configuration is not recommended, but unfortunately is prevalent in many designs. It is evaluated here for informational purposes only.

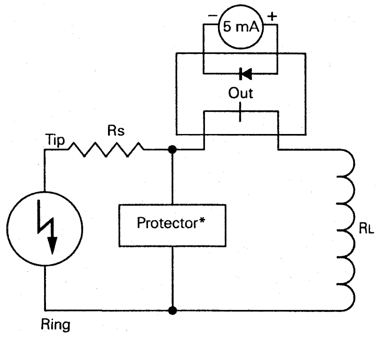
For central office and PBX equipment, three wiring configurations were explored. First, a solid-state protector placed tip to ring was evaluated. This is perhaps the most common configuration for central office design.The other two configurations use MOV overvoltage protection and an in-line current-limiting resistor. This resistor is often placed in the tip and ring leads in central office designs. For this study, only one in-line resistor was used. This assumes worst case, wherein the metallic surge will terminate to ground. Two values were used: 80 Ω, which is common in the United States and 20 Ω, which is common in Europe. Note that for both of these conditions, no load impedance is used in order to illustrate worst-case surge conditions. Any load impedance contributed by the line card electronics could greatly assist the SSR by absorbing some of the power dissipation from the surge.

Surge Tests

Figures 1 and 2 portray the test setup conditions. All of the tests simulate metallic (differential) surge stresses with the SSRs in their on-state. With regards to an SSR in these telecom applications, a longitudinal (common mode) stress only exercises the input-to-output isolation of the SSR and is of little interest.

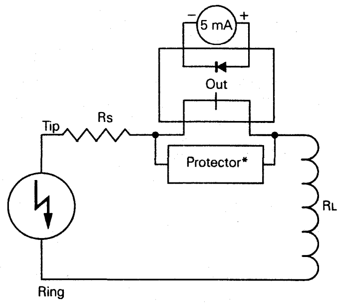
The SSRs were subjected to the most severe surge conditions. Little or no series resistance and very low load impedance values were used for these evaluations. For instance, FCC and Canadian test were all performed with absolutely zero series resistance. This would simulate a lightning induction directly at the station equipment.

Figure 1. Test setup with protector across tip to ring



Furthermore, the dc load used for these tests was only 50 W to 60 W. In many applications, this load impedance will be much higher. By far, most lightning surges are not as severe as those listed in the various surge test standards. Furthermore, these tests were performed with the SSRs biased on. SSRs in their normally off-state will survive all of the harsh stresses evaluated in this study.

Figure 2. Test setup with protector across SSR contacts



***Protectors**

	MOV: Siemens and Matsushita	MOV: Harris	Solid State: SGS Thompson
	or equivalent		
for 150 V SSR	SIOV-S14K50	V82ZA12	—
for 200 V SSR	SIOV-S14K75	V120ZA6	TPB150A
for 250 V SSR	SIOV-S14K95	V150ZA8	TPB200B
for 350 V SSR	SIOV-S14K150	V150LA20	TPB270A
for 400 V SSR	SIOV-S14K150	V150LA20	TPB270A

Conclusion

The results of the surge stress applications are shown in Table 1 which shows which SSR to use for a given application. For best performance under surge conditions, using a solid-state crowbar protector or an MOV directly across the SSR contacts is highly recommended. For applications using a solid state crowbar protector, any Form A or Form B SSR can be used. For applications using an MOV directly across the SSR contacts, use a Form A SSR like the 250 V LH1505, LH1518, LH1519, and the 400 V LH1516. For central office and PBX applications, add the LH1504 and LH1524 to the list. The most popular SSR for FCC 68.302 applications is the 350 V LH1500 or the more robust LH1540 Form A SSR.

Table 1. Surge performance data

Form A, I_F =5 µA Form B, I_F = 0	800 V, 10 x 560 µs, 100 A, Subscriber Telephone Equipment FCC 68.302				1000 V, 10 x 1000 µs, 50 A Subscriber Telephone Equipment CSA CS-03 2.1.2 (also applicable) 1000 V 10 x 700 µs, 40 A CCITT K.20				1000 V, 10 x 1000 µs, 100 A, Central Office and PBX Equipment Bellcore LSSGR 15.2 REA		
On-State Metallic Surge	**Solid State Protector T-R**	**MOV Across Contacts**	**MOV T-R Resistive Load**	**MOV T-R Inductive Load**	**Solid State Protector T-R**	**MOV Across Contacts**	**MOV T-R Resistive Load**	**MOV T-R Inductive Load**	**Solid State Protector T-R**	**MOV T-R**	**MOV T-R**
R_S (Ω)	0	0	0	0	0	0	0	0	0	≥80	≥20
R_L (Ω)	0	—	≥50	—	0	—	≥50	—	0	0	0
R_L*(Ω)	≥58	≥58	—	≥58	≥58	≥58	—	≥58	0	0	0
See Figure	1	2	1	1	1	2	1	1	1	1	1
LH1500	✓	✓	✓	S	✓	S,O	S,O	S	✓	S,O	S,O
LH1501	✓	S	S	S	✓	S	S	S	✓	S	O
LH1502 A/B	✓	✓/S	✓/S	S	✓	S	✓/S	S	✓	✓/S	✓/O
LH1503	✓	✓	✓	S	✓	S,O	✓	S	✓	✓	NR
LH1504	✓	✓	✓	S	✓	NR	✓	S	✓	✓	✓
LH1505	✓	✓	✓	S,O	✓	✓	✓	S,O	✓	✓	✓
LH1510	✓	✓	✓	S,O	✓	NR	✓	S	✓	✓	S
LH1511	✓	S	S	S	✓	S	S	S	✓	S	S
LH1512 A/B	✓	✓/S	✓/S	S, O/S	✓	NR/S	✓/S	S	✓	✓/S	S/S
LH1513	✓	✓	✓	S	✓	S,O	✓	S	✓	NR	S,O
LH1516	✓	✓	✓	S,O	✓	✓	✓	S,O	✓	✓	✓
LH1517	✓†	NR	NR	NR	✓†	S,O	NR	NR	✓†	✓	S,O
LH1518	✓	✓	✓	S,O	✓	✓	✓	S,O	✓	✓	✓
LH1519	✓	✓	✓	NR	✓	✓	✓	NR	✓	✓	✓
LH1520	✓	✓	✓	S	✓	S,O	NR	S	✓	S,O	S,O
LH1521	✓	S	S	S	✓	S	S,O	S	✓	S	O
LH1522	✓	✓	✓	S,O	✓	NR	✓	S	✓	✓	S
LH1523	✓	S	S	S	✓	S	S	S	✓	S	S
LH1524	✓	✓	✓	S	✓	NR	✓	S	✓	✓	✓
LH1527	✓	S,O/S	NR/S	NR/S	✓	S,O/S	NR/S	NR/S	✓	NR/S	NR/O
LH1530	✓	S	S,O	S	✓	S	S,O	S	✓	S,O	S,O
LH1531	✓	S	S,O	S	✓	S	S,O	S	✓	✓	S
LH1532	✓	✓	✓	NR	✓	NR	✓	S,O	✓	✓	S
LH1537	✓	NR/S	NR/S	NR/S	✓	NR/S	NR/S	NR/S	✓	S/S	O/O
LH1540	✓	✓	✓	NR	✓	NR	✓	S,O	✓	✓	S

Legend: ✓= relay survives repetitive surges, S=relay shorts or always on, O=relay opens, NR=not recommended, most relays will operate but possibility for SSR damage exists.

* Inductive load. AT&T 2746B transformer primary. † Not tested. ▮ Not recommended.

SIEMENS

Interfacing the Serial Input Dot Addressable Intelligent Displays with the Intel 5031/8051 Microcontroller Appnote 70

This application note is intended to serve as a design and application guide for users of the SCF574X and other similar display families in Siemens Opto Intelligent Displays data book, such as, SCE578X, SCD558X and SCD5510X with some minor modifications.

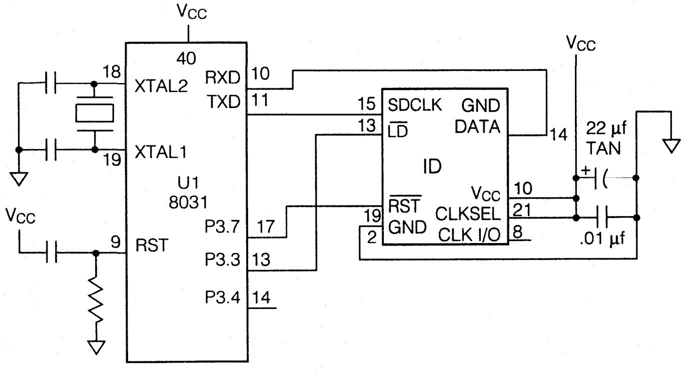
Description

The SCF5740 (Standard Red), SCF5742 (High Efficiency Red), and SCF5744 (High Efficiency Green) are 0.270 four digit 5x7 dot matrix, serial input dot addressable intelligent displays. The on-board CMOS is the heart of the display. It accepts decoded serial data and stores it in the internal RAM. The four characters are row multiplexed with RAM resident column data. The strobe rate is established by the internal or external MUX clock rate. The maximum external clock rate should be limited to 4 MHz.

Microprocessor Interface

In this application note, the 8031/8051 microcontroller family is used for demonstration, and the program is written in Assembly language. The display interface between SCF574X and Intel 8031 microcontroller is via serial port in mode 0, so the serial port control register will be a simple shift register. Serial data enters and exits through RXD. TXD outputs the shift clock. 8 bits are transmitted/received. Look at the Figure 1 for details.

Figure 1.



Loading data into the display

In the following example, the word "ABCD" is used for demonstration of displaying a message:

```
        .ORG 00H

BEGIN:      CALL RE_SET
            CALL LAMTST
            CALL CLEAR
            CALL BRGHNESS
NEXT:       CALL DISPLAY
            JMP NEXT
```

1. RESET ROUTINE: Reset the display to clear the Multiplex Counter, Address Register, Control Word Register, internal RAM and Data Register. The display will be blank, and brightness is set to 100%.

```
RE_SET:     CLR P1.2
            NOP
            SETB P1.2
            MOV SCON, #00H      ;SET SERIAL MODE 0.
            RET
```

2. LAMP TEST ROUTINE: This routine is used to test all LEDs by turning them on for a short time.

```
LAMTST:     MOV R0, #A0         ;DIGIT ADDRESS 0.
            MOV R1, #1FH        ;TURN ON ALL LEDs.
            MOV R3, #04H        ;4-DIGIT COUNTER.
            MOV R2, #07H        ;7-ROW COUNTER.
LOOP_1:     MOV A, R0           ;DIGIT ADDRESS
            CALL DISP           ;LOAD DATA TO THE DISPLAY.
LOOP_2:     MOV A, R1           ;LOAD DATA TO RAM
            CALL DISP           ;DISPLAY ROUTINE
            DJNZ R2, LOOP_2     ;TO DISPLAY ALL 7 ROWS.
            INC R0              ;NEXT DIGIT ADDRESS.
            DJNZ R3, LOOP_1     ;TO FINISH LAST DIGIT ADDRESS.
            CALL DELAY          ;TIME DURATION OF DISPLAY.
            RET
```

3. CLEAR: Clear the display. The display is blank and character address register will be set to A0.

```
CLEAR:      MOV A, #C0H         ;SET CONTROL WORD C0 TO CLEAR THE DISPLAY.
            CALL DISP           ;LOAD DATA TO THE DISPLAY.
            RET
```

4. BRIGHTNESS: Set the desired brightness level. In this example, the brightness is set to 53% with maximum peak current.

```
BRGHNESS:   MOV R1, #E1H        ;SET BRIGHTNESS LEVEL TO 53%.
            CALL DISP           ;LOAD DATA TO THE DISPLAY.
            RET
```

5. DISPLAY: This routine is written to display the word "ABCD."

```
DISPLAY:    MOV DPTR, #TABLE
            MOV R0, #A0H        ;DIGIT ADDRESS 0
            MOV R3, #04H        ;TO COUNT FOR 4 DIGITS.
LOOP_A:     MOV A, R0           ;INITIALIZE DIGIT ADDRESS FOR DISPLAY
            CALL DISP
```

```
        CALL DIG_DPLY       ;LOAD DATA TO THE APPROPRIATE DIGIT
        INC R0              ;UPDATE TO THE NEXT DIGIT ADDRESS
        DJNZ R3, LOOP_A
        RET
```

6. DISP routine: To out put data byte from the accumulator to the display

```
DISP:       CLR P1.0            ;PULL LOAD LINE LOW
            MOV SBUF, A         ;LOAD SBUF WITH DATA BYTE
            JNB SCON.1, $       ;TRANSMISSION NOT COMPLETE. WAIT.
            CLR SCON.1          ;TRANSMISSION COMPLETE.
            SETB P1.0           ;LATCH DATA TO DISPLAY.
            RET
```

7. DIG_DPLY routine: To output data bytes from the table to the display

```
DIG_DPLY:   MOV R1, #07H        ;7-ROW COUNTER.
LOOP_B:     CLR A
            MOVC A, @A+DPTR     ;LOAD DATA BYTE FROM TABLE TO ACC.
            CALL DISP
            INC DPTR            ;UPDATE TO THE NEXT DATA BYTE.
            DJNZ R1, LOOP_B
            RET
```

8. DELAY routine: Duration of the display

```
DELAY:      MOV R6, #1AH
            NOP
DELAY_1:    MOV R5, #EFH
            NOP
DELAY_2:    MOV R7, #1FH
            NOP
            DJNZ R7, $
            NOP
            DJNZ R5, DELAY_2
            NOP
            DJNZ R6, DELAY_1
            NOP
            RET
```

9.
```
TABLE:      DB  O4H,OAH,11H,1FH,11H,11H,11H     ; "A"
            DB  1EH,11H,11H,1EH,11H,11H,1EH     ; "B"
            DB  07H,08H,10H,10H,10H,08H,07H     ; "C"
            DB  1EH,11H,11H,11H,11H,11H,1EH     ; "D"


.END
```