POWER ELECTRONICS EUROPE

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THE EUROPEAN JOURNAL FOR POWER ELECTRONICS AND TECHNOLOGY

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Wind Of Change

According to the Global Wind Energy Council wind power could produce 1,000 TWh of electricity by 2020, a trebling from the estimated 350 TWh produced by the 158.5 GW of wind capacity in 2009. Depending on the demand projection, this would cover between 4.5-4.8% of the world's electricity needs, about the same share as is currently achieved in Europe. By 2030, 1,400 TWh would account for 4.9% to 5.6%.

Modern wind technology has an extremely good energy balance, last but not least due to innovative power electronics. The CO2 emissions related to the manufacture, installation and servicing over the average 20 year lifecycle of a wind turbine are generally 'paid back' after the first three to nine months of operation. Beyond this, wind power produces no CO2 emissions. The benefit to be obtained from carbon dioxide reductions is dependent on the fuel, or fuels, that wind power displaces; for example, emissions from coal for a kilowatt hour of electricity produced are higher than from natural gas. Calculations by the World Energy Council show a range of carbon dioxide emission levels for different fossil fuels. Working on the assumption that coal and gas will still account for the majority of electricity generation in 20 years' time - with a continued trend for gas to take over from coal - it makes sense to use a figure of 600 kg/MWh as an average value for the carbon dioxide reduction to be obtained from wind generation. The expected annual CO2 savings from wind energy under the reference scenario is 243 million tonnes in 2010, passing 500 million tonnes per year between 2015 and 2020, gradually climbing to 843 million tonnes per year of CO2 savings by 2030. This is small compared with the 18.7 billion tonnes of CO2 that the IEA expects the global power sector will emit every year by 2030. Under the Advanced scenario, by 2020 1.6 billion tons of CO2 would be saved every year, and this would grow to a considerable 3.3 billion tonnes per year by 2030 - thereby saving a sixth of all CO2 emitted by the electricity sector compared with the IEA's projections. What will make a significant difference to the climate is the speed at which cuts are made. So it is not only the total emissions reductions that are of value, but it is the timing of them. Wind power's scalability and speed of deployment is a critical part of any plan to get global emissions to peak and begin to decline by 2020, which is essential to put us on a pathway where global mean temperature rise can be kept below 2°C.

What wind power can save for the end-user has been studied by the Irish Wind Energy Association. Wind energy currently accounts for approximately 12% of Ireland's electricity needs. Wind generation is already having a significant impact on energy costs, with the total savings to consumers set to reach €36.6 million in 2011. Wholesale energy prices and therefore costs to consumers fall as the volume of wind energy increases. Although renewables generation across the island of Ireland require a subsidy from the consumer, on the basis of the commodity prices assumed in this analysis, the reduction in consumer costs is greater than the subsidy paid. If oil, gas and coal prices actually turn out to be higher than assumed in the analysis the relative savings to the consumer from having wind on the system could well be even greater. Wind generation does not add cost in today's market, nor indeed in the future. In fact, it reduces the cost of generating electricity plus the price to the end user, so the outcome of this study.

PV Module production capacity increased by nearly 70% over the course of 2010, reaching nearly 30 GW by the end of the year according to IMS Research. It is forecast to continue increasing, despite the growth of PV installations being predicted to slow from over 100% in 2010 to less than 20% in 2011. Demand for PV modules reached record levels in all regions in 2010, driven by the attractive returns presented by incentive schemes, particularly in European countries like Germany, Italy and Czech Republic - the three largest markets last year. However, like many others, these countries have reduced the rates they offer for electricity generated from PV systems from the start of 2011; and as a result, whilst global PV installations are still set to increase in 2011, they will do so at a far slower rate. Regardless of slowing installations, most suppliers, many of which remained capacity-constrained throughout 2010, are proceeding with aggressive capacity expansions. IMS Research forecasts that 35 GW of annual capacity will be reached within the first half of 2011, despite installations in the same period being predicted to reach no more than one fifth of that amount. As a result, it is likely that there will be an oversupply of modules this year, leading to tougher competition and decreasing prices from suppliers. On the other hand, the global PV inverter market is forecast to reach $8.5 billion by 2014, growing at compound annual growth rate of nearly 25%.

Thus power generation will have to be more flexible in the future to take into account variable sources of power such as wind and solar. Smart grids will be needed to allow management of demand as well as improved management of supply, and largely national grids will have to be better interconnected. This is a challenge for the years to come and a great opportunity for power electronics.

Achim Scharf
PEE Editor

High Growth for Microinverters

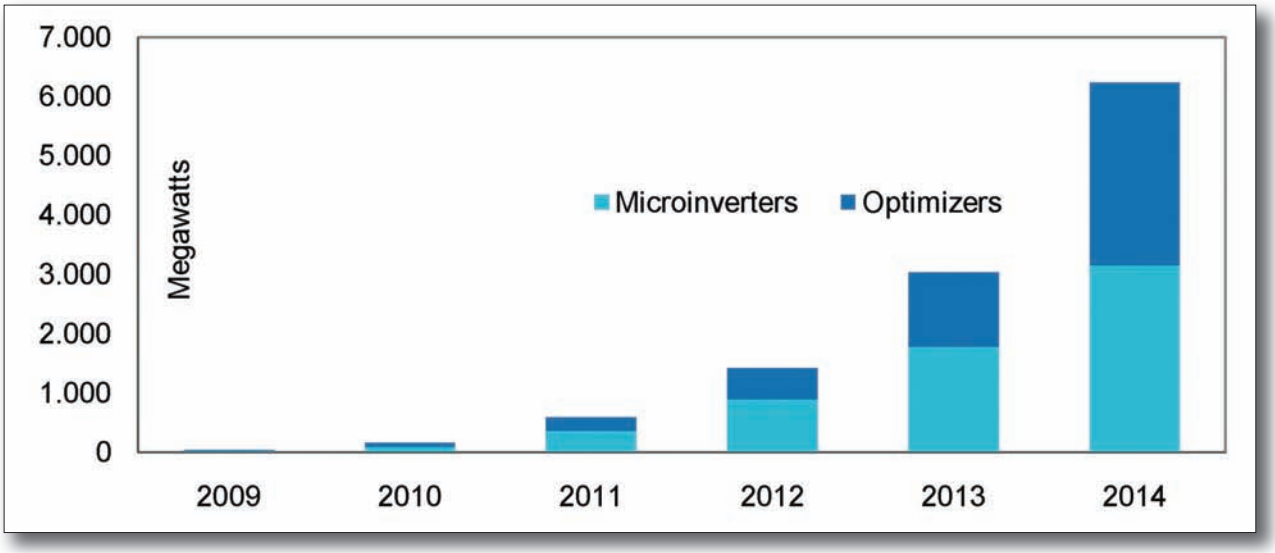
With their capability to increase the efficiency of solar systems, module level power management (MLPM) solutions are set for fast growth, with almost 40% of residential photovoltaic (PV) installations expected to use the technology in 2014, new IHS iSuppli research indicates.

Global shipments of MLPM systems, a category consisting of microinverters and optimizers, are set to rise to more than 6 GW in 2014, up by nearly a factor of 10 from today's 600MW. By the end of 2014, 38% of residential PV installations worldwide will employ MLPM solutions, up from 2 % in 2010.

Microinverters convert DC from a single solar module to AC power, while optimizers use DC/DC converter technology to take full advantage of the power harvest from PV systems. "With their capability to increase electricity production from a solar installation by as much as 25 %, MLPM systems offer a new approach to increasing PV efficiency," said analyst Greg Sheppard. "This will drive rapid uptake of MLPM systems, particularly in the residential segment. Additional benefits of MLPM include labor savings for installers, the advantages of per-panel monitoring and improved safety". PV systems typically increase their energy harvest using the so-called "three efficiencies:" efficient energy conversion, efficient manufacturing methods and efficient use of materials. However, MLPM increases harvest through a fourth route: the efficient management of solar modules using power semiconductor technology.

MLPM solutions currently carry a cost premium compared to solar systems using normal inverters, with microinverters adding $0.20 to 0.25/W for installations, and optimizers adding $0.15/W cost. However, with their high semiconductor content, MLPMs benefit from the cost reduction benefits of Moore's Law. The average selling price (ASP) for microinverters will decline to $0.29 in 2014, down from $0.88 in 2010. The optimizer ASP will fall to $0.08 in 2014, down from $0.18 in 2010. Enphase Energy at present dominates the microinverter area with more than a 90% market share; Enecsys Ltd. and SolarBridge Technologies recently entered the market. Meanwhile, SolarEdge Technologies Inc. has an almost 70% share of the optimizer market. With the MLPM market still in its very early stages, competitors are starting to flood into the business. There are at least 15 companies in the MLPM space, with more coming over the horizon, including inverter market giant SMA Group, which is believed to be readying a solution.

www.isuppli.com



Global MLPM shipment forecast Source: IHS iSuppli

Irish Wind Energy Rises

Wind energy generation will deliver savings to Irish consumers of €100 million by 2020, a study by the Irish Wind Energy Association (IWEA) and consultancy Redpoint reveals.

Wind generation is already having a significant impact on energy costs, with the total savings to consumers set to reach €36.6 million in 2011. Wind energy currently accounts for approximately 12% of Ireland's electricity needs. "Our analysis shows that increased levels of wind generation will displace coal and gas-fired generation, and reduce the costs of electricity production," said Phil Grant, Director, Redpoint Energy. "Wholesale energy prices and therefore costs to consumers fall as the volume of wind energy increases. Although renewables generation across the island of Ireland require a subsidy from the consumer, on the basis of the commodity prices assumed in this analysis, the reduction in consumer costs is greater than the subsidy paid. If oil, gas and coal prices actually turn out to be higher than assumed in the analysis the relative savings to the consumer from having wind on the system could well be even greater". "We have separately quantified the costs to the consumer of developing new transmission lines to connect wind generation. Comparing the costs expected in the Grid 25 development plan with a business-as-usual scenario we find that customers will save almost €100 million per year. This is because the saving in wholesale process of €256 million greatly outweighs the costs of PSO support of €52 million and the annual costs of new network of €108 million in 2020. Wind generation does not add cost in today's market, nor indeed in the future. In fact, it reduces the cost of generating electricity plus the price to the end user", added Michael Walsh, CEO of the IWEA.

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Semikron Strengthens Automotive Business

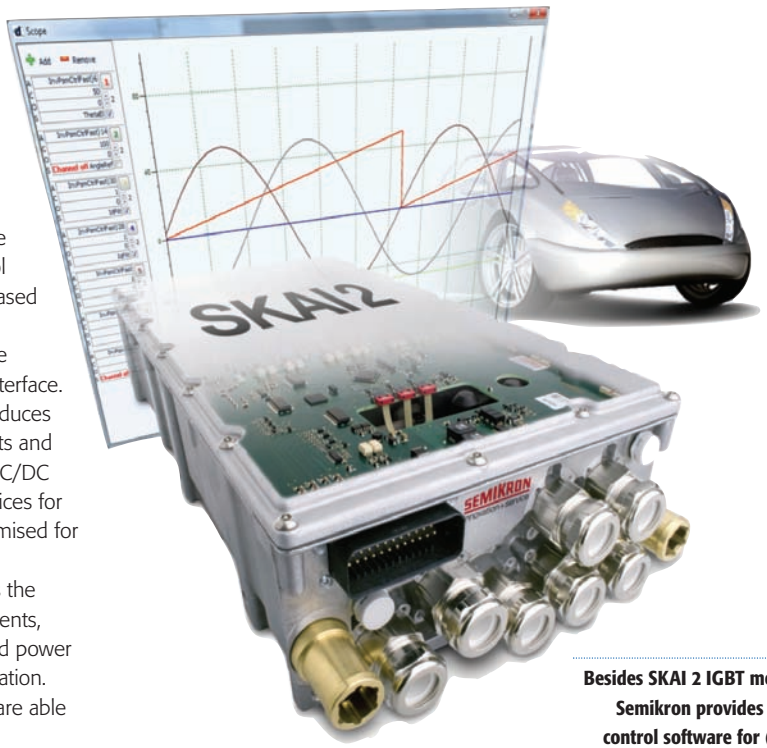
Semikron further strengthens its presence in and dedication to the electric and hybrid vehicle market by forming a 50/50 joint venture with drivetek, a development specialist for electrical drives and control technology. The joint venture, SKAItek GmbH, will provide motor control software optimized for the latest generation of SKAI 2 IGBT and MOSFET inverter systems for vehicle applications. Semikron also takes over the 50:50 joint venture Vepoint, working with the company Magna E-Car systems.

SKAI 2 with the optimized software is a drive train solution for vehicle inverter applications in the power range of 10 to 250 kVA and battery voltages from 24V to 900V. "The QUASAR software is based on a modern, field-oriented closed-loop control system", explains Peter Baumann, general manager of SKAItek and managing director at drivetek. "It guarantees steady control of the electrical machine up to the strong field weakening range for realisation of efficient and dynamic traction drives and generator solutions. QUASAR receives input from a central controller via CAN bus and converts this precisely into a speed or torque". The software is tailored to the control of brushless DC, interior and permanent magnet synchronous and AC induction machines. As a standard the motor control software also offers a set of additional control functions, e.g. battery deep discharge protection, over-voltage protection for DC energy recovery etc. Customer machine setup is easily done with the additional Q-Control software package. This PC based Windows application allows visualisation and setup of the customer system via CAN interface.

Vepoint develops and produces power electronic components and systems such as inverters, DC/DC converters and charging devices for the automotive market, optimised for hybrid and electric vehicle applications. The aim here is the reduction of space requirements, achieved by way of increased power density and degree of integration.

"With 50 employees, we are able to meet the ever increasing efficiency demands being placed on power semiconductor technology in the booming hybrid and electric vehicle market. Power electronics remains instrumental with regard to the future e-mobility sector, especially with a view to increasing emissions levels and the scarcity of resources," explains Riccardo Ramin, Managing Director of Vepoint.

www.semikron.com



Besides SKAI 2 IGBT modules Semikron provides motor control software for (H)EVs

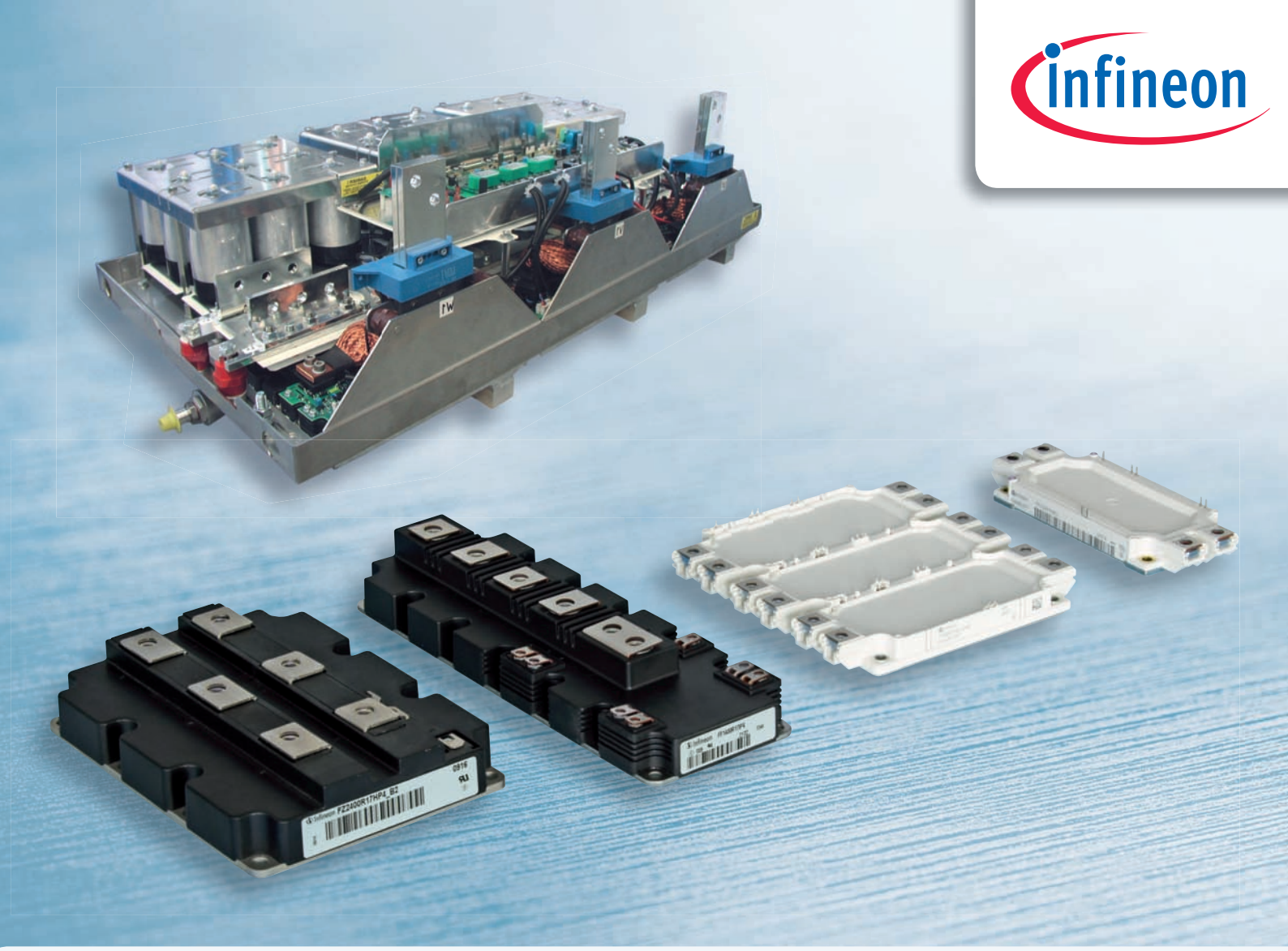
Rack PDU Market Reach $1 Billion in 2014

Driven by adoption of intelligent rack power distribution units (PDUs) in data centers, market researcher IMS Research predicts that global demand for rack PDUs will exceed $1 billion by 2014. The outlook is especially impressive, given the recent slump that has afflicted IT hardware markets in the wake of the recession.

A recent study on the market shows that revenue growth of intelligent rack PDU products (those that can monitor and meter information on electricity use) will nearly triple the rate of traditional, basic models. "The transition to intelligent rack PDUs is clearly under way in North America and picking up steam in the rest of the world. Rising electricity costs and concerns over the environmental impact of data centers are causing operators to critically examine power use and find ways to reduce it. This is driving the need for more refined information on electricity use, provided by intelligent PDUs", analyst Jason dePreaux commented. "Intelligent PDU features can range from simple load readouts to outlet-level power metering with remote switching ability and full integration into advanced infrastructure management programs".

Intelligent rack PDUs account for just 20% of unit shipments today. Their proportion is set to rise as more emphasis is placed on energy efficiency, dePreaux explains. "The growing popularity of standardized data center efficiency metrics, like Power Usage Effectiveness, encourages the gathering of detailed power data to help isolate servers which may be wasting power while laying idle. At the same time, we are seeing corporate-level energy policies that back-bill electricity costs to individual business units based on their consumption. If electricity costs aren't something IT managers worried about in the past, they soon will be". Annual revenue growth of the products rated above 10kW are expected to average over 20% over the next five years.

www.imsresearch.com



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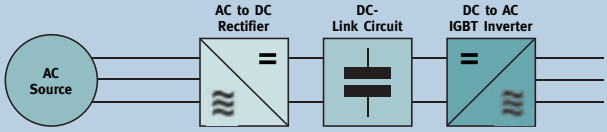


[www.infineon.com/highpower]

PCIM Europe 2011 Keeps Growing

The worldwide leading exhibition for power electronics, intelligent motion and power quality (May 17-19) proves itself as the indicator of the industry. With 270 already registered exhibitors, their number is 7% above the previous year. Even stronger grows the exhibition space. With 13.200 sqm the plus here is 16%. The number of visitors (2010: 6300) as well as the conference delegates (2010: 619) is also expected to increase.

The majority of international exhibitors will come from the USA, followed by Italy, Great Britain and France. "The number of Asian companies is on the rise, we now have registrations from 11 companies in China, who are looking for customers in the European markets", said Mesago's General Manager Udo Weller. "We have also attracted well-known names such as Bosch, EBV and Rutronik, who exhibit at PCIM 2011 for the first time".

The PCIM Conference will encourage an intensive dialogue between science and industry. Over the three days three keynotes, two special sessions, one round-table, 68 presentations in power electronics, 18 presentations in intelligent motion, 18 presentations in power quality, and 122 post papers will be offered.

Already on Sunday May 15, 2.00-5.00 pm a seminar (free of charge) by Ray Ridley "Frequency Response Measurements on Switching Power Supplies and Components" will be offered, followed by ten Tutorials on Monday May 16.

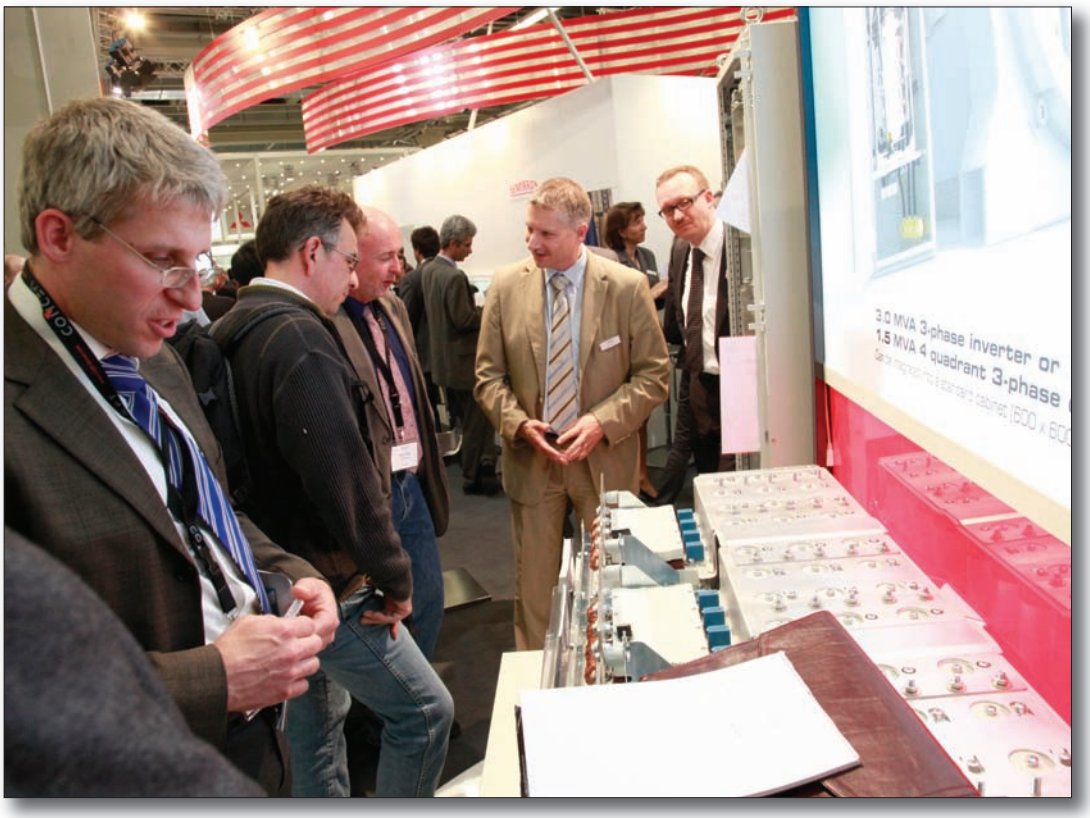
Again three Young Engineer Awards (€1000.00 each) will presented at the conference opening on Tuesday May 17, 9.00 am in Room Paris, to exceptional contributions from young professionals (under 35 years old). The papers are selected by the Conference Directors and sponsored by ECPE, Infineon Technologies and Mitsubishi Electric. Also the Best Paper Award (€1000.00 plus trip to PCIM Asia 2012) again will be sponsored by PEE and Semikron.

Exciting keynotes

The first keynote on May 17, 9.45-10.30 am in Room Paris, will be given by **Slobodan Cuk**, TESLAco/USA under the title "Single-Stage AC-DC Converter Topologies of 98% efficient Single-phase and Three-phase rectifiers". The goal of developing AC/DC converters with Isolation and Power Factor Correction feature in a single power processing stage and without a mandatory full-bridge rectifier has for years eluded Power Electronics researchers. Present AC/DC converters operated from a single-phase AC line are based on conventional PWM switching method and process the power through three distinct stages: full-bridge rectifier followed by Boost PFC converter and another cascaded isolated Full-Bridge DC/DC converter stage, which together use a total of 14 switches and three magnetic components resulting in efficiency limitation of around 90%, the present platinum standard. The new Hybrid switching method and several resulting new AC/DC converter topologies will be introduced which accomplish the same in a single-power processing stage designated as Single-phase rectifier consisting of just three switches and a single magnetic component albeit at a much higher efficiency approaching 98% and having a 0.999 power factor and 1.7% total harmonic distortion.

The ultimate solution is reached in an Isolated, Bridgeless, Three-phase AC-DC converter with Unity Power Factor (designated here Three-Phase rectifier), which converts the three-phase input power directly into a desired high frequency isolated DC output voltage (48V for telecommunications, 12V for data centers, etc.) again in a single power processing stage, but employing three isolation transformers operating at high switching frequency of 100kHz. The intermediate 400V high voltage DC bus of conventional three-phase AC/DC rectifiers is also eliminated resulting in direct cost and size benefits, while the high efficiency of 98% and other performance features of the above Single-phase rectifier solution are fully preserved.

The Three-phase rectifier processes the power in parallel and equally through each phase, resulting in additional size and cost savings. For example, a 1.2kW AC/DC converter is processing 400W power in parallel through each phase. The conventional three-phase approaches are incapable to do that and must process the full 1.2kW power through its second power processing stage, the Isolated DC/DC converter stage. Three-Phase rectifier takes a full advantage of Tesla's three-phase transmission system to convert constant



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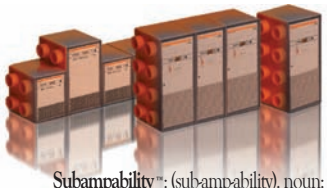

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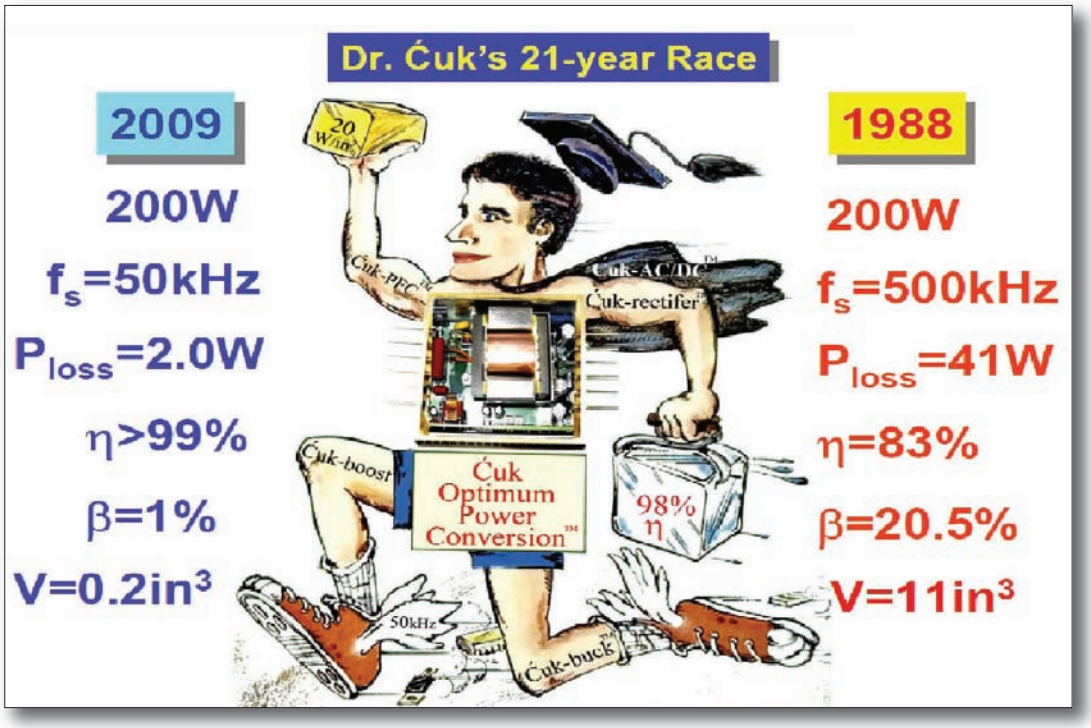


Keynote on the way to the "ideal" converter featuring low switching frequencies and low losses

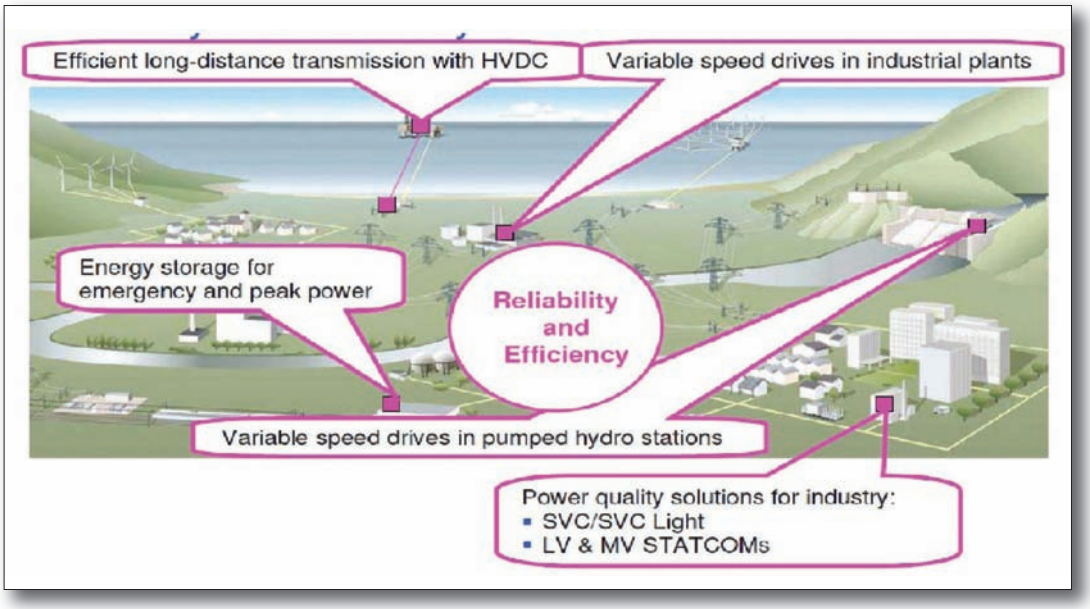
instantaneous input power directly to a constant DC output power, albeit isolated at high switching frequency, with near unity power factor (0.999), low total harmonic distortion (1.7%), smaller size and lower cost but at ultra high efficiency of 98%.

The second keynote on May 18 will be given by **Ambra Sannino**, ABB Corporate Research, Sweden under the title "The Role of Power Electronics in Smart Grids". Increased use of renewable generation and increased efficiency in transmission, distribution and utilization of electric energy are highest on the agenda. Research and development in electric vehicles has accelerated enormously and a shift in our everyday's habits can now be described as forthcoming. In Smart Grids, attention to the environment is combined with higher involvement of the consumers in the operation of the electric grid, through demand response schemes where the customer has a choice regarding when and how to consume. We can see four important pillars in the smart grids concept: Renewable integration; demand response; reliability and efficiency; and integration of electric vehicles. All four pillars, albeit to different extent, rest on the development and application of power electronic devices and systems, which are integral part of the interface of renewable sources to the grid, of electric vehicles and their interface to grid, and a key component to achieve increased reliability and efficiency (just think of the tremendous increase in efficiency when upgrading direct on-line motors to adjustable speed drives!)

The keynote speech will give an overview of the smart grids concept and the role of power electronics to make it reality, including several examples of smart grids demonstrators where power electronics is a key technology.

The third keynote on May 19 entitled "Electric Vehicles: why is it time now for mass production?" will be presented by **Patrick Bastard**, Renault, France. From a technical point of view, there are three main domains that have shown big improvements during the very last years: battery, electric powertrain (machine & inverter) and charging solutions (including intelligent navigation system for autonomy optimization). Even if the technical state of the art in these three domains makes it possible to go to mass production in a very near future, technical progress will go on in order to improve more and more performances and economics efficiency of electrical vehicles. Furthermore, in addition to technical progress concerning the car itself, it is important to keep in mind that electrical vehicles have really to be considered in the global context of electricity production and distribution. Communication between car and infrastructure as well as control of EV charge through optimized strategies are also key issues in order to take advantage as much as possible of a large EV fleet, from a technical point of view but also from an environmental one. This is also a big challenge, especially in the context of emerging smart grids.

The paper will describe the state-of-the art and some of the technical challenges for the future in the domain of electrical vehicles.



Keynote on how power electronics enable Smart Grids

Special session on wide bandgap technologies

For the fourth time time Power Electronics Europe has organised a Special Session with this year's focus on "High Frequency Switching Devices and Applications" on Wednesday, March 18, 10.00 - 13.00, Room Paris, featuring papers from Ertugul Sönmez, MicroGaN/D; Michael Briere, ACOO Enterprises/USA; Bob Callanan, Cree/USA; Jeff Casady, SemiSouth Laboratories/USA; Gerald Deboy, Infineon Technologies; Regine Mallwitz, SMA Solar Technology/D. The focus will be on Gallium Nitride and Silicon Carbide technology and devices in industrial and renewable energy applications, subjects of very high interest not only within the power electronics community. More in our next issue. **AS**

Allegro Four-Channel LED Drivers for Internal/External Illumination

Allegro MicroSystems, Inc. has released a new family of constant current LED drivers designed to address the emerging requirements of the internal and external illumination applications within the automotive market. Allegro's A6261/62/64 four-channel LED driver devices have been fully qualified to the highest levels of automotive quality standards and robustness.

The devices each offer four channels of up to 100 mA LED current each, and can be paralleled for higher currents. They operate with a low dropout voltage to minimize power dissipation, and do not require any ballast resistors.

The user selected current is provided to four outputs with each output equally sharing the load. The A6261/62/64 family also features short to ground protection which disables the shorted channel allowing the others to continue to operate. Open LED on any channel is also detected. The A6261/62/64 family also features a unique current foldback circuit, which uses the chip junction temperature in order to foldback the LED current and to protect the IC and LEDs.

Allegro is a registered ISO/TS 16949 company.

Key automotive applications include:

- **Exterior brake**
- **Exterior turn**
- **Exterior tail**
- **Exterior rear combination lighting (RCL)**
- **Interior dome**
- **Interior map**
- **Interior puddle lighting**
- **Commercial grade version of the A6261 (suffix E) for consumer lighting applications is also available**

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Towards Higher Efficiency in Power Electronics

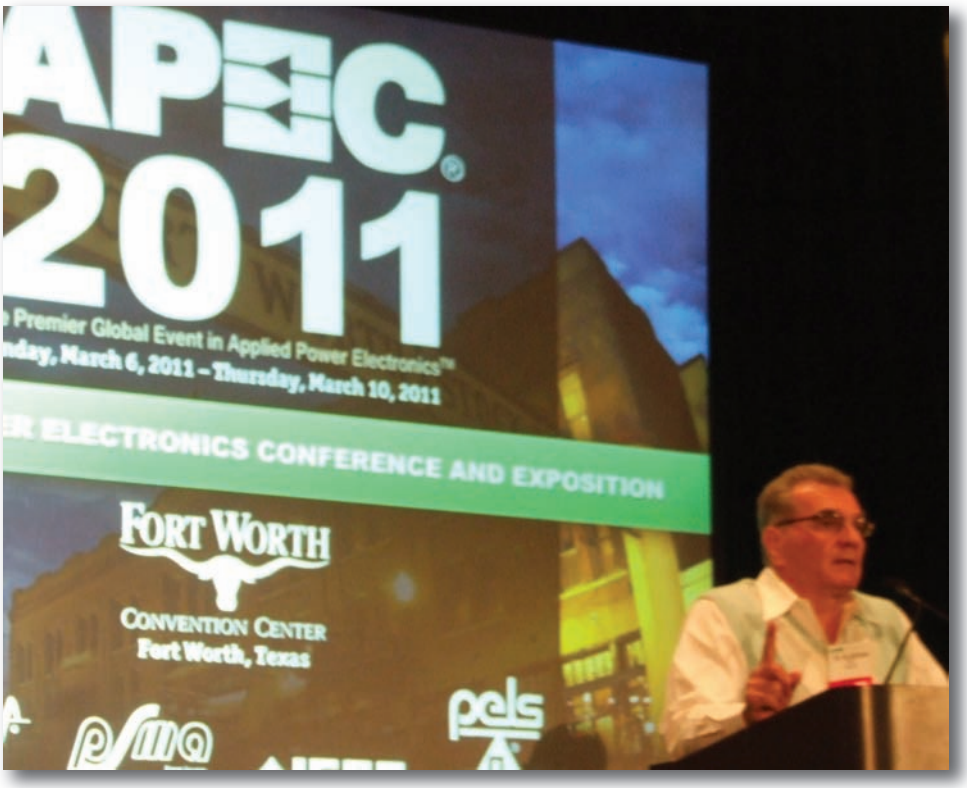
The Applied Power Electronics Conference and Exhibition (APEC) from March 6-10 in Fort Worth (USA) again turned out to be a successful event with more than thousand conference delegates and 170 exhibitors. Main topics were Wide Bandgap Semiconductors, efficient switching topologies, and applications such as renewable power sources including smart grids.

The conference started with several keynotes, one of them was given by Slobodan `Cuk, president of Irvine-based engineering firm TESLAco (**www.teslaco.com**), who is licensing on a non-exclusive basis the so-called `Cuk converter technology. "DC/DC designs based on this technology, can exceed 96% efficiency, which allows for convection cooling even if implemented in a small size chassis. Higher efficiency of DC/DC converters can be achieved by the reduction of conduction and switching losses in the power switches (transistors and diodes) as well as core and copper losses in the magnetic components. These problems have been addressed recently in the new patented TESLAconverter, with losses that are significantly lower than those of conventional switching converters", `Cuk noted.

The basic version of the TESLAconverter comprises of two primary side MOSFET switches, two secondary side diodes, one integrated magnetic structure, and three capacitors. The two primary side MOSFET switches operate in an out-of-phase manner.

The output diode operates in synchronism with the input switch while the complementary output diode operates in synchronism with the complementary input switch, which is just the opposite of the switch timing of the output diode rectifiers in the conventional forward converter with a voltage clamp. This specific switch timing enables that the DC-flux in the new Integrated Magnetics structure can be eliminated or significantly reduced for any operating condition. "High efficiencies exceeding 95% even at output voltages of 5V and below are achieved as a result of this topology, which employs a new principle of lossless switching. Very high power density results from both the smaller new integrated magnetics structure called DC Transformer and the significantly reduced power losses. In 3-phase converters the inductor size can be decreased by a factor of 40 and a small output capacitor can be used. Though we can realize high efficiency at relatively low switching frequencies, high-frequency switching devices will not become obsolete but will realize their full potential", `Cuk stated.

In AC/DC power supplies efficiency is already on a high level. "But today 88% efficiency have to be achieved at light load or 10% power, which is hardly to achieve for power supply manufacturers", said Aung Tu from Fairchild on behalf of PSMA (**www.psma.org**) by introducing the PSMA roadmap. The roadmap showed that digital control of power supplies becomes mainstream and is also moving into price-sensitive applications such as lighting. Also Gallium Nitride (GaN) for power electronic applications is generating a lot of interest and the market could reach $35 million in 2015.



Slobodan `Cuk was the first APEC keynote speaker, he presented in detail a new high-efficiency converter topology

More in wide bandgap semiconductors

As a gadget International Rectifier (**www.irf.com**) has demonstrated a 100W Class D audio amplifier equipped with a GaN power stage - built into an electron tube. But there are other emerging applications. "In the next 3-5 years GaN will be used in probably 5% of all power supplies", said IR's Tim McDonald, VP Emerging Technologies in his keynote. "650V GaN switches, to be released by end of this year, will have 50% lower on-resistance than Superjunction MOSFETs. These devices will have a cascode topology and be normally off. In order to realize the properties of GaN devices such as high switching frequencies the magnetic industry is forced to provide better solutions". The performance figure of merit for first generation GaN based 600V switches will exceed that of state-of-the-art Silicon based devices by at least a factor of 4. These improved switching performances make GaN based power devices excellent candidates for such high speed circuits as PFC AC/DC converters, as well as for use with switches in inverter circuits for motor drive or distributed energy generation applications.

A new GaN player is entering the stage named Transphorm Inc. (**www.transphormusa.com**), based in Goleta(California. "We have a complete solution, from wafers to module technology to

Transphorm's CEO Umesh Mishra claims to have a complete GaN solution, from wafers to module technology

manufacture GaN switches and diodes up to 600V. Also we can grow GaN on Si and also SiC wafers, according to customer requirements, and we can deliver custom-designed power modules that are easy to embed in virtually any electrical system", stated CEO Umesh Mishra. Prior to founding the company he co-founded Nitres Inc. in 1996, a start-up to develop GaN Transistors and LEDs. Nitres was acquired by Cree in the year 2000. The company recently completed a $38 million financing to capitalize on their portfolio. At APEC a converter test setup with output power of 760W at 400V and 100kHz switching was shown, also the company is sampling GaN diodes rated 600V/2A, with 6A coming soon.

Cree (**www.cree.com**) introduced in the conference its 4H-SiC JBS diodes and DMOSFETs for blocking voltages in excess of 1700V at junction temperatures greater than 175°C. A 10kW DC/DC converter employing the 4H-SiC components was built and demonstrated at 1000V and 32kHz at their booth, with total system efficiency of 97.5%. Also the 1200V SiC MOSFETs (see also PEE 1/2011, pages 21-22) were on display and gained great attraction also in the conference. "We see great interest in SiC MOSFETs since it saves money on the system side, though it's a more expensive part", stated CTO John Palmour.

Rohm (**www.rohmsemiconductor.com**) announced new 600V SiC Schottky barrier diodes (SBD). "SiC is the ideal material for power electronics with its high breakdown voltage, low power loss, high operating temperature and thermal conductivity. We are not the first vendor to offer SiC SBDs, but we are introducing devices with some differentiating capability such as forward voltage of 1.7V, and ampere rating of 20A, not dual 2x10A. Some of solar microinverter manufacturers are interested in the properties of our diodes - including thermal behavior. We also have 1200V SBDs and MOSFETs - currently in sampling with strategic automotive partners - to address higher power applications and to enable all-SiC power devices", said David Doan, Senior Technical Product Marketing Manager. With the recent acquisition of Erlangen-based SiCrystal AG (Germany), Rohm has the complete manufacturing capability for SiC semiconductors, from ingot formation to power device fabrication.

More efficiency for converters

NXP Semiconductors (**www.nxp.com**) unveiled the first MOSFET in the NextPower range with a 30V Power-SO8 MOSFET, featuring an on-resistance of 1.4mΩ at 4.5V. The new MOSFET, PSMN1R0-30YLC, is optimized for 4.5V switching applications and is packaged in LFPAK, the industry's toughest Power-SO8 package. The NextPower technology has been specifically optimized for high performance DC/DC conversion applications such as synchronous buck regulators, synchronous rectifiers in isolated power supplies and Power OR-ing. "This Superjunction derivate behaves like a lateral MOSFET, but is made vertical and features very low on-resistance and gate charge", stated NXP's Technical Manager Phil Rutter.

NXP's Technical Manager Phil Rutter introduced a 30V Superjunction derivate which behaves like a lateral MOSFET

International Rectifier's (**www.irf.com**) IR3550 is the first in a family of integrated 60A power stage products that delivers high efficiency (95% at $12V_{IN}$, $1.2V_{OUT}$, 300kHz) and thermal performance along with smallest footprint. The device integrates a synchronous buck gate driver, control and synchronous MOSFETs, and a Schottky diode into a 6mm x 6mm x 0.9mm PQFN package. "Our new PowIRstage solution has removed the bottleneck within the buck regulator, enabling higher current handling capability, and lower phase count. The IR3550 is compatible with most analog and digital controllers available on the market today, providing the designer the flexibility to select the PWM controller of preference", said Deepak Savadatti, Director Multiphase Products. The high switching frequency capability (1MHz max) allows for miniaturization of output inductors and input and output capacitors to help reduce overall solution size.

IR's Deepak Savadatti claims to have the coolest solution for 60A multiphase buck converters

National (**www.national.com**) showcased the LM5045 and LM5046 PWM controllers which integrate all four primary-side bridge MOSFET gate drivers, well-suited for delivering higher efficiency and higher power density in quarter-brick and eighth-brick power modules. The LM5045 PWM controller contains all of the features necessary to implement a conventional full-bridge topology power converter using either current mode or voltage mode control. For applications requiring zero-voltage switching to minimize electro-magnetic interference due to switching noise, the LM5046 PWM controller contains all the features necessary to implement a phase-shifted full-bridge topology. "These highly integrated controllers provide 2A high and low side gate drivers for the four external bridge MOSFETs in addition to the control signals for the secondary side synchronous rectifier MOSFETs and an internal high voltage start-up

National's Jim Broiles demonstrates the features of new PWM controllers

regulator", explained Sr. Marketing Manager Jim Broiles. Intelligent startup of the synchronous rectifiers allows monotonic turn-on of the power converter, even with pre-bias load conditions. The synchronous rectifier control signals offer independent and programmable leading/trailing edge dead-times between the primary and secondary MOSFET control signals for optimizing efficiency, and the SR signals are limited to 5V for use with digital isolators.

Maxim Integrated Products (**www.maxim-ic.com/Teridian**) launched an energy-measurement system on chip (SoC), the 78M6613, the first SoC energy-measurement solution for AC/DC power supplies that brings a higher level of management and control to servers and other equipment in data centers. "The SoC enables the capture and reporting of real-time energy data, which provides data center managers with the ability to quantify where energy is needed, being used, and more importantly, being stranded. Visibility into this critical data is a requirement in order to manage and control energy usage in power-starved data centers that cannot keep up with growing demands placed upon them. Power capping, load shedding and virtualization are all driving the need for real-time energy measurement and resource management in data centers", said Application & Business Manager Daniel D. Callen. The 78M6613 features the full range of AC power diagnostics, including power, power factor, voltage current, voltage sag and dip. On-chip flash and a microcontroller (MCU) enable the storage of calibration coefficients and eliminate the need for external components. **AS**

Maxim's Daniel Callen shows new SoC enabling the real-time measurement of power supplies

Like Phoenix Out of Ashes

Today Infineon Technologies is in good shape, for the financial year 2010 net profit was €660 million. Things could not have gone much better. The company is optimistic for the current financial year 2011 since it has maintained the momentum of the last financial year. Revenues in the first quarter 2011 were €922 million. Infineon's focus is now on markets offering high, long-term growth such as energy efficiency and mobility, as CEO Peter Bauer at the recent annual general meeting in Munich outlined. The following covers the major aspects of his speech.

Infineon today plays in a different league. The turnaround has been achieved. We have been in the black for six quarters in a row. One might say the 2009 financial year marked the dawn of a new era. Today we are no longer talking about potential, we are seeing results.

At present Infineon is firing on all cylinders. The volume of orders is excellent, providing plenty of fuel for the coming quarters. We will continue to see strong growth in the current financial year and will raise our profitability. However, that does not render us immune to any cyclical downturns. As the company turns its course away from the so-called "hog cycles" of some semiconductor markets, our business is now almost fully dependent on our customers' business cycles. We, as suppliers, are hit a little earlier and mostly a little harder by the fluctuations. However, having streamlined our portfolio, we are now far away from the extreme ups and downs of the past.

"Under the 2,052 chips on this wafer is the 3.5 billionth CoolMOS power transistor costing less than one Euro that increase energy efficiency in a host of applications", Peter Bauer stated

Strategic market segments

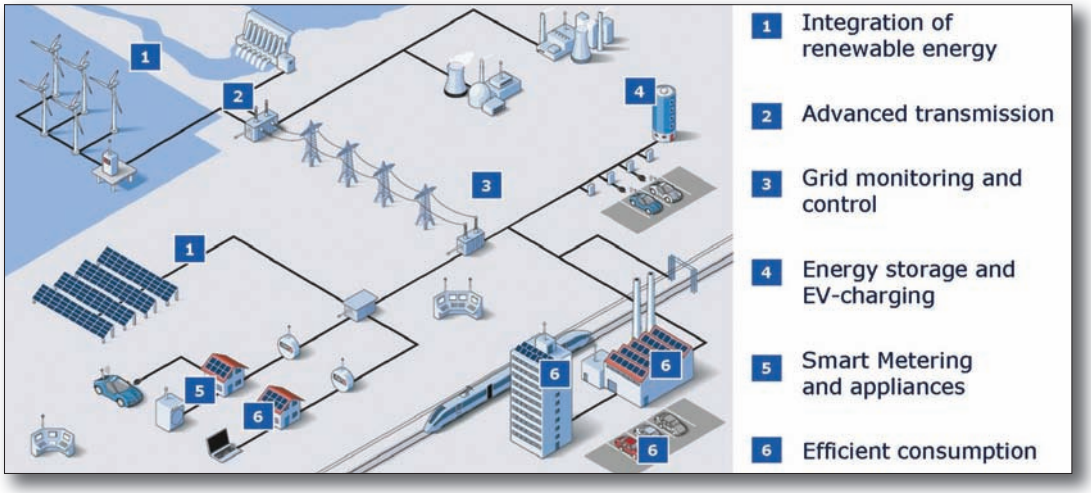
According to a study by the Accenture management consultancy and Barclays Bank, EU countries would have to spend €2.9 trillion in the coming years to achieve the climate goals in Europe, that is €2900 billion for technical innovation. €350 billion of that sum fall upon Germany. This money is invested most effectively in the electricity sector.

The semiconductor industry is in a key position here. Semiconductors are vital for generating power from wind, sun and water. State-of-the-art power semiconductors are essential for transporting energy over long distances. And without semiconductors, thrifty use of energy would be inconceivable, no matter whether in motors, power supply units, lamps, or in computers, TVs, and so on and so forth.

The development of renewable energy sources is an important part of the battle against climate change. What is generally forgotten in the debate is that it is necessary for conventional electricity networks to be transformed into smart grids. Smart grids are vital for efficiently interlinking a wide variety of decentralized power sources on the one hand and consumers on the other: Wind power stations, just like the rooftop solar system and in future the electric car in the garage, which both draws electricity and feeds it back into the grid.

Smart grid management is highly complex. Along the way from generation to consumption, electricity is converted umpteen times, from one frequency to another, from AC to DC and back, from a high voltage to a lower and even lower one. And we, with our power chips such as CoolMOS (see our feature "New 650V SJ MOSFET with Rugged Body Diode for Hard and Soft Switching Applications) or IGBTs, are on board each time. Behind the upgrading of conventional electricity networks into smart grids lies an enormous market. The annual smart grid investments are expected to increase annually from some $40 billion in 2010 to over $250 billion in the next 20 years.

What applies to energy efficiency, applies equally to mobility. The cards are being reshuffled. Transport as we have known it up to now will change drastically - particularly in the megacities of this world. Cities are expanding, 70 % of all people are expected to be city dwellers by the year 2050. Economic growth will increase faster there than the global economy as a whole. Particularly in



Smart grid management is highly complex, along the way from generation to consumption electricity is converted umpteen times by power semiconductors

the emerging-market cities, the economic momentum is breathtaking. The high momentum is however also accompanied by increasing problems. Cities account for around 80 % of the global CO2 emissions and for 75 % of the global energy consumption.

We are seeing a railroad renaissance with vast railway network expansion particularly in heavily populated countries like China. By the year 2020, the high-speed railway network will be expanded 54 % from currently 13,000 to 20,000 kilometers. That entails enormous investments in fleets of trains with drive systems packed full with power semiconductors enabling regenerative braking and energy management, while increasing comfort.

The growth in high-speed trains is not confined to China. Railway companies in Europe are also updating their fleets of trains. Eurostar in example recently ordered 10 new Velaro trains from Siemens. That is not only great business for Siemens, but also for Infineon. Each train comes with up to 130 IGBT modules capable of 6500V/800A each totalling nearly €100,000 in value.

Putting more trains on the rails alone will not solve the climate issue. A lot still has to be done in private transport as well and that is where the magic word is electric mobility. In order to facilitate the breakthrough of electric vehicles it is essential to understand the early adopters. Electric vehicles should not only be low priced and have an adequate range, they should also have emotional appeal. The Tesla Roadster's electric motor is controlled by 84 water-cooled power transistors from Infineon.

Possible constraints in the case of the electric car are still the high battery costs and limited driving range. However, with rapid progress in battery manufacture the price will soon drop to $400 per kilowatt hour. Then the electric car will become very attractive.

Focus on Asian markets

At the beginning of 2010 nobody here would have dared to forecast that Germany's economy would grow 3.6 % in the course of the year. Half the world can be felt to be drawn out of the crisis mainly by the booming Asian markets, with the heavyweights India and China. China presents itself as if there had never been a global economic crisis. The Chinese put a massive economic stimulus package into place early on, investing €400 billion in new rail networks, airports and in developing renewable energy sources. The result will be amazing. China's growth in 2010 was over 10 % despite tight curbs on lending.

Rising prosperity levels are boosting car sales. The year 2010 alone saw 18 million vehicles being sold in China - more than anywhere else in the world.

China is looking to make the jump to the top in renewables as well. They might soon leave the West behind in these technologies of the future, not least thanks to generous state funding. The Chinese solar industry is already larger than its German counterpart. And China built more wind power plants last year than the Americans who had held the scepter so far. Giants such as Sinovel and Goldwind have risen to become leading wind power companies and they have become our partners.

Driven by increased mobility demands on the part of burgeoning Asian middle classes and energy efficiency awareness, Asia has developed into a key global sales market for semiconductors. In the year 2009, Asia accounted for 57 % of the global semiconductor market. If forecasters are proved right, this figure will increase to 60 % by the middle of the decade with continued overall market growth.

Infineon's growth was disproportionately high in Asia compared to other regions. Based on the 2010 business figures, Infineon generates 42 % of its revenues in the Asia region including Japan.

Thus we will further expand our presence in the region. The new business unit in Peking that opened in January also illustrates this aim. We develop and manufacture IGBT stacks under one roof there. That enables us to provide tailored solutions for our local customers, such as Goldwind.

The scenario for 2050 may be as follows: cars will all run on eco-electricity. Cities will be linked by express trains - including in China, India and Brazil. And we will have sufficient clean energy thanks to renewable energies and power semiconductors.

www.infineon.com

Smart Metering for the Smart Grid

The term "smart meter" has been used to represent a variety of products on a spectrum ranging from a dumb meter with a radio attached for remote reading, to a high-tech, high-cost meter with multiple 2-way communications interfaces, supporting every conceivable measurement and tariff option, many of which may not be considered necessary today. Off-the-shelf meters may sound like a quick and straightforward option, but inevitably incumbent meter manufacturers have been forced to make many compromises in the design in order to make a product that could be used by a wide range of utilities. Sentec's CEO Mark England outlines some requirements on smart meters.

Demands on the applications of a smart meter will increase as other technology develops. As such, meters rolled out in the next few years must have the ability to adapt to changes in application that may happen in ten years' time, or utilities will find themselves with meters that need to be completely replaced every few years just to keep up. Utilities investing in smart meters need to take into account the advances made in metrology methodology, production methods and materials, communications technologies, electronic components, firmware and operating systems.

"Smart meters are important to the deployment of future applications", Sentec's CEO Mark England points out

How to measure current

There are many types of current sensors, such as those based on Hall Effect and flux gate sensing. These are more commonly found in industrial applications, rather than power metering.

Low-cost, low-current IEC meters typically use a manganin shunt in the "live" connection: this is essentially a low temperature coefficient of resistance, high-power resistor, dropping a few millivolts whilst passing the whole meter current. The approach becomes unsuitable at higher currents, because the shunt resistance must be lowered to limit thermal dissipation, and hence signal levels typically fall as the square of the maximum current.

A further option is the current transformer (CT), which divides down the current by a fixed ratio such that it can be measured across a low-wattage "burden" resistor on its secondary coil. A key advantage is that it is isolated, allowing measurement on multiple conductors at different voltages. However, CT's can be far from ideal, depending on the permeable core material, with cost rising as the maximum current and core material quality increase. Their disadvantage is susceptibility to tampering by readily-available DC magnets. Shielding is one solution, but adds cost and complexity.

Finally, there is the air-coupled sensor, often referred to as Rogowski coil sensors. These have precision coils that couple to the AC magnetic field from the conductor being measured, but reject field from adjacent conductors or the environment, simply through their geometry. The primary advantage is the lack of magnetic core material, meaning they are unaffected either by DC magnets or large transient overload currents. Historically, precision manufacture made them too expensive, but recent innovations have brought them into the mainstream of low-cost current sensing, for example Sentec's Mobius sensor used in the iCon electricity meter.

Smart metering - the first wave

The first wave of Smart Grid technology that will have a major effect as Smart Meters, currently being rolled out in many utility territories across Europe and the USA. As the gateway between the home and the utility network, smart meters are important to the deployment of future applications, such as home energy management and smart appliances. In addition they can provide a facility for feedback to the customer on their energy usage as well as valuable information to the utilities enabling them to better understand and balance energy supply and demand in the future, particularly as renewable, microgeneration and intermittent sources and EVs (requiring charging) become more common. The management of energy for both utility and customer is crucial - and you cannot manage what you haven't measured!

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		1600A	●	●	
	 140 x 190 mm	1200A			●
		1500A			●
		2400A	●	●	
		3600A	●	●	
2-Pack	 130 x 140 mm	600A	●	●	
		800A	●	●	
		1200A	●	●	
	 89 x 172 mm	600A	●		
		650A		●	
		900A	●		
	 89 x 250 mm	1000A		●	
		1400A	●	●	

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Measurement ICs for Modular Smart Meters

As installations of smart meters in homes and businesses accelerate globally, STMicroelectronics has unveiled a new set of metering chips that offer an accurate and cost-effective solution for next-generation smart meters.

Unlike traditional induction watt-hour meters, which are vulnerable to wear and fraud and provide only limited features, smart meters, or electronic meters, are intelligent devices that have no moving parts and can support sophisticated tamper detection and two-way communication for improved grid management and billing. More specifically, smart meters allow automatic remote meter readings by power utility companies and make energy consumption transparent and directly manageable for consumers. Some eight million smart meters were shipped in the US in 2009, while Asia is predicted to become the world's largest market by 2014, and large projects in Italy, France and Spain should help drive European installations beyond 100 million units by 2015.

"We believe that this new chipset is an important milestone. The new STPMC1 and STPMS1/S2 chips support a new modular approach that will offer greater accuracy and reduced costs in the development of leading-edge 'poly-phase' smart meters for industrial applications", said Pietro Menniti, ST's General Manager Industrial Business Unit.

Smart Grids and power-Line communications

Smart meters are a key enabler for the 'Smart Grid', a term that is widely used to describe the next generation of intelligent and digital networks that will add functions of monitoring, analysis, control and communication to the electricity grid to improve the reliability and efficiency, control costs and increase capacity.

In addition to smart meters, a key technology required to enable these intelligent and reliable networks is Power-Line Communications (PLC). ST's PLC chip solutions have already been massively employed in major national smart-metering infrastructure deployments, along with state-of-the-art metrology chips, or 'measurement' chips.

Smart meters include two main functions: a high-accuracy modulator for sensed current and voltage signals and a dedicated metrology processor to calculate energy consumption. In the next few years, smart-metrology functions are also expected to be widely adopted in home appliances, air-conditioning and power-supply systems. Single-phase metering chips such as ST's existing solutions - the STPM01, STPM10 and STPM11/12/13/14 chips - integrate these functions in a single component.

However, in three-phase, or poly-phase, smart meters for industrial applications, a modular approach that separates the current/voltage sensing from the metrology section can improve accuracy and economy. The modulator ICs in the sensing circuitry can be mounted closer to the measurement transducers to reduce the effects of noise. In addition, the same design can be re-used cost-efficiently in a range of metering products without redesigning the metrology section, simply by adding the required number of modulators.

Together, ST's new STPMC1 and STPMS1/S2 create a chipset for modular smart meters, supporting 50-60Hz IEC and ANSI standards for up to 0.2-class AC watt meters. The STMPC1 metrology IC, which has five input channels, accepts measurements from three phases with the option of using the fourth channel for tamper detection or temperature sensing, and the fifth channel to accept magnetic field information from a Hall sensor. It supports Rogowski coil, current transformer, shunt or Hall-effect current sensing and can be configured and calibrated for any international distribution standard.

The STPMS1 and STPMS2 are dual-channel delta-sigma modulators that convert analog current and voltage values from each phase and transmit digital data to the STPMC1. They can be placed very close to the current sensor to avoid long analog tracks and high-noise capture. In addition, the reduced number of connections and the discrete implementation leads to the potential use of three shunt resistors via low-cost isolation on digital data paths, instead of using significantly more expensive isolated sensors.

The STPMS1 has a first-order modulator, while the STPMS2 has a second-order modulator delivering enhanced accuracy.

The complete chipset for a three-phase meter, comprising the STPMC1 and three STPMSx modulator ICs, is priced at $4.50 for 1000 sets.

www.st.com

New measurement ICs for modular smart meters

Extended Solar Technology Portfolio

In face of the nuclear situation in Japan renewable energy is more important than ever, with governments around the world offering grants and tax incentives to encourage and support its development. Microsemi contributes by offering an extensive range of solutions for the photovoltaic (PV) market, supporting a wide array of applications in power harvesting, power management, power switching and power monitoring. With these products such as bypass diodes/switches, MOSFETs and IGBTs, DC/DC converters, mixed signal FPGAs, PWM modules the PV designer can develop applications to meet the increasing demand of PV deployments. The company announced their Solar strategy at APEC 2011.

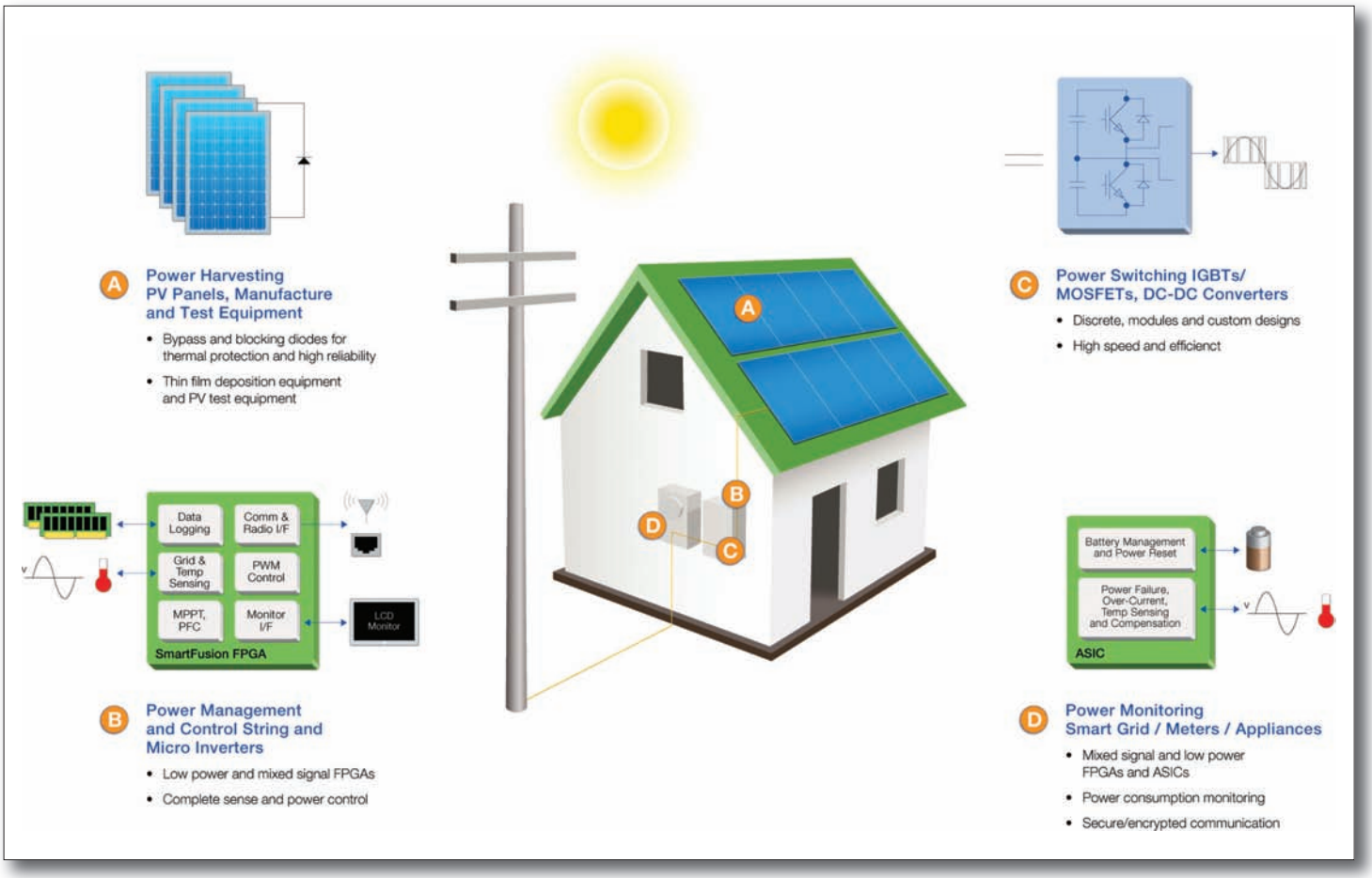
Microsemi recently has acquired Actel, a leading supplier of reprogrammable Field Programmable Gate Arrays (FPGAs), these devices with flash memory are well suited for implementing PWMs commonly used in inverter topologies. "Design techniques such as pulse-width modulation are used widely to convert from DC to AC. Our programmable logic devices allow for an increased number of PWM state machines as compared to current DSPs. Losses due to heat must be minimized, so flash-based low power technology is a big advantage, reducing operational expense in the form of smaller chassis fans", commented Development Manager Tim Morin.

The LX2400 Solar Bypass device provides a bypass path in PV module applications. It features low forward voltage drop and negligible heat generation - less than 10°C rise at 10A - the device is designed for 30 year product life and is fully functional from -50°C to +150°C. Designed specifically for solar panels, the Schottky barrier PV bypass diodes SFDS series 10A diodes (0.74mm thick) are packaged with flexible copper leads that have satellite-proven reliability. It can eliminate junction box or reduce junction box size. Microsemi offers a wide range of Schottky bypass diodes in axial, surface mount and through-hole devices. The standard current ranges are 10A-18A and 20V-45 V, but custom designs up to 60A and up to 200V are possible.

"With 26 years of experience in the power semiconductor module industry, we develop and manufacture semiconductor inverter modules with mix-and-match components and assembly materials. We also offer a range of input and output diode bridge modules such as recovery diodes, FRED and SiC diodes. Boost and buck choppers and resonant inverter topologies are available in the same low profile packages", added Microsemi's Director Switching Power Products, Glenn Wright. Along with SemiSouth a full-SiC power module has been developed (see PEE December 2010, pages 31-33).

The new 600 V CoolMOS™ C6 devices feature fifth-generation high voltage Superjuntion technology for extremely low conduction and switching losses, thus enabling the design of switching systems having new levels of efficiency and power density. CoolMOS C6 devices are easy to design in, more compact, lighter and cooler. They are well suited for high power, high performance switch mode applications. The new MOS 8™ IGBT has been optimized for low frequency operation (10kHz-30kHz), where conduction loss dominates overall system losses. The MOS 8 PT IGBZT portfolio already provides low conduction loss options at 2.0 V

BELOW: Components used for PV applications



"FPGAs are ideal for implementing PWMs in solar inverters", Microsemi's Tim Morin stated

(600V$_{BR(CES)}$) and 2.5V (900V$_{BR(CES)}$). The new APT44GA60BD30C reduces this to 1.5V, enabling further increases in overall system efficiency for 600V designs. Input is rated at 44A with a 38A maximum recommended at 10kHz and 27A at 30kHz. The ultra fast reverse recovery DQ diode is incorporated as an anti-parallel free wheeling diode.

The company's DC/DC product family supports up to 40V input voltages across a wide range of current output, up to 40A. The family includes switching regulators with built-in power FETs as well as controllers that use external power FETs and can operate at frequencies up to 2MHz.

Understanding energy consumption and providing the ability to change usage models in real time is being made possible by smart meters. Technological advances such as the mixed signal SmartFusion FPGA, which includes an analog front-end, embedded processor and programmable logic fabric in a single IC platform, gives designers the ability to develop smart meter systems that meet current and future needs.

A single computing platform that includes a processor and FPGA fabric gives the designer flexibility to partition designs into software and hardware elements. The embedded ARM Cortex-M3 operates at 100MHz, provides 125 Drhystone MIPs performance and includes up to 512 KB flash memory and 128 KB of SRAM. These abundant resources provide the ability to tackle system-level algorithms such as power management, communication interfaces, and encryption.

www.microsemi.com

"With 26 years of experience in the power semiconductor module industry, we develop and manufacture semiconductor inverter modules with mix-and-match components and assembly materials", Microsemi's Glenn Wright pointed out

Source for Power Modules

Curamik Electronics of Germany is a newly acquired division of Rogers Corporation, a leader in specialty materials. In business since 1983, Curamik is a worldwide leader in the development and production of direct bond copper (DBC) ceramic substrate products used in the design of IGBT modules. These devices are used in a wide range of products, including highly efficient industrial motor drives, wind and solar energy converters and HEV drive systems.

According to Rogers' CEO Robert D. Wachob this $154 million acquisition will add around $120 million in sales for the running year and will provide significant opportunities for future growth as the markets for IGBT modules are projected to grow by 15% over the next several years. "The addition of the Curamik offerings will expand our portfolio for Power Electronics and build upon the technical expertise and solutions of our Power Distribution and Thermal Management businesses. So far, there is no change in business. Our goal is to continue to rely on the sales and customer service support team to support the Curamik product line", added Market Development Manager Albert J. Mastrangelo. "We have also established a new busbar design and manufacturing facility in Chandler, Arizona. With this new capability in place, Rogers becomes the first laminated busbar manufacturer with a global footprint having dedicated manufacturing and engineering capabilities in the Americas, Europe and Asia Pacific regions".

At APEC 2011 the Power Distribution Systems exhibited the RO-LINX® family of custom-designed laminated busbars for power distribution applications. These high-current-density busbars provide high-power switching capabilities with minimal loss. RO-LINX Busbars, designed to control partial discharge, have a compact design and possess low inductance characteristics. Busbars are custom designed for each application like traction and propulsion, wind/solar inverters, industrial drives (VFDs), hybrid and electric vehicle (HEV), and military applications.

The Thermal Management Solutions Division exhibited their HEATWAVE™ thermal-management materials, which are suited for minimizing heat in high-power semiconductor packages and IGBT base plate applications. HEATWAVE materials are aluminum-silicon-carbide (AlSiC) metal matrix composites (MMCs) engineered for high thermal conductivity from 170 to 230W/m-K and tightly controlled coefficients of thermal expansion (CTE) from 5 to 14 ppm/K, which can reduce stress in semiconductors during thermal cycling. These AlSiC composites feature considerably lower density than other thermal management materials, including Kovar alloy, copper and stainless steel.

The company also announced its new SYRON 7000 and 7100 circuit materials, engineered for applications that demand outstanding high-temperature stability. These thermoplastic circuit laminates are characterized by a considerably higher melt temperature than PTFE circuit materials, with an estimated Underwriters' Laboratory (UL) relative thermal index (RTI) of greater than 210°C (410°F). They are also inherently flame retardant. Environmentally friendly SYRON thermoplastic circuit materials are halogen-free and compatible with lead-free solder processes. They are also resistant to the solvents and reagents commonly used in printed-circuit-board processing, and can operate in harsh chemical environments.

"With Curamik in hand we are able to supply all materials for high-power electronic applications", stated Rogers' Albert J. Mastrangelo

www.rogerscorp.com

Cutting Vehicle Emissions with Advanced Power Electronics

As car designers seek greater fuel efficiency to meet ambitious government-imposed emissions targets, improvements in power electronics and packaging technology can help to increase the number of kilometres travelled in exchange for the CO_2 emitted. **Benjamin Jackson and Shishir Rai, Product Management Automotive MOSFETs, International Rectifier Corp., El Segundo, USA**

Governments have identified reducing CO_2 emissions from cars as a major component of efforts to reduce greenhouse gas emissions under obligations such as the Kyoto protocol. In the EU, for example, some 20% of overall CO_2 emissions are attributed to road transport and a reduction strategy is now in place aiming to reduce average CO_2 emissions from new cars to 120 grams per kilometre by 2012. Although this target is not likely to be met on time, average new car emissions have fallen considerably and the European Commission is about to assess the feasibility of a new proposal from the European Parliament to reach 70g CO_2/km by 2025.

Electrifying the common car

With this increasing focus on emissions, fuel efficiency is growing in importance to car designers. In addition to improving aspects such as engine design and fuel management, components including power steering systems, water pumps and cooling fans have transitioned from being driven by the engine to become fully electric units. This has removed mechanical loads that sap the engine's power, and has also reduced the overall weight of the vehicle, delivering a net improvement in fuel efficiency.

Electrical systems are even more pervasive in hybrid-electric vehicles. A number of architectures are in use; a common arrangement places a motor/generator in the powertrain between the internal combustion engine and the gearbox. The motor/generator works with the engine to assist acceleration, is capable of propelling the car on battery power alone with the engine turned off, and is also able to recover kinetic energy normally lost during braking. An increasing variety of hybrid vehicles are now available, from ultra-economical small cars to high-performance vehicles capable of out-accelerating a conventional equivalent while returning around 20% better fuel economy.

The ultimate destination, of course, is for the car to have full electric drive. The first generations of such vehicles for public consumption are being introduced to markets now.

In cars with hybrid or fully electric propulsion, large electric drives are needed for the propulsion system, but the demands for equipment such as electric power steering and various body and interior equipment like windscreen wipers, mirror and seat adjusters, and HVAC controls will continue. Since conserving battery energy is crucially important, to maximise the travelling range of the vehicle, all of these drives and power-conversion systems must be extremely efficient.

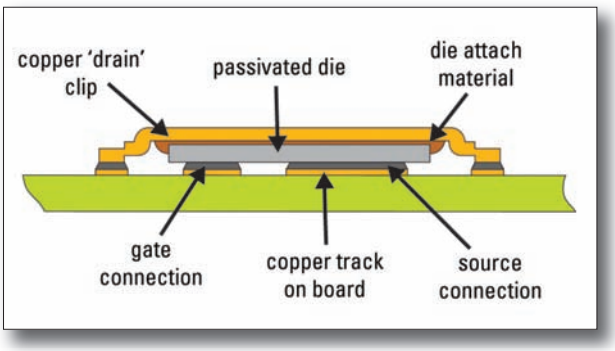


Figure 1: Cross-section of a generic DirectFET device

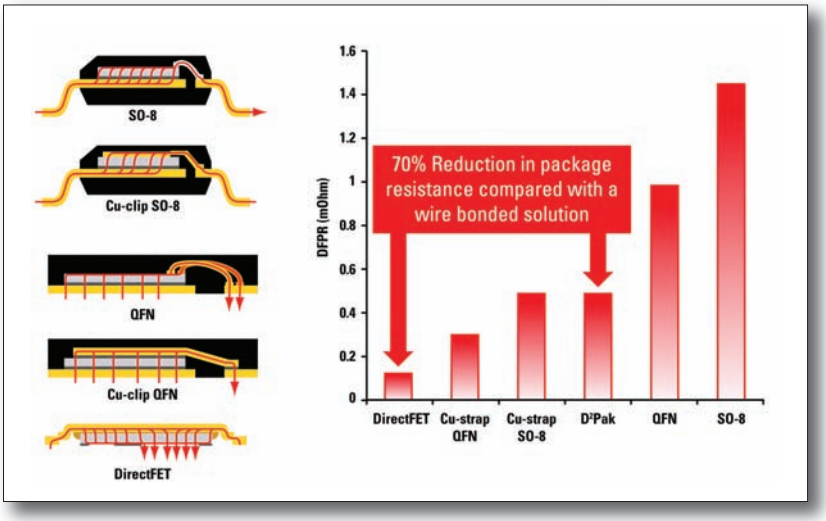


Figure 2: Comparison of package die-free package resistances (DFPR)

Efficient power semiconductors

Engineers designing drives for automotive applications must not only choose the most power-efficient topology for the drive, but also need to consider the properties of the power electronic components selected; in particular, the electrical losses incurred in the power MOSFETs used in the various bridge drivers, inverters and general power-switching functions throughout the vehicle's electrical infrastructure.

Manufacturers of power MOSFETs have made great strides in optimising the performance of the chip, to minimise both on-state resistance as well as losses during turn-on and turn-off. These conduction and switching losses are the two dominant loss mechanisms in a power MOSFET die, and

are usually interdependent: optimising the device for low conduction losses tends to sacrifice some switching performance, and vice versa. For this reason, a number of device types are available, allowing designers to prioritise low conduction loss where the MOSFET will have a high duty cycle or alternatively low switching loss in situations where fast switching is needed, or to choose a device offering a balance of both properties for general-purpose applications.

Another major component of losses in power devices is concerned with the electrical connections between the MOSFET die and the external terminals. The properties of these connections - particularly those to the source and drain, which carry the load current - are critical in determining the MOSFET's performance. Ideally, a metallic connection of large cross-sectional area is desirable. This effectively minimises the resistance of the connection and helps achieve a low value of Die-Free Package Resistance (DFPR), which defines the resistance which the package contributes to the on-resitance of the device.

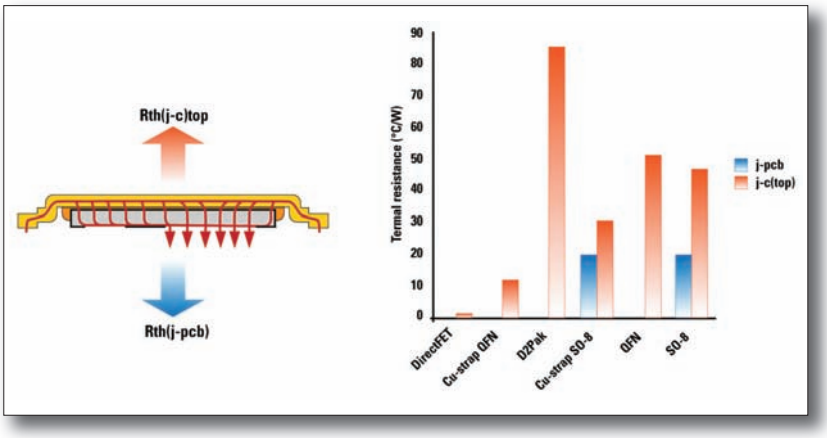


Figure 3: **Advantage of double-sided cooling**

Increasing the cross-sectional area of the connections also reduces the associated inductance, which increases efficiency, reduces heat generation and improves switching performance.

A large number of power package variants have been developed, particularly since the advent of surface-mount technology, aiming to increase the conductivity of these connections so as to improve both the efficiency and current rating of the device.

By optimising the silicon for low on-state resistance and ensuring the package has a low DFPR, the device designer can achieve a power MOSFET offering low overall on-state resistance, or $R_{DS(ON)}$.

Improving package design

Traditionally, wire bonding has been the dominant technique for connecting the die to the package terminals. Bondwires are inexpensive and straightforward to implement by bonding directly to the top metal of the die. However, each individual wire has a small cross-sectional area, which imposes parasitic resistance and inductance. To combat these effects and achieve the desired current-carrying capability, multiple bondwires must often be connected in parallel. Increasing the

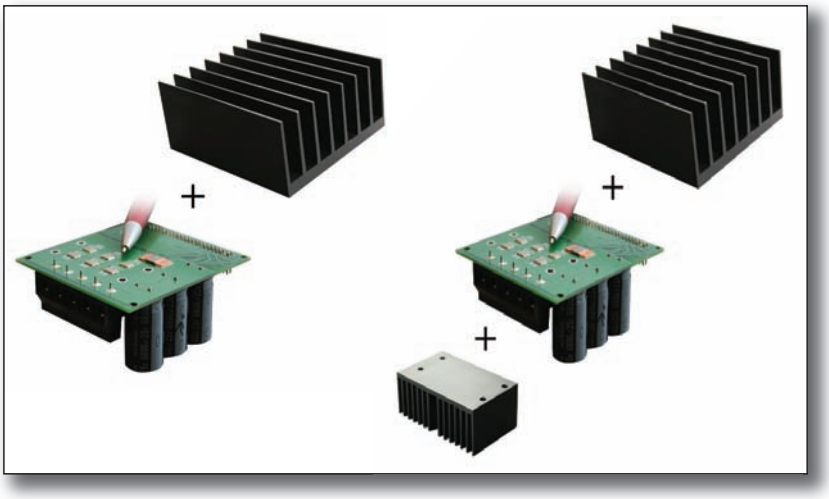


Figure 4: Bottom side of DirectFET inverter board and the heatsink (left) and additional heatsink for dual sided cooling (right)

number of individual connections however, also reduces the reliability of the device. A further disadvantage is that the bondwires on the top surface of the die prevent the use of other packaging techniques for removing heat directly through the upper surface of the package. However, cooling through the PCB becomes impractical in high-power applications. A complicated and costly mechanical attachment to a chassis or heatsink is then required. For these reasons, it can be argued that bondwire technology is one of the biggest roadblocks to improving both the thermal and electrical performance of power semiconductor packaging.

International Rectifier's DirectFET® technology eliminates bond wires from power MOSFET packaging altogether. The MOSFET die is fabricated with a solderable front metal finish in conjunction with a proprietary passivation system, which produces large gate and source contacts on one surface of the die and a large drain connection on the backside. The die is flipped, which exposes the gate and source metallisation on the underside of the package. These are then soldered directly to the PCB. A copper can is attached to the drain connection on the top-side of the flipped die. The can covers the entire upper surface area of the die, and is then brought down to create coplanar drain connections at the level of the PCB. Die-attach adhesive secures the die inside the can. Figure 1 illustrates the cross-section of a generic DirectFET device.

Eliminating the wirebonds also improves the DFPR to 150µΩ, which is insignificant compared to the on-resistance of the MOSFET die. Figure 2 compares the DirectFET DFPR with typical figures for legacy power packages, showing at least 70% improvement over the wire-bonded D2PAK package.

Furthermore, the DirectFET can is conductive and is equivalent of a 7oz PCB trace. This feature enables novel layouts of the power section in inverter and DC/DC converter, where the can itself acts as a busbar or PCB trace thereby saving PCB space and reducing PCB I^2R losses.

In addition to eliminating package resistance associated with a conventional leadframe and wirebonds, DirectFET also eliminates plastic packaging materials, which have poor thermal conductivity. The large copper drain connection also provides an alternate path for heat dissipation and an efficient thermal interface to an external heatsink. With effective cooling of both the top and bottom sides of the package, DirectFET significantly reduces thermal resistance compared to other power packages, as Figure 3 illustrates.

A further advantage of the DirectFET package is that the die utilizes a high percentage of the package PCB footprint. This allows a larger silicon die to fit in a much smaller DirectFET package enabling lower on-state resistance and higher power densities. By significantly reducing electrical losses, physical size and weight while allowing simpler mechanical assemblies, DirectFET delivers many advantages for designers of automotive equipment.

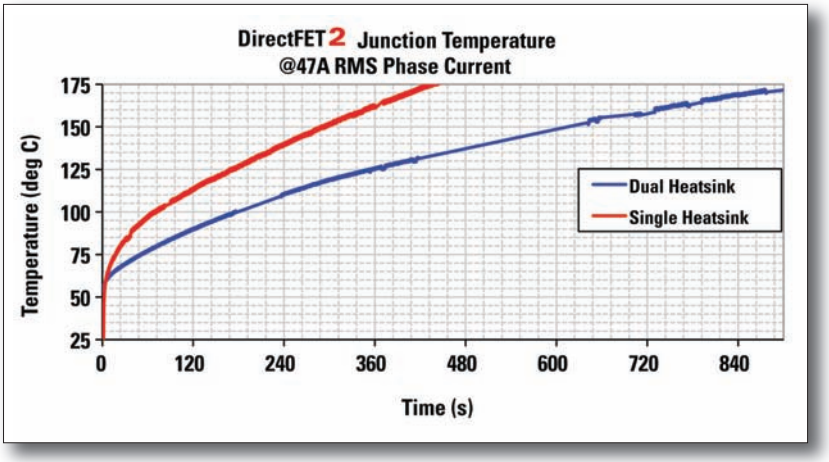


Figure 5: Comparison of single- and double-sided cooling performance

Automotive DirectFET in practice

To conclude with a practical example, Figure 4 shows a three-phase inverter board built using AUIRF7736M2 40V 3mΩ max. DirectFET power MOSFETs. The board has two layers of 71µm thick copper trace and measures 77mm x 83mm with all six DirectFETs fitting in an area of only 17mm x 47mm. At room temperature, the board can be operated at $40A_{RMS}$ continuously or at $50A_{RMS}$ for 5 minutes from a nominal 13V battery voltage. This performance is achieved with a single heatsink in contact with the DirectFETs as illustrated on the left hand side of Figure 4.

When a second heatsink is attached on the top side of the board (as illustrated on the right hand side of Figure 4) it allows the heat to spread evenly between the heatsinks resulting in a reduction in maximum junction temperature of the DirectFETs. When the board was operated at $47A_{RMS}$ with and without the top heatsink, it was found that that after 6 minutes of continuous operation the junction temperature of the DirectFETs was 35°C cooler when the top heatsink was attached. The graph of Figure 5 compares the die temperature with single- and double-sided cooling.

DirectFETs thus enable compact designs and offer the flexibility to cool the package from both sides. This results in maximizing the performance in a smaller space while also improving reliability by reducing the die temperature, thereby accomplishing more from less.

Literature

"Power Density and Performance Improvement of New Automotive Power Semiconductor Packages", Power Electronics Europe 1/2010, pages 20 - 22

New 650V SJ MOSFET with Rugged Body Diode for Hard and Soft Switching Applications

The new CoolMOS™ 650V CFD2 technology combines a high blocking voltage of 650V with lowest on-resistance and low capacitive losses together with an improved body diode ruggedness during reverse recovery especially for hard and soft switching applications. This article investigates the influence factors for improving the body diode ruggedness. The benefit of this new Superjunction device family with fast body diode is especially shown for a HID half-bridge topology. **M.-A. Kutschak, W. Jantscher, D. Zipprick, and A. Ludsteck-Pechloff, Infineon Technologies Villach/Austria and Neubiberg/Germany**

With the increasing demand for higher power density, especially soft switching topologies like half-bridge (e.g. HID half-bridge or LLC) and full-bridge concepts (e.g. ZVS bridge) seem to be the ideal solution. These topologies reduce the switching losses and increase the reliability of the system due to less dynamic di/dt and dv/dt stress on the power device. Such high stresses occur predominantly in light-load operation. It is already shown that Superjunction devices like the CoolMOS™ help to overcome this problem by inherent optimized charge carrier removal during reverse recovery and eliminating the problem of latch-up of the parasitic npn bipolar transistor. A significant reduction of the reverse recovery charge can be achieved by an enhanced recombination rate of the injected carriers resulting in lower reverse recovery peak currents during turn-off and strongly reduced reverse recovery charge by almost a factor of 10.

The new CoolMOS 650V CFD2 (Figure 1) is designed in this manner with improved reverse recovery behavior together with increased safety margin in breakdown voltage.

For optimized body diode (Figure 2) performance in hard switching conditions, especially the shape of the resulting reverse recovery waveform and the design conditions of the printed circuit board are important.

Reverse recovery behavior

The reverse recovery behavior of the new Cool-MOS 650V CFD is shown in Figure 3. It appears that the new devices have a very low reverse recovery charge Q_{rr}, reverse recovery time trr and maximum reverse recovery current I_{rrm} when compared to the standard device.

At the same time, the waveforms of the new device still show a soft characteristic, in spite of the strongly reduced Q_{rr}, t_{rr} and I_{rrm}. This characteristic is highly desirable during hard commutation in order to avoid voltage overshoot and to ensure reliable device operation.

The commutation ruggedness of the device is demonstrated in reverse recovery measurements in Figure 4, where the devices were tested up to di/dt of 2000A/µs. No device could be destroyed under these conditions and the waveforms show still a soft characteristic, compared to snappy waveforms for other superjunction devices. This is a clear advantage for the designer, once one can optimize its application for maximum performance without being concerned with device destruction during hard commutation of the body diode.

Of utmost importance for the designer is the dependence of Q_{rr} and t_{rr} on temperature. The Q_{rr} and t_{rr} values tend to increase with temperature, due to

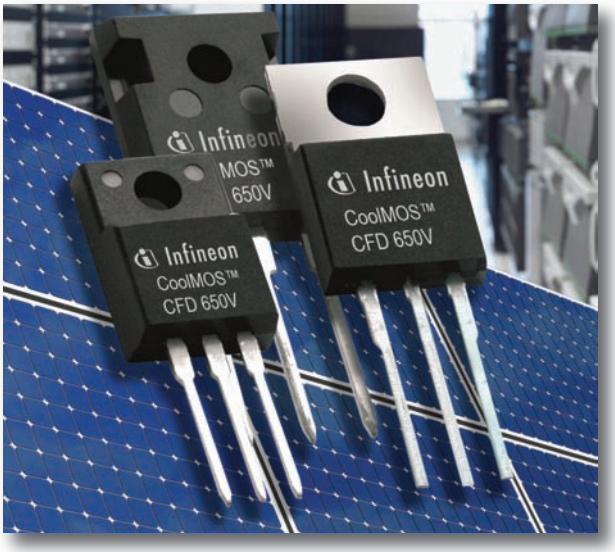


Figure 1: New 650V SJ MOSFET CoolMOS™ 650V CFD2 with integrated fast body diode

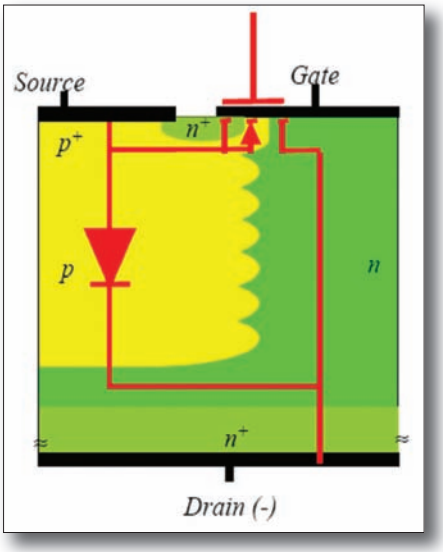


Figure 2: Schematic cross section of the CoolMOS high-voltage power MOSFET and its integral body diode

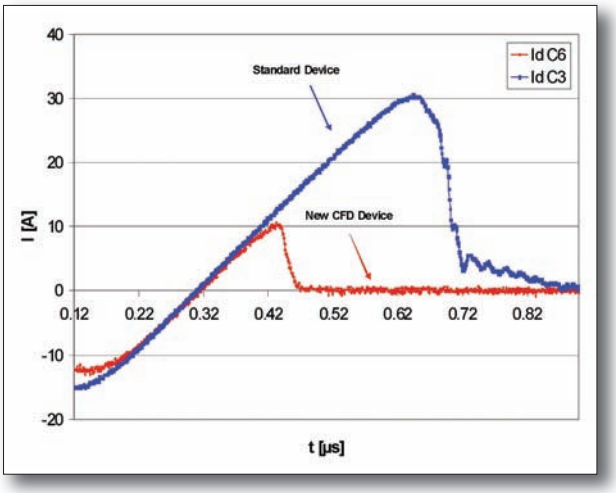


Figure 3: **Measured reverse recovery waveforms at di/dt=100A/µs, 25°C, Vr=400V. The new CFD device shows very low Q_{rr}, t_{rr} and I_{rrm} when compared to the standard device**

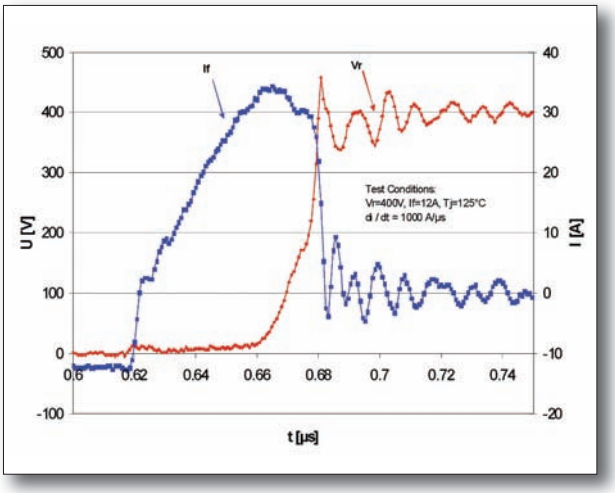


Figure 4: **Measured reverse recovery waveforms for the new CoolMOS 650V CFD2 device**

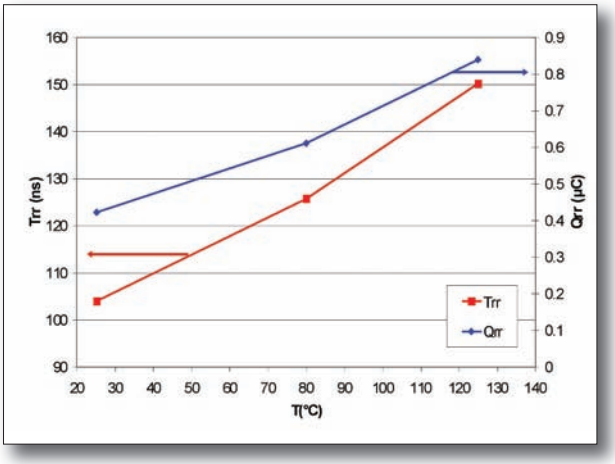


Figure 5: **Dependence of Q_{rr} and t_{rr} with temperature for the 310mΩ 650V CFD device**

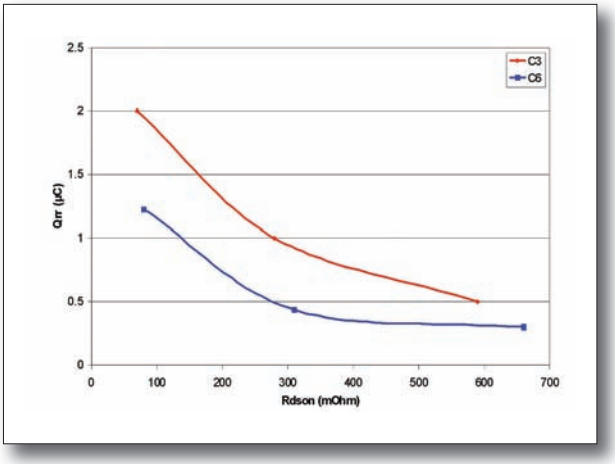


Figure 6: **Dependence of Qrr on R_{dson}, measured at 25°C and for the 80, 310 and 660mΩ 650V CFD2 devices in comparison with the former 600V CFD technology**

increased carrier generation in the device. This dependence is shown in Figure 5 for the 310mΩ 650V CFD2 device. A linear increase of Q_{rr} and t_{rr} with temperature is observed.

Another important aspect to be considered is the dependence of Q_{rr} and t_{rr} on the device R_{dson}. This can be seen in Figure 6, where the new 650V CFD2 device is compared with the former fast diode technology.

Performance evaluation in HID-bridge

We have also compared the performance of the new devices with the commercial available SPD07N60C3 in a HID half-bridge application. Using the new CFD2 devices, the diodes D2, D3, D4 and D5 can be eliminated and allow reduced system costs (Figure 7).

For reference Figure 8 shows, the waveforms obtained by using the SPD07N60C3 device as transistors T2 and T3 and additionally the diodes D2, D3, D4 and D5. With this setup, we achieved an efficiency of 91,81%. By removing the diodes in series to the transistors, the additional voltage drop in forward operation is eliminated. This solution requires, however, an even superior

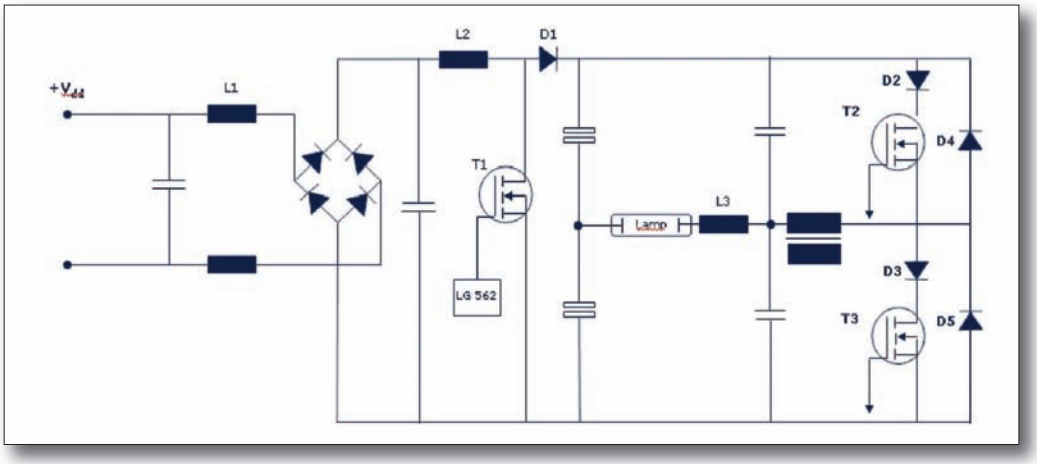


Figure 7: **Typical HID half-bridge circuit. By replacing the transistors T2 and T3 with the new CoolMOS 650V CFD2 device, the diodes D2 to D5 can be eliminated**

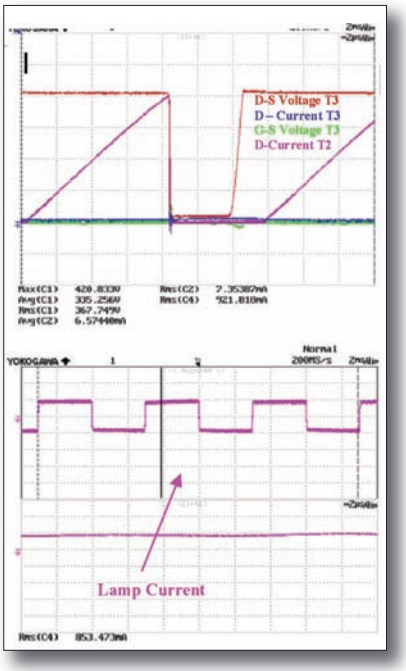


Figure 8: **Circuit waveforms during the turn-off phase of transistor T3 with SPD07N60C3 as switch and the diodes D2 - D5 (efficiency 91.81%)**

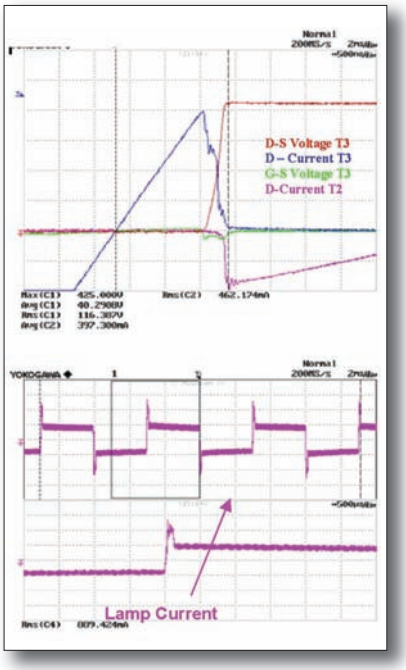


Figure 9: **Circuit waveforms during the turn-off phase of transistor T3 with SPD07N60C3 without the diodes D2-D5 (efficiency 89.72%)**

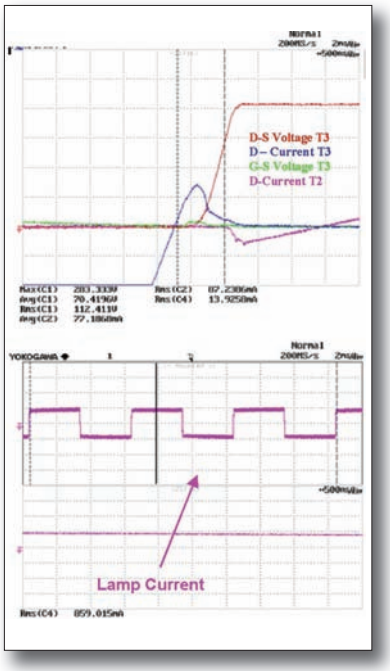


Figure 10: **Circuit waveforms during the turn-off phase of transistor T3 with IPD65R660CFD without the diodes D2-D5 (efficiency 92,81%)**

performance of the internal body diode of the MOSFET once the switching losses increase due to the reverse recovery charge stored in the MOSFET. This situation is depicted in Figure 9.

In addition to increased switching losses, this setup also has the disadvantage that the MOSFETs can eventually be destroyed due to the high reverse recovery current. A superior solution is achieved by using the new IPD65R660CFD device. Due to the superior performance of the internal body diode of the MOSFET, it is possible to implement a solution without the diodes D2-D5 and obtain at the same time a considerably better efficiency. This is shown in Figure10.

The optimized construction of the internal body diode of the new IPD65R660CFD device combined with a very low reverse recovery charge also enable reliable device operation.

Conclusions

Infineon's new CoolMOS CFD2 device, offers the lowest R_{dson} combined with a high blocking voltage of 650V. This new device features also a very low reverse recovery charge combined with a robust integral body diode. A specification of the maximum values of the Q_{rr} and t_{rr} will be available in the datasheet. We have also evaluated the performance of this new device in a typical HID Half-Bridge circuit, leaving out four diodes and getting superior efficiency. Due to the breakdown voltage of 650V and the robust construction of the integral body diode, this new device offers additional safety against destruction during hard commutation of the MOSFET.

With CoolMOS 650V CFD2 Infineon Crosses the 3.5 Billionth High-Voltage MOSFET Barrier

On January 19, 2011, the 3.5 billionth CoolMOS™ high-voltage MOSFET left the production line at the company's manufacturing facility in Villach, Austria, making Infineon the world's leading supplier of these 500 to 900V power transistors.

These energy-saving chips are now key components in PC power supplies, servers, solar power inverters, lighting and telecommunications power supplies as well as consumer electronics devices, for instance in flat-screen TVs and games consoles. Using energy efficiently and saving energy are becoming key requirements for all electrically powered industrial or household applications. Thanks to the CoolMOS chips a server board needs about 30W less of power. Projected on to around 60 million servers worldwide, energy savings would add up to 1.8GW, which is equivalent to the output of a nuclear power station. "The solar energy harnessing system for the soccer stadium in Kaohsiung, Taiwan, is a fine example of the successful deployment of our technology. CoolMOS chips in solar inverters ensure the highest possible energy efficiency. Therewith, the solar plant generates 1.1 million kilowatt-hours power and saves about 660 tons CO2 per year", commented Andreas Urschitz, General Manager Power Management and Supply Discretes.

The new 650V CoolMOS CFD2 is the world's first high-voltage transistor with a drain-source voltage of 650V and an integrated fast body diode, leading to softer commutation behavior and therefore better EMI characteristics. The product portfolio provides all benefits of fast switching SJ MOSFETs like better light load efficiency, reduced gate charge, easy implementation and outstanding reliability. Infineon expects the greatest market potential for this transistor to be in solar power inverters, server computers, LED lighting and telecommunications equipment.

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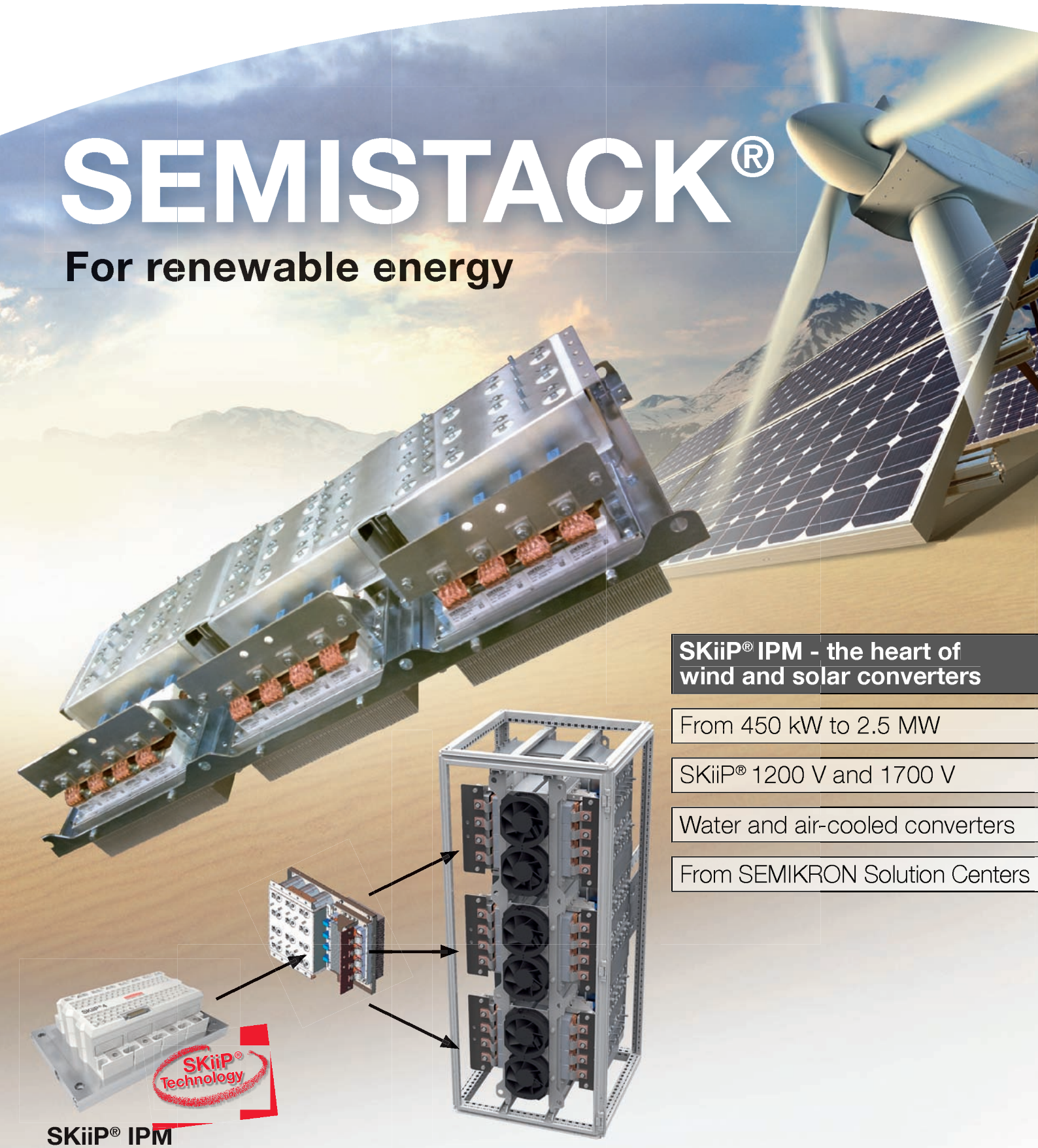

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Digital Power System Management Eliminates Blind Spot

Even though power management is critical to the reliable operation of modern electronic systems, voltage regulators are perhaps the last remaining 'blind spot' in today's systems, since they are without the means for directly configuring or monitoring key power system operating parameters. As a result, power designers have been forced to use a mixed bag of sequencers, microcontrollers and voltage supervisors to program basic regulator start-up and safety functions. Although digitally programmable DC/DC converters have been available for many years, most notably in VRM core power supplies with VID output voltage control, their ability to monitor operating status information directly from the voltage regulator, especially real time currents, has been missing. **Bruce Haug, Senior Product Marketing Engineer Power Products, Linear Technology Corp., Milpitas, USA**

Digital Power system management is opening up the blind spot with the ability to program and monitor various parameters of power supplies via a computer interface. Programmable parameters include the output voltage, sequencing, tracking, delay and ramp of multiple rails, the over current limit and over voltage set points and operating frequency. Digital power system management also can read back telemetry data and report back the input voltage, output voltage/current, temperature and even faults.

System architects of networking equipment are being pushed to increase the data throughput and performance of their systems as well as add functionality and features. At the same time, pressure is being applied to decrease the systems overall power consumption. In data centers, the challenge is to reduce overall power consumption by rescheduling the work flow and moving jobs to underutilized servers, thereby enabling shutdown of other servers. To meet these demands, it is essential to know the power consumption of the end-user equipment. A properly designed digital power management system can provide the user with power consumption data, allowing for smart energy management decisions to be made.

Multirail board level power system

Most embedded systems are powered via a 48V backplane. This voltage is normally stepped down to a lower intermediate bus voltage, such as 12V to power the racks of boards within the system. However, most of the sub-circuits or ICs on these boards are required to operate at voltages ranging from sub-1V to 3.3V at currents ranging from tens of milliamps to hundreds of amps. As a result, point-of-load (POL) DC/DC converters are necessary to step down from the intermediate bus voltage to the desired voltage required by the sub-circuits or ICs. These rails routinely have strict requirements for sequencing, voltage accuracy, margining and supervision.

It is not uncommon for as any many as 20 POL voltage rails in a datacom, telecom or storage systems and thus, system architects need a simple way to manage these rails with respect to their output voltage, sequencing and maximum allowable current requirements. Many processors require that their I/O voltage rise before their core voltage, alternatively certain DSPs require their core voltage rise before their I/O. Power down sequencing is also necessary. Therefore, designers need an easy way to make changes to optimize system performance and to store a particular configuration for each DC/DC converter in order to simplify the design effort.

In order to protect expensive ASICs from the possibility of an over-voltage condition, high-speed comparators must monitor the voltage levels of each rail and take immediate protective action if a rail goes out of its specified safe operating limits. In a digital power system, the host can be notified that a fault has occurred via the PMBus alert line and dependant rails can be shut down to protect the powered devices,

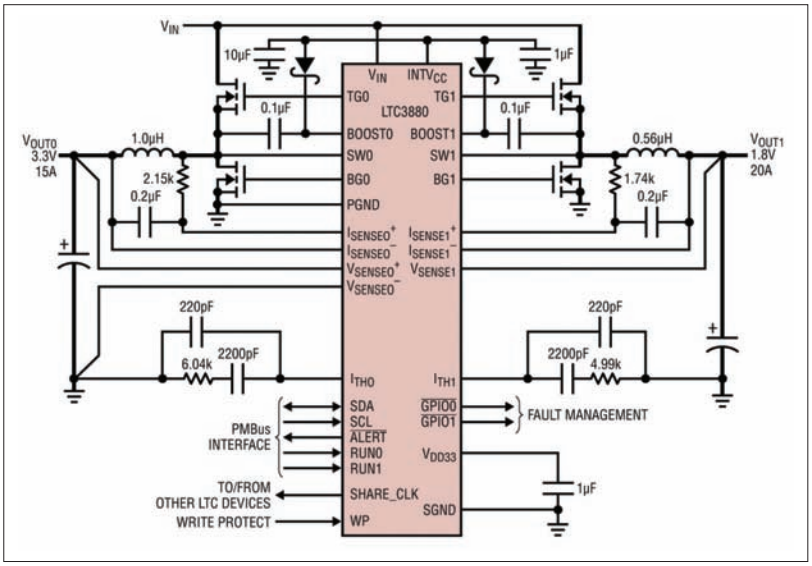

Figure 1: Typical LTC3880 applications schematic

Programmable Control Resolution/Accuracy		
Parameter	**LTC3880/-1**	**Alternatives**
V_{OUT} Command	8-bit, ±2%	6-bit, ±3%
V_{IN} Supervisor	8-bit, ±2%	6-bit, ±3%
OV & UV Supervisor	8-bit, ±2%	6-bit, ±3%
Current Limit	3-bit, ±5mV	2-bit
Telemetry Read-Back Resolution/Accuracy		
Parameter	**LTC3880/-1**	**Alternative**
V_{OUT} Reading	15-bit, ±0.5%	12-bit
Output Current	15-bit, ±1%	12-bit
V_{IN} Reading	15-bit, ±2%	12-bit
Input Current	±0.1%,	NA

Table 1: Some of the LTC3880/-1 programmable parameters and telemetry read-back capability and accuracy

such as an ASIC. Achieving this requires reasonable accuracy and response times on the order of tens of microseconds.

The recently announced LTC3880/-1 [1] provides highly accurate digital power system management with its high resolution programmability and rapid telemetry read-back for real-time control and monitoring of critical point-of-load converter functions. It is a dual output high efficiency synchronous step-down DC/DC controller with I²C-based PMBus interface with over 100 commands and onboard EEPROM. The device combines a analog switching regulator controller with precision mixed signal data conversion, supported by the LTpowerPlay software development system with easy-to-use graphical user interface (GUI). Figure 1 shows a typical application schematic.

The LTC3880/-1 can regulate two independent outputs or be configured for a two-phase single output. Up to six phases can be interleaved and paralleled for accurate sharing among multiple ICs, minimizing input and output filtering requirements for high current or multiple output applications. An onboard differential amplifier provides true remote output voltage sensing. Integrated gate drivers power all N-channel power MOSFETs from input voltages ranging from 4.5V to 24V. and it can produce ± 0.5% accurate output voltages up to 5.5V with output currents up to 30A per phase over the full operating temperature range. Accurate timing across multiple chips and event-based sequencing allow the optimization of power-up and power-down of complex, multiple rail systems. The LTC3880 features an onboard LDO for controller and gate drive power and the LTC3880-1 allows for an external bias voltage for highest efficiency. Both parts are available in a thermally enhanced 6mm x 6mm QFN-40 package.

Control interface for digital power system management

The PMBus command language was developed to address the needs of large multi-rail systems and is an open standard power-management protocol with fully defined command language that facilitates communication with power converters, power management devices and system host processors. In addition to a well defined set of standard commands, PMBus compliant devices can also implement their own specialized commands to provide an innovative approach to programming and monitoring of POL DC/DC converters. The protocol is implemented over the industry standard SMBus serial interface and enables programming, control, and real-time monitoring of power conversion products. Command language and data format standardization allows for easy firmware development, resulting in reduced time-to-market [2].

The LTC3880/-1 programmable control parameters include output voltage, margining, current limits, input and output supervisory limits, power-up sequencing and tracking, switching frequency, identification and traceability data. On-chip precision data converters and EEPROM allows for the capture and nonvolatile storage of regulator configuration settings and telemetry variables, including input and output voltages and currents, duty cycle, temperature and fault logging. Table 1 shows some parameters that can be programmed with the LTC3880/-1, its high resolution, the telemetry read-back capability and alternative solutions.

Configurations for the LTC3880/-1 are easily saved to internal EEPROM over the device's I²C serial interface. With configurations stored on-chip, the controller can power up autonomously without burdening the host processor. Default settings can be optionally configured by external resistor dividers for output voltage, switching frequency, phase and device address. Multiple designs can be easily calibrated and configured in firmware to optimize a single hardware design for a range of applications.

Analog control loop

The LTC3880/-1 is a digitally programmable controller for numerous functions like the output voltage, current limit set point, and sequencing to name a few, but it has an analog feedback control loop for best loop stability and transient response without the quantization effect of a digital control loop.

Figure 2 shows the different ramp curves within a controller IC with an analog feedback control loop (LTC3880) and with a digital feedback control loop. The analog loop has a smooth ramp, whereas the digital loop is like a step function that can result in stability problems, slower transient response, the need for more output capacitance in some applications and a quantization effect of the digital loop resulting in a higher output ripple.

Furthermore, the LTC3880 can save up to 50% of the amount of output capacitance as compared to digital control loop alternative and also have better stability with a shorter settling time. In addition, the digital control transient response has an oscillation prior to settling, due to the quantization effects and limitations of its ADC resolution. Figure 3 shows a transient response comparison of an analog control loop to a digital control loop.

Furthermore, a digital control loops

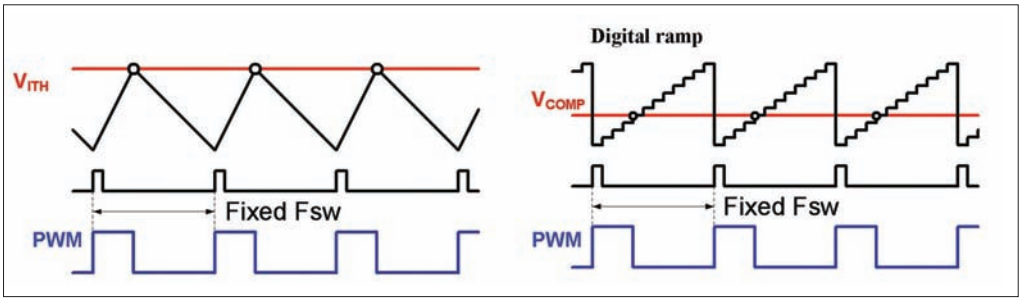

Figure 2: Analog control loop (left) vs a digital control loop

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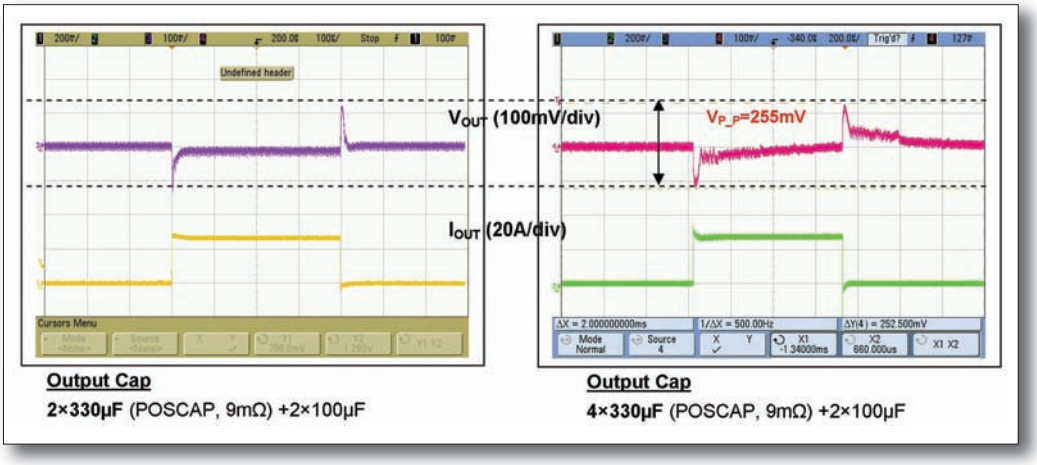

Figure 3: Transient response comparison of the LTC3880 analog control loop (left) vs a digital control loop with 25A load step for a 12V_{IN} to 1.2V_{OUT} DC/DC converter operating at 400kHz

quantization effect, due to the ADC, digital compensator and digital PWM adds additional voltage to the output ripple, depending on the ADC's resolution and loop design. By contrast, an analog control loop does not have this additional output ripple voltage.

Conclusions

One of the principal benefits of digital power system management is reduced design cost and faster time to market. Complex multi-rail systems can be efficiently developed using a comprehensive development environment with intuitive graphical user interface (GUI). Such systems also simplify in-circuit testing (ICT) and board debug by enabling changes via the GUI instead of soldering fixes.

Another benefit is the potential to predict power system failures and enable preventive measures to be taken, thanks to the availability of real-time telemetry data. Perhaps most significantly, DC/DC converters with digital management functionality allow designers to develop 'green' power systems that meet target performance with the ability to determine when to reduce overall power consumption by rescheduling the work flow and moving jobs to underutilized servers, thereby enabling shutdown of other servers. With minimum energy usage at the point of load, board, rack and even installation levels, reduces infrastructure costs and the total cost of ownership over the life of the product.

Literature

[1] "Step-Down DC/DC Controller with Digital Power Management", Power Electronics Europe Jan/Feb 2011, pages 14 - 15

[2] http://pmbus.org

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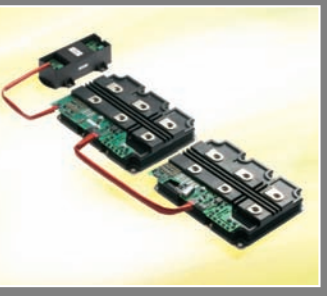

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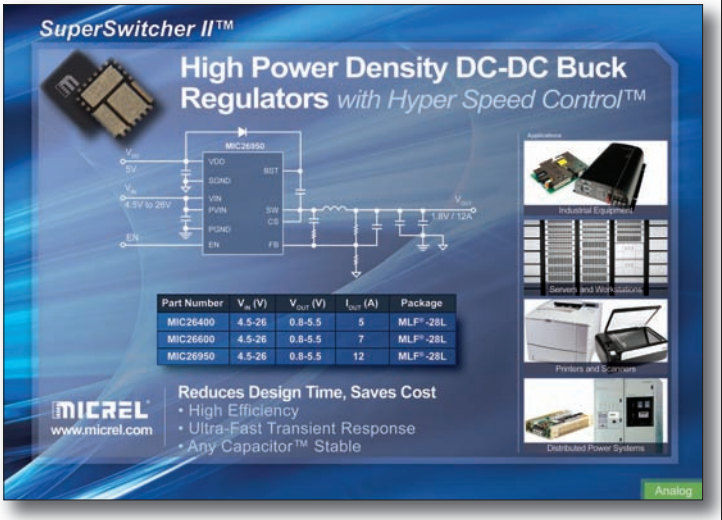
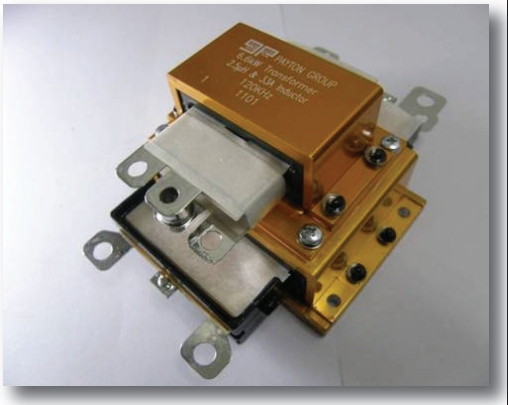


Micrel's MIC26xxx SuperSwitcher IITM family is comprised of three DC/DC buck regulators featuring proprietary Hyper Speed Control architecture allowing for ultra fast transient response requiring significantly lower output capacitance. The MIC26400, MIC26600 and MIC26950 devices operate with an input supply voltage range from 4.5V to 26V and deliver an output current of 5A, 7A and 12A respectively. The SuperSwitcher II family has been tailored to be stable with any capacitor and independent of output ESR, thus solving the perennial problem of stability that power designers face with distributed output capacitance. The buck regulators are capable of driving DC/DC loads at more than 95% efficiency with ±1% accuracy, with output adjustable down to 0.8V. These devices operate at a switching frequency of 300kHz.

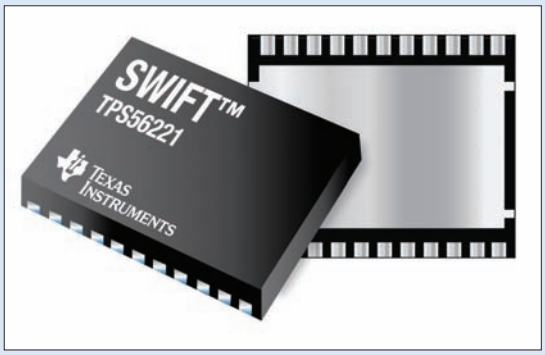
www.micrel.com

Low Profile Resonant Inductors

The demand for high efficiency low EMI designs, such as resonant topologies, is driving the need for high performance planar inductors to be used in power converters in series with the main transformer. Most resonant topologies do need a small amount of inductance to work properly, so Payton introduced a series of low profile, high efficiency, resonant inductors. The inductor can be positioned on top of the transformer in order to maximize use of the available area. The inductance can vary from 1µH to10µH and the current from few amps to 100A. The power dissipation is less than 15W and the temperature rise is less than 50K.



www.paytongroup.com



25A Buck with Integrated FETs

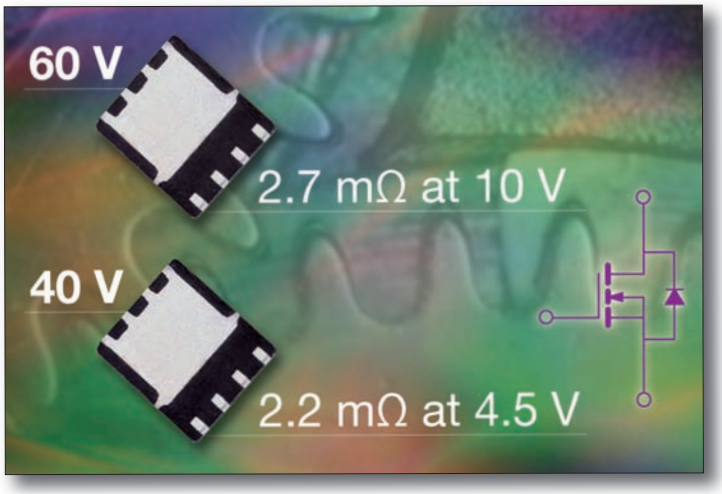
TI introduced at APEC the smallest, efficient step-down regulators with integrated FETs to support up to 25 A for telecommunications, networking and other applications. The TPS56221 synchronous SWIFT switcher with integrated NexFET MOSFETs achieves a power density greater than 200 W/in^3 with greater than 90% efficiency at high loads from a 12V input to a 1.3V output, delivering up to 25 A of continuous output current at 500kHz switching frequency. The 15A, 14V synchronous switcher TPS56121 is 3% more efficient at 5V input to 1.2V output and switches twice as fast as similar 15A products. The TPS56221 and TPS56121 come in a thermally enhanced 5mm x 6mm QFN package, and achieve a total solution size of 315mm^2. Both devices are the first switchers to integrate TI's NexFET technology, offer three selectable frequencies of 300kHz, 500kHz and 1MHz for design flexibility and support input voltages of 4.5V to 14V.

In addition to the high-current capabilities of SWIFT converters, TI's CSD86350Q5D NexFET Power Block, which was introduced last year, enables highly efficient, multi-phase point-of-load designs with higher current capability. The small, 5mm x 6mm stacked MOSFET, in a grounded, lead-frame SON package, supports frequencies up to 1.5MHz, reduces thermal impedance and simplifies layout. The CSD86350Q5D can achieve greater than 90% efficiency at 25A, and can be combined with TI's TPS40140 stackable controller to support multi-phase designs, scalable to 50A, 100A and higher.

www.ti.com/tps56221-pr, www.ti.com/mosfet-pr

60/40V Trench MOSFETs

Vishay's new 60V SiR662DP offers on-resistance of 2.7mΩ at 10V and 3.5mΩ at 4.5 V, and an FOM of 172.8 mΩ-nC at 10V and 105mΩ-nC at 4.5V.



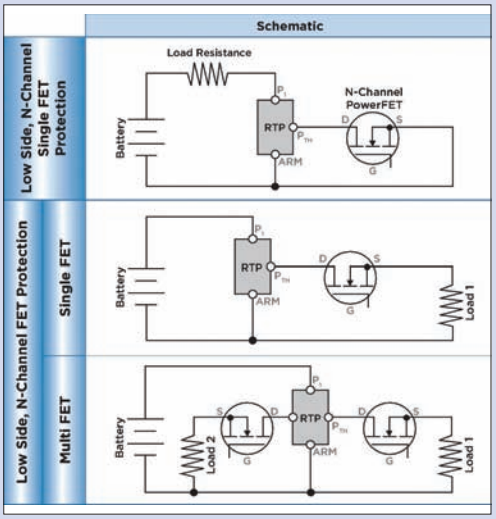
These low values will reduce switching losses across the whole operating range of the device. The 40V SiR640DP offers on-resistance of 1.7mΩ at 10V and 2.2mΩ at 4.5V, and an FOM of 128mΩ-nC at 10V and 76mΩ-nC at 4.5V. Both devices are built on a new silicon technology utilizing an optimized trench density and a unique gate structure. For designers, their lower on-resistance translates into lower conduction losses for reduced power consumption, especially at heavy loads. Their low FOMs reduce switching losses in high-frequency and switching applications, particularly at light loads and stand-by mode. The SiR662DP and SiR640DP are intended for secondary side synchronous rectification in DC/DC and AC/DC converters, primary side switching in DC/DC converters, point-of-load modules, motor drives, bridge inverters, and mechanical relay replacement. The MOSFETs' 4.5V rating will give many designers the opportunity to use a 5V power rail in their systems, already present for powering digital logic, without having to create a 10V power rail. The 4.5V rating will also significantly lower gate drive losses while allowing lower-voltage/lower-cost 5V PWM ICs to be utilized.

www.vishay.com

Reflowable Thermal Protection

TE's new Reflowable Thermal Protection (RTP) device is a low-resistance, robust surface mountable thermal protector. It has a set open temperature and can be installed using lead-free, SMD assembly and reflow processes. RTP devices can withstand the demanding environmental, life, and reliability requirements of automotive and industrial applications, including shock, vibration, temperature cycling, and humidity exposures. In the field, the RTP device opens if its internal junction exceeds the device's specified open temperature. The RTP device open temperature is selected so that the device does not open within normal component operating windows, but it does open in a thermal runaway event and before the melt temperature of typical lead free solders. After installation, with a one time electronic arming process the RTP becomes thermally sensitive. Before the arming procedure, the device can go through installation temperatures up to 260°C without going open. After arming, the device will open when the critical junction exceeds the open temperature. Arming can occur during test, or in the field. Once "armed", the device will permanently open when the device junction achieves its specified opening temperature.

www.circuitprotection.com



Automotive Hall-Effect Switches

The A1190/2/3 from Allegro MicroSystems Europe, are a range of user-programmable Hall-effect switches that complement the family of devices used in automotive seat-belt buckle, seat position, and gear-shift selector applications. These new devices incorporate enhanced high-voltage transient protection - a critical feature for automotive applications that do not allow protection circuits to be located close to the sensor. The two-wire unipolar Hall-effect switches can be trimmed by the user to optimise magnetic switch point accuracy in the application. Two-wire unipolar switches are particularly advantageous in cost-sensitive automotive applications, because they require one less wire for operation

than the more traditional open-collector output switches. In addition, inherently diagnostic capabilities are available, because there is always output current flowing in one of two narrow ranges. Any current level not within these ranges indicates a fault condition. On-chip transient protection, along with a Zener diode clamp, minimizes the effects of over-voltage conditions on the supply line. This improved high-voltage transient protection allows these devices to survive the conditions specified in ISO 7637-2 with 40V load dump for less than 0.5s with minimal, and sometime no, protection from discrete components.

Electrostatic discharge (ESD) protection has also been enhanced, with the devices capable of handling transients up to 8kV Human Body Model (HBM).

www.allegromicro.com/en/Products/Part_Numbers/1190/1190.pdf

Medium Voltage MOSFETs

Infineon's medium voltage power MOSFETs, OptiMOS™, are now available in the CanPAK™ package licensed from IR. These products can be used in a wide range of industrial applications like DC/DC converters, solar micro inverters, Maximum Power Point Trackers (MPPT) in solar energy systems, low voltage drives and synchronous rectification for servers. The addition of 60V-150V MOSFETs to this package enables power system engineers to optimize designs for power density, efficiency and excellent thermal behavior.

The metal 'can' construction enables double-sided cooling along with almost no package parasitic inductances. Thermal resistance on the top side of the package is very low (1.5K/W vs. 55K/W for a traditional DPAK), which allows efficient device cooling from still air convection in the power conversion systems of solar energy installations or fan-assisted airflow, which is common in servers for data centers. OptiMOS 60V-150V in CanPAK comes in on-resistance classes from 2.8 to 28m_.

www.infineon.com/canpak

1000A Hall Effect Current Sensor

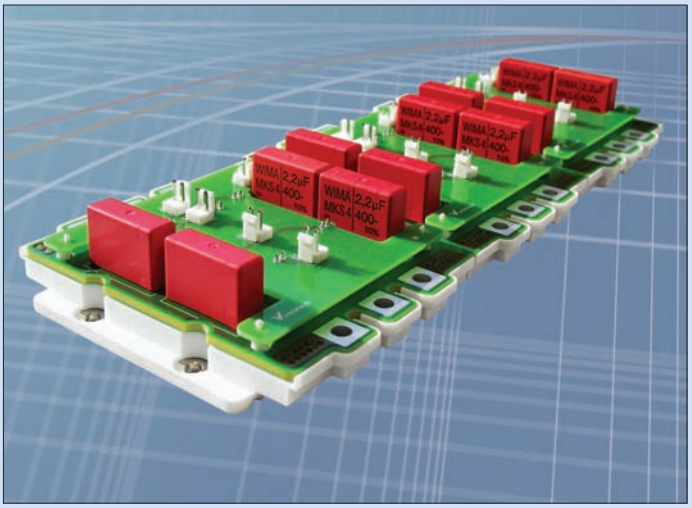
The continuous shortage on Hall Effect sensors in the market is generating big troubles on the industrial field and, of course, also in PV and wind inverters manufacturers. Thus Premo introduces a close loop 1000A Hall Effect sensor. By means of close loop solution the high accuracy and linearity is guaranteed keeping values as low as 0.1%. The current sensor allows overload capabilities with a measuring range up to ± 2000A. The current sensor is designed in order to meet the highest safety requirements and is fully isolated with plastic housing, meeting isolation values higher than 6000V AC. The product is completely sourced and produced in China and is currently available in 6-8 weeks. Samples and pilot orders from stock.

www.grupopremo.com

MNPC Power Modules

Vincotech's new low-inductive power module 3xflowMNPC 4w is designed for power applications up to 250kW, such as three-phase solar inverters. The new features a higher power rating in the new wide-body housing. Its Mixed voltage Neutral Point Clamped (MNPC) topology provides maximum efficiency for higher switching frequencies. This power module integrates all three phases of the MNPC inverter topology into a new low-inductive package with a high-power screw interface. The MNPC topology cuts output filter effort and filter losses by more than 50%, and switching losses by 50%. Rated for 1200V/600A, the module is destined for solar and UPS applications. Its low-inductive design and onboard DC capacitors extend maximum PWM frequencies up to 20kHz.

www.vincotech.com



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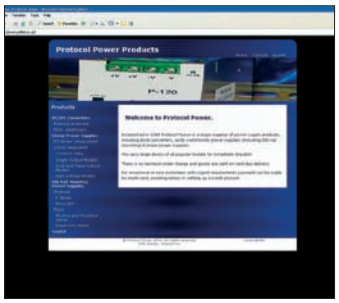

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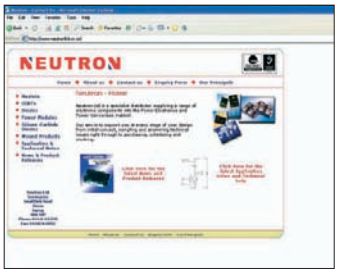

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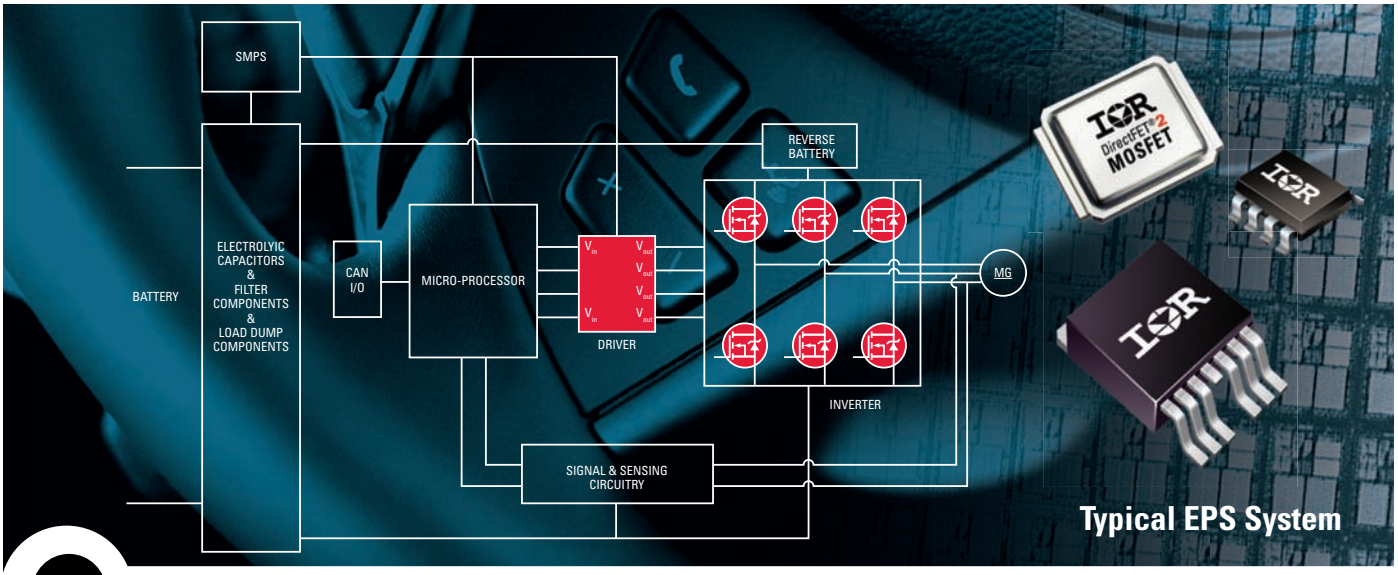

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40	1.25	400	160		AUIRFS3004-7P		
40	1.60	320	170		AUIRF2804S-7P		
40	1.75	340	160	AUIRFS3004		AUIRFB3004	
40	2.00	270	160	AUIRF2804S		AUIRF2804	AUIRF2804L
60	2.10	293	200		AUIRFS3006-7P		
60	2.50	270	200	AUIRFS3006		AUIRFB3006	
75	2.60	260	160		AUIRFS3107-7P		
75	3.00	230	160	AUIRFS3107			

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40	1.0	270	220	L8	Low $R_{DS(on)}$		AUIRF7739L2
40	1.6	210	147	L6	Low $R_{DS(on)}$		AUIRF7738L2
40	1.9	156	89	L6	Low $R_{DS(on)}$		AUIRF7737L2
40	3.0	108	72	M4	Low $R_{DS(on)}$	AUIRF7736M2	

Driver ICs

Part Number	Description	Packages	Output Current	Offset Voltage	VCC UVLO
AUIRS21814S	2ch High and Low –Side	SOIC14	+1.9 / -2.3A	600V	8.2V
AUIRS2110S	2ch High and Low –Side	SOIC16W	+2.0 / -2.0A	500V	8.2V
AUIRS2336S	3 Phase Inverter Driver	SOIC28W	+200 / -350mA	600V	8.2V
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