POWER ELECTRONICS EUROPE

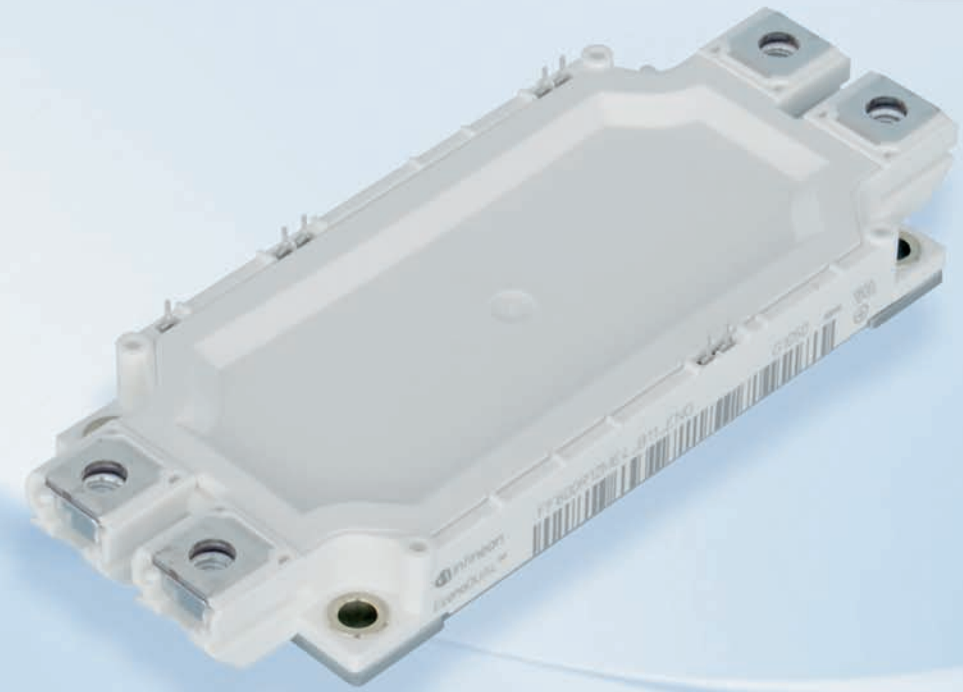
ISSUE 3 – April/May 2012 www.power-mag.com

POWER SEMICONDUCTORS

New SiC Thin-Wafer Technology Paving the Way of Schottky Diodes with Improved Performance and Reliability

THE EUROPEAN JOURNAL FOR POWER ELECTRONICS AND TECHNOLOGY

Also inside this issue



EconoDUAL™ 3 – Best in class

Highest Power Density with 600 A modules with 650 V / 1200 V / 1700 V IGBT4

The **'Best in class' EconoDUAL™ 3** portfolio with **new PressFIT** auxiliary terminals :

- FF600R07ME4_B11
- FF600R12ME4_B11
- FF600R17ME4_B11

The **EconoDUAL™ 3** modules key applications:

- Construction, commercial and agriculture vehicles
- High performance drives
- Wind applications

The **EconoDUAL™ 3** with optimized features:

- Improved switching characteristics
- Minimized thermal and electrical resistance
- Enhanced mechanical robustness
- PressFIT pins minimizes assembling costs and improves FIT rates

www.infineon.com/highpower

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

Production Editor Chris Davis
Tel: +44 (0)1732 370340

Financial Clare Jackson
Tel: +44 (0)1732 370340
Fax: +44 (0)1732 360034

Circulation Manager Anne Backers
Tel: +44 (0)208 647 3133
Fax: +44 (0)208 669 8013
Email: anne@abdatalog.co.uk

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

Armin Wezel
phone: +49 (0)30 52689192
mobile: +49 (0)172 767 8499
Email: armin@eurokom-media.d

Eastern US
Karen C Smith-Kernc
email: KarenKCS@aol.com
Western US and Canada
Alan A Kernc
Tel: +1 717 397 7100
Fax: +1 717 397 7800
email: AlanKCS@aol.com

Italy
Ferruccio Silvera
Tel: +39 022 846 716 Email: ferruccio@silvera.it

Japan:
Yoshinori Ikeda,
Pacific Business Inc
Tel: 81-(0)3-3661-6138
Fax: 81-(0)3-3661-6139
Email: pbi2010@gol.com

Taiwan
Prisco Ind. Service Corp.
Tel: 886 2 2322 5266 Fax: 886 2 2322 2205

Publisher & UK Sales Ian Atkinson
Tel: +44 (0)1732 370340
Fax: +44 (0)1732 360034
Email: ian@dfamedia.co.uk
www.power-mag.com

Circulation and subscription: **Power Electronics Europe** is available for the following subscription charges. **Power Electronics Europe**: annual charge UK/NI £60, overseas $130, EUR 120; single copies UK/NI £10, overseas US$32, EUR 25. Contact: DFA Media, Cape House, 60a Priory Road, Tonbridge, Kent TN9 2BL Great Britain.
Tel: +44 (0)1732 370340. Fax: +44 (0)1732 360034. Refunds on cancelled subscriptions will only be provided at the Publisher's discretion, unless specifically guaranteed within the terms of subscription offer.
Editorial information should be sent to The Editor, **Power Electronics Europe**, PO Box 340131, 80098 Munich, Germany.

Printed by: Garnett Dickinson.
ISSN 1748-3530

COVER STORY

New SiC Thin-Wafer Technology Paving the Way of Schottky Diodes with Improved Performance and Reliability

Silicon Carbide (SiC) Schottky barrier diodes (SBDs) have been on the market since more than a decade and sell today in millions of pieces per year, with proven quality in the field. The open SiC device market has exceeded $50 million in 2010 (excluding defense-related and R&D contracts) with an unexpectedly high penetration in the PV inverter segment where SiC Schottky diodes are now implemented in numerous systems, taking about 15% of the SiC device sales. PFC systems are still the top SiC device sales.

This confirms it as a mature technology, able to provide both full reliable and high-performance devices. Moreover, the increasing request for energy efficiency experienced in the last years is at the base of the constantly growing observed in many applications. Besides high-end server and telecom SMPS, where SiC SBDs have become a standard, increasing adoption is recorded mainly in solar inverters, motor drives and lighting. Our cover story presents the new thinQ!™ 5th Generation (G5) of SiC Schottky diodes from Infineon Technologies. In G5, both the capacitive charge and the forward voltage have been minimized through a new and exclusive production process. The improvements with respect to previous generations are discussed, with the support of direct application tests results. Full story on page 30.

Cover supplied by Infineon Technologies AG, Neubiberg, Germany

Looking at New Technologies

The largest PCIM ever will open on May 8 on Nuremberg fairgrounds with an extensive conference program and a great exhibition in two halls. The PCIM Europe conference together with the exhibition has evolved over the years as a major technical platform for discussing new developments within the field of power electronics in the conference seminars and demonstrating new achievements at the exhibition stands.

A range of new power devices based on Silicon and Wide Bandgap material such as Silicon Carbide (SiC) and Gallium Nitride (GaN) designed to meet the future requirements of power converters in terms of ultra high efficiency and high power density design will be discussed during the poster and oral sessions, particularly within PEE's Special Session "High Frequency Switching Technologies & Devices for Green Applications". According to market researchers, the GaN power device industry has probably generated less than $2.5 million revenues in 2011, as only two companies (International Rectifier & EPC Corp.) are selling products on the open market. However, the overall GaN activity has seen extra revenues as R&D contracts, qualification tests and sampling for qualified customers was extremely buoyant. At very short term, IRF and EPC will likely remain the two main vendors of GaN power devices on the open market in early 2012. This market is likely to stay below $10 million for devices, with the rest being made through R&D sales. But 2013 should signal the transition from qualification to production ramp-up for several new entrants. The device market could reach the $50 million threshold. In 2014, most of these new entrants will ramp-up their capacity, and by 2015 the availability and adoption of qualified 600V+ GaN devices should see the market grow very quickly, and open doors to non-consumer applications. If GaN is qualified in the EV/HEV sector, GaN device business could top the billion dollar line and the GaN-on-Si substrate market could exceed $300M revenues by 2019. While SiC power devices have been around for some years, GaN power semiconductors have only just appeared in the market. One of the key reasons for the promising outlook for GaN power devices is because GaN is a wide bandgap material which offers similar performance benefits to SiC but has greater cost reduction potential. This is possible because GaN power devices will be grown on a larger, lower-cost Silicon substrate. Six of the world's top ten discrete power semiconductor suppliers are planning to launch GaN power devices in the near future, and some may already be making devices for in-house end equipment. The open SiC device market has exceeded $50 million in 2010 (excluding defense-related and R&D contracts) with an unexpectedly high penetration in the PV inverter segment where SiC Schottky diodes are now implemented in numerous systems, taking about 15% of the SiC device sales. PFC systems are still the top SiC device sales. Although 6" SiC wafer capacity is now ramping-up for LED production at CREE, the power industry is not yet able to access it in volume.

This outlook is one of the reasons that PEE for the third time has organized a Special Session at PCIM 2012 on this subject. This Special Session on May 9 (10.00 - 12.30, Room Paris) is structured from lower up to high-power applications and will allow for direct comparison between technologies such as SiC and GaN, particularly at the final panel discussion with all presenters and auditorium. Five papers will be presented in this Special Session. The technical and electrical advantages of the AlGaN/GaN devices are understood and deployed successfully in RF application. To make these devices commercially successful for high voltage applications, also, new aspects needed to be considered. These aspects, which are of technical, topological and product strategical nature, are discussed and solutions are presented in the paper presented by MicroGaN (Germany). The current status of the development and current performance of the required 600 to 1200 V rated GaN on Si based devices at International Rectifier (USA) are presented in the second paper. From these results, it can be seen that high-voltage GaN based power devices can be expected to provide the same performance obtained using SiC devices, at a cost much closer to high performance Silicon based technologies. The design and performance of a 1 kW boost circuit based on a SiC BJT is presented by Fairchild in the third paper. Cree demonstrates in the fourth paper high-frequency high-power switching on the example of a single ended primary inductor (SEPIC) converter equipped with SiC MOSFETs. Tests were conducted at frequencies from 30 kHz to 300 kHz to provide a comprehensive loss comparison between the switches. Graphs will be presented showing optimum operating points that can be used as a guide in other hard switched power conversion applications. Finally, ABB Switzerland will give an insight in Opportunities and Challenges for Wide Bandgap Power Devices in Megawatt PE Applications. The goal of the paper is to understand and quantify the opportunities, but also the remaining challenges of using SiC in MW applications. An overview of the SiC technology status in connection to MW PE applications will be provided.

You are all invited to attend this Special Session and PCIM in general. Hope to see you there.

Achim Scharf
PEE Editor

GaN to Accelerate in 2013

The Gallium Nitride (GaN) power device industry has probably generated less than $2.5 million revenues in 2011, as only two companies (International Rectifier & EPC Corp.) are selling products on the open market. However, the overall GaN activity has seen extra revenues as R&D contracts, qualification tests and sampling for qualified customers was extremely buoyant.

At very short term, IRF and EPC will likely remain the two main vendors of GaN power devices on the open market in early 2012. This market is likely to stay below $10 million for devices, with the rest being made through R&D sales. "But 2013 should signal the transition from qualification to production ramp-up for several new entrants. The device market could reach the $50 million threshold. In 2014, most of these new entrants will ramp-up their capacity, and by 2015 the availability and adoption of qualified 600V+ GaN devices should see the market grow very quickly, and open doors to non-consumer applications. In 2015, 12-15 players will share the consumption of more than 100,000 x 6" (equiv.) epi wafers. Beyond that, if GaN is qualified in the EV/HEV sector, GaN device business could top the billion dollar line and the GaN-on-Si substrate market could exceed $300M revenues by 2019", stated Philippe Roussel, Power Electronics analyst at Yole Développement. "However, it is still unclear how car makers will choose between SiC, GaN or the current Silicon technology. At the substrate end, R&D activities are still quite fragmented between several options involving GaN-on-Sapphire, GaN-on-SiC, GaN-on-GaN, GaN-on-AlN and GaN-on-Silicon. Nevertheless, GaN-on-Si is likely to take a dominant position as 6" is now available with more than 7_m thick GaN epi and 8" is under qualification. 8" diameter availability is probably the parameter that will make this technology choice obvious".

A new trend is LED players now starting looking at this new business opportunity and wondering how to put in place a strategy of diversification to convert their existing extra LED capacity into power.

IMS Research expects the market for GaN power semiconductors to grow from almost zero in 2011 to over $1 billion in 2021. While Silicon Carbide (SiC) power devices have been around for some years, GaN power semiconductors have only just appeared in the market. One of the key reasons for the promising outlook for GaN power devices is because GaN is a wide bandgap material which offers similar performance benefits to SiC but has greater cost reduction potential. "This is possible because GaN power devices will be grown on a larger, lower-cost Silicon substrate", stated Senior Market Analyst Richard Eden. "The key market driver is the speed at which GaN-on-Si devices can achieve price parity with Silicon MOSFETs, IGBTs or rectifiers with equivalent performance. The speed of GaN transistor developments has accelerated in the last two years, possibly due to a realization that the market will be potentially huge. The launch of International Rectifier's "GaNpowIR" and EPC's "eGaN FET" devices started the low voltage market in 2010. The emergence of Transphorm and its 600V GaN transistors in 2011 created considerable interest in the prospects of GaN competing with high voltage MOSFETs and IGBTs. Six of the world's top ten discrete power semiconductor suppliers are planning to launch GaN power devices in the near future, and some may already be making devices for in-house end equipment".

However, IMS found that there are some barriers to main-stream market acceptance of GaN power devices. The first is availability, as few GaN transistors are available in mass production. Competing manufacturers' products are non-standard and there are no second-sources. Second, the technology lacks maturity so far. Overall device performance and GaN material defect rates need improvement. A third issue is design inertia; the need to educate customers about both the potential benefits of GaN and how to use the devices.

www.yole.fr
http://imsresearch.com

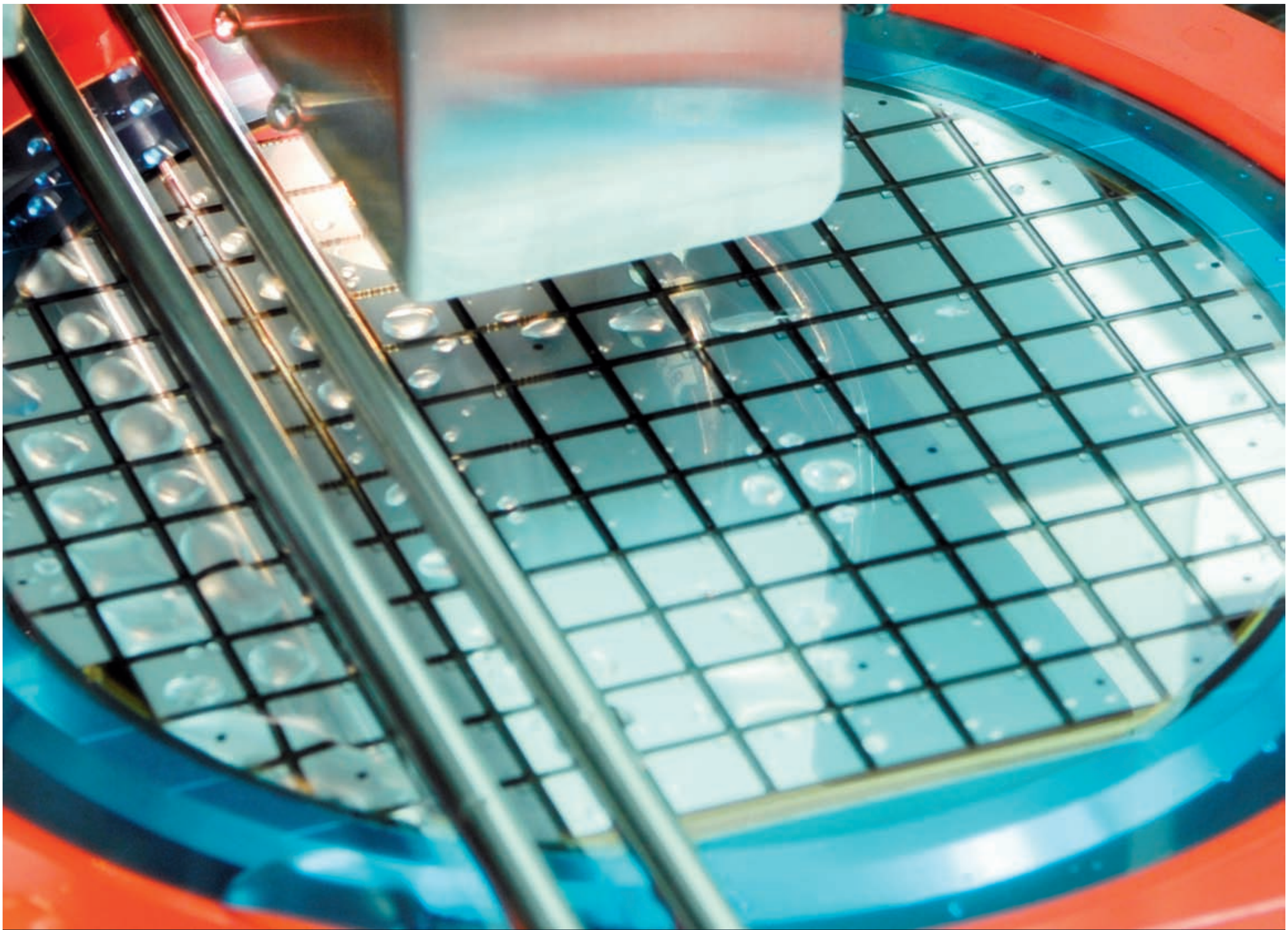
Wide Bandgap Semiconductor Alliance Founded

For a sustained support of research in wide energy bandgap semiconductor materials and technologies, Fraunhofer IISB in Erlangen, Germany, and LAAS-CNRS, Toulouse, France, initiated the foundation of the Wide Bandgap Semiconductor Alliance (WISEA). Including the Chair of Electron Devices of the University of Erlangen-Nuremberg, Germany, and CEMES-CNRS, Toulouse, France, the alliance covers all aspects of research and demonstrator development and makes the respective facilities available to third parties in cooperative projects. Power devices based on materials with a wide energy bandgap such as Silicon Carbide and Gallium Nitride show the capability to overcome the material-dependent limits of today's power electronic devices based on Silicon. Thereby, they will contribute essentially to the minimization of power dissipation.

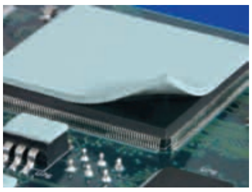
WISEA has access to a 1000 m² class-10 cleanroom in Erlangen, Germany, and to a 1500 m² class-100 clean room in Toulouse, France, dedicated to micro and nanofabrication. In particular for wide bandgap semiconductor materials and devices, specialized equipment is available to cover processing from epitaxy to metallization and packaging, including the fabrication of test structures and devices. Based on its experienced staff and state-of-the-art facilities, the alliance also offers advanced electrical and physico-chemical characterization as well as simulation and modeling from atomistic processes to the device level. The WISEA facilities are available for contract research as well as for third-party-funded collaborative projects.

WISEA acknowledges the initial support by the Federal Ministry of Education and Research (BMBF) of Germany and the Agence Nationale de la Recherche (ANR) of France within the Programme Inter Carnot Fraunhofer (PICF 2010) project MobiSiC.

www.iisb.fraunhofer.de, www.laas.fr

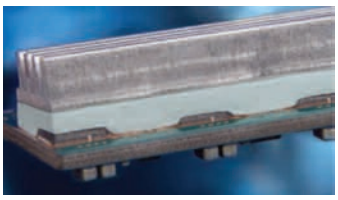


Solution: Bergquist S-Class Gap Pad® 5000S35


Gap Pad 5000S35's natural tack makes application clean and easy to handle.

Gap Pad 5000S35 is perfectly suited for high performance applications such as VRMs, BGAs and ASICs.

Bergquist's newest S-Class is the perfect combination of softness, low thermal resistance and high thermal conductivity. With a low bulk hardness (35 Shore 00) and high thermal conductivity (5.0 W/m-K) it conforms to demanding contours while maintaining its structural integrity. It is an ideal gap filling solution for applications with fragile components that can be damaged by harder materials that cause higher mounting pressure on components. Gap Pad 5000S35 is also an excellent solution for DVD drives, memory modules, and PC boards to chassis.


Excellent interfacing and wet-out makes GP 5000S35 ideal for fragile components with demanding contours and stack-up tolerances.

Ultra soft S-Class integrity offers easy application.

Gap Pad 5000S35 has a natural tack that eliminates the need for additional adhesive layers that can inhibit thermal performance. Its super soft, yet elastic nature provides excellent interfacing and wet-out, even to surfaces with high roughness or topography. Gap Pad 5000S35 features an embedded-fiberglass reinforcement that makes it puncture, shear and tear resistant. No tearing, flaking or crumbling – just clean and easy handling during the assembly process.

FREE S-Class swatch kit.

Visit our web site or call to qualify for your FREE S-Class swatch kit with product details.


FREE Gap Pad S-Class Swatch Kit

Call **+31 (0) 35 5380684** or visit **www.bergquistcompany.com/coolrun**

THE BERGQUIST COMPANY

European Headquarters - The Netherlands. Tel: EU +31 (0) 35 5380684 . D +49-4101-803-230 . UK +44-1908-263663

Thermal Materials • Thermal Substrates • Fans and Blowers

Powering Green Technologies

During fiscal year 2010 Infineon's revenue grew by over 50 percent; in the past year by a further 21 percent. To continue along this path, the company has expanded production capacity and has invested Euro 887 million - also in new manufacturing technologies. At the Annual General Meeting in March CEO Peter Bauer highlighted the recent achievements and gave an outlook on the role of power semiconductors in a changing world.

One example for progress in technology is the new 300-millimeter thin wafer manufacturing which enables us to produce power semiconductors far more cost effectively. A 300-millimeter thin wafer is thinner than a sheet of paper - ideal for power semiconductors, because this allows almost lossless conduction. In the meantime we have produced the first power semiconductor chips on a 300-millimeter thin wafer for testing purposes.

Asia is catching up very quickly - last but not least due to targeted government support particularly for products and applications. In Europe - especially in Germany - we are exposed to the risk of a substantial competitive disadvantage. We see this, for example, in regard to the electric automobile: The large markets are in Asia, the Japanese are the technology leaders, and government subsidies are much higher in Asia.

Asia - and China in particular - offers Infineon enormous market potential. In the past 2011 fiscal year, Infineon generated more than 40 percent of the Group's revenues in Asia. China alone accounted for almost 17 percent of revenue. For some products, such as IGBT switches for very high voltages and currents, China is already the largest single national market. The coming ten years will see rapid growth of China's middle class, with a corresponding increase in demand for goods containing semiconductors.

We Europeans have completely left the area of consumer electronics. In the telecommunications sector, we are nearly gone. We used to be technological leaders in both. Today, energy efficiency, mobility and security - these are global growth markets. The European Commission speaks of "key enabling technologies" as an important factor in global competition. Semiconductors are the key technology for electrical engineering. This, in turn, plays a central role for important German lead markets: alternative energy generation, power transmission, automobile production, mechanical engineering and plant construction.

The energy turnaround is one of the world's most pressing tasks. It is a matter of generating more electricity from wind, water and the sun. And to do so faster than we thought. Last March the world was alarmed by the terrible news from Fukushima. For me, nuclear power in countries like Japan or Germany was sufficiently safe, the lesser evil compared with fossil fuels. If all goes to plan, it produces cheap electricity and reduces the impact on the climate. However technology is good only as long as man can control it. It seems that there is no such thing as one hundred percent controllable nuclear power. That is the bitter lesson learned from Fukushima.

The energy turnaround is right. We have to get out of nuclear power and go into renewables more quickly. But we need more than solar and wind power stations for the energy turnaround. We need new lines to transport the power to where it is used. At present up to 10 percent of electric power is lost during transport. The answer to this problem: high-voltage DC transmission. Loss is minimized if direct current is transported at a level of up to 800,000 volts. However, the electricity has to arrive at the consumer's end as AC at 230 volts.

In particular, we have to encourage consumers to use energy efficiently and offer them the technical solutions to do so. We have not yet made enough headway on this front. The problem with the energy turnaround is not lack of intention, but lack of implementation. Two figures to add - a conventional power station uses chips worth about Euro 250,000. A modern offshore wind farm with the same output needs semiconductors worth about Euro 11 million - a factor 45!

In mobility semiconductors are to be found in express trains, metro trains, cars powered by combustion engines or electric motors, in hybrid cars, which have both, and in electric-powered two-wheelers. We are going to develop IGBT modules together with a major construction machinery manufacturer. These modules control electric motors driving the individual wheels of the construction machinery. Therefore there is no need for fault-prone gearboxes. Of course, the manufacturer's vehicles still have diesel engines, but they are used only for providing the electric motors with electric energy. The advantage of this technology is that each wheel can be driven individually in difficult terrain. The maneuverability is far greater than with conventional drives and the operational reliability is increased. Particularly when used in mines with tight bends, gearbox failure may lead to a breakdown.

www.infineon.com

"A conventional power station uses semiconductors worth about Euro 250,000, but a modern offshore wind farm with the same output needs chips worth about Euro 11 million", Infineon's CEO Peter Bauer points out

Power Integrations Acquires Swiss CT-Concept Technologie AG

Power Integrations has signed an agreement to acquire privately held CT-Concept Technologie AG (known as CONCEPT) for approximately 105 million Swiss francs in cash ($115 million).

Founded in 1986 and based in Biel, Switzerland, CONCEPT is a developer of highly integrated, drivers for high-voltage IGBT modules. The company's products are used in a range of high-voltage power-conversion applications including industrial motor drives, renewable energy generation, electric trains and trams, high-voltage DC transmission, electric cars and medical equipment. CONCEPT employs approximately 65 people and holds 14 patents with additional patents pending.

"CONCEPT's addressable market, already approaching $500 million, continues to expand with the growth in renewable energy, electric vehicles and high-efficiency industrial motors, and the efficiency of these clean technologies depends on cost-effective, efficient, reliable power electronics like CONCEPT's IGBT drivers. These dynamics make CONCEPT an extremely attractive business and an exciting addition to our company", commented Balu Balakrishnan, CEO of Power Integrations, this deal. Based on full-year 2011 results, he estimates that the acquisition will add approximately 10 percent to annual revenues, and expects the transaction to close during the second quarter of 2012.

CONCEPT's management team and employees will remain at the company's Biel headquarters, which will become Power Integrations' center of excellence for high-voltage driver design. Wolfgang Ademmer will continue as president of CONCEPT and will also become a vice president of Power Integrations. "As part of Power Integrations, we can strengthen our position in the value chain providing innovative driver technology compatible with all major IGBT module manufacturers", he stated.

www.powerint.com, www.igbt-driver.com

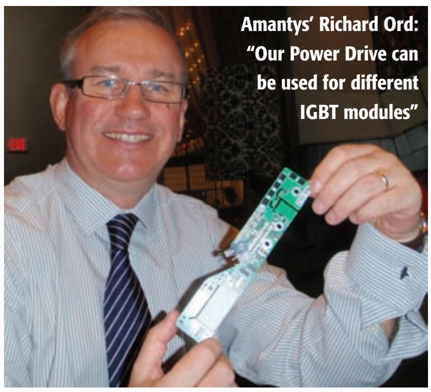
New Company introduces Gate Drive for 3.3 kV IGBT Modules

The Amantys Power Drive is a drop-in replacement for similar gate drive products. The gate drive is suitable for 2-level, 3-level and multi-level converters in a wide variety of applications and is capable of driving a range of IGBT modules from different manufacturers without gate resistor changes.

The single channel gate drive incorporates a number of system enhancements to deliver a compact solution. The Power Drive is configurable for various power modules and offers control of the rate of voltage and current change (dV/dt and dI/dt). It is compatible with existing drives due to same power and fibre-optic interfaces but offers improved characteristics for switching power modules from Infineon, Mitsubishi, Dynex and Toshiba. The Gate drive automatically detects the IGBT module. "As a new company with 15 employees in the power electronics industry, early customer engagement is vital to building relationships, earning recognition, and of course, building first revenues. By raising industry's expectations of a gate drive and how power is switched, this announcement paves the way for the intelligent power switch we're developing right now", said Marketing Director Richard Ord. To improve the efficiency and reliability of power switching a new approach is needed - tight control at the core of the system, right by the transistor; remote control and monitoring of the system from afar. "Our power architecture integrates all of these elements into a single intelligent power switch to deliver system control. This will prove critical in applications as diverse as renewable energy generation, data centre power supplies, and hybrid and electric vehicles", added CEO Bryn Parry. His comment on the PI/CT acquisition: "An acquisition such as this only reinforces the view that high power electronics is an area for increased focus, growth and opportunity. We will be interested to see how this will affect the appetite for IGBT manufacturers to seek out new and additional partnerships within the industry - as an independent supplier of power electronics products, we're very keen to develop such relationships".

The Power Drive will be shown first at PCIM Europe (booth 12-246).

www.amantys.com



Amantys' Richard Ord: "Our Power Drive can be used for different IGBT modules"

SEMIKRON Acquired Filter Company

SEMIKRON International acqired Nidecon, a manufacturer of technologically advanced power quality filtering solutions. The company’s head office is located in Vantaa (Finland). Since the foundation in 2006 Nidecon has striven to solve customer problems in modern power electronic applications, e.g. motor drives, high-speed applications and renewable energy systems.

Nidecon’s product portfolio includes LC/LCL filters, du/dt filters, common mode reactors and harmonic chokes for passive power factor correction. The current range covers 4 A to 2000 A.

SEMIKRON aims to integrate Nidecon’s power quality filters into power semiconductor solutions and to provide local production in the seven Solution Centers located in France, China, Korea, USA, Brazil, India and South Africa. “Nidecon s product range is quite complementary to our product portfolio”, said Dirk Heidenreich, CEO of SEMIKRON International GmbH. “It opens up new opportunities for the integration of power electronics components. New proprietary technologies enable Nidecon to reduce the typical filter size by 35 % to 50 %. Therefore, these innovated technologies are ideally suited for our power semiconductor solutions with integrated semiconductors, cooling, DC-link capacitors and driver electronics”. Prior to the acquisition, Nidecon was owned by the Finnish Industry Investment, the Finnish government-owned venture capital and private equity company and Power Fund I, a venture capital fund focusing on investing in renewable and distributed energy generation technology and energy-saving technology companies. The fund is managed by VNT Management.

www.semikron.com

“Nidecon’s filter products opens up new opportunities for the integration of power electronics components”, Expects SEMIKRON’s CEO Dirk Heidenrech

Electronics Manufacturing and Test Facility Opened in UK

The Manufacturing Technology Centre (MTC) has opened an electronics manufacturing facility that is unique in Europe - “a non production, production line”. The £2 million, dedicated electronics line, that provides end to end processing, will be used as a test bed for new processes by the UK manufacturing industry. The MTC is the result of a £40.55 million publicly funded investment and is housed in a landmark building located at Ansty Park near Coventry. There are four initial research partners: University of Birmingham, The University of Nottingham, Loughborough University and TWI Limited. There are three founding industry members: Rolls Royce, Airbus UK and Aero Engine Controls.

The electronics line is the first element of the MTC to be open for business. The MTC concentrates on assembly, fabrication and joining technologies, and forms a bridge between concepts emanating from academia and production scale manufacturing. “With input from founding member Aero Engine Controls we are focussing on the manufacture of high value, low volume circuit boards”, explained Clive Hickman, CEO of the MTC. “The manufacture of this type of circuit board is strategically important to the UK economy, due to its use in the defence, aerospace and automotive industries. Getting large volume manufacture right can be achieved by tackling the hidden variables causing process variations over time on a single product. The same is not true of low volume manufacture. At the MTC we can achieve high quality and yield, because our in-line monitoring allows us to capture the factors causing variation across multiple products. As we have the complete line, we can trace all the interactions and knock on effects. The user is then saved the great commercial cost of taking operational facilities offline to introduce a process innovation”.

The facility boasts cutting edge machinery and aims to be predictive of technology, enabling its users to try equipment out before investing in it themselves.

Selective processes feature the Mydata MY500 Solder Paste Jetting Machine, capable of stencil-less solder paste deposition driven directly from a CAD file. The MY500 even offers the potential to profile deposits. The Seho Powerselective machine represents the state-of-the-art in selective wave soldering to allow mixing of surface mount and conventional or through-hole components, without exposing the surface mount components to an extra thermal excursion. Amongst the inline monitoring equipment is the TRI TR7550 3D Automated Optical PCB Inspection machine, while fault detection is served by the DAGE XD7500 high resolution X-ray inspection machine. Capable of sub-micron resolution and oblique angle viewing, the XD7500 can help users to identify weaknesses in both their products and their processes.

www.the-mtc.org

MTC’s machinery enables users to try equipment out before investing in it

Power Electronics for a Greener World

PCIM
EUROPE

International Exhibition and Conference for Power Electronics, Intelligent Motion, Power Quality
Nuremberg, 8 - 10 May 2012

The largest PCIM ever will open on May 8 on Nuremberg fairgrounds with an extensive conference program. Having introduced the general topics as well as the seminars and tutorials in our previous issue, we now focus on the highlights of the conference - which also have an impact on the exhibition.

The PCIM Europe conference together with the exhibition has evolved over the years as a major technical platform for discussing new developments within the field of power electronics in the conference seminars and demonstrating new achievements at the exhibition stands. "We have once again this year seen an increase in the number and quality of papers submitted and selected the best and most important for inclusion in the program of oral and poster presentations. Special attention has been given to research carried out by young engineers; the presentation of the Young Engineers and Best Paper Awards at the opening ceremony ranks amongst the conference highlights", expressed General Conference Director Leo Lorenz.

A range of new power devices based on Silicon and Wide Bandgap material such as Silicon Carbide (SiC) and Gallium Nitride (GaN) designed to meet the future requirements of power converters in terms of ultra high efficiency and high power density design will be discussed during the poster and oral sessions, particularly within PEE's Special Session "High Frequency Switching Technologies & Devices for Green Applications" (see sidebar). "Many areas of application such as solar power systems, e-mobility, Smart Grids and multilevel converter topologies may open up new business fields as well as excellent job opportunities for both young and experienced engineers. Some major future challenges for the sector e.g. thermal management and reliability issues at both the component and system levels, managing parasitics and EMI resulting from ultrafast switching devices will be discussed in an open forum. High performance motor drives and advanced control circuits will also feature strongly at this year's meeting. The conference will address many of these topics. The key notes speeches are always a highlight of the event and this year will address smart energy distributed systems, solar power and power electronics in space applications. Three special sessions will be devoted to the current topical themes in the field of power electronics, such as the application of ultra fast switching devices, e-mobility and high performance motor control", Lorenz added.

Besides the three keynotes and special sessions 70 presentations will be given in Power Electronics, 29 in Intelligent Motion, 18 in the section Renewable Energy and Energy Management (formerly Power Quality), and finally 124 Poster Presentations. The latter are accessible for the exhibition visitors free of extra charge.

Opening and keynotes

Prior to the conference the opening ceremony will include the handing over of the awards for three young engineers and the best paper, the latter sponsored by PEE and Semikron.

The first keynote by Albert Crausaz, European Space Agency is entitled "Electrical Power Subsystem on Satellites". While space is using solar energy and batteries storage since decades, a short introduction on the constraints induces by the space environment is necessary to understand the specificities of the flown solution. The first part of the presentation will give a general overview of main space power converters topologies and the regulation principles. Alphabus, the newly-developed 22 kW payload telecommunication platform, will serve as the basis of the more concrete part of the presentation. The Alphabus batteries, solar arrays will be presented, but more emphasis will be

Leo Lorenz: "Power electronics opens new business opportunities, particularly at PCIM 2012"

Essential Link

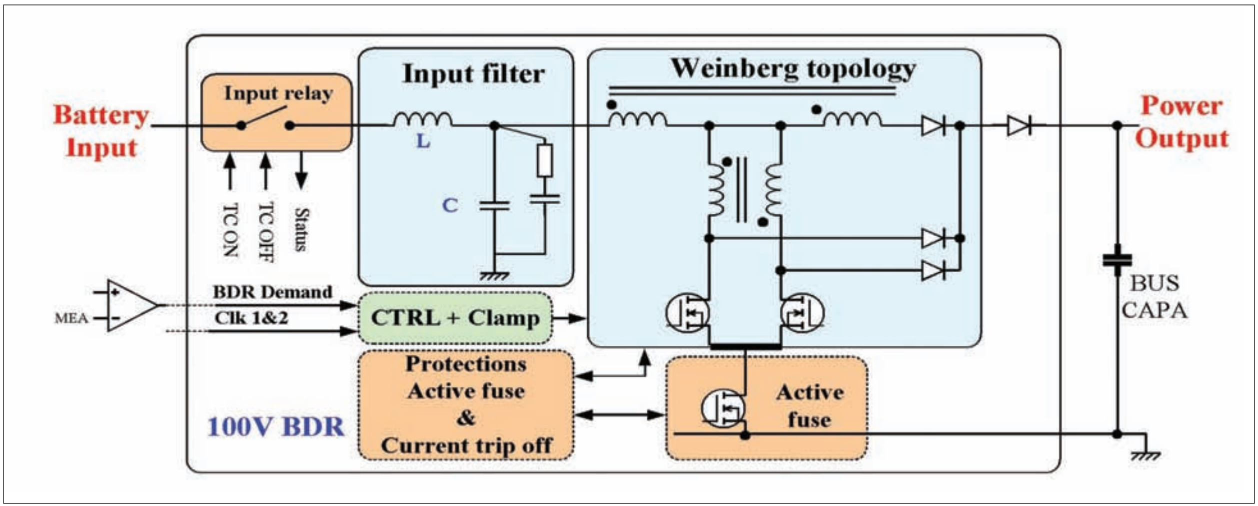
Proton-Electrotex, JSC
19, Leskova st., Orel, 302027, Russia
Tel: +7 (4862) 44 06 42
Fax: +7 (4862) 41 00 56
E-mail: sales@proton-electrotex.com

Linkedin

WWW.PROTON-ELECTROTEX.COM

PROTON-ELECTROTEX

Power semiconductor devices

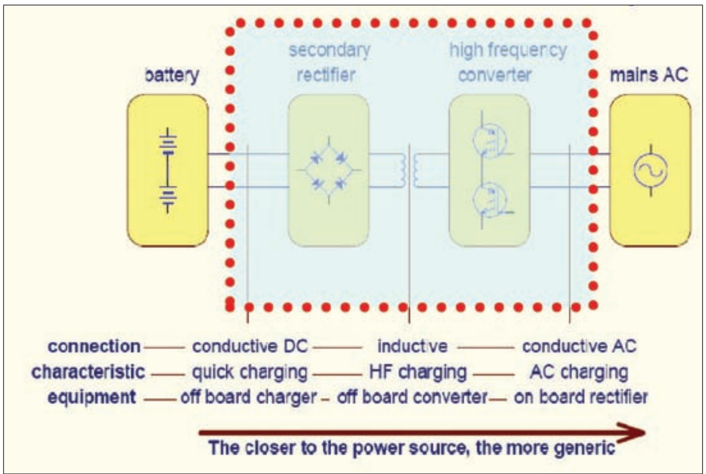


LEFT: Alphasat's main power regulator used in space applications Source: ESA/Astrium

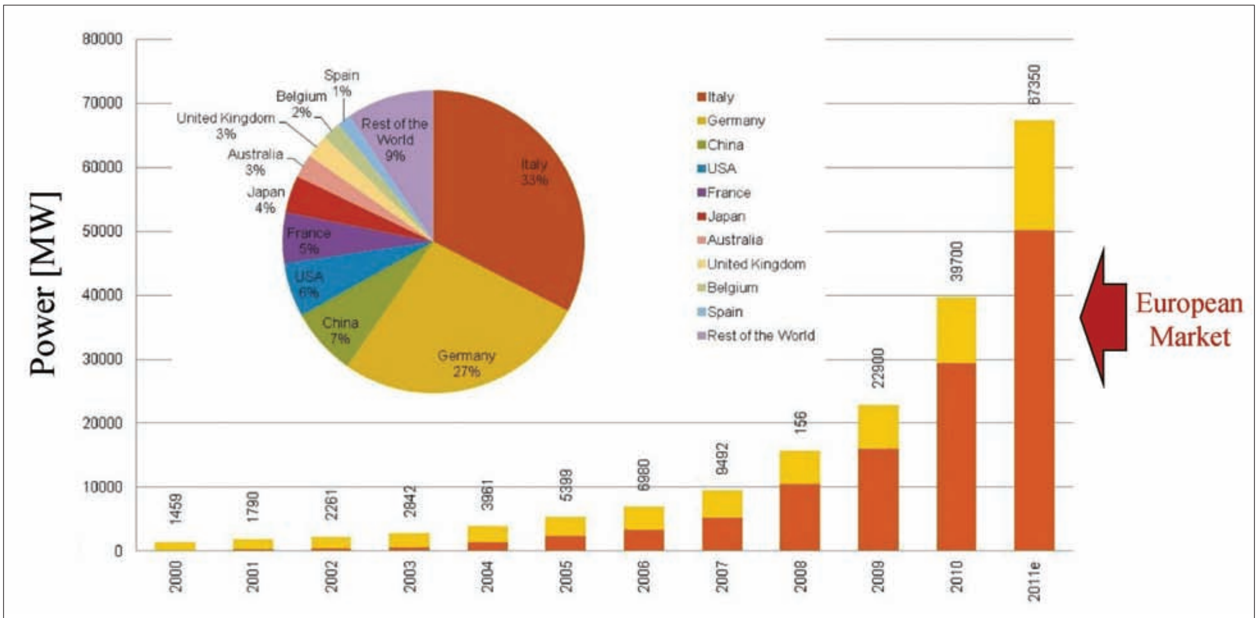
given on the main regulator and the achieved performances. Future developments in batteries and solar cells, and breadboard testing results of a GaN buck regulator will close this presentation, but open the door to future research and development activities.

The second keynote on May 9 by Peter Zacharias, University of Kassel entitled "Solar Power" adresses the recent and expected developments in the solar power market. It takes into account the changes within the market players but also the installed capacity and sizes of solar power plants and according consequences. The technical and economical market drivers are taken into account. The efficiency is not the most important selling argument anymore. Investment costs, balance of system and reliability of PV inverters influence the total cost of ownership and thus the profitability of an investment. Integration into the existing electric grid becomes more and more important. For example the limiting factor in the low voltage grid is usually not the current capability of the cables but the voltage constraints of the power supply region. Control of voltage and power flow is becoming more and more of interest and may result in a huge new market for power electronic applications.

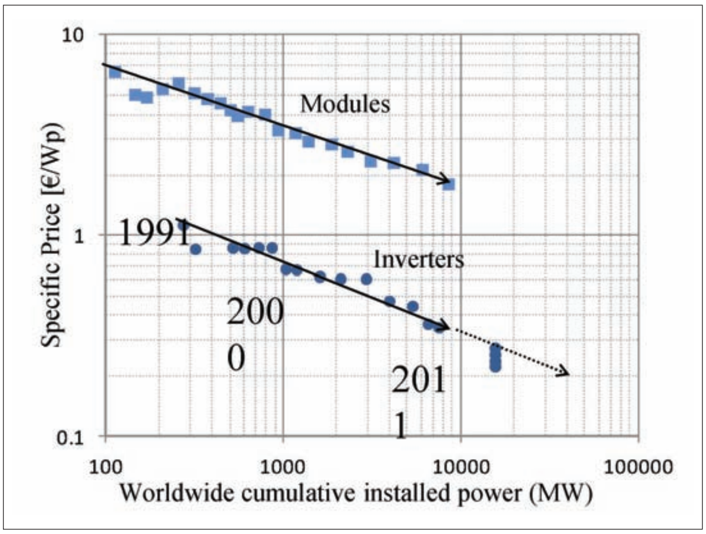
The third keynote on May 10 "Grid Integration of Renewables" by Frede Blaabjerg from Aalborg University covers the change-over to renewable energies. The global electrical energy consumption is still rising and there is a steady demand to increase the power capacity. It is expected that it has to be doubled again within 20 years. The production, distribution and use of the energy should be as technological efficient as possible and incentives to save energy at the end-user should also be set up. Two major technologies will play important roles to solve the future problems. One is to change the electrical power production sources from the conventional, fossil (and short term) based energy sources to renewable energy resources. Another is to use high efficient power electronics in power generation, power transmission/distribution and end-user application. This presentation will discuss some of the most emerging renewable energy sources, wind energy and photovoltaics, which by means of power electronics are changing character from being a minor energy source to be acting as important power sources in the energy system. Issues like technology development, implementation, power converter technologies,



ABOVE: Solving interfacing problems in e-mobility battery chargers



LEFT: Worldwide cumulative installed PV power Source: EPIA



Solar inverter and module "learning curves" Source: ISET

control of the systems, synchronization, anti-islanding, grid codes, system integration and future trends will be addressed in the presentation.

The Special Session "FPGAs in Intelligent Motion" on May 8 covers "FPGA Current Controller for Virtual Synchronous Machine", "Use of FPGA Model Based Design Flow for Motor Control on Servo Drives", "A Switching Control Strategy for the Reduction of Torque Ripple for PMSM", and "FPGA High Efficiency low Noise Pulse Frequency Space Vector Modulation".

The Special Session "E-Mobility - Battery Chargers" on May 10 cover papers on"Advantages and Challenges of Contactless Chargers", "A general overview of the need of the charging infrastructure and its integration in the smart grids", "DC Charging of Electric Vehicles - The Combined (Combo) Charging System as Universal Solution", "Batteries and SMART Batterymanagement", and finally "High Power DC Chargers for eMobility: Topologies, Requirements and Interconnectivity".

Outstanding presentations

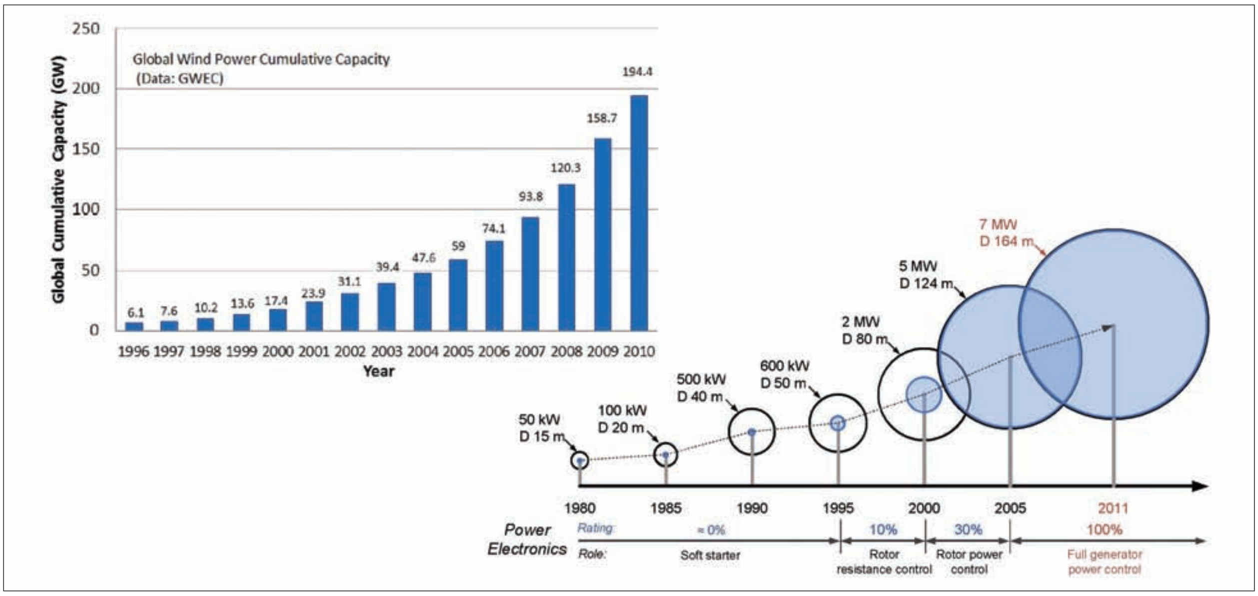
Out of the 70 Power Electronics presentations Technical Director Uwe Scheuermann had selected seven outstanding papers.

Toshiba presents with **"DTMOS-IV a $R_{DS(ON)}$ innovation by deep-trench filling superjunction technology".** The new 600V-class superjunction (SJ) MOSFETs: DTMOS-IV series feature lower on-state resistance by deep-trench filling process. The 30 % was attained by 27% of SJ pitch narrowing as compared with the DTMOS-III. In addition, better power efficiency was shown in PFC application by adjustment of $R_{DS(ON)}$*Q_{GD} designed to become compatible with DTMOS-III aiming at switching noise reduction, and 12% of output capacitance reduction.

Hitachi introduces a **"3.3kV High-Speed IGBT Module For Bi-directional and Medium Frequency Applications".** Optimized lifetime control of the internal power semiconductors lead to drastically decrease (40 %) of both of turn-off and recovery loss. This high speed characteristic is suited for bi-directional and high frequency applications such as resonant DC/DC converter. Recovery behavior at resonant DC/DC converter modeled cuircuit is demonstrated.

STMicroelectronics presents with **"Direct Comparison among different technologies in Silicon Carbide"** the first ST SiC prototype MOSFET, a normally-off SiC JFET and a SiC BJT. The analysis will compare their static and dynamic parameters with a special focus on each device driving requirement. It will be showed that, despite the higher R_{on}*A values, the SiC MOSFET exhibits superior dynamic performances and a very simple drive approach versus the other two competing devices. Thus the 1200V SiC MOSFET is the preferred option when dynamic performances become crucial in the power conversion context.

Rohm's paper **"Ultra low Ron SiC Trench devices"** presents SiC Schottky diodes and MOSFETs with trench structures. Firstly SiC Schottky diodes with newly developed trench structure successfully showed the lower forward



Worldwide cumulative installed wind power and turbine trends Source: GWEC

voltage drop than conventional SiC diodes while keeping the leakage current at acceptable level. Secondly, SiC MOSFETs with double-trench structure was developed. The new structure effectively reduced the highest electric field at the bottom of the gate trench which caused oxide destruction, thus robustness of the device has improved.

The paper **"Power Cycling Capability of New Technologies in Power Modules for Hybrid Electric Vehicles"**

presents some results of the joint research project "Electric Components for Active Gears (EfA)". The cooling of the power electronics is done by the cooling circuit of the combustion engine, which can reach temperatures up to 120°C. Therefore, the maximal junction temperature must be up to 200°C. Main challenge is the power cycling capability. With improved packaging technologies, this requirement can be fulfilled. Systematic power cycling tests to address different failure modes and to evaluate the improvement capability were executed. A capability of improvement of power cycling lifetime of a factor of 100 was found.

Semikron and Heraeus jointly present **"Al-Cladded Cu Wire Bonds Multiply Power Cycling Lifetime of Advances Power Modules".** The lifetime of classical power module design is limited by two major end-of-life failure mechanisms: solder fatigue and wire bond degradation. Advanced interconnection technologies as Ag diffusion sintering or transient liquid phase bonding techniques have been introduced as a replacement for the conventional chip solder interface to the DBC substrate. Experimental evidence has been presented, that diffusion sintering eliminates the impact of solder fatigue and allows exploiting the advantages of improved wire bond geometries. Still, the wire bond interconnection remains the main lifetime limiting factor. The replacement of Al wire bonds by Cu wire bond was proposed to increase the module lifetime. However, this technique requires the transit from Al surface metallization to Cu contacts, which implies considerable challenges to the chip technology. Implementing Cu wires with a cladding of Al is compatible with standard chip technology and allows multiplying the reliability of power modules without the need for Cu contacts on chips.

The University of Rostock has investigated the **"Short-circuit behavior of diodes in voltage source inverters".** Short-circuit ruggedness is an important feature of IGBTs in voltage source inverters. Besides the IGBT, also the freewhelling-diode can be exposed to a short-circuit situation. The short-circuit behavior of the diode strongly depends on the switching state of the ntiparallel IGBT. In this paper, the two different short-circuit types of diodes are discussed and the difference to the normal reverse recovery is explained. For the first time, the short-circuit type IV stress for diodes after a very short conduction time is experimental evaluated. **AS**

Special Session "High Frequency Switching Technologies & Devices for Green Applications"

PEE's Special Session on May 9 (10.00 - 12.30, Room Paris) is structured from lower up to high-power applications and will allow for direct comparison between technologies such as SiC and GaN, particularly at the final panel discussion with all presenters and auditorium.

Let's first have a look on the market. SiC device makers now offer the two most expected devices in the power electronics industry: the diode and the transistor. 2011 was the year of the first SiC MOSFET introduction with simultaneous offers from Rohm (Japan) and CREE (USA). These devices are used in real systems (air conditioners, motor drives, PV inverters) and significant effort is being directed toward the packaging side to capture all the added-value of the SiC (high temperature and high frequency operating). According to Yole Developpement (November 2011) the open SiC device market has exceeded $50 million in 2010 (excluding defense-related and R&D contracts) with an unexpectedly high penetration in the PV inverter segment where SiC Schottky diodes are now implemented in numerous systems, taking about 15% of the SiC device sales. PFC systems are still the top SiC device sales. Although 6" SiC wafer capacity is now ramping-up for LED production at CREE, the power industry is not yet able to access it in volume. Yole Développement expects 2012 to be the starting point for a wide diffusion of this 150mm substrate that should act as an incentive for the remaining reluctant companies, arguing that SiC wafers are not compatible with their existing tool-kit.

The Gallium Nitride (GaN) power device industry has probably generated less than $2.5 million revenues in 2011, as only two companies (International Rectifier & EPC Corp.) are selling products on the open market. However, the overall GaN activity has seen extra revenues as R&D contracts, qualification tests and sampling for qualified customers was extremely buoyant. IMS Research expects the market for GaN power semiconductors to grow from almost zero in 2011 to over $1 billion in 2021. While Silicon Carbide (SiC) power devices have been around for some years, GaN power semiconductors have only just appeared in the market. One of the key reasons for the promising outlook for GaN power devices is because GaN is a wide bandgap material which

The path of least resistance is through our new high efficiency XAL/XFL inductors

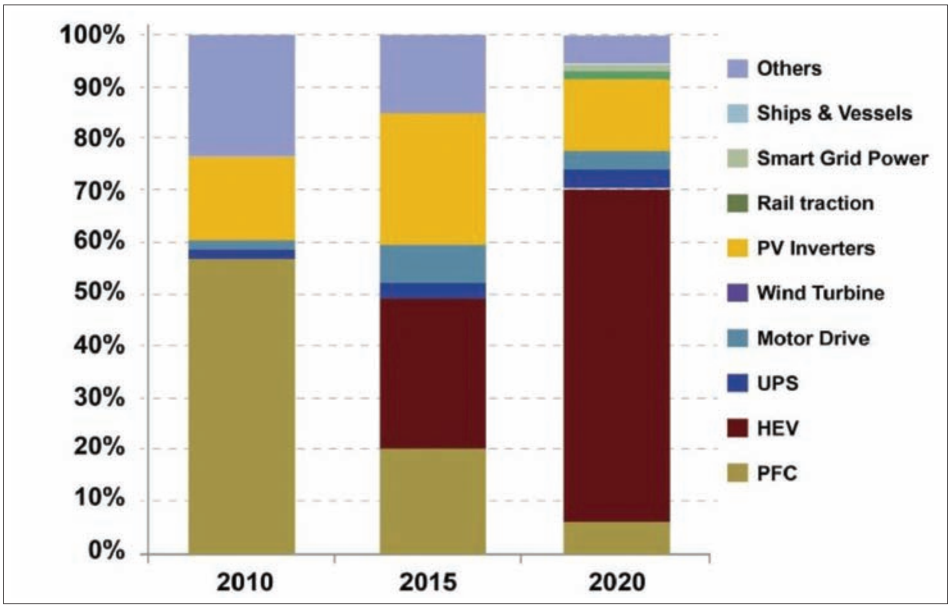
Compared to competitive parts, current zips right through our new XAL/XFL inductors.

Their DC resistance is significantly lower than other inductors of the same size. So your batteries last longer and your power supply runs cooler.

They easily handle large peak current, and their soft saturation characteristics often let you use a smaller size part without fear of overloading during transients. Built from a uniquely formulated material, XAL/XFL parts do not have the same thermal aging problems as some competitive parts.

See all the advantages of these new high efficiency inductors. Visit **coilcraft.com/xal.**

Competitors' 4.7uH inductors have much higher DCR per mm³ than Coilcraft's XAL5030.



SiC power applications relative to the year 2010
Source: Yole Developpement

offers similar performance benefits to SiC but has greater cost reduction potential.

Five papers will be presented in this Special Session.

Fist is entitled **"Efficient Power Electronics for the Price of Silicon - 3D-GaN Technology for GaN-on-Silicon"**, by Ertugrul Sönmez, MicroGaN, Ulm, Germany.

Today, the technical and electrical advantages of the AlGaN/GaN devices are understood and deployed successfully in RF application. To make these devices commercially successful for high voltage applications, also, new aspects needed to be considered. These aspects, which are of technical, topological and product strategical nature, are discussed and solutions are presented in this paper. From MicroGaN's perspective, today 4-inch GaN-on-Silicon wafers with the appropriate epi layer thickness are available, which make 600V devices feasible. The material quality improvements in 6-inch GaN-on-Silicon is closely monitored and it is a matter of homogeneity progress in the epi quality and thereby a matter of yield improvement to switch to 6-inch utilization. In order to enable commercialization with a smaller wafer diameter, MicroGaN developed a new technological approach, which cuts die size for given performance into half at least.

The second paper **"High Speed Switches for Green Energy"** will be given by Michael A Briere, ACOO Enterprises LLC, under contract to International Rectifier, Scottsdale, USA.

The major advantages of higher efficiency at higher density for GaN based power devices for use in conversion circuits such as AC/DC power supplies or DC/AC inverters for distributed power generation (eg photo-voltaics) are reviewed. Device models for GaN based HEMTs are presented and compared to measured characteristics. Results of mixed-mode models of various power conversion circuits including the DC/AC inverters used for solar cell arrays are presented and compared to measured data. The current status of the development and current performance of the required 600 to 1200 V rated GaN on Si based devices at International Rectifier are presented. From these results, it can be seen that high-voltage GaN based power devices can be expected to provide the same performance obtained using SiC devices, at a cost much closer to high performance silicon based technologies.

The third paper **"Silicon Carbide BJTs in Boost Applications"** will be presented by Anders Lindgren, Fairchild Semiconductor, Kista, Sweden.

In boost DC/DC converters, typically used in PV inverters and PFC circuits, increased switching frequency make a big impact on both size and cost. SiC bipolar junction transistors (BJTs) offer low loss high speed switching combined with low conduction losses, which enables higher switching frequency and maintains high efficiency. A SiC BJT was fabricated and packaged into an industrial standard TO-247 package. The high critical field strength of silicon carbide gives the possibility to have that low saturation voltages without driving the transistor into hard saturation. The design and performance of a 1 kW boost circuit based on the SiC BJT is presented in this paper.

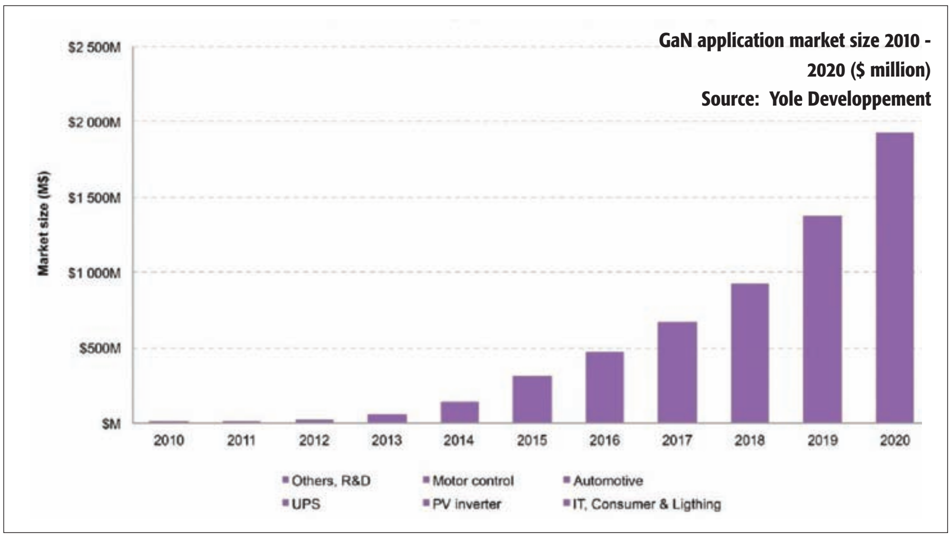
The fourth paper investigates **"Comparative High Frequency Performance of SiC MOSFETs Under Hard Switched Conditions"** by Bob Callanan, Cree, Durham, USA.

The SiC MOSFET was demonstrated by Cree and first results were presented at PCIM 2011. This demonstration showed the SiC MOSFET at 10kW switching at 32 kHz. Many applications require higher operating frequency therefore evaluating the performance of the SiC MOSFET and its comparative silicon switches is highly desirable. The first 10 kW demonstrator was a half-bridge buck-derived DC-DC converter with the output current being recirculated to the input voltage link thus avoiding the need for a high power load and providing a capability to directly measure overall system loss. Operation at higher frequencies was not practical due to the limitations of the transformer windings; proximity and skin effect losses became prohibitively high. The single ended primary inductor (SEPIC) converter now chosen provides the ability to buck and boost without inverting the output voltage thus making it a natural candidate for this application.

Tests were conducted at frequencies from 30 kHz to 300 kHz to provide a comprehensive loss comparison between the switches. Graphs will be presented showing optimum operating points that can be used as a guide in other hard switched power conversion applications.

Finally, Iulian Nistor, ABB Switzerland Ltd., Corporate Research, Dättwil, Switzerland, will give an insight in **Opportunities and Challenges for Wide Bandgap Power Devices in Megawatt PE Applications.**

Silicon based semiconductors, packages and system topologies are continuously improving towards achieving higher power, efficiency, reliability and controllability. Wide bandgap materials such as Silicon Carbide have been proposed for a long time as enablers of future power semiconductor technologies, but their acceptance in Megawatt Power Electronic applications has remained challenging until now. The goal of the paper is to understand and quantify the opportunities, but also the remaining challenges of using SiC in MW applications. An overview of the SiC technology status in connection to MW PE applications will be provided. **AS**



GaN application market size 2010 - 2020 ($ million)
Source: Yole Developpement

Welding Diodes with Increased Thermocycling Capability

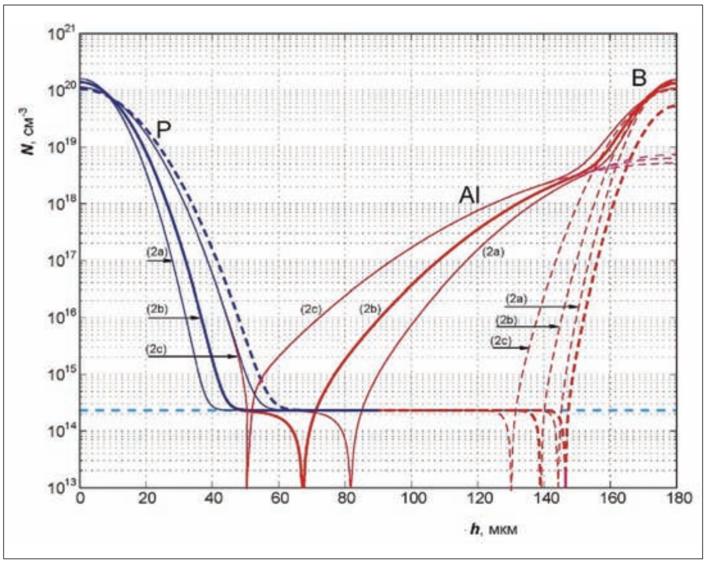
Proton-Electrotex extends the line of welding diodes in disk housing. Welding diodes are mostly used for resistive welding machines. Nowadays there is a huge demand in diodes with higher current capability to reduce the number of paralleled devices.

The operating peculiarities of diodes in welding machines are flashing short-time cycles, which lead to temperature increase of the semiconductor element, and its further cooling in conjunction with limitation on running time of welding machines ("heating-cooling" mode). As a result, the devices are continuously thermomechanically stressed. The key characteristics are non-repetitive peak surge current, operation time and rest time. All of these set strict conditions to static and dynamic characteristics of devices. Due to uneven distribution of pressing force and discontinuity of contact surfaces metal coating, some local smelting rates of the semiconductor element can occur.

Welding diodes produced by Proton-Electrotex

Local smelting of the welding diode element

Silver sintered welding diodes



Distribution of dopant atoms of phosphorus (blue curves), barium and aluminium (red curves) according to the standard technology (bold dashed lines) and in test sample 2 according to simultaneous acceleration of barium, aluminium and phosphor

For further development in the following directions

- increase of average direct current flowing through the device;
- increase of resistivity to electric thermocycling;
- decrease of static losses

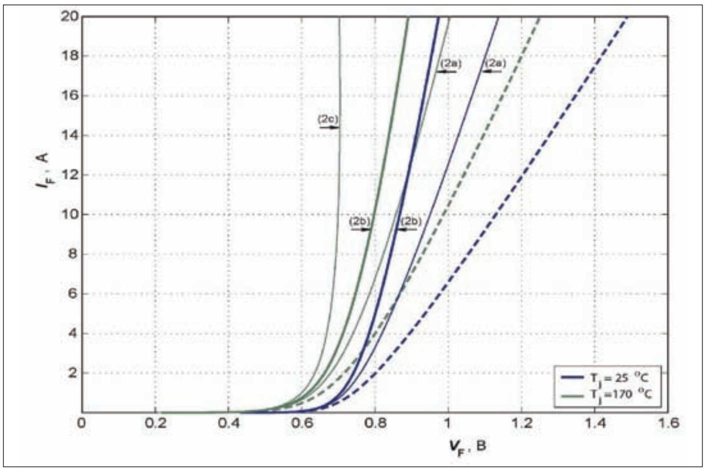
improvements in diodes structure were necessary. These goals are successfully achieved in the housingless welding diodes D056-9500 and D066-12500. The absence of ceramic housing leads to optimization of weight-dimensions characteristics, due to the decrease of number of contact surfaces heat resistance is decreased as well, which allows to conduct high currents even with substantial temperature difference. These diodes have to endure up to several millions welding cycles.

Silver sintering process

In order to improve electric thermocycling, pre-sintering on the basis of silver paste is employed.

Comparing to the standard alloy process, pre-sintering has the advantages of decreasing flaws in the silicon wafer and mechanical stress in the structure. The process enables to join the silicon wafers with thermal compensator by means of sintering under high pressure of silver nanoparticle powder. High thermal conductivity of this material and its coefficient of thermal expansion allow using this to join silicon wafers with thermal compensator. To ensure best performance hydraulic press is being used, which allow to regulate the temperature and pressure load. Moreover, to lower the values of electric and thermal resistance, improve mechanical durability of the contact surfaces, additional evaporation of layers on the surface of anode and cathode is being applied. Thus the characteristics have been improved substantially to the technical level which meets the modern high requirements of welding diodes.

To figure out the influence of change of wafer doping technology on distribution of dopant atoms and diodes characteristics, during the development process dopant profiles were calculated as well as some



Voltage-current characteristics on standard technology (bold dashed curves), and test sample 2 with simultaneous acceleration of barium, aluminium and phosphor

characteristics of the devices produced. Firstly, in standard technology, a virgin wafer was doped with phosphorus and after that with barium. Secondly, in test sample 2, a virgin wafer first is being doped with barium and aluminium, after that with phosphorus, and then barium, aluminium and phosphorus are being accelerated during a) 24 hours, b) 32 hours, c) 48 hours.

Distribution of dopant atoms in semiconductor element of the welding diodes produced according to the standard technology, as well as in test sample 2 of semiconductor element, produced according to the updated technology is shown in the fourth figure. The reference level of n-silicon doping is light blue dashed line.

Additional doping of semiconductor element of the welding diodes with aluminium leads to decrease of threshold voltage V_{TO} and maximum forward voltage V_{FM}, which lower the value of evolved power during operation and enables the welding diodes to conduct high currents at defined cooling. This is important during operation in pulsed mode, when the device conducts pulses of current, which lead to cyclic heating and cooling of semiconductor element. Decrease of evolved power during operation leads to lowering the temperature difference ΔT (in "heating-cooling" mode), which as a result increases the number of possible welding cycles.

Device	h_n, µm	h_b, µm	h_p, µm	V_{T0}, V (25 / 170°C)	r_T, µΩ (25 / 170°C)
Standard	61.44	84.95	33.61	0.758 / 0.705	0.037 / 0.028
Sample 2a	40.77	40.95	98.27	0.751 / 0.691	0.020 / 0.016
Sample 2b	46.87	20.45	112.68	0.748 / 0.686	0.012 / 0.011
Sample 2c	43.37	0	136.63	0.744 / 0.677	0 / 0.002

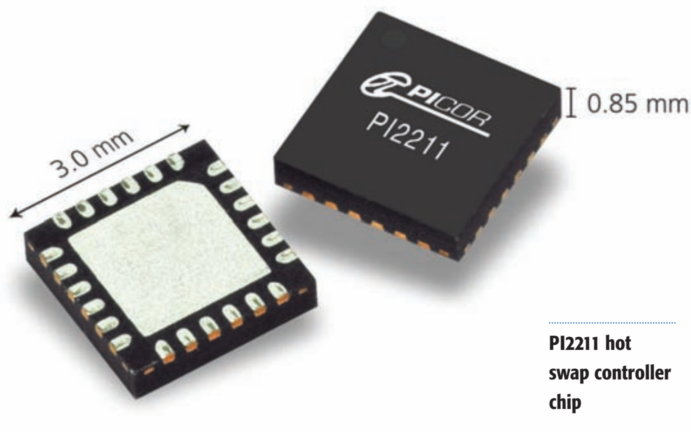
*) h_n – thickness of cathode n^+-area, h_p – thickness of anode p^+-area, h_b – thickness of n-base, V_{T0} – threshold voltage, r_T – differential resistance.

Estimation of some characteristics of standard technology welding diode and test samples 2 of this diode*

Hot Swap Controller for Continuous System Operation

Picor's new PI2211 limits the start-up current to a load, eliminating the electrical disturbance or possible voltage sag imposed on a backplane power supply. It performs hot swap protection during power-up or insertion and acts as a circuit breaker during steady state operation by controlling an external MOSFET and limiting the MOSFET junction temperature rise to a safe level.

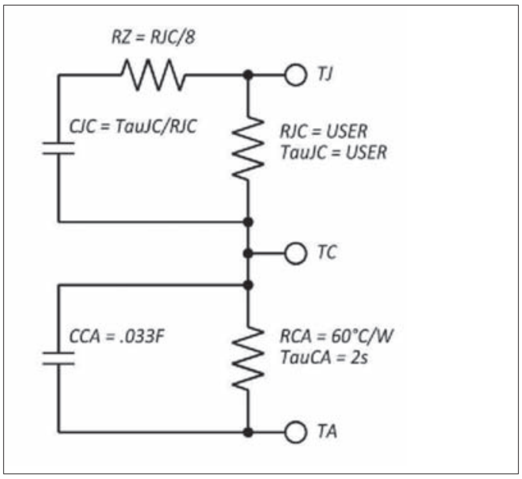
Upon insertion, the PI2211 initiates a user programmable turn-on delay where the gate of the MOSFET is held "off", providing input BUS de-bounce.



PI2211 hot swap controller chip

Then the MOSFET pass element is turned "on" in a controlled manner, limiting the current to a pre-defined level based on the value of a user selected sense resistor. The circuit breaker threshold protects against over-current by comparing the voltage drop across this sense resistor with a fixed internal reference voltage. Once the load voltage has reached its steady-state value, the Power-good pin is asserted "high" and the start-up current limit is disabled. Under voltage (UV) and Over Voltage (OV) trip points (user settable) ensure operation within a defined operating range in addition to a Enable/Disable feature shared with the UV input.

With Power-good established, the load current is continuously monitored with the MOSFET operating in the low loss R_{DSON} region. In this steady state operation, the PI2211 now acts primarily as a circuit breaker. An over-current threshold is fixed to be twice the start-up current limit and sets an upper current boundary that determines when a gross fault has occurred. Exceeding this boundary will initiate the PI2211 Glitch-Catcher circuitry and assert the power good pin low.



Simplified representation of the PI2211 thermal model

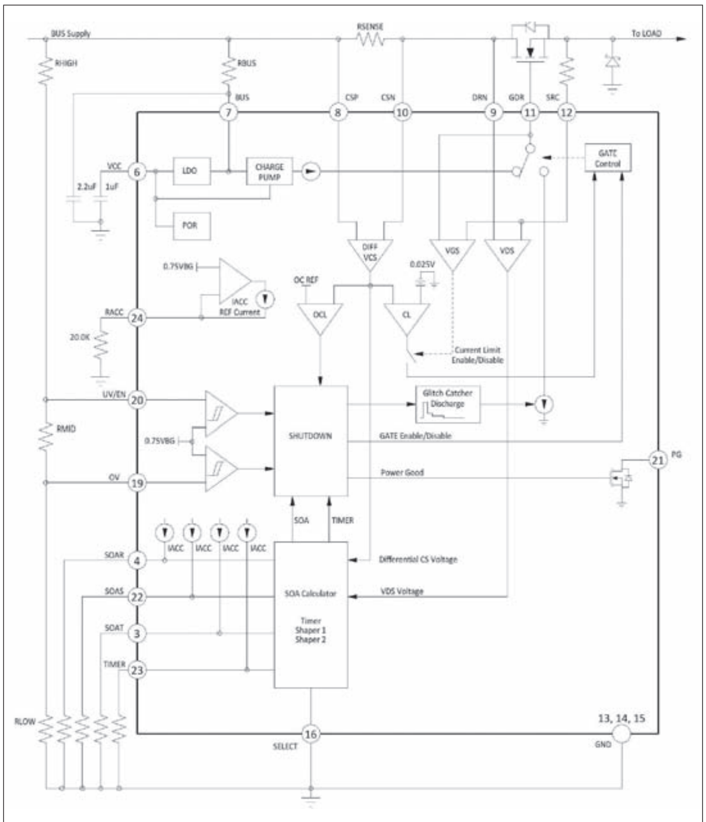
Preventing over-voltage events

The Glitch-Catcher feature prevents over-voltage events caused by the energy stored in the parasitic inductance of the input power path in response to a rapid interruption of the forward current during an over-current fault event. Acting as an active snubber, this circuitry mitigates the need for large external protection components by shunting the energy through the MOSFET to the low impedance load.

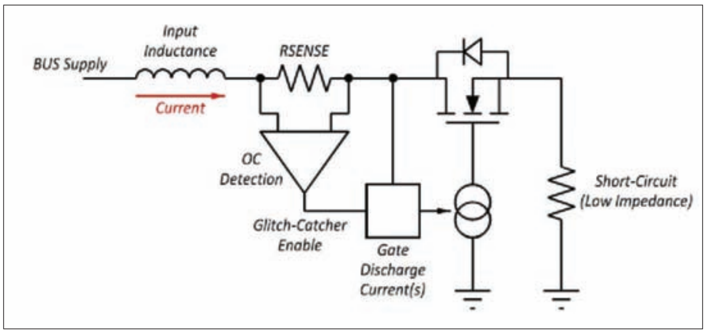
Emulating the junction temperature

The PI2211 ensures efficient operation within the MOSFET SOA by emulating the MOSFET junction temperature rise via a internal digital processor. The so-called True-SOA constantly monitors MOSFET power to calculate the junction temperature rise and determine the proper operation regardless of load conditions.

The amount of time that will turn a MOSFET on during SOA is



PI2211 Block diagram



Glitch-Catcher over-current fault detection circuit

The Shape Of Things To Come In The Automotive World

As the auto industry reshapes itself, one company is in the forefront of EMC and RF testing; providing everything you need to meet tomorrow's challenges. AR has high, medium & low power amps for whole vehicle, subsystem, component and interoperability testing. And AR amps have the performance, dependability and quality to cut any testing job down to size.

Now we're creating amps with "subampability," the ability to add power as needed and when additional budget dollars are available. With over three decades in automotive testing, AR is the number one source for everything from amplifiers and power-matched accessories to complete test systems.

Our RF Conducted Immunity test system tests to automotive specs with an unmatched level of reliability, flexibility and ease of use. The PL7004 pulse laser probe is designed specifically for use in measuring radar pulsed electric fields for the 1.2 - 1.4 & 2.7 - 3.1 GHz bands. Everything we do makes testing easier, more accurate and more cost-effective.

AR supplies a multitude of unique RF solutions to companies around the world – including the major automobile manufacturers. Our limitless support network is second to none, and everything we sell is backed by the most comprehensive warranty in the industry.

For any EMC/RF test on the entire vehicle or any of its parts, one company will always reflect well on your business, AR.

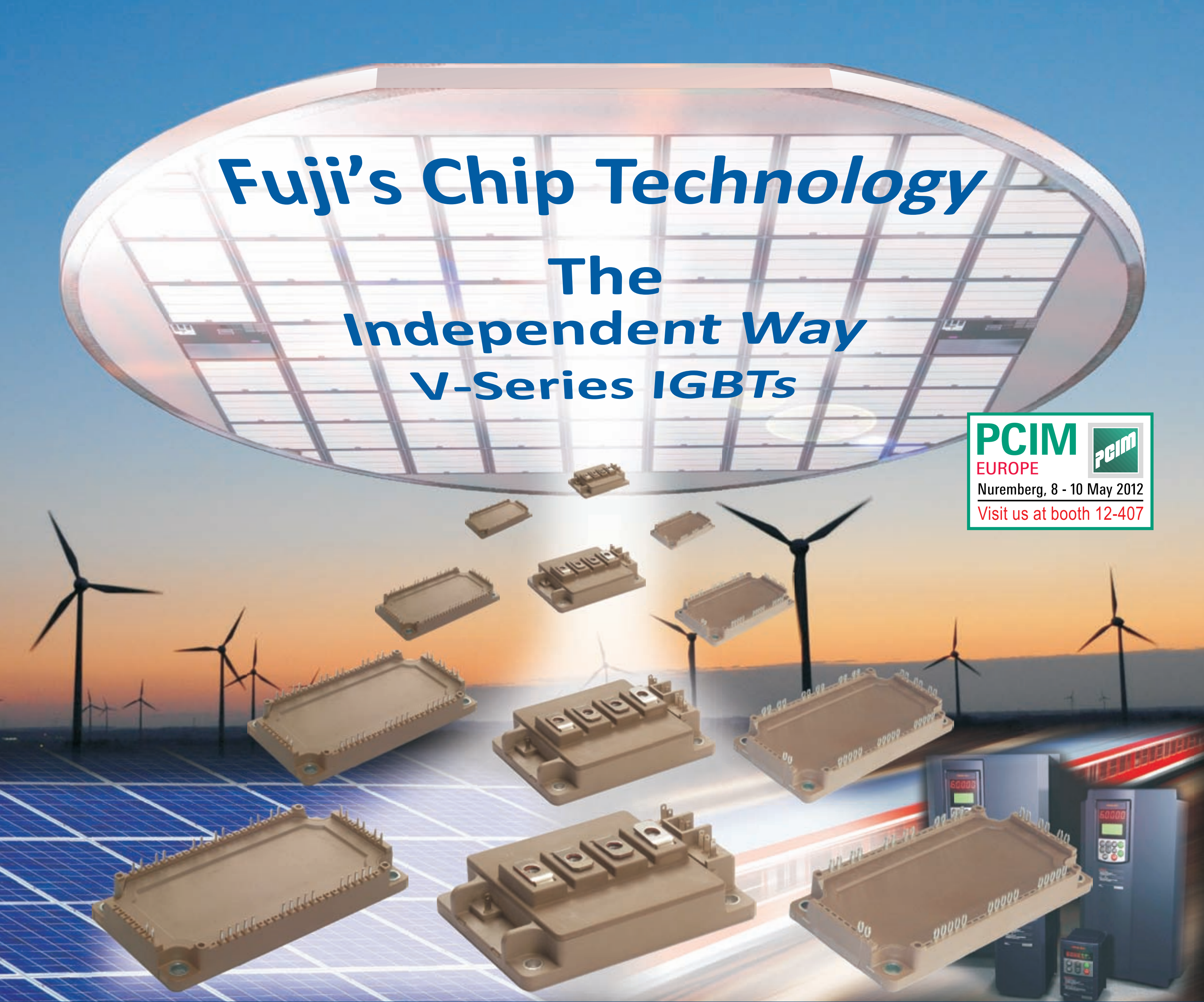
www.ar-europe.ie/contact.php

ISO 9001:2008 Certified

ar®

ar europe

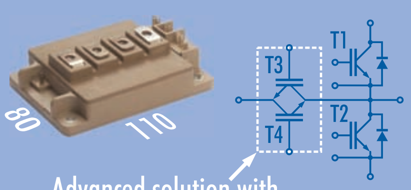
National Technology Park, Ashling Building, Limerick, Ireland • 353-61-504300 • *www.ar-europe.ie*
In Europe, call ar United Kingdom 441-908-282766 • ar France 33-1-47-91-75-30 • emv GmbH 89-614-1710 • ar Benelux 31-172-423-000



• Trench-FS IGBT • High thermal cycling capability • Low spike voltage & oscillation free • Excellent turn-on dIc/dt control by R_G

IGBTs for 3-Level inverters

1 phase IGBT modules



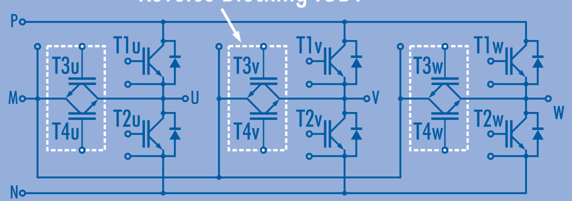
Advanced solution with Reverse Blocking IGBT

	T1 & T2	T3 & T4
200A*)	1700V	1200V
300A	1200V	600V
400A	600V	600V

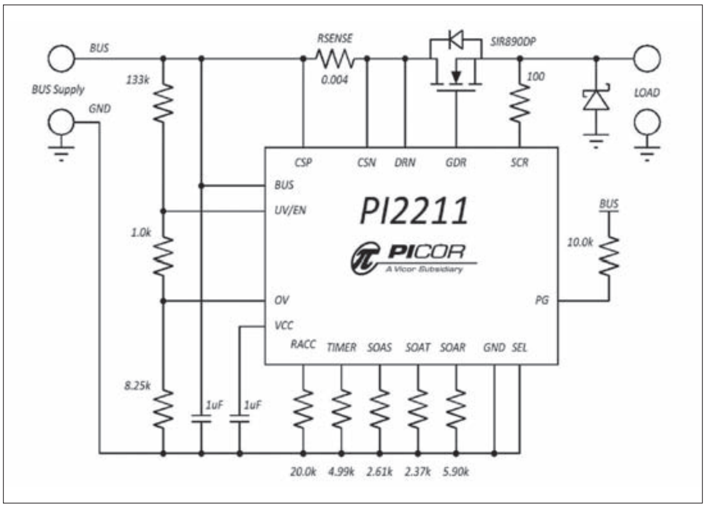
*) Under development

3 phase IGBT modules

Advanced solution with Reverse Blocking IGBT



	T1 & T2	T3 & T4
100A	1200V	600V



Typical PI2211 application schematic

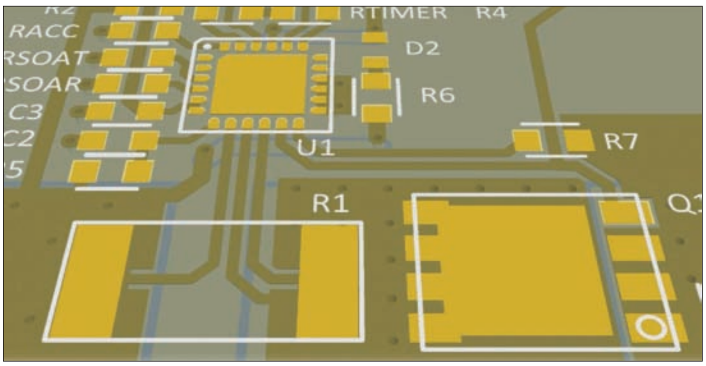
dependent on the calculated temperature rise, not a fixed time, making the pulse width dynamic with varying line voltages. The MOSFET will be kept on until an absolute 60°C junction temperature rise is predicted. Selecting 60°C as the maximum junction temperature rise allows for the use of the MOSFET at ambient temperatures approaching 90°C and prevents exceeding the MOSFET's maximum junction temperature, typically 150°C.

Once the junction temperature rise has been calculated to be 60°C, the MOSFET will shut down and allow for thermal cooling. While in True-SOA protection mode, the PI2211 will attempt to start the MOSFET when the True-SOA emulator has calculated that the junction temperature has dropped by 39°C. The 39°C thermal cycling range will retry start-up for a total of 16 pulses before the range is extended to 57°C, where the thermal cycling will go on indefinitely or until the low impedance load is removed. A typical hot-swap controller will only fault when a threshold is exceeded and cannot continuously protect the MOSFET during operation.

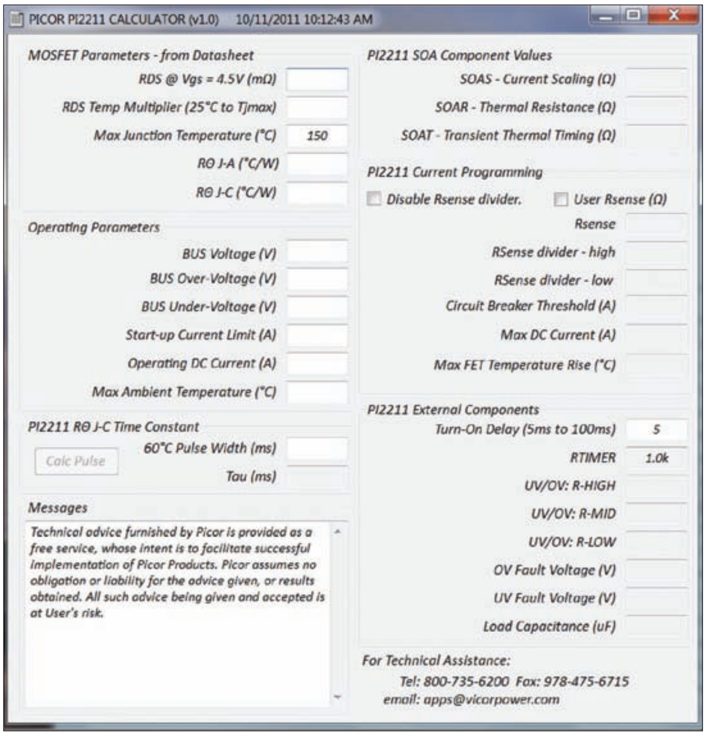
Emulation of the MOSFET thermal performance is possible with the use of the MOSFET manufacturers' transient thermal impedance curves. The True-SOA digital algorithm ensures maintaining a MOSFET within the actual SOA of the device, optimizing the size of the device without the need to oversize the MOSFET. The True-SOA is programmed for specific MOSFET thermal characteristics by the setting of three resistors which determines the magnitude and scaling of the current through the MOSFET.

Maintaining a MOSFET within its SOA boundary

The programmable digital model of a MOSFET thermal response to transient and static loads consists of two RC stages to emulate the total thermal equivalent of the junction-to-case and case-to-ambient characteristics of the device and its package. The case-to-ambient characteristics are fixed while the junction-to-case can be tuned to match the published data for a specific



Recommended PCB layout for measuring across the sense resistor R1



Windows-based PI2211 Design Calculator

MOSFET by two programming resistors R_{SOAT} and R_{SOAR} connected to the respective pins.

The R_{SOAT} resistor controls the time constant (T_{auP}) of the SOA junction-to-case model. This resistor programs the model to adhere to the manufacturer's transient thermal impedance graph of the junction-to-case response to "single pulse" power changes, as well as the extended SOA curves beyond the DC area limit. This instantaneous power calculation refreshes in less than 50 µs and predicts junction temperature rise within the 1 ms extended SOA MOSFET curves so the PI2211 will protect the MOSFET from prolonged heating with excessive static loads and hot-spotting from transient loads.

The R_{SOAR} resistor programs the model with the R_{THJ-C} of the MOSFET. Scaled by the ratio of the junction-to-case/case-to-ambient thermal impedances (R_{THJ-C}/R_{THC-A}), referenced on the fixed internal 60°C/W R_{THC-A} of the PI2211.

The RSOAS resistor programs the magnitude of the calculated current through the MOSFET and the power it is dissipating. All three of these resistors have a maximum value 20 kΩ. R_{SOAR} and R_{SOAS} have a 1 kΩ minimum value, the R_{SOAT} has a minimum of 1.30 kΩ. Values outside of these ranges will not stop the PI2211 from working, but will force the internal references to either their minimum or maximum values.

PCB layout

The printed circuit board layout shown is representative of the proper board layout for the most accurate current sensing by the PI2211. The sense line are connected to the internal centers of the sense resistor's pads, minimizing the added resistance of the receiving copper. Grounding for the PI2211 should be done using either a low current ground plane or a local ground plane, contacting with just the PI2211's ground pins and external components; then connecting this plane to the system ground at a single point. It is not recommended connecting the ground pins and external components to different ground planes or to high current ground planes.

Design calculator

The PI2211 component calculator program is designed to calculate the required programming resistors of the controller requiring the designer to enter just a few key thermal MOSFET parameters taken from the mµanufacturer's datasheet. It is capable of calculating both an under-voltage/over-voltage divider as well as a current sense divider. It can also derive a usable pulse width when a MOSFET's R_{THJ-C} curves are not given.

www.vicorpower.com

LED-Driver Design for Replacement of 100 W A19 Incandescent Bulbs

Power Integrations have designed an LED-driver reference design for high-power LED bulb replacement. The driver can deliver the power required for a 100 W incandescent bulb replacement in an A19 form factor. The non-isolated, 93 % efficient, high-power-factor LED driver is designed to drive a nominal LED string voltage of 78 V at 230 mA from an input voltage range of 195 VAC to 265 VAC (47 Hz - 63 Hz). The LED driver utilizes the very low-profile LNK460VG.

DER-322 fits neatly inside the A19 form factor, is EN61000-3-2 C (D) compliant and passes THD limits. With a PF above 0.95, it suits commercial as well as consumer applications. With PFC and CC conversion combined into a single switching stage, the design has a low component count, which enables miniaturization, lowers cost and increases reliability. It also eliminates short-lived electrolytic input bulk capacitors. Suitable for an A19 incandescent bulb replacement-driver but also reconfigurable as a T8 tube replacement driver, DER-322 is of interest to designers of both high-end LED lighting and those working on cost optimization of bulbs for retail sale. The reference design may be easily modified to support TRIAC dimming.

The LinkSwitch-PL (U1) combines a high-voltage power MOSFET switch with a power supply controller in one device. The IC provides a single stage power factor correction plus LED

current control. The LinkSwitch-PL controller consists of an oscillator, feedback (sense and logic) circuit, 5.85 V regulator, hysteretic over-temperature protection, frequency jittering, cycle-by-cycle current limit, loop compensation circuitry, auto-restart, switching on-time extension, power factor and constant current control. It provides high power factor while regulating the output current across a range of input (195 to 265 VAC) in a single conversion

Link Switch PL combines a high-voltage power MOSFET switch with a power supply controller

stage. The design also supports the output voltage variations typically encountered in LED driver applications. All of the control circuitry responsible for these functions plus the high-voltage power MOSFET is incorporated into the IC.

Input EMI filtering

Inductors L1-L3 and C1-C2 (see circuit schematic) filter the switching current presented by the buck converter to the line. Resistor R1, R2 and R3 across L1, L2 and L3 damp any resonances between the input inductors, capacitors and the AC line impedance which create peaks in the conducted EMI spectrum.

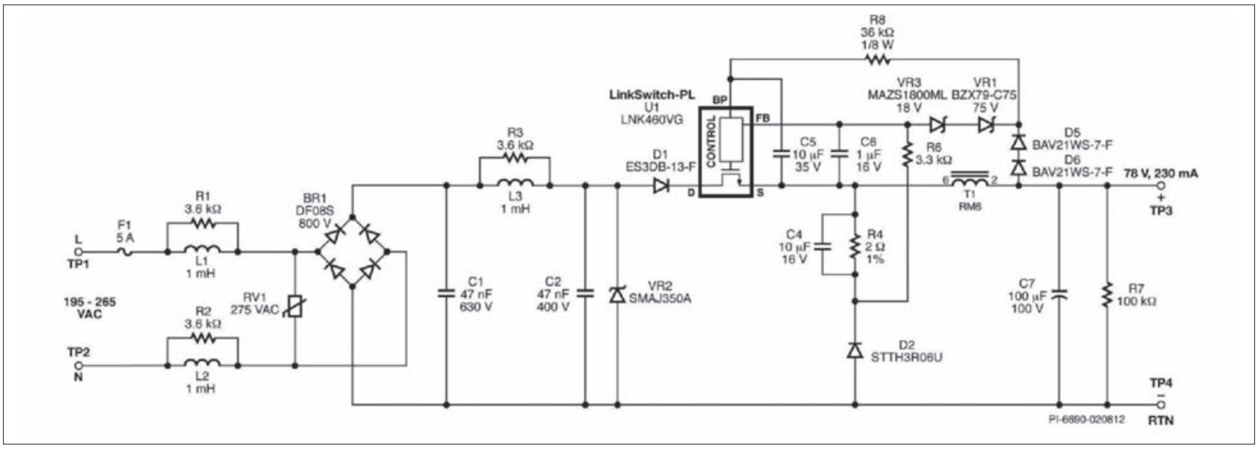
MOV RV1 provides a clamp to limit the maximum voltage during differential line surge events. Zener diode VR2 is added to increase immunity to differential line surge, clamping at a lower voltage than the MOV. Bridge rectifier BR1 rectifies the AC line voltage with capacitor C2 providing a low impedance path (decoupling) for the primary switching current. A low value of capacitance (sum of C1 and C2) is necessary to maintain a power factor greater than 0.9.

Power circuit

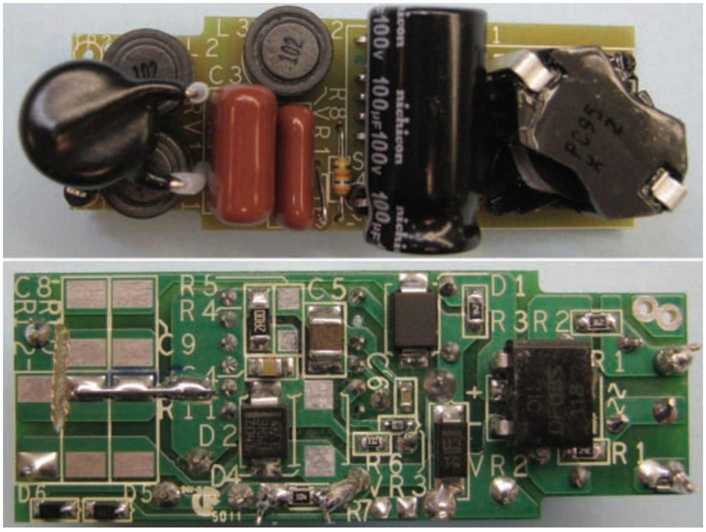
The circuit is configured as a buck converter with the SOURCE (S) pin of U1 connected to the cathode side of the freewheeling diode D2 and DRAIN (D) pin connected to the positive side of the DC rectified input through D1. Diode D1 is used to prevent reverse current to flow through U1. An RM6 core size was selected to optimize the inductor T1 for highest system efficiency. Capacitor C7 filters the switching frequency.

Capacitor C5 provides local decoupling for the BYPASS (BP) pin of U1 which is the supply pin for the internal controller. During start-up, C5 is charged to ~6 V from an internal high-voltage current source connected to the DRAIN pin. Once charged U1 starts switching at which point the operating supply current is provided from the T1 inductor via R8, D5 and D6.

Rectifier diodes D5 and D6 were selected to be low capacitance diodes to



Schematic of the reference design



Populated PCB top and bottom view

minimize the effect of the OVP circuit (D5, D6, VR1 and VR3) on the output regulation. A single ultrafast diode (e.g. UF4005) may be substituted for lower cost resulting in a ~10 mA increase in load regulation.

Resistor R4 is used to sense the diode current of the buck converter. The value was adjusted to center the output current at 230 mA at nominal input voltage. Capacitor C4 is used to filter the high frequency component of the diode current which helps improve overall efficiency by reducing the RMS current through R4. Resistors R6 and C6 provide additional filtering to lower the ripple of the voltage feed to the FEEDBACK (FB) pin of U1 for improved regulation.

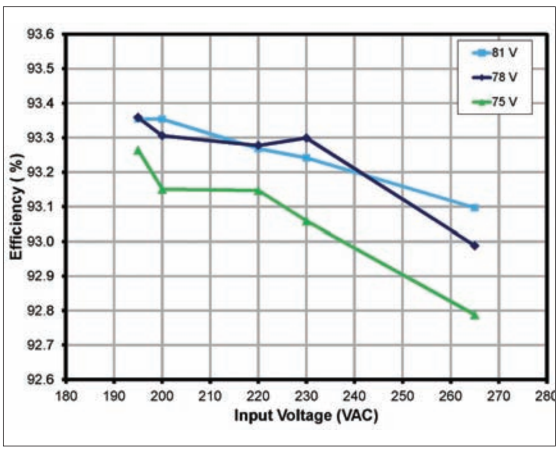
Open load protection

The LED driver is protected in the event of accidental open load operation by monitoring the voltage across the output inductor during energy decay (MOSFET off time). Zener diodes VR1 and VR3 set the OVP threshold which forces U1 to enter cycle-skipping mode.

During a disconnected load condition, the output capacitor can be charged to a voltage that exceeds the threshold of VR1 and VR3 because of the leakage current that flows to the output capacitor even when U1 is off. Resistor R7 is used to limit the maximum output voltage by partially discharging the output when the load is disconnected. This reduces efficiency during normal operation but also ensures the LEDs extinguishing completely when the AC is removed. Zener diodes VR1 and VR3 may be replaced with a single part where a suitable standard value exists.

For designs which require more precise OVP protection for the output capacitor, a Zener diode with Zener voltage greater than or equal to VR1 and VR3 can be added across the output.

www.powerint.com/sites/default/files/PDFFiles/der322.pdf



Efficiency vs. line and load measured using 3 sets of loads ranging 75 V - 81 V output voltage

New SiC Thin-Wafer Technology Paving the Way of Schottky Diodes with Improved Performance and Reliability

This article presents the new thinQ!™ 5th Generation (G5) of SiC Schottky diodes from Infineon Technologies. In G5, both the capacitive charge and the forward voltage have been minimized through a new and exclusive production process. The improvements with respect to previous generations are discussed, with the support of direct application tests results. **Vladimir Scarpa, Uwe Kirchner, Ronny Kern, and Rolf Gerlach, Infineon Technologies, Villach (Austria) and Neubiberg (Germany)**

Silicon Carbide (SiC) Schottky barrier diodes (SBDs) have been on the market since more than a decade and sell today in millions of pieces per year, with proven quality in the field. This confirms it as a mature technology, able to provide both full reliable and high-performance devices [6]. Moreover, the increasing request for energy efficiency experienced in the last years is at the base of the constantly growing observed in many applications. Besides high-end server and telecom SMPS, where SiC SBDs have become a standard, increasing adoption is recorded mainly in solar inverters, motor drives and lighting.

Figure 1 summarizes the sequence of 600 V SiC SBD launched by Infineon Technologies. Each new technology aimed to achieve a better price/performance ratio, thanks to new features, translated into key benefits at application level. In thinQ! second Generation (G2), a merged pn-junction has been integrated in the device structure, in order to reduce the diode losses under high current conditions, enhancing therefore the surge current capability of the devices [6].

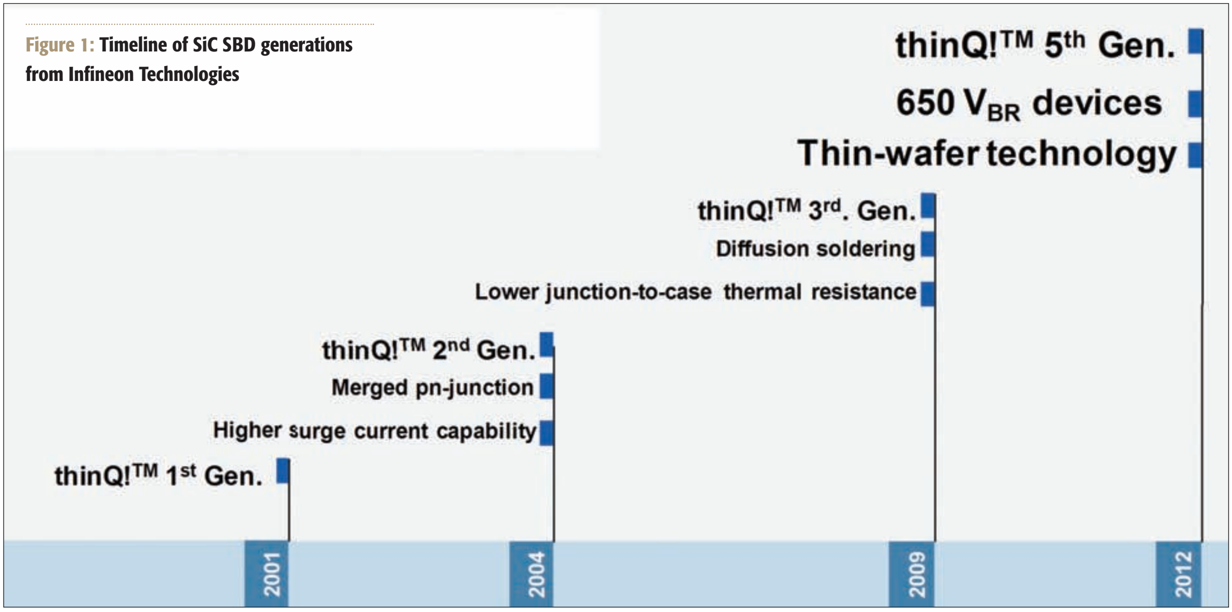
In the third generation (G3) a new solder technique has been introduced, namely diffusion soldering [6], resulting into an improved thermal conduction between the device chip and the lead-frame. Main results are a lower junction-to-case thermal resistance Rth,JC, and consequently higher power dissipation per device area.

The newest fifth generation (G5) combines the above mentioned improvements of former technologies with new features. The breakdown voltage has been increased to 650 V, while the devices are now produced with the exclusive thin-wafer technology [6], combined with a compacter cell layout, which enable to obtain lower device capacitive charge.

Technology background

As extensively described in a previous publication [6], Infineon Technologies has developed a manufacturing process able

Figure 1: Timeline of SiC SBD generations from Infineon Technologies



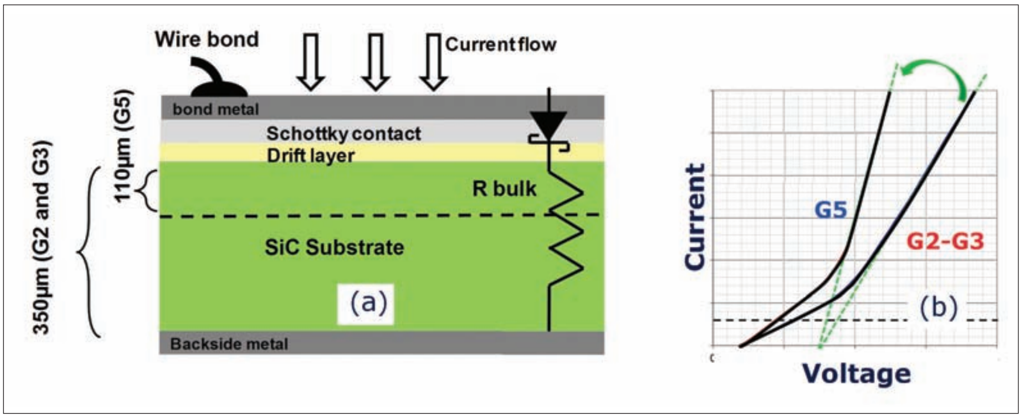


Figure 2: Schematic representation of a SIC diode with thick and thin wafers (a) and forward characteristics of identical sized devices with thick (G2-G3) and thin (G5) substrates (b)

to reduce the wafer thickness down to ~1/3 of the original one, as shown in Figure 2a, without increasing the number of defects per unit area in the SiC wafer. The thinning of the substrate results into a smaller differential resistance of the diode, with a clear effect on the output characteristics of the device for the same unit area (Figure 2b).

For a 650V SiC SBD, the substrate component is dominant in the overall diode resistance. Thin-wafer technology enables thus a significant reduction of the diode differential resistance, for identical chip sizes. This is graphically represented in the horizontal line in Figure 2b, which indicates the forward characteristics of two the wafers with different substrate thickness.

Together with the electrical characteristics, the thermal behavior of the G5 chip is also improved. A thinner chip results in a better thermal path between the wafer and the lead-frame. As a consequence, identical power dissipation leads to a smaller junction temperature increase in a G5 device compared to G2.

Figure 3 shows the thermal simulation of SiC Diodes with equal sized chips but different thicknesses in a TO220 package (P_{losses}=75 W). The color scheme indicates the temperature in °C. The backside of the lead-frame is hold to constant temperature (0°C). Here one can see that, for G5, the chip junction temperature is much lower due to improved thermal conduction to the lead-frame. In addition, better heat spreading into the copper lead-frame is observed in the G5 device.

Tailoring of the devices

Devices in G5 have been tailored to have forward voltage V_F=1.5 V under a given nominal current and junction temperature T_j=25°C. Figure 4a schematically shows the positioning of the actual three families of SiC SBDs, with respect to V_f and Q_c - the total capacitive charge at a reverse voltage V_R=400V, for the same nominal current. Figure 4b compares several current rated devices, from G2 and G5, where it is possible to see the massive reduction of the Q_c (30-40%) in G5 devices.

By comparing G2 with G5, the total charge Q_c is reduced despite same V_f, with consequent lower switching losses, as indicated by the blue arrow. By comparing G2 with G3, instead, G5 has comparable Q_c but lower V_f, and consequently lower conductions losses, as again indicated by the arrow.

Thermal resistance and surge current capability

With respect to device reliability of a power device, at least two other parameters are of great importance, namely the thermal resistance between junction and case, $R_{th,JC}$, and the surge current capability [6]. Therefore the datasheets contain as parameters the $R_{th,JC}$, the maximum surge current, IF,SM, evaluated for 10 ms sinusoidal current pulse, and the non-repetitive peak forward current If,MAX for after 10 µs rectangular current pulse.

In Figure 5 the three mentioned parameters for 8A devices in TO-220 package are plotted with respect to G5 values - absolute values can be found in [6]. As predicted by its better thermal behavior, G5 has a smaller R_{thJC} compared to G2 and G3. Moreover, $I_{F,SM}$ and $I_{f,MAX}$ of

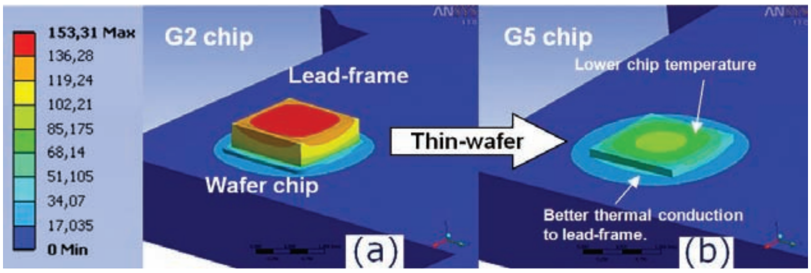


Figure 3: Thermal behavior of G2 device with thick chip thickness and soft soldering (a) while (b) shows a thin chip with diffusion soldering

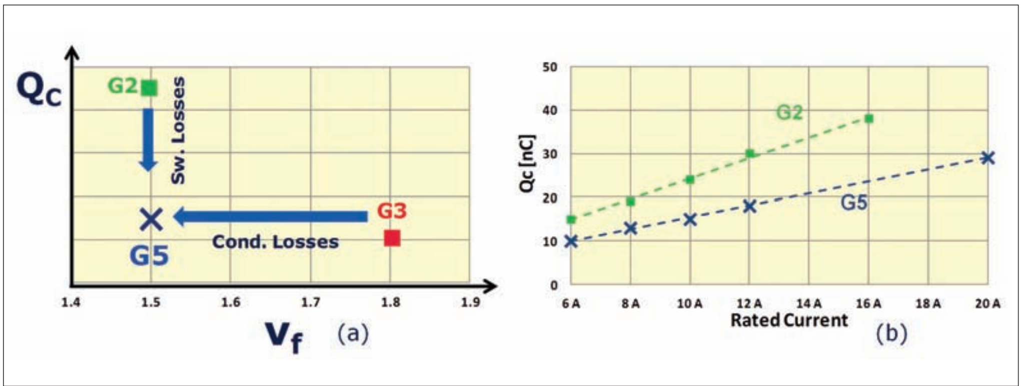


Figure 4: Device tailoring in G5, comparison with G2 and G3 regarding of Q_c and V_f (a). Arrows represent the benefit in terms of device lower losses. Comparison of device Q_c between 5G and G2 for several current ratings (b)

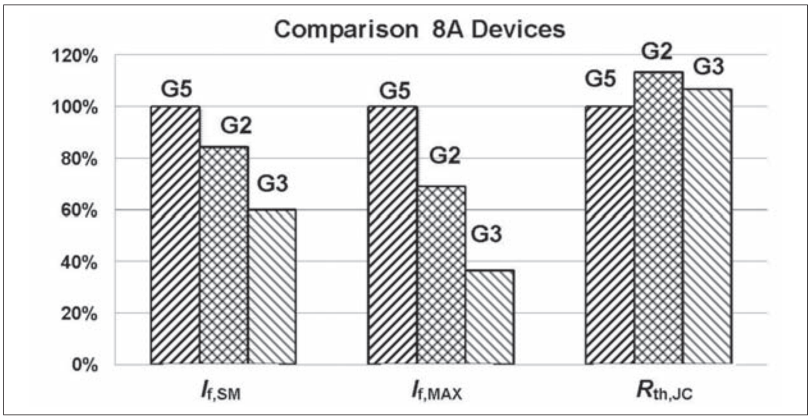


Figure 5: Comparison of surge current capabilities ($I_{F,MAX}$ and $I_{F,SM}$) and thermal resistance $R_{th,JC}$ between SiC SBD technologies (all data taken from datasheet of the corresponding 8A devices and are referenced to G5)

G5 is always larger than the other generations.

In G5, the lower $R_{th,JC}$ can be explained by the better heat dissipation of the thin chip. In addition, thermal behavior has also an impact on the surge current capability: G5 device is thus able to support higher current values, i.e. higher losses, before reaching the maximum junction temperature, and its consequent destruction.

CCM PFC application results

The performance of the G5 devices has been evaluated in a step-up circuit (boost). The setup is fed by the AC means (V_{in}=230 VAC) and contains a power factor correction (PFC) controller, for continuous current mode (CCM) operation. Further parameters and component values are presented in [4]. Figure 6 shows the CCM PFC circuit used in the experimental tests and its main parameters/component values. Figure 7a shows the efficiency curves of the above described circuit, as a function of the output power from different technology generations. In Figure 7b the efficiency is normalized to G5.

It is shown that the efficiency of G5 is higher than G2, especially at light load due to lower Q_c, i.e. lower switching losses. Vice versa, G5 is better than G3 is at high load conditions due to lower Vf values, i.e. lower conduction losses. Within the three discussed generations the G5 has the lower product Q_c x V_f, and becomes therefore benchmark in efficiency for the entire power range.

Conclusion

This article has introduced the new family of SiC Schottky barrier diodes from Infineon Technologies, produced through a new and exclusive thin-wafer technology. The main electrical and thermal benefits related to the thin-wafer technology have been addressed, as well as their impact in the device performance. As demonstrated by experimental tests in a PFC circuit, G5 offer the best balance between conduction and switching losses, offering the best efficiency to the system, over the full load range.

Literature

[1] Friedrichs, P., "SiC Power Devices - Lessons Learned and Prospects After 10 Years of Commercial Availability", at the The International Conference on Compound Semiconductor Manufacturing Technology 2011. http://gaasmantech.com/Digests/2011/papers/12b.1.pdf

[2] Bjoerk, F. et al, "2nd Generation 600V SiC Schottky Diodes Use Merged pn/Schottky Structure for Surge Overload Protection", APEC 2006

[3] Holz, M. et al, "SiC Power Devices: Products Improvement using Diffusion Soldering"; ICSCRM2008

[4] Rupp, R. et al „Performance of a 650V SiC diode with reduced chip thickness", ICSCRM2011

[5] Holz et al, "Reliability considerations for recent Infineon SiC diode releases", Microelectronics Reliability, 2007

[6] thinQ!TM SiC diodes datasheets (www.infineon.com/sic)

Param.	Description	Value
V_{in}	Input voltage	$230V_{ac}$
V_{out}	Output voltage	$400V_{dc}$
$P_{o.max}$	Max. output power	1.5kW
S	Power switch	IPW60R075CP
L	Inductance	680µH
f_{sw}	Switching frequency	100 kHz
T_{hs}	Heat-sink temperature	60°C

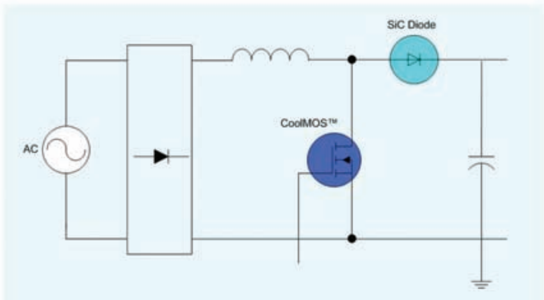


Figure 6: CCM PFC circuit used in the experimental tests and its main parameters/ component values

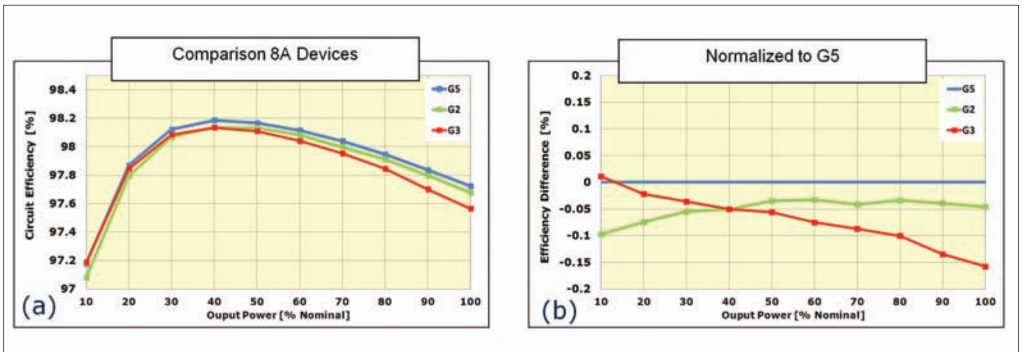


Figure 7: Efficiency results of PFC circuit with 8A devices from G2, G3, and G5 over full output range (parameters see Figure 6) in absolute values (a) and normalized values to G5 (b)

A Technology Platform for Advanced Power Electronic Systems

The SKiN technology eliminates the weaknesses of the classical module design and introduces an integrated platform architecture for the design of compact and reliable power electronic systems.

Uwe Scheuermann, Product Reliability Manager, SEMIKRON Elektronik, Nuremberg, Germany

The limits in lifetime of classical power modules have been investigated and discussed extensively during the last decades. Solder fatigue and wire bond degradation were identified as the dominant failure mechanisms under repetitive thermo-mechanical stress. The thermal interface material (TIM), required for mounting classical modules on heat sink, has been identified as the bottleneck for the extraction of heat from the chips; its reliability and long term stability is a matter of permanent concern for system designer. The SKiN technology eliminates all solder interfaces and all wire bonds, as well as the thermal grease layer in an integrated low profile design with enhanced reliability.

Silver sinter technology

The technology of Silver (Ag) diffusion sintering was developed and implemented in the late 1980s for large area interconnection of molybdenum discs to wafer size thyristors by Siemens. In the middle of the 1990s academic research at the technical university of Braunschweig demonstrated that the sinter technology can be adapted to replace solder interconnections in classical base plate power modules. Based on these activities, SEMIKRON developed a series production technology capable of simultaneously sintering a multitude of chips (IGBTs, diodes and sensor chips) in a single process step.

The characteristic of the Ag diffusion sinter interface is superior to a solder interface in every aspect: Enhanced thermal and electrical conductivity combined with a smaller coefficient of thermal expansion (CTE) and higher tensile strength of the interconnection advance the characteristics of the die attach. However, the most important improvement is the dramatic increase in melting temperature. The concept of homologous temperature - well known to mechanical engineers - illustrates this advantage. The homologous temperature is the ratio of operating temperature and the melting temperature of a material with both temperatures related to the absolute temperature scale.

For 150°C operation temperature, the homologous temperature of SnAg [3] - a standard solder alloy in power modules with a solidus temperature of 221°C - is 86 %. Even for high-melting solder alloys as AuGe [3] with a solidus temperature of 363°C the homologous temperature is 67 %. An Ag diffusion sinter layer in contrast exhibits a homologous temperature of only 34 % for an operation temperature of

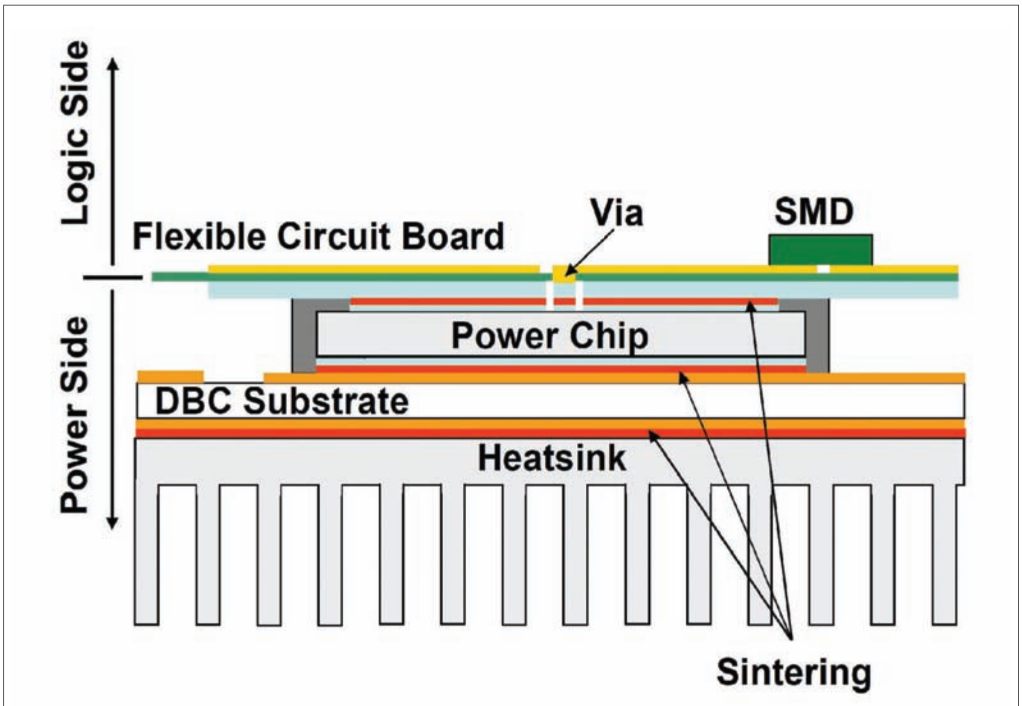


Figure 1: Cross section of SKiN technology platform

150°C. Mechanical engineers consider a material below 40 % of homologous temperature as mechanically stable, between 40 % and 60 % materials are operated in the creep range and are therefore sensitive to strain, whereas above 60 % they are considered unable to bear engineering loads. The latter applies for all conventional solder alloys in power modules, only the Ag diffusion sinter technology is expected to be mechanically stable due to its high melting temperature of 961°C. This consideration shows the high potential to enhance the reliability of power modules by replacing solder interfaces with Ag sinter diffusion layers, which is implemented in the SKiN technology for the chip-to-substrate interconnection.

Replacement of the wire bonds

Wire bonds have the attribute of the major weak link in the power cycling lifetime of the classical module design. Failure analysis after power cycling end-of-life tests with classical modules will always show wire bond degradation as the final failure mode. However, a more detailed analysis in some cases may reveal that solder fatigue has a significant impact on the degradation. Only after the introduction advanced modules, were the chip-to-substrate solder interface is replaced by the more reliable Ag sinter technology, the lifetime of wire bonds could be investigated without the influence of solder fatigue [1]. The results indicated a significant potential to increase the wire bond lifetime by geometry optimization of Al bond loops. Beyond that, first results of Cu wire bonds promise an even greater potential for wire bond lifetime improvement.

However, wire bond optimization has inherent drawbacks with respect to the performance and design of power modules: increasing the bond loop geometry decrease the ampacity of the wire bonds on the one hand and prevent a low profile design of the module architecture on the other. Therefore, the wire bonds are replaced by a layer contact, which is connected to the topside chip metallization by a Ag silver sinter process in the SKiN technology for reliable performance and a flat module profile.

Elimination of the thermal grease interface

A matter of continuous concern is the thermal grease interface required for the mounting of classical power modules on a heat sink. Although TIM layers are better than air gaps, the thermal conductivity is poor compared to the internal conductivity in a power module, thus these layers generate a considerable temperature gradient. A much greater problem however is the long term stability of this interface. Pump-out effects or separation of constituents can cause degradation of the interface thermal conductivity over time and can interfere with reliable system operation. There is still no standard procedure available to qualify the stability of TIM layers for operational lifetimes of 20 years or more.

The SKiN technology eliminates the TIM layer by connecting the DBC to a pin fin heat plate by an Ag sinter interconnection. This established an excellent thermal contact combined with a high reliability.

The SKiN technology concept

The SKiN technology integrates all previously discussed improvements in an advanced platform architecture. The schematic cross section is shown in Figure 1. The chips are connected to a standard DBC ceramic substrate by Ag sinter technology. The DBC is joined to the pin fin heat plate also by Ag sinter technology. A flexible circuit board connects the topside chip contacts with an Ag sinter connection as well. The flexible circuit board allows the formation of vias, so that the control signals from the upper 'logic layer' can the conveyed to the gate contact of the IGBTs. It also allows the integration of standard SMD components close to the chips. The lower 'power layer' supplies the load current to the chips.

The assembly process of this new technology is illustrated in Figure 2. In a first step, the chips are connected to the ceramic substrate by a sinter process. The chip passivation edges are then coated by an insulation material. Then the substrate is attached to the heat sink and the flexible circuit board is attached to the topside of the chips and to the contact areas on the DBC, thus establishing all electrical connections. This procedure can be arranged as a single sinter step or performed in two consequent sinter processes. A supporting frame aligns the elements during the process and the load terminals are joined to the substrate by sinter connections as well. The result is an extremely flat module architecture.

Advantages of the SKiN technology

The SKiN technology exhibits a compilation of unique advantages.

Compared to the classical module design with TIM interface, the thermal resistance is reduced by more than 20 % (the exact value depends on the specific cooling conditions). This improvement was

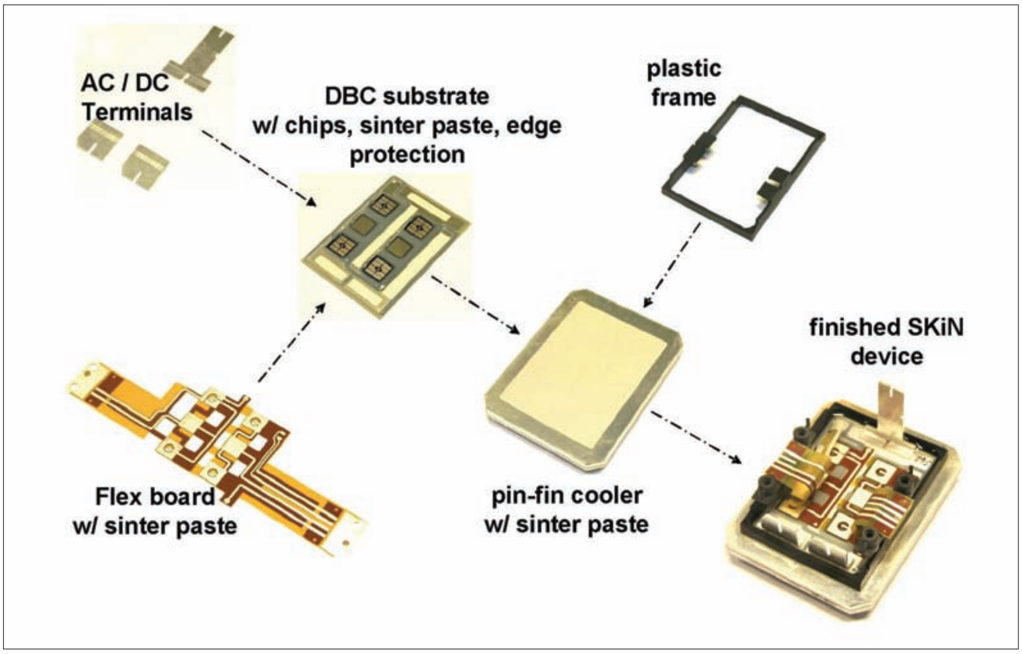


Figure 2: SKiN assembly process

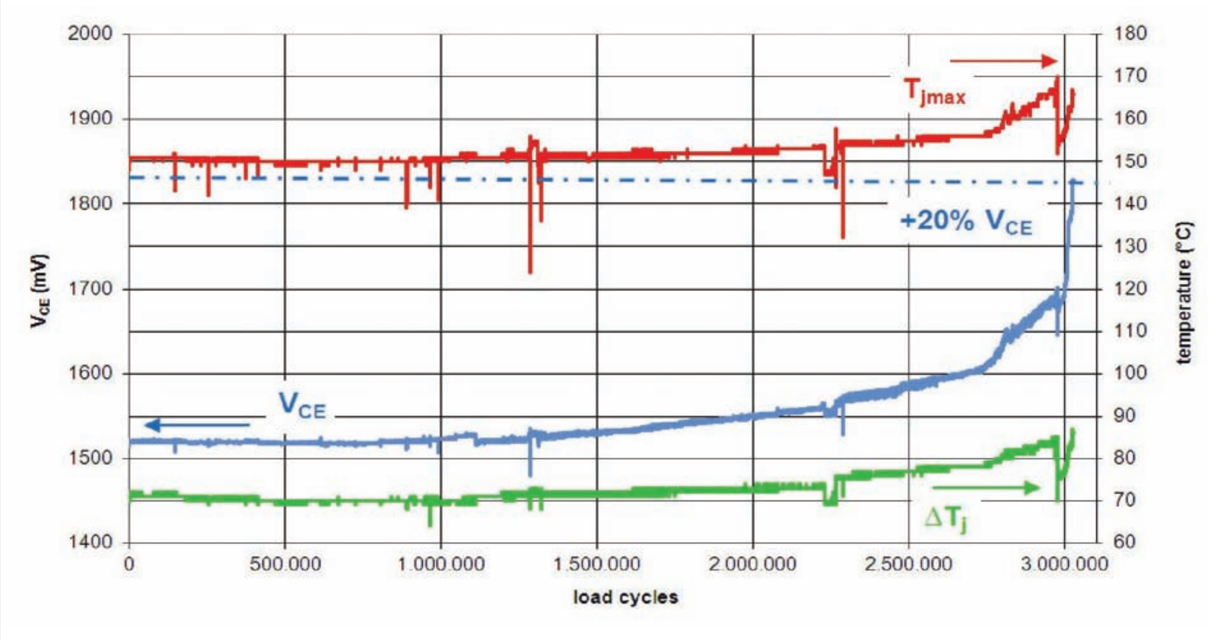


Figure 3: **Result of an active power cycling test at ΔT_j=70 K (T_{jmin}=80°C, T_{jmax}=150°C)**

evaluated by simulation and the simulation result for the SKiN module was verified by thermal measurements.

The surge current capability is increased by approximately 25 %. This result was measured for a SKiN phase leg modules in comparison to a benchmark design with identical layout and chips, were only the flexible circuit layer was replaced by traditional wire bonds.

The same benchmark modules were utilized to compare the reduction in parasitic inductance of the SKiN technology in relation to the classical wire bond connection. A reduction in parasitic inductance of typically 10 % was confirmed. A detailed analysis of the current flow during current commutation revealed, that this improvement is not attributed to the elimination of the wire bond loops, but it is rather evoked by a smaller enclosed lateral area of the current path on the SKiN flexible circuit layer.

The most important feature however is the excellent power cycling capability of the SKiN module. Figure 3 shows the result of an active power cycling test at ΔT_j=70 K (T_{jmin}=80°C, T_{jmax}=150°C). The test with DC constant current load pulses in constant time control (t_{on}=1.2 s, t_{off}=1.8 s) resulted in a total number of cycles to failure of 3 million cycles. For comparison, power cycling results at comparable test conditions for classical power modules in different stages of evolution are collected together with the SKiN technology in Table 1.

The first line in Table 1 gives the number of cycles to failure according to the lifetime model presented by the LESIT project, an early comprehensive investigation of active power cycling lifetime conducted in the middle of the 1990s. A typical result of a classical power module produced in 2010 - indicating the technology progress in almost 20 years - exhibits a lifetime enhancement of a factor of 5. Replacement of the chip solder connection by an Ag sinter technology combined with improved wire bond geometry has the potential to increases the lifetime again by a factor of 8. The SKiN technology escalates the power cycling lifetime further by approximately a factor of 5.

Although, technology improvements for the classical module design were proposed for each of the described advantages individually in the past, it is the implementation of all advantages in a single technology platform, which makes the SKiN technology so unique. The combination of excellent thermal performance, enhanced surge current capability with concurrently reduced parasitic inductance and the superior power cycling lifetime enables this technology to meet the demands of future power electronic applications. The SKiN technology allows the extension of the operation temperature range to 200°C - which is the next step on the silicon power device roadmaps - without the penalty of a reduced lifetime. The flat architecture of the SKiN technology facilitates a reduction of volume for power electronic systems and meets the demands for highly integrated compact solutions in power electronic energy conversion.

Literature

[1] U.Scheuermann, R.Schmidt: Impact of Solder Fatigue on Module Lifetime in Power Cycling Tests, Proc. EPE, Birmingham, 2011.

[2] M.Held, P.Jacob, G.Nicoletti, P.Scacco, M.H.Poech: Fast Power Cycling Test for IGBT Modules in Traction Application, Proc. Power Conversion and Drive Systems 1997, pp. 425-430.

[3] U.Scheuermann: Reliability of Planar SKiN Interconnect Technology, Proc. CIPS 2012

Table 1: **Power cycling results at comparable test conditions for classical power modules in different stages of evolution together with the SKiN technology**

technology	nf (ΔTj=70K)	relative factor	source
classical base plate module	15 800	1	[2] LESIT 1997
industrial modules (aspect ratio 0.21)	79 000	5	[1] EPE 2011
sintered chips + improved Al wire bonds	647 000	41	[1] EPE 2011
SKiN technology	3 024 000	191	[3] CIPS 2012

High-Speed GaN Switches for Motor Drives

High speed, low loss, 600V GaN switches offer unique advantages to motor drives. Increased bandwidth and improved system efficiency can be realized in a range of applications, from workhorse induction motors to high-performance servos. **Jim Honea, Transphorm Inc., Jun Kang, Yaskawa America Inc., USA**

There are two benefits for motor drives that come with high switching frequency: one obvious, and one not so obvious. The obvious benefit is increased system bandwidth. Drives for servo-motors and high-speed motors, for example, may require a fundamental excitation frequency of 1 kHz or more, with comparable sample and update rates for feedback and control. Systems such as these are presently constrained to a choice between coarse control - barely ten-steps per output cycle at a 12 kHz switching frequency - or high switching loss, incurred by switching IGBTs in the tens of kHz. Gallium Nitride (GaN) High-Electron Mobility Transistors (HEMTs), operating at switching frequencies over 100 kHz with low switching loss, can eliminate this constraint. With a CPU sampling time of 10µs, more sophisticated control algorithms can be applied to achieve high performance with much less digitizing error. The generation of agile drive waveforms with low-harmonic content thus enabled is critical for high-speed motors, but is also advantageous for the control of even 50/60Hz motors.

The less obvious benefit is improved system efficiency. As has been pointed out in these pages [1] and elsewhere, total energy consumption in motor and pump systems can be dramatically reduced through use of variable-frequency drives. This savings at the system level is actually achieved, however, at the cost of additional loss in the motor and inverter due to the switch-mode operation. Harmonics in the motor-current waveforms which do not produce torque serve only to heat either the motor or the inverter. Increasing the switching frequency can potentially lower the loss in the motor, since the ripple current and distortion are lessened, but at the cost of increased loss in the inverter.

That the inherent switching loss of the power devices in the inverter scale with switching frequency is readily recognized, but an essential point is that even ideal switches would incur a frequency-dependent switching loss due to the charging and discharging of external capacitances with each switching cycle. The windings and wiring of any motor will present a significant capacitance to the inverter outputs which will typically dominate the switching loss. The solution presented here is to increase the switching frequency high enough that small, practical output filters may be included to eliminate the switching frequency from the output waveforms altogether.

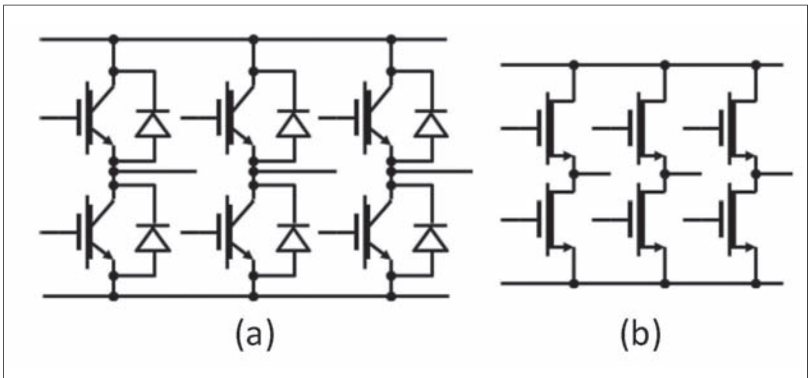


Figure 1: Three-phase bridges made with (a) IGBTs and discrete diodes, and (b) GaN HEMTs

Bridge circuits with GaN HEMTs

The combination of high electron mobility and low charge make GaN HEMTs nearly ideal switches for any application. Another particular advantage in bridge circuits is that they can carry the freewheeling current without the need of an additional anti-parallel diode. Figure 1 compares a traditional three-phase bridge, where each IGBT is paired with a freewheeling diode, to a three-phase bridge made with GaN

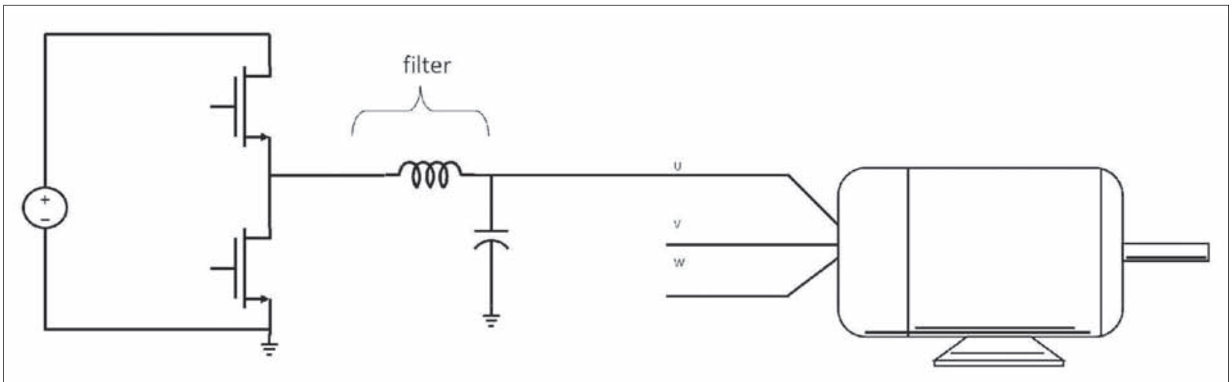


Figure 2: Inclusion of an output filter between a GaN bridge and a motor

devices. Because the HEMT channel exists in pure, undoped GaN, there is no parasitic junction to provide an unwanted current path, and bidirectional flow of just majority carriers can be realized in the channel. The switching loss is due solely to capacitive charges, which are small, and not recovery of any injected charge.

This diode-free functionality can be achieved either with single-chip GaN HEMTs, or with two-chip hybrid devices. In the latter case, a low-voltage silicon MOSFET provides the enhancement mode functionality, while the GaN device provides the crucial high-voltage blocking capability. The freewheeling current does indeed flow in the body diode of the silicon FET, but because it is a low voltage part, the injected charge is very small. The devices used in the following tests were, in fact, hybrid devices.

Inclusion of a small output filter, as shown in Figure 2, insures that the charge-related switching loss remains limited to the small charge of the devices. There is some loss associated with the filter inductor, but this inductor can be optimized for the application, and in the tests reported here, its loss is found to be acceptably small, given that that the switching frequency is essentially eliminated from the output to the motor. The filter, as drawn, introduces two poles in the transfer function of the inverter. The advantage of high switching frequency is that there is flexibility in the placement of these poles; a trade-off can be made between system bandwidth and ripple attenuation. Note that an EMI filter, which merely slowed the edges of the switching waveform, would not affect switching loss, since the ½ CV^2 energy associated with the external capacitance would still be dissipated with each cycle.

Efficiency gains realized in testing

A three-phase inverter, constructed as indicated in Figure 2, using six of Transphorm's 600V GaN HEMTs, was tested together with Yaskawa America, Inc., in a program funded, in part, by ARPA-E (ADEPT program). A 3 hp, 230 VAC induction motor with variable load was driven by both the GaN inverter, switching at 100 kHz, and an IGBT-based, commercial inverter, switching at 15 kHz. Both drives used a simple, open-loop V/F control for this test. The commercial inverter was connected directly to the motor, as is typical, while the GaN inverter was connected via the output filters. A 60Hz excitation was used in all of the following.

Figure 3 (a) compares the efficiency of just the inverters. Clearly both inverters are highly efficient, although it is significant

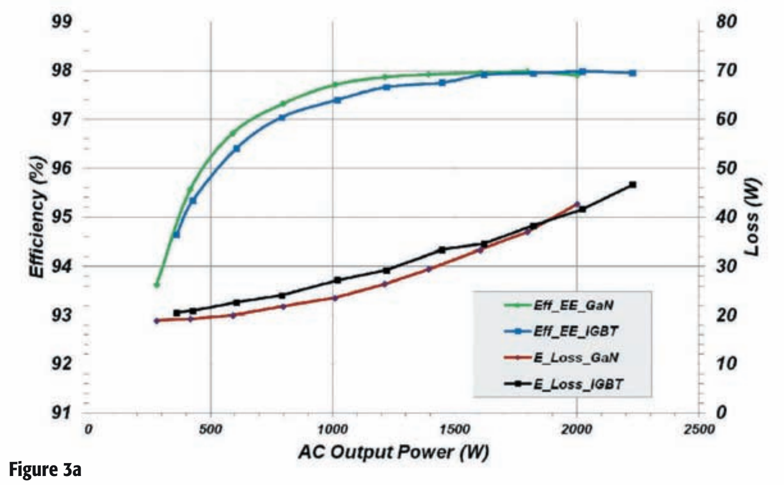


Figure 3a

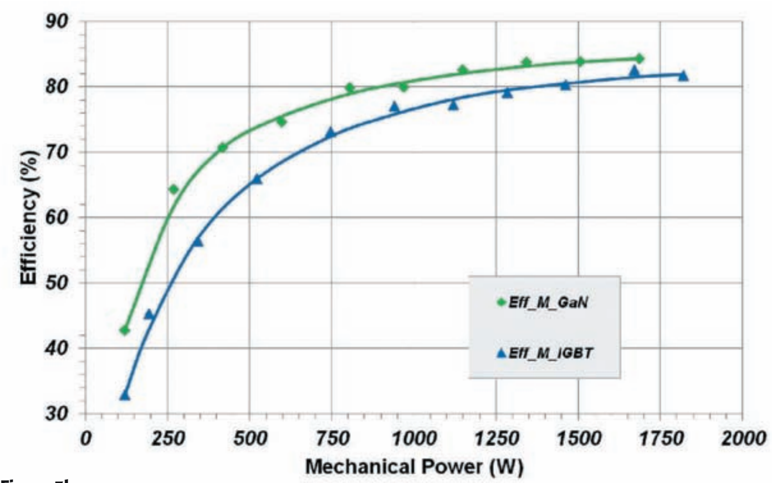


Figure 3b

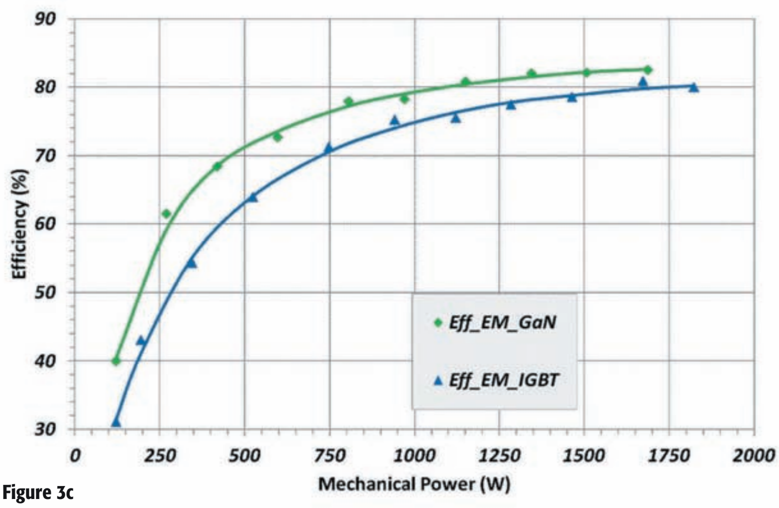


Figure 3c

Figure 3: Test results driving a 3 hp induction motor with variable load with

(a) Electrical Efficiency $\eta_E = \frac{P_{AC}}{P_{DC}}$ **(standby power subtracted);**

(b) Motor Efficiency $\eta_M = \frac{P_M}{P_{AC}}$

and (c) System Efficiency $\eta_S = \frac{P_M}{P_{DC}}$

to note that the GaN inverter, switching at a higher frequency and incurring additional loss due to inclusion of the filter, actually achieves a higher efficiency. This is due to isolation of the switching nodes from the external capacitance. Figure 3 (b) shows the motor efficiency for both cases. A significant degradation in efficiency is seen in the case of the IGBT drive, particularly at low load - about 4 % at 750 W, for example. Clearly the presence of harmonics associated with the 15 kHz switching cause significant heating of the motor. Figure 3 (c) shows the system efficiency. As expected, given the high efficiency of both inverters, the gain in motor efficiency is also realized in the system efficiency. An important point is that, while this improvement in motor efficiency could possibly be realized by simply increasing the switching frequency, without inclusion of the filter, the same gain in system efficiency would not be realized with that approach. The switching loss incurred in the inverter would be dramatically higher due to charging and discharging the motor and wiring capacitance.

Future developments

The topology presented here - a very simple voltage-source inverter coupled to a very simple LC filter - is, of course, not the only possible topology for motor drive. Numerous other topologies which have been developed, including various cycloconverters and multi-level voltage-source inverters, could realize similar benefits from low-loss, high-speed GaN switches. A switch configuration of particular interest for several of these topologies is the bidirectional switch. The matrix converter, for example, uses nine bidirectional switches to connect three input phases to three output phases. Two GaN HEMTs connected in series, either source-to-source or drain-to-drain, make a simple high-voltage bidirectional switch. This can be accomplished with discrete devices, but integrated bidirectional switches, which will be even more compact, more efficient, and lower cost, can be expected in the future.

The initial GaN HEMTs and Schottky diodes offered by Transphorm carry a 600 V rating, and are targeted for systems operating off of line voltages up to 240 VAC. For systems with higher line voltages, 1200 V devices will be available in the near future. For either voltage ratings, devices with higher current ratings can also be expected.

Conclusion

High-speed GaN transistors with low inherent switching loss have been used to demonstrate the improvement possible in both motor and inverter efficiency through high frequency switching. The method presented here makes use of small output filters, enabled by the high switching frequency, to isolate the motor and motor wiring from the switching nodes. This benefit, of potential value in any motor system, is in addition to the extension of system bandwidth, which is certainly a benefit for high speed motors and high-performance servos.

Literature

[1] A. Johannsen, "Power Modules for Fast Switching Motor Drive Applications", Power Electronics Europe, 4 (2009) 30-31

Power Integration for a Smoother Hybrid Driving Experience

Hybrid cars provide an important stepping stone between the conventional combustion engine and full electric propulsion. Engine start-stop technology is a key component of the major hybrid powertrains in the market today, and will benefit from greater power electronic integration to improve performance and reliability. **David Jacquinod, Application and Marketing Manager, Automotive Business Unit, International Rectifier Corporation, USA**

As always, in the automotive marketplace, the greatest excitement surrounds the most futuristic concepts. Today's is a new low-carbon motoring lifestyle in which owners plug-in their electric vehicles (EVs) to charge at home or in public areas such as supermarket car parks, instead of filling them with increasingly expensive petrol or diesel. However, numerous changes are needed in electric power and information infrastructures before widespread use of plug-in EVs can become a practicable proposition. Hybrid vehicles that feature a relatively small internal combustion engine, which is combined with an electric motor, offer a more readily usable proposition to help reduce vehicle emissions in the immediate future.

Various forms of hybrid vehicle are already in the marketplace, and all use auto stop-start technology to maximize the savings in combustion engine emissions. Full hybrids, which have a large electric motor capable of propelling the vehicle while the combustion engine is turned off, are capable of starting and stopping the engine automatically (auto startstop) to achieve seamless transitions between electric and conventional propulsion. An alternative is the mild hybrid, which uses a smaller electric motor/generator to provide assistance such as when extra power is needed for acceleration. In the mild hybrid, auto start-stop eliminates idling of the combustion engine. A mild hybrid powertrain can be produced at lower cost than a full hybrid system, making the environmental advantages of hybrid technology accessible to a broader range of markets.

An even more competitively priced configuration is the microhybrid, which combines a small combustion engine with auto start-stop to eliminate idling, and can be achieved without designing a completely new powertrain. Stop-start technology contributes to fuel savings of between 10% and 15 % for a microhybrid in a city or urban driving environment. This compares with 10-25 % in a mild hybrid and 25-40 % lower fuel consumption in a full hybrid. Market analyst Yole Developpement has predicted that microhybrid production will rise from around five million vehicles in 2012 to some 45 million in 2020; by far the most accessible and widely adopted hybrid format for the next few years.

Designing the start-stop system

Stop-start technology calls for some important changes to the vehicle's electrical systems. All types of hybrid vehicles are adopting improved battery technologies, for example, since conventional lead-acid batteries have significantly shorter lifetime when required to restart the vehicle repeatedly during each journey. Moreover, as the battery's voltage drops significantly when cranking the engine to restart, a power switch is needed to disconnect it from electrical systems such as the radio, climate control, GPS and interior or exterior lights to prevent this voltage drop interfering with correct operation. The battery voltage can fall to around 6V during cranking, whereas the electrical systems require a stable supply, or board net voltage, which is nominally 13V. An auxiliary battery or DC/DC converter provides this stable voltage while the main battery is disconnected, as shown in figures 1a and 1b.

The power switch is typically a power MOSFET of low on-resistance ($R_{DS(ON)}$), controlled by a gate driver that turns the switch off when necessary to protect electrical loads against fluctuations in the battery voltage. The key functional element of the gate driver is a boost converter capable of generating a gate drive voltage of around 15 V when operating from an input voltage in the range 4-36 V. Since the MOSFET power switch must remain turned on by default, even when the vehicle is parked, the driver must also have low current consumption, to minimize drain on the vehicle battery. However, designing a driver capable of meeting all these requirements using discrete components is challenging. Some designers have used an integrated gate driver IC as an alternative, but these are typically optimized for unrelated applications such as mobile phone handsets or PDAs.

A new gate controller optimized for start-stop applications enables designers to eliminate much of the complexity surrounding control of power switches for main battery disconnection. This driver, the AUIR3240S, has low quiescent current and is fabricated using a proven technology qualified at 175°C and used successfully in various automotive applications since 2006. Qualification at 175°C allows the start-stop driver and power switch to be deployed under the hood and thereby situated close to the main battery. The driver also integrates diagnostic circuitry for monitoring output current, and provides a thermal sensor interface supporting the design of robust and reliable systems.

The AUIR3240S is capable of driving several MOSFET power switches in parallel to achieve very low $R_{DS(ON)}$ with current consumption below 50 µA. Figure 2 shows a typical application circuit comprising the AUIR3240S, including the external components required for output current monitoring and thermal protection.

They key criteria determining the chosen MOSFET's performance in a start-stop application is its $R_{DS(ON)}$ and current rating, which must be adequate to carry the peak

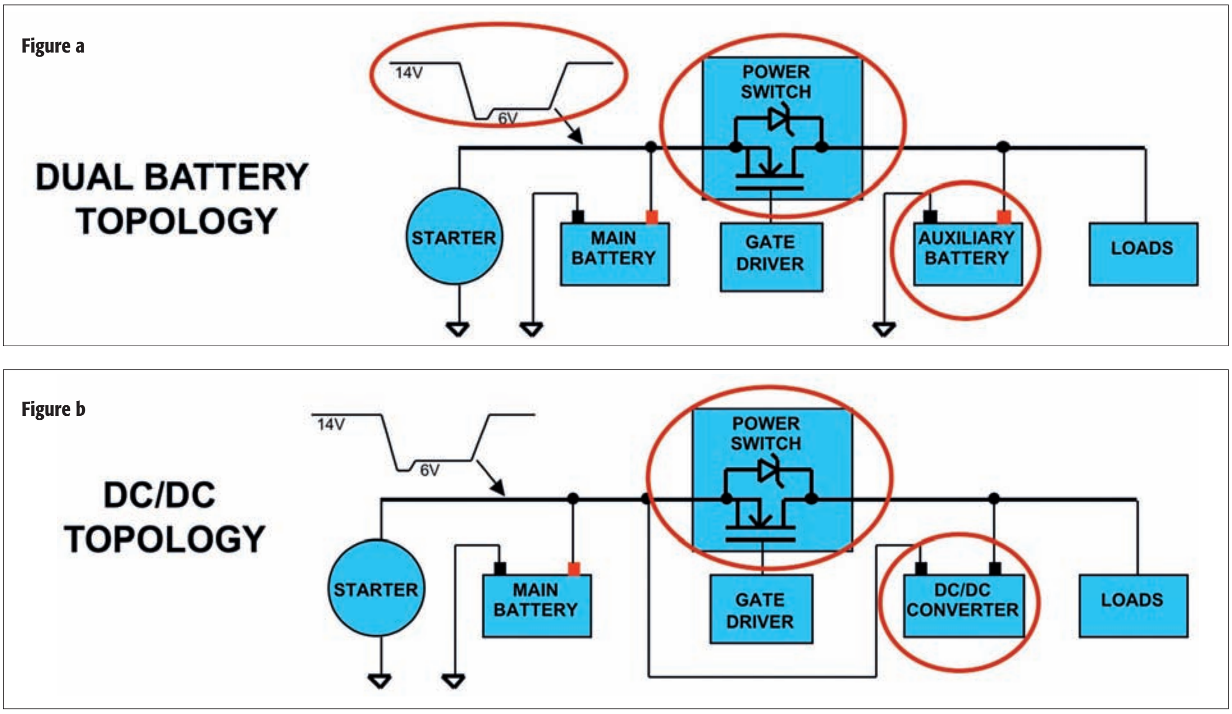


Figure 1: Start-stop power switch with auxiliary battery supply (a) and start-stop power switch with DC/DC converter (b)

load current calculated for the vehicle. Suitable MOSFETs that can be used with this device include the AUIRF1324S-7L or the AUIRF3004-7L, which are rated for 24V and 40 V breakdown voltage respectively. The AUIRF3004-7L provides a higher safety margin allowing the device to withstand voltage fluctuations above the nominal voltage. Both devices have low $R_{DS(ON)}$, which helps to minimize energy losses in vehicle modes when the power switch is turned on.

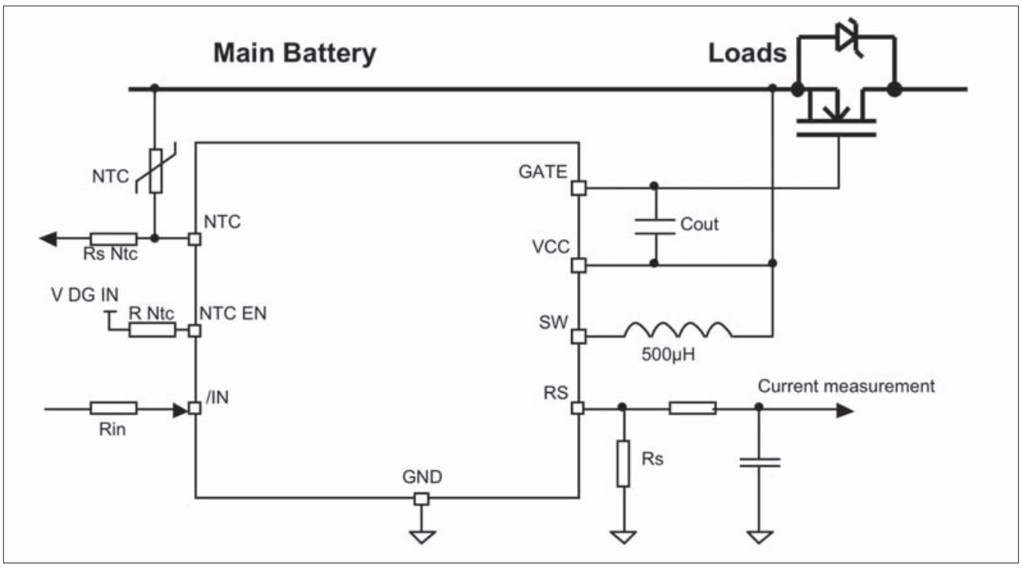
Conclusion

Influenced by factors such as environmental awareness and steadily rising petrol and diesel prices, car owners are increasingly sympathetic to new vehicle technologies that are effective in reducing emissions and improving fuel economy. Consumers are being encouraged to imagine charging small city cars overnight from an AC supply fed substantially from renewable energy sources such as wind or solar. In the short term, hybrid vehicles using smaller combustion engines that never waste fuel by idling can deliver valuable savings as a stepping stone into that future. Full, mild and microhybrid powertrain types are established. Among these, the microhybrid currently offers the lowest-cost, most accessible option.

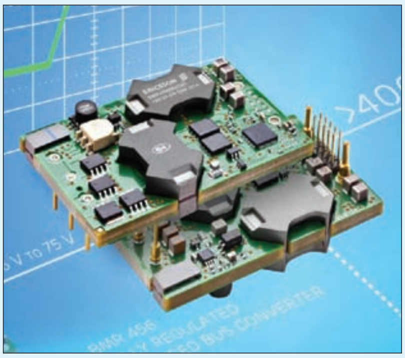
In a typical hybrid application, automatic engine start-stop operation is essential to deliver an acceptable user experience by ensuring seamless transitions between modes in which the engine is running and those where it is turned off. Suitable power switching is an important part of the start-stop system, and is needed to ensure correct operation of all vehicle electrical systems as engine cranking can take place automatically on multiple occasions during any journey.

A number of suitable power MOSFET switches are already available, but driver design has typically challenged engineers to build a low-power boost converter using discrete components or to choose from ICs originally conceived for non-automotive applications. The advent of IR's automotive-qualified dedicated start-stop controller IC, using proven technology qualified at 175°C, simplifies the design of more integrated, reliable and higher performing start-stop systems for all types of hybrid vehicles.

Figure 2: Integrated MOSFET gate driver with current monitoring and thermal protection



400 W Digital Bus Converter



Ericsson has unveiled its second digital-power Advanced Bus Converter platform (Frida II) for use with board-mounted DC/DC power modules in telecom and datacom applications. Built around the capabilities of the 32-bit ARM7TDMI-S microprocessor core, the FRIDA II platform offers a tightly regulated output voltage (2%) across the entire operational range (36-75V). Compared to the FRIDA I platform, the implementation of a highly advanced power controller, in conjunction with control algorithms, has made it possible to reduce the number of components used in the FRIDA II platform by 10 %. The integrated transformer and feedback components have also been specially designed to meet 2250 VDC isolation requirements. The first product based on the FRIDA II platform will be a quarter-brick bus converter (BMR456), which will deliver an output power of 400 W; followed by a new eighth-brick format 250 W device (BMR457).

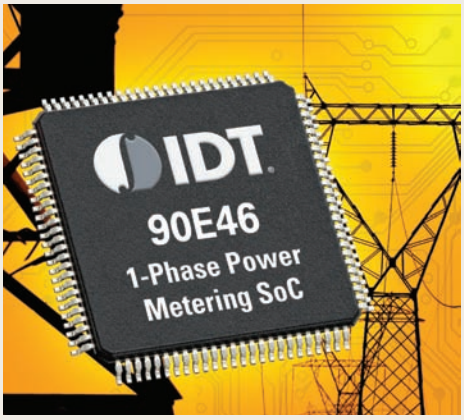
www.ericsson.com/powermodules

Chip Capacitors with Protective Coating

Syfer Technology introduces a range of multilayer chip capacitors (mlccs) suitable for high voltage applications, supplied with a built-in protective coating. Typically, with standard high voltage capacitors, a special coating is applied after the devices are soldered onto the board in order to minimise the risk of flashover from one termination on the chip to another. Syfer's ProtectiCap™ process applied to its high voltage range of mlccs has been developed specifically to address this issue. The integral coating, a matte tin layer over the nickel FlexiCap base termination, minimizes the risk of flashover and avoids the need for the customer to apply conformal coating after soldering. Aimed at applications such as power supplies, lighting ballasts, inverters/DC link, and general high voltage circuits, the X7R dielectric ProtectiCap range of mlccs combines high voltage capability with small package size. The capacitance range of devices in this series is 100 pF to 33 nF, package sizes range from 1206 to 2220, and voltages available include 2-5 kV. Typical devices include a 2 kV mlcc in 1206 package with capacitance range of 100 pF to 3.3 nF, 2 kV mlcc in 2220 package with capacitance range of 220 pF to 33 nF, 3 kV device in 1880 package with 100 pF to 3.3 nF capacitance range, and 5 kV mlcc in 2220 package with 220 pF to 4.7 nF capacitance range.

www.syfer.com

Power Metering SoC for the Smart Grid



IDT's 90E46 is a single-phase SoC for smart meter designs, which integrates an energy metering analog front-end with a real-time clock, temperature sensor, LCD driver, and ARM Cortex M0 microprocessor. The metering device offers a dynamic range of 5000:1, which enables meter manufacturers to merge various meter types into one, thus simplifying the design and manufacturing process for meter makers and reducing the storage and management complexity for utilities. The new metering SoC is fully compliant with international (both IEC and ANSI) and Chinese standards, and meets or exceeds the requirements set forth by the State Power Grid Corporation of China (SGCC). The device features 128 kB of internal flash memory, enabling users to store large instruction sets for the integrated microprocessor. The IDT 90E46 is available in a 100-pin TQFP package and is priced at $2.50 each for volumes of 10,000 units.

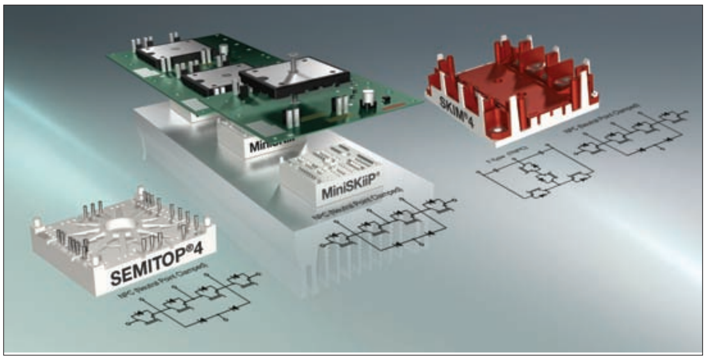
www.idt.com/go/PowerMeter

Automotive Power Controller

Texas Instruments introduced a dual output power supply for automotive applications that ensures stable, uninterrupted output voltages, even in cases where the input voltage drops significantly below the output voltage levels. The start/stop function in many new car models increases fuel economy, but also leads to significant drops in the supply voltage when restarting the engine. The TPS43330-Q1 family remains fully functional during such voltage drops and ensures that applications continue to work without interruption or performance reduction. The devices' ultra-low quiescent current makes the use of a separate standby voltage supply unnecessary, thus reducing system cost and complexity. In addition to the TPS43330-Q1 DC/DC controller, TI offers a large portfolio of power management ICs aimed at automobile applications, including step-down converters like the TPS57160-Q1 or PIMCs like the TPS65023-Q1. The LM25118Q buck-boost controller and TPIC74101-Q1 buck-boost converter help maintain stable output voltage over a wide supply voltage range. Samples of the TPS43330-Q1 and TPS43332-Q1 are available in an HTSSOP-38 (DAP) package. Suggested retail pricing for the TPS43330-Q1 family ranges from $2.85 to $3.10 in 1000-unit quantities.

www.ti.com/tps43330-q1-preu

Three-Level Modules for Solar and UPS Applications



SEMIKRON will be adding 3-level topologies to its product range. 3-level technology boasts a lower distortion factor and consequently reduced filtering requirements. The product range will now include MiniSKiiP, SEMITOP and SKiM 4 IGBT modules. The baseplate-free SKiM4 module is the most powerful IGBT module in the range, with rated currents of between 200 A and 600 A. As much as 250 kVA can be achieved without several modules having to be connected in parallel. SKiM4 modules come in TNPC technology for 650 V and 1200 V, and 1200 V in NPC topology. The modules in TNPC topology can deliver up to 900 VDC and 480 VAC, while those in NPC topology can push the EU low voltage directive to its limits of 1500 VDC and 1000 VAC. For smaller currents, baseplate-free, spring-contact IGBT MiniSKiiP modules are available. These modules feature solder-free mounting and are intended for rated currents of between 75 A and 200 A and reverse voltages of 650 V, enabling powers of up to 85 kVA. At 4.9 A/cm^2, the power density is very high, making this module ideal for use in compact systems. A further merit is the easy single-screw connection between module and heat sink and controller board. The counterpart to solder-free MiniSKiiP modules is the SEMITOP, an IGBT module which is 12 mm in height and soldered on to the Power Circuit Boards and used in applications with current ratings of 600 V/20 A -150 A. These baseplate-free solder-connection modules come in NPC topology and can deliver up to 65 kVA. The fact that no solid busbars are needed in SEMITOP and MiniSKiiP modules is the reason for their compact design.

Three-level technology was originally intended to be used to control voltages that were greater than the reverse voltage of the semiconductor device. Now the main purpose of this technology can be found in the output voltage waveform: instead of the full positive or negative DC link voltage, now half the DC link voltage is available for each side. In 3-level technology the multi-stage waveform is closer to an ideal sine wave than is the case for conventional 2-level topologies. The biggest advantage of 3-level technology is the lower distortion factor and consequently reduced filtering requirements. This is particularly important in applications where very clear output voltage and output current waveforms are needed, e.g. UPSs or solar inverter applications.

SEMIKRON manufactures power modules in two different 3-level topologies: NPC (Neutral Point Clamped) and TNPC (T-Type Neutral Point Clamped), both of which have their advantages. The advantage of NPC technology lies in the fact that it allows for a higher overall DC link voltage than each individual semiconductor die would be able to block. This enables manufacturers of solar inverters to apply a DC link voltage of up to 1500 VDC to the power modules as opposed to the maximum DC link of around 1100 VDC in 2-level modules. In terms of error management, NPC topology is less complex than TNPC, although the same high-quality output voltage waveform is achievable with both topologies. On the other hand, TNPC modules are slightly more powerful than NPC modules, since they require 8 rather than 10 different semiconductor dice.

80A Quarter Brick IBC

Vicor's new IB050Q096T80N1-00 quarter-brick IBC module can provide up to 850 W of output power, the new module operates from a 36 V to 60 V input voltage range, with 2,250 VDC isolation from input to output while achieving 98 % peak efficiency. Rated at up to 80 A, 850 W from 55 to 60 V_{in} and 550 W from 36 V_{in}, the 58.4 mm x 36.8 mm x 10.5 mm quarter-brick module allows designers to conserve valuable board space and achieve full load operation at 50°C with 400 LFM airflow. Its open frame construction facilitates airflow above and below the module to minimize temperature rise of downstream components. Operating at 1 MHz, the IB050Q096T80N1-00 IBC module cuts transient response time by a factor of 10 and eliminates the need for bulk capacitors across the intermediate bus. Designers can take advantage of Vicor's new IBC Power Simulation tool to interactively model the electrical and thermal performance of the module in application-specific operating conditions and thermal environments.

www2.vicorpower.com/850WIBC_DS_Link

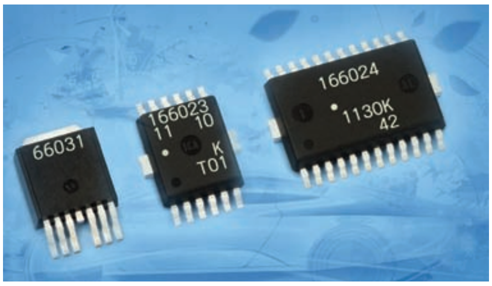
Wireless Charging ICs

On Semis' NMLU1210 is a 20 V N-channel full bridge semi-synchronous rectifier, that incorporates a dual Schottky barrier diode supporting up to 3.2 A operation plus two MOSFETs with a 17 mΩ (typical) $R_{ds(ON)}$ to minimize conduction losses and substantially increase efficiency of the charging system. Wireless inductive charging is becoming increasingly popular, freeing consumers from the inconvenience of the traditional wired approach. It works on the principle of an electromagnetic field being created for the rapid transfer of energy between the transmitter (in the charging station) and the receiver (in the portable device). The NMLU1210 is used by the receiver side to convert AC voltage generated by the transmitter to DC voltage used for battery charging. Offered in an ultra-low inductance thermally efficient package, it is optimized specifically for power management tasks in portable electronic products. This compact IC is highly suited to use in space-constrained environments. It has an operational junction temperature of –55 to 125°C.

www.onsemi.com

Power Devices for Automotive Body Applications

Renesas Electronics announced 14 new intelligent power devices (IPDs), including the _PD166023, designed for automotive applications driving exterior lamps such as headlamps and fog lamps as well as seat heaters and motors. An IPD is a power IC device that incorporates in a single package, or on a single chip, a power semiconductor switch (power MOSFETs) and its control circuit featuring interface to microcontroller (MCU) as well as protection functions and self-diagnostic. The new products are designed to detect and deal with error states instantly in order to provide a high level of durability. For example, exterior vehicle lamp applications require longer wire harnesses to connect the control unit to the lamps leading to a high possibility of undesirable events, such as shorted loads. These undesirable events may not be noticed by car drivers and result in severe stress conditions for the switch, the enhanced protection features expand device durability. The new products are also designed with self diagnostic features to detect and deal with error states instantly in order to provide a high level of durability and ensure functional safety at system level. The product lineup includes versions with on-resistance specification of 6 mΩ to 90 mΩ. The 6, 8, 10 and 12 mΩ products are available in a new 7-pin, TO252 package. An IPD can easily be replaced with another of a different on-resistance rating in the same package, either in the development stage or when making minor changes to a unit already in mass production, without a PCB change. Four products are available with a 7-pin TO252 package, six products with a 12-pin high-heat-dispersion HSSOP package, and four products with a 24-pin high-heat-dispersion HSSOP package. Samples of the new IPDs are available now, mass production is scheduled to begin in March 2013.



www.renesas.eu

Power Planar Transformers

Wuerth Electronics Midcom introduces the newly developed planar transformer product series optimized for frequencies ranging from 200 kHz to 700 kHz, with 500VDC isolation and 250 W power handling capabilities. Developed to be fully customizable to individual customer needs, the planar SMD transformers comes in multiple turns ratio options with optional Aux winding for maximum flexibility. The parts have a low-profile height of 10 mm and an operating temperature range of -40°C to +125°C. The patent-pending design offers a multitude of advantages compared to traditional bobbin-wound products including reduced size and weight, high efficiency, low leakage, consistent parasitics and excellent thermal characteristics. The use of pre-formed flatwires yields significant cost reductions compared to existing stacked layer and multilayer PCB designs.

www.we-online.com/planar

2-Wire Hall Effect Sensing Devices

The MLX92221 and MLX92241 Hall Effect sensors from Melexis are quipped with an EEPROM memory, allowing the setting of customer specific parameters for magnetic switch points, output polarity, IOFF current and magnet material temperature compensation coefficient. With a wide programmable magnetic range, the MLX92221 and MLX92241 both feature Hall Effect sensing elements operating from 2.7 V to 24 V voltage levels, allowing automotive, consumer and industrial applications to all be addressed. These devices integrate protection mechanisms to guard against electro-static discharge (ESD), reverse supply voltage and thermal overload. The reverse supply voltage protection protects the devices against incorrect connection of the supply line, up to -24 V.
The core magnetic sensor circuit in the devices of this platform is re-engineered with a special focus on the offset cancellation system, allowing faster and more accurate processing while not being effected by temperature. A programmable negative temperature coefficient is implemented to compensate for the natural behavior of permanent magnets to become weaker at elevated temperatures. The MLX92221 and MLX92241 are delivered in RoHS compliant single-in-line (SIL) packages for through-hole mounting, or in a 3-pin thin SOT (TSOT) packages for surface mounting.

www.melexis.com

Schottky Diode for Battery-Powered Products

7¶Toshiba Electronics Europe (TEE) has announced a new series of Schottky barrier diodes (SBDs) aimed at high-speed switching applications in the 500 mA to 1000 mA current range. Major application areas are DC/DC conversion or backflow protection in battery charger circuits. This new class of SBDs is designed for maximum reverse voltages of 30 V and offers typical leakage currents as low as 5 µA. Depending on the maximum current rating of the SBDs the typical forward voltages range from 0.38 V up to 0.43 V at 1000 mA, the typical diode capacitances range from 120 pF for the 500 mA type to 170 pF for the 1000 mA. The new series comprises the CUSxxF30 family in an SOD323 package featuring three different maximum current ratings. In addition the 500 mA device is also available as CBS05F30 - a compact LGA type (CST2B) package with a footprint of 1.2 mm x 0.8 mm and a maximum height of 0.4 mm.

www.toshiba-components.com

AC/DC Connverters

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

Busbars

www.auxel.com
Auxel FTG
Tel: +44 (0)7714 699967

Capacitors

www.powersemiconductors.co.uk
Power Semiconductors Ltd
Tel: +44 (0)1727 811110

Certification

www.productapprovals.co.uk
Product Approvals Ltd
Tel: +44 (0)1588 620192

Connectors & Terminal Blocks

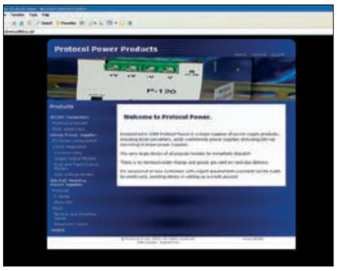
www.auxel.com
Auxel FTG
Tel: +44 (0)7714 699967

DC/DC Converters

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

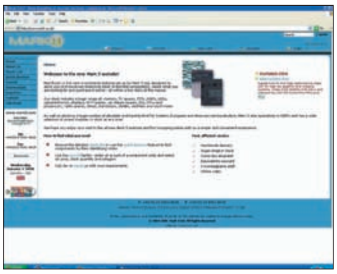
DC/DC Connverters

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399



www.protocol-power.com
Protocol Power Products
Tel: +44 (0)1582 477737

Diodes



www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

www.neutronltd.co.uk
Neutron Ltd
Tel: +44 (0)1460 242200

www.voltagemultipliers.com
Voltage Multipliers, Inc.
Tel: 001 559 651 1402

www.proton-electrotex.com/
Proton-Electrotex JSC/
Tel: +7 4862 440642;

Direct Bonded Copper (DPC Substrates)

www.curamik.co.uk
curamik® electronics GmbH
Tel: +49 9645 9222 0

Discrete Semiconductors

www.digikey.com/europe
Digi-Key
Tel: +31 (0)53 484 9584

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

Drivers ICS

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Fuses

www.powersemiconductors.co.uk
Power Semiconductors Ltd
Tel: +44 (0)1727 811110

GTO/Triacs

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

Hall Current Sensors

www.dgseals.com
dgseals.com
Tel: 001 972 931 8463

Harmonic Filters

www.murata-europe.com
Murata Electronics (UK) Ltd
Tel: +44 (0)1252 811666

IGBTs

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

www.neutronltd.co.uk
Neutron Ltd
Tel: +44 (0)1460 242200

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Magnetic Materials/Products

www.rubadue.com
Rubadue Wire Co., Inc.
Tel. 001 970-351-6100

Mosfets

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

www.neutronltd.co.uk
Neutron Ltd
Tel: +44 (0)1460 242200

Optoelectronic Devices

www.digikey.com/europe
Digi-Key Tel: +31 (0)53 484 9584

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Packaging & Packaging Materials

www.curamik.co.uk
curamik® electronics GmbH
Tel: +49 9645 9222 0

Power ICs

www.digikey.com/europe
Digi-Key Tel: +31 (0)53 484 9584

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Power Modules

www.auxel.com
Auxel FTG
Tel: +44 (0)7714 699967

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

www.proton-electrotex.com/
Proton-Electrotex JSC/
Tel: +7 4862 440642;

Power Protection Products

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Power Semiconductors

www.proton-electrotex.com/
Proton-Electrotex JSC/
Tel: +7 4862 440642;

Power Substrates

www.universal-science.com
Universal Science Ltd
Tel: +44 (0)1908 222211

Resistors & Potentiometers

www.isabellenhuette.de
Isabellenhütte Heusler GmbH KG
Tel: +49/(27 71) 9 34 2 82

RF & Microwave Test Equipment.

www.ar-europe.ie
AR Europe
Tel: 353-61-504300

Simulation Software

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

www.universal-science.com
Universal Science Ltd
Tel: +44 (0)1908 222211

Smartpower Devices

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

Switches & Relays

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

Switched Mode Power Supplies

www.biaspower.com
Bias Power, LLC
Tel: 001 847 215 2427

Switched Mode Power Supplies

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Thermal Management & Heatsinks

www.abl-heatsinks.co.uk
ABL Components Ltd
Tel: +44 (0) 121 789 8686

www.curamik.co.uk
curamik® electronics GmbH
Tel: +49 9645 9222 0

www.dau-at.com
Dau GmbH & Co KG
Tel: +43 3143 23510

www.lairdtech.com
Laird Technologies Ltd
Tel: 00 44 1342 315044

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

www.universal-science.com
Universal Science Ltd
Tel: +44 (0)1908 222211

Thyristors

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616
www.proton-electrotex.com/
Proton-Electrotex JSC/
Tel: +7 4862 440642;

Voltage References

www.irf.com
International Rectifier Co.
(GB) Ltd
Tel: +44 (0)1737 227200

ADVERTISERS INDEX