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IGBT DRIVERS

Fast Prototyping of Power Converters by Plug-and-Play Capability of SCALE-2 Driver Cores

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FOR POWER ELECTRONICS
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COVER STORY

Fast Prototyping of Power Converters by Plug-and-Play Capability of SCALE-2 Driver Cores

Make or buy? This becomes an increasingly important question for customers who need power stacks in their applications – such as solar or wind power systems – for cost reasons. Once it has been decided to go for an in-house solution, the task of designing a new power converter leaves the design engineer with the question of where to start the design. One reasonable approach is to place the focus on the most expensive parts of the system, namely the IGBT modules, which account for approximately 30% of the overall component cost. A proper evaluation of the cost and performance of the IGBT module would then yield a sound solution. A flexible, adaptable and state-of-the-art IGBT driver solution is required to enable efficient verification of the cost/performance ratio of possible IGBT modules. The newly designed CONCEPT Basic Boards in combination with the appropriate SCALE-2 driver core provide the necessary flexibility throughout the design. They help the engineer to achieve a well-balanced design which satisfies the need for cost optimization without sacrificing reliability. The new 2BB0108T and 2BB0435T Basic Boards offer an easy, low-cost way to evaluate the 2SC0108T and 2SC0435 gate driver cores with different IGBT modules and technologies by providing plug-and-play capability. The standardized DIC-20 interface used with all SCALE-2 plug-and-play drivers, with its wide adaptability, options for customized volume production and open access to schematics, layout data and support, makes such an approach into a fast, inexpensive and consequently very attractive solution.
Full story on page 23

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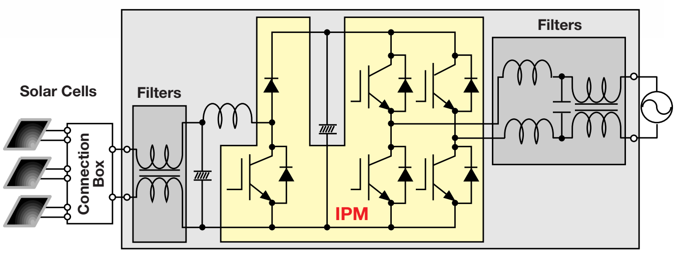

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Silicon Carbide and Gallium Nitride Gain Acceptance

Over 70,000 visitors and around 2,600 exhibitors, these were the cornerstones of Electronica 2010 in Munich. It became obvious that power electronics and in particular power semiconductors are centered around the exploding markets of power generation/distribution and electromobility. According to industry observers the market for SiC power semiconductors will grow significantly from today's $100 million to $400 million by the year 2013.

At the Electronica Automotive Conference Daimler sketched the requirements on power electronics components and technologies for the automotive industry. Because of the space constraints in cars and the increasing power range (up to 165kW at 650V) at high temperatures of inverters for (H)EVs new and reliable connection technologies for power modules such as AG sintering and liquid cooling capability are required. In terms of semiconductor technologies Silicon Carbide (SiC) will be favoured in the future due to its advantages over Silicon such as higher switching frequencies and thus smaller passive components (inductors and capacitors), higher efficiency and better thermal stability. But the basic material is still expensive and because of relatively low yield on small wafers high-volume market introduction of SiC devices will not happen before the year 2015. Japanese Rohm has already developed in 2009 an all 1200V SiC power module for Honda. And Infineon stated, that the high value of efficiency fosters the introduction of Silicon Carbide particularly in battery-driven electric vehicles (some detailed calculations on inverter efficiency can be found in our Electronica report).

An example of which is possible with SiC power switches and diodes were demonstrated by Cree. The company showed a prototype of a 1.7kV/10kW half-bridge inverter equipped with 1700V/20A SiC MOSFETs, 1700V/10A SiC Schottky freewheeling diodes and 2 x 1200V SiC bridge rectifiers. This power stage is running at 20 kilohertz switching frequency achieving an efficiency of 97.4 percent. This high efficiency level leads to very low losses which clearly can be demonstrated by the very low temperature of 39°C at the heatsinks for the switches and diodes. The very conservative design can be optimized particularly in case of the inductor core which could lead to an increase of the switching frequency up to 47kHz and 98% efficiency at significantly smaller size. The company also showed 150mm SiC substrates with micropipe densities of less than 10/cm^2 what will lower the cost for SiC MOSFETs and diodes in the near future.

Electronica was also a platform for announcing new Gallium Nitride power devices for the 600V range. International Rectifier has developed its GaN technology platform using GaN-on-Si hetero-epitaxy and device fabrication processing that can be performed in a standard modern Silicon CMOS manufacturing line with little modification to equipment or process discipline. GaN based power devices such as HEMTs (High Electron Mobility Technology) promise to deliver a FOM performance that is at least an order of magnitude better than state-of-the-art silicon MOSFETs. As in the case for already introduced low voltage devices, GaN 600V power devices also exhibit significantly better switching performance than Silicon based alternatives. In fact, the figure-of-merit for first generation GaN based 600V switches exceeds that of state-of-the-art Silicon based alternatives 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, IR stated. First 600V GaN diodes have been designed by MicroGan of Ulm/Germany and shown at Electronica by Diotec. These diode dies have been packaged (TO-220) and tested by Diotec surpassing stress tests beyond 800V. The 4A/600V SiGaN Schottky diode feature an ultra low barrier of 0.3V. Like any Schottky diode, it has negligible reverse recovery and a very low switching time, caused by junction capacity. The "stored charge" is comparable to that of SiC devices, while the forward voltage drop is according to Diotec much lower.

And Europe will take the lead in these emerging technologies. The aim of the 42-month project LAST POWER (Large Area silicon carbide Substrates and heTeroepitaxial GaN for POWER device applications) is to provide Europe with strategic independence in the field of wide bandgap semiconductors. The overall objective is to develop a cost-effective and reliable integration of advanced SiC and GaN semiconductors in the European power microelectronics industry. This will be achieved via specific objectives such as growth of large area (150mm) SiC and high quality heteroepitaxial GaN on 150mm Si wafers, beyond the current worldwide state-of-the-art for substrates, epitaxy and surface preparation; processing of reliable and efficient SiC and GaN devices on 150mm wafers; and to demonstrate high-performance devices with properties that cannot be obtained on Si, including a 1200V/100A SiC MOSFET, SiC JFET capable of operating up to 250°C, and GaN HEMT devices for power switching.

An example on the properties of all-SiC power modules can be found in our feature "Fast Switching 1200V Normally-Off SiC VJFET Power Modules". With high speed, normally-off 1200V SiC VJFET technology, the authors have shown record low switching performance (1.25 mJ) in an optimized commercially available (Microsemi SP1) module configuration. Parasitic oscillations and cross-conduction were investigated and shown to be well controlled with the optimized internal snubbers and use of a negative voltage rail.

This issue concludes our progress reports in power electronics for this year. We wish all readers a successful jump into year 2011.

Achim Scharf
PEE Editor

European SiC and GaN Program

The aim of the 42-month ENIAC (European Nanoelectronics Initiative Advisory Council) project LAST POWER (Large Area silicon carbide Substrates and heTeroepitaxial GaN for POWER device applications) is to provide Europe with strategic independence in the field of wide bandgap (WBG) semiconductors. This field is of major strategic importance as it involves the development of highly energy-efficient systems for all applications that need power, from telecommunications to automotive, from consumer electronics to electrical household appliances, and from industrial applications to home automation.

The consortium will develop European technology for the complete production chain for semiconductor devices built with SiC (Silicon Carbide) and heteroepitaxial GaN (Gallium Nitride on Silicon wafers). These two semiconductor materials offer higher speed, current capability, breakdown voltage and thermal capability compared to conventional silicon technologies. "The power semiconductor market, which represents approximately 30% of the overall semiconductor market, is set to change significantly in response to the ever-increasing demand for more energy-efficient devices," said project coordinator Salvatore Coffa, R&D General Manager at STMicroelectronics. "This key project, which targets secure strategic independence in the emerging field of SiC and GaN technologies, will place Europe at the forefront of energy-efficient devices".

The overall objective of the project is to develop a cost-effective and reliable integration of advanced SiC and GaN semiconductors in the European power microelectronics industry. This will be achieved via five specific objectives:

- Growth of large area (150mm) SiC and high quality heteroepitaxial GaN on 150mm Si wafers, beyond the current worldwide state-of-the-art for substrates, epitaxy and surface preparation;
- development of new dedicated equipments for material growth, characterization and processing;
- processing of reliable and efficient SiC and GaN devices on 150mm wafers;
- to demonstrate high-performance devices with properties that cannot be obtained on Si, including a 1200V/100A SiC MOSFET, SiC JFET capable of operating up to 250°C, and GaN HEMT devices for power switching;
- to develop advanced packages for high-temperatures devices and improve device reliability.

The partners in the LAST POWER consortium are STMicroelectronics (Italy), LPE S.p.A. (Italy), Consiglio Nazionale delle Ricerche, Istituto per la Microelettronica e Microsistemi (Italy), Epitaxial Technology Center (Italy), Foundation for Research & Technology-Hellas (Greece), NOVASiC (France), Consorzio Catania Ricerche (Italy), Institute of High Pressure Physics UNIPRESS (Poland), Università della Calabria (Italy), SiCrystal (Germany), SEPS Technologies (Sweden), SenSiC (Sweden), Acreo (Sweden), and Aristotle University of Thessaloniki (Greece).

www.eniac.eu

Power Integrations Invests in SiC

Power Integrations invests $30 million in Silicon Carbide, which includes an equity investment in SemiSouth, a technology license and other financial commitments, will help drive the continued expansion of SemiSouth's SiC fabrication facility.

SemiSouth, a privately owned corporation with offices in Starkville, Mississippi, focuses on SiC power devices and electronics. It was formed in 2000 as a spin-out from Mississippi State University with more than 20 US patents in Silicon Carbide power devices and has sold products globally through direct sales or distributors since 2005. It introduced the first commercial, available normally-off SiC JFET in 2008, enabling over 99% efficiency for prototype solar inverters. The company operates a clean room facility at its Starkville headquarters, where it employs more than 70 people. "SemiSouth has recently been recognized by its customers for having cost-effective, energy-efficient power semiconductor electronic products based on SiC technology. In response to global demand for our products in energy-sensitive markets such as solar inverters, server power supplies, wind inverters, and electric vehicle development, we needed to find the right investor willing to share our vision of expansion. We welcome Power Integrations' investment in SemiSouth's future, to allow us to quickly expand and serve our customers on a much broader scale. But we do not intend to go public, instead we expect to be acquired in the future by a large organization interested in our technology", stated SemiSouth's CEO Kenney R. Roberts. "SemiSouth has made impressive breakthroughs in the development of Silicon Carbide technology, attaining exceptionally high levels of efficiency and establishing SiC as an enabler of clean technologies such as solar energy and hybrid/electric vehicles. With a mutual focus on energy-efficient high-voltage semiconductor technology, Power Integrations and SemiSouth are natural strategic partners", stated Balu Balakrishnan, CEO of Power Integrations.

www.semisouth.com
www.powerint.com

"We welcome Power Integrations' $30 million investment in SemiSouth's future, to allow us to quickly expand and serve our customers on a much broader scale", commented SemiSouth's CEO Kenney R. Roberts

Best-in-class power density and reliability for highest performance

Infineon‘s PrimePACK™ high power module family presents a new member with best in class power density. The 1400A/1700V half bridge module offers a specially optimized concept for integration in wind turbine converter and solar applications. The most important benefits are improved thermal properties, low stray inductance and longest lifetime. With the introduction of the PrimePACK™ housing, Infineon established a standard for high power IGBT modules worldwide. Under permanent load in daily demanding use of renewable energy applications in rough environment with high humidity and salt content in the air the PrimePACK™ modules convince with their high reliability and robustness.

Key features:

- Highest power density
- Low stray inductance
- Extended lifetime
- Creepage and clearance distances made for 3.3kV modules
- Complete portfolio with chopper and half bridge modules
- RoHS compliant

[www.infineon.com]

Thermal Analysis Bottleneck and Shortcut Software

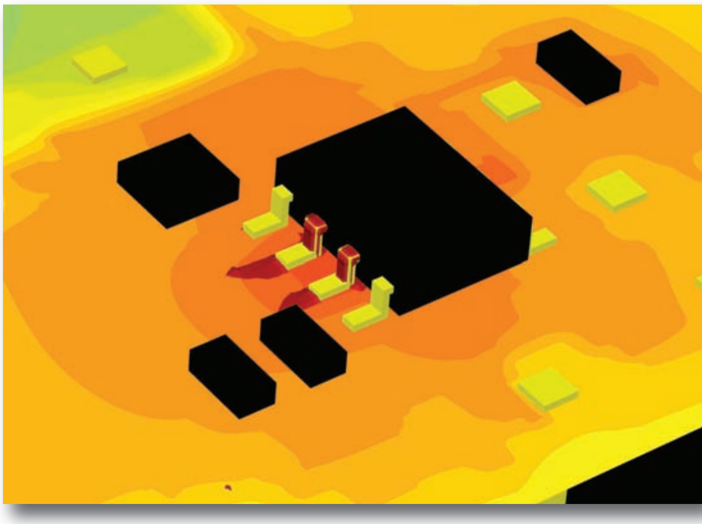
Mentor Graphics' new FloTHERM® 3D computational fluid dynamics (CFD) software for electronics cooling applications provides Bottleneck (Bn) and Shortcut (Sc) fields so that engineers can now identify where heat flow congestion occurs in the electronic design and why. It also identifies thermal shortcuts to resolve the design problem.

Together, the Bn and the Sc fields elevate the use of simulation from an observation tool which identifies heat management problems to an effective thermal design problem-solving tool which suggests potential solutions to the designer. The Bn field shows where in a design the heat path is being congested as it attempts to flow from high junction temperature points to ambient. Design changes to these bottlenecks can help solve the heat flow problem. The Sc field highlights possible solutions where the addition of a simple element to the design will provide a new effective heat flow path to further cool the system.

"The value of FloTHERM 9 is in the time and the cost it saved us when developing an IC for a new generation of Energy Star-compliant mobile phone chargers. The baseline simulation using the 'bottleneck' feature quickly highlighted a potential thermal issue, and further iterations confirmed our solution. To achieve the same result by building prototype boards would have taken a long time and drawn resources away from other critical work", stated Nigel Heather, VP of engineering at UK-based CamSemi.

Two additional enhancements have been made in the new FloTHERM v.9 product: XML model and geometry data importing to enable integration into existing data flows, and a direct interface to the Mentor Graphics® Expedition® PCB design platform. The direct interface enables users to import native Expedition PCB data, and delete or edit additional objects (heatsinks, thermal vias, board cutouts, EM cans) for more accurate thermal model design development.

www.mentor.com



The new Bottleneck feature is an effective thermal design problem-solving tool which suggests potential solutions, here at the charger design of CamSemi

TDK-Lambda Joins PMBus Alliance

TDK-Lambda has joined the PMBus™ Alliance. The PMBus protocol is a standard way to communicate with power converters and other devices in a power system.

Owned by the System Management Interface Forum (SMIF), the PMBus protocol is implemented over the industry-standard SMBus serial interface and enables programming, control, and real-time monitoring of compliant power conversion products. TDK-Lambda has already released products that implement PMBus technology; the HFE1600 series of single output AC/DC hot swap front end power supplies, for example, features an optional I²C compatible PMBus interface to programme the output voltage and current, and monitor output voltage, current and temperature, as well as fault monitoring and other features. TDK-Lambda is developing more new products that will implement the PMBus protocol as a feature.

www.pmbus.org
www.emea.tdk-lambda.com

Danfoss Silicon Power Expands Production Capacity

The power module production capacity at Danfoss Silicon Power in Schleswig, Germany has been expanded with 600m² recently. After this expansion, all available space in the 4,500m² building is fully utilized. Nonetheless, this expansion is not sufficient to meet the extremely high demand for power modules, also after 2015.

Therefore, the is expanding the power module capacity by moving from Schleswig to the facilities in Flensborg, Germany, which were formerly owned by Motorola. This expansion is yet another step in creating a strong power electronics center in the Danish/German border region. Danfoss is also expanding the solar inverter capacity by moving production to Nordborg and the resource center for frequency converters and solar inverters in Gråsten, Denmark. The new premises in Flensburg include about 18,000m² production and logistics area and 9000m² office area. Although they are modern and have been used for production of electronic devices before, they are to be prepared for clean room production in order to comply with the high TS16949 quality standards of power module production. The move will start in second quarter 2011 and be completed in 2012. It involves 200 employees now working in Schleswig. Danfoss Silicon Power plans to create about 200 jobs additionally in Flensburg by 2015. Danfoss Silicon Power is part of Danfoss Power Electronics division, who has experiences tremendous growth in all its businesses, including frequency converters, solar inverters and power modules in 2010.

www.danfoss.com/BusinessAreas/Silicon+Power

Power IC Solutions for Today's Changing Automotive Environment

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World class line up of automotive grade BLDC and MOSFET pre-driver control ICs. Allegro ICs simplify the interface to three phase brushless motors and can be integrated into systems from simple six-step (trapezoidal) control to solutions which require complex vector control. A similar product family also exists for driving brush DC motors.

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Transmission and steering systems require high reliability and high temperature operation. Automotive qualified BLDC and DC motor control ICs are specified and fully tested to operate in ambient environments up to 150°C.

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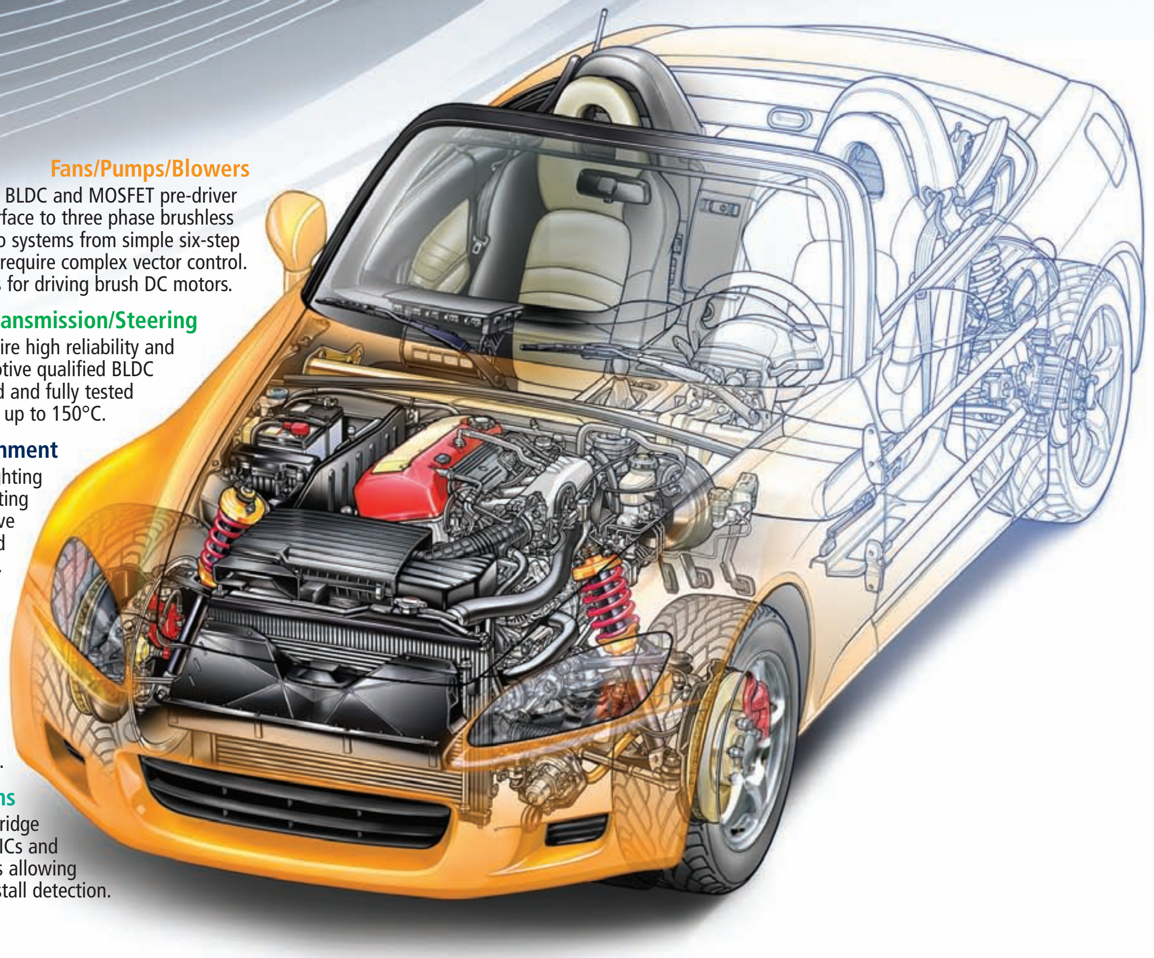
LED drivers designed to operate over the typical automotive battery and temperature ranges for automotive interior lighting such as map lights and dome lights, and exterior lighting such as daytime running lights, rear indicator and brake lights, and rear combination lighting.

Closure Systems

Allegro offers a complete line of full bridge automotive grade brush DC control ICs and system basis ICs for solid state solutions allowing greater flexibility for speed control and stall detection.



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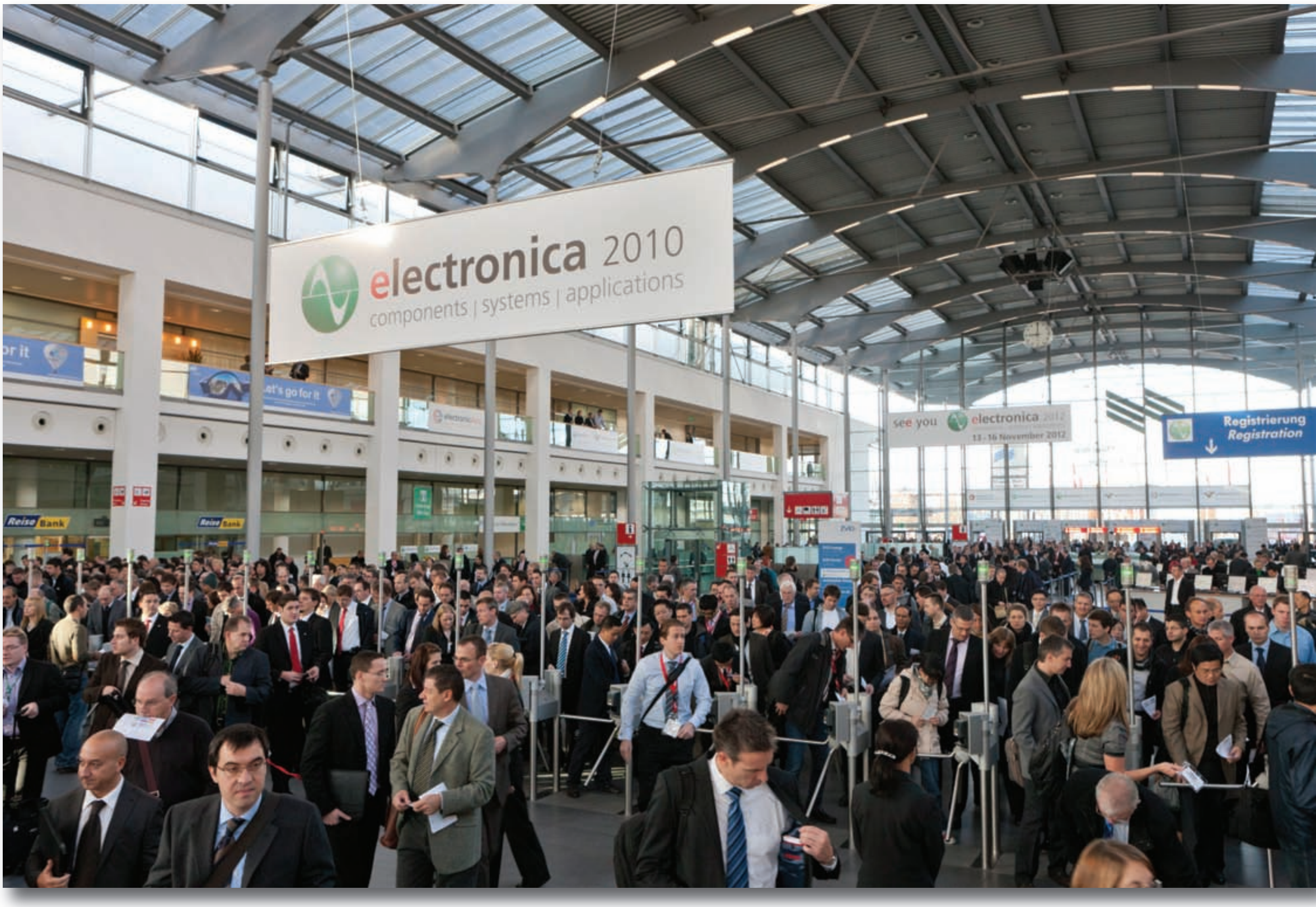
Renewable Energies and Electromobility Drive Power Electronics

Over 70,000 visitors and around 2,600 exhibitors, these were the cornerstones of Electronica 2010 in Munich. It became obvious that power electronics and in particular power semiconductors are centered around the exploding markets of power generation/distribution and electromobility.

Alone in the area of photovoltaics, 518 exhibitors presented electronic products for the management and monitoring. The topic of renewable energies also generally played an important role during the trade fair. Exhibitors showed storage technologies for wind and solar power plants, components for power electronics, inverters and energy harvesting solutions for building services and industrial applications. Energy efficiency also became part of the trade fair itself. Entire stands were fitted with LEDs for the first time. The advantages compared with conventional lighting were that heat generation is reduced to a minimum and that energy consumption is also substantially lower.

An other major trend is in so-called smart grids and smart meters. With a view to heading off impending problems, in 2005 the European Union came up with a concept, which it called the "smart grid", a vision of an intelligent, flexibly controllable electrical generation and distribution infrastructure. Governments and companies are committing large amounts of money to ensure that this vision becomes reality. The US Department of Energy has provided $4 billion in subsidies for smart grid projects. German energy utilities are planning to invest roughly €25 billion in smart grid technology by 2020. Key components for the power grid of the future are already available and have even been installed on a limited basis in some countries. One example is smart meters, intelligent, electronic electric meters. With smart metering, energy providers and consumers can for the first time record in detail



Over 70,000 visitors and around 2,600 exhibitors, these were the cornerstones of Electronica 2010 in Munich

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"We are back on sales levels before the crisis, particularly in automotive and industrial market segments", said Vishay's CEO Gerald Paul

where and how much electricity is being used and fed into the grid. Smart meters are also a potential mass application for power electronic components such as shunts offered i.e. by Isabellenhütte, which are fitted into a reference design demonstrated by Maxim **(www.maxim-ic.com)**.

Lead times for standard power semiconductors are still long. "We have experienced up to one year, but it is coming down now. We are back on sales levels before the crisis, particularly in automotive and industrial market segments", said Vishay's CEO Gerald Paul, representing with this statement the semiconductor industry as a whole.

Also new manufacturing capabilities can be used to overcome the bottlenecks in supply. Texas Instruments has taken the chance to purchase 300mm semiconductor manufacturing equipment at an opportune price from bankrupt Qimonda earlier this year. The Rfab is already running and produces analog ICs based on the company's LBC7 linear BiCMOS technology which is capable of integrating a variety of components, including power transistors (up to 40V), CMOS logic, bipolar transistors and passives. "We can process on such a wafer 45,000 devices at high yield greater than 90 percent at first run. This 300mm extension of our Richrdson fab will give us an additional revenue of $2 billion per year", said TI's Sami Kiriaki, SVP Power Management.

Next Crisis to come?

The world's greatest electronics event was also an opportunity to discuss the near-term business outlook for the industry as a whole. Peter Bauer, CEO of Infineon Technologies, Henri Richard, Senior Vice President Global Sales and Marketing of Freescale Semiconductor, Carlo Bozzotti, President and CEO of STMicroelectronics and Rick Clemmer, President and CEO of NXP Semiconductors discussed the consequences of the economic crisis in 2008 and 2009, its background and the impacts on the semiconductor industry. However, the participants on the podium also examined the economic crisis in 2000 and 2001, and the way in which it differs from the current situation.

In 2000 and 2001 a large number of manufacturers developed products that did not match customers' requirements and were therefore confronted with a lack of demand. The existing demand was only frozen in 2008 and 2009: Banks no longer provided loans and the industry was faced with extreme currency fluctuations. Both end customers and industry initially stopped making purchases and investments during this period. However, this situation is now being remedied with numerous purchases and investments, thus resulting in strong growth over the last few months.

In particular, large companies in the industry have for the most part reacted with great flexibility and prudence to the sales losses of up to 50 percent. In the last few months capacities have been increased again at almost the same speed as they were initially reduced in companies. The participants in the CEO Round Table all conceded that delivery bottlenecks occurred frequently and are continuing to do so. They said that the crisis had created one of the most important experiences which will primarily be evident in the automotive industry in future, i.e. the need for even closer cooperation between the semiconductor industry and its customers in order to interlink demand and production as closely as possible in future and carry out long-term planning.

According to the participants in the CEO Round Table, however, sensitivity to markets and end customers has also increased during the last two years. They said that every fluctuation on the end customer market becomes even more noticeable in companies the further they are away from the customer's value-added chain. They added that a better understanding and closer observation of these markets are therefore one of the most important experiences from the last two years.

According to the participants, however, it was important in particular to extend key competencies in a company during a crisis and forge ahead with research and development - also in view of declining sales and necessary savings. Since business cycles are becoming increasingly shorter by contrast with the capacity cycles in the semiconductor industry, it will be even more important in future to ensure that companies have the greatest possible flexibility in all areas.

Due to seasonal reasons, but also

"The 300mm extension of our Richrdson fab will give us an additional revenue in power ICs of $2 billion per year", stated TI's Sami Kiriaki

"The power density of inverters must be increased in the short term to 20kW/l and in the mid term to 30kW/l - from today's 8kW/l", stated Daimler's Axel Willikens

because the largest supply gaps have already been filled during the last few months, the industry is anticipating a short-term drop in growth in the fourth quarter of 2010. The participants in the podium discussion agreed, however, that the industry can basically look forward to a stable upswing. The semiconductor industry will provide solutions to many social challenges of the future. Since the innovation density is well above average, the semiconductor industry will be subjected to increasingly stronger fluctuations than other industries and will also have to recognize its opportunities during times of crisis.

Electromobility Pushes Power Semiconductors

The 2-day Automotive Conference also turned out to be a success with 323 delegates from 23 countries. A total of 1,281 exhibitors presented their products and services in the Automotive exhibition segment - 559 of them with products and services relating to electromobility. The most important topics were therefore automobile electronics and electromobility. In addition to the exhibition segment and conference, the program was supplemented by the automotive Forum.

Axel Willikens, Head of Power Electronics Development at Daimler, sketched the requirements on power electronics components and technologies for the automotive industry. Because of the space constraints in cars and the increasing power range (up to 165kW at 650V) at high temperatures of inverters for (H)EVs new and reliable connection technologies for power modules such as AG sintering and liquid cooling capability are required. In terms of semiconductor technologies Silicon Carbide (SiC) will be favored in the future due to its advantages over Silicon such as higher switching frequencies and thus smaller passive components (inductors and capacitors), higher efficiency and better thermal stability. "But the basic material is still expensive and because of relatively low yield on small wafers high-volume market introduction of SiC devices will not happen before the year 2015", he expects. In general, the power density of inverters must be increased in the short term to 20kW/l and in the mid term to 30kW/l - from today's 8kW/l!

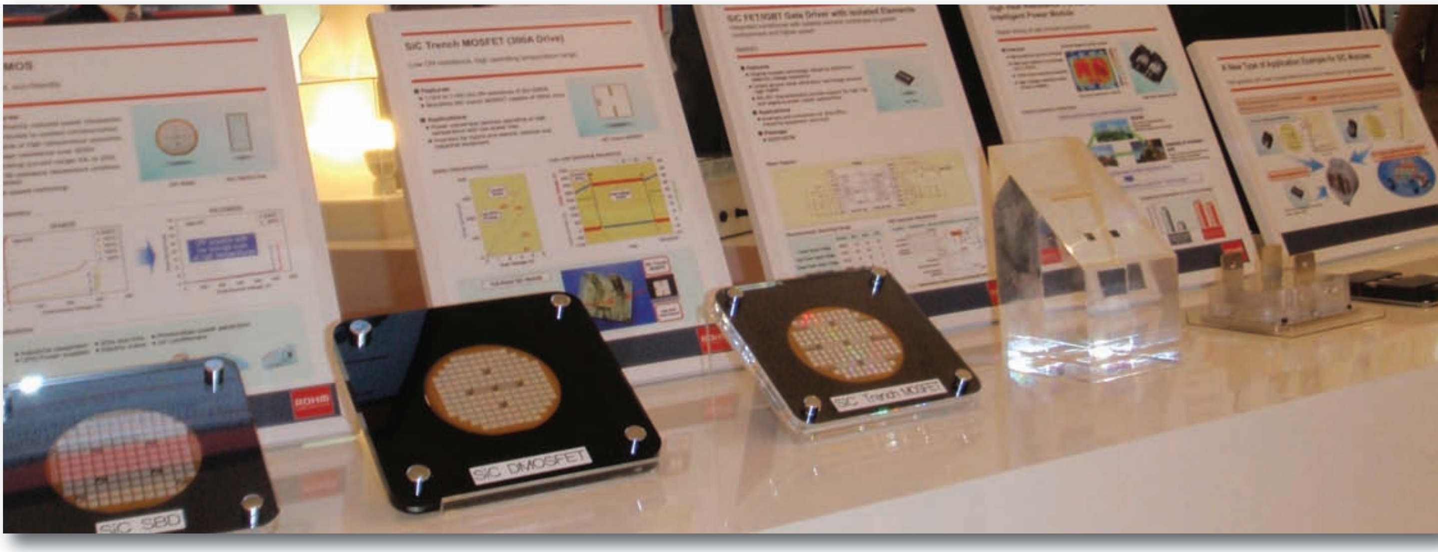
Mark Münzer, Director of Electric Drive Train Development at Infineon, gave an example on how efficiency of the inverter influences the total cost of ownership (TCO) for (H)EVs. For a full HEV at assumed cost of Euro 3,000 for the electric drive train and Euro 1.50 per liter fuel, cost over life time (200,000km) can be summarized to Euro 13,800. For a full electric vehicle (Euro 10,000 drive train cost, Euro 0.20/kWh) cost over lifetime accounts for Euro 16,000. A one percent increase in inverter efficiency will lead to a reduction of Euro 50 (0.4%) in case of the HEV and to Euro 240 (1.5%) in case of the EV for this cost over lifetime. Thus the efficiency of the inverter has a much higher influence on the TCO for pure electric vehicles, because higher efficiency will lead to smaller battery size an weight as well as lower electric power consumption per kilometer. In terms of power semiconductors SiC (JFETs and diodes) in the EV inverter will have highest efficiency (97.92%) compared to the company's Hybrid Pack 1 (96.29% efficiency), but also a higher TCO of Euro 329. For the HEV the added TCO for SiC is around Euro 65.

"Thus the high value of efficiency fosters the introduction of Silicon Carbide particularly in battery-driven electric vehicles", Münzer explained.

SiC and GaN at the exhibition floor

Rohm **(www.rohm.com/eu)** displayed its 1200V SiC MOSFETs (4.8mm x 2.4mm die size) and SBDs (5.14mm x 5.14mm) which already have been implemented in a full SiC power module for automotive applications. The new SCS110A series of SiC SBDs feature a reverse recovery time of 15ns - much less than the 35ns to 50ns of conventional Si-based FRDs. The series also reduces chip size by 15%, along with operating resistance, temperature characteristics, and forward voltage (1.5V at 10A). ROHM has also solved the problems associated with the mass production of SiC SBD devices, such as uniformity of the Schottky contact barrier and formation of a high-resistance guard ring layer that does not require high temperature processing, making uniform, in-house production possible. "We performed R&D on SiC for years, beginning with the development of an SiC MOSFET prototype in 2004, followed by power modules and SBDs. Improvements and

"The high value of efficiency fosters the introduction of Silicon Carbide particularly in battery-driven electric vehicles", Münzer explained



Rohm displayed its 1200V SiC MOSFETs, SBDs and wafers

enhancements were made to the SiC SBDs based on customer feedback in 2005. This led to the development of a uniform production system for SiC devices and the acquisition of SiCrystal AG of Germany in order to ensure a stable supply of high-quality SiC wafers", said Sales Manager Seiichiro Hashimoto.

Cree **(www.cree.com)** presented a prototype of a 1.7kV/10kW half-bridge inverter equipped with 1700V/20A SiC MOSFETs, 1700V/10A SiC Schottky freewheeling diodes and 2 x 1200V SiC bridge rectifiers. "This power stage is running at 20 kilohertz switching frequency achieving an efficiency of 97.4 percent. This high efficiency level leads to very low losses which clearly can be demonstrated by the very low temperature of 39°C at the heatsinks for the switches and diodes", explained R&D Director John Palmour. "The design is very conservative and no attempt was made to minimize size or optimize efficiency". Further optimization particularly of the inductor core could lead to an increase of the switching frequency up to 47kHz and 98% efficiency at significantly smaller size.

"Our new 150mm SiC substrates with micropipe densities of less than 10/cm_ will lower the cost for SiC MOSFETs and diodes substatially in the coming years", confirmed Cree's R&D Director John Palmour

One of the major issues in power testing high voltage power DMOSFETs is that any demonstration circuit to fully exercise the device by definition must be at a very high power level. This requires the use of a high power source and load. The approach taken for this demonstration was to construct a DC/DC converter and feed the output current back to the input of the converter. The converter delivers full power, but the power source need only deliver the circuit losses. This approach also gives a direct measurement of the total system power loss. "The switching losses are fairly moderate, being about 30 percent of the total device loss of 265 watts. Magnetic and rectifier losses together account to 200 watts. Here is a lot of improvement, and therefore higher frequencies are definitely possible", Palmour said. "And our new 150mm SiC substrates with micropipe densities of less than 10/cm_ will lower the cost for SiC MOSFETs and diodes".

According to Marketing Manager Paul Kierstedt the market for SiC power semiconductors will grow significantly from today's $100 million to $400 million by the year 2013.

International Rectifier **(www.irf.com)** demonstrated its latest achievement in Gallium Nitride (GaN) power semiconductors. Silicon power FETs, introduced some 30 years ago, enabled the widespread adoption of switch-mode power supplies. The Silicon IGBT, combining the ease of charge control with the benefits of conductivity modulated drift resistivity, has been another mainstay, especially in the lower frequency conversion systems, e.g. motor drive inverters. Of course, the same minority carrier injection that provides for lower ohmic losses also increases switching losses through the effects of subsequent tail currents. Over the last 3 decades significant engineering efforts have driven the improvement in the performance figure-of-merit (FOM) of these devices by more than an order of magnitude. However, as this technology approaches maturity, it becomes increasingly expensive to achieve even modest improvements in the device FOM.

IR has developed its GaN technology platform using GaN-on-Si hetero-epitaxy and device fabrication processing that can be performed in a standard modern Silicon CMOS manufacturing line with little modification to equipment or process discipline. GaN based power devices such as HEMTs (High Electron Mobility Technology) promise to deliver a FOM performance that is at least an order of magnitude better than state-of-the-art silicon MOSFETs.

"GaN technology is characterized by an intrinsic lateral structure, which simplifies packaging by virtually eliminating parasitic elements of wire-bonding stray inductance and parasitic resistance. Moreover, it enables possible integration of multiple switches and

"The figure-of-merit for first generation GaN based 600V switches exceeds that of Silicon based alternatives by at least a factor of 4", stated IR's VP of Emerging Technologies, Tim McDonald

driver IC function with protection and monitoring elements within common packaging or monolithic solutions", stated IR's VP of Emerging Technologies, Tim McDonald at a demonstration of the soon to be relased 600V devices. "As in the case for already introduced low voltage devices, GaN 600V power devices also exhibit significantly better switching performance than Silicon based alternatives. In fact, the figure-of-merit for first generation GaN based 600V switches exceeds that of state-of-the-art Silicon based alternatives 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".

First 600V GaN diodes have been designed by MicroGan of Ulm/Germany **(www.microgan.com)** and shown at Electronica by Diotec **(www.diotec.com)**. The 4A/600V SiGaN Schottky diode feature an ultra low barrier of 0.3V. Like any Schottky diode, it has negligible reverse recovery and a very low switching time, caused by junction capacity.

The "stored charge" is comparable to that of SiC devices, while the forward voltage drop is much lower: at 4A and 25°C it is typically 1.2V, at 100°C typically 1.6V.

Such devices are ideally suited for high frequency switching circuits, such as PFC and inverters. They boost PFC efficiency especially in partial load condition. Power losses in drive and solar inverters can be significantly reduced, just by bypassing the body diodes of Si Superjunction MOSFETs by such high speed free-wheeling diodes. These diode dies have been packaged (TO-220) and tested by Diotec surpassing stress tests beyond 800V. "I never have seen such an amazing robustness at first generation die in package", commented Diotec's product manager Udo Steinebrunner. **AS**

Numerical Simulation to Accelerate (H)EV Battery Development

The lithium-ion battery is a preferred candidate as a power source for hybrid electric vehicle (HEV) and electric vehicle (EV) due to its outstanding characteristics such as high energy density, high voltage, low self-discharge rate, and good stability. However, the HEV and EV market requires much larger lithium-ion batteries than those available in the market for consumer electronics. The possibility of significant temperature increases in large batteries during high power extraction, or even the risk of thermal runaway, is currently one of the major concerns confronting development of lithium batteries for electric vehicles. So, electric engineers need an accurate and yet simple to use thermal model that couples with their battery electric circuit model. **Xiao Hu, Lead Engineer, ANSYS Inc., Canonsburg, USA**

A properly designed thermal management system is crucial to prevent overheating and uneven heating across a large battery pack, which can lead to degradation, mismatch in cell capacity and potentially thermal runaway. Design of the thermal management system therefore requires knowledge about the cooling system as well as the amount of heat that will be generated by cells within the battery pack.

How simulation can help

Simulation can help on two levels, cell level and system level. Cell level refers to single battery cell, and system level could be either a battery module or a complete battery pack.

At a battery cell level, the focus is on detailed heat generation and temperature distribution within a battery cell. This type of study is pursued mainly by battery manufacturers and battery researchers. Experimental data reveals that the rate of heat generation varies substantially over time throughout the course of charging and discharging. Heat can be generated from internal losses of Joule heating and local electrode over-potentials, the entropy of the cell reaction, heat of mixing, and side reactions. If only the most important effects of Joule heating and local electrode over-potentials are considered, heat generation can be expressed by open

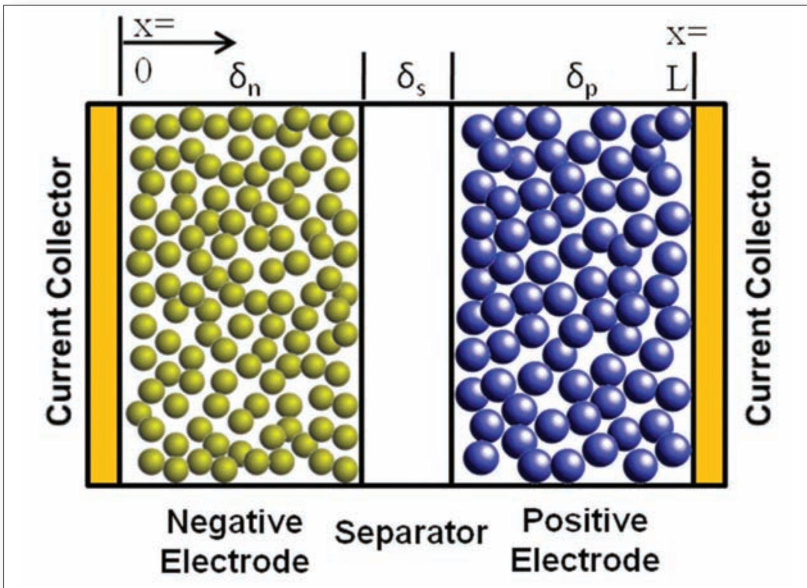


Figure 1: Schematic of a lithium-ion cell

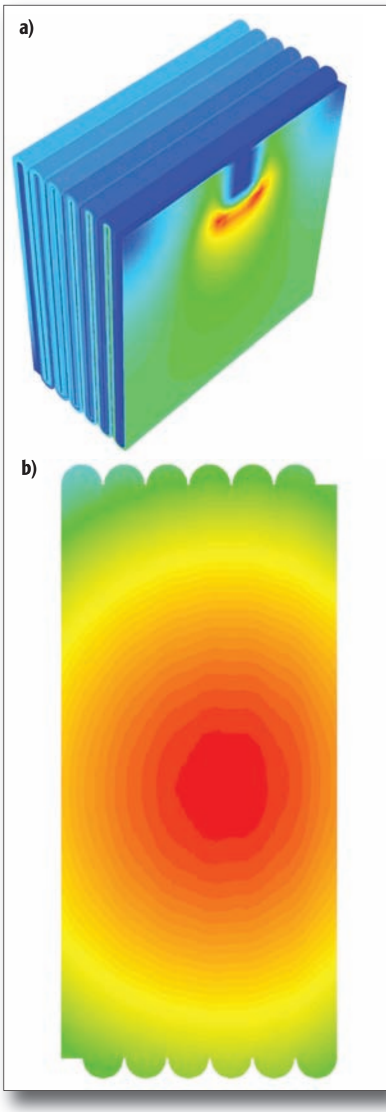


Figure 2: Typical results from models a) pack and b) detail generated in ANSYS® FLUENT®

Voltage & current range

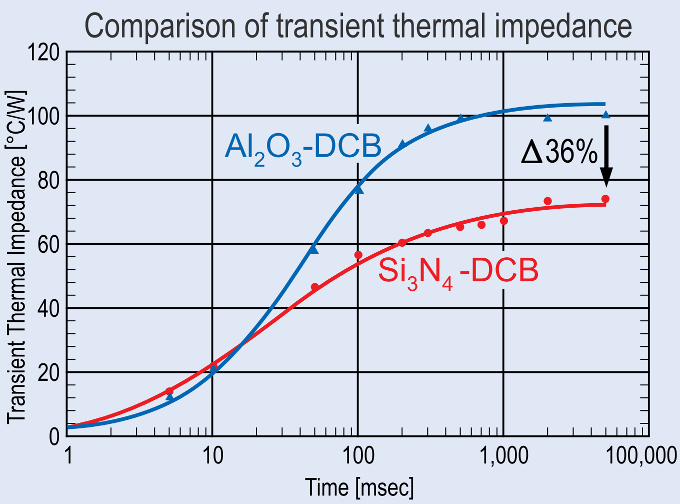
I_C	1200V	1700V
225A	●	●
300A	●	●
450A	●	●
550A		●
600A	●	

↓ SiN-DCB & thicker Cu pattern

↓ Lower thermal impedance
Higher bending strength & fracture toughness

↓ Higher thermal cycling capability
Higher reliability

- $T_{j\,(op)}$ = 150°C continuous operation
- $T_{j\,(max)}$ = 175°C
- New solder material for higher reliability
- Low switching losses & low over voltage spike



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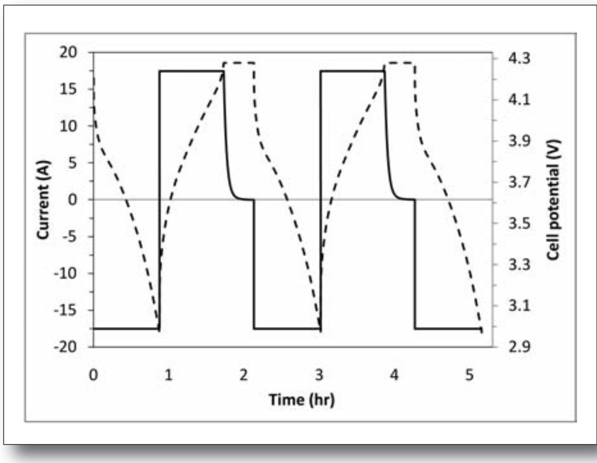

Figure 3: Charge and discharge cycle results from John Newman's electrochemistry model

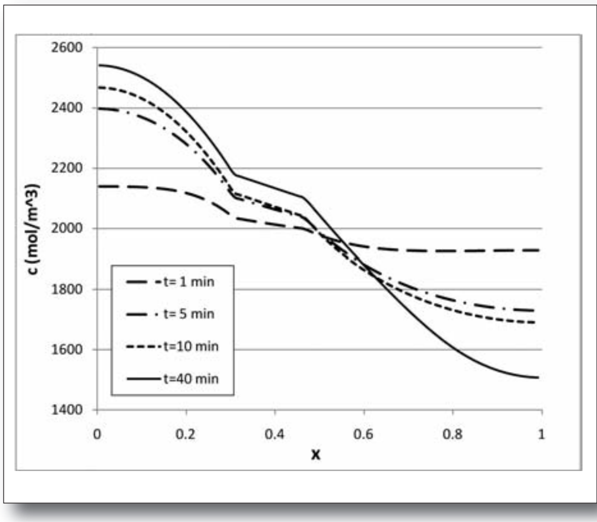

Figure 4: Concentration profiles during discharge

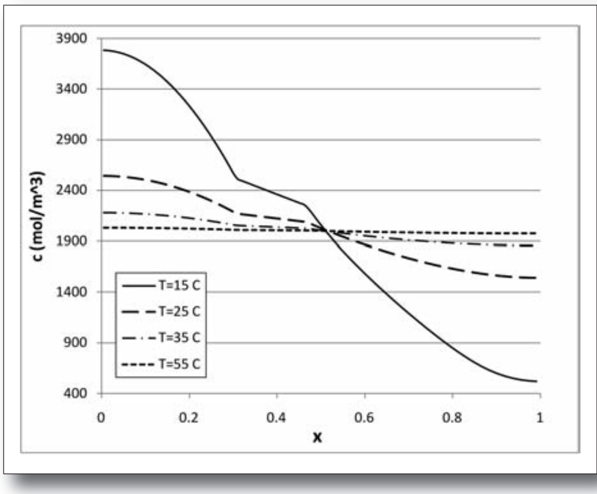

Figure 5: Concentration profiles under different temperatures

circuit potential and potential difference between the positive and negative electrodes. Figure 1 shows the schematic of a lithium-ion cell.

Models based on this area can be used to predict the potential and current density distribution on the electrodes of a lithium-ion battery as a function of discharge time. Then, based on the results of the modeling of potential and current density distributions, the temperature distributions of the lithium-ion battery are calculated. The results can then be used to examine the effect of the configuration of the electrodes, such as the aspect ratio of the electrodes and the placing of current collecting tabs as well as the discharge rates on the thermal behaviour of the battery. Figures 2a and 2b show typical results from such models generated in ANSYS® FLUENT®. The temperature distributions from the modeling were shown to be in good agreement with those from the experimental measurement.

While this type of model is simple to use and gives detailed information about temperature and current density distribution, it needs experimental testing data as input. As a result, this type of model cannot predict the impact of design changes on the battery thermal performance without re-conducting the testing. Physics based electrochemistry models, on the other hand, can be used to investigate the impact of battery design parameters on battery performance, which includes the geometry parameters, properties, and most importantly temperature. Physics based models can also provide inputs that would otherwise need experimental testing to obtain.

The most famous physics based model was originally proposed by professor John Newman from UC Berkeley. Such a model has been implemented in Simplorer®. Figure 3 shows charge and discharge cycle results from John Newman's electrochemistry model. Figure 4 shows the concentration profiles during discharge. One optimisation problem that is immediately apparent when examining Figure 4 is the determination of the initial concentration of electrolyte in the cell. The concentration used in Figure 4 is presumably determined due to the conductivity maximum that occurs at approximately this concentration. However, Figure 4 shows that the bulk of the composite cathode is at a significantly lower concentration, where the conductivity is also much lower as a result. This leads to severe transport limitations in the depth of the electrode, suggesting that a higher initial concentration leads to a somewhat lower conductivity in the separator, but a much larger conductivity in the composite cathode, where this is of prime importance. Figure 5 shows the concentration profiles under different temperatures. The information contained in such data tells battery designers when the limiting current occurs, and thus can help specify the temperature range that the cooling system has to maintain to avoid hitting the limiting current.

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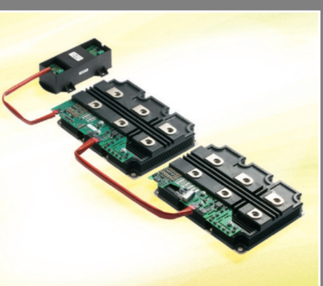


Paralleling with 1SP0335

New High Power Driver

Launching the next generation of high voltage IGBT gate drivers, CONCEPT introduces two new top class products – **1SP0635 and 1SP0335** - with an outstanding performance to cost ratio.
Consequent integration enables **cost down by 40%** compared to the first SCALE generation and significantly increased reliability. At the same time enhanced functionality, such as direct paralleling capability and Dynamic Advanced Active Clamping (DA^{2}C) assures excellent electrical performance and operation within the SOA of the IGBT.
Designed to fit all international standards these drivers are the perfect choice for high performance traction application, high power inverter and medium voltage drives.

Features

Plug-and-Play solution
For 1.2-3.3kV IGBT – 1SP0635
For 3.3-6.5kV IGBT – 1SP0335
Direct paralleling
DA^{2}C
Gate voltage monitoring
Supply voltage monitoring
Duty cycle 0..100%
Superior EMC behaviour
2-level and multilevel topologies
Meets EN50124 and IEC60077
Long service life

CT-Concept Technologie AG, Renferstrasse 15, CH-2504 Biel, Switzerland, Phone +41-32-344 47 47

www.IGBT-Driver.com

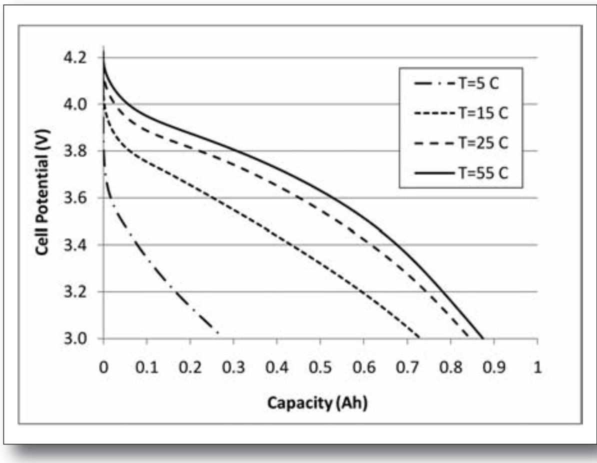


Figure 6: Cell voltage vs capacity at various temperatures

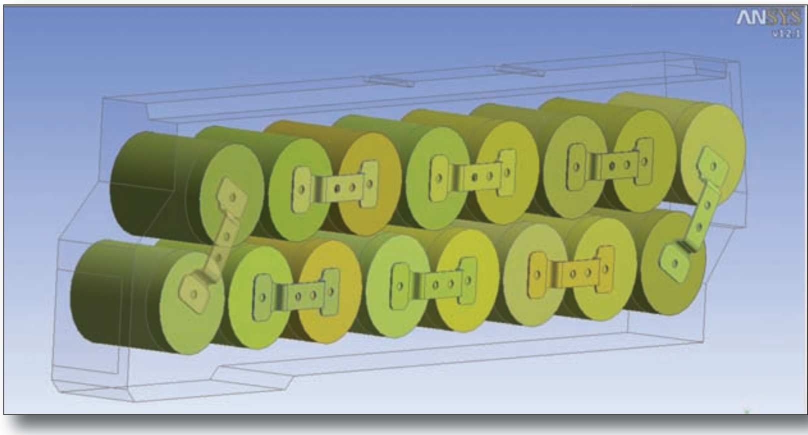


Figure 7: Simple CFD example

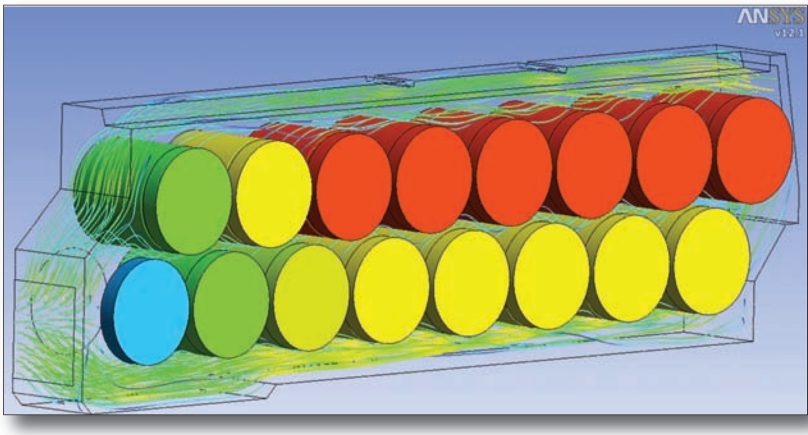


Figure 8: Complex CFD example

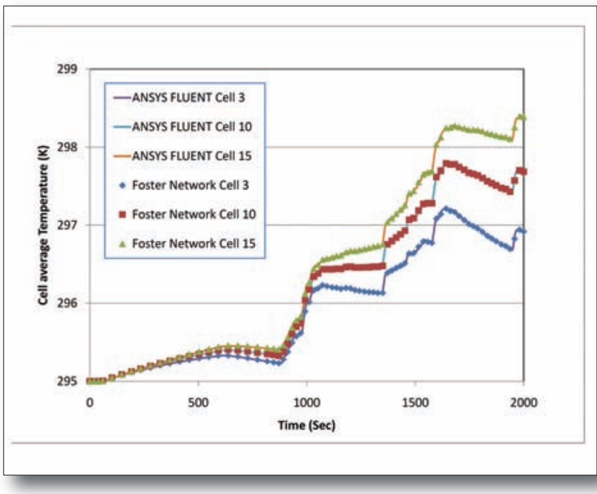


Figure 9: Comparison between Foster network model and full CFD

Another implication of Figure 5 is that battery run-time is a strong function of time, and battery life is longer with higher operating temperature. This is also confirmed in Figure 6 from the physics based electrochemistry model. Of course higher temperatures bring safety concerns, and thus this becomes another optimisation problem in battery design.

System level design engineers working at a module or pack level have a different set of requirements. Typically, these engineers cannot afford to simulate as many details as engineers working at the cell level can, and they also have a different set of simulation goals. For instance, Computational Fluid Dynamics (CFD) engineers working in battery thermal management are interested in maintaining the desired temperature range, reducing pressure drop, and maintaining temperature uniformity. And for them, detailed heat generation mechanisms and battery cell structure are not of primary interest. CFD has been widely used for predicting flow and heat transfer, and thus battery thermal management CFD simulation is just another application.

ANSYS has been working to make the process easier for the user. Rather than having to use different tools for geometry, meshing, post-processing, and optimisation, which are all integrated components of a CFD analysis, ANSYS Workbench™ creates all the aspects of the simulation under one umbrella. Geometries built within workbench tools or imported from other CAD packages are all parameterised.

An update of results due to a change of geometric parameters can be achieved in just one click. Data transfer between different simulation tools are handled seamlessly. With the help of ANSYS Workbench, a complete battery thermal CFD analysis, including optimization, can be done entirely within this environment. Figures 7 and 8 show such a CFD example performed by a major automotive OEM.

While CFD can give detailed thermal information about a battery thermal management system, it is time consuming to perform many transient simulations under different drive cycles. Model order reduction techniques exist to extract a model from CFD results, and the extract model, called Foster network model, gives the same solution as that from the full CFD model. However it runs much faster compared with CFD.

For the model shown in Figures 7 and 8, it takes a couple of hours to simulate one drive cycle under one single CPU. But for the extracted Foster network model, the simulation time is reduced to approximately 20 seconds, a time

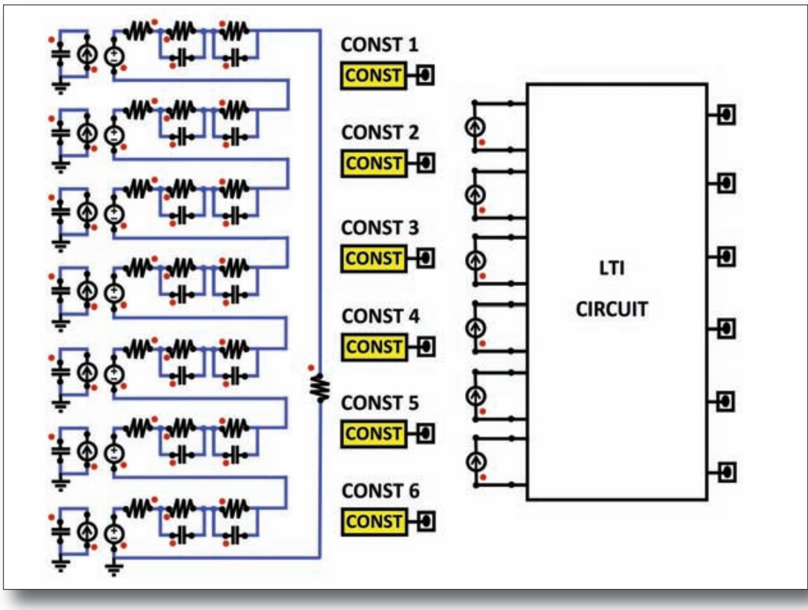


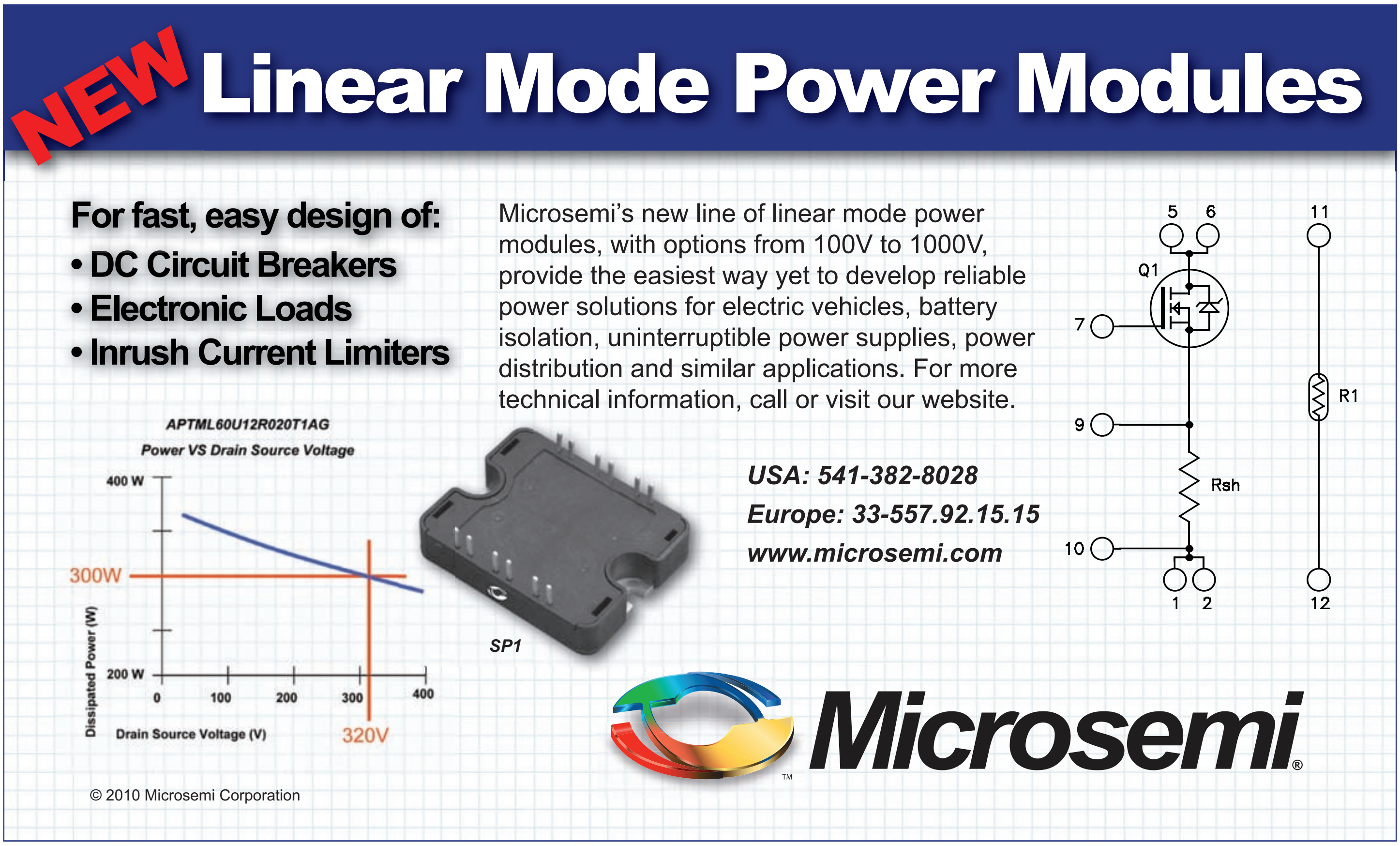
Figure 10: Complete dynamic battery model

reduction of more than two orders of magnitude. And yet, the Foster network model gives the same results as the original full CFD model. Figure 9 shows such a comparison. The model order reduction process is handled automatically by ANSYS Simplorer, which uses CFD results as inputs. This model order reduction technology opens the door for simulations that would otherwise have been impractical. For instance, battery thermal control system analysis would benefit from such a fast model.

Conclusions

The primary concern of electric engineers, is the electric performance of the battery rather than the thermal performance. However, as mentioned before, battery electric performance is a strong function of temperature. So, electric engineers need an accurate and yet simple to use thermal model that couples with their battery electric circuit model. Figure 10 shows such a complete dynamic model.

The complete electric circuit model of a lithium ion battery accounts for non-linear equilibrium potentials, rate and temperature dependencies, thermal effects and response to transient power demand. Traditional thermal network models can also be used to couple with electric circuit models. With the help of VHDL-AMS, which is an IEEE standard hardware simulation language supported by Simplorer, a traditional thermal network model can be generated easily. As a matter of fact, VHDL-AMS can be used for much more complex multiphysics and multi-domain problems, and the John Newman electrochemistry model mentioned above was generated using VHDL-AMS in Simplorer.



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Fast Prototyping of Power Converters by Plug-and-Play Capability of SCALE-2 Driver Cores

The new 2BB0108T and 2BB0435T Basic Boards offer an easy, low-cost way to evaluate the 2SC0108T and 2SC0435T gate driver cores with different IGBT modules and technologies by providing plug-and-play capability. The standardized DIC-20 interface used with all SCALE-2 plug-and-play drivers, with its wide adaptability, options for customized volume production and open access to schematics, layout data and support, makes such an approach into a fast, inexpensive and consequently very attractive solution.

Jan Thalheim and Olivier Garcia, CT-Concept Technologie AG, Biel, Switzerland

Make or buy? This becomes an increasingly important question for customers who need power stacks in their applications - such as solar or wind power systems - for cost reasons. Once it has been decided to go for an in-house solution, the task of designing a new power converter leaves the design engineer with the question of where to start the design. One reasonable approach is to place the focus on the most expensive parts of the system, namely the IGBT modules, which account for approximately 30% of the overall component cost. A proper evaluation of the cost and performance of the IGBT module would then yield a sound solution.

A flexible, adaptable and state-of-the-art IGBT driver solution is required to enable efficient verification of the cost/performance ratio of possible IGBT modules. The newly designed CONCEPT Basic Boards in combination with the appropriate SCALE-2 driver core provide the necessary flexibility throughout the design. They help the engineer to achieve a well-balanced design which satisfies the need for cost optimization without sacrificing reliability.

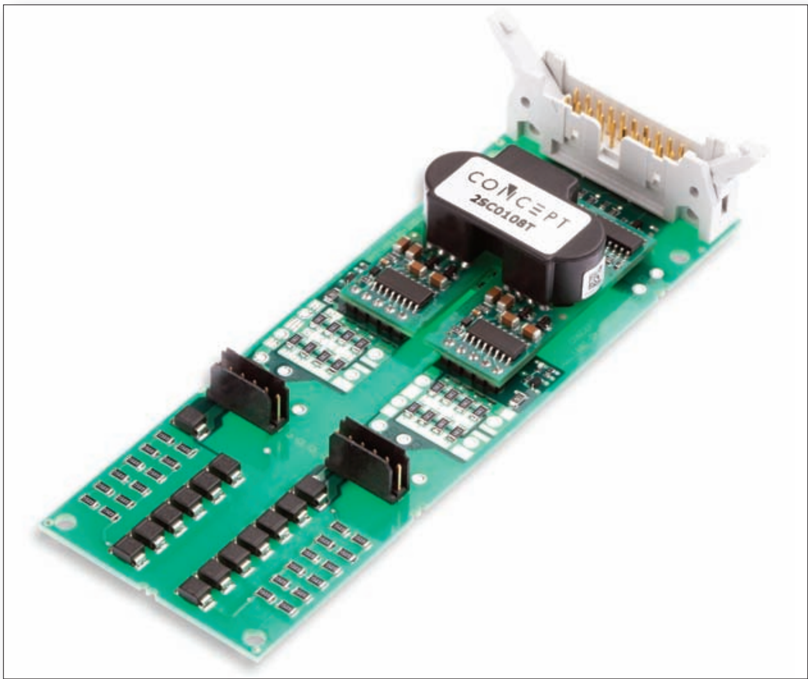

Figure 1: 2BB0108T Basic Board with 2SC0108T driver

Basic board as starting point

The 2SC0108T and 2SC0435T driver cores comprise complete and extremely compact 2-channel IGBT drivers equipped with DC/DC converters, short-circuit protection, supply-voltage monitoring, optional half-bridge control and support of Active Clamping. However, some effort - such as designing an adaptor board - must initially be made to set up the drivers to work in the initial power-stack prototypes.

Up to now, the fastest way to evaluate the advantages of SCALE-2 technology in an application was to take the ready-to-use plug-and-play drivers suited for immediate operation after mounting on the IGBT module. But this sometimes has the drawback that the mechanics, or even the power module itself, may not yet be fixed at this early design stage.

The use of basic boards overcomes this hurdle by enabling the user to select the IGBT driver first on the basis of the overall power needed in the inverter system. Once the gate resistors are assembled, the basic boards equipped with the driver core offer full plug-and-play functionality.

Different IGBT modules could then be evaluated in this way without changing the driver, leading to fast optimization of the power stack configuration.

Driver cores easily become plug-and-play

SCALE-2 has a significantly higher degree

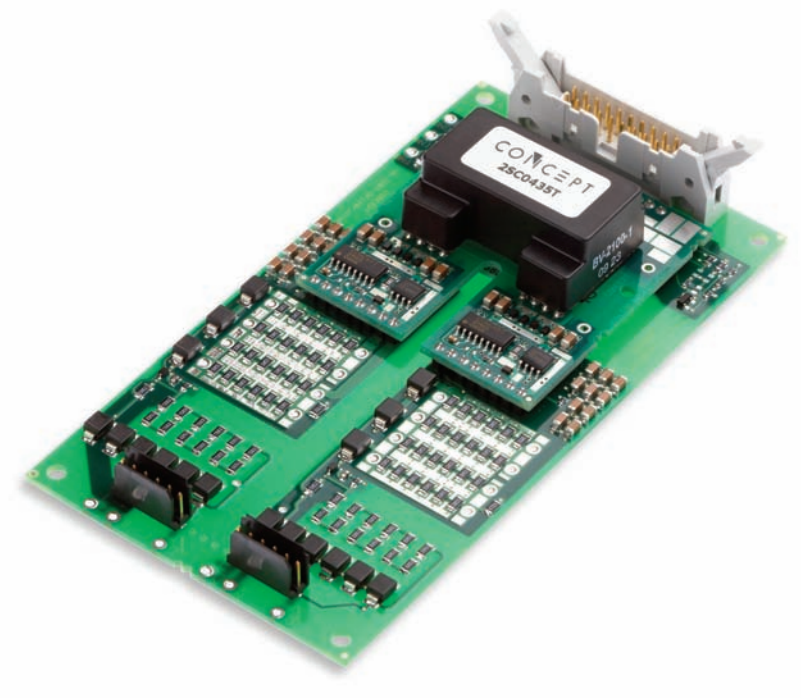

Figure 2: **2BB0435T Basic Board with 2SC0435T driver**

of integration, thus dramatically reducing the number of components on the driver boards. This results in maximum reliability, a smaller space requirement and much lower costs.

The compact basic boards have been designed to facilitate the set-up and evaluation of the SCALE-2 driver cores together with different IGBT packages and technologies.

The resulting plug-and-play solutions based on 2SC0108T or 2SC0435T drivers using the new 2BB0108T and 2BB0435T Basic Boards are shown in Figures 1 and 2 respectively. The topology of 2BB0435T is shown in Figure 4.

An important fact in this respect is the standardized DIC-20 interface, which is compatible with all other SCALE-2 plug-and-play drivers. Thus it allows a single control solution to be used for different power stacks. The turn-on and turn-off gate resistors of the two channels are generally not assembled in order to assure maximum flexibility. The boards support both SMD and wired-gate resistors.

The basic boards are available in three voltage classes to drive 600V to 1700V IGBT modules.

The 2BB0108T solution is primarily optimized to drive 34mm, 62mm and 17mm dual-housing and other IGBT modules up to a current of about 600A.

The high-performance 2BB0435T is designed to drive 62mm, 130mm x 140mm single and dual IGBT modules, 190mm x 140mm single IGBT modules, 17mm dual IGBT modules, as well as PrimePACK™ and EconoPACK™ IGBT modules.

Main features

Its plug-and-play capability means that it is ready to operate immediately after assembling the gate resistors.

The complete driver solutions provide both direct-driving and half-bridge modes with combined input and fault processing and an internally generated half-bridge dead time which is set at the factory to 3µs.

The V_{ce}-monitoring threshold is set at the factory to 10.2V to achieve universal short-circuit protection. The response time is set to 4.4µs for 600V IGBT modules and to 6.5µs for 1200V and 1700V IGBTs. A command blocking time of 90ms is also set after a fault event to ensure proper reset and thermal stability of the system. These functionalities can be deactivated by connecting the corresponding pins to signal ground at the primary-side interface.

The basic boards have been developed with a clear focus on full current and power utilization of the IGBTs. The Advanced Active Clamping function (see Figure 3) supports DC-link voltages up to 400V, 800V and 1200V for the IGBT voltage classes of 600V, 1200V and 1700V respectively. The 2BB0108T fully utilizes the gate output power of the 2SC0108T driver core, which is 1.2W per channel at ambient temperatures below 70°C and drops linearly to 1.0W at 85°C.

The 2BB0435T achieves a gate output

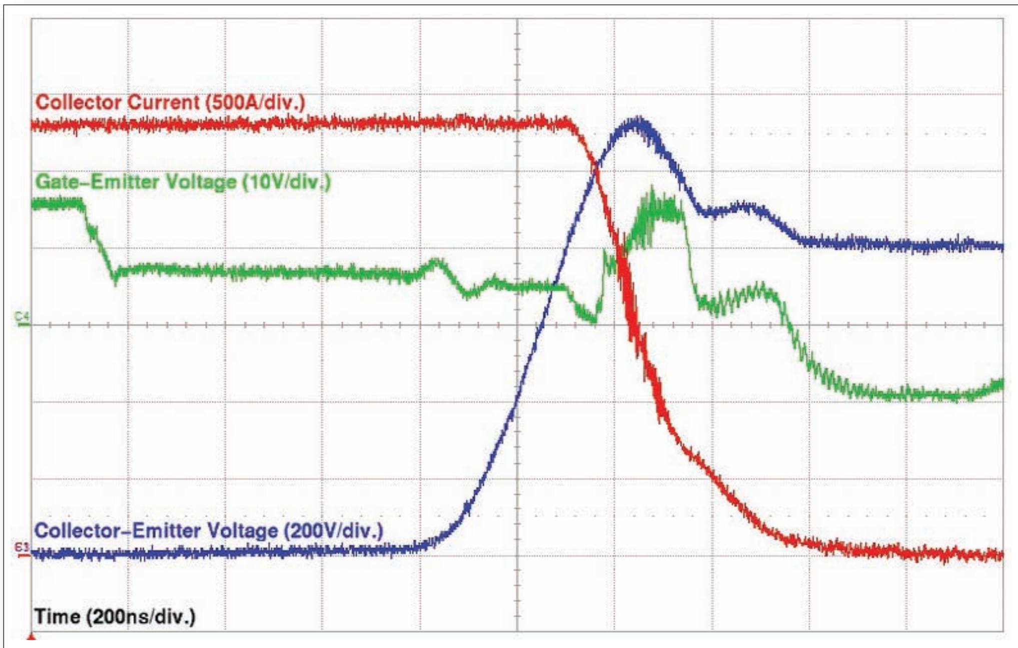

Figure 3: **Turn-off transition with Advanced Active Clamping of an FF1400R12IP4 IGBT by 2BB0435T**

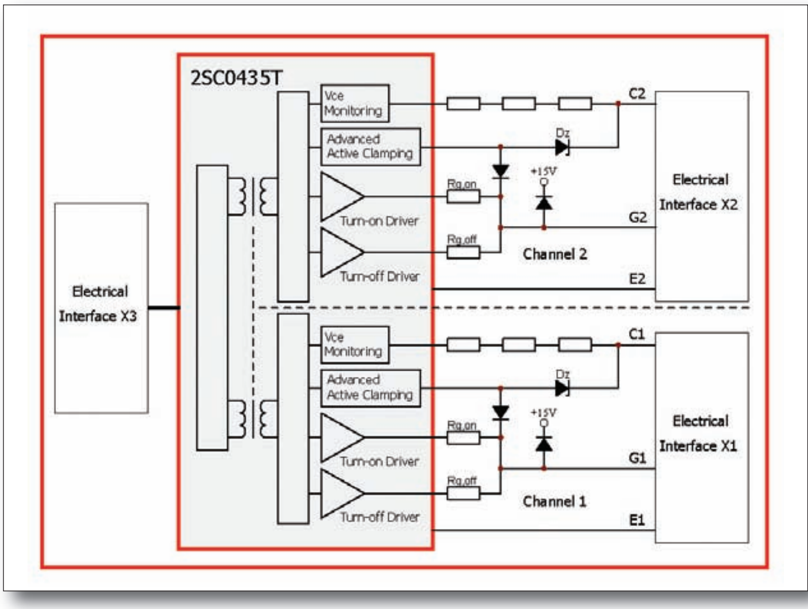

Figure 4: Topology of a plug-and-play driver using a 2BB0435T Basic Board

power of 3W per channel at ambient temperatures below 70°C which drops linearly to 2W at 85°C.

The complete driver solutions feature safe isolation to EN 50178, protection class II and UL compliance.

Scalability of converter power through direct paralleling

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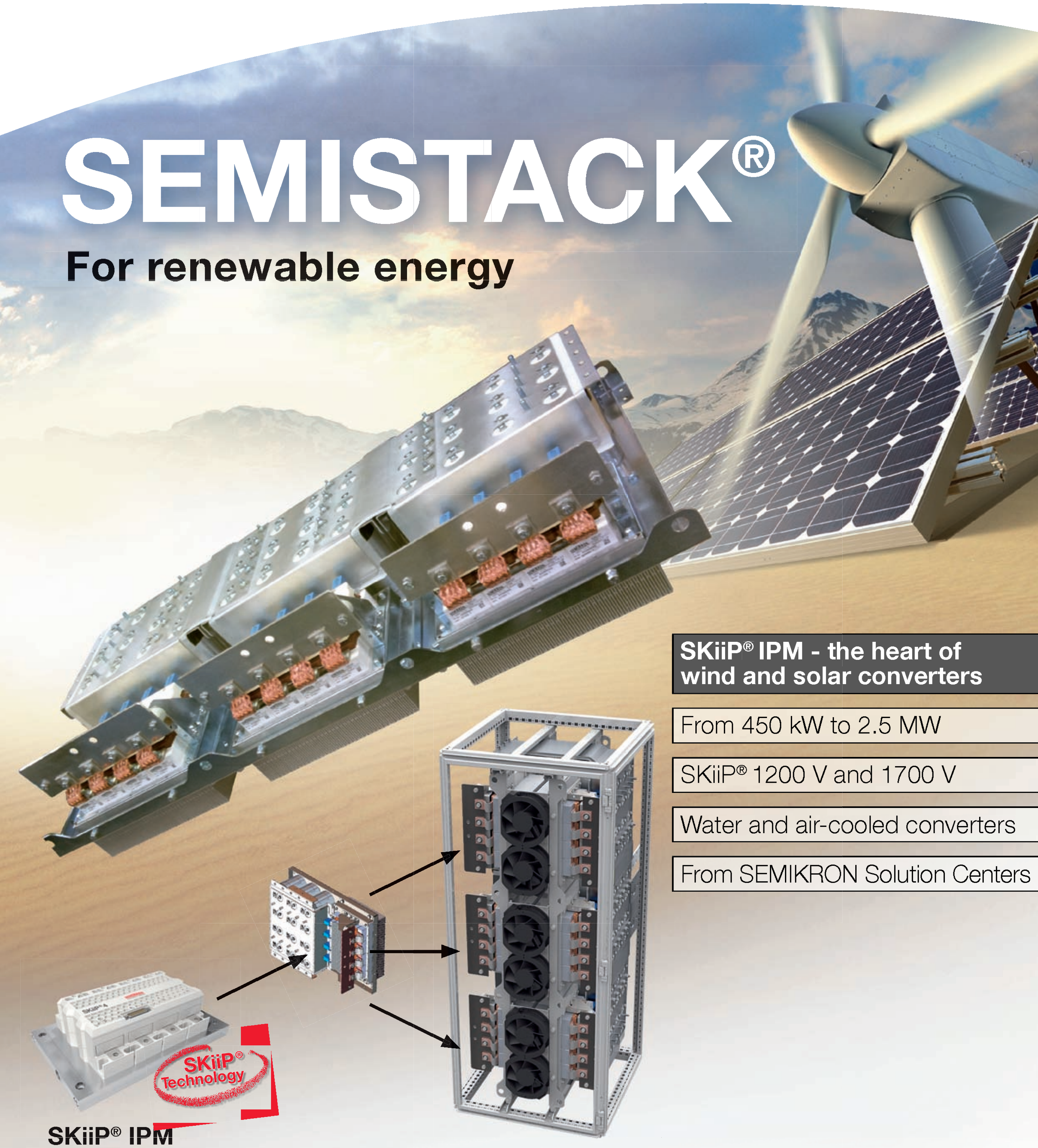

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Reliable and Safe Insulation in High-Voltage Inverter Applications

The market trends in high-voltage inverter applications such as wind turbines, renewable energy harvesting sites and industrial motor control applications require increasing working voltage levels and higher efficiencies. These trends are driving the use of 1700V intelligent power modules (IPMs) or IGBTs to meet these requirements. The reliable and safe insulation between low-voltage and high-voltage subsystems are key requirement for these designs. **Hakan Uenlue, Field Applications Engineer, Avago Technologies, Boeblingen, Germany**

In wind turbines and other renewable energy harvesting systems, converting and feeding energy from the generator to the grid requires high-voltage converters. When insulating the high-voltage subsystem from the low-voltage side (e.g., MCU, PWM generator), both the internal and external construction of the component plays an important role. A new intelligent optocoupler from Avago Technologies, the ACNV4506 (Figure 1), addresses insulation concerns in these systems. The device is available in a 500mil DIP10 package and has external insulation coordinates (creepage and clearance) of 13mm, which meets the IEC60664-1 standard. Moreover, it provides a minimum 2mm internal clearance - or Distance Through Insulation (DTI) - to offer designers extra flexibility for applications where high minimum internal clearances are required.

Figure 1: The ACNV4506 addresses insulation concerns high-voltage inverters for renewable energy applications

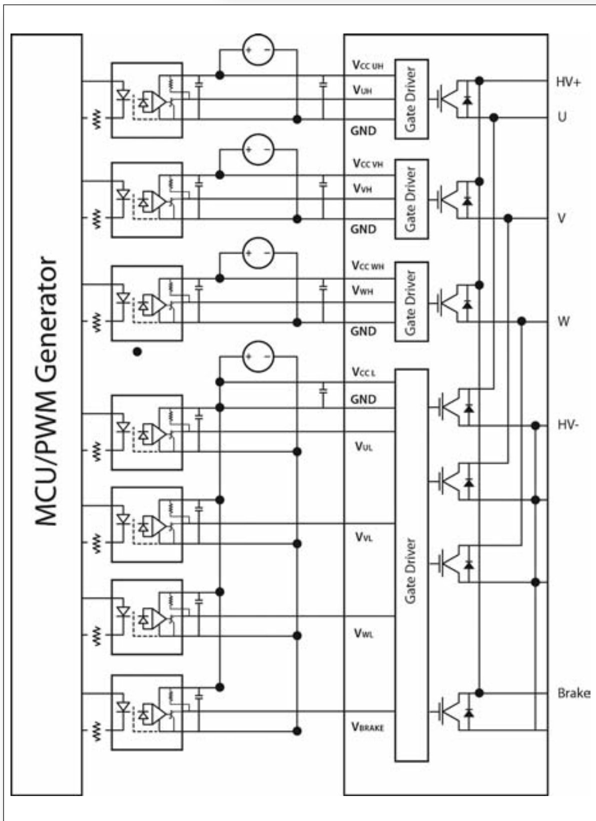


Figure 2: Interfacing MCU and IPM through ACNV4506 optocoupler

Interfacing a conventional 1700V IPM or IGBT

Figure 2 illustrates conventional 1700V IPM circuitry for industrial motor control. In this example, six ACNV4506 optocouplers are used for insulation of driving signals to high and low side IGBTs in an IPM. A seventh ACNV4506 device can be used for brake signal isolation. For additional signaling, such as fault feedback, additional optocouplers can be employed.

The IPM in Figure 2 uses inverted logic; when the input is high, the IGBT turns off and when the input is low, the IGBT turns on. The ACNV4506 optocoupler has an open collector output. Therefore, before the MCU and input side of the IPM is powered up; the optocoupler output logic level is high, which holds IGBT at OFF state. For certain families of IPMs, all three high-side floating power supplies (i.e., VCC_UH,

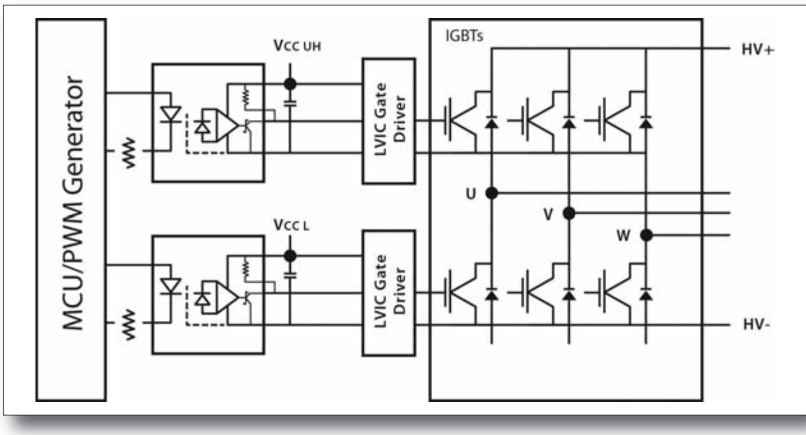


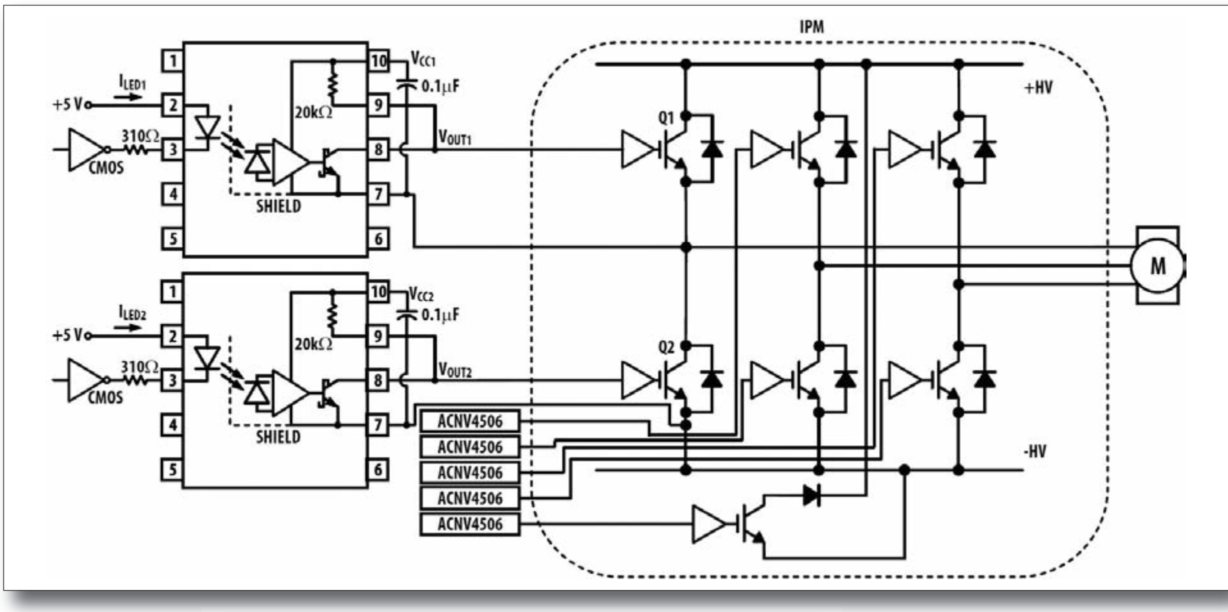
Figure 3: Insulation of IGBTs and their discrete gate drivers via an ACNV4506 optocoupler

VCC_VH, VCC_WH) and the low-side power supply (i.e., VCC_L), can have 15V. In other words, IPM inputs logic high is 15V.

The interface signal level calculations for output high level can be done according to the following equation

$$V_{OH} = V_{cc} - (R_L \times I_{OH})$$

where R_L is the pull up resistor needed for output transistor, and I_{OH} is the output transistor leakage current. For error-free driving of IPM inputs, a similarly matching resistor value can be found from this formula. For a 15V power supply and 50µA leakage current (maximum value for an ACNV4506 device, over -40°C to 105°C ambient temperature range), a 20kΩ pull resistor would be appropriate. In this case no external component should have to be used, as 20kΩ resistor is already included in the device's package (between pin 7 and 8). If a 5V power supply is used, a 3kΩ resistor would be appropriate and an external component for that purpose can be employed.



ABOVE Figure 4: Typical application circuit with recommended LED driver circuitry for best CMR performance

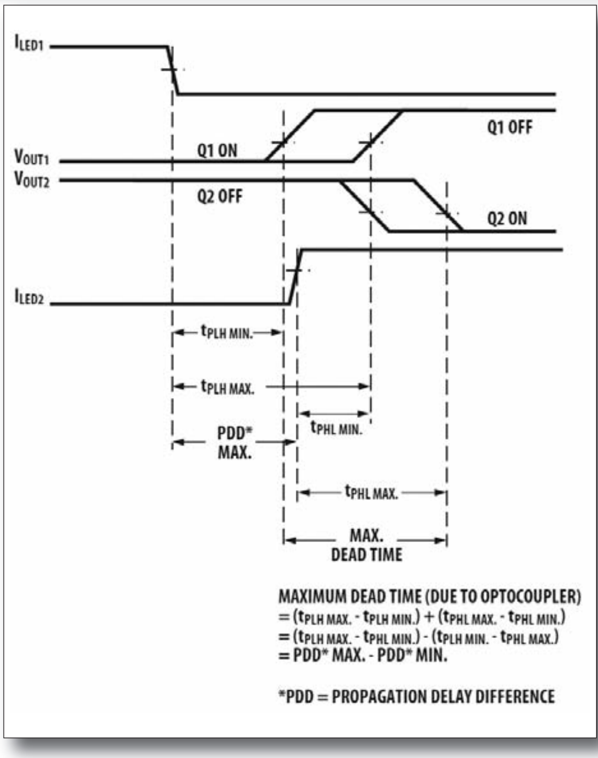


Figure 5: Waveforms for deadtime calculation

If gate drivers are not integrated into the power module, the ACNV4506 device can interface with gate drivers as shown in Figure 3. For respectively lower power modules, the discrete transistors can be used for driving IGBT gates and the ACNV4506 optocoupler can do the interfacing and insulation.

In some types of IPMs, where HVICs are integrated to gate driving stage, a low-voltage circuit can control high-voltage power devices through level shifting process. With this technology, all gate driver input circuits can be connected to one power supply, which enables input logic compatible from 5V to 20V. In this case optocouplers are used mainly to achieve electrical safety isolation between the low-voltage and high-voltage segments of the system.

Isolation of common mode transients

As isolation property, optocouplers are used to help prevent high-voltage transients from one side of the system to the other. There are two kinds of sources for such types of short-term unwanted signals:

- System internal sources (e.g., transients caused by switching IGBTs at high voltages), and
- system external sources (e.g., lightning pulses coupled to the system).

In addition to the external and internal construction of an optocoupler, an optically transparent faraday shield placed on detector IC helps to provide a robust Common Mode Rejection (CMR) of the component. For the best CMR performance, LED driving circuitry as shown in Figure 4, is recommended for designs. Using this approach, a minimum CMR of 30kV/µs at 1.5kV common mode voltage can be achieved.

Timing characteristics and further calculations

A typical application circuit for three-phase power converters or motor drivers can be seen in Figure 5. One of the unwanted effects in half-bridge versions of such IGBTs is to have both power transistors ON at the same time. Any overlap of these two devices (shown as Q1 and Q2 in Figure 4) will result in large currents flowing through these transistors between the high- and low-voltage rails. Therefore, in order to avoid possible complications caused by overlapping, designers should ensure appropriate signal timings so that both transistors will never be active at the same time. As a result, there will be a period of time in each signal cycle in which both transistors will be OFF. Since none of IGBTs are utilized, during this window of time, this causes possible limitations in efficiency of the overall system. To minimize this deadtime, the designer must consider the propagation delay characteristics of the optocoupler as well as the IPM IGBT gate drive circuit. When considering only the timing characteristics of the optocoupler, it is important to know maximum and minimum turn-on (T_{PHL}) and turn-off (T_{PLH}) propagation delay time specifications and propagation delay differences (PDD) between any two components.

Zero deadtime occurs when Q1 turns off at the same time point Q2 turns on. This is achieved when the signal to turn on Q2 is delayed by (T_{PLHmax} -T_{PHLmin}) from the turn off time-point of Q1. However, this method does not indicate what the maximum deadtime will be. In a very unlikely scenario, this occurs when one component with the fastest TPLH and other with the slowest T_{PHL} are in the same half bridge. The maximum deadtime in this case is equivalent to the difference between the maximum and minimum propagation delay difference specifications, as shown in Figure 5. For the ACNV4506 device, the maximum deadtime (only due to optocoupler) is (450ns - (-150ns)=600ns) in the temperature range of -40°C to 105°C.

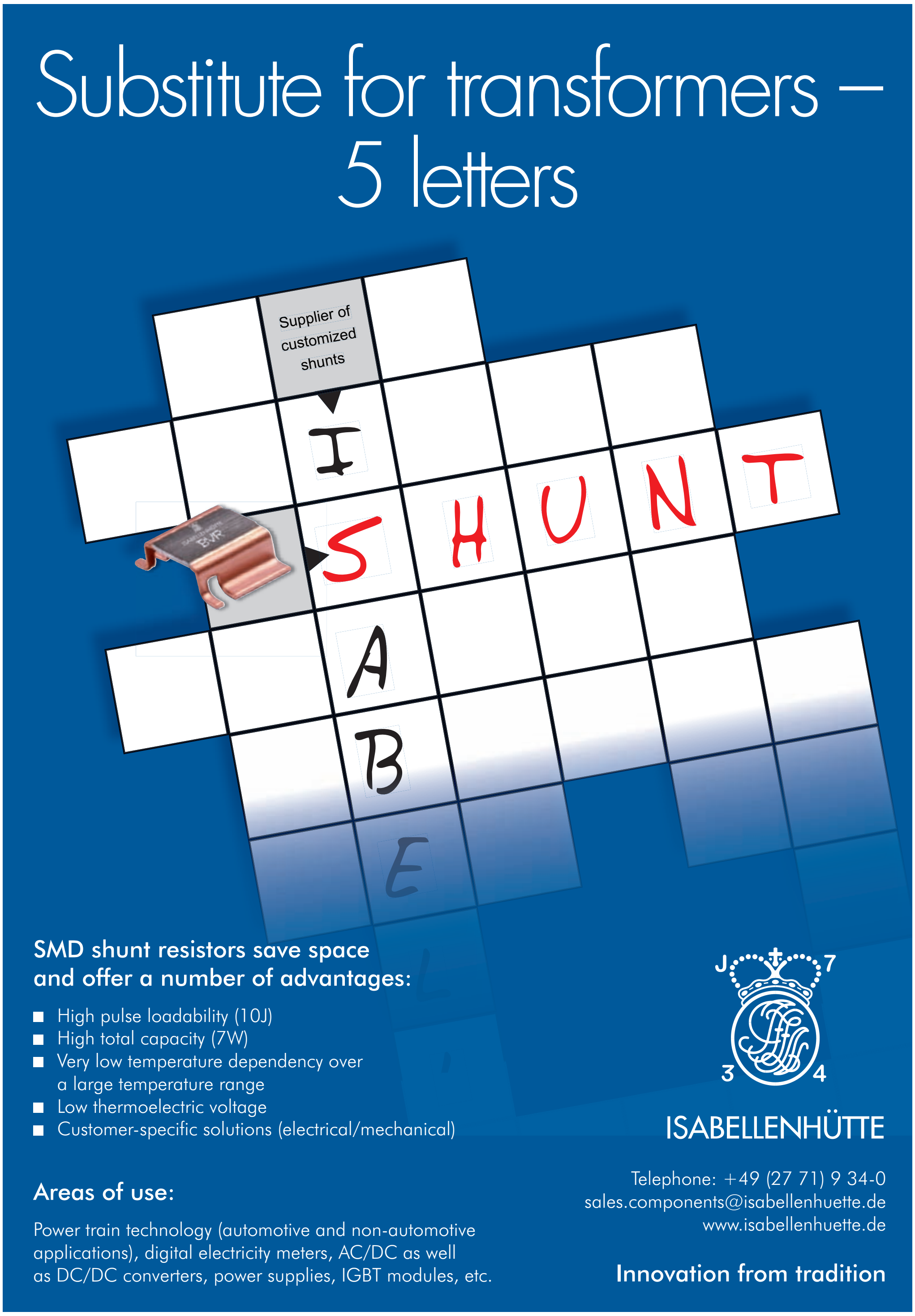
Conclusions

IPMs or IGBTs used in high-voltage inverter applications need to meet the trends for increasing reliability and safety. Designers can achieve electrically safe insulation of controllers of 1700V IGBTs or IPMs using optocouplers, such as the ACNV4506 device, which has continuous working voltage level of 2268Vpeak. They can also help isolate unwanted disturbances or transients, due to the component's high CMR performance. With output specification of up to 30V, this optocoupler can be used to help isolate the wide range of 1700V IPMs with different supply voltages.

Literature

[1] ACNV4506 Datasheet (AV02-2483EN, Avago Technologies)

[2] Application Note 5401: Optocouplers Isolated Circuit for IPMs and Gate Drivers



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Fast Switching 1200V Normally-Off SiC VJFET Power Modules

An all SiC based power module for use in high frequency and high efficiency applications has been developed. Using parallel combinations of 1200V enhancement mode SiC VJFETs and Schottky diodes, a total on-resistance of only 10mΩ was achieved at 100A drain current in a commercially available standard module configured as a half-bridge circuit. Careful attention to module layout, gate driver design, and the addition of optimized snubbers resulted in excellent switching waveforms with low total switching losses of 1.25mJ when switching 100A at 150°C. **David C. Sheridan and Jeffrey B. Casady, SemiSouth Laboratories, Starkville, USA**

A significant percentage of the targeted market for SiC power transistors will favor devices integrated into a module for higher power and complexity. It is often preferable to have higher power components in module form rather than multiple discrete devices in order to save both cost and area in the overall system design. Implementing modules also allows a much higher performance as gate drivers and control components can be placed close to the active switches, reducing parasitic capacitance and inductances, and allowing faster switching performance. It is also beneficial to the device manufacturer because of the ability to parallel smaller and hence higher yielding devices to reach the higher power levels is much easier in a power module than with discrete technology.

With significant progress being made in SiC VJFET, MOSFET, and BJT technology, this ability to create high voltage and higher current modules with smaller discrete devices is a natural progress for market adoption, but until recently, only few switching characterization reports of these types of all-SiC modules have been published [1-3]. In this article we show the full switching performance characterization of normally-off 1200V SiC VJFET switches in a half bridge module.

Using a standard module

The modules used were standard SP1 configurations offered commercially [4]. Thesemodules have a low profile and are built with AlN substrates for improved thermal performance. Figure 1 shows a picture of the completed module.

As shown in Figure 2, the modules contain a half-bridge (phase leg) configuration consisting of two series switches with anti-parallel diodes across each switch. Each switch position contains

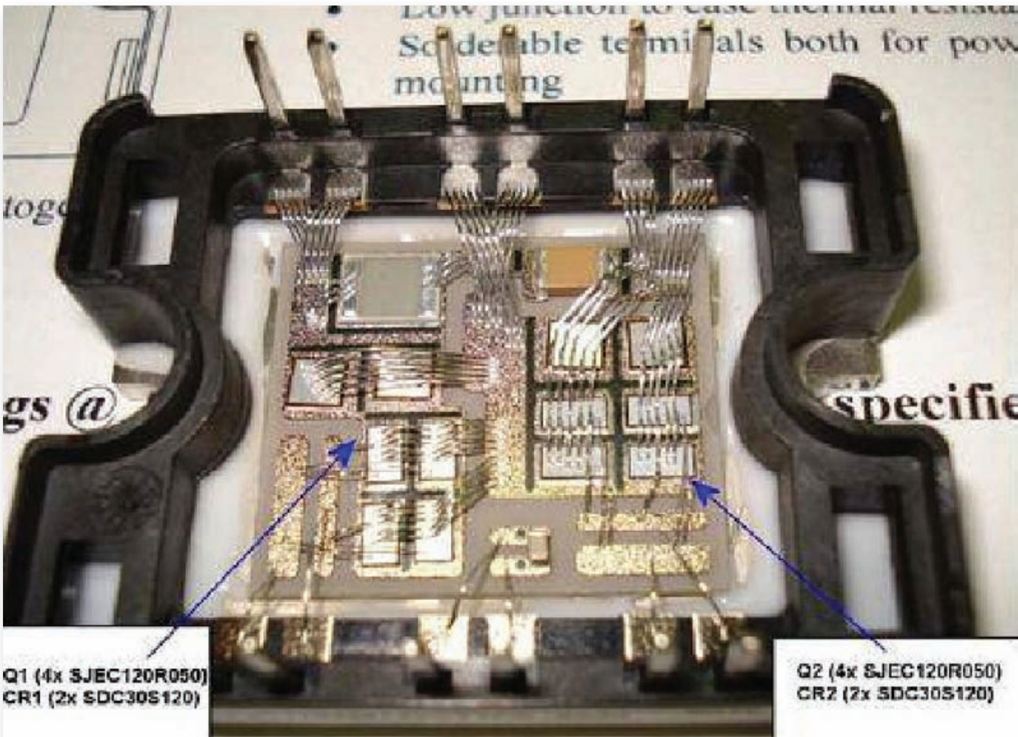


Figure 1: Photograph of the SP1 half bridge module showing JFET and diode scale

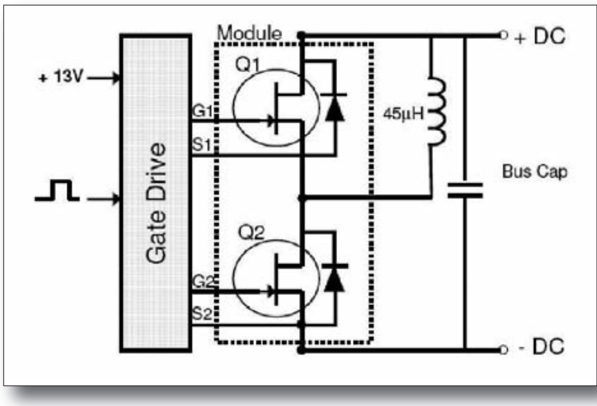


Figure 2: Schematic of the SiC module in the inductive switching test circuit without snubbers

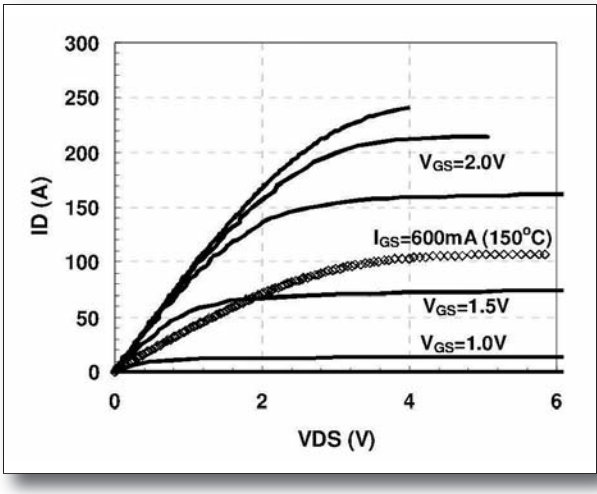


Figure 3: Output characteristics of a single switch in the module at 25°C (solid lines) and output for 150°C and I_{GS}=600mA (circles)

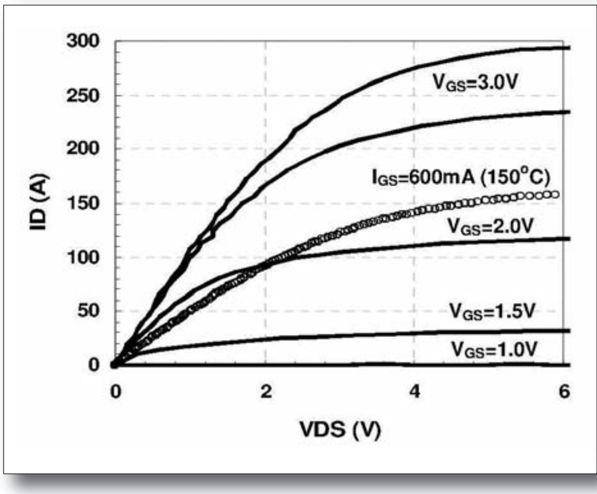


Figure 4: Output characteristics of higher current VJFET design [x] at 25°C (solid lines) and output for 150°C and I_{GS}=600mA (circles)

8 x 4.5mm^2 (2 x 2.25mm^2 active) enhancement-mode VJFETs (SJEP120R100 [5]) with 2 x 1200V/30A SiC Schottky diodes (SDP30S120 [5]). Each 4.5mm^2 VJFET die is targeted to have <100mΩ on-resistance and a threshold voltage of ~1V while capable of 1200V blocking voltage.

The VJFET and Schottky die only account for approximately half of the available layout area. Other layout features include source Kelvin connections and internal capacitor and snubber components.

Electrical optimization

The output characteristics of the module are shown in Figure 3. At ID=100A, the module on-resistance was 10mΩ which corresponds to a low 2.7mW-cm^2 specific on-resistance.

Maximum saturation current was over 200A at 25°C, reducing to over 100A at 150°C.

Devices with optimized channel design parameters for higher saturation current have shown up to 50% improvement in high-temperature saturation current [6] could be used if required by the application (Figure 4). Modules built with these higher current devices output ~150A at 150°C, appreciably increasing the available high temperature current.

Threshold voltage changes over temperature were modest as the nominal 1.15V V_{TH} was reduced by ~2mV/K to 0.9V at 150°C (Figure 5). At 150°C, the on-resistance increased to 27mΩ as expected from the 2.7 X reduction in majority carrier mobility and absence of interface effects seen in SiC MOSFETs.

For module characterization of switching performance, standard double pulsed measurements were conducted. The two positions in the half-bridge module served as the upper and lower switches, while the upper internal SiC Schottky acted as the freewheeling diode. An external 45µH inductor served as the load. Gate drive design was built from a custom discrete two-stage gate drive reference design [7] and scaled to support the larger die area and half-bridge topology. The two-stage design fist supplies a large 25A current pulse for ~100ns to quickly charge the required capacitances, and then reduces the drive current to a low adjustable continuous current level of ~500mA to maintain the VJFETs in a low $R_{DS(on)}$ conduction state across all temperatures. Modules were switched at a bus voltage of 600V and a drain current from 25A to 100A to characterize the switching losses.

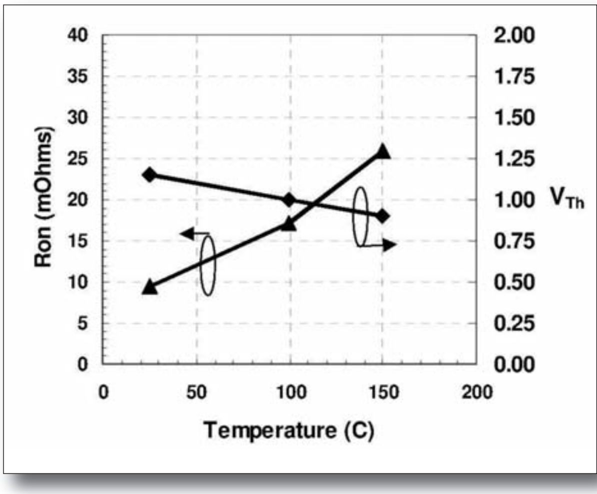
Although careful attention was given to layout of the module components to reduce the bond wire lengths and parasitic inductances, initial module waveforms were far from ideal. Significant ringing and oscillations appeared on both the output bus as well as reflections into the gate circuitry.

At these currents and power levels, the attractive properties of SiC transistors and diodes that allow fast switching and zero reverse recovery also bring new challenges to control the system interaction without minimizing the performance. In these module measurements of di/dt in the range of 5-8A/ns and dV/dt from 10-50V/ns are not uncommon. These transients resonating with the leakage inductance of the power circuit and active component capacitances resulted in unacceptable module performance. To alleviate the effect of the oscillations, optimized components for an internal RC snubber were added across the DC bus of the half-bridge module that immediately led to markedly improved waveforms.

On the gate side additional phenomenon may occur when switching at high dV/dt. Since there is a natural capacitive divider formed between the C_{GD} and the C_{GS} of the VJFET (similar to the MOSFET), high dV/dt occurring at the drain of the lower switch can cause current flowing through this divider, through the gate circuitry and cause unwanted turn-on of the upper switch. This cross-conduction effect can cause higher module losses as well as potential damaging currents in the gate circuit.

SiC switches in general are more prone to cross-conduction phenomena due to components. In comparison to other technologies, these results are 5-10x better than Si IGBT modules, and 45% lower losses than the best reported SiC MOSFET module results [8]. Because of the unipolar device, both E_{ON} and E_{OFF} remain low across the measured current range,and are independent of temperature.

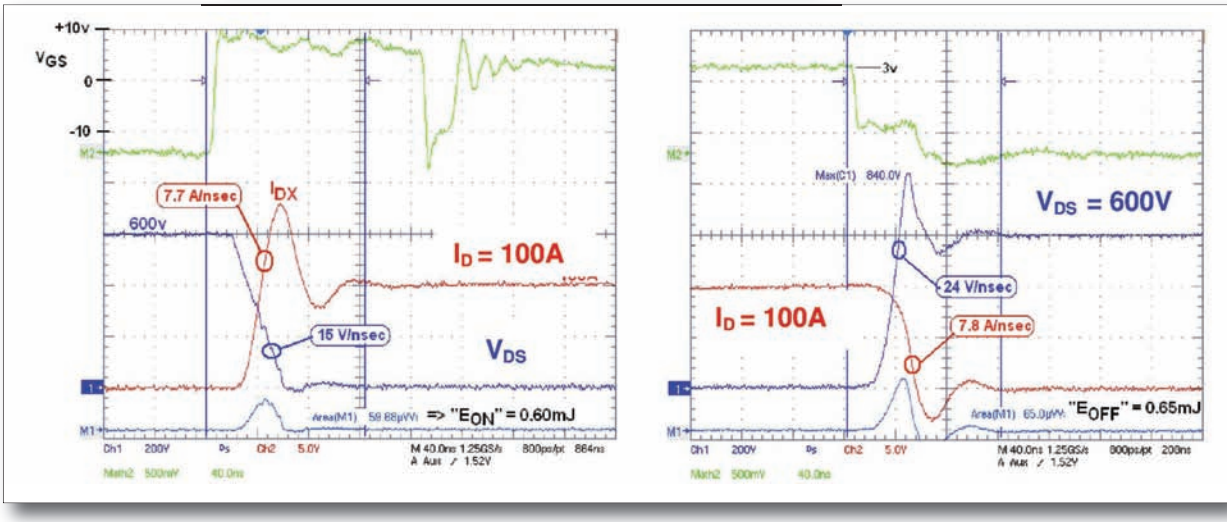
Figure 5: Module R_{DSon} and threshold voltage from 25°C to 150°C



Conclusions

As SiC devices migrate to higher power levels, multi-chip power modules offer a practical and necessary solution for a wide range of applications. However, the high speed transients capable in SiC devices at high voltages and currents highlight the need for careful design considerations for gate drive, wiring, layout, and module parasitic. With high speed, normally-off 1200V SiC VJFET technology, we have shown record low switching performance (1.25 mJ) in an optimized commercially available (Microsemi SP1) module configuration. Parasitic oscillations and cross-conduction were investigated and shown to be well controlled with the optimized internal snubbers and use of a negative voltage rail.

BELOW: Figure 6: Waveform capture of the turn-on (a) and turn-off (b) waveforms under inductive switching of I_D=100A and V_{DS}=600V at 150°C



the smaller die size (higher R_G) and larger CGD per unit area and given voltage rating. For this module, $R_{G,INT}$ ~ 1Ω, C_{GD} ~ 400pF, with a fast dv/dt of 20V/ns gives a rise in V_{GS} of 8V. This is several volts above the threshold voltage of ~1V. To prevent this effect, additional Gate-Source capacitors were added close to the die to and all measurements were conducted with a negative gate rail of V_{GS}=-13V.

Further reduction of gate oscillations was achieved by placing an additional small RC snubber across the Gate-Source capacitors. Examples of the turn-on and turn-off waveforms for I_D=100A and T_c=150°C are shown in Figures 6a/b.

Energy loss measurements vs load current and temperature are shown in Figure 7. At a load current of 100A, E_{ON} and E_{OFF} were measured to be 600μJ and 650μJ, respectively, for a total loss of E_{SW}=1.25mJ. Note that since the measurement was taken at the module terminals, the drain current contains both VJFET and snubber current components.

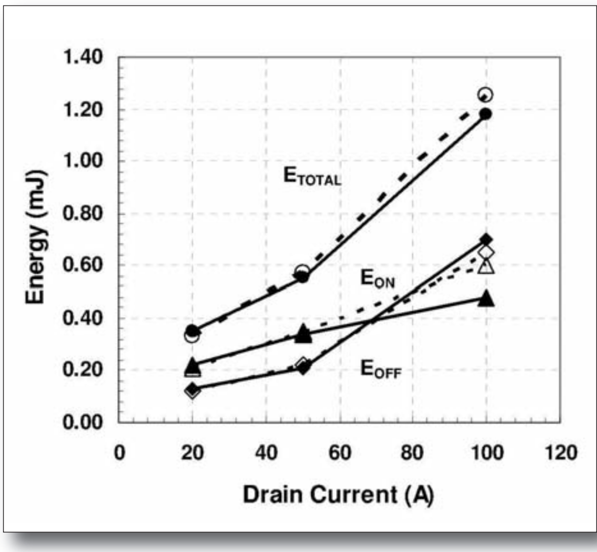


Figure 7: Module switching energy components vs drain current at 25°C (solid lines) and 150°C (dashed lines)

Literature

[1] J. Hilsenbeck, et al., Mat. Sci. Forum Vol. 645-648 (2010), pp. 1167-1170

[2] J. Scofield, et al, Mat. Sci. Forum Vol. 645-648 (2010), pp. 1119-1122

[3] K. Matocha, et al, Mat. Sci. Forum Vol. 645-648 (2010), pp. 1123-1126

[4] http://www.microsemi.com/catalog/pack.asp?packid=SP1

[5] A. Ritenour, et al, Proc. of 22nd ISPSD, Hiroshima, Japan, (2010), pp. 937-940

[6] http://www.semisouth.com/products/products.html

[7] R. Kelley, et al., Proc. PCIM, Nuremberg, Germany, 2009

[8] L.D. Stevanovic, et al., APEC., Palm Springs, CA, 2010, pp. 401-407

Renewable Energy Testing

A new versatile instrument combines the benefits of a high-speed oscilloscope and those of a traditional data-acquisition recorder in a single, portable instrument. It also incorporates a number of features that make it suited to tests on renewable energy systems. **Kelvin Hagebeuk, Yokogawa Europe, Amersfoort, Netherlands**

As an oscilloscope, the DL850 ScopeCorder (Figure 1) brings features like high sample rate, special triggers to capture transient events and analyses tools; as a data-acquisition recorder it implements high channel count (up to 128 channels), isolated high-voltage inputs (with up to 1kV optical isolation), and the ability to record to a hard disk or through a network to a PC.

This combination of features makes the instrument particularly suited to carrying out tests on renewable energy systems: in particular, on the inverters and associated power electronics used with wind, solar and tidal power generators. The ScopeCorder, with its multi-channel synchronisation, isolated inputs and 100 MegaSamples/second sample rate, is a tool to capture signals coming from these inverters along with control signals and other parameters - from electromechanical and temperature sensors, for example. These signals can then be viewed simultaneously so that 'cause and effect' analyses can be carried out.

Inverter measurements

Inverters used in renewable energy systems - as well as other applications including transport - are increasingly incorporating faster, higher-voltage devices which require isolated high withstand voltage measurements at higher sampling rates, as well as the ability to simultaneously measure greater numbers of signals for longer periods of time.

Traditional waveform measuring devices like digital storage oscilloscopes have limited capability for high-voltage inverter measurements because they lack the separately isolated inputs together with high-voltage isolation and high 12-bit resolution. Other waveform measuring solutions often require external (active) signal conditioning to achieve high-voltage isolation.

The DL850 ScopeCorder, on the other hand, uses a technology known as isoPRO® in its high-voltage measuring module to provide 100MS/s sampling with 1kV isolation and 12-bit resolution with no need for external active signal conditioning devices. isoPRO technology employs a system whereby digital data is converted to optical signals using a laser diode, with the data then being transferred via optical fibre to the instrument. As the data transfer rate of the

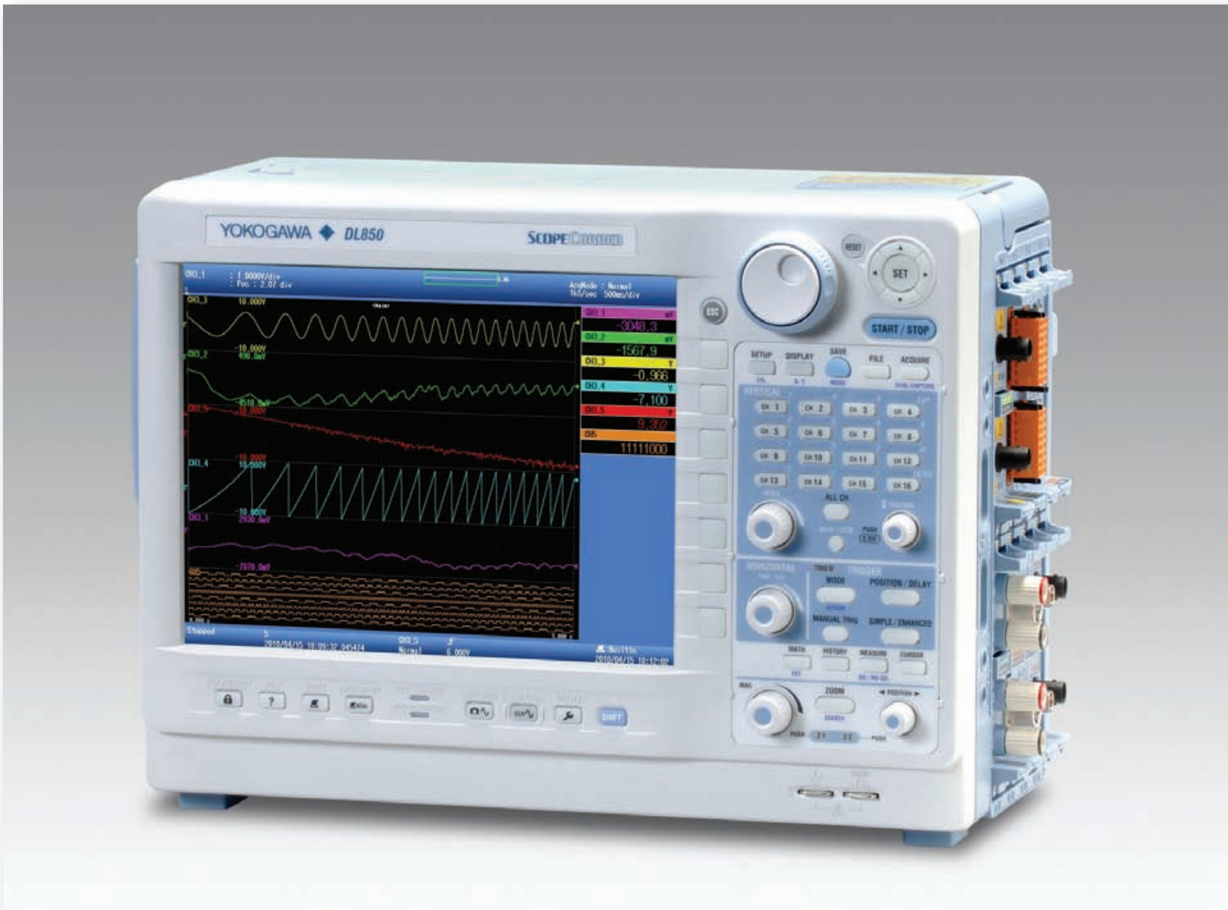


Figure 1: **The Yokogawa DL850 ScopeCorder signal waveform recording and measuring instrument**

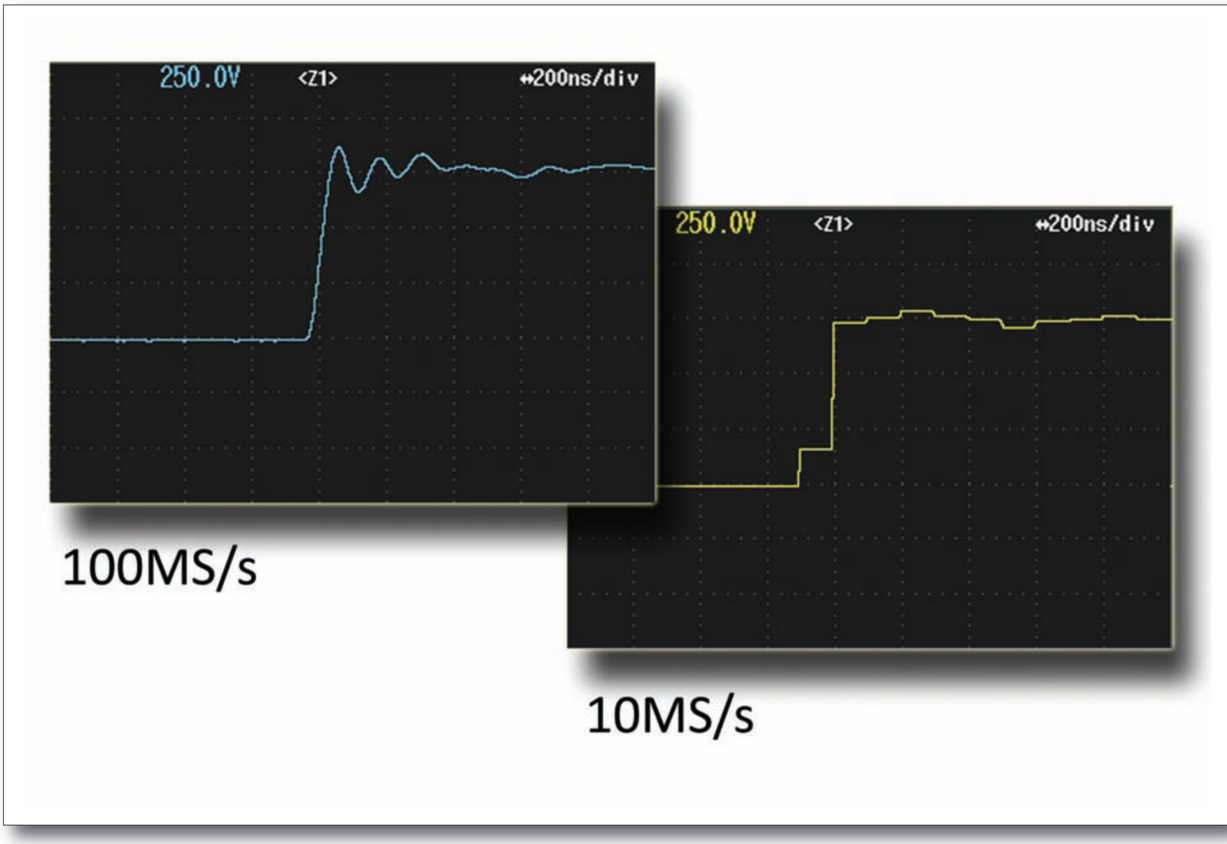


Figure 2: Comparison of measured inverter pulse waveforms using 100MS/s and 10MS/s sampling

laser diode is extremely high, large amounts of data can be transferred on a single device, and as a result the area of isolation becomes very small. Also, because optical fibre itself is an insulator, and the distance of signal transfer along the optical fibre is sufficient to provide the appropriate insulation, an insulating distance between the signal input and the main unit is provided even at a high voltage of 1kV. Using isoPRO technology, it becomes possible to package two channels of 100MS/s, 1kV high withstand voltage isolation measurement circuits in a compact module measuring approximately 100mm _ 200mm.

Figure 2 shows a pulse waveform of an inverter signal using this module. On the left is the measured result at 100MS/s, and on the right is the result using the predecessor 10MS/s module. It is clear that measurements with the 100MS/s high-speed isolation module provide more pulse details.

A further benefit of this technique is that it provides excellent noise rejection. Because the high voltage of inverters is switched at high speed, noise is necessarily introduced along the path of measurement. In the high-voltage isolation module, however, excellent noise rejection performance results in good CMMR (common-mode rejection ratio) values and also means that the floating voltage switching waveforms which are typical for inverters and devices such as IGBTs can be captured with high precision.

Moreover, using on-board analysis tools like cursor and waveform parameter measurements provides direct insight into the behavior of the total system. This combination of features contrasts with the limitations of a standard oscilloscope, which typically offers limited channel count (often only four inputs), 8-bit resolution, non-isolated inputs, no high-voltage inputs and limited memory.

Applications

In Europe, ScopeCorders are now being used for power-inverter testing in wind power development, but they have also found application in the areas of field service and maintenance. A typical field application is looking for voltage drops or transients, for which the ScopeCorder can be set up with special trigger conditions. For example, a special AC power-line trigger can be set so that, in the event of a voltage drop or glitch, the instrument will trigger on that glitch and capture that event. In this case the instrument will capture not just the basic voltage signal but also other parameters like current, temperature, turbine speed and logic control signals. As the ScopeCorder has the ability to bring all signals together in one measuring device incorporating on-board analysis tools, this will give easier and quicker insight into the cause of this transient event.

In this way, the ScopeCorder is being used as a tool to map the total behavior of the alternative energy source and its components.

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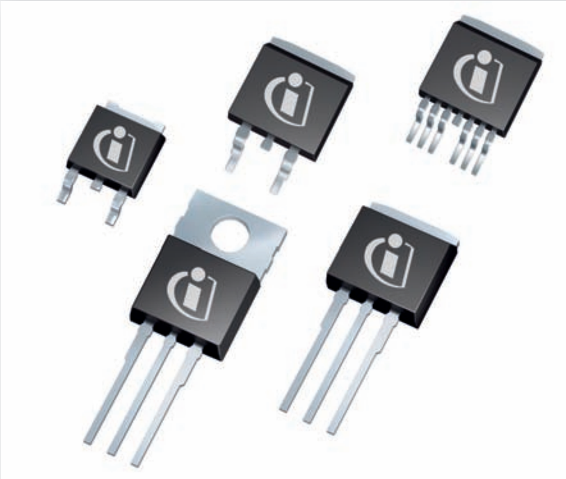


40V OptiMOS at Rutronik

The latest 40V OptiMOS™-T2 product family from Infineon offers best-in-class on-resistance (max. 0,98mΩ at $10V_{gs}$) and highest package current capability up to 100A in TO252-3, and up to 180A in TO263-7 for automotive motor and load control. The new single N-Channel 40V MOSFET product family in OptiMOS-T2 technology is available at distributor Rutronik now. All devices are fully automotive qualified to ACE grade and moisture sensitivity level 1. Due to lowest switching and conduction power losses they provide highest thermal efficiency. Optimized total gate charge enabling smaller driver output stages. The OptiMOS-T2 40V is targeted at all kinds of high-current motor control applications in 3-phase, H-bridge and half-bridge configurations - especially in combination with PWM. The power MOSFETs are available in all standard packages including TO252-3, TO263-3, TO263-7, TO262-3 and TO220-3.

www.rutronik.com

Shunt Isolator for Traction Applications

LEM introduces the DI series/Shunt isolator to enable high-accuracy current measurements in rail traction applications. DI Series transducers measure to a high degree of precision the very small voltages developed across low-resistance ohmic shunts in the primary power conductors feeding rail traction motors, spanning ranges of 30 to 200mV RMS. The DI series has specifically been designed to meet the provisional EN50463 standard for on-board energy monitoring. When used with a shunt Class 0.2 accuracy, the DI reaches the required Class 1R accuracy. The DI can then be part of the measurement chain of any on-board energy meter, as a key element in the recording of energy consumed (or returned to the supply under regenerative braking), according to the standards set out in the provisional standard. Coupled to a shunt used for current measurement, the DI provides necessary voltage insulation (withstanding 18.5kV RMS/ 50 Hz,/ for 1 minute as insulation test voltage) that is essential in networks up to 3000V.

DIs can easily be added to any existing shunts already mounted into the application when insulated operation is necessary. With a low current consumption of 25 mA, a frequency bandwidth of 10 kHz, LEM's DI shunt isolator meets the demands of modern rail systems and fulfils all new EMC requirements.

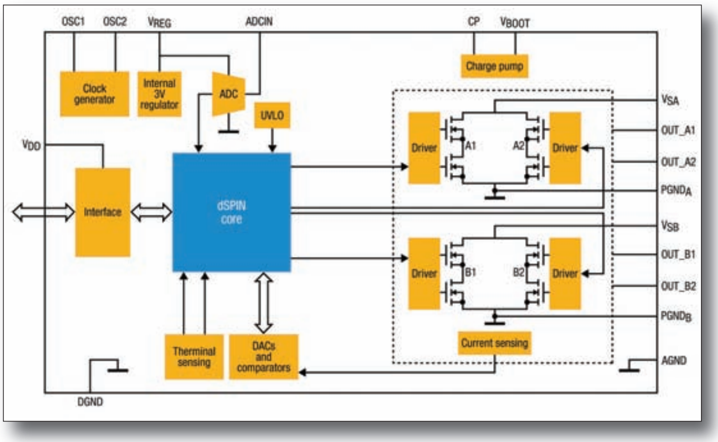
www.lem.com

Increased Power Density for MiniSKiiP

With an area of 59mm x 52mm and an overall height of 16mm, the MiniSKiiP(r) IPM from SEMIKRON is at least 50% smaller than conventional intelligent power modules in this power range. The connection technology allows for the development of compact inverters up to 15kW and reduced production costs. To achieve the high power density the power semiconductor chips and the DCB are thermally connected to the heat sink by way of an efficient pressure contact system without a base plate. The integrated SOI driver is mounted directly onto the DCB and connected to the gate terminals of the power transistors by short conductor lines via optimised gate resistors. These short connections ensure harmonious switching behaviour and reduce electromagnetic interference. As a result, less complex protection measures are needed to comply with the electromagnetic compatibility requirements. The short paths result in low parasitic inductances, which in turn mean lower over-voltages in the module, allowing for higher DC link voltages and greater efficiency. The MiniSKiiP IPM module and the power circuit board are mounted to the heat sink using a single standard screw. The entire power, gate and auxiliary connections are made by way of pressure contacts to the PCB rather than soldered contacts. This allows for quick and cost-reduced assembly. The 1200V 6-pack MiniSKiiP IPM has a high-voltage driver IC and features Trench-Field-Stop IGBTs, which are optimised for low switching losses and high current densities. At a rated current of 61A, an output power of up to 15kW is possible. 600V Converter-Inverter-Brake versions are also available.

www.semikron.com

Single-Chip Stepper Motor Controller

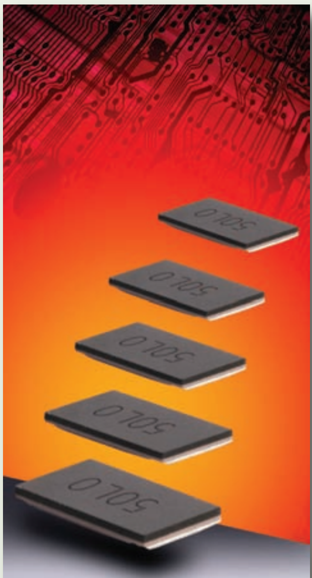


Motor drives up to 100W for security cameras, cash dispensers, ticketing machines, stage-lighting, printers and vending machines can now be realized more quickly, at lower cost and higher performance by using a complete motor-control system on a chip introduced by STMicroelectronics. The dSPIN™ combines all the necessary digital control, analog measurement, and power electronic circuitry for controlling stepper motors using ST's advanced BCD fabrication process. Implementing the motor-control calculations in hardware simplifies software design by requiring only acceleration, deceleration, speed and target position commands from the application microcontroller. This frees microcontroller resources to support other features. In addition to increasing integration the dSPIN ensures smooth movement of the motor by using a voltage-mode control algorithm allowing for full digital control, feeding the motor phases with an accurate sinusoidal waveform and resulting in position resolution of 128 microsteps per step. Other advantages include reduced resonances, mechanical noise and low-speed vibration, as well as reduced speed and torque ripple at low speeds. dSPIN (part number L6470) is available for full production in the thermally enhanced HTSSOP28 package (L6470H), priced at $4.50 in quantities of 1000, and will be available in PowerSO36 packages within the first half of 2011.

www.st.com

Automotive Power Inductor

Despite its small size, the new LPC4545 power inductor from KOA offers low DC resistance and allows high current rating in a package of 4.1mm x 4.6mm. Its construction is optimized for solderability and robustness. The new product is available in inductance values from 1µH up to 1.500µH with tolerances down to ±10%. Automated visual solder inspection of the side electrodes is possible. The operating temperature up to +125°C makes the LPC4545 it available for a broad range of applications, e.g. DC/DC converters, electric window and mirror contoller, LED lighting or car multimedia.



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Influence of Stray Inductance on High-Efficiency IGBT Based Inverter Designs

Loss reduction for better energy efficiency is one of the major aspects in advanced inverter designs. Development engineers are striving for technically best performing and cost effective solutions. State of the art power semiconductors, like the Infineon 1200V IGBT4, are one of the key elements to fulfill these requirements. Another important factor for loss reduction and high efficiency designs is the switching speed of power semiconductors which is influenced by the stray inductance of the different inverter solutions.

	IGBT[4] T4	IGBT[4] E4	IGBT[4] P4
E_{total} @ T_{vj}=150°C, L_s=20nH $E_{total}=E_{on}+E_{off}+E_{rec}$	80%	87%	100%
Softness: L_{smax} for soft turn off i.e. in 300A module @ T_{vj}=RT and V_{CE}=600V	55nH	80nH	>100nH

This article has been published in PEE 7/2010, pages 28 - 30. Unfortunately Table 2 on page 30 was accidentally mixed up with Table 1, so Table 1 appeared twice. For our readers convenience here the right table.

Co-Packaged IC/IGBT for Automotive DC/DC

The new AUIRS2191S 600V driver IC and AUIRGP50B60PD1 600V non-punch-through (NPT) IGBT from International Rectifier are intended for use in energy-efficient DC/DC automotive applications. The new devices feature fast switching speed and high power density making them well suited for use in high frequency DC/DC applications including high power DC/DC SMPS converters used in electric and hybrid electric vehicles. The AUIRS2191S dual channel 600V driver IC enables independent control of the high- and low-side in a half-bridge topology. The device provides up to +3.5A/-3.5A (source/sink) current capability with propagation delay times of 90ns (typical) making the switches highly responsive to driver command. The IC also features independent control of the high- and low-side to allow customization of dead time to minimize power loss and matched propagation delay on both channels. Operating junction temperature up to 150°C and under-voltage lockout for both channels are also offered. The IC features proprietary high-voltage integrated circuit (HVIC) and latch immune CMOS technologies to offer ruggedized monolithic construction. The output drivers offer a high pulse current buffer stage designed for minimum driver cross-conduction. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high-side configuration, operating up to 600V. The AUIRGP50B60PD1 600V NPT IGBT is co-packaged with a 25A ultra fast soft-recovery diode capable of operating at switching speeds up to 150kHz, making it an ideal substitute for MOSFETs in high power SMPS applications. The new automotive-qualified IGBT utilizes thin wafer technology, which ensures shorter minority carrier depletion time and hence faster turn-off.

www.irf.com

DC Link Capacitors for Drivetrain Inverters

Electronic Concepts have launched a series of DC Link High Current Film Capacitors specifically targeting the ever expanding Electric and Hybrid Electric Vehicle Market. Capacitance values range from 500µF to 1,000µF and voltage range is 450VDC to 1,000VDC. The capacitors have been designed to be capable of operating up to 200A RMS and maximum hotspot temperature of 110°C. The capacitors are compatible with the most commonly used IGBT-Modules. The compact designs allow for maximum volumetric efficiency and ease of mounting to the IGBT-Module. In addition to the standard product range, Electronic Concepts offers customised solutions on specific request.

www.electronicconcepts.ie

300mA Voltage Regulator

Ricoh Europe (Netherlands) has launched the R1191 with a three-mode operation and reverse current protection. In addition to the Chip Enabled (CE) pin, a new ECO pin has been added for selecting between three different operating modes. This feature is particularly suited to many modern applications with smart power management. The R1191 contains a reverse current protection circuit that prevents a backward current flow through the LDO, with Ricoh's enhanced solution addressing two different issues. First, it can block a reverse current flow through the LDO driver transistor (from output to input), preventing any possible damage to the LDO driver caused by a reverse current. It can also block a reverse current flow through the feedback resistors (from output to ground), with a maximum reverse current leakage of 100nA. An embedded fold-back current limit circuit decreases the output current in the case of a short circuit on the output to approximately 50mA, protecting the LDO and other electronic parts of the application from damage. It also includes thermal protection, with an internal sensor to detect operating temperature. In the event that the temperature reaches 150°C, the regulator will shut down to prevent further overheating. An auto-discharge function is an optional feature. It discharges the output capacitor quickly through an additional transistor connected between the regulator output and ground which is turned on once the LDO is disabled by the CE pin. For stable operation, small ceramic capacitors with low ESR and a minimum value of 4.7µF can be used.

www.ricoh.com/LSI/

Bare Element Current Sense Resistors

Stackpole Electronics' BR Series is an open element radial leaded current sense resistor that raises the element off of the PCB. This allows maximum heat transfer to the ambient air and lowers PCB temperatures as much as 20°C compared to similar molded or ceramic housed current sense resistors of similar size. This all welded design has very low inductance (less than 10nH), is flameproof, and offers current handling up to 70A. The BR Series is available in 1, 3, and 5W sizes, in tolerances down to 1% with TCR down to ±20ppm, and resistance values as low as 2.5mΩ. Pricing is size, resistance value, and tolerance dependent and ranges from $0.14 each to $.33 each bulk packaging of 1000 piece quantities.

www.seielect.com

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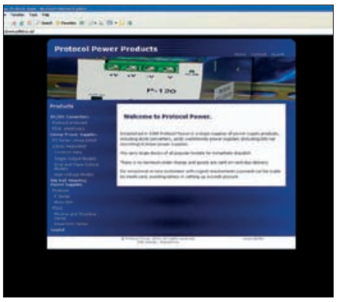

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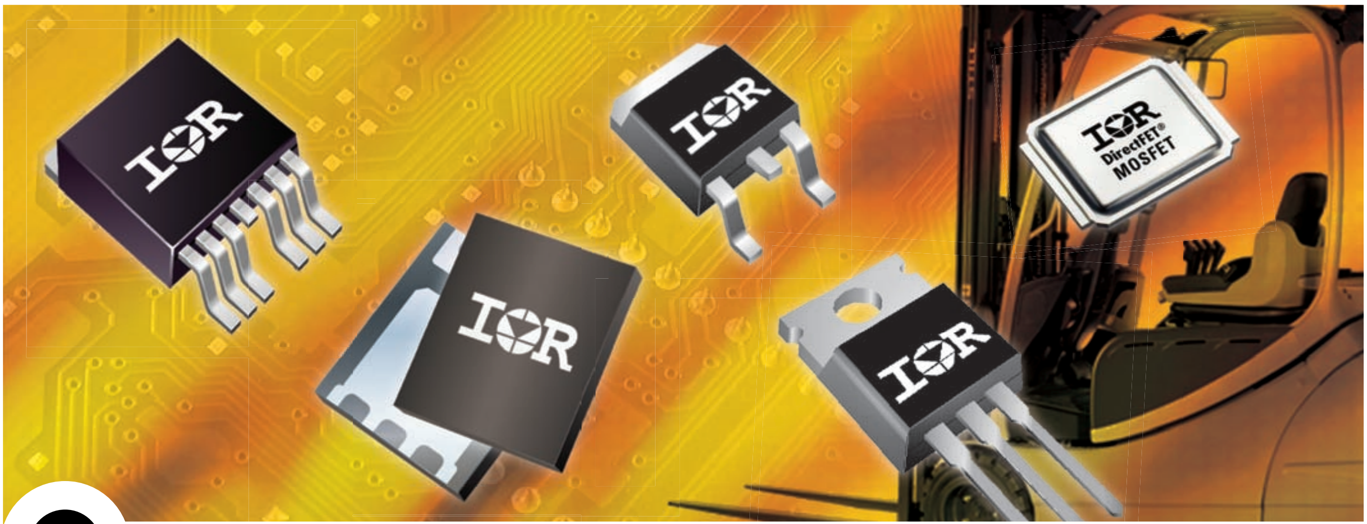

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IRFB3004	40	1.75	195	160	TO-220
IRFH5004	40	2.6	100	73	PQFN 5x6 mm
IRF7739L2	40	1	270	220	DirectFET-L8
IRFS3006-7	60	2.1	240	200	D^2PAK-7
IRFS3006	60	2.5	195	200	D^2PAK
IRFH5006	60	4.1	100	67	PQFN 5x6 mm
IRF7749L2	60	1.3	108	220	DirectFET-L8
IRFB3077	75	3.3	210	160	TO-220
IRFH5007	75	5.9	100	65	PQFN 5x6 mm
IRF7759L2	75	2.2	83	220	DirectFET-L8
IRFP4468	100	2.6	195	360	TO-247
IRFH5010	100	9	100	65	PQFN 5x6 mm
IRF7769L3	100	3.5	124	200	DirectFET-L8
IRFP4568	150	5.9	171	151	D^2PAK
IRFH5015	150	31	56	33	PQFN 5x6 mm
IRF7799L3	150	11	67	97	DirectFET-L8
IRFP4668	200	9.7	130	161	TO-247
IRFH5020	200	59	41	36	PQFN 5x6 mm
IRFP4768	250	17.5	93	180	TO-247
IRFH5025	250	100	32	37	PQFN 5x6 mm
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