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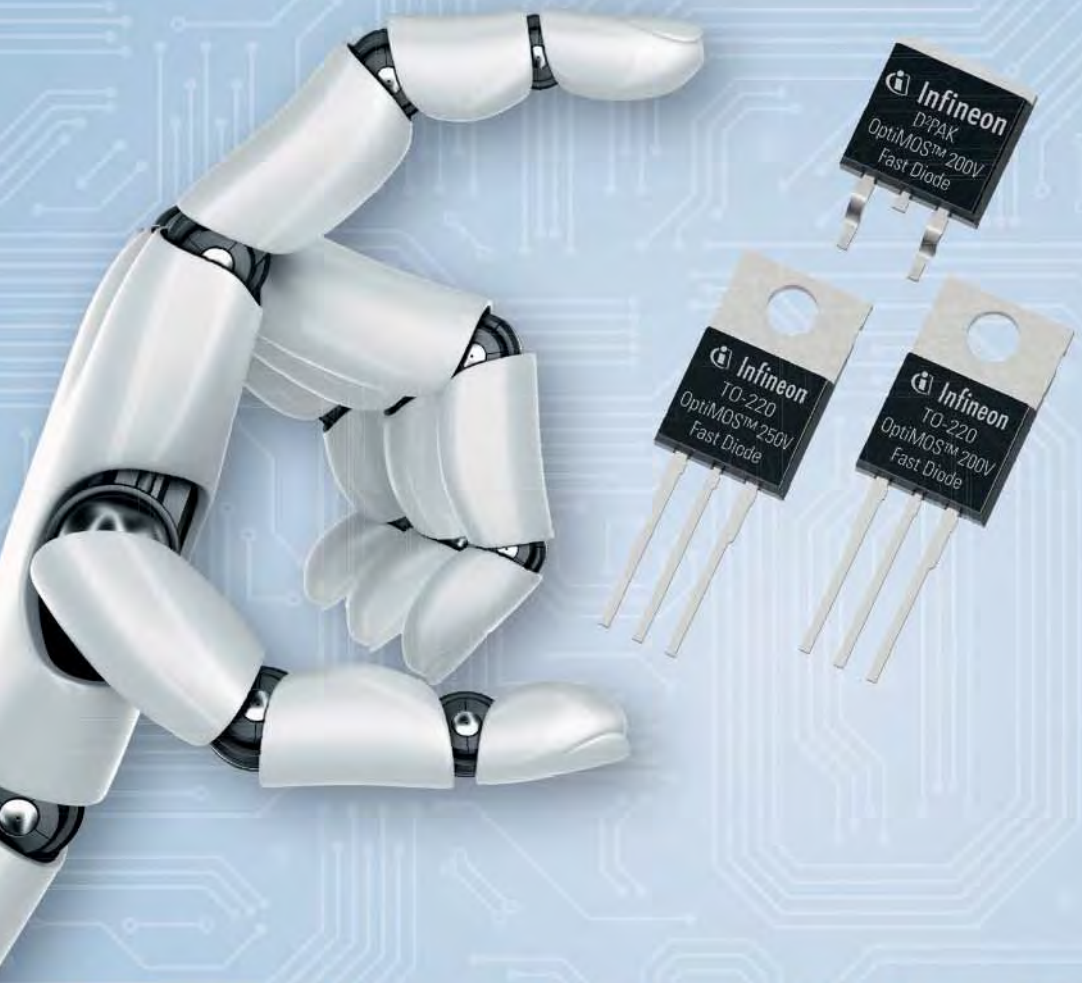
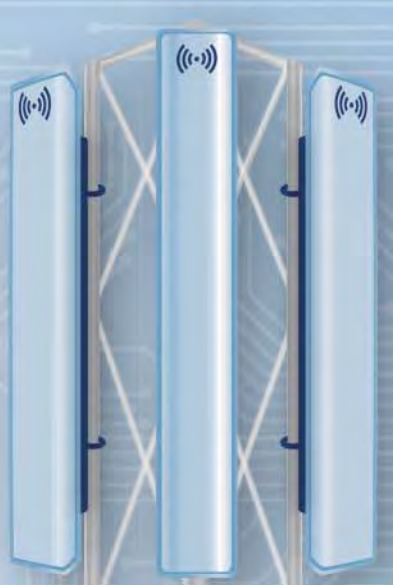
Bodo's Power Systems®

Electronics in Motion and Conversion

August 2014





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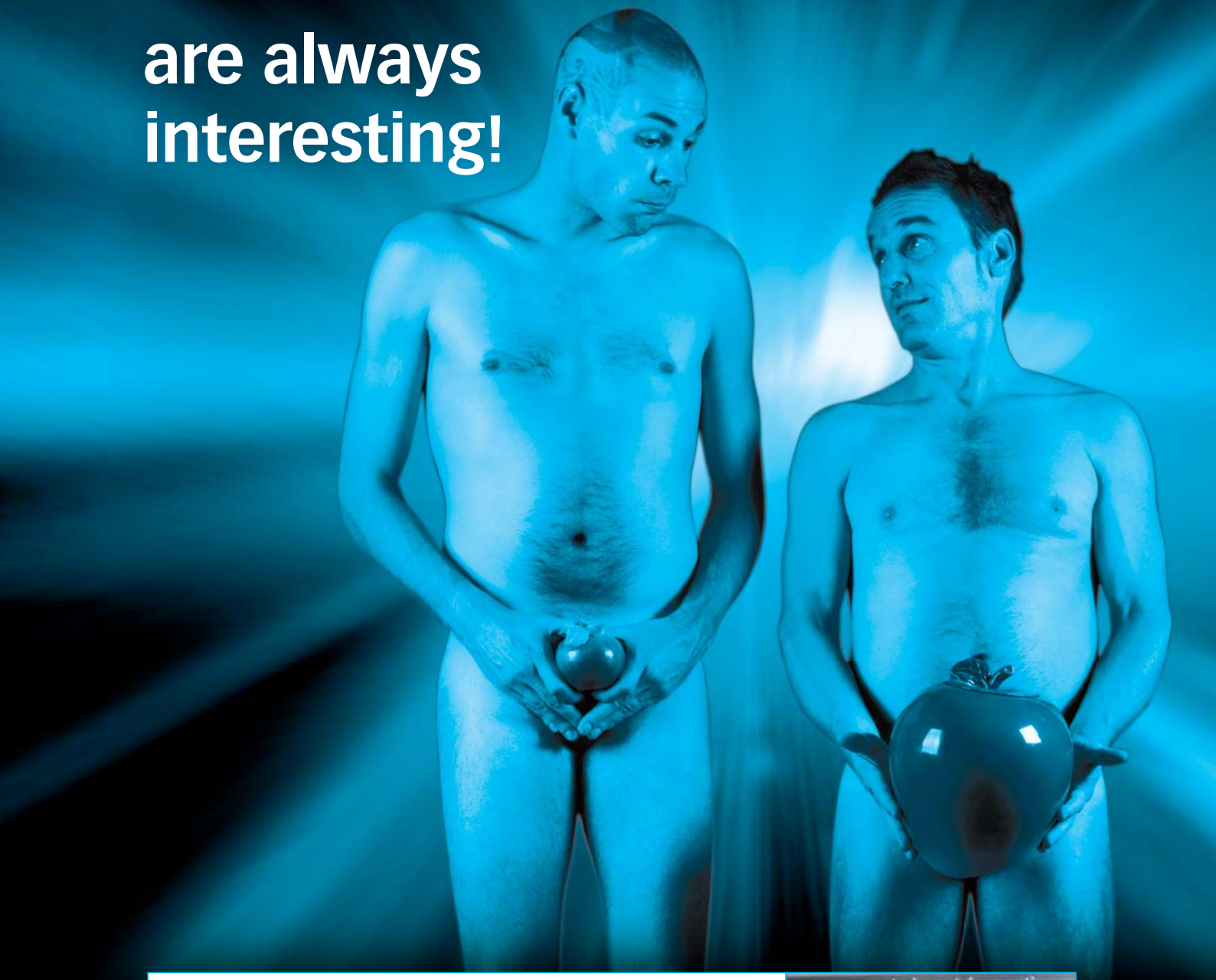

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Thanks to its modular and flexible design, VARIS™ offers compelling benefits. The desired power can be easily achieved via parallel connection of the modules. You are also free to choose your preferred cooling type. And the use of standard components makes VARIS™ both cost-efficient and sustainable. Talk to the House of Competence, because VARIS™ fears no comparison. Even with your current inverter systems, right?

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Read online and search for key subjects from all articles in Bodo's Power Systems by going to Powerguru: www.powerguru.org

powerguru.org

The Gallery

Vincotech
The Power to Move Ahead

Speed and Flexibility

Vincotech, a 100% independent company within **Mitsubishi Electric Corporation**, is a market leader in power modules. With over 40 years of experience Vincotech develops and manufactures high-quality electronic power components for Motion Control, Renewable Energy, and Power Supply applications.

What Vincotech offers:

- Power modules with various topologies ranging from 4 A to 800 A and from 600 V to 2400 V
- Designed with low stray inductance (Rectifier, Sixpack, PIM (CIB), IPM, Boost, NPC, H-Bridge, Half-Bridge, PFC, etc.)
- 21 different standard housings

The Vincotech difference:

- A large variety of standard products for qualified, reliable solutions
- Building blocks to design your product – flexible designs to meet your specific requirements
- Ultra-low inductance designs
- Phase-change material – no more thermal grease

Ultra compact power module for embedded drive application with PFC

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High-speed IGBT PFC boost curcuit

- PFC switching frequencies up to 100 kHz
- Open emitter topology
- New ultra-compact housing
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More details: www.vincotech.com/flowCIP_0B

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Events

Thermal Management 2014,
Denver CO, August, 6-7
www.thermalnews.com/conferences

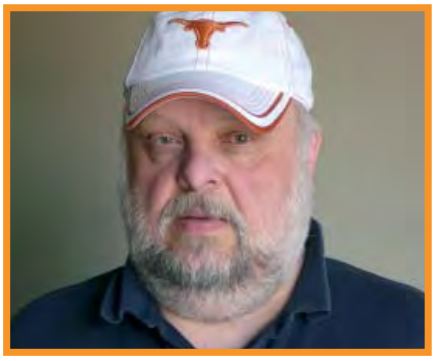
EPE ECCE 2014, Lappeenranta, Finland, August 26-28 www.epe2014.com/

ECCE 2014,
Pittsburg, PA, September 15-18
http://www.ieee.org/conferences_events/conferences/conferencedetails/index.html?Conf_ID=21325

Hybrid & Electric Vehicle Forum 2014,
Munich, Germany, September 17-18 h
ttp://transport.flemingeurope.com/hybrid-electric-vehicles-forum

INNOTRANS 2014, Berlin, Germany, September 23-26 www.innotrans.de/

What does One Hundred Mean?



It is quite a nice number in my view - one hundred magazines produced, every month on the first of each month, and now delivered world-wide to 24,000 print readers. This is about 4½ tons of paper, every month. Starting with our first edition in June 2006 through to this, the current issue, we've printed and mailed 450 tons finally by September 2014. Three stacked magazines equal about a centimeter, we have printed about 2,400,000 copies, which, if you were to pile them up and divide by 3, the pile would be 800,000 centimeters, or 8,000 meters, or 8 kilometers, or 26,000 feet high! Jets fly at that height, so we're making good strides in reaching the moon!

I have to say "Thank You" to my supporters worldwide, because you made it all possible. Ours is a very small and highly motivated team, with a few freelance supporters who process editorial content. Administration is handled mostly within the family, which allows me to claim that my magazine is the leanest publishing house in the world. It is a nice little family business.

What really matters most is up to date articles, ones that help engineers achieve better designs. Technical articles require concentration, scanning back and forth, and engineers find a magazine more comfortable than watching a display, screen by screen. Also, a computer screen doesn't work well in a lounge chair in the sun. On the balcony or in the garden, paper is the preferred way.

Will the young generation watching video clips ever be mature enough to do the designs they play with? An older generation of valuable designers learned to extract the information they needed from datasheets and application notes, not movies. A wise old engineer made the comment that movies are only good for green-horns. I say "If it helps the educational process, it is ok".

Using PowerGuru, all my published articles are easily searched by key word to find a relevant article that might help with the latest technology for an upcoming design. Now there is an App to access the PowerGuru archive. And all my magazine articles are archived as .pdfs on my website.

We will stay focused on getting you valuable information from leaders in industry and academia. Information is shared around the world in an instant. While creative designs may be developed at one location, implementation in manufacturing could be done any place in the world. Suppliers to automotive designs, for example, often establish facilities in locations where the auto is manufactured.

English has become the most common language for technical information. As a boy, I remember data books that were translated into German. Alfred Neye Enatechnik in Quickborn translated all the RCA data books into the German language. That was 45 years ago. It was a great help to my older colleagues who had not learned English during their time in school.

Communication is the only way to progress. We delivered twelve issues last year, each month, on time, every time. This year, the August issue marks 95 technical articles published, amongst 576 pages. They are all archived and retrievable at PowerGuru. As a media partner, Bodo's Power Systems serves readers across the globe. If you speak the language, or just want to have a look, don't miss our Chinese version: www.bodospowerchina.com.

My Green Power Tip for August:

If you prefer to read my magazine as a. pdf, downloaded from my web page, please let me know at registration on the website or by fax. This will help reduce the amount of paper we use to get the information out, but on the other hand, power consumption in internet server-centers will continue to grow.

See you soon at EPE, ECCE, and around the world.

Best Regards

ENERGY UNDER CONTROL

HO - A Range of Choices

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6 families cover nominal currents from 2.67 A to 250 A, PCB-through-hole, surface-mount or multiple panel mounting versions, and offer an aperture or integrated primary conductor.
LEM ASIC technology brings Open Loop transducer performance closer to Closed Loop transducers, providing you with better control and increasing the efficiency of your system, but at a significantly lower price.

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Future Plans for the Villach Site to Create Pilot Space for Industry

Infineon Technologies AG is expanding its Austrian site in Villach. Core emphasis is the on the expansion of expertise for the manufacturing of the future as well as research and development (R&D). "Pilot Space Industry 4.0" will realize and put to the test an innovative concept for networked and knowledge-intensive production. Research on new materials and technologies will also be intensified. Infineon's expansion plans foresee investments and research costs amounting to a total of € 290 million, creating approximately 200 new jobs in the period from 2014 to 2017, primarily in R&D.

Infineon has been actively engaged in the Industry 4.0 initiative from the very beginning; its pilot space in Villach is another step towards realizing this vision. Industry 4.0 embodies a paradigm shift in value creation and brings enormous opportunities to European industry. The Infineon Austria project is an important contribution towards increasing European competitive strength. The pilot operation in Villach will feature production based on a cyber-physical system with highly modern production control and automation systems.

A wide-scale research program with innovations in materials, processes, technologies and system expertise is the second pillar of the Villach site expansion, supporting development of the next generation of energy-efficient products. Here the program focuses on the integration of innovative substrates such as gallium nitride and silicon carbide, on MEMS (Micro-Electro-Mechanical Systems) and sensor technologies as well as on the continuing development of 300 millimeter thin wafer technology.

The many years of growth at Infineon Technologies Austria AG have been supported by a tightly knit collaborative network connecting the company, the city of Villach, the Austrian province of Carinthia, the Republic of Austria and European institutions. As a result it has been possible to turn southern Austria into a high-tech region and to contribute to raising the region's profile and increasing its competitive strength in the sense of "Smart Specialization". With the "Pilot Space Industry 4.0" project Infineon is taking the next step in development, meaning it will also collaborate even more intensively with research partners, universities, technical institutes and SMEs in the innovation system.

www.infineon.com

Move to New Headquarters and R&D Facility

GaN Systems Inc has moved into its new headquarters and R&D facility at 1145 Innovation Drive, Ottawa, Canada. Located at the heart of Kanata's high technology community, the move was necessitated by the company's expansion over the past twelve months and plans for continued rapid growth as GaN devices replace legacy silicon-based semiconductors in power conversion and control applications worldwide.

"We are committed to long term, fast-paced growth, and these new facilities will provide the resources and capabilities we need as we move rapidly from R&D to commercialisation this year." said Jim Witham, CEO. The new HQ and R&D facility is three times larger than GaN Systems' previous premises, with a tenfold increase in laboratory space. The labs have dedicated power and cooling, which is crucial, as Girvan Patterson, co-founder and President explains: "When you produce devices that can switch 200 Amps or more, it calls for some highly specialised facilities to fully test them. The power available in this location and our custom-designed labs will enable us to fully explore higher power applications and substantially accelerate the long term reliability testing of our devices."

Headcount has already increased significantly over the past six months and GaN Systems has expanded its global team as its power conversion devices, based on its proprietary Island Technology®, are commercialized. GaN Systems is believed to be the first company in the market with a wide range of parts already available for sampling.

www.gansystems.com

Cooperation Agreement to Form one of the World's Largest Converter Alliances

SMA Solar Technology AG and Danfoss A/S signed a contract to enter into a close strategic partnership. With this agreement, the two leading system technology specialists will start to further boost their competitiveness. The goal is to sustainably strengthen their cost positions through economies of scale and through joint development initiatives. According to the plans announced in February, Danfoss will acquire 20% of SMA's outstanding shares and sell its entire solar inverter business to SMA. The necessary approval by the antitrust authorities has already been granted.

"Danfoss is very successful in the field of automated drives. This market has been characterized by fierce competition for many years. Accordingly, Danfoss has focused its strategy on continuous cost reduction by using global procurement opportunities and technological innovations. We will benefit from this experience and from economies of scale, thereby strengthening our leading position in the global photovoltaic market. We will accelerate innovation cycles through collaborative efforts in development and systematically reduce our product costs," explained SMA Chief Executive Officer Pierre-Pascal Urbon. In addition, by taking over Danfoss's PV inverter business SMA will be able to serve the high-growth market segment of medium-sized PV systems in Europe, the U.S. and Asia even better.

www.danfoss.com

http://www.sma.de/

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Realize the benefits of SiC technology with our offering of SiC MOSFETs, diodes, MOSFET modules and SiC/Si hybrid modules from industry-leading manufacturers Cree, Microsemi, Vincotech and Powerex.

Find it all on our SiC Tech Hub, along with new product announcements and the latest SiC news and market trends.

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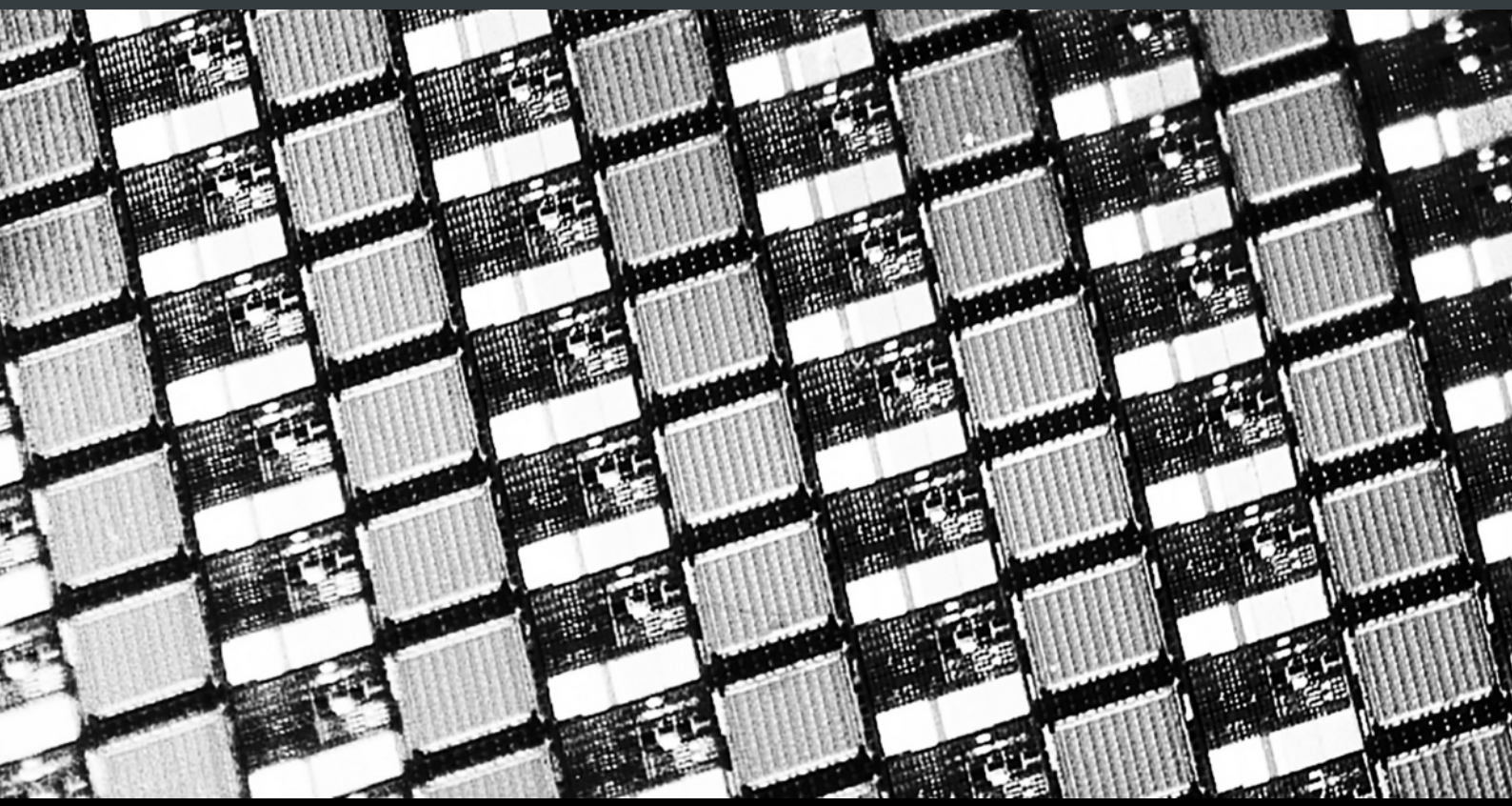

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LpS 2014 – Design and Engineering for Future LED Lighting Systems

With more than 60 lectures and over 100 exhibitors, the international LED professional Symposium +Expo will take place for the fourth time in a row. 1,300 visitors are expected from Sept. 30th to Oct. 2nd in Bregenz, Austria. Latest lighting system design presented in a new interactive lecture concept and an expanded exhibition area make the event highly relevant for everybody involved in the design and engineering of future LED lighting systems.
Bregenz, 13.6.2014 – Lighting system design based on LED and OLED technologies is challenging. Preferred solutions have to incorporate the latest technologies, smart systems, new standards, advanced functionalities and new user behaviors. Therefore, a holistic design and engineering approach is required in order to develop successful LED Lighting Systems for the future.

Event Program
The LpS 2014 covers the most important trends and visions in future LED lighting systems, from LED light sources and materials to manufacturing processes and system designs. Furthermore, the reliability and lifetime of LED lighting systems, as well as practical design approaches, will be discussed.

One of the lecture presentations will be about the development of a new color fidelity index, called CRI2012, presented by Dr. Kevin A.G. Smet from the Research Council Flanders. Attendees will learn the theory and practical use of the new color metrics. Traditionally the CIE color rendering index (CRI) has been used to describe the color rendition of white light sources, however the CRI index fails to accurately predict the color rendition of narrow-band or spiked spectra. This has increasingly become a problem with the advent of Solid-State Lighting, as the inability to correctly assess the color rendition of these light sources might hinder the acceptance of this new lighting technology. Another interesting presentation will be from Ralph Christopher Tuttle, Application Engineering Manager at Cree. He will present insights into the problem of the color shifts of LED packages, and will also cover the important topic of failure mechanisms in Solid-State Lighting. “High temperature results can be used to accurately model LED behavior at lower temperatures”, says Mr. Tuttle.

Human Centric Lighting (HCL) is a key topic in the lighting industry nowadays, promising a lot of future business potential. Dr. Walter Werner is a former System Architect at the Zumtobel Group and will present the challenges of HCL with a focus on components, controls and the networking environment. “We have some more steps to take before humans are back in the center of interest when it comes to lighting”, he says.
For a better understanding of lighting effects on system designs, Bartenbach Lichtlabor will run a workshop covering theory and practical demonstrations on visual perception.

These are just some examples of the many lectures presented in five parallel tracks during the three event days. The full event program is available on:

www.LpS2014.com/program

INTELEC 2014 - ‘Resilient Communications Energy for our Connected World’

INTELEC 2014 announces final program for the 36th annual conference to be held, from September 28 - October 2, at the Vancouver Convention Center in Vancouver. This year’s keynote address will be given by Alex Tang, Independent Management Consulting Professional on “ Time for Reflection: Telecommunications and Electric Power Resilience.” In addition, daily plenary sessions from industry leaders Fred Kaiser (Chairman, Alpha Technologies Inc.), Ewart Blackmore (Senior Research Scientist, TRIUMF) and Bruce Carsten (President, Bruce Carsten Associates) will provide their insights and industry perspectives on hot topics for the entire audience.
In addition, INTELEC 2014 promises to continue in its heritage of providing high quality oral and poster presentations on key issues confronting our industry. Coupled with the presentations are tutorials and workshops relevant to the group as well as and commercial papers whereby attendees can gain training and insight for to take home and implement at their own workplace.

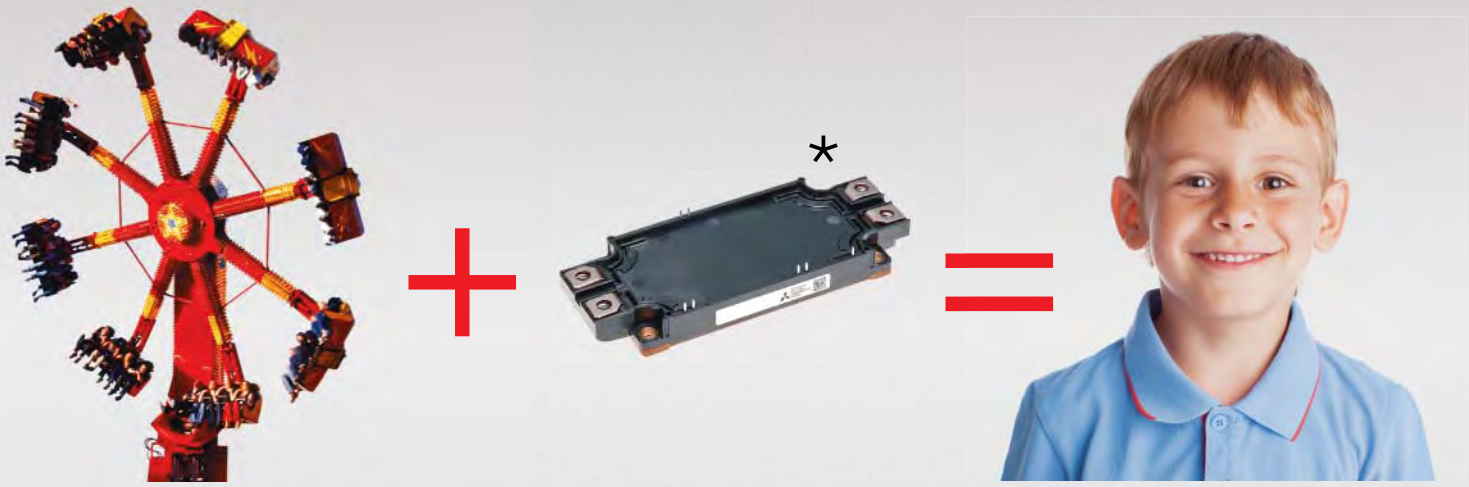
INTELEC©, the International Telecommunications Energy Conference, is the annual world-class technical forum which presents the latest developments in communications energy systems and related power-processing devices and circuits. This Conference, which serves the broad community of researchers, suppliers and operators, explores new technologies of power conversion, energy storage and systems design for telecom applications.
To register for the conference, please go to:

www.intelec2014.org/registration_

PCIM Asia Continues to Grow

PCIM Asia 2014 June closes with positive results. With 79 exhibitors on 5,000 square meters in the Shanghai World Expo Exhibition Center, it has grown again this year. Beside the leading companies of the industry e.g. CSR, CNR, Hitachi, Infineon, Mitsubishi, Semikron, Starpower, Questar and Vincotech, almost 30% of the exhibitors were first-time exhibitors or returned after a long period of absence. Amongst other well-known companies like Bomin, Chang Sung, Heraeus, Shenzhen Hoverbird, Texas Instruments, Toshiba or Wacker participated this year.

The conference with 359 participants closed also with good results. With excellent keynote presentations, five oral sessions and an attractive dialogue poster session, it provided a comprehensive, diversified program. In addition, the special session on the topic „Sensorless Control of AC Motors“ as well as the industry session „Power Devices for Electrical Vehicle and Renewable Applications“ were crowd pullers.



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Power Devices from Mitsubishi Electric.

Precise and efficient control of dynamic processes puts heavy demands on the components used. When it counts, power devices from Mitsubishi Electric are always first choice. Because, in addition to many innovations, they consistently provide added quality, performance and robustness – and therefore reliably ensure first-class results.

★ **6th Generation IGBT Module NX-Package**
- Excellent thermal conductivity by AlN substrate
- Superior power cycling capacity by optimized bonding
- 6th Generation IGBT with CSTBT™ Chip Technology
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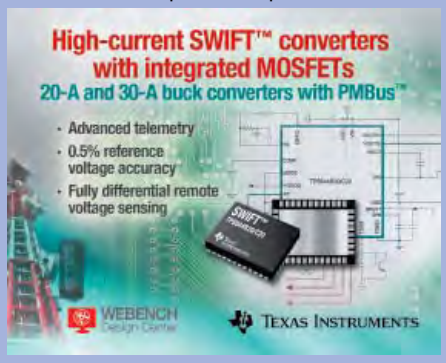
Changes for the Better

Industry's First High-Current PMBus™ Converters with Integrated MOSFETs

20-A and 30-A SWIFT™ DC/DC buck converters feature voltage, current and temperature monitoring

Texas Instruments introduced the industry's first 18-V, 20-A and 30-A synchronous DC/DC buck converters with PMBus interface. The SWIFT TPS544B20 and TPS544C20 converters feature small QFN packages and integrated MOSFETs to drive ASICs in space-constrained and power-dense applications in various markets, including wired and wireless communications, enterprise and cloud computing, and data storage systems. Used in conjunction with TI's award-winning WEBENCH® online design tools, the converters simplify power conversion and speed the power supply design process. For more information, samples and an evaluation module, visit www.ti.com/tps544b20-pr-eu and www.ti.com/tps544c20-pr-eu.



The highly integrated converters feature 0.5 percent reference voltage accuracy and fully differential remote voltage sensing to meet voltage requirements of deep sub-micron processors. Selectable D-CAP™ or D-CAP2™ adaptive on-time control mode is easy to use, provides very fast load transient response and reduces external component count. Programmability, real-time monitoring of the output voltage, current and external temperature, and fault reporting via PMBus simplifies power supply design, increases reliability and reduces component count and system cost. Watch a video on the benefits of buck regulators with PMBus interface.

For PMBus applications without output voltage, current and board temperature telemetry, TI offers the 12-A SWIFT TPS53915 buck converter. Get more information on TI's complete portfolio of SWIFT products.

TPS544B20 and TPS544C20 key features and benefits

- Integrated power MOSFETs support 20-A and 30-A continuous output current.
- On-chip PMBus interface and non-volatile memory simplify power supply design, provide voltage, current and temperature monitoring, and enable customization of the power supply.
- Selectable D-CAP or D-CAP2 adaptive on-time control mode eliminates output capacitors and requires no loop compensation, which minimizes the external component count.
- Other features include internal soft start, input under-voltage protection and thermal shutdown.

About SWIFT products from Texas Instruments

Part of TI's portfolio of industry-leading DC/DC converters, the SWIFT product line includes more than 130 converters with integrated MOSFETs supporting input voltage ranges from 3 V to 28 V. The products are designed to power DSPs, FPGAs and other processors, and are fully functional in TI's WEBENCH Power Designer, Power Architect and FPGA Power Architect design and prototyping tools. See more information on TI's SWIFT product portfolio.

About WEBENCH tools from Texas Instruments

The WEBENCH Designer and Architect component libraries include more than 40,000 components from 120 manufacturers. Price and availability is updated hourly by TI's distribution partners for design optimization and production planning. Offered in eight languages, the user can compare complete system designs and make supply chain decisions in minutes. Start a cost-free design in TI's WEBENCH design environment.

Availability, packaging and pricing

The SWIFT buck converters are available in volume now from TI and its authorized distributors. Packaged in a 40-pin, 5-mm by 7-mm by 1-mm QFN package, the 20-A TPS544B20 is priced at US$3.70 and the 30-A TPS544C20 is priced at US$3.90 in 1,000-unit quantities. Order an evaluation module for the TPS544B20 and TPS544C20.

Find out more about TI's power portfolio:

Download a TPS544C20 reference design from the TI Designs reference design library: "1V @ 30A Integrated FET Design with PMBus."

Download a guide to TI's extensive portfolio of PMBus product solutions, design tools and technical resources.

Get more information on all of TI's SWIFT DC/DC converters.

Search for solutions, get help and share knowledge in the Power Management forum in the TI E2E™ Community.

Download power reference designs from TI's PowerLab™ Reference Design Library.

About Texas Instruments

Texas Instruments Incorporated (TI) is a global semiconductor design and manufacturing company that develops analog ICs and embedded processors. By employing the world's brightest minds, TI creates innovations that shape the future of technology. TI is helping more than 100,000 customers transform the future, today. Learn more at www.ti.com.

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POWERING INFRASTRUCTURE

The increased amount of data and video being transmitted via the cloud has placed huge bandwidth and power demands on the infrastructure market. Designers a need a power partner with the expertise to improve system efficiency and simplify the design process.

The ISL85003/3A are the industry's most efficient 3A synchronous buck regulators.

Intersil's new technology delivers the industry's lowest $R_{DS}(ON)$ performance.

- Integrated high-side, low-side FETs
- Input voltage range 4.5V to 18V
- Output voltage adjustable from 0.8V, ±1%
- Efficiency up to 95%

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Power Modules – From Up and Down to Up and Coming

By Eckart Seitter, SVP Sales & Marketing and Managing Director, Vincotech

Power modules are key components in customers' applications. Rarely are they interchangeable as each application has its unique set of specifications, so customers depend on power module manufacturers far more than on other suppliers. This invests the latter with great responsibility to the former, and this duty-bound relationship makes the industry so exciting and challenging. If a company fails to earn the customer's confidence and build bonds of trust, it will be unlikely to thrive, much less survive, in this line of business.

Although the market for power modules has seen its share of ups and downs, it harbors great potential for long-term growth, on the order of around 10.7%*, or more than threefold discrete power semiconductors' 3.3%* market growth. Much of this is attributable to megatrends such as renewable energy, automation, e-mobility and industries' efforts to boost efficiency in face of climbing energy costs. None of these trends shows any signs of slowing, so this growth is sure to continue.

So why are modules outpacing discrete solutions when at cursory glance the latter would seem to be so much cheaper? A closer look reveals some clear advantages: Modules' many integration options give them a technical and economic edge over discrete solutions, especially at the point where electrical performance and heat dissipation converge. Whereas a discrete solution consists of up to 20 components - semiconductors, insulators, thermal grease and lots of screws - a power module provides the complete circuit, highly integrated in an electrically insulated housing. Some may even be fixed in place with just a single screw. All of this contributes greatly to the overall application's build quality and durability. On top of that, the module's compact design reduces stray inductances so that the individual chips can be switched faster at higher voltages to make the most of the latest generations of chips' performance. Looking at the big picture to consider the total cost of ownership, modules beat discrete solutions hands down.

A balancing act between cost and performance

Motion control applications are prevalent, so the drives market has proven stable with a potential growth rate of 14.3%*. The renewable energy segment is more volatile, and power module manufacturers have to be very agile here. Other interesting applications beyond these mainstream uses include (uninterruptible) power supplies, welding machines and energy storage systems.

Power modules can do wonderful things for a remarkably wide range of specifications. However, standard products do not always allow for the best solution. Striking the perfect balance between cost and performance often means adapting a standard product. This is why the best solution can only be found if the supplier understands the intricacies of the application and is willing to work closely with the customer until that solution stands.

The importance of being a reliable partner

No matter how we cut the pie, product cycles are long, and sales cycles extremely so, in every slice. This is why the relationship between the manufacturer and customer has to be close, trusting and open.

A power module manufacturer has to invest as much as two years up front before the deal may even be clinched, and then maintain very high support levels. This is why this fast-paced and ever-changing business requires a long-term view, an anticipatory mindset and in-depth understanding of customers' diverse markets.
Time is a problem on both ends: Suppliers make wafers and dice to order only. A ten-week wait is the norm even for samples. Customers expect manufacturers to be more agile than that, and deliver within four to six weeks. This gap has to be closed, and the only way to do it is with smart supply systems and close coordination that also requires trust and collaboration throughout the supply chain.

Customers calculate system costs over years because product lifecycles are so long. However, they still have to bend to price pressure, which is where power modules come into play. The key to containing costs is to take advantage of the next cost-optimized generations of semiconductor components. This requires rapid qualification and implementation in product designs.

However, any design change for custom applications involves tremendous effort. Reliability tests and qualification assessments have to be created anew. Vincotech has found a way to reduce this effort and costs – with a modular system comprised of pre-qualified components and processes. It affords each customer utmost freedom to pick the solution that best fits the given application. What's more, this system ensures qualified samples are available at the earliest turn.

At Vincotech, experience taught us that the best solutions come by collaborating with the customer, so we listen, think ahead, and strive to ask the right questions. Putting the customer and the application's specifications first and providing superior technical support throughout the product's lifecycle – this is what a responsible power module manufacturer does.

* Source: IHS Research, Power Semiconductors Discretes and Modules Report – 2013

www.vincotech.com

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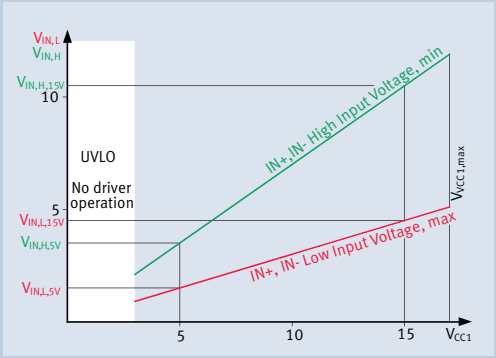

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Reinhold Theurer

Time to Celebrate a 'Golden' Era of Electronics

By Reinhold Theurer, VP European Sales, International Rectifier Corp.

Back in 1964 exciting things were happening in the World. It was the year of the Tokyo Olympics and the Beatles had just arrived in the US for the first time. In the World of electronics Sharp launched the World's first transistor-diode electronic desktop calculator and researchers from IBM reported the development of two experimental NPN transistors for solid-state memory applications.

Another company making giant leaps in technological developments was International Rectifier. Since 1947 IR has been at the heart of power management innovation. In 1960, after introducing solar cells two years earlier, IR produced the world's first solar-powered automobile and in 1962 the company introduced the first silicon controlled rectifier. Then in 1964 the company recognising the expansion and importance of the European market made the strategic decision to open the company's European headquarters here in Frankfurt.

Ideally positioned to service the whole of Europe, IR's European HQ is as integral to the company's worldwide network now as it was back then. As we celebrate our 50th anniversary in Europe, we have been presented with a great opportunity to look back at how both technology and IR has developed over this time and be proud of these achievements.

Pictured in Frankfurt, from front left to right: Eric Lidow (co-founder IR Germany) and Mrs. Lidow, Joachim Koegler (co-founder IR Germany) and Mrs. Koegler, Mr. Koegler's secretary

In recent years, fuelled by legislative and commercial requirements, companies have recognised the need to improve efficiency - and, thus reduce costs and save energy. Power semiconductors can now be found in computers and communications networking equipment, road vehicles and aircraft, industrial automation systems and consumer electronics products, and a whole host of other diverse and varied applications. For today's engineers they are as essential to the control of efficient, variable speed motors as they are to the effective migration of lighting designs from traditional incandescent, halogen and fluorescent technologies to solid state alternatives. And whether its analogue and mixed-signal ICs, integrated power systems or components, International Rectifier's advanced power management technologies can be found in all of these applications, and more .

IR GERMANY 50th Anniversary

IR continues to make significant investment in bringing new and innovative power management solutions to market. In addition to pushing the boundaries of silicon-based technologies, this means using the company's expertise and experience to create revolutionary new approaches to power management. Nowhere is this more dramatically illustrated than in the company's creation of the GaNPowIR® power device technology platform.

The result of more than seven years of research and development, is the GaNPowIR® platform using IR's proprietary GaN-on-silicon epitaxial technology to provide customers with improvements in key application-specific figures of merit (FOM) that are at least an order of magnitude better than current state-of-the-art silicon MOSFETs.

In Europe, automotive & industrial has always and continues to be key markets for International Rectifier. Exciting developments and trends are happening here too. Who would have thought that from the first solar-powered vehicle over 50 years ago that 'Smart' cars can now offer increased intelligence and support to the driver with outstanding assistance systems. The electronic content of these quite complex systems are exciting for power semiconductor suppliers and driving new requirements and demands to this sector.

Also, the electrification of powertrain continues as increasingly car manufacturers are adding Hybrid Electric Vehicles (HEV) and full Electric Vehicles (EV) to their platforms, albeit partly driven to meet stringent CO_2 emission regulations and targets. However, the mass adoption of EV and HEV depends largely on achieving cost, size and weight reduction and increased reliability. Achieving these goals requires an innovative, comprehensive approach including the development of specific semiconductor devices and packaging concepts.

In 1964 it would have been impossible to predict just how far the electronics industry would have moved on by 2014. And with the pace of innovation continually increasing, predicting developments over the next fifty years is almost impossible. What we do know, however, is that an expanding population, the increased spending power of emerging nations, concerns about energy availability and security of energy supply, and the need to minimise environmental impact, mean that the challenge to constantly improve efficiencies will remain with us. Ongoing development of power semiconductor and complementary technologies will play a critical role in helping designers address this challenge.

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TIM → **Significant Lower R_{th}** →
- **Lower T_j & smaller ΔT_j** *at same current/load* → **Significant higher power cycling lifetime**
- **Enables higher current/load** *at same Tj* → **Improved cost/performance ratio**

Fuji Electric

Innovating Energy Technology

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Fax +49(0)69-66 90 29 56 ▸ **www.fujielectric-europe.com**

Electronics Industry Digest

By Aubrey Dunford, Europartners

The European Commission and 180 companies and research organisations (under the umbrella of euRobotics) launch the world's largest civilian research and innovation programme in robotics. Covering manufacturing, agriculture, health, transport, civil security and households, the initiative – called SPARC – is the EU's industrial policy effort to strengthen Europe's position in the global robotics market (€ 60 billion a year by 2020). This initiative is expected to create over 240,000 jobs in Europe, and increase Europe's share of the global market to 42 percent (a boost of € 4 billion per year). The European Commission will invest € 700 M and euRobotics € 2.1 billion. SPARC is open to all European companies and research institutions.

SEMICONDUCTORS

WSTS predicts that the world semiconductor market will reach $ 325 billion in 2014, up 6.5 percent from 2013. This reflects a revision up from the WSTS Fall 2013 forecast, which projected 4.1 percent growth in 2014. All major product categories will show a high single digit growth rate, except microprocessors which will show a soft decline. The growth will be largely driven by smartphones, tablets and automotive. The highest growth rates are shown for the analog (9.1 percent) and sensor (9.1 percent) category. By region, all regions except Japan will grow from 2013. Europe is expected to reach $ 37.6 billion in 2013 (+7.9 percent in dollars). Solid growth for all product categories is expected to continue over the next 2 years.

ON Semiconductor, a semiconductor supplier for driving energy efficient innovations, has signed a definitive agreement to acquire Aptina Imaging, a provider of CMOS image sensors for automotive and industrial markets. ON Semiconductor will pay approximately $ 400 M in cash to acquire Aptina Imaging. The acquisition of Aptina vastly expands ON Semiconductor's image-sensor business and establishes the company as a leader in the fast growing segment of image sensors in automotive and industrial semiconductor market.

Intel announced that Cadence, Mentor and Synopsys are collaborating to support its 14nm Tri-Gate process technology to enable customers of Intel Custom Foundry. Intel Custom Foundry's 14nm design platform for systemon-chip (SoC) is targeted at cloud infrastructure and mobile applications. Intel's 14nm platform is the second generation to use 3-D Tri-Gate transistors. Intel has also entered into a strategic agreement with Rockchip, a Chinese fabless semiconductor company and mobileinternet SOC solution provider, to expand the breadth of and accelerate the rate at which it brings its Intel architecture and communications-based solutions to market for a range of entry-level Android tablets worldwide.

Avago Technologies, a semiconductor device supplier to the enterprise storage, wired, wireless and industrial end markets, and Seagate have entered into a definitive asset purchase agreement under which Seagate will acquire the assets of LSI's Accelerated Solutions Division ("ASD") and Flash Components Division ("FCD") from Avago for $ 450 M in cash.

DelfMEMS, a French supplier of RF MEMS switches targeting next generation multi-standard, multi-mode, mobile telephony, announces that the company has secured € 5.4 M in round C funding. This latest round of financing will be used to consolidate the organization and be ready for production ramp-up by the end of 2014.

Soitec and Shanghai Simgui, a Chinese silicon-based semiconductor materials company, have formed an international partnership to address both China's growing demand and limited worldwide production capacity for 200-mm silicon-on-insulator (SOI) wafers used in fabricating semiconductors for RF and power applications. The agreement represents the first step in establishing a SOI ecosystem in China.

PASSIVE COMPONENTS

Molex has recently acquired the heavy-duty connector business of Westec, an industrial connector manufacturer based in Milano, Italy. Westec's business consists of the manufacturing of more than 6,000 products, including a wide range of junction boxes, multi-pole connectors, and connector assemblies designed for automation, robotics and other harsh-duty industrial applications.

OTHER COMPONENTS

The Alliance for Wireless Power (A4WP) announces it is becoming the first to deliver a specification for multidevice wireless charging up to 50 watts. Increasing the standard to 50 watts expands the range of products capable of using its technology beyond smartphones to include laptops, tablets, and other consumer electronics. Notable tablet, personal computer and peripheral companies have joined the alliance, pushing the membership total past 100.

DISTRIBUTION

The European semiconductor distribution industry seems to be back on its track of slowly strengthening its position in the European high-tech industry. According to DMASS (Distributors' and Manufacturers' Association of Semiconductor Specialists) semiconductor distribution sales in Q1 2014 grew by 7.7 percent to € 1.6 billion. Germany grew by 6.6 percent to € 511 M, representing now 32 percent of the total market.

N2Power, a division of Qualstar, announces its distributor agreement with TTI Europe. TTI will handle all coordination of orders, shipments, and inventory of all N2Power high efficiency, high power density AC/DC and DC/DC embedded power supplies throughout Europe.

Crocus Technology, a French developer of magnetically enhanced semiconductor technologies for mobile security, embedded microcontrollers, magnetic sensors and harshenvironment electronics has appointed Ismosys as its pan-European (excluding UK and Ireland) sales & marketing representative. The seven strategically located Ismosys offices will focus on introducing Crocus' emerging solutions to European Tier 1 OEMs and will work closely with Crocus' authorised distribution channels.

This is the comprehensive power related extract from the «Electronics Industry Digest», the successor of The Lennox Report.

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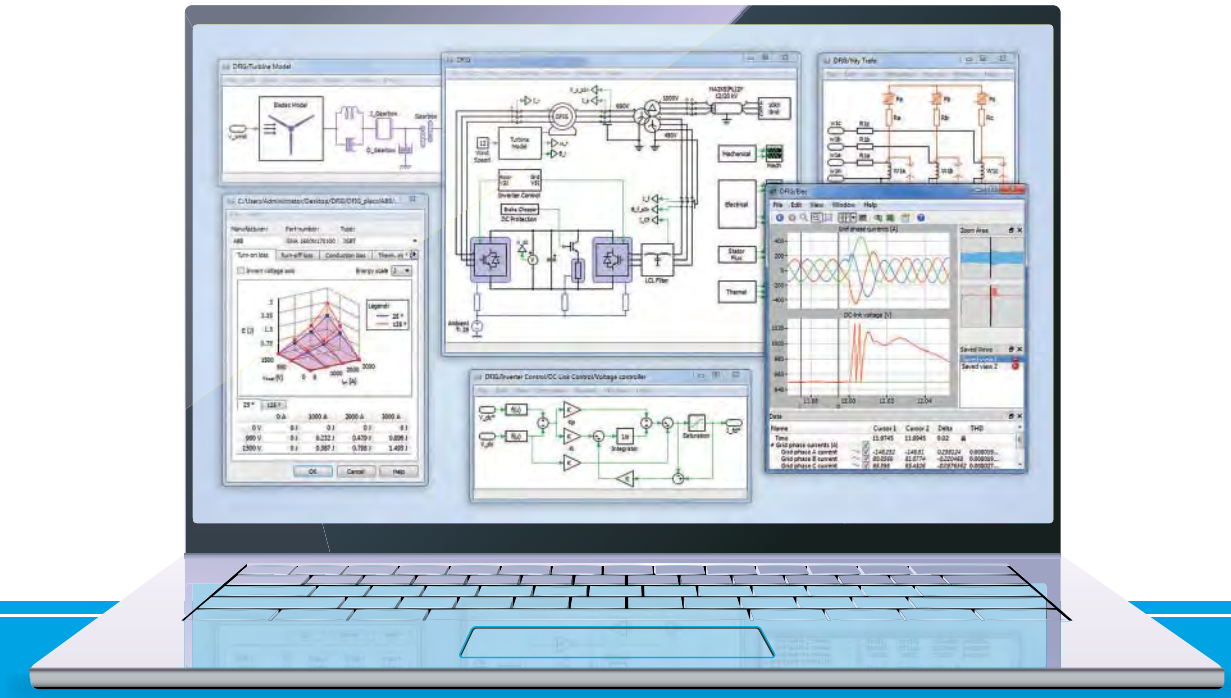

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Wireless Charging Technology Matures and is Ready to Expand

By Richard Ruiz Jr.; The Darnell group

Once thought of as a nascent technology focusing on stationary charging equipment for cell phones, tablets and other small low-powered devices, wireless charging has become a technology that has arrived. In fact, wireless power isn't about just reducing the number of external ac-dc power supplies in the world it's about increasing the capability of wirelessly powered devices in everything from cellphones to automobiles.

In addition to the wireless charging sleeves for the iPhone and other small devices, there are dozens of wireless chargers (charging pads) available in the market from Duracell, Energizer and others including those from JBL and Panasonic that double up as music players or alarm clocks.

A number of silicon designers and manufacturers, including IDT, Texas Instruments, Freescale Semiconductor and Intel, are focusing on wireless charging chips (transceivers and receivers). These chips are expected to be used in everything from portable devices to automobiles.

Food chains like Starbucks and McDonald's, airports and convention centers are piloting wireless charging services at their facilities, while a number of leading building material manufacturers like DuPont are thinking of embedding wireless charging chips into kitchen countertops and tables. In addition, car manufacturers including Toyota and Chrysler are considering incorporating in-car wireless charging for mobile phones, and technologies like Qualcomm Halo promise wireless charging of electric vehicles.

The past several months have seen a number of developments emphasizing the emergence of wireless charging technology as a viable and practical solution across a range of applications. In a development emphasizing that wireless power is more than just about devices for charging cells phones, the Alliance for Wireless Power (A4WP) announced continued momentum on the expansion of the organization's Rezence-based wireless charging capabilities, becoming the first to deliver a specification for multi-device wireless charging up to 50W.

Increasing the standard to 50W expands the range of products capable of using Rezence technology beyond smartphones to include laptops, tablets, and other consumer electronics. To support upcoming rapid product launches, publication and upgrade to the existing Baseline System Specification and certification program is expected by the end of 2014.

Wireless charging technologies operating at frequencies lower than 6.78 MHz are subject to technical limitations that make the move to higher power difficult to implement in a manner acceptable to consumers. While the organizations associated with these technologies are only now discussing the delivery of power in the 10-15W range, Rezence technology now delivers wireless power solutions in the 1-50W range that support multi-device charging while preserving freedom of placement in horizontal and vertical dimensions for a true drop and go user experience.

The Rezence specification also supports wireless charging of multiple devices with differing power requirements on the same charging surface, a feature unique to magnetic resonance technologies.

The elimination of the need to maintain multiple external power supplies, one for each electronic device, has long been a goal for both the consumers and manufacturers of consumer electronics equipment and over the past several months there have been a number of developments moving the industry towards this goal. In fact, Massachusetts-based WiTricity Corp. recently announced a technology licensing agreement with Intel Corporation to integrate their wireless technology to enable efficient, high performance wireless charging solutions for computing devices powered by Intel.

The agreement is centered on the Rezence specification, which was developed by the Alliance for Wireless Power. It offers unique benefits including simultaneous charging of multiple devices with differing power requirements, 'spatial freedom' for additional reach in the z-direction, and eliminating the hassle of accurate coil alignment – all on a single charging surface or in a charging region. It has been adopted by a number of leading mobile chipmakers, mobile phone manufacturers, and other key industry players. Both Intel and WiTricity are board members of the A4WP and are helping to drive the technical direction and adoption of the Rezence specification.

Wireless technology has also made strides in the automotive industry and although still in the early stages is expected to play a significant role over the coming years. In March, the Power Matters Alliance (PMA) announced it will expand features of its automotive specification to standardize wireless charging requirements beyond what is currently available in the market. This specification, spearheaded by Triune Systems, will offer OEMs a more comprehensive set of features.

The new automotive specification will incorporate multi-coil implementation for greater spatial freedom, alternative frequency ranges and reduced emissions to prevent interference with other vehicle systems. It will also incorporate advanced architectures for better efficiency and field upgradability – designed to keep pace with potential future requirements.

In a development likely to have a long-term effect on the wireless charging industry, the automotive component and system manufacturer HELLA KGaA Hueck & Co. is currently working with Paul Vahle GmbH, a manufacturer and supplier of power and data transmission systems to develop an inductive wireless charging system that could spark renewed consumer interest in electric and hybrid-electric vehicles.

Using this technology rather than using plug-in charging stations, car owners in the future will simply need to park over an inductive charging unit to trigger the process. In fact, with the use of inductive charging, electric vehicles also could conceivably be recharged when stopped at traffic lights or even while being driven. Although this is a long-term goal it illustrates the potential wireless charging has for the industry. As wireless charging has become more available and easier to use, it will allow automakers to reduce the considerable battery size and weight on electric and hybrid electric vehicles.

In another automotive development, the TDK Corporation also recently entered into a licensing agreement for wireless power transfer technology with WiTricity Corporation. The technology TDK intends to implement is known as resonant magnetic coupling for wireless power transfer. According to the company since power can still be transferred efficiently with the power source device and power capture device separated by several centimeters and through roadway materials such as concrete and asphalt, the technology is expected to find commercial application in EVs and other mobile areas requiring recharging.

Wireless charging technology in the automotive industry has become so big that 2014 Consumer Electronics Show (CES) in Las Vegas, Nevada, the Evatran Group, Inc., in partnership with Bosch Automotive Service Solutions announced that it is offering reduced promotional pricing to the first 250 customers who opt to Go PLUGLESS with their electric vehicle (EV) experience. The PLUGLESS system offers a wireless charging alternative to the repetitive process of unplugging and plugging-in electric vehicles.

The PLUGLESS system, the first wireless EV charging product in the world available to individual EV drivers, began in February 2014. The PLUGLESS system is currently compatible with all Chevrolet Volt model years and 2010 – 2012 Nissan LEAF model years. The system charges the Volt and LEAF as quickly as conventional corded systems and all vehicle features, such as charge-timers and phone applications, can be used with the PLUGLESS system. Additional vehicles and model years will be announced later in 2014.

Most component makers and solution providers are counting on the wireless charging market to grow significantly, and trying to include all leading technologies in their product range. In contrast to a couple of years ago, the number and type of eligible applications for wireless technology is expected to surge.

www.darnell.com

Envelope Tracking and Wireless Power Transmission

By Alex Lidow Ph.D.; Efficient Power Conversation

KEY TAKE AWAYS
eGaN® FETS are cost competitive, 10 times faster, and significantly smaller than comparable power MOSFETs. eGaN FETs are at the tip of the iceberg in enabling new applications.

Two of the most exciting new applications for eGaN FETs are envelope tracking and wireless power.

Envelope tracking can double the energy efficiency of RF power amplifiers. The Cisco VNI Mobile Data Traffic Forecast expects a 66% CAGR in data transmission from 2012 to 2017, making this a high-growth market where eGaN FETs solve a major power problem.

The wireless power market will enable us to charge our cell phones and tablets without annoying wires, and eventually eliminate the wall sockets in our homes and offices. eGaN FETs operate smoothly at the 6.78 MHz recently adopted as the transmission standard for wireless power.

In past issues of Technology Driving Markets, we discussed the disruptive nature of the eGaN FET and the inevitability of it displacing the aging power MOSFET. We also discussed how the superior capabilities of eGaN FETs are enabling new applications. This issue of Technology Driving Markets will discuss two significant applications enabled by eGaN technology: Envelope Tracking and Wireless Power Transmission.

Envelope Tracking: Can you hear me now?
The concept of envelope tracking for radio frequency amplifiers is not new. But the ever-increasing need for better base station efficiency and output power, as well as the need for improving RF power amplifier efficiency, is driving intense research and development in envelope tracking.

RF power amplifiers are used to transmit all of our voice and data through satellites, base stations, and cell phones. Conventional RF power amplifiers operate at a fixed power level delivering maximum power whether or not the transmitter needs it. When envelope tracking is deployed in a RF power amplifier, the amplifier does not operate at a fixed power level, but precisely fits the power to the amplifier's signal modulation needs. This is illustrated in Figure 1. The power modulation required is enabled by EPC's third generation, EPC8000 series FETs that can operate at the high voltages and switching speeds needed for efficient envelope tracking.

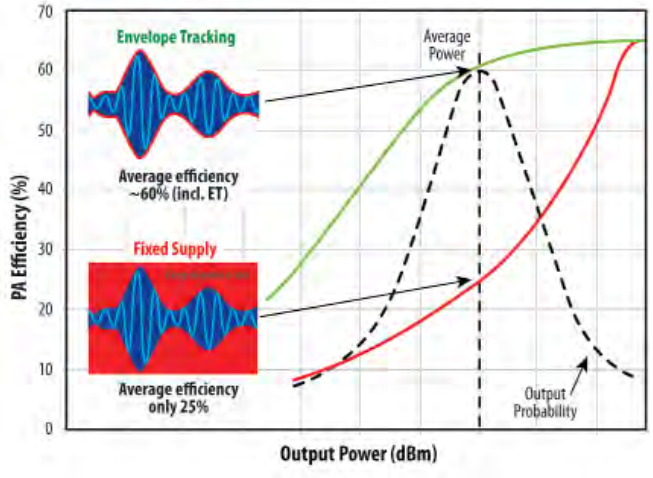

Figure 1: Schematic of fixed and envelope tracking power profile in a RF Power Amplifier

RF power amplifiers for 4G LTE technology have higher power requirements than previous generations and are the biggest beneficiary of envelope tracking. Today, 4G LTE technology is just 9% of the global wireless platform, but will eventually supersede earlier 3G networks in the world of data transmission. Envelope tracking can double the energy efficiency of RF power amplifiers.

Wireless Power: Cut the cord!
Wireless power applications are gaining popularity in many commodity products such as mobile phone chargers. Most of the wireless power solutions to date have focused on tight coupling with induction coil solutions operating at frequencies around 200 kHz. This is the Qi standard and its major drawbacks are conversion efficiency and its requirement for exact placement.

Industry leaders including Qualcomm, Intel, Broadcom, Samsung, Delphi, and Witricity have established a consortium (A4WP) for the development and commercialization of a recently selected high frequency standard (6.78 MHz) for wireless power transmission (Highly Resonant Power Transfer). The fast switching capability of eGaN FETs is ideal for highly resonant power transfer applications, while MOSFETs do not perform well at these frequencies.

Initial applications for wireless power transfer include cell phones, game controllers, laptop computers, tablets, and even electric vehicles that re-charge without being plugged in or having actual physical contact, proximity within a specified range is all that is required. The global wireless power transfer market CAGR is estimated at 55.5%. Demand for automotive wireless charging alone is expected to triple in the next 8 years and is forecasted to be $15.1B by 2020.

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Mature Wide Band Gap Semiconductors

By Bodo Arlt, editor BPS

The podium at PCIM Europe described a bright future for wide band gap semiconductors. SiC and GaN will both provide higher efficiency in future designs. Lead products have moved into production.

The industry was well represented by ten members of the leading manufacturers of these devices.
Their key statements are shared with you here, as it is important for me to communicate with those that missed the live discussion in Nuremberg.

Picture: PCIM Podium 2014 Presenters

Paul Kiersteadt, Cree: SiC MOSFET Reliability Meets Commercial & Military Requirements. Extensive reliability testing is required to predict a reliable life performance. The JEDEC qualification is not sufficient. Cree devices are extremely stable for 1,000 hours under positive and negative bias, and under accelerated conditions beyond the data sheet show no measurable changes.

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Alex Lidow, EPC:
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Girvan Patterson, GaN Systems:
In 2011 the maximum possible current in a lateral GaN parts was 10 Amps.
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Ranbir Singh, Gene SIC:
The GA20JT12 transistor shows a 50-54% decrease in Rds-on at Id =20 A, all temperatures compared to a 2nd generation, 1200 V/80 mΩ SiC MOSFET. The GeneSiC 1200 V/20 A standard rectifier demonstrates a 10X reduction in leakage current, as compared to its nearest SiC competitor.

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Peter Fridrich, Infineon:
SiC JFET – Infineon's choice to pave the way for SiC transistors. In a Solar inverter, dynamic performance demonstrates equal efficiency at 3X higher switching frequency. The savings in passive components compensate for higher device costs already today !

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Tim McDonald, IR:
Commercialization of 100V GaNpowIR® Devices: The Samsung HT-F9750W is the World's first GaN based class-D Audio Amplifier, in production.

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Kazuhide Ino, Rohm:
Rohm's technology evolution of SiC Power Devices has progressed to a 3rd generation of SiC Trench MOSFET's, produced on 6 inch wafers.

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Umesh K Mishra; Transphorm:
Gen 1 GaN modules are in use in kW class PV Inverters. A resonant LLC power supply stage enables both a 40% smaller size and lower losses.

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John Bendel, USCi:
The USCI JFET: a fast switching, 175C rated, 45mΩ – 1200V SiC Normally – On JFET
The USCI Diode: a best-in-class 1200V series, 50A/1200V JBS available.

www.unitedsic.com

In conclusion, we see both kinds of semiconductors becoming mature, and providing more efficient designs of practical solutions in industry. At this moment, GaN seems to be the accepted choice for ratings up to 600V, while SiC concentrates on 1200V and above.

Picture: PCIM podium 2014 Visitors

Ensure Your System Robustness by Choosing Hard Commutation Rugged Medium Voltage MOSFETs

Understanding hard commutation event and how to get the best system reliability and performance using Infineon's new 200V and 250V devices

By Alan Huang, Application Engineer, Infineon Technologies AG

Today, wide range of energy-critical applications can benefit from trench MOSFETs' low Figure of Merit ($R_{DS(on)}$ x Q_g) because of the MOSFETs' high blocking voltages. Infineon's OptiMOS™ power MOSFETs can, for example, achieve the breakdown voltages of up to 250V and offer industry's lowest figures of merit. However, $R_{DS(on)}$ and Q_g are not the only parameters that need to be considered while choosing proper MOSFETs for an application. An often neglected but essential example when it comes to the MOSFET selection for hard switching applications is the hard commutation of the body diode. Insufficient ruggedness of the body diode can lead to system failure and the issue becomes increasingly severe as the breakdown voltage increases. Infineon has developed a new series of hard commutation rugged devices, OptiMOS™ FD 200V/250V, which reduce Q_{rr} significantly and improve system reliability and performance at the same time.

Higher voltage field-plate MOSFET fills the gap but caution required

Choosing power MOSFETs with the breakdown voltages which tightly meet the application-specific de-rating requirement allows performance optimization of the devices in terms of figures of merit — on-state drain-source resistance ($R_{DS(on)}$) and switching gate charge (Q_g). Below 200V and above 600V, the MOSFET market is well served respectively by the trench field-plate technology and the superjunction technology. To address the gap in between and to serve a wider range of energy-critical applications with increasingly stringent system efficiency requirements, trench power MOSFETs with higher blocking voltages are being developed. As the breakdown voltage is being stretched, the physical limit of silicon as a trench FET is being put to test due to the more demanding operating conditions. To consider the intrinsic body diode limits and the increasingly important hard commutation ruggedness, therefore, becomes crucial.

Body diode, reverse recovery and hard commutation

Typical symbol of a MOSFET shows that there's a body diode in every MOSFET. Which means when a MOSFET is chosen, the body diode that comes along with it is also fixed. Since the diode is physically parallel to the channel, it is important for the diode to be considered during operation especially while the channel is in the off state. More specifically, in applications where the body diode conducts, designers must make sure the body diode is behaving as desired. It is necessary to consider the breakdown voltage of the diode (normally the same as the channel), and the maximum current going through the diode, both in the forward and the reverse directions. OptiMOS™ devices can normally handle continuous forward current up to the rated drain current. The reverse current occurs along with the undesired reverse recovery phenomenon. During the diode's turning off operation, reverse recovery occurs. The current goes negative and the area bounded by the negative current and the zero line denotes the reverse recovery charge (Q_{rr}). The reverse current potentially causes shoot through, and Q_{rr} yields additional loss and overshoot. This complete switching event, which involves forward-current-carrying body diode of a MOSFET experiencing reverse recovery during turn-off, is categorized as hard commutation.

In switching converters, body diodes are common instruments used to provide the freewheeling capability at no extra component cost. It is an advantage in this case where no external diode is required. However, the often neglected reverse recovery behaviour could cause device abnormality and lead to system failure. To properly select higher voltage class MOSFETs, it becomes increasingly important to consider the hard commutation event, and a reliable system requires careful selection of the MOSFETs with robust body diodes to fulfill the requirement of the application.

During the hard commutation turn-off transition, the diode is initially forward biased and it carries a positive forward current. As soon as the turn-off process is initiated, the current rolls off at a constant slope (*di/dt*) to zero, then reverses the direction. The negative current, also known as reverse recovery current (I_{rr}), finally reaches the negative peak (I_{rrm}) and then goes back up to zero. The reverse recovery process completes at this moment, and the body diode returns to its blocking state.

Reverse recovery charge (Qrr), overshoot and system robustness

The shaded area under the current curve in the negative region represents the reverse recovery charge - Q_{rr}. It is often approximated by the triangle area, where Q_{rr} can be quickly estimated by .

In a half-bridge configuration for example, reverse recovery occurs at the transition where the freewheeling body diode current of the low side pull-down FET is redirected to flow through the top side pull-up FET. The resulting reverse recovery current through the low side FET flows at the same direction as the redirected current through the top side FET. For a very short instance, the current flows directly from the input to ground; thus a shoot-through occurs. This behavior results in overshoot.

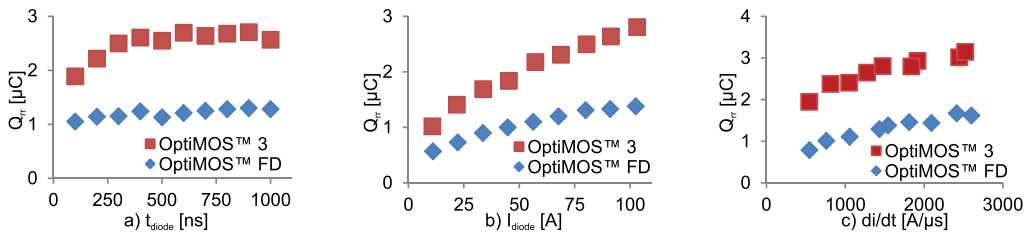

Figure 1: Qrr dependencies and OptiMOSTM FD Qrr benchmark

The amount of Q_{rr} has a direct impact on the overshoot level. The higher the Q_{rr}, the higher the overshoot. A severe overshoot puts the device into avalanche which may lead to device degradation over time. In other words, a device with higher Qrr is less susceptible to a rough hard commutation event. Therefore, Q_{rr} is a good indicator for device hard commutation ruggedness.

Qrr dependency and the key to improve system robustness

The amount of Q_{rr} depends greatly on the application condition and the device itself. Q_{rr} is influenced proportionally by the body diode conduction time, freewheeling forward current, and the commutation current slope, with different degrees of saturation.

Figure 1 shows the Q_{rr} characterization between two devices – OptiMOS™ 3 and the new OptiMOS™ FD 200V devices across different application conditions while keeping the other two dependents constant.

These curves suggest that by selecting hard commutation ruggedness and Q_{rr} optimized OptiMOS™ FD devices, Q_{rr} reduces significantly (40% to 60%) across all application conditions. By choosing the new OptiMOS™ FD devices, the designer could possibly avoid achieving the desired Q_{rr} or overshoot by tweaking the application conditions. In other words, the design efforts could potentially be minimized by omitting the following optimization or design steps:

- Tuning deadtime to reduce body diode conduction time
- Considering to a different topology in order to lower the diode conduction current
- Counterintuitively redesigning PCB to increase the commutation loop parasitic inductance or add external gate resistance in order to reduce current slope (*di/dt*)

Improve the reverse recovery behavior by selecting the new OptiMOS™ FD. Q_{rr} can be reduced in the device level regardless of the application condition.

Hard commutation optimization and the benefits

From Figure 1, Q_{rr} is reduced when choosing the new OptiMOS™ FD devices. Figure 2 shows the exact improvement in reverse recovery behavior. In these two hard commutation events (one with OptiMOS™ 3 200V and the other with OptiMOS™ FD 200V), the body diode conduction time and forward current are the same. In the diagram, it can be observed that the current rolls off at the same slope (*di/dt*) down to zero. Then it reverses the direction while in the negative region. With OptiMOS™ FD, the current reaches a lower negative peak, and the recovery takes shorter time to complete. In this case, the peak reverse recovery current reduction of 20% is observed, and the Q_{rr} drops approximately 40%. The shaded area represents the Q_{rr} reduction.

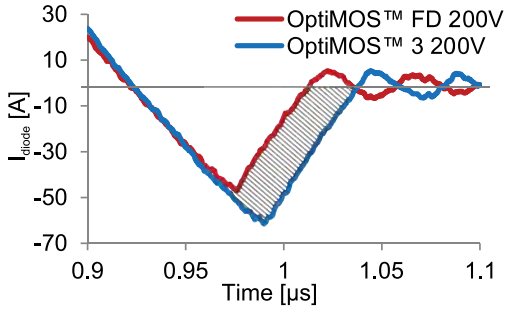

Figure 2: Commutation waveform comparison between OptiMOS3 and OptiMOSTM FD devices

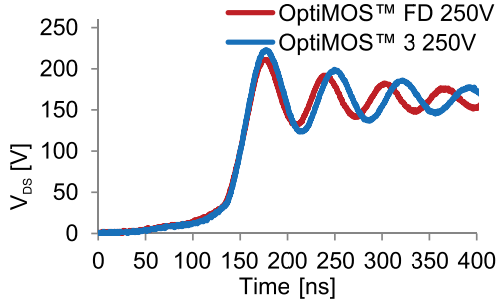

Figure 3: Overshoot comparison between 250V OptiMOSTM 3 and OptiMOSTM FD

The peak reverse recovery current is especially important for switching events where the device enters avalanche. The peak basically acts as the avalanche current which has a quadratic relationship to the avalanche energy. A reduction of 20% in avalanche current means a 36% of reduction in the energy. This significantly lowers the stress to the device and leads to an increased system reliability.

Q_{rr} reduction as explained earlier reduces overshoot. Figure 3 confirms that the new OptiMOS™ device yields lower overshoot with its reduced Q_{rr} (results for 250V devices are shown as an example). This eases design efforts to meet EMI compliance and de-rating requirement often set by the end customer.

The reduction in Q_{rr} not only minimizes overshoot but also reflects performance improvement in terms of system efficiency. Q_{rr} is wasted energy, so it translates directly into power loss. 40% lower Q_{rr} means to a significant reduction in power loss caused by Q_{rr}. In the synchronous rectifier stage on Infineon's 2kW ZVS full bridge phase-shifted (ZVS FBPS) DC-DC converter demo board [2], the new OptiMOS™ devices perform better than the previous generation OptiMOS™ 3 devices.

The originally optimized synchronous rectifier (SR) switches (OptiMOS™ 3 200V Best-in-Class devices) were replaced by the new OptiMOS™ FD 200V devices. 4 SR devices in total (2 in each SR branch) were replaced. The efficiency curves comparisons are shown in Figure 4.

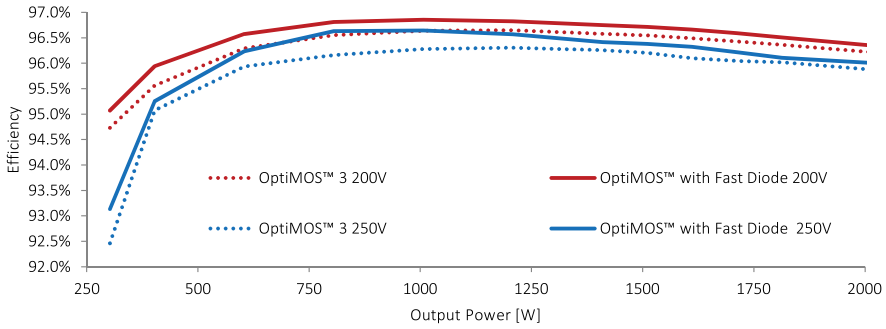

Figure 4: Efficiency comparison between OptiMOS™ FD and OptiMOS™ 3

The comparison demonstrates that by simply swapping the SR devices from previous generation OptiMOS™ 3 devices to the newest generation OptiMOS™ FD devices, significant overall efficiency boosts of up to 0.35% and 0.5%, respectively for 200V and 250V devices, were achieved.

Application-based selection

To determine whether hard commutation ruggedness optimized devices, namely OptiMOS™ FD devices, are necessary for the application, it is intuitively to consider whether the hard commutation event of the body diode occurs in the application. Applications which have been identified that can benefit greatly from the new OptiMOS™ FD devices include, but not limited to, secondary SR for telecom rectifier, industrial power supplies, motor drives (for 48V-110V system), DC-AC inverter, Class D audio amplifier, etc.

Conclusion

Selecting proper medium voltage MOSFETs is not only important to achieve the highest efficiency and performance but also essential to ensure system reliability. Infineon's new OptiMOS™ FD 200V/250V devices optimized for hard commutation ruggedness adds an extra layer of assurance to the system. With their uncompromised best-in-class figure of merits, $R_{DS(on)} \times Q_g$, they significantly reduce device level Q_{rr}, minimize overshoot and boost efficiency when compared with the previous industry benchmark OptiMOS™ 3 devices. These products provide Q_{rr} optimized solution for power system designers striving for highest standards of efficiency and reliability. Choose the new OptiMOS™ devices to enjoy fastest reverse recovery, lowest reverse recovery charge, minimized overshoot, improved hard commutation ruggedness and highest efficiency.

References

[1] Application Note Hard Diode Commutation of Power MOSFET - OptiMOS™ FD 200V/250V, March 2014

[2] Application Note Evaluation Board ZVS Phase Shift Full Bridge – CoolMOS™ CFD2 and OptiMOS™ 200V, March 2013

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1200V SiC Hybrid IGBT Modules for High Frequency Applications

Dedicated IGBT-modules for high switching frequency operation have been successfully introduced to the market over the past years. Typical applications are X-ray generators, CT-scanners, induction heating, welding, plasma cutters or inverters for isolated or contactless electrical power conversion.

By Eckhard Thal, Mitsubishi Electric Europe B.V., Ratingen, Germany

The switching frequency in those applications is usually higher than 20kHz, thus exceeding the range for which standard industrial IGBT-modules are optimized for. Since several years Mitsubishi Electric is offering a dedicated IGBT-series for those high frequency applications, called NFH-series. For reducing the switching loss it is using IGBT-chips with an optimized trade-off between Vce(sat) and Eoff. As next innovation step Mitsubishi Electric now is introducing it's Silicon Carbide Chip technology to this proven NFH-series design.

Hybrid SiC-IGBT module approach

A series of 1200V dual modules with current ratings between 100A and 600A was developed [1] by using SiC Schottky Barrier Diodes (SBD). This approach is called "Hybrid SiC" module. For better understanding the used terminology, please refer to Figure 1. A hybrid SiC module is containing Silicon-based IGBT in combination with SiC-based Schottky Barrier diodes. The IGBT-chips are kept the same in both the conventional NFH-series and new hybrid SiC NFH-series. The principle switching waveforms are given in Figure 1. Due to the fact that Schottky diodes as unipolar semiconductors don't have any reverse recovery charge, there is no reverse recovery loss. The absence of diode reverse recovery current on the other hand leads to a substantial reduction of IGBT turn-on energy.

A further reduction of total power loss can be achieved if both the active switch and the free-wheeling diode are made of SiC. This approach is called "Full SiC" module.

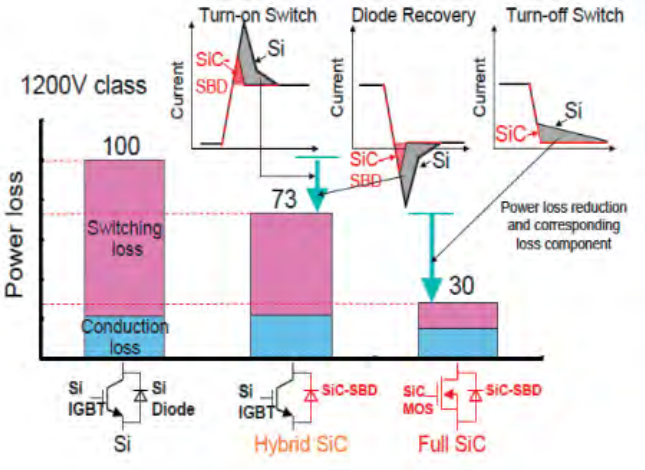


Figure 1: Evolution of SiC technology in power modules

Line-up & Package outlines

The line-up of new hybrid SiC NFH-series is shown in table 1; the package outlines are given in Figure 2. For the middle and large size packages the main terminals are located at the side of the housing. This arrangement allows using a laminated main terminal structure inside the module for reducing the internal package inductance Lint. For all current ratings of both middle and large size package this internal package inductance is in the range of 18…22nH (defined between P- and N- main terminals).

Type	Voltage	Current	Connection	Baseplate size
CMH100DY-24NFH	1200V	100A	2in1	48x94mm
CMH150DY-24NFH		150A		
CMH200DU-24NFH		200A		62x108mm
CMH300DU-24NFH		300A		
CMH400DU-24NFH		400A		80x110mm
CMH600DU-24NFH		600A		

Table 1: Line-up

Series	Connection	V_{CES} (V)	Ic (A)					
			100	150	200	300	400	600
NFH	Dual	1200	Small PKG	Small PKG	Middle PKG	Middle PKG	Large PKG	Large PKG

Figure 2: Line-up and Package outlines

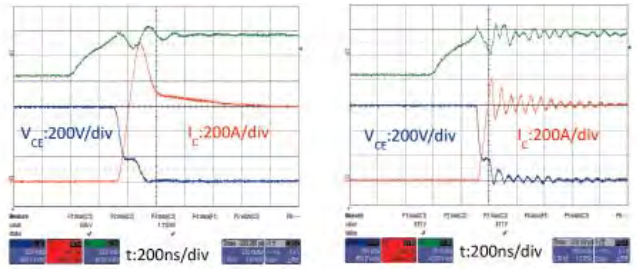
Switching behavior

The turn-on waveforms under inductive load condition of conventional NFH-module CM600DU-24NFH and new hybrid SiC module CMH600DU-24NFH are shown in Figure 3. Taking into account that both module types are using exactly the same IGBT-chips the difference in switching waveform is entirely the result of difference in free-wheel diode behavior. The key difference between both current waveforms can be explained by the lack of reverse recovery charge (and consequently the diode's reverse recovery current) in the hybrid SiC module CMH600DU-24NFH as the Schottky Barrier Diode is a unipolar semiconductor. Consequently both the turn-off loss of freewheeling diode and the turn-on loss of IGBT under inductive load switching are drastically reduced, as it can be seen in the switching energy diagrams given in Figure 4 and 5.

Loss performance comparison

A power loss simulation under inverter operation conditions (hard switching) with sine-wave PWM reveals the big impact of using SiC Schottky diodes instead of conventional Si-diodes for the NFH-series modules: at fc=30kHz the hybrid SiC module has just half of the total losses of its Si-counterpart, see Figure 6.

The dependency of total module power loss on PWM switching frequency fc is given in Figure 7. From this diagram it can be derived that the total power loss of new hybrid SiC type CMH600DU-24NFH at fc=50kHz is at the same level as its full Si-counterpart at fc=17kHz. Considering that both modules CMH600DU-24NFH and CM600DU-24NFH have the same power loss handling capability (same baseplate size and hence the same Rth(c-f); same Rth(j-c) for IGBT) it seems to be possible for such applications to triple the switching frequency fc while keeping the module power loss at the same level.



Conditions: Tj=125degC, V_{GE}=15V, V_{CC}=600V, R_G=0.52ohm

Figure 3: Ic-waveforms at turn-on

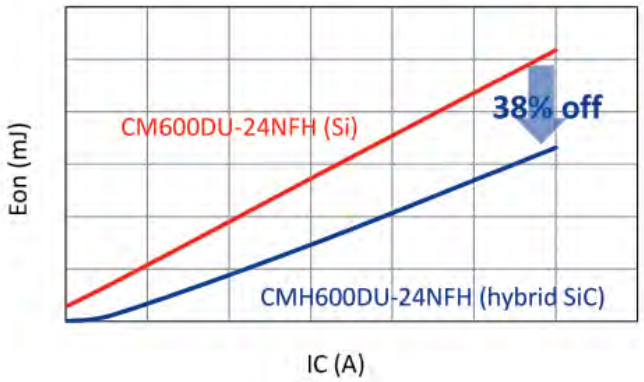
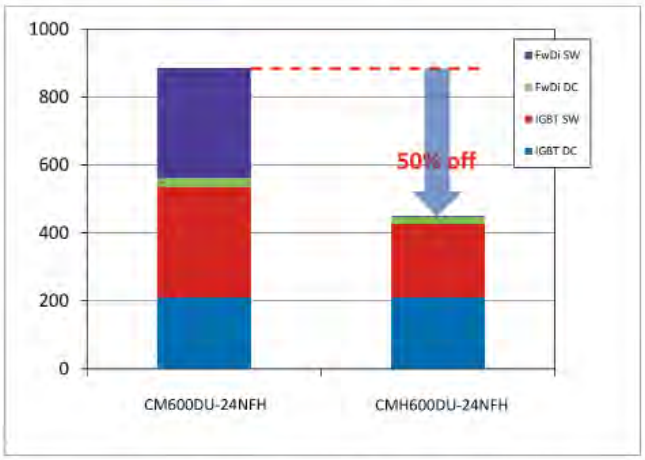


Figure 4: IGBT turn-on energy E(on) vs. current

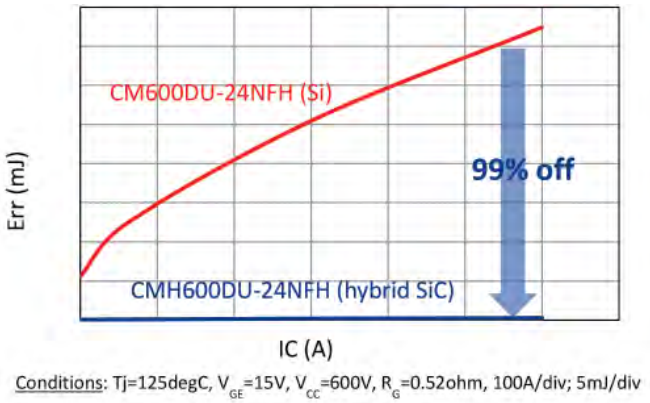
Application benefits

The described improvements in switching loss performance under hard switching conditions are offering system benefits basically in two



Conditions: Io=300A; fc=30kHz; PF=0,8; M=1; Vcc=600V; Vge=+/-15V; Rg=0.52Ω; Tj=125°C

Figure 6: Power loss simulation (inverter operation with sinus PWM)



Conditions: Tj=125degC, V_{GE}=15V, V_{CC}=600V, R_G=0.52ohm, 100A/div; 5mJ/div

Figure 5: Freewheeling diode turn-off energy vs. current

directions when using the new hybrid SiC NFH-series:
The most obvious one is the possibility of increasing the switching frequency fc. The size of inductive components in a power electronic system is often determined by the switching frequency.
Consequently an increase of fc can help to reduce size (and cost) of those inductive components.
Also the dynamic response of a power electronic system can be improved by increasing fc.
Another direction is improving the energy efficiency of a power electronic system. This is an interesting option especially in application where low system efficiency is penalized.

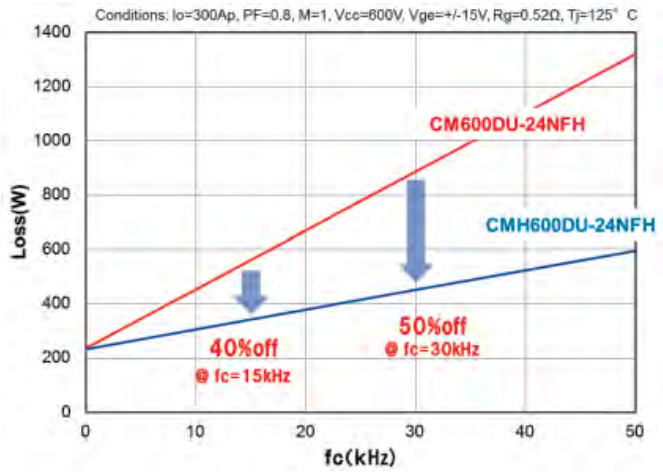


Figure 7: Power loss versus PWM switching frequency fc

In general reducing the power loss dissipated in the IGBT modules will help to reduce heat sink size. This is interesting for such applications where heat sink is the limiting factor for system size reduction.
Another potential benefit of using the new hybrid SiC series can be expected in soft switching applications. Here the principle absence of reverse recovery charge at diode turn-off can contribute to a further power loss reduction.

Summary and outlook

By using Mitsubishi's new hybrid SiC IGBT modules for high frequency applications a drastical reduction of switching loss is possible. The use of SiC Schottky Barrier diodes instead of conventional Silicon diodes as freewheeling diodes in the modules of NFH-series is eliminating the reverse recovery charge at freewheeling diode turn-off. Under hard switching inverter operation conditions this allows to increase the switching frequency by a factor of 2…3 compared with conventional Si-based IGBT modules.
Application benefits can be also expected when using the new hybrid SiC modules in soft switching applications due to the absence of reverse recovery charge at diode turn-off. Here further investigations are needed.

Literature

[1] "Mitsubishi Electric to Ship Sample Hybrid SiC Power Semiconductor Modules for High-frequency Switching Applications"; Press Release of Mitsubishi Electric Corporation; Tokyo, May 15, 2014

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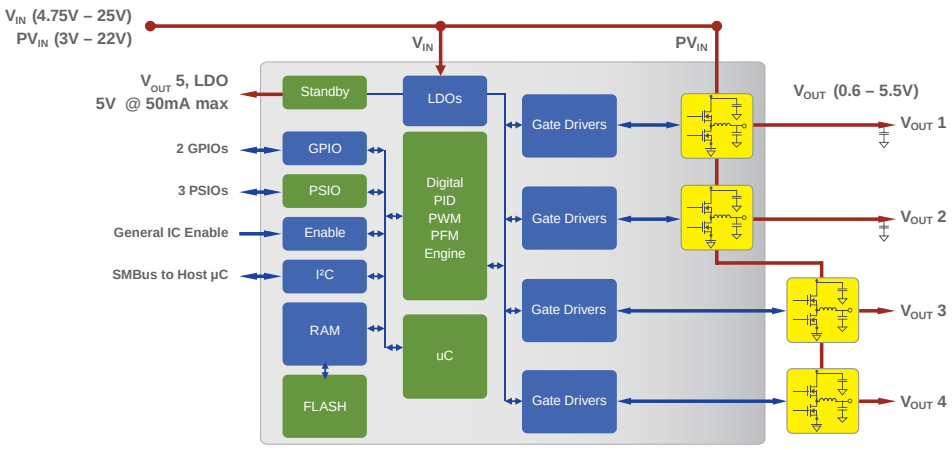

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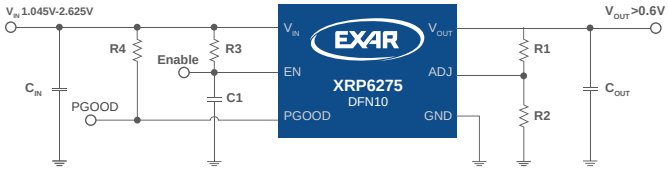

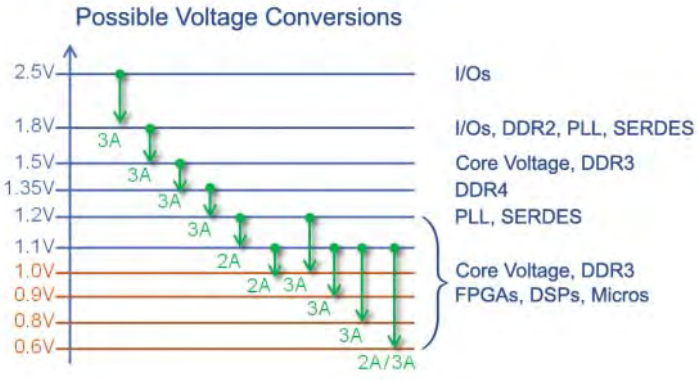

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Parameters and Characteristics of 1700V Planar NPT+ IGBT with Enhanced Injection for High Power Modules

Development results of 1700V NPT+ IGBT chips for modules with commutation power from 0,15 up to 4 MW

By P. Mashevich and T. Kritskaya, Angstrem JSC;
V. Martynenko; V. Muskatinev, A. Bormotov, M. Togaev, Electrovipryamitel JSC

Introduction

Power modules on the base of IGBT and FRD are currently the most common components in power converters for various applications. These devices have operation voltage from 600V up to 6500V. 1700V IGBT modules are important components in foregoing voltage range. They are used widely in high voltage DC and AC networks up to 800V and 1250V correspondingly; traction drives of city transport (metro, trolleybus and tramway), ship drives, railway and automotive transport, solar and wind power invertors, uninterrupted power supply, resonance invertors, welding and so on.

Companies Angstrem and Electrovipryamitel develop and produce IGBT and FRD chips and power modules on this base. Development results of 1200V IGBT modules on the base of Russian IGBTs and FRDs have been presented in [1]. This article presents main parameters and characteristics of new large square 1700V IGBT chip developed by Angstrem.

Manufacturing technology

For manufacturing of 1700V IGBT chips, thin wafers of uniform NPT silicon were used. Bipolar and field effect regions were formed on these wafers by means of donor and acceptor impurity implantation. NPT+ technology with planar MOS-controlled cells was chosen as simplest technology that provides required conductance and switching characteristics, rectangular SOA, high resistance to avalanche overloading and short circuit condition, low EMI level.

NPT+ technology uses additional n-layer close by each MOS-cell that provokes positive charge carrier accumulation near p-layer and rise of carrier density on emitter side [2]. This leads to enhanced electron injection, high conductivity modulation of n-base layer and to saturation voltage lowering.

Figure 1a shows cross-section of 100A/1700V NPT+ IGBT with standard cell dimensions and ring-shaped n-layer. Gate oxide thickness was local increased for input capacity lowering.

Figure 1b shows photo of single 100A/1700V NPT+ IGBT chip with operation surface 185 mm^2.

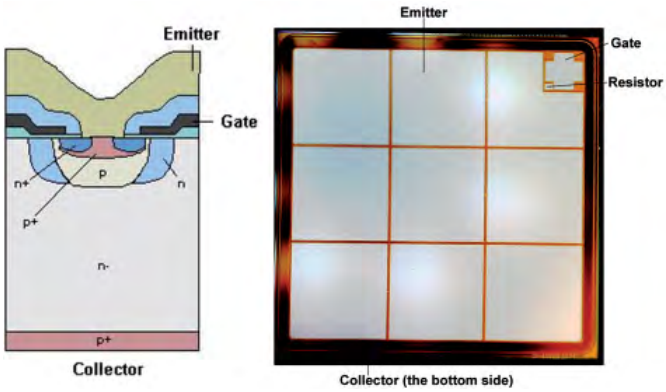

Figure 1: Cross-section (a) and emitter side of NPT+ IGBT chip (b)

Module assembling

Module assembling was carried out on Electrovipryamitel production line according to standard process. Half-bridge circuit was chosen, for maximum proximity of test conditions to real operation conditions in voltage source inverters with inductive load. Two NPT+ IGBT chips and two FRD chips were connected in anti-parallel each to other, one pair in each switch, in standard package MI3 94x34x30 mm. NPT+ IGBTs are designed for rated current of 100A, so in this circuit parameter system 2x100A/1700V has been realized. Competitor was assembled in package MI4 106x62x31 mm in half-bridge circuit too.

Static parameters

Static and dynamic parameters, RBSOA and SCSOA of 100A/1700V NPT+ IGBT were measured for verification of their switching ability and for evaluation of conformity to high voltage drive demands. All parameters and characteristics were measured on outer interfaces of modules. Static and dynamic parameters of IGBT chips were investigated in extreme electrical conditions by room and elevated temperature.

One of the main demands to IGBT is its ability to block voltage in wide temperature range with low and stable leakage currents. Parameters

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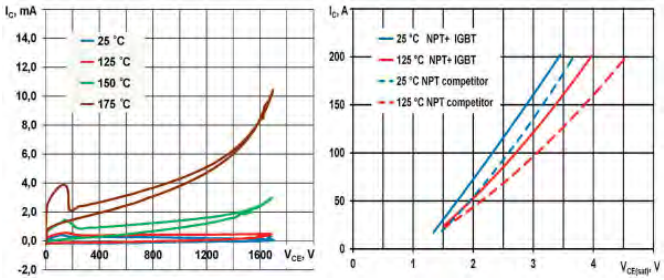
and characteristics of modern 1700V IGBT modules are specified by 125ºC. The maximum allowed chip temperature can be increased up to 150ºC and higher for some applications with hard demands to package dimensions and cooling conditions. Dependence of blocking voltage on temperature was therefore measured in temperature range 25 - 175ºC.

Figure 2a shows typical blocking characteristics of Angstrem NPT+ IGBT chips by 25, 125, 150 and 175ºC. It can be seen from Figure 2a that Angstrem IGBTs keep blocking ability up to 175ºC.

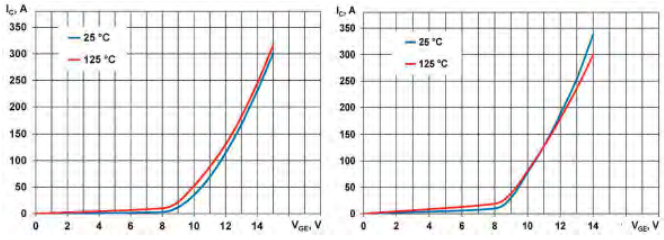


(a) (b)

Figure 2: (a) Blocking characteristics of Angstrem 100A/1700V NPT+ IGBT in temperature range 25 - 175ºC; (b) output current-voltage characteristics of 100A/1700V NPT+ IGBT (solid lines), NPT competitor (dotted lines)by V_{GE} = +15V, 25ºC (blue) and 125ºC (red)

Figure 2b presents forward current-voltage characteristics of Angstrem NPT+ IGBT and NPT competitor by V_{GE} = 15V and temperature 25ºC and 125ºC. It can be seen from Figure 2b that both NPT+ IGBT and NPT competitor have positive temperature dependence of saturation voltage in current range from 10 up to 200A. That allows parallel connection of NPT+ IGBT chips and modules on the base of these chips without special selection. It can be seen as well that NPT competitor has higher saturation voltage than new NPT+ IGBT (for example by 0.4V by 100A).

Figure 3 presents transfer characteristics of Angstrem NPT+ IGBT and competitor. They show collector current change during gate voltage change and forward trans-conduction gfs value that is determined as derivative of $I_C = f(V_{GE})$ by specified collector current. NPT+ IGBT and NPT competitor by collector current 100A have similar g_{fs} values that are equal near 50S.



(a) (b)

Figure 3: Transfer characteristics of 100A/1700V IGBT: (a) Angstrem NPT+ IGBT, (b) NPT competitor. Test conditions: V_{GE} = 50V, t = 10 µs, R_G = 15Ω

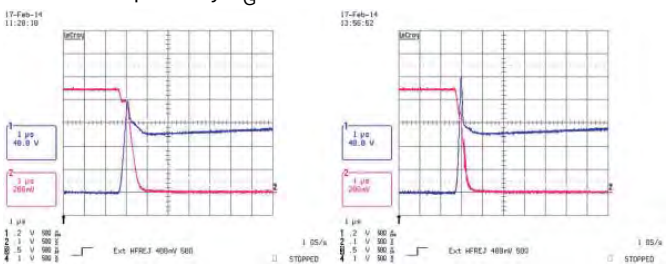
It can be seen from Figures 2 and 3 that main static parameters of IGBT modules on the base of Angstrem 1700V NPT+ IGBT are practically equal to that of NPT competitor and VCEsat is sufficiently better.

Switching parameters

Switching parameters of new IGBTs and competitors were measured in accordance with International Standard IEC 60747-9. Interaction between IGBT and freewheeling diode is present in half-bridge test circuit, due to inductive load identical to real application. EmCon soft recovery 1700V FRD was used as freewheeling diode. Stray inductance of measuring circuit including inner inductance of measured module was 220 nH. The same test circuit was used for turn-off from double current and short circuit investigations.

Switching characteristics have been measured by DC bus-bar voltage 900V, collector current 100A and temperature 25 and 125ºC. Outer gate resistor value was 15Ω in all experiments.

Figure 4 presents turn-on characteristics of 100A/1700V NPT+ IGBT and NPT competitor by R_G = 15Ω and 25ºC.



(a) (b)

_____ I_C (40 A/div) _____ V_{CE} (200 V/div)

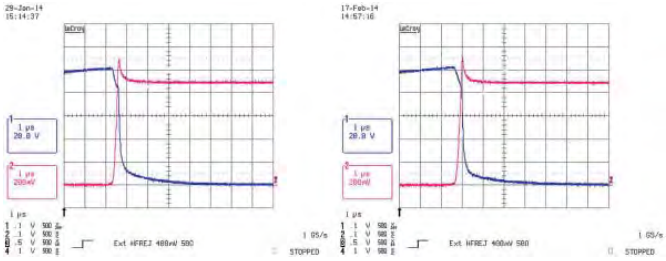
Figure 4: Turn-on wave forms of 100A/1700V transistors by 25ºC: (a) Angstrem NPT+ IGBT, (b) NPT competitor. Test conditions: V_{CC} = 900V, I_C = 100A, R_G = 15Ω

It can be seen from turn-on characteristics Figure 4 that NPT competitor has higher than NPT+ IGBT maximum peak collector current I_{Cmax}, due to higher current rate of rise occasioned by diode reverse recovery. That leads to high frequency oscillations during voltage decay by 25ºC. These oscillations disappear by 125ºC but I_{Cmax} value of NPT competitor remains twice as much as that of NPT+ IGBT.

Figure 5 shows turn-off characteristics of investigated transistors. Test conditions were: temperature 125ºC, collector current 100A, supply voltage 900V, input resistor value 15Ω. It can be seen from Figure 5 that turn-off characteristics of NPT+ IGBT and NPT competitor are practically similar. Transistors show soft turn-off with small inductive overvoltage (no more as 200V) without oscillations.

Measuring results allow to determine main dynamic parameters of NPT+ IGBT and NPT competitor that are placed usually in manufacturer catalogues: turn-on delay time $t_{d(on)}$, rise time t_r, turn-off delay time $t_{d(off)}$, fall time t_f. Total energy loss in IGBT during turn-on and turn-off was measured too (single pulse)

$E_{SW} = E_{on} + E_{off}$.



(a) (b)

_____I_C (20 A/div) _____V_{CE} (200 V/div)

Figure 5: Turn-off wave forms of 100A/1700V transistors: (a) Angstrem NPT+ IGBT, (b) NPT competitor. Test conditions: V_{CC} = 900V, I_C = 100A, R_G = 15Ω, T_j = 125ºC

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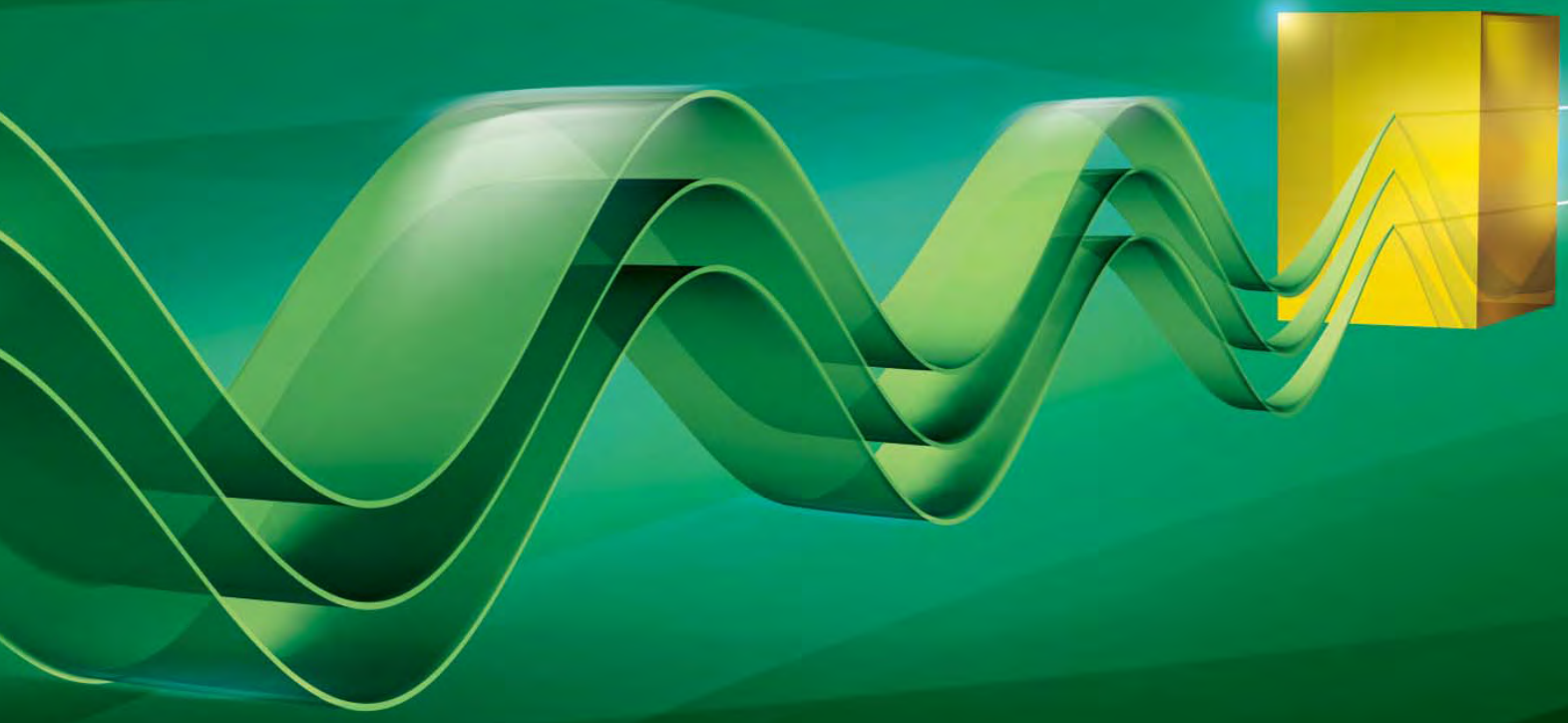

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Table 1 presents dynamic parameters of IGBT measured by test conditions: V_{CC} = 900V, I_C = 100A, R_G = 15Ω, T_j = 125ºC.

IGBT type	Turn-on test IGBT					Turn-off test IGBT			E_{SW} mJ
	$t_{d(on)}$ µs	t_r µs	I_{peak} A	E_{on} mJ	di/dt A/µs	$t_{d(off)}$ µs	t_f µs	E_{off} mJ	
NPT+ IGBT	0,4	0,19	170	53	405	0,46	0,8	31	84
NPT comp.	0,5	0,12	200	51	650	0,68	0,65	32	83

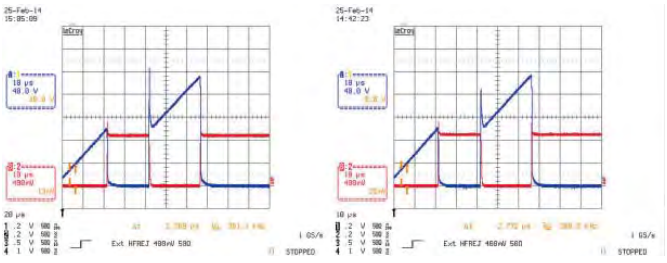
Table 1: Switching parameters of IGBT 100A/1700V (typical values)

It can be seen from Table 1 that switching parameters and energy losses by turn-on and turn-off of NPT+ IGBT and NPT competitor are similar. It should be noted that turn-off losses E_{off} of NPT+ IGBT can be reduced further by means of irradiation. The saturation voltage will be raise because of that, but irradiation dose can be adjusted so that V_{CEsat} not exceeds values for NPT competitor.

Over-current and short circuit resistance

IGBT resistance to double current and short circuit characteristics have been verified in half-bridge circuit with inductive load. IGBT should be able to switch-off double rated current. Device should sustain overvoltage and high du/dt up to 10 kV/µs that arises during sharp current fall. It should not generate high frequency oscillations that can arise on the late stage of collector current fall. All 100% of Electrovipryamitel IGBT modules are subjected to this test. This test allows revealing unreliable IGBTs with latent defects that cannot be revealed by other test methods.

Double current test is carried out by DC bus-bar voltage 900V and maximal allowed temperature. Figure 6 shows example of double current test of NPT+ IGBT and NPT competitor. Current increases linear after turn-on up to rated value (in our case 100A). Current falls after that to null level and in 10-20 µs (time needed for completion of all transients) continues to increase from rated value up to 200A. IGBT is turned-off at this instant. All transistors sustained successfully this test. Over-voltage during turn-off of double current was no more than 200V (V_{CEmax} < 1100V).



(a) (b)

_____I_C (40A/div) _____V_{CE} (400V/div)

Figure 6: Wave forms of double current test: (a) 100A/1700V Angstrem NPT+ IGBT, (b) NPT competitor. Test conditions: V_{CC} = 900V, I_{C1} = 100A, I_{C2} = 200A, R_G = 15Ω, T_j =125ºC

IGBT short circuit resistance is of key importance in drive applications. Short circuit characteristics of investigated IGBTs were verified in half-bridge test circuit in CS1 mode. This mode is realized by means of direct connection of charged capacitor to collector and emitter with subsequent IGBT turn-on for determined time.

Short circuit characteristics depend on following factors: gate voltage V_{GE}, DC bus-bar voltage V_{CC}, short circuit duration t_{SC}, junction current T_j. Short circuit characteristics are specified usually by V_{GE} = 15V. Increase or decrease of gate voltage can lead to short circuit current decrease or increase depending on IGBT transfer characteristic, i.e. collector current dependence on gate voltage.

Junction temperature increase leads to short circuit current decrease due to saturation voltage increase. Figure 7 shows short circuit current dependencies of Angstrem NPT+ IGBT and NPT competitor on gate voltage measured by room temperature and maximum allowable temperature.

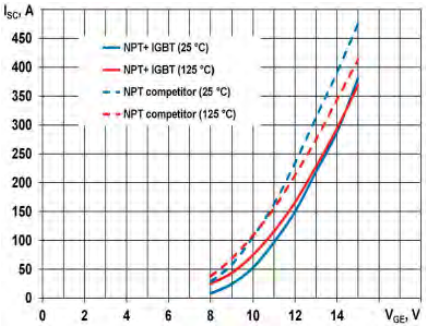
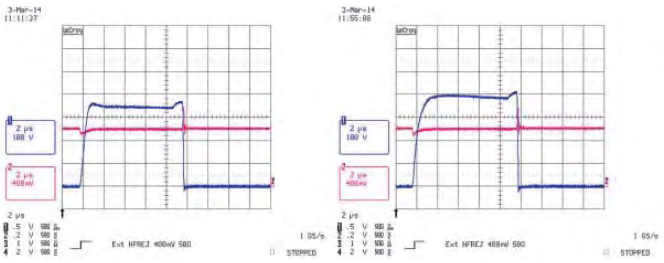


Figure 7: Short circuit current dependencies of NPT+ IGBT and NPT competitor on gate voltage. Test conditions: V_{CC} = 1000V, t_p = 10µs, R_G = 15Ω, T_j = 25ºC and 125ºC

It can be seen from Figure 7 that inversion point of competitor lays on the curve I_{SC} = f(V_{GE}) by current value 130A, and that of NPT+ IGBT – by current value 300A. As a consequence, a short circuit current of NPT+ IGBT and NPT competitor by 125ºC differs no more than by 50A.

Figure 8 presents current and voltage wave forms by short circuit of NPT+ IGBT and NPT competitor during specified duration 10µs under conditions V_{CC} = 1000V, R_G = 15Ω, V_{GE} = ±15V, T_j = 125ºC. It can be seen that transistors sustain this short circuit mode successfully. Short circuit current of NPT competitor was slightly higher than that of NPT+ IGBT. This can be explained by larger active surface of NPT competitor. Transistors were under high voltage up to 1400V (taking into account inductive over-voltage peak) simultaneously with short circuit current.



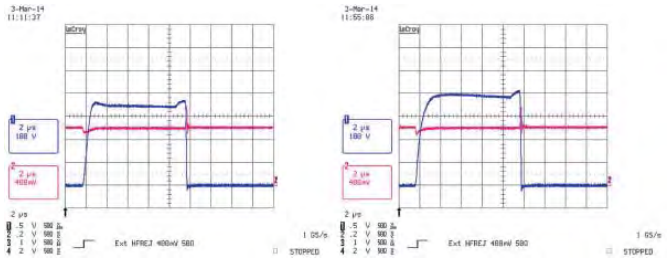
(a) (b)

_____I_{SC} (100A/div) _____V_{CE} (400V/div)

Figure 8: Short circuit wave forms: (a) Angstrem NPT+ IGBT, (b) Npt competitor. Test conditions: V_{CC} = 1000V, t_p = 10 µs, R_G = 15Ω, V_{GEon} = +15V, V_{GEoff} = -15V, T_j = 125ºC

Figure 9 shows current and voltage wave forms during short circuit duration over 10 µs. Series of subsequent tests of NPT+ IGBT has been carried out by V_{CC} = 1000V, V_{GE} = ±15V, T_j = 125ºC and short circuit durations 30 and 40 µs. Tests show that these devices restrict short circuit current to 4,5 rated current level. Over-voltage during short circuit turn-off not exceeded 360V, maximum voltage V_{CEmax} was no more as 1400V that was in SOA limits for 1700V NPT+ IGBT.

Short circuit current gives rise of power losses in IGBT (more as 500 kW peak value). This power dissipation heats IGBT chip up to 200ºC and more. This temperature rise increases voltage drop on transistor and automatically limits short circuit current. Current decay on I_{SC} pulse "shelf" demonstrates this limitation (Figure 9).



(a) 100A/1700V NPT+ IGBT (b) have sustained SCSOA test
_____ (100 A/div) _____ (400 V/div)

Figure 9: Short circuit current wave forms of 100A/1700V NPT+ IGBT: (a) by t_p = 30 µs, (b) by t_p = 40 µs. Test conditions: V_{CC} = 1000V, R_G = 15Ω, V_{GEon} = +15V, V_{GEoff} = -15V, T_j = 125ºC

successfully and have demonstrated high short circuit resistance by elevated voltage and temperature by 4-fold allowable current duration without parameter deterioration.

Conclusion

Angstrem has developed design and base technology process of modern 100A/1700V NPT+ IGBT with chip surface 185 mm^2. New devices have low conduction and switching losses, high resistance to over-current and short circuit. They keep blocking ability in temperature range much higher than operation temperature. Electrovipryamitel begins in the near future production of high power modules with rated currents up to 2400A. The developments of IGBTs continue. The aims are operation voltage increase, trade-off improvement, controlled and soft turn-off of transistors and diodes.

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2nd Generation Si and SiC SGTOs for Extreme Pulse Power and Sub-Microsecond Switching

Through a series of ARL Cooperative Agreements, Silicon Power has been able to optimize Silicon and SiC Super GTOs (SGTOs) for extreme pulse power, operating in excess of 10kA/cm^2, about a 10-fold higher density than the traditional thyristor. Moreover, SGTO active turn-off also provides the opportunity for supporting recovery voltage times (t_q) of 10µs or less at high dV/dt.

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This article will detail both Silicon and SiC devices and modules operating at these power densities and some of the modeling that supported 2nd generation SGTO success.

SGTO vs. GTO

Silicon Power's SGTO is an IC foundry-fabricated GTO. Despite designing the SGTO to several generation old design rules (ensuring high yields) the cell structure is 3,000 times denser than legacy GTO designs. The planar design of the junction termination extension (JTE) allows replacing the deep diffusion junction with shallow ion implanted emitter and upper base. The thinner upper base lowers the series resistance of the device, while simultaneously reducing the requisite charge to be removed during turn-off, see Figure 1. The increased cell density improves current uniformity. Combining these benefits yields a greatly reduced forward drop, a 3x reduction in turn-off losses and 100x improvement of turn-on losses.

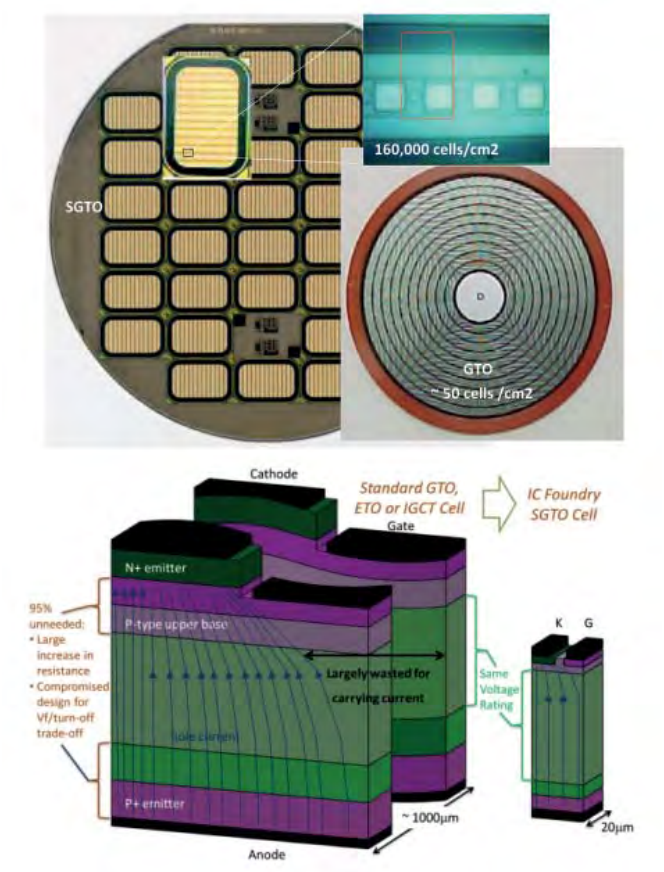

Figure 1: Upper: SGTO cell density compared to legacy GTO cell density. Lower: Deep diffusion legacy technology compared to planar IC foundry-fabricated SGTO

Enabling a cell density of 160,000/cm2 is Silicon Power's proprietary ThinPak lid [1]. ThinPak replaces wirebonds to intimately contact the highly interdigitated fingers with very low parasitic resistance and inductance. Further benefits of ThinPak include: orders of magnitude improvement in thermal cycling over wirebond [2], a robust known good die (KGD) platform to increase module yields and large top side metal patterns for electrode attachment, as shown in Figure 2.

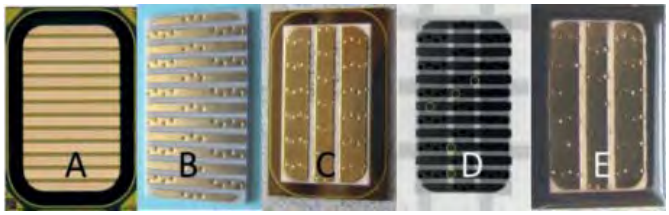

Figure 2. A) 3.3cm2 SGTO B) 2cm2 ThinPak C) Assembled SGTO ThinPak D) X-Ray and electrically tested ThinPak E) KGD ThinPak passivated for strike and creep.

Simulations of Gen2 Technology

First generation SGTOs achieved current densities over 6kA/cm2, but suffered from higher than anticipated losses under very high dI/dt conditions and lower than expected I2t capability (10,000A2s). To improve upon first generation technology a study was done to investigate: the impact of percentage of emitter area, current distributions within a cell and current distribution across several cells with a common metal emitter electrode.

The impact of percentage of emitter area on I2t capability was calculated using a lumped charge model to simulate turn-on and conduction losses allowing a maximum temperature rise of 400C, see Figure 3.

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The minimum pulse width calculated in Figure 3 can be reduced further by increasing the gate current triggering the device. For each factor of e increase in gate current the curve can be shifted to the left by one transit time (55ns for a 6kV Si SGTO).

With the impact of emitter area understood, the current distribution across the cell with ideal ohmic contacts was simulated. Current crowding at the edge of the gate electrode is inevitable, but is mitigated by increasing the emitter area. Figure 4 demonstrates this effect as a function of total device current.

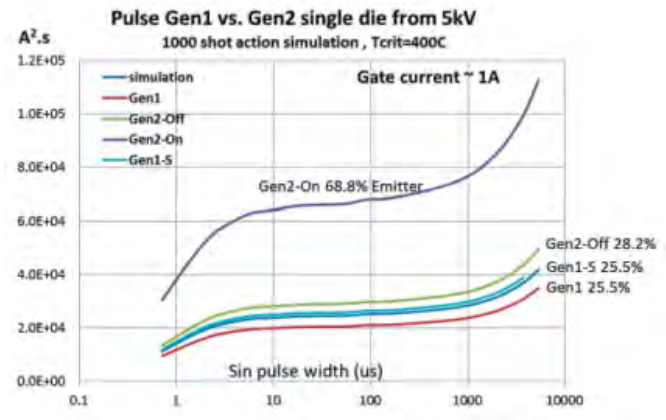

Figure 3: I2t capability as a function of percentage of emitter area and pulse width

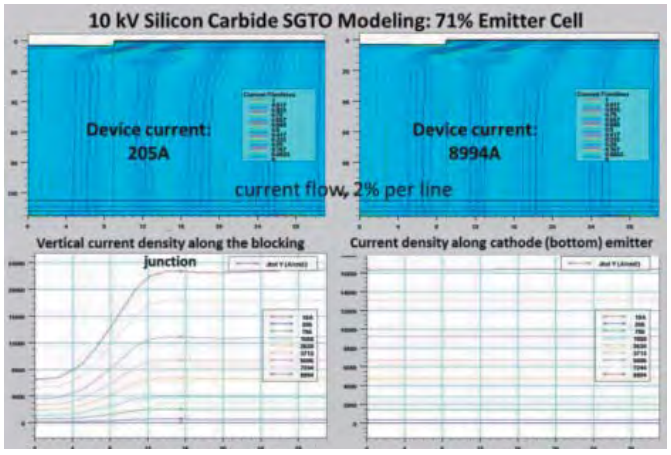

Figure 4: Upper: Vertical current flow lines for a 10mm SiC SGTO carrying 20A (left) and 9kA (right). Lower: Plot of current density across the blocking junction (left) and the backside of the device (right) as the current increases from 20A to 9kA.

Exacerbating this affect is the finite resistance of the emitter electrodes connecting several cells. As the current flows laterally through the emitter/electrode a resistive voltage drop develops. This voltage drop debiases the gate and reduces injection into the lower base, further degrading performance. While ThinPak greatly reduces the lateral distance current must travel compared to wirebonds, the high cell density mandates that some lateral current must flow through the emitter electrode before reaching the ThinPak lid.

To quantitatively study the debiasing due to lateral current flow, several emitter electrodes were placed on the emitter and connected in series with resistors in the mixed mode simulation. This enabled finite resistance to be added between the electrodes, simulating the resistance of the 4mm thick gold electrodes used in fabrication. As Figure 5 shows, the debiasing becomes severe enough to completely eliminate injection at points as close as 120µm from the ThinPak electrode connection. The current flow lines as a function of device current can be found in Appendix A.

Figure 5 also serves to demonstrate the upper bound for spacing the electrodes in Gen2 designs. Interestingly, because SiC needs one tenth the thickness of epi to support the same voltage as Si, this non-uniform current flow is still evident at the back of the device. Figure 6, Upper shows how poor the current balance becomes without careful design.

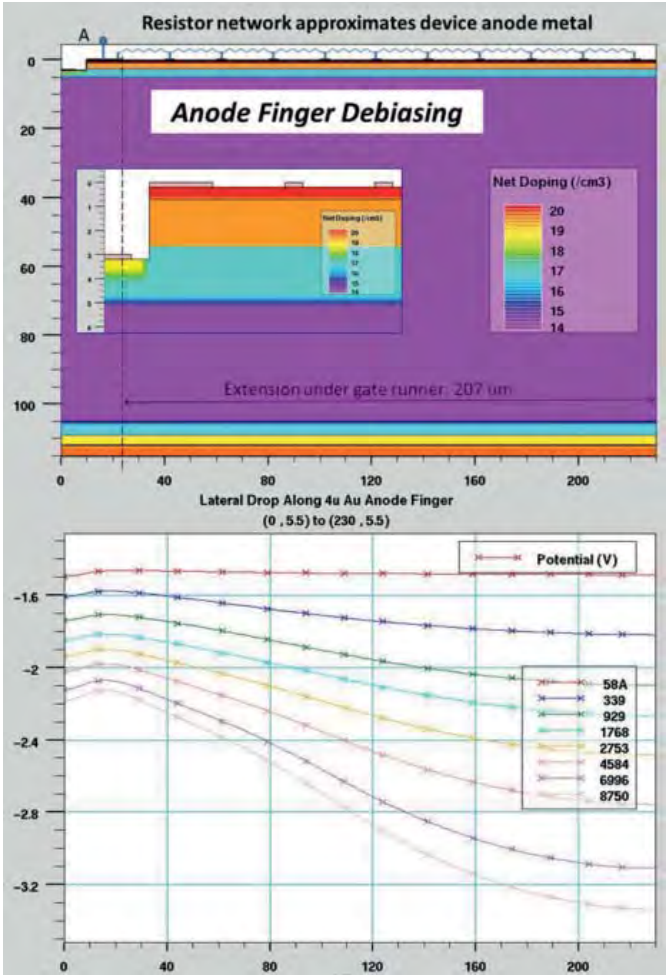

Figure 5: Upper: Cross-section of several cells sharing one electrode. Upper Inset: Exploded view of emitter showing discrete electrodes. Lower: Voltage debias as a function of device current along the upper base-emitter junction

Local temperature rise within the device is proportional to the power density, Figure 6, Lower demonstrates the impact non-uniform current distributions have on temperature gradients, reducing the number of pulses before a failure occurs.

Gen2 Si and SiC SGTO designs were carefully laid out to mitigate current non-uniformities.
Complimentary devices to Gen2-on, the Gen2-off were also studied. For Gen2-off, the gate area is increased relative to emitter area. The larger gate area reduces current crowding in the upper base during turn-off, when the anode current must be extracted from the gate terminal. The reduction of this current crowding mitigates rebiasing of the upper base-emitter junction which results in failed turn-off.

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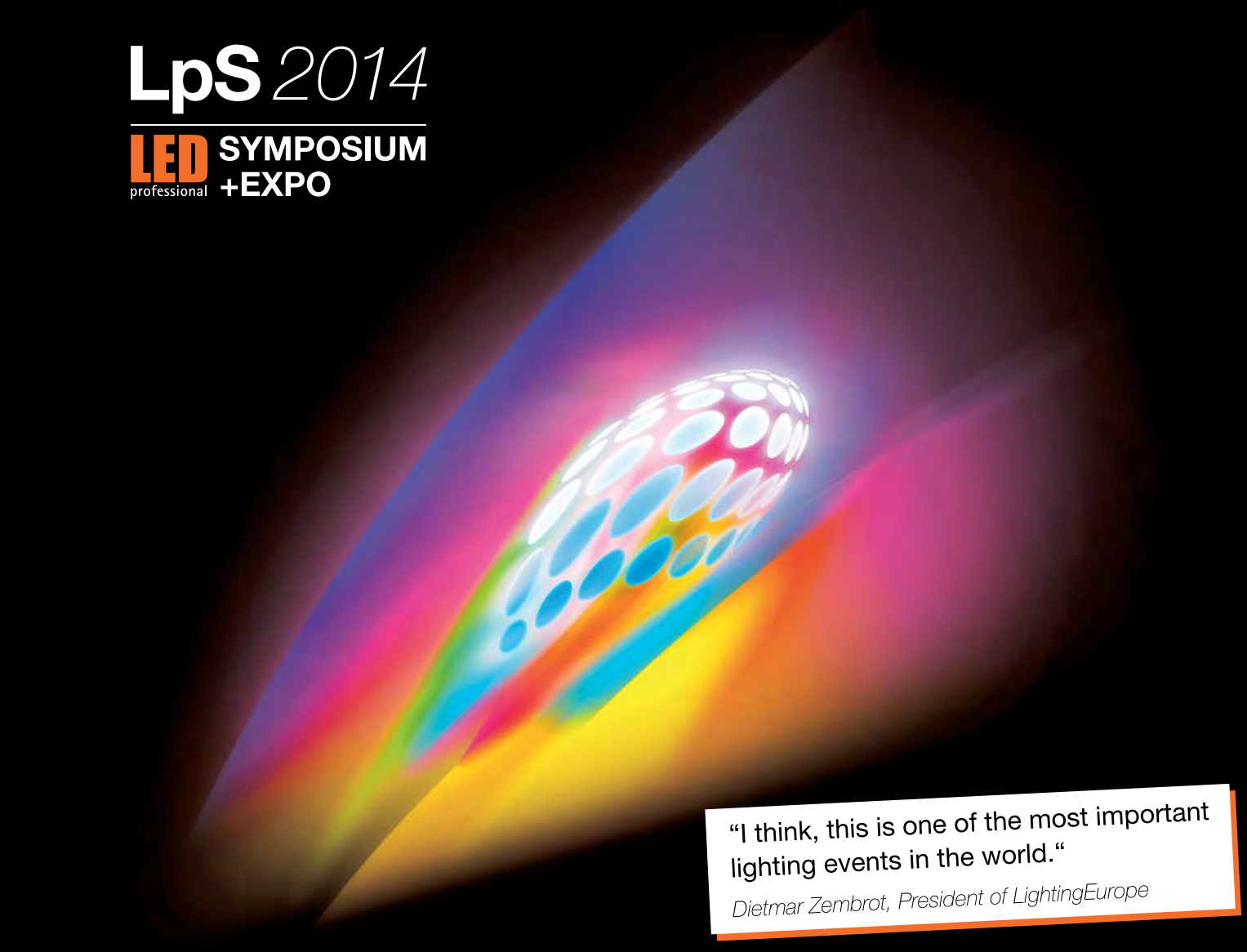

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Experimental Results

The first Gen2-on devices were designed with the same active area as our Gen1 device, making direct comparisons between the two technologies completely transparent.

The Gen2-on device increases the Gen1 emitter area by a factor of 2.7, roughly the same ratio of resistance between the two technologies. However, because the current is distributed more uniformly, and therefore the temperature excursions are less severe, the I2t capability for the Gen2-on device is more than doubled (22.6kA2s), while at the same time dissipating less power than the Gen1 device.

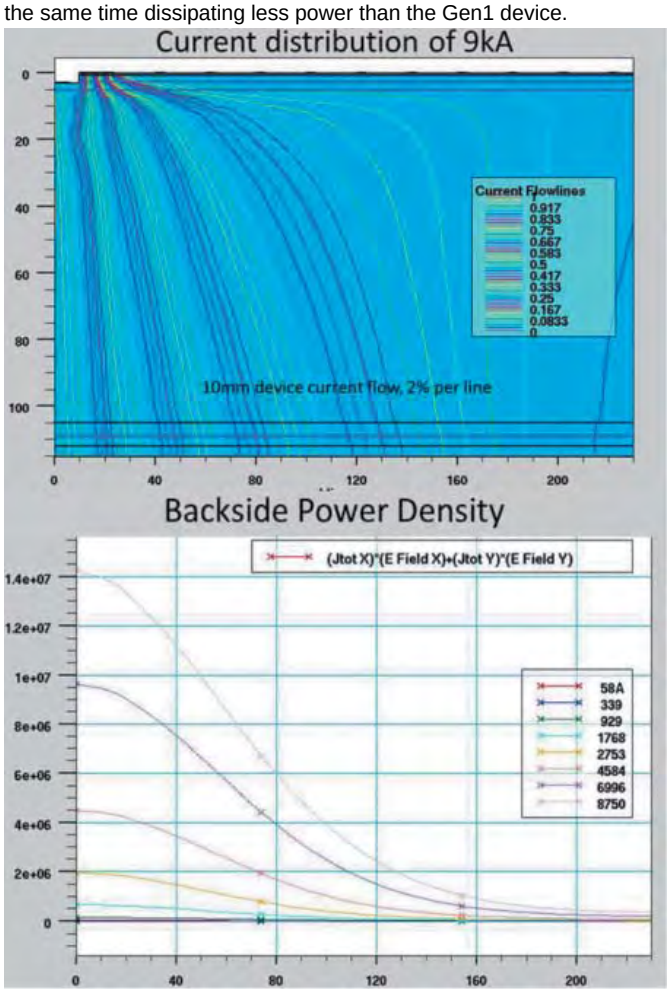

Figure 6: Upper: Current distribution of 9kA Pulse through a 10mm device. Lower: Power density along the backside of the SiC SGTO as a function of device current

To fully exploit the Gen2-on's capability a low parasitic inductance and resistance module holding 8 devices in parallel was designed. The module design enables mxn arrays of modules to be connected in parallel (m) and in series (n). Three modules were assembled in series offering a 10kV DC rating with a volume of less than 100in3. The modules are triggered with a current transformer and have gate-emitter shunt resistors built in to hold the devices off. A photo of this 1x3 Pulse Switch Assembly (PSA) is shown in Figure 8. The PSA includes voltage grading resistors to ensure the voltage is shared equally among the levels, along with a coaxial bus structure that offers a simple, yet low inductance connection to the PSA.

The PSA was characterized by discharging a diode clamped 10mF capacitor with no load through the switch. A waveform and the I-V plot are shown in Figure 9. The I-V plot shows good linearity between

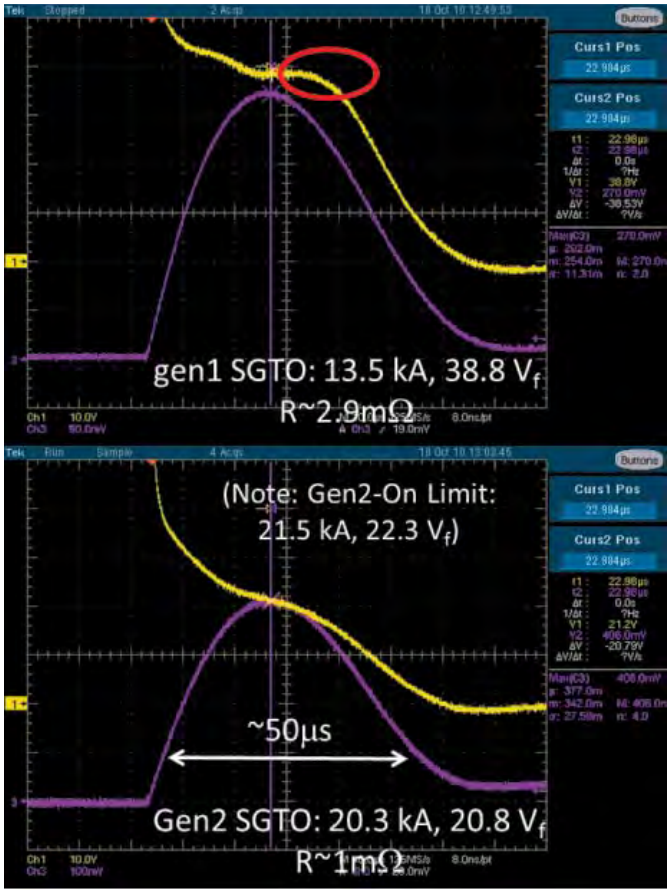

Figure 7: Upper: Gen1 SGTO near limit of operation at 13.5kA and 38.8V. Lower: Gen2-on with same active area conducting 20.3kA with a Voltage drop of only 20.8V

I and V over the entire test range. Using this I-V plot, the PSA achieved a resistance of only 375mOhm and a diode knee (VD) of 3.63V! The parasitic resistance of the module electrodes was measured to be 26µOhm, meaning each Gen2-on device averages only 792µOhm and a VD of 1.21V.

Also demonstrated was a Gen2-off operating in sub-microsecond pulse mode. A 20 Ohm resistor was used as a load switched at 2kV to produce a 100A turn-off where the entire pulse lasted only 600ns, see Figure 10. This first attempt at sub-microsecond switching delivered 80% of the energy to the load!

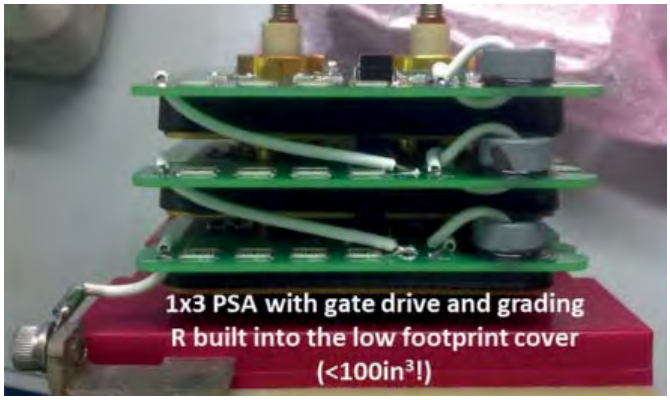

Figure 8: 10kV DC Pulse Switch Assembly (PSA) consisting of 24 Gen2-on SGTOs

The promising preliminary results for Gen2-on and Gen2-off technology can be tailored to fit a broader range of applications through various post-process alterations making the technology a versatile tool for any high-voltage/high-current application. We expect superior results with our Gen2 SiC SGTOs as the minority carrier lifetime has been increased enough to allow for altering the lifetime profile after fabrication. The combination of thinner epi and engineered minority carrier lifetime profiles enables higher efficiencies in the sub-microsecond pulse range.

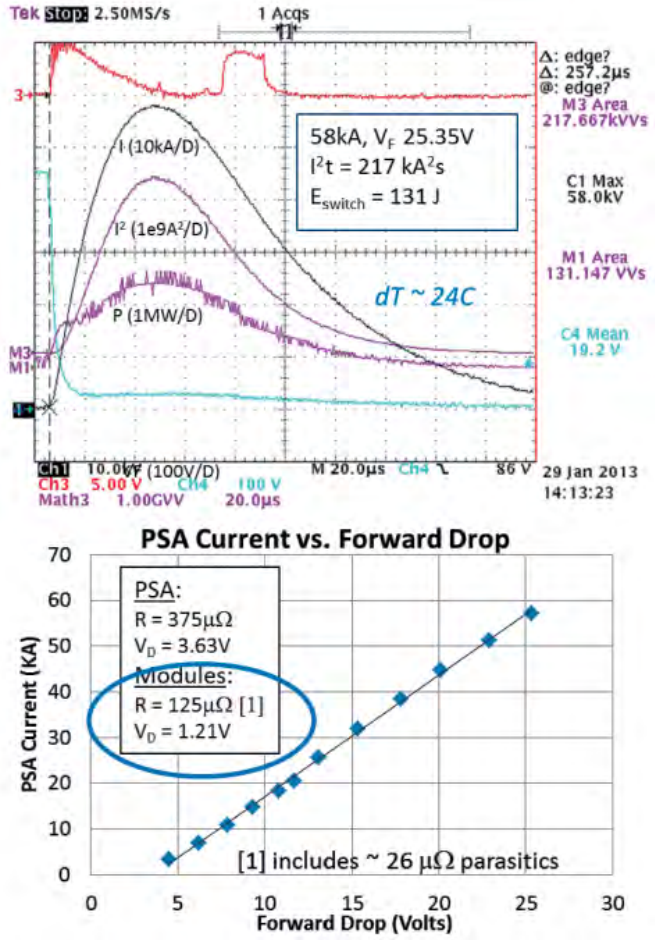

Figure 9: Upper: 58kA discharge through PSA, 217kA2s, 131J dissipated and DT~24C. Lower: I-V relationship for 1x3 PSA, each module demonstrates an on-state resistance of 125µOhm and a VD = 1.21V

Summary

Extensive simulations were conducted, emphasizing the difficulty of achieving uniform current and heating distribution for pulse discharge events with large magnitudes of peak current.

Gen2-on and Gen2-off Si SGTOs have been demonstrated. The Gen2-on SGTOs provide at least a factor of 2 improvement of I2t capability over Gen1 devices without increasing the power dissipated, and the Gen2-off successfully transmitted a sub-microsecond pulse. A comprehensive study is underway to determine where Si versus SiC Gen2 devices will offer the best performance. Obviously SiC Gen2 devices offer higher breakdown voltages compared to Si devices, however the volume of the SiC Gen2 SGTO is roughly 7 times smaller for the same voltage and current rating compared to a Si Gen2 SGTO. Therefore, the DT for the same pulse is about 7 times higher. However, the physical properties of SiC permit larger temperature excursions (up to 4 times given SiC's larger band gap and roughly 4x higher elastic modulus).

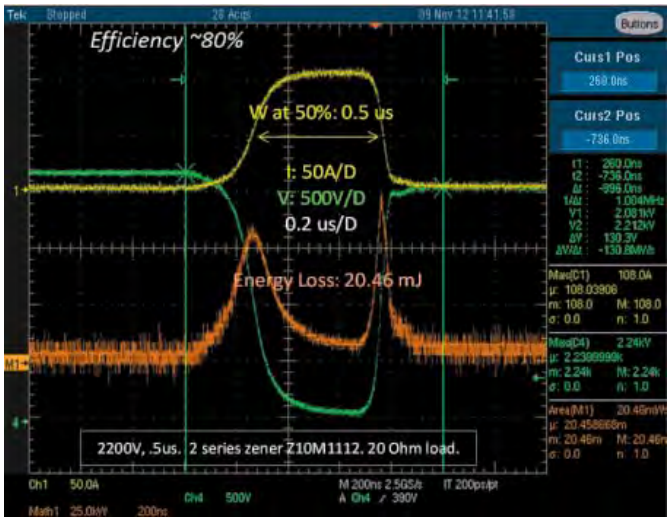

Figure 10: Sub-microsecond switching of a 6.5kV Si Gen2 SGTO

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Feature-Rich Optocoupler Enables IGBT Driving Scalability

High scalability of an IGBT driving solution and consistent protection measures are essential requirements for a power converter platform design. The ACPL-339J gate drive optocoupler uses dual outputs to drive a current buffer's upper and lower MOSFETs separately, thus allowing delicate timing control techniques to be integrated in the optocoupler. This design essentially enables current scalability of the buffer stage as the MOSFET pair can be changed to a higher rating one without changing the isolation and driver interface. Therefore, consistency of protection features provided by the optocoupler is maintained.

By Hong Lei Chen, Product Manager, and Ivan Yang, Field Application Engineer, Avago Technologies

One of the requirements in a power converter platform design is the capability of covering a wide range of power ratings. This requires sufficient scalability of the IGBT driving solution to accommodate for different IGBT ratings. For example, in low power (several kW and below) motor drives or inverters, a gate driver circuit with up to 1.5 A output current would be suitable. For a medium power model, such as from several kW to 30 kW system, a 2.5 A output current gate driver shall be used instead. Converters with power rating from tens of kilowatts to hundreds of kilowatts and even megawatts, a current buffer stage consists of BJTs or MOSFETs or both is often needed to boost current driving capability from several amperes to tens of amperes [1, 2]. The current buffer stage can be integrated in a driver module [3], or available as a standalone chip [4, 5]. Figure 1 illustrates the driving current required for different IGBT classes and converter power ratings along with a suitable gate drive part number [1].

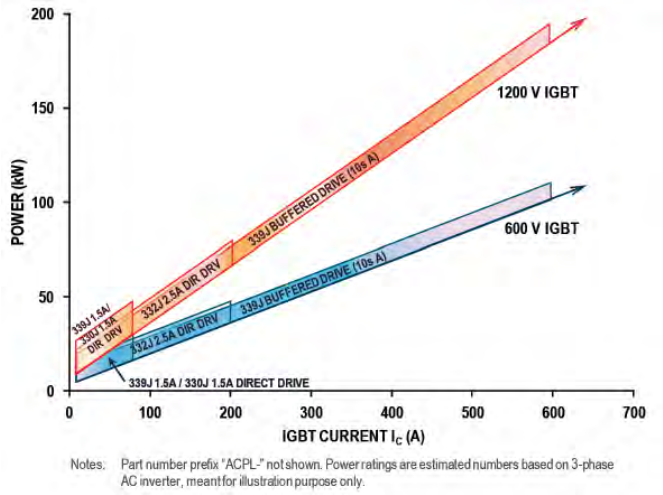


Figure 1: Driving current for different IGBT classes

For a platform design, a common gate driver circuit is preferred to cover a diverse power rating with minimum component changes. Therefore choosing a topology with sufficient scalability that's able to cover very wide current range is the key to achieving this design goal. The ACPL-339J is suitable for such designs. For low power models, the ACPL-339J's 1 A peak output current is able to directly drive a power switching device with rating up to 1200 V/50 A. For high power models, a buffer stage can be inserted between the ACPL-339J and IGBT. Designers have the flexibility of choosing different current ratings according to given IGBTs without changing the ACPL-339J, as illustrated in Figure 2. With appropriate design, the buffered gate driver is able to drive IGBT with rating of 1200 V/600 A [8]. Leveraging on MOSFET-based current buffers, the ACPL-339J successfully extends its coverage from low to high power models and provides a highly scalable solution.

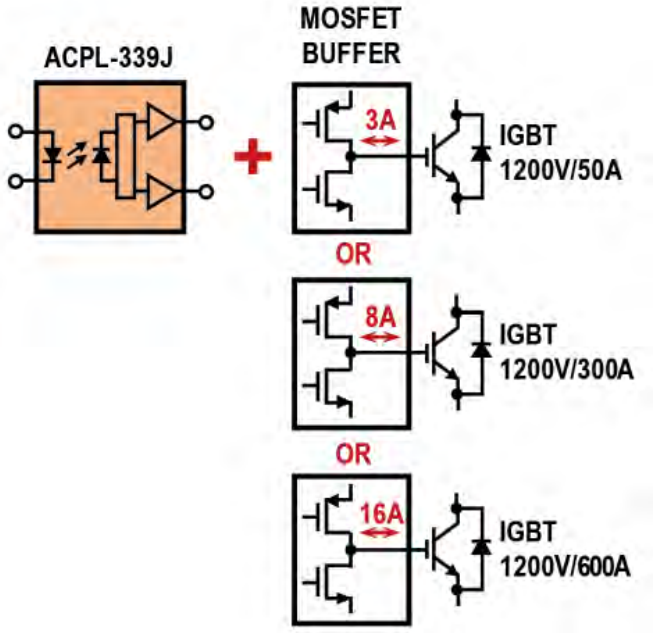


Figure 2: Flexible gate driver design with wide range of current buffer choices

Besides driving current scalability, another important consideration is consistent protection measures across different models based on the same platform design. Gate drive optocouplers vary in not only output current, but also in protection features and feedback logics. For in-

stance, the ACPL-330J's output is normally High without fault; while the ACPL-339J's FAULT (no overbar) output becomes High when a fault condition occurs. Therefore to maintain consistency across different models, a design shall stick to same gate drive interface once fixed. In this article, using the ACPL-339J with a recommended current buffer and its integrated protection features will be discussed in detail.

Driving current scalability

There are many different kinds of current buffers available. These include the topologies discussed in reference [2] using discrete devices, and integrated buffer chips such as the IXDD630 [4]. The ACPL-339J is optimized to work with a MOSFET-based current buffer given its properties stated below in comparison with a BJT-based counterpart:

- MOSFET is a voltage-controlled device that requires less current to switch and no DC current to maintain on,
- MOSFET switches quickly with shorter turn-on time, and
- Significant lower power loss within the current buffer stage [6, 7].

However, there are mainly two challenges that are needed to be addressed before enjoying the benefits: (1) a simple CMOS buffer structure will suffer large shoot-through current during switching transition period, and (2) input to output logics are inverted when a non-inverting buffer is desired [2]. The ACPL-339J takes care of these challenges using an integrated active timing control technique to prevent cross conduction in the external buffer stage, and factors in the logic inversion in its drive logic block [8].

Connecting the current buffer

Figure 3 shows a simplified inverter application circuit including the block diagram of the ACPL-339J, the current buffer and surrounding components. Uniquely designed to support MOSFET-based current buffers of flexible current ratings while providing a robust optical isolation barrier, the ACPL-339J has an LED direct input stage (LED1) and dual outputs, V_{OUTP} and V_{OUTN}, to drive P- and N-MOSFET separately. The device includes a Drive Logic & Overlap Protection block to control internal buffers for V_{OUTP} and V_{OUTN}, respectively, and an active timing control technique to provide a "dead time" (both P- and N-MOSFETs of the current buffer are off) between alternate drive pulses. This dead time is usually of sufficient duration to assure that the On states of the MOSFET pair do not overlap under any conditions.

As one can see, connecting in this way allows for the driver circuit design being easily ported over from one inverter model to another. This is done by exchanging the MOSFET pair according to IGBT classes used in different models, without changing the isolation and driver interface. Therefore, this design provides a highly scalable IGBT driving solution.

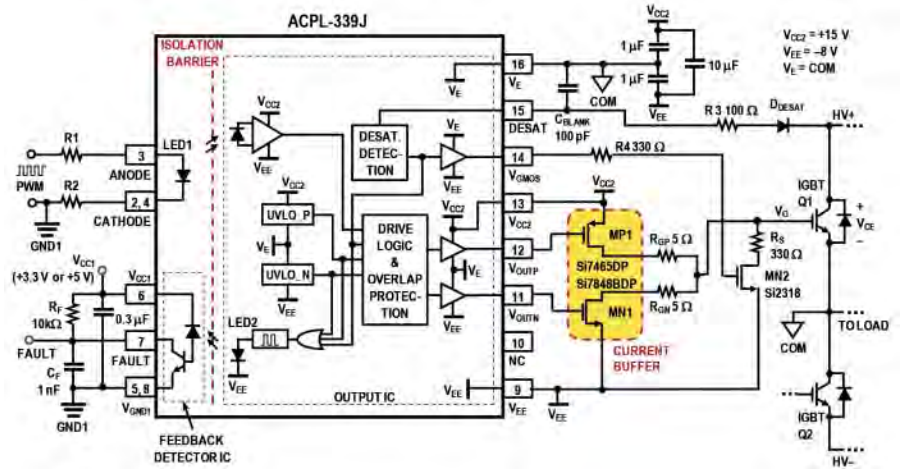


Figure 3: A simplified connection circuit including block diagram of the ACPL-339J

Applications	IGBT Class	Qg	Est. Peak Charging Current	MN1	MP1	MN2
Low Power	1200V/50A	300 nC	3 A	Sanyo ECH8619 (2-in-1)		Vishay SI2308
Medium Power	1200V/300A	2000 nC	8 A	Vishay SI7414	Vishay SI7415	Vishay SI2308
High Power	1200V/600A	4000 nC	16 A	Vishay SIS434	Vishay SI7611	Fairchild FDC5612

Table 1: Recommended MOSFETs suitable for different IGBT classes

Selecting MOSFETs

Current driving capability requirement of the MOSFETs, MP1 and MN1 as shown in Figure 3, can be estimated by the IGBT gate charge and desired charge up time. The equation below shows an example:

$I_{CHARGE} = Qg / t_{CHARGE}$,
where Qg is the total gate charge specified in respective IGBT data sheet.

For a 1200 V/50 A IGBT, typical Qg is approximately 300 nC. For charging time of
200 ns, the I_{CHARGE} will be:

I_{CHARGE} = 300 nC / 200 ns = 1.5 A.

The calculated charging current is an average current. Peak current can be estimated by doubling the average current, as a rule of thumb. So for this example, a 3 A peak current MOSFET driver rating will be appropriate. Table 1 lists some recommended MOSFETs with their ratings and part numbers that are suitable for different IGBT classes. Note Qg are typical numbers, refer to respective IGBT specifications for actual figures.

Circuit operation

The ACPL-339J consists of 2 LEDs and 2 IC dies, housed in an SO-16 package (Figure 3), providing the input receiving circuitry, the output power stage, and two optical-coupling channels. Along the electrical isolation barrier, it divides into an input side and an output side. The input side includes an LED (LED1) to receive pulse width modulation (PWM) signal, and a Feedback Detector IC to receive fault status feedback signal from LED2, which is located on the output side. Beside LED2, the output side has an IC chip that performs mainly the driving and protection functions. It detects photo signal from LED1 and generates drive logics to separately control V_{OUTP} and V_{OUTN}, which drives the P- and N-MOSFETs of the current buffer, respectively.

The ACPL-339J operates on three supplies: V_{CC1} of +3.3 V or +5 V (with respect to V_{GND1}), V_{CC2} of +15 V and V_{EE} of –8 V (both with respect to V_E). Under normal operation, PWM signal source directly drives the LED1 of the ACPL-339J, using resistors to limit its current within recommended range of 6 to 10 mA. Choose an MCU with sufficient output current capability as PWM source, or use a buffer stage. Figure 4 shows the ACPL-339J normal operation input-output waveforms.

Intelligent IGBT protection

Costly IGBTs are the heart of a power converter, and are required to withstand high DC bus voltage. The efficiency and reliability provided by these power devices are of the utmost importance when maximizing a system performance. The ACPL-339J is featured with various IGBT protection functions, including under voltage lockout (UVLO), desaturation detection, “soft” IGBT shutdown, and isolated fault feedback. Appropriate use of these features can provide maximum design robustness and consistent IGBT and power converter protection scheme across different models.

Under voltage lockout

Under certain conditions such as system start up or fault conditions, the supply voltage (equivalent to the fully-charged IGBT gate voltage) can be lower than a desired level. Insufficient IGBT gate voltage can result in high turn on resistance, hence large power loss and even IGBT damage. The ACPL-339J has two UVLO logic blocks, UVLO_P and UVLO_N, to constantly monitor voltage levels of V_{CC2} and V_{EE}, respectively. When either of these two power supplies is lower than their respective thresholds, the gate driver will block the IGBT from turning on, or shut it down if it’s already turned on.

Desaturation Detection

Besides monitoring supply voltages, the ACPL-339J Output IC also keeps an eye on the DESAT pin voltage, and reports IGBT desaturation fault when this voltage exceeds 8 V. IGBT desaturation can be caused by phase or rail supply short circuits, control signal failures, and overload conditions. Under desaturation condition, the IGBT current and power dissipation increases drastically, possibly leading to catastrophic failures due to overheat. To protect IGBT, the ACPL-339J monitors its collector-emitter voltage, and triggers an IGBT shutdown sequence if the collector-emitter voltage exceeds a certain level. Table 2 shows the ACPL-339J inputs and outputs truth table according to the application circuit shown in Figure 3. Corresponding status of the current buffer MOSFETs and the IGBT are also included in the table to help understand the circuit operation.

Input and conditions			Outputs				Status
LED1	UVLO_P OR UVLO_N	DESAT	FAULT	V_{OUTP}	V_{OUTN}	V_{GMOS}	
X	Triggered	Function disabled	V_{CC1}	V_{CC2} (MP1 Off)	V_E (MN1 On)	V_E (MN2 On)	IGBT Off, Fault condition
ON	Not triggered	Triggered	V_{CC1}	V_{CC2} (MP1 Off)	V_{EE} (MN1 Off)	V_E (MN2 On)	Soft shutdown, IGBT Off, Fault condition
ON	Not triggered	Not triggered	V_{GND1}	V_E (MP1 On)	V_{EE} (MN1 Off)	V_{EE} (MN2 Off)	IGBT On, normal operation
OFF	Not triggered	Function disabled	V_{GND1}	V_{CC2} (MP1 Off)	V_E (MN1 On)	V_{EE} (MN2 Off)	IGBT Off, normal operation

Note: “X” denotes Don’t Care.

Table 2: ACPL-339J application circuit operation truth table

From the truth table, it can be observed that the ACPL-339J outputs (V_{OUTP}, V_{OUTN}, V_{GMOS} and FAULT feedback) are controlled by combinations of LED1 input and conditions of UVLO and DESAT. LED1 input and DESAT condition are ignored when UVLO fault is triggered. When UVLO fault is cleared, and LED1 is On, the DESAT condition will determine the outputs. In this way the UVLO and desaturation detection features work together closely to ensure seamless IGBT protection [8].

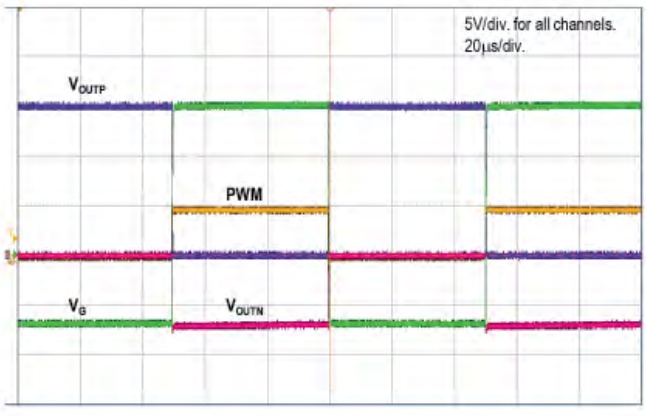
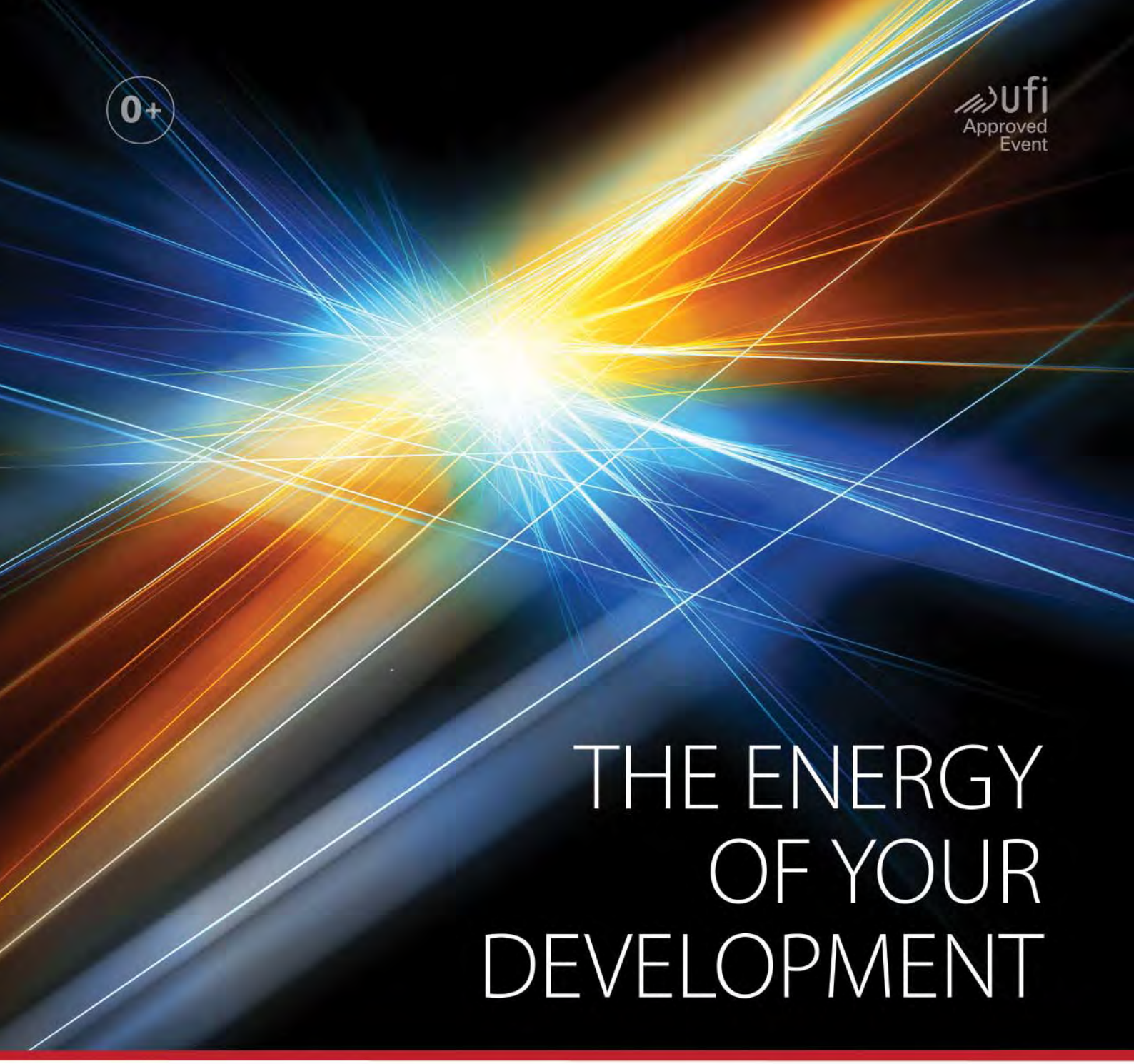


Figure 4: ACPL-339J normal operation input-output waveforms



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Soft shutdown

When an IGBT desaturation fault is detected, the ACPL-339J will shut down the IGBT immediately but "softly" by transferring the gate control from MN1 and MP1 to MN2. During soft shutdown process, V_{OUTP} goes High and V_{OUTN} goes Low, V_{GMOS} switches from Low to High to turn on MN2. MN2 and RS slowly discharge the IGBT gate at a decay rate corresponding to the time constant of RS and IGBT gate capacitance (denoted as CIN, not shown in Figure 3). For example, given R_S of 330 Ω and C_{IN} of 10 nF, the decay period is 4.8 × 330 Ω × 10 nF = 15.8 µs [8]. This is a much slower, or "softer", shut down process compared to the normal turn-off timing through MN1 and R_G of 5 Ω. Change R_S to a larger resistor say 1 kΩ for even longer shutdown time. Figure 5 to Figure 7 show IGBT shut down timing (gauged by gate voltage fall time from 90% to 10%) for normal operation, soft shutdown with 330 Ω resistor, and soft shutdown with 1 kΩ resistor, respectively. Measurements were done based on the ACPL-339J typical application circuit (Figure 3) with an IGBT FF50R12RT4 connected.

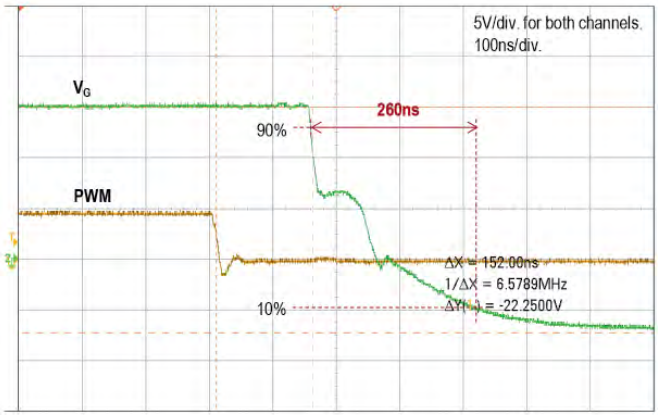

Figure 5: Gate voltage fall time of 260 ns in normal operation shutdown

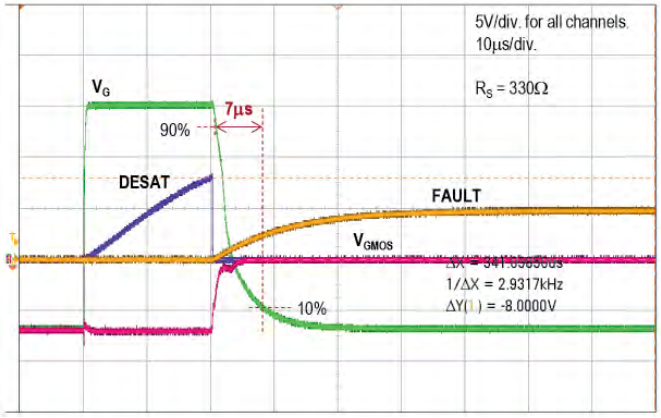

Figure 6: Gate voltage fall time of 7 µs in soft shutdown with 330 Ω resistor

Soft shutdown protection is a local IGBT protection mechanism; shut down action is immediately triggered when DESAT pin voltage exceeds 8 V to ensure timely reaction to high risk of damage fault conditions such as short circuit. On the other hand, soft shutdown reduces the IGBT current to zero in a controlled manner to avoid potential IGBT damage from over voltages due to inductive load. Along with DESAT trigger, fault status is transmitted back to the microcontroller via LED2 and FAULT pin, as shown in Figure 6.

Conclusion

Uniquely designed to work with MOSFET-based current buffer capable of diverse current ratings to drive IGBTs, the ACPL-339J makes it easier for system engineers to design a hardware platform that can be easily ported over. It provides a cost effective solution to maximize scalability of an IGBT gate drive design for motor control and power conversion applications ranging from low to high power ratings.

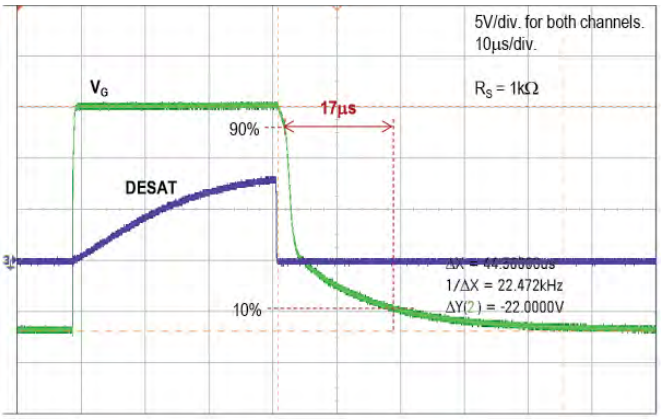

Figure 7: Gate voltage fall time of 17 µs in soft shutdown with 1 kΩ resistor

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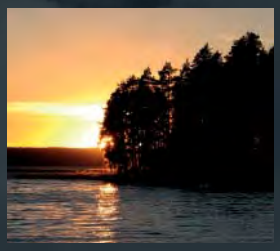

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Decentralised Drive Technology Solution with MPU

In factory automation, decentralised drive solutions have many benefits over centralised drive solutions. For the latter, the frequency inverter and control unit is mounted inside a control cabinet and it requires multiple cabinets as well as star cabling topology for each drive.

By Thomas Mauer, Texas Instruments

Decentralised drives have the frequency inverter and control unit either directly attached or positioned close to the drive – this simplifies cabling as line topology can be used and reduces the overall number of installed control cabinets. In particular, production sites with many drives benefit from a decentralised solution as it can be found in manufacturing streets with belt conveyer or luggage transportation belt at airports or high rack warehouses.

Many manufacturers of decentralised drive solutions follow a modular system approach with the following building blocks: The central control or supervisor unit, the motor control, the frequency inverter, power stage or gate driver, motor current sensing and position encoder, motor protection unit and the industrial Ethernet or fieldbus interface. Often those blocks are spread over multiple subsystems with individual microcontrollers, microprocessors, digital signal processors (DSPs) and FPGAs/ASICs.

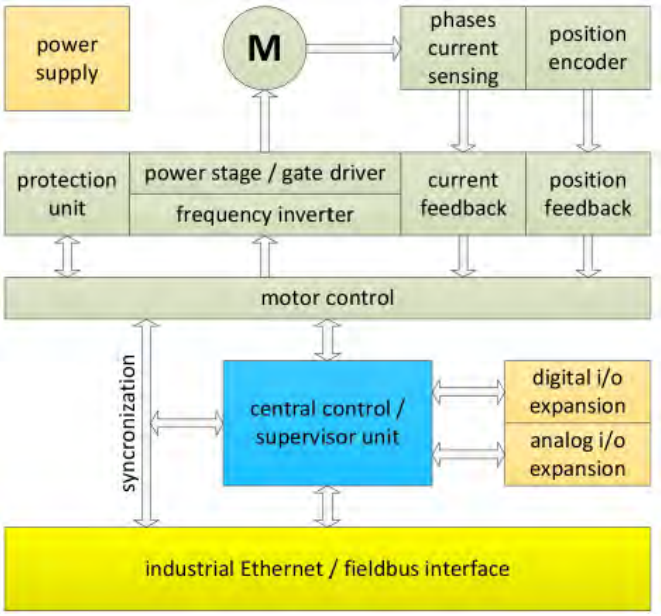

Figure 1: Decentralized drive system block diagram

This modular system approach has the benefit that each subsystem can be developed or replaced by itself. But it also has trade-offs like component sourcing from multiple vendors, non-compatible application programming interfaces (APIs) between the subsystems and it requires a large PCB footprint. All this makes the production of decentralised drive solutions more expensive.

The integrated system approach

Manufacturers of decentralised drive solutions can save production cost with the Sitara AM437x microprocessor family from Texas Instruments (TI) which integrates many of those building blocks into a single device. The powerful ARM Cortex-A9 processor handles many of the application tasks including motor control, fieldbus stack and central control unit. The industrial Ethernet, motor position encoder and real-time critical tasks are resourced by the industrial communication subsystem (ICSS). The remaining decentralised drive building blocks are sourced by integrated peripherals, for example the enhanced pulse-width modulator (ePWM), the enhanced quadrature encoder peripheral (eQEP) and the on-chip ADCs. Overall the Sitara AM437x solution allows architecting the decentralised drive solution across multiple subsystems while integrated into a single microprocessor device.

How decentralised drive building blocks are integrated into the Sitara AM437x

Many motor control loop algorithms exist and the IP used is the differentiating mark of the manufacturer's products. One of the algorithms, field oriented control (FOC), is used to drive a 3-phase brushless DC (BLDC) motor. For this algorithm the motor control loop is processed, as an example, every 100µs (10kHz). In the control loop the next PWM's duty cycle is calculated. With the usage of a real-time operating system (RTOS), like SysBios from TI, the ARM Cortex-A9 can execute the motor control loop. The floating-point support within the ARM Cortex-A9, as well as the processor speed between 300MHz and 1GHz, helps to reduce the execution time of the motor control loop – hence there is more execution time available for other tasks. Those tasks may include the fieldbus stack for industrial Ethernet, the control/supervisor unit, statistic database and web-/maintenance-services.

Once the motor control loop has finished its calculations the ePWM peripheral is updated with new duty cycles. The ePWM output acts as frequency inverter, which is fed into the power stage to create the 3-phase power signal for spinning the motor.

The ePWM block also generates the trigger signal to start the measurement of phase currents and motor position feedback. Those measurement results are used by the next cycle of the motor control loop. The phase currents are translated into voltage levels and sampled by the on-chip ADC. An external high precision position encoder with an EnDAT 2.2 measures the motor position or BiSS interface. The ICSS interfaces with the EnDAT/BiSS encoder and acquires the motor position for the motor control loop. Alternatively the enhanced quadrature encoder (eQEP) with lower position resolution or any other feedback system via the parallel or serial interfaces can be used.

The fieldbus interface, nowadays based on one of the many industrial Ethernet solutions, is used to exchange drive control commands and process data with the programmable logic controller (PLC). The Sitara AM437x has a flexible industrial Ethernet interface based on ICSS. The ARM Cortex-A9 application loads an ICSS firmware at system start time with the manufactures preferred real-time Ethernet (RTE) protocol. TI and its partners offer the most common RTE protocol solutions including EtherCAT, Profinet RT/IRT, Sercos 3, Ethernet/IP and Power-Link. The Sitara AM437x also supports legacy serial based fieldbus solutions like Profbus DPv1 slave and CAN.

Additional integrated peripherals complement the decentralised drive building blocks. For example the enhanced direct memory access (EDMA) for transferring memory blocks of data without processor involvement, USB for interfacing to a service terminal on a laptop, or GBit Ethernet MAC to connect to an Ethernet infrastructure.

The industrial development kit

The AM437x industrial development kit (IDK) combines the entire set of building blocks for a decentralised drive solution. The development kit supports a 3-phase motor with the DRV8313 power stage and has protection against fault conditions like overheating and current overload. The fault signal of DRV8313 is fed into the PWMs TRIPZONE input which immediately disables ePWM signal generation in order to protect the power stage.

The IDK supports a M12 connector to directly interface to an EnDAT 2.2 position encoder from Heidenhain. Here the SN65HVD78D transceiver converts the high-speed EnDAT 2.2 levels into signal levels accessible by ICSS.

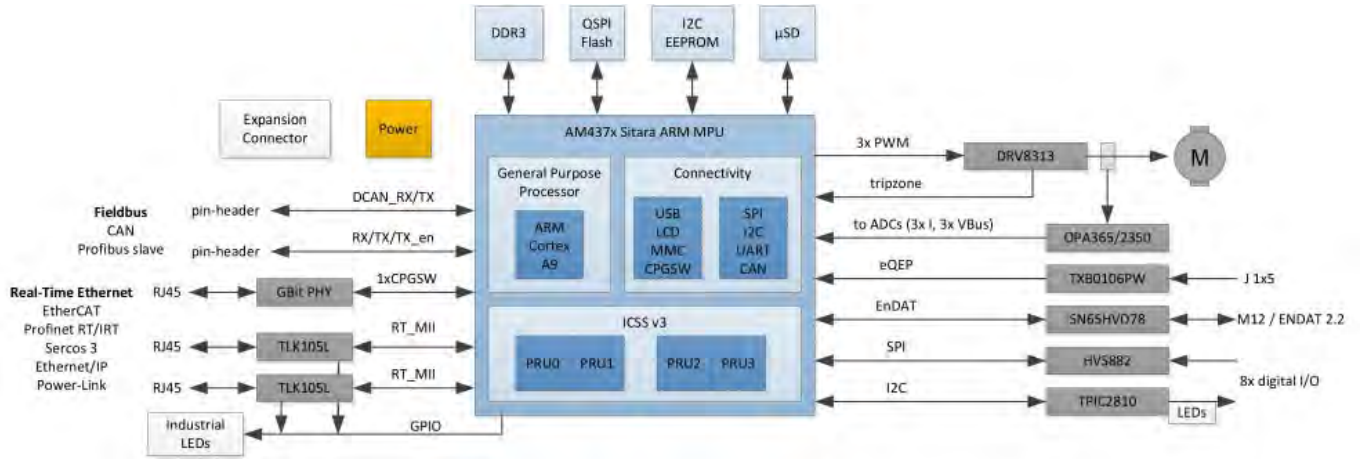

Figure 2: IDK System Block Diagram

Two instances of TLK105L, an Ethernet PHY for industrial and harsh environments, are used for the industrial Ethernet interface. The PHY has additional diagnostic capabilities for measuring signal quality or the distance at which a cable break occurred.

The IDK has expansion connectors to support evaluation of applications beyond the baseline IDK use cases: This could be multiple motors, higher motor voltages, high precision ADCs with Sigma-Delta interface and additional fieldbus interfaces.

The power supply subsystem on IDK is build up by a discrete solution based on TPS5402D. Alternatively the AM437x supports the integrated power management unit (PMU) with TPS65218 which is used by the AM437x Starter Kit boards.

ADConclusion

The Sitara AM437x saves production cost for manufacturers of decentralised drive solutions by integrating major system building blocks into the microprocessor. This saves component cost and PCB space. For maximum flexibility the AM437x supports external interfaces for connecting optional system building block and resources.

TI offers the AM437x IDK bundled with the industrial software development kit (industrial SDK) to customers of decentralised drive solutions. The kit allows evaluating and developing application with a motor control framework, position encoder EnDAT 2.2 interface, current feedback and industrial Ethernet protocols.

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Unique PFC Controller for Design Challenges of Packaged Air Conditioner

Air conditioners are an important appliance in almost every residential and commercial building. While both window-type and duct-type air conditioners are common in the market today, duct-type air conditioners are becoming more main stream today due to their ease of installation.

By Wen Chien, BLDC Product Line Marketing Manager, Fairchild Semiconductor

However, duct work passing through walls can at times ruin the interior design aspects of a space. This is creating a new concept in air conditioning, the duct-less packaged air conditioner. Unlike the duct-type that only provides cooling air within a room or a floor, the packaged air conditioners need to cover the entire building and thus its power rating is much higher than duct-type air conditioners. Because of this high power rating, inverterizing is the trend in order to accelerate energy savings. Inverterized motors will however cause worse power factor (PF) and harmonics on power grid, therefore a power factor correction (PFC) controller is consequently needed. Conventional passive PFC and single channel active PFC are not able to meet the requirements for PFC in a packaged air conditioner for various reasons such as size, heat dissipation and efficiency management. To address this challenge, Fairchild has introduced a new PFC controller which is interleaved to not only meet these requirements but also to include other features which are unique for the packaged air conditioner industry.

Development Trends of Air Conditioners

Air conditioners are a popular home appliance in developed countries – as well as developing countries – in recent years, with annual production quantities increasing significantly, now up to more than 100 million units annually according to statistic data from several market research companies. With the significant volume annually produced, air conditioners inevitably face more stringent energy saving requirements, and the acceleration of moving to inverter type compressors that use permanent magnet synchronous motors (PMSM) / brushless DC (BLDC) motors is the evident proof.

The data indicate that more than 40% of motors have been inverterized today worldwide. The down side is that inverter compressors will deteriorate power factor, resulting in more power drawn from the AC outlet than the actual demand, and pollute the power line grid with harmonics. Therefore, a corresponding PFC measure needs to be taken. For window-type and duct-type air conditioners, passive PFC was used. However, the current trend is moving to a single-channel boost continuous conduction mode (CCM) PFC due to stricter regulations.

Window-type air conditioners hanging on the wall are not considered aesthetic and duct-type air conditioners require drilling holes along the duct path, not always possible in existing structures without ruining the interior design. This affects each living room and bed room as each normally will have a window-type unit or need a duct created. Packaged air conditioners are, therefore, pursued better option for many applications. Packaged air conditioners centralize all of the required coolant energy in one unit and it is placed in the backyard as indicated in figure 1. Its installation happens prior to construction for interior decoration and thus the pipes are hidden. Since the packaged air conditioner unit has to provide cooling for the whole building, its power rating is certainly much higher than a normal room air conditioner. The power rating could range from 5 kW to 7.5 kW, requiring all of the electronic components controlling the BLDC/PMSM compressor to have a higher power rating level.

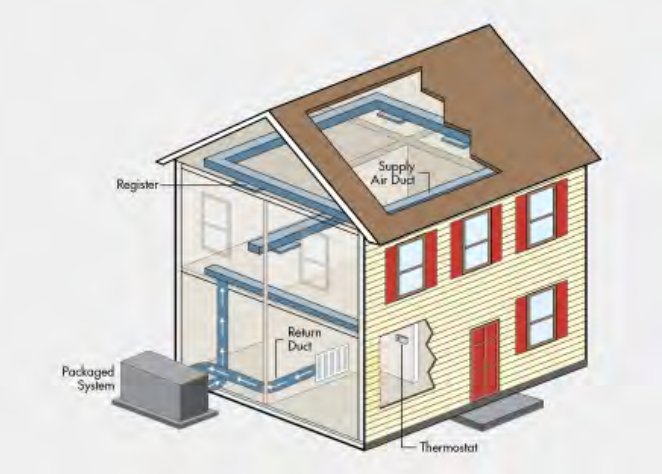

Figure 1: Packaged air conditioner unit and the house

Bottleneck of PFC Controller in Packaged Air Conditioner

When the power rating of an application is required to be in the range of 5 kW to 7.5 kW, the front-end PFC controller design and component selection will be challenging. Today's single-channel boost CCM PFC is not applicable in this situation either in terms of inductance size or electronic power components. The PMSP/BLDC motor or compressor's DC bus voltage after the bridge rectifier is up to 311 V at 220 V AC line input. The current drawn and flowing through the IGBT and/or fast recovery diode will be 24 A. The selection of high current devices is very challenging with very limited choices. Its heat dissipation design is another challenging area when considering the current solutions available in the market.

Benefits of Interleaved Topology

In the past, the interleaved boost PFC topology was introduced

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primarily for the power supply application in the personal computer industry. Figure 2 shows simple diagrams of the single-channel and the interleaved topology.

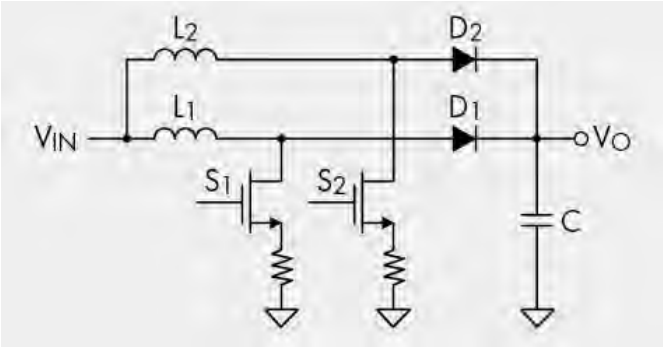

Figure 2: Single Channel Boost CCM PFC and Interleaved Two Channels Boost CCM PFC

As shown in figure 2, the current flowing through the inductor is split into two paths, thus the current flowing through each device in interleaved topology is halved and its heat dissipation, I x Vdrop, is halved as well in active devices such as switching MOSFETs and fast recovery diodes. Moreover, the heat dissipation in the inductors will be not just one half but one quarter. The heat source in an inductor is derived from Ohm's law – that is I2xR. When flowing current is reduced to one half, its heat will consequently only be one quarter. This big reduction in heat can bring a big advantage on inductance design, by which the heat dissipation surface of the inductor design can be reduced, greatly reducing the inductance volume. Figure 3 shows a real example of inductance volume comparison of 2.5 kW design in terms of single channel versus a 3-channel interleaved option. The reduction percentage is up to 60%.

Figure 3: Comparison of Inductor Volume

Just imagine how large the inductance volume will be at 7.5 kW without using interleaved topology, and it clearly becomes quite challenging to have an inductor for the power rating. Based on the experiences of designing PFC circuits, 2.5 kW~3kW per channel is optimal in terms of inductance design and the easy selection of active MOSFETs, IGBT and diodes. For a 7.5 kW design, the 3-channel topology should be best suited.

Other Features Required for Packaged Air Conditioners

Besides PFC, whose importance has been addressed in the second section of this article, some other features are less noticed but also required to achieve greater energy-savings. A configurable and adjustable boost output voltage is very helpful to optimize system efficiency on the fly. Under some circumstances, input AC line voltage might drop for a while due to instability and the conversion efficiency of the air conditioner will be deteriorated due to a wider gap between the input AC voltage and the boost output voltage. The configurable-and-adjustable feature can be used to improve the efficiency with the assistance from an MCU which can monitor the AC line change all the time.

A packaged air conditioner is not required to operate at full power all the time although it provides cooling air for several rooms in a building. The air conditioner will work at light load when the on/off controllers in some rooms are not switched on. The PFC efficiency of an interleaved topology is not optimized if all of the interleaved channels are enabled at light load. Figure 4 illustrates the relationship between load, channel and efficiency.

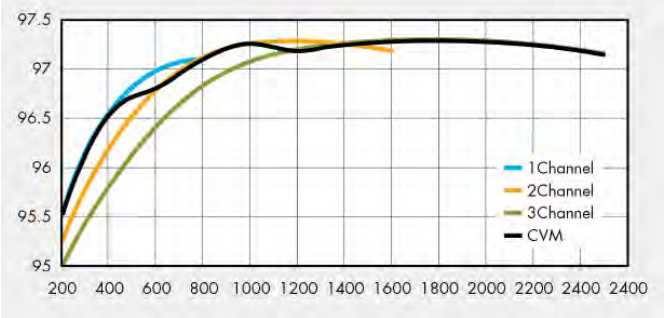

Figure 4: Interleaved PFC efficiency vs. Load vs. enabled-Channel-Number

To manually switch on channels vs. load power by an MCU is not always easy due to the lack of load power information. An automatic mechanism such as the black curve shown in Figure 4 will be much anticipated.

World's First 3-Channel PFC Controller Solves All the Design Pains at Once

The FAN9673Q is an interleaved Boost CCM PFC controller from Fairchild which is designed for high power industrial applications such as packaged air conditioner, high power motor, UPS, Welders, etc. The main features are:

- Worldwide first 3-channel interleaved PFC controller to drive up to 9 kW
- Two modes of channel on/off: controlled by MCU or automatic on/off by internal mechanism
- AC input peak detection let the user easily capture AC line information
- Configurable-and-adjustable output voltage help optimize system performance
- Differential current sensing reduces cost of current transformer by using simple resistor with good ground noise immunity

These features are unique and an ideal fit for packaged air conditioner design requirements and the challenges addressed in previous paragraphs.

Packaged air conditioners are the future star in the industry but still face many design challenges as the power ratings increase. To meet all the challenges at once, the FAN9673Q is designed with the highest integration by using an interleaved topology and many unique features to power PFC designs and help designers develop amazing products.

To learn more about FAN9673Q please visit:

www.fairchildsemi.com

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Acopian Power Supply Receives 4-Star Honors for Supplier Excellence from Raytheon

Acopian Power Supplies announced that it received a 4-Star Supplier Excellence Award for 2014 from Raytheon's Integrated Defense Systems (IDS) business. Over 180 supplier partners, that support the IDS business, were recognized for outstanding performance. The award was presented at Raytheon's Supplier Appreciation Event, held June 4, 2014 at Raytheon's Andover, Massachusetts facility. Acopian Power Supply had won the 3-Star Supplier Excellence Award in 2013.

Raytheon's IDS business instituted the Supplier Excellence Awards program to recognize suppliers who have provided outstanding service and partnership in exceeding customer requirements. Award candidates were judged on specific criteria, including overall quality, on-time delivery, process improvement initiatives, innovation, and success in meeting or exceeding safety standards. This places Acopian among the top 0.5% of the 10,000 Raytheon suppliers. The Four-Star requirements for quality and delivery are 97%, and Acopian achieved 100% delivery and 100% quality scores.

www.acopian.com

DTMOS IV Super Junction Power MOSFET Family to 650V

Toshiba Electronics Europe (TEE) has expanded its family of high-efficiency and compact super junction MOSFETs with devices offering voltage ratings to 650V. The 650V MOSFETs are ideal for applications that may have to operate in environments with fluctuating mains supplies or very low temperatures. Extended voltage capability also supports improved design flexibility by increasing safe operating margins.

Toshiba's latest 650V power MOSFETs are based on the company's fourth generation super junction DTMOS IV deep trench process and are available in seven different compact packages. Devices can be supplied with an integrated fast recovery diode (FRD), which helps to reduce component count and board space in high frequency switching applications. Target applications for the 650V series will include switch mode power supplies, lighting ballasts, photovoltaic inverters and other designs that require a combination of high-speed operation, high efficiency and low EMI noise.

The 650V line-up of devices is available in D-PAK, I-PAK, D2-PAK, I2-PAK, TO-220, TO-220SIS and TO-247 package options. Maximum RDS(ON) is from 1.2Ω down to just 0.055Ω.

www.toshiba-components.com

Automotive-Qualified AUIRFN8403 in Compact PQFN 5X6 Delivers High Efficiency

International Rectifier has introduced the automotive-qualified AUIRFN8403 COOLiRFET™ power MOSFET for automotive applications that require compact size and high current performance including pump motor control and automotive body control.

Available in a compact PQFN 5x6mm package, the AUIRFN8403, the first in a family of new devices, utilizes IR's most advanced COOLiRFET™ 40V trench technology, delivering ultra-low 3.3mOhm on-state resistance (Rds(on)) and offering 95A high current carrying capability. The PQFN package features extended lead with end-lead plating to ensure effective solder-ability and an easy-to-inspect solder joint:

The AUIRFN8403 offers more than a 50% size reduction compared with conventional DPAK (TO-252) packages, and significant thermal performance improvement compared to an SO-8 package to provide a cost effective ultra-compact, high efficiency, high density solution for automotive applications IR's automotive MOSFETs are subject to dynamic and static part average testing combined with 100 percent automated wafer level visual inspection as part of IR's automotive quality initiative targeting zero defects. AEC-Q101 qualification requires that there is no more than a 20 percent change in Rds (on) after 1,000 temperature cycles of testing.

www.irf.com

Industry's First 1200V/25mΩ MOSFET in TO-247 Package

Cree has shattered the on-resistance barrier of traditional 1200V MOSFET technology by introducing the industry's first commercially available silicon carbide (SiC) 1200V MOSFET with an RDS(ON) of 25mΩ in an industry standard TO-247-3 package. The new MOSFET, designated the C2M0025120D, is expected to be widely adopted in PV inverters, high voltage DC/DC converters, induction heating systems, EV charging systems, and medical CT applications.

Based on Cree's proven C2M SiC MOSFET technology, the new device has a pulsed current rating (IDS Pulse) of 250A and a positive temperature coefficient, providing engineers with greater design flexibility to explore new design concepts. The high IDS Pulse rating makes the device suitable for pulsed power applications, and the positive temperature coefficient allows the devices to be paralleled to achieve even higher power levels.

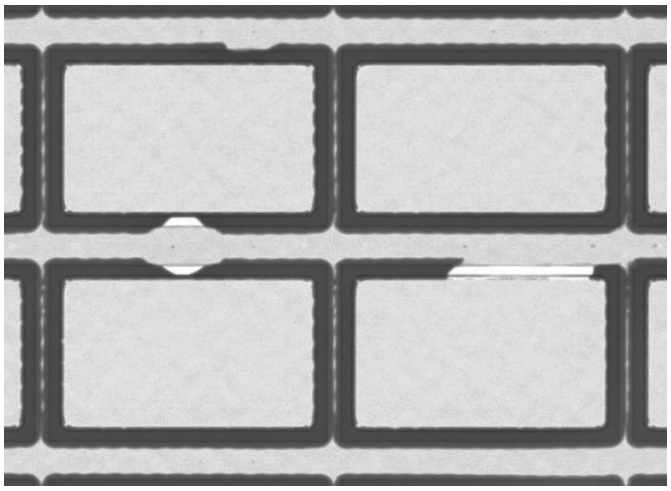
The higher switching frequency of the new C2M0025120D SiC MOSFET enables power electronics design engineers to reduce the size, weight, cost, and complexity of power systems. For medical applications, such as CT systems, Cree's C2M MOSFETs provide a 5X reduction in switching losses and enable much higher power density. Combined with the lower switching losses, the added benefit of low RDS(ON) greatly improves the thermal characteristics and can potentially even eliminate system fans, resulting in quieter and more cost effective medical imaging systems.

www.cree.com

MEMS Wafer Inspection System

Sonoscan has announced its AW322 200™ fully automated system for ultrasonic inspection of MEMS wafers. Based on Sonoscan's C-SAM® technology, the system images and identifies internal gap-type defects down to 5 microns in size. It is especially useful for finding non-bonds, voids and other defects in the seals surrounding the MEMS wafer cavities.

AW322 200™ system features include: Two loadports, two stages and multiple transducers, enabling it to image two 8-inch MEMS wafers simultaneously. Other models in the AW series are available to accommodate wafer sizes from 100-300mm. The SECS/GEM-enabled Robotic Handling Station includes alignment and drying operations. Waterfall™ technology to minimize water exposure during scanning. Sonoscan's advanced analysis software for accurate application of the user's accept/reject criteria.



In operation, the Robotic Handling Station counts and unloads wafers from the carriers, aligns wafers for scanning and positions wafers on the stage. The transducers travel over 1 m/s while pulsing ultrasound at frequencies up to 230 MHz and receiving thousands of return echoes per second. Both the transducers and the 500 MHz bandwidth pulser/receiver were designed and manufactured by Sonoscan. The key defects imaged in MEMS wafers are non-bonds of the seal to a wafer, voids within the seal material and other gap-type defects that can compromise the hermeticity of the cavity.

After scanning, both the acoustic wafer image and the wafer data can be used for accept/reject determination. Criteria are defined by the user with respect to acceptable defect counts and sizes.

Photo: White areas in this 230 MHz Sonoscan acoustic image show incomplete (left) and complete (right) breaks in the seal around MEMS cavities.

Sonoscan, Inc., 2149 E. Pratt Blvd., Elk Grove Village, IL 60007. Phone 847 437-6400; Contact person: Bill Zuckerman, x237; email bzuckerman@sonoscan.com

www.sonoscan.com

Industry's First 5 kohm Digital Potentiometers with Specified 36V Operating Voltage

Microchip announced the expansion of its 36V digital potentiometer (digipot) portfolio with two new volatile, I2C™ devices: the MCP45HV31 and MCP45HV51 (MCP45HV31-51). These are the industry's first digipots to offer a 5 kohm resistance with a specified operating voltage of 36V. In addition, they provide 10V to 36V analogue operation and 1.8V to 5.5V digital operation, for systems requiring wide signal swings or high power-supply voltages. The MCP45HV31-51 digipots support both 7-bit and 8-bit resistor configurations, and a high terminal/wiper current, including the ability to sink/source up to 25 mA on all terminal pins for driving larger loads. These features, combined with an extended temperature range of -40°C to +125°C, make the MCP45HV31-51 well suited for a broad range of high-voltage and high-temperature applications, including those in the industrial, automotive and audio markets.

The MCP45HV31's 7-bit resistor network resolution enables 127 resistors and 128 taps, while the MCP45HV51's 8-bit configuration supports 255 resistors and 256 taps. Additionally, both digipots provide RAB resistance options of 5, 10, 50 and 100 kohms. Both devices also feature a 1 µA typical serial-interface inactive current, and a 2 MHz typical bandwidth operation (-3 dB) at the 5 kohm resistance level.

Microchip's 20-Pin TSSOP and SSOP Evaluation Board (TSSOP20EV) allows system designers to quickly evaluate the operation of the new MCP45HV31-51 digipots, in the 14-pin TSSOP package option.

The MCP45HV31 and MCP45HV51 digital potentiometers are available today for samples and volume production, in 14-pin TSSOP and 20-pin, 5x5 mm QFN packages.

http://www.microchip.com/get/FAHU

First Power Analyzer to Measure Narrowband, Full Spectrum and Harmonics Simultaneously

When it comes to increasing efficiency, precise power analysis plays an ever-growing role. In electric vehicle research and variable frequency drive applications the fundamental and the full spectrum often have to be measured simultaneously. In the past users had to accept a compromise: they had to choose between narrowband and full spectrum values. With the new LMG670 precision power analyzer both become available at the same time. The innovative DualPath architecture enables the user to measure narrowband and full spectrum values up to 10 MHz simultaneously – free of aliasing defects – and to compare them in one view. The LMG670 can also measure harmonics and interharmonics up to the 2,000th order according to EN 61000-4-7, a single click is sufficient to toggle between RMS values and harmonics. An optional I/O card allows parallel measurement of speed and torque values in perfect synchronization with RMS power values. The new LMG670 can be equipped very flexibly with up to seven power measurement channels. According to the requirements of the application at hand, the user can choose between three types of power measurement channels, which offer different bandwidths and accuracies. The maximum obtainable accuracy is 0.015% of the measured value plus 0.01% of full scale. In addition, the excellent common-mode rejection ratio (CMRR) of >120 dB even at 100 kHz guarantees accurate results when measuring applications with steep

rising edges and high pulse frequencies. Optimal matching of current and voltage channels ensures precise results also at very small power factors.

The user interface of the LMG670 is designed to provide quick access to all relevant functions. All parameters, like wiring, measurement range, filters etc. can conveniently be set via the 8.9" touch display (1024x600 WSVGA). Results can be displayed graphically as well as in tabular form, the user can easily switch between different views as needed.

www.zes.com

ECCE 2014

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The 6th Annual IEEE Energy Conversion Congress and Exposition (ECCE 2014) will be held in Pittsburgh, Pennsylvania, USA on September 14-18, 2014. ECCE has come to be regarded as the ideal environment for industry, academia, and startups to meet, collaborate, motivate, and innovate over global initiatives in research and industrial advancements. With a record number of submitted digests the conference expects to be the largest ECCE to date. An exciting list of events include 1) a plenary session featuring speakers from US national labs and global industry champions, 2) numerous technical sessions on energy conversion systems and technologies as well as components and materials, 3) exposition featuring exhibitors displaying the latest advances in energy conversion technology . Please visit http://2014.ecceconferences.org/ for more information and be a part of this international hotspot on all things related to energy!

Ac-Dc Supplies with Addition of Battery Charging and Back-Up Features

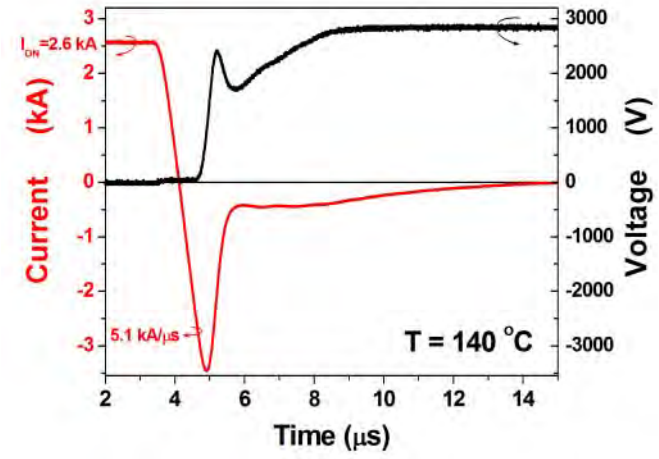
CUI Inc announced the release of a new ac-dc power supply family targeting applications that demand 100% uptime. Available in 75 W, 100 W and 155 W configurations, the PSF series is designed with built-in battery charging and back-up functionality. Under normal operating conditions, the units are able to charge the stand-by battery and also supply direct power to the load. In the event of electrical power (AC) failure, the PSF series automatically switches to DC power from the battery source to ensure continuous operation of the system.
The PSF series accommodates a universal input voltage of 90~264 Vac and is available in two different output formats. The dual output version features 13.8 V and 27.6 V – one output goes towards powering the load, while the other output is available to charge the battery. The triple output models include an additional 5 V, 3A regulated output. The PSF series comes with built-in protections that add a great deal of flexibility and decrease complexity for the system designer. Protections include brownout (due to low AC input voltage), battery low cut-off, and battery polarity by resettable fuse. These features are in addition to over-load, output over-voltage, constant current limit, and short circuit protections.
The series is available in form factors that include open frame and enclosed versions, with or without a built-in fan. All models carry UL/cUL and TUV 60950-1 safety certifications for ITE, commercial and industrial equipment.

The PSF series is available through distribution with prices starting at $73.59 per unit at 100 pieces. Please contact CUI for OEM pricing.

www.cui.com

Fast Recovery Presspack Diodes for IGBTs and IEGTs

ABB has developed a new range of fast 4.5 kV diodes offering enhanced Safe Operating Area (SOA) and controlled (soft) reverse recovery at high di/dt and dv/dt levels. These diodes were developed for IGCT based applications, where they function in harsh conditions as clamping, neutral-point clamping and free-wheeling diodes. They also proved to operate safely in power-electronic circuits employing IGBT and IEGT presspacks, where di/dt values of up to 5 kA/µs are particularly required. This operation is possible thanks to a doping profile of the silicon wafer, which was optimized for a wide range of current densities and di/dt values. The figure shows the reverse recovery current and voltage waveforms of a diode 5SDF 20L4520 with 85 mm pole piece at 140 °C. The observed long recovery tail time at a current of 2.6 kA ensures that there is enough excess carriers for soft recovery behavior at low current densities. An optimized housing design for a low thermal resistance secures a stable long life operation up to the rated current and maximum junction temperature.



Picture: Reverse recovery of a diode 5SDF 20L4520 in the test circuit with a StakPak IGBT module 5SNA 2000K450300 from ABB (Ls = 200 nH, Rg ON,OFF = 0.47 - 11 Ω).

www.abb.com/semiconductors

SiC-MOSFET Modules Generation

Vincotech, a supplier of module-based solutions for power electronics, has rolled out SiC-based products for ultra efficient, high-frequency operation in solar inverter, UPS, and battery management applications. This generation of SiC MOSFET-based power modules comes in two versions. One is a flow3xPHASE 0 SiC three-phase inverter module with 3x BUCK/BOOST and split output topology; the other is the flow3xBOOST 0 SiC with three-channel boost circuits.
Both modules feature the latest generation of SiC MOSFET switches designed for ultra fast switching frequencies >100 kHz. They are able to achieve >99 % peak efficiency at fPWM = 64 kHz. Equipped with integrated DC capacitors, these new flow 0 SiC modules provide ultra-low inductance. The flow3xPHASE 0 SiC and the flow3xBOOST 0 SiC modules come in low-inductive, 12 mm flow 0 housings with Press-fit pins. Samples of these modules may be sourced on demand from our usual channels.

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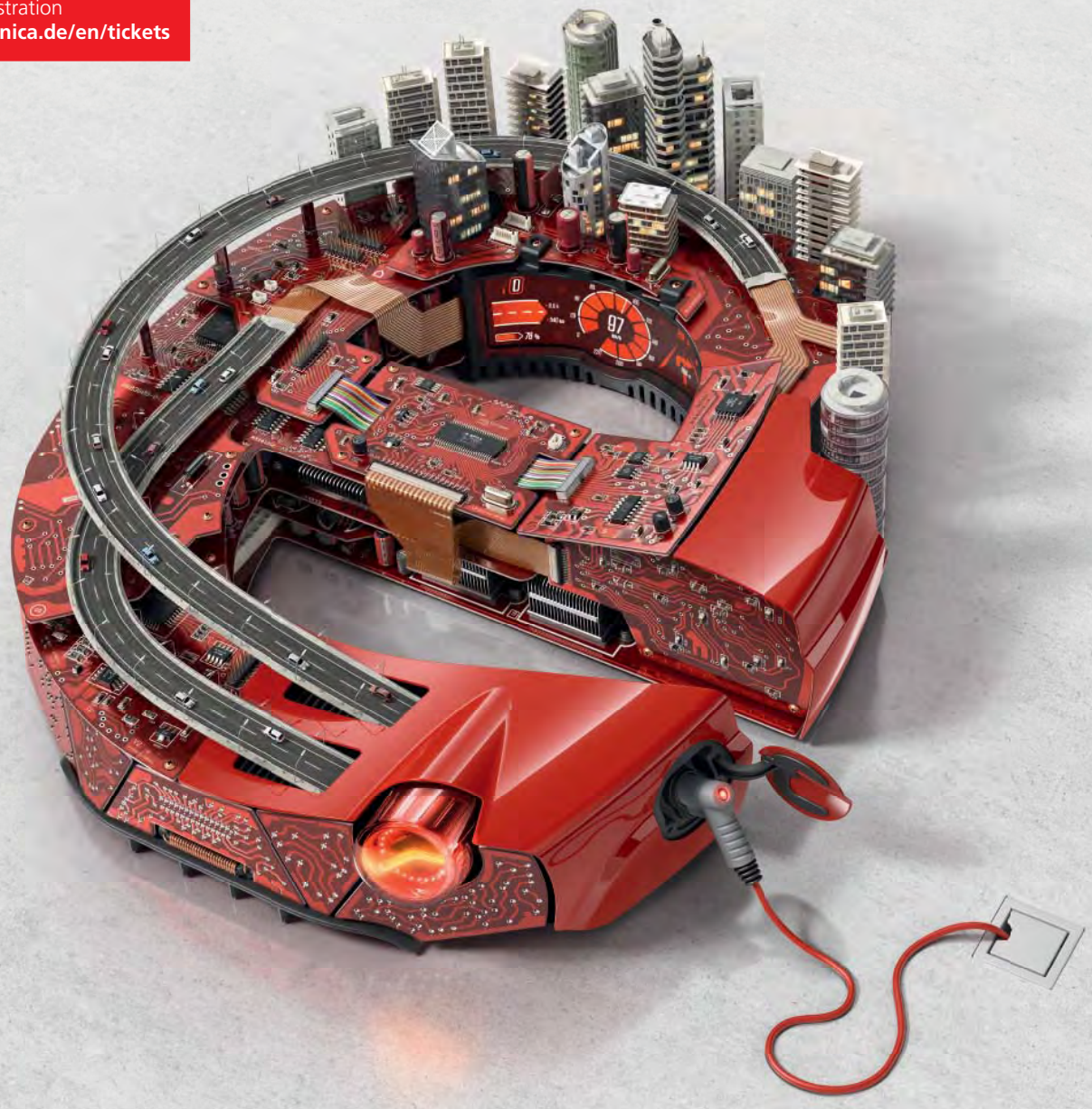

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First Digitally Programmable Multiphase Intel® VR12/12.5 Compliant

Intersil Corporation announced the ISL6388, a 6-phase pulse-width modulation (PWM) controller with non-volatile memory (NVM) that is compliant with Intel's VR12/12.5 specification. Designed for server and high-end desktop applications, the ISL6388 digitally programmable multiphase controller features multiple time programmable NVM that allows for the creation of custom configurations during the design process, eliminating the need for a soldering iron to make adjustments. The new multiphase controller is supported by the company's latest release of the PowerNavigator™ graphical user interface, which allows designers to easily use Intersil's digital power products without writing a line of code. The ISL6388's patented enhanced adaptive pulse positioning (EAPP) architecture provides outstanding transient response using a linear control loop, avoiding beat frequency issues, and improving transient response over competitive solutions.

The configurability capabilities of the ISL6388 are further enhanced by Intersil's PowerNavigator GUI, which is an easy-to-use, drag-and-drop, free downloadable interface that provides the flexibility designers need to quickly set up and control any power supply architecture. PowerNavigator's "hardware-free" mode lets users select components prior to hardware development, without design digital risk. The PowerNavigator 5.1 GUI provides access to all commands and setup configurations, including the ability to load predefined configurations for common applications. This enables unprecedented ease of use when coupled with the company's digital controller solution.

In the computing market, transient performance and efficiency are some of the biggest concerns for designers, especially when fast transients can result in beat frequencies. The ISL6388's advanced patented EAPP architecture utilizes a linear loop, eliminating the setup complexity of competitive solutions while providing greater bandwidth, thus improving system performance and reducing output capacitance. Combined with adjustable auto phase dropping and diode emulation, the ISL6388 can deliver high efficiency across the entire load range.

http://www.intersil.com/products/ISL6388.

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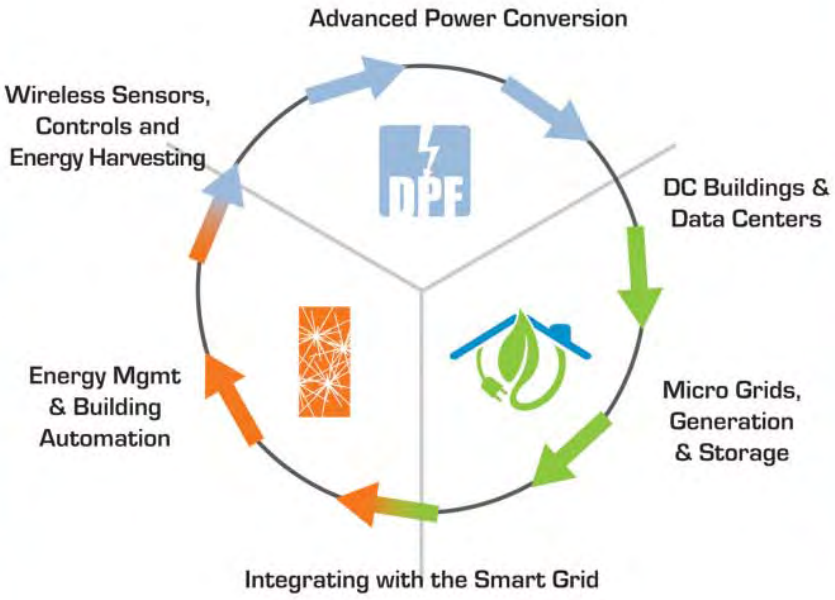

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IGBT Gate Driver Core Family with 4.5kV and 6.5kV Products

IGBT gate driver manufacturer CT-Concept Technologie GmbH, a Power Integrations company, has announced the availability of its 1SC0450V single driver core for IGBT modules with blocking voltages of 4.5kV and 6.5kV. The product is very compact and enables IGBTs to be paralleled using only one driver core, which further reduces system size and increases reliability.

A member of CONCEPT's high voltage gate driver core family, the 1SC0450V is based on the company's SCALE™-2 chip set and a partial discharge free, low coupling capacitance, high voltage DC/DC transformer. An advanced transformer design allows test voltages up to 10.4kVRMS and a partial discharge extinction voltage of 7800Vpeak. The driver core measures just 60mm by 90mm long with a height by the DC/DC transformer of only 27.50mm.

Explains Michael Hornkamp, CONCEPT's Director Regional Marketing and System Engineering: "Our high voltage gate driver core family - which also includes the 2SC0535T 3.3kV and 2SC0635T 4.5kV dual gate driver cores - reduces component count, therefore products are compact and very reliable." CONCEPT's 1SC0450V gate driver cores are suitable to drive all 4.5kV and 6.5kV IGBT modules currently available on the market. Target markets include traction and other high voltage applications.

www.IGBT-Driver.com

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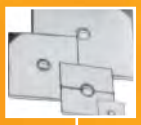


1947: IR opens for business, launching selenium rectifiers

1954: Commercializes germanium rectifiers

1959: A pioneer in silicon controlled rectifier (SCR)

1962: Introduces new epitaxial process for producing industry's most stable high voltage SCRs

1979: Patents first commercially viable Power MOSFET (HEXFET®)

1980: Introduces high reliability power semiconductor devices for space programs

1983: Launches first commercially viable high voltage power ICs

1996: Introduces MOSFET and Schottky in a single package

1950 **1960** **1970** **1980** **1990**

2000

Introduces wafer level package (FlipFET™)

2001: Invents integrated building blocks for DC-DC converters (*iPOWIR*™)

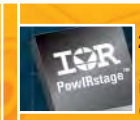
2002: Invents first dual-sided surface mount package (DirectFET®)

2003: Introduces *iMOTION*™ Integrated Design Platform

2006: Introduces AC-DC Smart Rectifier™ IC

2007: Introduces Sup*IR*Buck® Integrated Voltage Regulators

2008: Introduces revolutionary GaN-based Power Device Technology Platform



2011: Introduces PowIRstage™ integrated devices

IR: Introduces CHiL® digital controller

2012: Introduces *µIPM*™ power modules

IR: Launches COOLiRIGBT™

2013

IR: Commences commercial shipments of GaN devices

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