ISSN: 1863-5598

ZKZ 64717
06-17

Bodo's Power Systems®

Electronics in Motion and Conversion

June 2017

SiC for Automotive

WELCOME TO THE HOUSE OF COMPETENCE

ENGINEERING | PRODUCTION | **GvA SOLUTIONS** | DISTRIBUTION

FLEXIBLE POWER

IS IN THE NATURE OF VARIS™!

VARIS™ – THE MODULAR CONVERTER SYSTEM

- Tested and ready-to-connect converters
- Cross-industry system solutions
- Scalable power through parallel connection
- Customizable
- Cooling method freely selectable
- Economic and sustainable through the use of standard components

GvA Leistungselektronik GmbH
Boehringer Straße 10 - 12
D-68307 Mannheim
Phone +49 (0) 621/7 89 92-0
VARIS@gva-leistungselektronik.de
www.gva-leistungselektronik.de

GvA Power Electronics

Viewpoint 4
The World Needs Free Journalists

Events 4

News 6-10

Blue Product of the Month 12
Win a Microchip PICDEM Lab II Development Platform!
Microchip

VIP Interview 14
Power Modules
By Claus Petersen, President Danfoss Silicon Power

VIP Interview 16-18
SiC - the high Performance Power Semiconductor
By Henning Wriedt, US-Correspondent Bodo's Power Systems

Cover Story 20-26
Reliable SiC Power Devices for Automotive Applications
By Felipe Filsecker and Aly Mashaly, Rohm

Driver IC 28-30
EiceDRIVER™ and CoolMOSTM CFD2 Join for High Efficiency in Refrigeration
By Wolfgang Frank, Infineon Technologies AG

IGBT Module 32-34
Half-Bridge vs. Sixpack Modules for Motor Drives
By Patrick Baginski, Vincotech GmbH, Unterhaching/Germany

Technology 36-39
A Performance Comparison of GaN E-HEMTs versus SiC MOSFETs in Power Switching Applications
By Jason (Jianchun) Xu, Di Chen, GaN Systems Inc.

Power Supply 40-41
Innovative Remote Sense Approach for Power Supply Test & Measurement Systems Eliminates Potential Problems
By David Hoffman, VP Engineering, Versatile Power

New Products 42-56

The Gallery

4power!

WÜRTH ELEKTRONIK

#redCUBE

WE speed up the future

REDCUBE Terminals are the most reliable high-power contacts on the PCB level. Low contact resistance guarantees minimum self-heating. Four different designs cover all leading processing technologies and offer a wide range of applications.

www.we-online.com/redcube

- Flexibility in processing and connection technologies
- Highest current ratings up to 500 A
- Board-to-Board and Wire-to-Board solutions
- Extremely low self-heating
- Robust mechanical connection

REDCUBE PRESS-FIT

REDCUBE PLUG

REDCUBE SMD

REDCUBE THR

Bodo's Power Systems®

A Media
Katzbek 17a
D-24235 Laboe, Germany
Phone: +49 4343 42 17 90
Fax: +49 4343 42 17 89
editor@bodospower.com
www.bodospower.com

Publishing Editor
Bodo Arlt, Dipl.-Ing.
editor@bodospower.com

Junior Editor
Holger Moscheik
Phone + 49 4343 428 5017
holger@bodospower.com

Senior Editor
Donald E. Burke, BSEE, Dr. Sc(hc)
don@bodospower.com

UK Support
June Hulme
Phone: +44(0) 1270 872315
junehulme@geminimarketing.co.uk

Creative Direction & Production
Repro Studio Peschke
Repro.Peschke@t-online.de

Free Subscription to qualified readers
Bodo´s Power Systems
is available for the following
subscription charges:
Annual charge (12 issues)
is 150 € world wide
Single issue is 18 €
subscription@bodospower.com

circulation ASC audit since 09/2006 print run 24 000

Printing by:
Brühlsche Universitätsdruckerei GmbH
& Co KG; 35396 Gießen, Germany

The World Needs Free Journalists

Some shameful things are going on around the world, and it's time to insist our political leaders be guided by common ethics and the rules of democracy. Colleges and universities are having their freedoms curtailed, and some countries mistreat journalists for their differing views. Jail without proper review is not acceptable. These actions are the beginning of "alternative facts," but will end up with "alternative" realities. These actions must be stopped early enough to avoid the world ending up in the hands of dictators. There must be a free press.

Lessons of history should be plain enough to the public but many voters seem unaware of their larger responsibility. The generation that suffered from World War II is nearly gone. I was born after that and had the luxury of not being affected by the war that ravaged Europe for such a long period. Fortunately, the French and Dutch have voted for candidates that are, in the democratic way, good for Europe. We all have to work hard to keep peace.

This world is the only one we have. We must save its resources and hand over to our grandchildren a world that is healthy. Nature sometimes shows clearly how disastrously weather can affect the world. We add our own disaster by ignoring global warming. History has its lessons here as well - nuclear power plants in Russia and Japan have shown how dangerous they are. Nuclear waste is forever in comparison to our lifetimes. Our kids will pay with their future for it.

But recently we have the Intersolar Conference in Munich. Here is where alternatives pay off - alternative energy, much better than alternative facts.

Putting away all my concerns for the moment, I hope you will have a nice vacation during the summer.

Bodo's Power Systems reaches readers across the globe. If you are using any kind of tablet or smart phone, you will find all of our content on the new website www.eepower.com. 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 June:
It is not necessary to fly long distances for vacation. You may not have discovered your neighborhood.
Start now and find out.

Best Regards

Events

CWIEME Berlin 2017
Berlin, Germany, June 20-22
www.coilwindingexpo.com/berlin

PCIM Asia 2017
Shanghai, China, June 27-29
www.mesago.de/en/PCC/home.html

SEMICON West 2017
San Francisco, USA July 11-13
www.semiconwest.org

EPE ECCE 2017
Warsaw, Poland, September 11-14
www.epe2017.com

Intersolar North America 2017
San Francisco, USA, July 11-13
www.intersolar.us

Thermal Management 2017
Denver, USA August 8-9
www.thermalnews.com/conferences

EV Tech Expo 2017
Novi, USA, September 12-14
www.evtechexpo.com

HusumWind 2017
Husum, Germany, September 12-15
www.husumwind.com

Power Fortronic 2017
Reggio Emilia, Italy, September 20-21
www.powerfortronic.it

LpS 2017
Bregenz, Austria, September 26-28
www.LpS2017.com

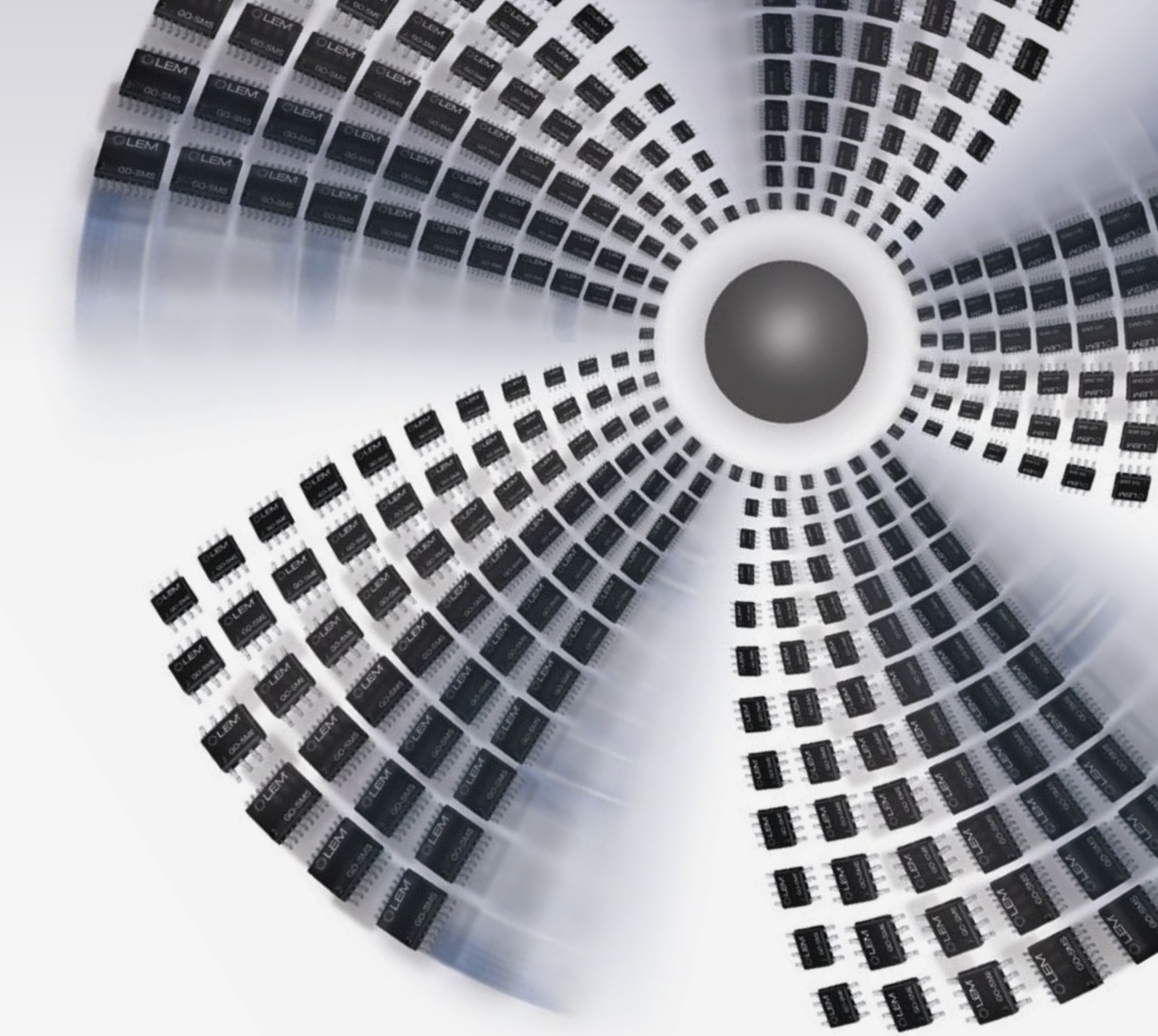
ECCE 2017
Cincinnati, USA, October 1-5
www.ieee-ecce.org/2017

Power Electronics 2017
Moscow, Russia, October 24-26
www.expoelectronica.primexpo.ru/en

SEMICON Europa 2017
Munich, Germany, November 14-17
www.semiconeuropa.org

productronica 2017
Munich, Germany, November 14-17
www.productronica.com

sps ipc drives 2017
Nuremberg, Germany, November 28-30
www.mesago.de/de/SPS/home.html



GO. A breath of fresh air in power electronics.

Cost-effective and accurate, miniature isolated current sensor GO speeds your drives applications. A unique sensor with an integrated primary conductor achieves optimum temperature accuracy, measuring from -40 to +125 °C in a surface mounted SO8 or SO16 package.

- 4-30 A nominal current
- Better than 1.3 % accuracy @ +25°C
- Differential Hall principle measurement: Very robust against external fields
- 2 µs response time
- Up to 3 kV RMS isolation
- Double Over-Current Detection outputs for short circuit and over-load protection (SO16 version)

At the heart of power electronics.

www.lem.com

LEM®

Smart Integration of Renewable Energies

Renewable energies are taking the world by storm. As a result, decentralized energy generation and above all the smart integration and management of renewable sources of energy are becoming increasingly important. Intersolar Europe is taking up this topic at the Smart Renewable Energy special exhibit and collaborating with three Helmholtz Association centers to demonstrate what the energy supply of the future could look like. Intersolar Europe, the world's leading exhibition for the solar industry and its partners, will be held from May 31–June 2, 2017 in Munich.

The success of renewable energy continues uninterrupted around the world. According to a new report published by the McKinsey Global Institute, the global share of energy from renewable sources could grow from the current 4 percent to 36 percent by 2035. A substantial amount of this will be contributed by solar energy. According to the figures recently published by SolarPower Europe, 76 gigawatts (GW) of solar energy were installed in 2016 – compared to just 50 GW in 2015. China and USA in particular led the surge last year, with both countries almost doubling their solar expansion.

The consequence of the rapid development worldwide: The share of renewable energy in the power grid is constantly increasing. In light of this, the question of how renewable energy can be effectively integrated into power grids and energy systems is becoming ever more important – because supply safety must be guaranteed in the new energy world. Renewable energies do not supply the same amount of power at all times of day or year, so the global energy transition needs a modern, smart infrastructure and innovative storage options to ensure that the necessary quantities of power, heat and fuels are available at all times. Intersolar Europe is exploring this topic at the Smart Renewable Energy special exhibit (hall B2, booth B2.140).

Intelligently connected – Researchers test the energy networks of the future

The Karlsruhe Institute of Technology (KIT) and its project partners from the Helmholtz Association – the German Aerospace Center (DLR) and the Forschungszentrum Jülich (FZJ) – will present how new methods and technologies can shape the energy system of the future. Their new infrastructure platform Energy Lab 2.0, funded by the German government and the Federal State of Baden-Württemberg, investigates the complex interplay of components in the energy systems of the future. As a "real-life laboratory" and simulation platform, Energy Lab 2.0 tests new approaches to integrating diverse technologies into the energy system. Among the topics the researchers are exploring is how different storage technologies are best connected to electricity generation and consumption. This is linked to the question of what sort of an information and data network is required to facilitate this. For the first time in Europe, larger test facilities for generating renewable electrical energy, for storing and converting energy to gas, fuels and heat as well as for reconverting chemical energy sources back into electricity are being combined with each other in a facility network.

The core of the Energy Lab 2.0 is the Smart Energy System Simulation and Control Center, where the all data from the facility network come together, and are analyzed, stored and used for simulations. "The changes in the energy world require a new grid architecture and IT-based approaches in order to intelligently connect and control the different players. Extensive research in the Energy Lab 2.0 will be devoted to this issue over the coming years. Intersolar Europe is a great opportunity for us to present the project to trade visitors and to provide inspiration for how the framework conditions might be designed," says Professor Dr.-Ing. Roland Dittmeyer from the Institute for Micro Process Engineering at the KIT.

Expert discussions at the Smart Renewable Energy Forum

The experts behind the Energy Lab 2.0 will be introducing the project and other groundbreaking research initiatives for realizing the energy transition on June 1, 2017 in the Smart Renewable Energy Forum, directly opposite the special exhibit. This will be followed by a question and answer session with industry professionals. On all three days of the exhibition, pressing issues for the new energy world will be tackled at the forum and discussed by experts from a broad range of disciplines.

Intersolar Europe 2017 will take place from May 31–June 02, 2017 at Messe München.

www.intersolar.de/en

Energy-Saving Wireless Module

AMBER wireless GmbH, a Würth Elektronik eiSos Group company, offers an extremely compact and energy-saving wireless module - the AMB2621 Bluetooth Smart module. A special feature: Besides standard control with UART commands, smartphones or other devices can be connected to form a module by initializing with the "peripheral only" operating mode.

AMB2621 is a 2.4 GHz BLE wireless module based on the Bluetooth Smart 4.2 standard, sized just 11 x 8 x 1.8 mm, offered with or without integrated antenna. AMBER wireless uses the Nordic chip nRF52832 in this module, i.e. a 32-bit ARM Cortex-M4 CPU and a 512 kB flash memory. The AMB2621 firmware supports the "peripheral only" operating mode allowing easy expansion of existing hardware with the BLE interface. In its default state, this mode provides static key pairing and a transparent UART interface. "Our customers can install and use the module with ease, without having to previously configure it and without changing the interface in their application in a big way", explains Patrick Becker, Head of Sales at AMBER wireless. "We purposefully introduced the option of operating the wireless module as 'peripheral' in the sense of the Bluetooth protocol, as this covers around 90 percent of applications. Devices are equipped with this kind of wireless module so you can connect with them. This means that pairing is initiated from a mobile device, for example to control building technology."

Easily retrofittable

Thanks to the "peripheral only" operating mode, the AMB2621 Bluetooth Smart module is especially energy-saving, as the UART (Universal Asynchronous Receiver Transmitter) interface is only active once a wireless connection is established. Uncomplicated static passkey pairing is used as a security device as in the hands-free system in the car. The AMB2621 Bluetooth Smart module is suitable for all manufacturers wishing to connect their electronic control with a mobile device. It does not make a difference whether this control has been on the market for years or is just in the development phase.

www.amber-wireless.de

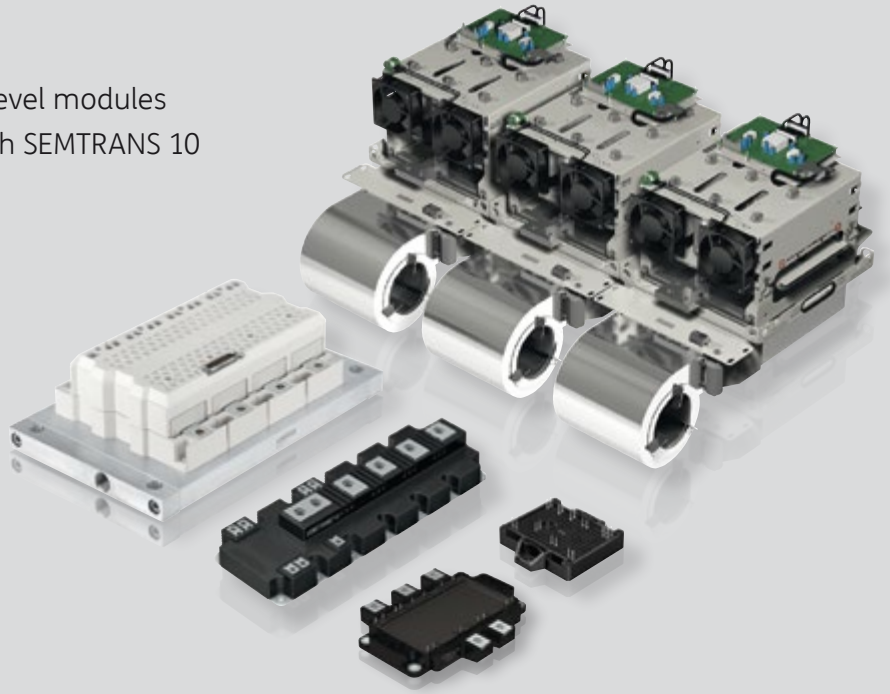
SEMIKRON
innovation + service

1500V_{DC} in Solar?
We cover all your needs.

Power Modules
- Broadest portfolio of 2-level and 3-level modules
- Up to 750kW without paralleling with SEMTRANS 10
- Plug & play drivers

IPMs
- 1700V SKiiP 4 product range

Power Electronic Stacks
- Ready-to-use power stacks and customized designs
- Including drivers with ASIC chipset
- IntelliOff function enabling 1500V_{DC} voltage



www.semikron.com/1500v-solar

IEEE International Electron Devices Meeting Announces 2017 Call for Papers

The 63rd annual IEEE International Electron Devices Meeting (IEDM), to be held at the Hilton San Francisco Union Square hotel December 2-6, 2017, has issued a Call for Papers seeking the world's best original work in all areas of microelectronics research and development.

The paper submission deadline this year is Wednesday, August 2, 2017. For the second year in a row the IEDM submission deadline is about 1½ months later than what had been the norm, reducing the time between paper submissions and publication of the cutting-edge research results for which the conference is known. Authors are asked to submit four-page camera-ready abstracts (instead of the traditional three pages), which will be published as-is in the proceedings.

Only a very limited number of late-news papers will be accepted. Authors are asked to submit late-news abstracts announcing only the most recent and noteworthy developments. The late-news submission deadline is September 11, 2017.

63rd International Electron Devices Meeting

"Based on the success of the later paper-submission deadline last year, we have decided to make it an IEDM tradition," said Dr. Barbara DeSalvo, Chief Scientist at Leti. "This helps ensure a rich and unique technical program."

At IEDM each year, the world's best scientists and engineers in the field of microelectronics gather to participate in a technical program consisting of more than 220 presentations, along with special luncheon presentations and a variety of panels, special sessions, Short Courses, IEEE/EDS award presentations and other events highlighting leading work in more areas of the field than any other conference. For more information, interested persons should visit the IEDM 2017 home page at:

www.ieee-iedm.org

Electrical Engineers and Manufacturers Prepare for CWIEME Berlin

Between the 20th and 22nd June, the world's leading exhibition for coil winding, electric motor and transformer manufacturing will open its doors to more than 6,500 visitors from approximately 80 countries. Representing design engineering, manufacturing, R&D, procurement, and management, the vast majority of these visitors are important decision makers and influencers in the electronics, electric motor, transformer, generator, automotive and energy sectors.

CWIEME Berlin is once again offering its complimentary matchmaking service to help connect these visitors with relevant suppliers as efficiently as possible. Among the 750 exhibitors present, visitors will find a diverse range of products on offer from design software, winding machines, insulation and shielding materials, to entire components, and quality testing services – everything required to design and bring an electric motor, transformer or generator to market.

"The matchmaking service is a very good tool to connect with contacts and companies that visit CWIEME Berlin. We found it very positive and have been recommending it to other people," says Shaun Flaherty, sales manager at Italian electrical laminations manufacturer Sitem.

2017 will also see the return of the New Exhibitor Zone, designed to help visitors easily discover new suppliers and establish new contacts. "We had a lot of pre-scheduled meetings but also a lot of spontaneous meetings. Usually at showsyou have a lot of people passing by, looking at your booth and taking away some of the brochures but the average of the conversations that we had here was about 15 to 20 minutes, which is quite long for a fair, so that was a great success," says Max Brandt, head of sales at copper and copper alloy winding supplier MKM (Mansfelder Kupfer und Messing GmbH).

CWIEME Berlin will also be running its regular schedule of free-to-attend key note speeches, seminars and workshops with a particular focus on new pathways to optimisation and efficiency; the next generation of transportation and e-mobility; and data, connectivity and automation.

In 2017 CWIEME Berlin will also be holding its first CWIEME Global awards, celebrating excellence from across the electrical engineering and manufacturing industries. In each of the eight categories, winners will demonstrate design ingenuity, efficiency and operational excellence, outstanding teamwork, and strategic thinking.

"With so many new applications and material and technical developments gaining prominence, it is an extremely exciting time to be part of the electrical design and manufacturing industry. We are very much looking forward to discovering some of these innovations and rewarding achievements as part of the CWIEME Global Awards," says Haf Cennydd, CWIEME portfolio director at Ascential.

www.coilwindingexpo.com/berlin

Fuji X-Series 6 in 1 & PIM

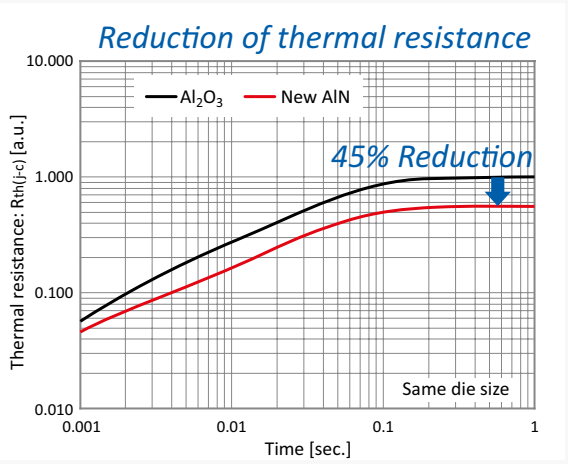
with high performance AlN DCB

MAIN FEATURES

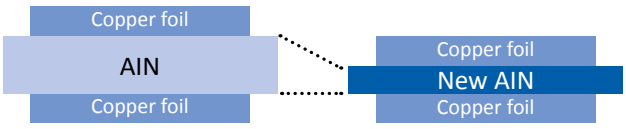
- **Improved switching performance**
- **Reduced on-state voltage**
- **Enhanced power cycling capability**
- **Increased output power**
- **Tj(op), max = 175 °C**

NEW THIN AlN SUBSTRATE

- **Improved thermal cycling capability**
- **Rth(j-c) was reduced by 45 %**



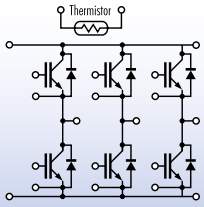
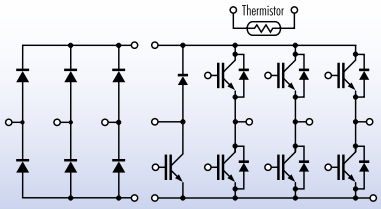
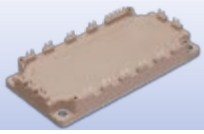
CROSS-SECTION STRUCTURE OF SUBSTRATE



Conventional ALN substrate

New thinner AlN substrate

Line-up Plan 1200 V

	6 in 1	EP2 & EP3	PIM	
	100 A		75 A	
	200 A		150 A	

Fuji Electric
Innovating Energy Technology

Fuji Electric Europe GmbH
Goethering 58
63067 Offenbach/Main – Germany

Fon +49(0)69-66 90 29 0
info.semi@fujielectric-europe.com
www.fujielectric-europe.com

Reliability of Power Electronics Converter Systems

Reliability of power electronics converter systems is a book published by IET in 2015. This book is edited by four of well-known experts in power electronics and engineering reliability; Henry Shu-Hung Chung, a professor at City University of Hong Kong, Huai Wang, an associate professor, and Frede Blaabjerg, a professor, at Alborg University and Michael Pecht, a professor, at University of Maryland, College Park. Despite the importance of reliability in design and control of power electronic converters, very few books have been published on this topic. The current book has been authored in sixteen chapters by a group of authors and editors from prestigious institutes.

First chapter of this book covers basic definitions and key terms in reliability engineering with focus on their applications in power electronics converters. This chapter provides a useful introduction to reliability engineering for readers who have not been extensively exposed to this topic beforehand. Chapter 2 briefly presents the failure mode modeling and life prediction techniques in power electronic converters. Data driven methods for the life prediction are summarized along with mathematical expressions which requires readers to have some statistical background for complete understanding of the content. Chapter 3 focuses on reliability issues associated with the DC-link capacitor. Failure modes, failure mechanisms and stressors for different type of capacitors, life-time models, and finally reliability-oriented design and monitoring methods for capacitive DC-link are surveyed. Chapter 4 deals with packaging of power electronics converters and contains different methods of accelerated testing and lifetime determination in power electronics converters. This chapter focuses more on mechanical stresses and thermal tests. Chapter 5 discusses the lifetime modeling of a power electronics module. Three modeling methods i.e. thermal, empirical and physical-based are reviewed followed by several examples. Minimizing DC-link capacitor is the main topic for chapter 6. Although it helps improving the reliability, this chapter does not directly deal with any reliability formulation. Chapter 7 begins with a brief introduction to wind power systems followed by some literatures review and public domain available data on the reliability of wind converters. Reliability improvement via active thermal control is presented in Chapter 8. Some techniques such as modulation strategy and reactive/active power control are surveyed along with several interesting examples. Life time modeling of power devices is again presented in chapter 9 but with a different approach. This chapter begins with a brief overview of failure mechanisms of a power module and then presents the lifetime modeling using various mathematical methods.

The life testing and monitoring of power modules are discussed in Chapter 10. Initially, the power cycle testing is described and then the voltage, the current and most extensively the temperature measurements are presented. Chapter 11 talks about stochastic hybrid system modeling (SHS) including Markov chains, Markov reliability and Markov rewards models followed by a case study in which SHS is used in the modeling of a photovoltaic system. Chapter 12 covers fault-tolerant adjustable speed drive systems. It categorizes various faults as well as hardware and software remedies to increase the reliability. All faults and remedies are sorted in tables for quick reference which is quite useful. Chapters 13 and 14 discuss some reliability concerns and calculations in wind and photovoltaic energy generation systems. These chapters along with chapter 7 could be possibly presented as a single chapter. Reliability of power supplies for computers is covered in Chapter 14. An example for each reliability assessment stages including the reliability qualification plan, DFMEA ranking table and DFMEA worksheet is presented. Then, thermal profile, de-rating and fan/capacitor life analyses are described. At the end, highly accelerated life tests as well as vibration and shock tests and manufacturing conformance test are reviewed. This chapter is one of the most concise and informative chapters of the book. This book ends with a chapter on high power converters in which readers do not see much about reliability.

This book is a valuable resource in the field of power electronics reliability offering a rich bibliography and numerous case studies. Citing industrial standards such as MLT and IEC is a prominent feature of this book which makes it useful for whom working in relevant industries. However, there are some inconsistencies throughout the book notably chapters arrangement and repetitive materials. This problem is commonly seen in edited technical books where several authors have contributed to the book. I would recommend this book to researchers and graduate students who want to access to an extensive and up-to-date literature review and case studies and to engineers who are interested in the topic and specially like to know about relevant standards and testing. It is worth mentioning that readers should have some backgrounds in statistics and reliability theory to better understand the book.

www.theiet.org/

This Review is provided by:
Arash Hassanpour Isfahani, PhD, SMIEE; Product Engineer,
Electric Motor Electrified Powertrain Propulsion Systems
FCA US LLC, 800 Chrysler Drive, Auburn Hills, MI USA 48326
ahassanpour@ieee.org

10th International Conference on Integrated Power Electronics Systems – CIPS 2018

In the next decades, power electronic system development will be driven by energy saving, intelligent energy management, power quality, miniaturisation and high reliability. Monolithic and hybrid system integration will include advanced device concepts including wide bandgap devices, new packaging technologies and the overall integration of actuators or drives, i. e., mechatronic integration.

CIPS is consequently focused on the following main aspects:

- assembly and interconnect technology for power electronic devices and converters
- integration of hybrid and mechatronic systems with high power density
- systems‘ and components‘ operational behaviour and reliability

Basic technologies for integrated power electronic systems as well as upcoming new important applications will be presented in interdisciplinary invited papers.

The conference focus is today more important than ever – increasing functionality, energy efficiency and system reliability while decreasing cost. We invite all engineers coming from industry and academia engaged in power electronics-related

- system development
- component development
- reliability engineering
- research

to share their research and technical achievements submitting a paper to CIPS 2018 till the deadline 15 July 2017. The conference will take place 20 to 22 March 2018 at Stuttgart.

www.cips-conference.de

Avago Technologies Optocouplers

Take the Risk Out of High Voltage Failure!

Optocouplers are the only isolation devices that meet or exceed the IEC 60747-5-5 International Safety Standard for insulation and isolation.

Stringent evaluation tests show Avago optocouplers deliver outstanding performance on essential safety and deliver exceptional High Voltage protection for your equipment. Alternative isolation technologies such as magnetic or capacitive isolators do not deliver anywhere near the high voltage insulation protection or noise isolation capabilities that optocouplers deliver.

IEC 60747-5-5 Certified

BROADCOM®
connecting everything®

Win a Microchip PICDEM Lab II Development Platform!

Win the PICDEM™ Lab II Development Board (DM163046) from Bodo's Power! The board is a development and teaching platform for use with 8-bit PIC® microcontrollers (MCUs). At its center, a large prototyping breadboard enables users to easily experiment with different values and configurations of analog components for system optimization. Several external connectors allow for user-customizable expansion, while our library of labs and application notes enrich the development experience. The PICDEM Lab II Development Board is also fully compatible with our latest software development environment.

Features:

- Supports all 8-bit PIC MCUs from 6 to 40 pins
- Programming headers and power connections for all MCU sockets
- Three individual power supplies
- 5V, 3.3V, variable (1.5-4.5V)
- Large breadboard area for external analog and sensor connections
- External connections for industry-standard communications and expansion interfaces
- Lab hardware and documentation for four labs included in the box
- RS232 and Bluetooth® Low Energy interfaces

The original PICDEM Lab Development Board has remained one of the most popular development tools for PIC MCUs since its introduction. Microchip has taken this concept and expanded it for 21st century embedded development. The PICDEM Lab II Development Board supports any 8-bit PIC microcontroller (6-, 8-, 14-, 18-, 20-, 28- and 40-pin footprints), and provides an expansive array of connections for programming, I/O, analog and communications interfaces. The PICDEM Lab II Development Board will be a valuable resource to engineers across a broad spectrum of specialties, from analog designers looking to explore the power and flexibility of MCU-based systems to engineering professors seeking a flexible and relevant teaching tool that they can add to their curricula.

For your chance to win a Microchip PICDEM Lab II Development Board, Visit:

http://www.microchip-comps.com/bodo-picdemlab11

and enter your details in the online entry form.

www.microchip-comps.com

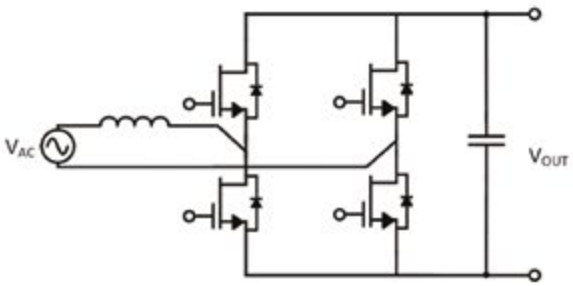
USCi
United Silicon Carbide, inc.

Silicon Carbide,
Our Sole Focus,
Your Superior Solution.

650V SiC – Totem Pole PFC

USCi SiC Cascodes provide low Qrr enabling continuous conduction mode (CCM) Totem Pole PFC.

Totem Pole PFC circuits leveraging SiC Cascodes enable power supply designs to reach 80 PLUS Titanium efficiency levels.



Find out more at www.UnitedSIC.com
sales@unitedsic.com

Danfoss Silicon Power Establishes Manufacturing in Utica, New York

In March 2017 Danfoss Silicon Power announced that the company is establishing a second production site in Utica, New York State in the USA.

We have asked Claus A. Petersen, General Manager and VP of Danfoss Silicon Power a few questions about the new set up.

It was announced in March 2017 that Danfoss Power is establishing production in the US. When can we expect that the production is fully up and running?
"When the partnership between Danfoss Silicon Power and the New York State was announced in March, that was also the launch for the procurement process of equipment. We expect the first equipment to arrive in Utica in the fall of 2017, and should initiate the first production in the beginning of 2018. By the end of Q1 2018, we expect to be fully up and running to serve our customers with fully qualified modules out of the Utica facility"

In the announcement, General Electric (GE) was also mentioned as a partner in the NY-PEMC (New York Power Electronics Manufacturing Consortium), what role does GE play in the Danfoss manufacturing set up?
"Yes, GE is part of the PEMC set up and will also occupy a small part of the new facility. GE is part of the consortium due to their production of SiC semiconductors, which they are producing in a similar set up to Utica in Albany, New York. One aspect of the establishment in Utica will be to produce modules specifically for GE based on their own SiC semiconductors. However, the facility is a pure Danfoss Silicon Power setup; based on the same successful customized business model currently running in Flensburg. We continue to remain 100% chip independent, an important part of our differentiation. The close cooperation with our strategic semiconductor partners allows us to offer the best suitable, customized solutions to our broad range of applications and customers."

Silicon Carbide (SiC) was also mentioned in the announcement as one of the primary reasons to set up the facility in Utica. How do you see the development of Silicon Carbide (SiC)?
"No doubt that SiC is here now. Just a few years ago, we were all arguing when we would see the impact of the technology in power semiconductors. In high voltage, SiC is already in use in different applications, such as Solar and Battery Storage. The benefits of SiC are to be fully utilized when the benefits are calculated at system level. Being able to utilize the characteristics of SiC, such as high switching frequencies and low losses, the right packaging technologies needs to be applied. Danfoss Silicon Power has the right technologies, such as DBB®, Cu-wirebonds, sintering, molding and ShowerPower® applied in its advanced power module solutions. Going forward also lower voltage applications will start benefitting by using SiC and we will most certainly also see SiC applied in high end automotive applications.

Why has Danfoss Silicon Power chosen the first step for a global foot print to be in the US?
"The strategy for Danfoss Silicon Power has long been to establish ourselves in the US. The timing now has been decided by the opportunity given by the New York State. We are growing heavily and starting a new facility in the US to also better accommodate our US customer base seems to be the right strategic step. This might, however, be followed by other expansions in the near future. Our near-term focus will be to bring Utica up to full production capacity, producing highest quality power modules for our existing and new US customers."

Read more about Claus A. Petersen, VP and General Manager and Danfoss Silicon Power:

Claus A. Petersen has been responsible for the Danfoss Silicon Power business since 1998, where he has successfully grown the business to be a top 3 supplier of Power Modules in Europe. Danfoss Silicon Power employs approximately 450 employees and is expecting to employ about 100 new colleagues in Utica in the next 2-3 years.

Claus A. Petersen, has been part of the Danfoss Group since 1984, working in several areas of the business, however, the latter 20+ years in the Power Electronics business.

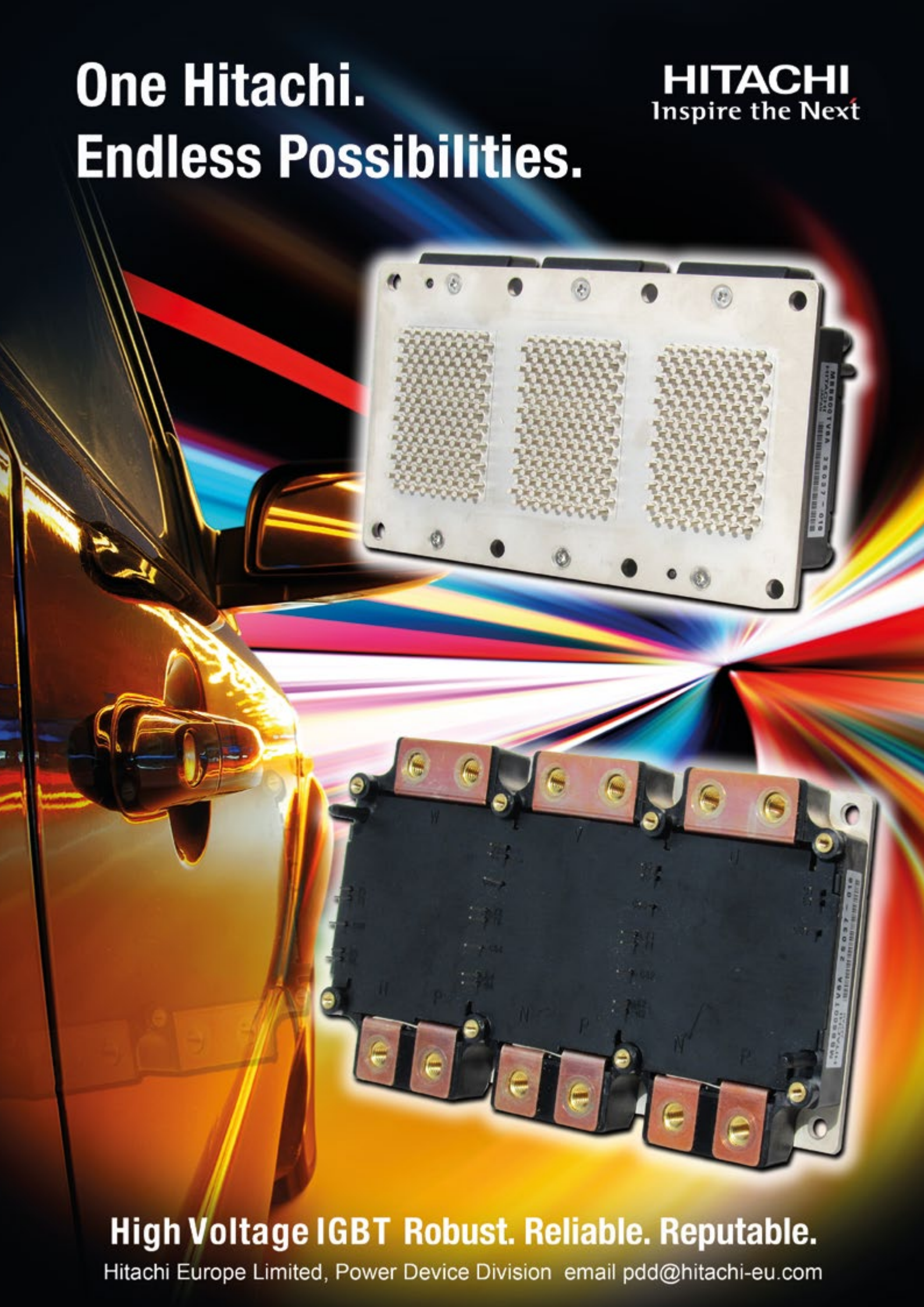
Danfoss Silicon Power develops and manufactures customized power modules and power stacks to industrial applications; such as motor drives, welding and medical equipment, renewables; solar and wind and into the automotive industry of EVs/HEVs as well as several auxiliary applications.

Besides his responsibilities as General Manager of Danfoss Silicon Power, Claus A. Petersen is a board member of CEMEP, ZVEI and the Danish Electric Vehicle Alliance.

www.siliconpower.danfoss.com

One Hitachi.
Endless Possibilities.

HITACHI
Inspire the Next



High Voltage IGBT Robust. Reliable. Reputable.

Hitachi Europe Limited, Power Device Division email pdd@hitachi-eu.com

SiC - the High Performance Power Semiconductor

USCi (United Silicon Carbide, Inc.) is a major player in power electronics, specializing in the development of high-efficiency silicon carbide (SiC) devices with expertise in Schottky barrier diodes, JFETs, MOSFETs, and solid state circuit breakers.

VIP interview with USCi-CEO and President Dr. J. Christopher Dries about his company and its positioning in the power electronics market.

By Henning Wriedt, US-Correspondent Bodo's Power Systems

Henning Wriedt: USCi was founded in 1998. What were the company charter and the founder's expertise at that time?

Christopher Dries: You're correct Henning, USCi was founded quite some time ago. That original incarnation of the business began as many early stage technology businesses begin . . . spinning out of a University. In the case of USCi, these origins began at Rutgers University, where the original founders had been working in SiC for some time, demonstrating at the research level the first of many types of SiC devices, Schottky Diodes, JFETs, MOSFETs, BJTs, and even early integrated circuits.
In my experience however, it often takes much longer than original founders think to achieve commercial success. My own background is in InP and GaAs devices for optoelectronics. The scientific community knew that these devices were ideal for telecommunication systems as early as the 1970s and early 1980s, but did not achieve significant commercial success until the markets and materials matured in the 1990s and early 2000s.
Our current board and management team at USCi (who along with our employees own the company) recognized that SiC was in an early gestation period in 2009 when we purchased the assets of the business. Whether prescient or lucky, I believe that we have captured the market timing beautifully, matching USCi's technology and manufacturing model with exponentially growing market demand.

Figure 1: SiC manufacturing

Henning Wriedt: What makes Silicon Carbide so unique, compared to the current workhorse Silicon? Is it just the wide band gap?

Christopher Dries: The fact that SiC is a wide bandgap material is certainly the basic physical reason it is unique, but the fact that it can be grown in bulk crystals as large as 150 mm is what makes it the leading commercial high performance power semiconductor.
The bulk crystal structure enables SiC designers to build high cell density vertical current flow devices. This attribute coupled with USCi's advanced thin wafer technology allows our team to compete with the most advanced Si transistors with more than 10X smaller die size. While SiC is still expensive, this advanced technology allows our team to provide cost-performance that exceeds anything that Si or even GaN can provide at present from 650 V and up.

Henning Wriedt: The first SiC devices were Schottky diodes, followed by junction-gate FETs and MOSFETs for high-power switching. What is next?

Christopher Dries: Basic switching functionality is really just the tip of the iceberg for SiC devices. At USCi, we believe that higher levels of functional integration are the future of our industry. While there will always be a home for discrete power switches, we can do much more through higher levels of integration, where we let each materials system do what it can do best.
For example, integrating our small die size SiC switch technologies with state of the art Si based controllers and ICs is a simple way to provide enhanced value for our customers.
In addition, the utilization of half-bridge building blocks with integrated controllers is another higher level of value where we see the industry headed. Lastly, in USCi's case, we see new topologies such as Totem-Pole PFC, enabled by our advanced switches overtaking traditional topologies such as boost PFC circuits.

Henning Wriedt: How is your current product portfolio structured?

Christopher Dries: I would argue that we have the broadest SiC technology portfolio in the world at present, spanning Schottky Diodes, JFETs for circuit protection, Cascodes for switching, MOSFETs for medium voltage, and Supercascodes for voltages > 3.3 kV. In addition, we manufacture these products on two geographically distinct manufacturing lines. One runs 100 mm wafers and the other runs 150 mm.

We have been careful not to get "in-love" with our own technology, but instead to be technology agnostic, using the best device for each voltage application. In the case of rectifiers, that is obviously JBS structure diodes. For switches from 650 V – 1700 V, Cascode devices, which incorporate a low-voltage MOSFET in series with a normally on JFET, are the ideal switch. For high Rds on applications (> 200 mohm) in the 1200 V range, one could make a good argument for a MOSFET due to the additional packaging cost of a Cascode. For medium voltage applications, we see little differentiation between MOSFETs and Cascodes in overall performance, although the diode behavior here gives the edge to the Cascode. Lastly, at voltages > 3.3 kV, we believe nothing can beat the Supercasode in terms of ease of use, performance, and cost.

Henning Wriedt: Please explain your foundry services. Who are the typical customers for these services?

Christopher Dries: In our context, foundry services simply means that we are willing to run custom current or voltage rating devices for customers on any of our released platforms. For example, if a customer wants a 100 A 1700 V Schottky diode which is not in our standard portfolio, we are happy to run that device for them on our platform with the addition of a modest amount of NRE over and above our standard prices.

Henning Wriedt: How do you define custom devices for special applications?

Christopher Dries: Custom devices are different from our foundry services in the sense that they require some modification in addition

to straightforward mask geometries to achieve the end customers' goals. This may be using a special metallization to enable brazed lead manufacturing for a customer, or tailoring the device structure, doping, and overall characteristics to achieve a particular saturation characteristic in a JFET for a customer.
We have developed so much experience now in such a broad array of device types, that most modifications that a customer may want can be thoroughly developed and modeled in TCAD in such a way that we can hit a new device implementation on the first run.

Henning Wriedt: You concentrate on the development of normally OFF switch solutions. Is this driven by certain applications?

Christopher Dries: The world desires normally off devices for switching functions. This is why we developed our Cascode devices as the ideal SiC switch. They provide a universal gate drive, meaning they can use any standard Si drive solution whether it be an IGBT or high voltage MOSFET, while at the same time remain compatible with the unique -5 – 20 V drives of most SiC MOSFETs.
We provide this while providing a 4.5 V threshold, and body diode performance that rivals that of a SiC Schottky Diode. Our customers love them because they can simply drop them into any switch solution they are using and run at higher power density and higher efficiency, while not breaking the bank.

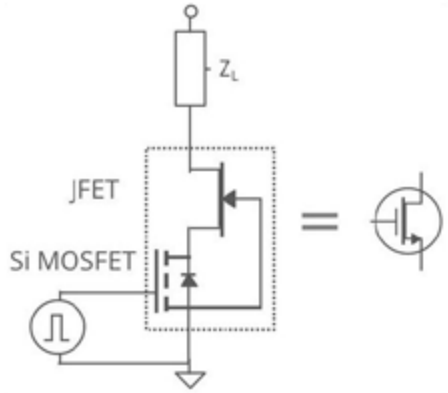


Figure 2: SiC Cascode configuration

Henning Wriedt: How significant is the Supercascode technology for your company?

Christopher Dries: The Supercascode is simply an extension of our standard Cascode technology to higher voltages, 3.3 kV and higher . . . the sky is the limit. The beauty of this technology is that it uses all of our standard off the shelf 1200 V or 1700 V FETs, an inexpensive voltage balancing network, and the entire switch is controlled by a single 30 V or so, high threshold voltage Si MOSFET. This means it is extremely easy to control with a standard gate drive, while having superior diode performance, while costing a fraction of the cost of any alternative wide bandgap switch.
This technology is extremely important to our business as it will become a cornerstone of devices in traction and other high voltage applications such as solid state transformers. As electrical distribution models change from using ohms law to distribute power through the path of least resistance, to systems that dynamically route power in through the most efficient route possible, we expect our supercascodes to be at the heart of these power routing systems.

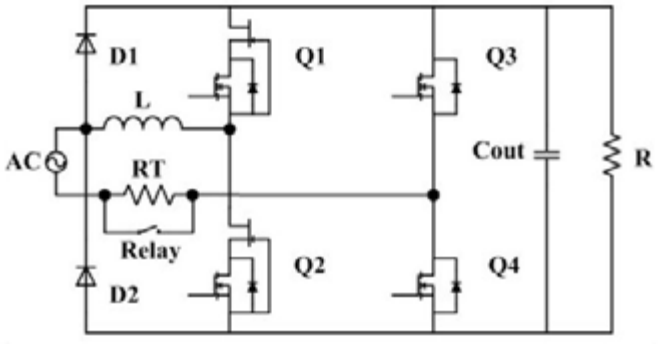


Figure 3: 1.5 kW Totem-pole PFC diagram

Henning Wriedt: What can the electronics industry expect from USCi in the upcoming two years?

Christopher Dries: With the success that we have achieved with our Cascode technologies in standard TO-247 and TO-220 package designs, you can expect a massive proliferation of our devices into source kelvin connected packages that enable our customers to extract the highest performance out of our devices.
We will also begin to deploy our Cascodes which incorporate a low voltage MOSFET and SiC JFET in stacked form. This means that the two devices will be provided as a single unit with the low voltage MOSFET bonded directly to the high voltage JFET producing a single die that performs as an ideal Si like high voltage switch.
Lastly, USCi will release our high temperature capable IC platform within the next two years. This will enable our customers to design high temperature >300 °C circuits in our JFET platform for use in various hi-reliability applications.

www.UnitedSiC.com

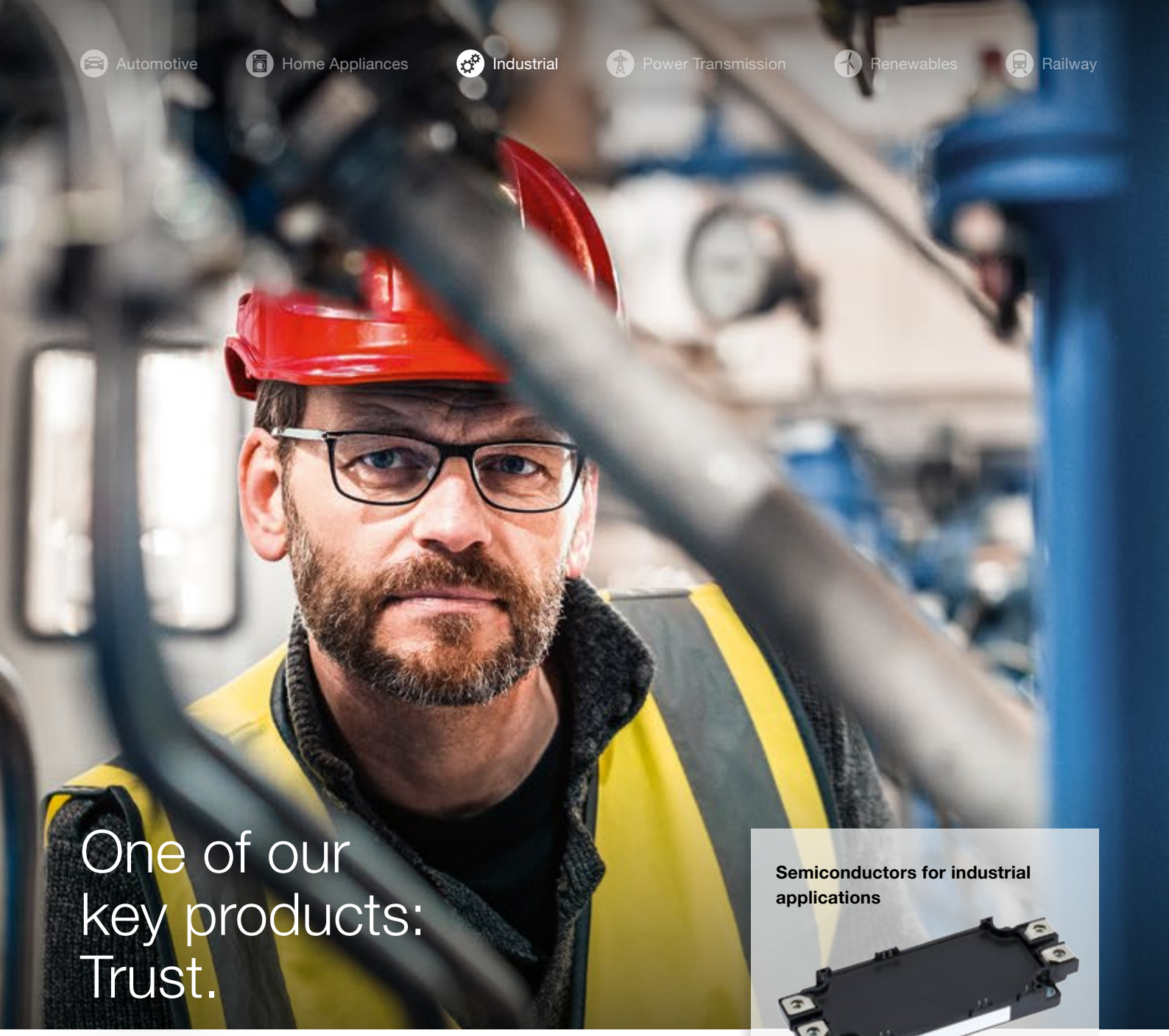
Biography of Dr. J. Christopher Dries, President and CEO:

Chris oversaw the acquisition of USCi in 2009 and has served as President and CEO ever since. In addition to his capacity as CEO, Chris serves as a member of the Board of Directors and is an Investor in the company.

Chris helped build and sell Sensors Unlimited to Finisar Corporation, participated in the buy-back of the business and then subsequent sale to Goodrich Corporation in 2005 where he served as VP of Research and Development of the Imaging business. Chris obtained his bachelor's degree from Duke University and Ph.D from Princeton University, both in Electrical Engineering.

His various areas of expertise include photodetectors, OEICs, high-speed electronics and focal planes for hyperspectral imaging. He serves on the Princeton Graduate School Leadership Council, the Princeton Electrical Engineering Department Advisory Board and the Duke University Engineering School Board of Visitors. Dr. Dries earned a B.S. in Electrical Engineering from Duke University in 1994, an M.A. and a Ph.D. from Princeton University in 1996 and 1999, respectively. His thesis research was on the fabrication and use of strained layers of InGaAsP in photodetectors and quantum well lasers.

Automotive | Home Appliances | Industrial | Power Transmission | Renewables | Railway



One of our key products: Trust.

Power Devices from Mitsubishi Electric.

Precise and efficient control of dynamic processes puts heavy demands on the components used. With 30 years history of IGBT production and continuously inventing pioneering technologies, Mitsubishi Electric provides superior experience and expertise to meet such requirements. Latest chip technology as well as mounting and assembly technologies offer user benefits like extended module lifetimes, high power density for compact design, easy system assembly and support of scalable platform concepts.

Semiconductors for industrial applications

7th Generation IGBT Modules NX-Package

- 7th Generation IGBT with CSTBT™ chip technology
- Superior long term reliability by optimized bonding and direct potting
- High thermal cycling capability by Insulated Metal Baseplate (IMB) structure
- Pre-applied Phase Change Material (PC-TIM) and PressFit
- Comprehensive line-up for 650 V, 1200 V and 1700 V

eco Changes for a greener tomorrow

More Information:
semis.info@meg.mee.com
www.mitsubishichips.eu

Scan and learn more about this product series on YouTube.

MITSUBISHI ELECTRIC
Changes for the Better

Reliable SiC Power Devices for Automotive Applications

Power devices are a key elements in electric and hybrid electric vehicles. As one of the technology leaders in SiC power devices Rohm has been supplying electric vehicle manufacturers with SiC power devices since 2012.

By Felipe Filsecker and Aly Mashaly, Rohm Semiconductor GmbH

The mission of Rohm is to produce power devices that meet high reliability standards at all times. This philosophy has enabled Rohm to increase the SiC business in the automotive field with a steadily growing demand and close cooperation with customers. This article focuses on automotive-grade SiC power devices, including some of their common applications and reliability data. In detail, this comprises an overview of SiC MOSFETs and Schottky barrier diodes and their main target applications, e.g. battery charging systems and power train inverters. Special focus is put on the qualification process of our devices including experimental results from reliability tests, such as gate oxide reliability, cosmic radiation ruggedness and SiC MOSFET's body diode bipolar degradation effect.

The prospects for electric vehicles (EV) have greatly improved, turning electric mobility into a subject of significant interest. Car manufacturers, industrial companies and research institutes have joined forces in order to push forward the planned mass production of hybrid and electric vehicles. In doing so, newly developed power electronic systems are also being integrated into EVs. Due to the special requirements demanded by automotive OEMs, system developers are confronted with new challenges. The required space, weight and efficiency play an important role. Furthermore, the overall system cost and the expenses should remain low, while at the same time top-quality and reliability need to be guaranteed for the products.

For a successful integration of EVs into the mobility landscape, technological barriers need to be overcome with concepts that are able to push the barriers away from the current limitations. There is a general consensus among automotive manufacturers that the standard approach does not always achieve performance targets for EVs or meet all design restrictions. The autonomy range of a car is a direct reflection of the power train efficiency and energy management system. On the other hand, public infrastructure systems such as high-power fast charging systems of several hundreds of kilowatt have to operate under tight size and efficiency restrictions. The semiconductor material SiC and its physical properties seem to have all the potential needed to fulfill these new market demands.

Rohm is a market leader in SiC-based power devices whose cooperation with automotive manufacturers dates back to 2012, with the inclusion of SiC Schottky Barrier Diodes (SiC SBDs) in battery charging systems. This has only been possible by offering high reliability and quality standards. In last years, the increasing demand in the automotive market segment has lead Rohm to shift the focus towards this market, aiming to fulfill the requirements of this particular industry in every aspect. It is clear that new technologies do not only bring improvements, but also many questions. Topics such as reliability and quality are as important as the performance benefits obtained by them. At Rohm we are aware of this and do our best to offer a good balance between performance, technological innovation and quality.

This article gives an overview of our automotive-grade power device portfolio, which consists of SiC MOSFETs and SiC SBDs. The first section of this article is focused on the application of our devices as well as new market trends. The other section is dedicated to a selection of experimental results related to SiC MOSFET reliability.

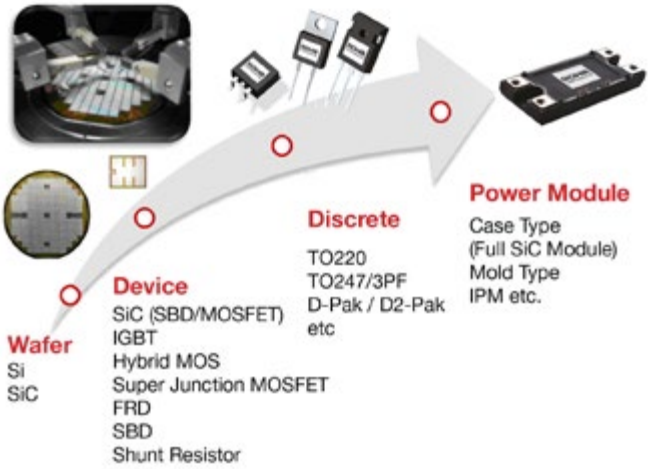


Figure 1: Rohm's in-house integrated manufacturing system for power devices

Rohm's in-house power device development

The high quality standards in our SiC power devices can be assured by our in-house integrated manufacturing system, where every aspect of the device manufacturing is under our control, see Figure 1. This starts as early as at the SiC substrate production, where high quality wafers are produced out of raw silicon and carbon powder. The substrate is a key element for the device quality as some failure mechanisms are directly related to material defects present in low quality wafers. This production step is carried out in Germany by our subsidiary SiCrystal, market leader in SiC substrate manufacturing. The high-quality substrate wafers enable the fabrication of reliable and innovative power devices which is the core of Rohm's contribution to the development of SiC power semiconductor technology. This has been proven by the successful introduction of SiC planar and trench MOSFETs back in 2010 and 2015, respectively. The power devices are sold in a second step as either bare die product, or packaged as discrete devices or in power modules. The discrete devices can be found in through-hole technology (THT) or as surface-mounted devices (SMDs), the power modules are offered in industry-standard C and E type formats. Our full control of the device manufacturing

Design for power efficiency and EMC compliance

As a leader in test and measurement, Rohde & Schwarz provides a large portfolio of solutions for development, optimization and debugging of power electronics.
Choose from our broad range of

- Oscilloscopes
- Spectrum analyzers
- EMC test receivers
- Vector network analyzers
- Power supplies
- Power analyzers

More information at:
www.rohde-schwarz.com/ad/power-electronics

ROHDE&SCHWARZ

process, quality controls and traceability system allows us to identify and correct possible issues that might arise in any phase of the production chain.

Automotive-grade SiC power devices

Components used in automotive applications have to comply with higher qualification standards than for industrial applications. In the case of power devices the standard AEC-Q101 describes the stress tests that discrete semiconductors need to pass in order to claim automotive-grade qualification. Rohm's product portfolio of SiC SBDs and MOSFETs that comply with this standard is summarized in Table 1.

Device type	Part no.	Voltage	Current / Rds,on	Package
SBD	SCS2xxAJ	650 V	6-20 A	TO-263AB
SBD	SCS2xxAG	650 V	6-20 A	TO-220AC
SBD	SCS2xxAE2	650 V	20-40 A	TO-247
SBD	SCS2xxKG	1200 V	5-20 A	TO-220AC
SBD	SCS2xxKE2	1200 V	10-40 A	TO-247
MOSFET	SCT2xxxKE	1200 V	80-450 mΩ	TO-247

Table 1: Automotive-grade SiC power devices in Rohm's portfolio, after AEC-Q101

SiC SBDs are available in different packages and current ratings, for voltages of 650V and 1200V. They belong to the second generation which features a very low forward voltage and leakage current, and are used in automotive applications since 2012. SiC MOSFETs are available for the 1200V voltage class in planar technology (2nd gen.) and TO-247 housing. The new trench devices (3rd gen.) are currently in qualification process.

EV applications for power devices

Conductive charging

As stated in Figure 2, the first use of SiC devices in automotive applications is related to the SiC SBD in conductive battery chargers, also known as on-board chargers (OBC). They are intended to offer a simple solution to charge the car with a standard household connection and are thus limited to 3.6kW in single-phase and 11kW in three-phase ac input configuration (mode 1 after IEC 62196).
A conventional single-phase 3.6kW OBC can be built as shown in Figure 3. The two-stage PFC is composed in this case of a diode-bridge rectifier and a boost converter. The isolated dc/dc converter is commonly realized with a full-bridge converter on the primary side of the transformer and a diode bridge on the secondary side. To achieve an optimum efficiency in the PFC stage, 650V SiC SBDs are already applied as boost diodes, as Si devices would limit the switching frequency to unwanted levels. As efficiency levels increase, the next stage of development of OBCs includes 650V SiC MOSFETs for the PFC and dc/dc full-bridge switches. The use of 1200V SiC SBDs for the output rectifier is also an attractive solution for batteries operating at high voltage levels. As a reference for coming all-SiC OBCs, the system presented in [1] achieved efficiency levels over 95% using 1200V SiC MOSFETs and SBDs at 3.1kW output power.

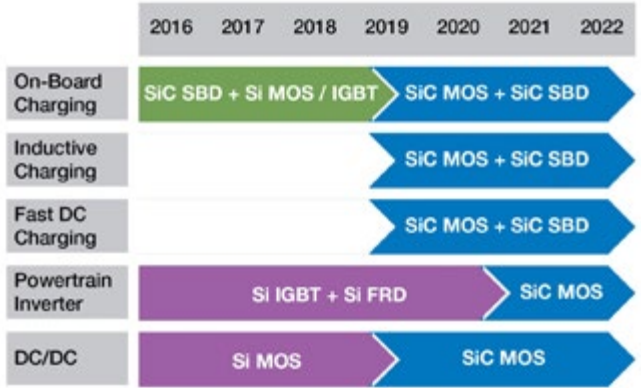


Figure 2: Potential for SiC power devices in automotive applications

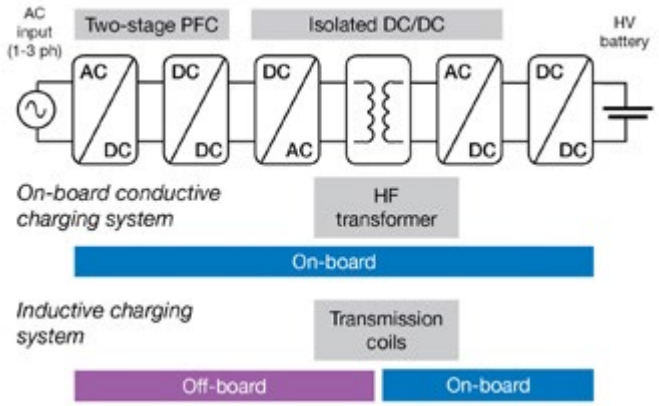


Figure 3: Examples of charging systems for electric vehicles

Wireless charging

Wireless charging for EVs is also an attractive solution for battery charging systems, although the ease of connection translates into a higher system complexity and lower efficiency, see Figure 3. SiC devices can play a key role in these converters, where efficiency (>90%) and 85kHz operating frequency requirements stated in the coming SAE J2954 standard are hard to achieve using standard Si devices. In the optimized design proposed in [2], an efficiency of roughly 94% could be estimated (ac mains to battery) by using 1200V SiC MOSFETs in a 50kW system.

Figure 4: Improvement of perfomance and size reduction in power train inverter with SiC SBD technology for Formula-E racing car

SEMIKRON
innovation + service

Power Electronic Stacks

When Time to Market Counts

You want to...

- **reduce time to market**
- **limit your financial investment**
- **control your cost of development**
- **save costs on manufacturing of stack assemblies**

We are the global market leader in power electronic stacks with over 200,000 assemblies in the field. Five global stack centers provide optimized, pre-qualified and field-tested stack assemblies. Our stacks feature short lead times while still easy to customize for your needs. Our global stack centers provide worldwide coordination, engineering, manufacturing and test to localize manufacturing of your stack assemblies.

Further information: www.semikron.com/power-stacks
Contact us: power-stack@semikron.com

Power train inverter

The power semiconductors used in power train inverters are subjected to high thermal and load cycling. They must exhibit a high short-circuit ruggedness and require a high power rating. The current solutions are mostly based on Si IGBTs as this kind of technology offers a high maturity level and low price. However, benefits of wide bandgap technology on system level, such as reduced volume and higher efficiency, are shifting the interest to SiC MOSFETs as a possible replacement for Si IGBTs in future inverters, see Figure 2. To showcase this trend, Rohm has partnered with the Venturi Formula-E team, where we provide SiC SBDs and MOSFETs for the main traction inverter of a fully electric racing vehicle. The current season features a racing car equipped with Si IGBTs and SiC SBDs, the old Si-based inverter and the new hybrid Si/SiC inverter are shown in Figure 4. For the next season, the IGBTs will be replaced by SiC MOSFETs, enabling even higher efficiency levels and lower volume.

SiC MOSFET reliability

The benefits of SiC technology in power electronic systems are clear, as briefly discussed in the previous section. In order to take advantage of them reliability levels similar to the ones achieved by Si power devices, such as power MOSFETs and IGBTs, need to be achieved. This bears several technological challenges related to new phenomena present in these devices that were unknown in traditional Si technology. The success of power device manufacturers is highly related to the ability to master them and develop stable processes that ensure high reliability at a reasonable price, without neglecting device performance. Rohm power devices are aimed at achieving a good trade-off between performance and reliability which has found a positive response in the market. Our SiC power devices undergo the same tests that standard Si devices require to be qualified for either industrial or automotive use.

Gate oxide reliability

When talking about SiC MOSFETs gate oxide reliability is usually a common concern. Early devices experienced some problems that made many people think that a proper solution would be hard to find. Years of continuous improvement have shown the opposite. Commercially available devices from Rohm feature high gate oxide reliability, with lifetime values far beyond 20 years, as Figures 5 and 6 indicate. Figure 5 shows lifetime plots for 2nd gen. planar and 3rd gen. trench MOSFETs, based on High Temperature Reverse Blocking (HTRB) tests. This test stresses the device with a reverse voltage and high temperature. The electric field that builds up inside the device stresses the gate oxide interface until it fails. This is repeated for many devices and the results are recorded. The lifetime of the device under worst-case operating conditions of 950 V for a 1200 V is obtained by extrapolating the experimental results. This yields a lifetime of over 100 years for both device types.

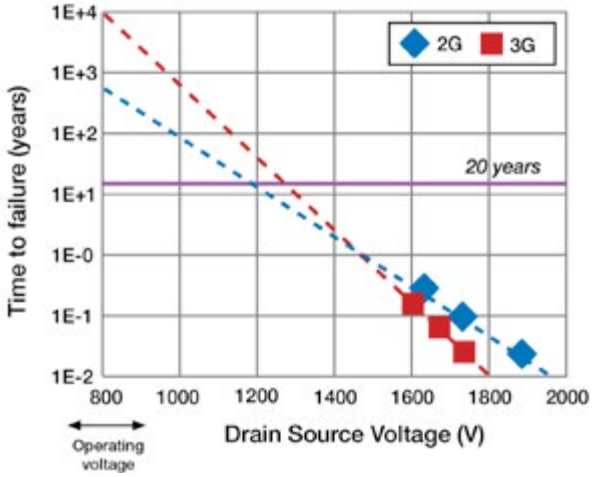


Figure 5: Lifetime calculation based on High Temperature Reverse Bias (HTRB) test on 1200V SiC MOSFETs (10 pcs. per each data point, Tj = 150 °C, 70% failure for 2G, 50% failure for 3G)

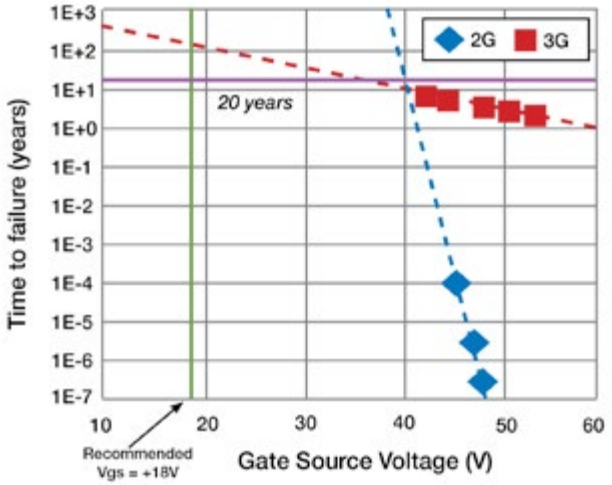


Figure 6: Lifetime calculation of gate oxide based on High Temperature Gate Bias (HTGB) test on 1200V SiC MOSFETs (10 pcs. per each data point, Tj = 175 °C, 70% failure for 2G, 50% failure for 3G)

The other critical condition for the gate oxide is related to the conduction state. In this case the stress is concentrated between the gate and source terminals as a positive voltage is needed to turn on the MOSFET channel. Rohm's MOSFETs have a recommended gate-source voltage of +18V. For the accelerated tests voltages between 40 and 50V were applied. The extrapolation of these results shows that a lifetime of 20 years is obtained with a gate-source voltage higher than 30V. Thus, operation at +18V should not be a concern regarding oxide lifetime.

Cosmic radiation ruggedness

Our planet is under constant cosmic radiation in form of atomic particles that are known to cause failures in power semiconductor devices. Incident neutrons collide with the atomic lattice of the device generating highly localized currents that eventually lead to device failure. This effect is known as Single Event Burn-out (SEB) and can

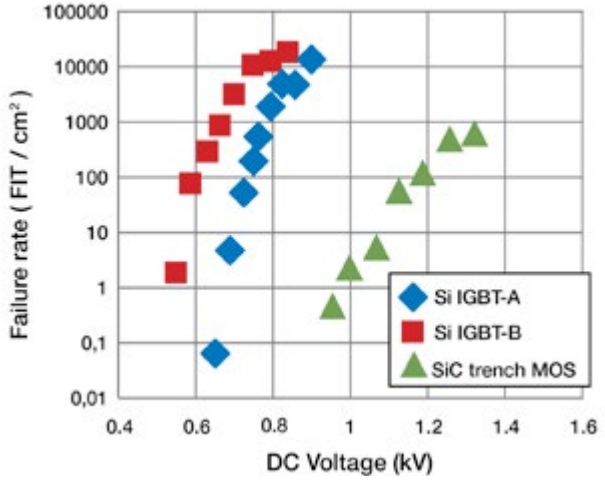


Figure 7: Cosmic radiation induced SEB failure rate of 1200V Si IGBTs and Rohm SiC trench MOSFETs, based on data from [4]

only take place if a voltage over a certain threshold value is applied to the device, usually around 70% of the device breakdown voltage [3]. In traditional Si IGBTs and MOSFETs, the operation voltage is limited to 80% of the device voltage class in order to remain under a rate of 100 FIT. For applications that demand lower failure rate levels, use of devices from a higher voltage class is common. Besides the applied voltage, other parameters that have influence in the failure rate are device area, semiconductor material properties and environmental conditions. Studies performed to assess the cosmic radiation ruggedness of new SiC power devices have been successfully conducted.

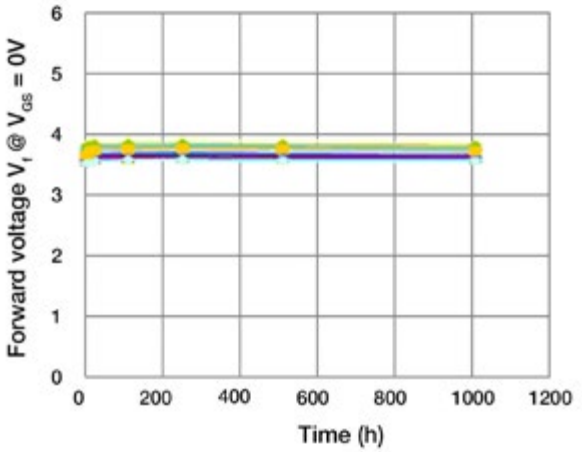


Figure 8: Forward voltage of body diode during DC current stress test (SCT3040KL, IF = 10A, Tj = 175°C, 20 pcs., G-D shorted)

Figure 7 shows results of a test conducted at the ANITA facility in Sweden [4]. This study concluded that SiC trench MOSFETs have a better performance regarding SEB than comparable Si devices. This makes it possible to operate them at higher voltages than Si devices with FIT rates still in reasonable levels. By considering EV battery systems reaching voltage level of 800V in the near future, this is an attractive feature of SiC devices.

Body diode stability

Both crystal defects and the manufacturing process of SiC MOSFETs have a great influence on the stability of the body diode. By acquiring the energy of hole-electron recombination when forward current flows a certain type of a crystal dislocation changes its type from linear to planar shape. This can lead to a degradation of the on-state resistance of the body diode and the MOSFET. Based on its expertise in different manufacturing processes at substrate, epitaxial growth and device level, Rohm's devices exhibit no bipolar degradation effect. DC current stress tests conducted to 20 planar MOSFETs from Rohm show that these devices do not experience significant degradation even after stressing the body diode with 10A for 1000 hours, as the forward voltage remains constant, see Figure 8.

Avalanche mode capability

Certain applications demand that the power device is able to go into avalanche mode without failure. This is usually caused by overvoltage due to high di/dt and parasitic inductances. For example, an unwanted interruption of the dc charging process using long cables. Other applications demand the connection of power switches to inductive

loads, where the avalanche mode of the device is considered in the design. Devices without avalanche capability, such as IGBTs, rely on voltage snubber circuits and active gate control to avoid device destruction. SiC MOSFETs, in planar or trench structure, feature intrinsic avalanche ruggedness. Figure 9 shows the waveforms for the planar MOSFET during single-pulse avalanche operation. The tested device is able to dissipate 1.2J without failing.

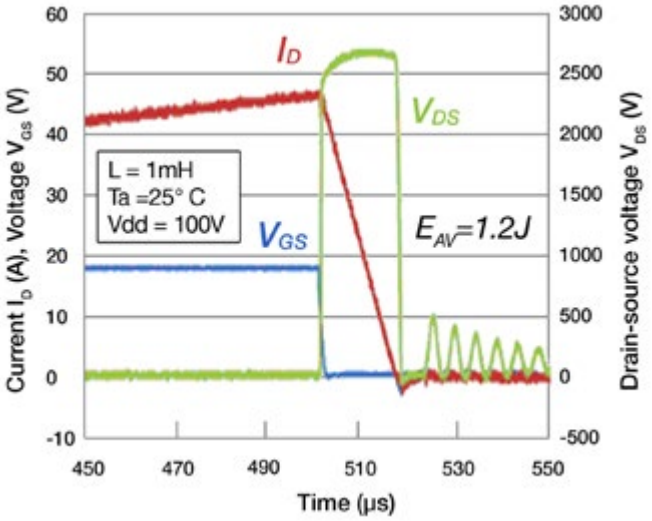


Figure 9: Avalanche operation mode waveforms for 2G MOSFET SCT2080KE (planar)

Conclusions

EV technologies are under serious development and will change the mobility landscape in a few years. Due to the high performance requirements, a shift from traditional solutions to new concepts will take place. SiC devices, with their improved physical properties, are a key element of this new landscape. As briefly discussed with some application examples, the benefits on the system level are clear. The reliability of Rohm SiC devices is under constant improvement; their qualification as automotive-grade devices is a proof thereof.

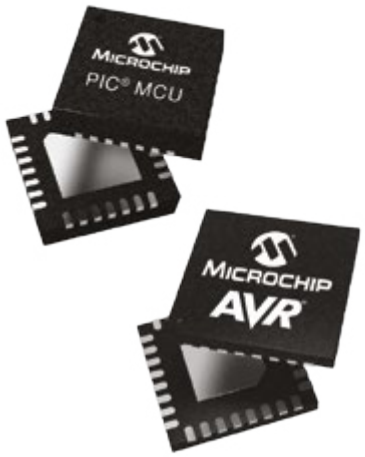
References

1. B. Whitaker et al., "A High-Density, High-Efficiency, Isolated On-Board Vehicle Battery Charger Utilizing Silicon Carbide Power Devices," in IEEE Transactions on Power Electronics, vol. 29, no. 5, pp. 2606-2617, May 2014.
2. R. Bosshard and J. W. Kolar, "All-SiC 9.5 kW/dm3 On-Board Power Electronics for 50 kW/85 kHz Automotive IPT System," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 5, no. 1, pp. 419-431, March 2017.
3. H. Kabza et al., "Cosmic radiation as a cause for power device failure and possible countermeasures," Proceedings of the 6th International Symposium on Power Semiconductor Devices and Ics, Davos, 1994, pp. 9-12.
4. C. Felgemacher et al., "Cosmic radiation ruggedness of Si and SiC power semiconductors," 2016 28th International Symposium on Power Semiconductor Devices and ICs (ISPSD), Prague, 2016, pp. 51-54.

PIC® & AVR® MCUs

Together Your Possibilities are Unlimited

You have a desire to make technology smarter, more efficient and accessible to everyone. Microchip has a passion for developing products and tools that make it easier for you to solve your design problems and adapt to future needs. Microchip's portfolio of more than 1,200 8-bit PIC® and AVR® microcontrollers is not only the industry's largest—it incorporates the latest technologies to enhance system performance while reducing power consumption and development time. With 45 years of combined experience developing commercially available and cost-effective MCUs, Microchip is the supplier of choice due to its strong legacy and history in innovation.



Key Features

- Autonomous peripherals
- Low-power performance
- Industry-leading robustness
- Easy development

microchip DIRECT
www.microchipdirect.com

MICROCHIP

www.microchip.com/8bitEU

EiceDRIVER™ and CoolMOS™ CFD2 Join for High Efficiency in Refrigeration

Home appliances, which run 24h and 7 days a week, have high efficiency requirements. Therefore, the use of MOSFETs is preferred over IGBTs. Modern MOSFET technologies based on the superjunction principle are nevertheless difficult to control in motor drive applications. This article describes the basic considerations for a successful gate drive circuit design and explains the benefits of combining EiceDRIVER™ ICs and CoolMOS™ CFD2.

By Wolfgang Frank, Infineon Technologies AG

Commutation cell analysis of BLDC drives

A half-bridge cell as depicted in Figure 1 is enough to study the switching behaviour of all FETs. S1 and S2 are switching in a buck configuration, S4 is turned on permanently to provide the return current path. S1 is the active switch. The inductor current ramps up when S1 is turned on. S2 is the rectifier switch, its body diode carries the inductor current when S1 is off and the inductor current ramps down. This mode of operation takes place for one third of the motor's cycle. Then the same operation moves to the next half-bridge. The switch mode operation of MOSFETs causes high *dv/dt* and *di/dt*.

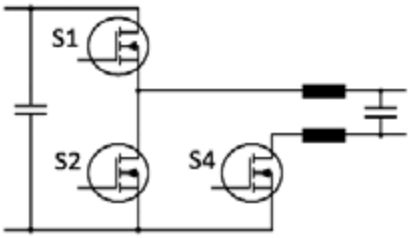


Figure 1: Switching cell

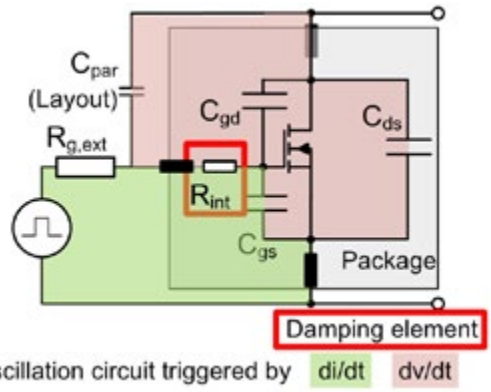


Figure 2: Parasitic elements of the MOSFET, package, layout and driver

A major risk of high *dv/dt* is shoot through. S1 is turned on and the resulting *dv/dt* across S2 couples to its gate and a voltage spike appears. If the coupling spike is high enough to reach the FET's gate threshold voltage, then both FETs in the bridge will be on for a short period of time, causing failures also in components such as shunt resistors or electrolytic capacitors.

Another risk is gate oscillation, which can be triggered at turn-on. High *di/dt* causes a voltage drop across the source inductance of the FET's package and layout. This voltage forms a negative feedback to the driving voltage, causing the FET's gate to resonate as depicted in Figure 3.

Additionally, high *dv/dt* at turn-off can couple to the gate through the drain-gate capacitance, causing oscillations.

These concerns are related to the FET's parameters, package and layout parasitics as shown in Figure 2. These have to be addressed by the gate driver design.

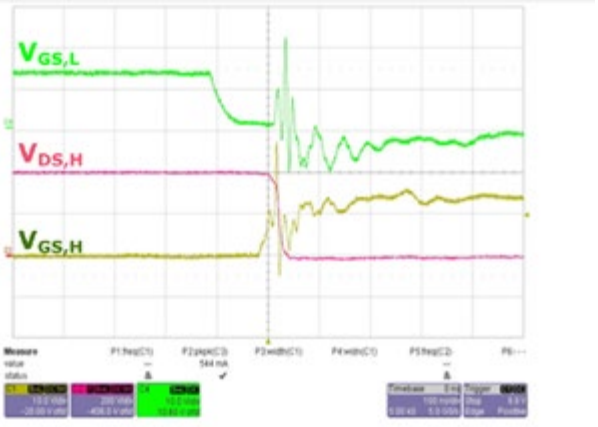


Figure 3: Strong oscillations during turn-on of a MOSFET

Origin of *dv/dt* and application effects

The *dv/dt* takes place during the charging period of the reverse capacitance C_{rss}, according to Figure 2 represented by the charge Q_{gd}. Hence, the C_{gd} value and the charging current level are two factors that affect *dv/dt*. Higher gate resistance R_g value means charging C_{rss} with lower current which extends the miller plateau time and reduces *dv/dt*.

The current change rate dI_{rec}/dt during reverse recovery of the MOSFET´s body diode generates a voltage across the parasitic source inductance which is a positive feedback to the driving voltage. It causes a faster charging of C_{rss} and higher *dv/dt*. Diodes with snappy recovery behavior lead to higher *dv/dt*. Moreover, the snappiness increases the voltage overshoot on S2, caused by the loop inductance.

During turn-off, the non-linear capacitance C_{oss} in Super-Junction FETs like CoolMOS™ CFD2 and the low C_{oss} values at high voltages V_{ds} lead to increased *dv/dt*. This provides a low switching loss and fast voltage transition but also requires careful layout- and gate driver design techniques considering the higher *dv/dt*.

Proposed gate circuit design for CoolMOS™ CFD2

Figure 4 shows a proposed schematic using CoolMOS™ IPD65R420CFD. Mainly a capacitor C_{ds}=0.47nF is added to each bridge´s switch node to limit and linearize the *dv/dt*. This is the most reliable approach to prevent the shoot-through and resonance problems. In motor drive applications, the typical switching frequency is low, therefore the added capacitor C_{ds} only has a minor impact on the switching losses. Other driving parameters are chosen considering:

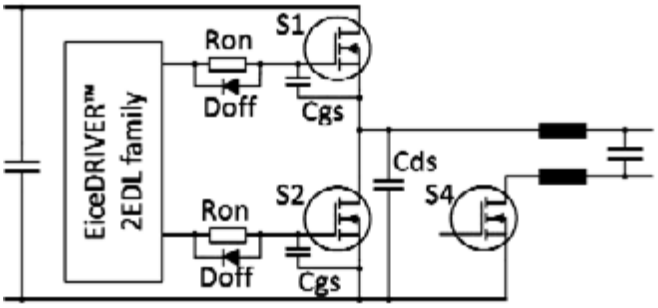


Figure 4: Proposed gate circuit schematic for CoolMOS™ CFD2 using EiceDRIVER™2EDL family

- R_{on} = 1000 Ω → slower turn on, longer plateau, reduced *dv/dt*.
- R_{off} = 0 Ω → Lower impedance to GND when turned off, lower voltage coupling spike.
- C_{gs} = 0.47nF → reduced C_{rss}/C_{iss} ratio, reduced drain-gate or Miller coupling gain.
- C_{ds} = 0.47nF → controlled / linearized *dv/dt* at turn on, this has the benefit of removing gate oscillation and reduce EMI.

The circuit is operated by a 2EDL05N06PF EiceDRIVER™ IC. Based on Infineon´s SOI technology, it provides excellent robustness against negative transient voltages [3]. The excellent properties of the integrated bootstrap diode supports the requirements of high power density and cost-performance ratio.

Layout recommendations

Figure 5 depicts a layout with minimized stray inductance due to the short distance between high side source terminal and low side drain terminal. The low side transistors on the bottom layer are shifted to the left side with respect to the high side transistors on the top layer. This leads to a thermal decoupling of both transistors. Furthermore, the low side transistors move even closer to the respective gate resistors. The shift also allows that the drain terminals of the low side transistors move directly underneath the source terminals, so that an appropriate number of vias provides a close connection to the high side source terminals. Hence, the loop inductance is minimized. A double sided assembly can be avoided when placing the low side transistors appropriately onto the top layer. This of course will lead to higher area consumption.

In general, these layout guidelines are recommended for reducing noise and resonance in the gate drive loop:

- Gate driver as close as possible to the gate.
- Minimum external capacitance gate to drain.
- Slow down *dv/dt* by properly choosing gate resistor R_g.
- Separate power ground from gate driver ground.
- R_g as close as possible to the gate pin.
- Use thick trace between gate driver and gate.

The physical proximity of the gate resistors to the gate terminals in combination with the reduced stray inductances leads to an improved performance and excellent switching behavior of the CoolMOS™ transistors. A turn-on waveform of the proposed driving circuit design is given in Figure 6. It shows a clean gate signal free of oscillations and the drain-source voltage slowly ramping down to 0V during the Miller plateau region, too.

The same behavior can be expected for the other two switching bridges given that the layout and driving circuit is the same.

Conclusion

CoolMOS™ CFD2 offers efficiency benefits in motor drive applications. The proposed gate drive circuit design using the EiceDRIVER™ 2EDL family ensures an oscillation-free switching. This leads to the conclusion that CoolMOS™ CFD2 can be efficiently and reliably operated in drives systems. Additionally, Infineon´s SOI technology which is used for the 2EDL family provides a high robustness with respect to *dv/dt* in motor drive applications and an excellent controllability of CoolMOS™ CFD2.

References

1. R. Mente, F. Di Domenico, M.A. Kutschak, A. Steiner: CoolMOS™ CFD2 first 650 V rated super junction mosfet with fast body diode suitable for resonant topologies, Application Note, Infineon Technologies, February 2011.
2. W. Choi, D. Son, M. Hallenberger S. Young: Driving and Layout Requirements for Fast Switching MOSFETs, Fairchild Semiconductor Power Seminar 2010-2011, Fairchild, 2011.
3. J. Song, W. Frank: Robustness of level shifter gate driver ICs concerning negative gate voltages; Proceedings of PCIM 2015, Nuremberg, Germany, 2015.

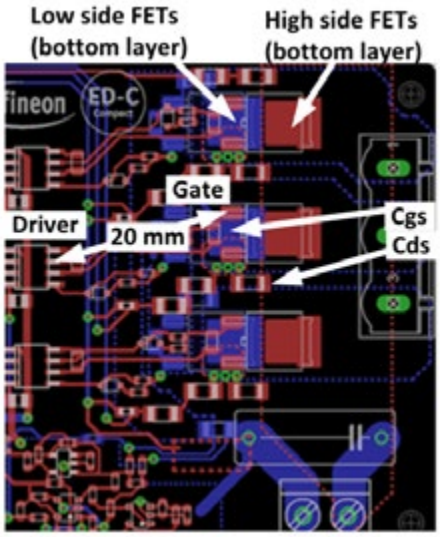


Figure 5: Example of a layout with minimized stray inductances by means of double side assembly

www.infineon.com

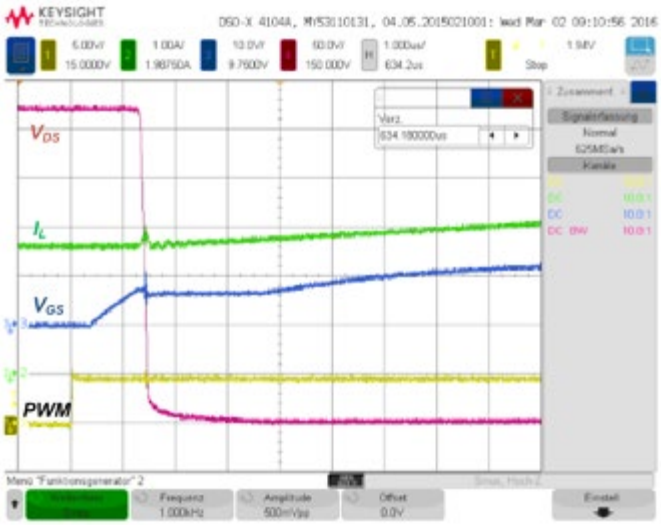


Figure 6: Turn-on waveforms at DC-link voltage V_{DC} = 320 V and load current I_L = 2.5 A. V_{DS} (red, 50 V/div), I_L (green, 1 A/div), V_{GS} (blue, 10 V/div), PWM (yellow, 5 V/div), time scale 1 µs/div]

Vincotech

FOR 10+ YEARS

YOUR RELIABLE MiniSKiiP® PARTNER FOR REAL CHIP-LEVEL MULTI SOURCING

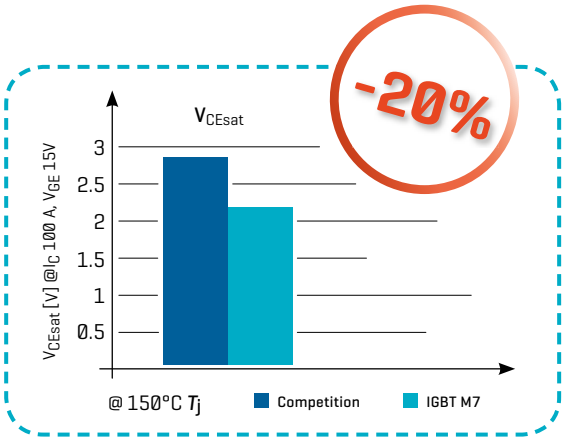
INDUSTRIAL | EMBEDDED | SMPS

MiniSKiiP® Now Also Featuring IGBT M7

Vincotech has extended its range of MiniSKiiP® products with the new IGBT M7 chip. These modules raise the performance bar for motion control applications with this latest-gen chip technology. This new IGBT M7 chip or the Trench IGBT4 – the choice of semiconductor is all yours. Our comprehensive MiniSKiiP® product portfolio encompasses PIMs, sixpacks, half-bridges, and rectifier-plus-brake configurations with nominal currents ranging up to 400 A.

Main benefits

- Solder-free SPRiNG technology for super-fast assembly
- No copper baseplate for enhanced cost efficiency
- Choice of standard IGBT4s or the latest IGBT M7 chip technology with 20 % lower static losses and superior EMC
- Pre-applied, high-performance TIM to cut manufacturing costs
- Combination of phase-change material and Si_3N_4 DCB for more output power or longer life



www.vincotech.com/MiniSKiiP

EMPOWERING **YOUR IDEAS**

Half-Bridge vs. Sixpack Modules for Motor Drives

The use of one power module for each phase is state-of-the-art in solar and UPS applications even at relative small power ratings whereas in drive applications a single module for the whole application is commonly used.

By Patrick Baginski, Vincotech GmbH, Unterhaching/Germany

PIM or Sixpack modules are most often used for low and medium power applications such as 3 phase motor drives since these modules have all the semiconductor switches in one housing. This simplifies the heat sink assembly because only one or two screws are required to mount these modules. A question which often arises is if lower semiconductor junction temperatures can be achieved by using a single Sixpack module or by using three individual half-bridge single leg modules for a 3 phase inverter stage design.

In solar and UPS applications, it is state-of-the-art to use one half-bridge module for each phase whereas a single Sixpack power module is commonly used for motor drive applications. Several differences between these two applications are obvious:

On the one hand, variable frequency drives (VFDs) are designed in so call frame sizes. One frame size can have several power ratings. For the highest power rating of a given frame size, the power module's layout area is fully occupied with semiconductors and in the smallest power rating, the same module footprint and pinning is used with much smaller semiconductor die sizes. If a higher power rating is required, the next power module size is considered which usually results in a larger frame size. In contrast to solar and UPS applications, no consideration for frame sizes exists since these inverters are not assembled in control cabinets where the width and the height is limited.

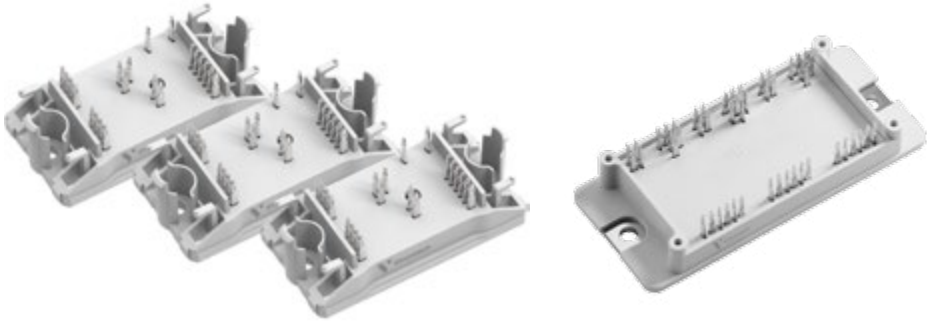


Figure 1: 3 x flow 0 housings vs. 1 x flow 2 housing

Solar and UPS applications provide a fixed grid frequency of 50 Hz or 60 Hz which leads to a lower ripple and variations in the semiconductor's junction temperature. In contrast, many motor drive applications have to provide full power even at a rotor speed of 0 RPM which leads to high stresses on the bond wires due to high currents. This requires the VFD to be designed to support an overload current capability as high as 300 % in some applications. This means that the inverter has to be designed and be able to provide 3 times the nominal inverter current for a specified time period which can last for many cycles.

UPS applications do not have to deal with these high currents too often. The high current requirements for UPS applications are lower and are only necessary to open circuit breakers and fuses during failures and fault conditions. Solar applications do not have these high overload current requirements at all.

Three module versus single module approach

The most important parameter to consider in this comparison is the junction temperature of the semiconductors under a given condition and environment. Figure 2 shows two simulation results with a given aluminum heat sink at an ambient temperature of 40 °C and an air flow of 3 m/s blowing from the bottom through the heat sink fins. The heat sink base has a thickness of around 8 mm and the fins have a length of 50 mm. The left picture shows the temperature rise of three half-bridge modules using an Al_2O_3 DCB each with 60 W losses and the right picture shows a Sixpack module based on a 3 mm copper baseplate with 180 W losses. For this comparison, the same current rating and semiconductor technology and material is considered. The spacing between these three modules is selected to be 13 mm, and the modules are positioned on the left side of the assembly to allow space for the input filter, control board, etc. located on the right side of the assembly.

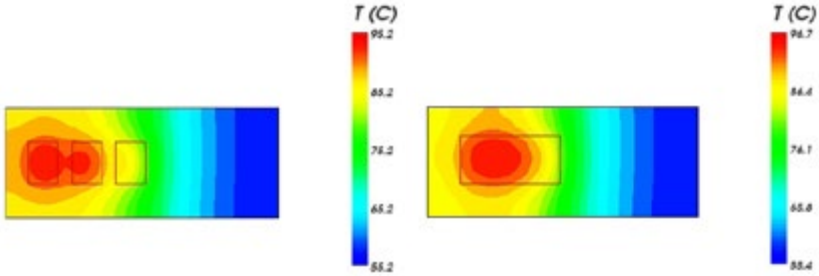


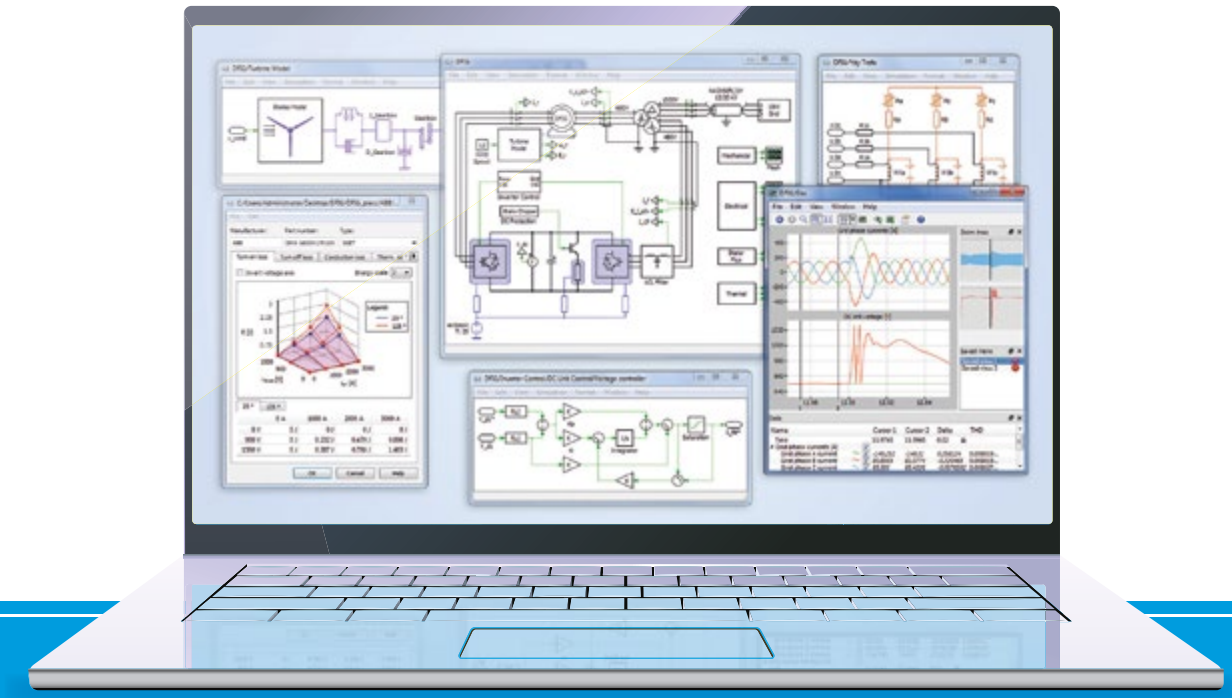
Figure 2: 3x flow 0 Al_2O_3 with each 60 W losses vs. 1x flow 2 with 180 W losses

Comparing these two thermal images, it can be seen there is little difference in the heat sink base temperature profile. Using the given R_{th} values from the modules' datasheet, the semiconductor junction temperature can be calculated and are shown in Table 1:

plexim
electrical engineering software

plecs

THE SIMULATION SOFTWARE PREFERRED
BY POWER ELECTRONICS ENGINEERS



MODELING DOMAINS

- Electrical
- Control
- Thermal
- Magnetic
- Mechanical

KEY FEATURES

- Fast simulation of complex systems
- Code generation
- Frequency analysis
- Available as standalone program or Simulink blockset

Get a free test license
www.plexim.com/trial

No real advantage can be seen from this comparison. In contrast, there seems to be a disadvantage if three individual half-bridge modules are used instead of a single Sixpack module. The reason for these poor results is because the three individual half-bridge modules were placed too close to each other and the worse R_{th} due to the missing baseplate resulted in higher junction temperatures. The RMS current chosen in these examples was only 1/3 of the nominal 75 A chip current rating and was driven with a switching frequency of approximately 5 kHz.

	3x *flow* 0 Al_2O_3	1x *flow* 2
Module losses / W	60	180
Heat sink temperature / °C	95	97
IGBT Junction temperature / °C	112	108
Diode Junction temperature / °C	102	92

Table 1: Losses and temperatures of 3x flow 0 Al_2O_3 and 1x flow 2

The next simulation shown in Figure 3 shows the temperature distribution on the heat sink when the three half-bridge modules were spaced further apart and placed in an optimized arrangement.

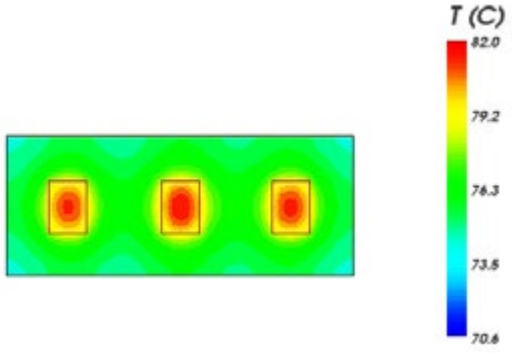


Figure 3: 3x flow 0 Al_2O_3 with each 60 W losses optimally distributed

The temperatures are shown in the Table 2:

	3x *flow* 0 Al_2O_3
Module losses / W	60
Heat sink temperature / °C	82
IGBT Junction temperature / °C	99
Diode Junction temperature / °C	89

Table 2: Losses and temperatures of 3x flow 0 Al_2O_3 optimal located

In this case the semiconductor junction temperatures of the optimally distributed modules were 13 K lower compared to a single power module located on the left side. This is exactly the difference of the heat sink temperature compared to the simulation where the three individual modules were closely spaced. However, the complete mechanical assembly concept needs to be considered when placing other components around these modules to optimize these lower temperatures.

Handling three smaller power modules can be more difficult than handling a single larger module. Another challenge might be the module's housing tolerance. Different module heights after soldering results in stresses on the PCB and the components mounted on these PCBs. Pull forces on the pins of the power module have to be avoided to minimize mechanical stresses. To eliminate the challenge of different module height tolerances, all power modules at Vincotech are also available with Press-fit pins. With this highly reliable interconnection technology all modules can be pressed into the PCB and maintain the same height to the heat sink assembly eliminating possible mechanical stresses.

One crucial factor to take into consideration for this comparison is the total cost of ownership. It is difficult to estimate the costs for changing the location of other components such as capacitors and inductors placed around the module. It is also difficult to estimate the costs of assembly due to different manufacturing processes and locations. However, as a module manufacturer the costs of the different sized power modules are known and a price comparison of the different options can be made.

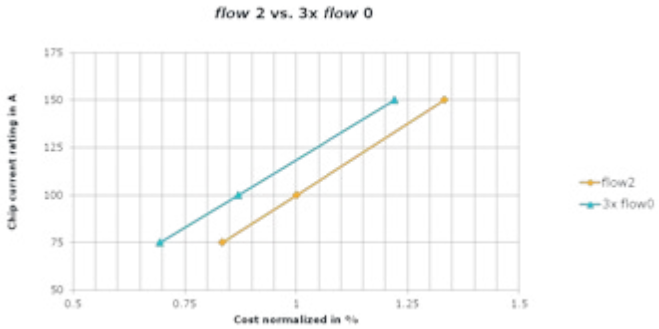


Figure 4: flow 2 vs. 3x flow 0

As can be seen in Figure 4, the *flow* 2 Sixpack module is slightly more expensive when compared to three *flow* 0 half-bridge modules with the same chip current rating. This is because of the additional copper baseplate of the *flow* 2 module that holds 3 DCBs with one half-bridge on each DCB. From a cost perspective the difference between these two options is 10 % to 15 % dependent on the current rating.

Conclusion

The implementation of three *flow* 0 half-bridge modules instead of one Sixpack *flow* 2 module for motor drive applications was considered in this discussion. The resulting junction temperatures depends highly on how well multiple power modules can be placed on a given heat sink to distribute the heat generated in these modules. Three *flow* 0 half-bridge modules placed close to each other will result in an even higher junction temperature of the semiconductors compared to one *flow* 2 Sixpack module. An optimized distribution of *flow* 0 half-bridge modules results in a much lower junction temperature. Also, from a cost point of view, the *flow* 0 half-bridge module without a massive copper baseplate is less expensive in this approach. If multiple modules are handled correctly, their maximum semiconductor junction temperature and their total cost of ownership can both be lowered.

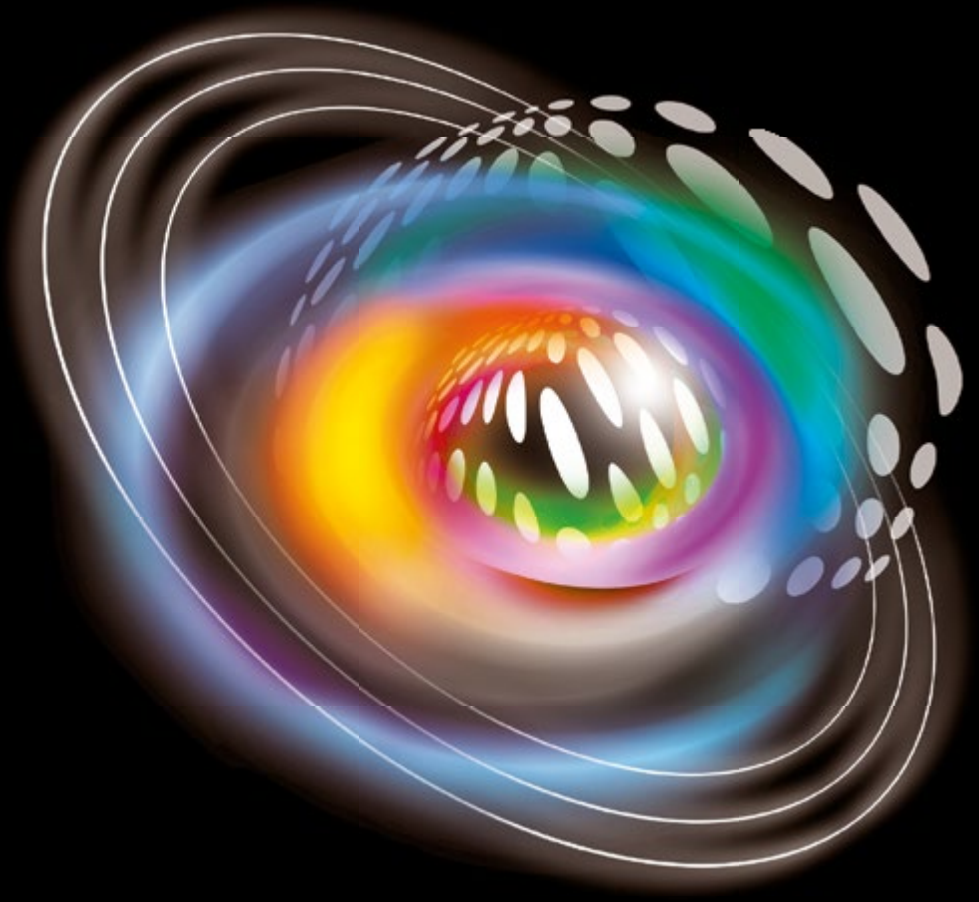
www.vincotech.com

LpS 2017

LED professional SYMPOSIUM +EXPO

OPEN EVENT BROCHURE

www.lps2017.com/brochure



7TH International

LED professional Symposium +Expo

Smart Technologies for Lighting Innovations

SEPTEMBER 2017

26TH - 28TH

BREGENZ

AUSTRIA

www.lps2017.com

Organized by Luger Research e.U.

A Performance Comparison of GaN E-HEMTs Versus SiC MOSFETs in Power Switching Applications

Research on wide bandgap (WBG) devices has been conducted for many years. The reason that the properties of Gallium Nitride (GaN) and Silicon Carbide (SiC) excite power engineers is because they show substantial performance improvements over their silicon-based counterparts.

By Jason (Jianchun) Xu, Di Chen, GaN Systems Inc.

Both GaN and SiC have material properties superior to Si for switching power devices. WBG devices offer five key characteristics, including high dielectric strength, high-speed switching, tolerance of high operating temperature environments, high current density, and low on-resistance. However, currently, there are few papers that compare how GaN and SiC devices perform in real power switching applications. In this article, we present the results of a head-to-head comparison of GaN E-HEMTs and SiC MOSFETs used in a DC-DC synchronous buck converter application. Due to lower internal capacitances and zero reverse recovery charge, we conclusively demonstrate that GaN E-HEMTs offer significant improvements in power conversion efficiency, especially at higher frequencies.

Figure 1: GS66508T-EVBDB

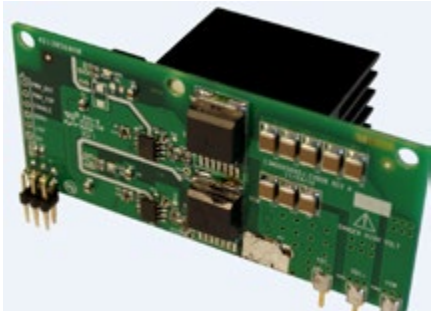


Figure 2: C3M0065090J-EVBDB

Figure 3: Bottom-side of GS66508T-EVBDB

Figure 4: GS665MB-EVB

For this study, the performance of the GaN transistor GS66508T (650 V/ 30 A, 50 mΩ) from GaN Systems Inc. was compared with the SiC MOSFET C3M0065090J (900 V/ 35 A, 65 mΩ) from CREE Inc. To simplify comparing the GaN E-HEMT and SiC MOSFET, the test used a common evaluation motherboard GS665MB-EVB, paired with an interchangeable daughterboard (Figures 1-4). These boards are configurable either as a buck, boost or double-pulse tester. The two daughterboards also have a very similar design. They both contain the same PCB layout, 2 oz. copper, 4 PCB layers, homogeneous thermal via and layout parasitics. The very fast switching speeds exhibited by GaN and SiC transistors require gate drivers that combine very high timing accuracy with excellent common-mode transient immunity (CMTI). To accommodate these criteria, Silicon Labs' Si8271 isolated gate driver with high CMTI was used on both daughterboards.

Table 1 shows the electrical characteristics of the GaN E-HEMT GS66508T and the Cree SiC MOSFET C3M0065090J. These characteristics have a major influence on the fundamental performance of the devices.

A half-bridge, hard switching, double pulse test was conducted under 400 V/ 15 A on both GaN and SiC daughterboards. The turn-on resistor Rg(on) was 10 Ω, while the turn-off resistor Rg(off) was 1 Ω. The results of two double pulse switching tests follow. Figure 5 and

	GaN E-HEMT GS66508T	*Cree SiC MOSFET C3M0065090J*
Package	Low inductance GaN*PX*™	D2PAK
VDSmax	650 V	900 V
ID@25°C	30 A	35 A
RDS(on)@25°C	50 mΩ	65 mΩ
VGS	-10/+7 V	-4/+15V
Ciss	260 pF	660 pF
Coss	65 pF	60 pF
Crss	2 pF	4 pF
Qg	5.8 nC	30.4 nC
Qgs	2.2 nC	7.5 nC
Qgd	1.8 nC	12 nC
Qrr	0 nC	245 nC

Table 1: Electrical Characteristics

Figure 6 show a close-up view of the turn-on and turn-off periods, and demonstrate the switching performance of the GaN E-HEMT GS66508T versus the SiC MOSFET C3M0065090. In the turn-on period, dv/dt of the GaN E-HEMT reached 90 V/ns, 4X faster than the SiC MOSFET 18 V/ns. In the turn-off period, dv/dt of the GaN E-HEMT performed 2X faster than the SiC MOSFET.

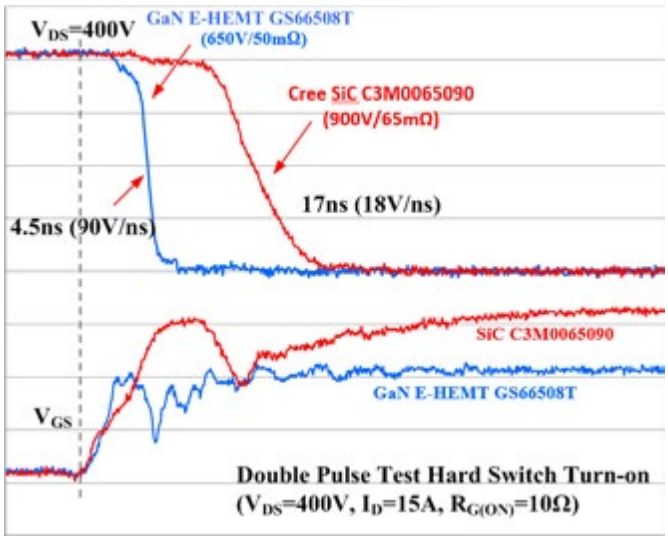


Figure 5: Double Pulse Test Hard Switch Turn-on

Figure 7 shows the switching loss measurements with a drain-to-source voltage of 400 V, drain current from 0 to 30 A for GS66508T and C3M0065090J. The turn-on loss dominated the overall hard switching loss. For GaN E-HEMT, Eon at 0 A is the Qoss, caused by the Coss at the high side switch. For the SiC MOSFET, Eon at 0 A is the sum of Qoss and the reverse recovery charge Qrr at the high side switch. Using the same test conditions, the GaN E-HEMT shows a much improved Eon/Eoff. The Eon/Eoff difference between GaN and SiC can be quantified by calculating the switching loss: (Eon+Eoff)×fsw. For example, at 400 V/ 15 A, and 100 kHz, the switching loss Psw of GaN is 5.217 W, while the Psw of SiC is 15.211 W, ΔPsw=9.994 W. However, at 200 kHz, the Psw of GaN is 10.434W, versus a SiC Psw of 30.422 W, ΔPsw=19.988 W. The result, shown

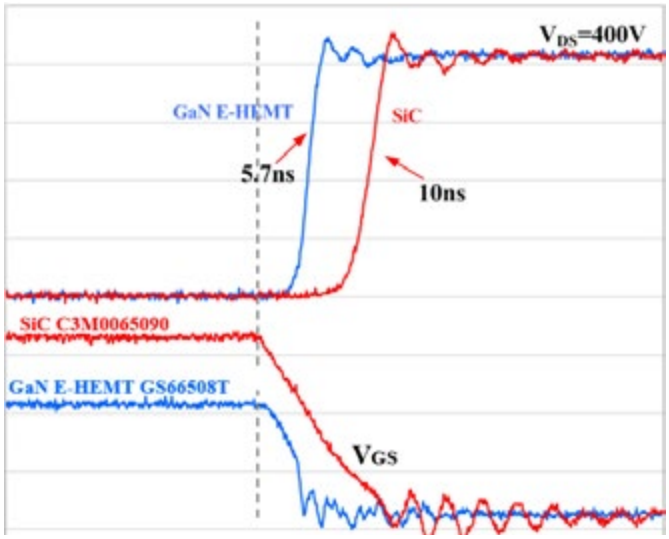


Figure 6: Double Pulse Test Hard Switch Turn-off

in Fig. 8, clearly shows that at higher switching frequencies, GaN provides a significant performance improvement over SiC. For instance, at 100 kHz, GaN provides 10 W savings, but in the same system at 200 kHz, 20W is saved.

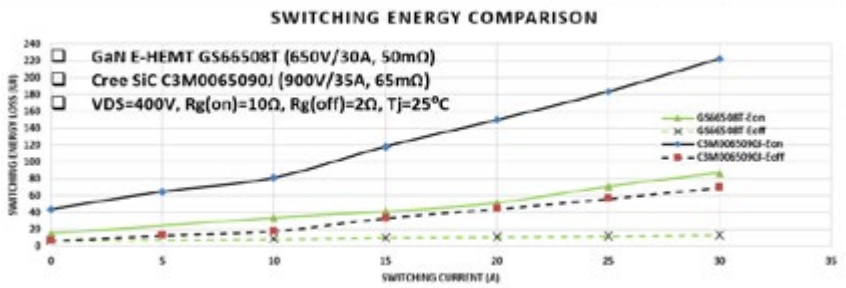


Figure 7: Switching Energy of the GS66508T versus the C3M0065090J

Figure 8: 400 V/ 15 A GS66508T and C3M0065090J Switching Loss Comparison

To measure the thermal resistance of both devices, a 35x35 mm heatsink was mounted on bottom of both daughterboards. In addition, an electrical fan with an air flow of 12.0 CFM (0.340 m3/min) was attached to the heatsink. Using the same test conditions, for the C3M0065090J measured 7.724°C / W, versus an for the GS66508T of 5°C / W. The thermal resistance from junction to ambient of GaN measured 1.5X better than SiC, as shown in Figures 9-11.

A synchronous buck converter with an input voltage of 400 V and an output voltage of 200 V was tested. At a 200 kHz switching frequency, the output power varied from 100 W to 1 kW. Figure 12 compares the sync buck converter system efficiencies and the device's hard-switching junction temperature using GaN E-HEMTs versus SiC MOSFETs. The graph

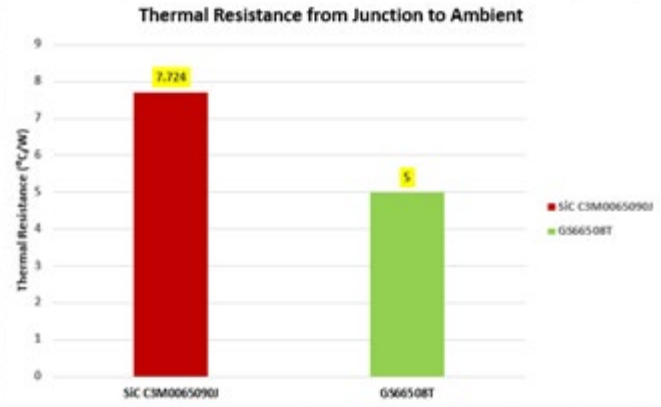


Figure 9: Thermal Resistance Comparison of GaN vs. SiC

shows that the efficiency and junction temperature using GaN E-HEMTs performed better than SiC MOSFETs under same test conditions. Power loss of the devices was equal to $\frac{Tj\text{-}Tamb}{Rth(JA)}$.

Figure 10: GS66508T Thermal Resistance Setup

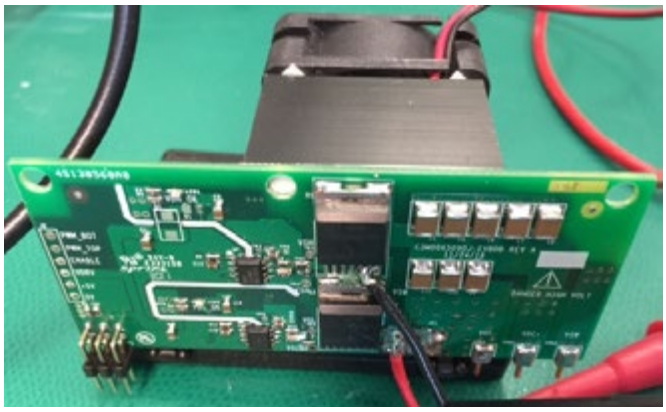


Figure 11: C3M0065090J Thermal Resistance Setup

From 0 to 1 kW, at 200 kHz GaN Ploss is only 45%-59% that of SiC. Table 2 shows the performance improvement of GaN E-HEMTs over SiC MOSFETs at an output power of 900 W. At Pout = 900 W, the Tj of the GaN E-HEMT was 59°C lower than the SiC MOSFET, and the power loss of GaN was 5.38 W lower than that of SiC. The superior performance of GaN versus SiC can be attributed to its lower Eon/Eoff. Because the conduction loss was small, the switching loss (Eon+Eoff)*fsw accounts for over 85% of device's total power loss. Hence, as the switching frequency increases, GaN E-HEMTs will perform better than SiC MOSFETs.

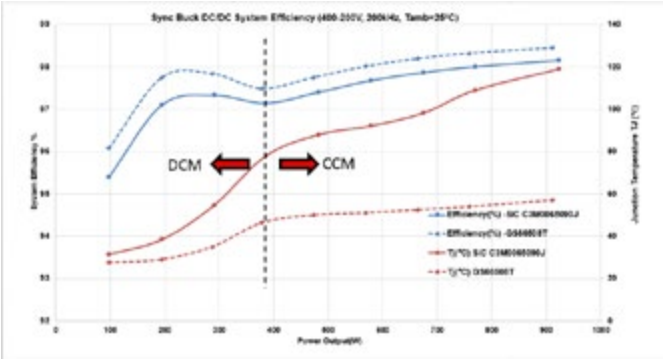


Figure 12: Synchronous Buck DC/DC System Efficiency (400 V - 200 V, 200 kHz, Tamb = 25°C)

Pout 900 W	Tj Fsw = 200 kHz	Ploss Fsw = 200 kHz	ΔTj Fsw = 200 kHz	ΔPloss Fsw = 200 kHz
GaN GS66508T	57°C	6.4 W	59°C	5.38 W
SiC C3M0065090J	116°C	11.78 W		

Table 2: Power Loss and Junction Temperature Comparison at Pout = 900 W

Conclusion

This article compares the fast switching device characteristics of GaN E-HEMTs versus the best competing SiC MOSFETs. When used in synchronous buck DC/DC converter applications, the converters that use GaN E-HEMTs exhibit much higher efficiencies than ones that use SiC MOSFETs. In this application, the results clearly demonstrate that the performance of GaN E-HEMTs exceeds the performance of the best SiC MOSFETs in terms of switching speed, parasitic capacitance, switching loss and thermal characteristics. Furthermore, compared with their SiC counterparts, GaN E-HEMTs facilitate the construction of significantly more compact and efficient power converter designs.

www.gansystems.com

Innovative Remote Sense Approach for Power Supply Test & Measurement Systems Eliminates Potential Problems

Remote sense is an effective voltage-regulation technique used in test and measurement applications and is often critical to achieving accurate and repeatable test results. A new and innovative approach to remote sense in programmable power supplies eliminates the remote sense wires – and all their potential noise problems.

By David Hoffman, VP Engineering, Versatile Power

Traditional Approach to Remote Sense

Remote sense is a well-established method for accurately regulating the DC power at the point of load by eliminating the effect of voltage drops in the connecting cables. This is particularly important in test and measurement applications where the accuracy and consistency of the power supply voltage over a range of load conditions is often critical to achieving accurate and repeatable test results.

Figure 1 illustrates the sense arrangement in a power supply that does not use a remote sense connector. In this example, a high input impedance sense amplifier in the power supply, combined with an error amplifier, controls the output voltage as the load varies.

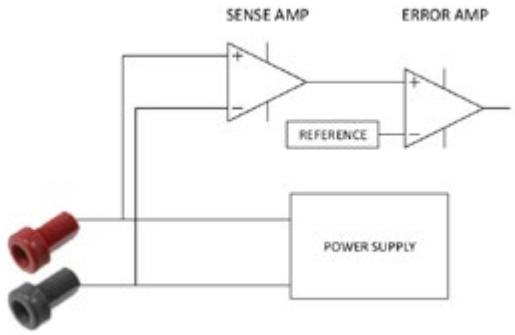


Figure 1: Basic power supply load regulation without remote sense

Figure 2 illustrates a power supply using a typical remote sense configuration. Remote sense tightly regulates the power supply voltage at the point of load by compensating for the voltage drop across the wiring connecting the power supply to the load. A power supply with conventional remote sense includes a second pair of (sense) leads that originate at the load and then are directly connected to power supply's sense amplifier. Low value resistors, typically 10Ω to 100Ω, are used to connect the sense lines to the output terminals of the power supply. As long as the resistance of the sense wiring is much lower than these resistors, the sense amplifier will measure the voltage at the load. If no remote sense wires are connected to the load, then the sense amplifier is connected to the output via these low value resistors.

Drawbacks of Conventional "Wired" Approach

The conventional remote sense technique that depends on wires and connectors is fraught with potential problems – namely, noise interference in the remote sense lines and potentially damaging ground loops or reversed polarity connections. These drawbacks can limit its usefulness and accuracy. In addition, failure mechanisms associated with this topology frequently occur.

— Injected Noise

A common problem with the sense leads used in remote sense is that they are long and prone to picking up noise from the environment. Any noise picked up by the sense leads will be amplified by the power supply. This can result in a noisy output, oscillation of the power supply or even failure of the power supply.

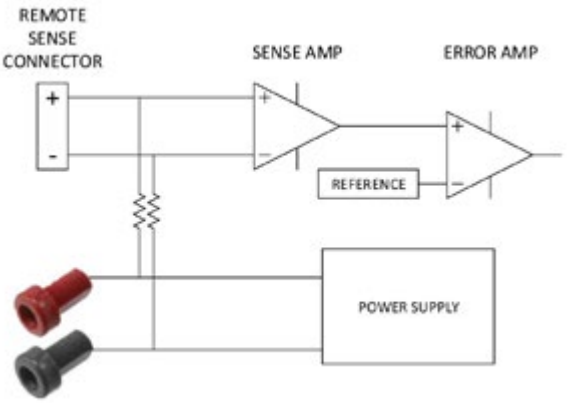


Figure 2: Power supply load regulation with remote sense compensates for voltage drop in the connecting leads

Care must be taken with the sense leads to avoid noise sources. The sense leads are often prescribed to be a twisted pair to minimize this problem. In some cases, the output leads of the power supply must be separated from the sense leads to eliminate problems. Small value resistors are typically used between the remote sense connector and the output, since if large-value resistors are used, the input impedance of the remote sense would be so high that the noise problem would be insurmountable. Unfortunately, the resistors cannot be made so small that there is no noise problem due to ground loop issues. In some cases, additional shielding of the remote sense wires is required in high noise environments.

Many power supply companies employing the typical approach to remote sense have had ongoing customer complaints and power supply failures that eventually were tracked back to injected noise issues.

— Ground Loops

Ground loop problems are a common cause for the return and repair of many power supplies. Any power supply, and particularly high-current power supplies, can create a significant voltage drop in the wires connecting the output of the power supply to the load. This is the reason remote sense exists. Unfortunately, should the leads to the load be undersized or become accidentally disconnected, damage to the power supply internal remote sense circuit can result. This occurs because any drop across the load wires is reflected across the two series resistors that are necessary in the sense circuit. Should either load wire momentarily open, or should the drop in the load wires be sufficient, the sense resistors will conduct enough current to cause them to fail.

In the case of remote sense, Versatile Power has developed a patent pending technique utilizing digital control to eliminate all the problems discussed above while providing additional benefits. With the Versatile Power BENCH XR power supply (Figure 3), no leads are required other than the power leads to the load, thus simplifying installation by eliminating the extra wires. This solution is just as accurate as wired remote sense without the associated risk.

Remote sense is accomplished by determining the resistance of the leads to the load. Once this data is known, then Ohm's Law can be used to determine the voltage needed on the output of the power supply to get the proper voltage on the load. By applying the versatility of its digital control,

Figure 3: The Versatile Power Bench XR power supply uses patent pending digital remote sense to eliminate wires

— Reversed Polarity

Reversed polarity, unfortunately, happens all too frequently in applications. If, during set-up, the remote sense leads are inadvertently connected in reverse, the destruction of the sense resistors is a highly probable outcome. The power supply's overcurrent protection will likely limit the damage, but the sense resistors will most likely need replacement.

Benefits of New "No Wires" Approach

Most of the test and measurement power supplies on the market today are designed with analog control loops. Many have digital front panels and digital interfaces for the user but the actual control of the power supply is still done with analog circuits. Through full digital implementation a programmable power supply can be controlled in many ways that are simply not possible with an analog control loop. The control loop can be changed in real time, for instance, to accommodate many types of loads. Power supply performance can also be easily tailored to meet specific customer needs.

the power supply can sense the output current and recalculate the output voltage requirement at the switching frequency of the supply. With this approach to remote sense, the power supply can respond to variations in the load current far faster than a wired remote sense scheme can.

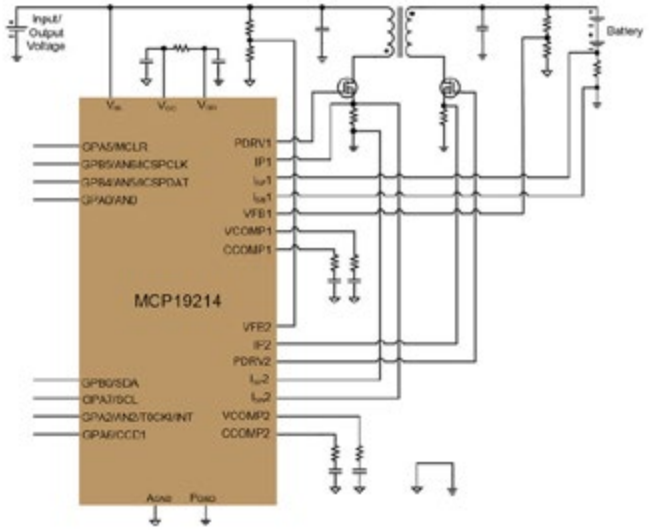
Setup is very easy. First, the power supply is connected to the load. Then, using an automated calibration procedure, the power supply leads are shorted at the load. The power supplies' digital signal processor then measures the lead resistance.

With this done, the short is removed from the load and the power supply will automatically compensate for any load variation. There is no possibility of picking up noise from sense wires. Also, there is no possible ground loop or reverse connections. And finally, there is no limit to the amount of load wire compensation voltage as there are no sense resistors that can be damaged.

https://versatilepower.com/

Single-Chip Digitally Enhanced Power Analog Solution for DC-DC Power Conversion

A Digitally Enhanced Power Analog product for DC-DC power conversion is now available from Microchip Technology Inc. The single-chip solution controls DC-DC converters and is capable of accepting a high voltage input (up to 42V) while simultaneously regulating a wide output voltage range (300 mV to several hundred volts, depending on topology). The device is ideal for industrial and automotive environments and is particularly suited for battery charging and LED drive applications. For more information, visit: www.microchip.com/mcp19215



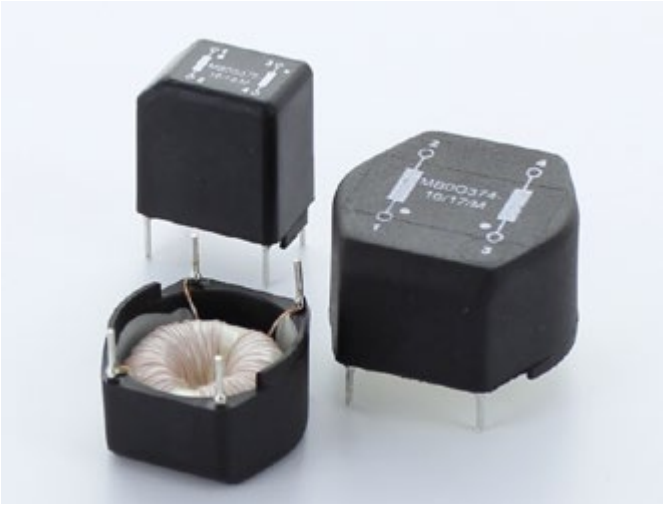
The MCP19215 is a dual controller, offering the ability to control two flyback, SEPIC, boost and/or Ćuk circuits simultaneously. The two circuits can even be different topologies. Alternatively, it can be configured to control one power train bidirectionally, maintaining voltage or current regulation in either direction through the power converter. This allows the circuit to dynamically switch between constant voltage and constant current operation, while also switching the direction of the power conversion. The benefits of this include the ability to use the same power supply to control both power in to and power out of a storage device (like a battery or a super-capacitor) while fuel gauging. In addition, it can switch automatically between sourcing and sinking power with a fast response time. This will maintain power on critical system voltage rails in a server or automation application, or conserve power in a renewable energy or automotive application.

All of the major performance parameters are completely configurable within the microcontroller core that is managing the analog control loops within the device. Current limit, operating frequency, fault responses, and over- and under-voltage lockouts can all be tailored to the application.

www.microchip.com

TCM Series of High-Reliability Common-Mode Inductors

Exxelia is pleased to introduce the TCM series of common-mode inductors. Designed and qualified to be compatible with aerospace and other high-reliability applications, the TCM series is a cost-effective solution for harsh environments.



Exxelia designed this extensive and cost-effective range to be an easy commercial (COTS) solution for aerospace, defense, and other high-reliability applications.

The TCM series is available in a through-hole package for horizontal or vertical mounting. TCM chokes are offered with inductances from 0.7 mH to 47 mH under rated currents from 0.3 to 4.0 A. Each unit is thoroughly tested with a dielectric withstanding strength of 1,500 VAC. Excellent thermal properties allow the series to operate from -55° C to +125° C. The high mechanical performance of the component materials (all meeting to UL94 V0 rating) makes TCM a perfect fit for aviation, defense and transportation industries.

The TCM series of common-mode chokes is designed into circuit boards of a large number of power electronic devices used for a wide range of applications, including switch-mode power supplies and converters, inverters, battery management systems, and chargers. Exxelia's TCM series fully complies with the requirements of RoHS and REACH.

www.exxelia.com

pcim
ASIA

International Exhibition and Conference
for Power Electronics, Intelligent Motion,
Renewable Energy and Energy Management

Power for Efficiency

27 – 29 June 2017

Shanghai World Expo Exhibition and Convention Center
Shanghai, China

www.pcimasia-expo.com

mesago
Messe Frankfurt Group

messe frankfurt

Programmable Supplies Feature Remote Sense without Wires

Versatile Power, producer of programmable bench and OEM power supplies, introduces its BENCH XR line of 600W programmable supplies. BENCH XR power supplies are the industry's first to provide accurate point-of-load voltage regulation over a wide range of load conditions – without the use of an auxiliary remote sense circuit. Remote sense is implemented utilizing the Versatile Power's patent-pending digital control to instantaneously adjust the voltage at the output terminals in response to changes in output current. This innovative technique eliminates output noise that is often introduced by conventional remote sense wiring. In addition, by eliminating the remote sense wiring, the BENCH XR is not susceptible to failures caused by ground loops or reverse polarity sense wiring connections. The BENCH XR series of 600W programmable power supplies are packaged in a compact, 1U, ½-rach width enclosure. Five models provide for output voltage and current ranging from 30V to 400V and 2.5A to 33 A. Digital display of output current and point-of-load voltage is provided. Multiple standard I/O interfaces (Ethernet, USB 2.0 and analog) facilitate setup and operation of test protocols. The BENCH XR series is compatible with LXI Class C specifications and supports the Standard Commands for Programmable Instruments (SCPI) language.

www.versatilepower.com

Superjunction +FETs™ Push Performance Envelope

D3 Semiconductor, a company bringing together affiliated semiconductor companies and top-talent experts, announces its inaugural entry into the power semiconductor market with the launch of its

+FET™ line of 650V-rated superjunction MOSFETs. +FET MOSFETs enable high-efficiency solutions for a range of hard-switched applications, including PFC boost and inverters used in telecom, enterprise computing, UPS and solar.

The +FET product roll-out includes over 50 devices with 13 different RDS(ON) ratings ranging from 1000 mOhms to 32 mOhms. Packages types include: traditional thru-hole (TO-220/TO-220FP), surface-mount (DPAK/D2PAK) and advanced surface-mount (5x6/8x8) devices. For all package sizes and ratings, D3 Semiconductor's +FET devices exhibit a Qg RDS(ON) FOM (Figure of Merit) that is among the highest available.

The high efficiency of the new +FET MOSFETs, gained by lowering switching and conduction losses, helps to simplify thermal management. The devices' smooth switching behavior reduces switching noise and drives faster design cycles by lowering the need for snubber circuits. Their advantage of higher ampacity per package type improves power supply density, which in turn enables the use of advanced surface-mount packages in higher power designs.

"In addition to the +FET's excellent performance and reliability, our roadmap is changing the DNA of power devices by infusing mixed-signal functions into high-voltage switching devices," said Tom Harrington, D3 Semi's Chief Technology Officer.

www.d3semi.com

First Automotive-Qualified GaN FETs

Transphorm Inc. announced that its second generation, JEDEC-qualified high voltage gallium nitride (GaN) technology is now the industry's first GaN solution to earn automotive qualification—having passed the Automotive Electronics Council's AEC-Q101 stress tests for automotive-grade discrete semiconductors.

Transphorm's automotive GaN FET, the TPH3205WSBQA, offers an on-resistance of 49 milliOhms (mΩ) in an industry standard TO-247 package. The part initially targets on-board charger (OBC) and DC to DC systems for plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEV). Today, OBCs are uni-directional (AC to DC) using standard boost topologies. However, being that GaN FETs are bi-directional by nature, they become the perfect fit for the bridge-less totem-pole power factor correction (PFC) topology. Meaning, a bi-directional OBC can then be designed with GaN to reduce the number of silicon (Si) devices, weight and overall system cost of today's solution.

"With the electrification of the automobile, the industry faces new system size, weight, performance, and cost challenges that can be addressed by GaN," said Philip Zuk, Senior Director of Technical Marketing at Transphorm. "However, supplying this market means devices must meet the highest possible standards for Quality and Reliability, those set by the AEC. At Transphorm, we have a culture of Quality and Reliability.

www.transphormusa.com

SEMICON® WEST

SMART STARTS HERE

A SEMICON West like never before with SMART new ways to experience it

Microelectronics is in transformation, and so is SEMICON West. For 2017, we've reimagined the industry's flagship event:

- **THINK SMART—** With all-new programming focused on Smart Automotive, Smart Manufacturing, MedTech, IoT, and more, plus advanced workshops, training, and presentations from the best in the business.
- **MAKE SMART—** Cruise the refreshed Expo Hall and discover the latest technologies from 600+ global innovators.
- **DREAM SMART—** Let the immersive, VR- and AI-driven SMART Journey take you on a hyper-visualized tour of tomorrow's breakthroughs in autonomous motoring, advanced manufacturing, and more.
- **CONNECT SMART—** Network 'til you drop with meet-the-expert receptions, informal gatherings, and exciting new events like the exclusive Summerfest at AT&T Park where you'll catch up with customers, colleagues, and partners to watch the MLB All-Star Game.

GET SMART—and Register Today **WWW.SEMICONWEST.ORG**

PLATINUM SPONSORS

APPLIED MATERIALS® make possible

KLA-Tencor

Lam RESEARCH

TEL™

JULY 11–13, 2017 | MOSCONE CENTER | SAN FRANCISCO, CA

semi™

Drum Cores for EMI Filtering and Switch Mode Power Supplies

Premier Magnetics, global producer of high-quality magnetic components, introduces its line of low-cost, high-performance drum core inductors designed for EMI filtering and switch mode power supply applications. With a product offering of over two dozen models with inductance values from 100 to 10,000 µH, the new PM-R Series boasts low dc resistance (DCR), providing low temperature rise at high peak currents. Their combination of high peak current and high self-resonant frequency (SRF) make the PM-R Series inductors an ideal drop-in replacement for lower-performing drum core devices. And in applications where the devices' maximum height of 10.0 to11.5 mm is acceptable, the PM-R Series offers a cost-effective alternative to surface-mount inductors.

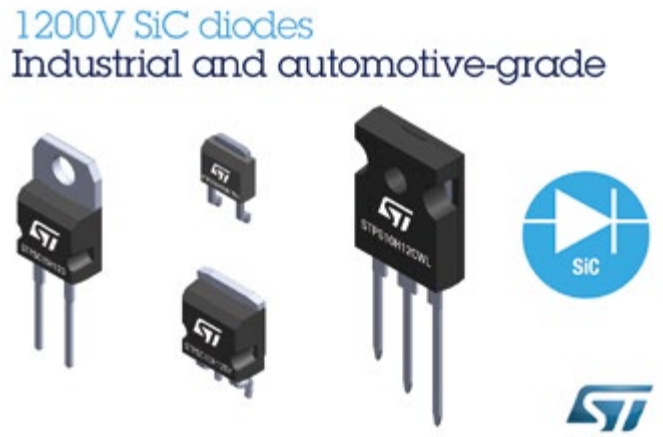
Premier Magnetics' PM-R drum core inductors are offered in two series, PM-R2 (7.5 mm, dia. x 10.0 high, max) and PM-R3 (9.5 mm, dia. x 11.5 high, max), each offering models with a range of 100 µH to10 mH. Both series of inductors are available with sleeving (+125°C); and without sleeving (+155°C). Standard operating temperature range is -40C to 130C, with higher temperatures available. The radial-leaded components are RoHS compliant.

www.premiermag.com


HUSUM
Wind
The German
Wind Trade Fair
and Congress
DO BUSINESS –
CREATE THE FUTURE
The trade fair for
on- and offshore wind
energy in Germany
12 – 15 September
WHERE ELSE?
Husum, Germany
husumwind.com
MESSE
HUSUM
CONGRESS
in co-operation with:
Hamburg Messe

1200V Silicon-Carbide Diodes Deliver Superior Efficiency

A full range of 2A-40A 1200V silicon-carbide (SiC) JBS (Junction Barrier Schottky) diodes from STMicroelectronics enables a wider range of applications to benefit from the high switching efficiency, fast recovery, and consistent temperature characteristics of SiC technology.
ST's SiC-diode manufacturing process creates extremely robust devices with the best-in-class forward voltage (lowest VF), giving circuit designers extra freedom to achieve high efficiency and reliability using diodes with lower current rating and therefore lower cost. This makes SiC technology more accessible for cost-conscious applications including solar inverters, industrial motor drives, home appliances, and power adapters.

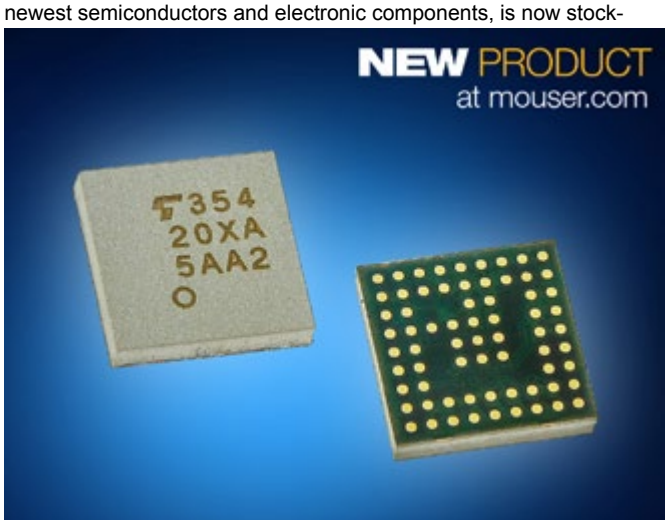


At the same time, performance-oriented applications that demand SiC for superior efficiency, low weight, small size, or best thermal properties can extend these advantages using ST's latest 1200V SiC diodes. The higher efficiency margin provided by their lower forward voltage drop (VF) delivers important benefits for automotive equipment such as On-Board Battery Chargers (OBC) and charging stations for Plug-In Hybrid or Electric Vehicles (PHEV/EV). On the other hand, overall robust electrical performance ensures a perfect fit in telecom and server power supplies, high-power industrial Switched-Mode Power Supplies (SMPS) and motor drives, uninterruptible power supplies (UPS), and large solar inverters.

www.st.com/sic-diodes-1200v-news

Enable Tap-to-Transfer Capabilities with TransferJet Module

Mouser Electronics, Inc., the authorized global distributor with the newest semiconductors and electronic components, is now stocking the TJM35420XLQ TransferJet™ compliant wireless module from Toshiba. Designed to address the needs of the rapidly growing market for proximity wireless applications, the TJM35420XLQ module contains radio frequency (RF) components and a crystal oscillator to simplify the design of TransferJet applications. TransferJet is a tap-and-transfer solution that uses fast 375 Mbps transfer speed to enable quick downloads of digital content between two devices.
The ultra-small Toshiba TJM35420XLQ module, available from Mouser Electronics, incorporates the TransferJet wireless IC, which implements TransferJet functions with wireless, digital-signal-processing, host-interface, and memory-interface functions. TransferJet technology uses close proximity wireless transfer technology to allow large volumes of data, media or video to be shared securely at speeds over five times' faster than Wi-Fi. As a close proximity wireless system that radiates very low-power radio waves, it causes virtually no interference to other wireless systems and maintains performance even if others are using TransferJet nearby.



www.mouser.com

First USB Type-C Load Switch

Alpha and Omega Semiconductor Limited introduced the AOZ1375, AOS's first Type-C Power Delivery full-compliant power protection switch. AOZ1375 is bidirectional current-limited load switch with reverse current blocking capability intended for applications that require circuit protections and soft start function. This device offers a best-in-class RDS(ON) (17.8mohm) in a thermally enhanced 3x3mm DFN package, making it an ideal solution for the latest notebooks, ultrabooks, desktops, monitors, dockings/dongles, and Thunderbolt/ USB Type-C PD applications.

The device operates from voltages between 3.4V and 23V, and features two power switch terminals, VINT and VBUS which are rated at 28V Absolute Maximum. This is a perfect protection load switch solution for battery charging using USB PD protocol. When used as a source switch, the internal current limiting circuit protects the supply from large load current. The back-to-back switch configuration blocks any leakage between VINT and VBUS pins when the device is disabled.

The AOZ1375 is fully programmable with comprehensive protections including soft start; short-circuit protection, thermal protection, over-current and over-voltage protection. Multiple operating voltages (5V/9V/15V/20V) with programmable over-voltage threshold make it fully compliant with USB PD 3.1 power profile.

www.aosmd.com

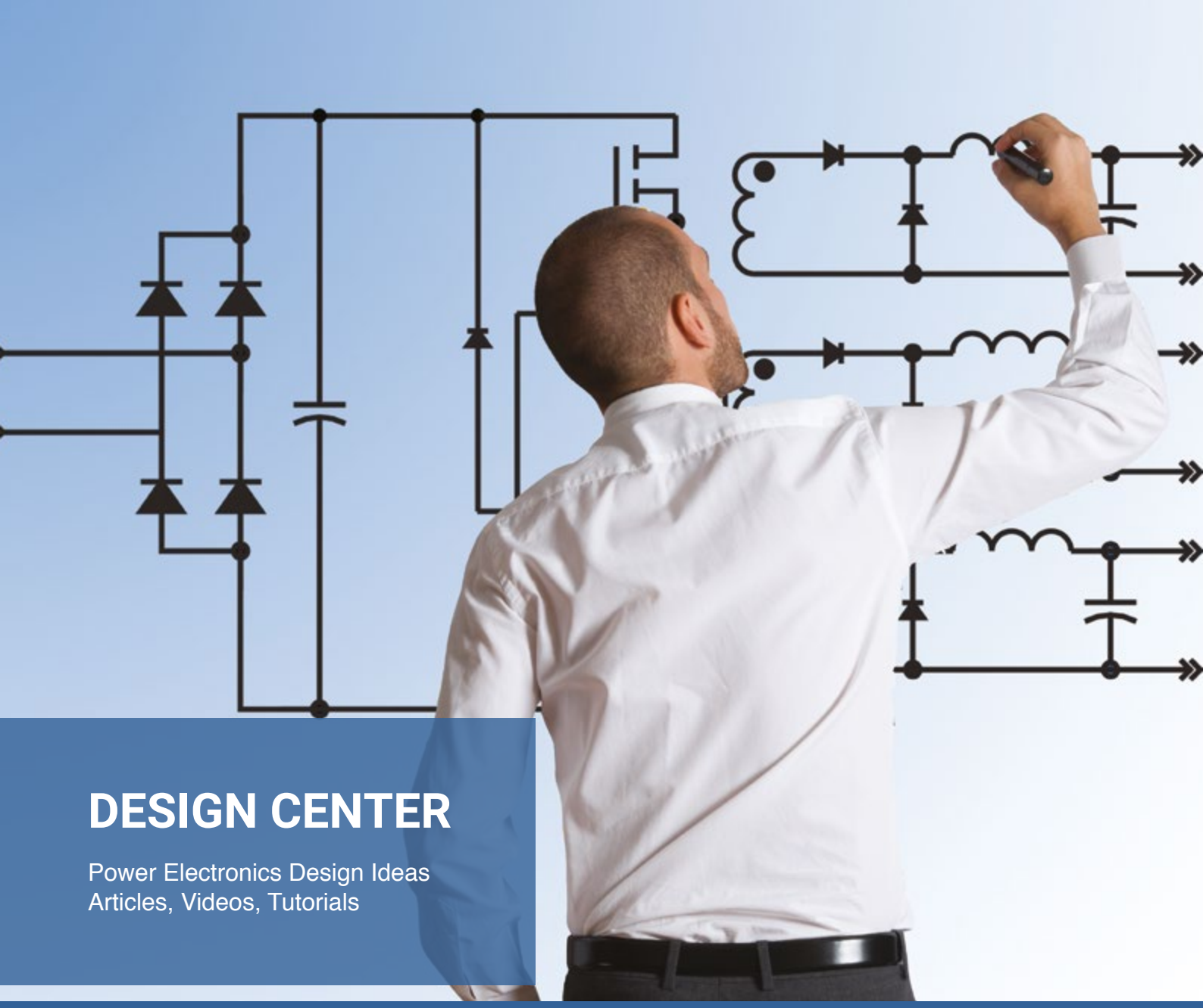
High Current Integrated DC Motor Driver IC

Allegro MicroSystems Europe has announced a motor driver IC designed for pulse-width-modulated (PWM) control of DC motors. Allegro's A5950 is capable of peak output currents up to ±3 A and operating voltages up to 40 V. This device is targeted at the automotive market with end applications to include heads-up-display, shift drive, door closure and engine thermal management applications. It is also targeted at the commercial market to drive brush DC motors for ATM cash dispensers, robotic vacuums, printers, copiers and ticketing and vending applications.

Input terminals are provided for use in controlling the speed, direction and torque of a DC motor with externally applied PWM control signals. Internal synchronous rectification control circuitry is provided to lower power dissipation during PWM operation and low current standby mode is included to improve efficiency. Internal circuit protection includes overcurrent protection, motor lead short to ground or supply, thermal shutdown with hysteresis, undervoltage monitoring of VBB, and crossover-current protection. Diagnostic features include an analogue output that can be used to monitor the current through the external sense resistor and an open drain FAULTn output.

The A5950 is supplied in a low-profile 4 mm × 4 mm, 16-contact QFN (suffix "EU") package with wettable flank option (suffix "-J"), or a 16-lead eTSSOP (suffix "LP"), both with exposed power tab for enhanced thermal performance.

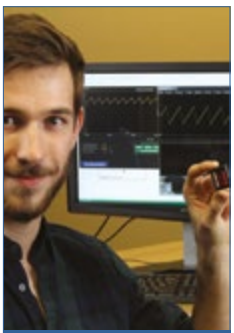
www.allegromicro.com



DESIGN CENTER

Power Electronics Design Ideas
Articles, Videos, Tutorials

RIDLEYENGINEERING.COM



Education

Software

Hardware

Design Ideas

RIDLEY ENGINEERING

601 E Daily Drive, Suite 112 | Camarillo CA 93010 | info@ridleyengineering.com | +1 805 504 2212 | POWER SUPPLY DESIGN CENTER GROUP on Linkedin

Quasi-Resonant Flyback Controller and Integrated Power IC CoolSET™ Family

Infineon Technologies AG introduces the fifth generation of the stand-alone quasi-resonant flyback controller and integrated power IC CoolSET™ family. The latest development in this family of devices offers improved efficiency, faster startup, and better overall performance under varying load conditions. The new ICs are especially designed for AC/DC switch mode power supplies in a great variety of applications such as aux power for home appliances, server, and industrial SMPS.

The latest 700 V and 800 V CoolMOS P7 families are integrated together with a fifth generation controller into a single package. The newly implemented cascode configuration for the high voltage MOSFET in combination with the internal current regulator provides fast startup. Light load performance is optimized through an Active Burst Mode (ABM) with selectable entry/exit thresholds.

The design of the device incorporates new algorithms to minimize the switching frequency spread between different line conditions and simplify EMI filter design. Device protection includes input over-voltage protection, brown in/out, pin short to ground, and over-temperature protection with hysteresis. All protection features are implemented with auto-restart to minimize any interruption to operation.

www.infineon.com/coolset-gen5

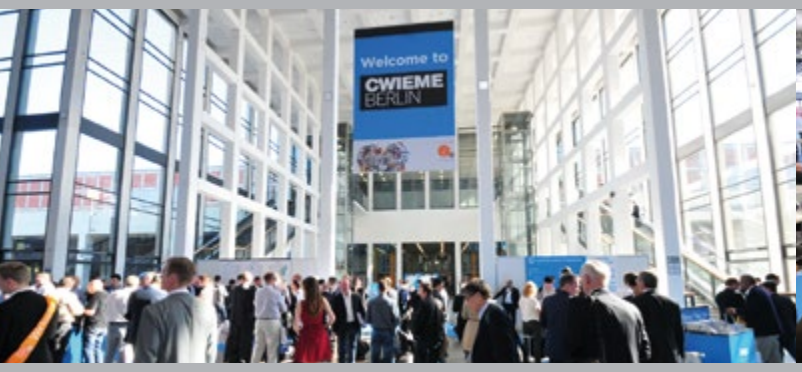
CWIEME BERLIN

www.coilwindingexpo.com/berlin
20-22 June 2017 Messe Berlin

JOIN US AT CWIEME BERLIN 20-22 JUNE 2017

With over 750 specialist suppliers, thousands of products and technologies and more than 30 hours of high level technical presentations and tutorials, CWIEME Berlin is the world's leading event dedicated to coil winding, electric motors and transformer manufacturing technologies.

If you are looking to discover the latest materials and machinery, find cost-effective solutions, make new contacts or simply want to keep up-to-date with the industry, a visit to CWIEME Berlin will be time well spent.



THE HEART OF OUR INDUSTRY

To register for your free ticket, go to
www.coilwindingexpo.com/berlin/BPN

TRENCHSTOP™ Advanced Isolation Package for Discrete IGBTs

Infineon Technologies AG introduces the package technology TRENCHSTOP™ Advanced Isolation. It is available for TRENCHSTOP and TRENCHSTOP Highspeed 3 IGBTs for best-in-class thermal performance and simpler manufacturing. The two versions are performance optimized to replace both fully insulated packages (FullPAKs) as well as standard and high performance isolation foils. The new package targets applications like power factor correction (PFC) for air conditioner, uninterruptible power supply (UPS) and power converters for drives.

By removing the need for isolation materials and thermal grease, designers can reduce assembly time by up to 35 percent. At the same time they improve reliability by eliminating misaligned foils. The thermal resistance (R th) of the new package is 50 percent lower than with a TO-247 FullPak and 35 percent lower than a standard TO-247 with an isolation foil. These improvements translate into a better performance such as a 10° C lower operation temperature than a FullPak with similar IGBT. Using the Advanced Isolation package, system efficiency can be increased by 0.2 percentage points over standard TO-247 with isolation foil.

The package also has a low coupling capacitance of just 38 pF, which means better EMI performance and potentially smaller filters. The improved thermal characteristics can also contribute to better reliability because the IGBT will run at a lower temperature which reduces stress on the component.

www.infineon.com\advanced-isolation

Lowest Rss MOSFET with Advanced CSP Technology

Alpha and Omega Semiconductor Limited announced the release of AOC3860, a common-drain 12V dual n-channel MOSFET with the lowest on-resistance in the product family of 2.15mOhm typical at 4.5V gate drive. This device provides further improved source-to-source resistance, which is a critical factor for smart phone makers to achieve faster battery charge with a higher charging current. The demand for faster charge comes from both the higher capacity of the battery pack and heavy use of the smart phone with data ranging from email and web browsing to video streaming. With the heavy duty use and shorter time for standby, charging has become a great feature for the newest smart phones. The market is seeing charging power increase from the traditional 5W to larger wattages of 15W or 25W, by raising either output voltage or output current. For battery packs, this always translates to a higher charging current. A MOSFET is a critical part of the battery charging circuit, which needs to provide reliable protection with minimum power loss and temperature rise. The AOC3860 is the latest product with the best Rss and the smallest mounting size in the AlphaDFN™ family, which is a market-proven product family in the battery protection module market. The typical Rss is 2.15mOhm with 4.5V gate voltage, and 2.25mOhm with 3.8V gate voltage. The chip size is further reduced to a 3.05x1.77mm. “AOC3860 is a great example of our effort in continuously improving product performance with AOS process technology and knowledge base. Compared with our previously released product, we were able to reduce Rss by 10%, and at the same time significantly reducing the device size by 14%.

www.aosmd.com

Advertising Index

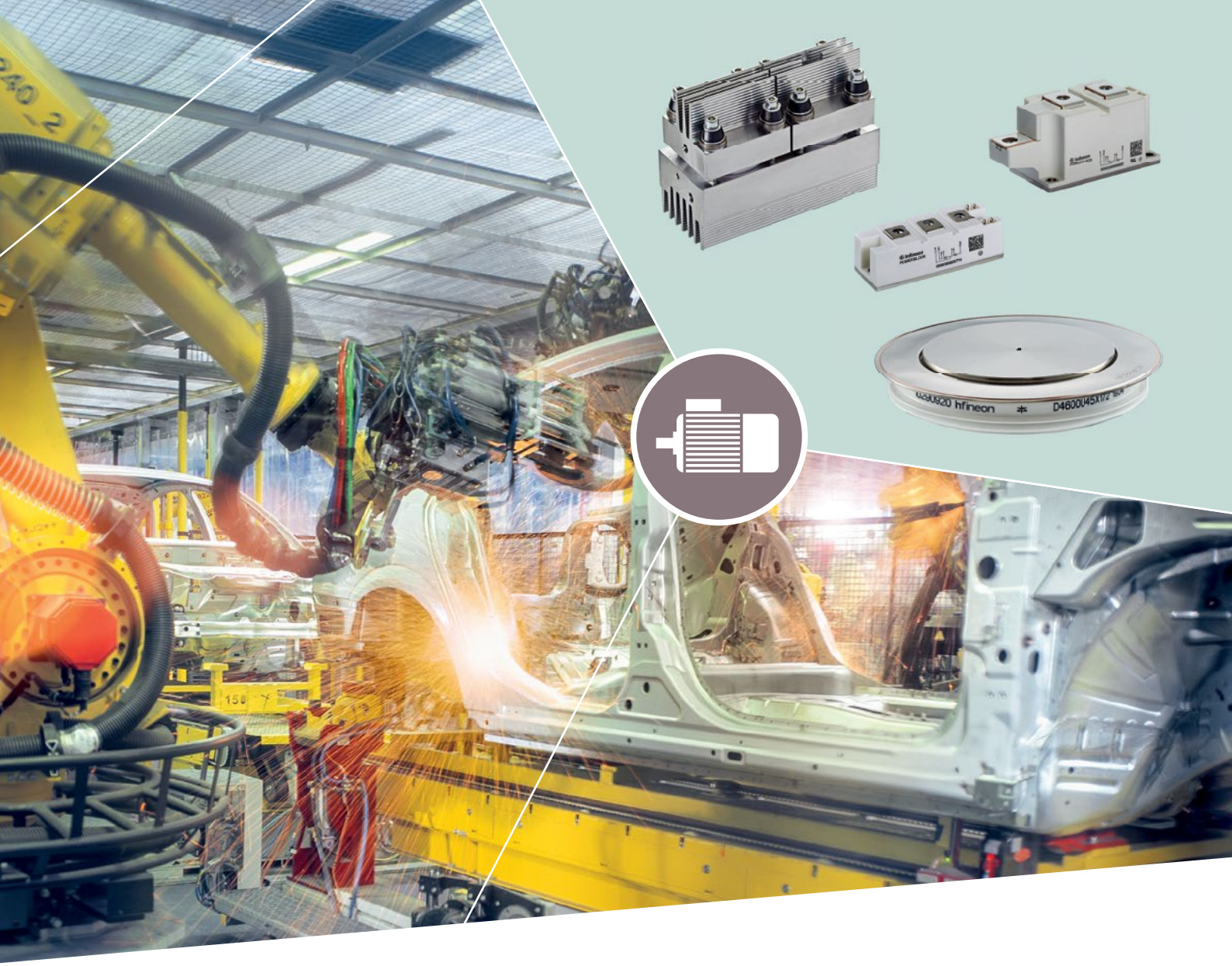
ABB Semiconductor	C3+39	IXYS	55	Rohde & Schwarz	21
Broadcom	11	LEM	5	RSG Acal	29
Cwieme	54	LpS2017	35	Schurter	49
Danfoss	25	Knowles	51	Semicon West	46
Dr.-Ing. Seibt	30	Malico	47	Semikron	7+23
electronic concepts	1	Mersen	53	Thermal	26
Fuji Electric Europe	9	Microchip	27	TT Electronics	17
GvA	C2	Mitsubishi	19	USCi	13
Hioki	56	NORWE	37	Vincotech	31
Hitachi	15	Omicron	41	VMI	17
Husum Wind	48	PCIM Asia	43	West Deane	51
Infineon	C4	Plexim	33	Würth	3
Itelcond	8	Proton	45		
ITPR	38	Ridley	52		

Thyristors

Low losses for efficient transmission.

ABB Semiconductors' new generation of thyristors enable HVDC transmission lines of up to 12 GW in a single installation, with a conversion efficiency beyond 99.6 %. Each device has the capacity to conduct in the range of 5000 A to 6250 A, has blocking capability of up to 8500 V and offers power savings up to 1 kW per device at rated current.

abb.com/semiconductors



We drive your success

Reduce risks, speed up your development projects and shorten time to market

Thyristors & Diodes for industrial drives:

- Infineon® Power Start: New soft starter module
  - One footprint fits all current classes
  - 20% more compact design
- Infineon® Prime Soft family
  - New ultra-soft free-wheeling diodes for IGBTs
  - Increased turn-off capability up to 5 kA/µs
- Infineon® Eco Blocks: Cost-effective thyristor / diode module family
  - High performance over lifetime
  - Cutting-edge module technology with highlights including 100% x-ray inspection

www.ifbip.com

Infineon Technologies Bipolar