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ISSUE 5 – JULY/AUGUST 2008

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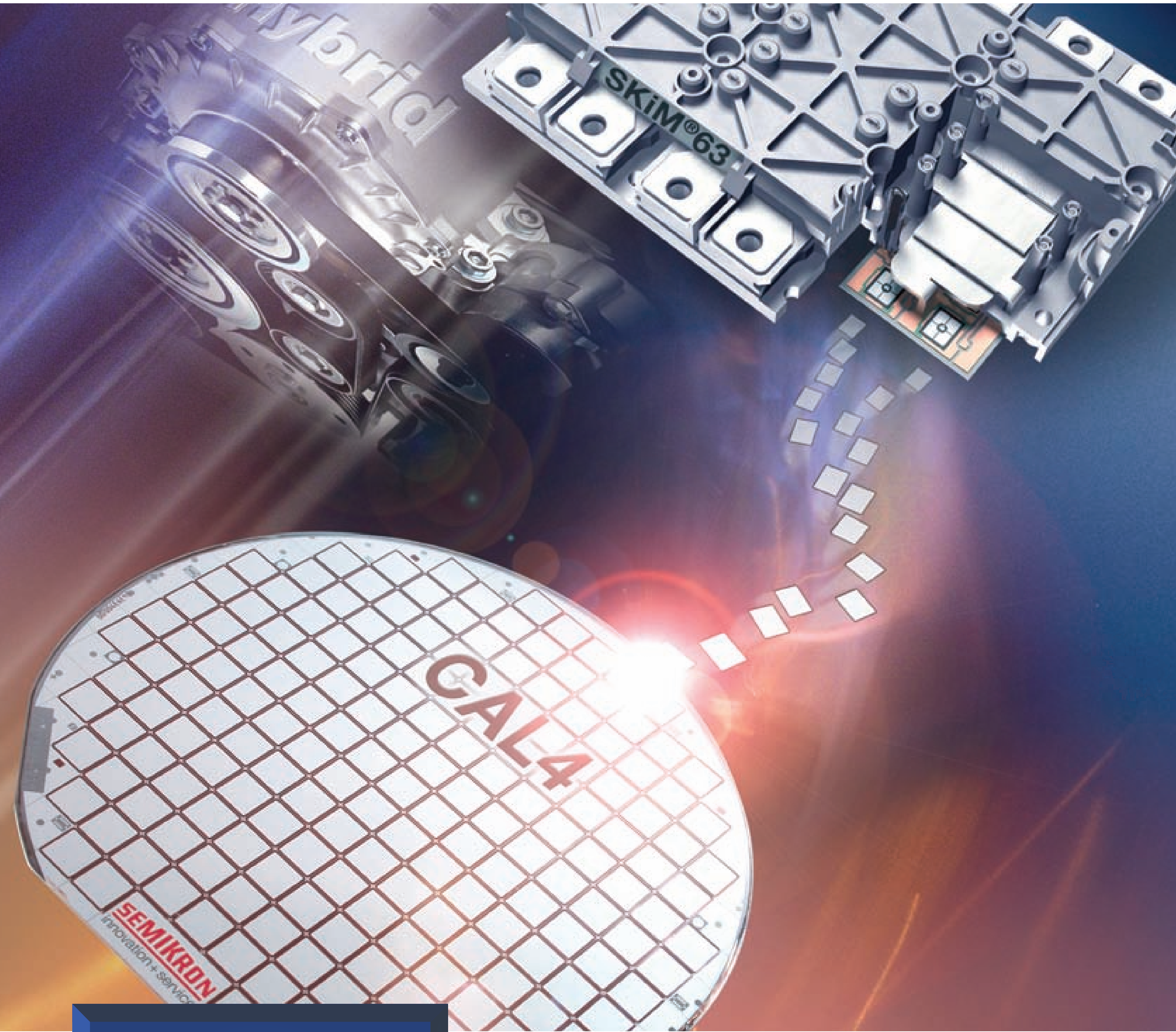

THE EUROPEAN JOURNAL
FOR POWER ELECTRONICS
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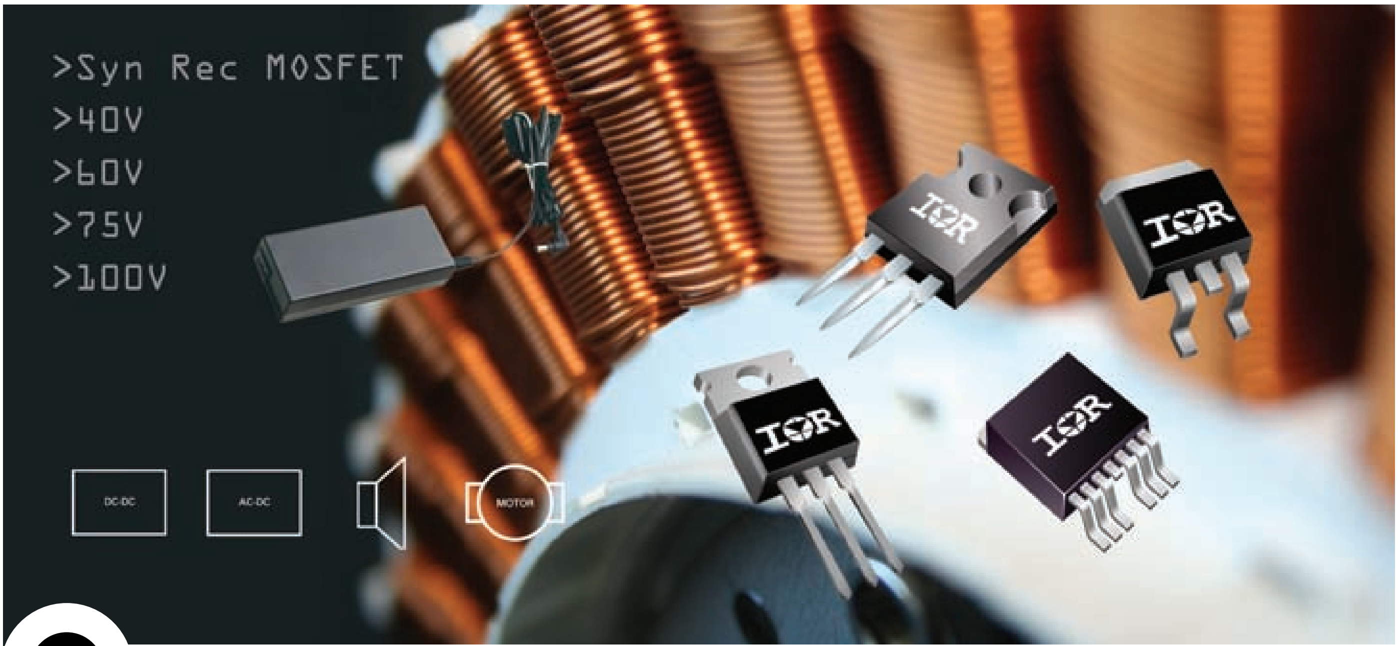
Also inside this issue



Lower $R_{DS(on)}$ Higher Performance

Part Number	V_{DS} (V)	I_D (A)	$R_{DS(on)}$ Max V_{GS}=10V (mΩ)	Qg (nC)	Package
IRF2804PBF	40	270	2.3	160	TO-220
IRF2804SPBF	40	270	2.0	160	D²-PAK
IRF2804S-7PPBF	40	320	1.6	170	D²-PAK -7
IRFB3306PBF	60	160	4.2	85	TO-220
IRFP3306PBF	60	160	4.2	85	TO-247
IRFB3206PBF	60	210	3.0	120	TO-220
IRFS3206PBF	60	210	3.0	120	D²-PAK
IRFP3206PBF	60	200	3.0	120	TO-247
IRFS3207ZPBF	75	170	4.1	120	D²-PAK
IRF2907ZS-7PPBF	75	180	3.8	170	D²-PAK -7
IRFB3077PBF	75	210	3.3	160	TO-220
IRFP3077PBF	75	200	3.3	160	TO-247
IRFS4310ZPBF	100	127	6.0	120	D²-PAK
IRFP4310ZPBF	100	134	6.0	120	TO-247
IRFB4110PBF	100	180	4.5	150	TO-220
IRFP4110PBF	100	180	4.5	150	TO-247

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On the Road to Saving Energy

In 1999, the price of oil hovered around $16 a barrel. By early 2008, it had crossed the $100 a barrel mark and reached $144 by July. The reasons for the surge ranged from the relentless growth of the economies of China and India to widespread instability in oil-producing regions, including Iraq and Nigeria's delta region. Triple-digit oil prices have redrawn the economic and political map of the world, challenging some old notions of power. And as consumers around the world struggle to fill their gas tanks, captains of the oil industry are getting a raise. Obviously there is no upper limit in sight.

Americans i.e. use a lot of oil, and also have the largest market for cars. Although they constitute only 5% of the world's population, they consume 25% of global oil production. America epitomises the petroleum-dependent lifestyle. Oil is the raw material that makes possible the functioning of nearly every component of the US economy, directly or indirectly. It provides 40% of the nation's power supply - far more than any other source. Oil powers industries, heats our buildings, and provides the raw material for plastics, paints, textiles, and other materials. But it is in transportation that oil is most essential - it provides 97% of the fuel used by America's enormous fleet of trucks, trains, planes, ships, buses and cars. "We have staked our entire way of life on a non-renewable resource that may be largely exhausted within the next 30 years. All of the current and projected alternative energy sources will not be able to replace oil in the near future. But Americans continue to act as if there is no problem as they buy more and bigger cars and commute longer distances from energy-inefficient suburban developments. It doesn't take much imagination to realize that when (not if) we run out of oil, our accustomed way of life will change radically. But even before that day, our gas-guzzling lifestyle erodes our national security, destroys the environment, and makes us very vulnerable to fluctuating oil prices", so says a US comment. But change can be seen on the horizon – the three big carmakers Chrysler, Ford and GM are struggling because their energy-inefficient pick-ups and SUVs are not selling as expected. Though the European cars are more energy-efficient, drivers have to pay very high gasoline prices compared to the US, so it's time for gasoline savings or a radical change towards electric and fuel-cell driven cars. "For every automaker who can sell a zero-emissions car, we will commit a $5,000 tax credit for each and every customer who buys that car. For other vehicles, whatever type they may be, the lower the carbon emissions, the higher the tax credit", Republican presidential candidate John McCain recently outlined a series of new proposals for dealing with the energy and environmental crises. That should be music to the ears of the big automakers, who fear that the large price tags that will accompany the first few generations of plug-in hybrids and electric cars will be prohibitively

expensive for consumers who are more concerned with cutting their fuel budgets than stopping global warming. GM predicts a price tag in excess of $30,000 for the early model Chevy Volts, and says it expects to take a loss on the car for years to come. If a McCain or Obama administration were to step in and subsidize the sticker price of the Volt or its competitors, it might go a long way towards ensuring their success in the American market. McCain said that his administration would offer a $300 million bounty for any innovator who could develop a battery package that has the size, capacity, cost and power to leapfrog the commercially available plug-in hybrids or electric cars. Such a battery would have to come at a cost of 30% of the current options and be viable for mass production, effectively ending the debate over whether non-petroleum-powered vehicles were capable of spreading a 500km distance. $300 million may be the most lucrative science fair prize ever offered, but it is unclear how much additional incentive it would provide to developers. Given the trajectory of oil prices, a technology that could so drastically cut the expense of driving or transporting goods is already worth plenty on the open market. Still, it's admirable that McCain is focused more on rewarding success than providing open ended subsidies to the automobile industry. Several consecutive administrations have provided lucrative grants to Detroit, but until a few years ago, it seems to have had little effect. In Europe, most of the carmakers favoured diesel engines and were reluctant to develop hybrid drives, but this situation changes now.

That is why Power Electronics Europe has organised a well received session 'Automotive Power' at PCIM 2008. The four papers presented illustrated the importance of power semiconductors for affordable and energy-efficient hybrid drives. Two of these are published in our Automotive Power section, besides all the other valueable informations about power electronics.

Emjoy reading.

Achim Scharf
PEE Editor

TI Intensifies Focus on Power Management

Steve Anderson has been appointed to a senior vice president position, leading the company's new Power Management strategic business unit. The new organization is part of TI's analog business strategy to better focus on solving customers' analog, power management and energy efficiency design challenges.

Bringing more than 19 years of experience in the power supply industry, Anderson has had several leadership positions, most recently leading TI's System Power Management business in High-Performance Analog. He came to TI in 1999 as part of the company's acquisition of Power Trends, a Chicago-based power module provider, which Anderson joined in 1989. TI has consolidated its analog power product lines into a single Power Management strategic business unit to place it alongside its Analog and Logic businesses. The three businesses will apply their customer and technology resources to provide power architecture, signal chain and application-specific solutions, respectively.

Recently, TI has acquired Ireland-based Commergy Technologies, a power supply reference design provider that specialises in energy efficient and compact architectures. The acquisition allows TI to broaden its focus on improving energy efficiency in today's end-equipment designs, especially in the areas of AC adapters and high-power-density computing and server systems.

Commergy has expertise in several design areas, such as planar magnetics, power factor correction (PFC), power topology design, thermal management, EMC design and high-power density design. Several semiconductor industry analyst firms, such as iSuppli and Databeans, rank TI as the top worldwide supplier of power management ICs with approximately 15% market share.

Databeans forecasts that the power management industry will continue to increase in importance, with a compound annual growth rate of approximately 15% over the next 5 years.

http://power.ti.com

Steve Anderson

First HT Superconductor Power Transmission Cable

American Superconductor Corporation (AMSC), Long Island Power Authority (LIPA) and the US Department of Energy (DOE) recently celebrated the commissioning of the world's first high temperature superconductor (HTS) power transmission cable system in a commercial power grid.

The 138kV system, which consists of three individual HTS power cable phases running in parallel, was energised in April 2008 and is operating successfully in LIPA's Holbrook transmission. The HTS cable system contains hair-thin, ribbon-shaped wires that conduct 150 times the electricity of similar sized copper wires. This power density advantage enables transmission-voltage HTS cables to utilise far less wire and yet conduct up to five times more power – in a smaller right of way – than traditional copper-based cables.

When operated at full capacity, the HTS cable system is capable of transmitting up to 574MW. The DOE previously funded $27.5 million of the $58.5 million total project cost, which advances the Department's ongoing efforts to modernise the electricity delivery infrastructure.

HTS power cables are envisioned by the DOE as a component of a modern electricity superhighway – one that is free of bottlenecks and can readily transmit power to customers from remote generation sites, such as wind farms. LIPA's installation, which is the longest and most powerful superconductor cable system in the world, includes three phases connected through six outdoor terminations. It was designed, manufactured and installed by Nexans.

The cable cores utilise HTS wires produced by AMSC, which also is the prime contractor for the project. The liquid nitrogen refrigeration system was manufactured by Air Liquide. Three 2,000-foot-long vacuum-insulated flexible cryostats provide high-quality thermal insulation maintaining the cable cores at cryogenic temperature.

AMSC is leading the development of an extension of LIPA's HTS cable system. The new project calls for the replacement of one of the existing HTS cable system's phases with a 600m long cable made with 344 superconductors.

www.amsc.com

High-Brightness LED Driver

38-V, 1.2-A Switch Boost Converter

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Applications

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  - Ultra-mobile PCs
  - LCD photo frames
  - Industrial laser diodes
  - Medical and industrial lighting

Features

- Wide input voltage range up to 18V
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- 1.2-MHz switching frequency
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- 90% power efficiency
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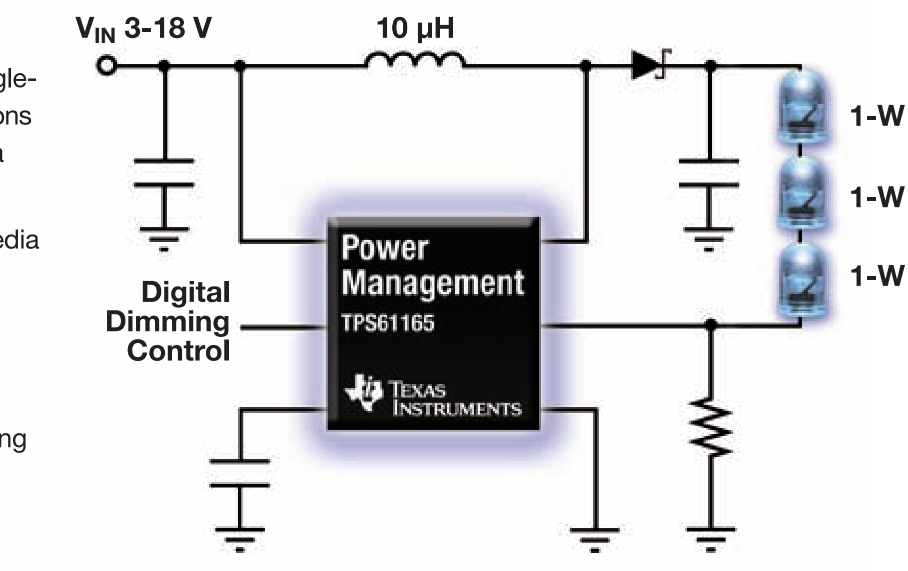
- 2mm x 2mm x 0.8mm, 6-pin QFN with thermal pad



The **TPS61165** is the first high-output power boost converter that can drive up to three 1-watt LEDs in series. The tiny power circuit can manage backlight LEDs for media form factor displays up to 9 inches in diameter.

White LED Drivers that Support 3 to 12 LEDs

Device	Topology	# of LEDs	V_{IN} (V)	Switch Current Limit (A)	V_{OUT}	Efficiency (%)	Package	Price (1k)*
TPS61160	Boost	6	2.7 to 18	0.7	27	90	2 x 2 QFN	$0.85
TPS61161	Boost	10	2.7 to 18	0.7	38	90	2 x 2 QFN	$1.00
TPS61165	Boost	10	3.0 to 18	1.2	38	90	2 x 2 QFN	$1.45
TPS61081	Boost	7	2.5 to 6	1.6	27	87	3 x 3 QFN	$1.45
TPS61150A	Boost	6 x 2	2.5 to 6	0.7	27	85	3 x 3 QFN	$1.65
TPS60251	Charge Pump	5 + 2 + 1	2.7 to 6.5	–	6.5	90	4 x 4 QFN	$1.40
TPS40211	Boost	12 x 10	4.5 to 52	6.0	5 to 250	90	3 x 3 SON	$1.10

** Suggested resale price in U.S. dollars in quantities of 1,000.*

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Solar Inverter Market Shines Brightly

SMA Solar Technology held an impressive 33% share of the global solar inverter market in 2007 according to analysis from IMS Research.

The German-based inverter supplier which plans to float soon on the Frankfurt Stock Exchange enjoyed strong revenue growth last year as the market expanded dramatically, particularly in Europe. A new study reveals that in 2007, SMA accounted for nearly one-third of all global solar inverter revenues and was more than three times the size of its nearest competitor. "This leading position may seem particularly attractive to potential investors, given SMA's position today in a number of regional markets, coupled with the tremendous market growth projected for the future", commented Research Director Ash Sharma. IMS Research forecasts that revenues from solar inverters will double in less than 4 years, as current and future incentive schemes drive this dynamic market to new heights.

www.imsresearch.com

Climate Savers Computing Initiative

Murata Power Solutions has become an associate member of the Climate Savers Computing Initiative, a non-profit organization established by environmentally aware consumers, corporations, and environmental protection organisations.

The broad aim of the Climate Savers Computing Initiative is to improve the energy efficiency of computers and other IT equipment both in terms of design and use and in so doing reduce their environmental impact.

The Initiative starts with the ENERGY STAR 4.0 specification for desktops, laptops and workstation computers - including monitors - and gradually increases the efficiency requirements over the next four years.

The ENERGY STAR 4.0 specification, which took effect in July 2007, requires power supplies to be at least 80% efficient for most of their load range. It also puts limits on the energy used by devices when inactive, and requires systems to be shipped with power-management features enabled.

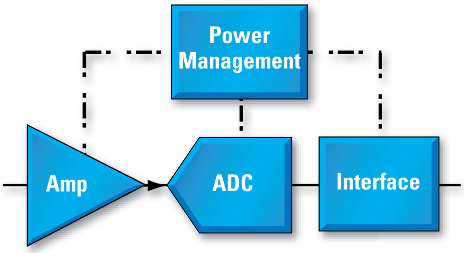
"Due to the nature and application of our products, we can have a major and positive effect on the energy use and efficiency of computer related products and systems. The impact computer systems have on the environment through their energy usage is staggering. Supporting the significant reduction of that impact through the design of efficient products, and our associate membership of the Climate Savers Computing Initiative to encourage the proper use of power saving functionality is crucially important", commented John Wanes, Business Lead for the Power Supply Business Unit, Murata Power Solutions.

www.murata-ps.com

Optimize Performance at the Lowest Power

National's PowerWise® Solutions Help Engineers Design Energy Efficient Systems

PowerWise products are analog and mixed-signal semiconductors that balance higher performance with lower power consumption.



PowerWise subsystems are architectural innovations designed to enable energy-efficient systems.

PowerWise Metrics Help Designers Compare Analog Components

PowerWise metrics are formulas and thresholds that distinguish energy efficient components from those that are less efficient. National has developed PowerWise metrics for 24 product categories and selected the best-in-class energy efficient products in each of these categories. Each PowerWise product has a PowerWise label and rating which summarizes its key specifications.

PowerWise® Efficiency Ratings
(4 out of 24 categories shown)

Product Family	Metric	Threshold	Units
Switching Regulators	Peak Efficiency	≥ 95	%
High-Speed ADCs	$\frac{P}{2^{ENOB} \cdot F_s \cdot ch}$	≤ 2.5	pJ/conversion
Equalizers	$\frac{P}{T_r \cdot ch}$	≤ 20	pJ/bit
Timing Solutions	$\frac{P \cdot t_j}{ch}$	≤ 55	mW*ps

PowerWise Resources Help Designers Improve System Performance to Power

Visit *national.com/powerwise* for white papers, app notes and design tools that help system engineers by highlighting the optimal balance between performance and power consumption at the component, subsystem and system level.

Find PowerWise products, metrics, white papers, app notes and tools at:

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National Semiconductor

Nextreme is Awarded NC Green Business Fund Grant

Nextreme Thermal Solutions has been awarded a grant from the North Carolina Green Business Fund to enhance the efficiency of thin-film thermoelectrics used to convert waste heat into electricity.

Efficiency of power conversion is becoming increasingly important across all market segments, including IT, automotive, and industrial manufacturing. As energy costs continue to skyrocket, the efficiency of power delivery systems is becoming a critical attribute to the overall product value. One way to improve electrical efficiency is to extract waste heat from the system or components and convert a larger portion of that heat into usable energy.

Nextreme's thin-film embedded thermoelectric generator (eTEG) generates electricity via the Seebeck effect, where electricity is produced from a temperature differential applied across the device. A very thin, nano-engineered material delivers a Seebeck coefficient 150% greater than conventional thermoelectric material. A unique aspect of Nextreme's materials is that they can be engineered at a nano-scale, providing improvement options not available in traditional thermoelectric manufacturing processes. The grant will be used to optimise the thin-film growth process with the goal of doubling the power output of a single device from 250 to 500mW.

Nextreme is currently working with customers in the powering of remote sensors that can monitor equipment and human activities without the use of batteries by simply using energy sources available and harvesting the waste heat to power the sensors. Other applications include thermal batteries that can be used to power implantable medical devices and capturing waste heat from exhaust manifolds to improve fuel efficiency in automobiles.

Nextreme's thin-film thermoelectric products are manufactured in volume with the Thermal Copper Pillar Bump process, an established electronic packaging approach that scales well into large arrays. The process integrates thin-film thermoelectric material into the solder bumped interconnects that provide mechanical and electrical connections for today's integrated circuits. Unlike conventional solder bumps, thermal bumps function as solid-state heat pumps on a microscale. The stack-up of a thermal bump, including the thin-film material, solder and electrical traces, is only 100µm high and has a diameter of 238µm. The thermal bumping process can be implemented at the package-, die- or wafer-level, and is used today to fabricate discrete modules.

www.nextreme.com

National Semiconductor Enters Photovoltaic Market

National Semiconductor announced that it has entered the photovoltaic market with new technology designed to increase the overall energy output of solar electric power generating systems. The company's SolarMagic technology extracts the maximum power efficiency of each photovoltaic panel, even when some panels in the array are compromised by shading, debris or inherent panel-to-panel mismatch.

"Our entry into the photovoltaic market is a natural extension of our focus on energy efficient systems. Our technologists solved this real-world problem and are enabling consumers to produce more energy under adverse conditions and reduce the payback time of their investment with an environmentally friendly source of power", said Brian L. Halla, National's CEO.

Today's solar installations are disproportionately impacted by non-uniformities, caused by shading, panel mismatches or dirt accumulation. For example, a small amount of shading in the array can cut the energy harvest of a system in half. This significantly limits the energy output, design and location of typical residential solar installations. Shading conditions can even invalidate local utility and governmental incentives, making certain installations cost-prohibitive. SolarMagic recoups up to 50% of the lost energy through a per-panel electronics solution that maximises power output of multi-panel installations, thereby minimising the economic impact of shading and other real-world conditions.

National has entered field trials with REgrid Power, one of the largest solar installers in California.

Additional solar companies are stated to join the field trials over the next months, and National will expand field trials to include installers in other countries with high adoption rates of solar.

Later this year, SolarMagic products for solar installers and system providers to include in their installations will be offered.

www.national.com/solarmagic

Major Trend Energy Efficiency

PCIM Europe 2008, from 27 to 29 May 2008, attracted 252 exhibitors and 56 represented companies from 26 countries in an exhibition area of 10,600 sqm. Once again the participation of numerous companies from overseas (57%) underlines the high international standing. The large number of companies from the USA, France, United Kingdom and Italy is particularly noteworthy. The number of new exhibitors is also worth mentioning: 31 additional exhibitors were at PCIM for the first time. Also the number of visitors (6,500) and conference delegates (592) marked a new high. PCIM Europe 2009 will take place in Nuremberg, Germany, 12 – 14 May 2009.

Power Electronics and its applications in Motion and Power Quality have a large influence on the development of technology and are applied in all stages of energy flow - from Power Generation to Power Distribution and to Power Use. Power Electronics is playing a key role in the energy saving and energy efficiency fields. Consequently, the sector is seeing a significant rise in the use of power semiconductor technologies in fields of application such as the automotive, telecommunications and domestic appliances industries. It is, therefore, not surprising that energy efficiency was an important subject throughout the conference and exhibition.

Conference awards

The three best papers submitted by young professionals aged under 35 years received a Young Engineer Award (prize money of €1,000). The winners were Luc Lowinsky, LAPLACE Research Laboratory, France with the subject '3 MVAR Single Phase STATCOM based on AC Chopper Topology'; Matthias Neumeister, Siemens AG, Germany with 'Investigation of Surge Current Capability of SiC MPS Diodes', and Marco Bock, Siemens AG, Germany with 'Methods for Path Decomposition of Redundant CNC-Axes'.

Luc Lowinsky proposed a 3 MVAR single phase STATic COMpensator (STATCOM) based on an AC Chopper topology. In France, 25kV single phase AC railway lines have to be equipped with reactive power compensators to reduce the penalties for reactive power consumption. For the dimensioning, 3.3kV IGCTs devices were considered and experimental results for a 100kVAR prototype were presented. Matthias Neumeister investigated the surge current capability of Silicon Carbide (SiC) Merged-Pin-Schottky (MPS). The diodes were impinged with trapezoidal respectively sinus shaped surge current pulses at different pulse times and temperatures. Thereby the diode structures provide a different responsiveness depending on the diode design. The destruction mechanism for these diodes is temperature limitation of the material, in this case the anode metallisation. Another sort of diode shows destruction at lower current density by occurring hot spots, while surge current, the first type of diode reaches astonishingly high temperatures on the anode face. This sort of diode was simulated with a simplified temperature model.

Roughly 600 people attended the oral and poster sessions at PCIM 2008

PCIM 2008 awardees (left to right) Matthias Neumeister (Siemens), Sponsor Oleg Khaykin (CEO IR), Luc Lowinsky (LAPLACE Research Lab), Marco Bock (Siemens), Sponsor Thomas Harder (GM ECPE), Sponsor Achim Scharf (Editor PEE), Stéphane Lefebvre (SATIE), Prof. Alfred Rufer (PCIM General Chairman), Leo Lorenz (PCIM Chair PE), and Udo Weller (GM PCIM)

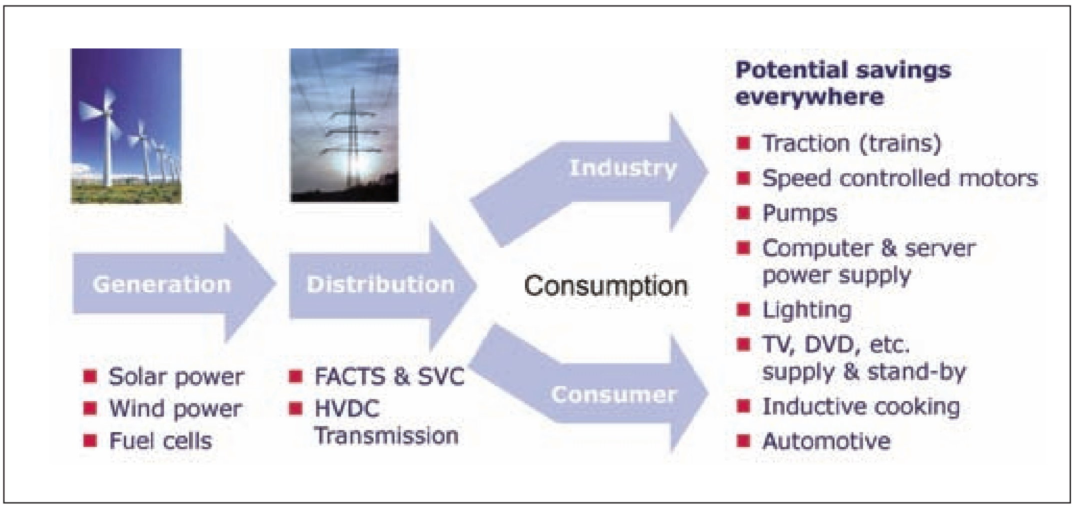
Marco Bock described two algorithms that decompose the path in the geometric domain by applying spline approximation methods, since machine tools with redundant axes require special methods to control their motion along given paths. The machining time of a redundant two-dimensional machine tool has been simulated with this motion control methods and has been compared with that of non-redundant machines. The productivity of redundant machines is considerably higher than that of non-redundant machines with the same working range.

The Best Paper Award for 'Power Electronics in Industrial or Automotive Applications', sponsored by Power Electronics Europe, was presented at the opening session of the conference. The paper 'Investigations on ageing of IGBT transistors under repetitive short circuit operation' given by Stephane Lefebvre, SATIE Laboratoire Ecole Normale Supérieure de Cachan, France won an invitation to PCIM China 2009 Conference in Shanghai (including flights and accommodation). The major content of this paper can be found in our first feature.

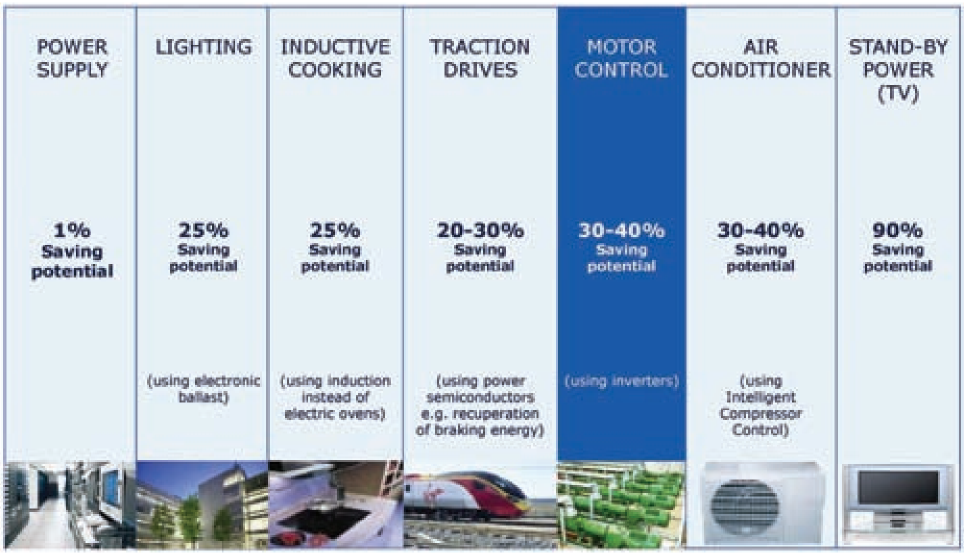
Energy efficiency and power electronics

The rising demand for energy in all forms and the recent series of dramatic increases in energy prices have made it evident that energy must be used more efficiently. According to the European Commission, about 180 million tons of CO_2, the equivalent output of around 50 power stations, could be saved by 2010 with new and energy-efficient products and appliances alone in Europe. To reach these goals, new highly efficient power electronic technologies are needed as an enabling factor to reduce today's massive waste of energy, while keeping the conveniences of technical progress – this was one of the focal point of this year's PCIM in Nuremberg.

Pumps are the single largest



Energy-efficiency chain and potential savings Source: Infineon



Energy saving potentials in various application fields Source: Infineon

consumer of electricity with 160 TWh per annum in the EU, accounting for 79 million tonnes of CO_2 emissions. With variable speed control through inverterised drives, the duty point of the pump follows an unchanged system curve. Changing the speed moves the pump curves in accordance with the affinity laws, meaning that the pumping capacity is exactly matched to the process requirements. Though the initial cost for an inverterised drive is higher, a payback through energy savings and better process control can be expected in a two-year period. In Germany alone, the use of motors with electronic speed control may lead to 20% of energy savings avoiding 17 million tons of CO_2.

It is estimated that lighting amounts to approximately 15% of the world total electricity consumption. Electronic ballast for fluorescent lighting saves up to 25% of the energy compared to magnetic lamp ballast. Further reductions are feasible by using daylight linked dimming systems. Light emitting diodes (LED) are the most dynamic light sources with the potential to catch up with high intensity discharge lamps (HIDs) by 2010. LEDs offer benefits such as small size, long life, low heat output and durability. LED converters are based on a current-controlled buck with outputs of 300, 500 and 1050mA supplied to a chain of LEDs. No ignition circuit, filament-heating or observation conditions like end-of-life is necessary. And there are no special requirements regarding the stability of the regulation and dimming is relatively easy – another opportunity for power electronics. Various surveys confirm that, by using state of the art energy efficient technologies, 20% of the current energy consumption in the European Union could be saved, translating into 60 billion Euros per year.

Approximately a quarter of current CO_2 emissions is known to come from the transport sector. And traffic fatality is still increasing worldwide. In order to create a society that will continue to enjoy the convenience that automobiles bring, in other words, to achieve sustainable mobility, automobile makers must work to reduce automotive CO_2 emissions and to enhance technologies for vehicle safety even further. A hybrid car has an inverter that provides tens of kilowatts of power to drive the motor by converting DC voltage to AC voltage. The power semiconductors that are used to control the current are therefore critical key devices for hybrid technology, and this is the topic of PCIM's session 'Automotive Power' organised by Power Electronics Europe.

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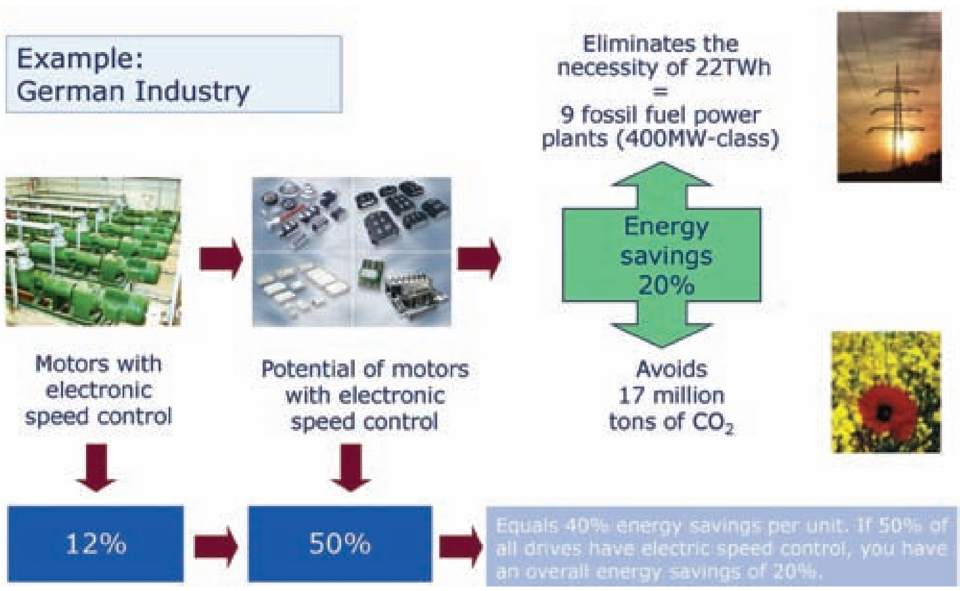
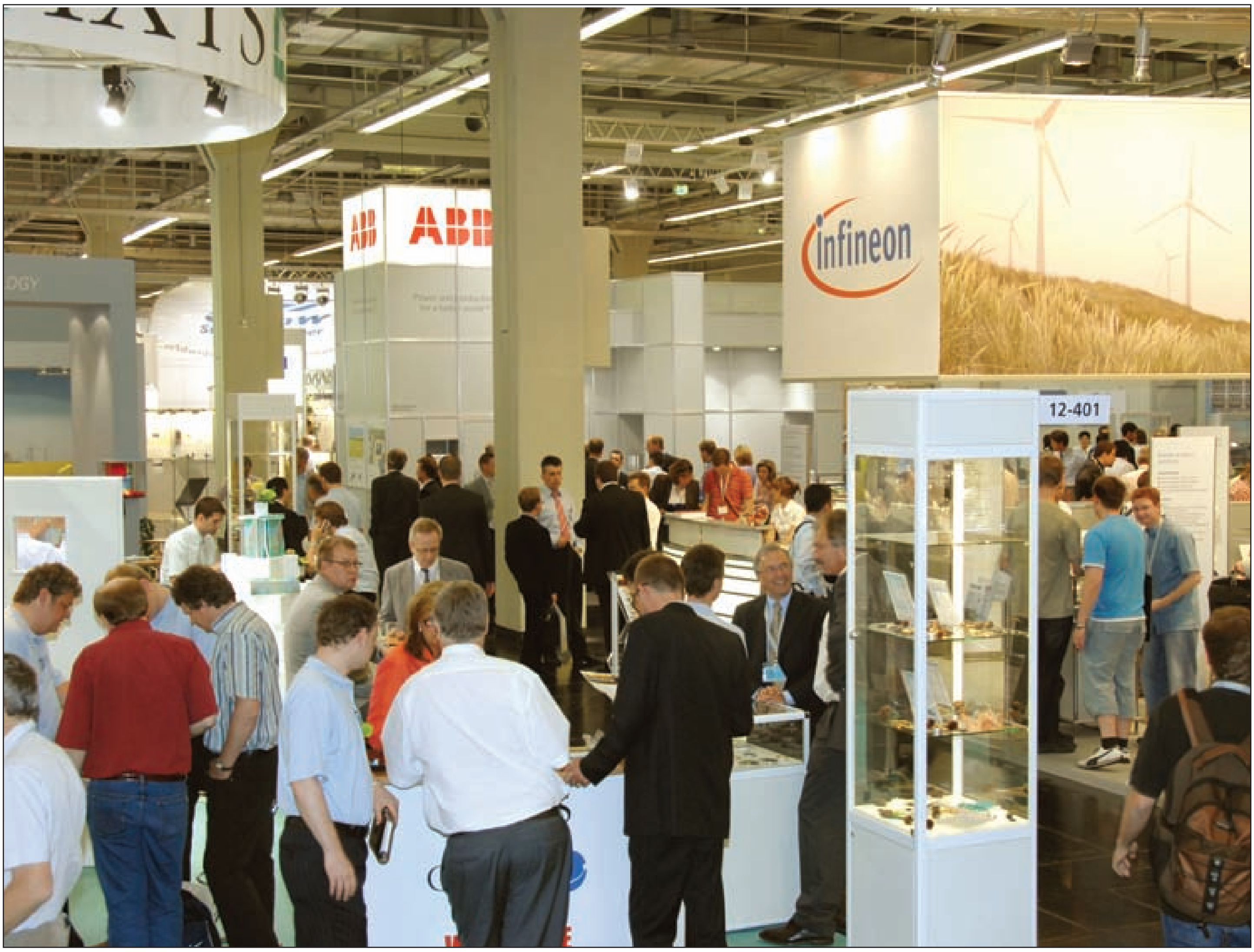


Energy savings through inverterised drives Source: ZVEI/Infineon

New PCIM 2008 Exhibits

The main exhibits at PCIM 2008 ranged from semiconductors, components and sensors, motors and rectifiers through to power management systems, simulation and design software, as well as many of the latest developments in the power electronics sector.

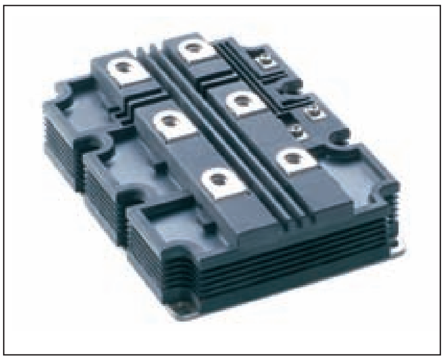


The 252 PCIM exhibitors showed great interest in power electronic products and solutions

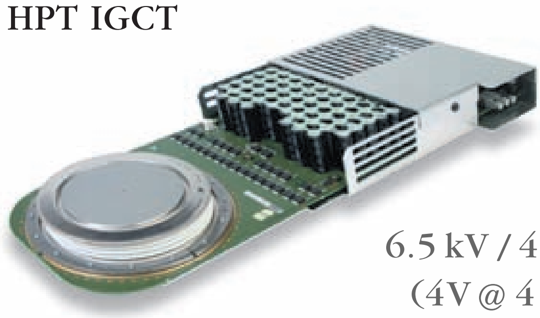
PCIM offers sector specific answers to the questions being asked by product and system designers, R&D managers, managing directors and buyers from the following industries: industrial electronics, automotive engineering, office and data management technologies, computer and communications, medical technologies, telecommunications, consumer-electronics and energy management. The following gives an overview on selected categories.

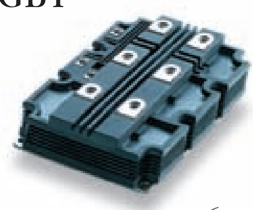
IGBTs and modules

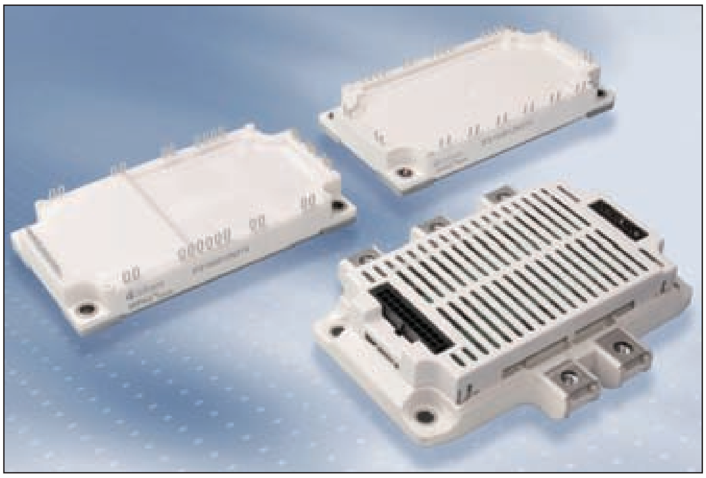
ABB introduced the 750A/6.5kV SPT+ IGBT module aimed at traction applications complementing the 1500A/3.3kV and 1000A/4.5kV versions. All combine the controllability of the former SPT cell with significantly reduced losses and highly increased ruggedness of the next generation STP+ technology. ABB's HiPak modules use the popular 190 x 140mm and 130 x 140 mm footprints. They are available in two standard isolation voltages (6 and 10.2kVRMS) and a variety of circuit configurations. HiPak modules exclusively use Aluminium Silicon Carbide (AlSiC) base-plate material for superior thermal cycling



ABB's 750A/6.5kV SPT+ IGBT module aimed for traction applications







Infineon's new MIPAQ family of IGBT modules

capability and Aluminium Nitride (AlN) isolation for low thermal resistance. They are realised with Soft Punch Through (SPT and SPT+) chip technologies, which combine low losses with soft switching performance and rectangular Safe Operating Area.

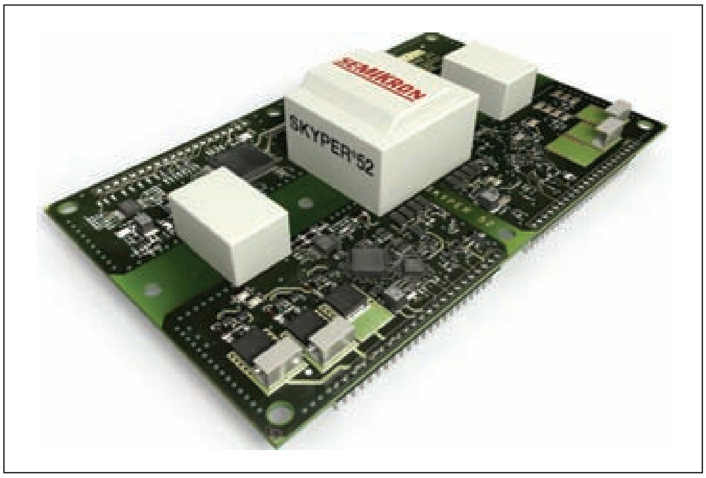
Mitsubishi Electrics new IGBT generation of 3.3kV R-Series adopts 'Fine Planar MOS gate Light Punch Through HVIGBT (FP-LPT-HVIGBT)' and 'Soft reverse Recovery HV-Diode with high robustness (SR-HVDi)' structures, which reduce the power losses and increase the rated current while maintaining the mechanical compatibility with the existing H-Series. The current density of the new IGBT chip is 94%, compared with a conventional IGBT while the diode chip's current density remains unchanged. At rated current and 125°C the new IGBT operates with a 30% lower $V_{CE(sat)}$ than a conventional IGBT. In addition, the peak collector current (i.e. I_{rr} of the diode) is reduced by 20%, consequently reducing the IGBT turn-on switching energy (E_{on}) by 10%. The maximum operation temperature is extended from 125 to 150°C.

Its new series of of 1200V Intelligent Power Modules (IPM) available for rated currents of 5, 10, 15, 25 and 35A dubbed PS22A7X represents the Vers. 4 series of DIP-IPM (Dual In-Line Package IPM) devices for home appliances package air conditioners and small drives. It combines Mitsubishi's CSTBT (Carrier-Stored Trench Gate Bipolar Transistor) technology, shrink-process ICs, and novel heat dissipating insulation sheet, leading to 30% smaller package and reduced on-state voltage and switching losses. The reduction of size has been achieved by a circular-shaped MOSFET replacing the traditional oval-shape MOSFET used for voltage level shifting in the High Voltage IC. The internal three-phase inverter structure, combined with control ICs, basically equals the previous version of DIP-IPMs, but the open-emitter type products offer three divided emitter terminals of low-side IGBTs to sense the inverter phase currents flowing through external shunts. The PS22A7X series offers logic filtering functions in order to obtain enhanced immunity against noise propagated from signal lines.

Infineon Technologies introduced its new MIPAQ family of IGBT modules that offer a high level of integration. MIPAQ (Modules Integrating Power, Application and Quality) products enable highly efficient power inverter designs to be used in Uninterruptible Power Supply (UPS); industrial drives, such as compressors, pumps and fans; solar power plants; and air conditioning systems. The modules are characterised by enhanced testing and are delivered as known-good systems. All MIPAQ products feature an IGBT six-pack configuration. The MIPAQ family today includes three products. The modules 'MIPAQ base' and 'MIPAQ sense' offer significant board space savings. The family members differ in certain functionalities. For example, the 'MIPAQ base' module integrates shunts, while the 'MIPAQ sense' module offers an additional current measurement feature that is fully digital with galvanically isolated output signals, and the 'MIPAQ serve' module includes adapted driver electronics. The latter i.e. covers the 1200V and 100A, 150A and 200A range comprising an IGBT sixpack configuration, a full set of driver ICs as well as a temperature measurement. Inside the module there are galvanically isolated drivers based on Coreless Transformer Technology. Samples of 'MIPAQ base' and 'MIPAQ sense' are expected to be available in Q3 2008 with start of production scheduled for Q2 2009. Sampling of 'MIPAQ serve' modules is projected to begin in Q4 2008 and start of volume production in Q3 2009.

Semikron has unveiled a new IGBT driver generation for 1200 and 1700V IGBT modules. It has two 9W output channels and a peak gate current up to 50A, making it suitable for parallel connected IGBT modules with a total current up to 9,000A. The SKYPER 52 is based on fully digital signal processing, allowing for the transmission of isolated sensor signals and individual protection level settings. Differential digital signal processing not only provides numerous technical advantages, but also ensures a high level of signal integrity and hence, high noise rejection. With the digital driver switching characteristics, shut-down levels, as well as error processing, can be set to meet the given application requirements. Digital signal processing does not depend on the component parameters, is highly robust, and is unaffected by temperature fluctuations or the affects of ageing. If an error is detected, this then means that all of the power transistors can be switched off either individually or sequentially. Overvoltages, especially those that occur in short-circuit turn-off conditions, are reduced by the IGBT driver. To do so, the driver switches the power transistor smoothly. This is possible thanks to intelligent turn-off control. Furthermore, with the new

Semikron's digital driver SKYPER 52 is based on fully digital signal processing



MiniSKiiP IPM, an IPM for solderless assembly and motor power up to 15kW

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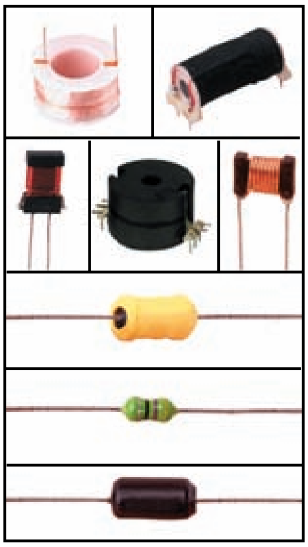

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graphic interface GUI the benefits of a user-friendly configuration platform that can run on Linux, Mac OS X or Windows systems can be used.

Semikron's Miniskiip IPM features a thermal resistance of 0.95K/W and junction temperature of 175°C. It was developed for motor power up to 15kW and has a latch-up free SOI driver IC for reliable driving already integrated. Power, control and auxiliary contacts are connected directly to the printed circuit board via springs. Snap-on mounting with one standard screw achieves a cost-efficient assembly of module, printed circuit board and heatsink. A high voltage driver IC with an advanced level shifter technology is integrated into the 600V Converter-Inverter-Brake IPM and the 1200V Inverter (sixpack) Miniskiip IPM providing IGBT driving without an optocoupler. The SOI technology provides complete latch-up immunity, since all switches are dielectrically insulated. A down-level shifter for each channel allows the presence of negative secondary offset voltages. The integrated gate driver remains fully operational for any applied offset voltage down to -50V. The gate driver IC features an over-current shut-down circuit protection by using an external shunt resistor in the ground plane shutting down the IPM in case of over-current, as well as an under-voltage lockout for all channels and fault signaling. A shut-down can be also forced by the system controller using the shut-down input. Cross-conductions are prevented by the interlock logic.

CT-Concept's new SCALE-2 IGBT driver has a significantly higher degree of integration, thus reducing the number of components on the driver boards. This results in maximum reliability, a smaller space requirement and much lower cost. Scale drivers have been in the market since 1998 and supplied by IGBT module makers such as ABB or Infineon (though Infineon support their own ICE drivers). SCALE-2 is scalabe for applications from a few kW to several MW, from low-voltage power MOSFETs up to parallel and series-connected 6.5kV IGBTs. The SCALE-2 chipset consists of two ICs: the logic-to-driver interface (LDI) and the intelligent gate driver (IGD). SCALE-2 ASICs are also offered in customised versions for volume quantities. The chipset has integrated interfaces for signal transmission via optical fibers or transformers. In the latter case, the drive signals and error acknowledgements are transmitted directionally via a transformer on each channel.

The IGBT drivers have an extremely short transit time of less than 100ns and a jitter of less than ±2ns. They are suitable for all known applications – the chipset supports not only two-leve,l but also three-level and multi-level topologies. Optimised active clamping is integrated as in predecessor systems. The gate driver chip (IGD) has an integrated output stage for gate currents up to 6A. The useful output current can be increased to about 40A by simple means. The complete functionality of the DC/DC converter is integrated in the primary (LDI) chip. The user interface has a Schmitt trigger characteristic and is compatible with all logic families from 3.3 to 15V. The chipset has highly effective ESD protection on all pins, ensuring safe operation in rapidly switching systems and extremely perturbed environments. The first three product lines based on SCALE-2 presented at PCIM 2008 were an ultra-compact driver core with 20A output current and 20W drive power in planar transformer technology, a plug-and-play driver series for all PrimePACK modules, and a modular plug-and-play driver series for driving individual, as well as parallel or series-connected 3.3 to 6.5kV IGBTs

Vincotech, the former Electronic Modules division of Tyco Electronics, released four module families specially designed for solar inverter applications. The modules are optimised for power ranges between 2 and 6kW to satisfy the requirements of transformer-based (up to 400VDC) and transformer-less (400 and 800VDC) architectures. The chip technologies used are optimised for the individual requirements of each system. The two modules for transformer-based architectures enable the use of small transformers. Transformer-less systems are covered by a boost plus inverter circuit in one individual module. Neutral point architectures, with their advantage of low leakage current, low switching losses and maximum power point optimisation between two input strings, are addressed by the symmetric boost and the NPC inverter modules. All modules are housed in the compact flow0 package (66mm x 33mm x 17mm). New sixpack families in four different housings for the motor drive and uninterruptable power supply markets complete Vincotech's spectrum from 10 to 150A. Equipped with IGBT4 (1200V) and IGBT3 (600V) for low conduction losses, the four families cover every three-phase motor drive and UPS inverting up to 30kW. High performance versions using an improved substrate are optional.

Power supply

IR extended its SupIRBuck family of wide input, single output integrated point-of-load (POL) DC/DC voltage regulators with the introduction of the IR380x family for consumer embedded POL applications up to 14A. Size and feature set are optimised for high performance consumer applications, including set-top boxes, LCD TVs, game consoles, desktop PCs and graphics cards. The new application-specific devices integrate control ICs with HEXFET MOSFETs in a 5mm x 6mm power QFN package saving up to 70% space compared to discrete solutions. This family of voltage regulators is designed for 4, 7 and 12A of output load current at 600kHz and 6, 9 and 14A at 300kHz respectively. Key features include wide range input of 2.5 to 21V and output range of 0.6 to 12V, pre-bias start up, a choice of two fixed switching frequencies, hiccup current limit, thermal shutdown and precise output voltage regulation. The thermally enhanced packages with slim 0.9mm profile, allow mounting on the back-side of the motherboard for additional space saving and enable no-air flow operation without heatsink below 10A.

AVX has introduced a new range of products within its TRJ professional series tantalum chip which delivers significantly lower ESR while achieving reliability levels twice that of standard tantalum devices. 124 new devices with the combined benefits of enhanced reliability (0.5%/1000hrs) and low ESR are now available in the professional TRJ series. Standard and low ESR TRJ capacitors are available in EIA standard A, B, C, D and E case sizes in voltages ranging from 6.3 to 50V and capacitance values from 0.1 to 470µF. The 6.3, 10 and 25V rated voltage parts target the most popular output voltages of DC/DC converters and battery applications (3.3, 5 and 12V). AVX's new FFVS range of medium power capacitors feature very high frequency operation and low stray inductance. Suitable for applications such as very high frequency ripple (>100kHz) DC filtering for induction heating, the devices exhibit an inductance of less than 10nH on certain models.

600V capacitors are offered in capacitance values of 22, 90, 140 and 195µF. 800V devices are rated at 58, 92 and 128µF, and 900V models at 34, 40, 65 and 90µF. Featuring a dry polypropylene dielectric technology, FFVS capacitors are very reliable with an extended life.

V•I Chip announced a constant current PRM regulator demonstration board for light LED applications such as street/stadium lighting, high-end projectors, active outdoor advertising and architectural installations. The board provides a precisely regulated current as required for direct-drive multi-LED applications where the intensity and brightness are controlled by regulating the current through the LEDs. The board can be used to provide adjustable current up to 5A at 48V when employed as an stand-alone non-isolated source or can be combined with the range of VTM transformers to provide an adjustable isolated current up to 100A. A PRM+VTM pair uses less than 1W for every 1,000 Lumens generated by the LEDs for high performance applications. This solution is a complement to using BCM bus converters with low voltage driver ICs for lower power applications such as LED TV backlighting.

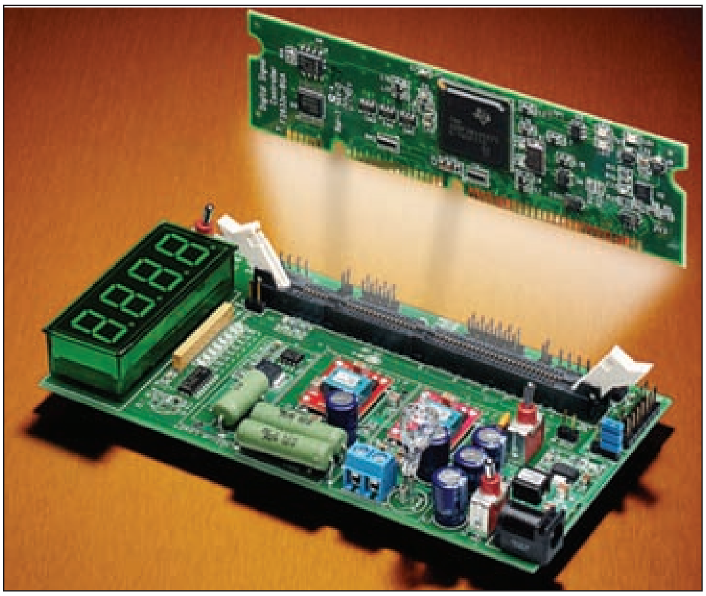
Texas Instruments announced five new experimenter and application-specific development kits for its TMS320F28x digital signal controllers. The modular kits enable rapid prototyping of application specific DC/DC and AC/DC Digital Power Developer's Kits. To reduce development time, code examples and full hardware design details along with TI's Code Composer Studio 32KB limited integrated development environment (IDE) are included. To accelerate development of software controlled digital power applications, the Digital Power Experimenter's Kit will be free to attendees of the one-day digital power workshops being held worldwide. The Digital Power Experimenter's Kit is intended for those new to software based digital power management by providing a

Toshiba's evaluation platform that will simplify and speed the development of BLDC motor drives

high function development environment including a DC/DC motherboard using two digital non-isolated PowerTrain modules along with an F2808 controlCARD. The DC/DC board also includes a digital multimeter and an active load that design engineers can use to perform transient response analysis and tuning.

The DC/DC Digital Power Developer's Kit targets multi-rail and multi-phase applications and using a F28044 DSC based controlCARD to demonstrate the capabilities of the device as a 16-rail digital power controller. It includes a DC/DC motherboard using eight digital non-isolated PowerTrain modules useful for prototyping DC point-of-load power control in a wide range of equipments for industry, communications infrastructure and consumer electronics. The AC/DC Developer's Kit is a complete, 80W rectifier development platform and uses a two-phase interleaved power factor correction (PFC) front end and a phase-shifted full-bridge secondary. The system is fully controlled by a single F2808 controlCARD and is useful for prototyping communications systems such as server farms and base stations, as well as telecom and consumer equipment.

TI also introduced a power supply controller for unregulated output voltages that achieves up to 97% system efficiency in an intermediate bus architecture. The controller allows intermediate bus architecture power systems to combine the highest amount of energy savings, high power-density and low system costs in telecom and data communication systems with multiple downstream point-of-load conversions. The UCC28230 implements load-dependent dead-time control to improve efficiency over the entire output load range. It also has 1-D output that shorts the primary-side winding, which keeps the self-driven synchronous rectifiers under control during start-up and shut-down and through transient conditions.



TI's Digital Power Developer's Kit

Inverter

Toshiba Electronics Europe has launched an evaluation platform that will simplify and speed the development of BLDC motor drives. The TB6582FG_EVB3 brings together a motor controller IC and the single-chip inverter introduced at PCIM 2007 to provide a complete sensorless sine-wave motor control and driver solution on a single board with input main voltages to 220VAC and output currents from 1 to 3A. Control of motor rotation speed in both forward and reverse directions is achieved by changing the PWM duty cycle based on the input from a host microcontroller. The board features integral circuitry that calculates rotor speed and position using phase current information, eliminating the need for Hall sensors. A triangular wave generator with a carrier wave frequency of 252Hz and an integrated dead time function are also incorporated into the device. In addition, a lead angle adjustment capability allows applications to be tuned for optimum efficiency.

Current transducer for automotive battery-monitoring applications

Current transducer

LEM has introduced the HAB xx-S family of current transducers for automotive battery-monitoring applications. These transducers have been designed to measure DC, AC, or pulsed currents up to ±100A. A new ASIC offers resolution 2.5 times better than previous models and a two-fold improvement in offset error, coupled with a significant reduction in price. The transducers use open-loop, Hall-effect technology that removes the need to cut the [primary] cable carrying the measured current. They provide a PWM output signal proportional to the primary current being measured and operate from a unipolar 5V supply. Temperature measurement capability can be integrated with the addition of a fourth connection pin to the transducer package. Output resolution is 0.03A with a linearity of 0.2%. Electric offset error is typically 0.075A across the temperature range from –10 to 65°C, and 0.15A across the full range from –40 to 125°C.

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Investigations on Ageing of IGBTs Under Repetitive Short-Circuit Operations

This paper received the Best Paper Award at PCIM 2008, sponsored by PEE. It describes experimental results concerning the ageing of 600V IGBTs under repetitive short circuit conditions. A critical energy, which is dependent on test conditions, has been already pointed out which separates two failure modes. The first, with a cumulative degradation effect, requires some 10,000 short circuits to reach failure, and the other leads to the failure at the first short-circuit with a thermal runaway effect. This paper is focused on the first failure mode. **M. Arab and Z. Khatir (INRETS-LTN), S. Lefebvre (SATIE), and S. Bontemps (Microsemi PPG), France**

In order to understand the ageing mechanism, 600V IGBT dies have been packaged by Microsemi. The packaging has been made in order to make possible the characterisation of some degradation by the measurement of different electrical characteristics, particularly the effects of device ageing on on-state voltage, short-circuit current and Al metallisation degradation which leads to resistance increase. The short circuit capability is one of the figures of merit which defines the robustness of the power semiconductor components, especially for IGBTs.

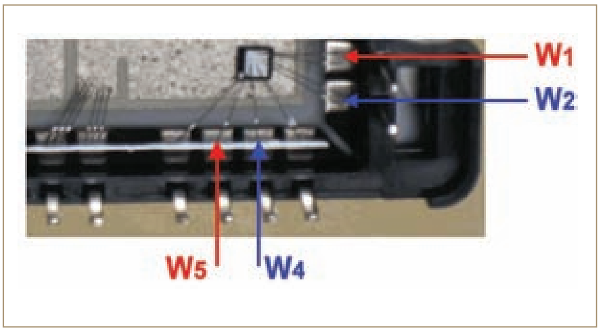


Figure 1: Dedicated IGBT power module realised by Microsemi with bond pads (W1-W4)

Development of power modules in order to highlight ageing indicators

Experimental test conditions consist of repetitive short-circuit operations applied to the device under test (DUT) with the same energy dissipated in the die until destruction. This energy is supplied by a set of capacitors and a circuit breaker (1200V/200A IGBT) that allows the DUT explosion to be avoided by an over-current detection (200A). An acquisition card controls the DUT gate drive pulses and allows the tests to stop when failure is detected. These tests are performed with a gate to emitter voltage equal to 15V in the on-state. A repetitive cycle of 0.33Hz is chosen in order to avoid the average overheating of the chip. A heating plate allows the case temperature to be controlled and the case temperature influence to b considered, especially at 25 and 125°C.

Each 1000 short circuits, several electrical parameters are regularly measured during the repetition of the short-circuit operations: on-state voltage (V_{CEON}), threshold voltage (V_{GETH}), input/output capacitors (C_{ISS}, C_{OSS}), gate leakage current (I_{GES}), collector leakage current (I_{CESS}) and short-circuit current (I_{SC}). The first three have been measured for 25°C junction temperature, leakage currents have been measured at 125°C, and short-circuit current during the short-circuit test.

Threshold voltage is measured for different values of emitter current in order to evaluate transconductance evolution (10µA, 100µA, 500µA and 1mA). Gate leakage current is estimated using a

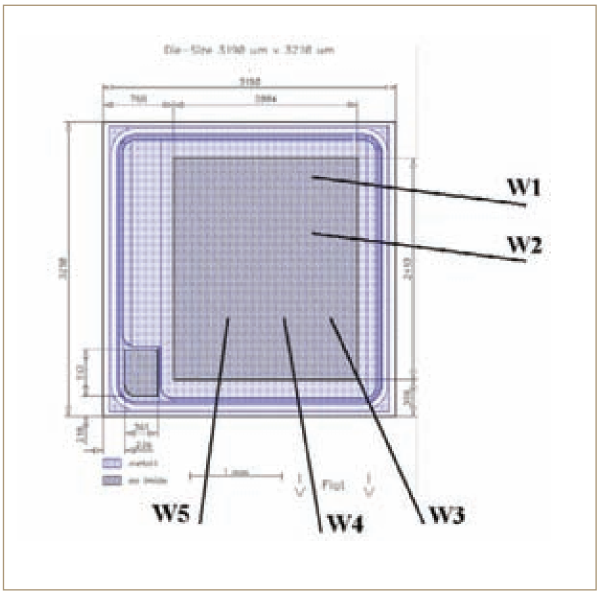


Figure 2: Bond wires locations on emitter metallisation pad of IGBT die

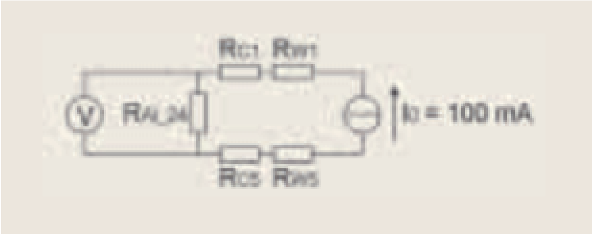


Figure 3: Part of Al layer measurement

KEITHLEY 6430 SMU. The collector leakage current is measured for a collector to emitter voltage equal to 200V (6430 SMU) at 125°C junction temperature.

In order to set up test campaigns allowing the ageing of tested devices to be followed, other electrical parameters must be evaluated. During short-circuit cycles, not only the bulk of the device is strongly thermally constrained, but also its immediate vicinity such as aluminium metallisation of emitter pad and bond wires (especially electrical contact between wires and metallisation). In order to characterise the electrical resistances of die metallisation pad, as well as contact between bond wires and metallisation, Microsemi has realised a dedicated package. Several modules with 600V IGBT dies (in Trench Field Stop technology) have been provided for this study. A four-probe contact design was chosen for the bond wire connections (with judicious location of bond contacts) in order to perform precise measurement of the Al metallisation layer (Figures 1 and 2).

Figure 3 gives an example of measurement methodology for Al layer resistance evaluation, where RAL_24 is the Al layer resistance between wires 2 and 4, R_C are the contact resistances between Al layer and bond wire and R_W are the wires' resistances.

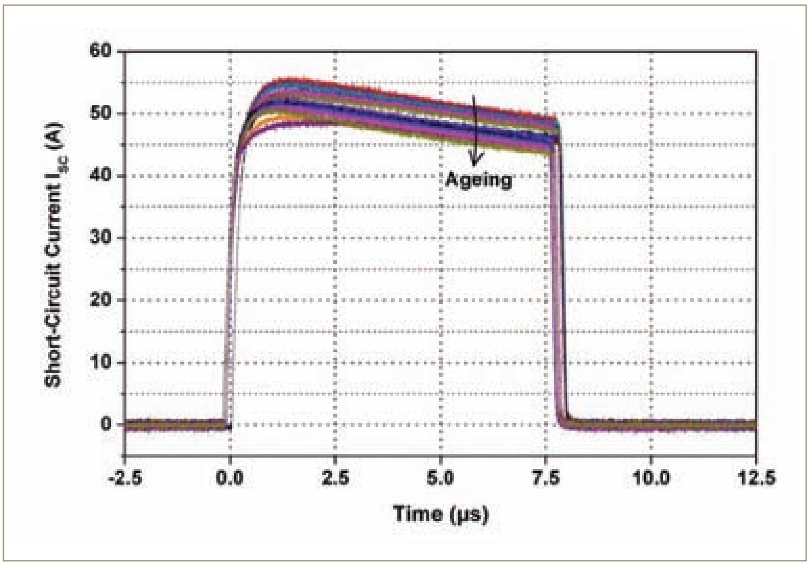


Figure 4: Decrease of short circuit current during repetition (T_{CASE} = 125°C, U = 400V)

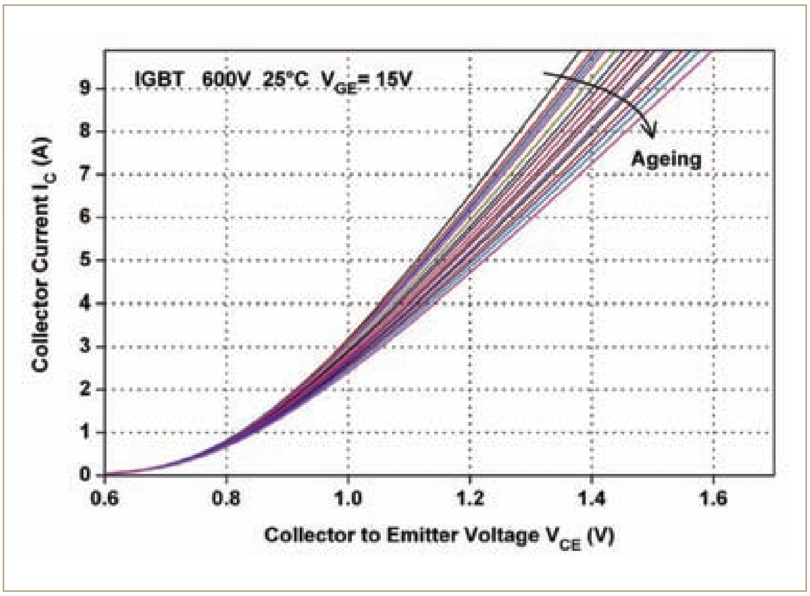


Figure 5: Increase of the on-state voltage during repetition of short circuit operations (T_{CASE} = 25°C, V_{GE} = 15V)

Characterisation results

Several 600V IGBT dies were tested in repetitive short-circuit operations and in ageing mode conditions (dissipated energy lower than the critical value). Supply voltage is equal to 400V and dissipated energy to 156mJ. Results are given for only one device which has failed after 87900 short circuits. All results obtained with other devices are similar to the one presented. On all tested devices, we can note no significant variation of the threshold voltage for different emitter currents, input/output capacitors, gate leakage current and collector leakage current. However, short circuit waveforms regularly stored during the repetitive tests show a significant decrease of short circuit current (I_{SC}), before the failure appears (Figure 4).

On-state voltage is another electrical parameter that presents a regular variation during the tests. Figure 5 shows an increase of the on-state voltage periodically measured during the repetition of the short circuit operations.

The electrical resistance of Al layer and bond contact resistance have been characterised regularly during ageing. It is well known that Al reconstruction appears in the Al layer when it is subjected to temperature cycles, especially at high temperature. Due to the large difference of coefficients of thermal expansion (CTE) between Al and Si, significant plastic deformation occurs in the aluminium layer leading to severe degradation.

After about 10,000 short circuits, the resistance of the Al layer significantly and regularly increases until failure occurs (with an increase by a factor of approximatively 2.5 for RAl_24). Contrary to on-state voltage which consistently increases from the beginning of the tests, about 10,000 cycles are necessary to show significant evolution of Al sheet resistance. It seems that these two phenomena are not correlated.

Failure analysis

Failure analyses using SEM (Scanning Electron Microscopy) have shown that the

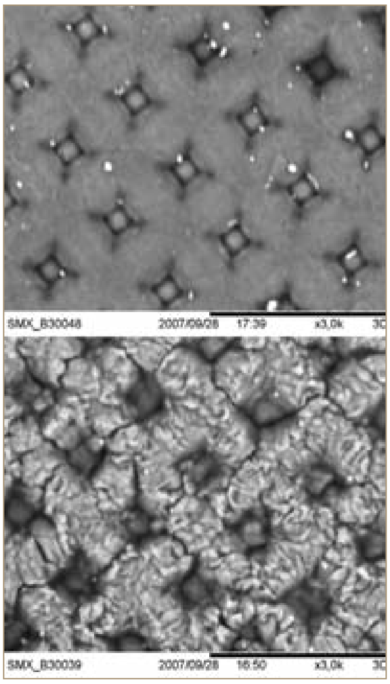


Figure 6: Al reconstruction before test (upper) and after 24,600 short-circuit cycles

failure is located to the emitter bond wire contact with significant reconstruction of the Al layer. However, the short circuit repetition generates thermal cycling in the DUT with high temperature variations. This thermal cycling introduces periodical compressive and tensile stresses in the thin emitter metallisation film due to the CTE mismatch between aluminium (23.8ppm/K) and silicon chip 2.6ppm/K). Consequently, stresses arising within the aluminium thin-film during repetitive short circuit operations of the device lead to high plastic deformation with dislocation glide.

Figure 6 shows micrographs of emitter metallisation before and after tests. A strong degradation of the metallisation after cycling is observed. This degradation causes an increase of the metallisation resistance and weakens the bond wire contacts. Cracking also take places around the bond wire contact as shown in Figure 7, leading to increase the contact resistance. In addition, the bond wire contact is probably weakened by thermo-mechanical stress induced by thermal cycling due to the repetitive short circuits. The degradation of the wire bond contact leads to an increase in the bond contact resistance. As a consequence, the local temperature rises and enhances thermal fatigue. The local temperature increase is large enough to eventually trigger the parasitic transistor of the IGBT and could explain failure at turn-off observed after repeating many short-circuits.

Failure always leads to wire bond lift-off (Figure 8) as a consequence of the high current density and of the local melting of the bond end (Figure 9).

Conclusion

Measurements allowed by Microsemi packaging have shown the effect of the repetition of short circuit operations on the increase of the resistivity of the Al layer. This is explained by Al reconstruction and cracks of the metal layer due to ageing. Strong degradation of the metallisation (Al reconstruction and cracks), as well as bond wire lift-offs, were observed on all tested devices. In these specific conditions of test (dissipated energy lower than the critical value), failure always appears at turn-off when the device begins to open the short circuit current which looks like dynamic latch-up. The local increase of temperature due to wire contact degradation and Al layer ageing when repeating short circuit could explain the failure at turn-off considering the trigger of the parasitic transistor of the IGBT which is facilitated by the temperature rise.

Literature

The full paper has been published within the PCIM 2008 Proceedings (ISBN 978-3-89838-605-0).

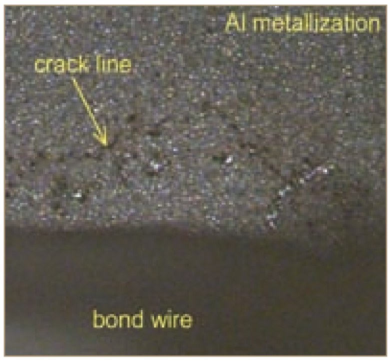


Figure 7: Cracking around the bond wire contact (optical image, 200x)

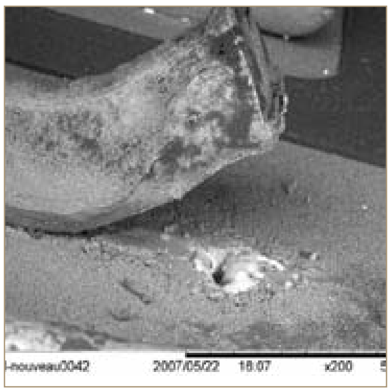


Figure 8: Bond wire lift-off after failure

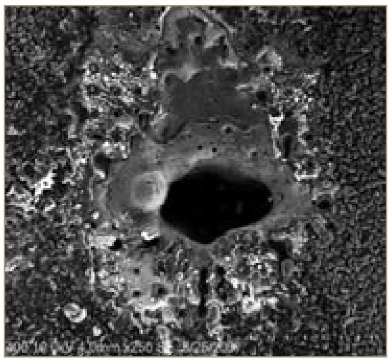


Figure 9: Melted hole on the footprint of an aluminum bond wire after lift-off

Semiconductors in Hybrid Drives Applications

With the upcoming importance of energy saving in future cars as well as CO_2 reduction, today's hybrid cars show the potential of reaching more efficiency in automotive applications. Besides the power semiconductor devices used for the main inverter, additional electronic components will be needed in future vehicles. The structure and function of the different hybrid drive components, as well as used semiconductors and the latest IGBT, MOSFET and SiC technologies, will be described below. According to the special needs of hybrid drives applications, future trends like increased junction temperature or new interconnection technologies will be illustrated. **Ingo Graf and Mark Nils Münzer, Infineon Technologies Warstein and Munich, Germany**

Depending on the functionality and power range, three systems (Micro-Hybrid, Mild-Hybrid and Full-Hybrid) are implemented in available cars. The level of hybridization has direct impact on fuel consumption. Figure 1 shows an overview on the implemented functionalities and potential fuel savings in hybrid cars.

Hybrid system architecture

Besides the combustion engine, a minimum of one additional electric motor/generator is integrated in Mild- and Full hybrid cars. Here, the electrical motor is driven by battery voltages in the range 120 to 400V. An additional high voltage battery (e.g. new lithium ion) is implemented as well. For exchanging energy between the 14VDC power net and the DC high voltage (HV) power net, a DC/DC converter is used. Steering the electric motor is realised by using a DC/AC inverter. An optional additional DC/DC boost converter can be used to increase the battery voltage. The hybrid system allows additional auxillary drives realised by additional inverters (DC/AC). New opportunities like ventilating and air conditioning (HVAC), power steering or oil pumps will be possible (see Figure 2).

Typically, the inverter is realised by six IGBT switches, each with antiparallel diode in power modules well known from industrial and traction applications. The switching frequency is in the range of 8 to 10kHz.

For DC/DC converters different configurations can be used. H-bridge and half-bridge topologies can be found, as well as configurations with active (MOSFET, CoolMOS, IGBT) and passive components (diodes). The optional booster is often realised as a half-bridge with two switches (for 600V IGBT/diode or 600V CoolMOS).

Figure 1: Level of hybridisation in cars

An optimised DC/DC behaviour with low voltage ripple can be reached by increasing the switching frequency up to 100kHz. Therefore, low power DC/DC converter topologies are realised by MOSFET devices.

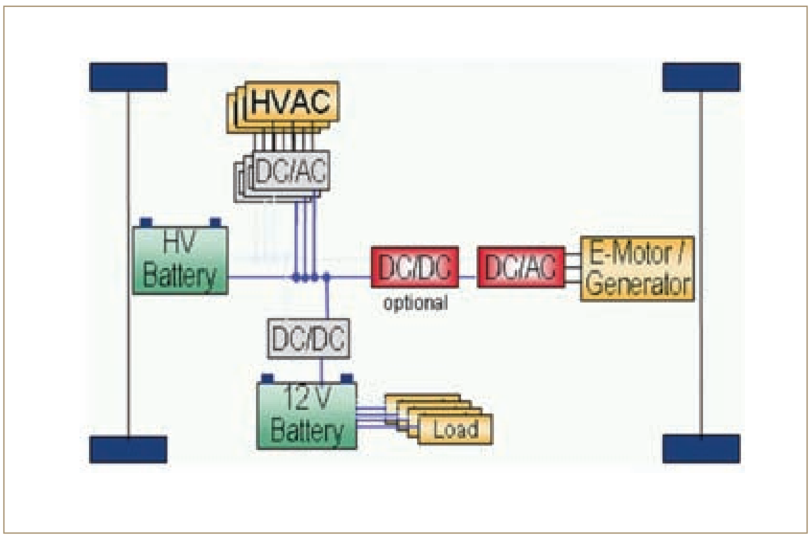


Figure 2: System architecture of a hybrid vehicle

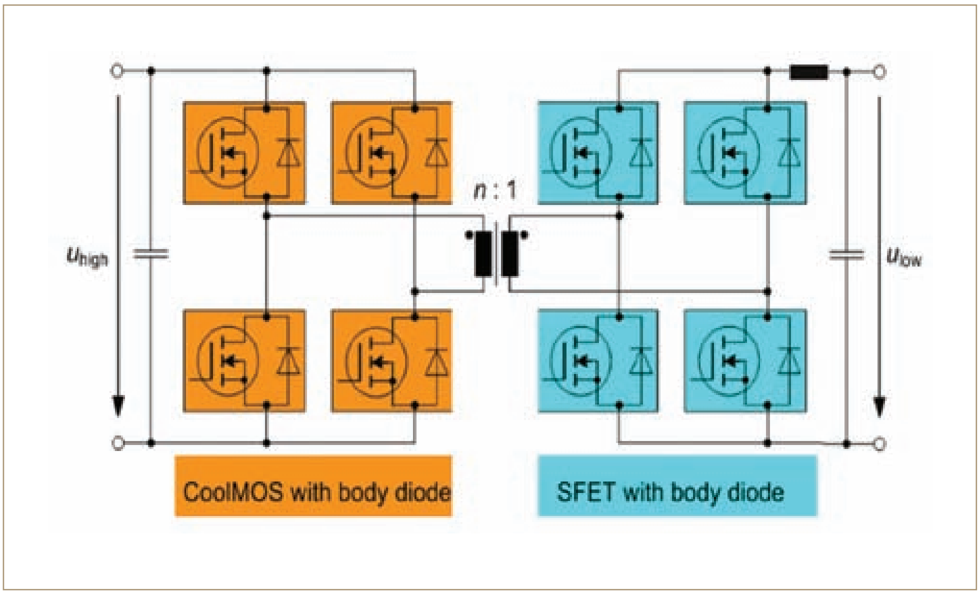


Figure 3: **DC/DC configuration (dual active bridge)**

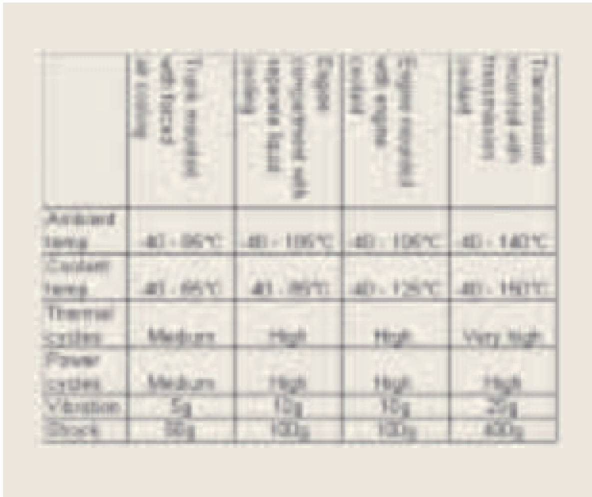
The switching losses of MOSFETs are much lower compared to IGBTs in this operation mode. For example, the DC/DC converter (between 14V and HV power net) can be realised with two H-bridges (dual active bridge). The low voltage side consists of e.g. 40V MOSFETs and the HV-side by e.g. 600V CoolMOS devices (Figure 3). All inverter and converter configurations request appropriate driver ICs and driver stages for an optimised switching behaviour of the used IGBTs and MOSFETs.

Requirements for HEV power electronics

Besides cost and performance, quality is a major topic for HEV power electronics. Although expected quality level and lifetime are same for all components, the environmental stress that determines the requirements for each component might be very different. As with most automotive components, the requirements for power semiconductors vary between different mounting places and cooling conditions. A power semiconductor module that is mounted on a forced air cooled heatsink in the trunk will experience less vibration and thermal cycles over the expected lifetime than a transmission mounted power semiconductor module that is cooled by the transmission oil.

In terms of thermal resistance, liquid cooled systems show significantly better behaviour than air cooled systems. Due to the low losses, mild hybrid systems can still be cooled with forced air cooling. Full hybrid systems need liquid cooling to dissipate the power (see Figure 4).

To improve the efficiency of a hybrid drive, it is important to reduce the losses in the power semiconductor. MOSFET and IGBT are the predominant power semiconductors in HEV applications. Due to the uni-polar characteristic, the switching losses of a MOSFET are significantly lower than those of an IGBT. As a result, applications with high switching frequency (>100kHz) are the domain of MOSFETs, while applications with low switching frequencies (<10kHz) are typically dominated by IGBTs. The unipolar characteristic also leads to a



	[illegible]	[illegible]	[illegible]	[illegible]
Ambient temp	[illegible]	[illegible]	[illegible]	[illegible]
Coolant temp	[illegible]	[illegible]	[illegible]	[illegible]
Thermal cycles	Medium	High	High	Very high
Power cycles	Medium	High	High	High
Vibration	5g	10g	10g	[illegible]
Shock	50g	100g	100g	400g

Figure 4: **Requirements for different mounting and cooling conditions of power electronics**

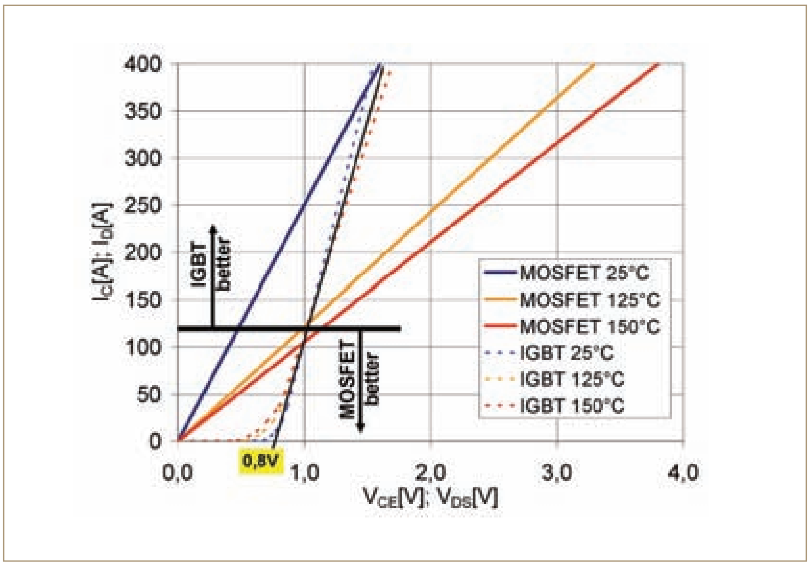


Figure 5: **Conduction losses of same area 600V IGBT/Diode and 250V Trench MOSFET**

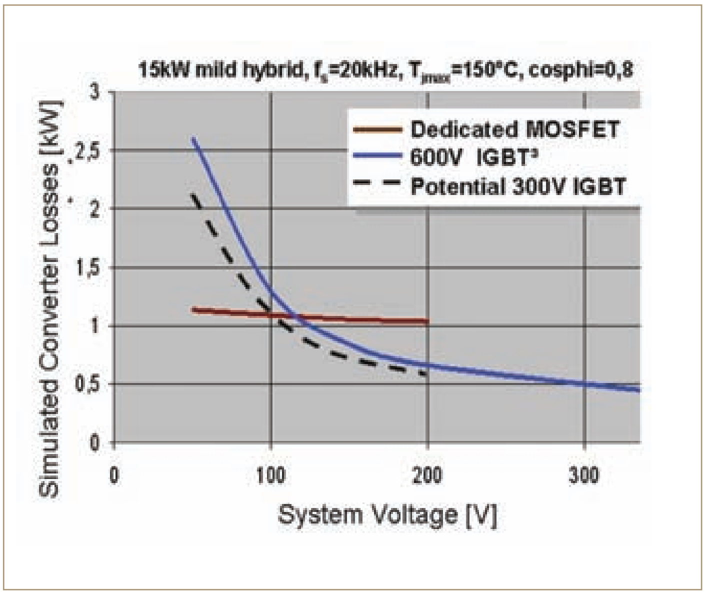


Figure 6: Converter losses versus system voltage for different chip technologies

resistive transfer characteristic. In contrast, the transfer characteristic of the IGBT shows a threshold voltage of about 0.8V due to the pn junction at the back side of the IGBT. Only above this voltage can a resistive characteristic be observed (see Figure 5). While the resistive part scales with the blocking voltage the threshold is independent. Therefore, IGBTs are less suitable for low voltage applications then MOSFETs.

As can be seen in Figure 6 the 600V IGBT is superior to a dedicated MOSFET as long as the system voltage is higher than ~120V. To show the potential of future IGBT devices with lower breakdown voltages, the results of a 300V IGBT have been estimated and included in this figure.

Besides the influence of the losses on the efficiency of a hybrid drive, they also directly influence the cost of the system, especially the cooling and necessary silicon area. The losses generated in the silicon heat up the device. To keep the chip temperature below the maximum allowable junction temperature a significant effort in cooling has to be made. Chip sizes and thus, costs, could be reduced at improved electrical characteristics (overall losses and robustness) step by step, and as a result, the inverter efficiency rises at more compact sizes.

One essential key topic was the development from the vertical IGBT device structure (PT) to the current

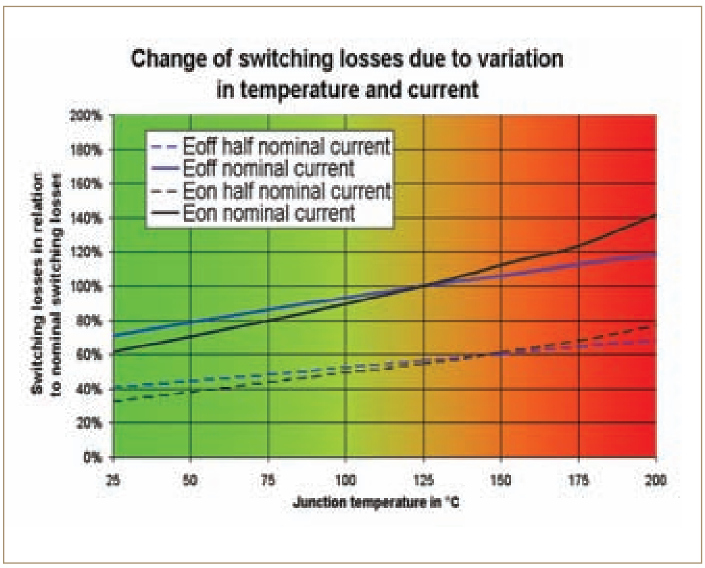


Figure 7: Influence of temperature on switching losses

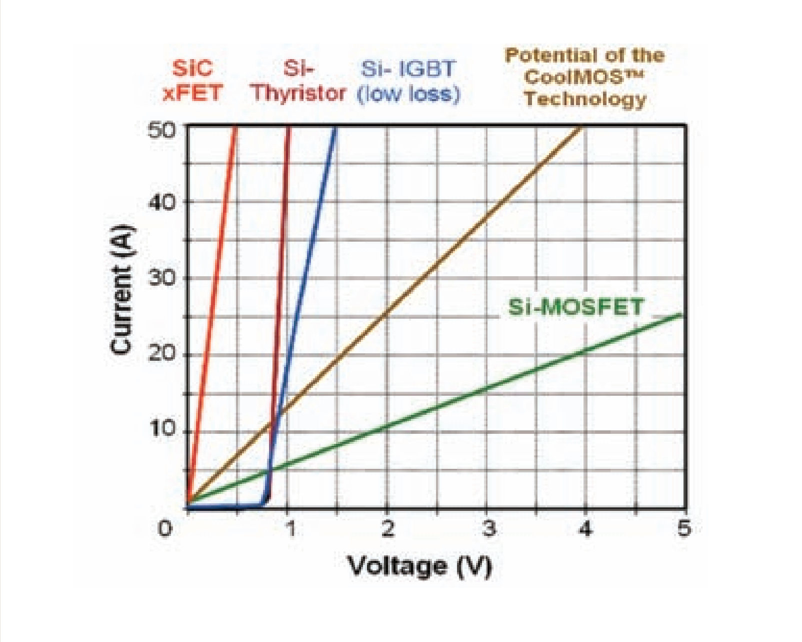


Figure 8: **Expansion of virtually loss-less switching voltage range by unipolar SiC switches**

Field Stop device structure (FS), resulting in a continuous reduction of the active device thickness. This is very important as on-state as well as switching losses directly correlate to the device thickness. Thus, a leading edge process technology for ultra-thin IGBT and diode silicon wafers is one key factor. Modern 600V IGBTs and free-wheeling diodes are now in production with only 70µm thickness.

High temperature capability

To minimise the cooling effort, it is necessary to increase the maximum allowable junction temperature. With the introduction of 600V IGBT3, the allowable junction temperature has been raised by 25°C to 150°C operational and 175°C maximum. As can be seen in Figure 4, this increase can be fully utilised as the conduction losses are almost independent of the temperature. Also, the switching losses are only slightly increased when going to higher temperatures (see Figure 7).

Also, during switching as well as short circuit tests, the IGBT3 showed its robustness at a junction temperature of 200°C. These results show that, in general, an increase of the junction temperature for future IGBT generations is possible. This will be essential to meet the future needs of power electronics especially in hybrid vehicles.

Talking about the future of power semiconductors, of course silicon carbide (SiC) has to be mentioned, as this material shows many advantages compared to silicon - 10 times higher electrical breakdown field, 3 times better thermal conductivity and a high temperature operation well beyond 200°C. In some high performance industrial applications like PFC (power factor correction), it already makes sense and commercially available 600V silicon carbide Schottky diodes do their work. Higher blocking pin diodes are also in the development phase. For silicon carbide switches JFET and MOSFET designs are under investigation. Figure 8 shows the potential of such semiconductors compared to existing technologies. The conduction losses of an SiC-xFET could decreased by a factor 3 compared to a low loss Si-IGBT. Due to the large band gap of 3.2eV, there is no development of a SiC-IGBT. As a first

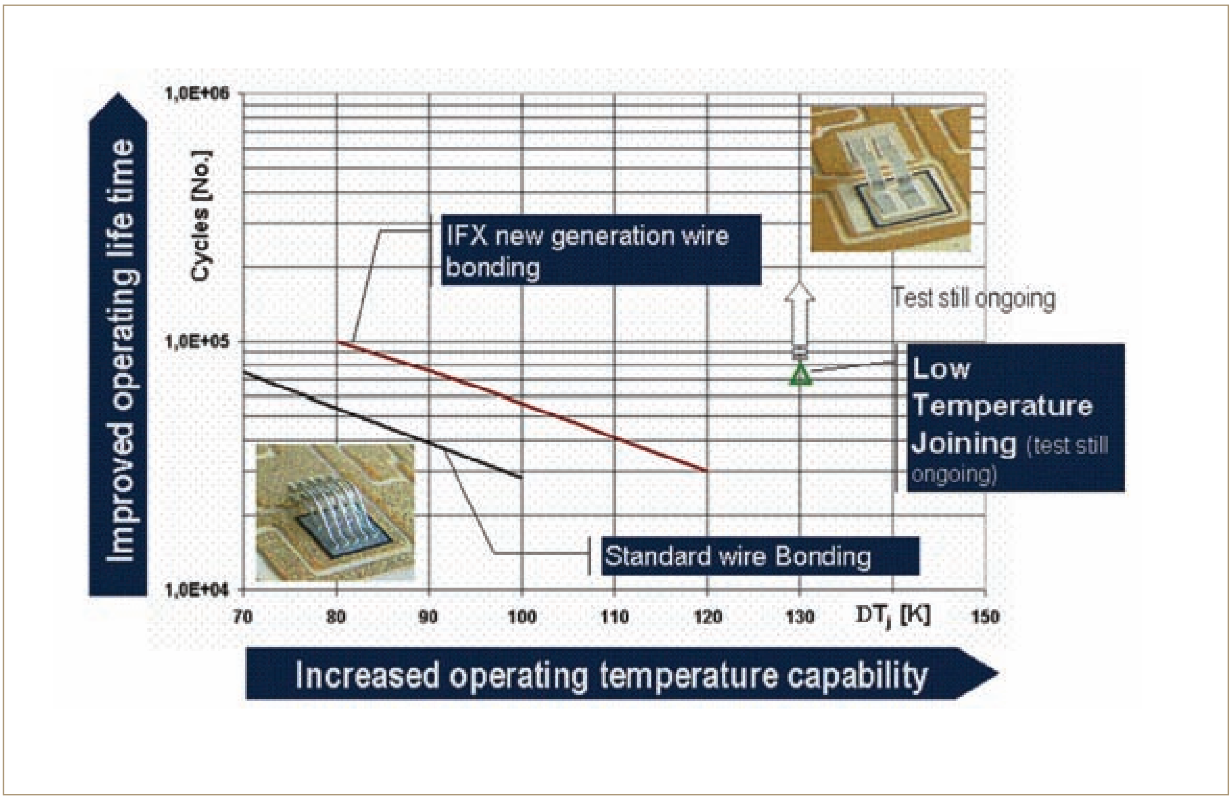


Figure 9: **Improvement of power cycling as a result of new interconnection technologies**

step, maybe the combination of a Si IGBT switch and a SiC Schottky diode will become attractive in hybrid car applications.

New interconnection technologies

Today, power semiconductor modules usually contain several IGBTs and diodes, which are soldered onto a metallised ceramic substrate. To connect the top side of the chips, wire bonding is state of the art. Multiple substrates are connected to a baseplate by use of soft-solder joints

Changing the maximum allowable junction temperature of the power semiconductor will directly change the thermal stress on the interconnection of the chip surface. A typical wear-out effect at the chip surface is the wire bond lift off. To test this interconnection, power cycling tests are performed. The number of cycles that a device survives is related to the temperature swing, the maximum temperature and the slopes. For the introduction of a maximum junction temperature of 175°C, the wire bonding process has already been improved from standard wire bonding to the IFX new generation wire bonding (see Figure 9). For future designs results of the low temperature joining process are promising. As can be seen the tests were still ongoing after 70000 cycles with a temperature swing of 130°C.

Over the lifetime of DCB modules, the layers are prone to recurring mechanical stress, due to the ongoing thermal cycles. Caused by the current flow in the semiconductor and the resulting heat-up, the materials used, such as copper, ceramics, silicon and aluminium expand with their different coefficients of expansion. This may lead to premature solder fatigue between the DCB substrate and the baseplate. The result is delamination of the solder layer and the increase of the thermal resistance caused by this. Finally, the component fails due to overheating.

For industrial applications modules with a standard DCB (Al_2O_3) in conjunction with a copper baseplate are usually used, as the requirements for thermal cycling capability are much lower here than in traction applications for example. For these, a combination of materials is often used consisting of an AlN DCB and an AlSiC baseplate.

An important qualification test for semiconductor modules is the so-called thermal shock test (TST). In this two- chamber test, the module is permanently exposed to temperature fluctuations of -40 to 125°C (or 150°C) and from 125°C (or 150°C) to -40°C. After the test with a predetermined number of cycles the degree of solder layer delamination between baseplate and DCB is evaluated. Power semiconductors for hybrid drives bear requirements of up to 1000 cycles of thermal shock. This requirement cannot possibly be achieved with a standard DCB module construction. One solution would be the use of the material combination mentioned above – AlN DCB with AlSiC baseplate.

This approach, however, results in added material cost and is suitable primarily where the heatsink temperature is already at a very high level. Considering the temperature fluctuations and number of required thermal cycles during the lifetime, a cost optimised solution has to be found for the power semiconductor concept. One solution is the use of a so-called 'improved' Al_2O_3-DCB in conjunction with a copper baseplate. This combination of materials is mainly suitable for mild hybrid systems and some full hybrid systems.

When designing the power semiconductor module, particular consideration needs to be given to the load profile during the lifetime of the hybrid vehicle. Once the required profiles are available detailed in passive temperature fluctuations and current profiles, a suitable combination of materials (DCB/baseplate) can be determined.

Conclusion

The special requirements in hybrid cars have deep impact on the right choice of semiconductor solutions. The development of new power semiconductors and interconnection technologies can help to save costs by a reduction of losses and an increase of the maximum junction temperature. The development of new chip generations will yield higher power densities and reduced chip areas at the same time.

Resonant Motor Drive Topology with Standard Modules for Electric Vehicles

Weight and volume reduction of the system have the highest priority in electric vehicles, which leads to high motor frequencies. To gain the advantage of high speed drives without the disadvantage of high power losses, resonant switching topologies are required, without becoming too complex and whilst still satisfying the required reliability. The automotive miracle of increased reliability at reduced cost has to become true again to make this vision real. A new standard component which supports an innovative switching topology might be an important step forward. **Michael Frisch, Vincotech, Munich, Germany**

The demand for electrical drive solutions for transportation applications has increased heavily. This is driven by the so-called mega trends such as mobility, energy efficiency, and reduction of CO_2 emissions.

Besides, the electrical drive technology offers additional functions and features for those applications. In the current situation the availability of technical solutions is the bottleneck for a realisation of the new applications which pop up in excessive numbers. The Swiss company BRUSA is one of the commercial know-how sources for the required drive system. It decided to develop a standard inverter with the purpose of covering multiple high-end applications with small volume, and having a proven and tested concept as a starting point for a development of high volume applications as hybrid car or electrical car.

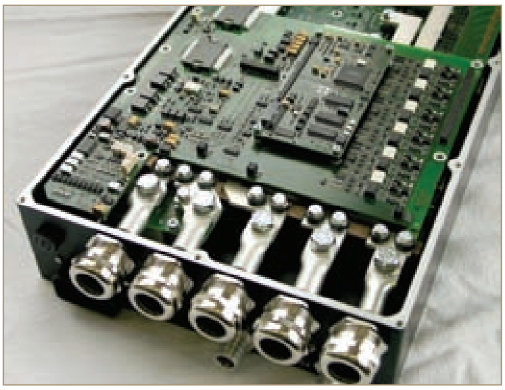


Figure 1: 3~ inverter DMC144

Specification for a standard motor drive inverter

BRUSA developed a 3~ inverter which had to cover the requirements of the project, but also to provide the flexibility of possible usage in other applications (Figure 1).

The requirements for this motor drive system comprised two types of 3~ inverter with 100 to 500VDC and 200 to 1000VDC voltage, scalable output power in 40kW steps (e.g. 40kW, 80kW), compact outline, liquid cooled, IP65 protection grade, and efficiency >97%.

To achieve small size and weight goal the maximum motor speed will be high. When using a sinusoidal motor current the PWM frequency has to be relative high. The alternative of a rectangular pulsed phase current will cause a DC-current ripple and also a mechanical torque ripple (Figure 2). This ripple will cause several unwanted effects such as additional losses in the battery, audible noise, and vibration which might cause unpredictable problems in the whole electromechanical setup as a broken electrical interconnection or increased thermal contact.

A sinusoidal phase current will generate continuous torque without high frequency vibrations (Figure 4). On the other hand, an inverter with sinusoidal output current requires higher PWM frequencies. In order to avoid increased power dissipation in the inverter electronics, a solution for low switching losses in the inverter is needed.

Inverter electronics at component level

Highest quality and reliability levels are a must in automotive applications. All subsystems have to be qualified and optimised to achieve the reliability and cost targets. All this has to be done with the available resources in reduced time to meet the time to market specifications. To increase the reliability and reduce cost in a high volume series production, it is important to minimise the complexity of the system. Repeating structures can be realised with identical functional blocks. This reduces development as well as qualification efforts and time. The repeating power electronics structure for drives and

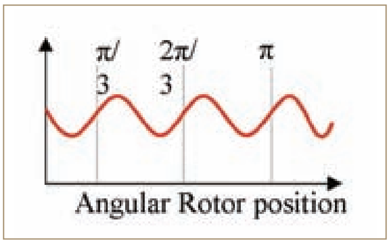


Figure 2: Torque ripple with rectangular pulsed phase current

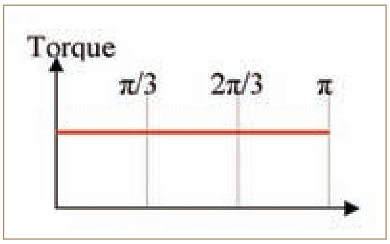


Figure 3: Torque signal at sinusoidal phase current

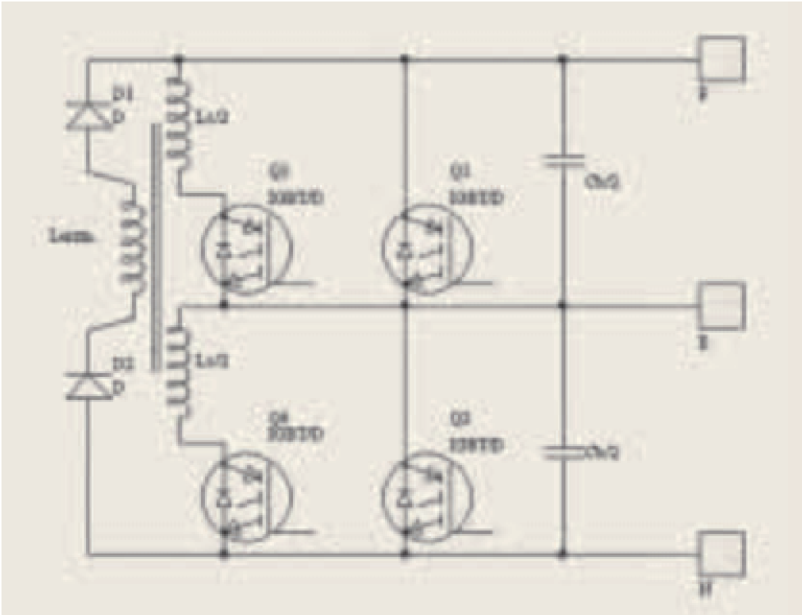


Figure 4: SoftSwing – topology

bi-directional DC/DC converters is the half-bridge circuit. A module which incorporates this function is a conclusive subsystem for motor drive applications.

The combination of a high and low switch in one module makes it easy to minimise the inductive loop in the DC-link by retaining the flexibility to distribute the circuits in the available space. This increases the freedom for the system design and reduces the complexity, which is especially important in the limited space in hybrid car applications.

Power modules with half-bridge topology are available as standard products, e.g. flowPHASE 0 (1200V/150A and 600V/200A).

The requirement of compact high performance motors without torque ripple leads to solutions with high motor speed and high PWM frequencies. Switching frequencies >20kHz will cause unacceptable switching losses in standard hard switched inverter topologies with the usual three-phase inverter bridges. Special soft switching concepts are required to reduce the maximum power dissipation in the semiconductors. The resonant SoftSwing topology was selected to answer this challenge. Hard switching inverters provide a considerably lower PWM-frequency than Soft Swing inverters would do.

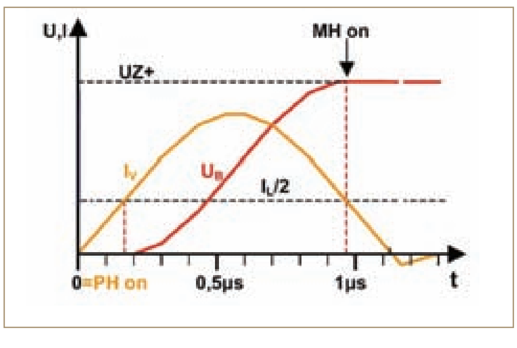
However, the standard half-bridges are obsolete now. The modules do not support such an approach sufficiently. The new task is to develop a universal power module for motor drives and DC/DC converters in hybrid and fuel cell vehicles with electrical output power: 30 to 100kW, DC-voltage 150 to 450V and 600 to 900V. The module has to support the special requirements of the SoftSwing topology at an ultra-high motor speed of 100,000rpm (ca. 1700Hz) and a PWM frequency of 24 to 48kHz.

The bridge point is formed by the two main IGBTs and is connected to an auxiliary circuitry, consisting of small bridge capacitors and an auxiliary half-bridge with small IGBTs and coupled inductors on their drains (Figure 4). In the case of active switch-on (Figure 5), the external gate stimulus turns on only the auxiliary IGBTs (PH on), which conduct first. Subsequently, the current ramps up flowing into the inductor. Due to the coupling, the same current ramps up in the other inductor through the free-wheeling diode of the passive auxiliary switch. Once the sum of these auxiliary currents reaches the load current level, no load current flows through the main free-wheeling diode, which is then about to set the bridge point free.

The bridge capacitors and the inductors form an LC-oscillator and the bridge voltage starts to swing around its neutral point, which, in this case, is the virtual centre tap of the DC-link. If the damping is sufficiently low, the bridge voltage nearly reaches the other rail potential where it is trapped by the zero current, zero voltage turn-on of the corresponding main IGBT (MH on). From this point on, the auxiliary inductors release their stored energy as their currents start to ramp down. With the load current continuously flowing, the main IGBT current must ramp up to compensate for the disappearing auxiliary current. Once the load current is completely commuted, the inductors need to be demagnetised, for which the auxiliary IGBT has to be turned off. One solution to perform demagnetisation is by using a well-coupled demagnetising winding. Once the auxiliary inductors are completely demagnetised, the half-bridge is ready for another active commutation.

Advantages of this topology are zero current - zero voltage switching. The reverse recovery charge is not absorbed when the load current commutes from the free-wheeling diodes into the IGBT. The bridge capacitors protect the IGBTs from high voltage as the tail current occurs during turn-off. Due to the absence of significant switching losses, the IGBTs can be utilised up to their rated DC-capability. Ageing related to periodical thermal expansion of the chip, caused by adiabatic switching loss absorption, is completely avoided. The circuit is extremely rugged and tolerant in overload conditions. At 24kHz, the power dissipation is only half that of conventional hard switched topologies. Due to the absence of reverse recovery spikes, the circuit generates extremely low disturbance emissions. In particular, DC-link filtering against conducted emissions becomes

Figure 5: Switch on signals



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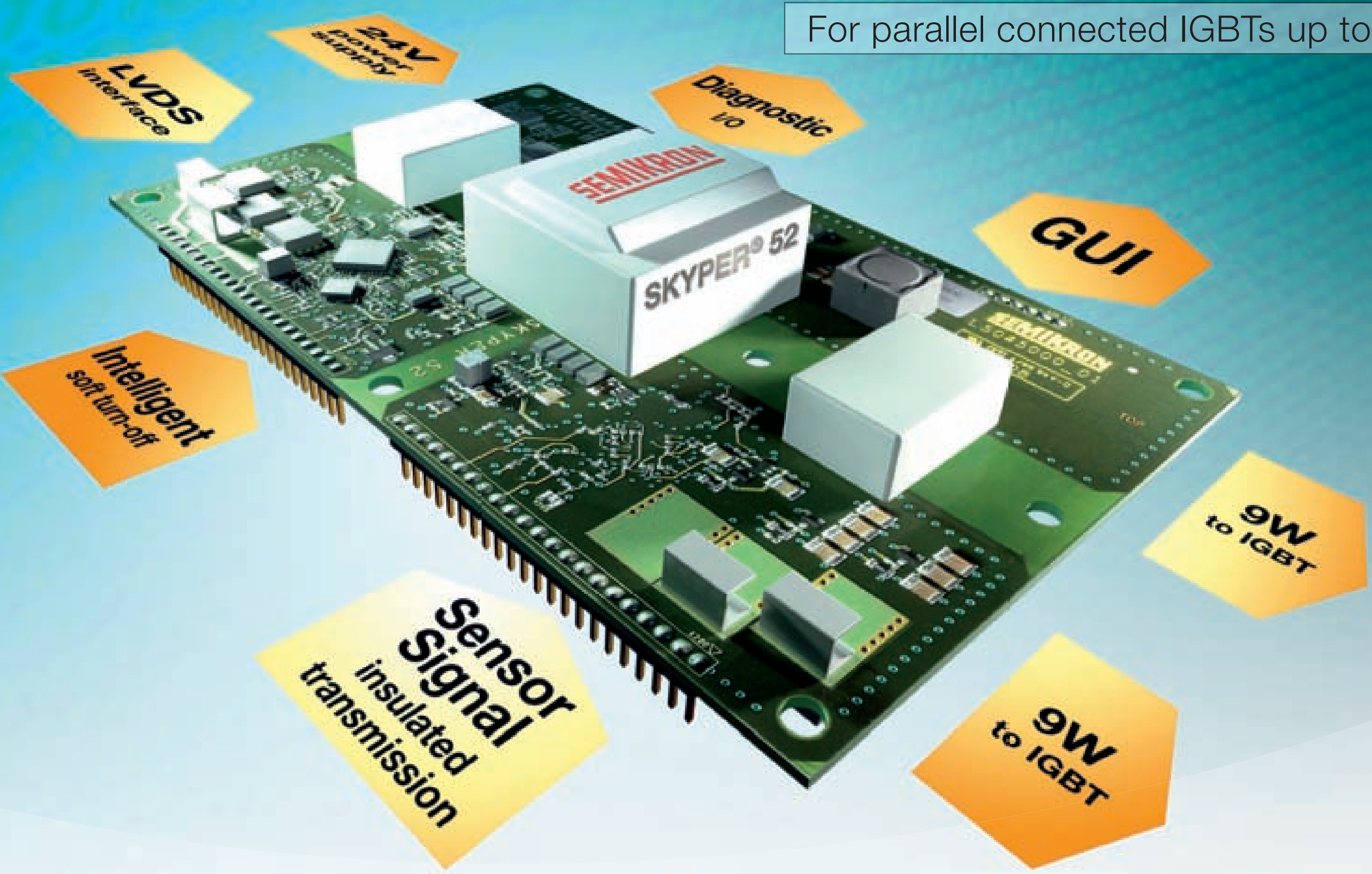

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unnecessary. High PWM-frequencies are allowed, leading to sinusoidal motor currents of up to 2kHz or more. This allows innovative, high power density motor concepts. Low du/dt reduces the dielectric stress of the motor insulation and thus, enhances the reliability during the expected lifetime of the vehicle.

On the other hand, the commuting time affects the PWM of course. Generally, the turn-on delay, which depends on the current, has to be considered at the control part. In addition, the demagnetising time limits the minimum turn-on time to approximately 3% of the PWM cycle time. Standard gate drivers cannot perform well, in particular if they operate with a fixed dead time. Any dead time will increase the turn-on delay and is therefore counterproductive.

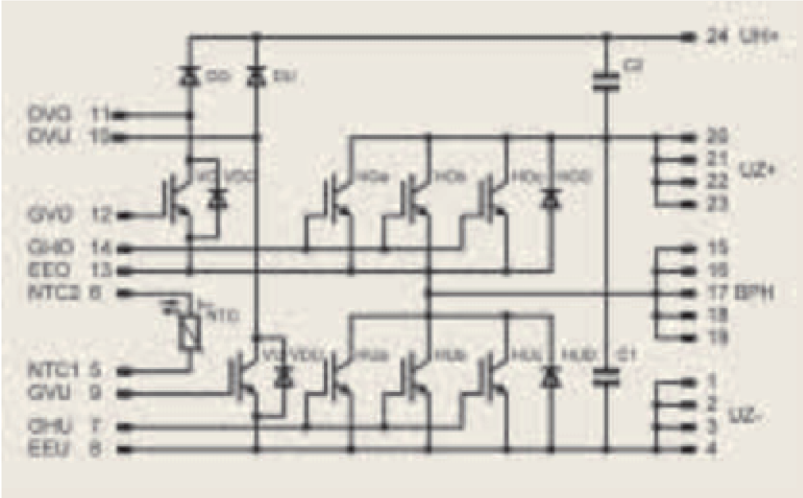


Figure 6: Module schematics

Module definition

To be developed is a power integrated module with lowest possible inductances, in order to achieve subsystem levels which can be tested, qualified and produced at constant quality levels, using state of the art technologies and fabrication processes. The repeating structure for drives and bi-directional DC/DC converters is the phase leg topology. To achieve maximum flexibility, the phase leg function with incorporated SoftSwing topology is integrated into a single module (Figure 6).

The module is realised on a DBC substrate, which is directly mounted onto the system heatsink. For a better thermal interface to the cooling medium, AlN was chosen as substrate material. For applications with lower power demand, the standard Al_2O_3 DBC can be used. A baseplate-less solution is preferred, due to the outdoor usage with harsh requirements with regard to thermal cycling capabilities.

In order to achieve the required performance levels, the module's main power bridge consists of paralleled high speed IGBTs, designed for fast switching applications, with a given total nominal current of 150A (600V: 3 x 50A trench-field stop-IGBT + 100A ultra-fast recovery FRED. 1200V: 3 x 25A planar-field-stop-IGBT + 75A ultra-fast recovery FRED). The challenge for this pre-switch IGBT is the high current in short time. The device is far away from the thermal limits because of the short duration time of 1µs. But this component has to carry the complete phase current plus the reverse recovery current of the main diode at switch-on. IGBTs are rated only up to three or four times nominal current. It is likely that the IGBTs will work also with higher current during the 1µs period but, in this case, the component would be out of specification. The short circuit rating will not help, because the specified 10 times nominal value is only allowed for non-repetitive short circuit conditions.

The integrated capacitors are SMD components, specified for the required power and voltage levels. An SMD temperature sensor for monitoring of the module temperature is integrated as well. Three such modules represent a complete power kit of 40 kW continuous electrical output power. Higher power ratings are possible by paralleling. It is now possible to achieve 40, 80 and 120kW with the same components (Figure 7). The two different chip technologies (600 and 1200V) support DC voltages up to 900V.

A first application is a rail-based electric vehicle with 6 to 8 seats and its own drive mechanism with energy storage on board (energy recovery), a maximum incline climbing ability of 55%, maximum travel speed of 80km/hr, and capacity of 3000 people/hour/direction. The vehicle's batteries are only fully charged overnight. Thus, it is possible to use a high amount of cheap off-peak mains power.

Conclusion

The softPHASE 0 modules are easy to use components for designing high efficient inverter and DC/DC converters in SoftSwing resonant topology. The phase leg concept provides the flexibility to distribute the inverter over the available volume in the application. The scalable power by paralleling multiple modules is a further advantage of the presented solution. The power modules are designed under the maxim of gaining highest power density as well as lowest stray inductances. High switching frequencies enable even special e-motors with extremely low leakage inductance to perform well. This is particularly beneficial for ultra-high speed drives or motors with a high pole pair number.

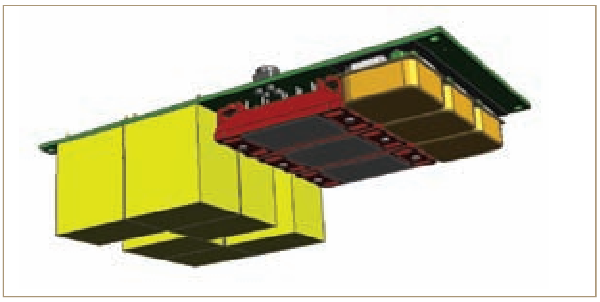


Figure 7: Power PCB with three modules

Figure 8: Passenger transportation system application

More Power at the Same Size

The new 1200V CAL diode provides 30% more power yet is still the same size as the previous chip generation, leaving more space in the power module. What's more, the new fourth generation of CAL freewheeling diodes is suitable for high application temperatures up to 175°C. These benefits mean that IGBT modules now take up less space and can be used with higher temperatures, making them suited for use in harsh ambient environments such as the engine compartment of hybrid electric vehicles.

Dr. Volker Demuth, Product Manager, SEMIKRON, Nuremberg, Germany

Power density is today's magic word in the world of high tech yet affordable electric drives, especially when it comes to the two workhorses in power electronics - the IGBT and its accompanying freewheeling diode. Together, these two components constitute the core of high tech power electronic solutions. Regardless of the application – motor control systems or power conversion units in solar power systems or wind power installations – trends continue to go in the direction of increased power density on the same-sized chips. In fact, high power density means smaller footprint, greater freedom in design and, even more importantly, lower cost. In terms of the power semiconductor itself, this trend means that the usable current per chip area can be increased due to higher current density.

However, regarding the technology used and the physics that apply, limits are often reached. The inevitable diode and IGBT power losses cause the components to heat up, resulting in high temperatures in the power electronics system. Such high temperatures during operation are, however, particularly unfavourable as they shorten the service life of power devices. As a result, costly cooling solutions are often used to contain the temperature in the power electronic components. Thus, financial gains made owing to the increase in current per chip area may be virtually cancelled out by the costs for additional cooling, meaning that for total systems there is no real cost advantage. As a manufacturer of freewheeling diodes, Semikron has concentrated its efforts on finding a solution to this problem for diodes.

Towards higher operating temperature

In the end, the maximum permissible operating temperature of the semiconductor limits the usable current. Just enough current is applied to the diode as required to cause the maximum permissible operating temperature to be reached. Any further increase in current density causes the temperature of the diode to increase – unfortunately to the detriment of the diode's service life.

How can this problem be solved? First of all, diode heating due to power losses could be reduced. On the one hand, losses occur when the diode is in conducting state (static losses). On the other hand, losses occur when the diode is commuted from conducting to blocking-state (dynamic losses). One possible way of increasing the current per chip area while keeping the temperature constant is to reduce the static and dynamic diode losses. But this is not an easy task. The first problem is that static and dynamic losses cannot be optimised independently. A reduction in static losses leads to an increase in dynamic losses, and vice versa. In the end, the losses would essentially be unchanged, which does not result in any real advantage as regards to chip temperature. Other further constraints to the current density are due to important diode requirements: the freewheeling diode must not generate overvoltage during AC operation, should display high robustness at high currents, and must not generate high-frequency interference noise (EMI). A good freewheeling diode boasts a well-balanced combination of all requirements, which leads to a situation where the increase in current density by reduction of power losses is associated with considerable development time/effort and cost.

Another possible solution to this problem would be to accept higher operating temperatures. Usually, freewheeling diodes have a continuous duty temperature of 125°C and a maximum temperature of 150°C. If the temperature was increased by 25°C to 150°C for continuous duty - or to a maximum temperature of 175°C - the current density of the freewheeling diode went up by 20 to 30%. This approach can, however, be detrimental to the long-term stability of the power semiconductors, especially in view of the

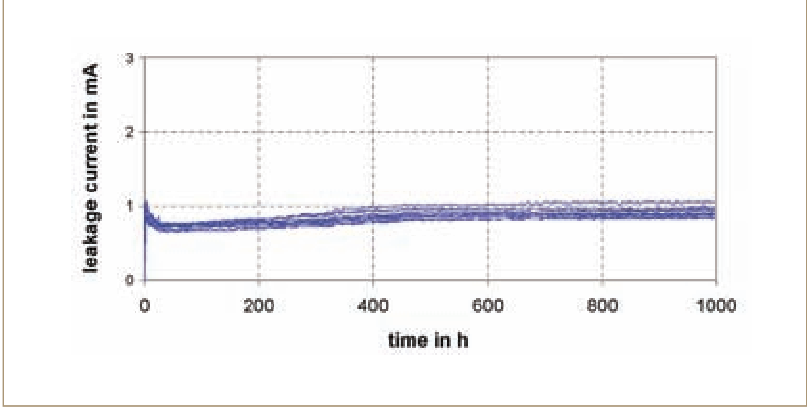


Figure 1: High temperature reverse bias test (HTRB) to show the stability of the freewheeling diodes at 175°C

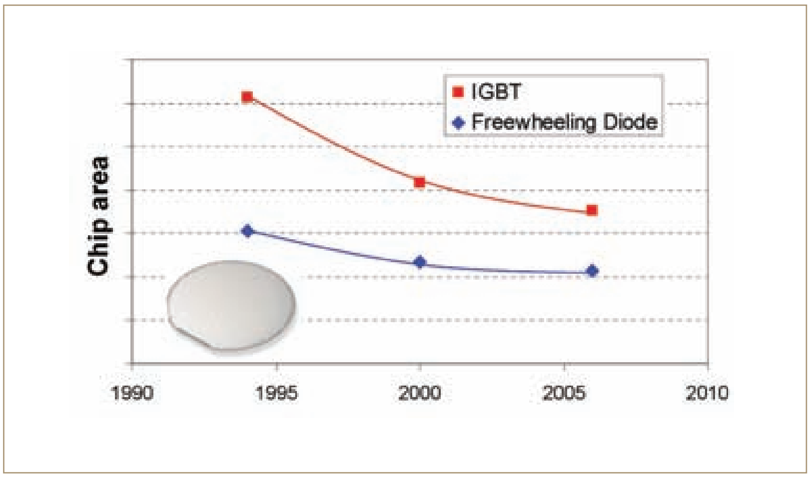


Figure 2: Development of chip size for IGBT and freewheeling diodes in the last decade. Improvements in the device technology lead to a significant decrease of chip area. This trend however, seems to slow down, due to the fact that it is more and more difficult to mange the heat generated in the power semiconductor devices

expected average service life of 8 years. But this approach has one major advantage: no compromises have to be made in terms of diode properties - increased current density and a well-balanced combination of diode properties.

High operating temperatures are particularly harmful to the diode passivation layer. The function of the passivation layer is to provide electric isolation of typically 600, 1200 and 1700V. In the previous CAL diode generations, this task was performed using a passivation layer made of composite glass. This glass passivation layer has proven reliable over the years; one shortcoming of this material, however, was that the maximum diode temperature was limited to 150°C. Higher temperatures alter the properties of the glass and adversely affect its insulating properties. This leads to leakage currents that may further increase the diode temperature, thus accelerating the glass degradation process. For this reason, Semikron has re-thought its passivation concept and has come up with a new passivation scheme for the CAL4 diode: a combination of an oxide layer and field ring concept. An additional polymer passivation layer protects the entire structure.

The new passivation concept has proven to be highly thermostable and reliable. To verify thermostability, accelerated reliability tests are performed usually. These tests involve exposing the diode to high temperatures and a constant blocking voltage for a period of 1000 hours. A change of the glass passivation often causes a continual increase of the leakage current. A reliable diode is deemed to show no significant increase of leakage current during the test. At 175°C the CAL4 diode displayed the ideal properties, thus verifying the excellent high-temperature properties of the new passivation concept: the diode blocking state currents were low and showed no signs of increasing despite the long test period. Figure 1 shows the leakage current of CAL-freewheeling diodes as a function of test time. Throughout the whole test period of 1000hr the leakage currents are low and stable, proving the thermostability of the diode even at such high temperatures.

High temperatures and low cost

Thus, all prerequisites are in place to raise the temperature by 25 to 150°C in continuous operation and to 175°C at maximum. The known reliability of the CAL diodes is preserved, as is the balance between electrical losses, robustness and noise immunity.

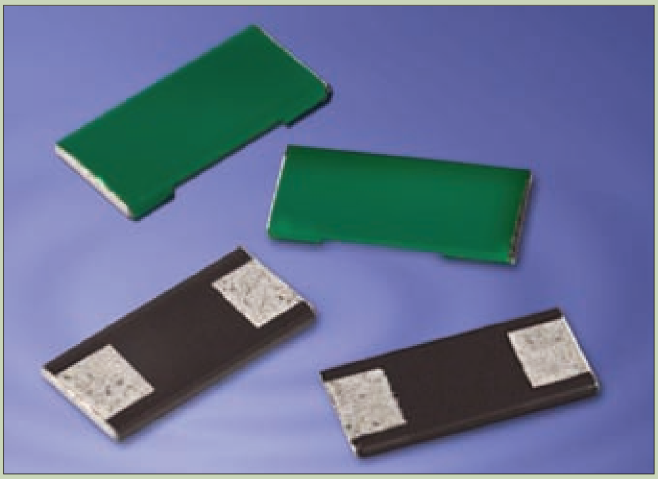
Exactly what effect does the higher operating temperature have on the increase in power of the diode? Simulations of typical operating conditions show that, depending on the application, the increase to 175°C results in 20 to 30% higher load currents for the same size diode. Or in other words, with the same load current, the size of the diode can be reduced by 20 to 30%. For the user, this means more space and thus, more leeway in the design of power modules. Along with the also improved new IGBT generations, the volume of power modules can consequently be further reduced. This trend becomes impressively apparent when we look at the development of chip sizes for IGBT and freewheeling diodes over the past few years (see Figure 2).

It was possible to significantly reduce the chip size of the IGBT in the last decade. With the new CAL4, this trend is also continuing with freewheeling diodes. However, it seems that both for diodes and IGBTs, it is becoming more and more difficult to further increase the current density for the next chip generation.

The new CAL 4 has the cost advantage of high current density, without further costs being entailed, for instance through cooling solutions. Cost and volume of the power electronics system are drastically reduced. This is an advantage, particularly for applications where space is limited: the power electronics no longer has to 'emigrate' because of lack of space, but can now often be installed in places that are technologically more practical. Coupled with higher reliable operating temperature, this gives them a strong competitive edge - power semiconductors can now also be installed in places where they could not be used previously due to ambient temperatures that were too high. It is the engine compartment of hybrid vehicles, where average ambient temperatures of 105°C require costly solutions by either using complex cooling solutions or going back to larger chip areas. The increased operating temperature of 150°C has eliminated this disadvantage - more power and easier to construct plus lower cost.

What will the next generation of freewheeling diodes look like? Is a further increase in the current density still possible with silicon, or will the silicon now be replaced by diodes made of silicone carbide (SiC)? It seems that silicon freewheeling diodes will still be in the race. On the one hand, newly promising designs pave the way of reducing the overall losses. On the other hand, the new passivation scheme also seems to be suitable for temperatures above 175°C. A maximum temperature of the diode in the range of around 200°C could be possible, providing another significant step towards higher current densities. Technology will continue to move along the path towards providing even more power at less space.

Current Sense Metal Element Resistors

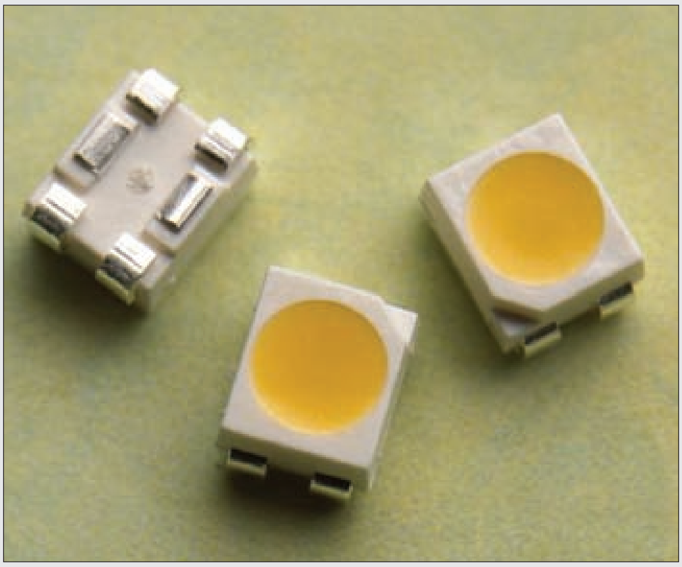


TT electronics IRC offers new metal element chip resistors for high volume, high current power electronics applications. With a small footprint and surface mount design, the resistors require less board space than a comparably rated wirewound, making them suitable for densely-packed applications such as voltage regulation modules, power supplies, DC/DC converters, and electric motor control devices.

The ULR Series resistors feature power ratings of 1, 1.5, 2, 2.5 and 3W at 80°C. Resistance range is from 0.5 to 10mΩ, with standard tolerances of ±1% and ±5% and TCRs as low as ±50ppm/K, depending on power rating and resistance value. Operating temperature ranges from -55 to 170°C.

www.irctt.com

SMT LEDs come in four new colours



Avago Technologies has added four new colours to its series of 0.5W power PLCC-4 SMT LEDs for use in automotive and electronic sign applications.

The new colours include a brighter cool white, as well as warm white, blue and green. They feature a wide 120-degree viewing angle, and have been optimised for long operating life under severe environmental conditions. can be used for backlighting dashboards, dome and map lighting, puddle lamps, rear reverse lamp indicator lighting and license plate illumination in automotive applications.

The ASMT-QxBE series can also be used for decorative lighting in general lighting applications, channel lettering in ESS applications, and for backlighting instrument panels and displays in industrial equipment, office automation and home appliance applications.

www.avagotech.com/led

Control and Power Handling Hybrid Solutions

TT electronics BI Technologies has combined its small signal and power hybrid technologies to develop an integrated control and power handling hybrid solution. While conventional assemblies require larger packaging to provide adequate thermal management, hybrid modules combines thermally conductive ceramic substrates with discrete components or bare die through the use of vacuum low flow die attach, providing a smaller, more efficient solution than comparable products. Typical applications for the custom hybrid modules include motor drives, power amplifiers and power conversion. The hybrid module is capable of handling power to 100A, with voltage rating up to 1000V.

www.bitechnologies.com/products/microcircuits.htm

Smallest High-Performance MOSFET

NXP Semiconductors offers a new range of small signal MOSFET devices housed in one of the world's smallest packages, the SOT883 with an ultra-small 1.0mm x 0.6mm footprint.

Designed for use in DC/DC converter modules, power supplies for LCD TV and load switching for cellular phones and other portable devices, the SOT883 MOSFETs' low 0.5mm profile and very low on-resistance of less than 0.65Ω at 2.5V enable more compact and power-efficient products. The new series also features turn-on times of 12 to16ns and turn-off times of 17 to 24ns.

www.nxp.com

600V Trench IGBTs

International Rectifier has launched a family of 600V IGBTs that reduce power dissipation by up to 30% in UPS and solar inverter applications up to 3kW. The new application-specific devices use field stop trench technology to reduce conduction and switching losses, and are optimised for switching at 20kHz with low short circuit requirements. Co-packaged with ultrafast soft recovery diodes in TO-220 (up to 10A rated current) and TO-247 (48A), the new family of IGBTs has lower collector-to-emitter saturation voltage and total switching energy than punch-through and non-punch-through type IGBTs.

www.irf.com

MOSFET and IGBT Gate Drivers

Zetex has announced a series of bipolar gate drivers for switching MOSFETs and IGBTs in power supplies and motor drives.

Capable of sinking currents up to 9A, the low cost ZXGD3000 series enables fast charging and discharging of gate capacitances, resulting in rapid switching times. There are four high-speed non-inverting gate drivers in the series, covering a supply voltage range of 12 to 40V. Their fast switching emitter-follower configuration achieves propagation delays less than 2ns and rise/fall times of 10ns.

The ZXGD3000s prevent latch-up and eliminate shoot-through, so helping to improve circuit reliability and improve EMI performance. Available in the six-leaded SOT23 package, the devices' high current gain and low input current requirement allows direct interface with low power controller ICs, so removing the need for additional buffer circuitry. To simplify PCB layout and to help minimise trace inductance, the SOT23-6 package pin-out has been optimised with a flow-through design approach putting inputs and outputs on opposite sides of the device.

www.zetex.com

Modular power platform

Vicor introduces a modular power platform: the VI BRICK, incorporating the technical attributes of V•I Chip technology and a robust packaging that facilitates thermal management and through-hole assembly.

Models include high-current density low-voltage DC/DC converters, a wide range of efficient bus converters (BCM), and individual modules (PRM and VTM) for both regulation and transformation. VI BRICK BCMs provide a solution for Intermediate Bus Architecture or point-of-load (POL) designs that require multiple output voltages. They are available with nominal input voltages including 48VDC (11 models) and high voltage up to 380VDC (three models) and a wide array of output voltages from 1.5 to 48VDC. VI BRICK PRM and VTM modules offer a scalable architecture for DC/DC power conversion utilizing Factorized Power in a robust 'brick-like' package designed for efficient thermal management.

These models include six PRM regulation modules which perform the regulation function and twelve VTM transformation modules that take the 'factorized bus voltage' from the PRM and provide transformation and isolation. VI BRICK models are available in a base temperature grade of –40 to 100°C, operating with a slotted-flange baseplate and through-hole pin style.

www.vicoreurope.com

200mA LDO Regulators

Toshiba Electronics Europe (TEE) has expanded its family of low drop out (LDO) voltage regulators with a new series of CMOS devices that offer high ripple rejection ratio, low quiescent current, and very low output noise voltage.

Available with output voltages from 1.5 to 5.0V, devices in this LDO regulator family (TCR5SBxx series) deliver a maximum output current of 200mA and are supplied in a SOT25 (SMV) package. They have a low typical quiescent current of 40µA and a dropout voltage of 85mV (at 50mA). The ripple rejection of 80dB at 1kHz is independent of output voltage. This makes the LDO especially suitable for power supply applications that are very sensitive to variations in supply voltage (e.g. RFICs). Additionally, without external noise bypass capacitors an ultra-low output noise voltage (VNO) rating of just 30µVrms - independent of output current - is achieved.

All products in the TCR5SBxx series offer an on/off control function and built in overcurrent protection to further enhance design flexibility and minimise external component count.

www.toshiba-components.com

Power MOSFETs for Mobile Applications

NEC Electronics Europe announced the availability of two new package types, 8p-VSOF and Mini-HVSON, for notebook computer and other mobile device applications. Besides realizing very low on-state resistance values and high speed switching characteristics, the 7 devices in the new packages have the additional advantage to reduce the mounting areas significantly. Two N-channel and one P-channel MOSFET have a 3.3 x 3.3 x 0.9mm Mini-HVSON package. Compared to a conventional 5.1 x 6.0 x 1.8mm SOP8 package the mounting area of this 8pin Mini-HVSON package is reduced to about one third, maintaining low on-resistance values of 7.3mΩ (uPA2800T1L) and 9.6mΩ (uPA2801T1L) for the two N-channel MOSFETs.

The 30V P-channel device (uPA2801T1L) has a 13mΩ. Four new devices have a 2.8 x 2.9 x 0.8mm 8p-VSOF package with a significantly smaller mounting area in comparison to 3.2 x 6.4 x 1.2mm TSSOP8 package. Besides the two 30V N-channel MOSFETs (uPA2520, uPA2521) with on-resitance of 13.2 and 16.5mΩ, a dual -12V P-channel device (uPA2550) and a complementary device +/-30V (uPA2590) are available. These low-voltage switching devices are suitable for applications such as power switch of mobile devices and DC/DC converters.

www.eu.necel.com/mosfet

Low Noise DC/DC Converter

Enpirion's new EP5368QI switch-mode converter features a proprietary low loss integrated inductor, PWM controller, MOSFETs and compensation network in a tiny 3 x 3 x 1.1mm QFN package. This high level of integration greatly simplifies design and reduces part count and size.

The device has a 4MHz switching frequency and achieves up to 94% efficiency. It provides 600mA of continuous output current over the industrial temperature range, and 700mA over the commercial temperature range. The complete solution requires only 2 MLCC capacitors for a footprint of 22mm². This part has shrunk from its first generation, which had a 32mm² solution footprint. Integration of the inductor makes switch-mode converter design an almost turnkey experience. Further, the part uses a 3pin voltage selector to choose one of seven preset common output voltages or an external resistor divider.

The overall design experience is nearly as easy as that of designing in a linear regulator, with the efficiency of a switcher. It is well-suited for a broad range of mobile and wireless broadband applications, including (but not limited to) smart phones, wireless data cards, portable gaming devices, navigation systems, personal media players, and advanced mobile processors.

www.enpirion.com

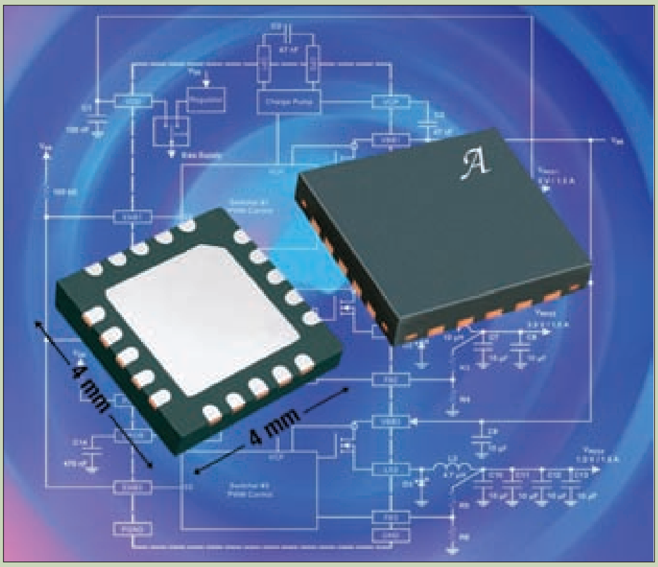
Low On-Resistance MOSFETs

Infineon's new OptiMOS 3 40, 60 and 80V families reduce power losses by as much as 30% in a given standard TO package. On-resistance is 1.6mΩ for 40V products in SuperSO8 packages, 3.5mΩ for 60V products in D-PAK packages and 2.5mΩ for 80V products in D²-PAK packages. This low on-resistance is linked with a thermal resistance of 0.5K/W and a continuous current rating of 100A.

The OptiMOS 3 40V family meets the needs of fast-switching SMPS and DC/DC converters in a variety of applications, such as printers, non-isolated industrial converters and isolated DC/DC converters, in which 30V MOSFETs do not offer sufficient breakdown voltage. The S3O8 package represents a 60% footprint reduction over standard SO8 or SuperSO8 devices. The OptiMOS 3 60V and 80V families are primarily intended for secondary side rectification in SMPS and in motor controls and drives for DC/DC brushless and brushed motors. The 80V devices are also suited to telecommunications applications.

www.infineon.com/optimos

Triple-Output Buck IC



The new A4490 from Allegro MicroSystems Europe is a triple-output stepdown switching regulator integrated circuit providing three high-current outputs that are adjustable from 0.8 to 5V with a maximum current of 2A. Operating from an input voltage range of 4.5 to 34V, the A4490 uses multi-phase switching to reduce electromagnetic interference and minimise stress on the input capacitors by interleaving the turn-on cycle of the regulators.

Features like soft start, power-on reset output and a small 4mm x 4mm QFN package make this new device an ideal choice for many portable, office automation and consumer applications. The A4490 uses 550kHz fixed frequency switching which allows the selection of small, inexpensive inductors and ceramic output capacitors. A charge pump provides the supply to drive the power switches to ensure operation at very wide operating duty cycles and to avoid the need for power draining clamp circuits.

www.allegromicro.com

Current Sense Resistors

IRC's current sense product offering includes current sense resistors in ceramic flat chips, cylindrical surface mount chips, leaded and surface mount metal element devices, wirewound devices, as well as transistor-packaged high current resistors. Low resistance range ceramic chips in standard sizes (LRC, LRF, LVC and LRF3W series) are offered with ohmic values down to 0.003Ω at power ratings to 3W. Cylindrical chip resistors) CHP, CHP-1X and PPS-1 series) come with ohmic values down to 0.1Ω and power ratings to 2W.

Metal element resistors are vailable as surface mount chips (ULR series), as well as open air resistors in surface mount (OARS, OARS-XP series) and through-hole versions (OAR, OARS-XP series); as well as a high current four-terminal resistor (CSL series) and traditional axial leaded devices (LOB series) with ohmic values down to 0.00025Ω and power ratings up to 5W. High power resistors are available in surface mount TO-263 packages (SMPH series); as well as TO-126, TO-220, TO-247 and SOT-227 packages (MHP series) with power ratings up to 600W and with ohmic values as low as 0.01Ω.

Ceramic packaged power wirewound devices include standard axial leaded (LPW, PLO series); four-terminal devices (4LPW series); vertical packaged devices (PWRL series) and surface mount wirewounds (WA80Z and WSM series). Ohmic values are down to 0.001Ω with power ratings up to 15W.

www.irctt.com

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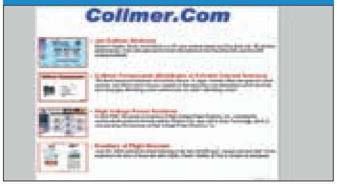

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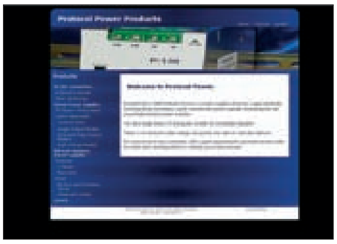

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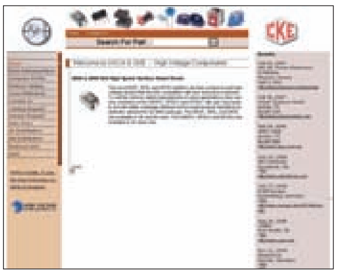

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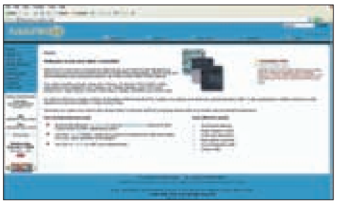

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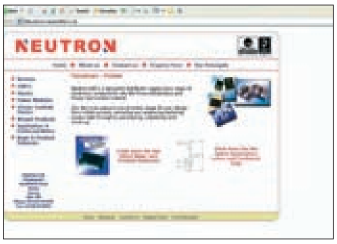

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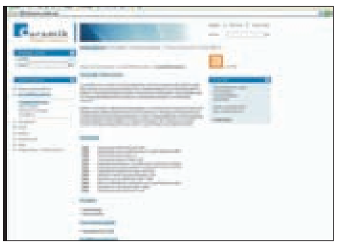

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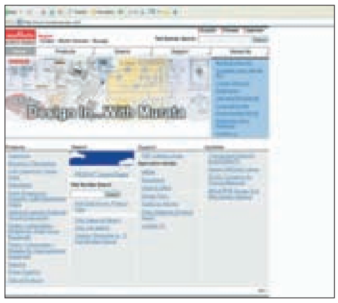

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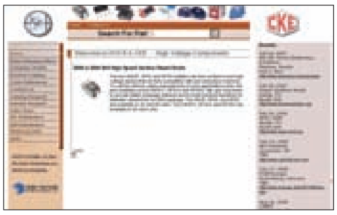

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