



## Infrared Data Communication According to IrDA<sup>®</sup> Standard

### Part 1: Physical Layer

#### What is IrDA?

IrDA is the abbreviation for the **Infrared Data Association**, a non-profit organization for setting standards in IR serial computer connections. The following is an original excerpt from the IrDA Web site (<http://www.irda.org>).

#### Executive Summary

IrDA was established in 1993 to set and support hardware and software standards which create infrared communications links. The Association's charter is to create an interoperable, low-cost, low-power, half-duplex, serial data interconnection standard that supports a walk-up, point-to-point user model that is adaptable to a wide range of applications and devices. IrDA standards support a broad range of computing, communications, and consumer devices. International in scope, IrDA is a non-profit corporation headquartered in Walnut Creek, California, and led by a Board of Directors which represents voting membership worldwide. As a leading high technology standards association, IrDA is committed to developing and promoting infrared standards for the hardware, software, systems, components, peripherals, communications, and consumer markets.

#### Industry Overview

Infrared (IR) communications is based on technology which is similar to the remote control devices such as TV and entertainment remote controls used in most homes today. IR offers a convenient, inexpensive and reliable way to connect computer and peripheral devices without the use of cables. IrDA connectivity is being incorporated into most notebook PCs to bring the most cost-effective and easy to use support available for wireless technologies.

There are few US, European or other international regulatory constraints.

Manufacturers can ship IrDA-enabled products globally without any constraints, and IrDA functional devices can be used by international travellers wherever they are, and interference problems are minimal. Standards for IR communications have been developed by IrDA. In September 1993, IrDA determined the basis for the IrDA SIR Data Link Standards. In June 1994, IrDA published the IrDA standards which

includes Serial Infrared (SIR) Link specification, Link Access Protocol (IrLAP) specification, and Link Management Protocol (IrLMP) specification. IrDA released extensions to SIR standard including 4 Mbit/s in October 1995. The IrDA Standard Specification has been expanded to include high speed extensions of 1.152 Mbit/s and 4.0 Mbit/s. This extension will require an add-in card to retrofit existing PCs with high speed IR, and a synchronous communications controller or equivalent.

In 1995, several market leaders announced or released products with IR features based on IrDA standards. These products include components, adapters, printers, PCs, PDAs, notebook computers, LAN access, and software applications. In November 1995, the Microsoft Corporation announced it had added support for IrDA connectivity to the Microsoft Windows 95 operating system, enabling low-cost wireless connectivity between Windows 95 based PCs and peripheral devices.

IrDA's interoperable infrared serial data link features low power consumption with data speeds up to 4 Mbit/s, allowing a cordless 'walk-up-to' data transfer in a simple, yet compelling way. Applications are in both consumer and commercial markets with a universal data connection relevant in the use of docking and input units, printers, telephones, desktop/ laptop PCs, network nodes, ATMs, and handheld mobile peers (PDA meets PDA). Yesterday's systems with IR capabilities such as Newton, Omnibook, Wizard and Zoomer are not easily compatible with each other or other complementary devices. IrDA is the response in which many segments of the industry have committed themselves to realizing the opportunity of a general standard providing data links which are non-interfering and interoperable.

#### The IrDA - Standard

The current IrDA physical layer standard is version 1.4 and includes all changes and add-ons up to VFIR with 16 Mbit/s. Version 1.4 replaced version 1.3 which is obsolete as are all former versions from 1.0 to 1.2. Referring to these versions currently can describe only historical steps of the IrDA - development.



## How IrDA Transmission Works

The transmission in an IrDA-compatible mode (sometimes called SIR for serial IR) uses, in the simplest case, the RS232 port, a built-in standard of all compatible PCs. With a simple interface, shortening the bit length to a maximum of 3/16 of its original length for power-saving requirements, an infrared emitting diode is driven to transmit an optical signal to the receiver.

This type of transmission covers the data range up to 115.2 kbit/s which is the maximum data rate supported by standard UARTs (see figure 1). The minimum demand for transmission speed for IrDA is only 9600 bit/s. All transmissions must be started at this frequency to enable compatibility. Higher speeds are a matter of negotiation of the ports after establishing the links.

Higher speeds require special interfaces which operate at 1.152 Mbit/s and use a similar pulse-shortening process as in the RS232-related mode, but with a pulse reduction to 1/4 of the original pulse length. The fastest data rate supported by IrDA is 4.0 Mbit/s (often called FIR), operating with 125-ns pulses in a 4-PPM (PPM = **P**ulse-**P**osition **M**odulation) mode. The typical interfaces for the various modes are shown in figure 2. In the following chapter "IrDA Standard - Physical Layer", the definitions of the IrDA standard are given.

Optical output power and receiver sensitivity are set to a level where a point-and-shoot activity ( $\pm 15^\circ$ ) is sufficient for point-to-point communication, but prevents the pollution of the ambient by straying needless power. Transmission over a distance of at least 1 m is ensured. The detector front end receives the transmitted signal, re-shapes the signal and feeds it to the port. The system works in a half-duplex mode that allows only one transmission direction to be active at any given time.

For frequencies up to 115.2 kbit/s, the minimum output intensity is defined with 40 mW/sr. For higher speeds, a higher output intensity of 100 W/sr minimum is used. The sensitivity thresholds are 40 mW/m<sup>2</sup> and 100 mW/m<sup>2</sup> for SIR and FIR respectively.

The wavelength chosen for the standard is between 850 nm and 900 nm.

An additional IrDA standard was generated in 1997 (voted Feb. 1998) for Control applications, the so-called IrControl standard.

This standard is using the IEC1603-1 sub carrier frequency allocation with a carrier at 1500 kHz. The transmission capacity is 72 kbit/s. This system has still some compatibility problems with the SIR/FIR

IrDA Standard. One of the disadvantages is that the detector circuitry is different from the other, base-band system. Therefore, integrating both into one application is expensive. Using IrControl and SIR/FIR in one application would imply that two IR hardware channels must be built-in. The Very Fast IR (VFIR, min. 16 Mbit/s transfer rate over more than 1 m) established in 1999.

## What do I need to enable IrDA Transmission?

The simplest way of optical interfacing in the SIR mode is shown in figure 1. For pulse shaping and recovery, the Vishay Semiconductors device TOIM4232 is recommended. The front end including transmitter and receiver should be realized for example by the integrated transceiver module TFDU4100 or other devices of the 4000 series. The TFDU4100 can also be directly connected to Super I/Os.

A transimpedance amplifier is used in the receiver for input amplification. Its output signal is fed to the comparator input, whose reference level is adjusted to efficiently suppress noise and interferences from the ambient.

Additionally, the digital pulse-shaping circuit must be inserted for shortening the pulse to be emitted to 1.6  $\mu$ s (i.e., 3/16 of the bit length at 115 kbit/s) and pulse recovery of the detected signal to comply with the IrDA standard. Only the active low bits (0) are transmitted.

For the high-speed mode, the TFDU6102 or other devices from the 6000 series are recommended to be operated with e.g. NSC's or SMC's IrDA-compatible Super I/O circuits. Circuit proposals for the various modes can be found in our application section. A block diagram is shown in Figure 2.

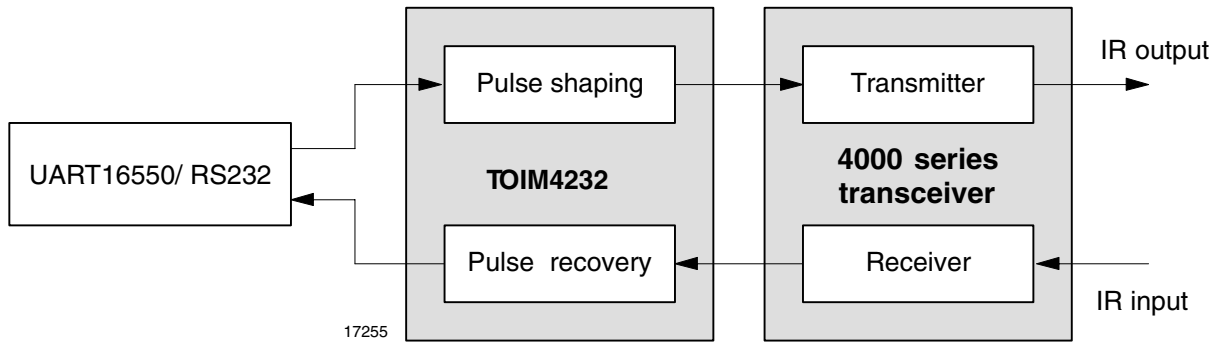


Figure 1. Block diagram of one end of the overall SIR link

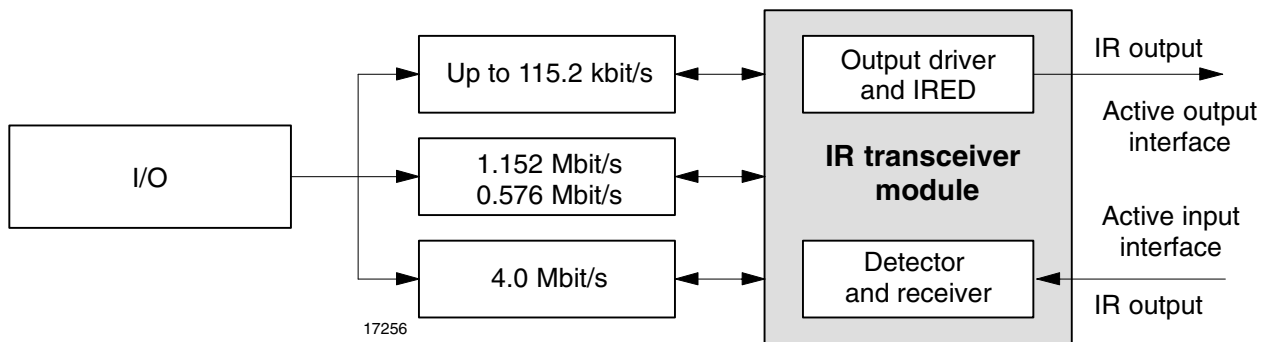


Figure 2. Block diagram of one end of the link for signaling rates up to 4.0 Mbit/s

The IrDA standard documentation can be found on the IrDA web site <http://www.irda.org>. The documents which are public and can be downloaded are shown on the next page.

The physical layer is responsible for the definition of hardware transceivers for the data transmission. The physical layer is therefore discussed in the following chapters which define the properties of the front end devices manufactured by Vishay Semiconductors.



## Standards available for public access and download on [www.irda.org](http://www.irda.org)

Standards, specifications and guidelines are available under the addresses

<http://www.irda.org/standards/standards.asp>

<http://www.irda.org/standards/guidelines.asp>

<http://www.irda.org/standards/specifications.asp>

The following documents describe the IrDA Standards:

### **IrDA SIR Data Specification**

(<http://www.irda.org/standards/pubs/IrData.zip>)

containing

### **IrDA Serial Infrared Physical Layer Link Specification IrPHY 1.4**

([http://www.irda.org/standards/pubs/IrPHY\\_1p4.pdf](http://www.irda.org/standards/pubs/IrPHY_1p4.pdf))

### **IrDA Serial Infrared Link Access Protocol (IrLAP)**

IrDA Serial Infrared Link Management Protocol (IrLMP)

IrDA Tiny TP

IrDA Point and Shoot Profile

Test Specification

Other available documents

IrDA Financial Messaging (IrFM™) Point and Pay Specification

IrDA Financial Messaging (IrFM™) Test Specification

IrDA IrLAPFast Connect Application Note

IrDA Adapter Application Profile and Test Specification

IrDA Control Specification

IrDA Infrared Communications Protocol (IrCOMM 1.0)

IrDA Infrared Tiny Transport Protocol (IrTinyTP 1.1)

IrDA Infrared LAN Access Extensions for Link Management Protocol (IrLAN 1.0)

IrDA Object Exchange Protocol (OBEX™) Ver. 1.3

IrDA Object Exchange Protocol (OBEX™) Test Specification Ver. 1.0.1

IrDA Minimal IrDA Protocol Implementation (IrLite)

IrDA Plug & Play Extensions to IrLMP 1.0

IrDA Infrared Mobile Communications (IrMC)

IrDA Infrared Transfer Picture Specifications (IrTranP)

IrDA Dongle Interface specifications

IrDA Infrared for Wrist Watches specification (IrWW) Serial Port Profile, IrModem Profile and Test Specs

Serial Interface for Transceivers

IrDA Point and Shoot

IrDA Point and Shoot Application Profile

IrDA Point and Shoot Test Specification



## IrDA-Standard - Physical Layer

### Specification

In SIR mode, the data is represented by optical pulses between 1.6  $\mu\text{s}$  and 3/16 of the bit length of the RS232 data pulse in SIR mode. Pulse-length reduction is also applied in the higher frequency modes. The limits of the standards are shown in tables 1 and 3. The optical radiant intensity and detector sensitivity are adjusted to guarantee a point-to-point transmission in a cone of  $\pm 15^\circ$  over a distance of at least 1 m. The radiant intensity and the sensitivity of the front end can be increased to ensure a transmission over 3 m (see figure 3). Data from the optical interface standard are documented in tables 2 to 4.

### Media Interface Specification

#### Overall Links

There are two different sets of transmitter/ receiver specifications. The first, referred to as Standard, is for a link which operates from 0 to at least 1 meter. The second, referred to as the Low Power Option, has a shorter operating range, and is only defined up to 115.2 kbit/s. There are three possible links (see Table 1 below): Low Power Option to Low Power Option, Standard to Low Power Option; Standard to Standard. The distance is measured between the optical reference surfaces. The **Bit Error Ratio** (BER) shall be no greater than  $10^{-8}$ . The link shall operate and meet the BER specification over its range.

**Signaling Rate and Pulse Duration:** An IrDA serial infrared interface must operate at 9.6 kbit/s. Additional allowable rates listed below are optional. Signaling rate and pulse duration specifications are shown in table 2.

For all signaling rates up to and including 115.2 kbit/s the minimum pulse duration is the same (the specification allows both a 3/16 of bit duration pulse and a minimum pulse duration for the 115.2 kbit/s signal (1.63  $\mu\text{s}$  minus the 0.22  $\mu\text{s}$  tolerance). The maximum pulse duration is 3/16 of the bit duration, plus the greater of the tolerance of 2.5 % of the bit duration, or 0.60  $\mu\text{s}$ .

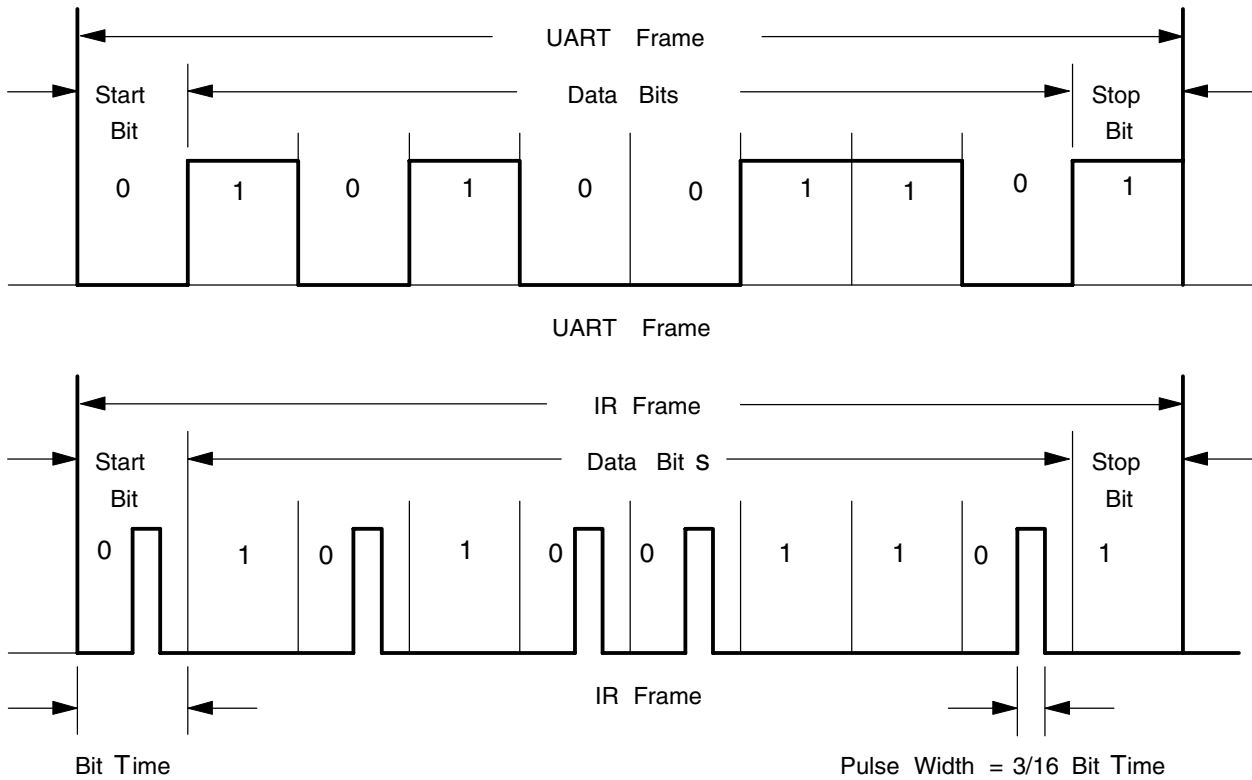
For 0.576 Mbit/s and 1.152 Mbit/s, the maximum and minimum pulse durations are the nominal 25 % of the bit duration plus 5 % (tolerance) and minus 8 % (tolerance) of the bit duration.

For 4.0 Mbit/s, the maximum and minimum single pulse durations are the nominal 25 % of the symbol duration plus and minus a tolerance of 2 % of the symbol duration. For 4.0 Mbit/s, the maximum and minimum double pulse durations are 50 % of the symbol plus and minus a tolerance of 2 % of the symbol duration. Double pulses may occur whenever two adjacent chips require a pulse.

The link must meet the BER specification over the link length range and meet the optical pulse constraints.

	Low Power - Low Power	Standard - Low Power	Standard - Standard
Link Distance Lower Limit, meters	0	0	0
Minimum Link Distance Upper Limit, meters	0.2	0.3	1.0

Table 1: Link Distance Specifications

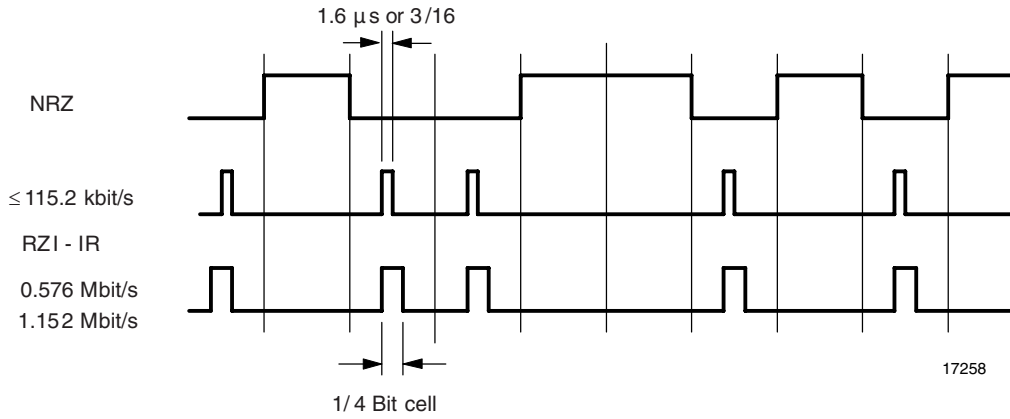


17257

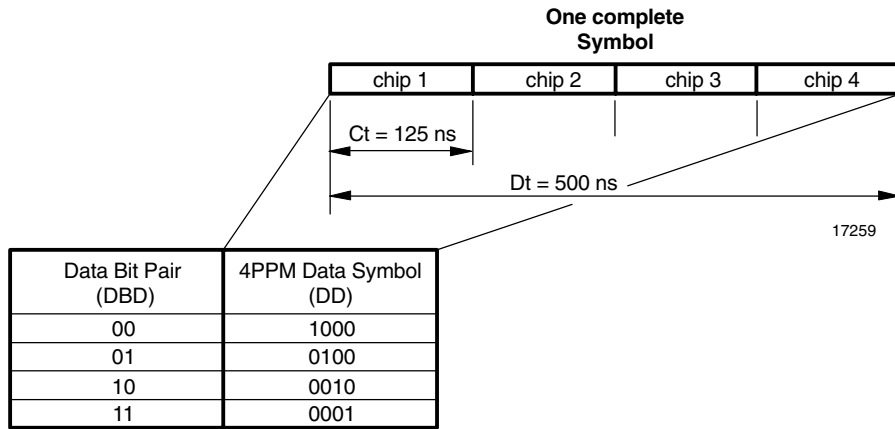
Signaling Rate	Modulation	Rate Tolerance % of Rate	Pulse Duration Minimum	Pulse Duration Nominal	Pulse Duration Maximal
2.4 kbit/s	RZI <sup>*)</sup>	± 0.87	1.41 μs	78.13 μs	88.55 μs
9.6 kbit/s	RZI <sup>*)</sup>	± 0.87	1.41 μs	19.53 μs	22.13 μs
19.2 kbit/s	RZI <sup>*)</sup>	± 0.87	1.41 μs	9.77 μs	11.07 μs
38.4 kbit/s	RZI <sup>*)</sup>	± 0.87	1.41 μs	4.88 μs	5.96 μs
57.6 kbit/s	RZI <sup>*)</sup>	± 0.87	1.41 μs	3.26 μs	4.34 μs
115.2 kbit/s	RZI <sup>*)</sup>	± 0.87	1.41 μs	1.63 μs	2.23 μs
0.576 Mbit/s	RZI <sup>*)</sup>	± 0.1	295.2 ns	434.0 ns	520.8 ns
1.152 Mbit/s	RZI <sup>*)</sup>	± 0.1	147.6 ns	217.0 ns	260.4 ns
4.0 Mbit/s	4 PPM	± 0.01	115.0 ns	125.0 ns	135.0 ns
Single pulse	4 PPM	± 0.01	240.0 ns	250.0 ns	260.0 ns
Double pulse	HHH (1.13)	± 0.01	38.3 ns	41.7 ns	45.0 ns

Table 2: Signaling rate and pulse-duration specification

<sup>\*)</sup> RZI = Return to Zero Inverted



## 4.0 Mbit/s





## HHH (1,13) Modulation Code for the 16-Mbit/s VFIR Standard

The HHH (1, 13) modulation code has the following salient features:

- Code Rate:  
 $2/3$  ,
- Maximal Duty Cycle:  
 $1/3$  (~ 33 % ) ,
- Average Duty Cycle:  
~ 26 % ,
- Minimal Duty Cycle:  
 $1/12$  (~ 8.3 % ) ,
- Run-Length Constraints:  
 $(d, k) = (1, 13)$  ,
- Longest Run of '10' s:  
yyy'000'101'010'101'000'yyy ,
- Chip Rate at Data Rate 16 Mbit/s:  
24 Mchips/s ,
- System Clock at Data Rate 16 Mbit/s:  
 $N \times 12$  MHz (where  $N \geq 4$ ).

The HHH(1,13) code is a Run Length Limited (RLL) code that provides both power efficiency and bandwidth efficiency at the high data rate. The signaling rate of the code is 24 Mchips/s allowing a rise and fall time of 19 ns. LED on time is further improved by having a 26 % average duty cycle for random data. The lower duty cycle is achieved by scrambling the incoming data stream. The run length constraints  $(d, k) = (1, 13)$  ensure an inactive chip after each active chip, i.e. only single-chip-width pulses occur. This feature allows a source or a receiver to exhibit a long tail property. To take full advantage of the  $d = 1$  feature of HHH(1, 13) in strong signal conditions, clock and data recovery circuitry should be designed to ignore the level of the chip following an active chip and assume these chips are inactive. The 13 in HHH(1, 13) denominates that the maximum number of chips without a signal is 13. That limits the lower cutoff frequency of the system and optimizes threshold trigger stability in receiver designs. The modulation code is enhanced with simple frame-synchronized scrambler/descrambler mechanisms as defined and described in the IrDA IrPhy 1.4 standard. While such a scheme does not eliminate worst-case duty cycle signal patterns in all specific cases, the probabilities of their occurrence are reduced significantly on average. This leads to a better "eye" opening and reduced jitter in the recovered signal stream for typical payload data.



### Active Output Interface

The active output interface (IRLED) emits an infrared signal. Key parameters for this interface, defined by IrDA physical layer specification are shown in table 3. A complete specification is available from IrDA.

Specification	Data Rates	Type	Minimum	Maximum
Peak wavelength, $\lambda_p$ , $\mu\text{m}$	All	Both	0.85	0.90
Maximum intensity in angular range, $\text{mW/sr}$	All	Std	-	500 <sup>*)</sup>
		Low Power	-	500 <sup>*)</sup>
Minimum intensity in angular range, $\text{mW/sr}$	115.2 kbit/s and below	Std	40	-
		Low Power	3.6	-
	Above 115.2 kbit/s	Std	100	-
		Low Power	9	-
Half angle, degrees	All	Both	$\pm 15$	$\pm 30$
Signaling rate (also called clock accuracy)	All	Both	See table 2	See table 2
Rise time $t_r$ , 10 % to 90 %, fall time $t_f$ , 90 % to 10 %, ns	115.2 kbit/s and below	Both	-	600
	115.2 kbit/s to 4.0 Mbit/s		-	40
	16 Mbit/s		-	19
Pulse duration	All	Both	See table 2	See table 2
Optical overshoot, %	All	Both	-	25
Edge Jitter, % of nominal pulse duration	115.2 kbit/s and below	Both	-	$\pm 6.5$
Edge Jitter, relative to reference clock, % of nominal duration	0.576 and 1.152 Mbit/s	Both	-	$\pm 2.9$
Edge Jitter % of nominal chip duration	4.0 Mbit/s	Both	-	$\pm 4.0$
	16.0 Mbit/s	Std	-	$\pm 4.0$

Table 3: Active output specification

\*)For a given transmitter implementation, the IEC 60825-1 AEL Class 1 limit may be less than this.

See section 2.4 above and Appendix A.

### Tolerance Field of Angular Emission

The optical radiant intensity is limited to a maximum of 500  $\text{mW/sr}$  and an angle of  $\pm 30^\circ$  to enable the independent operation of more than one system in a room. In figure 3, the tolerance field of an infrared

transmitter's emission is shown. A typical far field characteristic of a transmitter is also shown in this figure.

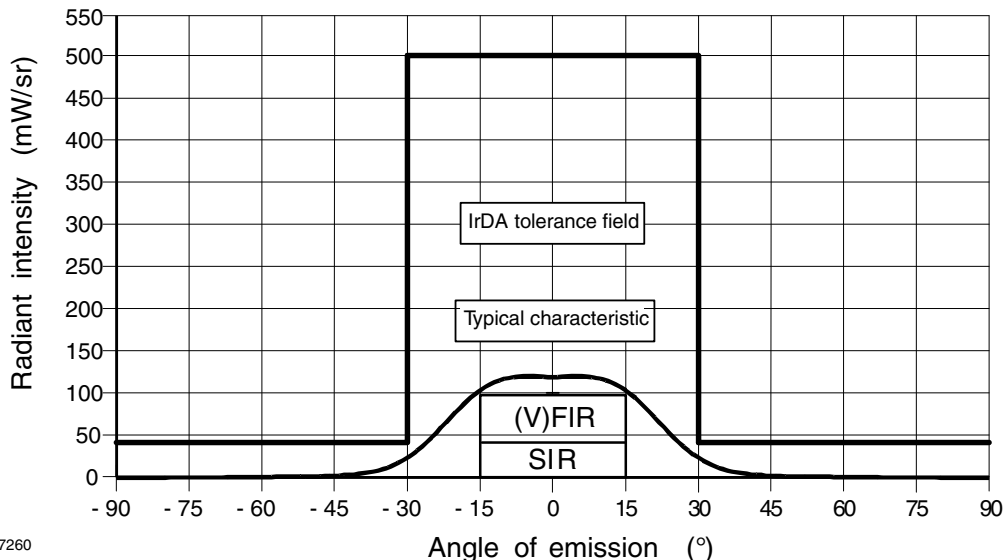


Figure 3. Tolerance field of angular emission



### Active Input Interface

When a infrared optical signal impinges on the active input interface (PIN photodiode), the signal is detected, conditioned by the receiver circuitry, and transmitted to the IR receive decoder.

Specification	Data Rates	Type	Minimum	Maximum
Maximum irradiance in angular range, mW/m <sup>2</sup>	All	Both	-	500
Minimum irradiance in angular range, mW/m <sup>2</sup>	115.2 kbit/s and below	Low Power	9.0	-
		Std	4.0	-
	Above 115.2 kbit/s	Low Power	22.5	-
		Std	10.0	-
Half angle, degrees	All	Both	15	-
Receiver latency allowance, ms	4.0 kbit/s and below	Std	-	10
		Low Power	-	0.5
	16.0 Mbit/s	Both	-	0.10

Table 4: Active input specification

### Active Input Specification

The following five specifications form a set which can be measured concurrently:

- Maximum irradiance in angular range, mW/m<sup>2</sup>
- Minimum irradiance in angular range, mW/m<sup>2</sup>
- Half-angle, degrees
- Bit Error Ratio, (BER)
- Receiver Latency Allowance, ms

These measurements require an optical power source and means to measure angles and BERs. Since the optical power source must provide the specified characteristics of the Active Output, calibration and control of this source can use the same equipment as that required to measure the intensity and timing characteristics. BER measurements require some method to determine errors in the received and decoded signal. The latency test requires exercise of the node's transmitter to condition the receiver.

Definitions of the reference point etc., are the same as for the Active Output Interface optical power measurements except that the test head is now an optical power source with the in-band characteristics (peak wavelength, rise and fall times, pulse duration, signaling rate and jitter) of the Active Output Interface. The optical power source must also be able to provide the maximum power levels listed in the Active Output Specifications. It is expected that the minimum levels can be attained by appropriately spacing the optical source from the reference point.

Figure 4 illustrates the region over which the Optical High State is defined. The receiver is operated throughout this region and BER measurements are made to verify the maximum and minimum requirements. The ambient conditions of A.1 (page 20) apply during BER tests; BER measurements can be done with worst case signal patterns. Unless otherwise known, the test signal pattern should include maximum length sequences of "1"s (no light) to test noise and ambient, and maximum length sequences of "0"s (light) to test for latency and other overload conditions.

Latency is tested at the Minimum Irradiance in angular Range conditions. The receiver is conditioned by the exercise of its associated transmitter. For rates up to and including 1.152 Mbit/s, the conditioning signal should include maximum length sequences of "0"s (light) permitted for this equipment. For 4.0 Mbit/s 4 PPM operation, various data strings should be used; the latency may be pattern dependent. The receiver is operated with the minimum irradiance levels and BER measurements are made after the specified latency period for this equipment to verify irradiance, half angle, BER and latency requirements. The minimum allowable intensity value is indicated by "minimum" in figure 5, since the actual specified value is dependent upon the data rate, SIR or FIR.

### Low Power Standard and Full Range Operation

The message that a Low Power device must be a special design is often propagated, but is incorrect. Full standard devices can be operated easily with reduced IRED drive current to fulfill the low power

specification. However, devices specially designed for Low Power applications with low profile package are not able to cover the full standard because of limited efficiency and little drive current capability.

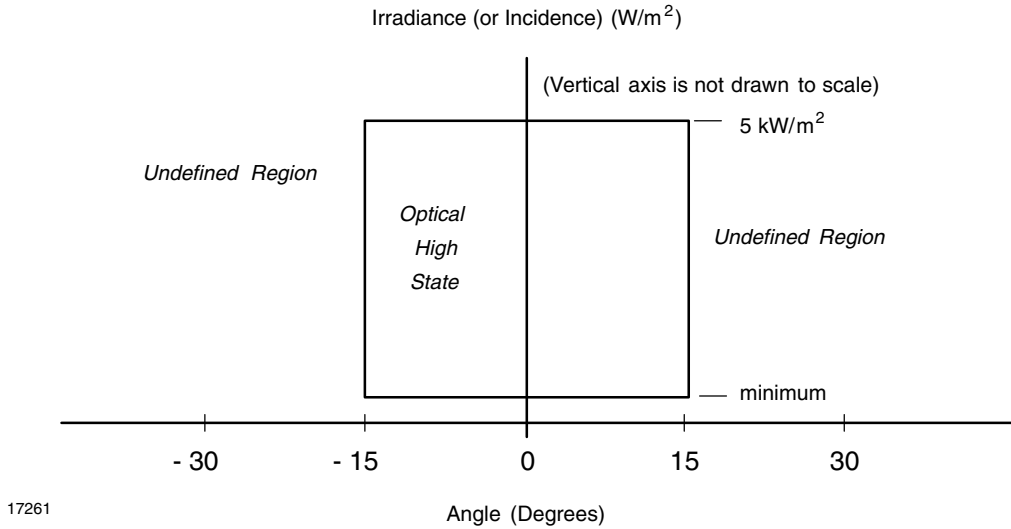
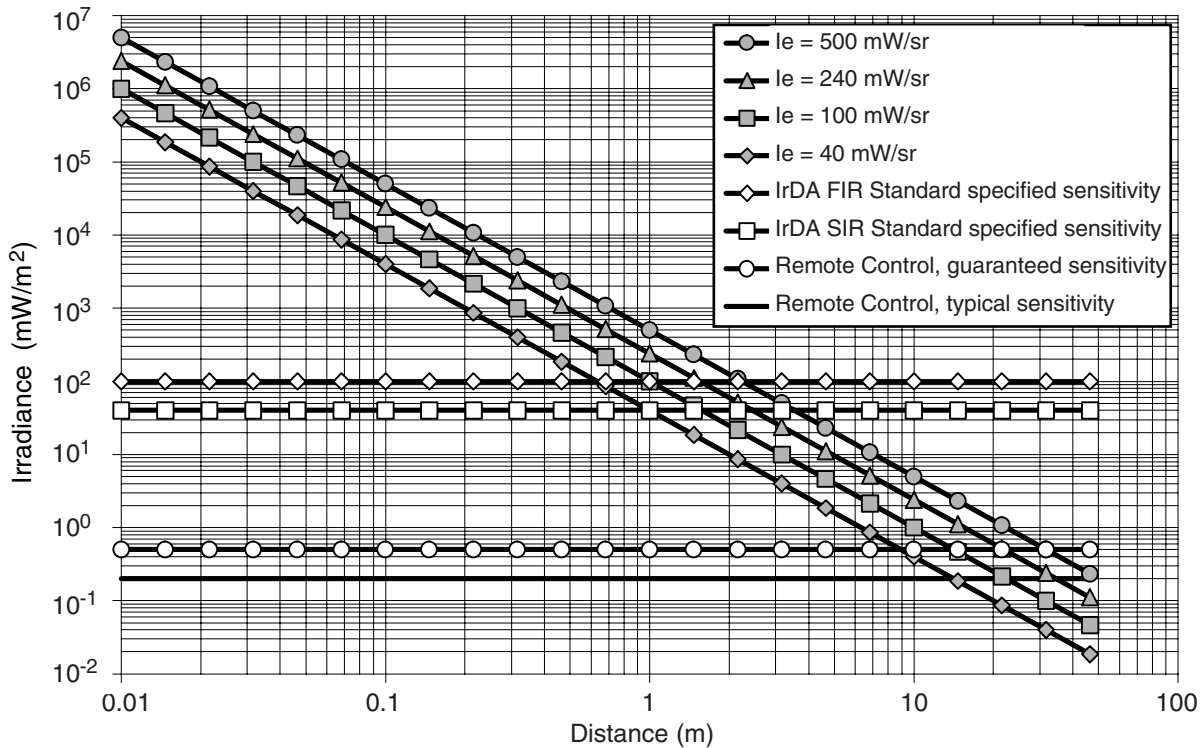


Figure 4. Optical High State Acceptable Range

## Transmission Distance

From figure 5, the transmission distance as a function of the sensitivity (necessary irradiance on the detector) can be read. For example: Sensitivity given as a minimum irradiance on the detector of  $40 \text{ mW/m}^2$ , combined with an intensity of  $40 \text{ mW/sr}$ , results in a transmission distance of  $1 \text{ m}$ . A combination of a detector with a minimum irradiance of  $10 \text{ mW/m}^2$  and an emitter with  $250 \text{ mW/sr}$  can transmit over almost

five meters. Vishay Semiconductor transceivers work well with standard remote control receivers and can therefore be operated as remote control transmitters. The physical layer properties of the devices are defined under ambient conditions listed in an appendix which has been reprinted in the following chapters.



17262

Figure 5. IrDA and Remote Control maximum transmission distance. For Remote Control receivers operating with IrDA transmitters a sensitivity of  $0.7 \text{ mW/m}^2$  can be assumed.



## Appendix A. Test Methods

Note - A.1 is Normative unless otherwise noted. The rest of Appendix A and all of Appendix B are Informative, not Normative {i.e. it does not contain requirements, but is for information only}. Examples of

measurement test circuits and calibration are provided in IrDA Serial Infrared Physical Layer Measurement Guidelines.

### A.1. Background Light and Electromagnetic Field

There are four ambient interference conditions in which the receiver is to operate correctly. The conditions are to be applied separately:

- **Electromagnetic field:** 3 V/m maximum (Refer to IEC 61000-4-3. test level 2 for details) (For devices that intend to connect with or operate in the vicinity of a mobile phone or pager, a field of 30 V/m with frequency ranges from 800 MHz to 690 MHz and 1.4 GHz to 2.0 GHz including 80 % amplitude modulation with a 1 kHz sine wave is recommended. Refer to IEC 61000-4-3 test level 4 for details. The 30 V/m condition is a recommendation; 3 V/m is the normative condition.)
- **Sunlight:** 10 kilolux maximum at the optical port This is simulated with an IR source having a peak wavelength within the range 850 nm to 900 nm and a spectral width less than 50 nm biased to provide  $490 \mu\text{W}/\text{cm}^2$  (with no modulation) at the optical port. The light source faces the optical port. This simulates sunlight within the IrDA spectral range. The effect of longer wavelength radiation is covered by the incandescent condition.
- **Incandescent Lighting:** 1000 lux maximum. This is produced with general service, tungsten filament, gas-filled, inside-frosted lamps in the 60 Watt to 150 Watt range to generate 1000 lux over the horizontal surface on which the equipment under test rests. The light sources are above the test area. The source is expected to have a filament temperature in the 2700 to 3050 degrees Kelvin range and a spectral peak in the 850 nm to 1050 nm range.
- **Fluorescent Lighting:** 1000 lux maximum This is simulated with an IR source having a peak wavelength within the range 850 nm to 900 nm and a spectral width of less than 50 nm biased and modulated to provide an optical square wave signal ( $0 \mu\text{W}/\text{cm}^2$  minimum and  $0.3 \mu\text{W}/\text{cm}^2$  peak amplitude with 10 % to 90 % rise and fall times less than or equal to 100 ns) over the horizontal surface on which the equipment under test rests. The light sources are above the test area. The frequency of the optical signal is swept over the frequency range from 20 kHz to 200 kHz. Due to the variety of fluorescent lamps and the range of IR emissions, this condition is not expected to cover all circumstances. It will provide a common basis for IrDA operation.