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Bodo´s Power™ Systems

Systems Design Motion and Conversion

September 2007

Spring Contacts

Switched Reluctance Drives
Active Clamp Topology
Electrolytic Capacitors
Digital Light Control

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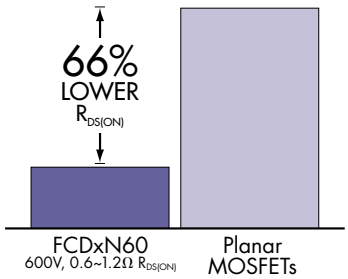

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CONTENTS

Viewpoint
More Efficiency and Less Losses are Key 4

Events 4

News 6-9

Product of the Month
Aluminum Electrolytic Capacitors Snap-in Series 10

Guest Editorial
It's Way More than Downloading Datasheets and Application Notes... 12
By Dr. Uwe Knorr, Vice President of Marketing and Sales, Transim Technology Corporation

Market
Electronics Industry Digest; *By Aubrey Dunford, Europartners* 14

Market
Rechargeable Batteries Charging Ahead in Europe
By Douglas Bess, Editor, PowerPulse.Net 16

Market
Energy Harvesting is "The Next Big Thing";
By Linnea Brush, Sr. Research Analyst, Darnell Group 17

VIP Interview
Interview on Power Module Technology with Peter Ingram,
President of European Operations, IXYS 18-19

Cover Story
Spring contacts - reliable alternative to critical solder contacts
By Daniel Seng, Product Manager, SEMIKRON Elektronik 20-23

Capacitors
Long-Term Stability of Aluminum Electrolytic Capacitors
By Christian Baur, Product Marketing Aluminum Electrolytic Capacitors and Norbert Will, Development of Aluminum Electrolytic Capacitors 24-26

Motion Control
2-phase Switched Reluctance Motor Drives
By Byoungchul Cho, Sungil Yong, Motion Control System Group, Fairchild Semiconductor, Korea 28-29

DCDC Converter
Using Digital Control to Improve Light Load Behaviour
By Roberto Cappelloni, Senior Power Supply Designer, ROAL Electronics S.p.A. 30-31

Power Supply
Power Converter Developer Kit; *By Perry Shugart, Director Power Converter Business, American Superconductor Corporation* 32-35

Power Management
TinySwitch-PK Doubles Peak Power Budget
By Doug Bailey, VP Marketing, Power Integrations 36-37

Measurement
Process Flow Optimization; *By: Chew, Chim Lai, Yeoh Theng Hooi, Chua Seng Yee, Avago Technologies Malaysia* 38-40

Opto
Revolution in the Cockpit; *By Andreas Biß, Product Marketing Optoelectronics, Sharp Microelectronics Europe* 42-44

Power Supply
A Discussion of the Active Clamp Topology
By John Bottrill, Senior Applications Engineer, Texas Instruments 46-49

Green Product of the Month
Miniature Rogowski Probes Upgraded for Power Electronics Market 50

New Products 52-56

The Gallery

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Events

Ansoft Design Seminars
www.ansoft.com/firstpass

National Power Seminars
www.national.com/see/powercourses

Fairchild Power Seminars
www.fairchildsemi.com/powerseminar07

EPE, September 2-5, Aalborg DK, www.epe2007.com

Husum Wind, September 18-22, Husum D, www.husumwind.com

Semicon Europa, Oct. 9-11, Stuttgart D, www.semi.org/semiconeuropa

Electrical Power Quality and Utilisation, Oct. 9-11, Barcelona, www.epqu2007.com

Digital Power Europe, Nov. 13-15, Munich, www.dpfeurope.darnell.com

Productronica, Nov. 13-16, Munich, www.productronica.com

SPS/IPC/DRIVES, Nov. 27-29, Nuremberg, www.mesago.com

More Efficiency and Less Losses are Key

Electric Hybrid Vehicles can do a lot to reduce energy consumption – first they operate electric-only in stop-and-go traffic and then recover stored momentum without braking.

Modern inverter technology, active and passive components enable efficient solutions for electric drives in automobiles. As seen in the August issue, Infineon has a basketful of solutions culminating in “Project eCart” – a system engineering approach to help automakers speed up designs that reduce energy use. Green Power reduces global warming and is one facet of these developments. Such innovations would be encouraged through stricter EU regulations.

Electric hybrid designs have already been functionally demonstrated in Europe. While I worked in industry I was involved in getting high performance IGBTs designed into prototypes of a smart electric vehicle in Switzerland. The project however, a vision of Swatch the watchmaker, was ahead of its time a Millennium ago in the 90s. The development resources in place at Biel, Switzerland are now gone but such cars are appearing.

Infineon has developed a full power set to serve electric hybrid needs - from the controller to the inverter and including battery management systems. Drive by wire, the comfort of modern sensors and lighting with LED’s all contribute to more efficient energy usage. Peter Bauer, member of the Infineon Management Board and head of the company’s Automotive Industrial and Multimarket business group, states that Infineon is the most successful non-Japanese chip supplier for automotive applications in Japan.

The electronic system for combustion motor management has also provided a much cleaner generation of engines. The system relies on the IGBT for precise ignition – products provided by Fairchild from Mountaintop, Pennsylvania, where the IGBT started in the mid 80s. Unfortunately, the SUV (Suburban Utility Vehicle) has countered this reduction in pollution but new hybrid versions are now in production. It is nothing less than our world that we need to protect for future generations.

Electric hybrids clearly show the need for energy storage with practical applications demonstrating the use of battery and super capacitors for storage. Companies like Maxwell are pushing the usage of super capacitors in public transportation busses. Flywheels for mechanical energy storage have been discussed in the past, but as yet I have not seen automotive applications.

Summer is now at its best. We are relaxing but looking forward to the upcoming EPE and HusumWind. The fall will bring an emphasis on semiconductor manufacturing - first at the Semicon Europa in Stuttgart in October and then the Productronica in Munich in November. Semiconductor manufacturing and assembly, including the thermal aspects, are critical subjects in Power Electronics – improvements increase efficiency and small steps result in significant savings in losses. Losses turn into heat that needs to be cooled. Heat may be appreciated in the winter but already global warming has begun to show dangerously mild winters. So we’ll see if we can’t soon sit outside in the “Biergarten” during the Productronica in November.

My Green Power recommendation for September is to enjoy the sun of an Indian Summer and before turning up the heat in your house, try a pullover sweater.

See you in Stuttgart, Munich or Nuremberg at the SPS/IPC Drives.

Best regards

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Silicon Carbide Supply Agreement

Microsemi Corporation and SemiSouth Laboratories Inc. of Starkville, Mississippi, announced today that they have entered into an agreement which provides for cooperation between the two companies in the area of silicon carbide (SiC) epitaxy wafer supply as well as certain technical exchanges. SemiSouth is a privately held company specializing in SiC material and device fabrication

Russell Crecraft, Microsemi Power Products Group Vice President and General Manager, stated "We are pleased to enter into a closer working relationship with SemiSouth. Microsemi's requirements for SiC wafers will grow in the future and we expect that this agreement will help SemiSouth's talented team of engineers to continue their progress toward highly manufacturable silicon carbide epitaxy."

SemiSouth's President, Jeff Casady commented "At SemiSouth, our long-term goals have always been to enable the SiC power device market through high-quality SiC epitaxy wafers and devices. We are excited to be able to work with Microsemi by supplying them epitaxy wafer products needed for their product goals. Microsemi has a great track record of supplying high performance power device products, and this agreement represents a great step forward for the SiC power electronics market."

www.microsemi.com

www.semisouth.com

DOSA Adds Power-One and NetPower

The Distributed-power Open Standards Alliance (DOSA) announced that Power-One, Inc, and NetPower Technologies have joined the industry alliance. DOSA was established in February 2004 to develop standards for DC-DC converters to ensure compatibility and facilitate second sourcing for customers. Alliance membership includes Tyco Electronics Power Systems, Inc., SynQor, Inc., C&D Technologies, Delta, Lambda, Ericsson, Artesyn/Emerson, Wall Industries, Acbel and Bel Power.
Bill Yeates, Power-One's CEO, commented, "Power-One looks forward to contributing to DOSA. We welcome the opportunity to enhance our broad line of board-level DC-DC solutions with products specifically developed in collaboration with this important, customer-focused industry alliance. We strongly believe that Power-One's DOSA membership will be in the best interests of our customers, and our company."
Ed Wiest, VP of Sales at NetPower commented, "We are excited to be part of the DOSA organization. As a new member, we look forward to participating in the development of industry standards. We believe DOSA is establishing itself as the most influential standards organization in the industry, and we welcome the opportunity to be a part of it."
Founded by Tyco Electronics and SynQor, DOSA carries the mission to establish standards over a broad range of power converter form factors, footprints, feature sets and functionality for both non-isolated point-of-load (POL) and isolated applications.
"DOSA membership now includes twelve of the world's largest and best known DC/DC converter manufacturers," said Sabi Varma, general manager, Tyco Electronics' Power Systems business. "DOSA has established itself as the leading industry alliance and the de facto standard for DC/DC converter modules."

www.dosapower.com

Microchip Launches Icwiki Web Site

Microchip announces Icwiki a Web site that enables engineers to collaborate and share information related to semiconductor products, applications and best practices. Using Wiki technology, participants can change content on the site and participate in Web logging ("blogging"), voting and messaging. ICWiki is available in several different languages, including English, Chinese, Japanese, French, German, Italian, Portuguese, Russian and Spanish,

Following recent trends toward online social networking, ICwiki was designed to help engineers share knowledge about designs and applications, as well as helping university students gain access to knowledge that can help bridge their transition from academia to industry. Participants can work together in either public or private blogs via the site's Group Decision Support Systems (GDSS) feature. Subject areas on the new Wiki include particular market areas such as automotive, home appliances and robotics; functional topics such as algorithms, oscillators, PCB layout best practices and signal conditioning; and product topics such as microcontrollers, Digital Signal Controllers (DSCs), analogue and memory products.

The new ICwiki, whilst promoting links between academia and industry, also forms an important part of the "University of Microchip". This is Microchip's education and training program, not only supporting universities all around the world, but also encompassing training provision in Regional Training Centers (RTCs) worldwide, at Microchip's MASTERs conferences and in online Design Centers.

www.microchip.com/ICwiki

The Best-Selling 2-Channel IGBT Driver Core

The 2SD315AI is a 2-channel driver for IGBTs up to 1700V (optionally up to 3300V). Its gate current capability of ±15A is optimized for IGBTs from 200A to 1200A.

The 2SD315AI has been established on the market as an industrial standard for the last four years. The driver has been tried and tested within hundreds of thousands of industrial and traction applications. The calculated MTBF to MIL Hdbk 217F is 10 million hours at 40°C. According to field data, the actual reliability is even higher. The operating temperature is -40°C...+85°C.

The driver is equipped with the award-winning CONCEPT SCALE driver chipset, consisting of the gate driver ASIC IGD001 and the logic-to-driver interface ASIC LDI001.

Chipset Features

- Short-circuit protection
- Supply undervoltage lockout
- Direct or half-bridge mode
- Dead-time generation
- High dv/dt immunity up to 100kV/us
- Transformer interface
- Isolated status feedback
- 5V...15V logic signals
- Schmitt-trigger inputs
- Switching frequency DC to >100kHz
- Duty cycle 0...100%
- Delay time typ. 325ns

Driver stage for a gate current up to ±15A per channel, stabilized by large ceramic capacitors

Specially designed transformers for creepage distances of 21mm between inputs and outputs or between the two channels. Insulating materials to UL V-0. Partial discharge test according IEC270.

Isolated DC/DC power supply with 3W per channel

More information: www.IGBT-Driver.com/go/2SD315AI

CT-Concept Technology Ltd. is the technology leader in the domain of intelligent driver components for MOS-gated power semiconductor devices and can look back on more than 15 years of experience.

Key product families include plug-and-play drivers and universal driver cores for medium- and high-voltage IGBTs, application-specific driver boards and integrated driver circuits (ASICs).

By providing leading-edge solutions and expert professional services, CONCEPT is an essential partner to companies that design systems for power conversion and motion. From custom-specific integrated circuit expertise to the design of megawatt-converters, CONCEPT provides solutions to the toughest challenges confronting engineers who are pushing power to the limits.

As an ideas factory, we set new standards with respect to gate driving powers up to 15W per channel, short transit times of less than 100ns, plug-and play functionality and unmatched field-proven reliability.
In recent years we have developed a series of customized products which are unbeatable in terms of today's technological feasibility.

Our success is based on years of experience, our outstanding know-how as well as the will and motivation of our employees to attain optimum levels of performance and quality. For genuine innovations, CONCEPT has won numerous technology competitions and awards, e.g. the "Swiss Technology Award" for exceptional achievements in the sector of research and technology, and the special prize from ABB Switzerland for the best project in power electronics. This underscores the company's leadership in the sector of power electronics.

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www.IGBT-Driver.com

Let experts drive your power devices

Global Power Resource Center to Address Automotive Challenges

Fairchild Semiconductor has expanded its Global Power Resource Center with the addition of a facility in Ann Arbor, Michigan. This new center—near the heart of the North American automotive market—responds to the burgeoning need for functional power solutions, including multi-die modules, for automotive power applications. The center is staffed by seasoned electrical engineers with extensive design experience and a thorough understanding of the application requirements for today's automotive designs.

www.fairchildsemi.com/designcenter/index.html

EMCUK 2007 Conference

Newbury Racecourse Event and Conference Centre, Newbury Berks, on the 16th and 17th of October.
An international, five-session, two day conference will prove a major attraction for design engineers of electronic products to be used in all sectors - consumer, medical, industrial, military, transport, telecom - who are required to meet high frequency EMC compliance requirements. Running as an integral part of EMCUK 07, the UK's only EMC event, the conference will feature international speakers drawn from governmental and regulatory organisations, as well as leading industry figures and suppliers.
Session 1 will be a full one day training course entitled: 'Electronic Fundamentals for Good EMC'. Delegates will hear from two of the most respected authorities in the field, Keith Armstrong of Cherry Clough Consultants and Tim Williams of Elmac Services.
Running concurrently on day one, Session 2 focuses on the automotive sector. Entitled 'Navigating Automotive Compliance', this stream will be chaired by Martin O'Hara of the Automotive EMC Network, and include presentations from representatives from Ford and MIRA.
Day two will see sessions covering: Defence and Avionics; EMC Regulations and Standards; EMC in Railways; and EMC Measurements and Design Principles.
QinetiQ, BAE Systems, TUV and ERA provide expert speakers during the Defence and Avionics program. Industry veterans Dave Imeson, Compliance Europe & Chris Marshman, York EMC Services Ltd will discuss EMC Regulations and Standards, before chairing a review on EMC Measurements and Design Principles for the rail industry.
In the final session, Ken Webb of TUV Product Services will chair a review of 'EMC Measurements and Design Principles'.

www.emcuk.co.uk/visitors

Silica and Seoul Semiconductor

Seoul Semiconductor and SILICA, an Avnet (NYSE:AVT) Company, have entered into an agreement whereby Avnet will distribute Seoul's entire line of LEDs and solid state illumination products in Europe. The agreement, which takes effect immediately, makes energy efficient lighting solutions and other LED applications more readily available to European industrial customers. SILICA's extensive customer base enables Seoul Semiconductor to significantly extend its reach to potential new customers who will benefit from Seoul's advanced LED technology, and SILICA's in-depth technical and commercial support.

Seoul Semiconductor recently introduced a number of highly innovative LED technologies, amongst them "Acriche", the world's only semiconductor light source capable of running directly from household AC power without the need for additional converters. Acriche includes essentially the brightest single-die white LEDs, which are expected to replace conventional light sources such as fluorescent or incandescent lamps.

Both Seoul and SILICA foresee LED technology breakthroughs such as Acriche to serve as the future lighting source of choice for commercial/residential applications by portable lighting manufacturers, architects, manufacturers of TV and computers' displays, automotive designers and makers of traffic signals, handsets and signage.

According to Miguel Fernandez, Silica president, "Seoul Semiconductor's broad range of advanced LED technology will revolutionise many segments of the lighting industry and is therefore a valuable addition to our existing portfolio. SILICA expects to have a strong emphasis on the Illumination market in the future and the partnership with Seoul

marks a major development in our product strategy. We will work with customers through a pan-European team of dedicated illumination-focused engineers to ensure that our customers will enjoy not just a single source of supply, but also the in-depth technical support that is essential for realising successful product design within the shortest possible timeframe."

www.silica.com

www.acriche.com

Alan Denny for the Battery Monitoring Division of LEM

LEM SA has appointed Alan Denny as the new Business Development Manager for its Battery Monitoring Division.

Alan brings LEM an extensive experience in the power electronics market. His professional career has included various technical and operational management positions and more recently he has worked as managing director for Europe & the Middle East and Africa with PK Electronics and was managing director with NDSL. Paul Van Iseghem, CEO of LEM said, "Alan brings outstanding credentials to LEM and will be a vital member of our team. His experience in the battery monitoring market will be invaluable as we continue to develop cutting-edge components that meet the needs of the most demanding applications."

Based at LEM's headquarters in Geneva, Alan Denny will play a key role in ensuring that LEM continues to deliver high standards of service and product quality and remains at the forefront of innovative technology. He will focus on driving the business forward by developing a global network of channel partners who will integrate the LEM components into their own battery management systems.

www.lem.com

Cirrus Signs Agreement to Acquire Apex

Cirrus Logic announced that it has signed a definitive agreement to acquire Apex Microtechnology for $42 million in cash. Founded in 1980 with headquarters in Tucson, Ariz., Apex Microtechnology is a leading innovator of integrated circuits, hybrids and modules used in a wide range of industrial and aerospace applications that require high-power precision analog products, such as PWM and power amplifiers. These precision amplifiers are used for driving motors, piezo electrics, programmable power supplies and other devices requiring high power and precision control. Apex Microtechnology employs approximately 90 people.

"Apex Microtechnology's proven success and diversified customer base gives Cirrus Logic the expertise to expand into high-power industrial markets," said Jason Rhode, president and chief executive officer, Cirrus Logic. "Combining Cirrus Logic's signal processing and IC design skills with Apex's expertise in power drivers and amplifiers will allow us to introduce precision power products with higher levels of integration and functionality."

http://apexmicrotech.com/BPS

http://cirrus.com

Energy Storage Systems for Hybrid Autos

Maxwell announced that it has signed a memorandum of understanding (MOU) with Valeo, a leading Tier 1 supplier to automakers worldwide, covering a development collaboration to incorporate Maxwell's BOOSTCAP(R) ultracapacitors in Valeo's next generation StARS+X — "stop-start" and regenerative braking system, which reduces automobile fuel consumption and emissions and powers additional electrical functions.

The new 14+X StARS (starter alternator reversible system) consists of a reversible starter-alternator, a multi-cell ultracapacitor energy storage module and other power and control electronics in a 14-volt architecture that enables standard gasoline and diesel engines to shut down during idle phases and restart instantly, eliminating fuel consumption and emissions anytime the vehicle is stopped. Valeo estimates that the system can reduce fuel consumption and associated emissions by about 12 percent in normal operation and more than 20 percent in stop-and-go urban traffic.

www.valeo.com

www.maxwell.com

Aluminum Electrolytic Capacitors Snap-in Series

High current handling capacity and compact size

With the newest aluminum electrolytic capacitors EPCOS is setting standards for current handling capacity, operating life and ultra-compact size.

EPCOS has developed the new B43540 snap-in aluminum electrolytic capacitor especially for DC link applications in frequency converters. The ESR and internal thermal resistance have been optimized to enable a 20 to 60 percent increase in current handling capacity in comparison to previous products of the same volume depending on operating conditions (see Table).

Comparison of B43501A9477M (85 °C series) and B43540M9477M (85 °C series, max. current handling capacity)

	B43501A9477M	B43540B9477M (New)
I_{AC} @ 60 °C, 100 Hz, 30.000 h	4,85 A	**5,95 A (+23 %)**
$I_{AC, max}$ @ 60 °C, 300 Hz	6,06 A	**8,33 A (+37 %)**
$I_{AC, max}$ @ 60 °C, 10 kHz	6,92 A	**10,64 A (+54 %)**
ESR_{typ} @ 20 °C, 100 Hz	140 mΩ	**130 mΩ (-7 %)**
ESR_{typ} @ 60 °C, 100 Hz	100 mΩ	**80 mΩ (-20 %)**
ESR_{typ} @ 60 °C, 10 kHz	37 mΩ	**22 mΩ (-41 %)**
Dimensions (d x l)	35 x 45 mm	**35 x 45 mm**
R_{th} internal	100 %	**46 % (-54 %)**
Price Index	100 %	**110 %**

Table: Comparison to previous products

Although the B43540 series is designed for temperatures of 85 °C and an operating life of 10,000 hours they significantly surpass the performance of today's 105 °C series at typical operating conditions. When operated at up to 93 percent of the rated voltage these capacitors can be used at 105 °C without any problems. Like all snap-in series from EPCOS the industrial series B43540 is also available at no extra charge in 3-pin design to prevent polarity reversals errors.

Ultra-compact and long-lived

The new snap-in aluminum electrolytic capacitors of the B43305 and B43508 series from EPCOS offer significant space saving ability. The components feature the same electrical properties as earlier types, but are smaller by up to two case classes. That corresponds to a height reduction of 5 and 10 mm. In this way the components enable the design of even smaller power supplies and frequency converters. The further miniaturization was achieved by the use of new materials, an improved capacitor winding design and an optimized concept for the mechanical construction. EPCOS is best in class in terms of the capacitance density achieved. B43508 series is designed for use at temperatures of 105 °C and then attains an operating life of 3000 hours. The 1000 ìF / 400 V type at 35 x 55 mm can be regarded as a benchmark in this class.

The ultra-compact B43305 series is the highest volume-specific CV product. Typical examples are the 680 ìF / 450 V type at 35 x 45 mm or the 1000 ìF / 400 V at 35 x 50 mm. EPCOS also offers these ultra-compact series at no extra charge in 3-pin design to prevent polarity reversals errors.

AlCap design tool

The free AlCap design tool from EPCOS helps to calculate capacitor banks and individual capacitors (download under www.epcos.com/tools). Based on the entry of individual parameters such as voltage, current, ambient temperature, or cooling conditions AlCap generates individualized solutions, providing such information as operating life, price index, part numbers and further key data. The database for the tool includes all high-voltage screw-terminal and snap-in capacitors, even the new B43305, B43540 and B43508 series. The results can be easily transferred into a spreadsheet or saved as PDF files.

www.epcos.com

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- Standard or individual housings
- Flexible pin-out
- Custom or standard circuits
- Silicon from world class suppliers
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It's Way More than Downloading Datasheets and Application Notes…

How Web 2.0 helps to change semiconductor marketing and application engineering

By Dr. Uwe Knorr, Vice President of Marketing and Sales, Transim Technology Corporation

Not only has the Internet accelerated our communications (Who can still do business without e-mail, remote access, web sites, ...?). It has also fundamentally changed the way we gather information (think Google, Yellow Pages, …). The semiconductor industry recognized early the attraction of electronic data sheets, parametric tables and search engines. Slow, expensive and inflexible catalogs and mailed CDs were quickly replaced by web sites featuring a wealth of technical information. Application notes, data sheets, selection guides and parametric search engines are characteristic for most of today's semiconductor manufacturer's web sites. They are nicely complimented by cool advertisements and the obligatory investor relations section. Increasingly online purchasing, evaluation kit and sample order systems are becoming available.

The web presence of the semiconductor manufacturer community has come a long way. Information is faster and more easily accessible and business processes are significantly shortened. However with all the advances in providing information - it still takes a sharp engineering mind to translate all that information into a working design. Even if a potential user finds the data sheet and application note for a power management IC with the speed of light (or probably more the speed of a DSL line) he or she still needs to read, digest and translate the complex set of equations, diagrams and design rules into a real design. Developing the solution is still a time consuming process and requires highly skilled design engineers. Both are rare in today's world of short product development cycles and a shortage of electrical engineering students all over the world.

Semiconductor manufacturers have been doing a great job providing highly skilled and responsive field application engineering (FAE) teams that help customers with answers. However FAEs have limited bandwidth and can't travel all the time. Building FAE teams also has limits as hiring FAEs is a rather expensive proposition (if you can find them on the market). This is amplified by the desire of many manufacturers to serve more horizontal markets. Focusing on high volume top level customers helps to keep the factories humming at high utilization levels, is good business practice and provides the lion's share of revenue for most companies. Unfortunately that comes at the price of rather low margins and volatility in the revenue stream. Spreading out into more horizontal markets is a widely seen as one solution to reduce volatility and capture the more attractive margin potential in a broader customer base.

The only way to provide high quality support to those high margin customers is a virtual extension of the application engineering team. Transim Technology Corporation has been working for many years with numerous manufacturers implementing WebSIM® (Online Design Centers or "electronic FAEs"). WebSIM® complements application engineering teams taking over a wide variety of routine application engineering tasks and thus increasing the bandwidth of the application department. Valuable application engineering resources can then focus on the really tough problems.

Starting with a design interview page, WebSIM® selects appropriate products and solutions and customizes standard reference designs according to the user's design requirements. WebSIM® automatically calculates external components, optimizes loop gain and compensation and selects appropriate vendor parts (Do I use manufacturer A or B? Would I be better off with one big or two small capacitors?), and generates a complete design schematic all the way to the Bill of Materials. An instant verification engine based on remote simulation allows testing and verifying the design providing information about the expected performance of the IC. All of this happens in a web browser. No need to install (expensive) design software. Web browsers are inherently easy to use, compatible with all kinds of hardware and software platforms.

While this is obviously a very attractive proposal for semiconductor buyers there is a whole range of benefits for the manufacturer of those parts. Besides the very high customer satisfaction and the well known advantages of web based solutions (24/7, worldwide, fast deployment, etc.) manufacturers can significantly shorten the release cycle of their products and avoid the distribution and maintenance of spreadsheets or executables.

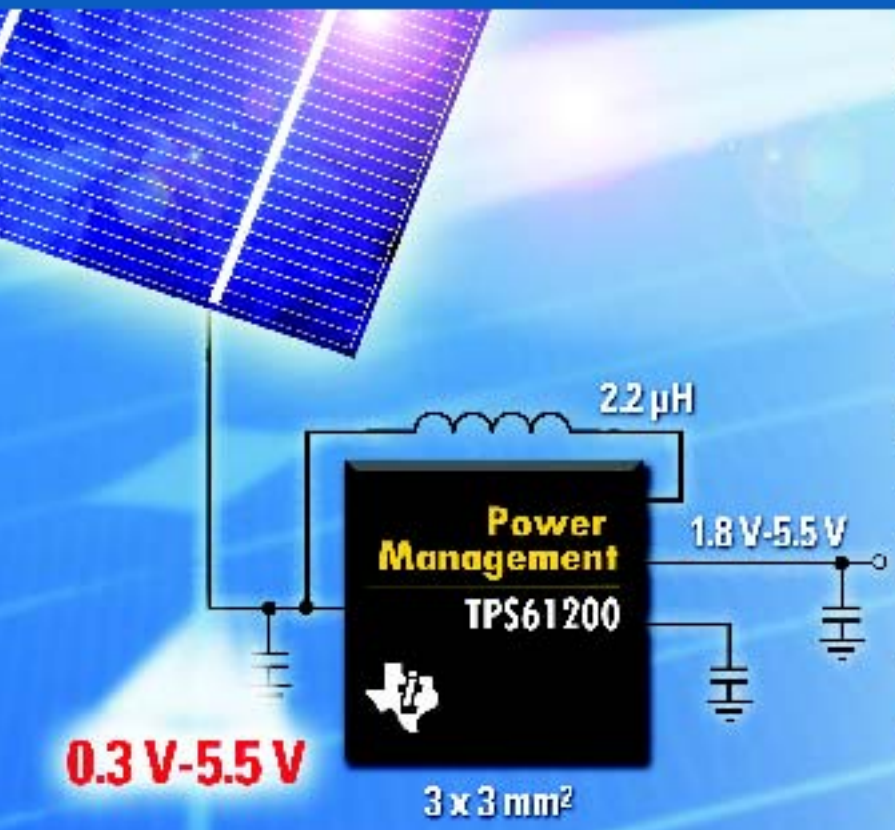
Moreover the latest advances in Internet technology now allow a direct integration of web based solutions with hardware. Transim already developed and demonstrated at APEC 2007 the first solution for PMBus programming through the web. Users can simply configure command and monitoring scripts from the convenience of their web browser and interact with the evaluation board connected to the USB port of their computer. Users can change chip settings on the fly and monitor its status. Convenient waveform and digital displays are available. In the near future there will be a web-based remote diagnostics module. Once the connection to the evaluation board has been established an application engineer can debug a system from any location in the world.

This and many more ideas can be implemented with today's Internet (some call it Web 2.0). It is just a matter of your imagination. Transim is here to help you capture these ideas and transform them into productivity tool. We look forward to talking to you.

www.transim.com

0.3-V Input Boost DC/DC Converter

Manages Single Solar and Micro-Fuel Cells



Applications

- Single solar cell and micro-fuel cell powered products
- 1-/2-/3-cell alkaline, NiMH or 1-cell Li-Ion battery-powered products
- Portable solar charger
- Portable audio and media players
- Digital still camera
- Digital radio player

Features

- Input voltage: 0.3 V to 5.5 V
- Start-up into full load at 0.5 V input voltage
- Automatic down conversion mode enables continuous operation during $V_{IN} > V_{OUT}$ conditions
- Power save mode for improved efficiency at light loads
- Switch current limit: 1.5 A (max)

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The **TPS61200** is the industry's lowest input-voltage boost converter, enabling portable electronic end equipment to draw power from new energy sources such as solar and micro-fuel cells. This tiny power management circuit can operate with input voltages as low as 0.3 V with high efficiency, and provides an extremely low 0.5-V start-up capability under any load condition.

Device	V_{IN} (V)	Switch Current Limit (A)	V_{OUT}	Efficiency (%)	Package	Price (US$)*
TPS61200	0.3 to 5.5	1.35	1.8 to 5.5	95	3 x 3 mm QFN-10	$1.70
TPS61081	2.5 to 6.0	1.3	V_{IN} to 27	85	3 x 3 mm QFN-10	$1.05
TPS63000	1.8 to 5.5	1.8	1.2 to 5.5	90	3 x 3 mm QFN-10	$2.75
TPS717xx	2.5 to 6.5	–	0.9 to 6.2	–	1.5 x 1.5 mm SOT	$0.40

*Suggested resale price in U.S. dollars in quantities of 1000

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Electronics Industry Digest

By Aubrey Dunford, Europartners

GENERAL

The ZVEI forecasts that the German electrical technology and electronic industries will enjoy a growth of turnover of at least 6% in 2007 to € 190 billion. The industry in Germany had increased the number of its employees by 4000 to 806500 by the end of 2006. The ZVEI expects that by the end of this year the number of employees in the industry will be 815 000.

SEMICONDUCTORS

Worldwide semiconductor capital equipment spending is forecast to total $43.1 billion in 2007, a 2.7 percent increase from 2006, so Gartner.

STMicroelectronics will rationalize three of ist manufacturing operations. Over the next two to three ears, the company will wind down operations at its 6-inch (150mm) wafer fab in Carrollton, Texas, its 8-inch (200mm) fab in Phoenix, Arizona and its back-end packaging and test facility in Ain Sebaa, Morocco. Bosch will license ST's BCD8 process technology, enabling Bosch to design and manufacture automotive products using this technology in its own wafer fabrication plant.

In 2006, IC companies headquartered in the Americas region held almost half of the worldwide IC sales marketshare, about the same share as 21 years earlier in 1985, so IC Insights. European companies have always held 8-10% of the worldwide IC market. IC Insights believes that the European companies will stay in this narrow range through 2011. The Asia- Pacific companies will continue to gain market share and represent almost one-third (32%) of worldwide IC sales in 2011 from 26% in 2006.

Cirrus Logic, a designer of analog, mixed-signal and embedded integrated circuits, has signed a definitive agreement to acquire Apex Microtechnology, a US-based provider of precision high-power analog amplifier products, for $42 million in cash. Founded in 1980, Apex Microtechnology develops integrated circuits, hybrids and modules used in a wide range of industrial and aerospace applications. Apex employs approximately 90 people.

Avago Technologies has closed its acquisition of Infineon Technologies AG's Polymer Optical Fiber (POF) business unit based in Regensburg, Germany.

OPTOELECTRONICS

iSuppli has upgraded its forecast of global large-sized LCD-TV panel shipments in 2007 to 77.5 million units. In 2009, LCDs will become the world's dominant television display technology, accounting for 52 percent of unit shipments. Separately, a strong recovery in the desktop PC monitor market in the second and third quarters is expected to drive sales to 163.2 million units in 2007, up 14 percent from 2006. The notebook PC LCD panel market is expected to reach 99.6 million units in 2007 and 161.5 million units in 2011.

Pelikon is investing a further GBP 3 million towards the R&D of its flexible electroluminescent (EL) display technology, as it prepares to commercialise its hybrid displays. Established in September 2000, Pelikon has invested GBP 17 million to date in its UK manufacturing and R&D.

PASSIVE COMPONENTS

elvia PCB group has signed a commercial and industrial agreement with Sagem Communication, Safran group. The industrial agreement covers the acquisition of the Sagem Lannion plant (in Brittany France). This activity is transferred to a new company called "eLci". The commercial agreement covers the supply of PCBs to the main subsidiaries of the Safran group.

OTHER COMPONENTS

German power supplies provider Puls has opened a new manufacturing facility at Chomutov in the Czech Republic. The new factory will eventually employ 350 people and represents an investment in European manufacturing by Puls of € 17 million.

Applied Materials has made a strategic investment in Semprius, a start-up which is developing a patented technology for the transfer printing of semiconductors onto virtually any hard surface, including glass, flexible or rigid plastic, metal or other semiconductors.

Solomon Technologies has signed a letter of intent to acquire Unipower Corporation, a US-based manufacturer of power supplies and related equipment for telecom, datacom, network equipment and industrial applications. Unipower has overseas operations in the United Kingdom.

DISTRIBUTION

Avnet Time, a business unit of Avnet Electronics Marketing EMEA, has acquired the UK-based Interconnect, Passive and Electromechanical (IP&E) distributor, Flint Distribution (55 employees). Flint will be combined with the Avnet Time organisation.

A new specialist power conversion distribution company, PIV Technology, has been launched in UK. Founded by Marc Hogg, who brings more than 15 years' experience of working in the power supply market, PIV Technology's first franchise is Recom, the Austria/German based manufacturer of DC/DC products. PIV Technology is also launching with Hengfu (China), Magtech Industries (USA) and Elementech (China).

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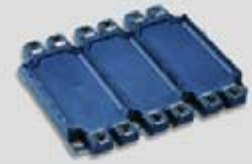
1200V: 50A - 450A
1700V: 150A - 400A

1-Pack IGBT
600V: 600A
1200V: 200A - 800A



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Rechargeable Batteries Charging Ahead in Europe

By Douglas Bess, Editor, PowerPulse.Net

Numerous announcements regarding rechargeable battery developments (good and not so good) have been coming out of Europe. Most recently, Nokia issued a product advisory for the Nokia-branded BL-5C battery manufactured by Matsushita Battery Industrial Co., Ltd. of Japan between December 2005 and November 2006. This product advisory does not apply to any other Nokia-branded battery.
Nokia has identified that in very rare cases the Nokia-branded BL-5C batteries subject to the product advisory could potentially experience overheating initiated by a short circuit while charging, causing the battery to dislodge. Nokia is working closely with Matsushita and will be cooperating with relevant authorities to investigate this situation.

Nokia has several suppliers for BL-5C batteries who have collectively produced more than 300 million BL-5C batteries. This advisory applies only to the 46 million batteries manufactured by Matsushita between December 2005 and November 2006, from which there have been approximately 100 incidents of overheating reported globally. No serious injuries or property damage have been reported.
Chipidea Microelectrónica SA, a provider of analog/mixed-signal subsystems and intellectual property, announced what is claimed to be the industry's most compact, silicon-proven step-down dc-dc converter IP core to support an external supply voltage up to 4.2V while using regular 3.3V System-on-Chip (SoC) devices found in CMOS processes. The CI2512tl step-down dc-dc converter IP core is the latest offering from the company, and is said to allow SoC designers to integrate dc-dc converter functionality into their designs and avoid the additional expense of higher voltage process options.

This dc-dc converter IP core maintains a power conversion of greater than 90% over a large load range (up to 150mA) using PWM/PFM (Pulse Width Modulation/Pulse Frequency Modulation) controls. It accepts any battery with a voltage supply ranging from 2.7 to 4.2V, such as a lithium battery, and features a programmable output voltage ranging from 0.6 to 2.0V.

The high programmability of the dc-dc IP core output voltage gives SoC integrators full flexibility to optimize system performance. The IP core is said to achieve a high level of integration including internal references, internal regulators and system power-on-reset to enable a "plug-and-play" power management functionality. The IP core comes with a fully functional Verilog behavior model to ease integration and system verification.
"As part of the industry's most comprehensive offerings in power management IP, our step-down dc-dc converter IP provides SoC designers with the ability to overcome some of their most vexing challenges for system integration," said Nuno Ramalho, Vice President of Audio and Power Solutions for Chipidea. "This core's highly integrated functionality addresses such design issues as the generation, observation and management of multiple voltage domains. This in turn lets SoC engineers focus on the key differentiating characteristics of their chips and helps them speed time to market."

The latest core is part of the CI2512 step-down dc-dc converter IP family that is available in TSMC 130nm and 90nm process technologies. In addition, Chipidea offers the CI2522 step-down dc-dc converter IP family, a fully integrated, low pin count solution in SMIC 130nm process technology. Both offerings will soon be available in other top-tier semiconductor foundries.

Aiming for a different class of portable applications, England's Moixa Energy has released its USBCELL – a rechargeable battery that can charge from any USB port without the need for any recharging devices, cradles or cables. According to the company, the user simply needs to pop the lid to reveal a built in connector and charger, and plug into any powered USB port on a desktop, laptop, keyboard or games console, to charge the battery.
According to the company, the USBCELL can be used exactly like a normal battery, meaning there is no need to purchase packs of alkaline batteries, or invest in or carry a charger. Currently available in the AA format, the USBCELL will shortly comprise a full range of standard formats, phone and camera batteries. The 1.2V AA USBCell provides a maximum of 1300 mAh, and a 90% charge is reached after a charging time of about 320 minutes.
Targeting much-higher-power uses, Saft announced that it is manufacturing what is claimed to be the highest power lithium-ion (Li-ion) cells in the world. The VLV range of cells is said to exhibit a specific power double that of typical high power cells that are available for defense applications and hybrid electric military vehicles. Saft's high power VLV line consists of three sizes of cells (VL4V, VL8V, and VL12V). New for 2007, will be the VL6A, a high power cell designed for civil applications that require peak power, such as windmill blade pitch control.

"Our VLV cells are already being manufactured and are currently in use on military fighter aircraft providing emergency back-up power to operate flight controls and to start the APU," said Dr. Kamen Nechev, Manager of Advanced Development, Saft Space and Defense Division. "The VL6A is an exciting addition to our portfolio of very high power cells and will satisfy the power demands of many emerging technologies. We are in a unique position because Saft is the only supplier offering cells at this high level of power."
Saft's portfolio includes 6, 8 and 12A hour cells with a maximun charge voltage of 4.1V and an average voltage of 3.6V. Specific power exceeds 9kW/kg for two-second long pulses and 12kW/kg for 100ms-long pulses. The cells are capable of continuous discharge of 6kW/kg. The cells are used in battery products ranging from 28V to as high as 600V.
Saft developed the cells complete with electrical hardware and software monitoring capabilities claimed provide a completely safe power solution for its customers. The cells can be used for a variety of applications, including emergency power for military fighter aircraft, supplemental acceleration and breaking in military hybrid electric vehicles, as well as intermediate energy storage in directed energy systems.

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Energy Harvesting is "The Next Big Thing"

By Linnea Brush, Sr. Research Analyst, Darnell Group

Most of the companies getting a jump on "the next big thing" in power management are not well-known in the power supply industry. Many are start-up companies, and many are based in Europe. With potential unit sales in the billions, however, these companies have targeted the low-power sensor and device market. They are highlighted in the latest report in the Energy Harvesting, Micro Batteries and Power Management ICs series: "Competitive Environment." This 62-page report discusses the activities of low-profile companies poised to have a big impact.

Each of these markets is unique, with different characteristics defining them and driving them. The energy harvesting companies are, for the most part, small start-up companies. Many are in Europe, like EnOcean, Ubiwave and Perpetuum. Companies like Powercast and Perpetuum have commercial products, while others are still in the prototype stage. Like most emerging technologies, the energy harvesting landscape has many specialized competitors. The profiles in this report cannot cover them all, but it does provide a detailed review of the more significant products and technologies.

Many of the energy harvesting companies have found it useful to partner with IC companies. IDS Microchip, for example, has a near field communications solution they did for Texas Instruments similarly. EnOcean has worked with the Fraunhofer Institute and Perpetuum is working with Dust Networks. Many of these companies are members of the ZigBee Alliance, as well. The IEEE 802.15.4 standard (ZigBee) is now expected to co-exist with other standards such as Z-Wave, Insteon, LonTalk and others.

What is agreed upon is that wireless technologies are "hot" - customers want them and find wireless cheaper. Customers also want low power and high reliability. Where demand differences come in is with batteries. Some customers want batteries and some do not. In general, the power requirements of batteries need to be minimized, and both established companies and start-ups are trying to meet this need. EaglePicher, Tadiran and Varta, for example, are capitalizing on their existing lithium technologies to offer micro batteries for energy harvesting applications. Front Edge, Oak Ridge Micro-Energy and Solicore are newer companies offering ultra-thin film batteries. Although many energy-harvesting solutions (such as microgenerators) are aimed at "getting rid of batteries," they are still likely to be used in many wireless sensor networks.

The most established companies offering wireless sensor network and energy harvesting solutions are the power management IC companies. Texas Instruments, Nordic Semiconductor, STMicroelectronics – these manufacturers and more have a variety of products targeted at ultra-low-power applications. Some, like Advanced Linear Devices, have specific modules for energy harvesting. These products are expected to help drive down costs, since high volumes are necessary to achieve market penetration. Radiocrafts, for instance, is "aiming for high-volume manufacturing." Most companies see commercial adoption of ZigBee products and related energy harvesting solutions in two to three years.

Darnell's Energy Harvesting, Micro Batteries and Power Management ICs series: "Competitive Environment" is available for immediate delivery.

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Interview on Power Module Technology

with Peter Ingram, President of European Operations, IXYS

By Bodo Arlt, Editor BPS

Bodo Arlt: What future end markets will drive IXYS for power module technology?

Peter Ingram: The traditional market for power modules, drives and UPS will continue to have a very high priority. Variations and adaptions of electric drive technology will be utilized to provide systems for renewable energy requirements, and obviously for future electric drives in Automotive.

Bodo Arlt: What is IXYS position besides the wide range of IGBT modules?

Peter Ingram: IXYS has a wide range of products, not only IGBT modules. There we a wide range of consumer and telecom applications where IGBT modules have only limited access.
Other technologies than IGBT Modules are and will continue to have great opportunities for power semiconductor companies like IXYS

Bodo Arlt: What are the technologies that IXYS can offer innovation for leadership?

Peter Ingram: Our leading position, in house DCB, bipolar expertise as with the SONIC Diodes and transfer molded DCB packages will support and grow the leadership of IXYS in innovation in the IGBT module market. In other areas like high power, high frequency and VOIP, IXYS also has innovative technologies.

Bodo Arlt: What are you views to forward integration?

Peter Ingram: In all areas, there is a trend to forward integration requested by the customer base, and ideally served by the Semiconductor supplier. This is not only limited to a growing interest in IPM's for customers with a weak technology base but also into high power systems where Stacks or system solutions are being in increasingly focused on. The systems knowledge is available within a company like IXYS, but it is important not to compete with your customers but serve their requirements.

Bodo Arlt: What makes IXYS different from traditional module suppliers?

Peter Ingram: IXYS has many years of experience not only in power semiconductors but in DCB and packaging. Also IXYS has always approached complete solutions not forgetting the other components, like bipolar parts, necessary to give a customer complete service. Nevertheless it has never forgotten to offer slot-in standard products to enlarge the potential supplier base.

Bodo Arlt: What makes IXYS different from traditional semiconductor companies?

Peter Ingram: IXYS has always been open not only to standard products but has and always will be open to make customized products. Such products allow the customer competitive benefit in their own market. It also has relative to the size of the organisation, one of the widest spectrums of technologies that can be offered.

Bodo Arlt: How much is IXYS involved in the end customer's application?

Peter Ingram: Without understanding and supporting end customer applications it is not possible to develop the right products for the future. However, most end customers understand more than we can ever do about their own market, so what we offer is partnership and support.

Bodo Arlt: How much is IXYS involved in automotive applications using the advantage of modules for hybrid technology?

Peter Ingram: IXYS has for many years been supporting the industrial automotive market with modules and has new products like the GWM series that have gained in roads in the automotive market. Electric drive systems and the associated periphery for future car technologies are part of the forward strategy for IXYS.

Bodo Arlt: What will be the future for IGBT gate driver technology?

Peter Ingram: There will be no one gate driver technology. For high voltage systems, magnetic or optical isolation will be a necessity. For lower voltage systems, the IXYS SOI technology will have obvious advantages and great potential. The compatibility of such technologies to be integrated into Power packages obviously will influence the route that will be chosen.

Peter H. Ingram

Peter H. Ingram serves as the President of European Operations for IXYS since 2000.
From 1994 to 2000, he served as the Vice President of European Operations.
From 1989 to 1995, he served as the Director of Wafer Fab. Operations.
Mr.Ingram worked with the Semiconductor Operations of ABB from 1982 until these operations had been acquired by IXYS.
Mr. Ingram received an Honors degree in Chemistry from the University of Nottingham.

Bodo Arlt: Green Energy what kind of input will this have on the power semiconductor business ?

Peter Ingram: The world wide long term necessity to limit the energy usage to the available regenerative energy will have extreme impact on the Power Semiconductor business. Both in the technology we provide as well as the continued innovation in our customers products. Power Semiconductors provide solutions both to reduce energy consumption as well as increasing the out put of regenerative energy. This will give increasing growth opportunities on all fronts, drives, telecom, automotive etc.

Bodo Arlt: How does IXYS see the future of SIC devises?

Peter Ingram: SIC technology is interesting but is decades way from replacing silicon. The challenge to silicon by SIC technology is already driving improvements in Silicon technologies.

Bodo Arlt: Who are your competitors you believe will stimulate the race for leadership?

Peter Ingram: We have no one specific competitor that will stimulate leadership. All competitors stimulate. Stagnation in innovation would, in particular, stimulate Far East and Asian competition.
The race for leadership will be predominately driven by the capability of the individual companies
to adapt to future challenges.

Bodo Arlt: Thank you for your time shared with my readers.

www.IXYS.com

Spring contacts - reliable alternative to critical solder contacts

Power Module for Powerful Applications

More and more new electronic circuits and chip technologies are now being used in solar inverters to increase the efficiency rate of inverters and, consequently, overall system efficiency. The consequence for power electronic modules: they have to be efficient, flexible and environmentally compatible at the same time.

By Daniel Seng, Product Manager, SEMIKRON Elektronik

Figure 1 To help boost the efficiency of solar inverters, MiniSKiiP power electronics modules boast a very low thermal impedance.

The photovoltaic sector is currently experiencing an uninterrupted period of growth. In 2006, sales of solar thermal installations in Europe went up by more than 35%, taking the total solar thermal capacity to around 1,900 Megawatt (MW). According to the German Solar Thermal Industry Association (BSW-Solar e.V.), the German solar thermal market and the total turnover generated by the sale of solar thermal installations saw a 58% increase on the previous year's figures last year, totalling 2 billion euro.

To help ensure that solar thermal inverters are highly efficient, MiniSKiiP power modules have a very low thermal impedance. This helps improve power dissipation and ultimately means that the power circuitry is utilised more effectively. A solar inverter featuring MiniSKiiP came out top in tests carried out by Germany's consumer watchdog Stiftung Warentest and achieves an efficiency rate of up to 95.6 % - and still uses standard silicon IGBT and diode chips.

The MiniSKiiP module boasts a high degree of integration on a minimum of space. A complete Converter Inverter Brake circuit configuration (CIB) with a chip rating of 100A and blocking voltage of 1200V is integrated into a compact MiniSKiiP 3 case (59 mm x 82 mm) (Figure 2). MiniSKiiP modules also feature an unusually flexible interface. The power and auxiliary terminals can be positioned nearly anywhere on the surface of the module. This flexibility is also possible inside the module, due to the many different circuits in the same case.

Efficiency and environmental compatibility are not only important once the inverter is in operation. These factors are vital even in the assembly stage. With MiniSKiiP modules, the power switches, PCB and heat sink are

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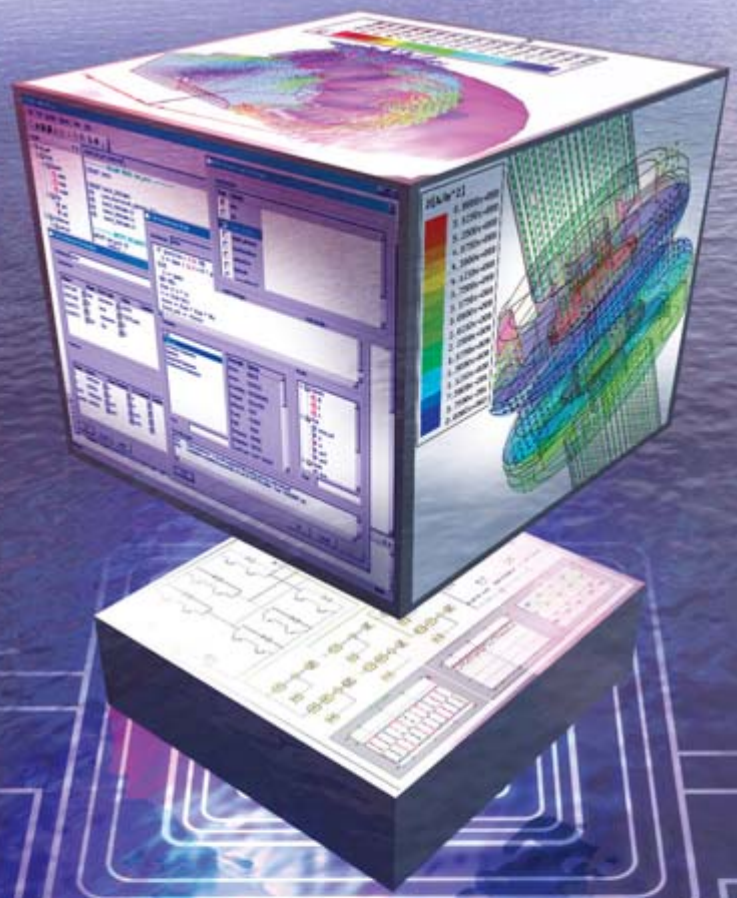

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connected in one step. The power circuitry is not soldered onto the PCB, as in other modules, but is connected using SEMIKRON's patent-protected pressure-contact technology, which is based on spring connections between the driver board and the power module instead of rigid solder connections. As a result, demanding and time-consuming soldering processes can be done away with in the production of the inverter. Thermally or mechanically induced stress that can occur when the inverter is in operation is reduced thanks to the moving contacts, guaranteeing long-lasting and safe electrical connection. This can also be seen in long-term applications where the module has been used in decentralised drives, mounted directly onto the motor. Today, more than 300 million of these springs are in use and have proven their reliability – in full compliance with the RoHS directive, of course.

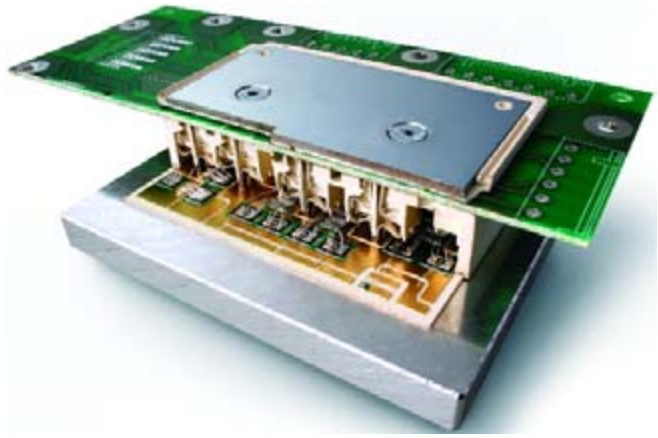

Figure 2 Cross section of a mounted MiniSkiiP module with spring contact technology.

Nowadays, other companies are also trying their hand at using solder-free connection technology for modules in this power class. In press-fit technology, for example, the load connectors are fitted into existing holes on the PCB, meaning that soldering is avoided entirely here. One shortcoming of this technology is the fact that soldering or bonding is still needed to connect the terminals to the DCB. With the spring contact technology used in MiniSKiiP, by way of contrast, this would not be necessary. (Figure 3). And the less soldering needed in the production of power modules, the less the impact on the environment.

Cost-efficient design-in:	**solder pin**	**spring contact**	
Utilisation of PCB area	0	+	routing without through holes
Assembly time / costs	0	+	easy solder-free mounting
Connection of power module	0	+	easy alignment, high tolerance
Long-term reliability of the contacts:			
Temp. cycling	0	+	free of cold joints
Shock + vibration	0	+	no solder fatigue

Figure 3 Solder pin versus spring contact.

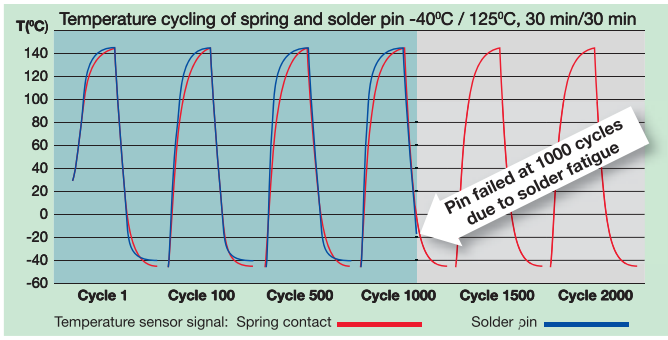

Figure 4 Temperature cycling of spring contact and solder pin.

To further simplify the customers' processes, we now offer our customers the option of ordering MiniSKiiP modules with a pre-printed thermal paste layer (Figure 5). The thermal paste layer is applied in a highly automated printing process. The customer can then do away with this sensitive and time-consuming step in his final assembly process – a clear time and cost advantage. In addition, the thermal paste layer is spread optimally and has the ideal thickness, resulting in better thermal performance and increasing the lifetime and durability of the power electronic module.

The fact that the customer can choose between two different covers for the MiniSKiiP module also offers the customer greater flexibility in terms on PCB layout. Depending on the final application requirements, a flat cover is available for very compact designs or a cover with space for individual SMD components on its underside. As MiniSKiiP modules featuring spring contacts require no through contacts on the PCB, SMD components can be easily placed onto the PCB. This allows for ultra low inductive PCB designs, which can

Figure 5 MiniSKiiP module with thermal paste layer.

Topology	I_{Cnom}
CIB	4A - 100A @1200V
	6A - 100A @600V
AC	4A - 150A @1200V
	6A - 150A @600V

Table 1 Power rating and topologies of the MiniSKiiP power module.

boost the overall efficiency of the complete converter.

MiniSKiiP modules are designed for 600V and 1200V chip off-state voltages and predominantly feature Trench IGBT technology in combination with SEMIKRON CAL diode.

In the 1200V range, the latest Trench IGBT4 technology is used in combination with the CAL I 4 diode. These chips may be used for a junction temperature of up to 175°C.

Due to this chip combination and the 25°C increase in junction temperature, better inverter performance is possible than in previous technologies with the same chip rating. Power dissipation is also reduced by around 20% in comparison to the predecessor generation, making the complete inverter much more effective overall.

In addition to the CIB configuration, standard modules are also available in standard inverter topology, non-controlled rectifiers with brake chopper, as well as half-controlled rectifiers with brake chopper.

For solar inverters, purpose-designed modules in two-phase semiconductor topology with 600V and 1200V IGBT's are available. With many different possible spring arrangements, an extremely flexible layout is possible. This means that the chips can be optimally arranged in the module and inverter efficiency consequently further increased owing to very low-loss switching. These modules can also be equipped with SiC diodes instead of CAL diodes. This can once again boost the overall efficiency of the complete solar inverter. In short, with the right combination of innovative circuit topology and innovative case you have the optimum module for solar applications, designed to minimize power losses.

With the dimensioning and simulation tool SEMISEL from SEMIKRON one can select, configure and dimension modules. SEMISEL can be found at http://semisel.semikron.com/start.asp and offers an extensive online help function, should help be required. This free tool is the fast and reliable way of selecting the right power circuitry for a wide range of applications. The customer can enter a specific heat sink characteristic, for example, and will be given realistic temperatures for the complete power electronic system. Different customer-specific load conditions can also be entered and the resulting losses and temperatures viewed.

www.semikron.com

Spring contacts, reliable alternative to solder contacts

The success of the power module MiniSKiiP lies in the solder-free connection of the power and auxiliary terminals to the PCB and DCB. Electrical contact is established through mechanical springs which allows for an extremely easy module assembly or disassembly on the customer´s side. With the spring contacts a longer lifetime is guaranteed especially under thermal and mechanical stress. Today, more than 300 million spring contacts are reliably in use today.

Long-Term Stability of Aluminum Electrolytic Capacitors

This is of particular benefit for automotive customers

Aluminum electrolytic capacitors are used in a variety of automotive applications. These include engine management systems for fuel injection as well as control systems for fan and windshield-wiper motors, electronic steering systems, airbags and multimedia equipment.

By Christian Baur, Product Marketing Aluminum Electrolytic Capacitors and Norbert Will, Development of Aluminum Electrolytic Capacitors

Storage affects leakage current behavior

A key parameter of aluminum electrolytic capacitors is the behavior of their leakage current when they are operated immediately after storage. The leakage current is the current flowing through the capacitor on DC voltage: it remains relatively high shortly after a DC voltage is first applied to it and then drops after several days to a low current, which is known as operating leakage current. As a rule, leakage current behavior is determined by the leakage current that continues to flow through the capacitor after the DC voltage has been applied for five minutes.

The dielectric of an aluminum electrolytic capacitor consists of the aluminum oxide formed electrochemically on an etched aluminum foil. The quality of the oxide, which changes during the manufacture and subsequent use of the capacitor, determines the insulating properties of the dielectric. The DC conductivity of the oxide increases as a result of processing the oxide-coated anode foil during capacitor assembly and the conductivity is again lowered in the final forming process. When it is subsequently stored at zero voltage, the insulation properties of the dielectric are impaired. In order to minimize this perturbing conductivity, it is eventually necessary to repeat the forming process under voltage in order to repair and build up the oxide layer again. If the oxide has degenerated more pronouncedly, a high-forming current flows during the reforming process, thus increasing the forming requirement (Figure 1).

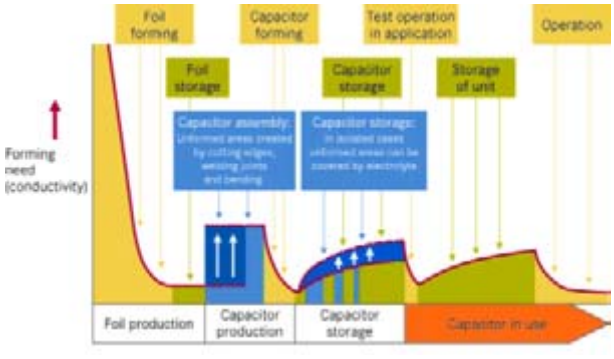

Figure 1: Leakage current of aluminum electrolytic capacitors

Storage of aluminum electrolytic capacitors

Two different phenomena can have a negative impact on the internal insulation of an aluminum electrolytic capacitor during storage: oxide degeneration and post-impregnation effects. When a voltage is subsequently reapplied, the regeneration leakage current may initially rise again.

a) Oxide degeneration

Depending on the electrolyte class and temperature, ionic parts of the electrolyte can diffuse into the dielectric or oxide and alter the oxide crystal structure. Electrical defects and ionic charge carriers are then produced in the oxide.

Although glycol-based electrolytes have the drawback of producing higher leakage currents, they offer the advantage of repairing defects in the oxide very effectively when current is flowing. This makes them especially well suited for high-voltage aluminum electrolytic capacitors.

In the low-voltage range, in which oxides are more homogeneous, electrolytes based on gamma butyrolactone solvents are sufficient to produce a reliable and voltage-resistant dielectric. In this case, it is advantageous when these electrolytes are almost completely unable to penetrate the oxide or break bonds, thus ensuring a well-insulating oxide even after potential-free storage lasting decades. If these electrolytes nevertheless sporadically and temporarily lead to high leakage currents after such storage, this is due to post-impregnation effects.

b) Post-impregnation effects

The oxide can be electrochemically formed in the component only where it is also coated with electrolyte and is connected electrically to the cathode foil via the electrolyte, thus allowing the required forming current to flow in these regions. In a new capacitor, this is the case on more than 99.9 percent of the oxide area to be formed.

In the radial capacitor shown in Figure 2, the positive feedthrough also known as a paddle tab, was formed only in the winding element area. No oxide was able to form in the vicinity of the rubber plug

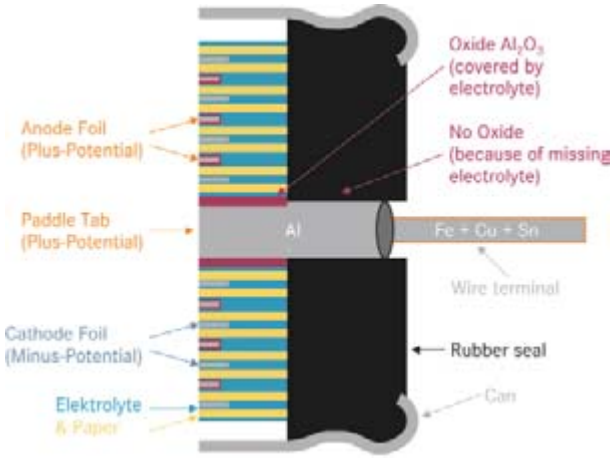

Figure 2: Partial Forming in the terminal area

where the electrolyte has not penetrated. This is not a disadvantage for the insulation because no leakage current can flow in the absence of electrolyte. However, if some electrolyte subsequently penetrates this region, a supplemental forming process must be conducted to create an isolating oxide the next time a voltage is applied (Figure 3). This means that increased leakage current flows until the anodic aluminum surface newly wetted with electrolyte has been formed.

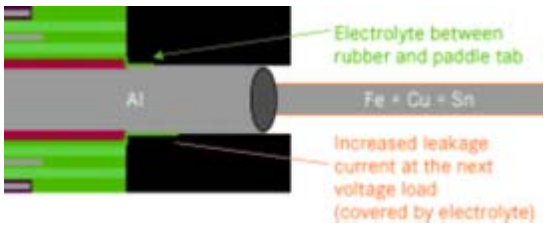

Figure 3: Reforming in the terminal area

In low-voltage aluminum electrolytic capacitors with solvent electrolytes, all areas can be expected to be wetted and as a result show a very low leakage current in the long term, i.e., after the storage and transport periods and before their first operation in the application. Supplemental reforming effects are caused by subsequent wetting and in principle also apply to high-voltage electrolytes, although they are of minor importance due to the dominant effect of oxide degeneration in high-voltage capacitors. However, test operation under voltage is also of benefit for the long-term leakage current behavior of high voltage capacitors in this electrolyte class, because each forming step makes the isolating properties of the oxide more stable.

In order to also keep the forming condition stable during storage of the equipment, larger temperature fluctuations and prolonged shocks should be avoided. Aluminum electrolytic capacitors with solvent electrolytes of the SIKOREL class can normally be stored over a period of more than 15 years without exceeding the leakage current limit specified for the new component.
In capacitors with polar electrolytes used in high-voltage capacitors made by EPCOS, the chemical interaction between electrolyte and oxide dominates the blocking behavior of the dielectric. The storage temperature for these capacitors should be as low as possible, and certainly below 25°C. This enables reaching storage periods longer than the specified two years. However, even after the permissible storage time has been exceeded, no damage to the capacitor is to be expected; there is merely an increase in the leakage current lasting several minutes.

Irrespective of the electrolyte used, the operating leakage current at equilibrium is very low. The leakage current adapts itself to the equilibrium state (voltage, temperature distribution, insertion geometry, shocks). If the equilibrium changes after long constant operation due to a higher voltage or temperature, charge carriers in the dielectric are reactivated so that a higher leakage current flows again. Under certain circumstances, equilibrium changes that make the electrolyte flow may also wet anode areas that were not effectively wetted under the old equilibrium. These anode areas may also include tiny regions with sporadic weak points that were incompletely formed. Apart from the classical production of the dielectric by formation of a non-conductive oxide, foreign inclusions may produce a defect site that continuously generates a local leakage current. These defects (Figure 4) can apparently be corrected in equilibrium by the formation of a gas bubble. The gas generated by the local leakage current expels the electrolyte at the defect site so that the local current flow also stops.

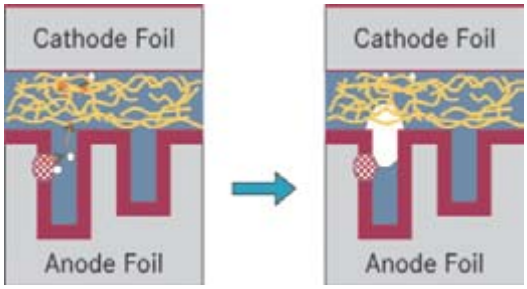

Figure 4: Defect sites lead to gasing

The leakage current certainly also causes the capacitor to age by consuming some of the constituents of the electrolyte for the oxide forming or regeneration. As a rule, however, this mechanism does not determine the rate by which the capacitor ages. It should be noted that high perturbing leakage currents occur only a short time after the voltage has been applied, i.e., they can essentially be neglected during the entire operating period. In practice, a high leakage current leads to premature capacitor death only when the current cannot drop fully due to an excessive voltage or incorrect polarity, which is increased by high temperatures. The rapid gas generation then leads to bursting at the predetermined breaking point.
In applications supplied by a standard or rechargeable battery, as is typically the case in motor vehicles, there is always the concern that the high leakage current of a component could discharge the battery. This hazard is negligible with state-of-the-art electrolytic capacitors from EPCOS. This also applies for self-extinguishing high-voltage electrolytes. Undamaged aluminum electrolytic capacitors can produce high leakage currents only briefly, but never over long periods of time. Under suitable conditions of use, they may be operated over decades.

Long storage periods for aluminum electrolytic capacitors
For the series of aluminum electrolytic capacitors listed below, which are suitable for automotive applications, EPCOS specifies in regard to the leakage current a storage period of up to 15 years at a temperature below 40°C. After the storage period, the expected leakage current is still in the order of magnitude of the original limit.

Radial series: B41853, B41858, B41888, B41866, B41896, B41868
Axial/solder-star series:
B41684/B41784, B41691/B41791, B41692/B41792, B41693/B41793, B41694/B41794, B41695/B41795, B41696/B41796
Snap-in and large-size series: B41505, B41605, B41607
Screw-terminal series: B41550, B41554, B41570

If the capacitors are stored for a prolonged period, the properties of their leakage current may change and lead to errors at the final inspection. Users are recommended to insert the capacitors at an early stage and then store the completed equipment. The capacitors will then not only be optimally formed, but the soldering on the circuit board will be performed while the solder points of the component are still new. The completed equipment should be stored at a low temperature and be exposed to minimum temperature fluctuations.

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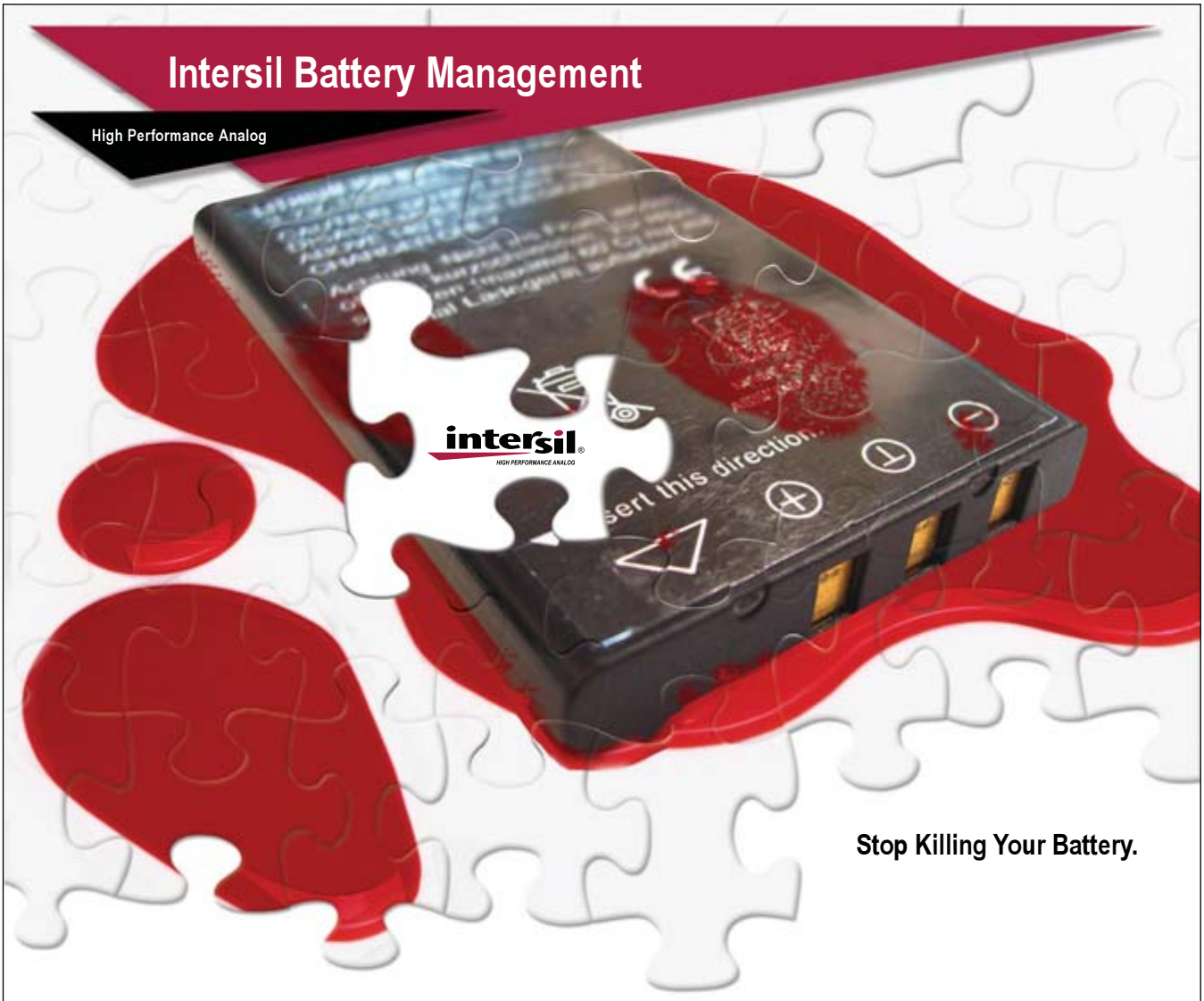

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Single Cell Li+/Polymer Battery Chargers

- ISL6291
- ISL6292
- ISL6292C
- ISL6292D
- ISL6294
- ISL6297
- ISL6298
- ISL6299A
- ISL9203A
- ISL9204
- ISL9214

Charging Safety

- ISL9200
- ISL9209
- ISL9209B
- ISL9209C
- ISL9212
- ISL9212A
- ISL9212B

Authentication

- ISL6296
- ISL9206

Fuel Gauges

- ISL6295

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2-phase Switched Reluctance Motor Drives

SRM is used mainly in vacuum cleaners

There is growing attention about the use of energy-efficient devices to preserve the environment. The concern for energy efficiency is forcing the industry to find new solutions without compromising the application requirements.

By Byoungchul Cho, Sungil Yong, Motion Control System Group, Fairchild Semiconductor, Korea

Switched Reluctance Motors have been considered to be an alternative to AC drives because of their high efficiency, high power per unit volume & weight, high torque-cost ratio, controllability over a wide speed range and good reliability for high speed operation. In the home appliance industry, the SRM is used mainly in vacuum cleaners because it operates at high speeds - tens of thousands of rpm – and requires high torque to generate strong suction. Since the main source of audible noise in vacuum cleaners is its fan, the noise caused by SRM is significantly reduced. Moreover, controversy over the harmful effects of carbon dust generated by the brush in the more widely used universal motor vacuum cleaners is spurring the development of an inverter-type vacuum cleaner. In recent years, single-phase SRMs for vacuum cleaners have been developed to minimize the price of SRM drive circuitry. To meet these needs, Fairchild Semiconductor has already developed a single-phase SRM power module to meet market demand and growing trends in the industry.

The reluctance motor operates on the principle that a magnetically salient rotor is free to move to a position of minimum reluctance to the flow of flux in a magnetic circuit. Therefore, it can operate with any number of phase windings, however for conventional machines there are some guidelines governing the choice of stator and rotor pole numbers. The main factors concerned with the choice of phase number are the required starting performance and the rated output power; the maximum speed. These two factors influence the choice of phase number. Single-phase motors are less attractive when the required rated power is significantly greater than 1kW, because of discontinuous nature of its torque, which leads high peak current of device and the size of the DC link capacitor. Single-phase motors must also be ruled out where difficult loads are concerned, for instance loads which combine direct-drive and high friction. Two phase motors can be started under difficult load conditions and they will generally be cheaper than three phase equivalent, due to the lower component count in the power electronic drive.

Fairchild semiconductor developed two phase SRM module for its prominent merit over single-phase. Unlike to the previous single-phase SRM, this module is SIP (Single-In-line Package), which helps to make compact PCB layout and system. In this paper, the structure, introduction, distinctive features and the convenience provided by this module are shown. In addition, the application considerations are described with typical operating waveforms.

Overview of the SRM Module

Figure 1 is an external view of the power module. Figure 2 is a block diagram of an SRM module. The IGBTs and FRDs have been selected according to their practical application. The IGBTs are designed to optimize the trade-off between conduction and switching losses over the drive conditions. The typical Vce(sat) of IGBT is 2.1V at 25°C, 30A condition. The high-speed built-in HVIC enables the use of a single power supply without a photo coupler. The HVIC drive circuitry is designed to optimize the switching characteristics and to minimize system noise.

The 2-phase SRM module in SIP package provides two main protective functions. One is control supply under-voltage lockout. When V_{BS} or V_{CC} are below its detect level, the internal gating signal is blocked by each drive IC, which prevents abnormal operation. Once the supply voltage rises again over the reset level, the module is operated by the command signals. The other function is short-circuit current protection. A 2-phase SRM module can monitor the inverter leg current by using an external shunt resistor. This current information is inputted to Csc pin and when this voltage is over 0.5V, the internal gating signal is blocked by low-side drive IC and the fault-out signal is generated to send this situation to micro controller.

The SRM power module not only offers space efficiency but also enhances productivity and cost effectiveness in mass production. Four NPT-IGBTs, four FRDs, three drive ICs and discrete bootstrap diodes in the module are used in the main power circuits of 2-phase SRM drive systems employing asymmetric converter topologies. The SRM module has all these components and an additional thermistor. By placing a thermistor inside the module rather than on the heat sink, the actual silicon temperature can be tracked with a smaller time constant and verified with lower margin of error. The typical thermal resistance between IGBT junction and thermistor, Rth(j-th), is 3.2(°C/W). In addition to these features, the discrete bootstrap diodes are used in the module rather than embedded one in the HVIC to enhance the reliability.

The package is designed to guarantee the best heat transfer from the power chips to the outer heat-sink by using IMS package. The IMS substrate uses an aluminum plate at the base. The upper side of the substrate consists of a thermally conductive dielectric layer and a copper cladding on which the cir-

cuit etched. This takes advantage of high thermal conductivity and simple manufacturing. Figure 3 shows the cross sectional structure of 2-phase SRM module. The total thickness of the molding is 5.5mm.

Figure 1.
External view of 2-phase SRM module

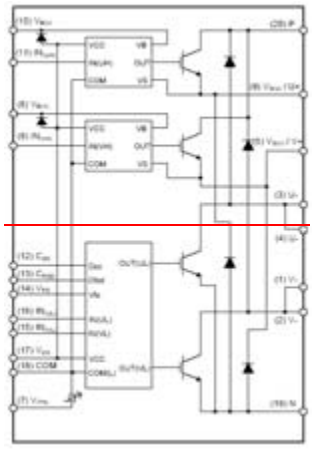

Figure 2. Internal block diagram of 2-phase SRM module

The 2-phase SRM module provides two types of lead forms shown in Figure 4. One is Y-form lead and the other is L-form lead. It takes advantage of the free arrangement of heat-sink as well as PCB design flexibility. For the design of 2-phase SRM module, isolation distances of pin-to-pin and pin-to-heat sink should be considered. As shown in Figure 5(a), clearance and creepage distances of pin-to-heat sink are 3.10mm and 4.08mm respectively. As shown in Figure 5(b), clearance and creepage distances of pin-to-pin are 2.35mm and 4.15mm respectively.

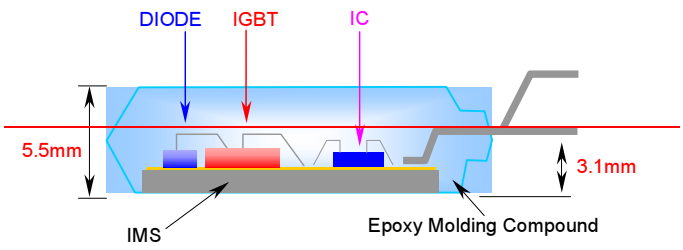

Figure 3. Cross sectional structure

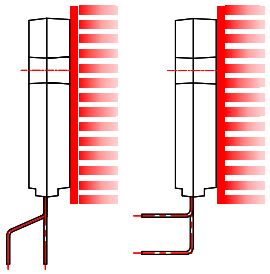

Figure 4.
Lead forms of-2 phase SRM module

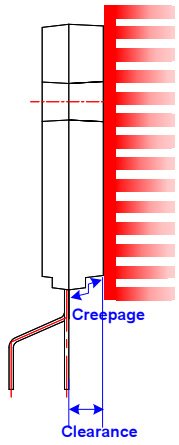

Figure 5a. Isolation distance pin-to-Heatsink

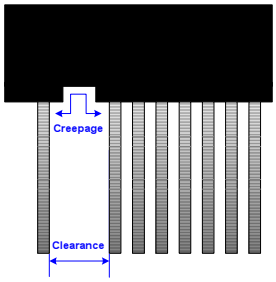

Figure 5 b. Isolation distance pin-to-pin

Electrical Characteristics of the SRM Module

The NPT IGBT and ultra fast recovery diodes used in 2-phase SRM are designed for optimized power rating. Because 2-phase SRM drive for vacuum cleaner has a small switching frequency around 3kHz, conduction loss is more important to make small power loss than switching loss. Figure 6 shows DC&AC characteristics of proposed module. Figure 7 shows the phase current for vacuum cleaner using 2-phase SRM.

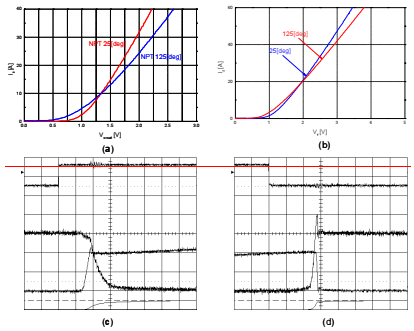

Figure 6. DC & AC characteristics: (a) IGBT V-I curve, (b) FRD V-I curve, (c) Turn-on waveforms at Ic=20A, T=25[deg], (d) Turn-off waveforms at Ic=20A, T=25[deg]

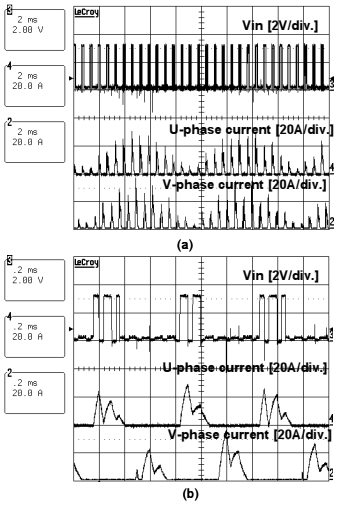

Figure 7. phase current for vacuum cleaner: (a) U & V phase current, (b) extended waveforms

Conclusions

2-phase SRM module for symmetric bridge converter is introduced. In addition to the single-phase SRM module, this will provide the design flexibility, easy assembly and particularly excellent cost-effectiveness. By using optimized NPT IGBT, the total power loss is minimized to be suited in the application, where the conduction loss is dominant compared to the switching loss.

Using Digital Control to Improve Light Load Behaviour

The control loop response can be changed whenever needed

Since the very first Digital Power Forum which took place in 2004, many articles have been written touting the general advantages of using digital control. It was at this time that ROAL Electronics introduced into the marketplace the first digitally controlled DC-DC converter.

By Roberto Cappelloni, Senior Power Supply Designer, ROAL Electronics S.p.A.

Today the majority of the power supplies designed by ROAL incorporate this architecture, and although this practice is now considered common, we are still discovering new advantages of using digital power.

Understanding which is the minimum load of a converter is an important issue for those familiar with power supply design. It is not easy to maintain a stable behaviour at light load, especially when the design requires high output power. Many techniques surfaced in the past years: burst mode, cycle skipping, frequency reduction; but these are not always the best solutions, and it really depends on the final application.

The flexibility of the digital based design platform can help to improve the light load behaviour of the converter. This article will describe the technique implemented in a 3Kw DC-DC converter design to address the light load voltage stability issue.

The diagram in Figure 1 depicts the ROAL base platform for a multiphase digitally controlled telecom DC-DC converter. The input stage covers ANSI and ETSI standards, and includes an EMI filter to meet class A conducted and radiated emissions. An auxiliary converter is taking care of all the bias voltages required for the entire system. The digital part on the left is composed of a low cost 8 bit 10MIBS capability µcontroller and a 16 bit DAC. It is basically receiving information about the input and output voltages, generat-

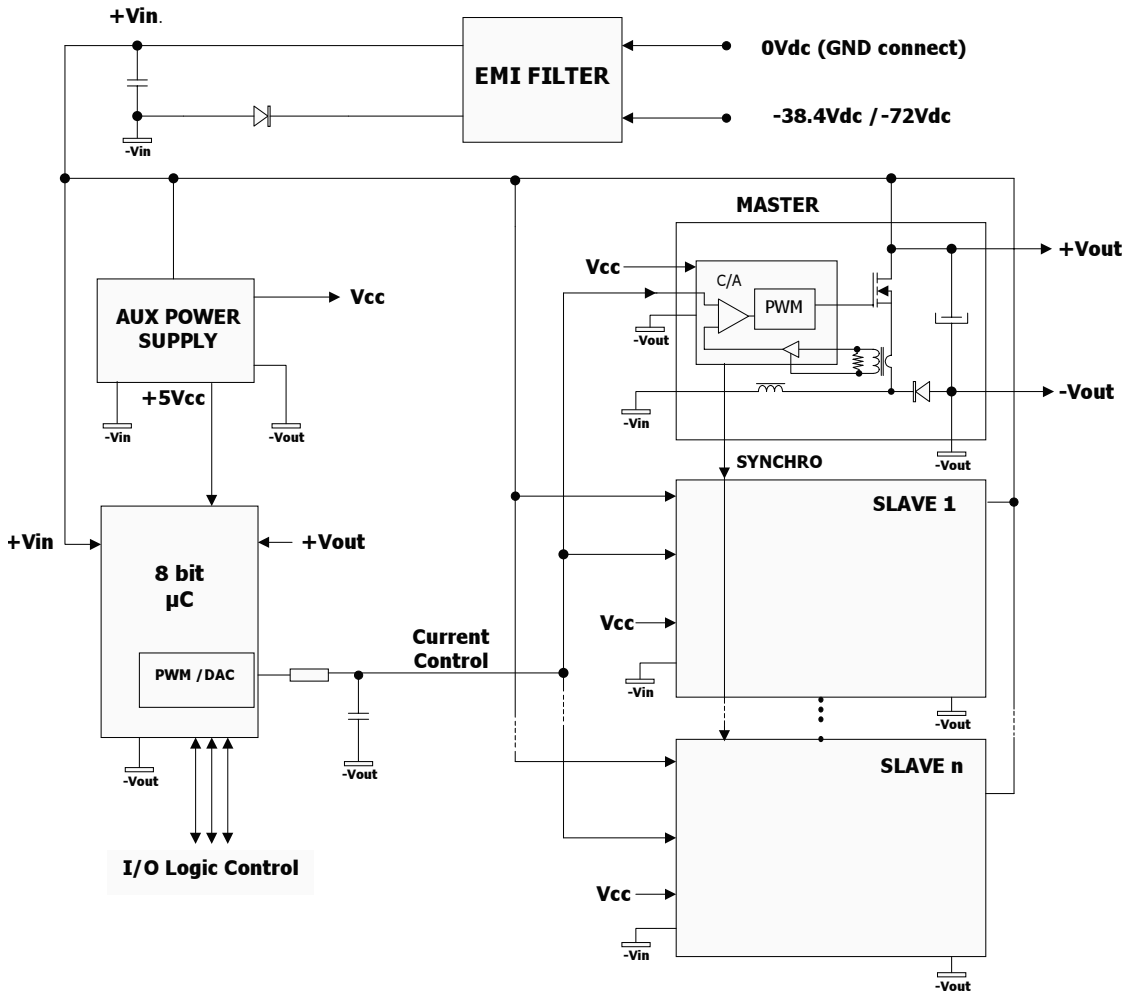

Figure 1: ROAL base platform for a multiphase digitally controlled telecom DC-DC converter.

ing through a DAC, a current control voltage toward the analog part of the scheme. The voltage loop is then managed by the µcontroller.

It also provides the monitoring and alarm functions, including:

- User interface and sequencing features
- Fan rotation detection and speed control
- Input over/under voltage detection
- Output over/under voltage detection
- ANSI/ETSI input range selection
- Temperature monitoring

The analog part on the right is composed of three synchronised phases, and the current control voltage drives it. Every power phase is designed to manage 1Kw and can be paralleled with the proper shift phase to achieve the total power needed. In this case, the three-phase implementation drives us to choose a 120° shift synchronization feature that also allows a reduced input and output ripple current and lower EMI emissions.

The digital and analog sections are separated because the µcontroller is not powerful enough to generate the duty cycle for the power MOSFETs; a standard PWM chip is taking care of the waveform generation. The reason for this fractioning is the extreme flexibility; it is possible to go from 1 to n phases with almost no firmware changes. With the same control voltage the µcontroller can drive n phases, it is just a question of hardware replication!

The specification for this product requires a very stable output voltage, even at no load, but with all three engines working at light load this is difficult to achieve. As a first step we decided to switch off two of the three phases for an output power lower than 100W and this change resulted in a good measure of improvement due to the reduced power per control step, but the design was still critical. An increased loop gain could keep the output stable, but it is not adequate for the entire load variations.

Now we have to think digitally, all the variables are available directly at the µcontroller pins: output voltage, output load, phase activation capability, so the firmware can find the best parameters based on the above information. The best way to improve the no load performance is make the loop compensation a function of the load and number of phases activated. In this way we optimize the control loop for an output power below 10W and, at the same time, we improve the light load efficiency, since there is no reason to waste power. The improved converter now exhibits stable behaviour at every load, even at no load.

It stands to reason then, that different algorithms can be implemented depending upon design specification requirements. For example, the feedback loop can change on each phase of activation. Another requirement of this design is for a no load to full load dynamic step change that forces the implementation of a delay in the firmware to avoid excessive over- and under-shoot variations. The non-linear control loop is also making this load variation possible, even with a modest bandwidth of few kHz.

All of this just goes to show that the control loop response can be changed whenever needed - something that is very difficult with an analog approach.

Before the advent of digital control capabilities in power supply design, hardware engineers were alone on the bench with only their tools, forever tweaking and experimenting with different design approaches to solve the many anomalies associated with the behavioural characteristics of power supplies. Now with the firmware side complete, the intellectual process seems very clear to us - we are four hands instead of two. We work side-by-side with our software engineers, combining our particular skill sets and learning to speak the same language – the language of digital control. Through effective teamwork, hardware and software designers can identify and answer design questions like:

- Can this parameter be a function of the input or output voltage?
- Can we dynamically adjust the output voltage?
- Can we implement the output voltage trimming digitally?

This may sound very trivial, but when faced with challenging requirements and shortened times to market, true digital power management has tremendous value, and produces incredible results.

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Power Converter Developer Kit

A fully self-supportive, high density power converter

The demand for power conversion is ever increasing [1]. Major drivers for this increasing demand include growth of distributed generation systems and uninterruptible power supply (UPS) systems, higher system efficiency requirements, and increased demand for higher levels of power quality and power reliability.

By Perry Schugart, Director, Power Converter Business,
American Superconductor Corporation

In many projects, the development time for the power conversion system is a major factor (critical path) in getting the product to market. The need for rapid development of both power converters and power conversion systems is essential for original equipment manufacturers, value added resellers, system integrators and end-users to get their products to market quickly and stay ahead of their competition.

This article discusses the American Superconductor (AMSC) PowerModule™ PM1000 power converter Developer Kit's (PDK) ability to quickly develop power conversion systems to address a wide range of applications.

The Solution

The PowerModule PM1000 PDK developed by AMSC allows original equipment manufacturers (OEM), value added resellers, system integrators and end-users to quickly develop power conversion systems to address a wide range of applications. Using the PowerModule converter's graphical user interface (GUI) you can quickly modify parameters of the four standard software modules of the PM1000 to meet your specific application needs.

The PM1000 is a fully self-supportive, high density power converter that incorporates a dual DSP controller that can also be used to incorporate a user's control algorithms and eliminate the need for a separate controller. The PM1000 in the PDK comes pre-configured as a 3-phase power converter and can support any of the following power conversion types: AC-DC, DC-DC, or DC-AC. The PM1000 is also loaded with one of four application specific software modules (Active Rectifier, DC-DC, AC Voltage Source, or Motor Control).

The GUI provides the interface on a developer's computer for setting up the PM1000 parameters, passing parameters back to the user interface for display and/or calculations and control of the system by the operator. The GUI provides the ability to quickly integrate and diagnose a PM1000 power conversion system.

AMSC developed the PM1000 as a modular design, Power Electronic Building Block (PEBB) [2], that can be quickly configured to meet different application needs from both the hardware and software viewpoints.

This combines the advantages of a proven power converter platform with the ability to rapidly develop a custom configuration.

Easy Development

The programming environment for the PDK utilizes a fiber optic link to communicate between the PM1000 and GUI (on the developer's computer). A hardware interface, the PowerModule converter Asynchronous Serial Terminal Adapter (PASTA), is used to convert fiber optic signals to asynchronous serial or CAN, which are the standard communication protocols for the PM1000 converter.

The GUI interface displays all internal parameters and variables in tabular form. Variables may be flagged for continuous update, and parameters may be changed in real time.

Status of the PM1000 converter is displayed at the bottom of the main screen, along with error messages associated with range checking of parameters or communication faults [3].

A separate screen is provided with buttons to start, stop, or clear faults within the PM1000 converter. Other screens are provided to allow parameters to be retrieved from or stored to non-volatile memory; to observe fault history, status and warning messages; and to scan through message logs.

A diagnostic screen is provided which functions like a digital oscilloscope to observe the dynamic behavior of internal variables.

The user can set up a trigger variable and level (up to four variables at the same time), and acquire 128 data points per variable at rates up to once per A/D sample. This allows control loops to be tuned or voltages and currents to be monitored [3].

The diagnostic screen provides output in tabular form and as a file, which may be loaded into Mathcad® or Excel® for analysis or graphing.

Rapidly Create Power Conversion Systems

The PDK allows you to modify the pre-loaded application specific software module to create powerful new applications that solve a host of power conversion challenges. Each of the software modules serves as a baseline for modification. Modifications are made to the parameter database to meet an end user or OEM's specific needs.

For modifications to the core software (regulators) or the system state machine (start/stop sequencing and response to external events), contact AMSC.

The four application specific software modules are designated as:
- Active Rectifier,
- DC-DC,
- AC Voltage Source and
- Motor Control.

Active Rectifier (functions as a current souce) implements most of the common AC line interface requirements and is the building block for rectifiers, VAR generators, voltage stabilization and active power filter applications.

DC-DC implements either one or two quadrant control of power flow between different DC voltage potentials. A phase shifted PWM signal is applied to each phase to minimize the DC current ripple and allow smaller, simpler filters. Either buck or boost operation may be selected.

AC Voltage Source provides a fixed amplitude and frequency, 3-phase, 3 wire voltage output, and can be used to power passive and active loads from a wide variety of energy storage devices or rectified AC power sources.

Motor Control implements a sensorless induction motor control algorithm, which provides field oriented control of induction motors. Encoder feedback may be employed to provide a significant improvement in low speed and dynamic performance [3].

Connect-and-Go
To facilitate an easy to use development platform, the PDK can be quickly configured in our simple connect-and-go three-step process:

1. Load the GUI software onto your computer,
2. Attach the fiber optic cable between your computer and the PM1000, and
3. Attach the system components and power cables.

The PDK is now configured and ready to customize the application-specific software module of the PM1000 to meet the developer's specific needs.

Application Overview
The PDK is configured to one of the four standard operating modes. An overview of each of these modes is provided below.

The PM1000 in the accompanying five figures is connected to the serial-to-fiber adapter (PASTA) and the user-supplied external components (computer, system components and power cables). The power ports are the busbars for input and output power (DC terminals and AC terminals). The power flow can be from DC to AC or in reverse. Other ports provide fiber optic (PASTA), analog and digital (System Hardware Interface - SHI) interfaces between the PM1000 and the external components.

Active Rectifier
In the Active Rectifier application, the PM1000 is a two quadrant (bi-directional power flow) AC to DC converter that converts 3-phase AC voltages to a regulated DC bus voltage. It regulates the DC bus voltage to a setpoint level and acts to maintain that value independent of load changes and power flow direction. It can inject reactive current at the fundamental frequency into the power system to influence the power factor of the converter system.

An AC line filter can be designed to eliminate much of the harmonic content of the AC line currents to help meet harmonic distortion standards, such as IEEE 519. Figure 1 shows a block diagram of a typical Active Rectifier application.

Active Rectifiers are used as frontend converters to AC and DC motor drives.

Other applications have the following requirements:
- Bi-directional current (power) flow is required
- Power quality on the AC line side is a constraint

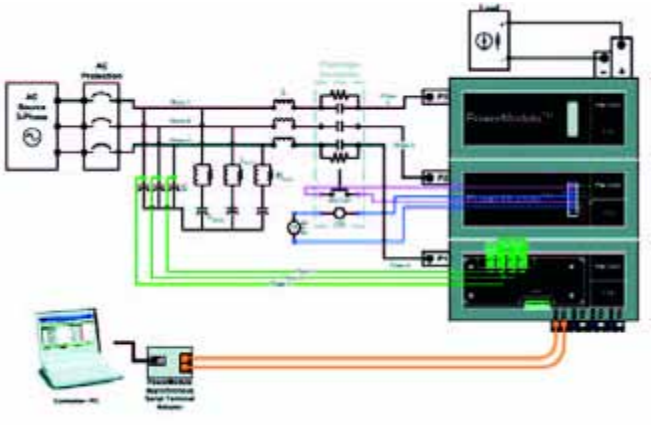


Figure 1: Block diagram of a typical Active Rectifier application.

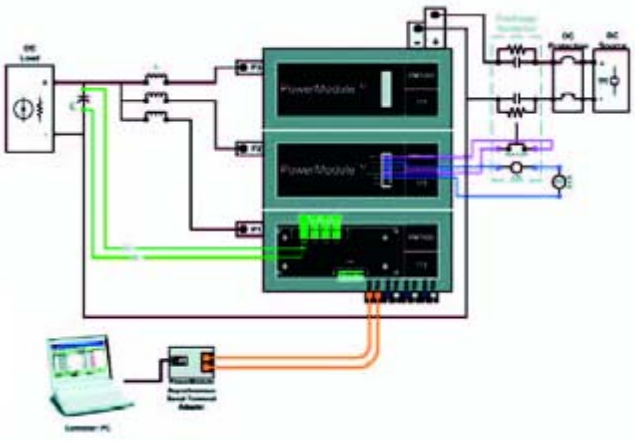


Figure 2a: Block diagram of a typical DC-DC Buck application.

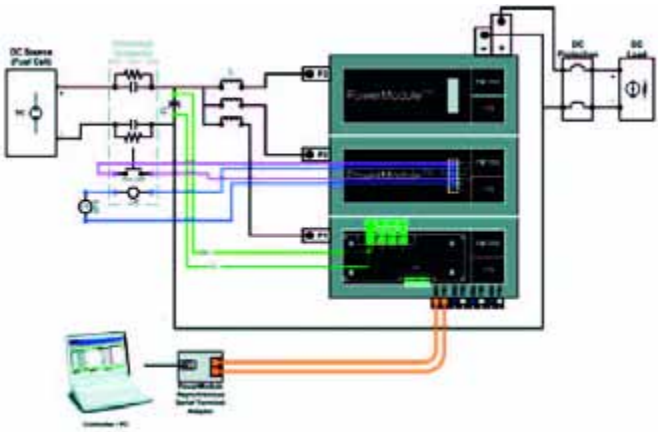


Figure 2b: Block diagram of a typical DC-DC Boost application.

- Unity or near unity power factor operation is required
- Reactive current (VAR) injection into the AC line is required
- DC bus voltage needs to be boosted above the level obtained with a passive rectifier

DC-DC

In the DC-DC application, the PM1000 is a two quadrant, bi-directional current flow buck or boost converter. The converter regulates both the voltage and current at the DC load voltage output.

The DC-DC converter function can be implemented with as little as one pole, but poles can be paralleled to allow for more current capability. Figures 2a and 2b show block diagrams of typical DC-DC applications.

DC-DC converters are used in DC power systems to convert energy from one voltage level to another. A common application is to control DC motors.

Other applications have the following requirements:
- Bi-directional current (power) flow
- Buck mode (load voltage lower than source voltage) to regulate voltage/current at DC load (shown in Figure 2a)
- Boost mode (load voltage higher than source voltage) if the power source is replaced by a battery, ESS or other power source, in which case the voltage at the PM1000's DC bus is regulated (shown in Figure 2b)

AC Voltage Source

In the AC Voltage Source application, the PM1000 is a two quadrant DC to AC converter that converts the DC input power to a 3-phase, 3 wire, AC voltage. It regulates the magnitude, frequency and relative phases of the 3-phase, line to line, AC voltages independent of load changes. An AC output filter is used to reduce the voltage harmonics presented to the load.

Figure 3 shows a block diagram of a typical AC Voltage Source application.

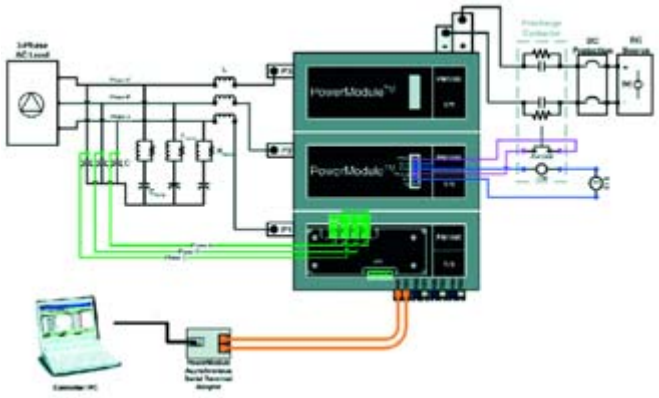


Figure 3: Block diagram of a typical AC Voltage Source application.

AC Voltage Source converters are used to convert energy from DC voltage sources and energy storage devices such as batteries, flywheel generators and ultra capacitors to AC voltages. A common application is an uninterruptible power supply (UPS).

Other applications have the following requirements:
- Stable and balanced AC voltage source
- Bi-directional current (power) flow
- High quality power on the AC load side

Motor Control

In the Motor Control application, the PM1000 is a two quadrant (bi-directional power flow) DC to AC converter (inverter) designed to drive AC induction motors at variable speed. It uses a sensorless, stator flux oriented type of control to produce good transient torque response and speed regulation.

Encoder feedback may be employed to provide a faster dynamic response, more accurate speed regulation and significant improvement in low speed torque.

It can operate the motor at rated torque with nearly rated current at any speed.

Figure 4 shows a block diagram of a typical Motor Control application.

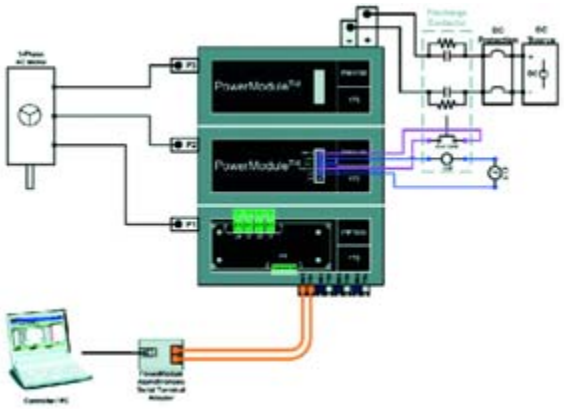


Figure 4: Block diagram of a typical Motor Control application.

Motor drive inverters are used to start and operate induction motors under variable speed applications to drive fans, pumps, conveyors and other loads. These motor drives can be paralleled to allow for higher power applications.

Motor drive inverters meet the following requirements:
- Operating induction motors at variable speed or with controlled torque
- Good dynamic torque and speed performance
- High torque/amp starting conditions

Example Development

The following example illustrates the advantages of using the PowerModule PDK versus a typical in-house development effort.

In Scenario 1, a typical OEM in-house development is undertaken to develop a power conversion system to meet their application requirements.

Here, the OEM will define the system requirements and develop both the required hardware and software for their power conversion system. The OEM´s internal resources (cost center) are used forthe development.

The OEM's development time for their power conversion system is affected by three limiting factors:
- Both hardware and software need to be designed and developed,
- More iteration time is required due to the newly developed hard-

ware and software being utilized and
- The OEM's resources focused on the hardware and software will not have the knowledge, experience and capability of an organization which has it as a core competency.

In Scenario 2, an OEM utilizes the PM1000 (in place of internally developing the power converter) along with the GUI to tailor the PM1000's software to meet their application requirements. Here, the

OEM will define the system requirements and use the PDK for both the hardware and software for their power conversion system.

The OEM's development time for their power conversion system is reduced by three contributing factors:
- Both the hardware (PM1000) and software (application specific software modules and GUI) exist and only minor software modifications are needed. Modifications to the software or control flow can be supported by AMSC,
- Only minimal iteration time is required due to proven hardware and software being utilized (debug time should be reduced due to the fact that the standard software algorithm was already proven modifications being a small portion of the final algorithm),
- and Less time is required for transferring this system into production (the PM1000 is a proven power converter platform is already used in high volume).

In these examples, the typical in-house development (Scenario 1) time for a power conversion system is 14.5 months; while the PDK development (Scenario 2) time for a power conversion system is only 2.75 months. The comparison of a typical in-house development versus using the PDK to develop a power conversion system is depicted in Figure 5.

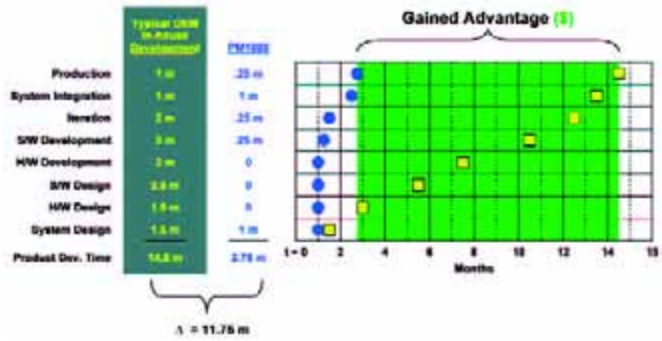


Figure 5: Power conversion system development comparison.

The PDK is provided with the following items:
- 3-Pole, 175 kVA PM1000, air- or liquid-cooled
- Application specific software
  - — Active Rectifier,
  - — DC-DC,
  - — AC Voltage Source or
  - — Motor Control
- Integrated pre-charge control interface (pilot relay & 24VDC supply)
- Graphical User Interface software (GUI)
- Serial-to-fiber adapter — PASTA
- PM1000 User Manual

As a result of using the PDK, the cycle time to develop a power conversion system is reduced by 11.75 months.

The shorter time from using the PDK for development equates to 11.75 months of gained advantage to realize earlier revenue recognition, an additional opportunity/project, or further design refinement of the current project. The ability to quickly fabricate power conversion systems will be a determining factor for the leaders in the marketplace [1].

Summary

The American Superconductor PowerModule™ PM1000 Developer Kit (PDK) provides a platform for OEMs, VARs, system integrators and end-users to quickly develop power conversion systems (from both hardware and software viewpoints) to address a wide range of applications.

Using the PDK can reduce the cycle time associated with developing a power conversion system. This reduction in time provides the potential for earlier revenue realization, taking on an additional opportunity/project, or further design refinement.

References

[1] Perry Schugart, Reduce Time to Market with Rapid Prototyping of High Power Converters, PCIM Europe 2004 Conference, May 25-27, 2004

[2] T. Ericsen et al., Standardized Power Switch System Modules (Power Electronics Building Blocks), Power Systems World '97, Sept. 9-13, 1997

[3] Dave Gritter, Power Converter Development using AMSC's Power Electronic Building Block, PEDAC'04 Conference, March 22-24, 2004

TinySwitch-PK Doubles Peak Power Budget

TinySwitch-PK incorporates a 700 V MOSFET

An important goal of electronics design today is to optimize cost and minimize power consumption. Personal video recorders (PVRs) and other consumer products containing disk drives represent an interesting challenge in this regard.

By Doug Bailey, VP Marketing, Power Integrations

These units run extremely smoothly and at relatively low power when in the steady state. However in start-up their motor draws many times the static consumption in order to spin the platter quickly up to speed. A supply engineered to provide the start-up current will cost more and be larger and in itself consume more power than that required the majority of the time. Power Integrations Inc. (PI) have developed a device that provides the solution to the peaky power requirements of PVRs and other applications with seldom-used motors

Other examples of consumer equipment with intermittent high peak loads are the drawer opening motor in a DVD player, active loudspeakers (e.g. MP3 docking stations) and photo and thermal printers. For these applications PI has introduced the TinySwitch-PK off-line switcher family. As an example the TNY375P in a low cost DIP-8 package provides a continuous output power of 6W with 12.5W peak and by clever manipulation of switching frequency the peak power can be delivered through a transformer with a core size designed for just 6W. The largest component in the family (TNY380P) can supply peak power of 35W.

TinySwitch-PK is an off-line switcher that uses an on/off control method perfected by PI (See Figure 1)1.

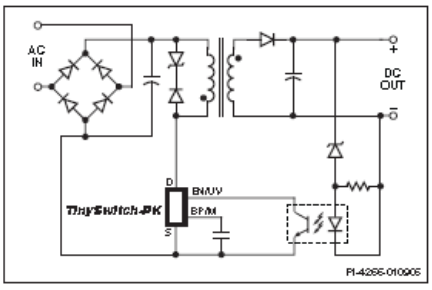


Figure 1. Typical peak power application

TinySwitch-PK incorporates a 700 V MOSFET, oscillator, ON/OFF controller, current limit (user selectable), and thermal shutdown circuitry. When enabled, the oscillator turns the power MOSFET on at the beginning of each cycle. The MOSFET is turned off when the current ramps up to the current limit. Since the highest current limit level and frequency of a TinySwitch-PK design are constant, the power delivered to the load is proportional to the primary inductance of the transformer and peak primary current squared.

The internal clock of the TinySwitch-PK runs at all times. At the beginning of each clock cycle, it samples the EN/UV pin to decide whether or not to implement a switch cycle, and based on the sequence of samples over multiple cycles, it determines the appropriate current limit. At high loads, the state machine sets the current limit to its highest value. With TinySwitch-PK, when the state machine sets the current limit to its highest value, the oscillator frequency is also doubled, providing the unique peak mode operation. At lighter loads, the state machine sets the current limit to reduced values. At these lower current limit levels, the oscillator frequency returns to the standard value.

Thus by adjusting the oscillator frequency and current limit the TinySwitch-PK is able to generate up to 280 percent of the design power level for a given number of transformer primary winding turns and bobbin size.

A key issue in power supply design is safety and reliability. The TinySwitch family has been developed to be used by general analog designers who are not necessarily power supply experts. It requires few external components and a power supply can be implemented on a single sided printed circuit board. However the peak power feature

does mean that the system designer needs to think about the total energy budget in a peak power situation. At peak current level heat will rapidly build up not only in the TinySwitch device but also in the transformer and other components. TinySwitch incorporates thermal shutdown with hysteresis. The shutdown threshold is typically set at 142°C at which the device will safely switch off. When the die temperature has fallen by 75°C switching will automatically re-start. Hysteresis is incorporated to prevent a build up of heat beneath the device and subsequent burning of the printed circuit board. For safe operation of other components in the power supply the designer must consider the frequency and duration of peak power occurrences to ensure that excessive heat build up does not occur. Appropriate sizing of components, ventilation and heat sinking should be considered.

Figure 2 illustrates the complete circuit diagram for a multiple output power supply such as would be used in a DVD player.

The choice of key components for this AC-DC flyback power supply may be quickly made by reference to guidelines in AN-42 published by PI2. The application note takes the designer through the process of component selection and transformer design via the use of the PI XIs design spreadsheet, part of the PI ExpertTM design software suite, freely available from PI.

The nightmare for a power supply designer is that he completes an efficient cost effective design and then the load requirement or system thermal budget changes. Flexibility for such changes is built in to the TinySwitch-PK family with the current limit being determined by the value of a capacitor connected to the BP pin (C4 in fig 2). A ceramic capacitor as small as 0.1µF may be used for decoupling the internal power supply of the device, but a larger capacitor size can be used to adjust the current limit. A 1µF BP/M pin capacitor will select a lower current limit equal to the standard current limit of the next smaller TinySwitch-PK device, and a 10µF BP/M pin capacitor will select a higher current limit equal to the standard current limit of the next larger device. By selection of the appropriate capacitor value the designer can set the current limit appropriate for the application but also has the flexibility to change to a different device in the TinySwitch-PK family without re-designing the transformer, output stage, layout or affecting the circuit EMI.

Further application examples and design guidelines for cost effective power supply designs are available from PI. DI-115 covers the design of a flyback power supply for DVD players and DI-145 illustrates a 10W continuous (15W peak) power supply for portable game player applications.

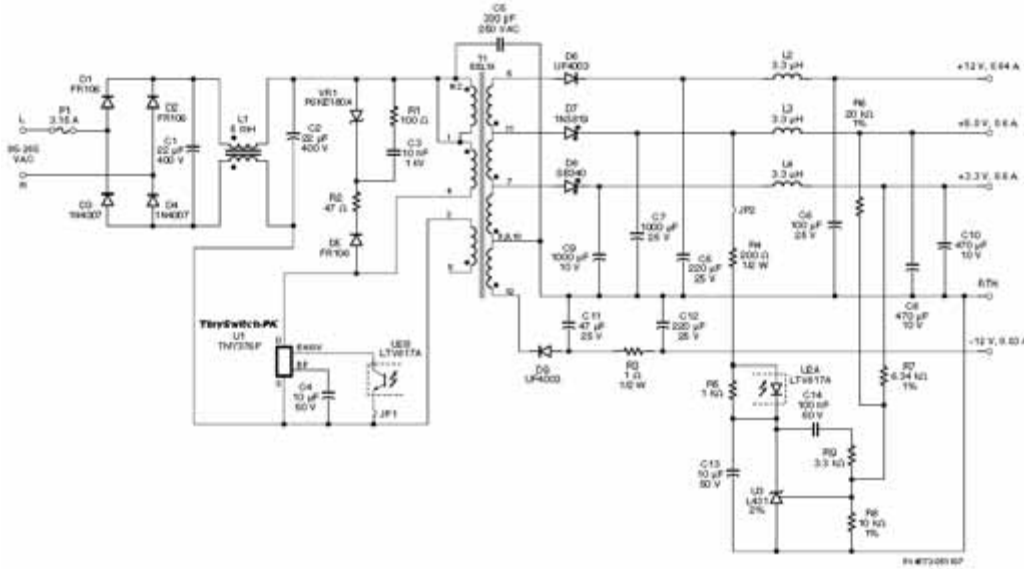


Figure 2. Four output 7.5W (13W peak) power supply

TinySwitch-PK enables an analog designer to quickly produce a switching power supply optimized for cost and efficiency that will outperform bought-in systems, together with the flexibility to accommodate late design changes.

References:
TNY375-380 TinySwitch-PK Family, Power Integrations Inc.
Application note AN-42. TinySwitch-PK Family. Power Integrations Inc.

www.powerint.com

Process Flow Optimization

Absolute Encoders in Valve Control

In process flow control, there are many factors affecting variability but the greatest contributor is the control valve's performance. Issues associated with control valves, such as dead band, actuator/positioner's design, response time, valve type and sizing, all have huge impacts on process flow. Extensive studies on control loops have indicated as high as 80% of all control loops did not perform adequately in reducing process variability, apparently due to various issues with the control valve.

By: Chew, Chim Lai, Yeoh Theng Hooi, Chua Seng Yee, Avago Technologies Malaysia

In order to implement tighter control loops, the key is to focus on improving performances of these control valves' components. This paper will focus on the methods used to improve accuracy and resolution of control valves.

Consumer requirements in today's world dictates the need for manufacturers to rigorously improve product features while lowering price, to keep pace with the competition. This leads to improved efficiency by minimizing process variability. Industries such as paper fabrication, bottlers, and even hydroelectric power plants require very precise process flow control to maintain high levels of efficiency in their operations. To achieve this, the process flow control systems must be capable of instantaneous and precise responses, via control valves.

The application of Avago's AEAS-7000 encoder enhances valve precision by increasing the step size resolution. AEAS-7000 offers 16-bits single turn resolution with an additional 14-bits for multi turn (total of 30-bits). In other words, within one full turn of the stem (360°), there are 16-bits or 65,536 steps. This translates into the resolution of each step size to be 0.005°.

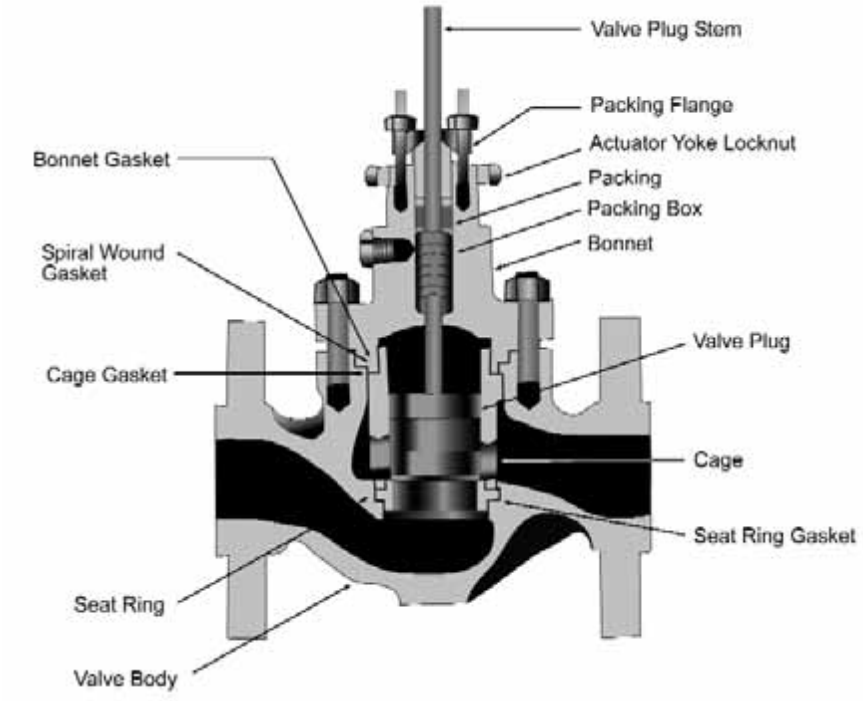


Figure 1. Cross section view of a sliding stem control valve

Combined with high sensitivity flow rate sensors, fine resolution motors and fast controllers, the performance of the total system solution is phenomenal.

Conventional Control Valve Mechanism

There are various types of valves currently available, such as gate, globe, pinch, diaphragm, needle, plug, ball and butterfly valves. Gate, plug and ball valves are used primarily for turning on and off liquid or gas flows, although in certain applications, these valves may be used for throttling.

Most single seated valves use cage or retainer style construction. These valves can be easily modified to provide reduced capacity flow, noise attenuation or for elimination of cavitations.

The design of the control valve needs to satisfy a series of conditions such as limiting flow rate, allowable sizing pressure drop, effects of fittings, etc. This topic will focus purely on the effect of control valves on flow rate and pressure drop (See Figure 1).

The valve coefficient C_v , is determined by flow rate, q, and allowable sizing pressure drop, $P_1 - P_2$, as shown below:

$$C_v = \frac{q}{N_1 F_p \sqrt{\frac{P_1 - P_2}{G_f}}}$$

where N_1 is a constant, F_P is the piping geometry factor and G_f is liquid specific gravity.

In a flow control system, flow rate sensors detect variations in flow rate; typically fluctuations of less than 1% or 2%. If the fluctuations are due to changes in the settings,

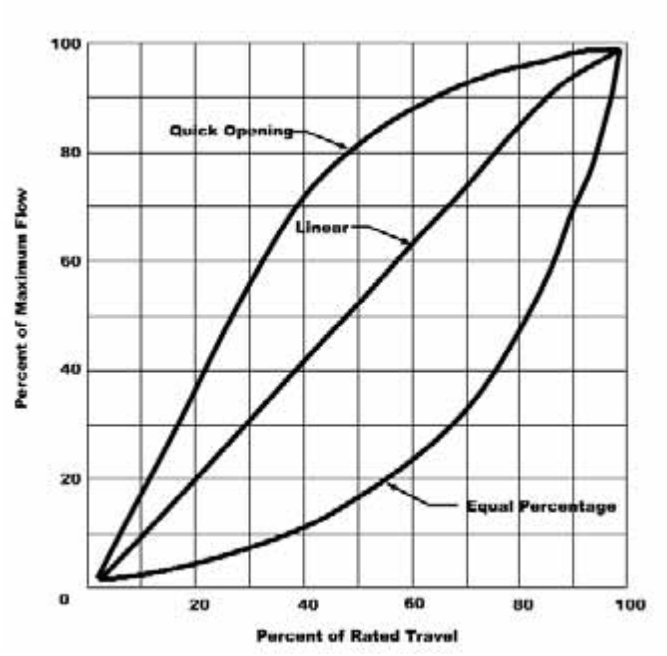


Figure 2. Inherent flow characteristics curve

then these rates of change can be monitored and controlled to follow either linear, equal percentage or quick opening (assuming usage of cages for globe style valve bodies)(Figure 2).

If the fluctuations were not due to an intentional process flow change, then the system needs to regain equilibrium by compensating for the undesired deviation. The ability to fine tune and maintain equilibrium is very dependent on detection of small perturbations and having fast system response. Correction of flow dynamics is implemented via a closed loop system involving a flow sensor, microcontroller or microprocessors and control valves.

Enhancement of control valve solution with Avago optical encoder

Avago enhances control valves by promoting faster valve response time and smaller step size resolution.

For butterfly valves, the positions of fully open or closed involve a complete movement of 90°. Throttling is controlled by pneumatic actuators. The precise flow control is very much dependent on detection of the flow rate and how accurately the system can move the pneumatic actuators.

With 16-bits accuracy lending each step size 0.005° resolution, slight fluctuations or perturbation in flow can be easily compensated by a slight rotation of the actuator. Figure 3 depicts a simple butterfly valve mounted with Avago's AEAS-7000 encoder.

For example, assume use of a highly sensitive flow rate sensor or pressure sensor. A small fluctuation of 0.1% was detected by the sensor. If the system was designed to respond and correct for 0.1% fluctuation, then the change in flow, based on the valve equation for Q, would be:

$$Q = N.\ \pi r^2 \sqrt{\frac{2g.(P1 - P2)}{\rho}}$$

thus,

$$\frac{\delta Q}{Q} = \frac{\delta P}{2P}$$

The system will require a change of 0.05% in flow rate. This translates to a change of cross sectional area of the valve by:

$$\delta A \quad \pi r^2 (1 - \sin\theta)$$

with a minimum angular resolution of 0.005° (Note: θ = 0° for fully closed and θ = 90° for fully open).

Avago's absolute encoder is capable of providing 16-bits resolution (0.005°), which exceeds expectation and minimum requirement.

For sliding stem valves and gate valves, the movement involves multiple rotations. Each rotation brings the wedge closer to the seat, finally sealing the opening. Gate valves are typically not used for throttling due to high erosion of the gate. For certain applications, where the design of the gate valve's allow such controlled action, the usage of Avago's AEAT-86AD enhances the control of these gates.

Figure 5 shows how Avago absolute encoders can work in tandem with these valves, by monitoring multiple rotational movements (14-bits) as well as controlling precise rotational position within each single turn (16-bits).

Advantages of AEAS-7000 and AEAT-86AD encoder for control valves

- Accurate movement of 0.005° step size within each rotation
- Capable of tracking multiple turns (16,384 turns)
- Provides additional information such as speed and direction for precise control
- Small module size
- Consumes minimum amount of power
- High reliability allows AEAS-7000 and AEAT-86AD to be almost maintenance free
- The entire modules of AEAS-7000 and AEAT-86AD do not generate noise or vibration
- AEAS-7000, with optical technology, is a state-of-the-art solution capable of enhancing process flow rate control

Conclusion

Process flow control is vital in industries such as the food industry (bottled drinks, can drinks, breweries, etc.), petroleum, chemical, sewage industries and even hydroelectric power plants. The key factor affecting process flow control is the control valve. The need for the control valves to respond instantaneously and precisely is even more prevalent when companies push for higher throughput and efficiency. Any process variations must be instantly compensated to reduce losses in throughput and efficiency.

With the introduction of high accuracy encoders into control valves, the entire control system can be optimized, which translates into higher productivity and lower yield loss.

References

Figure 1, 2, 3, 5: "Control Valve Handbook", Fisher Controls International reference guide.

"Statistical process control in Continuous Flow Process", John R English and Kenneth E Case.

"Process Dynamics and Control" , Dale E. Seborg, Thomas F. Edgar, and Duncan A. Mellichamp

Figure 3. Diagram displaying mounting of Avago's absolute encoder on a butterfly valve

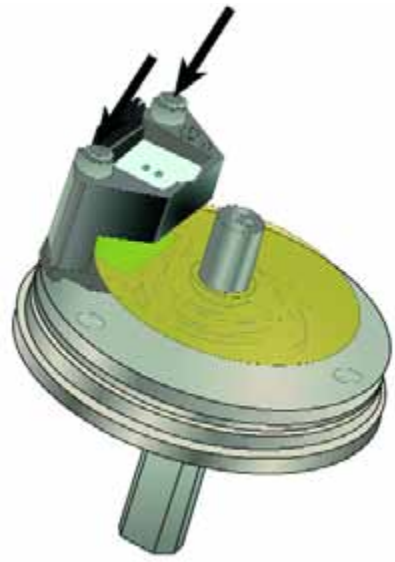


Figure 4. Zoom-in diagram of the mounted absolute encoder with code wheel

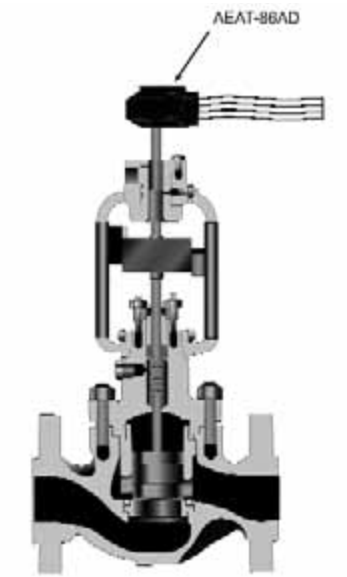
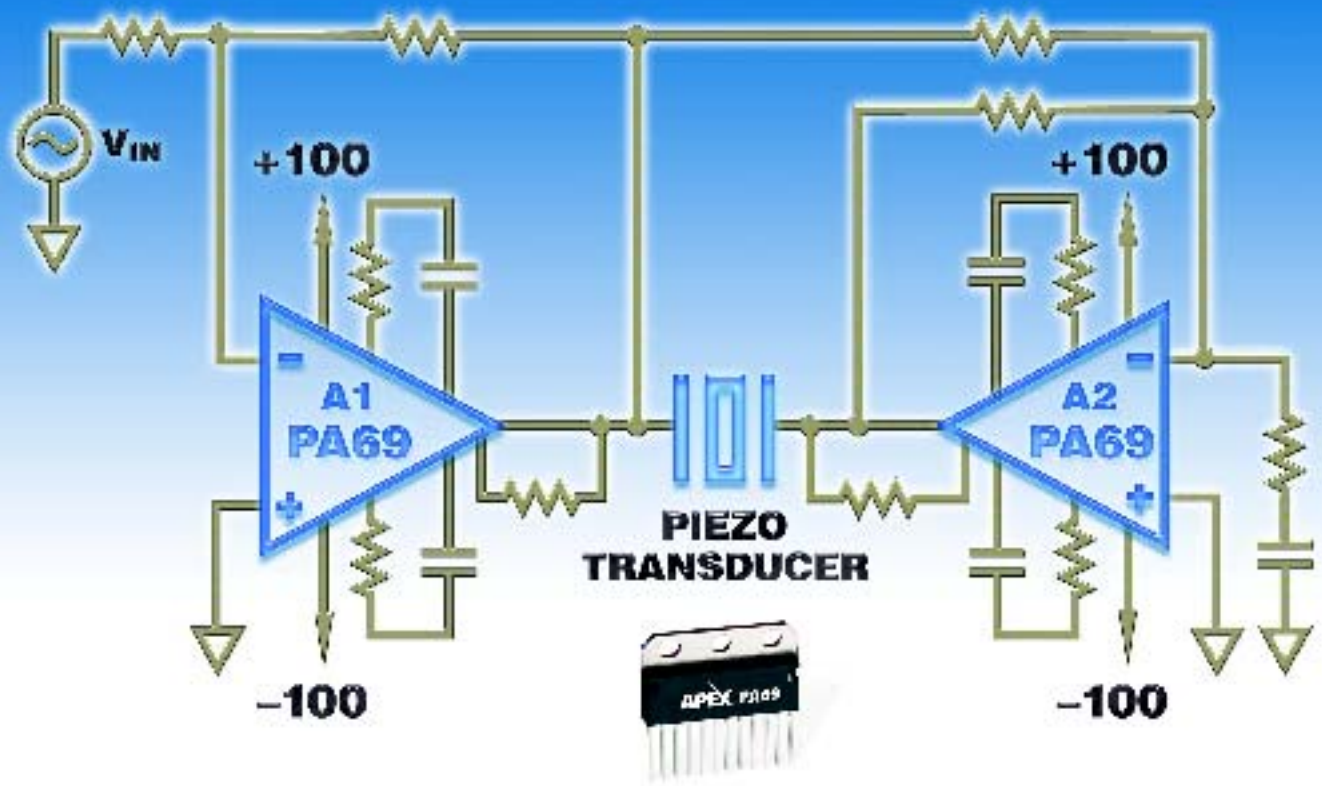


Figure 5. Cross section area of the sliding stem valve with Avago AEAT-86AD mounted on the stem

POWER, PERFORMANCE, VALUE

Precision ICs



Drive Piezos with High Voltage High Speed Low Quiescent Current

Model	Supply Voltage V	Output Current mA	Slew Rate V/µs	Power Bandwidth kHz	Production Volume Pricing 10K pcs USD
PA69	±100	50	200	200	$11.35
PA69A	±100	75	250	200	$13.60
PA86	±100	100	350	300	$10.15
PA86A	±100	150	350	300	$21.65
PA78	±175	150	350	200	$24.05

New series of power amplifier ICs offers performance and price combinations starting at 200V, 200V/µs, 2.5mA and $11.35

The PA78 Series of *Precision ICs* combines new levels of power amplifier performance for speed, voltage supply, quiescent current and price. For applications that demand high voltage drive power that's equally responsive, the PA69, PA86 and PA78 offer you a multitude of performance and per unit cost combinations to choose from.

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TFT liquid crystal screens and optoelectronics change passenger compartments.

So-called Central Information Displays (CID) continue to appear in more and more car dashboards. Although the CIDS are mainly used in luxury cars at the moment, experts estimate an average growth of around thirteen percent per annum in Europe over the next few years.

By Andreas Biß, Product Marketing Optoelectronics, Sharp Microelectronics Europe

This development is not just attributable to the equipment of luxury cars. Medium-sized and compact cars are increasingly being equipped with TFT LCDs for driver information and entertainment. Amongst other factors, this trend is being driven by technological developments that are now enabling installation of LCDs in cars for the first time and thus offering drivers real added value in comparison to traditional display instruments.

LCDs are changing interior design

The basic requirements for car LCDs are an extended temperature range of
-30°C to 80°C and increased vibration resistance, in order to cope with extreme weather and road conditions. Various technologies are used to ensure consistently clear legibility under constantly changing light conditions. Sharp displays don't just fulfil these minimum requirements for the automotive sector – the company has also developed a whole range of technologies to optimise display usage in cars. These include automotive TFT LCDs with a contrast ratio of 3000:1, which can not only be integrated seamlessly into the standard matt black dashboard areas thanks to their optimised black level, but can also ensure clear representation of the entire colour spectrum, even in bright ambient light. So-called 'self-heating backlights' enable a rapid cold start for liquid crystal displays at low winter temperatures and the dual directional and triple directional viewing displays developed by Sharp itself provide entirely new options for individual car infotainment for the driver and passengers.

Photointerrupter for multi-layer menu navigation

The introduction of TFT LCDs in cars has also resulted in new possibilities and requirements for the design of car interior electronics, surface feel and ergonomics. The most obvious change accompanying the introduction of CIDs is the consolidation of various switch functions into one centre control switch. In contrast to mechanical rotary and toggle switches, the multifunctional centre switches must reproduce an incredibly high number of switching states in order to navigate the multi-layer menu guides shown on the CIDs for navigation, audio, telephone, air-conditioning etc. Sharp photointerrupters make it possible to separate the mechanical design of switches from their electrical design, allowing for much greater flexibility in development, as the mechanical characteristics of the switch no longer influences the final haptic design of the operating elements. Tested in accordance with the strict specifications of AEC-Q100, the photointerrupter is used as a micro photoelectric barrier, triggered when the switch process is interrupted. Their very small size, with a side length of only a few millimetres, means that Sharp photointerrupters can be integrated without difficulty in any kind of switch. A typical centre switch has several interrupters, which cover both linear (up-down, left-right, in-out) and rotary movements. The compact dimensions of the interrupter make it possible to resolve the 360° rotation into up to 400 incremental steps, depending on application requirements.

A further advantage of the electro-mechanical disconnection is long life, since the no-contact switching process means no wear. Sharp photointerrupters are therefore a cost-effective, maintenance-free alternative to magnetic switches, for example.

More comfort and less gasoline consumption through IR sensors

Distance measurement sensors (DMS) can also take over the function of switches for car interior electronics. In addition to comparatively low costs, the advantage of these sensors is that, as non-contact switches, they are not subject to mechanical wear and have very compact dimensions. In contrast to traditional IR sensors that calculate distance from the strength of the reflected IR rays, Sharp DMS technology is based on the rules of trigonometry. The sensors measure the distance to an object on the basis of the angle from which the reflected beam reaches the detector. The distance is therefore measured irrespective of the colour of the clothes worn by those inside the car (such as gloves) or the colour of the car interior, resulting in reliable activation of the corresponding applications. This means Sharp DMS are highly flexible for use in cars.

Example non-contact switches: they are particularly useful if you can't see the switch. The interior lighting may, for example, be turned off simply by a wave of the hand close to the switch, without having to fumble for the switch in the dark. Sensors can also be useful for setting the seat position, by activating the Central Information Display at the time when the hand is close to the seat switches, which are often positioned where it is difficult to see them, in order to show which seat adjustment lever the hand is in contact with. It is normally difficult to distinguish between the levers under the seat.

Example automatic air-conditioning control: when integrated into the dashboard or car doors, the DMS can determine which seats are occupied and adapt the cold air requirement and air-conditioning system performance accordingly. Drivers who usually drive alone will then benefit from reduced petrol consumption. Dust sensors are a useful additional devices for automatically controlling car air-conditioning systems. They not only function as sensors to indicate when the next service is due, but also automatically ensure clean air. Sharp

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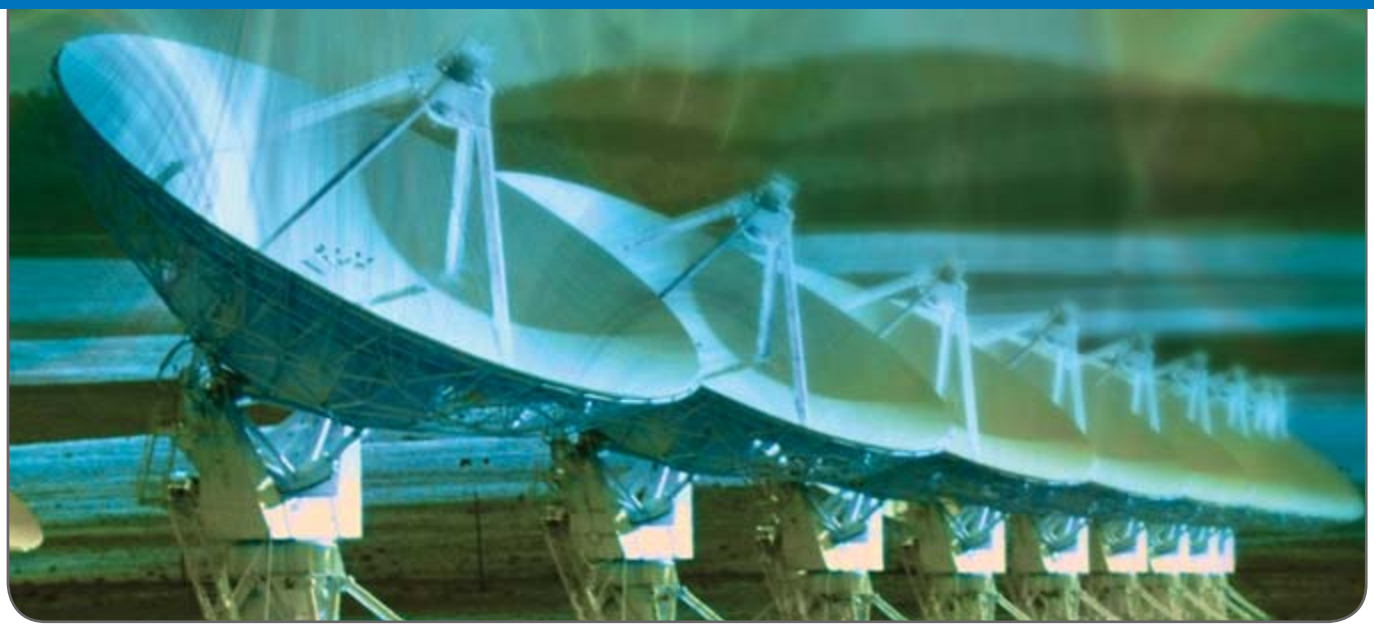

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dust detectors register aerosol particles at a concentration as low as only 0.1 mg / m³. This high sensitivity is achieved through the use of pulsing IR signals with a pulse width of 0.32 ms. Even sporadic dust quantities can be registered reliably as peak values. For example, if you pass a construction site, the dust sensor sends a control signal that temporarily increases the performance of the ventilation and air-conditioning systems. Traditional detectors based on continuous light cannot usually register such sporadic particle clouds, as the actual material quantity is too low.

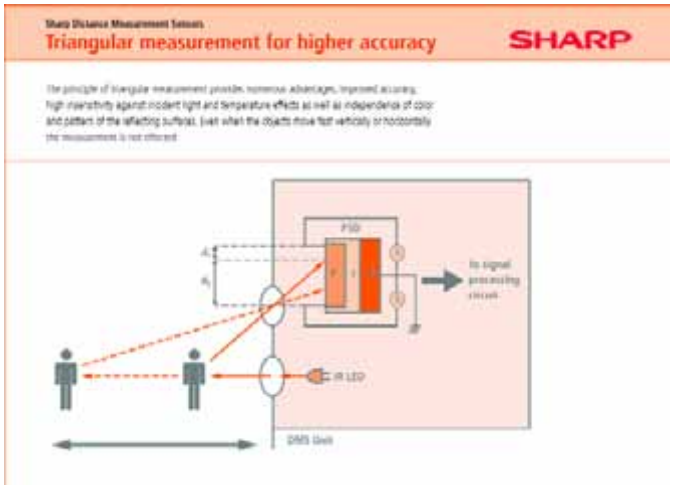

Figure 1: Triangular measurement for higher accuracy

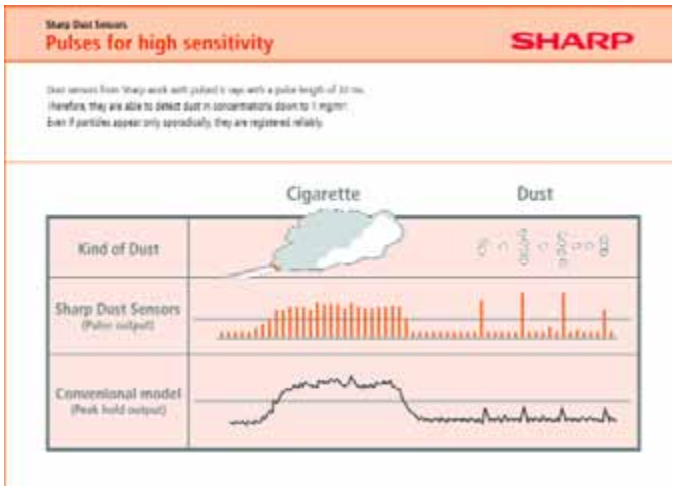

Figure 2: Pulses for high sensitivity

Brightness sensors for automatic control of display backlighting

TFT LCDs in cars not only offer new options, but also bring new requirements with them, such as automatic control of display background lighting. The correct brightness setting for the Central Information Display is heavily dependent on ambient brightness. In bright sunlight, the display needs to shine more brightly to be easily legible, while the display should be dimmed in dark light conditions. The changeover between light and dark ambient conditions sometimes occurs very quickly during driving, often when a vehicle drives into a tunnel or underground car park or because of changing weather conditions, for example. Control of the display brightness must therefore be automatic, on safety grounds at the very least. Without it, for example, the vast difference in brightness between the display and the surroundings during night driving could seriously impair the driver's vision. Distracting reflections in the windscreen are only one consequence. By looking at an overbright display, a driver is dazzled as if by a torch. This will prevent the driver from seeing what is going on outside correctly, increasing the risk of accidents.

Taking the eye as the perfect sensor, Sharp has developed new OPIC brightness sensors that automatically adapt the LCD brightness to the ambient light. These sensors are characterised by the fact that they reproduce the brightness sensitivity of the human eye almost exactly, i.e. they mainly react within the range of visible light at wavelengths of approx. 450 to 650 nm. Integrated temperature compensation also ensures consistent operation of the sensors across the entire relevant temperature range of –40 to + 85ºC for use in automotive applications. In contrast, traditional photodiodes are influenced by a significantly wider wave spectrum and the ambient temperature. They are therefore not suitable for the accurate control of display brightness.

A further crucial factor for automatic control of car LCD backlights is the rapid reaction time of the sensors, as the ambient brightness can change in a fraction of a second, e.g. when entering a tunnel. Sharp sensors require only up to 25 microseconds to adjust to new light conditions. The display background lighting can thus be altered precisely, efficiently and immediately.

The Sharp OPIC ambient light sensors are suitable for controlling the brightness of both CCFL and LED backlit displays. A microcontroller receives the OPIC sensor output signal and controls the relevant driver for the backlight. For brightness control for LED backlights, Sharp also offers LED driver ICs synchronised with the brightness sensors. These ICs work directly with the sensor signals. This means there is no need for a microprocessor to be connected in the middle.

Summary:

Optoelectronic switches offer a wide range of options for implementing complex switches and automatic connections in car interiors. One of the many advantages is the separation of the mechanical and electrical switching process. This gives car interior developers more freedom when it comes to the surface feel of switch design. To a certain extent, sensors can entirely replace classic switches and function as non-contact 'switches'. This makes it possible to automate individual applications such as the control of display brightness and air-conditioning and thereby increase their efficiency. Sensors therefore contribute directly to lowering fuel consumption. Thanks to the separation of the mechanical and electrical switching process, optoelectronic switch elements are not subject to wear, unlike traditional toggle and rotary switches. They are also much cheaper than magnetic switches – a major advantage, particularly for the price-sensitive automotive industry.

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A Discussion of the Active Clamp Topology

Primary switches are switching in a lossless manner

The Active Clamp is a topology being favored for a significant number of power converters. There is a misconception, however, that the main FET turns on in a zero voltage condition. The transition of the clamp FET to the main FET is the subject of this article.

By John Bottrill, Senior Applications Engineer, Texas Instruments

To generate the waveforms presented in this paper, a schematic of the UCC2891 Engineering Verification Model (EVM) was used (see Figure 1). The EVM was tested with 50V on the input, and two different loads on the output. The first was at a load of 0.5 amps. The second was at a load of 6.0 amps. Current loops were put in series with the primary and secondary windings so that the currents through the transformer could be measured. Understanding the effect requires a detailed look at the idealized transformer. This will be used to explain the effects seen in the waveforms.

The magnetizing inductance represents the magnetic flux in the core when a current is present. Increasing the current in a winding by applying a voltage to it increases the magnetic flux. Allowing current out of a winding by magnetically inducing voltage, results in a decrease of the magnetic flux. In short, anything that stores energy increases the magnetic flux, and anything that reduces the stored energy reduces the stored magnetic flux.

Figure 2 shows an idealized transformer block where the magnetizing and leakage inductance are separate from the actual transformer.

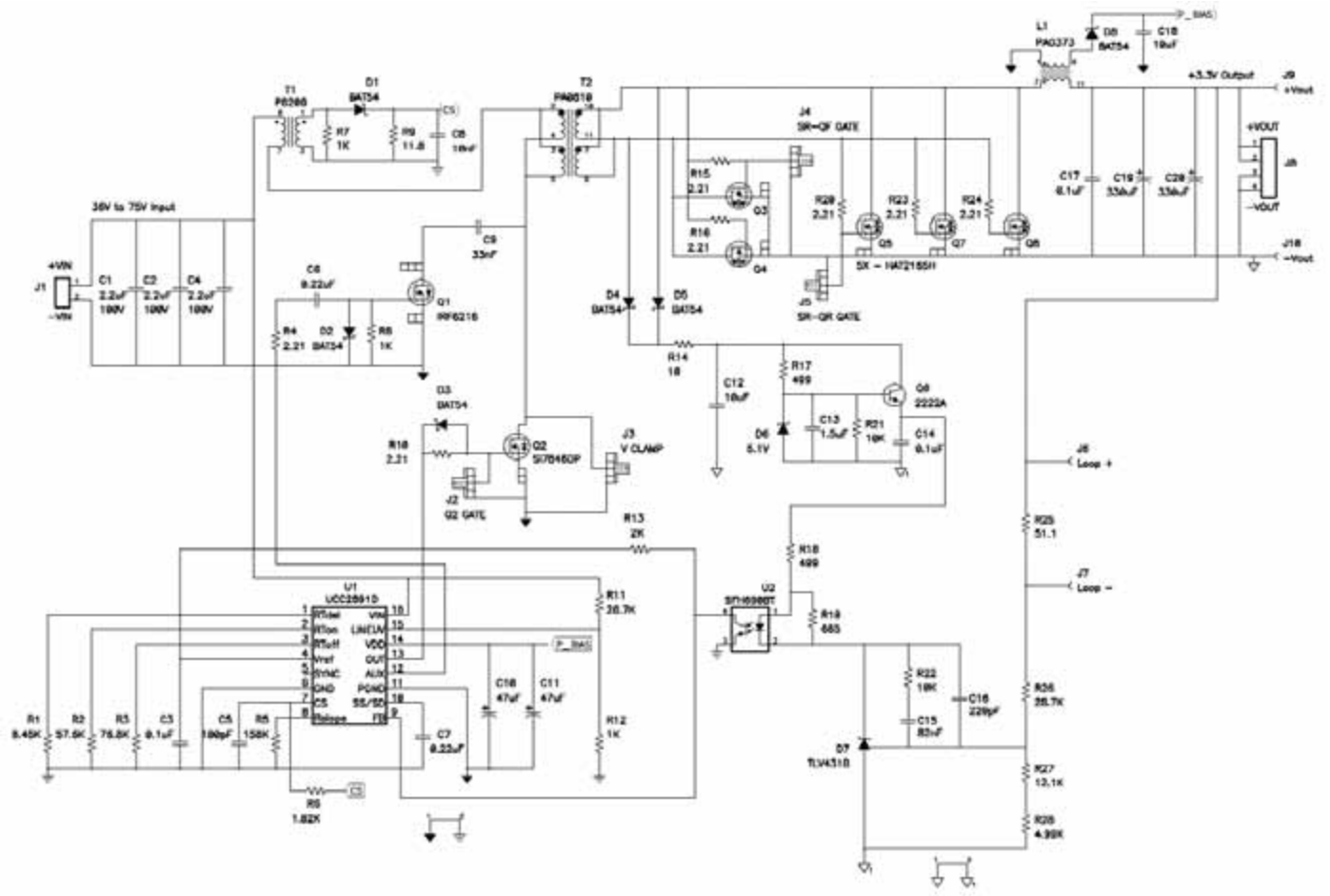

Figure 1 – Schematic of the UCC2891EVM

When power is being delivered to the load, current flows through both the magnetizing inductance and the primary of the transformer. The current in the primary is transformed and conducted out the secondary to the output inductor.

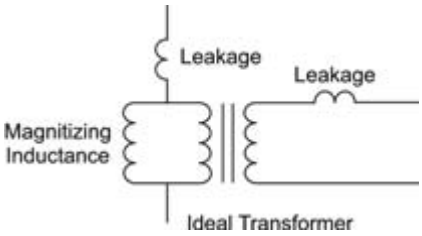

Figure 2 – Idealized Transformer

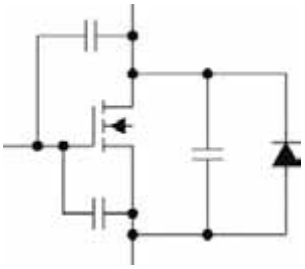

Figure 3 – Detailed Model of the Switch

When the unit is in the clamp mode, the magnetizing current first flows into the clamping capacitor then back out of the clamping capacitor. However, there is no current in the primary as the winding polarity is such that the current flow is blocked by the secondary side switching element (Q3 and Q4). In addition to the idealized transformer, a detailed model of the switches also will be needed to help explain the effect (see Figure 3).

This FET model has an inherent body diode. So if a reverse voltage is applied across the FET, it appears as a diode. In addition to the diode, the inherent capacitances are shown. The presence of these capacitances are needed to explain some of the effects being observed.

Figure 4 shows the switching waveform of the converter at a load current of 0.5 amps and over slightly more than a full cycle.

Figure 5 shows the same picture with an output current of about 6.0 amps.

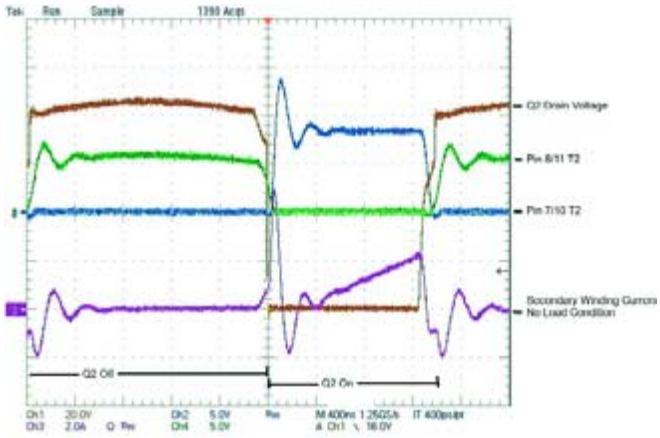

Figure 4 – Waveforms at 0.5 amps out

The difference between the waveforms of Figures 4 and 5 is the output current, which only occurs once Q2 turns on (see Figure 1). By that time, the effect we are interested in has already happened.

The effect we are looking at occurs between the time Q1 turns off and Q2 turns on. To look at this more closely, we need to expand this section of Figures 4 and 5. Let's look closely at this section in Figure 6, which is an expansion of the waveforms under the conditions of Figure 5.

Figure 6 shows that when Q1 turns off, the voltage across the primary winding starts to decrease. Once the secondary side leakage inductance is overcome, the secondary side voltage starts to decrease, and the current starts flowing in the secondary side winding. In the transformer model, this current has to come through the ideal transformer. Therefore, it robs the magnetizing current from the magnetizing winding. This in turn causes the total current in the primary winding to effectively decrease by the amount of current that is circulating through the magnetizing inductance and the primary of the ideal transformer. This decrease in current in the primary is also a decrease in the leakage current in the primary.

Figure 7 demonstrates this by showing the same time frame, but focusing on the primary current – rather than the secondary current.

As can be seen in a comparison of the two pictures, when the current on the output begins to increase, the current on the primary likewise decreases. The primary decreases by about 100mA. The current on the secondary increases to about 600mA. The transformer is a six-to-one turns ratio, so that confirms the direct correlation.

If the time between Q1 turning off and Q2 turning on were sufficiently long, the voltage across the primary would collapse completely. The magnetizing current would then flow through the internal diode of the FET and through the output choke to the output capacitors. Because the magnetizing current is much smaller than the load current, it is not possible for it to result in a voltage across the transformer. If the transformer secondary voltage were to collapse, any magnetizing current would simply supplement the current coming through the output inductor that is being drawn through Q5, Q7 and Q8. Because current would be coming through these transistors body diodes, the transformer secondary winding would be clamped to 0V.

Where is the secondary current coming from the transformer going?

There is still a positive voltage across the secondary of the transformer with pins seven and ten positive, so it is not going through the body diodes of Q3 and Q4. It is going to the parasitic capacitive elements of the secondary switches more than anywhere else. If we look at the current waveform, the time it flows and the change in voltage, we can calculate the effective secondary capacitance at about 12nF.

Q3 and 4 are HAT2165H and have a Coss of 1200pF at 10 V. This goes down as the drain to source voltage decreases. The Crss for the same 10V is about 400pF. At about 3 V, Coss is over 2000pF

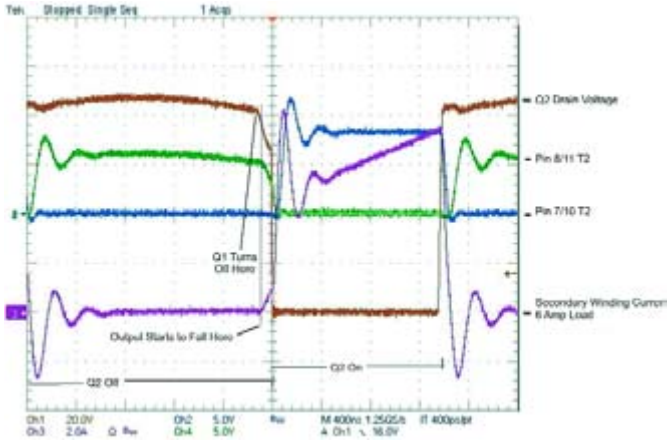

Figure 5 – Waveforms at 6.0 amps out

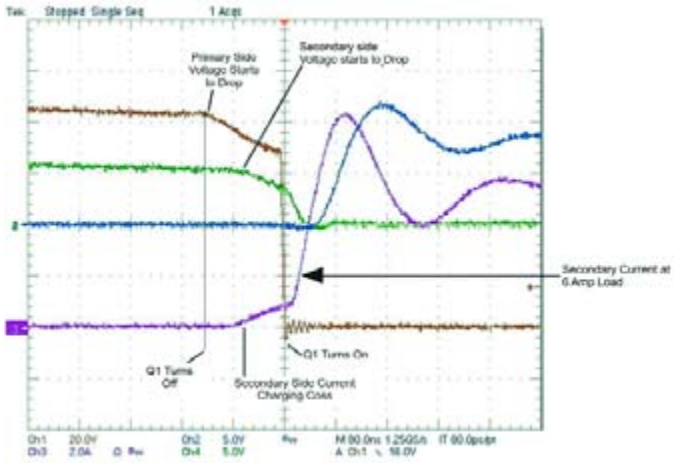

Figure 6 – Expansion of Figure 5

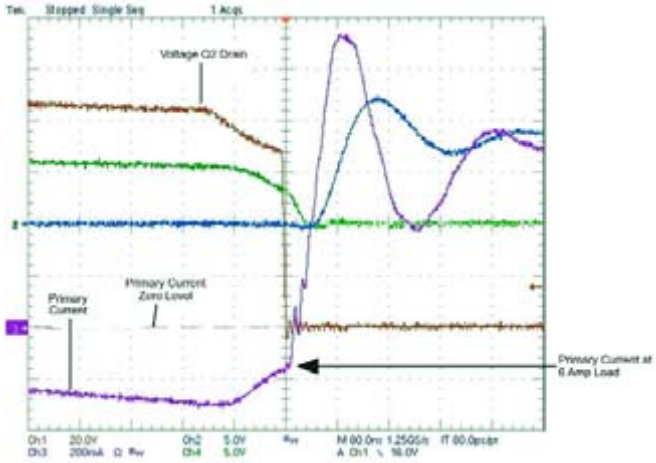

Figure 7 Same image as Figure 6 except primary current instead of secondary.

and rapidly rising. Crss is over 500pF and also rapidly rising, according to the data sheet. This, however, does not account for the 12nF. This same transformer winding, however, is connected to the gate of Q5, Q7 and Q8 and they have a Ciss capacitance of 5nF each. Each would be 15nF. All in all, the 12nF calculated is well within the margin of error for the amount of capacitance from the data sheet, and we have determined that the current is going into the capacitance of the FETs.

What will the current on the primary switch look like when Q2 turns on and why?

Looking at the waveform in Figure 7, the current in the primary side of the transformer is negative to the direction of current flow once Q2 is turned on. The change of current in that winding is not instantaneous (thanks to the leakage inductance), so the FET is fully on and low impedance before that current materially changes direction. In fact, from the waveforms for the first 5ns or so, the current through the primary is negative to the direction that it will eventually be as Q2 remains on.

However, there is the drain to source capacitance of Q2, and drain to source capacitance of Q1 that will immediately discharge through Q2. These are fairly small values so though the switching will not be 0V switching. It will be close to zero current switching with only parasitic capacitive elements providing current through the FET switch, hence, the losses.

There is a large primary current spike that is coincident with the outputs transitioning and the Q5, Q7 and Q8 conducting momentarily in the forward direction, either from the gate not being discharged fast enough or from body diode conduction. In conclusion, both primary switches are switching in a lossless manner. Q1 is switching in a 0V condition, and Q2 is switching in a zero current state – if you ignore the drain to source capacitance discharging currents.

www.ti.com

Miniature Rogowski Probes Upgraded for Power Electronics Market

The highly successful CWT Ultra Mini range of ac current transducers from Power Electronic Measurements Ltd have been upgraded with improved mechanical features and uprated high frequency performance. The units feature a clip-around Rogowski coil thin enough (maximum cross section only 1.7mm) to ensure that it fits between the legs of a T0220 semiconductor device and also making it easier for use in confined spaces. Six models are available in the range covering sensitivity from 200 to 5.0mV/A with corresponding peak currents of 30 to 1200A. Higher current ranges can be made available on request.

These devices are ideal for measuring switching transients, sinusoids and pulsed currents of between 1 and 1200A in power electronic installations. Other applications include:

Semiconductor switching waveforms in otherwise inaccessible areas of circuitry.
High frequency sinusoidal, pulsed and transient currents.
Ac currents superimposed on large dc currents.
Harmonic current components.

The mechanical improvements to the product include the use of a new, tough and abrasion resistant coil insulation, together with a robust new coil clip-together mechanism and a rated peak voltage insulation of 1.2kV.

These are accompanied by improvements to the high frequency performance now covering -3dB bandwidth of 20MHz regardless of current rating. In addition, there is improved peak di/dt capability across the range, and capability of loading into 50 ohm to drive long output cables.

The established features of this equipment include typical accuracy of ±2%. The Rogowski coil loads circuits under test by only a few pH's, while the circuit does not need to be altered to accommodate a bulky current probe which would effectively alter the circuit performance. The probe is also wide-bandwidth from a few tens of Hz to 20MHz enabling measurements of rapidly changing currents or relatively long duration pulses of several tens of microseconds (even hundreds for the higher current ratings). The instrument also provides an isolated measurement at ground potential (unlike co-axial shunts in high sided applications).

The Rogowski coil cable has a circumference length of 80mm, and cable length between integrator box and coil is one metre as standard. Operating temperatures are 0° to +40°C for the integrator and

-10°C to +70°C for the Rogowski coil assembly (with further information for operation at higher temperatures soon to be available).

Further information is available from:
Power Electronic Measurements Ltd
164 Lower Regent Street
Beeston
Nottingham NG9 2DJ
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Telephone: 0115 925 4212
Fax: 0115 967 7685
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Switchable Power Amplifier Module

Mitsubishi Electric Corporation announces a switchable power amplifier for WCDMA handsets that increases the talk time while reducing the number of components on the BOM by omitting the DC/DC converter needed by conventional WCDMA power amplifiers so far. The InGaP HBT (Hetero-junction Bipolar Transistor) module BA01254 which is integrated in a package measuring just 4 x 4 x 1.2mm3 provides a maximum output power rate of 27.0dBm (at a gain of 26.5dB) with an efficiency of 40%, 24% and 7%, respectively at typical output power rates of 27dBm, 16dBm and 8dBm, respectively.
The module is suited for the frequency range from 1920 to 1980MHz and operates from supply voltages of 3.4V while drawing quiescent currents typically only 12mA. While the Rx band noise power is specified with typically -139 dBm/Hz the ACLR5 (adjacent channel leakage power ratio) is as low as -41dBc or -52dBc.
By September of 2007 Mitsubishi Electric plans to release another new set of switchable power amplifier modules for band 9 (1752.4 - 1782.6MHz), band 2 (1850 - 1910MHz) as well as band 5 (824 - 849 MHz).

www.mitsubishichips.com

Two-Channel 120W Class D Audio Amp Reference Design

International Rectifier has introduced the IRAUDAMP4 Class D audio power amplifier reference design. Compared to typical circuit designs, the new reference design illustrates how designers can reduce PCB board space by 50 percent for Class D audio amplifiers for the entire mid-voltage range of mid- and high-power amplifiers for home theatre applications, professional amplifiers, musical instruments and car entertainment.

Showcasing IR's IRS20955 200V digital audio driver IC and the IRF6645 DirectFET® digital audio MOSFETs, the IRAUDAMP4 reference design is a two-channel, 120W half-bridge design offering 96% efficiency at 120W, four ohms. The design incorporates critical protection features such as over-current protection, over-voltage protection, under-voltage protection, DC-protection, and over-temperature protection, in addition to housekeeping functions such as a +/- 5V supply for analog signal processing for the preamplifier and a +12V supply (Vcc) referenced to -B for the Class D gate driver stage. The two-channel design is scalable for power and a number of channels, and requires no heatsink under normal operating conditions.

www.irf.com

2.8kV Asymmetric Thyristors

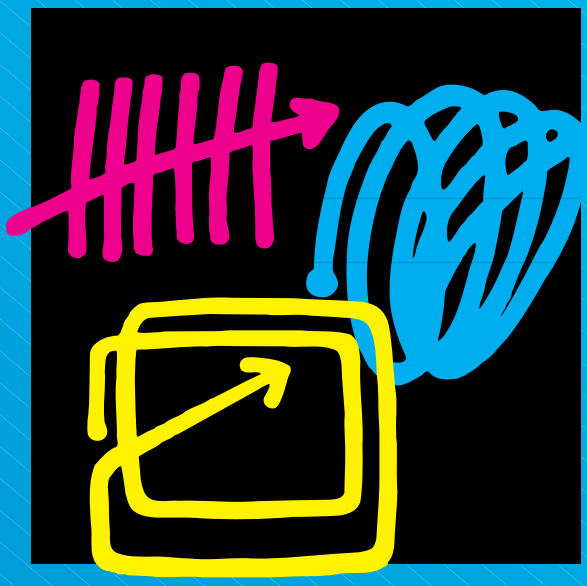
Westcode Semiconductors Limited (An IXYS company) announces the launch of two new 2.8kV Asymmetric thyristors. These new fast thyristors represent a new silicon technology development, employing advanced process technology and novel device design. This advanced asymmetric structure offers an improved combination of on-state voltage and turn-off time for this voltage class, which results in better energy efficiency than symmetrical structured devices.

The devices are available in three VDRM ratings, 2.8kV, 2.5kV and 2kV, for all devices VRRM is limited to 10 volts. The larger device has RMS current rating of 2555A; identified by part numbers A1237NC280, A1237NC250 and A1237NC200. The smaller device has RMS current rating of 1040A; identified by part numbers A0516YC280, A0516YC250 and A0516YC200. All are encapsulated in fully hermetic, ceramic walled packages, the A1237NC device is dimensioned 26mm thick with a 47mm diameter copper pole face, the A0516YC device is 14.5mm thick with a 25mm diameter copper pole face.

The new design uses our advanced thyristor technology with an asymmetric vertical structure, optimising the forward voltage drop against the turn-off time at the cost of the symmetrical blocking characteristic. For example, the A1237NC device has an on-

state voltage of 2.1V at 2000A with a typical turn-off time of 25µs. This presents unrivalled switching speed for the current rating and voltage class. The low losses of the new device offer the opportunity to design more energy efficient power control systems.

www.westcode.com



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Compact Power Modules for Solar Inverters

Microsemi Corporation has introduced a new line of standard power modules for solar inverters utilizing its space saving compact SP3 package

The eight new Microsemi solar inverter modules feature full bridge configurations combining low saturation “Trench & Field Stop” IGBT top switches with fast NPT IGBT bottom switches for unipolar switching. The top IGBTs operate at line frequency, while the bottom IGBTs switch at frequencies from 15 kHz to 50 kHz. Total losses are minimized, enabling maximum solar inverter efficiency. “With their very low 12mm profile and a small 40.8 mm x 73.4 mm footprint, our new power modules provide a very compact power solution for solar inverters. The low inductance of the isolated SP3 package gives excellent performance at elevated switching frequencies. Solderable terminals facilitate easy mounting to a PCB,” said Serge Bontemps, Power Modules Products Development Director in Merignac, France. Diodes in the new modules are matched to the power transistors for improved solar inverter efficiency as well. High speed, soft recovery DQ series diodes are designed in parallel with the top IGBTs to provide low recovery losses in combination with the bottom fast IGBTs. Low forward voltage diodes protect the bottom IGBTs during output current zero crossings. Integrated thermal sensors monitor the module case for over-temperature protection.

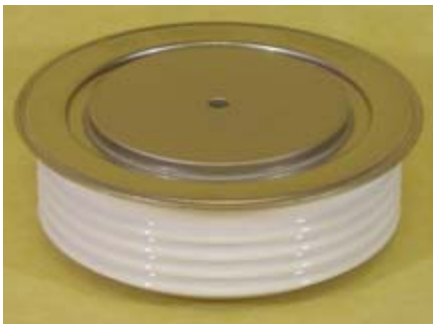
The new Microsemi power modules line includes five 600V and three 1200V models. COOLMOSTM devices are available in one 600V module, allowing it to operate at even higher switching frequencies with minimum conduction losses.

www.microsemi.com

5.5kV Extra Fast Recovery Diode

Westcode Semiconductors Limited (An IXYS company) announces the launch of a new 1300A, 5.5kV extra fast recovery diode. The new diode is the first in a planned introduction of high power, higher voltage diodes using an advanced PIN structure. The device combines the low forward voltage drop of the PIN structure with fast soft recovery to give an energy efficient solution for medium voltage rectification applications.

The new design uses specialised processing techniques to give a vertical PIN structure, optimising the forward voltage drop, <2V at IF1300A, against the 5.5kV blocking voltage. Advanced life-time control techniques results in an extra fast diode with trr of 15µs and di/dt capability greater than 1000A/µs. Overall resulting in a 5.5kV device with low on-state losses but extra fast switching, without compromising on current rating or maximum operating temperature.



The device is available in three voltage grades, identified by part numbers F1300NC45P – 4.5kV, F1300NC50P – 5kV and F1300NC55P – 5.5kV. All are encapsulated in a fully hermetic, ceramic walled package with 47mm diameter copper pole faces.

The low losses of the new device offer the opportunity to design more energy efficient rectifiers in medium voltage applications. Typical applications are as anti-parallel or clamp diodes in conjunction with IGBTs, IGCTs or other fast switching devices in traction, medium voltage drives etc. The high di/dt and low forward loss also make the device ideally suited to series operation as fast rectifiers in applications such as pulsed power or power conversion.

www.westcode.com

Eurocard Plug-in Inverter Delivers 100VA

Absopulse Electronics has recently released the CSI 100-EU series, a 100VA sine wave inverter in Eurocard plug-in format, measuring 3Ux160mmx10HP. This compact, lightweight design is suitable for modular rack-mount applications in industrial, utility, telecom, mobile and other rugged environments.

The CSI 100-EU provides regulated sinusoidal output voltage of 115Vac continuous at 60Hz or 400Hz, or 230Vac continuous at 50Hz. Low output frequency versions, including 20Hz for ringing generators, are available. The output is fully isolated and floating. Input voltages include 24V, 36V, 48V, 110V or 125Vdc. Efficiency is input voltage dependent, typically 80% at full load.

www.absopulse.com

Warm White Power LED for Solid-State Lighting

Avago Technologies announced the addition of a 1-Watt warm white light emitting diode (LED) to its family of Moonstone power LEDs. Available in one of the industry's thinnest packages, Avago's ASMT-MY00 LED provide designers of solid-state lighting applications with a competitively robust and reliable package that provides high brightness illumination and easy installation. Avago's ASMT-MY00 is ideal for use in applications that require ultra-high-brightness LEDs, such as decorative lights, garden lights, task and reading lights, architectural, accent and marker lights.

Avago's ASMT-MY00 high brightness LED package, which feature a smooth radiation pattern and 110-degree viewing angle, is a high performance energy efficient device that has been developed to withstand high operating temperatures and driving currents. With an exposed pad design, this 1-Watt warm white power LED provides excellent heat transfer from the package to the motherboard to enable the ASMT-MY00 to be driven at a current of 350mA. Moreover, this LED delivers up to 56 lumens to provide superior lumens to watt efficiency.

www.avagotech.com/led

www.avagotechlighting.com

High Efficiency 2.5 MHz Synchronous Buck Regulator

Micrel launched the MIC2238, a 2.5MHz dual 800mA synchronous buck (step-down) regulator housed in a tiny 3mm x 3mm MLF® package. The MIC2238's unique switching architecture scheme, Trickle Mode, enables industry- leading light load efficiency for Li-Ion battery powered systems that require maximum efficiency in order to prolong use. The MIC2238 is a perfect choice for portable applications including cellular phones, portable media players, WiMax modules, GPS systems, digital still and video cameras.

The device offers an input voltage range from 2.5 to 5.5V and an ultra-low quiescent current of 28uA at light loads. This assures that only a trickle of current is drawn from the battery, thereby and extending valuable standby time. Moreover, the MIC2238's design offers two modes of operation, a variable frequency Trickle Mode™ operation for highest light load efficiency with an automatic switchover into full load, and an option for running the device at a constant frequency. In addition, the device offers a power good output signal for sequencing capability. The MIC2238 is available in a tiny 12-pin 3mm x 3mm MLF with a junction operating range from -40°C to +125°C.

www.micrel.com

Refreshing of AC Film Capacitor Line

A refreshed series of AC film capacitors is about to make Electronic Concepts, Inc.'s line of quality capacitors even more attractive, the company said.
Electronic Concepts, Inc. is placing a renewed emphasis on its 5MPA series of film capacitors, and thus is offering stock and revised market pricing. By means of material acquisition, product design efficiencies, production optimization, and a strong commitment to the line, Electronic Concepts, Inc. is refreshing product pricing and committing to a limited stocking arrangement with Elcon Sales, the company's distribution partner.
Electronic Concepts, Inc. will begin a program of stocking specific, high-demand capacitance and voltage values among its 5MPA capacitor products, which are available this summer. Capacitors are generally an important component of alternating current ("AC") applications.
The 5MPA series of AC film capacitors - a dry polypropylene metallized film-features a combination of physical and electrical properties that maximize performance, reliability, and space utilization.

The 5MPA series is excellent for use in AC motor-drive applications in which high PWM and other feedback currents are present, along with high frequency.
The 5MPA series has been approved by Underwriters Laboratories.

www.ecicaps.com

Smallest 2.25-MHz Low-Power DC/DC Converters

Texas Instruments introduced its smallest 2.25-MHz high-performance, step-down DC/DC converters, which support low-power DSPs and microcontroller-based portable electronics. Extending battery life in Bluetooth headsets, cell phones and other Li-Ion battery-powered applications, the high-performance converters save valuable board space. TI's 300-mA, 600-mA and 1-A synchronous, step-down DC/DC converters can efficiently regulate output voltages down to 0.6 V with +/-1.5 percent accuracy, enabling the devices to power TI's newest C5000 and DaVinci™ DSPs, low-power MSP430 microcontrollers and other controllers with ultra-precise processor core supply requirements.

The TPS62290 provides up to 1 A of output current, and can be powered by a single-cell lithium-ion (Li-Ion), three-cell nickel metal hydride (NiMH) and three-cell alkaline batteries with an input voltage range of 2.3 V to 6 V. The converter, which operates at a low 15 µA quiescent current, enters a power save mode during light load operating conditions and maintains efficiency up to 95 percent over the entire load current range. For low-noise applications, the device can be forced into fixed frequency pulse width modulation (PWM) mode by pulling the MODE pin high. In the shutdown mode, the TPS62290's current consumption is reduced to less than 1 µA.

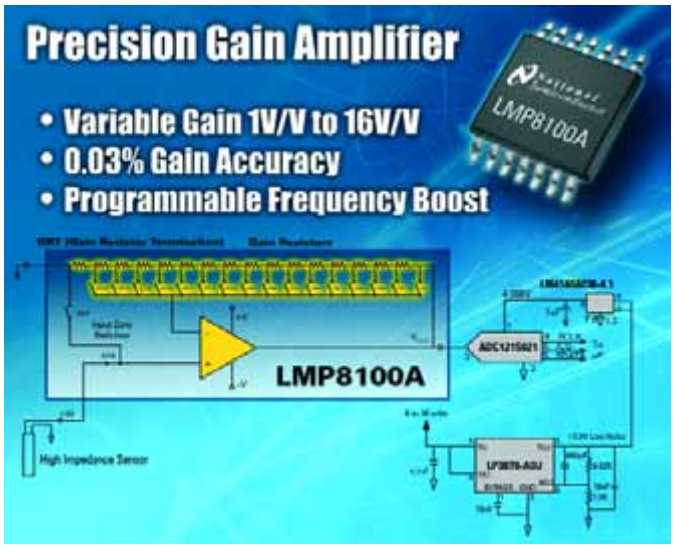
http://power.ti.com

Industry's Highest-Precision Programmable Gain Amplifier

National Semiconductor introduced the industry's highest-precision programmable gain amplifier (PGA), enabling a new level of signal-conditioning performance in sensor interface applications and data acquisition systems targeting the industrial and instrumentation markets.

National's LMP8100A delivers guaranteed 0.03 percent gain accuracy using a software adjustable gain (in 1V/V increments) from 1V/V to 16V/V over the full industrial temperature range of -40 degrees C to 125 degrees C. National also offers the LMP8100 semi-precision grade PGA, which provides guaranteed 0.075 percent gain accuracy over the -40 degrees C to 85 degrees C temperature range. The amplifier's closed-loop gain is set by an array of 16 precision thin-film resistors. At the core of the PGAs is a precision 33 MHz CMOS input, rail-to-rail, input/output (RRIO) operational amplifier with a typical open-loop gain of 110 dB.

The LMP8100A provides four levels of internal frequency compensation, which at the higher gain settings increases the usable signal bandwidth. Its input zero calibration feature allows the user to measure the output offset voltage to calibrate any errors resulting from temperature or voltage shifts. The amplifier's control modes are programmed via a serial port that also allows several devices to be cascaded, permitting an array of LMP8100 amplifiers to be programmed by a single microcontroller serial data stream. The device's control-mode registers are double-buffered to ensure glitch-free transitions between programmed settings.



http://amplifiers.national.com

ADVERTISING INDEX

ABB entrelec	23	electrovac	1	Microsemi APT	37
ABB semi	C3	EPE	45	Productronica	51
Ansoft	21	Epcos	25+26	Roal	31
APEC	47	Fischer elektronik	C2	Semicon	43
Apex	41	Fuji Electric	15	SPS drives	53
Correlec	49	Infineon	3	Texas Instruments	13
CT Concept Technologie	7	International Rectifier	C4	Tyco Electronics	39
Danfoss Silicon Power	11	Intersil	27	Würth Elektronik	19
Datatronics	17	IXYS	19	VMI	35
Denka	49	LEM	5		

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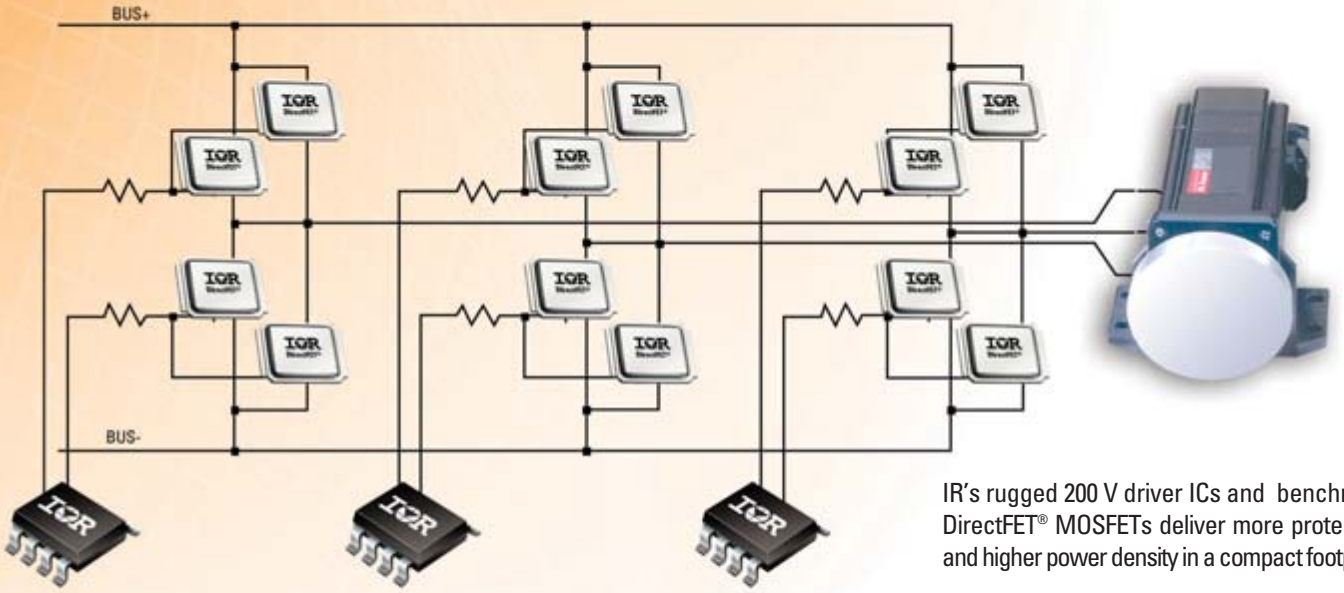

IR's rugged 200 V driver ICs and benchmark DirectFET® MOSFETs deliver more protection and higher power density in a compact footprint.

IRS200x FEATURES

- High-side circuitry powered by bootstrap power supply
- Undervoltage lockout protection
- 3.3 V, 5 V, and 15 V input logic compatible
- Cross conduction prevention logic (for half-bridge drivers)
- Shutdown input available on IRS2004(S)PBF
- 50 V/ns dV/dt immunity on floating Vs pin

DirectFET FEATURES

- 1.4° C/W junction to case thermal resistance ($R_{th(J-C)}$) enables highly effective top-side cooling
- Less than 1° C/W $R_{th(junction-pcb)}$ in half the footprint of a d-pak
- Over 80% lower die-free package resistance (DFPR) than d-pak
- 0.7 mm profile compared to 2.39 mm for d-pak

200 V Driver ICs

Part	Package	UVLO	Compliance	Typical Current	Input Logic	Additional Features
IRS2001PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	HIN, LIN	Independent high & low side drive
IRS2001SPBF	SOIC8 Bulk					
IRS2001STRPBF	SOIC8 Tape & Reel					
IRS2003PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	HIN, LIN/N	Deadtime
IRS2003SPBF	SOIC8 Bulk					
IRS2003STRPBF	SOIC8 Tape & Reel					
IRS2004PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	IN, SD/N	SD Input & deadtime
IRS2004SPBF	SOIC8 Bulk					
IRS2004STRPBF	SOIC8 Tape & Reel					

DirectFET MOSFETs

Part	Package	Polarity	VBRDSS (V)	$R_{DS(on)}$ 4.5 V Max. (mΩ)	$R_{DS(on)}$ 10 V Max. (mΩ)	I_D @ TC = 25° C (A)	Qg Typ	Qgd Typ	$R_{th(JC)}$	Power Dissipation @ T_C = 25° C (W)
IRF6635	DirectFET	N	30	2.4	1.8	180	47.0	17.0	1.4	89
IRF6613	DirectFET	N	40	4.1	3.4	150	42.0	12.6	1.4	89
IRF6648	DirectFET	N	60		7.0	86	36.0	14.0	1.4	89
IRF6646	DirectFET	N	80		9.5	68	36.0	12.0	1.4	89

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