POWER ELECTRONICS EUROPE

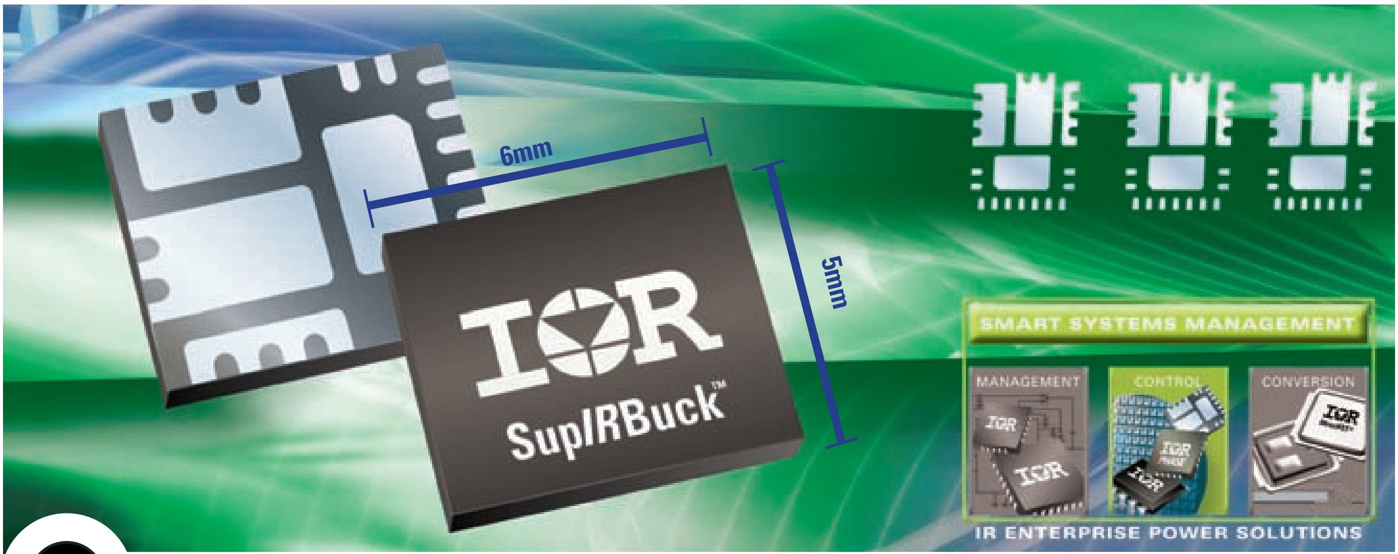
ISSUE 2 – MARCH 2008

POWER MODULES

New Intelligent Power Module Series

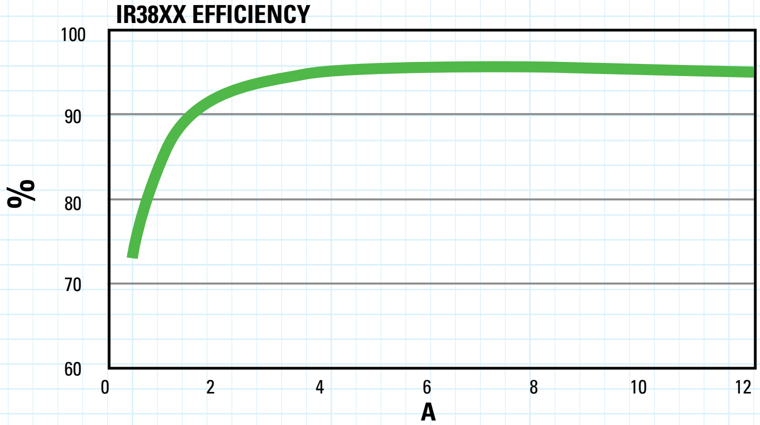
THE EUROPEAN JOURNAL FOR POWER ELECTRONICS AND TECHNOLOGY

Also inside this issue



SupIRBuck™ Integrated Regulators: Simply Smaller, Cooler

Save Energy, Accelerate POL Design, Shrink Footprint 70%



The SupIRBuck™ family of versatile point-of-load (POL) voltage regulators shrink silicon footprint 70% compared to discrete solutions and offer up to 10% higher full-load efficiency than monolithic power ICs.

Features

- 600kHz switching frequency
- 4A/7A/12A output options
- Programmable soft start with enable
- Programmable over-current protection
- 0.6V reference voltage with 1.5% accuracy
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- Optional 300kHz, DDR memory tracking, programmable PGOOD

Benefits

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- Enables single input voltage rail
- Wide input voltage range
- Common footprint for 4A, 7A and 12A power regulators
- Fewer discrete components

Part Number	V_{IN} Max/Min	V_{OUT} Max/Min	Max Current	F_{SW}	Package	Features
IR3812MPBF	21 / 2.5	12 / 0.6	4A	600KHz	5mm x 6mm QFN	OCP; OTP; Tracking
IR3822MPBF	21 / 2.5	12 / 0.6	4A	600KHz	5mm x 6mm QFN	OCP; OTP; PGood
IR3822AMPBF	21 / 2.5	12 / 0.6	6A	300KHz	5mm x 6mm QFN	OCP; OTP; PGood
IR3811MPBF	21 / 2.5	12 / 0.6	7A	600KHz	5mm x 6mm QFN	OCP; OTP; Tracking
IR3821MPBF	21 / 2.5	12 / 0.6	7A	600KHz	5mm x 6mm QFN	OCP; OTP; PGood
IR3821AMPBF	21 / 2.5	12 / 0.6	9A	300KHz	5mm x 6mm QFN	OCP; OTP; PGood
IR3810MPBF	21 / 2.5	12 / 0.6	12A	600KHz	5mm x 6mm QFN	OCP; OTP; Tracking
IR3820MPBF	21 / 2.5	12 / 0.6	12A	600KHz	5mm x 6mm QFN	OCP; OTP; PGood
IR3820AMPBF	21 / 2.5	12 / 0.6	14A	300KHz	5mm x 6mm QFN	OCP; OTP; PGood

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International Rectifier
THE POWER MANAGEMENT LEADER

Editor Achim Scharf
Tel: +49 (0)892865 9794
Fax: +49 (0)892800 132
Email: achimscharf@aol.com

Production Editor Elaine Gladwell
Tel: +44 (0)1322 380057

Editorial/Advertisement Administration
Clare Jackson
Tel: +44 (0)1732 886495
Fax: +44 (0)1732 886149

Circulation Manager Anne Backers
Tel: +44 (0)208 647 3133
Fax: +44 (0)208 669 8013

INTERNATIONAL SALES OFFICES
Mainland Europe:
Victoria Hufmann, Norbert Hufmann
Tel: +49 911 9397 643 Fax: +49 911 9397 6459
Email: pee@hufmann.info

Armin Wezel
Tel: +49 9568 897 097 Fax: +49 9568 897 096
Email: armin@eurokom-media.de

UK
Steve Regnier, Tim Anstee
Tel: +44 (0)1732 366555
email: Sales@starmediaservices.co.uk

USA West Coast Sales
Shelley Kelly
Tel: (310) 547 1777 Fax: (310) 519 0809
Email: shellyscott@sbcglobal.net
USA East Coast Sales
Karen C Smith-Kernc
email: KarenKCS@aol.com
Alan A Kernc
Tel: +1 717 397 7100
Fax: +1 717 397 7800
email: AlanKCS@aol.com

Italy
Ferruccio Silvera
Tel: +39 022 846 716 Email: ferruccio@silvera.it
Taiwan
Prisco Ind. Service Corp.
Tel: 886 2 2322 5266 Fax: 886 2 2322 2205

Publisher Ian Atkinson
Tel: +44 (0)1732 886495
Fax: +44 (0)1732 886149
Email: IATKINSONTMI@aol.com
www.power-mag.com

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Editorial information should be sent to The Editor, **Power Electronics Europe**, PO Box 340131, 80098 Munich, Germany.

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COVER STORY

New Intelligent Power Module Series

The popularity of IGBTs in a wide range of industrial power conversion applications is a direct result of the technological advances that have been made. The development over the last few years has made the IGBT a power switch with rugged switching characteristics, low losses and simple gate drive. Continuous market growth of general purpose inverters and servo drives is boosting the demand of Intelligent Power Modules (IPM). The new IPM 'L1-Series' featuring high speed and low loss IGBT chips with full gate CSTBT and is mechanical compatible to the existing L-Series IPM. Full story on page 21.

Cover supplied by Mitsubishi Electric Europe

Digital Power on the Move

Digital power is no longer a promise, but a commercial fact with many available products. The reasons for the market interruption are competitive cost compared to analog solutions and additional functionality at almost no extra cost. Additionally, international policies for energy saving, like Energy Star or European Codes of Conduct, can be more easily met using digital power. This may become a driving force for digital power adoption, though the market is in its infancy, according to IMS research analyst David Dewan at a recently held ECPE seminar. Digital power refers not only to the digital implementation of the control loop of a power converter, but also to the power management in its broader sense, including monitoring and fault detection, programming of the loop filter and control algorithm, tracking of output voltages, sequencing of different voltage rails, margining of power converters or remote maintenance. Digital power can improve efficiency, from 92% in an analog rectifier up to 96% in a digitally controlled rectifier for telecom applications. Two main approaches can be distinguished: Fully digital controlled converters including closed loop control (driven by ICs or microcontrollers) and digitally managed analog or semi-digital contolled converters (complete modules which use digital techniques for control and/or power management). Attention also needs to be paid to the communication bus. Among the available alternatives, PMBus is becoming most popular, already adopted by the main players. An increasing market transition from analog to digital power is foreseen in the near future. Though associated controller ICs are the domain of US-based manufacturers and Texas Instruments should first of all be mentioned here, this can be changed in the near future through an alliance of Zilker Labs and STMicroelectronics. And research in digital power at European universties is in an advanced state, i.e. at the Universty of Paderborn (Germany) or the Universty of Padova (Italy).

In the late 1990s, based on Digital Signal Processor C2000, Texas Instruments contributed to developing the first fully digital controlled UPS. Using a DSP to digitally control the switching and power management of an UPS system was the first practical application for digital power. In December 2002, Texas Instruments introduced the industry's first digital signal processing (DSP) Development Kit dedicated to power supplies. With the UCD9240, in April 2007, Texas Instruments Introduced the First 'Digital Power System Controller, and in May 2007, TI released a new concept 'PowerTrain' combining the UCD9240 and termination module PTD08A010W. In May 2004, Artesyn Technologies Inc., Astec Power, and a group of semiconductor manufacturers formed a coalition to develop an open architecture communications standard for power systems control. The coalition included semiconductor suppliers Intersil Corp., Texas Instruments, Volterra Semiconductor, Microchip Technology Inc, Summit Microelectronics, and Zilker Labs Inc. The digital protocol, named Power Management Bus or PMBus, aimed to be implemented over the industry-standard I²C serial bus. With the introduction of the Z-One Digital IBA architecture in March 2004, Power-One announced the integration of power conversion, control, and communications in point-of-load power units. All digital ingredients seem to be in place for success, but why is Digital Power not massively used everywhere? Patrick LeFevre from Ericsson Power Modules gave the answer: "By nature, technology switch always generates debates among the concerned community and digital power follows the same pattern. Digital Power is a technology evolution, not a technology revolution and, as such, it will follow the same market rules as other evolutions". Additionally, patent infringements leadings to disputes between i.e. Artesyn and Power-One could also slow down adoption.

Time will tell whether Digital Power will be adopted in Europe, particularly within the members of the European Power Supply Manufacturers Association (EPSMA). Certainly support by European IC manufacturers would be helpful. And by the way, this technology can also help to reach the European goal of increasing the efficiency of external power supplies in the 36 to 250W range up to 87% at 100% load by 2009. We will see and keep you informed.

Achim Scharf
PEE Editor

High Growth for Digital Power Anticipated

Due to the increasing interest in so-called Digital Power, ECPE organised a seminar from February 20-21 in Munich. The mixed academic/industrial program attracted more than 80 delegates and gave new insights in terms of market evolution, technology and applications.

"Digital Power is now happening, but with sales of $2.2 million in 2007 for fully digital power supplies, is in its infancy compared to the sales figure of analog/digital power supplies at more than $300 million", stated IMS analyst David Dewan. Today, digitally controlled power supplies are offered i.e. by Cherokee, Eltek-Valere, Emerson Embedded Power, Ericsson Power Modules, and Power-One. "But the future looks bright; we forecast annual growth rates of roughly 50% up to $1.5 billion by the year 2011 for hybrid digital power supplies, and 44% for Power ICs, from $120 million in 2007 to $600 million in 2011. Nevertheless, by 2011 only 7.1% of the merchant power supply market is fully digital, and the same applies with 7.3% for the power IC market". Though the initial costs of fully digital solutions are somewhat higher, the advantages can be paid back in a short period of time. "Digital power can improve efficiency, from 92% in an analog rectifier up to 96% in a digitally controlled rectifier for telecom applications", Dewan stated.

"Also power manageability comes with digital power, and interleaved power factor correction can be better implemented", commented Infineon's Manfred Schlenk

"It's not efficiency at one power rail that counts, it's the efficiency of the whole digital power system", said TI's Francois Malleu

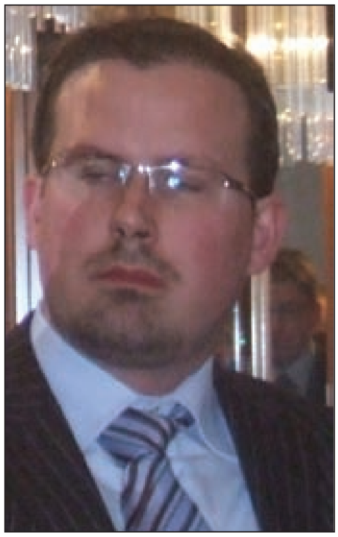
"It's not efficiency at one power rail that counts, it's the efficiency of the whole system", commented Francois Malleu, EMEA Business Development Manager from Texas Instruments. The company presented a paper describing efficiency improvements by intelligently selecting different phase configurations based on different load conditions where, at light load, only one phase is enabled verse having all phases turned on during full load operation. "There's also a short time to market for a new design, just by changing software".

Frank Schafmeister, from Delta Energy Systems Germany, agreed with this efficiency statement. "Efficiency is a major concern, particularly in server power supplies, one of our major businesses. Here, the operators of data centres raise standards much higher than legislation". And this tranlates into real savings for electrical energy. "At Google's data centres, an increase of 1% in efficiency saves them $1 million", added Manfred Schlenk from Infineon. "Also, power manageability comes with digital power, and interleaved power factor correction can be better implemented".

"One can time-share an inductor for different phases saving space and cost as well", added Aleks Prodic from the University of Toronto

Aleks Prodic, from the University of Toronto, views the reuseability of digital power buildings blocks as a big advantage. "And, by the way, though higher efficiency the heatsink can be reduced significantly, making the total system smaller. One can also time-share an inductor for different phases saving space and cost as well".

But according to IMS's analysis, adoption takes time. "We have implemented monitoring and communication fuctions in our power supplies which can be solved with cheap 8bit microcontrollers. If we move to digital power, we envision other factors such as better efficiency, but here other points such as improvements in passive and magnetic components have to be considered. We will not switch to digital power overnight; this is dependent also on the pricing of the chips", Schafmeister concluded.



" We will not switch to digital power overnight, this is dependent also on the pricing of the chips", Delta's Frank Schafmeister concluded

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Literature

Digital Power Forum Europe, Power Electronics Europe Dec 2007, pages 14-15.

www.ecpe.org

Developer Forum on Battery Technologies

Primary (disposable) batteries and secondary (rechargeable) batteries are the focus at the developer forum hosted by batteryuniversity.eu and the University of Applied Sciences Aschaffenburg/Germany.

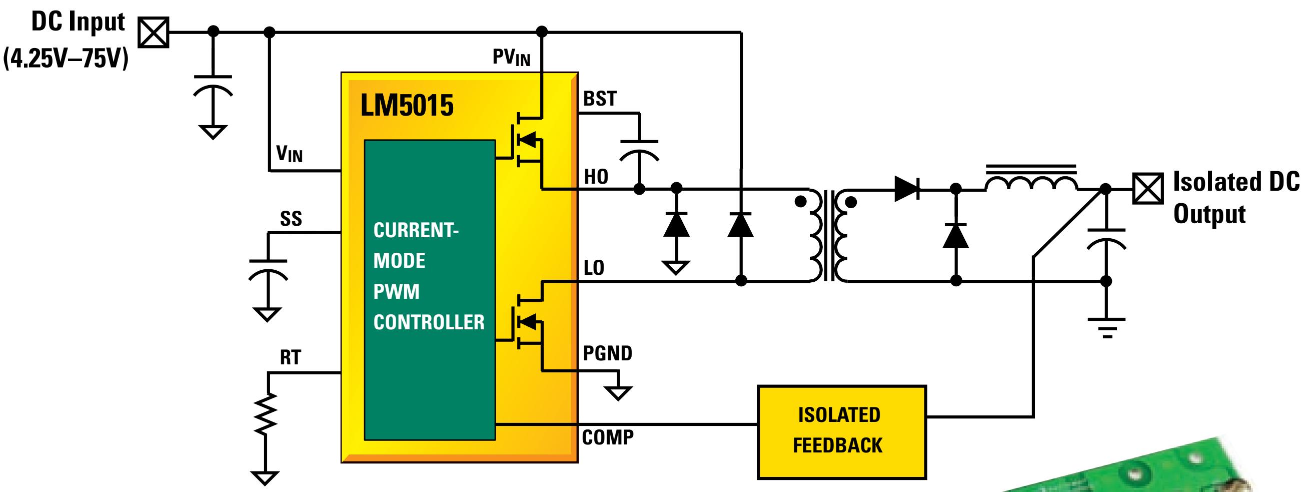
The goal of this first event, held from April 9 to 10, 2008 in Aschaffenburg, Germany, is to present in 28 sessions a broad knowledge on different topics such as current battery technologies and chemicals, battery drives for electric vehicles, battery test systems, regulations and standards, battery charging technologies, safety requirements, safety tests and protection circuits. Attendance fee for the two-day forum is 480 Euros plus VAT.

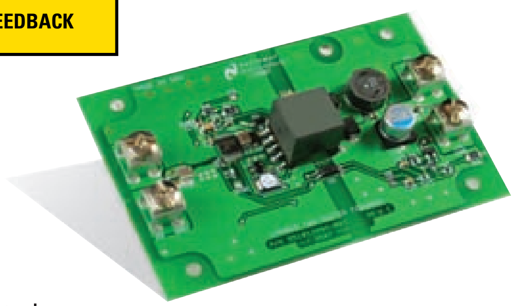
www.batteryuniversity.eu

Industry's First High-Voltage Monolithic Two-Switch Forward DC-DC Regulator

national.com/power

LM5015 Switch-Mode Regulator Features Ultra-Wide Input Voltage Range from 4.25V to 75V





LM5015 Features

- Dual integrated 75V N-channel MOSFETs
- Ultra-wide input voltage range: 4.25V to 75V
- Adjustable output voltage
- Integrated current sensing and limiting
- Current-mode control
- Oscillator synchronization capability
- Programmable soft-start

Product ID	V_{IN} min (V)	V_{IN} max (V)	Integrated Switches	Switch Voltage Rating (V)	Current Limit (A)	Package
LM5000	3.1	40	Low-Side	75	2	TSSOP-16 / LLP-16
LM5001	3.1	75	Low-Side	75	1	SO-8 / LLP-8
LM5002	3.1	75	Low-Side	75	0.5	SO-8 / LLP-8
LM5015	4.25	75	Low- and High-Side	75	1	TSSOP-14EP

Applications

Communications, computing, industrial, medical, video, and test and measurement.

For samples, datasheets, and more, visit:
national.com/power

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The Best-Selling 2-Channel IGBT Driver Core

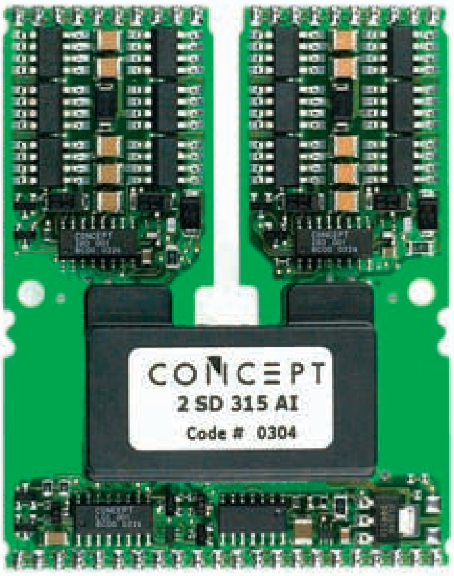
The 2SD315AI is a 2-channel driver for IGBTs up to 1700V (optionally up to 3300V). Its gate current capability of ±15A is optimized for IGBTs from 200A to 1200A.

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.

CONCEPT

CT-Concept Technologie AG
Renferstrasse 15
2504 Biel-Bienne
Switzerland

Tel +41-32-344 47 47
Fax +41-32-344 47 40

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Let experts drive your power devices

Lineage Runs Tyco Electronics Power Systems Business

Tyco Electronics has sold its division Tyco Electronics Power Systems to the Los Angeles headquarted Gores Group, a private equity firm focused on acquiring controlling interests in mature and growing businesses, for $100 million in cash. A newly formed company, Lineage Holdings, will keep the business running.

Lineage Holdings operates through two separate entities, Lineage Power and Vincotech. Lineage Power is headquartered in Mesquite, Texas, with approximately 1900 employees and provides power supply and power conversion products and services to telecom service providers and enterprise customers. Vincotech provides power modules and other technologies used in industrial, automotive, and GPS applications. Vincotech is based in Germany, with 600 employees and manufacturing operations in Hungary and China. "All US employees will become members of the new company, while the assets and employees of the business in Shanghai, India, Germany and certain other European jurisdictions will be transferred following the satisfaction of certain regulatory and other customary closing conditions. Gores will provide financial support and leverage its operating expertise to create a platform for profitable growth", commented Ryan Wald, Managing Director of the in 1987 founded Gores Group.

www.gores.com

Wind Power Acclerates Power Semiconductor Business

Recent studies by Frost & Sullivan estimate the Western European Wind Power Market market of $9 billion in 2006 to reach $15 billion in 2013. The North American Wind Energy Generator Market is between $4 and $5 billion in 2006 and is estimated to touch $50 billion in 2013.

Germany, playing the pied piper, heralded a new era in renewable energy by introducing meticulously planned energy policies and robust Government support for the wind power market. The Western European market registered a stunning growth rate of 18% in cumulative installed capacity in 2006, largely thanks to German feed-in tariffs and their Spanish equivalent. "Ever since Germany passed the Renewable Energy Act in 2000 and amended it in 2004, there has been no looking back for the Western European wind power market", notes Research Director Harald Thaler. "The Act relating to the purchase of renewable energy for four times the market rate made German wind installations soar and catapulted Germany to the top slot in the global wind market". The 2001 EU directive on renewable energy requires each member state to achieve a set percentage of renewable energy in their power supply by 2010. For electricity supply, the overall European target is for 21%.

Meanwhile, the US wind energy industry is well on course to add more than 3GW to its power generating capacity in 2007, topping its 2006 record of 2.5GW. The country's production tax credit (PTC) is an influential growth factor, as installations increase and decrease depending on PTC's extension and termination. "Industrial investments in production base and developer confidence are also affected due to wavering PTC policy", says Research Analyst S. Prem Anand. "However, state-based policies such as renewables portfolio standard (RPS), renewable electricity standards, and renewable energy production incentive (REPI) moderately compensate for inconsistency in PTC implementation". The US market witnessed a late surge in new wind turbine installations in the past two years, but it still trails Germany in the global ranking. The wind power market in Canada becomes increasingly dynamic due to federal and, more importantly, provincial efforts to promote this market. The country will greatly benefit from the new wind legislation aimed at achieving 10 GW wind power generation by 2010.

www.energy&power.frost.com

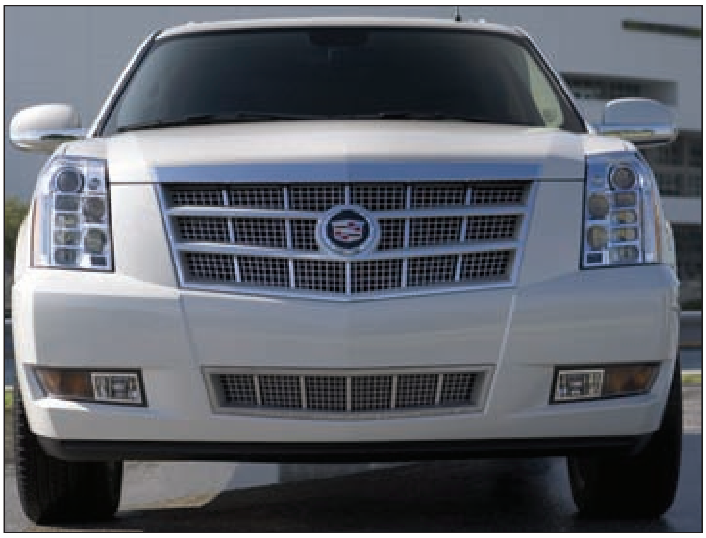
LEDs Move Forward in Automotive

The car is becoming an ever more important home for light-emitting diodes (LEDs) as an alternative to incandescent light bulbs and halogen and xenon lamps. Their importance is set to explode, doubling from a $0.65 billion business in 2006 to $1.3 billion within 10 years, according to a recently published IMS report 'LEDs in Automotive Applications'. These figures are also of interest for the various manufacturers of LED drivers.

Today, most of the value comes from applications inside the car, such as backlighting dashboards and displays, and supplying a wide range of indicator lamps. However, the LED value from external lamps will rise from a third of the LED total to over a half by 2013. Most external LED lamps are at the rear, as brake, tail and turning lights. "However, Daytime Running Lights will become much more widely used in the future. This business will grow from under $5 million in 2006 to over $100 million by 2013", commented analyst Jamie Fox. LED DRLs, which were first introduced on the Audi A8 in 2004, are currently used on less than 1% of vehicles. However, IMS Research forecasts that, with very strong growth after 2009, the market revenues for LED DRLs in the next decade will be similar to revenues for LEDs for functions used in rear lighting applications today. DRLs are the application that will lead the way for LEDs to move forward from the rear of the vehicle into front lighting.

This year, the soon-to-be released Audi R8 will feature a full LED headlamp, supplied by Automotive Lighting, with LEDs supplied by Osram and Lumileds. This will be the second vehicle to feature LEDs in the headlamp, after the Lexus LS600h, which used Koito headlamps with Nichia LEDs. The fact that Osram, Nichia and Lumileds (which also led the way for LEDs used in Daytime Running Lights) are the three LED companies pioneering this technology is no coincidence; as these three companies dominate the market for LEDs supplied to the global car industry. As well as supplying LEDs for headlamps, the trio have the largest share of the high-value LED market in automotive applications; such as in rear lighting and in instrument clusters and other interior applications. While many other suppliers, such as Toshiba, Avago and Everlight, sell LEDs into this sector, they sell fewer.

Lumileds and Nichia do not compete with each other to a large extent, as IMS analyst Jamie Fox explained: "Lumileds sell LEDs mainly for exterior applications, while Nichia sell mainly for interior applications. There are also geographical differences in the supply chain; for example, Nichia do not sell many LEDs for automotive applications in Europe, where Osram are strong (in both interior and exterior applications)". In the next decade however, as the battleground moves from interior and rear lighting applications to the front of the vehicle, this seems set to change. Lumileds, Nichia and Osram all provide LEDs of high brightness and quality that are well-suited to forward lighting applications.



The Cadillac Escalade Platinum is the first SUV in the world to be fitted with LED headlights as standard **Source: Cadillac**

First LED headlight

The Cadillac Escalade Platinum is the first sports utility vehicle (SUV) in the world to be fitted with LED headlights as standard. OSRAM LEDs perform all the functions in the headlights supplied by Hella – low beam, high-beam, daytime running light, position lights and side marker lights. Each headlight contains seven OSTAR headlamp LEDs – five for low beam and two for high beam. Daytime Running Light is provided by dimming the low beam. This means there is no need for an extra light source. This intelligent solution is only possible with LEDs. Each headlight also has a position light with white Advanced Power TopLEDs and a side marker light with yellow Power TopLEDs.

Headlamp of the Cadillac Escalade Platinum, seven OSTAR LEDs perform all the functions Source: Hella KGaA Hueck&Co/Osram

The OSTAR Headlamp LED was developed specifically to meet the requirements of Hella, the headlight manufacturer. It is among the brightest LEDs for use in the automotive sector. With a colour temperature of 5500 Kelvin, much higher than the 4000 Kelvin of xenon light, these tiny light sources create a light with the same colour impression as natural daylight. The OSTAR is particularly robust and can withstand ambient temperatures from -40° to +125°C. "Helping to create lighting solutions for automobiles is part of our core business", said Wolfgang Lex, Head of the LED business unit at OSRAM Opto Semiconductors. "In our cooperation projects with manufacturers advanced headlight designs have gained in importance in recent times. Because LEDs are so small, designers have almost unlimited freedom so they can clearly differentiate from competitors".

www.imsresearch.com
www.osram-os.com

New CEO for International Rectifier

Effective March 1, 2008, Oleg Khaykin will serve as IR's President and Chief Executive Officer, succeeding Donald Dancer, who has served as acting Chief Executive Officer since August 2007.

Mr Khaykin, 43, brings global experience in the semiconductor industry, having served most recently as CEO of Amkor Technology, a provider of semiconductor assembly and test services, with 22,000 employees worldwide. At Amkor, he was responsible for all aspects of sales, marketing, R&D and manufacturing operations, including accountability for the development and implementation of corporate and business strategy, business development, strategic partnerships and IP management. Prior to joining Amkor in 2003, Mr Khaykin was Vice President of Strategy and Business Development at Conexant Systems and its spin-off Mindspeed Technologies, where he held positions of increasing responsibilities from 1999 to 2003. Prior to Conexant, he was with The Boston Consulting Group, a leading international strategy and general management consulting firm, where he worked with many European and US firms on a broad range of business and management issues, including revenue growth strategies, operational improvement, M&A, divestitures, and turnaround and restructuring.

www.irf.com

Avnet Memec Distributes Current Sensors from Allegro

Avnet Memec, the highly specialised semiconductor distributor of Avnet Electronics Marketing EMEA, adds a new range of automotive-grade, Hall-effect linear current sensors from Allegro MicroSystems Europe to its portfolio.

Each of the new products consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimised through the close proximity of the magnetic signal to the Hall transducer. The devices are supplied in a surface mount SOIC8 package. The leadframe is plated with 100% matt tin, which is compatible with standard lead (Pb) free printed circuit board assembly processes. Internally, the device is Pb-free, except for flip-chip high-temperature Pb-based solder balls, currently exempt from RoHS. Avnet Memec operates from 30 offices in 17 European countries and represents major semiconductor franchises on a pan-European basis. Its many major supplier partners include Cirrus Logic, Lattice, Marvell, NEC, and Silicon Laboratories.

www.avnet-memec.eu

PCIM Europe 2008
International Exhibition & Conference for
POWER ELECTRONICS
INTELLIGENT MOTION
POWER QUALITY
27 – 29 May 2008
Exhibition Centre Nuremberg

Get Up-to-Date with Tutorials

Europe's leading Exhibition and Conference for Power Electronics, Intelligent Motion and Power Quality/Energy Management is on the road to success again. In 2007, the exhibition achieved its largest exhibition space ever with 10,500 sqm, but already the figures for this year's event in Nuremberg (27-29 May 2008) are showing an increase.

The PCIM Europe Conference offers a three-day user-oriented program with renowned experts from industry and science. The day before the exhibition and conference, a series of tutorials will help answer the key questions currently being posed in the power electronics sector. With ten full day tutorials on Monday 26 May 2008, the conference offers an unparalleled programme. The tutorials will be led by top experts from the USA, France, Switzerland, Austria and Germany. The following gives an overview on the power electronics related topics.

Higher efficiency power conversion

Tutorial 1 held by Ionel Dan Jitaru, Delta Energy Systems (USA) will present a comprehensive overview of the latest techniques aimed at maximising the efficiency. The first part will focus on the topology selection, wherein new topology structures will be presented. The latest topologies are developed as a result of the latest changes in the system architecture and the availability of digital control. A special section will be dedicated to the rectification techniques and 'intelligent' rectification for low and high voltage application. Another section is dedicated to the new magnetic structures for efficiency optimisation. The magnetic section will be presented, together with the latest packaging technologies which play a critical role in efficiency optimisation through the minimisation of the parasitic elements in the circuit and heat management. The last section is dedicated to the digital control and digital assisted power conversion for efficiency optimisation. This new section underlines the future of power conversion using 'intelligent' power processing for efficiency optimisation. The presentation will be highlighted with design guidance, design example and experimental results.

Mr Jitaru has pioneered several trends in power conversion technologies such as 'Soft Switching', 'Full integrated multilayer PCB packaging concept', 'Synchronized rectification' and 'Intelligent power processing'. Some of these technologies have been covered by twenty-two granted patents and ten pending patents.

Advanced design with MOSFET and IGBT power modules

Tutorial 2 will be presented by Professor Josef Lutz, Chemnitz University of Technology, and Dr. Tobias Reimann, ISLE GmbH, Ilmenau (both Germany). The programme covers Power Devices/Modules/Reliability (new developments in MOSFETs, IGBTs, freewheeling diodes, module layouts, thermal mismatch/stress, power cycling capability, design for reliability); Drive and Protection (principles, failure modes/detection, current, voltage, temperature protection); Topology-dependent Power Losses (DC/DC and DC/AC converters, load cycles, calculation of heatsink); Device Induced Electromagnetic Disturbance Parasitics; and Special Application Aspects (paralleling and series connection, special effects in ZVS/ZCS topologies, special problems related to new device technologies, dynamic ruggedness of power diodes).

Mr Lutz joined Semikron Electronics in 1983. First, he worked in the development of GTO Thyristors, then in the field of fast recovery diodes. He introduced the Controlled Axial Lifetime (CAL) diode, is holder of several patents regarding fast diodes, and has published 116 papers and conference contributions. Since August 2001 he has been Professor for Power Electronics at Chemnitz University of Technology. Mr Reimann received his PhD in 1994 from the Ilmenau Technical University in the field of power semiconductor applications for hard and soft switching converters. In 1994, he was one of the founders of the ISLE company.

High frequency conductor losses in switchmode magnetics

Tutorial 3 by Bruce Carsten, Bruce Carsten Associates Inc. (USA) emphasizes an intuitive understanding of AC Skin and Proximity Effect losses in transformer and inductor windings. Formulas and approaches are provided for calculation of AC winding losses with arbitrary current waveforms. Methods for measuring AC winding resistance are discussed, with cautions on invalid measurements. Myths and misunderstandings are discussed, including that 'skin effect' is the current distribution in an isolated conductor, that foil and litz wire conductors reduce loss 'because they have more skin area', and that losses are inherently reduced when a solid conductor is replaced by litz wire of the same area. Loss mechanisms unique to planar winding will be presented.

Bruce Carsten has 37 years of design, development and research experience in high frequency and switchmode magnetics, at power levels ranging from 100mW to over 10kW and frequencies from up to MHz.

Advanced control techniques for switchmode power supplies

Tutorial 4 by Dr. Richard Redl, ELFI SA (Switzerland) presents advanced control concepts for switchmode power supplies, including single-loop (PWM, ripple regulators) and multi-loop (current-mode, feedforward) analog control, and also digital control. Auxiliary control functions (efficiency optimization, balancing paralleled or multiphase converters, overload protection, and reducing noise emission and sensitivity) are also discussed. Emphasis is on practical considerations and on providing guidelines about selecting the best control technique for an application.

Mr Redl is a Fellow of the IEEE and the director of ELFI SA, an electronics consulting company in Switzerland, specialising in power supplies and other power-conversion equipment, electronic ballasts, and integrated circuits for power management. He holds 22 patents, has written over hundred technical papers, and co-authored a book on the dynamic analysis of power converters.

Electromagnetic compatibility for higher frequencies power designs

Tutorial 5 by Jacques Laeuffer, Supèlec (France) deals with how to manage high frequency parasitic resonances just after semiconductors commutation, i.e. between MOS capacitance and transformer stray inductance; how to balance inductances reduction with capacitances increase; how to choose and design EMC optimised power converters (from 100W up to 100kW), and how to avoid expensive shielding. Over about 1MHz, conventional circuit theories with localised constants like 'parasitic capacitances' or 'stray inductances' need to be improved with a physical understanding of the electromagnetic propagation in and around power circuit.

Mr Laeuffer has 25 years experience in the field of Power Electronics for various applications, including inverters for radar servo controls, high frequency resonant converters, high voltage transformers for X-ray generators, and automotive drive systems for hybrid vehicles. He has written 74 technical papers, and is inventor of 27 patents. He received the 'Grand Prix de l'Innovation' of PSA Peugeot Citroen for year 2004.

FPGAs in drive technology with training on Sigma-Delta-ADCs

Tutorial 6 by Professor Dr Jens Onno Krah and Rolf Richter covers Inverter Design and Basic control hints for power stages, as well as applications for Sigma Delta Digital to Analog Converters. More and more functions like feedback processing or field bus implementations are realised in Field Programmable Gate Arrays (FPGA). Due to the innovation cycles of the semiconductor suppliers the size and the cost of the more and more complex and powerful inverter systems is not increasing. The FPGA Integrated Development Environment – Hands On Training – will include design flow, design entry, creating a project, creating a design using a block editor and VHDL, constraint entry, timing analysis, and implementation of a Sigma-Delta DAC/ADC.

Professor Dr.-Ing. Jens Onno Krah studied electrical engineering at the University Wuppertal and obtained his PhD 1993. Until February 2004 he worked as technical director for Danaher Motion, formerly Seidel Servo Drives. He was responsible for the development of the Danaher Motion Servo Drives. Since March 2004 Professor Krah has been teaching control engineering at the University of Applied Sciences Cologne. Dipl.-Ing. Rolf Richter studied electrical engineering at the University of Applied Science Bielefeld. From 1992 to 2001, he developed High-End processor and controller boards at dSPACE GmbH in Paderborn. Since 2001, he has been working as Field Application Engineer at EBV Elektronik in Munich as a specialist for programmable logic devices (PLD & FPGA) from Altera.

Practical switching power supply design

Tutorial 7 by Dr. Ray Ridley, Ridley Engineering Europe (France) covers some of the numerous topics that a power supply designer must be familiar with. The modern power supply designer is faced with a bewildering array of technology choices. As a result, many engineers choose design paths that lead to final products that are inadequate for today's demands. This seminar will provide new and unique insights that highlight the best ways to design switching power supplies. Numerous industry examples are presented to show how many modern products are victims of poor power supply design and how you can avoid mistakes.

Mr Ridley is the president of Ridley Engineering Inc. in the US, and Ridley Engineering Europe. He provides assistance to companies worldwide in the form of consulting, test equipment, design software, and unique hands-on power supply design courses. He has been designing switching power supplies for over 28 years.

Application opportunities of SiC devices

Tutorial 9 will cover different aspects from devices and material basics up to application specific topics by team of SiC specialist from Infineon and SiCED. The tutorial will give an introduction into SiC power devices in general, highlighting differences to silicon devices with respect to technology, device performance and application prospects. Special attention will be paid to commercially available devices like Schottky diodes (300V...1700V) and emerging switching devices. Topics like the cost efficient utilization of SiC devices and reliability aspects will be covered, as well as special features arising from application studies. Finally, an outlook to the future development directions in SiC technology will be given, taking into account the competitive environment of advanced silicon solutions and alternative wide band gap semiconductors, as well as the future role of (high voltage) SiC devices in power electronics.

IGBT gate drive technologies

Finally, Tutorial 10 by Dr. Reinhard Herzer and Markus Hermwille, SEMIKRON International (Germany) will cover Fundamentals (power control system, inverter principles, methods of potential separation, different applications), Power Devices (parameter and characteristics, parasitics, switching behaviour, switching times and losses), Driver Fundamentals (gate driver topologies, influence of different gate driver components on the switching behaviour, transmission of control signal and driving energy, transmission principles, galvanic isolation and level shift, variants of power supply: DC/DC converter, bootstrap power supply, charge pump, gate driving technologies and different gate drive circuits), Protection Techniques (under voltage protection, short pulse suppression and interlock, different kinds of short circuit protection, hard and soft turn-off), or Using IGBT Drivers (input and output signals, dimensioning and design of gate resistors, gate clamping, connection between gate driver and IGBT module, paralleling of modules).

Mr Herzer studied Electrical Engineering and, in 1984,received his PhD in the field of Microelectronics, and in 1992, his Habilitation in the field of Power Devices and Smart Power ICs from the Ilmenau Technical University. He joined Semikron Electronics Nuremberg, Germany in 1995 as head of the MOSFET, IGBT and IC research department. Mr Hermwille studied Electrical Engineering at the University of Applied Sciences in Dortmund, Germany. He was then employed as Sales Engineer at Thomson-CSF, he joined SEMIKRON in 2000 as Product Manager.

Comprehensive conference program

The conference program includes more than 120 first-time presentations delivered by international speakers. Four keynote papers, **Higher Junction Temperature in Power Modules - a demand from hybrid cars, a potential for the next step increase of power density for various Variable Speed Drives, Higher Frequencies Power Transformers Designs, Technologies for Practical Motor Drive System with Matrix Converter,** and **Mega-Speed Drive Systems: Pushing Beyond 1 Million RPM**, will highlight recent breakthroughs and upcoming applications. Within the special session '**Automotive Power**' organised by Power Electronics Europe, representatives from industry will report on their experiences and results with power electronics for hybrid vehicles. Finally, the Best Paper Award also sponsored by Power Electronics Europe will be presented at the opening ceremony.

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Reliable Power Electronics for Windmill Generators

In the megawatt range, high-power electronics applications need powerful semiconductors. However, even the largest semiconductors available today are still not strong enough for some applications. It is therefore necessary to connect them in parallel. **Dejan Schreiber, Senior Applications Manager, SEMIKRON, Nuremberg, Germany**

One possible solution is discussed in this context: power electronics assembly, IGBT base units containing IGBTs and diodes, heatsinks, DC-link capacitors, drivers and protection, auxiliary power supply and a PWM controller (one independent unit), arranged into a three-phase inverter. Such units can be connected in parallel, for example for a four-quadrant drive windmill with permanent magnet generator and a full-size 4MW converter, which is presented here. A method is described of obtaining higher levels of power in medium-voltage windmill applications that involves using line interface connection of variable-speed, medium-voltage PM generators with no voltage and power restrictions, as well as proven semiconductors and components. Basic power electronic units are connected in series for higher voltages and in parallel for higher power levels.

Comparison of IGBT efficiency with different blocking voltages

IGBTs are the working horses of power electronics systems. Today, IGBTs are manufactured in various voltage classes, from 1200 or 1700V for different industrial applications, as well as for the medium-voltage classes 3.3, 4.5, and 6.5kV. Which voltage class is best suited to high-power applications? The answer to this question lies in putting the IGBTs in the largest casing available in order to obtain inverters. Of course, it is much simpler to simulate available power under optimal working conditions.

To do so, the largest standard casing (IHM, 190mm wide) is taken. The IGBTs are packed into this casing and the optimal operating regimes defined - V_{dc} DC operational link voltage, V_{ac} AC output voltage, a carrier switching frequency F_{sw} of 3.6kHz and best possible cooling conditions. Figure 1 (left) shows the different available power levels, calculated on the basis of the given parameters.

The results show that the maximum available power using 3.3kV, 1200A individual modules would be one half of the equivalent power obtained using 1.7kV, 2400A IGBTs. The 6.5kV, 600A IGBT modules provide just one quarter of what would be obtained with a 1700V IGBT. The reason behind these results is the losses that occur in IGBT modules. If we calculate the efficiency of the three converters shown in Figure 1 (right) at same cooling conditions and $F_{sw} =$ 3.6kHz; $\cos\varphi = 0.9$ and same module, we can see that the losses have a ratio of 1:2:4.

For this comparison, we have used the same carrier switching frequency. This enables us to design inverters with relatively small filters. A comparison using different carrier switching frequencies would lead to variations in the output sinusoidal filters used. Given all of the above, it can be seen that the greatest efficiency is accomplished by using the 1700V IGBT, a standard industrial product with a very reasonable price per module.

IGBTs for 1700V are packed in various module casings. For comparison, we can take the largest single-switch module, the IHM 2400A/1700V, and compare two such modules with a dual module of similar size and length, SKiiP1513GB172. If the two SKiiPs are put back to back on one heat sink, a half-bridge is obtained for currents 2 x 1500A = 3000A (case temperature = 25°C), or 2250A for a case temperature of 70°C. Two single-switch modules will provide a half-bridge for 2400A. If we compare the results of the calculations, we can see that the SKiiP solution provides higher output currents throughout the complete range of switching frequencies than a standard module in the largest available case would (see Figure 2).

If a more powerful SKiiP module is

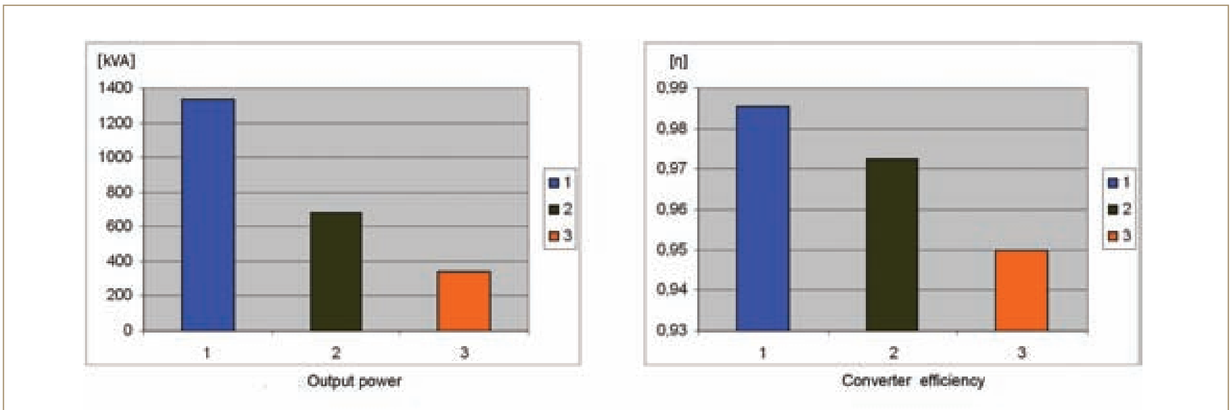
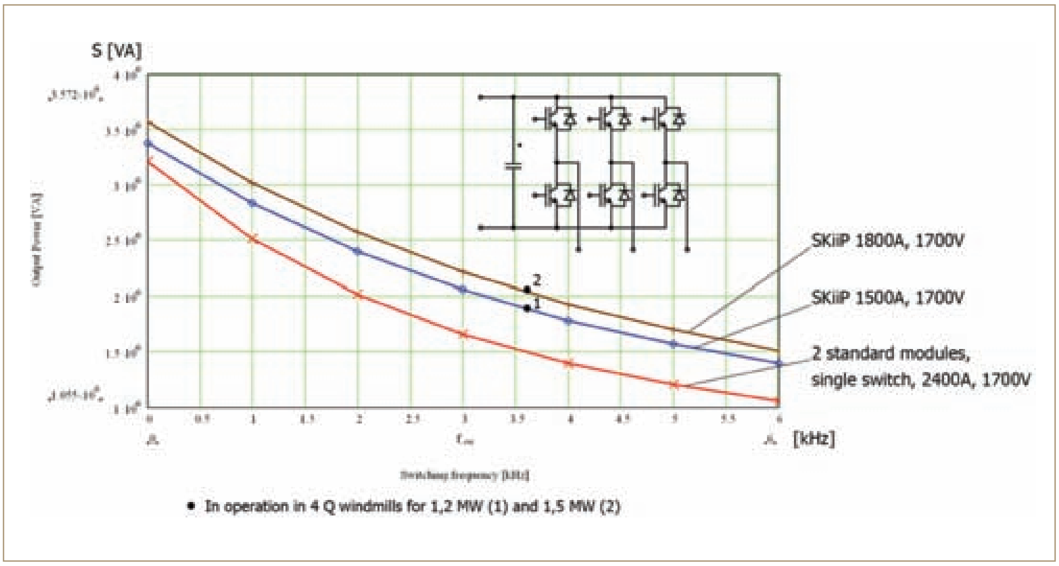


Figure 1: Comparison of output power (left) and efficiency of IGBT converters with different blocking voltages at same cooling conditions and F_{sw} = 3.6kHz; cosφ = 0.9 and same module

Figure 2: **Available inverter power versus switching frequency**



taken, for example the SKiiP 1800A, 1700V, which uses an aluminum nitrate (ceramic) substrate, even more power is available from a three-phase inverter, i.e. 1800kVA (see Figure 3).

Paralleled IGBT modules

Numerous solutions are feasible for the parallel operation of IGBT modules, i.e. one three-phase inverter for the entire power. Here the phase leg is constructed with several IGBT modules connected in parallel and one powerful driver. Each IGBT module must have its own gate resistor and symmetrical DC link and AC output connection [1]; and hard paralleling of three-phase IGBT base units. The whole system is controlled via one controller and its PWM signals. All of the three-phase inverters are connected to a common DC link voltage. Paralleling is achieved using driver paralleling boards for each individual base unit driver. Slight variations in driver propagation times (less than 100ns) are compensated for with small AC output chokes; (<5µH inductance). All of the three-phase inverters run simultaneously, with the small time delays that occur being compensated for with additional AC chokes. To ensure proper load-current sharing, symmetrical layouts and positive temperature coefficients for IGBT saturation voltages are used [2].

An other solution as described under [2] features additional PWM signal correction for each base unit. Additional PWM corrections are performed to control precise load-current sharing in paralleled base units; parallel operation of several units with synchronous PWM and the elimination of circulated current using additional sophisticated PWM control [3]; or galvanic load isolation for each base unit. Each base unit supplies power to the load through insulated windings. Each base unit has its own controller. PWMs are independent, non-synchronous, free-running signals, and each base unit has its own separate DC link. On the grid side, each base unit has its own sinusoidal LC filter. Circulated currents between different DC links do not exist provided the outputs are galvanically insulated. This is the easiest parallelisation method for standard independent basic units with standard independent controllers. A simple design based on galvanic insulation on the generator side is shown in Figure 4.

Three 1500kVA four-quadrant drive units are connected to separate generator windings of a permanent magnet windmill generator. Each four-quadrant drive is a standard drive with its own generator-side and grid-side controllers. The purpose of the fourth controller is to provide uniform generator torque sharing. Should problems occur in one of the 4Q drives during operation, the remaining drives will continue to operate. The system described is used in a 3.6MW windmill with a PM generator with three separate windings. The system is designed for up to 12 four-quadrant drives in parallel and for the connection of 12 generators or 12 generator windings [4].

Series connection of base units

Windmill design engineers have a number of aspects to take into their designs, i.e. high-power wind turbine, low losses, variable speed, high degree of efficiency, use of proven semiconductors, clean sinusoidal line current using a simple line transformer, good line power factor

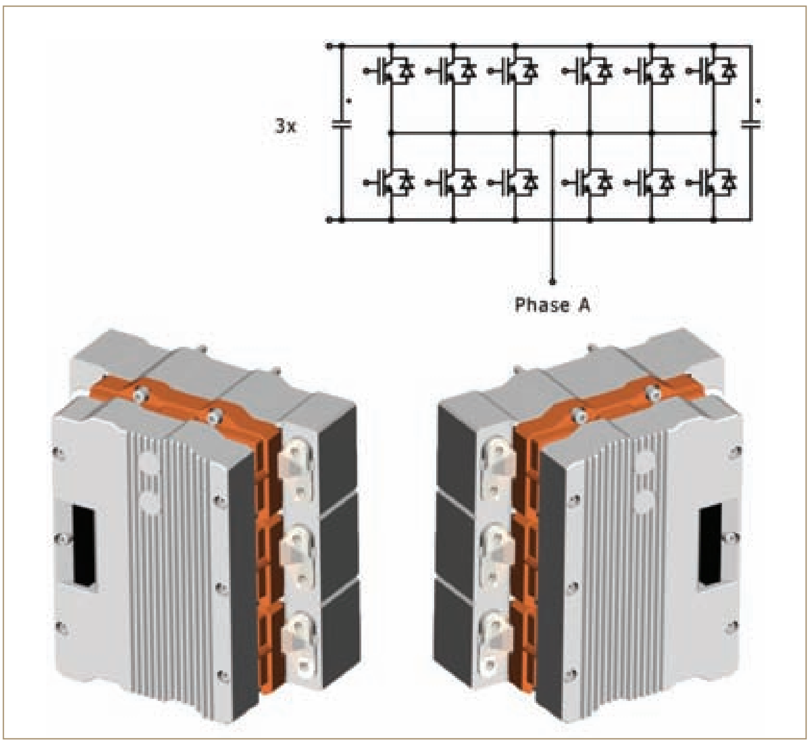
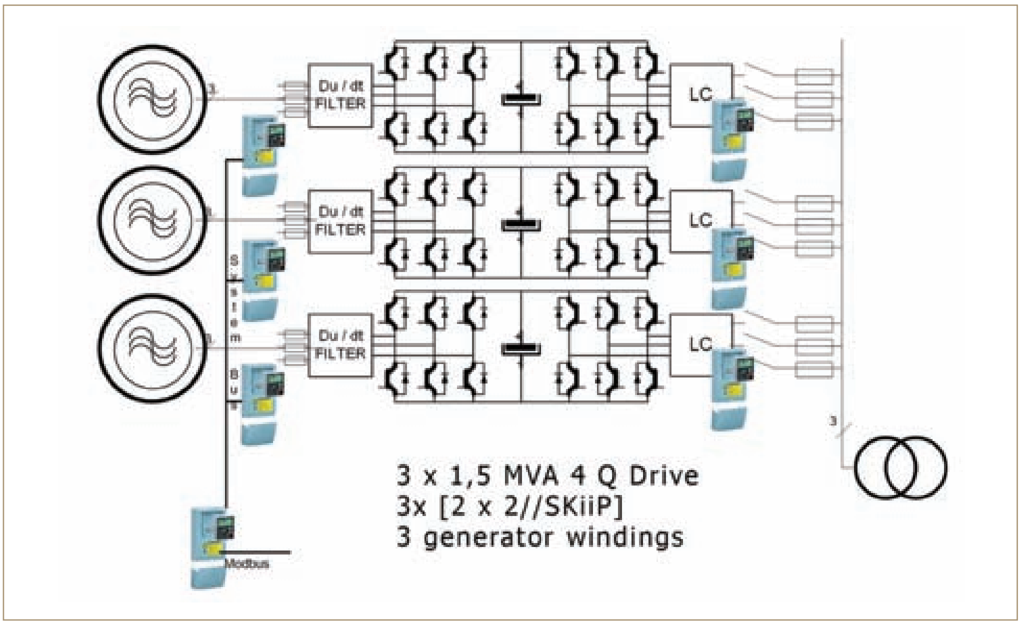


Figure 3: **Example of a 1800kVA base unit**

Figure 4: **Three independent 4Q drives in parallel with separate motor windings, the drive can operate with one or two drives in parallel**



and low THD, active and reactive power control, modular design to allow for use with various powers and voltages, quick assembly, high degree of reliability, and lowest possible costs. Best solution is the medium-voltage generator.

A medium-voltage generator is a must in high-power windmill designs of the future. Medium-voltage silicon, however, is not suitable for such applications. The right solution is therefore to connect base units in series.

An example: a 5MW windmill generator with 6.3kV rated output voltage has output currents of 3 x 436A_{rms}. The rectified variable speed generator voltage is in the range of 1 to 10kVDC. How can such variable voltage be connected to the grid?

Each windmill needs to have its own transformer to allow for connection to the grid; grid voltage would be in the range of 20 to 30kV, which would be the transformer output voltage. The transformer can be produced with several - in this case 10 - three-phase windings, each for 3 x 690V, which are used as input voltages. The new medium-voltage windmill principle is shown in Figure 5.

One base unit, a 600kVA three-phase inverter, is attached to each three-phase winding. A fourth IGBT leg can be connected in front of each base unit. This arrangement can be referred to as a medium-voltage cell. All of the cells can be connected in series, as shown in Figure 7. If the IGBT switch of the fourth leg is switched-off, the generator DC current will charge the cell DC-link voltage. The three-phase inverter on the cell-grid side discharges, controlling its own DC-link voltage. For 3 x 690VAC voltage, the DC-link voltage will be 1050V. Ten base units in series can produce a Counter Electro Motive Force (EMF) of up to 10 x1050 = 10.5kV. The voltage remains balanced with the rectified generator voltage. If the generator speed is lower, the generator voltage will be lower, too. For this reason, to control the rectified DC current, which in turn means controlling the generator torque, some of the cells have to be bypassed. If five cells are bypassed, the remaining counter EMF is 5 x 1050 = 5.25kV. Bypassing more cells will increase the DC current and the generator torque. Bypassed cells can deliver full reactive power to the grid. If one cell is not functioning, it will also be bypassed. The maximum cell DC link voltage is 1200V. For this reason, even as few as nine cells in series can carry the rectified generator voltage of up to 9 x 1200V = 10.8kV.

Conclusion

High-power applications use numerous IGBT modules. It is far better, however, to use more switches with separate controls, e.g. several units connected in parallel or in series rather than one large single unit. The advantages are as follows: good line power factor and low current THD with a lower switching frequency and fewer passive components, modular design that is suitable for various powers and voltages, as well as quick assembly, use of proven semiconductor elements, greater efficiency, high degree of reliability, and extremely low costs per kW.

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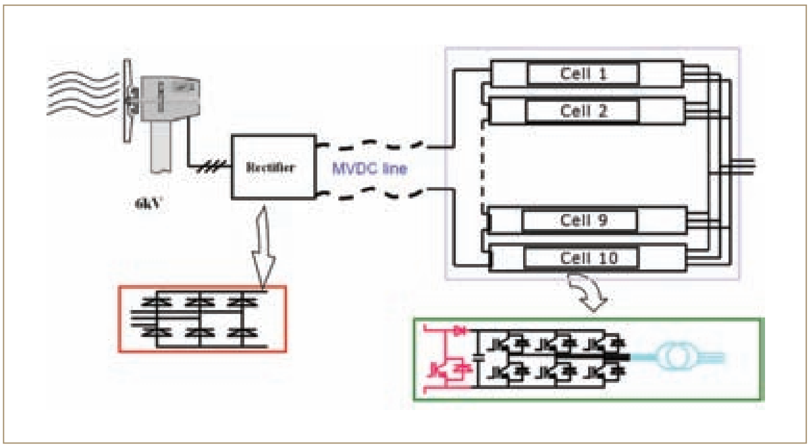


Figure 5: **Cell-based medium-voltage windmill**

New Intelligent Power Module Series

Continuous market growth of general purpose inverters and servo drives is boosting the demand of Intelligent Power Modules (IPM). The new IPM 'L1-Series' featuring high speed and low loss IGBT chips with full gate CSTBT and is mechanical compatible to the existing L-Series IPM. **Prasad Bhalerao and Robert Wiatr, Mitsubishi Electric Europe, Ratingen, Germany**

The popularity of IGBTs in a wide range of industrial power conversion applications is a direct result of the technological advances that have been made. The development over the last few years has made the IGBT a power switch with rugged switching characteristics, low losses and simple gate drive.

Advances in module design

The existing L-Series IPM family (50 to 600A/600V, 25 to 450A /1200V) uses well-proven 5th generation CSTBT IGBT chip and is designed for optimized switching and conduction losses for reduced EMI performance up to 20kHz. The series is equipped with newly developed protection and control IC making easy interface with supplier circuitry.

Using the advantage of existing L-Series package, L1-Series incorporates new full gate CSTBT IGBT chip for improved electrical performance. The new L1-Series IPM family includes 50 to 300A/600V and 25 to 150A/1200V compatible L-Series IPM package and also introduces new 7 in 1 small package (90mm x 50mm) for 50A/600V and 25A/1200V range. Table 1 shows the line up and package outline of new L1-Series IPM for 600 and 1200V. L1-Series is suitable for a wide range of applications such as servo drives, air conditioners and standard motor control.

Figure 1 shows the difference of CSTBT structures in L-Series and L1-Series IPM. The inactive plugging cell merge into active parallel gates in full gate CSTBT gives better trade-off performance ($V_{CE(sat)}$ and $E_{(off)}$). Also $V_{CE(sat)}$ of 1.9V of L-Series IPM is further reduced to 1.75V (@ T_j = 125°C) in L1-Series by keeping E_{off} almost at the same level. The total switching losses in L1-Series is reduced by 15%, as compared to L-Series at comparable conditions. Table 2 shows the comparison of characteristic data of L-Series and L1-Series IPM. It can be seen that power cycling is increased by almost 63% by new wire bond technology. Figure 2 shows a loss comparison of L-Series 75A/1200V and L1-Series (conditions: V_{cc} = 600V, V_D = 15V,

L1-Series Line up and Package

600V	50A	50, 75, 100, 150A	200, 300A
1200V	25A	25, 50, 75A	100, 150A
	Type S 7in1	Type A(screw) / B(pin) (L-Series compatible)	Type C (L-Series compatible)
Package Size	90 x 50 (mm)	Type A: 131 x 66.75 (mm) Type B: 120 x 55 (mm)	135 x 110 (mm)

Table 1: **L1-Series IPM product line-up**

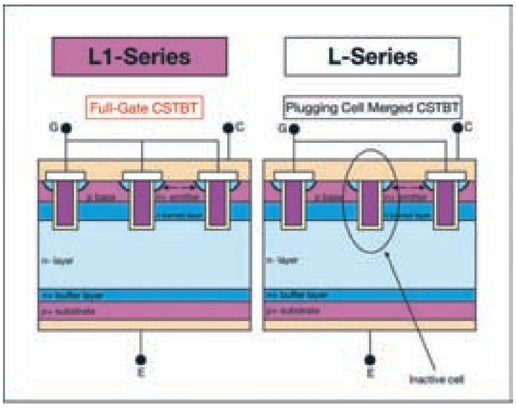


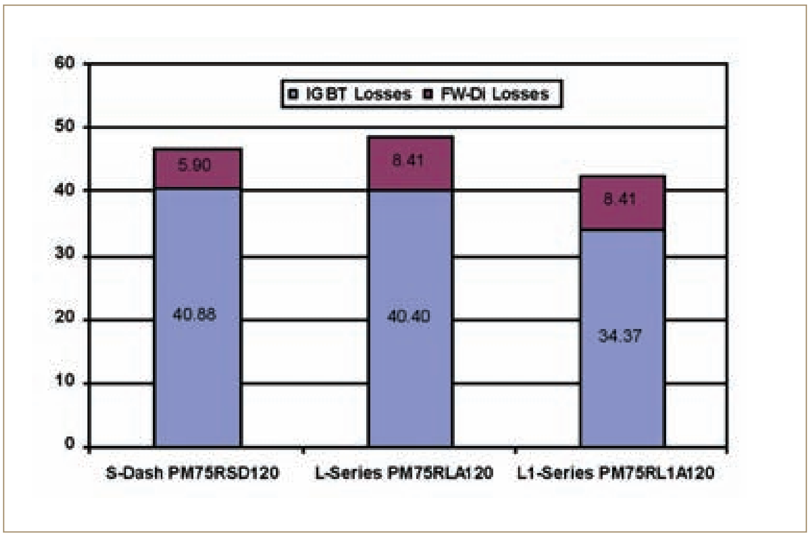
Figure 1: **New full gate CSTBT structure of L1-Series IPM**

	L-SERIES IPM	L1-SERIES IPM
$V_{CE(sat)}$ (V_D = 15V, I_C = 75A, T_j = 125°C)	1.9V	1.75V
E_{on} (V_D = 15V, V_{CC} = 600V, I_C = 75A, T_j = 25°C)	10.2mJ	10.5mJ
E_{off} (V_D = 15V, V_{CC} = 600V, I_C = 75A, T_j = 25°C)	6.5mJ	6.5mJ
$R_{th(j-c)}$	0.21°C/W	0.21°C/W
Power cycle (Δ T_j of 1000 Million cycles)	29°C	46°C

Table 2: **Comparison of electrical data of L-Series and L1-Series IPM (75A/1200V)**

Figure 2: Loss comparison of L-Series 75A /1200V and L1-Series

$I_L = 33A_{rms}$, $f_c = 5kHz$, p.f = 0.8, 3 phase PWM).

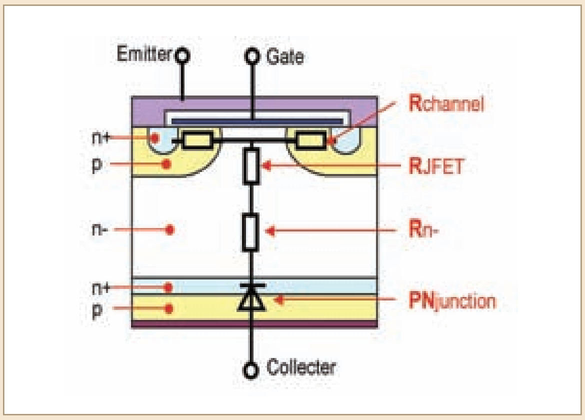


Conclusion

With the improved electrical performance at the same time keeping the high level of mechanical compatibility with existing L-Series IPM, new L1-Series IPMs offer a better product for servo, air-conditioning and standard motor control customers. Such improvement in IPM technology will get more attention and approval from the market in order to reduce the size, cost and time of the entire system.

Advances in power semiconductors

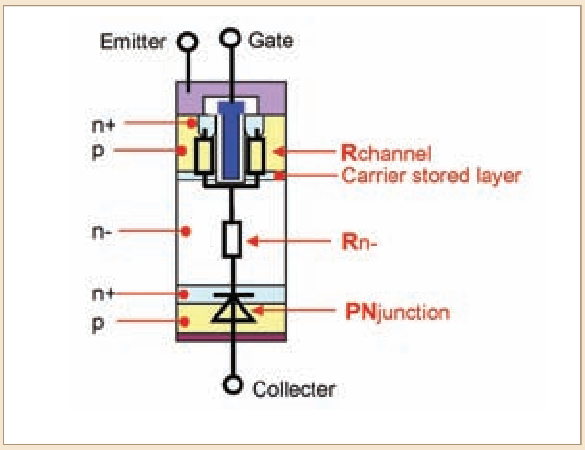
Improvements in the IGBT performance have generally been achieved by finer surface patterns and shallow diffusion technologies. But this conventional structure has four major resistance portions – MOS-channel, JFET, n-layer and PN-junction. The voltage drop of JFET and n- layer occupies more than 50% of the total saturation voltage $V_{ce(sat)}$. A significant performance gain was obtained by moving from planar IGBT structures to trench gate cell structures for the IGBT combined with a new carrier lifetime control process. Due to their high internal amplification, $\Delta V_{GE}/\Delta I_C$, trench gate IGBTs show increased natural short-circuit currents. In addition, the high cell density trench gate devices have an increased gate capacitance, resulting in higher power requirements for the gate driver. For heightened switching frequencies specially, this fact has to be considered for gate drive design.



Structure of planar IGBT

To surmount these drawbacks, still keeping the significant advantages of trench gate IGBTs, the Carrier Stored Trench Gate Bipolar Transistor (CSTBT) has been developed, which yields low on-state voltage compared with conventional IGBTs. Key technologies of this CSTBT are trench gate and carrier stored layer. Because the current through the narrow JFET area causes voltage drop of JFET portion, CSTBT is removing the JFET area completely by trench gate structure. The current can flow from the MOS-channel to the n- layer directly. As a result, CSTBT has no JFET voltage drop.

Secondly, the current through the resistance of n- layer causes voltage drop in n-layer. It is necessary to increase the carrier density in n- layer in order to decrease the resistance of n- layer. However, real carrier density in n- layer has some local distribution: at collector side the carrier density is rich, whereas at emitter side it is lean. Therefore, the main voltage drop in n- layer is caused by emitter side lean area. So it is very effective to increase the carrier density of emitter side area in order to decrease the voltage drop in n-layer. The carrier stored layer is employed nearby the emitter side n- layer. This carrier stored layer can intercept the escaping carriers like a 'water dam'. Thus, the carrier density at the emitter side of n- layer is increased, the total resistance of n- layer is decreased, and consequently the voltage drop in n- layer is reduced. Furthermore, increased carriers in n- layer by carrier-stored layer fasten the turn-on switching ability. So CSTBT can reduce not only static losses, but also switching losses.



Structure of CSTBT

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System-Oriented IGBT Module for High Power Inverters

Although IGBT modules with blocking voltages up to 6500V are available today, there are many applications that require the design of inverters with ratings close to or even beyond 1MVA with 1200V or 1700V devices. The recently introduced PrimePACK module housing, together with the new IGBT4 technology in 1200 and 1700V, fits this market by enabling a cost-effective and modular inverter design. **Piotr Luniewski and Uwe Jansen, Infineon Technologies AG, Warstein, Germany**

Applications like variable speed drives, UPS-systems, heavy-duty commercial vehicles, as well as grid connection of microturbines or renewable energy systems, like windmills or large solar farms, often imply system restrictions that do not allow designs with higher voltage levels. A converter design faces at least two problems: power part volume and efficiency. When a converter dedicated to high-power application is considered, then in most cases the power electronic equipment, consisting of IGBT modules, DC-link capacitors and heatsink, is usually installed in control cubicles having a height of 1.80 to 2.20m, airflow from bottom to top and being placed in front of a wall. An alternative approach uses racks where several heatsinks placed above each other are cooled by a horizontal airflow entering the cabinet at the front and leaving it at the back. In both cases, the most important dimension for the end user is the width of the cabinets.

Reducing the inverter size

To limit overall equipment size, it is therefore advantageous to use a heatsink as long and deep as possible, but with limited width. Hence, a PrimePACK module with narrow and long baseplate helps to achieve the right heatsink dimensions and proper heat distribution. Further reduction in heatsink volume is possible by operating this module with extended junction temperature T_{vjop} = 150°C. Figure 1 shows that increasing operating junction temperature is a much more useful means to increase power dissipation than to increase heatsink size significantly beyond module footprint.

Converter efficiency is mainly determined by the semiconductor technology used for IGBTs and diodes. Hence, in recent years much effort has been spent in tailoring semiconductor technology to the different applications and power levels. To meet more recent growing requirements for 'Energy Efficiency,' the PrimePACK module is equipped with the new Trench-/Fieldstop IGBT4 generation. Thus, the module family comes as a product basically dedicated to two inverter power levels: medium (E4) and high power (P4) in 1200V [1] and 1700V class. Major focus has been set on further reduction of the forward voltage drop and switching losses. However, especially in high power applications, low dynamic losses are not the main target. To cope with over-voltages and EMI, appropriate controllability and a certain softness during module

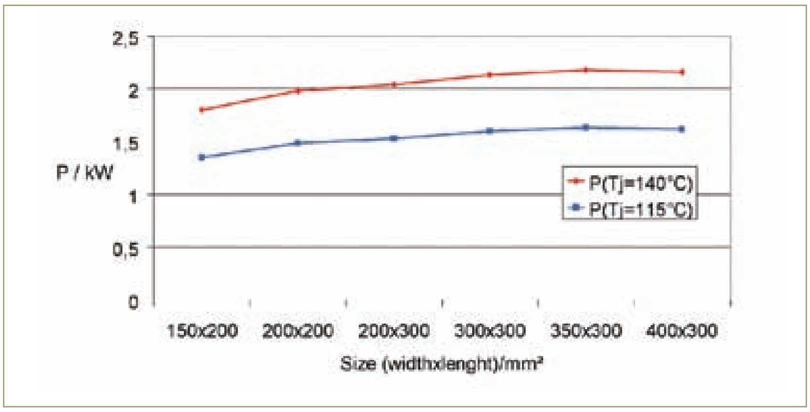

Figure 1: **Power dissipation of a 150mm x 150mm module at different junction operating temperatures**

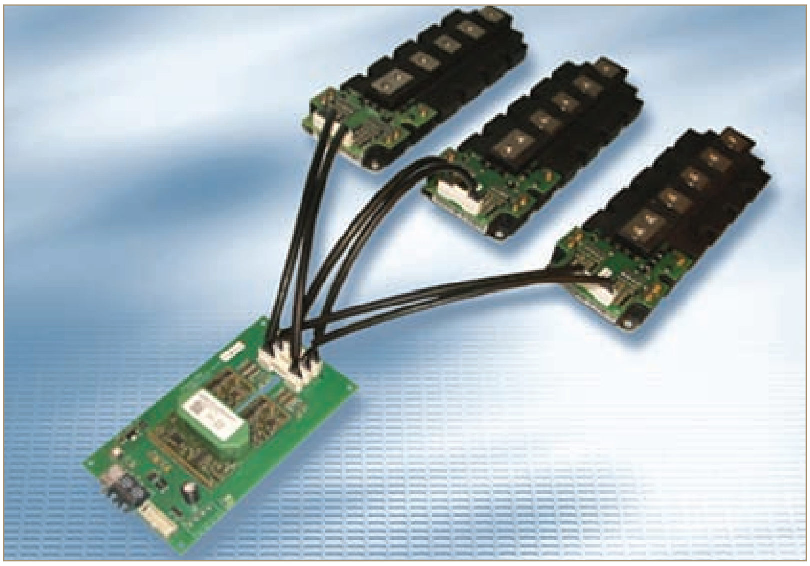

Figure 2: **Flexible driver system consisting of MA300Exx, 2ED300E12-SFO and 2ED300C17-S for 1200 and 1700V PrimePACK modules**

switching is required and seen as main development target [2]. Thanks to various current ratings, the PrimePACK modules provide a good match to converters with different power range without changing the module housing.

As most of the converters consists of several branches where each one has two IGBTs in series, the PrimePACK module is in half-bridge configuration together with FWD diodes embedded in one housing. This type of internal layout and connections reduces stray inductances in commutation loop compared to legs composed from single modules.

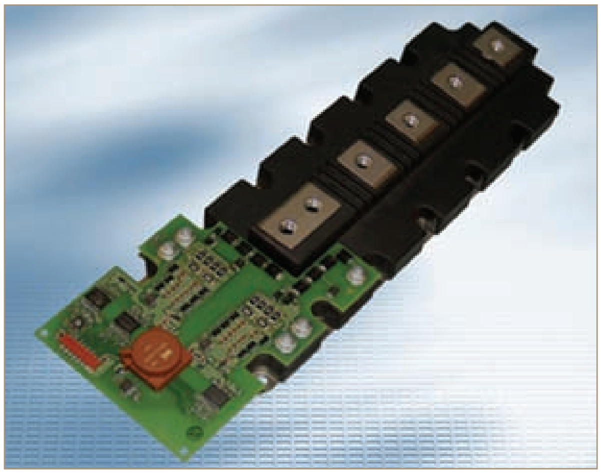

Figure 3: The 2ED250E12-F evaluation driver board for 1200V single PrimePACK module

Increasing output power

Increased power of the inverter system can be realised by parallel connection of smaller inverters or by paralleling modules in one inverter design. The long and narrow module shape and the half-bridge configuration are especially beneficial where paralleling modules in one inverter is preferable.

Modularity of the power inverter system on one hand is given by system oriented module design, but on the other hand, the IGBT driver must support the flexibility goals. Efficient use of modules in parallel connection with optimised current balance requires applying a suitable IGBT driver approach [3]. Figure 2 shows an example of where a driver system can be used for 1200V as well as for 1700V PrimePACK modules with minor changes. This driver kit is suitable for driving up to three modules in parallel. In any case, one EiceDRIVER 2ED300C17-S drive and one 2ED300E17-SFO adapter board is necessary. The number of module adapter boards MA300EXX is always the same as the number of modules [4, 5].

In a converter requiring only one high power module, modularity in parallel operation is not needed and the driving system can be optimised, resulting in reduction of cost and volume. The PCB driver designated 2ED250E12-F employing an EiceDRIVER-IC 1ED020I12-F [6] and dedicated to the 1200V devices of the PrimePACK family is depicted in Figure 3. Thanks to the Coreless Transformer technology [7] and protection functions implemented in the design, the 2ED250E12-F driver complements the PrimePACK module as a building block comparable to an IPM (Intelligent Power Module) in half-bridge configuration.

Conclusion

PrimePACK modules today are available in 1200 and 1700V class, various current ratings and two different IGBT technologies. This approach makes these modules mechanically universal and electrically suited for many high power applications. Finding a perfect match to final design by appropriate trade-off between static and dynamic loses is additionally supported by a modular driver approach [3].

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Current Sensor Selection for Demanding Applications

Following on from the general approach we adopted in PEE 8-2007, we now concentrate our attention on the three principle technologies used where accurate, reliable and cost-effective current measurement is required. With this article we will restrict current sensor types to the three major types, namely shunts with and without galvanic isolation, open-loop hall-effect current sensors and closed-loop hall-effect current sensors. **Warren Pettigrew, CTO Raztec Sensors, Christchurch, New Zealand**

At this point, we should now analyse the major aspects affecting current sensor performance that should be considered when identifying the most suitable sensing technology for a given application.

Effects of temperature

Maintaining accuracy over the automotive temperature range of -40 to 125°C can be a challenge for a number of reasons. Just about everything drifts with temperature!

Additionally, the failure rate of many components accelerates at high temperatures, particularly if there is significant self-heating in the device. Closed loop sensors (Figure 1) have considerable self-heating which severely restrict their application at high temperatures. In fact, very few closed-loop sensors are available with a 125°C rating.

Shunts (Figure 2) also have considerable self-heating, particularly at high current, and if the shunt resistance is high so as to give a good signal amplitude. This can lead to considerable variations of resistance with current. Additionally, unless materials are very carefully selected and temperature gradients are minimised, thermoelectric voltages can completely distort low current readings. Ultimately, it is thermoelectric generated voltages combined with input offset voltage drift of the interface amplifier that limits the low current measuring capability of a shunt.

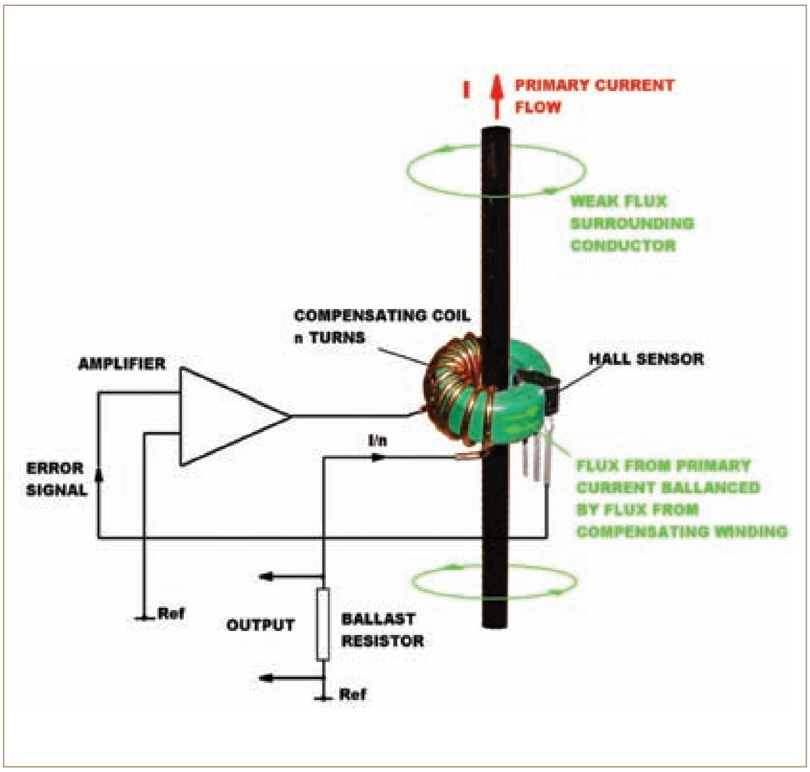

Figure 1: **Closed loop current sensor operation**

Open-loop sensors (Figures 3 and 4) are also not without their problems either at high temperatures or, more importantly, temperature shift. Provided the primary conductor is appropriately proportioned, open loop sensors have insignificant self-heating with low frequency current flow, but their performance may change with temperature. These sensors are prone to drift of offset and gain, but temperature stable devices are available. However, an open loop sensor is unlikely to match the gain stability of closed loop.

Figure 2: **Shunt with four terminals**

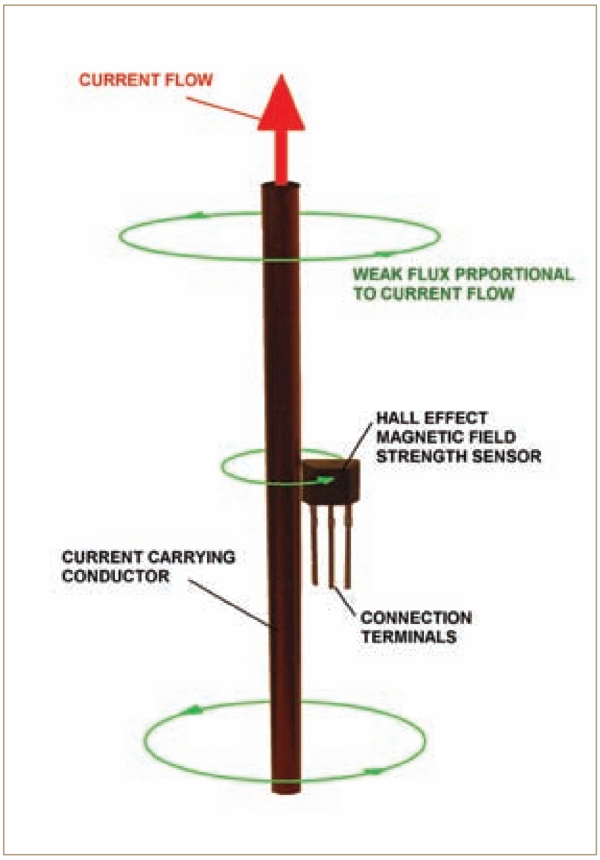

Figure 3: Coreless open loop current sensing

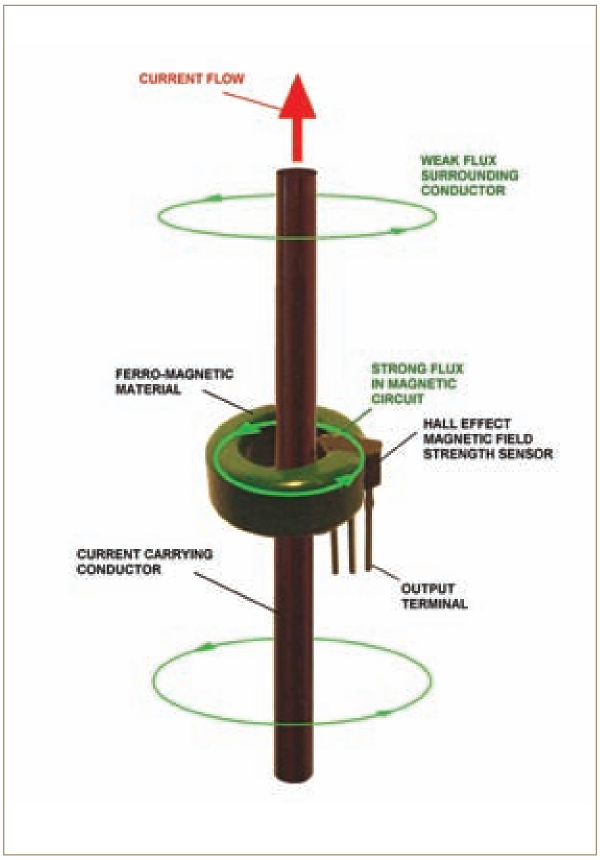

Figure 4: Open loop current sensor operation

Offset stability

The suitability of a sensor to measure small currents accurately (as well as high currents) is dependant on the stability of the offset voltage.

As mentioned above, temperature changes cause offset shift, but a significant contributor is shifts due to remanence effects in the magnetic circuit of the sensor. Reasonably good material can cause a 0.5% shift of output after a significant current excursion. The greater the excursion, the greater the shift of output. Very special material may be twice as good and leave 0.25% of remanent shift. Both open and closed-loop sensors are equally affected by remanence. Only an air circuit exhibits zero remanence.

But sensors that don't use flux concentrators without suitable shielding are very vulnerable to stray magnetic fields. Even the earth's magnetic field can look like 0.4A. Shifts due to nearby solenoids can be very large, as will the influence of nearby current carrying conductors.

Shunts can exhibit variable offsets from thermo-electric effects due to temperature gradients in the shunt or its interfacing circuitry, which certainly includes its amplifier and A/D converter.

Dynamic range

The upper limit of a closed loop sensor is limited by the current rating of the compensating winding. This may have a high short-term rating, but thermal time constants are likely to be fast and the winding is a significant heat generator. The lower limit is set by remanent voltage.

Open loop sensor span may be limited by either core saturation or magnetic field sensor saturation. Ferrite cores have a lower saturation than iron based cores which limit their usefulness to about 180AT. Current rating is tailored by altering the magnetic circuit reluctance by altering the width of the magnetic sensor air gap. Materials with high saturation flux densities may be selected, but these tend to have high remanence. Additionally, iron cores exhibit considerable heating with high frequency (>20kHz) current flow. Ferrite is much superior in this regard. The lower practical limit again is set by remanence and possibly also by thermally induced null drift. A dynamic range of 200:1 is very practical for open and closed-loop sensors.

The upper current rating of shunts is set by their heating. Heating is proportional to the shunt resistance. But the signal to noise ratio and precision to a large extent is also proportional to the resistance. Therefore, the greater the required precision, the greater the heat generated. The lower limit is set by thermoelectric voltages, input offset drift and noise. A practical dynamic range for shunts would be 1000:1, but this is dependant on a number of factors.

This dynamic range can be matched by coreless open-loop high (~1500A) current sensors that incorporate magnetic screening. These devices are largely immune to remanence effects and offset drift can be managed down to low levels.

Also, in practice the dynamic range of a

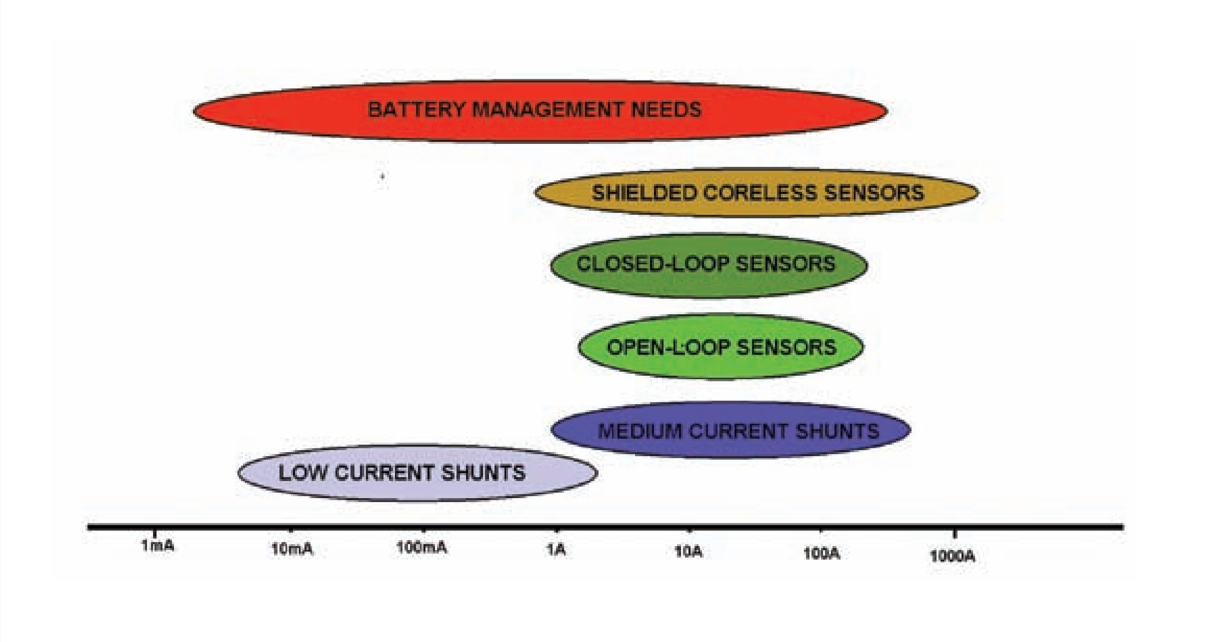

Figure 5: Typical current ranges for single devices of each current sensing technology

sensor is governed by the signal to noise ratio. This is especially true in high frequency circuits where noise filtering could kill the frequency response. For example, if a 10,000:1 dynamic range was required and the maximum voltage swing was 2V, 0.2mV must be sensed reliably. This could well be a challenge in a practical environment where noise levels could be in the order of hundreds of millivolts.

The author of this article has recognised the need for a practically priced sensor with a wide dynamic current range and will describe a solution in a following article. Such devices are particularly relevant to accurate and reliable battery management.

Frequency response

The frequency response of open loop sensors has been traditionally limited to about 20kHz, but this does not have to be the case. It is possible to manufacture sensors that respond to frequencies to 350kHz. The limitation is normally the hall element buffer amplifier. It is relatively easy to achieve good (~100kHz) frequency response from closed loop sensors by incorporating their inherent current transformer. The closed loop sensor is effectively a CT with the DC offset voltage added.

The frequency response of a shunt is dependant on its inductance; this being proportional to its length. High frequency currents induce Ldi/dt effects which can easily swamp the I x R voltage. If this noise is filtered, the frequency response could well be compromised.

Just as shunts are vulnerable to di/dt effects, open and closed-loop sensors are vulnerable to dv/dt effects. Unless carefully designed and electrostatic screening is implemented, switching noise can swamp sensor output – particularly if switching voltages are high.

These problems can be alleviated somewhat with digital systems. The D/A conversion can be implemented away (in time) from the power bridge switching point.

Destructive overload capability

Open loop current sensors excel with this quality. The rating is purely the rating of the conductor passing through the device. The provision of adequate apertures is not a significant design challenge.

Closed loop sensors are not quite as good, as they absorb significant quiescent current when the primary current is high. This generates appreciable self-heating, but they are immune to short duration high current transients.

High (fault) currents can easily damage shunts. They are constructed like a fuse. Also, a thermal transient could alter their calibration.

Size

For currents above about 50A, open-loop sensors become smaller than shunts. Often the size is defined by creepage requirements for the particular voltage rating. Closed-loop sensors are always a little larger due to the bulk of the included compensating winding.

Price

The stand-alone cost of a shunt is generally less than other DC capable sensing technologies. However, if we take into account the cost of interfacing devices and components necessary to give necessary common-mode rejection or galvanic isolation, then shunts may well not be the cheapest option. Open and closed loop sensors can generally ‘talk’ directly to an A/D or analogue circuitry. Some closed loop sensors do require a ballast resistor. Due to the cost of the compensating winding and its driver, closed-loop sensors will always be more expensive than open-loop for the same size.

Conclusion

As illustrated by Figure 5, there is at present no one technology that is suitable for accurately providing the wide range required by particularly demanding applications such as high power battery management... but with recent developments, all of that is about to change. It is often not easy to decide the most appropriate technology. It may be necessary to do trial designs incorporating each technology before a conclusive decision can be made. Hopefully, this article can help a little with the process. It may be that none of the technology is appropriate. In this case, it may be best to approach a specialist supplier. They may well be able to help with a custom solution.

Literature

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Gate Drive Optocoupler Simplifies Inverter Design

Replacing conventional single and multi-speed electric motors with semiconductor-based variable-speed drives offers significant energy savings. A growing number of engineers choose to use integrated gate drive optocouplers in their inverter designs. First of all, integrated gate drive optocouplers provide both level shifting and reinforced (safe) isolation at the interface between the power stage and the control circuitry. The new ACPL-H312 integrated gate drive optocoupler is a basic building block for all kinds of inverters.

Erik Halvordsson, Avago Technologies, Böblingen, Germany

As an effect of high energy prices and increased attention to environmental issues, the market for energy-saving or 'green' technology is soaring. Replacing conventional single- and multi-speed electric motors with semiconductor-based variable-speed drives offers significant energy savings and a return on investment which can readily be seen in the electricity bill. By introducing the same type of technology into cars (hybrid electrical vehicles), the automotive industry is able to save 20 to 30% on total fuel consumption. On the supply side of the energy equation, semiconductor-based inverters are enabling efficient conversion of green energy, for example solar or wind energy, into electrical power. In the examples mentioned above, the investment in new technology is offset by a savings in energy consumption. For such investments to make sense, it is critical to keep maintenance costs as low as possible. Therefore, producers of drives are challenged to provide smaller and more feature-rich products, while maintaining or improving the overall system performance and reliability.

Reduced footprint

The new ACPL-H312 integrated gate drive optocoupler is a smaller version of the well-known Avago HCPL-3120 (see Figure 1), a basic building block for all kinds of inverters. Providing the same output current (2.5 A), but packaged in a 'stretched' SO-8 package, the new device saves 40% on board space, compared to the previous DIP-8 version, while providing the same isolation properties. The supply current needed to power up the output side is specified at 3mA maximum, allowing for a low cost bootstrap power supply.

The ACPL-H312 contains a GaAsP LED. The LED is optically coupled to an integrated circuit with a power output stage. These optocouplers are ideally suited for driving power IGBTs and MOSFETs used in motor control inverter applications. The high operating voltage range of the output stage provides the drive voltages required by gate controlled devices. The voltage and current supplied by these optocouplers make them suited for directly driving IGBTs with ratings up to 1200V/100A. For IGBTs with higher ratings, the ACPL-H312 series can be used to drive a discrete power stage which drives the IGBT gate.

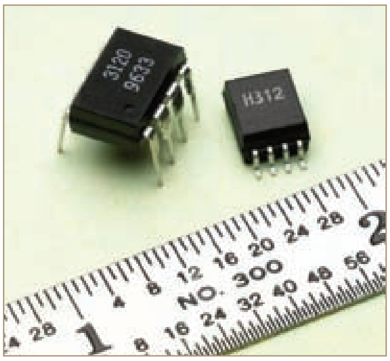


Figure 1: ACPL-H312 (right) next to HCPL-3120

A fundamental strength of optocouplers is their ability to suppress common-mode noise transients. A power inverter of the type shown in Figure 2 is an application where such transients exist naturally. The half-bridge configuration can, for example, be a part of a three-phase motor drive which converts the high voltage DC link into an alternating (AC) current by switching the power transistors on and off in a synchronised manner. The control

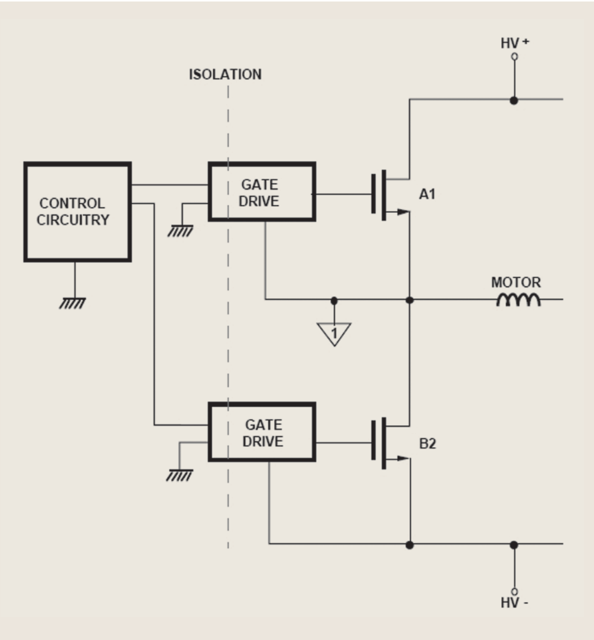


Figure 2: Half-bridge power inverter

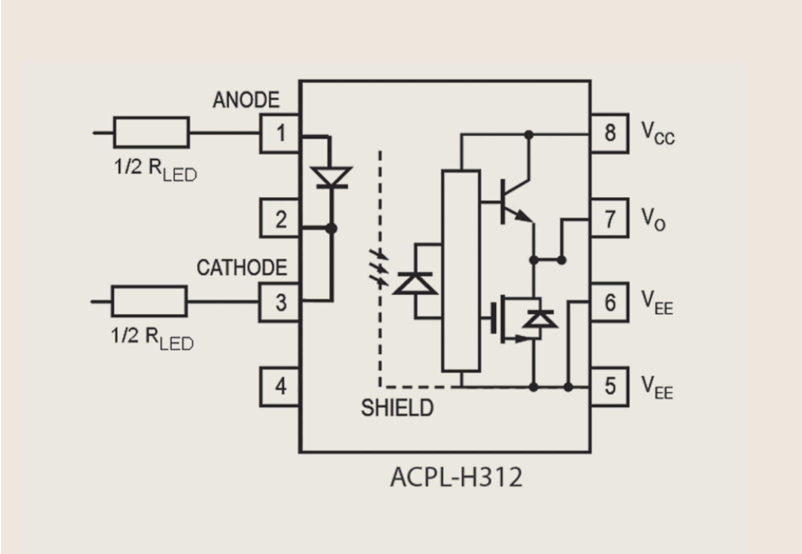


Figure 3: Common-mode transient suppression

circuitry and the gate drive optocouplers on the isolated side are all connected to the same ground. On the power side, however, the ground of the high side (upper) gate driver is actually floating, connected to the source of power transistor A1. Through switching the power transistors on and off, common-mode transients (of thousands of volts per microsecond in typical applications) are created between the control side and the power side in this application. Such common-mode transients could potentially cause an erroneous turn-on of a power transistor which, in turn, could cause permanent damage to the drive. The performance in terms of common mode transient rejection of the gate drive stage is therefore directly linked to the reliability of the inverter.

Optocouplers such as the ACPL-H312 outperform other technologies in terms of common-mode transient rejection. A good optocoupler design minimises the capacitive coupling between the input and the output sides and also minimises the adverse effects of leakage currents that flow across the isolation barrier. One reason is that by using optical coupling technology, the physical separation distance at the signal coupling interface (inside the package) can be kept as wide as possible. The large separation distance and proprietary packaging technology provides a very low parasitic capacitance across the device.

In addition to the wide internal separation distance, optical isolation technology has the advantage that a grounded Faraday shield can be deployed to cover the receiver IC. The Faraday shield will divert transient currents flowing from the input side directly to the output ground to prevent the gate drive IC from turning on due to leakage currents flowing from the isolated side. On the input side, there are several ways of designing LED drive circuitry that ensures that the LED is kept in its desired state. For example, by using two LED resistors instead of one (see Figure 3), the system is made less sensitive to common-mode transients. This subject is further discussed in data sheets and application notes published on the Avago website. Figure 4 shows a typical application circuit with negative IGBT gate drive.

Conclusion

Avago is developing, producing and continually improving LEDs for use in optocouplers. Concerns are sometimes raised that light output degradation of the LED could cause devices to stop functioning after a certain time in use. Indeed, high temperatures and drive currents will have an impact on light output – but it is important to stress that the recommended operating conditions in datasheets have significant guard bands to ensure that this will not happen in practice. In addition to the guard banded specifications, the quality of the LEDs are monitored and stress tested at extreme temperatures and drive currents. LED degradation is not likely to cause problems in real applications.

The new ACPL-H312 integrated 2.5A gate drive optocoupler will enable power electronic designers to shrink their PCB layouts without compromising system performance or isolation properties.

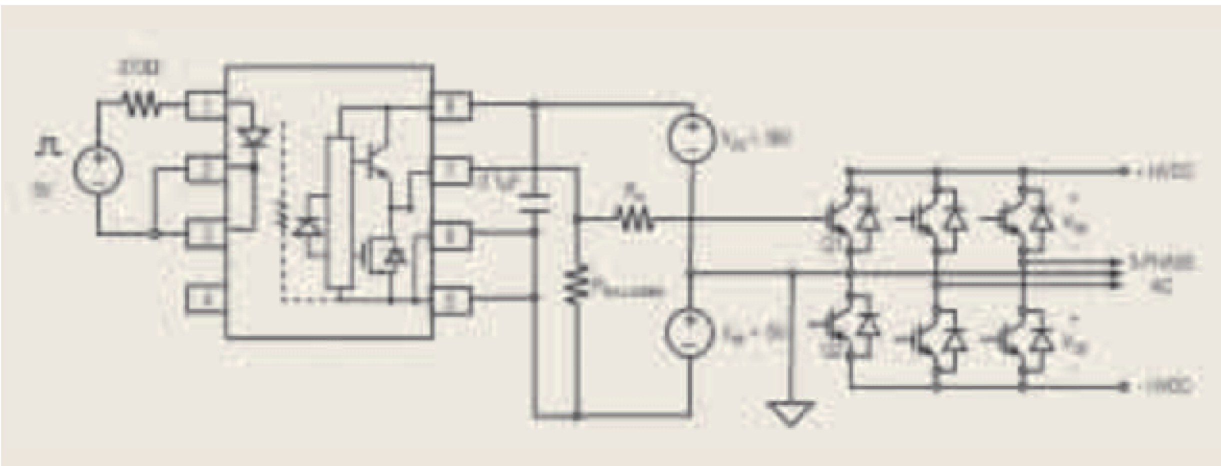


Figure 4: Typical application circuit with negative IGBT gate drive

Ceramic Heatsink Provides Innovative Thermal Management

A new ceramic technology offers an innovative solution for thermally sensitive components and circuits, thanks to its excellent thermal conductivity and stability characteristics and its compact form. CeramCool is the ideal heatsink for high-power semiconductors where it demonstrates its ability to handle high power peaks. **Alfred Thimm, Service Center Design, CeramTec AG, Plochingen, Germany**

Heat-sensitive semiconductor components are often mounted onto substrates. These substrates need to provide electrical insulation while, at the same time, ensuring adequate thermal conductivity. The result is often a kind of 'sandwich' with multiple layers made from different materials, which simultaneously translates into numerous production steps. Each layer is a potential risk and poses an additional obstacle to thermal conductivity. CeramCool transforms the substrate into a heatsink itself. The difference is readily visible in this high-power LED example (see Figures 1 and 2).

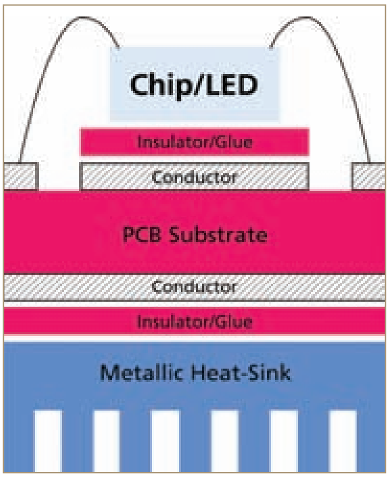


Figure 1: Typical LED system with multiple layers and different thermal coefficients of expansion (TCEs), potential risks are delamination, corrosion, and degradation

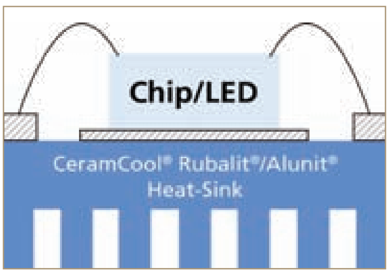


Figure 2: Simpler and smaller LED System with CeramCool and direct metal-to-metal connection

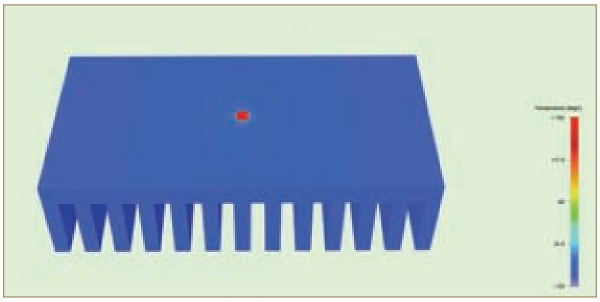


Figure 3: Aluminium cooler remains cool overall, but the chip is getting hotter and has a maximum temperature of 169°C (Source: Fraunhofer Institute)

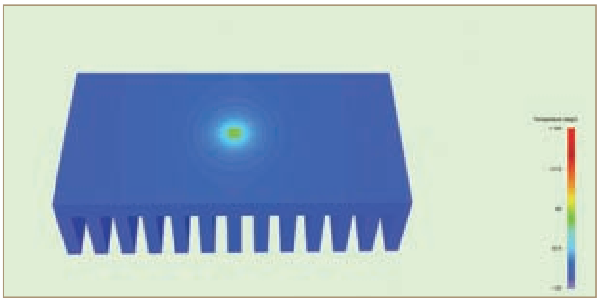


Figure 4: The ceramic heatsink is getting hotter and dissipates the heat coming from the chip, leaving the LED cooler at 82°C (Source: Fraunhofer Institute)

Long life through excellent thermal management

CeramCool is made from ceramic materials such as 450MPa high bending strength material Rubalit 708 (with 96% Al_2O_3), smooth surface Rubalit 710 (with >99% Al_2O_3) or high thermal conductivity material Alunit AlN (180W/mK). These materials have a thermal expansion coefficient (TCE) that is close to semiconductor materials. Especially Alunit® has a TCE of 4.6ppm/K (RT–300°C) that comes very close to Si of 4.7ppm/K. In common the materials possess excellent electrical characteristics (breakdown voltage >20kV/mm at RT, specific resistance >1014Ω*cm) and good electromagnetic compatibility.

At the same time, they are waterproof and corrosion-resistant. CeramCool can be exposed directly to the atmosphere economizing on additional insulation, cooling systems etc. The simplified construction (without glues, insulation layers) combined with a direct and permanent bond between the high-power LED and CeramCool heatsink create good thermal conductivity and electrical isolation for the entire assembly. Secure thermal management increases component life and stabilises for example the LED's colour rendering index.

Cool LED and hot heatsink

The Fraunhofer Institute in Nuremberg, Germany, compared two heatsinks of the same geometry with regard to their surface temperature - a typical aluminium fin cooler with a glue bonded chip versus CeramCool made of Rubalit or Alunit with metalisation pad and directly soldered LED. The contrasting images make the most essential thing clear, even if not at first sight: The aluminium heatsink remains relatively cool, but the chip reaches a maximum temperature of 169°C (Figure 3). The adhesive layer required for the aluminium assembly is blocking heat dissipation. In contrast, the ceramic heatsink becomes hot and dissipates the resulting heat over its surface (Figure 4). The reason is simple, the LED chip is directly and reliably bonded to the electrically insulating

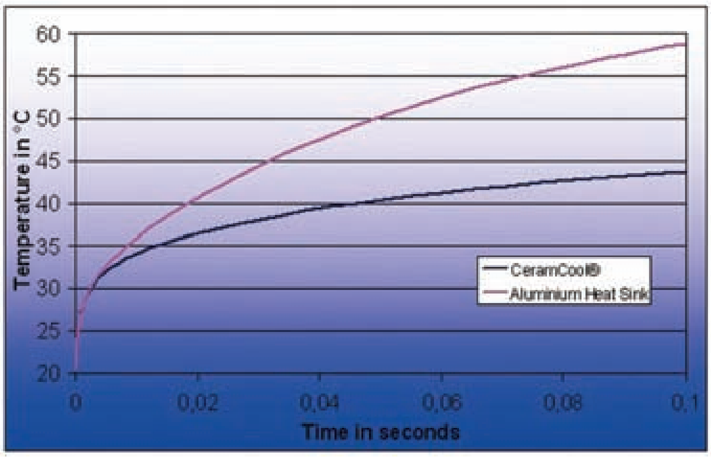


Figure 5: After 0.1s CeramCool reaches a temperature of only 45°C versus approximately 60°C with aluminium (Source: Fraunhofer Institute)

CeramCool using only metals. The result is convincing. The chip's maximum temperature is with 82°C half that of the aluminium assembly. If the heatsink becomes hot it takes the burden off the LED and does exactly what it is made to do, namely cooling of the critical components.

Figure 5 shows the starting phase. What happens to the chip? With CeramCool it gives off its heat to the ceramic heatsink immediately and without barriers. Proof of the system's high dynamics: after 0.1s CeramCool reaches a temperature of only 45°C versus approximately 60°C with aluminium. This results in great load reduction while considerably increasing component life.

Heatsink acts as circuit carrier

CeramCool can be coated directly with proven thick-layer technologies with its high adhesion force (WNi(Au), AgPd, Au, DCB, AMB...) or thin-film processes with its smooth surfaces (allowing precise light angles). A finish for better soldering can be obtained using electroless nickel or gold (immersion or cathodic deposition).

The possibility of metallisation makes the whole surface of the heatsink useable as a circuit carrier which can be firmly packed with LEDs and drivers on customised circuit layouts - while providing reliable electrical insulation (Figure 6). The process can be simplified by bonding the chip directly onto the specially designed CeramCool metallic surface - chip on heatsink!

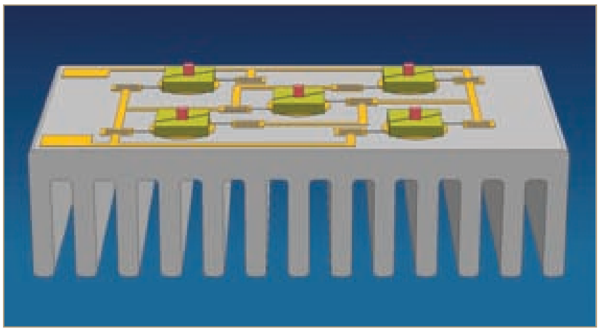


Figure 6: A customer specific layout is applied on the surface and packed with components, qualified processes and RoHS conforming materials can be used

Conclusion

CeramCool has been received the Manufacturing Excellence Award 2007 for the best product innovation, the ceramic heatsink for high-power electronics. One of its important features is its high degree of freedom of design. One the one hand, it can be manufactured according to customer specifications for example with individual forms, with or without metallisation, with sizes between 1 and 200mm and a thickness from 0.05 up to 50mm (Figure 7). On the other hand, product designers obtain a new level of design freedom for their final product. This is because the simplified construction, the ability to use the heatsink as a circuit carrier and efficient thermal management make it possible to achieve miniaturisation.

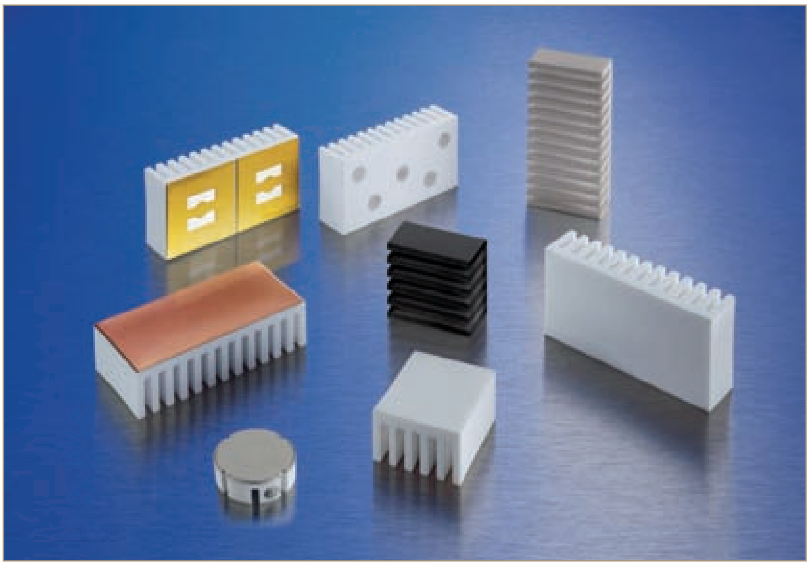
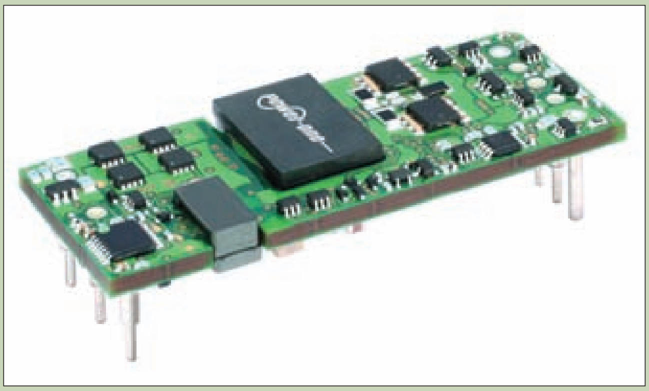


Figure 7: CeramCool in different construction and metallisation forms

Eighth Brick Provides 93% Efficiency

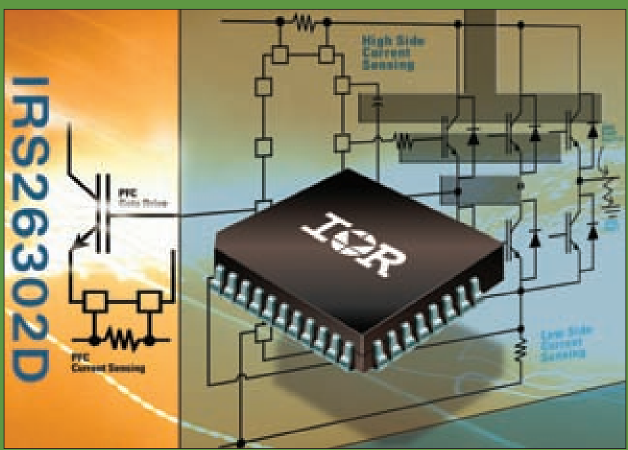


Power-One's new eighth-brick DC/DC converter SQE48T10120 provides 12V at 10A at 93% efficiency. Other features include low-profile height (9.5mm), wide-input-range (36 to 75VDC) operation, an on-board input differential LC filter, remote sense, and start-up into pre-biased loads.

The device is protected against input under-voltage, over-temperature, output over-current, and output over-voltage. Regulatory agency approvals include UL60950, including basic insulation requirements. The product is designed to meet Class B conducted emissions, per FCC and EN55022, when used with an external filter.

www.power-one.com

Three-phase 600V IC Features Extra Channel for PFC



International Rectifier offers the IRS26302D protected 600V three-phase gate driver IC with ground fault protection. The IC has a seventh gate drive channel for a power factor correction (PFC) switch or inverter brake, making it well-suited to medium power appliance motor control and many other general-purpose three-phase inverter applications. The IC integrates power MOSFET/IGBT gate drivers with three high-side and three low-side referenced output channels to provide 200mA/350mA drive current at up to 20V MOS gate drive capability operating up to 600V. An additional low-side driver is provided for a PFC switch or inverter brake. The IC incorporates negative versus immunity circuitry to protect the system from catastrophic events that can be seen during high-current switching and short-circuit conditions in addition to ground fault protection, critical features for industrial systems that require high levels of robustness and reliability.

Also, an advanced input filter has been integrated to reject noise and reduce distortion, improving system performance in many motor control applications. To address the needs of space constrainted applications the IRS26302D features integrated bootstrap functionality, reducing the bootstrap power supply from six components to three, while providing VBS over-voltage protection for the system through the use of additional integrated intelligent protection circuitry.

www.irf.com

Current Sense Transformers

Murata Power Solutions offers three new surface-mount current sense transformers (5300, 5400 and 5500 series) which can be used to measure or monitor AC currents in high frequency applications such as SMPS, motor controllers, and electronic lighting ballasts. Designed to measure AC currents up to 10A, the 5300 series comprises 10 different devices with a primary current rating to 10A and between 20 and 200 turns, depending on the resolution of current measurement desired. A primary to secondary isolation of 500V_{rms} in an industry-standard footprint helps simplify their inclusion into existing product designs.

The 5400 and 5500 series are designed to measure AC currents up to 15A and are available with 50, 100 or 200 turns. The 5400 series provides 1200Vrms primary to secondary isolation. The 5500 series is offered in a low profile package, with a primary to secondary isolation of 1000V_{rms}.

www.murata-ps.com

N-Channel 3A MOSFET Driver

Linear Technology offers the LTC4444, a high-speed, high input supply voltage (100V) synchronous MOSFET driver designed to drive upper and lower power N-Channel MOSFETs in synchronous rectified converter topologies. This driver, combined with power MOSFETs and DC/DC controllers, form a complete synchronous converter. This driver can source up to 2.5A with a 1.2Ω pull-down impedance for driving the high-side MOSFET and source 3A with a 0.55Ω pull-down impedance for the low-side MOSFET, making it ideal for driving high gate capacitance, high current MOSFETs.

The LTC4444 can also drive multiple MOSFETs in parallel for higher current applications. Its fast 8ns rise time, 5ns fall time of the high-side MOSFET, and 6ns rise time, 3ns fall time of the low-side MOSFET when driving a 1000pF load minimise switching losses. Adaptive shoot-through protection is integrated to minimise dead time while preventing both the upper and lower MOSFETs from conducting simultaneously. The LTC4444 is configured for two supply-independent inputs. The high-side input logic signal is internally level-shifted to the bootstrap supply, which may function at up to 114V above ground. Furthermore, this part drives both upper and lower MOSFET gates over a range of 7.2 to 13.5V.

Boost Converter Manages Multiple High-Brightness LEDs

Texas Instruments offers a new high-brightness LED driver with an integrated 40V, 1.2A switch in 2mm x 2mm QFN package that can drive up to three 1W LEDs in series.

The TPS61165 features an input voltage range of 3 to 18V to efficiently manage multiple high-power LEDs used in single-cell, battery-powered applications or point-of-load designs with a 9V or 12V bus. LED brightness can be controlled by a digital single-wire interface or PWM signal. The digital interface can program an internal register to set the LED current to one of the 32 logarithmic steps.

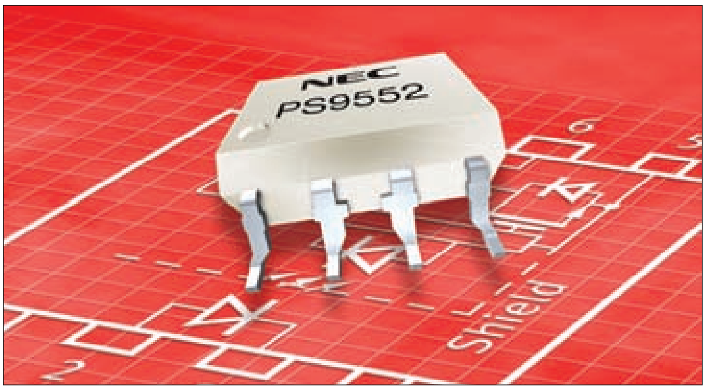
The converter also comes with built-in protection features, such as open LED protection, soft-start, over-current limit and over-temperature protection. In addition to driving illumination LEDs, the TPS61165 can drive backlight LEDs for media form factor displays up to 9in diameter, such as those used in ultra-mobile PCs and LCD photo frames, industrial laser diodes or medical and industrial lighting.

www.ti.com/tps61165-pr

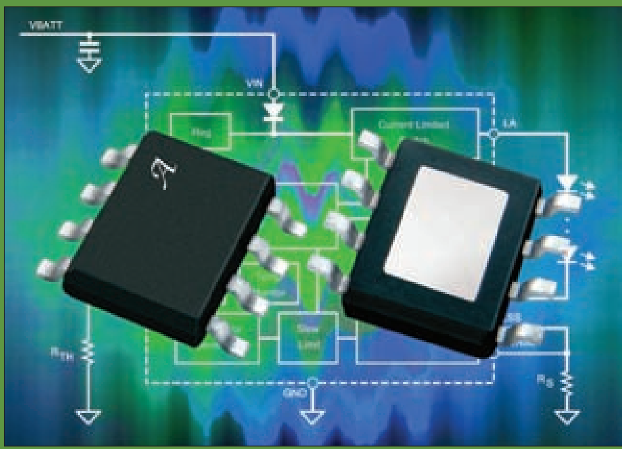
2A IGBT/MOSFET Gate Drive Optocouplers

NEC's new PS9552 consists of a GaAlAs LED on the input side and a photo diode with processing circuit and power stage on the output side. It is a combination of a fast optocoupler providing galvanic isolation and an IGBT/MOSFET driver supplying high output voltage and current. The design features common mode transient immunity of at least 15kV/µs, output current of 2A and high switching speed. The plastic DIP package provides 8mm creepage distance, 0.4mm isolation distance and 5000Vrms isolation voltage, and complies with common insafety standards (eg, UL, VDE 0884, CSA, BSI). The optocoupler is suited for industrial inverter and motor control applications where a microcontroller unit needs to be isolated from the high-power inverter side. It can drive 1200V/100A IGBTs.

www.eu.necel.com/opto



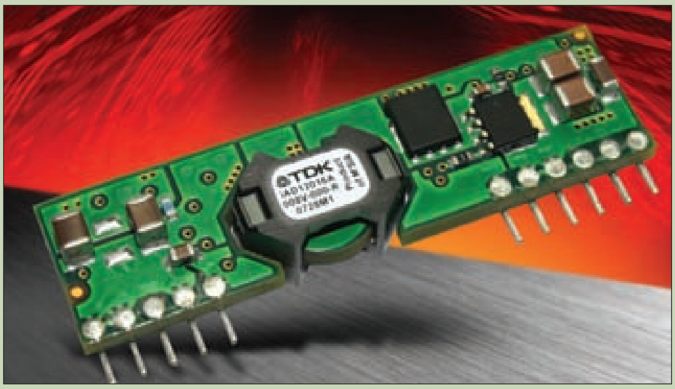
Automotive-Grade LED Driver IC



The new A6260 IC from Allegro MicroSystems Europe is a high-brightness constant-current LED driver which is designed to operate over the typical automotive voltage and temperature ranges. The input voltage is specified down to 6V, and the device will operate at up to 40V. The linear constant-current output can be adjusted to deliver up to 350mA in a typical application. Several automotive-grade protection features are included. The IC is protected against short circuits to ground or battery, and a thermal shutdown circuit disables the IC if the junction temperature reaches 165°C. In addition, integrated reverse battery protection eliminates the need for an external reverse battery diode. Typical applications for the A6260 include automotive interior lighting such as map lights and dome lights and exterior lighting such as rear indicator and brake lights and rear combination lighting. Industrial and consumer high-intensity LED lighting applications will also benefit from the device's feature set.

www.allegromicro.com

DOSA Point-of-Load Converter



Lambda has added to its range of POL converters with the launch of the iAD series of non-isolated, single inline package, through-hole mounting devices.

Featuring a DOSA compatible pin-out, the iAD series addresses a broad range of applications from telecoms through to industrial equipment. With its wide input range from 6 to 14V, the device is well suited for powering a diverse range of loads in a variety of architectures including distributed power, for example regulated 9 or 12V bus rails, and non-regulated 4:1 and 5:1 bus converter systems.

Furthermore, its broad output adjustment range from 0.8 to 5.5V, its maximum output power of 80W and its ability to start into a pre-biased load make it especially useful in ASIC/FPGA and other applications where multiple voltages can be present. Special attention has been paid to the electrical design to gain a high power conversion efficiency of up to 94%. The iAD standard features include fixed frequency operation, remote sense, remote on/off, flexible output voltage sequencing, auto-recovery of input under-voltage and output over-current protection circuitry. Negative polarity on/off, no output voltage sequencing, an industry standard narrow 9.6 to 14V input voltage range, and short 3.3mm pins are offered as options.

www.lambda-europe.com

Switching MOSFETS for Synchronous DC/DC Converters

Toshiba Electronics Europe has added two new devices to its UMOS V-H 30V MOSFET series which provide higher drain current (45A max.) and lower on-state resistance (3.1mΩ min.). Compared to previous process technology, the UMOS V-H Series improves many of the key parameters required for better power efficiency of low-side MOSFETs in a synchronous DC/DC converter, including lower on-state resistance and reduced self-turn-on loss, achieved through lower gate-to-drain capacitance, lower gate resistance, and optimised gate threshold voltage. On the high-side MOSFET, UMOS V-H technology enables fast switching through low gate switch charge and gate resistance.

The SOP Advance package with a footprint of 5.0mm x 6.0mm features a 41% lower profile than a standard SOP-8 package, and enables approximately 47% higher power dissipation.

www.toshiba-components.com

Current Transducers Offering Current Output

LEM's LTSP model operate from a single 5V power supply and measures positive and negative AC, DC and pulse currents of 8, 12 and 25Arms on printed circuit boards and provides a current output instead of voltage output. This allows the LTSP to detect currents up to at least 14 times the nominal current.

The LTSP uses the same ASIC as LEM's LTS and LTSR models, allowing Hall-effect closed-loop current measurement in an extremely small package (22mm x 10mm x 24mm). The LTSP provides better offset drifts than units based on traditional discrete technology, as well as access to the internal reference (2.5 V) on a separate external pin, for use with microcontrollers and/or A/D converters.

www.lem.com

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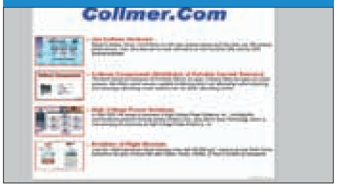

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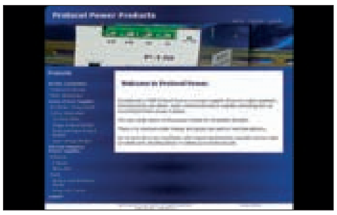

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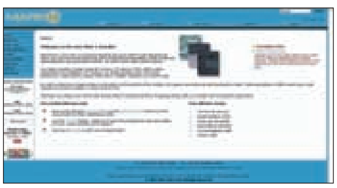

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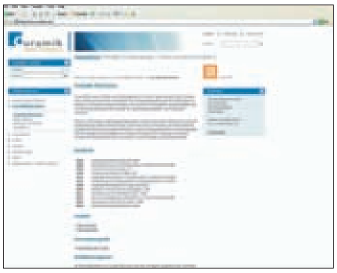

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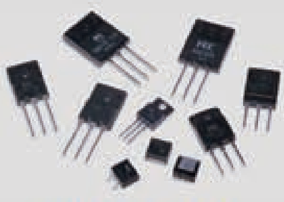

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