ISSN: 1863-5598

ZKZ 64717
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Bodo´s Power Systems®

Electronics in Motion and Conversion

May 2018

ABB 3300V TSPT+ IGBT module

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GvA Power Electronics

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The Gallery

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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

Events

EV Tech Expo 2018
Hannover, Germany, May 15-17
www.evtechexpo.eu

IPEC ECCE Asia 2018
Niigata, Japan, May 20-24
www.ipec2018.org

EnerHarv 2018
Cork, Ireland, May 29-31
www.enerharv.com

PCIM Europe 2018
Nuremberg, Germany, June 5-7
www.mesago.de/en/PCIM

SMT Hybrid Packaging 2018
Nuremberg, Germany, June 5-7
www.mesago.de/en/SMT

Now it is Summertime!

It will be exciting to meet once again in Nuremberg in early June for PCIM Europe. We can all hope that the asparagus stays good into June. For the last quarter century, it comes to mind that PCIM Europe has been always in May – so no problems for the asparagus. I've been an advisory board member since the late 80's - time does fly by, but asparagus remains a special treat.

Fortunately, technical innovations are the norm. In the 90s IGBT switches, based on silicon, had a major impact – power electronics became more efficient and applications multiplied. Now the story continues with wide band gap devices achieving even more efficient designs. Progress is evident at all power semiconductor conferences around the world. For example: at APEC in Texas, and at TX and CIPS in Stuttgart; SiC and GaN technology has been the major focus.

Wide band gap devices are taking over more and more of the historically served areas of silicon devices.

In a tradition of nearly two decades, I will invite experts from industry leaders to present their latest achievements with wide band gap development. Come to the podium at PCIM Europe on

Wednesday, 6th of June,
at Hall 6, Booth 155

From 13:30 to 14:30 we have
"SIC – Devices for the Future Design"

From 14:30 to 15:30 we have
"GaN – Devices for the Future Design"

Mark up your calendar and we will see you in Nuremberg, a few weeks from now. PCIM is the big family event. I hope the weather will be nice to us, to match sunny Texas, Florida or California.

Engineers for progress for all people around the world. Our political leaders have to learn such pluralism, rather than play with protectionism, regardless of its appeal in the short term. We have only this one world and need to do the best for future generations. We must be able to explain the work we do to our grandchildren with pride. So we need to be careful with what we do and how we influence progress. It always takes resources and we must to understand that these are not endless – spend them wisely !

Bodo's Power Systems reaches readers across the globe. We have just started to partner with EE tech to enhance the service for North America. 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 May:
Water your flowers in the garden with rain water, rather than using drinking water from the tap.

See you in Nuremberg in June.
Best Regards

EETech Announces New Partnership with Bodo's Power Systems

Adam LaBarbera

EETech Media and Marketing is excited to announce its partnership with Bodo's Power Systems, making EETech the exclusive North American sales channel for Bodo's Power Systems. This partnership gives clients working with EETech's sales team premium service and support to one the top power publications in print.

"Bodo's Power Systems magazine is the number one power publication globally. Partnering to bring our collective experience and audiences together is a logical next step," said Adam LaBarbera, co-founder and CEO of EETech.

Bodo Arlt, founder and publishing editor at Bodo's Power Systems, echoed those sentiments, saying "Partnering with EETech enables us both to grow our reach. Bodo's Power Systems has a long-standing reputation of being a reliable source of the latest power news for electrical engineers. Knowing that EETech understands the importance of quality, timely information for EEs makes for a great partnership that we are very excited about."

Bodo's Power Systems' editorial mission is to focus exclusively on the technical needs of power electronics engineers. It is available in both print and online format in English and and Chinese, and provides the global engineering community with detailed technology, applications, products, and news. "This mission complements All About Circuits' goal of providing professional electrical engineers with industry news, educational resources, and technical explorations of components and systems to help EEs keep up with the fast-paced world of electronics design," said AAC's director of digital content, Kate Smith.

www.eetech.com

www.bodospower.com

PCIM Europe: Exhibitor Numbers Rise at Record-Breaking Pace

The list of exhibitors already includes over 470 companies, 51% of which are from abroad. In 2017 the exhibition counted a total of 465 exhibitors. Key players in power electronics and smaller, specialized companies, will be presenting their portfolio at the PCIM Europe from 5 - 7 June 2018. The focus of products will be on power semiconductors and passive components which are offered by 36% of exhibitors; this is followed by power converters / power supply and thermal management (25% respectively) as well as coils and magnetic materials (20%). These areas of focus make this event a must for all trade visitors from the fields of industrial electronics, electric mobility, automobiles, automation and power supply. This professional group will also find the diverse offering on E-mobility highly relevant. The spectrum includes a special exhibition area and focused lecture forum as well as keynote talk, two lecture sessions and a poster presentation from the conference program.

The international conference, which will take place at the same time as the Exhibition, connects the worlds of research and industry with over 300 high-quality first-publications, making it the meeting point for experts in power electronics and users around the world.

On every day of the conference, a renowned keynote speaker will provide insights into the future of the field.

www.pcim-europe.com

RECOM Power Appoints SISTEC as New Distributor for Japan

RECOM

RECOM Power GmbH proudly announced their new distribution agreement with SISTEC Co., Ltd for Japan effective immediately. SISTEC is now authorised to market and distribute the extensive range of RECOM product offering in a range of fields including information, telecommunications, industrial equipment, amusements, automotive, and home electronics.

"This appointment is a strategic move for RECOM to strengthening its position in the Japan market. Sistec has a strong sales team and we are confident that this appointment will improve our customer service and expand our presence in Japan." said Jordi Torrebadell, Representative Director of RECOM Power K.K.

www.recom-power.com

Supervisory Board Extends CFO Dominik Asam's Contract to 2023

The Supervisory Board of Infineon Technologies AG has extended the contract of Chief Financial Officer Dominik Asam by five years until December 31, 2023. Dominik Asam has been a member of the Management Board since January 1, 2011. His current contract expires on December 31, 2018. By extending his contract, the Supervisory Board acknowledges Dominik Asam's large contribution to the company's sustainable and profitable growth path.

www.infineon.com

SEMIKRON Foundation and ECPE Honour Mr. Stefan Matlok and Mr. Diogo Varajão

The jury has decided to give the SEMIKRON Innovation Award 2018 to Stefan Matlok from Fraunhofer IISB in Erlangen, Germany for his outstanding work on 'Zero Overvoltage Switching "ZOS"'
In power electronics turning off an electrical path is causing trouble by parasitic inductance leading to oscillations and voltage overshoot. The novel Zero Overvoltage Switching (ZOS) method offers the possibility to unleash unlimited switching speed in real-world applications without overvoltage on the semiconductors. Moreover, in best case, it is even avoiding any subsequent parasitic oscillation. The idea is to use the intrinsic parasitic inductances and parasitic capacities to build up a resonant circuit. The turn off event excites the resonant circuit and the free-wheeling diode stops it automatically after half a period, e.g. after a view nanoseconds. These resonant parasitic elements are thereby utilized to switch off a fixed current in a nearly lossless, overvoltage- and EMI compliant way. By designing the circuit and parasitics properly, there is no extra component necessary as parasitic inductance is now functional part of the topology
The SEMIKRON Young Engineer Award 2018 is given to Mr Diogo Varajão from AddVolt AS in Porto, Portugal for his contributions on 'ACDC CUBE: Single-stage Bidirectional and Isolated AC-DC Matrix Converter for Battery Energy Storage Systems'
The ACDC CUBE technology consists in a new modulation and control strategy for the high-frequency link matrix converter. The matrix converter is a key element of the system, since it performs a direct AC to AC conversion between the grid and the power transformer, dispensing the traditional DC-link capacitors. Hence, the circuit volume and weight are reduced and a longer service life is expected when compared with the existing technical solutions. The innovation was validated through a prototype tested in the laboratory. Experimental results demonstrate the capability to control the grid currents in the synchronous reference frame in order to provide services for the grid operator. Additionally, the battery current is well regulated with small ripple which makes this converter appropriate for battery charging of EVs and energy storage applications.

www.semikron-stiftung.com

Workshop Focuses on Enabling the Energy Harvesting Ecosystem

The Power Sources Manufacturers Association (PSMA) is pleased to announce EnerHarv 2018, the organization's inaugural International Energy Harvesting Workshop, to be held in Cork, Ireland, May 29-31, 2018. EnerHarv 2018 will be a focal point for a community of experts and users of energy harvesting and related technologies to share knowledge, best practices, roadmaps and experiences and to create opportunities for collaboration. The event has a limited capacity of 100 registrants, so early registration is encouraged. The PSMA EnerHarv international workshop will follow the very successful format used at the PSMA Industry Sessions on Energy Harvesting conducted at APEC 2017 and APEC 2018. However, this three-day event will provide more in-depth information and ample time for exchanging ideas and knowledge, networking, and developing opportunities for collaborative partnerships. The May 29-31 workshop will also feature dedicated demonstrations from many top- tier vendors of parts and systems, allowing participants to view the technologies (hardware, visualization and simulation tools, etc.) in operation and to interact directly with the developers.
"A key workshop message and driver is that emerging technologies, if properly guided and integrated, will enable a dramatic penetration of energy harvesting solutions into a broader range of applications," said Mike Hayes, EnerHarv General Chair.

www.enerharv.com

eMove360° Battery Conference with BMZ and Batteryuniversity

Sven Bauer,
CEO BMZ Group

As part of the eMove360° Europe 2018 International Trade Fair for Mobility 4.0 - electric - connected - autonomous, organizer MunichExpo will once again hold a congress accompanying the exhibition, the eMove360° Conferences. A key topic is battery technology, the heart of electric mobility, both in economic and technical terms. Organizer MunichExpo has entered into a partnership with two very wellknown companies in this sector for this central topic: BMZ GmbH, one of the largest European battery manufacturers, and Batteryuniversity GmbH, an independent test laboratory for batteries of all technologies, will organize the Battery Conference together with MunichExpo within the eMove360° Conferences. The congress will be held in parallel to the eMove360° Europe 2018 (16-18 October 2018) on the grounds of Munich Fair. Two days will be spent exclusively on batteries for electric vehicles and all related aspects along the entire value chain. In addition to the definition of the conference content, BMZ and its subsidiary Batteryuniversity will also moderate the individual sessions of the Battery Conference and cooperate with MunichExpo in the acquisition of speakers and conference participants. Furthermore, both companies will also use the opportunity to present their innovations at a large booth to the international expert audience at the eMove360° Europe 2018.

www.bmz-group.com
www.emove360.com


Automotive
Home Appliances
Industrial
Power Transmission
Renewables
Railway
pcim EUROPE
Nuremberg
5–7 June 2018
hall 9
booth 343
Lecture, 6 June, 11:40–12:00 hrs.
Exhibitor forum, hall 7, booth 507
"Highest PWM Switching Frequency with 1700V Si-IGBT Modules"
One of our key products: Trust.

Michael Sleven new Business Development Manager for EMEA

Hitachi Europe Ltd is pleased to announce the appointment of Michael Sleven as Business Development Manager for its European operations, effective from 3rd April 2018. Based in Germany, Michael brings a wealth of both power electronic and industry experience to the role, with former positions held at Mitsubishi Electric Europe B.V. and most recently at Infineon Technologies AG where he worked for over 10 years. Michael's principal responsibility is to enhance the customer experience, delivering innovative Hitachi technologies including Silicon and Silicon Carbide, to maintain Hitachi's continued success within the European power semiconductor market. Michael's technical expertise and aptitude enhance recent appointments, strengthening Hitachi Europe's high quality front-end client support and future roadmap development.

www.hitachi.eu

ROHM Receives Certification Under the ISO26262

ROHM has announced that it has received certification for the development process under the ISO 26262 functional safety standard for automotive products by third-party certification authority TÜV Rheinland in Germany. This certification allows ROHM to develop automotive-grade devices that achieve the highest level of safety (ASIL-D). ISO 26262 was formulated in 2011 as an international standard for functional safety in response to the rising demand for safety performance along with the increasing automation and functionality required in the worldwide automotive market.

In recent years, technical innovation represented by ADAS has accelerated, and to ensure the highest level of safety in vehicles it is necessary to achieve safety targets at the semiconductor level that make up automotive components. 'In ISO 26262 Functional Safety Standard for Automobiles, demand is growing in recent years for a higher level of safety in the electronic components to be used in on-road vehicles. ISO 26262 is also an important standard because it will cover technical innovations related to advanced driver-assistance systems (ADAS). Such innovations are one of the hottest auto-industry topics in recent days. The second edition of the standard is scheduled to be issued this year. The standard's scope will be expanded to include buses, trucks and motorbikes. There will be a new section on the reliability of semiconductors, because devices containing semiconductors are central to functional safety, which is essential to the development of autonomous vehicles. ROHM receives an ISO 26262 process certification, ahead of any of its competitors. I believe that this will enable them to produce a stable supply of functionally safe products. The company will be engaging in product development in compliance with ASIL-D, and it seems likely that the results of their efforts will be of substantial benefit to their customers.' stated Mr. Schweinfurter, President & CEO of TÜV Rheinland Japan Ltd.

www.rohm.com/eu

Fraunhofer and VDE Establish Competence Center for Batteries and Storage Systems

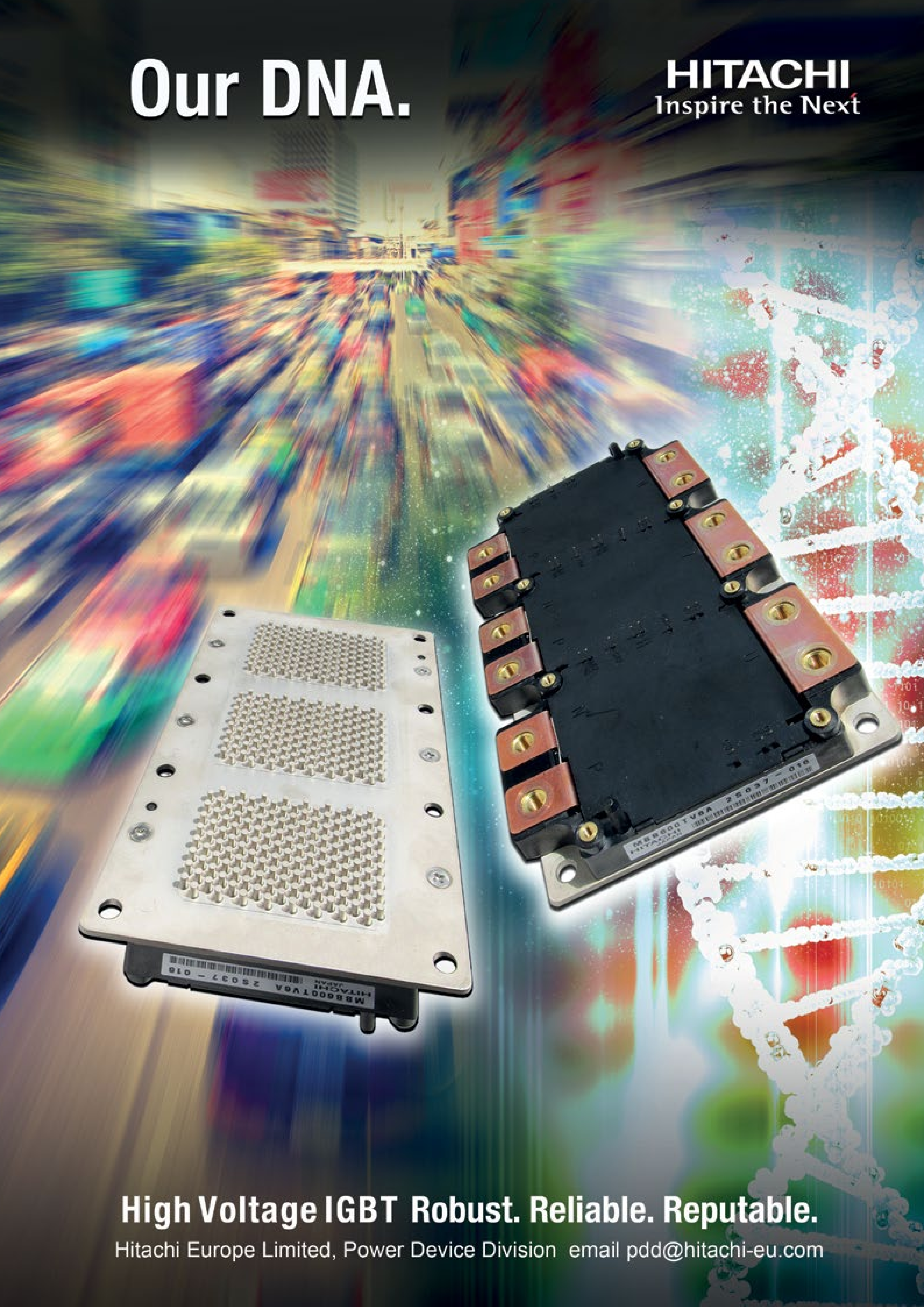
Market-oriented R&D as well as testing and certification of batteries and energy storage systems support the global energy transformation and further the expansion of electric mobility. Over 30 million euros shall be invested in the new competence center located in Freiburg, Germany. The Fraunhofer Institute for Solar Energy Systems ISE, the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institute, EMI and the Association of German Electrical Engineers VDE are establishing a new competence center for batteries and energy storage systems in Freiburg. The three partners are reacting to the rising demand for safe and commercially viable batteries and energy storage systems, pinpointing them as key technologies for the future of electric mobility and the increasing use of renewable energies.

The portfolio of the new center consists of applied, market-oriented R&D in battery cells and systems, the development of new testing standards, carrying out safety and performance tests as well as the certification of components and complete battery systems and also energy storage plants in the field. The bankability and insurability are especially addressed. The focus lies on stationary storage systems, electric mobility as well as mobile applications.

www.ise.fraunhofer.de/en

www.vde.com/en

www.emi.fraunhofer.de/en


Our DNA.
HITACHI
Inspire the Next
High Voltage IGBT Robust. Reliable. Reputable.
Hitachi Europe Limited, Power Device Division email pdd@hitachi-eu.com

Intersolar Europe 2018 is Fully Booked

Intersolar Europe 2018 is already sending out positive market signals. The exhibition space is already fully booked three months before the start of the event, which is a clear reflection of the growth in photovoltaics (PV) being reported globally. With worldwide PV deployment of around 110 gigawatts expected this year alone, there is a sunny outlook around the globe. From June 20-22, 2018 in Munich, the world's leading exhibition for the solar industry will examine what the future of the PV market could hold and which areas still hold untapped potential. Thanks to the boom in the PV market over the last 12 months, Intersolar Europe 2018 is looking forward to welcoming, alongside its established exhibitors, a much greater number of new exhibitors working across all areas of the PV industry - from maintenance and operation to cell production. Cutting-edge, decentralized energy technologies are key areas of focus for these companies. The industry is transitioning to a new energy world, in which networks, digitalization and decentralization will play a central role - and technology will no longer be considered in isolation, but rather as part of a bigger system.

www.intersolar.de/en

www.TheSmarterE.de/en

Upcoming PLECS-Workshops

PLECS Workshop
Advanced Workshop on Modeling and Simulation of Power Electronic Systems
Kiel, Germany; May 8th to 9th, 2018

PLECS Workshop
Advanced Modeling and Simulation of Power Electronic Systems
Torun, Poland; Tuesday, May 15th, 2018

PLECS Workshop
Advanced Modeling and Simulation of Power Electronic Systems
Warsaw, Poland;
Wednesday, May 16th, 2018

PLECS Workshop
Advanced Modeling and Simulation of Power Electronic Systems
Szczecin, Poland; Thursday, May 17th, 2018

PLECS Workshop
Advanced Modeling and Simulation of Power Electronic Systems
Wrocław, Poland
Friday, May 18th, 2018

RT Box Workshop
Real-Time Simulation using the PLECS RT Box
Zurich, Switzerland
Wednesday, June 20th, 2018

RT Box Workshop
Real-Time Simulation using the PLECS RT Box
Zurich, Switzerland
Wednesday, July 25th, 2018

www.plexim.com/events

Capacitors Division is Renaming Under the Identity of Knowles Precision Devices

Four years ago, Dielectric Laboratories (DLI), Novacap, Syfer Technology and Voltronics came together into a single organization referred to as Knowles Capacitors - a division of the newly formed Knowles Corporation. With the way these brands interact to make innovative contributions to the passives market, the decision has been made to rename this division as Knowles Precision Devices.
At inception the division had a combined history exceeding 175 years and joined together some of the world's leading speciality capacitor and passive device manufacturers. The more representative brand of Knowles Precision Devices, or KPD, reflects both the company's historic leadership position in capacitors and its role in making innovative advancements in devices such as filters, power dividers, and oscillators. No legal entity names are affected by this change, nor has any internal structure been altered. However, this move will allow KPD to more accurately, and clearly, articulate who they are to their customers and markets. It creates an umbrella for the brands of Compex, DLI, Johnson MFG, Novacap, Syfer and Voltronics to be recognised and grow. It will also help customers to differentiate between KPD's passive component products and those audio devices offered by other Knowles Inc divisions. Knowles Precision Devices is now a premier global source for Capacitors, RF Filters, EMI Filters, Resonators, non-magnetic components and advanced dielectric materials.

PRECISION DEVICES knowles
COMPEX • DLI • JOHANSON MFG
NOVACAP • SYFER • VOLTRONICS

www.knowles.com

Four Conferences for the First Time at electronica

The conferences in the context of electronica are getting new additions this year. In addition to the Automotive Conference, Embedded Platforms Conference and Wireless Congress, the Medical Electronics Conference, all dealing with developments and trends in electronics, will take place for the first time. Applications to hold talks for the four conferences is now possible. electronica will take place In Munich from November 13 to 16, 2018. The electronica conference program focuses on the challenges of electronics and its applications. In addition to the already established conferences—the electronica Automotive Conference (eAC), the electronica Embedded Platforms Conference (eEPC) and the Wireless Congress—experts are now also presenting the latest developments in electrical engineering at the electronica Medial Electronics Conference (eMEC).Talks and presentations can now be submitted for all conferences. The submission deadline is Monday, April 30, 2018.

https://electronica.de/en

New President for Semiconductor Business in Europe

Mitsubishi Electric Europe announced the appointment of Wolfram Harnack as President of the Semiconductor – European Business Group, effective April 1, 2018. He succeeds Kenichi Makino, who will take on new responsibilities at the headquarters of Mitsubishi Electric in Tokyo, Japan. Kenichi Makino has held the position of Product Marketing Director and Division Manager Semiconductor in Europe since April 1, 2014. Wolfram Harnack began his career at Mitsubishi Electric Europe in March 2015 as Vice President and Deputy Division Manager Semiconductor. "Together with Kenichi Makino, we have already set the course for further growth in our business area over the last three years through strategic investments. Our customers are increasingly being measured by the energy efficiency of their applications," explains Wolfram Harnack. "In fulfilling these requirements, we want to support our customers as best as possible, because power semiconductors can make a decisive contribution here".
For the Semiconductor division, the German branch in Ratingen also manages the export activities for EMEA.

www.mitsubishielectric.de/en

Improved Fabrication Process of Nano-Structures for Electronic Devices

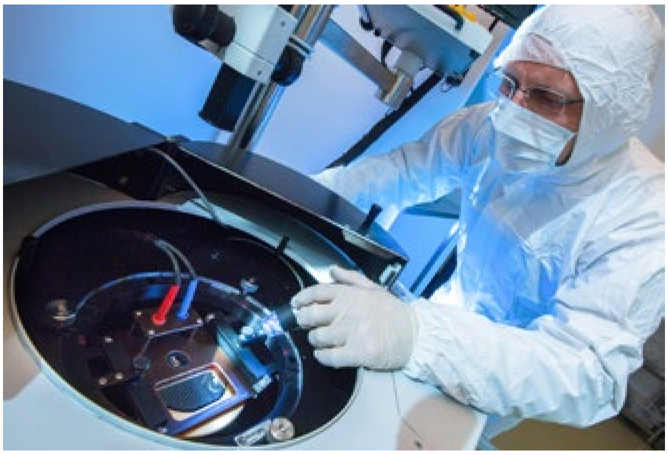
Researchers at RIT have found a more efficient fabricating process to produce semiconductors used in today's electronic devices. They also confirmed that materials other than silicon can be used successfully in the development process that could increase performance of electronic devices. This fabrication process - the I-MacEtch, or inverse

metal-assisted chemical etching method - can help meet the growing demand for more powerful and reliable nano-technologies needed for solar cells, smartphones, telecommunications grids and new applications in photonics and quantum computing.
"What is novel about our work is that for the first time we are looking at applying I-MacEtch processing to indium-gallium-phosphide materials. I-MacEtch is an alternative to two conventional approaches and is a technique that has been used in the field - but the materials that have been explored are fairly limited," said Parsian Mohseni, assistant professor of microsystems engineering in RIT's College of Engineering. He is also director of the EINS Laboratory at the university.
Demands for improved computer processing power have led researchers to explore both new processes and other materials beyond silicon to produce electronic components, Mohseni explained. The I-MacEtch process combines the benefits of two traditional methods - wet etching and reactive ion etching, or REI. Indium-gallium-phosphide is one of several materials being tested to complement silicon as a means to improve current capacity of semiconductor processing.

www.rit.edu

Innovative Leap in Power Electronics

3-5 Power Electronics GmbH (35PE) in Dresden is entering the market with a new technology for high-voltage and high-current applications in power electronics. The company was founded in 2015 and specializes in the development and production of gallium arsenide (GaAs) power semiconductors. On April 11, 2018, its first production plant went into operation in the Dresden Technology Center. “Silicon-based elements are used for many applications today. However, these elements do not achieve the level of performance that will be required in the future for goals such as the implementation of Industry 4.0-capable technologies or the breakthrough of electric mobility. The gallium arsenide structures that we produce offer the required power density, efficiency, and reliability within an incredibly compact system,” explained the two Managing Directors Dr. Gerhard Bolenz and Dr. Volker Dudek, who founded 35PE together with Richard J. Kulle. All three managers have decades of experience in the international semiconductor industry. In the production plant, 35PE processes GaAs wafers under high vacuum to produce GaAs power semiconductors. With this innovation, the company has set itself apart from competitors. As of now, twelve patents have been applied for and registered in Europe, China, Japan, and the USA for process technology, material designs, and component designs. Further applications are currently being processed.



gerhard.bolenz@3-5pe.com

Strategic Investment in Silicon Carbide Semiconductor Technology

Mersen announces an agreement to acquire 49% of CALY Technologies, a Lyon-based start-up company developing Silicon Carbide (SiC) semiconductor devices along with a proven experience on protection functions. Mersen and CALY Technologies unite their strength to better serve power electronics and electrical distribution markets with innovating and disruptive products. This move is the outcome of several years of collaboration and co-patented core technology developments. Thanks to this investment, Mersen will expand its portfolio of over-current, surge protection and current limiting products and solutions while developing its expertise in semiconductor technologies. These semiconductor electrical protection devices will serve fast growing markets such as Electric Vehicles, Electrical Energy Storage, Critical-Load Buildings, Photovoltaics and Aerospace.

www.mersen.com

www.caly-technologies.com

Technology Showcase at SEMI European Imaging & Sensors Summit

The Technology Showcase at the SEMI European Imaging and Sensors Summit (19-21 September 2018 in Grenoble, France) highlights some of the newest and unique imaging and sensors-enabled applications in the industry. No matter if you are a startup, well-established company, researcher, or individual, we invite you to submit your innovative product for presentation!

From all selected presenters, one winner will receive a free booth at the SEMI European Imaging & Sensors Summit 2019!
Here are 3 Steps to Participate:

1. display the significance of your product on the current tech market/application
2. make sure your product is featured in a pre-event media advisory, which includes your product photo
3. submit your Technology Showcase information by May, 15 2018

At the conclusion of the Technology Showcase, audience members will vote to select the winner.
Each selected presenter will receive:

- One complimentary pass to SEMI European Imaging & Sensors Summit 2018
- Table to display your demo at European Imaging & Sensors Summit

www.semi.org/eu/events

Tiny µModule Boost Regulator for Low Voltage Optical Systems

Analog Devices, Inc. announced the "Power by Linear" LTM4661, a low power step-up µModule regulator in a 6.25mm x 6.25mm x 2.42mm BGA package. Only a few capacitors and one resistor are required to complete the design, and the solution occupies less than 1cm² on single-sided or 0.5cm² on double-sided PCBs. The LTM4661 incorporates a switching DC/DC controller, MOSFETs, inductors and supporting components.

By Roland R. Ackermann, Correspondent Editor Bodo's Power Systems

The main voltage rails in electrical equipment are going down to 2.5V, 1.8V or even lower than 1.0V, but it is still in common to find higher voltages including 5V for interface, 12V for analog circuits and 5V or above for motor drive or bias power supply for optical devices such as laser and photo diode. Not only battery-operated equipment, but also daughter boards and extension boards in industrial equipment often have limited voltage sources, which require a step-up convertor to generate these voltages. The LTM4661 is Analog Devices' first step-up regulator module which allows smaller solution size and simpler design.

Figure 1: The device allows smaller solution size and simpler design.

The LTM4661 operates from a 1.8V to 5.5V input supply and continues to operate down to 0.7V after start-up. The output voltage can be set by a single resistor ranging from 2.5V to 15V. The combination of the small, thin package and wide input and output voltage range is ideal for a wide range of applications including optical modules, battery-powered equipment, battery-based backup systems, bias voltage for power amps or laser diodes and small DC motors.

The LTM4661 can deliver 4A continuously under 3.3VIN to 5VOUT, and 0.7A continuously under 3.3VIN to 12VOUT. The LTM4661 employs synchronous rectification, which delivers as high as 92% conversion efficiency (3.3VIN to 5VOUT). The switching frequency is 1MHz, and can also be synchronized to an external clock ranging from 500kHz to 1.5MHz. The LTM4661 1MHz switching frequency and dual phase single output architecture enable fast transient response to line and load changes and a significant reduction of output ripple voltage. The LTM4661 has three operation modes: Burst Mode operation, forced continuous mode and external sync mode. The quiescent current in Burst Mode operation is only 25µA, which provides extended battery run time. For applications demanding the lowest possible noise operation, the forced continuous mode or external sync mode minimize possible interference of switching noise.

Figure 2: LTM4661 low power step-up µModule regulator

The LTM4661 features an output disconnect during shutdown and inrush current limit at start-up. Fault protection features include short-circuit, overvoltage and overtemperature protection.

The LTM4661 operates from –40° to 125° operating temperature.

PN	**LTM4661**	**LTC3124**
Configuration	Module	Discrete
Vin	1.8V to 5.5V	1.8V to 5.5V
Vout	2.5V to 15V	2.5V to 15V
Isw (mini)	Not Specified	5A (2.5A per phase)
Iout (DC)		
3.3Vin to 5Vout	2A (mini of max Iout)	2.5A (typ)
5Vin to 12Vout	1A (mini of max Iout)	1.5A (typ)
Package	6.25x6.25x2.42 (BGA)	3 x 5 (DFN) 5 x 6.4 (TSSOP)
Component Count on standard demo board	4 (C x 3, R x 1)	15 (L x 2, C x 6, R x 4)

Table 1: Comparison between LTM4661 (Module) and LTC3124 (Discrete). The LTM4661 requires less external components.

Absolute Maximum Ratings

VIN...– 0.3V to 6V
VOUT..– 0.3V to 18V
COMP, FREQ ....– 0.3V to INTVCC
SYNC/MODE, SDB ....– 0.3V to 6V
Operating Internal Temperature Range ....– 40°C to 125°C
Storage Temperature Range ....– 55°C to 125°C
Peak Solder Reflow Body Temperature ...250°C

Positioning

The LTM4661 is the Analog Devices' first step-up regulator module. It requires only 4 external components, whereas an equivalent discrete solution requires about 15 components.

Summary of Features

- Complete Solution in <1cm² (Single-Sided PCB) or 0.5cm² (Dual-Sided PCB)
- Input Voltage Range: 1.8V to 5.5V, Down to 0.7V After Start-Up
- Output Voltage Range: 2.5V to 15V
- Up to 4A DC Output Current
- ±2% Maximum Total DC Output Voltage Regulation Over Load, Line & Temperature
- Output Disconnect in Shutdown
- Inrush Current Limit
- External Frequency Synchronization
- Selectable Burst Mode® Operation
- Output Overvoltage & Overtemperature Protection
- Ultrathin 6.25mm × 6.25mm × 2.42mm BGA package

www.linear.com/product/LTM4661

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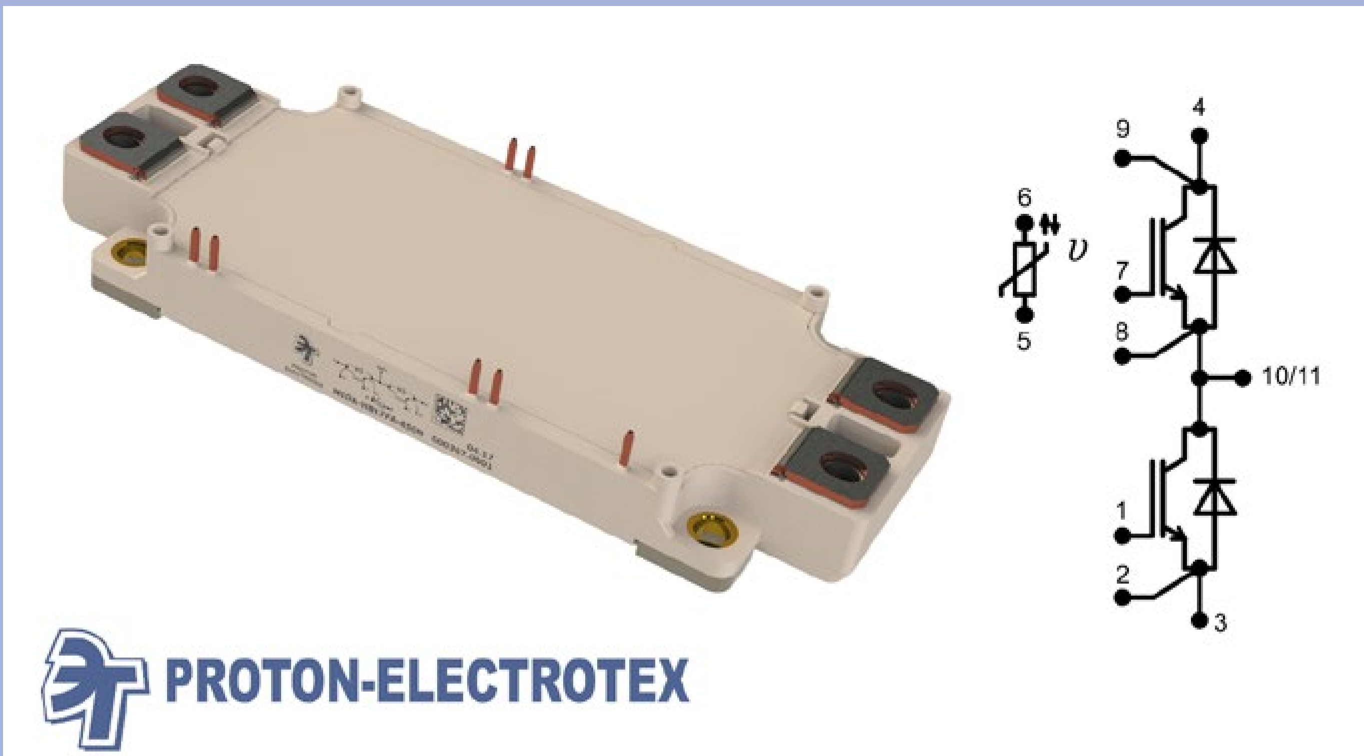
MIDA Half-Bridge IGBT Modules for Low Inductive System Designs



Proton-Electrotex introduces new half-bridge IGBT modules under the code name MIDA. The new series will join the family of the launched in 2016 MIAA (62 mm) and MIFA (34mm) modules available in various topologies from 75 A to 400 A at 1200V and 1700V. MIDA modules will expand the current rates up to 600 A.

The new low inductance modules feature optimized electrical performance combined with high reliability, improved DCB and improved thermal and power cycling.

The all new MIDA IGBT modules are equipped with Trench FS technology supporting very high junction temperatures of Tvj (op) = 175 °C, which makes the modules a perfect choice for photovoltaic systems, wind power, drives, uninterruptable power supplies and other applications.

The new half-bridge modules come from 300A to 600A at 1200V and 1700V, also available with TIM.

MIDA IGBTs are available under the following part numbers:

- MIDA-HB12FA-300N
- MIDA-HB12FA-450N
- MIDA-HB12FA-600N
- MIDA-HB17FA-300N
- MIDA-HB17FA-450N

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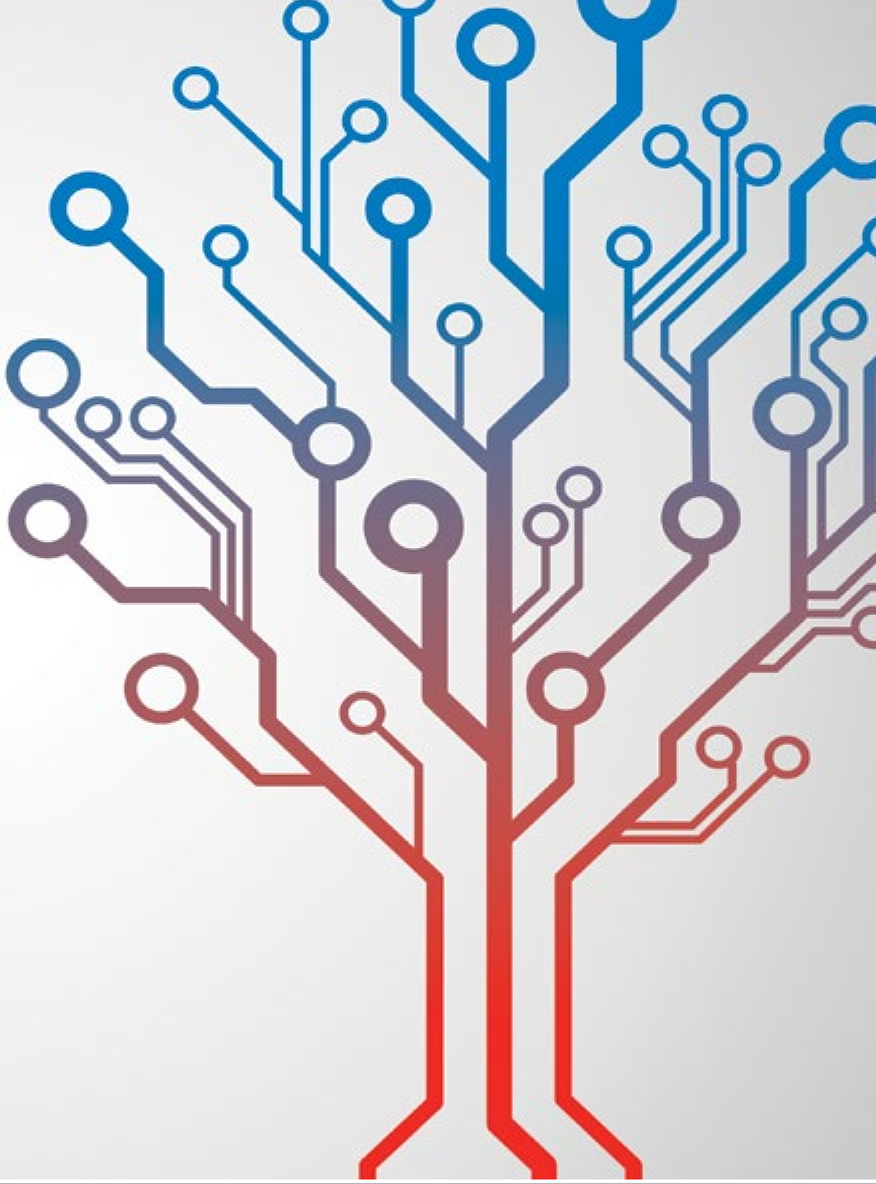
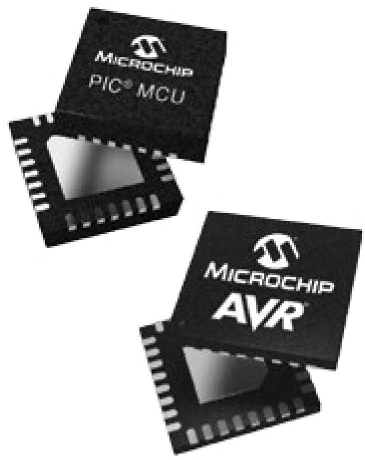


You have a desire to make technology smarter, more efficient and accessible to everyone. Microchip has a passion for developing products and tools that make it easier for you to solve your design problems and adapt to future needs. Microchip's portfolio of more than 1,200 8-bit PIC® and AVR® microcontrollers 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
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Maxim's Himalaya uSLIC Solution, the Industry's Smallest Power Modules, Revolutionizes Design for Highly Space-Constrained Applications

4-42V wide-input DC-DC power modules deliver 2.25x smaller solution size, high efficiency, and simplified design

Designers working on space-constrained applications can now dramatically reduce solution size and increase efficiency with the family of micro system-level IC ("uSLIC") modules from Maxim Integrated Products, Inc. (NASDAQ: MXIM). The MAXM17532 and MAXM15462 ultra-small (2.6mm x 3.0mm x 1.5mm), integrated DC-DC power modules are part of Maxim's extensive portfolio of Himalaya power solutions that enable industrial, healthcare, communications, and consumer markets. With these modules, customers get the full benefits of industry-best switching regulators with the size and simplicity of a linear regulator (LDO).

Miniaturization is the next frontier that enables emerging trends such as artificial intelligence and machine learning. Next-generation system designs such as IIoT sensors, network infrastructure equipment or medical and consumer devices need to collect, synthesize, and act upon data. This requires more power in ever-reducing space without impacting thermal budget. To fit into small enclosures that are deployed in harsh mechanical, electrical, and thermal environments means designers need shock and vibration tolerance, EMI compliance, increased energy efficiency, high temperature operation, and small size–a multidimensional challenge.

Maxim's uSLIC™ power modules shrink the solution size of the power supply by 2.25x with an ultra-small package size. This is achieved by integrating a synchronous wide-input Himalaya buck regulator with built-in FETs, compensation, and other functions with an integrated inductor. This enables the designer to use the modules in small space-constrained systems while complying with mechanical and EMI standards. In addition, engineers simplify designs as they no longer need to deal with conventional bulky, power hungry regulators. Instead, they can integrate the ready-made power module into almost the same space of a tiny LDO. IThe uSLIC DC-DC buck regulator modules, which operate over a wide input range as low as 4V to as high as 42V, support multiple applications across nominal input voltages of 5V, 12V, 24V, and 36V. They operate over the -40-degree Celsius to +125-degree Celsius temperature range.

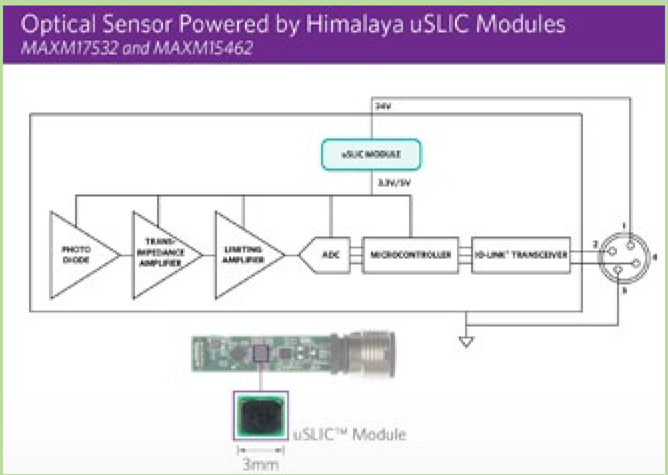

Figure 1: Powered by Himalaya uSLIC

Key Advantages

- Smallest Solution Size: 2.25x smaller solution size compared to competing solutions; available in a compact, 10-pin 2.6mm x 3.0mm x 1.5mm uSLIC package
- High Efficiency: Peak efficiency of 90% and higher in smallest form factor (less than 15mm^2 solution size); superior thermal performance
- Simplified Design: Fully synchronous buck regulator with built-in compensation; integrated inductor for ease of design and faster time to market
- Rugged: Compliant to CISPR 22 (EN 55022) Class B EMC emission standards, as well as JESD22-B103/B104/B111 drop, shock, and vibration standards

http://bit.ly/Himalaya_uSLIC_power_modules

Applied Power Electronics Conference and Exposition-APEC 2018

APEC, the premier annual event in applied power electronics enables power electronics professionals to meet, exchange the latest technical knowledge and develop valuable industry insights.

By Gary M. Dolny, US-Correspondent Bodo's Power Systems, gary.dolny.us@ieee.org

The 2018 Applied Power Electronics Conference and Exhibition (APEC) was held from March 4-8, 2018 in San Antonio Texas, USA. APEC, which is sponsored by the Power Sources Manufacturers Association, (PSMA), the IEEE Power Electronics Society (PELS) and the IEEE Industry Applications Society (IAS) is considered the premier global event in the applied power electronics field. APEC focuses on the practical and applied aspects of the power electronics business and covers a wide range of topics of interest to all branches of the power electronics field including OEMs, designers, manufacturers, marketing and sales. The conference addresses issues of both immediate and long-term importance to both students and practicing power electronics engineers. The venue was the sprawling Henry B. Gonzalez Convention Center in downtown San Antonio which provided ample space for the conference events including technical sessions, professional education seminars, social and networking events and a huge exhibit featuring more than 300 vendors.

The technical program began on Sunday, March 4 with a series of Professional Education Seminars. These seminars were tutorial in nature and combined both theory and practical applications. They were designed to further educate both students and working professionals in power electronics and related fields on the latest power electronics technologies and design techniques that are critical to the industry. This year there were six tracks devoted to Fundamentals, Design, Reliability and Safety, Wide Bandgap, Inverters, and Grid. These were followed by a Monday plenary session featuring six presentations by industry leaders focused on current needs and future possibilities in energy efficiency. For the first time, the APEC plenary was live streamed courtesy of IEEE.TV.

Tuesday through Thursday featured the technical and industry sessions. The technical sessions consisted of nearly 600 rigorously peer-reviewed papers from academic institutions, industry and governments worldwide. The review process emphasized the most innovative technical solutions to current problems in order to achieve the highest quality technical program. An industry track ran in parallel to the technical sessions. Speakers in the industry sessions made a presentation only, without a formal written manuscript to appear in the conference proceedings. This allowed APEC to present the latest developments from the leading companies in the industry that would otherwise be unavailable.

Although the industry sessions featured primarily technical presentations, there were also sessions devoted to business, manufacturing, and regulatory issues. In addition to the technical presentations, the conference featured a dialog session, which consisted of papers presented in a poster format. These presentations were selected through the same rigorous peer-review process as the oral presentations but addressed more specialized topics. These sessions offered participants and presenters the opportunity to speak at length and in detail about the work in a manner that was not available during the oral sessions.

Figure 1: Vendors display the newest power electronics products at the APEC exhibit hall.

Tuesday evening featured three well-attended "Rap Sessions". In these sessions a panel of experts presented their opinions on current and controversial topics relevant to the industry, then interacted with audience questions and comments. This year's topics involved the impact of magnetics vs devices on power conversion, gate drive and isolation techniques, and the ongoing debate of GaN vs SiC vs Si for next generation power devices.

A key feature of APEC is always the large and well attended exhibit. This allows conference attendees to examine and evaluate the latest product offerings from the leading suppliers in the industry. A wide range of products including power supplies, devices, passives, design tools, test equipment, software and other services were on display by over 300 exhibitors. The conference also included a series of exhibitor seminars. These were half-hour presentations that offered a more in-

depth discussion of the various exhibitor's products and services than was available by simply visiting the booths.

A clear industry trend that was evident at this year's APEC conference is that the need for increasing both efficiency and power density is driving steady progress of the wide bandgap semiconductor devices, both GaN and SiC. These newer materials offer both improved switching and on-state performance as well as higher temperature operation compared to silicon and are continuing to gain market acceptance, particularly in the higher performance applications. SiC adoption is being led by the hybrid electric vehicle and industrial applications followed closely by renewable energy and industrial markets. GaN is seeing increased acceptance in battery chargers, telecom and servers

The performance benefits of GaN were highlighted in a number of industry and technical presentations. D. Kinzer of Navitas Semiconductor discussed the advantages of GaN technology for a number of USB-PD laptop adapters ranging from 27 W to greater than 70 W. The key point of this discussion was that although GaN can offer 5-10X better performance than Si in key figures of merit at the device-level for hard switched circuits, the bigger advantage is the use of monolithic integration with faster, soft-switched topologies. The presentation demonstrated the integration of a 650 V GaN FET with on resistance in the 110-560 mohm range, with a GaN driver, regulator, dV/dt control and logic circuitry. This resulted in 2-3% improved efficiency compared to silicon using an active flyback zero-voltage switched topology.

S. Apter of VisIC Technologies presented a 1200 V half-bridge module based on GaN technology. The module is configured as a half-bridge with high-performance GaN switching transistors, gate drivers and sense circuits integrated into a single package. Experimental results were presented from a 3.6 kW CCM buck application circuit at a switching frequency of 100 kHz. Total efficiency including conductor losses was shown to be above 97.5%.

G. DeBoy of Infineon discussed the value of enhancement-mode GaN HEMT devices for high-frequency and high-efficiency applications. Compared to a classical silicon superjunction structure the lateral GaN HEMT offers 10x reduced output charge, zero reverse recovery charge and 10x lower gate charge. This enables better efficiency in resonant circuits and near lossless switching. He emphasized that since the performance advantages have been well-characterized, the focus in GaN needs to move toward manufacturing and reliability issues. Data was presented showing <5% variation in dynamic Rds over a wide range of temperature and operating conditions. He also presented Weibull plot data of failure mechanisms of devices tested to destruction. From this he used established models of accelerated failure that predicted >50-year GaN lifetime at 100 ppm failure levels. He also demonstrated a 3 kW, 12 V output server power supply using e-mode GaN devices. He predicted that use of GaN would lead to both OPEX reductions due to the higher efficiencies and CAPEX reductions due to higher power density in data center applications.

P. DiMaso of GaN Systems presented a comprehensive analysis of GaN power device switching from a systems perspective. The presentation showed how the inherent performance advantages of GaN HEMTs such as fast switching and small dead times can be used to advantage in a number of circuit topologies including a bridgeless totem pole for PFC, LLC half-bridges, and a phase-shifted full bridge. He also emphasized that GaN HEMTS exhibit a stable threshold voltage over the normal operating temperature range which, coupled with the positive temperature coefficient of Rdson, eliminate current mismatches and current runaway thus simplifying parallel device operation.

SiC technology continues to mature as it transitions from a research activity toward increasing acceptance in high-volume commercial applications. To enable this widespread commercialization of SiC diodes and MOSFETs, high-volume, high yield, and low-cost manufacturing capability is necessary. A joint presentation by S. Banerjee of Littelfuse and A. Wilson of X-FAB described efforts toward this end. Wilson described how, with the support of the Power America Institute, X-FAB was able to leverage the economies of scale associated with a large volume CMOS fab to offer foundry capabilities for commercial SiC production. Wilson noted that more than 90% of the SiC processes are compatible with the processes already available in the silicon fab and stated that this approach has been successful in the production of both 1200 V SiC diodes and MOSFETs from the 150 mm X-FAB facility.

A. Bhalla of United Silicon Carbide discussed the use of advanced SiC-based components to improve the performance of totem-pole PFC and vehicle on-board charger applications. He advocated the use of an integrated cascode combining a high-performance HV SiC JFET integrated with an optimized LV Si MOSFET in a single package. This combination offers standard gate drive and required no negative Vgs for turn-off. The structure also exhibits low diode Qrr and fast switching.

A. Curbow of Wolfspeed described a high-power density SiC based 150 kW inverter. A key point of his presentation is that drive, control and system designs must be optimized to complement the high-performance of the SiC devices. The inverter operated at 40 kHz and exhibited a power density of 780 W/in3.

X. Zhang of Monolith Semiconductor discussed system design challenges associated with utilizing SiC devices in high-efficiency, high-power density inverter designs and outlined a number of best practices to address these challenges. He stressed the importance of both power loop design and gate drive design and integration. Key characteristics of the gate driver include sufficient current capability to minimize switching loss, good isolation performance, and effective protection including fast turn-off during de-saturation due to the reduced short circuit capability of SiC MOSFETs, as well as overvoltage and undervoltage lockout.

Y. Jiao of Delta Power Electronics Laboratories (DPEL) presented an experimental analysis of several state-or-the-art 1.2 kV SiC power switches. The comparison included both trench and planar SiC MOSFETS as well as a SiC JFET cascode. The devices were evaluated for both static and dynamic performance using both the intrinsic body diode as well as an external SiC Schottky diode as the freewheeling device. Their comprehensive analysis clearly presented the advantages and disadvantages for each of the device types and provided guidance for device selection to optimize system level performance based on application needs.

A full session was devoted to reliability and ruggedness of wide bandgap devices. A joint presentation by S. Watts Butler of Texas Instruments and T. McDonald of Infineon addressed the crucial topic of wide bandgap semiconductor qualification standards by introducing the new JEDEC Committee on Wide Bandgap Power Electronic Conversion Semiconductors, JC-70. Industry standards such as these are critically important to accelerate the widespread adoption of the wide bandgap devices. This committee was chartered by JEDEC in late 2017 and is tasked to deliver reliability qualification standards, test methods and measurement techniques, data sheet elements and device specifications unique to GaN and SiC devices in power conversion circuits. RF/microwave applications are not covered since their performance requirements are fundamentally different from power conversion applications. Although the standards are expected to encompass many of the traditional power device qualification tests such a thermal cycle, HTRB and HTGB, they are also likely to address typical use conditions in targeted applications and dynamic testing such as high temperature operating life, switching lifetime testing, and dynamic Rdson.

A subsequent presentation by A. Ikoshi of Panasonic illustrated the use of dynamic high-temperature operating life testing to demonstrate reliable operation of GaN gate injection transistors (GITs). The test used an inductive load switching test circuit in which both current and voltage could be independently varied as acceleration parameters. Based on these acceleration parameters they predict > 20 year lifetime in a totem-pole PFC circuit.

P. Friedrichs of Infineon presented a comprehensive discussion of gate oxide and threshold voltage reliability considerations for SiC MOSFETs. He noted that the gate oxides of SiC MOSFETs exhibit several challenges compared to Si. These include higher tunneling currents due to the larger bandgap, higher internal electric fields and inherently higher defect density. He emphasized the mechanism by which these higher substrate defects, along with particles and process variations known as extrinsic defects, can lead to localized oxide thinning and premature reliability failures. The extrinsic failures can be mitigated by reducing substrate defect density, reducing the number of process induced defects and limiting gate oxide electric field. The extrinsic reliability can be further improved by electrically screening devices to ensure excellent reliability.

J. Ingman of ABB discussed the importance of H3TRB testing as a means for assessing the long term reliability of SiC devices in industrial environments. He proposed test conditions of 85°C, 85% relative humidity and 80% of rated voltage for a minimum of 1200 hours. He stressed that the failure condition should be deviation from an initial reference value rather than to the final datasheet spec.

Next year's APEC will take place from March 17-21, 2019 at the Anaheim Convention Center in Anaheim, CA, USA. The paper submission deadline is July 09, 2018. Additional information can be found at

www.ieee.org/conferences_events/conferences/conferencedetails/index.html?Conf_ID=35578

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

Between 20 and 22 March Stuttgart welcomed the 10th International Conference on Integrated Power Electronics Systems (CIPS), organised by VDE and ECPE in the frame of the ECPE Annual Event 2018. Since the first CIPS in 1999, this biennial conference has been focused on the integration of hybrid and mechatronic systems with high power density and systems' or components' operational behaviour and reliability, respectively.

By Prof. Andreas Lindemann (Univ. of Magdeburg),
Prof. Nando Kaminski (Univ. of Bremen), CIPS Technical Chairs

The number of high quality submissions and 350+ participants, both the highest number ever in this conference series, has emphasised the major interest of the international power electronics community in these topics. Again, CIPS had a good mixture of participants from industry, research institutes and academia and provided an excellent forum for scientific exchange and networking. The peer-reviewed contributions are available in the proceedings and will be accessible via digital libraries.

One trend became apparent at CIPS 2018: New power semiconductor devices based on the wide band-gap materials silicon carbide (SiC) and gallium nitride (GaN) fertilise the development of system integration as well as non-standard applications. Those fast switching devices require packaging solutions and circuit components which contribute only small parasitic elements, e.g. stray inductances, and avoid issues due to electromagnetic interference (EMI). Furthermore, they impose the necessity to implement additional measures, processes and tests to ensure a suitable reliability. This is a precondition for their use in conventional but also new applications of power electronic systems, which require e.g. high power density, reliable operation under harsh conditions such as high temperature, and of course lowest cost. Figure 1 shows an example of the impressive research results presented at CIPS 2018: The power supply by ETH Zürich offers a remarkably high power density of 14.8 kW/l. The excellent mixture of CIPS contributions from industry as well as from universities and research institutes proves that the hot topic of integrated power electronic systems is dealt with in science, industrial research and product development. While the technology is mature enough for industrial use, substantial further research is required to cope with future challenges.

During the conference dinner speech, Prof. Eckhard Wolfgang, who is together with Prof. Dieter Silber Honorary Chairman of CIPS, reflected the history of CIPS at the occasion of its decadal jubilee. During the closing ceremony Christina DiMarino of the Center of Power Electronics Systems (CPES) received the CIPS Young Engineer Award sponsored by ECPE for her paper "Fabrication and Characterization of a High-Power-Density, Planar 10 kV SiC MOSFET Power Module".

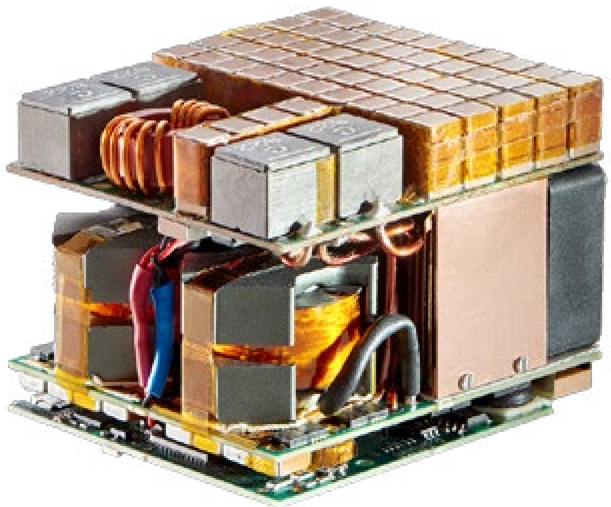

Figure 1: Little Box 2 by PES at ETH Zürich (figure courtesy of ETH Zürich)

Bianca Böttge of Fraunhofer Institute for Microstructure of Materials and Systems (IMWS) received the best poster award sponsored by the VDE for presenting her work "Novel specimen design to test engineering plastics for power electronic applications". Afterwards, the General Chairmen Prof. Leo Lorenz and Thomas Harder from ECPE together with the Technical Chairmen Prof. Andreas Lindemann, Otto-von-Guericke-Universität Magdeburg, and Prof. Nando Kaminski, Universität Bremen, expressed their sincere thanks to the topic chairs, the reviewers, the authors, the organisers and all others who had contributed to the success of CIPS 2018. Finally, the next CIPS conference was announced: It will take place in spring 2020.

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Enhanced Trench 3300V TSPT+ IGBT Module Brings Highest Current Density and Robustness

With the arrival of the Enhanced Planar (SPT+) IGBT cell technology, ABB set a benchmark in device performance that still today competes with Trench cell IGBTs. Nevertheless, the market continuously demands increased performance. ABB has thus combined the merits of the Enhanced Planar cell with Trench technology and created the Enhanced Trench TSPT+ IGBT. The new 3300V TSPT+ represents the latest generation IGBT cell technology, enabling a further loss reduction and hence the possibility to increase the current density.

By Raffael Schnell, Chiara Corvasce and Silvan Geissmann, ABB Semiconductors

With the new device a HiPak2 (140 x 190mm2) can be rated at 1800A; a 20 percent increase in current density over the previous SPT+ generation rated at 1500A. Alongside reduced losses and increased current density, robustness is an important consideration for demanding power electronic applications like traction and transmission and distribution (T&D). Higher voltage Trench cell designs are known to suffer from so called degradation effects. ABB has invested time and resources to mitigate Trench cell degradation without compromising on device performance. The result sees the launch of the 3300V, 1800A TSPT+ IGBT at PCIM 2018 in Nuremberg.

Technology

IGBT cell technology

The Enhanced Trench cell IGBT builds on the N-type enhancement layer, known from the SPT+ technology, and combines it with the Trench technology [1]. The combination is the resulting Enhanced Trench cell or TSPT+ technology (Figure 1).

The TSPT+ cell is implemented as a stripe design. To achieve the targeted enhanced carrier concentration near the trench emitter, aimed to reduce conduction losses, the TSPT+ cell is combined with the characteristic N-enhancement layer. This greatly reduces the hole drainage through the cell. The P-well between the trenches is designed to achieve a low input capacitance and hence an optimized IGBT turn-on behavior and to support the blocking voltage. The P-well is resistively coupled to the emitter node in order to optimize the trade-off of controllable turn-on and conduction losses.

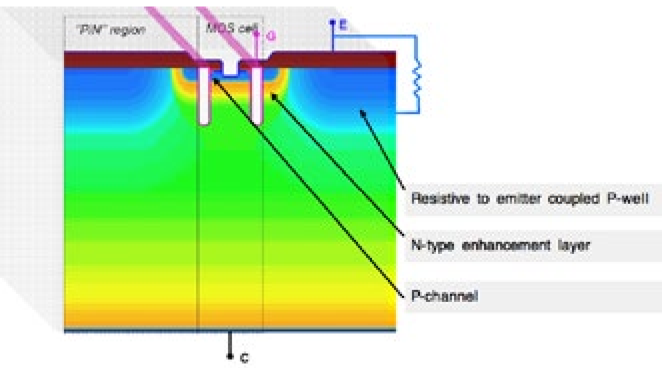

Figure 1: The Enhanced Trench (TSPT+) cell

Diode technology

The 3300V 1800A TSPT+ IGBT module uses a Field Charge Extraction (FCE) diode with a Field Shielded Anode (FSA) design (Figure 2).

The FCE [2] concept aims at a better losses versus softness trade-off, as it allows a reduction in the diode thickness. This reduces the losses without sacrificing the softness during diode recovery. This is achieved by introducing P+ islands at the diode cathode. During the tail-phase of the diode reverse recovery, the electrons are deflected around the P+ islands causing a lateral voltage drop (DV). At the end of the tail-current phase this voltage drop exceeds the built-in junction voltage (~0.6V) and the P+ islands inject holes that avoid a sudden snap-off of the tail current.

The FSA [3] technology features a double anode design with a shallow doped P- layer that blocks the electric field during diode off-state from the deep-level proton irradiation. Hence, the deep levels generated by the proton irradiation are shielded from the electric field. Its impact to the hot leakage current are thus heavily minimized, enabling the diode to be rated at 150°C.

Mitigation of Trench degradation

Trench cells especially for high-voltage applications are known to suffer from degradation effects [4]. During IGBT turn-off at an elevated current and voltage, the IGBT enters into dynamic avalanche. This means charge carriers get accelerated enough from the high local electric field to generate electron hole pairs. Due to the high local field in the IGBT, the generated charge can have enough energy and momentum to get injected into the gate-oxide. Since the oxide of trench cells is much more exposed (Figure 1) than that of planar IGBTs, trench IGBTs are prone to so called "hot carrier injection" into the oxide, especially at the exposed trench bottom. Consequently, charges are trapped within the oxide which alters and degrades the oxide properties. This has measureable impact on device parameters like

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gate-threshold change, gate leakage increase, capacitance change and, as a further consequence of this, an increase of the IGBT turn-on switching speed.

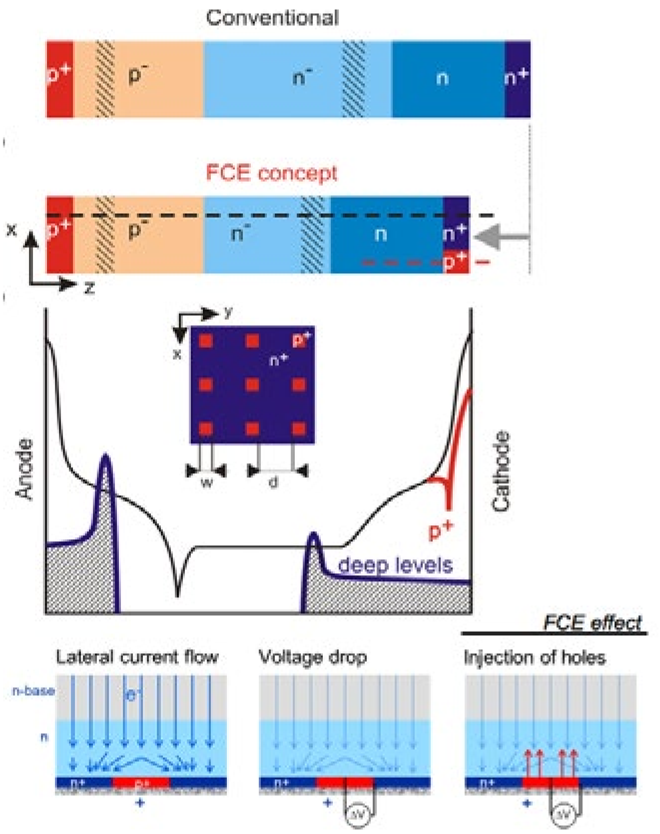

Figure 2: The FCE and FSA diode technology

Avoiding trench cell degradation means that the oxide of the trench needs to be protected and shielded from the hot carriers. In the most consequent extent this probably could be done, but would set back performance of the trench design to that of an enhanced planar cell. This would render the practical benefit of trench obsolete. Hence it is important to mitigate the effect of trench cell degradation to such an extent that it is moved out from the regular range of operation.

This can be done by protecting the trench cell to a reasonable amount from the hot carriers and by moving the position of the dynamic avalanche by way of a 3D optimization of the trench layout, together with a high quality gate oxide. In addition, dynamic avalanche can be reduced by the gate-driving conditions, such as using a higher turn-off gate resistor.

Trench degradation is mainly influenced by turn-off current and voltage and accumulates with the number of turn-off events. ABB has optimized the trench cell design to avoid degradation in the nominal operation conditions as there one has to practically account for infinite turn-off events during life time. In addition, the degradation effects at elevated conditions like IGBT turn-off at SOA with countable events during an IGBT life time, have to be minimized and characterized for a better understanding.

Figure 3 shows the effect of trench degradation for the ABB devices and an identical rated other trench based device. Both devices are subjected to 125’000 turn-off events at 1.5 times nominal current and an increased DC-voltage of 2300V. For the driving the recommended datasheet turn-off gate-resistor is used for both tested IGBTs. The ABB device shows an identical turn-on behavior prior to and after the 125’000 turn-off events, hence no degradation. The other trench cell design shows a significant increase in turn-on speed after being subjected to 125’000 turn-off events. As a result of the faster switching, the IGBT turn-on current respectively the diode IRR is significantly higher. This means the diode is more stressed and a further degradation of the trench cell yields to an even faster turn-on. The diode could finally fail due to operating outside of its safe operating area.

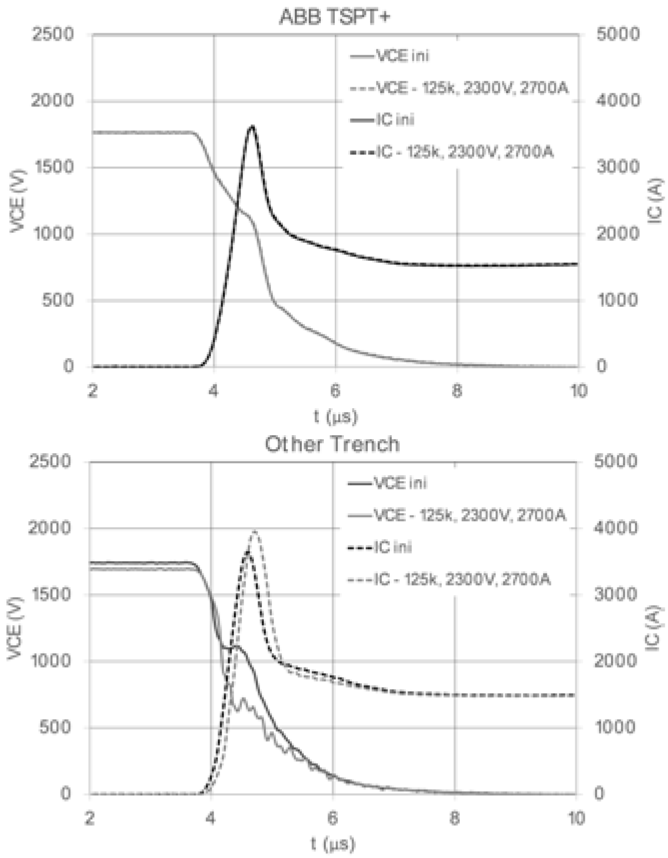

Figure 3: Nominal turn-on behavior before and after 125k turn-off events at 2300VDC, 2700A (1.5x nominal)

So far the tests with the optimized ABB TSPT+ IGBT have shown no degradation if operated at nominal current or below. The tests with several hundred thousand to millions of cycles have also shown that degradation is mostly dependent on the switched turn-off current and the dissipated dynamic avalanche energy [5], therefore a higher turn-off gate resistor reduces the degradation to some extent. This can be also one reason why manufacturers of the latest trench-based IGBT modules typically recommend rather large turn-off gate resistors compared to planar devices.

The investigations on trench degradation are continuing in order to improve the understanding of the impact of various application parameters.

Device characteristics

The new 3300V TSPT+ IGBT offers a significant reduction in conduction losses compared to the previous generation. This has enabled, a 140 x 190mm2 sized HiPak2 module to be rated at 1800A. In order to lift the diode performance to the same performance level than that of the TSPT+ IGBT, ABB has re-designed the internal module layout and increased the FCE/FSA diode chip area by 20 percent. This gives a reduction of both the diode conduction losses and thermal resistance.

The key characteristics of the 3300V 1800A TSPT+ module are shown in table 1:

	25 °C	150 °C
Conduction losses Ic/ If = 1800 A		
VCEsat	2.4 V	3.0 V
VF	2.1 V	2.2 V
Switching losses Vcc = 1800V, Ic/ If = 1800A Rgon = 1.2 Ohm / Rgoff = 4.7 Ohm, CGE = 330nF, Ls = 100nH		
Eoff	2.7 J	3.95 J
Eon	3.2 J	3.9 J
Erec	1.6 J	2.55J

Table 1: Key characteristics of the 3300V, 1800A TSPT+ HiPak2 IGBT module

The new TSPT+ IGBT is suitable for many applications, including 2-level and 3-level inverters. For 3-level topologies, the DC-link stray inductance typically has higher values compared to the 2-level counterparts. This increases the requirements on inherent soft switching characteristics of both the IGBT and especially the diode. The TSPT+ IGBT features a stronger anode compared to its SPT+ predecessor. This ensures a softer IGBT turn-off with less overvoltage. Figure 4 shows the 3300V 1800A TSPT+ module at extreme turn-off conditions with double nominal current of 3600A to 2600Vdc. The switching characteristics is very smooth and without excessive overvoltage.

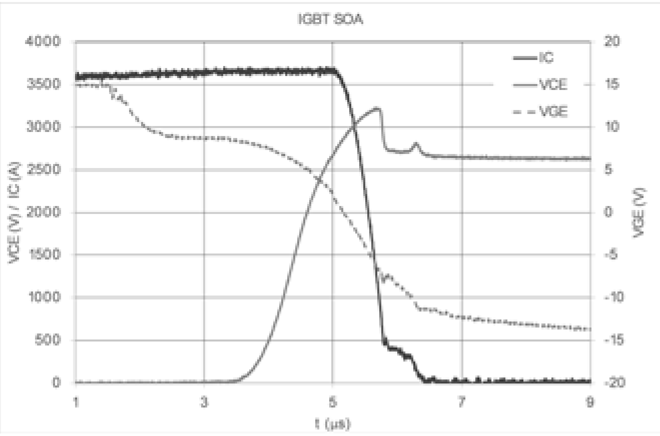

Figure 4: IGBT SOA, VCC = 2600V, ICoff = 3600A, RGoff = 4.7Ohms, CGE = 330nF, Ls = 100nH, Tvj = 150°C

For a soft diode switching characteristic a field charge extraction (FCE) diode design is chosen. The FCE diode implementation in the new 3300V 1800A TSPT+ HiPak2 module sets a new benchmark in terms of softness combined with record low losses. Figure 5 illustrates the soft switching characteristics over the full current range at the critical extreme low temperature of -40°C and an increased DC voltage of 2300V. In addition the switching speed is faster than the datasheet recommendation with an RGon of 0.67Ohms instead of 1.2Ohms.

Application performance

The new 3300V 1800A TSPT+ IGBT offers significant reduced losses compared to previous generations. Its inherent soft switching characteristics makes it suitable for a variety of applications such as 2-level, 3-level topologies used in propulsion inverters for railway applications, renewables like wind-turbines or industrial drives. Optimization for low conduction losses means the TSPT+ IGBT is ideally suited for modular multi-level (MMC) inverters with rather low switching frequency such as those used in HVDC and FACTS applications.

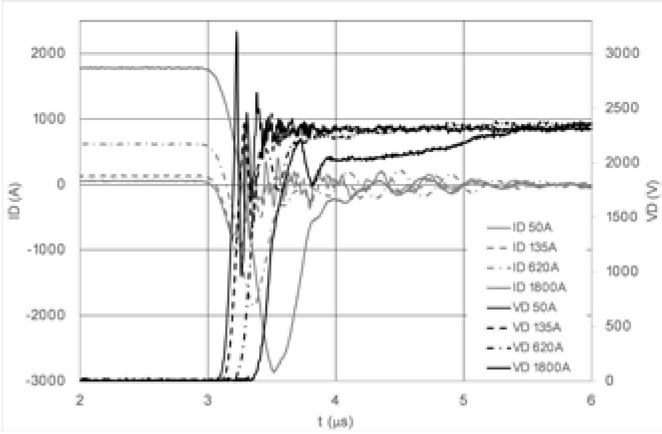

Figure 5: Diode softness, VD = 2300V, IF = 50..1800A, RGon = 0.67Ohms, CGE = 330nF, Ls = 100nH, Tvj = -40°C

A good measure of IGBT performance in real applications is the so called performance plot [6]. Figure 6 shows the inverter output current versus switching frequency for a 2-level inverter as used for instance, in traction propulsion drives. It compares three generations of 190 x 140mm sized HiPak2 modules. The new TSPT+ module shows close

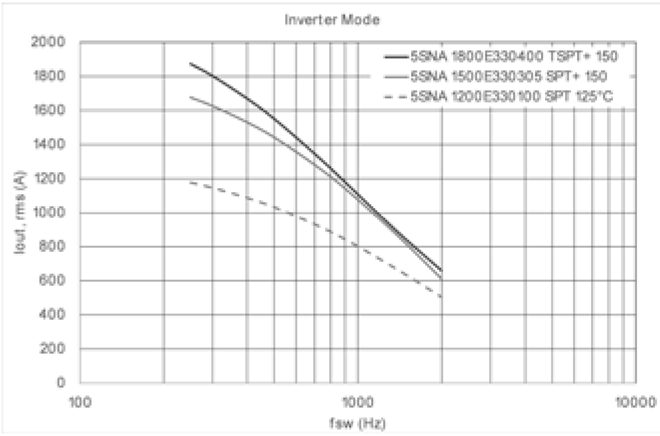

Figure 6: Inverter output current versus switching frequency: TA = 60°C, Rth (h-a) = 8K/kW

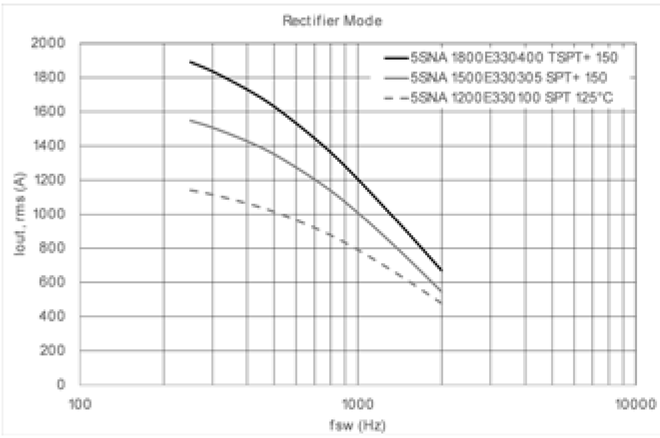

Figure 7: Output current in rectifier mode versus switching frequency: TA = 60°C, Rth (h-a) = 8K/kW

to 15 percent improvement compared to the previous SPT+ generation and even more than 50 percent improvement compared to the 1200A rated SPT generation. This provides the potential to replace a 1200A rated 190 x 140mm SPT HiPak2 module with a third smaller 130 x 140mm 1200A rated HiPak1 TSPT+ module. This is a significant reduction of inverter volume.

The benefit of the larger diode area and the FCE/FSA diode of the TSPT+ IGBT module is shown in the rectifier mode performance (fig. 7). The new module outperforms its SPT+ predecessor by more than 20 percent and the SPT module by a healthier 65 percent. This is highly important in case of regenerative breaking or for line-side converters in traction applications. It also enables a full 4-quadrant operation in HVDC and FACTS applications.

Summary

The new 3300V enhanced Trench TSPT+ IGBT module from ABB offers significantly reduced losses compared to previous generations. Thus, the current density can be increased to 1800A for 190 x 140mm sized HiPak2 module. This lets customers make more compact inverter designs with up to a third volume savings compared to earlier generations.

The TSPT+ IGBT and the new FCE/FSA diode offer excellent robust and soft switching characteristics, making it the device of choice for a large variety of applications.

ABB will present the 3300V 1800A TSPT+ HiPak2 IGBT module at PCIM 2018 in Nuremberg. It will be the first module with the enhanced Trench technology, followed by a 3300V 1200A 130 x 140mm sized HiPak1 module beginning of 2019 and other voltage classes like a 4500V 1500A rated 190 x 140mm HiPak2 module in the coming years.

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eGaN® Technology is Coming to Cars

Automotive technology has entered a renaissance with the emergence of autonomous cars and electric propulsion as the driving forces. IHS Markit estimates that 12 million cars will be autonomous by 2035 and 32 million cars will have electric propulsion according to Bloomberg New Energy Finance, Marklines. Both trends translate into a large growth in demand for power semiconductors. This is also happening at a time when silicon is reaching its performance limits in the world of power conversion, thus opening a huge new market for power devices based on gallium nitride grown on a silicon substrate (GaN-on-Si).

By Alex Lidow, CEO and Co-founder of Efficient Power Conversion (EPC)

Why GaN for cars?

Over the past eight years during which GaN power devices have been in mass production, several large applications where GaN has significant advantages over the aging silicon MOSFET have emerged − LiDAR (Light Detection and Ranging), radar, 48 V – 12 V DC-DC conversion, high-intensity headlamps, and on-board electric vehicle charging.

One of the first applications anywhere for GaN transistors and ICs was LiDAR, prompted by the creative thinking of Dave Hall at Velodyne. The idea was to trigger laser pulses so fast that the time of the flight of light of the emitted photons could be accurately measured, making it possible to rapidly measure distance within a few centimeters at distances of a few hundred meters. Using a spinning disk with several solid-state lasers stacked parallel to the axis of rotation, Velodyne was able to create a fast and accurate digital point cloud, such as that shown in figure 1. Much to everyone's amazement, this sensing technology, combined with cameras and radar sensors, was used by many to create prototype autonomous vehicles.

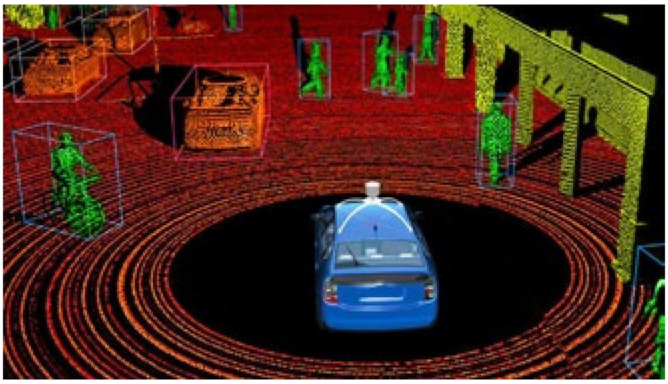

Figure 1: LiDAR sensors using GaN FETs create a fast and accurate digital point cloud that is used by autonomous cars to identify surrounding structures and obstacles.

eGaN® FETs from EPC were the logical choice to use for firing the laser because the FETs could be triggered to create high-current pulses with extremely short pulse widths (See figure 2). The short pulse width leads to higher resolution, and the higher pulse current allows the LiDAR system to see further. These two characteristics, along with their extremely small size, make eGaN FETs ideal for radar and ultrasonic sensors in addition to LiDAR.

LiDAR was just the start of a trend. Along with the array of sensors used to provide input for navigating and controlling the vehicle, a new market developed for high performance graphic processors to integrate these sensor inputs, digest their meaning, and decide what commands to send to the self-driving actuators. Fast processing speed being a key attribute, companies such as Mobileye (now part of Intel) and nVidia have introduced ultra-fast multicore processors. These processors can gather, interpret, integrate, and make sense of all the inputs from multiple radar, LiDAR, camera, and ultrasonic sensors quickly enough to safely navigate our roads and highways.

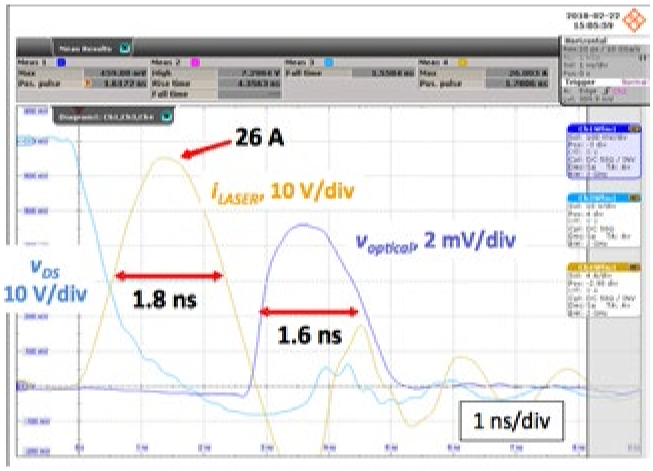

Figure 2: An EPC2202 AEC-Q101 qualified FET is used to generate a 1.8 nano-second pulse (yellow trace) at a peak current of 26 A. The optical receiver pulse signal is shown as the blue trace.

Need for 48 V – 12 V Power Distribution Systems

A cost of these high-performance processors is that they are very power hungry and put an additional burden on traditional automotive 12 V electrical distribution buses. The solution to providing the high-power levels to these processors needed for automotive LiDAR systems turns out to be the same solution being applied to operate high performance gaming systems, high performance servers, artificial intelligence systems, and even cryptocurrency mining – implementation of a 48 V distribution bus, where current levels and wire sizes can be reduced by a factor of four. Also, 48 V is the highest practical voltage for these applications because, given overshoot and various fault conditions, the voltage on the bus will stay below 60 V, avoiding the need for additional (and costly) safety measures.

The advantages of 48 V become even more evident when all the new power hungry electronically-driven functions and features appearing on the latest cars are considered. For example:

- Electric start-stop
- Electric steering
- Electric suspension
- Electric turbo-supercharging
- Variable speed air conditioning

These new functions and features are opening a large new market for 48 V – 12 V DC-DC converters. Power can be generated at 48 V and converted to 12 V to run legacy systems and battery packs.

Superior Performance of GaN FETs and ICs

GaN FETs and ICs are the most efficient way to get from 48 V to 12 V as shown in figure 3. GaN devices are many times smaller than a silicon power MOSFET, and many times faster [1] which leads to higher efficiency as well as smaller, lower cost peripheral components. eGaN FETs from EPC are also on par with silicon when it comes to volume pricing [2]. Now the technology is taking the next step to wide-spread adoption by the automotive world by passing AEC-Q101 qualification testing.

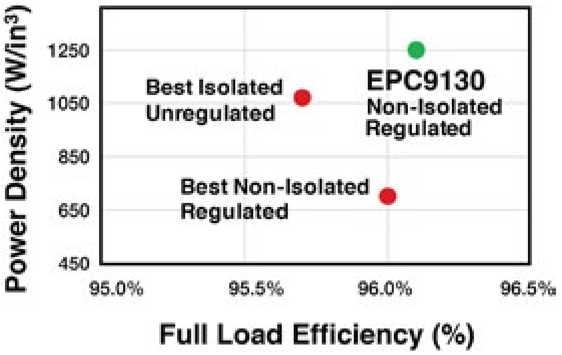

Figure 3: The EPC9130 is a 700 W 48 V – 12 V DC-DC converter based on EPC2045 eGaN FETs. It has higher power density and higher efficiency than the best silicon-based converters. The eGaN FET-based converter also has the lowest cost bill of materials.

eGaN technology has been in mass production for over eight years, accumulating billions of hours of successful field experience in automotive applications.

AEC-Q101 Qualified eGaN FETs

EPC is offering its first two products that have completed AEC-Q101 qualification testing. The products, EPC2202 (figure 4) and EPC2203 (figure 5), are discrete transistors in wafer level chip-scale packaging (WLCS) with 80 VDS ratings. These first AEC-Q101 qualified products will soon be followed with several more discrete transistors and integrated circuits designed for the harsh automotive environment.

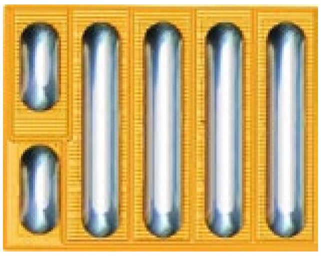

Figure 4: The 80 V EPC2202 device passed AEC-Q101 testing. It measures 2.1 x 1.6 mm and has a pulsed current rating of 75 A.

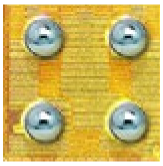

Figure 5: The 80 V EPC2203 device passed AEC-Q101 testing. It measures 0.9 x 0.9 mm and has a pulsed current rating of 18 A.

The EPC2202 is an 80 V, 16 mΩ enhancement mode FET with a pulsed current rating of 75 A in a 2.1mm x 1.6mm chip-scale package. The EPC2203 is an 80 V, 73 mΩ part with a pulsed current rating of 18 A in a 0.9mm x 0.9mm chip-scale package. These eGaN FETs are many times smaller and achieve switching speeds 10 – 100 times faster than their silicon MOSFET counterparts. Both products are designed for a wide range of emerging automotive applications including:

- LiDAR
- 48 V – 12 V DC-DC Converters
- High Intensity Headlights
- Ultra-high Fidelity Infotainment Systems

To complete AEC-Q101 testing, these eGaN FETs had to undergo rigorous environmental and bias-stress testing including humidity testing with bias (H3TRB), high temperature reverse bias (HTRB), high temperature gate bias (HTGB), temperature cycling (TC), as well as several other tests. Of note is the fact that these wafer level chip-scale (WLCS) devices passed all the same testing standards created for conventional packaged parts, demonstrating that the superior performance of chip-scale packaging does not mean a compromise to ruggedness or reliability. These parts are produced in facilities certified to the Automotive Quality Management System Standard IATF 16949.

Conclusion: eGaN® Technology is Coming to Cars

Automotive electronics can now take full advantage of the improved efficiency, speed, smaller size, and lower cost of eGaN devices with the completion of the AEC-Q101 qualification testing of the EPC2202 and EPC2203. Throughout 2018 there will be several additional 80 V parts undergoing certification, expanding the range of performance to higher currents.

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Oscilloscopes for Measurements on Advanced Power Semiconductors

The Benefit of Isolated Inputs

Advanced semiconductors now support previously unattainable efficiency and power density. At the same time, however, they place higher demands on T&M equipment used in the development of power electronics. Oscilloscopes with isolated input channels prove as a powerful yet cost-efficient alternative to expensive laboratory equipment and do today provide analysis capabilities on the level of laboratory oscilloscopes.

By Dr. Markus Herdin, Product Manager for Oscilloscopes at Rohde & Schwarz, Munich

Very short rise times and low losses are two major advantages of power transistors based on SiC and GaN semiconductors. These advantages translate into higher efficiency and power density. At the same time, advanced semiconductors of this kind provide high breakdown voltages, which is necessary for high-power converters. This applies especially in the case of electrical drives and power converters. However, the specified voltage limits for the semiconductors must be strictly followed due to the risk of destruction.

Designers are thus faced with some new challenges:

- Switching times that are significantly less than 10 ns generally require measurement bandwidths greater than 200 MHz, which is larger than the bandwidth typical high-voltage differential probes offer.
- In order to optimize switching converters, it is often necessary to simultaneously display and analyze multiple floating signals. This prohibits ground-referenced measurements using passive probes on laboratory oscilloscopes.
- Measurement voltages range from a few volt in case of gate-source voltages up to 1000 V with similar isolation requirements between different channels.

Isolated channel oscilloscopes - an excellent solution

Specialized probing solutions are available in order to achieve very high common mode rejection but a single probe often costs much more than an oscilloscope. In addition, the input voltage range of these probes is sometimes limited so that only selected measurements are possible. For many developers of power electronics, this is simply not a viable option.

Advanced oscilloscopes with isolated input channels provide an economical yet effective alternative. The portable R&S Scope Rider is

Figure 1: Measuring the gate source (C1, C2) and output voltage (C3) of a resonant converter; source: Rohde & Schwarz

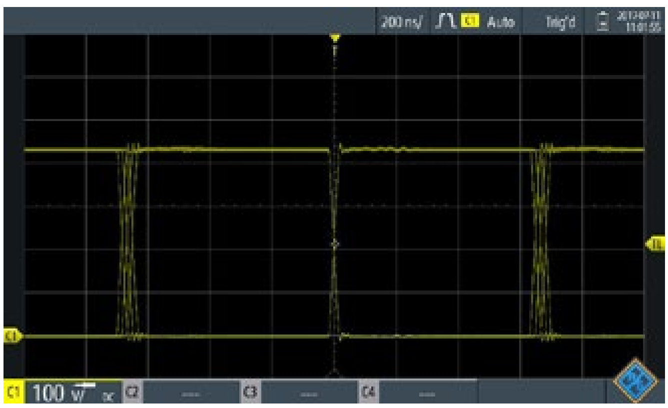


Figure 2: Measuring the switching cycle of a GaN-based power factor correction (PFC) output stage; source: Rohde & Schwarz

a good example of such an instrument. It has four isolated input channels that can be used to perform floating measurements of voltages up to 1000 V (RMS) – without requiring active differential probes. With 500 MHz bandwidth, it is well suited for measurements on advanced SiC and GaN semiconductors. Moreover, it can be battery-powered for mobile applications. Unlike other oscilloscopes with isolated inputs, the R&S Scope Rider provides analysis capabilities on the level of laboratory oscilloscopes, including an extremely fast acquisition system with an acquisition rate of up to 50,000 signal waveforms per second, flexible trigger functions and a wide range of automatic measurement functions.

Correct connections are essential

Performing high-quality measurements on power electronics requires the right test instrument and the right probe as well as careful attention to the correct connection. Passive probes are ideal for measurements with an oscilloscope that has isolated input channels. Here, the contacts with the signal and ground connections must be as short as possible in order to minimize ringing and achieve a high common-mode rejection. Ground springs generally help to ensure optimal contacting when using a passive probe. However, when measuring on high voltages, prefabricated contact points must be used for safety reasons. Normally, small conductor loops are soldered onto the contact points so the passive probes can be connected there. In certain situations, a BNC connector can also be installed as an alternative. BNC adapters can then be used with the probe in order to achieve a nearly ideal connection.

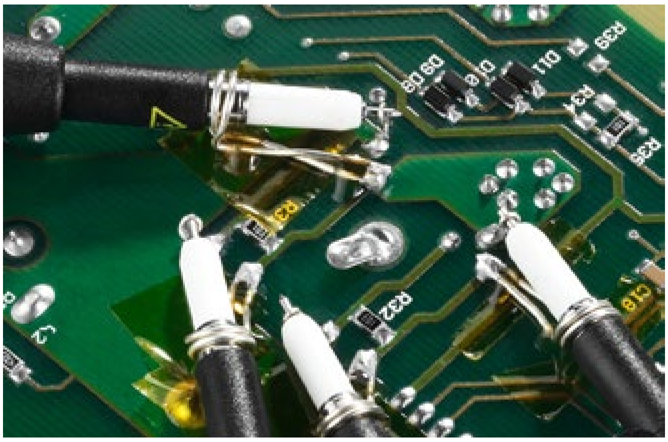


Figure 3: Prefabricated conductor loops for safe measurement of hazardous live voltages using passive probes and an oscilloscope with isolated inputs; source: Rohde & Schwarz

Differential probes can generally be connected arbitrarily in the circuit. However, when making measurements with isolated input channels, the exact points where the signal conductor and the ground are connected are important. The unbalanced design used in isolated input

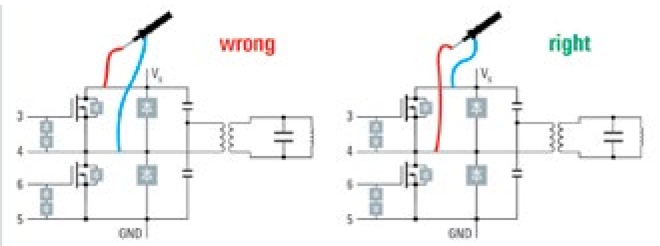


Figure 4: For measurements with isolated input channels, the signal conductor should always be connected to the appropriate measurement point; source: Rohde & Schwarz

stages results in much lower capacitance between the signal path and earth potential compared to what exists between the ground path and earth potential. In order to obtain satisfactory measurement results, the signal path should be connected to the appropriate measurement point.

The input voltage derating is important

Converters for electrical drives typical operate with clock frequencies in the range from 10 kHz to 100 kHz. In order to make safe measurements on converters of this kind it is essential to consider the so-called “derating” of the maximum voltage of the measuring system vs. frequency. For every measurement system, the maximum permissible voltage between the input terminals, or one input and the earth potential, decreases with frequency. If this voltage is exceeded, the user can be endangered. The R&S Scope Rider allows measurements with full signal amplitude up to 100 kHz, making the instrument well suited for this application.

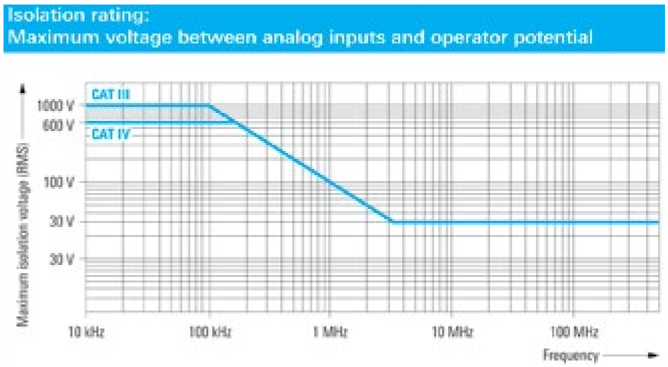


Figure 5: Derating of the maximum voltage between the oscilloscope input and earth potential in case of the R&S Scope Rider. Clock frequencies up to 100 kHz can be safely measured with the maximum permissible input voltage; source: Rohde & Schwarz

If the DUT is also connected to the electrical installation, the measurement category must be taken into account, too. Depending on where the DUT is connected in the electrical installation, the measuring system must tolerate different levels of voltage peaks on the input channel without endangering the user due to flashovers or short circuits. As the location gets closer to the building connection for the electrical installation, higher levels of voltage peaks can occur, thereby increasing the required overload protection. An isolated oscilloscope in category 4 (CAT IV rating) provides the necessary degree of safety. The R&S Scope Rider has overload protection of up to 8000 V and is thus appropriate for 600 V (RMS) in a CAT IV environment or 1000 V (RMS) in a CAT III environment.

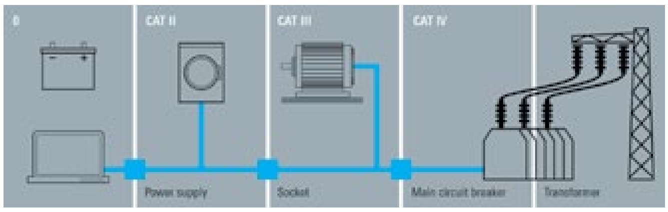


Figure 6: Measurement categories in line with EN 60664-1; source: Rohde & Schwarz

Additional functions simplify everyday measurements

Cutting-edge oscilloscopes offer a number of functions that greatly simplify everyday measurements. For power electronics, this includes automatic measurement functions for calculating the apparent, active and reactive power, flexible triggering capabilities to allow selection of specific signal elements in a switching operation, and a measurement data logger or history function for long-term monitoring of selected measured values or signals.

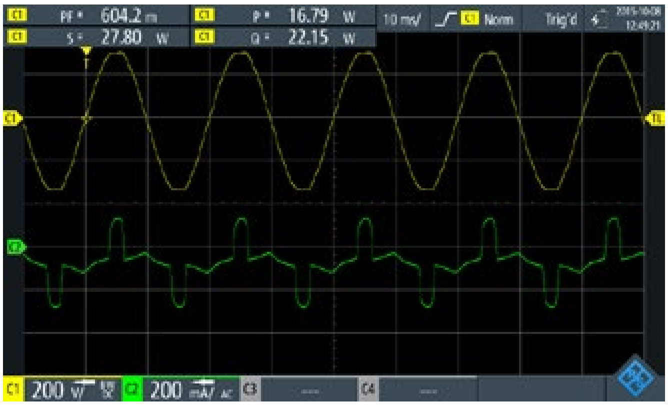


Figure 7: Automatic measurement functions calculate the apparent, active and reactive power as well as the power factor from the measured voltage (channel 1) and current (channel 2); source: Rohde & Schwarz

Another useful analysis function is provided by the harmonic analyzer. Current and voltage harmonics are unwanted spurious products of converters. These harmonics must lie within specified limits in order to avoid a negative impact on the quality of the power distribution network. Other important parameters include the phase relationships between the different harmonics as well as the total harmonic distortion (THD).

The R&S Scope Rider provides these measurement functions thanks to its harmonics analysis function. Up to four channels can be simultaneously and automatically evaluated, displayed and monitored with respect to predefined limits if necessary.

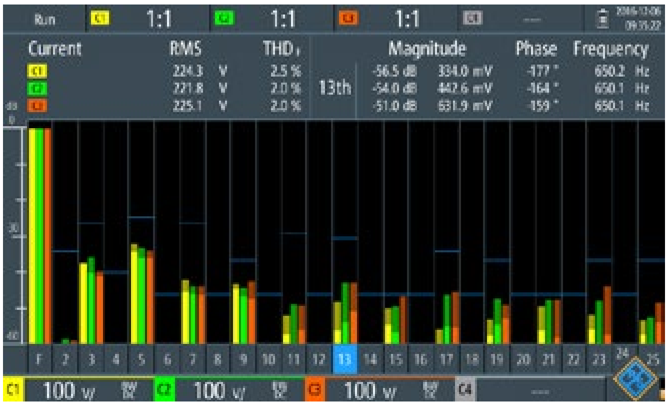


Figure 8: Harmonics analysis of a three-phase 100 V signal. The blue lines show the current limit value in line with EN 50160. The 13th harmonic and its characteristics are highlighted; the highlighted levels for the three channels lie between –56.5 dB and –51.0 dB; source: Rohde & Schwarz

In order to provide maximum safety for hazardous test situations, the R&S Scope Rider (R&S RTH) can be remotely operated via WLAN to fully decouple test instrument operation from the DUT.

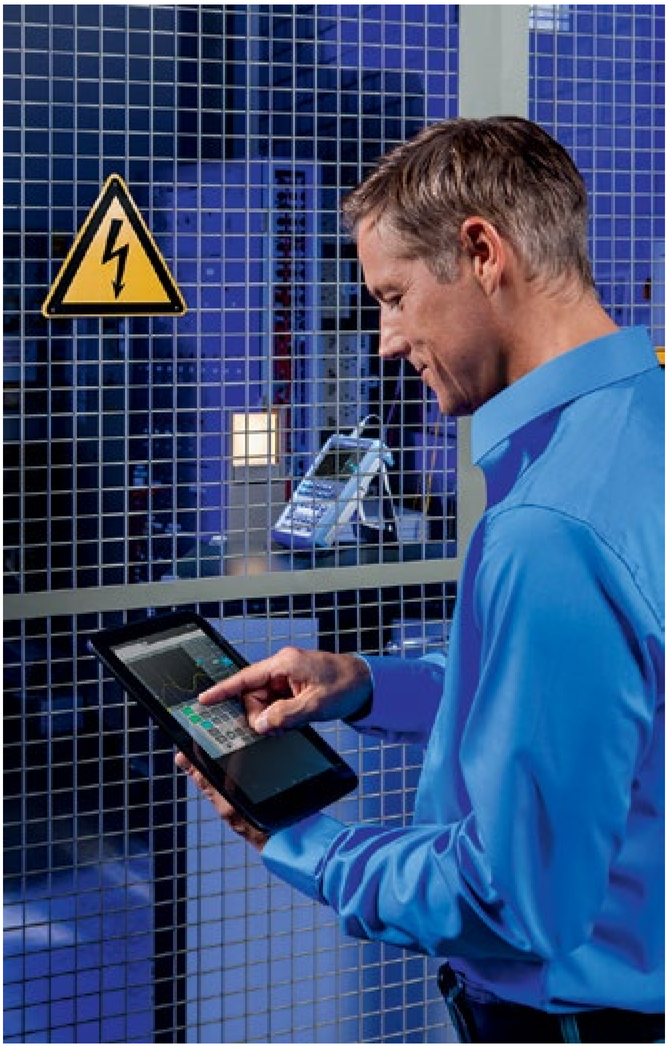


Figure 9: In especially hazardous test situations, the R&S Scope Rider can be remotely operated via WLAN; source: Rohde & Schwarz

Summary

Developers have already come to appreciate oscilloscopes with isolated input channels as a powerful yet cost-effective alternative for safely performing measurements on power electronics modules. Thanks to advanced frontend technology, up to 500 MHz bandwidth and powerful signal processing, these oscilloscopes are now also appropriate for measurements on circuits with GaN- or SiC-based semiconductors. The R&S Scope Rider from Rohde & Schwarz is an impressive representative of this class and is also well suited for classic oscilloscope applications due to its wide range of analysis capabilities as well as its uniquely designed isolated input channels.

www.rohde-schwarz.com/ad/press/scoperider

Silicon Nitride Substrates for Power Electronics

Today's power module designs are primarily based on Al_2O_3 or AlN ceramic, but increasing performance demands are causing designers to consider advanced substrate alternatives. One example is seen in xEV applications where an increase in the chip temperature from 150°C to 200°C reduces switching losses by 10%. Additionally, new packaging technologies like solder and wire bond free modules are making the current substrates the weak link.

By Manfred Goetz, Senior Product Marketing Manager, Rogers Germany GmbH

Another significant driver of special importance is the need for increased life time under harsh conditions such as with wind turbines. They have an expected lifetime of 15 years without failure under all environmental conditions; hence designers for this application are looking for improved substrate technologies as well. A third driver for improved substrate options is the emerging use of SiC components. The first modules using SiC and optimized packaging showed loss reduction of between 40 to 70 % compared to traditional modules, but also the need for new packaging methods including Si3N4 substrates. All these trends will limit the future role of traditional Al2O3 and AlN substrates, while substrates based on Si3N4 will be the designer's choice for high performance power modules in the future.
The excellent bending strength, high fracture toughness and good thermal conductivity make Si3Ni4 well suited for power electronic substrates. The characteristics of the ceramic and a detail comparison of key values like partial discharge or crack growth show a significant influence to the final substrate behavior like heat conductivity and thermal cycling behavior.

Comparison of Si3N4 and other ceramics
The main properties for selection of insulating materials for power modules are thermal conductivity, bending strength and fracture toughness. A high thermal conductivity is critical for rapid heat dissipation in a power module. The bending strength is important for handling and usability of the ceramic substrate in the packaging process, while the fracture toughness is key in predicting reliability.

	Al_2O_3 96%	AlN	ZTA (9%)	Si_3N_4
Thermal conductivity [W/mK]	24	180	28	90
Bending strength [MPa]	450	450	700	650
Fracture toughness [MPa / $\sqrt{m}$]	3,8-4,2	3-3,4	4,5-5	6,5-7

Table 1

As seen in Table 1 Al2O3 (96%) shows a low thermal conductivity and low mechanical values. However, the thermal conductivity of 24 W/mK is sufficient for many of today's standard industrial applications. The big advantage of AlN is the very high thermal conductivity of 180 W/mK, despite having only moderate reliability. This is a result of the low fracture toughness and similar bending strength to Al_2O_3.
The increasing demands for higher reliability spurred the development of ZTA (zirconia toughened alumina) ceramics recently. These ceramics show a significantly higher bending strength and fracture toughness. Unfortunately, the thermal conductivity of ZTA ceramics is in the same range as standard Al_2O_3 and therefore it is of limited use in high power applications with the highest power densities.
A comparison shows that Si3N4 combines high thermal conductivity with high mechanical performance. The thermal conductivity can be specified at 90 W/mK, and it has the highest fracture toughness of the compared ceramics (6,5 – 7 [MPa / $\sqrt{m}$]). These properties lead to the expectation that Si3N4 will show the highest reliability as a metallized substrate.

Reliability
Several different metallized substrates were tested for reliability with a passive thermal cycling method. All substrate combinations are shown in Table 2. For each combination, the same layout was used, including same copper thickness d(Cu) = 0.3 mm. There were no additional design features like dimples or step etching to increase reliability. The test conditions were defined as follows:

- 2 chamber test systems
- dT = 205 K (-55°C to +150°C)
- exposure time 15 min
- ramp up time < 10 s

The different specimens were checked by ultrasonic microscope to detect delamination and conchoidal fracture:

- after every 5 cycles for Al_2O_3, HPS9% (ZTA) and AlN DBC
- after every 50 cycles for Si_3N_4 AMB (active metal brazing)

Combination	Copper Layoutside [mm]	Ceramic [mm]	Copper Backside [mm]	Thermal Cycles [1]
Al_2O_3 DBC	0.3	0.38	0.3	55
HPS 9% (ZTA) DBC	0.3	0.32	0.3	110
AlN DBC	0.3	0.63	0.3	35
Si_3N_4 AMB	0.3	0.32	0.3	5000

Table 2

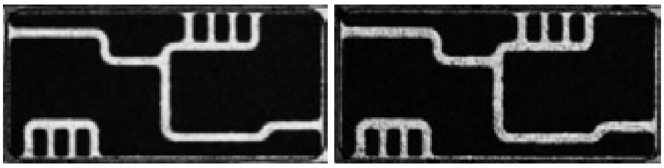
Conchoidal fracture is the typical failure mode in temperature cycling and was detected on Al_2O_3, HPS9% and AlN -DBC substrates. In general this breakdown appears due to the different thermal expansion values of copper and ceramic during changing temperature.

The lowest reliability in thermal cycling was observed for AlN DBC substrates with 35 cycles. This result can be explained by the lowest measured fracture toughness (K1C = 3 - 3,4 [MPa / $\sqrt{m}$]) of the ceramic. Very close to this result is Al_2O_3 DBC with 55 cycles. The best perfor-mance for the traditional materials was demonstrated by the HPS9% DBC, with two times higher reliability (110 cycles) than standard Al_2O_3.

No failures of the Si3N4 AMB samples have been detected at 5000 cycles. The reliability could be increased by a factor of 45x compared to HPS9% DBC. The outstanding result of 5000 thermal cycles was achieved due to the high fracture toughness of Si3N4 (K1C = 6,5 - 7 [MPa / $\sqrt{m}$]) even though the bending strength is slightly lower than HPS9% (650 MPa vs. 700 MPa).

These results highlight that the bending strength of ceramics used to build metallized substrates is not key to the lifetime of the substrate. The physical property of the ceramic that is most important to predict reliability appears to be fracture toughness.

Picture 1: The main difference in failure mechanism of HPS9% DBC substrates and Si3N4 AMB after several thermal cycles.



Picture 2: The Si3N4 ceramic material is still undamaged after more than 5000 cycles.

Picture 1 and 2 shows ultrasonic pictures of the main difference in failure mechanism of HPS9% DBC substrates and Si3N4 AMB after several thermal cycles. While we can detect a conchoidal fracture inside the brittle HPS9% ceramic material, the Si3N4 ceramic material is still undamaged after more than 5000 cycles.

Thermal Performance:
Five different groups of metallized substrate samples were measured for thermal resistivity (Rth).

Diagram 1 shows the results of our thermal resistivity testing. All specimens used for this Rth analyses were metallized with 0.3 mm copper layer on both sides. As expected, the substrate using 0.63 mm Al2O3 showed the highest Rth. This is caused by the low thermal conductivity of Al2O3 (24W/mK).

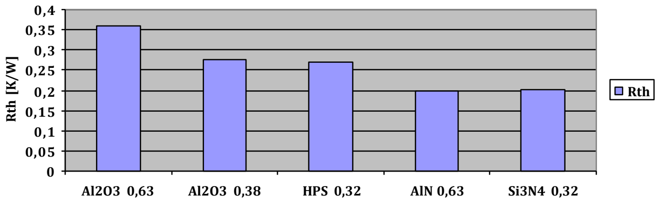


Diagram 1: Results of our thermal resistivity testing

The Rth of the 0.32 mm HPS 9% DBC and 0.32 mm Al2O3 DBC were in the same range.

The AlN DBC with the highest thermal conductivity of 180 W/mK had the lowest Rth despite using a 0.63 mm thick ceramic layer.

The thermal conductivity of Si3N4 (90W/mK) is half that of AlN and explains why the Si3N4 AMB shows a similar Rth to AlN DBC by using half of the ceramic thickness (0.32 mm for Si3N4 compared to 0.63 mm for AlN).

Conclusion:
The increasing demand for longer life time cycles and higher thermal performance in power modules can be realized with high strength Si3N4 insulating material.

The investigation showed that the reliability of Si3N4 was better by a factor of 50 using comparing Si3N4 AMB (active metal brazing) technology compared to conventional HPS9% DBC ceramic materials. The higher mechanical properties of Si3N4 ceramic, especially its very high fracture toughness (K1C) contributes to its enhanced reliability. Furthermore, Si3N4 higher strength allows it to be used with a thinner cross section giving it comparable thermal performance to AlN.

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IGBT Driver Module Enables High Power Systems Design with Reduced Design Time and Cost

IXYS Corporation's new IXIDM1403 driver module, designed with an objective to serve the market with IGBT driver parts that enable a short design cycle and the lowest design cost possible, combines supreme compactness with the highest performance and reliability. IXIDM1403 supports dual-channel high power IGBT modules with up to 4000 V isolation voltage, switching speed up to 50 kHz, short-circuit protection, and supply-voltage monitoring.

By Abdus Sattar PhD, and Leonid Neyman PhD, IXYS Digital Power

IXIDM1403 is a high-voltage isolated gate driver module based on the IX6610/IX6611/IXDN630 chipset, which allows creation of an isolated IGBT driver with a high voltage isolation barrier between the primary and secondary sides and between secondary side drivers. This creates a very flexible architecture, which can be used for 3-phase motor drivers, half-bridge switches, push-pull converters, other Uninterruptible Power Supply (UPS) applications, renewable energy, and transportation, which require isolation between the primary and secondary sides and/or between secondary side drivers.

An internal power supply provides up to 2 W per channel of isolated power to drive both upper and lower IGBTs, effectively isolating the MCU from high power circuitry. Operating from a single polarity 15 V power source, it provides +20 V/–5 V to drive the IGBT gates and +3.3 V to drive the MCU, maintaining up to 4 kV isolation voltage between the MCU and gate drivers and between gate drivers as well.

Built-in under-voltage and over-voltage protection prevents the IGBTs from operating at gate voltages outside of the optimal window and informs the MCU about such conditions without regard to the source of the problems, which may come from either the low/high side IGBT behind the isolation barrier or the primary side before the isolation barrier.

Over-current protection with a 300 mV threshold can be implemented by utilizing either a current-sense resistor or IGBT de-saturation event. This feature turns the IGBT off immediately after the collector current exceeds a value set by the user and informs the MCU, allowing it to make an appropriate decision.

TTL-level compatible input signals from an external MCU are used to operate secondary side drivers. The IXIDM1403 implements a dual-channel bidirectional transformer interface, which transmits the primary side input commands from the MCU to the secondary side and information from the secondary side to the MCU. Asynchronous data transmission is implemented by narrow pulses to prevent the transformer's core saturation.

A narrow pulse detector is also implemented to prevent transmission of very narrow false PWM input signals to the drivers. Input signal pulses with width narrower than 100 ns are suppressed and pulses with width greater than 350 ns are transferred to the drivers. To avoid limitations to the input pulse maximum width, only short pulses representing rising/falling edges of the input signals are transmitted from the primary side, while the secondary side restores the original pulse width.

The secondary side gate drivers convert the incoming PWM logic signals to +20 V/–5 V (with respect to COMMON) bipolar gate drive signal with a typical 30 A peak drive current capability.

The built-in dead time delay circuitry, with channel A priority, prevents the IGBTs from turning on simultaneously. If channel B is active and channel A is forced into on-state, channel B becomes disabled immediately and the channel A IGBT turns on with a preset delay time. After channel A becomes inactive, channel B, if active, turns on with the same delay time. If channel A is active and channel B is forced into on-state, this command will be ignored as long as channel A remains active. If channel A becomes inactive before the command activating channel B expires, channel B becomes active with a preset delay time after channel A becomes inactive. A single input signal source can be used to create a complementary switching pair of IGBTs in a half-bridge configuration by setting channel B as permanently enabled and operating channel A only.

Dead time between pulses at Gate A and Gate B outputs is hardware programmed to ~420 ns. If the dead time required to operate specific IGBTs is greater than implemented in IXIDM1403, it should be programmed by the MCU or factory-adjusted to the required value.

The over-temperature protection function disables the IGBTs if the internal module temperature exceeds 150°C, and resumes normal operations when the temperature falls below 125° C. If the IGBT assembly is equipped with a temperature sensor, the IXIDM1403 is able to translate its signal to the MCU. A dual-channel bidirectional transformer interface allows for transmission of information to the MCU about secondary side power supply faults and IGBT over-current conditions.

All fault conditions at the primary side stop execution of the PWM cycle at both drivers, while all fault conditions at the secondary side stop the PWM cycle at the affected driver only. If fault conditions ap-

pear before the start of the PWM cycle, the PWM cycle will be ignored as long as fault conditions exist.

The IXIDM1403 power block is designed to provide up to 2 W of power and features a start-up mode and a run mode. In the start-up mode, the converter operates from the internal oscillator and activates only a portion of the power switches to reduce the dynamic current consumption/power dissipation. After start-up, the converter activates all the power switches and goes into run mode. The run mode is held off ~1.28 ms. Transmit operation is disabled during start-up mode to minimize current draw in the secondary side. After run mode begins, it continues until a restart occurs, which returns the power block to start-up mode.

In the run mode, the power block operates either from an internal or external clock. Use of an external clock from the MCU minimizes noise interference between IXIDM1403 devices when used for multi-phase applications like motor drivers. A converter's watchdog timer prevents potential damage due to the absence of an external clock. Whenever the external clock period exceeds the watchdog timeout of 40 µs, the converter switches to the internal clock.

Each of the IXIDM1403 IGBT drivers also contains an over-current (OC) comparator with a
300 mV threshold with respect to the COMMON pin. Over-current protection can be implemented either by using a low value current sense resistor, an IGBT with a secondary current sense output, or utilizing a de-saturation event. If an over-current fault occurs, the driver's output is forced low for the remainder of the cycle. Normal operation resumes at the beginning of the next PWM gate drive cycle.

A noise filter at the current sense input may be required due to low sense voltage. The OC comparator has an internal 100 pF capacitor connected in parallel to the input; therefore, only a serial resistor can be added to create such a filter. To prevent false tripping, the OC comparator's input is grounded during the off time of the IGBT and remains grounded for 3.5 µs immediately after the IGBT turns on. When an over-current event occurs, the Output Faults Pulse Generator creates a narrow 200 ns pulse that is used by the Fault Control Logic to communicate the fault condition to the MCU.

The IXIDM1403 is available in a 55 x 50 x 28 mm package with a 12-pin, 1 mm-pitch FFC connector to communicate with an MCU, two 5-pin, 2.54 mm-pitch headers to provide signals to/from the IGBTs, and one 2-pin, 2.54 mm-pitch header to translate signals from an external temperature sensor to the MCU.

Figure 1 shows an example of an application where IXIDM140 is used to operate IXYS's phase leg IGBT module MIXA225PF1200TSF.

Figure1: IXIDM1403 – MIXA225PF1200TSF Module Assembly

Powered from a single polarity 15 V power supply, IXIDM1403 operates two 1200 V IGBT devices with a maximum collector current of 360 A. This design allows the MCU to alert customers about under– or over-voltage conditions on the primary and secondary sides, and overload conditions when the IGBT goes into de-saturation mode. The MCU can be powered from this module and does not require a separate power source. If a user prefers to drive the MCU from an external power source, this can also be accomplished. Additionally, internal IXIDM1403 logic can be powered from the same external source, minimizing power consumption from the 15 V power supply.

Typical applications for this design are shown in Figures 2 and 3.

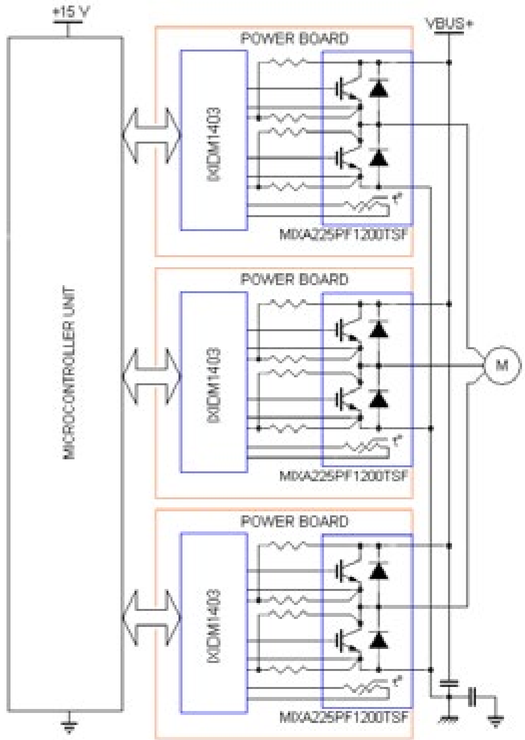

Figure 2: Typical Application Circuit of a Three-phase Motor Driver

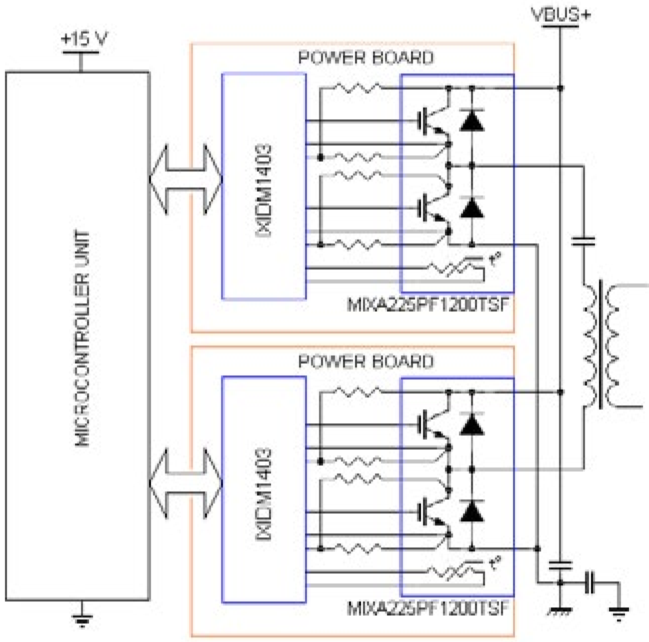

Figure 3: Typical Application Circuit of a Full-bridge Inverter

Figure 4 and 5 display typical IXIDM1403 performance with the MIXA-225PF1200TSF module as a load.

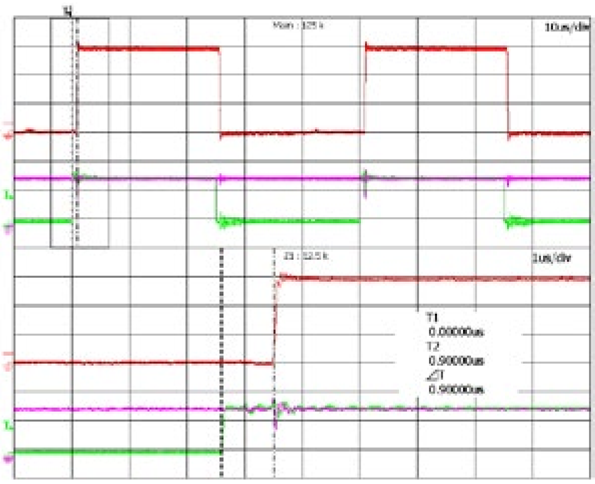

Figure 4: MIXA225PF1200TSF Operating in Complementary Mode with a Single Signal Source at IXIDM1403 Channel A and Channel B Permanently Enabled

Input to Output Propagation Delay at Rising Edge
Channel 1 – red – IGBT Module pin #3, 4 voltage
Channel 2 – green – IXIDM1403 channel A input signal
Channel 3 – magenta – IXIDM1403 channel B input signal

Note: The lower portion of Figure 4 is magnified 10 times the upper portion.

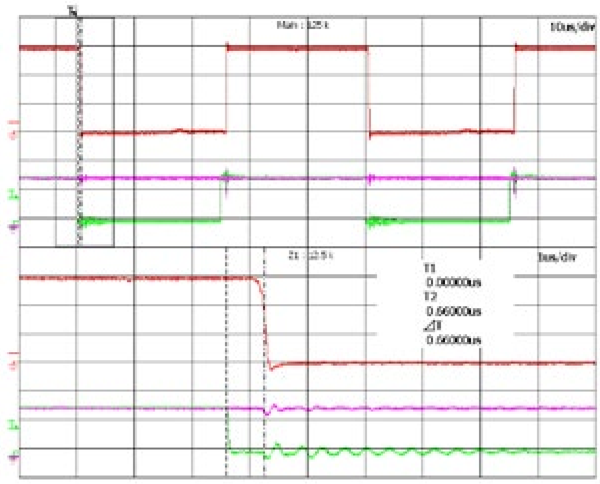

Figure 5: MIXA225PF1200TSF Operating in Complementary Mode with a Single Signal Source at IXIDM1403 Channel A and Channel B Permanently Enabled

Input to Output Propagation Delay at Falling Edge
Channel 1 – red – IGBT Module pin #3, 4 voltage
Channel 2 – green – IXIDM1403 channel A input signal
Channel 3 – magenta – IXIDM1403 channel B input signal

Note: The lower portion of Figure 5 is magnified 10 times the upper portion.

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Electrolytic Capacitor Leakage Current

Aluminum electrolytic capacitors ("alu-caps", "e-caps") are mission-critical components in many power electronic devices. Increased demands for energy efficiency, the expanding use of renewable energy and the growing share of electronics in the automotive industry have driven the widespread use of these components.

By Dr. Arne Albertsen, Jianghai Europe Electronic Components GmbH

In many applications, service life and reliability of the device depend directly on the corresponding parameters of the electrolytic capacitors. While earlier contributions of the author gave an overview of electrolytic capacitor technology [1] as well as the topics of life time estimation [2], reliability [3] and limits of voltage proof [4], this article focuses on the leakage current of electrolytic capacitors.

Construction of aluminum electrolytic capacitors

Aluminum electrolytic capacitors comprise a voltage range from of a few volts up to approx. 700 V and offer a wide capacitance range from 1 µF up to about 1 F whilst having a compact construction at the same time. The surface of a highly roughened anode foil made from aluminum with a thin dielectric layer of aluminum oxide is fully contacted by a precise-fitting cathode, the electrolyte liquid (Figure 1).

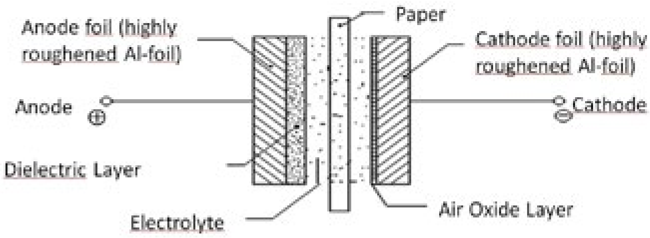

Figure 1: Internal structure of aluminum electrolytic capacitors

An electro-chemical process called "anodic oxidation" or "formation" produces the dielectric layer on the surface of the roughened anode foil. The quality of formation (i.e. the composition and thickness of the dielectric layer) are essential for high reliability of the electrolytic capacitors during operation. Figure 2 shows an electron micrograph of the surface of an etched high voltage anode foil.

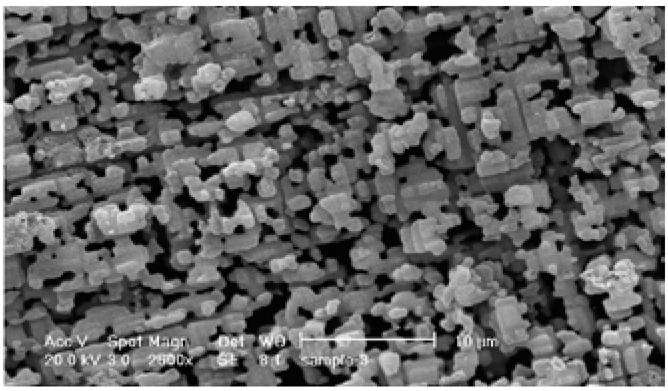

Figure 2: Surface of an etched anode foil

Figure 3 shows the layer structure of the dielectric in cross section. On the aluminum foil ① is a layer of amorphous aluminium oxide ②, followed by crystalline ③, and finally a layer of hydrated oxide ④.

The compact molecules of the amorphous layer ② are only loosely bound, i.e. they have little interaction with each other. This is useful when fluctuations of the electric field induced by a ripple current stimulate them, because less heat is dissipated compared to tightly coupled molecules. The "friction" between the molecules is low.

The molecules in the crystalline layer ③ are more closely arranged and offer a good insulation resistance, which yields small leakage currents.

The large molecules of the hydrated layer ④ can be easily polarized and generate relatively high "friction losses". At higher temperatures, water molecules in the hydrated layer dissociate and weaken the crystalline layer ③, too, and thus lead to an increase in leakage current.

A goal for the development of new anode foils is therefore to reduce the thickness of the hydrated layer and at a same time to increase the amorphous layer. Jianghai has its own factories for the formation of the anode material thanks to its strategy of vertical integration and can optimize the technology of the anode formation.

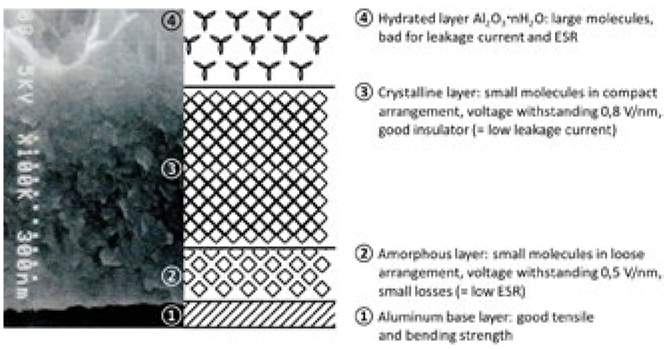

Figure 3: Layer structure of the aluminum oxide dielectric of a high-voltage capacitor (left: electron micrograph, right: schematic representation)

Leakage current

Defects in the dielectric of the anode are a major cause of the leakage current observed with electrolytic capacitors. Defects result from manufacture-related damages (cutting of the film, riveted connections of the tabs), crystal errors, the presence of foreign atoms in the

aluminum base layer, mechanical stress (from winding), and partial dissolving of the oxide layer in the electrolyte [5].

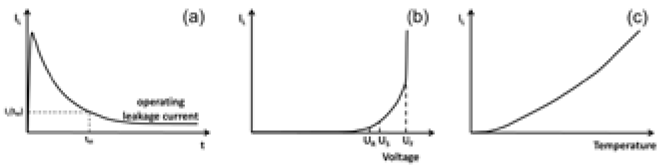

Figure 4: Electrolytic Capacitor leakage current as a function of time (a), voltage (b), and temperature (c)

The dielectric absorption, bypass currents parallel to the capacitor cell as well as tunnel effects [6] make smaller contributions to the leakage current. Within a few minutes connected to voltage, the electrolytic capacitor leakage current decays approximately exponentially and takes on an almost constant value, the operating leakage current (Figure 4 (a)).

The operating leakage current [5] as a measure of the forming condition of anode foil depends on the time, applied voltage, temperature, and history of the capacitor (fig. 4 (a) ~ (c)). Typical values of the operational leakage current range between approx. 5 ~ 15% of the data sheet value of leakage current amount and are usually reached after several ten minutes of continuous operation.

Storage of electrolytic capacitors

The leakage current specified in the data sheet shall be valid even after a long, voltage-free storage period and has therefore a much higher numerical value than the operating leakage current. The oxide layer dissolves to a certain extent as a function of temperature and electrolyte composition, because without any voltage applied, the oxide layer cannot regenerate ("self-healing") [5].

Thus, devices kept for maintenance purposes should be operated from time to time. The periods of time for a brief "regeneration operation" depend on the type of electrolytic capacitors used, and are typically in the range of several years.

When storing fresh, not yet assembled and soldered capacitors, Jianghai recommends not to exceed a period of 12 months after arrival at the end user prior to processing and use. Longer storage times may negatively affect the solderability or cause increased leakage current during the first operation. Depending on the series and the environmental conditions during storage, longer storage periods may be agreed upon individually.

While low-voltage capacitors (up to 100 V rated voltage) with solvent-based electrolyte systems are usually very stable, high-voltage capacitors (from 160 V rated voltage) with ethylene glycole-based electrolytes and in particular so-called "low ESR" types with aqueous electrolytes may exhibit an increase of leakage currents throughout their lifetime.

15 ~ 30 minutes of operation of the electrolytic capacitors via a resistor (low-voltage: 100 Ω, high-voltage: 1 kΩ, see [7], section 4.1 "pretreatment") at a voltage increased gradually to rated voltage may heal the weak spots in the dielectric and lower the leakage current below the data sheet value.

Balancing of capacitor banks

In a series connection of capacitors, the voltage across the capacitors splits according to the ratio of insulation resistances of the capacitors (or in relation to the reciprocal leakage currents of the capacitors) [8].

To ensure a uniform distribution of the voltage, the quiescent current I_Q through the voltage divider resistors in Figure 5 should exceed the (operating) leakage current by several times. The use of electrolytic capacitors from the same production lot is beneficial, because they have usually less deviations of leakage currents among them than products from different batches.

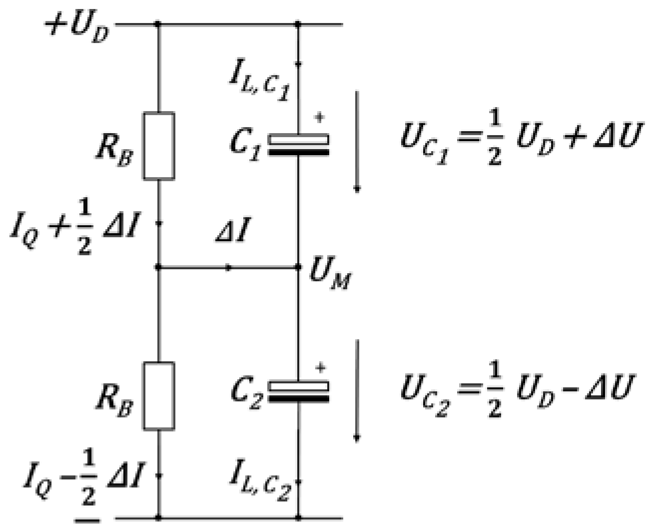

Figure 5: Passive balancing of e-cap voltages with resistors (acc. to [9])

The midpoint voltage U_M can be computed as [8]:

$$U_M = \frac{(I_{L,C_2} - I_{L,C_1}) \times R_B}{2} + \frac{U_D}{2} \qquad 1$$

Equation (1) shows that the midpoint voltage U_M differs from the desired ideal value of U_D/ 2 by a value which is proportional to resistance R_B and leakage current difference.

For the estimation of the balancing resistors R_B, a good compromise between power losses and acceptable voltage difference needs to be found.

The leakage current difference of the electrolytic capacitors at upper category temperature can be estimated by equation (2) [8]:

$$I_{L,C_2} - I_{L,C_1} = \frac{0{,}003 \times C \times U_D}{2000} \quad \left[\frac{mA}{\mu F \times V}\right] \qquad 2$$

Solving equation (1) for and substituting the expression for by eq. (2) yields:

$$R_B = \frac{2000 \times (2 \times U_m - U_D)}{0{,}003 \times C \times U_D} \quad [\mu F \times k\Omega] \qquad 3$$

For ideal balancing resistors, i.e. with identical resistance values, the midpoint voltage would equal the electrolytic capacitor's rated voltage. Real resistors are however subject to a tolerance, so that also the midpoint voltage will deviate from the ideal of the half dc link voltage. With a tolerance of the resistance values of e.g. ±5%, the resulting midpoint voltage will deviate from the ideal value by almost 10% [8] in the worst case. It is therefore advisable to use low tolerance resistors and to choose a midpoint voltage below the rated voltage of the capacitors when employing passive balancing.

Many options: intermediate circuit topologies

For a parallel connection of several branches of electrolytic capacitors connected in series, also the question arises for the topology of the balancing circuit: all branches individually balanced (Figure 6a) or to connect the midpoints of all branches and to apply central balancing (Figure 6b) - or rather perform the balancing of capacitors in groups (Figure 6c)?

Each of these topologies (a) ~ (c) has specific advantages and disadvantages [8]:

(a) individual balancing

Advantage: in case of a failure of an individual electrolytic capacitor due to short circuit, just one other capacitor in the branch of the defective electrolytic capacitor suffers from overvoltage. The remaining electrolytic capacitors in the bank are initially unaffected by the failure of a single branch of the bank.

Disadvantage: There is a higher wiring effort with more resistors and connections (and thus a higher space requirement and cost).

(b) centralized balancing

Advantages: in the steady-state, average capacitance and leakage current values of the upper and lower half of the bank will approach each other. There are only two central balancing resistors used, which may have relatively high ohmic values as upper and lower half of the dc-link are similar.

Disadvantage: in case of failure of a single electrolytic capacitor due to short circuit, several electrolytic capacitors may be damaged by overvoltage. Care must be taken to achieve a uniform distribution of the current flow into the individual branches of the capacitor bank as well as a homogenous ambient temperature distribution in the vicinity of the capacitor bank.

(c) Group balancing

Figure 6 c) shows a possible combination of (a) individual and (b) centralized balancing. This topology combines the advantages and disadvantages of the individual variants.

In addition to passive balancing, also the so-called active balancing is found in particular in large inverters. The active balancing circuit concept, which can be realized in cascode-voltage follower topology, for example, offers some advantages [9]:

- It can be used resistors with small losses
- Energy cost savings over the lifetime of the inverter
- Better balancing accuracy in the steady-state
- Low-cost solution

However, a disadvantage of active balancing is that no automatic discharge of the dc-link intermediate circuit occurs when the inverter is switched off. The safe discharge of the intermediate circuit when switched off must therefore be ensured by other means.

Summary

Due to their design, aluminum electrolytic capacitors have the peculiarity of requiring an operating leakage current to allow for the so-called „self-healing“. The leakage current is closely related to the composition and the construction of the dielectric layer. A closer examination of the dielectric layer shows that it consists of various layers of aluminum oxide. By a suitable process control during the forming of the anode material, the properties of the dielectric can be optimized. In electrolytic capacitors for demanding applications, providers such as Jianghai, which rely on their own formation facilities for the anode foils, are offering technical advantages.

The leakage depends on the duration of the operation, the operating voltage, temperature as well as the prehistory of the electrolytic capacitors. The duration of a voltage-free storage of electrolytic capacitors is time-limited. The difference in leakage current between electrolytic capacitors (even if they come from the same production lot) is so large that it requires a balancing of the voltage

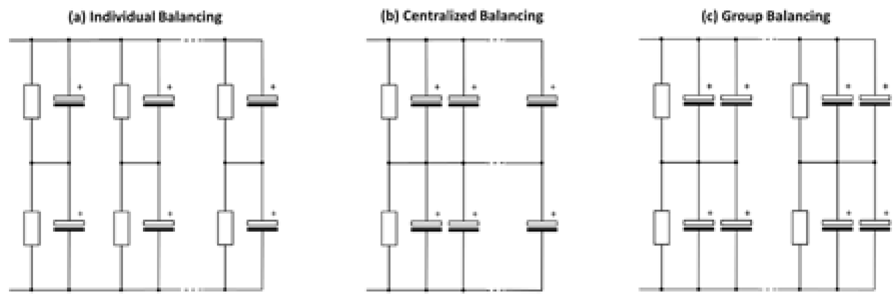

Figure 6: Topologies of passive balancing for e-cap dc-link circuits

drop over a series of capacitors. The article presents the method of passive balancing and gives practical advice on properly dimensioning the resistance values. Finally, the article mentions a method for the active balancing and gives references for further reading.

The applicability of the models and their results shown here depend in individual cases on the series and the application. Therefore, a close project monitoring and confirmation of the assessments by the electrolytic capacitor manufacturer is always required.

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Company

Jianghai Europe Electronic Components GmbH, with headquarters and warehouse in Krefeld, Germany supports the European customers of Nantong Jianghai Capacitor Co., Ltd. (Jianghai) in Nantong, China. Jianghai was founded in 1958. While Jianghai developed and produced in the beginning specialty chemical products (such as electrolyte systems), from 1970 it started the design and production of aluminum electrolytic capacitors. Pre-materials like etched and formed anode foils were added to the productionportfolio. Film- and polymer capacitors complement the product portfolio. Jianghai is the largest Chinese manufacturer of e-caps and one of the three leading manufacturers of snap-in and screw terminal type capacitors in the world.

Author

Dr. Arne Albertsen studied physics focusing on applied physics at the University of Kiel. He earned diploma (1992) and PhD (1994) degrees on the measurement and analysis of current-time-series of ion channels in biological membranes. In industry, he worked in various areas of environmental and process engineering plant construction. Since 2001, he is dedicated to the marketing and sales of passive and discrete active components for leading companies like Vishay and KOA. Since November 2008, he is responsible as Senior Sales Manager for several European key account customers of Jianghai Europe Electronic Components GmbH (Krefeld). The focus of Dr. Albertsen is the design-in and application support for capacitors in professional industrial applications. Since 2011, Dr. Albertsen volunteers as an expert for electrolytic capacitors and Deputy Chairman in the standardization body „K611“ of the DKE in DIN and VDE.

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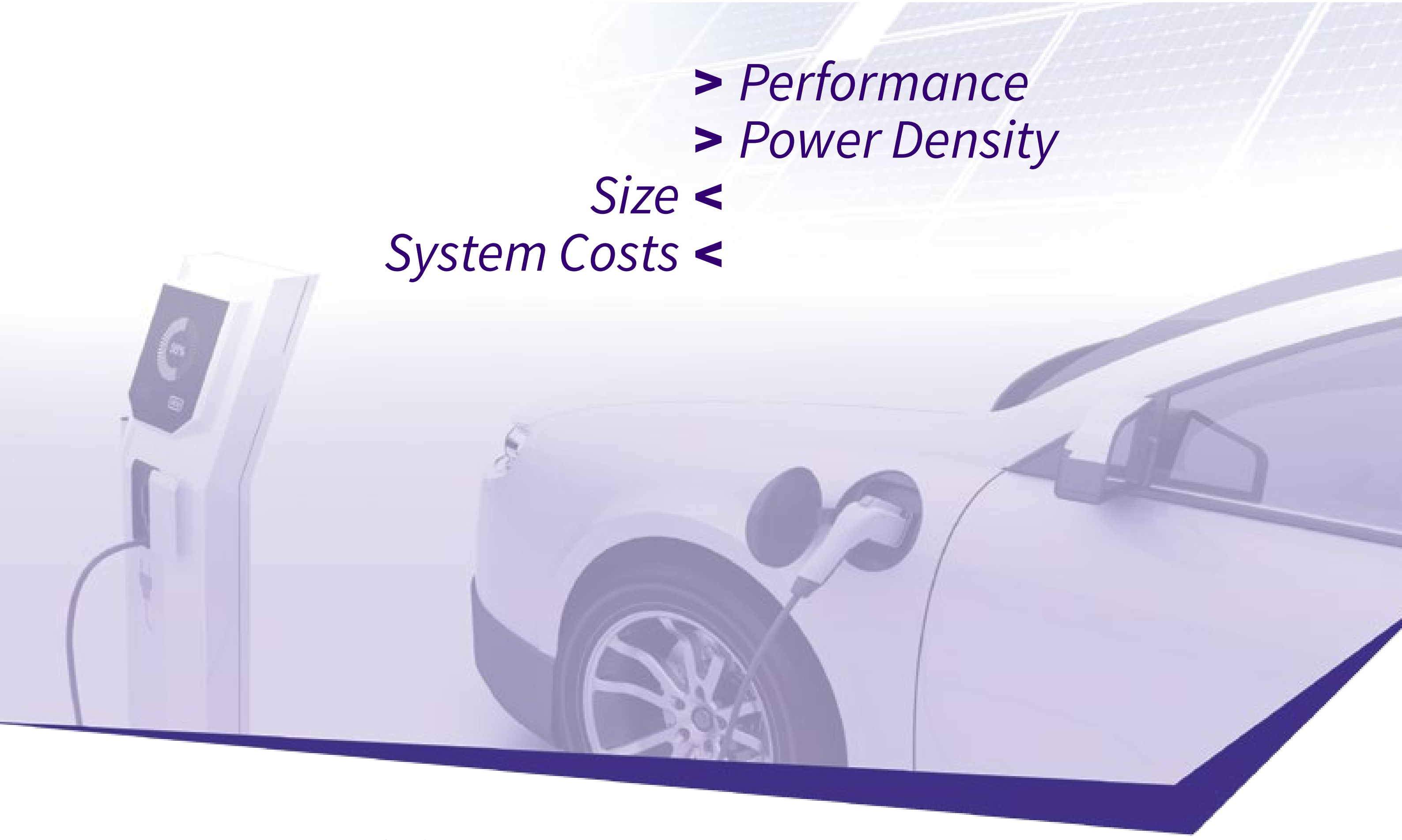

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Intermediate Voltage to Increase Power Conversion Efficiency

There are different solutions for applications that require conversion from a high input voltage down to a very low output voltage. One interesting example is the conversion from 48 V down to 3.3 V. Such a specification is not only common in server applications for the information technology market, but in telecommunications as well.

By Frederik Dostal, Analog Devices

If a step-down converter (buck) is used for this single conversion step, as shown in Figure 1, the problem of small duty cycles emerges. The duty cycle is the relationship between the on-time (when the main switch is turned on) and the off-time (when the main switch is turned off). A buck converter has a duty cycle, which is defined by the following formula:

$$\text{Duty Cycle} = \frac{\text{Output Voltage}}{\text{Input Voltage}}$$

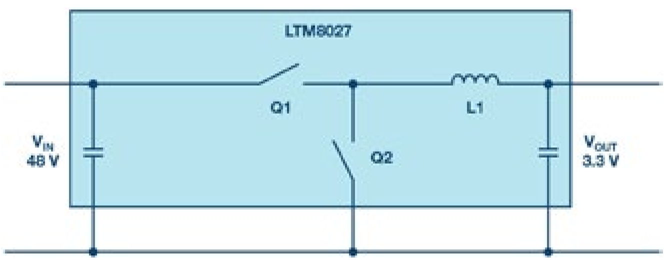

Figure 1: Conversion of a voltage from 48 V down to 3.3 V in one single conversion step.

With an input voltage of 48 V and an output voltage of 3.3 V, the duty cycle is approximately 7%.

This means that at a switching frequency of 1 MHz (1000 ns per switching period), the Q1 switch is turned on for only 70 ns. Then, the Q1 switch is turned off for 930 ns and Q2 is turned on. For such a circuit, a switching regulator has to be chosen that allows for a minimum on-time of 70 ns or less. If such a component is selected, there is another challenge. Usually the very high power conversion efficiency of a buck regulator is reduced when operating at very short duty cycles. This is because there is only a very short time available to store energy in the inductor. The inductor needs to provide power for a long period during the off-time. This typically leads to very high peak currents in the circuit. To lower these currents, the inductance of L1 needs to be relatively large. This is due to the fact that during the on-time, a large voltage difference is applied across L1 in Figure 1.

In the example, we see about 44.7 V across the inductor during the on-time, 48 V on the switch-node side, and 3.3 V on the output side. The inductor current is calculated by the following formula:

$$i_L = \frac{1}{L}\int u_L dt$$

If there is a high voltage across the inductor, the current rises during a fixed time period and at a fixed inductance. To reduce inductor peak currents, a higher inductance value needs to be selected. However, a higher value inductor adds to increased power losses. Under these voltage conditions, an efficient LTM8027 μModule® regulator from Analog Devices achieves power efficiency of only 80% at 4 A output current.

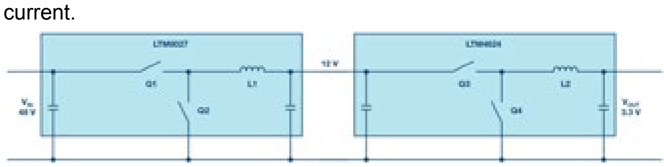

Figure 2. Voltage conversion from 48 V down to 3.3 V in two steps, including a 12 V intermediate voltage

Today, a very common and more efficient circuit solution to increase the power efficiency is the generation of an intermediate voltage. A cascaded setup with two highly efficient step-down (buck) regulators is shown in Figure 2. In the first step, the voltage of 48 V is converted to 12 V. This voltage is then converted down to 3.3 V in a second conversion step. The LTM8027 μModule regulator has a total conversion efficiency of more than 92% when going from 48 V down to 12 V. The second conversion step from 12 V down to 3.3 V, performed with a LTM4624, has a conversion efficiency of 90%. This yields a total power conversion efficiency of 83%. This is 3% higher than the direct conversion in Figure 1.

This can be quite surprising since all the power on the 3.3 V output needed to run through two individual switching regulator circuits. The efficiency of the circuit in Figure 1 is lower due to the short duty cycle and the resulting high inductor peak currents.

When comparing single step down architectures with intermediate bus architectures, there are many more aspects to consider besides power efficiency. However, this article is only intended to look at the important aspects of power conversion efficiency. One other solution to this basic problem is the new LTC7821, hybrid step-down controller. It combines charge pump action with a step-down buck regulation. This enables the duty cycle to be 2× VIN/VOUT and, thus, very high step down ratios can be achieved at very high power conversion efficiencies.

The generation of an intermediate voltage can be quite useful to increase the total conversion efficiency of a specific power supply. A lot of development is being done to increase the conversion efficiency in Figure 1 with such short duty cycles. For example, very fast GaN switches can be used, which reduce the switching losses and, as a result, increase the power conversion efficiency. However, such solutions are currently more costly than a cascaded solution, such as in Figure 2.

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Cost and Efficiency of Level-3 DC Fast-Charging Power Modules—A Benchmark Comparison

The market for electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) is heating up with environmental concerns, consumer demand, new laws, and government incentives all adding fuel to the fire.
Of course, it will take a lot more charging stations to keep all those EVs and PHEVs on the road. In this article, we briefly review EV chargers' power Levels 1, 2 and 3, take a big-picture look at the charger market, and then zoom in for a closer inspection of Level-3 DC fast-charging solutions. A comparison of the latest architectures and topologies follows before we draw our conclusions in closing.

By Baran Özbakir, Junior Product Marketing Manager, Vincotech GmbH

Introduction

Most people charge their EVs at residential locations simply because Level 1 charging with household power is just so convenient. Level 2 is the higher-power option—experts expect it will eventually become the preferred method for public and private use. This type of device is an on-the-go solution. It can be installed practically anywhere for charging on the fly. Level 1 and Level 2 chargers draw on single-phase supplies. Level 3 is the game-changer for EVs because it will mitigate range anxiety, putting to rest the fear that the vehicle will run out of juice on the road. Level 3 chargers connected to three-phase power supplies are going up like gas stations once did, with operators deploying them in shopping areas, theaters, hotels and the like. Fig.1 provides a quick run-down of charging levels.

	Level	Charger Location	Current	Power
	Level 1	On-Board	AC	<3.7 kW
Slow chargers	Level 2	On-Board	AC	<3.7 kW and <22 kW
Fast chargers	Level 3	On-Board	AC (three-phase)	>22 kW and <43.5 kW
Fast chargers	Level 3	Off-Board	DC	Currently <200kW

Figure 1: EV charger power levels

Batteries' charging periods range from 20 minutes to 20 hours, depending on the output power of the electrical vehicle charger (EVC). Take, for example, an EV with 27.2 kWh net battery capacity. A 3 kW residential charger replenishes this battery's capacity from 0% to 80% in nine hours. A DC-DC off-board fast charger (Level 3) does this in less than 45 minutes.

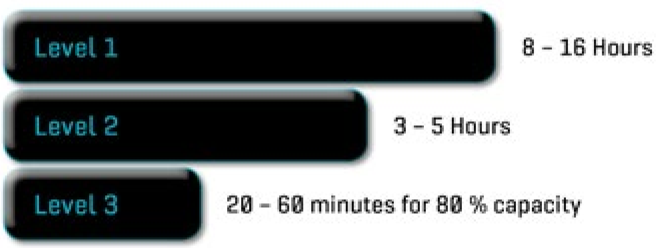

Figure 2: Average EV charging time

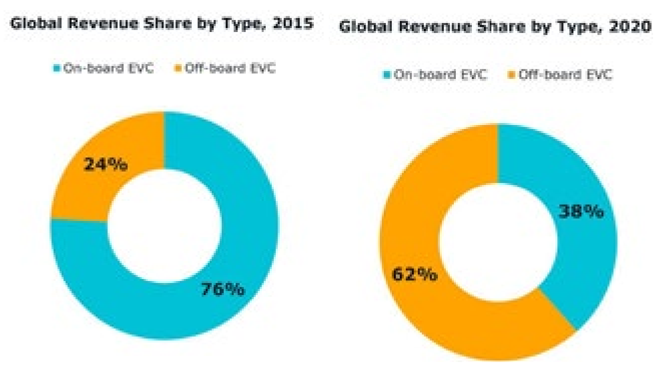

Figure 3: Global revenue share by type; Source: QY research (March 2016)

A Look at the Market

Publicly accessible charging stations are being deployed faster than EV makers are selling their cars. The number of charging outlets spiked in 2016, rising by 72% while the global EV fleet grew by roughly 60%. This upsurge suggests that a tipping point has been reached with more and more markets adopting EVs. Again, the fast off-board DC charger is the ticket to electric mobility. The market figures tell the story of the off-board charger's potential. On-board EVCs accounted for a far larger share of global revenue in 2015, but the scales are tipping towards off-board chargers. According to projections for 2020, theirs will be the far bigger slice of the revenue pie. What is more, the forecast calls for a 23% compound annual growth rate (CAGR) between 2015 and 2020. Fig. 3 depicts global revenue share for 2015 and the predicted share in 2020.

System Architectures and Topologies

Three main system architectures are on the market at the time of writing. A quick review of each follows.

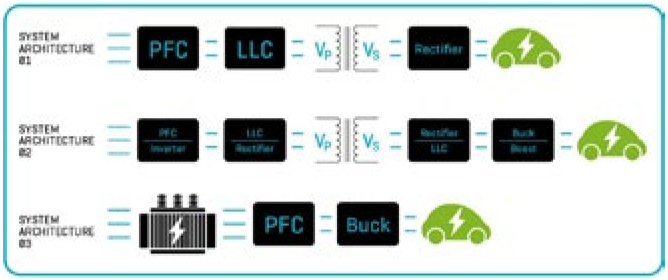

Figure 4: System architectures

System Architecture 1

This is the state-of-the-art system architecture for up to 200 kW. Composed of several units, it is a modular system.

System Architecture 2

This is a bidirectional Vehicle-to-Grid (V2G) system. It is mainly designed for residential applications where the EV serves as the storage unit. V2G is one of the key elements of smart-home applications and the smart grid.

System Architecture 3

This is the latest design aimed to serve the higher power (>500 kW) market. A medium-voltage transformer furnishes power directly to the system. It does not use any resonant topology as the medium-voltage transformer provides the galvanic isolation from the grid.

Three-phase PFC Topologies

Three-phase PFC is an appealing solution for engineers seeking high power density and high efficiency. It is common practice to combine three single-phase modules in an AC system, thereby achieving the required output power level with three-phase PFC. This section briefly explains the prevailing three-phase PFC topologies, and benchmarks these in the context of an EV charger's application conditions.

We benchmarked costs and efficiency to illuminate the topologies' strengths and weaknesses. Switching frequencies are higher (>40 kHz) in PFC modules for charger applications, so for this comparison we considered IGBTs in switches and SiC diodes at the positions where reverse-recovery losses occur. Fig. 6 shows the benchmarked efficiencies and costs on a comparative scale. Note that SPFC and ANPFC topologies' efficiencies are nearly the same given the same component technologies. However, ANPFC requires just one gate-driver, which reduces the overall system's cost.

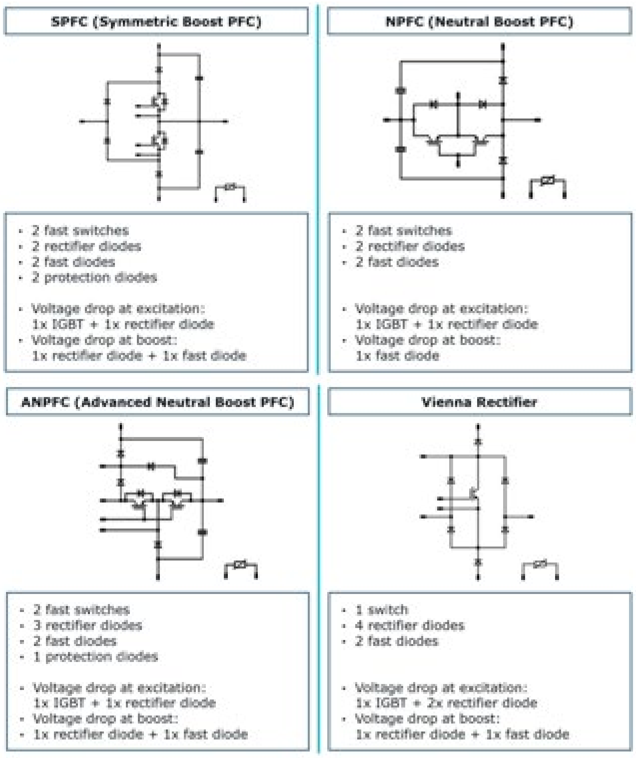

Figure 5: Three-phase PFC topologies

LLC Topologies

The resonant topology in an EV charger application serves two purposes—to provide the galvanic isolation and convert DC to DC. The industry uses several resonant (soft-switching) topologies. This paper's comparison is based on LLC, the state-of-the-art resonant topology for charger applications. LLC is a soft-switching topology. Every design's parameters are unique, so finding the right module for the application is more of challenge than for hard-switching topologies. Several configurations with various component technologies are available. The double H-bridge consists of two cascaded H-bridges with 650 V components. The second configuration is an H-bridge with 1200 V components. The double H-bridge topology enables us to use 650 V components where the voltage at PFC's output is divided in two and routed to each H-bridge.

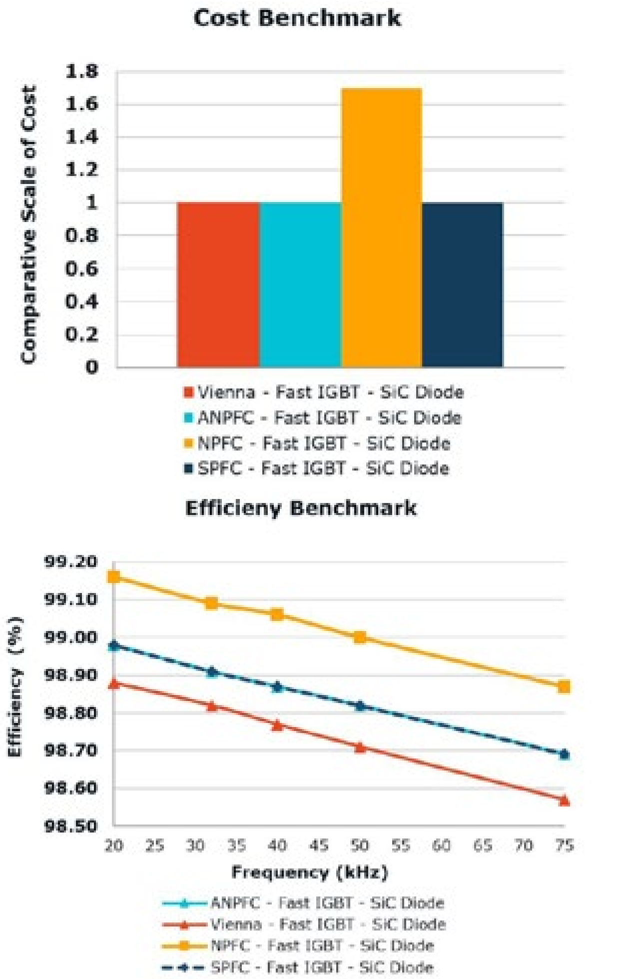

Figure 6: Benchmarked efficiencies and costs on a comparative scale

We benchmarked and compared costs and efficiencies to gain deeper insight into these topologies' benefits and drawbacks.

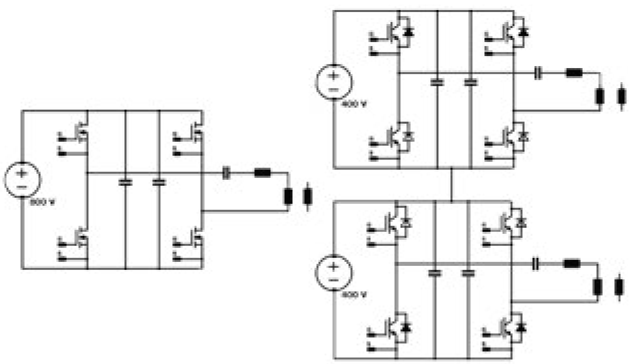

Figure 7: H-bridge topologies

The SiC-MOSFET version exhibits the greatest efficiency across the entire load range. The performance of IGBT and Si-MOSFET solutions in the double H-bridge topology is comparable at 100% load. However, the Si-MOSFET solution's loss is lower than the IGBT solution's at partial loads, which is attributable to the Rdson steepness.

The upshot of all this is that the SiC-MOSFET is the go-to solution for high efficiency in all load situations. Si-MOSFET is a compromise between cost and efficiency. And the cost-effective solution is IGBT-based. Another alternative to the SiC-MOSFET solution is to over-size components. For example, IGBTs and Si-MOSFETs may be oversized by installing parallel chips in the module; this increases efficiency throughout the load range. Oversizing drives costs up, but this option may still be cheaper than the SiC-MOSFET solution. Oversizing also enhances reliability because the junction temperature drops.

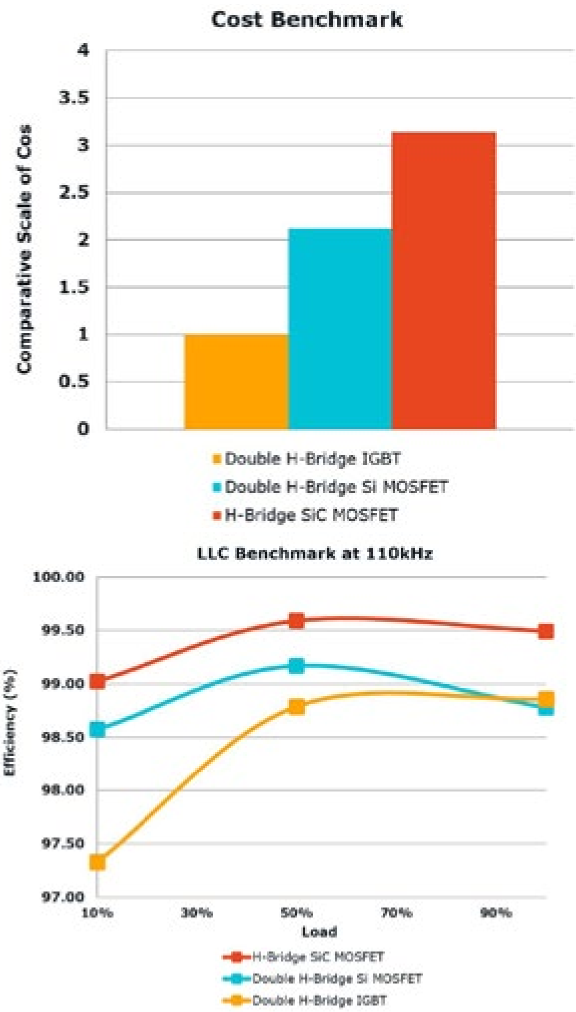

Figure 8: Benchmarked efficiencies and costs on a comparative scale

Conclusion

In this article, we briefly reviewed EV chargers' power Levels 1, 2 and 3, took a big-picture look at the charger market, and then zoomed in for a closer inspection of Level 3 DC fast-charging solutions. This market is booming, with a 72% rise in the number of publicly accessible chargers and a 60% increase in EVs in 2016. Level 3 system architecture will gain traction in the near future as EVs' battery capacity increases. None of the other three-phase PFC topologies can match ANPFC's price–performance ratio. On the other hand, LLC topologies figure prominently in Level 1 and 2 system architectures, where the winner in the price-performance stakes is an IGBT with a double H-bridge. The upshot: One size does not fit all. Charging stations are a priority market for Vincotech. We offer the right solution to meet the demands of each customer's applications—either with our standard power modules or our customer-specific solutions.

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Power Supply with Excellent Insulation for Medium-Voltage Systems

Power semiconductors with high reverse voltages and extensive current carrying capacity are indispensable for expanding an intelligent, locally supplied energy network. However, to operate these components reliably – be it for control, monitoring or communication purposes – external auxiliary voltage that is isolated from earth potential is always required, which places enormous demands on the insulation. The new "GvA Power Supply System" features high insulation voltage and partial discharge resistance, combined with remarkable performance and efficiency.

By Thomas Schneider and Christoph Bergold, GvA Leistungselektronik GmbH

The dramatic pace of change in electrical energy networks due to the use of generators that are increasingly decentralised is making it ever more challenging for network operators to guarantee network stability. The elimination of large synchronous generators that allowed the networks' protective devices to work flawlessly by providing reactive power and ensuring the required short-circuit current, has sparked intensive work on alternatives. The combination of large and small energy storage systems in the future means it is essential to adapt to the prevailing network conditions very quickly in order to guarantee instantaneous, primary and secondary control power. The required high-blocking power semiconductors such as IGBTs, IGCTs and thyristors with blocking voltages greater than 7000 V are already available on the market and are used in compensation systems, network interconnections and filters. But all of these semiconductor switches have one thing in common: to work, they need additional auxiliary voltage, using which the component in question can be controlled, monitored and protected. These essential auxiliary voltages are at a high level relative to the earth potential and so must have appropriate insulation. Not only the actual insulation strength is significant here, but also the freedom from partial discharges. GvA is launching an extremely compact, high-performance DC-DC converter that is designed perfectly for jobs like these.

GPSS (GvA Power Supply System)

The standout features of the GPSS are:
- Extremely compact (73 mm x 200 mm x 165 mm)
- Two separate outputs
- Continuous output: 150 W per channel
- Typical output voltage: 35 VDC
- Typical supply voltage: 24 VDC
- Max. efficiency: 94%
- Insulation voltage: 35 kVAC
- Partial discharge extinction voltage: 21 kVAC (prim. – sec.)
- Partial discharge extinction voltage: 14 kVAC (sec. – sec.)
- Clearance: 210 mm (prim. – sec.)
- Clearance: 165 mm (sec. – sec.)

The GPSS has been developed specifically to provide auxiliary voltages and provides two electrically isolated output voltages. What sets it apart is its extremely compact design and high power rating of at least 150 W per channel. Each channel is controlled individually and has an inrush current limiter to limit the output current for loads with a high capacitive input, and a short-circuit current limiter and shutdown facility. If there is a constant overload, the intelligent control ensures the channel affected is shut down and reactivated again automatically once the fault has been cleared.

Figure 1: Due to its high insulation voltage, the GvA Power Supply System is ideal for medium-voltage applications.

The converter topology used consists of a full-bridge series resonant converter on the primary side and a synchronous rectifier in a B2 circuit on the secondary side. This circuit configuration enables efficiency of up to 94% and therefore helps ensure that the device's inherent heating is very low and that minimal external cooling is required.

The typical supply voltage is 24 VDC, with the full available capacity lying in the range from 21.6 VDC to 25.2 VDC. As the two output channels are controlled separately from each other, unbalanced loads are also possible, and the outputs can be connected in series.

The base plate of the GPSS is used both as a mounting plate and as a cooling plate for the primary switching step. The low thermal power loss of both primary full bridges is dissipated externally via the base plate. It must therefore be ensured there is sufficient heat removal.

Figure 2: The new GPSS is the perfect insulating supply unit for IGCT and IGBT stacks.

Monitoring the operating statuses

Every GPSS monitors its key operating parameters and indicates the status via a fibre optic transmitter on the primary side of the device. The status of the outputs (overload or short circuit) is signalled after a defined delay, and inadmissible input voltage ranges or excessive temperatures in the primary switching step are indicated.

Figure 3: Due to its modular design, the GPSS can also be operated in parallel, multiplying the number of output channels.

Connecting GPSS modules in parallel

If an application requires more than two auxiliary voltages, the GPSS modules can be connected in parallel on the primary side in any configuration thanks to their flexible design. In this regard, it is possible to monitor all GPSS by means of a single light guide, greatly simplifying monitoring management. Coding takes place via the input plug and is designed to be fail-safe; consequently an open circuit is also recognised as a fault.

In principle, the power supply on the primary side of the GPSS modules can be looped through from module to module. In this case, only the max. current load of the input jack and connector strip needs to be observed.

The housing and its insulation

The GPSS has two output channels with an insulation voltage of at least 35 kVAC in respect of each other and the input side. As the fairly large potential differences occur between the outputs and the base plate of the GPSS, which is normally at earth potential, a partial-discharge extinction voltage of at least 21 kVAC is guaranteed for this insulation section, while the extinction voltage for the insulation between the two outputs is at least 14 kVAC.

To allow these parameters to be guaranteed over a long operating period, high priority was given to the electrical stability and the behaviour under environmental influences when choosing the material for the housing. The material used has been tried and tested for years and is also used to produce medium- and high-voltage insulators. It can be shaped easily by appropriate means and can be processed without air or gas being trapped. It is immune to aggressive environmental influences and does not change its characteristics, even during long

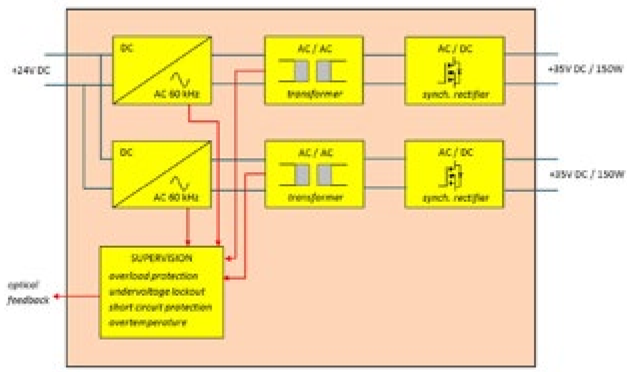

Figure 4: Schematic block diagram of a GPSS 221-24

periods of extreme electrical load. The specially developed geometry of the inner isolation barrier ensures the electrical field is distributed uniformly between the primary and secondary sides. This optimised field control prevents excessively high local field strengths, preventing associated inner partial discharges in the electronic module on the secondary side.

The external insulation is primarily ensured by the high tracking resistance – the housing material used has a CTI > 600 – and the large creepage and clearance distances of 210 mm and 180 mm respectively between the output and input.

Converter topology

The consistent demand for minimal losses and the lowest possible inherent heating requires a resonant converter topology with zero-voltage switching or zero-current switching behaviour. A series resonant circuit is used in the GPSS for operating reliability reasons and because of its good control characteristics, particularly in the event of an overload or short circuit. A pot core is used for the transformer, and the insulating material is located between its two halves. Due to the large air gap that results from this, the magnetic coupling of the two pot core halves is reduced and the leakage inductance increases. Nevertheless, appropriate circuitry measures optimise the transformer's efficiency, while simultaneously reducing the system-induced natural resonant frequency. This has a two-fold positive effect on the overall efficiency. Firstly, the transformer's magnetisation loss is reduced, and secondly, the lower switching frequency relieves the load on the output stage and less energy is required for driving the MOSFET.

Basic Electrical Characteristics

2 Channel System		Symbol	Min.	Typical	Max.	Unit
Supply voltage	Nominal input voltage	V_{cc}	21.6	24	25.2	V_{DC}
Output voltage	Unregulated DC output voltage	V_{out}	29	35	41	V_{DC}
Continuous output power	Continuous output power 1 channel	$P_{cont.\_1ch}$	130	150	170	W
Continuous output power	Continuous output power 2 channels together	$P_{cont.\_2ch}$	260	300	340	W
Input current	V_{cc} = 24 V_{DC} / P_{2ch} = 300 W	I_{cc}		14	16	A
Short circuit shutdown time	Output shortened	T		60		sec
Efficiency	P_{tot} = 300 W (sym. load)	η	91	92	94	%

The series resonant circuit topology enables relatively simple controlling and also offers excellent operating reliability, even in the event of an overload or short circuit, because it is inherent in the system itself.

The alternating voltage transmitted to the secondary side of the transformer is converted to DC voltage using an adaptive synchronous rectifier and offers minimal semiconductor losses in any operating state.

In a nutshell, the GPSS offers a simple, reliable power supply for active components and modules in cases where customary DC-DC converters cannot be used due to their limited insulation properties. These components not only include power semiconductors such as IGCTs and IGBTs in medium-voltage converters, but also general protection, monitoring or control modules that have a high potential relative to earth and require an electrically isolated power supply.

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Using Sintering Technology to Reduce Failure Rate of High Current Thyristors

This article explores several ways to reduce degradation and early failures of power semiconductor thyristors with a semiconductor chip dia. 80 mm or more using low-temperature sintering of silicon chips and molybdenum discs. The authors study comparative relations between $VT_{O/rT}$, R_{thjc}, IT_{AV}, IT_{SM} and mounting force for options with sintering/alloying and standard cathode layer or molybdenum cathode layer with evaporated protective interface, and select the best design to minimize the amount of early failures in the field.

By Dmitry Titushkin, Alexey Surma, Alexander Stavtsev, Proton-Electrotex and Sergey Matyukhin, Orel State University

Introduction

Leading manufacturers of power semiconductors tend to focus on reliability of conversion equipment and its components due to growing in-service failure costs. Failure here implies a degradation failure.

Degradation failures are unavoidable since they are caused by natural ageing and wear out of structure and materials. For this reason manufacturers of power semiconductors keep improving their engineering solutions to minimize probability of a degradation failure. For example, using sintering technology in production of single-chip power semiconductor thyristors, diodes [1,6] and IGBT devices [2,4,5,10] helps to decrease the chance of degradation failures at the final stage of operation and improves their service life [3,4,8-10]. Minimizing degradation failures is mainly achieved by a high cycling resistance of the junction between semiconductor chip and molybdenum disc, as well as lower junction-housing thermal resistance [3,4,6,7] leading to higher maximal surge current [1].

However, apart from degradation failures during normal operation a customer can also experience early failures during run-in period caused by defects unidentified by production and acceptance quality control. At the same time carrying out the run-in period in operation conditions by the manufacturer is economically impractical. Thus, minimizing the amount of early failures is only possible by reducing the probability of potentially defective devices. A major part of power semiconductor thyristors and diodes are "low cost" products where silicon chip is joined with molybdenum disc by alloying technology with silumin soldering alloys. This process is characterized by high dispersion of thermal resistance across the surface area caused by insufficient fusion in the weld and higher deformation of the semiconductor chip after the joining process. This problem is especially relevant for thyristors and diodes with area of the semiconductor chip equal or more than 50 cm2. Optimizing the joint profile between the silicon chip and molybdenum disc allows to reduce the insufficient fusion and deformation profile. Aside from temperature profile, the amount of insufficient fusion is also affected by roughness of the joined surfaces, quality of components cleaning, etc. Consequently using the sintering technology to produce power semiconductors not only reduces the amount of degradation failures and improves service life, but also minimizes early failures during run-in period.

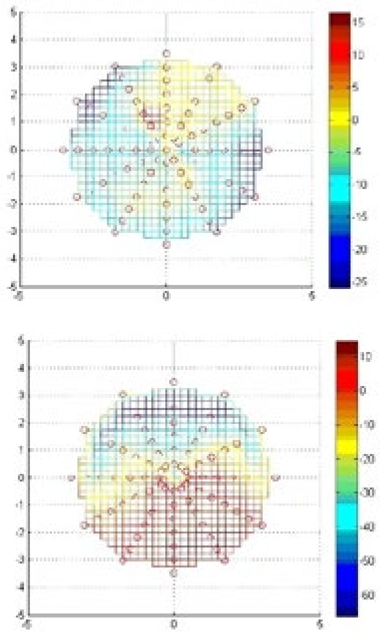

Figure 1: Profile of semiconductor element deformation (sintering on the left, alloying on the right)

Experimental Samples

Our experimental samples were thyristors TF173-2000-18 with semiconductor chips dia. 80 mm, where silicon chip and molybdenum disc were joined by sintering and alloying technology. Each of these options had two variants of cathode layers: standard cathode layer and molybdenum layer with evaporated protective interface.

Research program included the following:

- measurement of comparative deformation profiles of the semiconductor elements;
- measurement of comparative relations between on-state threshold voltage and resistance (VTO/rT) and mounting force in the range of 30 kN to 50 kN;
- measurement of comparative relations between junction-housing thermal resistance (Rthjc) and mounting force in the range of 30 kN to 50 kN;
- calculation of comparative relations between on-state current (ITAV) and mounting force in the range of 30 kN to 50 kN;
- finding values of destructive surge on-state current (ITSM).

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Deformation of the Semiconductor Element

Deformation profiles are shown on Figure 1.

Figure 1 demonstrates that deformation profile for the sintered semiconductor element is much smoother than for the semiconductor element alloyed on silumin soldering alloy. Residual bend of the alloyed semiconductor element is 11 µm. Residual bend of the sintered semiconductor element is 45 µm.

Electric Properties

Relations between average values of VTO/rT, Rthjc, ITAV and mounting force are shown on Figures 2-5.

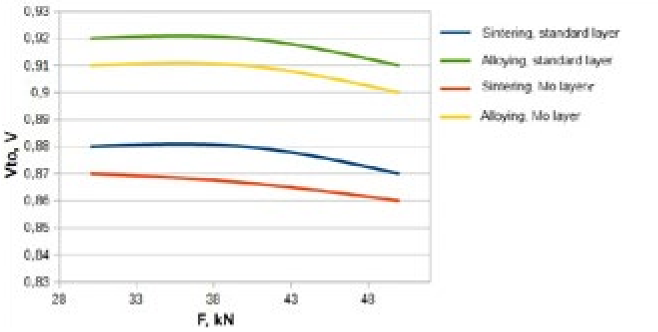

Figure 2: Relation between VTO and mounting force

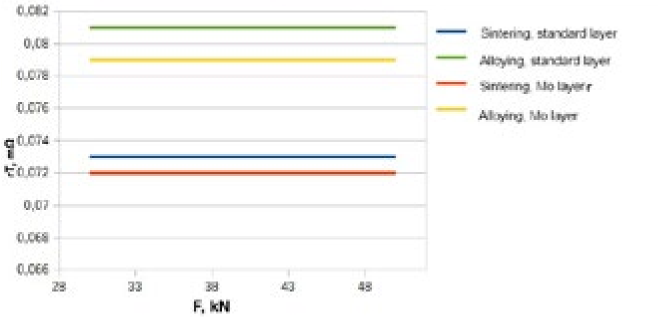

Figure 3: Relation between rT and mounting force

The graphs demonstrate that option "Sintering, Mo layer" has the lowest values of VT0/rT (-5,8% and -11,2% respectively in comparison to the standard option — "Alloying, standard layer"). However, option "Sintering, standard layer" has the lowest thermal resistance Rthjc (-9,7% in comparison to standard option) and the highest results of calculated average current (+12,8% in comparison to standard option). It should also be noted there is a higher relation between anode thermal resistance and mounting force for sintered options in comparison to alloyed options. Theoretically it can be explained by deformation of the semiconductor element, when alloyed options start forming surfaces of third or higher order that can not be completely straightened with external installation force. As for the sintered structures, they are characterized by a dome-shaped surface that straightens under higher force. It is also confirmed by absolute values of anode thermal resistance that are lower for the sintered options.

From the point of view of destructive surge current, this value is higher by 5,7% for options "Sintering, Mo layer" and "Sintering, standard layer" in comparison to standard option.

Conclusion

This article explored comparative relations between VTO/rT, Rthjc, ITAV, ITSM and mounting force for options with sintering/alloying and standard cathode layer/molybdenum cathode layer with evaporated protective interface. It was shown that in order to reduce the amount of early failures encountered by a customer it is preferable to use option "Sintering, standard layer" as the basic structural element, since this option had the lowest values of thermal resistance and the highest on-state current.

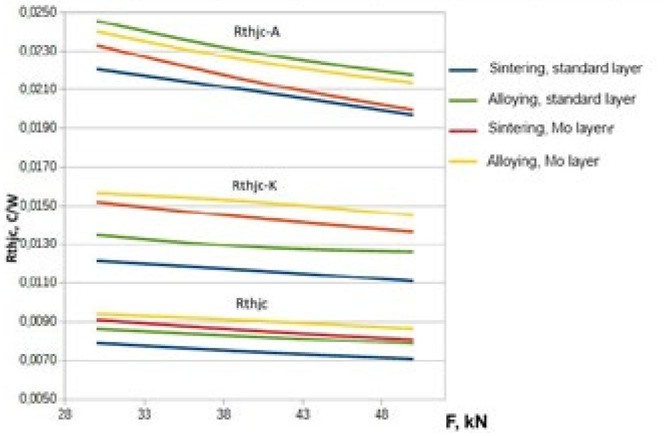

Figure 4: Relation between Rthjc and mounting force

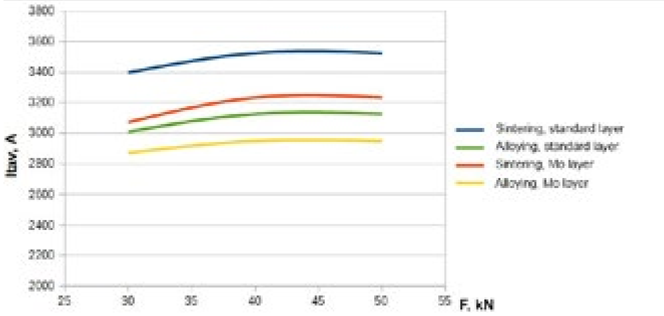

Figure 5: Relation between ITAV and mounting force

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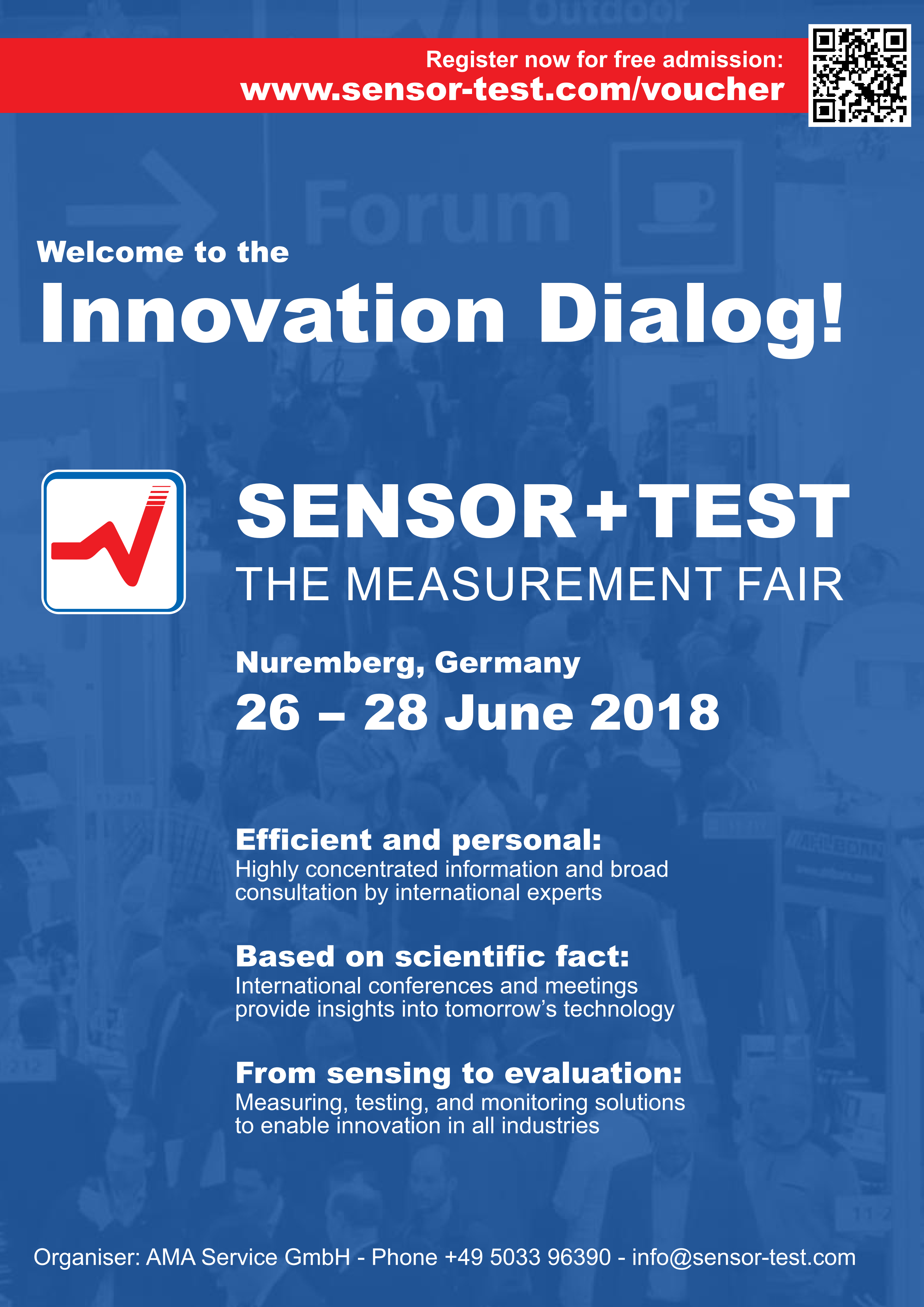
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What They Don’t Teach About Synchronous Rectifiers in School – Selected Topics from Real Designs

In recent years, global regulatory agencies have proposed efficiency standards to further improve global energy savings. It has become mandatory for manufacturers to improve the efficiency of existing standalone power supply products to meet DoE Level VI in order to sell them to the US market. Additionally, manufacturers are also expected to design products under other energy specifications, such as EU CoC V5Tier2 specs.

By Zhihong Yu, AC/DC & Lighting Product Marketing Manager &
Walter Yeh, Field Application Engineering Deputy Manager, Monolithic Power Systems

To push for higher efficiency in AC/DC adapters, many have found that switching a flyback output Schottky diode to a synchronous rectifier (SR) controller with a MOSFET generally saves efficiency by 2~3% or more. Some have also found that using SRs help save diode heatsink and assembly cost, designers can also use a cheaper primary MOSFET or thinner output cables to save cost and still meet the target efficiency.
While this article does not intend to cover all aspects of SR design, it does present a few selected topics related to a few practical concerns in engineers’ real lives.

SR at Continuous Conduction Mode (CCM)
In Figure 1, a flyback SR controller is used to drive a MOSFET switch in an AC/DC adaptor. Here, the flyback controller may operate at critical conduction mode (CrM), continuous conduction mode (CCM), or discontinuous conduction mode (DCM).

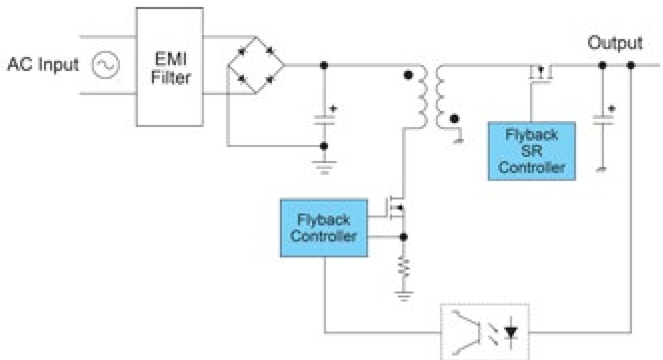


Figure 1: Typical Block Diagram for a Flyback Power Supply Used in Fast Chargers

When adaptors runs at CCM mode at start-up or full load, the current in the SR switch is designed to avoid falling to zero when the primary switch tries to turn on. Therefore, it is critical to turn off the SR very quickly to prevent a shoot-through from the primary to secondary side, which results in high spikes and potential damage. MPS’s solution is to adjust the SR switch V_G to keep the MOSFET’s V_{DS} constant. As the current drops during CCM, the driver’s V_G also drops, so the MOSFET is running in linear mode (see Figure 2). Therefore, when the voltage finally reverses, the driver turns off very quickly at a low V_G to ensure safe CCM operation. This is a robust control method, as it is independent of the line input condition. Additionally, the body diode conduction time is minimized to ensure optimum efficiency. MPS’s SR controllers are designed not only to support CCM, but DCM and CrM as well.

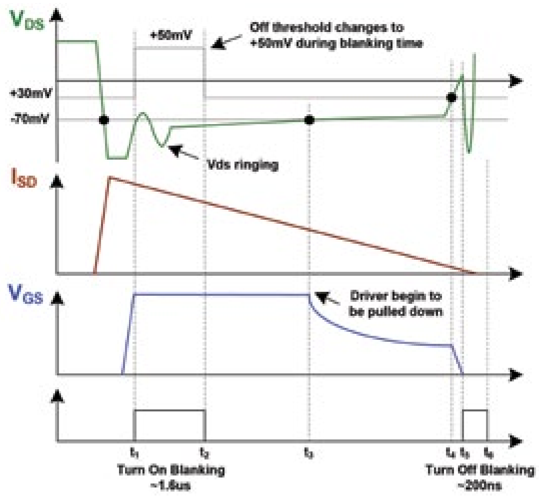


Figure 2: MPS SR Controller Operation Principles

For a detailed explanation of MPS’ CCM-compatible SR operation and design tips, please refer to the AN077 application note1.

MOSFET Package Inductance Influence at CCM and CrM
There is always some ramp up/down time at the secondary current switching decided by the input/output, transformer turns ratio, and inductance. The MOSFET package inductance also affects the secondary current turn-off.
As the secondary current starts to change polarity and turn off (t1 in Figure 4), the MOSFET package inductance (Ls) causes an instantaneous voltage on the sensed Vds, as shown in Equation (1) and Equation (2):

$$V_{DS} = -I_{DS} \cdot r_{DS(ON)} + V_{LK}$$

$$V_{LK} = L_S \cdot \frac{dI}{dt}, \frac{dI}{dt} = \frac{Vd}{Ls}, Vd = Vout + Vin_{dc}/n$$

Where Vin_{dc} is the input average DC, n is the transformer turns ratio, and Ls is the leakage inductance.

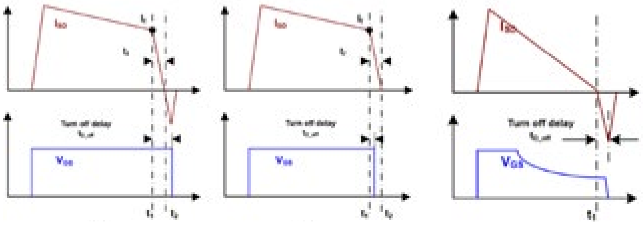


Figure 3: Various Turn-Off Waveforms when Affected by Package Inductance

For MOSFETs in TO220 packages, the package inductance can be as high as 6.4nH at 100kHz, and Vlk can be as high as a few hundred mV, hitting the SR controller turn-off threshold and causing the SR controller to turn the gate off (starting from t1). Since t1 is an early turn-off time, the package inductance is helpful for preventing shoot-through, especially in deep CCM condition.
For various circuit designs, we may see different turn-off waveforms under CCM (see Figure 3a and Figure 3b). For Figure 3a, the current drops to zero, but the SR is not completely turned off.
Therefore, cross conduction may occur and reflects in reverse current. For Figure 3b, the SR is able to turn off just before the secondary current turns to zero (t2). This is the optimal design.
More importantly, Figure 3c shows that in CrM, the SR controller turns off when the secondary current is almost zero, meaning there is always a reverse current of dI/dt*Toff.
When a MOSFET has much less package inductance (such as in QFN or SOIC), the SR turns off the gate at a later time when the MOSFET current is falling lower. Even with a lowered Vg under Vds regulation control, the reverse current is still higher than a MOSFET with a higher package inductance. This is independent of the Vds control introduced in Section 1.

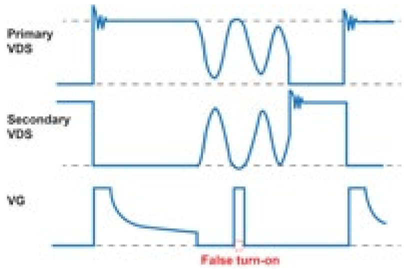


Figure 4: SR Waveform with Potentially False Turn-On during Demagnetizing Ringing

Some improvement options are listed below and can be combined in one design.

- Choose SR MOSFETs with very low Qg (to speed up turn-off).
- Add an RC snubber across the SR MOSFET (to absorb the reverse spike).
- Use SR controllers with high turn-off current
- Increase transformer leakage inductance to slow down the secondary current dI/dt at turn-off (at tradeoff of higher primary MOSFET voltage spike) or slow down the turn-on of the primary MOSFET (at small efficiency tradeoff)
- Use a SR controller with a higher regulated voltage (70mV in Figure 2 using the MP6902). With a higher regulated Vds, Vg can drop fairly low before turning off, resulting in a faster turnoff.

Ringing – Good and Bad

When MOSFETs turns on and off, there is always some ringing caused by stray inductance in the layout, system, component parasitic capacitances, etc. Failure to accommodate the influence caused by ringing may lower the efficiency and even cause fatal problems.

An example of a ringing-induced issue is shown in Figure 4. As the secondary current falls to zero, the primary switch Vds has resonance between the transformer main inductance and MOSFET Cds, which is reflected to the secondary side. Normally, the valley of this resonance should not touch the ground level, but sometimes the resonance valley may drop low enough to reach the SR turn-on threshold. This can be caused by factors such as the reverse recovery of the diode in the primary-side RCD snubber.
As the slew rate of this Vds resonance is always much lower than the real turn-off slew rate (thanks to large main inductance), MPS MP6908 uses a unique slew rate programming pin to help decide when is the real turn off, and when is the normal Vds resonance (see Figure 4).

The Need for Real Drop-In Replacement of Schottky Diodes

Although the advantage of SR is well-accepted, changing an existing design from using Schottky diode to SR drivers plus an SR MOSFET still involves adding quite a few components to the BOM, redoing many qualifications, and so on.
An alternative solution is to integrate the SR MOSFET inside the SR driver IC, creating a co-pack and an entirely new design with minimal BOM change (see Figure 5). This solution is called an ideal diode.

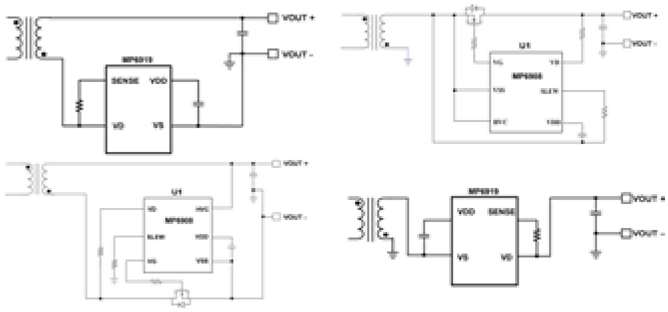


Figure 5: MP6908 Controller and Ideal Diode Application Circuit on Low Side and High Side

The benefits of MPS's new ideal diodes include:

- Minimal BOM and board space.
- Drop-in replacement of Schottky diodes without auxiliary winding at high or low side.
- Optimized integrated gate driver.
- Optimized MOSFET for different power levels and voltage ratings.
- Flexible SMT and thru-hole package options

Why is the MPS MP6908 a Suitable Option for Practical SR Control Designs?
The MP6908 is the latest SR control IC from MPS. There will also be a series of ideal diodes created based on the MP6908 controller. Some key features for this controller IC include:

- No need for auxiliary winding for high-side or low-side rectification.
- Supports DCM, quasi-resonant, and CCM operations.
- Supports a wide output range down to 0V (even at an output short circuit, the SR is kept powered, and MOSFET body diode never conducts to the short-circuit current).
- Ringing detection prevents a false turn-on.
- Superfast 15ns propagation delay and 30ns turn-off delay.

Summary

This article introduced some topics related to real-life engineering situations in synchronous rectifier (SR) designs. By understanding more about end applications, MPS is able to define and create better SR control ICs.

www.monolithicpower.com

Optimized Thermal Layout for CIPOS™ Nano Half-Bridge Intelligent Power Modules

This article discusses considerations for PCB design required to achieve the best thermal performance in a motor drive using CIPOS™ Nano half-bridge Intelligent Power Modules (IPM). We present an approach that uses thermal simulations with ANSYS Icepak software to create an optimized thermal layout. We show that the simulations are validated by experimental motor test results through temperature capture via a thermal camera. This paper targets intelligent power module application design engineers and PCB layout engineers who would like to obtain better system thermal designs in their final product.

By Pengwei Sun and Pei Jin, Infineon

Thermal Simulation

In a three-phase motor drive system, three half-bridge IPMs are needed. The placement of the three half-bridge modules on a PCB for optimal thermal performance is of interest to circuit designers. Four different placement configurations are explored. First, we did thermal simulation on each of these configurations. Figure 1 shows the four configurations. In the simulation, we use the same copper area for each power pad, which is 1oz copper, 120mm^2. To simplify the simulation and exclude other thermal impacts, we ignore peripheral components.

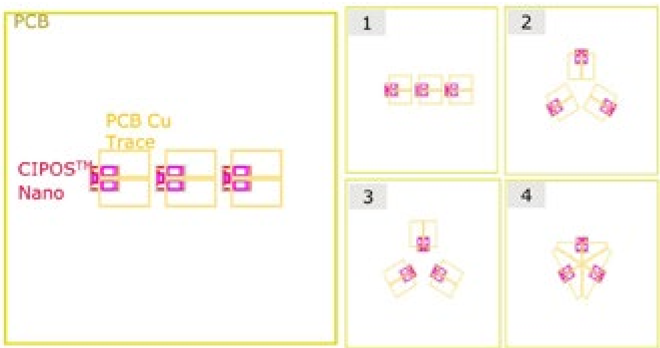


Figure 1: Four configurations of layout

We ran simulations for two conditions of operation. For the light load condition, we assume each CIPOS™ Nano IPM has a power loss of 0.3W, and for full load condition, we assume each CIPOS™ Nano IPM has a loss of 1W. Table 1 shows the simulation results. Figure 2 shows both the light load and the full load simulation thermal images. From the simulation results we can see that option 2 is the optimal layout, which has the least temperature rise under the same power dissipation. At light load condition, it is 5ºC better than the regular layout, option 1. At full load condition, it is around 10ºC cooler than option 1.

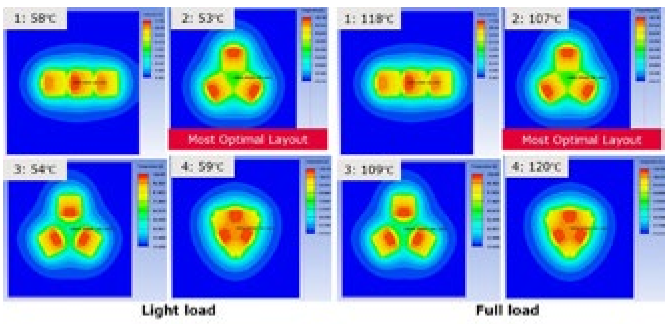


Figure 2: Light load and full load simulation results

Case	Total Power Loss (W)	Tj_Max (°C)	Rthja (°C/W)
Option1	3	117.69	30.90
Option2	3	106.70	27.23
Option3	3	108.85	27.95
Option4	3	120.16	31.72
Option1	0.9	57.87	36.53
Option2	0.9	53.51	31.68
Option3	0.9	54.04	32.27
Option4	0.9	58.97	37.74

Table 1: CIPOS™ Nano thermal simulation results

Experimental Verification

Thermal simulation shows that PCB layout of three half-bridge CIPOS™ Nano IPMs affects thermal performance. We would like to confirm this finding to provide customers guidelines to optimize their PCB design. We made two different PCB layouts, which are option 1 and option 2, and tested them out under the same operating conditions. The results did confirm the findings of the simulations. Figure 3 shows the PCB layout of regular option 1 and the optimal layout, option 2.

The motor drive test conditions are as follows: switching frequency 6 kHz, 2-phase discontinuous SVPWM, DC bus voltage 300V, ambient temperature 25°C, light load operation at 0.5Arms and 115W, and full load operation at 1Arms and 230W. Figure 4 shows the light load thermal images and the full load thermal images. The thermal images prove that option 2 has better performance than option 1: At light load and full load option 2 is 5°C and 8°C cooler, respectively.

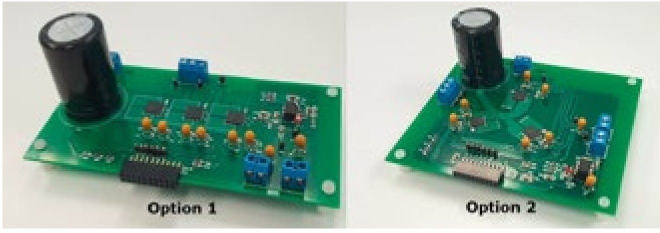


Figure 3: PCB layout of option 1 and option 2

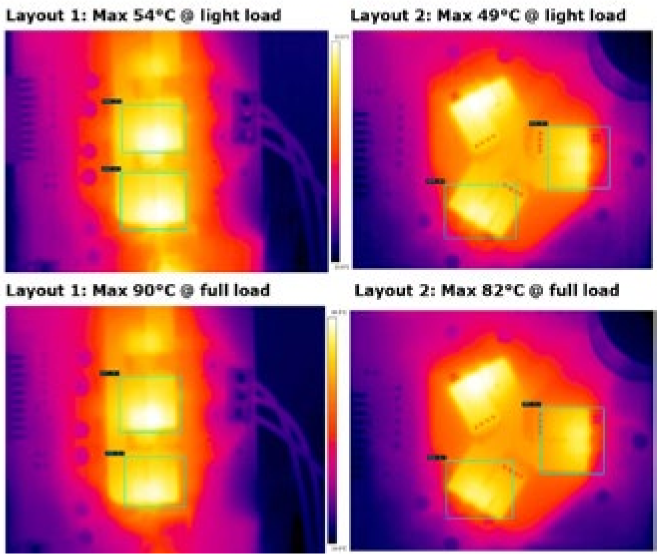


Figure 4: Light load and full load thermal images

Conclusion

In this article, several layouts have been proposed to see which one offers the best thermal performance when three half-bridge CIPOS™ Nano IPMs are used. Through both simulation and experiments, option 2 is proved to be the best option with the lowest junction temperature when the same copper area and the same power are applied to each option. On the other hand, option 2 can sustain higher losses or use smaller PCB area if the same junction temperature is required among different designs. In addition, option 2 provides a circular layout which fits very well in applications where the motor drive board is required to be in that shape in order to be better embedded in the motor casing.

www.infineon.com

Isolated Gate Driver Board for SiC Power Module

Analog Devices, Inc. in collaboration with Microsemi Corporation introduced the first-in-the-market high power evaluation board for half-bridge SiC power modules with up to 1200 V and 50 A @ 200 kHz switching frequency. The isolated board is engineered to improve design reliability while also reducing the need to create additional prototypes—saving time, lowering costs, and decreasing time to market for power conversion and energy storage customers. Analog Devices and Microsemi will showcase the board at APEC 2018 taking place March 4-8, 2018, in San Antonio, Texas.

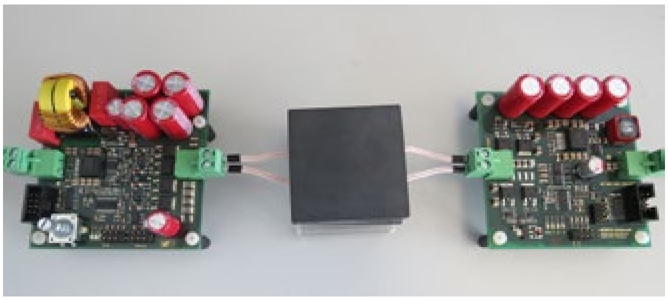
The new board can be used as the building block of more complex topologies, such as full-bridge or multi-level converters, for complete bench debugging of customer solutions. It can also function as a final evaluation platform or in converter-like configuration for full test and evaluation of Analog Devices' ADuM4135 isolated gate driver with iCoupler® digital isolation technology and LT3999 DC-DC driver in a high-power system. The high-power evaluation board enables Microsemi's SiC power modules to provide benefits such as a common test bench, higher power density for reduced size and cost, and isolated and conductive substrate and minimum parasitic capacitance for

higher efficiency, performance, and excellent thermal management. These attributes make the board suitable for applications including electric vehicle (EV) charging, hybrid EV (HEV)/EV onboard charging, DC-DC converters, switched mode power supply, high-power motor control and aviation actuation systems, plasma/semi cap equipment, lasers and welding, MRIs and X-rays.

www.analog.com/EVAL-MICROSEMI-SIC-MODULE

Combining Wireless Power and Data Transmission

Under the name 760308EMP-WPT-200W, Würth Elektronik eiSos and Infineon Technologies AG are offering a 200-watt development system for wireless power transfer. What makes the development kit special is that the link between the transmitter and receiver coils can be used to transfer not only power but also data. The 760308EMP-WPT-200W development kit comprises a power supply, a transmitter unit and a receiver unit, and is an innovative and powerful solution thanks to the products from Würth Elektronik and Infineon (MOSFETS, drivers, microcontrollers, voltage regulators).



The transmitter side consists of a full bridge and a resonant circuit made up of the WPT coil and the resonant capacitors connected in series. Due to the phase shift between voltage and current in the resonant circuit, the system operates in zero voltage switching (ZVS) mode. The result is a very high level of efficiency for the overall system.

On the receiver side, a synchronous rectifier with downstream filtering and sieving. Thanks to the AM modulation of the alternating field between transmitter and receiver, any data can be sent from the receiver side to the transmitter side. A sample application would be a mobile device that sends sensor data to a base station during the charging process. All the data needed to implement this kind of proprietary system is offered for free download.

www.infineon.com

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SL Series Programmable Power Supplies Expanded to 8 kW in 1U

Magna-Power Electronics has increased the power capability of its popular 1U (1.75" high) SL Series to 8 kW with the addition of 17 new models. The new 8 kW models further extend the SL Series lead for the most programmable power in 1U within its product class. The SL Series now spans 99 models from 1.5 kW to 8 kW, from 5 Vdc to 1000 Vdc, and from 1.5 Adc to 250 Adc. The new 8kW models come in response to Magna-Power users' ever-increasing demands for rack-mount power density. The SL Series was introduced in 2013 as Magna-Power's first 1U power supply, building upon over 30 years of innovation in power electronics. When first introduced, the product series was offered up to 4 kW, an industry first for its product class. In 2015, the product series was further expanded to 6 kW and has since grown into Magna-Power's most popular product line, satisfying the application demands for: automated test equipment (ATE) system integration, automotive testing, oil and gas, consumer product validation, and aerospace systems testing. On the 8 kW models' introduction, Adam Pitel, Magna-Power's Vice President of Operations said: "Magna-Power's growth is fuelled by incorporating state-of-the-art devices and technologies, while ensuring reliability through the company's innovative power processing topologies."

www.magna-power.com

MIL 39006-Qualified Wet Tantalum Capacitors

Exxelia introduces two new ranges of wet tantalum capacitors qualified to MIL 39006/22 and MIL 39006/25. Exxelia has received the M-Level (1.0%/1000h) MIL-PRF-39006/22 and MIL-PRF-39006/25 qualifications approval for its new ranges of wet tantalum capacitors. MIL 39006/22 and MIL 39006/25 respectively equivalent to CLR79 and CLR81 types feature hermetically sealed cylindrical tantalum cases and axial leads. Both ranges are available in all cases: T1, T2 T3 and T4 with extended capacitance and voltage ratings. MIL39006/22 is qualified for voltages from 6V to 125V and provides from 1200µF @ 6V to 56 µF @ 125V. MIL 39006/25 is qualified for voltages from 25V to 125V and provides from 680µF @ 6V to 82 µF @ 125V. Both ranges combine high energy density with large temperature ranges -55°C up to 125°C and are available with H vibration and shocks features.

These state-of-art MIL-qualified wet tantalum capacitors are widely used in avionics applications where high performance and extreme reliability are required. Performance highlights compared to solid tantalum capacitors include more capacitance, higher ripple currents, lower ESR and lower dc-leakage current.

www.exxelia.com

TMF Series 5 ~30 Watt AC/DC Power Modules

Traco Power has announced the release of their TMF family of 5 ~ 30 watt encapsulated power supplies that are safety approved to IEC/EN/ES 60601-1 edition 3.1 for 2xMOPP (Means of Patient Protection) and are BF compliant (Patient Connected applications) with an ISO 14971 risk management file. These fully encapsulated modules are designed for PCB mounting and come in 5, 10, 20 and 30 Watt packages with fixed output voltages of 5, 12, 15 and 24 VDC. These models feature a low leakage current <100 µA, an I/O isolation of 4000VAC and are rated for class II operation with no earth ground connection required making them suitable for BF rated applications. Their compact size of 1.62 x 1.07 x 0.75” (5W); 2.06 x 1.06 x 0.75” (10W); 2.15 x 1.78 x 0.93” (20W); and 2.52 x 1.79 x 0.93” (30W) make them suitable for a wide range of medical and industrial applications including dental, home health care, test & measurement and any mobile/portable requirements

www.tracopower.com

PV200-27Bxx Series for New Energy

Mornsun added 200W PV200-27Bxx to PV series to further meet customer demand for higher powers, based on 5-40W ultra-wide & ultra-high input voltage DC/DC PV05 / PV10 / PV15 / PV40 series, which are widely used in new energy-related photovoltaic, energy storage BMS, high voltage inverter and other industries. The new series PV200-27Bxx has the following advantages:

1) Ultra-wide & ultra-high input voltage, high power, high efficiency

PV200-27Bxx series provide a wide input voltage range of 250-1000VDC, power up to 200W to meet higher demands for high-power power supply in ultra-wide and ultra-high input voltage application, and high efficiency up to 87%, low power consumption and more energy-saving.

2) Complete protection, high reliability

PV200-27Bxx series have input voltage protection to avoid frequent restart of system to maintain the system’s stability. Offering MTBF over 300,000h, they have reverse input voltage protection, output short circuit, over-current and over-voltage protection. These protections greatly reduce the probability of failure of the power supply itself while greatly enhance the safety performance of the module power supply and the load under abnormal working conditions.

3) CE certified (pending)

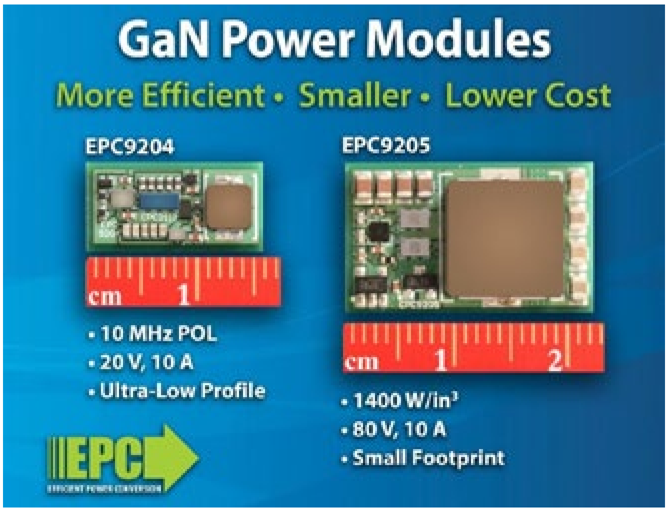
PV200-27Bxx series meet EN62109 standards (pending) with a certified voltage of 1000VDC. The series offers isolation voltage up to 4000VAC and high reliability, to effectively protect the safety of the system.

Applications: Photovoltaic power generation, stored energy and high voltage frequency conversion, etc.

www.mornsun-power.com

GaN Power Modules Deliver Over 1400 W/in³ for 48 V – 12 V DC-DC

Efficient Power Conversion Corporation (EPC) introduces two new GaN power modules for DC-DC conversion, increasing efficiency across the 48 V to point-of-load power architecture. The EPC9205 is a high-power density PCB-based power module for 48 V – 12 V conversions while the EPC9204 address the 20 V – point-of-load conversion with an ultra-thin profile PCB-based power module. The EPC9205 is an 80 V, 10 A PCB-based power module featuring the 100 V EPC2045 eGaN FET for "plug and play" evaluation of the high performance gained with gallium nitride power transistors. The EPC9205 exceeds 1400 W/in³ per cubic inch in a 48 V – 12 V application and occupies less than one-tenth of a cubic inch of board space. Applications benefitting from the performance of the EPC9205 include the high-performance servers needed for demanding computing applications such as multi-user gaming systems, autonomous cars, artificial intelligence, and cryptocurrency mining. The EPC9204 is a 20 V, 10 A PCB-based power module featuring the 30 V EPC2111 eGaN® IC capable of operating up to 10 MHz. This high frequency capability of the GaN solution reduces the size of the passive components resulting in an ultra-low profile of just 1.2 mm from PCB board. Applications benefitting from the performance of the EPC9204 include point-of-load power conversion for servers, thin form factor mobile devices, and USB-C. According to Alex Lidow, CEO and co-founder, "As expectations for increasingly power-hungry applications expand while the conflicting desire for equipment to be small and lightweight persists, reducing size and decreasing power consumption is critical. The efficiencies achieved by the EPC9204 and EPC9205 small form factors show how GaN-based power devices, available now, are driving the next generation of computing."



www.epc-co.com

Quick Charger Using GaNFast™ Power IC

Navitas Semiconductor announced the world's smallest, fastest charging mobile adapter enabled by GaNFast power ICs. The 27W design delivers 5x greater power than standard smartphone chargers and is 2x higher power density. With world-wide input voltage capability and a new Type C connector with USB-PD 3.0 and Qualcomm Quick Charge™ 4.0 features, this lightweight reference design delivers an extremely portable 'go anywhere, charge anything' solution. "The 27W is another size and speed breakthrough for consumers enabled by GaNFast technology, and with Quick Charge 4.0 compliance, you can decrease the amount of time you spend tethered to an outlet giving your device '5 for 5' — that's 5 hours of battery life from 5 minutes of charging" said Stephen Oliver, Navitas' vice president of sales & marketing. "Now that the high-frequency power eco-system of GaNFast power ICs, new controllers, new magnetics and soft-switching topologies has been established, we'll see a wide-range of fast-charging, high density designs on the market."

Using a Navitas' high-speed, half-bridge GaNFast power IC in the advanced Active Clamp Flyback (ACF) topology, the 27W reference design measures only 39 x 37 x 16 mm (uncased) and achieves a world-record power density of 1.2 W/cc (19 W/in3) uncased and 0.7 W/cc (11 W/in3) assuming a 2.5 mm case thickness.

www.navitassemi.com

1W Regulated SMT DC-DC Converter

Murata has expanded its product range of embedded-core technology DC-DC converters with the NXF1 series, a cost effective, fully regulated, high isolation converter with 3.3 V or 5 V outputs from Murata Power Solutions. Inputs available are nominal 3.3 V and 5 V in an industry-standard surface-mount package with a uniquely low profile. Line regulation is typically better than 0.03 % and load regulation typically better than 0.5 %. All parts have continuous short circuit protection with auto re-start or latch-off depending on model and temperature. Input range is +/-5 % around the nominals of 3.3 V and 5 V. Parts are 100% production tested to 3kVDC and have agency recognition pending for 'basic' protection at 250 Vrms and 'reinforced' protection at 125 Vrms to UL60950. Medical recognition to ANSI/AAMI ES 60601-1 is also pending for 2 MOOPs (Means Of Operator Protection) and 1 x MOPP (Means Of Patient Protection) at 125 Vrms and 1 MOOP (Means Of Operator Protection) based upon a working voltage of 250 Vrms max, between Primary and Secondary.

muRata INNOVATOR IN ELECTRONICS

Typical applications for these converters are in systems where agency-recognized isolation is required with tight output regulation as is needed in power for remote pressure, hall-effect, mass airflow and other sensors. Markets addressed include alternative energy/solar power, transportation, telecom/wireless equipment and medical.

www.murata.com

Fuses Attain Qualified Products List (QPL) Status

AEM, Inc. announces that its FM13 series of surface-mount solid body fuses have earned inclusion in the of Defense Logistics Agency's Qualified Parts List (QPL). The FM13 series are the only parts in its class to attain QPL status in compliance with the MIL-PRF-23419/13 high-performance standard.

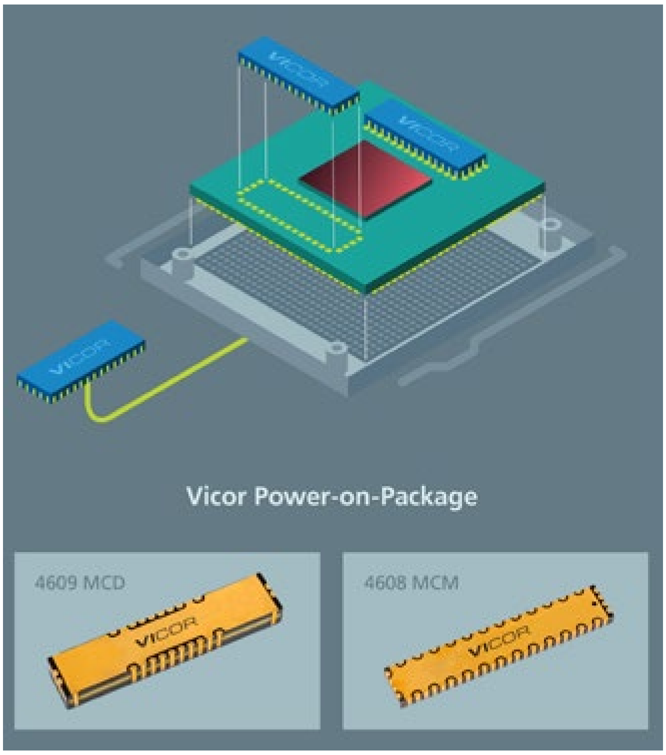
AEM's high-reliability FM13 series features a precision thick-film fusible element with a glass arc suppressing system that ensures that arc, plasma and vapor are contained within the fuse package during overload-current conditions. The positive temperature coefficient of the fuse element causes an increase in resistance (prior to opening), thereby preventing an absolute short circuit to the power source. The surface-mount solid body fuse devices are rated for operation between -55 and +125 degrees Celsius. No current or voltage derating is required during vacuum operation.

The FM13 series' high-reliability performance earned them a coveted spot on the QPL listing. According to the Defense Logistics Agency, the QPL is "a listing of products or family of products that have met the qualification requirements set forth in the applicable specification." The listing "is used by government activities to determine approved sources of supply for items they wish to procure."

AEM's General Manager, Jeff Montgomery, said: "To be solely listed and qualified to this specification is a great achievement for AEM, Inc." He continued, "AEM continuously strives to meet our customer's requirements for space and other harsh environment applications. We are very pleased with this achievement and how it complements AEM's 35-plus years of space heritage. AEM's MIL-STD-790 and AS9100 certified facilities have and will continue to provide our customers with unique component solutions to meet their mission critical program needs."

www.aemcomponents.com

Power-on-Package System Provides up to 1,000A Peak Current



Vicor Corporation announced a new Power-on-Package ("PoP") ChiP-set including Modular Current Multipliers ("MCMs") for high performance GPU, CPU, and ASIC ("XPU") processors. PoP MCMs multiply current and divide voltage from a 48V source in close proximity to XPUs to enable higher levels of XPU performance. Power distribution efficiency and system density rise beyond the limitations of conventional 12V input multi-phase voltage regulators lacking current multiplication. Power-on-Package is an enabling technology for high current Artificial Intelligence ("AI") processors and 48V autonomous driving systems. Power-on-Package modules build upon Factorized Power Architecture (FPA) systems deployed in high performance computers and large scale datacenters. FPA supports efficient power distribution and direct conversion from 48V to sub-1V XPUs. With current multiplication deployed in close proximity to high current processors, PoP MCMs overcome previous barriers to improved performance. A pair of MCM4608S59Z01B5T00 (MCMs) and a MCD4609S60E59H0T00 Modular Current Multiplier Driver (MCD) provide 600A continuous and up to 1,000A peak at up to 1V. Owing to their high density, low profile package (46 x 8 x 2.7mm) and low noise attributes, Modular Current Multipliers (MCMs) are suitable for co-packaging within the XPU substrate or adjacent to it. Close proximity to the XPU eliminates substantial power loss and bandwidth limitations incurred in the "last inch" of the current delivery path from the boundaries of 12V multi-phase regulators.

www.vicorpower.com

Step-Down Converters for Always-on Automotive Applications

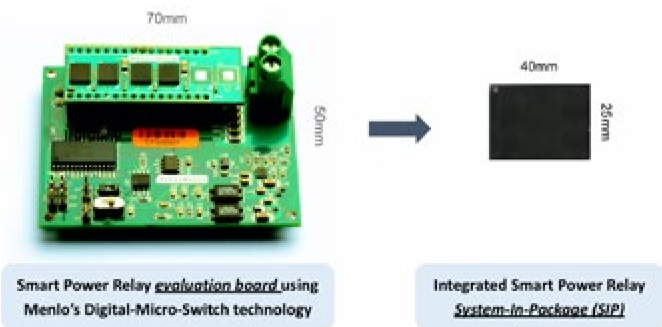
System designers looking to create small and highly efficient 40V load dump-tolerant applications can now utilize the ultra-compact, pin-compatible MAX20075 and MAX20076 step-down converters from Maxim Integrated Products, Inc. The MAX20075 and MAX20076 step-down converters offer the industry's lowest quiescent current (IQ) and comes in an ultra-small size solution with integrated compensation. This enables minimal external components that can lead up to 50% savings in board space making them ideal products for always-on automotive applications. Customers expect always-on applications to bring them experiences richer and more compelling than ever before. However, designers are challenged with having to balance delivering advanced features with meeting size constraints, power-saving features, and high efficiency. The MAX20075 and MAX20076 in peak current mode draw the industry's lowest IQ - just 3.5µA in the low power operating mode, which is key to meeting the stringent OEM IQ consumption requirements of 100µA per module. The converters enable low noise operation via pin-controlled spread spectrum and fixed 2.1Mhz operation to meet CISPR 25 Class 5 EMI compliance. Furthermore, added advantage of the 2.1Mhz operation and internal compensation is that it lowers the solution size and the bill of materials (BOM) compared to a non-synchronous device that operates in

the AM band. The MAX20075 and MAX20076 are available with a low minimum on-time mode operation, which allows the converters to support large input-to-output conversion ratios.

www.maximintegrated.com

200V/10A Digital-Micro-Switch Smart Power Relay Technology

Menlo Micro announced its new 200V/10A Digital-Micro-Switch (DMS) Smart Power Relay technology.



Until now, many industries have had to live with the tradeoffs of solid-state controls, including high-leakage currents, lack of air gap and complicated thermal management, or electromechanical solutions that are slow, bulky and expensive. "Our DMS technology enables extremely small, lightweight power relays that combine the best features of solid-state and mechanical devices," noted Menlo Micro SVP of Products Chris Giovanniello. "The market is constantly demanding reductions in size, weight, power, and cost. We are now able to fulfill that demand and create an entirely new class of control products for industrial IoT markets." Demonstrating the scalability of the technology, Menlo has combined over 200 micromechanical high-voltage switches, with fully integrated protection and controls, into a Smart Power Relay evaluation board. The credit-card-sized board is capable of carrying 10A of DC current, without the need of a heat sink. This unprecedented level of current handling for a MEMS switching device is due to Menlo's proprietary materials, designs and wafer-level processing techniques. High-power, high-reliability RF switches manufactured by Menlo are already in applications such as medical instrumentation, test and measurement equipment, and reconfigurable software-defined radios. Typically, these switches are 3-terminal devices operating in the 25W to 50W range. For the Smart Power Relay, Menlo has created a fully isolated 4-terminal architecture, complete with advanced features such as over-current protection.

www.menlomicro.com

Film Capacitors: Ultra-Compact DC Link Solution

TDK Corporation presents an extremely compact EPCOS film capacitor for the DC link of inverters. With dimensions of just 40 mm x 58 mm (d x l) it offers a rated voltage of 350 V DC and a capacitance of 65 µF. This means that the capacitor, which has the order number B32320I2656J011, has a very high capacitance density of 0.9 µF/cm3 and offers up to 50 percent more capacitance per volume than comparable capacitors. The space it requires on the PCB is correspondingly small. Other features include the low ESR of just 10 mΩ and the high ripple current capability of 3.7 A.
Both the plastic can and the epoxy resin sealing material are designed to be flame-retardant in accordance with UL 94 V0. The capacitor is designed for a temperature range from -25 °C to +65 °C. The capacitor has an integral thermal fuse that trips at a current of 5 A and a temperature of 115 °C.
Typical applications include the HF filtering in inverters, for example in domestic appliances, as well as general DC applications.

www.epcos.com/ac_capacitors

Soft Starter Modules for a Broad Range of Current Classes

Infineon Technologies Bipolar GmbH & Co. KG is launching Infineon ® Power Start designed for low voltage soft starter applications. The new module family meets the market's needs for cost effective and compact semiconductor solutions. With its new design, Power Start

focusses on reducing complexity and number of components. Customers, in return, profit from shorter development times and simplified production processes of soft starters. Typical low voltage soft start applications include belt conveyors, big fans, and mills. Most of all they can be found in pumps which are used for water and waste water transportation as well as for oil production. The new design concept of the Power Start module allows for one slim foot-print of 55 mm fitting a broad range of current classes. In comparison, other existing soft start solutions need several different housings. This new feature enables straightforward integration of the module together with the bypass contactor into the typical design space. Power Start provides an integrated heatsink and can be mounted easily and without having to use thermal grease. The module makes use of double sided cooling, thus it can withstand overload currents of up to 2200 A for duration of 21 seconds. This delivers an industry leading power to price ratio.

www.infineon.com/powerstart

Power Analyzer Performs Compliance Testing to International Standards

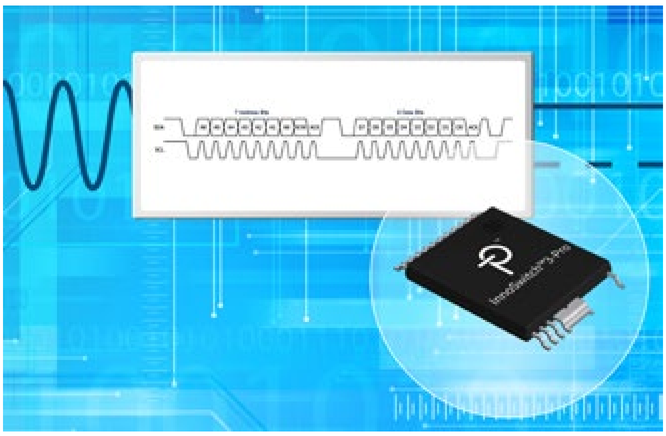
Vitrek introduces the latest generation of its popular line of power analyzers, now equipped with the built-in capability to conduct compliance

testing to a number of key environmental performance standards. The PA900 Precision Multi-Channel Harmonic Power Analyzer can be set up to analyze the power output or consumption of the device under test and automatically display the results. This is a significant advance over other power analyzers that require PC-based software to conduct such analysis. The PA900 sets the standard for affordable graphical power analyzers. It integrates a high-accuracy, wideband waveform digitizer with advanced computational capability, a large high-resolution display and a full-color touchscreen user interface. The unit's intuitive touchscreen operation – with built-in data history, scope mode and waveform zoom – allows users to explore many aspects of power measurement in greater detail than traditional power analyzers. The PA900 delivers waveform visualization and measurement results necessary to validate the performance of power critical designs, such as LED lighting, solar power inverters, electric vehicles and aviation power distribution. Its Virtual Power Analyzer function facilitates energy-efficiency measurements, while its 0.03% basic accuracy and (up to) 5MHz bandwidth provide world-class performance. In addition, the PA900 now includes the capability of measuring up to 500th harmonics and multi-unit linking for as many as 12-channel applications.

www.vitrek.com

Off-Line Switcher IC Supports USB PD 3.0 + PPS

Power Integrations announced the release of its InnoSwitch3-Pro family of configurable off-line CV/CC and CP flyback switcher ICs. Capable of delivering up to 65 W and achieving up to 94% efficiency across line and load conditions, the new devices permit precise,



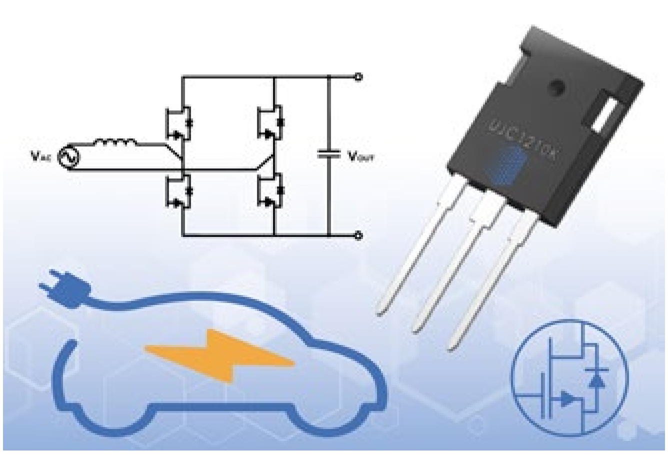
dynamically adjustable, control of voltage (10 mV step) and current (50 mA step), via a simple two-wire I2C interface. Devices may be paired with a microcontroller or take inputs from the system CPU to control and monitor the off-line power supply. Applications include virtually any rapid-charging protocol, including USB Power Delivery (PD) 3.0 + PPS, Quick Charge™ 4/4+, AFC, VOOC, SCP, FCP and other industrial and consumer battery chargers, dimmable LED ballast drivers and field-configurable industrial power supplies.

InnoSwitch3-Pro power-conversion ICs include a microprocessor VCC supply - eliminating the need for an external LDO to power the microcontroller; also included is an n-channel FET driver which may be used to enable or disable the main power output. Together with integrated bus voltage, current and fault-reporting telemetry and dynamically configurable protection functions such as OTP, line OV/UV, output OV/UV, and short-circuit, the BOM count for a sophisticated offline power supply is significantly reduced and design complexity is dramatically simplified.

www.power.com/products/innoswitch/innoswitch3-pro.

650 V Silicon Carbide FETs

UnitedSiC has announced the UJ3C series of 650 V SiC FETs as drop-in replacements for silicon Superjunction MOSFETs. Available in standard TO-220, TO-247 and D2PAK-3L packages, they operate with standard Si-MOSFET gate drive, eliminating the need to re-design drive circuits, while offering low RDS(ON) and low gate charge to reduce system losses. Used for power factor correction and DC-DC conversion in both hard-switched and ZVS-switched systems, applications include electric vehicle (EV) chargers, power supplies, motor drives and renewable energy inverters. The maximum drain current (ID) ratings for these SiC transistors ranges from 31 amps to 85 amps. Low RDS(ON), specified at 27 milli-ohms, is best in class for TO-220 devices. Furthermore, a built-in low Qrr body diode eliminates the need for an anti-parallel diode. With their combination of low RDS(ON), high current rating and excellent thermal performance, the UJ3C series can be used in hard-switched converters and zero-voltage switching applications such as LLC and phase-shifted full bridge converters. The devices also enable switching frequencies of up to 500 kHz, allowing designers to reduce the size and cost of other system components, including bulky inductors, capacitors and thermal management parts.



www.unitedsic.com

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