ISSN: 1863-5598

ZKZ 64717
04-19

Bodo´s Power Systems®

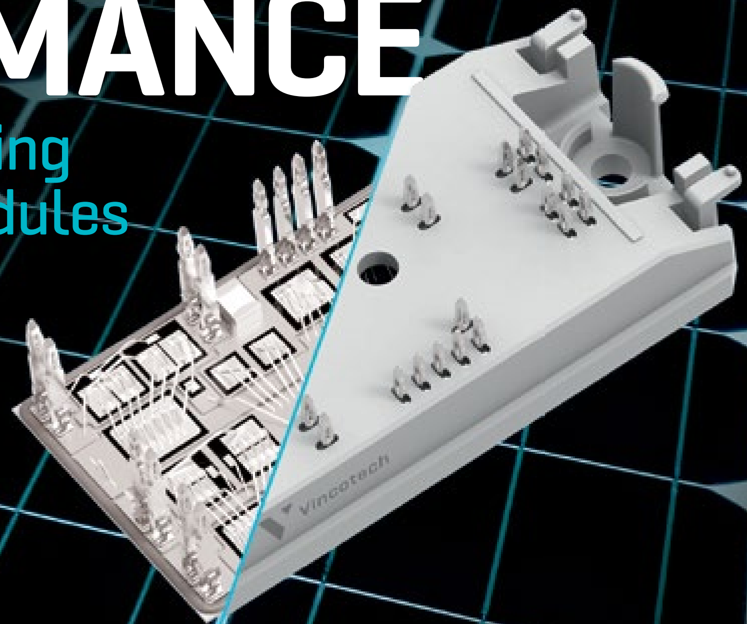
Electronics in Motion and Conversion

April 2019

VINCOTECH @
PCIM
2019
EUROPE
BOOTH 9-310

MAKING THE MOST OF SIC MOSFETS' PERFORMANCE

The Challenges of Using SiC-Based Power Modules



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GvA Power Electronics

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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

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

www.bodospower.com

Counting the Days to PCIM

The first half of the year is always a busy period. We are just back from California and the APEC show ! Gary Dolny accompanied us and, as an expert with decades of experience, he knew just which sessions were most important. Keep an eye out for his summary in our upcoming issue. I could concentrate on seeing the show and meeting our numerous clients, partners and friends. It's been a trip full of good impressions - on the professional side as well as personally. Seeing Venice Beach and the Golden Gate Bridge again, 13 years after my first visit, is another beautiful memory.

Next month the destination for the power community will be Nuremberg in Germany. I was there in February for embedded world and I can assure you that the public transportation system (which I used for the first time) works perfectly. Transit service from the airport into the city as well as after the show back to the airport by underground was absolutely smooth. Even when the show closed for the evening and hundreds of visitors hit the station, I only waited 10 minutes for the train. Did you know that Nuremberg has the first subway system worldwide, in which both driver-operated trains and computer-controlled trains share the tracks?

At PCIM our booth will again be in Hall 7, #540. Visit us for a chat, or better yet a short rest and a water - running around those halls is tiring ! This year, Bodo's traditional podium discussion, on WBG devices and applications, will also be held in this Hall 7. The Podium location is only a few steps away from our booth - very convenient. Beside this new location, there will be a "Meet the Speakers" lounge, where you can have a discussion with our speakers after their presentation. This is totally new, and I'm excited to see

the results – lots of good discussion I hope. We've invited the Wide Band Gap experts and a chat with them will be insightful.

Bodo's magazine is delivered by postal service to all places in the world. It is the only magazine that spreads technical information on power electronics globally. We have EETech as a partner to serve North America efficiently. If you are using any kind of tablet or smart phone, you will find all of our content on the 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 the Month:
We should encourage our children to become involved in "Fridays for Future", instead of threatening them with penalties for staying away from class. The kids are right !

Best Regards

Events

Smart Systems Integration 2019
Barcelona, Spain, April 10-11
www.smartsystemsintegration.com

Battery Experts Forum 2019
Frankfurt, Germany, April 10-12
www.battery-experts-forum.com

ExpoElectronica 2019
Moscow, Russia, April 15-17
www.expoelectronica.ru

IWIPP 2019
Toulouse, France, April 24-26
www.iwipp.org

Thermal Summit 2019
Los Angeles, CA, USA, May 2
www.thermalsummit.com

Satellite 2019
Washington, DC, USA, May 6-9
www.satshow.com

Battery Show Europe 2019
Stuttgart, Germany, May 7-9
www.thebatteryshow.eu

EV Tech Expo Europe 2019
Stuttgart, Germany, May 7-9
www.evtechexpo.eu

PCIM Europe 2019
Nuremberg, Germany, May 7-9
www.mesago.de/en/PCIM

State of the
ART & ATO

ATO Series

Split-core Current Transformers

- Compact, self-powered
- 10 & 16mm diameter aperture
- Accuracy class 1 & 3
- Operating frequency: 50 / 60 Hz

PERFECT LOOP TECHNOLOGY
Patent
ref. WO 2009
/001185 A1

ART Series

Unique, IP57, flexible and thin 1 kV Rogowski coil

- Rated insulation voltage 1 kV CATIII
- Accuracy class 0.5 without calibration
- 2mm hole to pass security seal
- Electrostatic shield

Supporting SiC Drivers Through its Technical Competence Center

AgileSwitch India Pvt Ltd was established with a goal to provide Development & Applications Support to customers, particularly in Asia. “Through AgileSwitch India we are directly addressing the growth opportunities in Asia”, said Rob Weber, CEO. Also present at the opening of the new facility was Nitesh Satheesh, General Manager of AgileSwitch India, who added “In addition to supporting customers in the US & Europe, our goal is to expand AgileSwitch India into a Technical Competence Center for SiC Gate Drivers”. AgileSwitch develops transformative technology that dramatically improves the performance and efficiency of electric vehicle and renewable energy applications. Patented Augmented SwitchingTM technology in our Gate Driver Cores, Plug and Play Gate Drivers are suitable for SiC and IGBT switches. They are used in a variety of applications including electric vehicles, solar inverters, wind turbines, energy storage, motor drives, energy storage, traction and other high reliability markets. Furthermore, AgileSwitch drivers can be fully customized to meet the needs and demands of virtually any customer application. With an ongoing product development commitment, AgileSwitch is continuously expanding the product line of gate drivers.

www.agileswitch.com

Global Online Distribution Partnership

Navitas Semiconductor and Digi-Key Electronics announced a distribution agreement to provide worldwide, 24-hour availability and accelerate market penetration and revenue ramp of GaNFast™ power ICs. GaNFast power ICs enable power systems to simultaneously achieve MHz-frequency and highest-efficiency operation. These advances translate to smaller, faster, lighter, and lower cost power conversion in mobile fast chargers and adapters, IoT, TVs, EV/Hybrid, LED lighting and new energy solutions. “Navitas is extremely excited to partner with Digi-Key,” said Stephen Oliver, Vice President of Sales & Marketing for Navitas. “GaNFast ICs are the ideal, easy-to-use, robust, ‘digital-in, power-out’ solution and now, with Digi-Key’s best-in-class service, this technology is readily available to every power electronics designer around the world.” The NV6113, NV6115 and NV6117 single GaNFast power ICs are 650V-rated and available in the tiny 5x6mm QFN package. A series of videos and technical papers introduces GaNFast technology, applications and end-customer examples. Product datasheets and application-specific design kits enable fast implementation for new and upgraded designs. “Digi-Key is proud to offer the world’s first GaNFast power ICs from Navitas. Integrating the GaN gate driver, GaN FET, and GaN logic into a single package simplifies the circuit design,” said David Stein, Vice President of Global Supplier Management at Digi-Key. “Our 24/7 global support network with the integration of GaNFast power ICs will be a powerful combination to accelerate the development of a new class of power systems.”

www.navitassemi.com

Receiving the German Certification “Baumusterprüfbescheinigung”

LEM is pleased to become the first company to receive the German certification for the EM4TII (Energy Meter For Traction) DC energy meters. The steadily increasing battery capacity has helped the EV market grow, but the most appealing use cases remain short journeys in an urban setting. To make electric vehicles the vehicle of choice for the wider market and to reduce the carbon footprint of private transport, a network of fast chargers must be installed, allowing users to make long trips without worrying about range or the charging time. Energy suppliers have already started to deploy fast charger networks (30min, 150kW) and expect ultra-fast chargers (<10 min, 350kW) by 2020. Fast and ultra-fast chargers provide direct current (DC) as they are directly connected to the battery.

As from April 2019, new regulations will enter in force that require energy providers to only charge energy delivered to the car (it is normal not to pay the losses related to the performance of the charger). Today only certified AC energy meters exist for billing electricity to the end user.

As DC solution, LEM proposes the proven DC meter for railway applications called EM4TII which has successfully passed all required tests and has obtained the type approval certification, the Baumusterprüfbescheinigung by PTB (Physikalisch-Technische Bundesanstalt). In parallel, for the future requirements of the market, LEM will introduce soon a new ‘LEM Direct Current (DC) Meter’, much more compact than the previous version of the EM4TII. This new meter will be as accurate and universal, whatever the topology of the charging station (up to 600 kW).

www.lem.com/en

Formula E All-Electric Racing

Mouser Electronics is proud to announce its sponsorship of the GEOX DRAGON Formula E Team throughout the 2018–19 racing season. Mouser is backing the team this year in collaboration with TTI, Inc. and valued suppliers Molex and AVX. This marks the fifth-straight year that Mouser and Molex have sponsored Formula E racing. The

Mouser-sponsored team takes to the 2.093 km Autódromo Hermanos Rodríguez track at the Mexico City E-prix on February 16.
“Formula E cars require the latest sustainable and — most importantly — high-performance components to gain a competitive edge,” said Todd McAtee, Vice President, Americas Business Development for Mouser Electronics. “By teaming up with TTI, Molex and AVX to sponsor Formula E, Mouser shows its commitment to keeping engineers up to date with innovative technologies.”
“TTI is proud to again partner with Mouser to support this exciting sport and what it means to sustainable automotive technologies of the future,” said Mike Morton, TTI Chief Operating Officer.
“We are all looking forward to this season of Formula E. The Gen2 car is a huge step forward in electric racing technology, and it will be exciting to see how it evolves the already popular sport,” said Fred Bell, Vice President of Global Distribution for Molex. “As proud supporters since the inception of Formula E, Mouser and Molex wish the GEOX DRAGON team a very safe and successful season on the road.”

www.mouser.com/formula-e

Wide Bandgap Semiconductor Power Packaging Challenges

The International Workshop on Integrated Power Packaging announces IWIPP 2019, to be held in Toulouse, France, April 24-26, 2019. IWIPP, utilizing focused technical tutorials and a series of in-depth technical sessions aims to foster and facilitate disruptive change in the development of power packaging technologies required to help realize the performance entitlements of wide bandgap (WBG) semiconductors in practical power electronics applications.

IWIPP

“Many experts believe that the development of packaging technology has not kept pace with recent advancements in power semiconductor technology, especially with the emergence of fast-switching wide bandgap semiconductors,” reported Brandon Passmore, Technical Program Chairman. “IWIPP seeks to bring together technical experts in the various engineering disciplines that intersect at the development of high-performance packaging for power semiconductors,” he continued. “Due to this multi-disciplinary focus and the accelerating industry need, IWIPP is quickly becoming a premier international workshop that attracts leading researchers from around the globe to share ideas on these important topics.”
IWIPP will be keynoted by a Plenary Session featuring addresses by Dr. Ahmed Elasser, Principal Systems Engineer at GE Global Research Center and Dr. Christophe Lochot, Electrical System R&T Group Leader at Airbus Operations SAS.

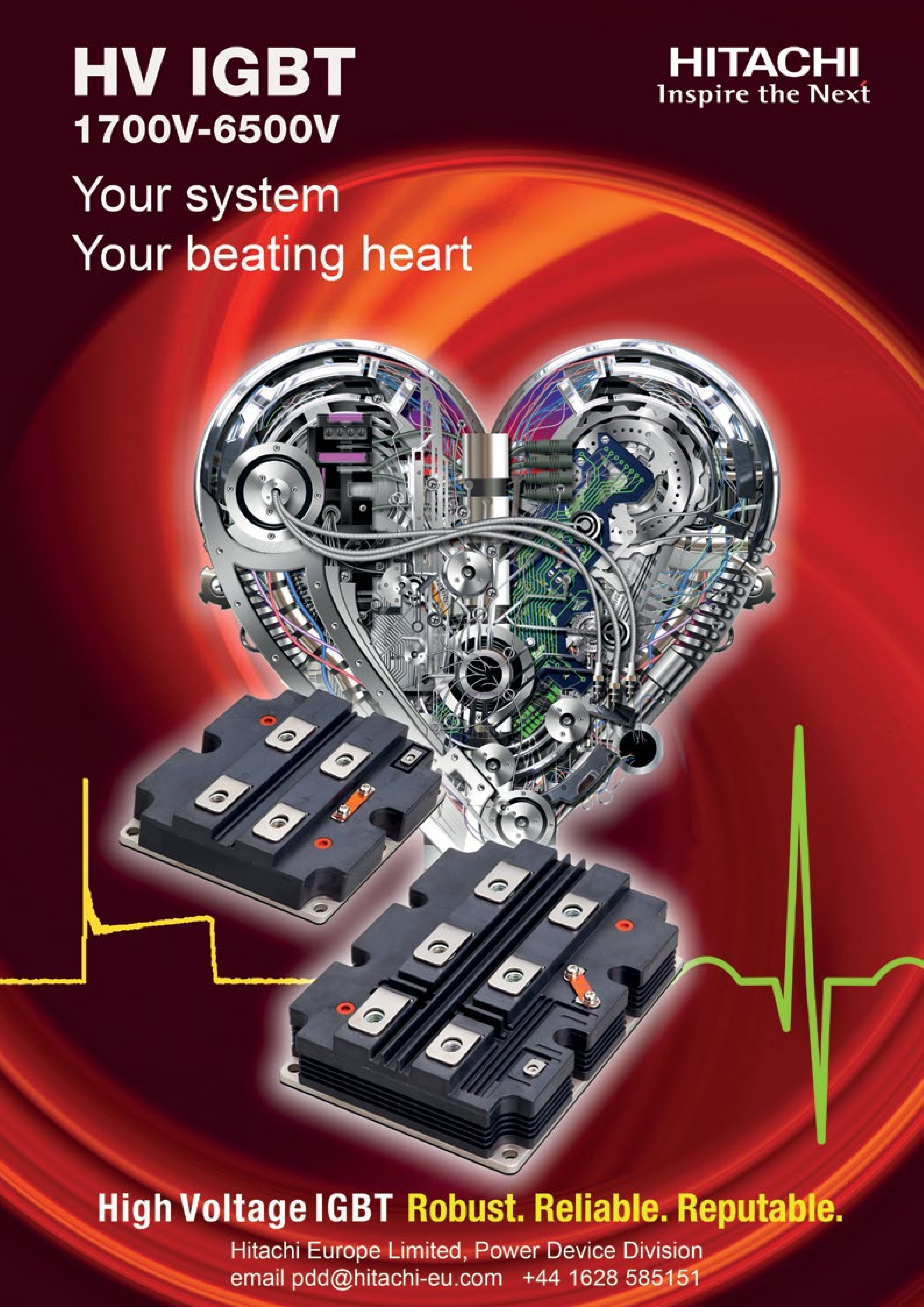
www.iwipp.org

PCIM Europe 2019: Topics and Highlights

In less than three months from today, the leading international exhibition and conference for power electronics, intelligent motion, renewable energy and energy management, the PCIM Europe, will be opening its doors. All indicators show that the event is set to be a success.

From 7 – 9 May 2019, market leaders as well as small, specialized companies will be showcasing their products and components at the PCIM Europe in Nuremberg, Germany. Among other things, trade visitors can look forward to innovations in power semiconductors and passive components, which are presented by 39% and 38% of the exhibitors respectively, as well as in thermal management (25%) and power converters (21%).
Once again, this year, the number of exhibiting companies is expected to exceed 500, more than half of them from abroad.
For the first time ever, there will be Guided Tours on the trend topic of e-mobility, introducing exhibitors that specialize in this application of power electronics. Interested visitors have the possibility of signing up for these tours online prior to the event. Tickets for the PCIM Europe are available at pcim-europe.com/tickets as well as on-site at the exhibition grounds.

https://pcim.mesago.com/events/en.html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HITACHI
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Your system
Your beating heart
High Voltage IGBT Robust. Reliable. Reputable.
Hitachi Europe Limited, Power Device Division
email pdd@hitachi-eu.com +44 1628 585151

Silicon Nitride Ceramic Substrates

Heraeus Electronics announced a strategic partnership with Toshiba Materials to jointly develop and produce metal ceramic substrates made of silicon nitride (Si3N4), which are used in high-performance electronics. The growth of the e-mobility market, in particular, has created an increased demand for more efficient, economical, and reliable power electronic components for hybrid and electric vehicles. This full-scale collaboration will enable both companies to address this critical need.

Silicon nitride metal ceramic substrates possess excellent thermal conductivity and mechanical properties, which are used as heat-dissipating and insulating parts in power modules. It is expected that demand for silicon nitride metal ceramic substrates with high reliability will increase in the future by expanded use in power modules installed in electric vehicles.

Both companies gain by combining their expertise in ceramic substrate production, technology for the bonding of metal and ceramics, structuring, finalizing, and sales to better supply the market. Toshiba Materials provides the metal ceramic substrates, which Heraeus Electronics structures and finalizes to meet customer specifications. Toshiba Materials continues to supply finalized substrates on established markets.

www.heraeus.com

Franchise Agreement Signed

EBV Elektronik announces that it has entered a distribution agreement with Power Integrations. With this agreement EBV will franchise Power Integrations' products including ac-dc switching converter ICs for chargers and many other applications, LED drivers for lighting, the new BridgeSwitch™ brushless dc motor drives targeting appliances, and high-power gate drivers & boards. The franchise agreement will be effective immediately. Power Integrations' products are key building blocks in the clean-power ecosystem, enabling the generation of renewable energy as well as the efficient transmission and consumption of power in applications ranging from milliwatts to megawatts.

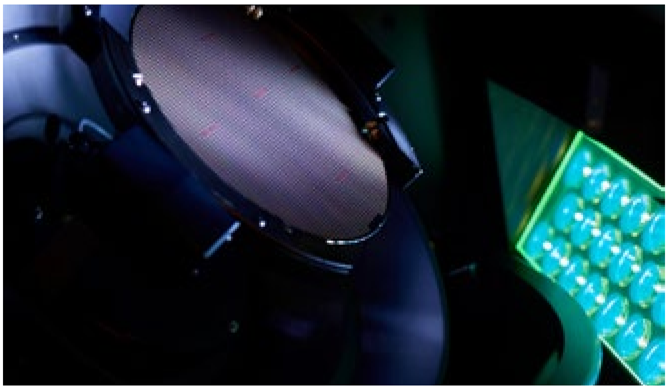
The company is a leader in high-voltage integrated circuits for energy-efficient power conversion, and also gate-driver technology for medium- and high-voltage inverter applications.

Ben Sutherland, Vice President Worldwide Sales, Power Integrations Inc. comments: "We are delighted to sign this agreement with EBV Elektronik, as it will enable a broad spectrum of customers to access our products, supported by the technical capabilities and customer service that EBV is renowned for. EBV will carry our complete product portfolio, and we are especially excited about the prospect of working together on our gate-driver products, which will complement the IGBT modules that EBV already offers. Our new BridgeSwitch motor-drive ICs should also be very interesting for EBV's customer base."

www.power.com

High-Voltage Galvanic Isolation Technology

X-FAB Silicon Foundries SE has announced the full volume production release of its high temperature galvanic isolation semiconductor process. This proprietary technology is fully automotive qualified, and offers greater reliability levels compared to options offered by the competition. Galvanic isolation electrically separates circuits in order to improve noise immunity, remove ground loops, and increase common mode voltage. It can also protect human interfaces from contact with high voltages. An example where this plays an important role is the control of IGBT or SiC power modules in industrial and automotive environments. Further applications include data communication in field bus systems, battery management systems or the usage in medical equipment.



X-FAB offers two types of packaged galvanic isolation devices for customer evaluation. The capacitive coupler test chip, G3-C1, has an isolation layer thickness of 11 µm and was tested to withstand up to 6,000 Vrms (the maximum limit of the test setup). An inductive coupler test chip, G3-T06, is also available for customer evaluation and has an isolation layer thickness of 14 µm.

www.xfab.com/en

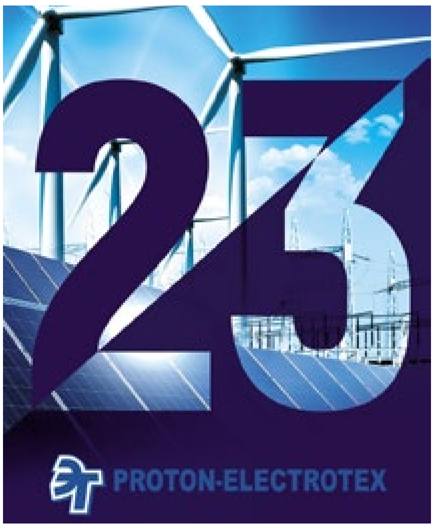
Growth Potential for Research, Development and Quality Assurance

On February 20, 2019, Prof. Dr. h. c. mult. Reinhold Würth opened the new site of the Würth Elektronik eiSos Quality Design Center (QDC) in the Chinese technology metropolis Shenzhen, accompanied by Xingdong Jia, Chairman of the "Bureau of Industry and Information Technology of Shenzhen" as a representative of the Chinese government. The QDC team assumes functions in the areas of quality assurance, R&D, product qualification, material monitoring and after-sales service. Currently 133 employees work in the building, compliant with the latest energy standards, which was built and put into operation in seven months. Located in the high-tech district of Low Carbon City, the building offers space for up to 250 employees.

Other guests of honor among the 40 or so participants at the opening were besides Reinhold Würth, Chairman of the Supervisory Board of the Würth Group's Family Trusts, Benjamin Würth, Member of the Supervisory Board, Robert Friedmann, Chairman of the Central Managing Board of the Würth Group, Rolf Bauer, Honorary Member of the Advisory Board of the Würth Group, as well as the CEOs of the Würth Elektronik eiSos Group, Oliver Konz, Thomas Schrott and CTO Alexander Gerfer. Special recognition was given to Project Managers Dirk Knorr, Head of Total Quality Management, as well as Yangyang Chen and Michael Weser, Division Managers at QDC Shenzhen, who succeeded in expanding, relocating and commissioning the QDC in record time.

www.we-online.com

Celebrating Its 23rd Anniversary



On February the 6th, Russian manufacturer of power electronics Proton-Electrotex celebrated its 23rd anniversary. The company was established in 1996 and in just few years managed to become an established brand in the high-tech industry of semiconductor devices. In these years the company has developed a complete portfolio of power semiconductors used in electric transport, power grids, metallurgy, arc welding and many other industries. The first project of the company was disc and stud diodes and thyristors.
In 2003 production of power modules was launched, followed by IGBT modules in 2016. Today the company continues its research of new IGBTs, and devices based on silicon carbide. In 2018 the company set several financial and production records. Turnover increased by near 20%, and the number of active clients reached 1,200 organizations. Proton-Electrotex continues to expand its staff and remains the key Russian company in the field of power semiconductors.
Other achievements in 2018 included taking the 10th place among all the industrial organizations of Russia according to the rating of the radio-electronic industry of Russia, passing the second stage of "Made in Russia!" voluntary certification, being listed for the Ministry of Economic Development of the Russian Federation project "National champions", and establishing relations with several new major distributors.

www.proton-electrotex.com/eng

Independence Pays Off

Nexperia announced that in just two years as a standalone company, it is significantly out-performing the market, achieving growth figures of over 35%, introducing more new products and expanding its annual manufacturing capacity to more than 100 billion parts. Increased investment has led to an increase in market share as the company has been able to fulfill customer demand.
In its two years as an independent company, Nexperia also launched over 1500 products. These new discretes, logic and MOSFET parts were successfully introduced in the market, and the company is winning new business with leading companies in existing and new market sectors. Comments CEO Frans Scheper: "We are proud of our history, which goes back very nearly 100 years to well-known names such as Philips and NXP, but now as a stand-alone company we can pursue our own strategy and goals and achieve even more. As a result, we are on a fast track to become a 2 BUSD player by 2021". Over the last 18 months, the industry has generally experienced shortages. To counter this, Nexperia has significantly expanded capacity at its Guangdong, China, facility and strongly increased wafer output at its front end fabs in Hamburg and Manchester. Frans Scheper: "We have been able to grow our market share because we invested at the right time in new facilities", he explains, "growing output by almost 20% in the last two years". Importantly, the majority of Nexperia's products are manufactured to exceed the demands of the automotive standard, AEC-Q100/101."

www.nexperia.com

Named in the 2019 Global Cleantech

EpiGaN

The Global Cleantech 100 serves as an annual guide to leading companies and themes in sustainable innovation. It features independent, for-profit companies best positioned to solve tomorrow's clean technology challenges. This year marks the 10th edition of the list.
"We at EpiGaN are delighted and honored with this nomination for the 2019 Global Cleantech 100," said Dr Marianne Germain, CEO and co-founder of EpiGaN nv. "It is another great reward for EpiGaN's highly committed team. Innovative GaN technology enables drastic energy savings, volume and weight reductions of power systems, miniaturization and significant cost reduction in areas where traditional Si solutions cannot meet current or future system requirements. EpiGaN offers unique and state-of-the-art solutions addressing the demanding mm-wave specifications for 5G cellular networks. EpiGaN's product portfolio also covers sensor applications. At our production facility in Hasselt (Belgium), we have developed unique GaN-on-Si and GaN-on-SiC wafer technologies up to 200mm on Si, and 150mm on SiC, which are more robust and offer differentiation to our global customer base. This year we are significantly scaling up our production capacity to meet the increasing demand ofs our customers for EpiGaN's state-of-the art GaN technology."

www.epigan.com

SCALE-iDriver SiC-MOSFET Gate Driver

Power Integrations announced the SIC1182K SCALE-iDriver™, a high-efficiency, single-channel SiC MOSFET gate driver that delivers the highest peak output gate current available without an external boost stage. Devices can be configured to support different gate-drive voltage requirements matching the range of requirements seen in SiC MOSFETs today and include advanced safety features making them both compact and robust.

The SIC1182K offers up to 8 A output at a junction temperature of 125°C allowing these devices to support SiC-MOSFET inverter designs up to several hundred kilowatts without a booster stage. This results in high system efficiency and enables customers to produce only one design to cover their entire product portfolio of differently-rated power inverters. A switching frequency of up to 150 kHz supports multiple applications.

SCALE-iDriver SIC1182K SiC gate drivers feature Power Integrations' high speed communications FluxLink™ technology, dramatically improving isolation capability. FluxLink is a revolution in signal transmission replacing optocouplers and capacitive or silicon-based solutions, significantly improving reliability and delivers reinforced isolation up to 1200 V. SCALE-iDriver devices also include system-critical protection features such as desaturation monitoring and current SENSE read out, primary and secondary undervoltage lock-out (UVLO) and Advanced Active Clamping (AAC). More, the protection circuits provide safe shut down within 5 microseconds, meeting the fast protection needs of SiC devices. SIC1182K SiC gate drivers exhibit high external magnetic field immunity, featuring a package that provides ≥9.5 mm of creepage and clearance, using material that has the highest CTI level, CTI600, to IEC60112.

Comments Michael Hornkamp, senior director of marketing for gate-driver products at Power Integrations: "Silicon Carbide MOSFET technology opens the door for decreasing size, lower weight and reduced losses in power inverter systems. The SCALE-iDriver family pairing with FluxLink™ technology enables safe, cost-effective designs for inverters with very few external components up to 100 kW, ensuring functional safety as well as compact packaging and maximized efficiency. Key applications include UPS, photo-voltaic systems, servo drives, welding inverters and power supplies."

SCALE-iDriver technology minimizes the number of external components that are needed and reduces the BOM: tantalum or electrolytic capacitors are not required; only one secondary winding is needed. A two-layer-PCB can be used which increases design simplicity, cuts component count and eases supply chain management.

Power Integrations' SCALE-iDriver SIC1182K SiC gate drivers meet IEC60664-1 isolation coordination for low voltage equipment below 1000 V and IEC61800-5-1 electric motor drive inverter regulations. UL 1577, 5 kVAC for 1 min, is pending and VDE0884-10 is in process.

Devices are available now, priced at $4.65 in 10,000 piece quantities. Technical information is available from the Power Integrations website at
http://www.power.com/products/scale-idriver-ic-family/sic1182k/

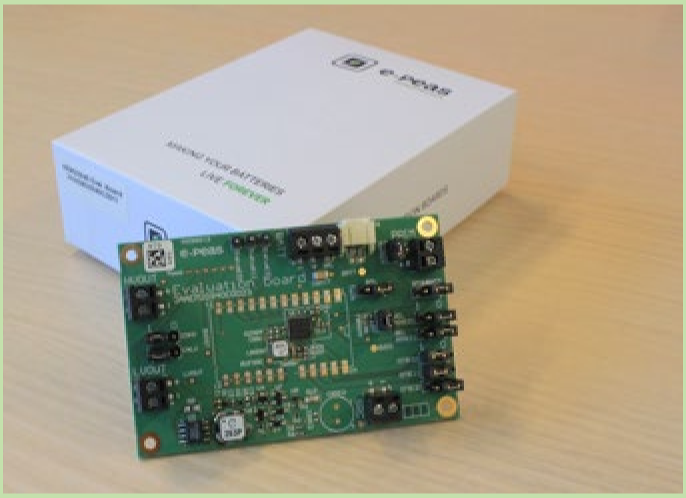
www.power.com

GREEN PRODUCT OF THE MONTH

Ultra-Low Power Technology for Thermally-Based Energy Harvesting

IC is Capable of 100mV Cold Start, with Extended Input Voltage Range

e-peas has announced the introduction of a power management IC specifically optimized for energy harvesting from thermal sources in wireless sensors application.



Supplied in a space-saving 28-pin QFN package, the AEM20940 is a highly advanced device based on proprietary technology that is capable of extracting available input current up to levels of 110mA. Taking DC power from a connected thermal electric generator (TEG), it can supervise the storing of energy in a rechargeable element and simultaneously supply energy to the system via 2 different regulated voltages. This is done through its built-in low noise, high stability 1.2/1.8V and 2.5/3.3V LDO voltage regulators. The lower voltage can be employed for driving the system microcontroller, while the higher voltage is intended for the RF transceiver.

Through the AEM20940's deployment, it will be possible to extend the system battery life or, in many cases, eliminate the primary power source from the system completely. By this any dependence on having to regularly replace batteries (which often has serious logistical challenges associated with it, as well as adding to the overall expense) can be removed. A key characteristic of the device is its ultra-low power start-up characteristics. It can achieve a cold start (with no stored energy available) from just a 100mV input voltage and 80μW input power with an external module. Sophisticated energy management functions enable fast supercapacitor charging and warn when stored energy reserves are running low.

"Having a thermal energy harvesting solution to add to our portfolio is a significant step forward for the company, as we look to establish ourselves as the leading IC manufacturer in the rapidly maturing energy harvesting sector, offering the most complete and innovative PMIC products," explains Geoffroy Gosset, co-founder and CEO of e-peas. "It means that our clients will be able to design IoT systems that can efficiently extract energy from their surrounding environment whatever the available sources."

The main target applications envisaged for the AEM20940 are in industrial process monitoring, HVAC and predictive maintenance.

www.e-peas.com

Molded Core - Power Inductors or Bus Bars for Automotive and Industrial Applications

Win an AVR-IoT WG Development Board (AC164160) from Bodo's Power and make it easy to deploy IoT devices to Google Cloud IoT Core's artificial intelligence and machine learning infrastructure.

The AVR-IoT WG development board combines a powerful 8-bit ATmega4808 MCU, an ATECC608A CryptoAuthentication™ secure element IC and the fully certified ATWINC1510 Wi-Fi® network controller.

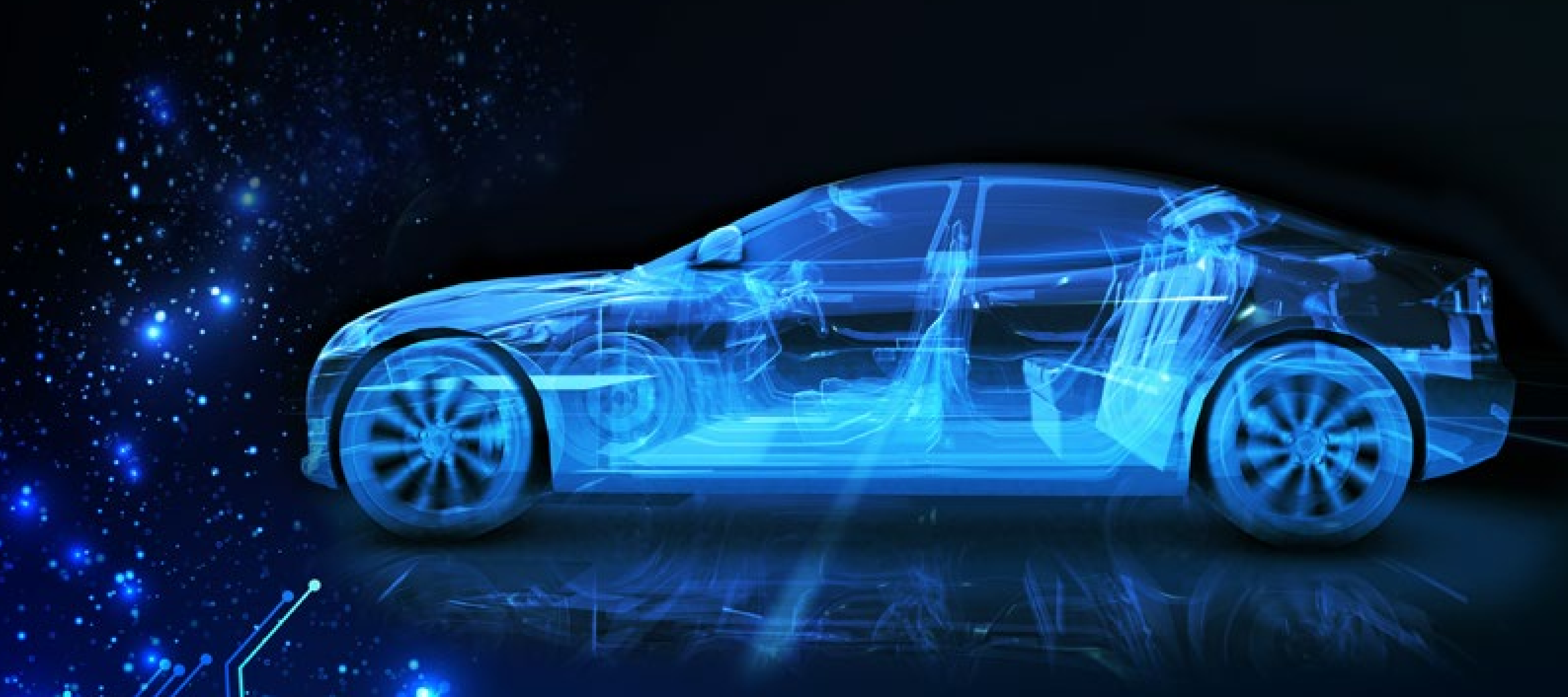
The solution combines a powerful AVR microcontroller (MCU), a CryptoAuthentication secure element IC and a fully certified Wi-Fi network controller to provide a simple and effective way to connect embedded applications.

The AVR-IoT WG Development Board gives developers the ability to add Google Cloud connectivity to new and existing projects with a single click using a free online portal at www.AVR-IoT.com. Once connected, developers can use Microchip's rapid development tools, MPLAB® Code Configurator (MCC) and Atmel START, to develop and debug in the cloud.

The board combines smart, connected and secure devices to enable designers to quickly connect IoT designs to the cloud. The board is compatible with more than 450 MikroElektronika Click boards™ that expand sensors and actuator options.

For your chance to win the AVR- IoT WG development board (AC164160), visit
http://page.microchip.com/Bodos-Power-AVR-IoT.html
and enter your details in the online form.

www.microchip.com



Broadcom Optocouplers

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The Challenges of Using SiC MOSFET-Based Power Modules for Solar Inverters

This acticle examines SiC MOSFETs as a viable option for meeting the rising demand for faster switching and greater efficiency in 1500 V solar applications. It looks at their benefits – SiC MOSFETs enable deeper integration and greater power density – and their drawbacks in terms of switching performance. The intrinsic properties of the latest generations of devices appear to inhibit performance and reliability. This article analyzes the root cause of these limitations and proposes solutions to overcome them.

By Matthias Tauer, Vincotech GmbH

Advanced Neutral Point Clamped (ANPC) Solar Inverter

The object of investigation is an ANPC (active neutral point clamped) power module equipped with Si IGBTs and SiC MOSETs as bare die. This ANPC is an improved version of the three-level NPC inverter topology. Figure 1 depicts an ANPC schematic with four grid-frequency synchronized IGBTs (T1-T4), their anti-parallel diodes (D1-D4), and two fast-switching MOSFETs (T5 and T6). The target application is a 1500 V string inverter with high switching frequency (up to 64 kHz) and high efficiency. Figure 1 shows one phase out of the three-phase inverter system, including the power module, dc-link capacitors (CDC1 and CDC2) and inverter choke (LAC).

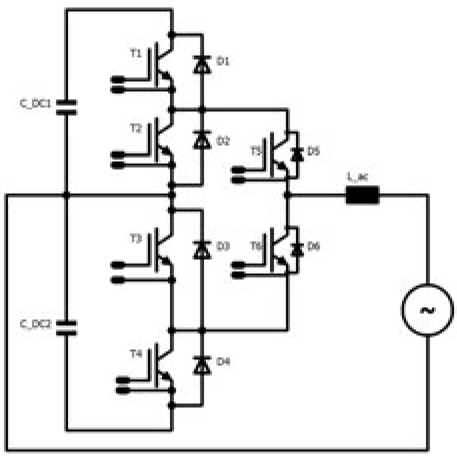

Figure 1: Active neutral point clamped (ANPC)

The switching performance of various suppliers' SiC MOSFETs was investigated in a hard-switching, totem-pole half-bridge configuration. All measurements were taken at a double-pulse characterization test station with a power module as shown in figure 1. The same DCB layout was used for all three measurements to ensure the parasitic inductance attributable to the layout, wire bonding and distance between pins would not affect the results. The only variable was the investigated type of SiC MOSFET. This characterization test station's low-inductive drive circuit supports positive and negative multiple-ampere gate drive currents. One SiC MOSFET was selected as an example for the in-depth investigation conducted for this paper.

The double-pulse measurement assessed the low-side MOSFET T6's switching waveform and switching energies. This MOSFET formed a commutation pair with the body-diode of the high-side MOSFET T5. T6 stayed on for a prolonged period to build up current, and was then switched off for a short time to allow the current to commutate fully in the body-diode of the opposite MOSFET T5. Then the low-side MOSFET T6 was turned on again and the MOSFET and diode's switching waveforms and energies were measured at that moment.

Double-pulse measurement result

The turn-on waveform of the low-side MOSFET T6 shown in figure 2 indicates a sharp spike of the drain current followed by ringing of the drain current and gate voltage. This indicates a parasitic turn-on of the opposite device, also called cross-conduction or shoot-through.

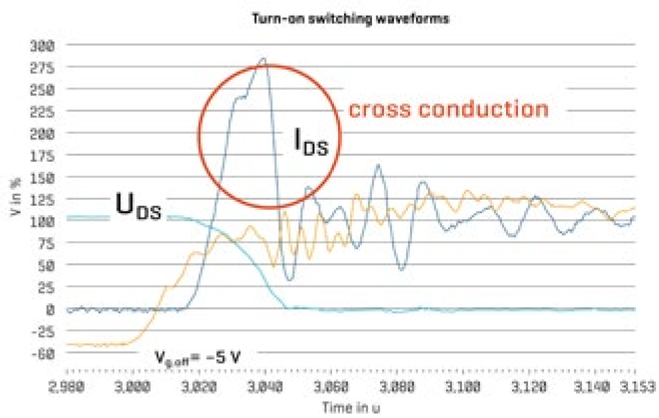

Figure 2: Cross-conduction at low-side SiC MOSFET turn-on, U_{ds}: light blue, I_{ds}: dark blue, U_{gs}: yellow (U_{dc}=600 V, I_{ds}=140 A, T_j=150 C, V_g=-5/16 V)

Explanation of the root cause

Before the low-side MOSFET T6 turns on, the current is freewheeling in the body diode of the high-side MOSFET T5. During turn-on, the current commutates from the high-side diode to the low-side channel (figure 3). This causes the diode to block and the voltage potential of the midpoint to change with high dv/dt from DC+ to 0 V.

Figure 4 shows the position of the SiC MOSFET's intrinsic capacitances. The Miller capacitance C_{gd} is located between drain and gate, while C_{gs} is between the gate and source, and C_{ds} is between the drain and source.

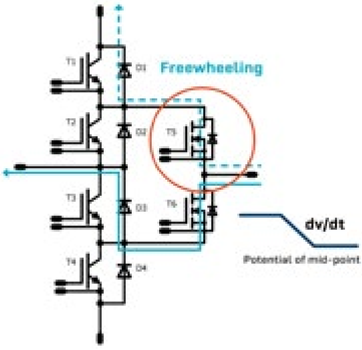

Figure 3: The current path in hard-switched ANPC

The voltage across C_{ds} increases with high dv/dt. The current then flows through C_{gd} and C_{gs}. The voltage on C_{gs} rises. If it reaches the turn-on threshold, the MOSFET starts conducting current in its channel.

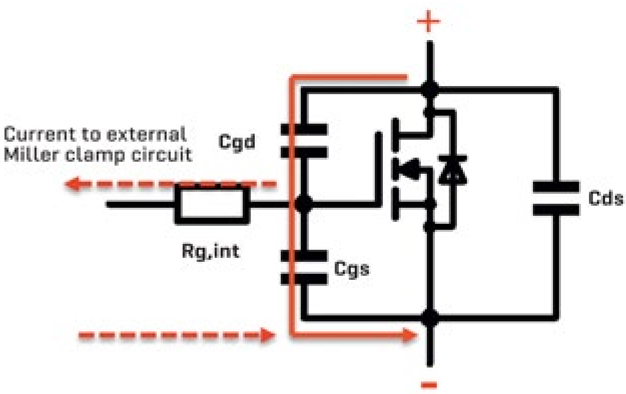

Figure 4: The SiC MOSFET's internal device capacitances and gate resistance

This renewed turn-on causes the current spike in the low-side MOSFET's drain shown in figure 2, and therefore also high switching energies. The operation junction temperature limits the highest acceptable power dissipation per MOSFET, which means the high switching energy limits the maximum switching frequency.

Proposed solutions

This chapter describes potential solutions, analyzes their effectiveness and looks at how these are put into practice.

Miller clamp circuit

A common way of removing the injected current from the device is to install an external Miller clamp circuit in the gate driver. The external clamp circuit's effectiveness depends on the inductance between the clamp circuit and the MOSFET, and on the internal gate resistance.

The gate loop's inductance is below 4nH, including the module's pin, bond wires and DCB copper tracks.

In this case, the MOSFET's internal gate resistor limits effectiveness — the higher the gate resistor value, the less effective the external Miller clamp circuit. The gate resistor in this example has several ohms, which prevents the charge's removal.

Negative gate voltage bias

Another option is to increase the negative gate voltage bias until any parasitic turn-on is undetectable. However, most suppliers limit the maximum negative gate voltage to a value of around -5 V, including all transients. Experiments show that a negative voltage spike appears when the MOSFET is turning off. This spike imposes a limit on the static negative gate voltage as the sum of both may not exceed the maximum ratings. In that case, this solution is not an option.

If the negative spike exceeds the given limits for device reliability, this will cause the gate oxide to degrade. This has a negative impact on long-term reliability because the threshold voltage may decrease to zero as the oxide deteriorates.

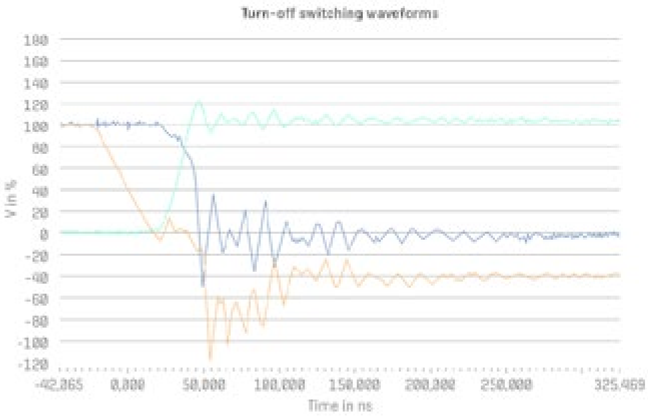

Figure 5: Low-side SiC MOSFET turn-off, U_{ds}: light blue, I_{ds}: dark blue, U_{gs}: yellow (U_{dc}=600 V, I_{ds}=140 A, T_j=150 C, V_g=-6/16 V)

ANPC with split output

Another proposed solution is to decouple the high- and low-side MOSFETs by splitting the circuit into two parts with a separation inductance in between.

The module's pin stray inductance serves as the separation inductance. No additional external circuit components are necessary.

Two additional diodes have to be added in the power module to keep the circuit functional (figure 6).

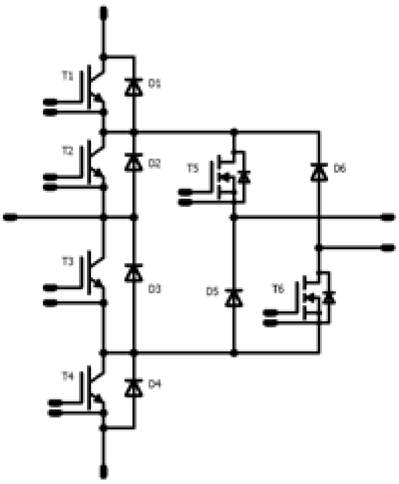

Figure 6: ANPC with split output

The added inductance disables the given switch's output capacitance, thereby preventing exposure to high dv/dt and Miller capacitance-induced charging injected into the gate. This first step can reduce the second current spike (figure 7), but not eliminate it all together.

ANPC with split-output and integrated gate capacitor

A further step can be taken to fully overcome the limitations imposed by the Miller effect: Install a capacitor in the module between the MOSFET's gate and source (figure 8). The absence of a second current spike in figure 9 shows that this prevents parasitic turn-on.

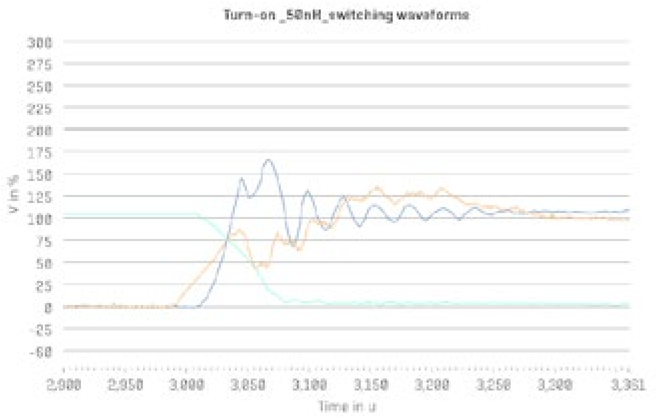

Figure 7: Low-side SiC MOSFET turn-on with 50 nH separation inductance, U_{ds}: light blue, I_{ds}: dark blue, U_{gs}: yellow (U_{dc}=600 V, I_{ds}=140 A, T_j=150 C, V_g=0/16 V)

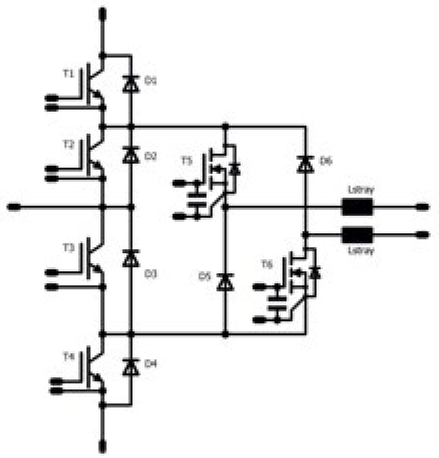

Figure 8: ANPC with split output and gate capacitor

The gate capacitor reduces dv/dt, which has the added benefit of reducing EMC.

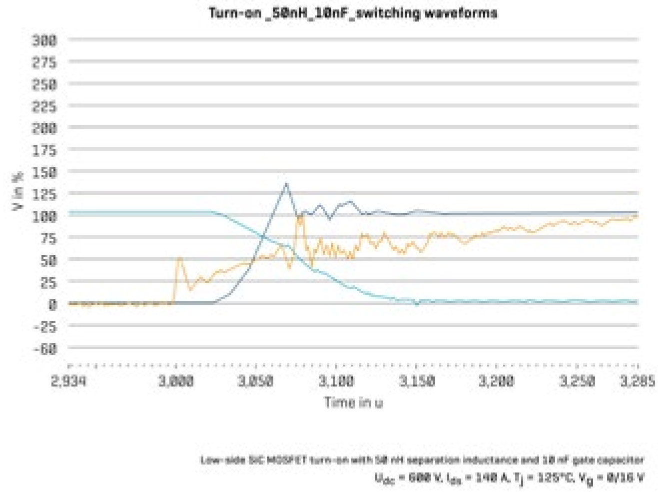

Figure 9: Low-side SiC MOSFET turn-on with 50 nH separation inductance and 10 nF gate capacitor, U_{ds}: light blue, I_{ds}: dark blue, U_{gs}: yellow (U_{dc}=600 V, I_{ds}=140 A, T_j=150 C, V_g=0/16 V)

Conclusion

The above paragraphs describe and discuss various remedies to the root cause of the limitations of SiC MOSFETs operated in hard-switched, totem-pole applications. A SiC MOSFET has to operate reliably throughout its service life, so the main concerns to be taken into account here are the gate oxide and therefore the maximum positive and negative gate voltages. Exceeding the maximum device ratings in static or dynamic conditions may cause the gate structure to degrade and the threshold voltage to drift. This would eventually result in component failure and, as a consequence, device failure. A split output paired with an integrated capacitor between the gate and source as presented here can help overcome the limitations in switching performance and enable the device to be operated to its specifications.

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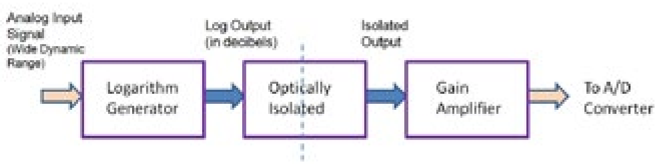
Isolated Logarithmic Amplifier Using High-Linearity Optocouplers

Logarithmic amplifiers with its log functionality are useful for compressing wide dynamic range signals whereby the measured quantities are in decibels (dB) and they are used in a wide variety of applications such as video, medical, test and measurement system. Logarithmic amplifiers can be built to a compact, easy to use and cost effective circuits suitable for certain analog designs.

By Nelson Quek and Robinson PS Law, Broadcom Inc.

Because of high voltage presence in industrial applications, it is necessary to protect equipments and personnel operating the motors through galvanic isolation. HCNR201/200 can be used for current sensing and voltage monitoring in motor control drives, switching power supplies and inverter systems.

The HCNR201/200 analog optocouplers is commonly added to isolate the analog signal in the front end module of an application circuitry. The optocoupler will be placed between the analog input and the A/D converter to provide isolation of the analog input from the mixed signal ADC and other digital circuitries.



Optical Isolation using HCNR201/200
Isolation using Broadcom optocouplers will protect the control part (such as the MCUs) from the high voltage side of the IGBTs, in the case of malfunctioning of the IGBTs for motor drives.

Broadcom high linearity optocoupler, HCNR201/200 provides an excellent solution in isolating analog signals in various applications that require good stability, linearity, bandwidth and low cost. HCNR201/200 consists of 1 LED and two closely matched photodiodes (PD1 and PD2). The important parameter for HCNR201/200 is the transfer gain and it determines how closely matched are the two photodiodes. HCNR201 is with tighter transfer gain of 5% and HCNR200 is with transfer gain of 15%. With the tight transfer gain governed by the photodiodes, Broadcom high linearity optocouplers virtually eliminate the nonlinearities and drift characteristics of the LED, with HCNR201 achieving 0.07% non-linearity over temperature. An example of an isolated gain amplifier circuitry using the HCNR201/200 is illustrated below and the HCNR201/200 is connected in photovoltaic mode as the voltage across the photodiodes are essentially zero volts.

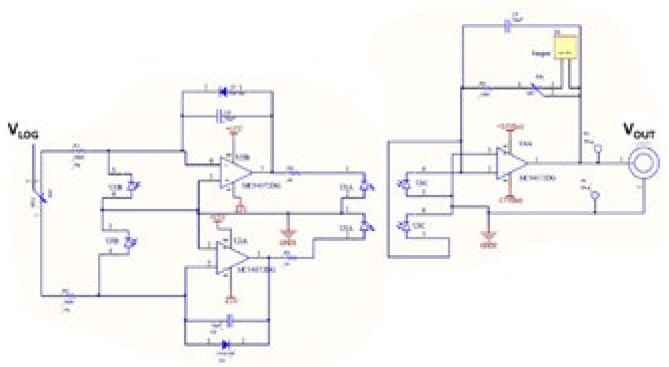


Figure 1: HCNR201/200 Bipolar Analog Input Isolation circuitry (U1A, U1B, U1C and U3A, U3B, U3C as 2 HCNR optocouplers respectively)

The above bipolar input voltage circuit uses either two HCNR201 or HCNR200 optocouplers (U1 and U3). The top half of the circuit consisting of Photodiode (U1B), R1, D1, C5, R5 and LED (U1A) is for the positive input voltages. The lower half of the circuit consisting of Photodiode (U3B), R3, D2, C9 and R4 and LED (U3A) is for the negative input voltages. The diodes D1 and D2 help reduce crossover distortion by keeping both amplifiers active during both positive and negative portions of the input signal. Balance control VR2 at the input can be used to adjust the relative gain for the positive and negative input voltages. The gain control VR1 can be used to adjust the overall transfer gain of the amplifier. The capacitors C5, C6, and C9 are the compensation capacitors for stability.

$$\mathrm{V_{LOG}} = \mathrm{I_{PD1}} * (\mathrm{R_1} + V_{R2}) \qquad \text{................ (1)}$$

$$\mathrm{V_{OUT}} = \mathrm{I_{PD2}} * (\mathrm{R_6} + V_{R1}) \qquad \text{................ (2)}$$

$$\frac{\mathrm{V_{OUT}}}{\mathrm{V_{LOG}}} = \mathrm{K_3}\frac{R_6 + V_{R1}}{R_1 + V_{R2}}$$

K3 is the transfer gain of HCNR201/200.

$$K3 = \frac{I_{PD2}}{I_{PD1}}$$

IPD2 is the current flowing through photodiode, PD2 and IPD1 is the current flowing through photodiode, PD1.

Therefore, if R1 + VR2 = R6 + VR1, then the gain of the amplifier will be unity and output signal will follow the input signal.

Logarithmic Generator

For applications involving signals with large dynamic range, it's difficult to deal with both small and large amplitude signals. Thus, it will require a log amplifier for signal compression.

A simple circuit for logarithmic function generator is shown in Figure 2. The circuit is constructed with a pair of matched transistors, Q1, Q2 and operational-amplifiers. Transistors Q1 and Q2 will serve as the feedback element for the inverting operational-amplifier. The circuit output, VLOG is the logarithmical value of the input signal, VIN.

With zener diode, LM329, collector current for Q2 is fixed and therefore, VBE2 is fixed. Only VBE1 will be affected by input signal, VIN.

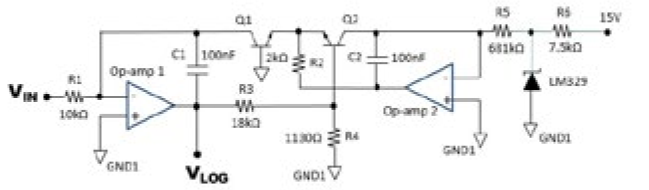


Figure 2: Logarithmic Generator Circuit

Output voltage, VLOG is proportional to the difference in the base emitter voltages of Q1 and Q2.

$$V_{LOG} = \frac{R_3 + R_4}{R_4}(V_{BE2} - V_{BE1}) \qquad \text{...................... (1)}$$

For different collector currents at Q1 and Q2, the VBE difference is governed by

$$\Delta V_{BE} = -\frac{kT}{q}\log_e\frac{I_{CQ1}}{I_{CQ2}} \qquad \text{...................... (2)}$$

Substituting equation (2) to (1), with difference of V_{BE2} and V_{BE1} as ΔV_{BE}

$$V_{LOG} = -\frac{kT}{q}\,\frac{R_3 + R_4}{R_4}\,\log_e\frac{I_{CQ1}}{I_{CQ2}} \qquad \text{...................... (3)}$$

ICQ1 and ICQ2 equations are as below:

$$I_{CQ1} = \frac{V_{IN}}{R_1} \qquad \text{........... (4)} \qquad\qquad I_{CQ2} = \frac{V_Z}{R_5} \qquad \text{................. (5)}$$

Substituting equation (4) and (5) into (3) :

$$V_{LOG} = -\frac{kT}{q}\,\frac{R_3 + R_4}{R_4}\,\log_e\frac{V_{IN}\,R_5}{V_Z\,R_1} \qquad \text{...................... (6)}$$

With Vz of LM329 = 6.9V, and R5 = 681kΩ, R1 = 10kΩ, the logarithmic amplifier circuit gain is set by the R3 and R4 divider, (R3+R4) / R4 to a factor of 1V/decade.

kT / q is equal to 0.02568V @ room temperature of 25°C where k is the Boltzmann's constant (1.38064852 x 10^{-23} $m^2.kg.s^{-2}.K^{-1}$), T is the temperature in Kelvin and q is the charge of an electron (1.60217662 x 10^{-19} coulombs).

VBE1 is the base-emitter voltage for bipolar transistor, Q1 and VBE2 is the base-emitter voltage for bipolar transistor, Q2. ICQ1 is the collector current for bipolar transistor, Q1. ICQ2 is the collector current for bipolar transistor, Q2. VZ is the zener diode voltage.

Evaluation Board

Above evaluation board is built by cascading Figure 2 and Figure 1 together. Component U1 and U3 are the two HCNR201/200 optocouplers providing isolation between the input and output circuitry.

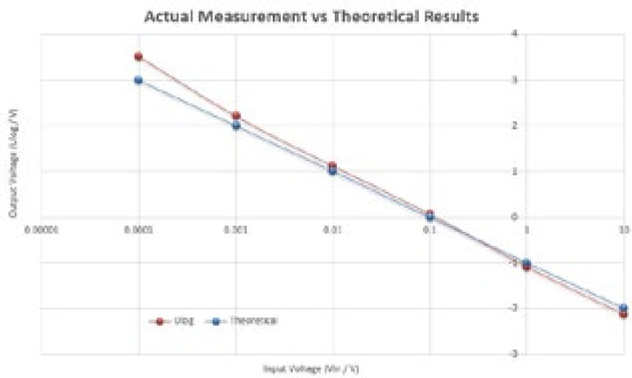


Figure 3: Vout vs Vin plot (DC input signal)

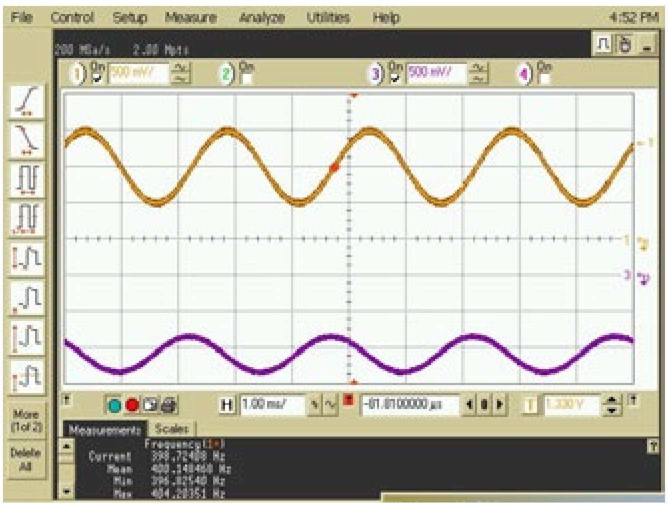


Figure 4: Vout vs Vin plot (AC input signal)

Results

DC Performance

Figure 3 shows the plot of output voltage vs input voltage for different DC input voltages ranging from 0.1mV to 10V. Theoretical results are computed based on Equation 6. Actual Measurement result is based on the evaluation board built from the cascaded isolated and logarithmic circuits in Figure 1 and 2 respectively.

AC Performance

Figure 4 shows the output voltage signal (purple waveform) with 1Vp-p AC input signal (orange waveform). Input AC signal is riding on 1Vdc, therefore from Figure 3 plot, output is with -1Vdc. Based on -3dB cutoff frequency, and output signal is found to be at 0.5Vp-p which is at half of the input signal. The bandwidth (-3dB) of this circuit is therefore, 400Hz.

For AC performance, the instantaneous input AC signal level must not be less than or equal to 0V as logarithmic value of 0V and negative input value is undefined. If input AC signal of less than or equal to 0V is applied, the logarithmic value will be clipped at the maximum value.

Summary

Logarithmic amplifiers applications include digital communication systems, analytical, medical test and instrumentation whereby safety isolation plays an important role as well.

These types of industrial applications measure the physical quantities over a wide dynamic range and therefore use log amps to match the dynamic output to the linear input range of the signal. HCNR201/200 high linearity optocouplers will provide the optical isolation to ensure data integrity and to protect operators from high voltages.

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[4] HCNR201/200, High-Linearity Analog Optocouplers Evaluation Board User's Manual, AV02-1134EN, Avago Technologies. Apr 2, 2008

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Automotive High Capacity Power Module

The automotive industry is currently undergoing a tremendous change. Due to higher awareness of the negative impact of air pollutants on human health and the climate change due to CO2 emission, electrification in passenger cars, busses as well as commercial vehicles is becoming ever more important. Mitsubishi Electric as one of the pioneers in electrified vehicles, which started mass production of automotive power modules in 1997, is today delivering optimal power module solutions for all power classes.

By René Spenke and Hussein Khalid – Mitsubishi Electric Europe B.V.

With the J1-Series power modules, Mitsubishi Electric is delivering a family of automotive grade standard modules to meet different power classes. For the high power variant, our customers can choose between the CT1000CJ1B060 with 650 V chips or the CT600CJ1B120 with 1200 V chips. With current ratings of 1000 A for the CT1000CJ1B060 and 600 A for the CT600CJ1B120, Mitsubishi Electric offers a solution for the highest power demands.

Our long experience in the market of electromobility was incorporated in the development of the J1 power module family to meet the requirements of the automotive industry for high efficiency and reliability, high power density and low weight. In this article it will be explained how these requirements are met.

Type Name	CT1000CJ1B060	CT600CJ1B120
Ratings (I_C / V_{CES})	1000 A / 650 V	600 A / 1200 V
Circuit / Sensing Function	6 in 1 Temperature sensor (all phases) Current sensor (all phases)	
Package Size	163 x 124.5 x 20.9 (mm)	

Table 1: High power J1-Series Line-up

Figure 1: J1 series power module in high power package

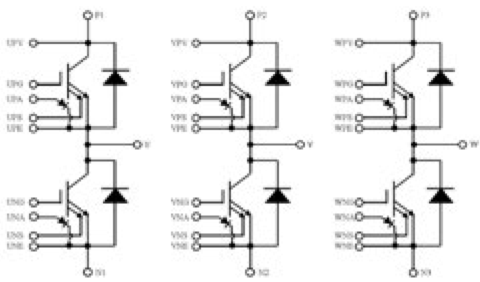

Figure 2: Circuit diagram of J1 module high power package

Mitsubishi 7th Generation IGBT chip

The 7th generation of Mitsubishi Electric's IGBT chips features the Carrier Stored Trench-Gate Bipolar Transistor (CSTBT^{TM}) technology, reducing the power losses significantly as compared to previous IGBT generations. Important factors are the low collector-emitter saturation voltage $V_{CE(sat)}$ and the reduced turn-off switching losses of the latest chip generation. This is achieved by the ultra-thin chip technology. It is supported by incorporation of on-chip sensors for real-time protection functions such as short-circuit detection, which reacts significantly faster than the conventional desaturation detection. Additionally, a temperature sensor is integrated at the chip center for over-temperature detection and optimal utilization of the chip performance.

The good performance of the IGBT chip is supported by an optimized Relaxed Field of Cathode (RFC) diode in parallel, which has low forward voltage drop and soft reverse recovery. Because of the better reverse recovery behavior of the RFC diode, the IGBT can be turned on faster which also reduces the turn-on losses.
Below pictures show a schematic of the IGBT chip with the location of the temperature sensors, which are included in each chip of the J1-series modules and a waveform of the real-time short circuit detection.

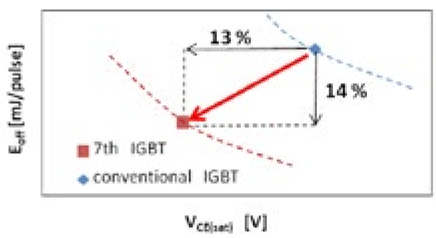

Figure 3: Improvement of Conduction and Turn-off losses by 7th generation IGBT

Direct Lead Bonding (DLB) Package Technology

Conventional power modules use bond wires to contact the top sides of the chips. Instead, Mitsubishi Electric J1-Series power modules feature the Direct-Lead-Bonding (DLB) technology which replaces the bond wires by copper lead frames to conduct the high currents. While conventional bond wires are prone to lift-off under power cycling, this failure mechanism cannot be seen in the DLB technology, leading to a significantly higher power cycling lifetime. This is an important factor for the lifetime of automotive inverters because the dynamic driving profiles and harsh environmental conditions lead to frequent high temperature swings.

Besides that, the DLB technology provides several other advantages: The high contact area between the chip and the lead frame reduces the temperature gradient between the chip hotspot and the chip edges and generally leads to a better conduction of heat away from the chip.

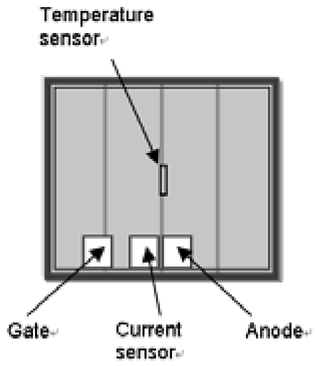

Figure 4: Location of sensors and signal terminals on IGBT chip

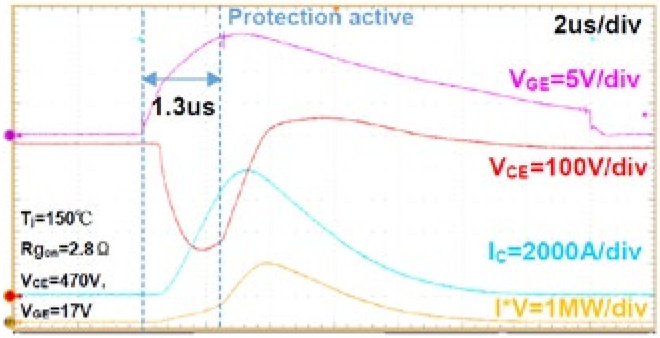

Figure 5: Waveform example of arm-short of CT1000CJ1B060

Internal Package Layout

Although the J1-Series automotive modules are designed to be comparably compact, with increasing power rating the package size increases which typically leads to an increase in the parasitic package inductance. The resulting switching voltage spikes limit the maximum switching speed of the IGBTs and hence increase the switching losses. Nevertheless, the package of the high power J1-Series was optimized to reduce the package inductance by a laminated bus bar layout with parallel current paths to cancel the magnetic flux. The low parasitic inductance is again supported by the DLB technology using large area copper frames.

Another outstanding feature of the J1-Series package design is the elimination of the solder layer between the substrate and the baseplate. This results in a reduction of the thermal resistance and an improvement of the thermal cycling capability.

Direct Cooled Pin-Fin Aluminum Baseplate

In automotive applications liquid cooling of the drivetrain components such as the traction inverter or electrical machine is standard. For a compact design with good thermal characteristics the J1-Series modules are equipped with an aluminum baseplate with Pin-Fin structure for direct liquid cooling. Using aluminum as a baseplate and Pin-Fin material reduces the weight of the module and additionally has higher durability when exposed to liquid coolants than for example copper, which needs additional plating.

Chip Parallel Connection

In order to reach the high output current of the power module, chips are operated in parallel. The module is designed with respect to optimizing the current balance between parallel chips. One factor is that the internal structure was optimized, so that the DLB is the emitter side connection of the chips and that it minimizes the difference of the inductances between the parallel chips. Figure 9 shows a comparison between using a single chip and two chips in parallel. Looking at the output of the current sensor on one of the chips, it can be seen that for the same measured value the output current is nearly doubled if two chips are operated in parallel. This proves the good current sharing of the parallel connection.

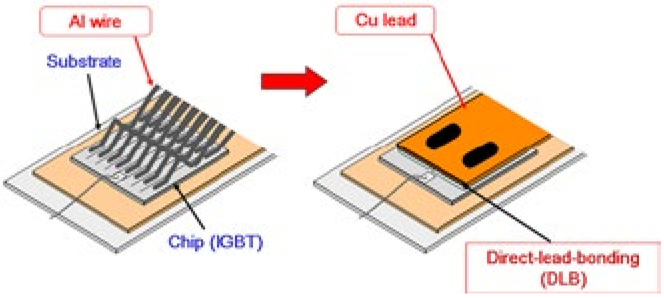

Figure 6: Comparison of conventional wire bond and Direct-lead-bonding technology

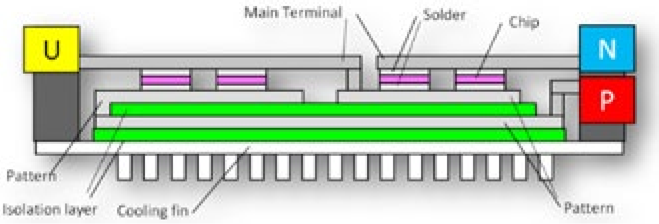

Figure 7: Cross section of J1-Series high power package

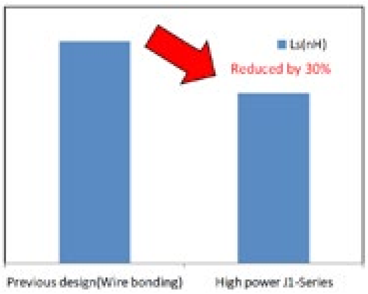

Figure 8: Parasitic inductance comparison of High Power J1-Series and conventional design

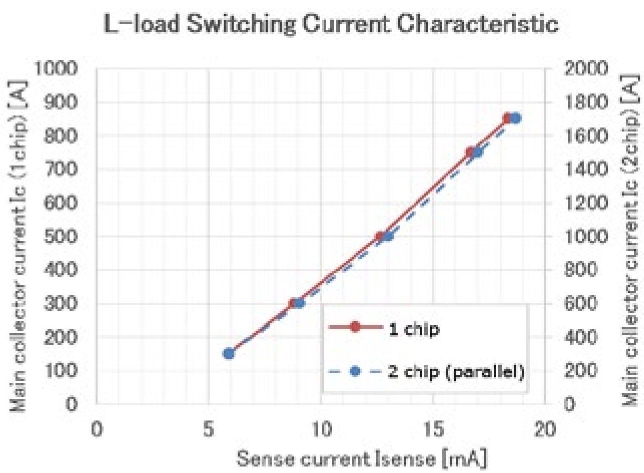

Figure 9: Current distribution characteristics between two chips of CT1000CJ1B060

Inverter Simulation Results

Performance of the J1 high power Module was evaluated by inverter simulation. Below graphs show the simulated junction temperature of the IGBT chips for different inverter output currents at a switching frequency of f_c = 5 kHz, a coolant temperature of T_w = 65 °C and a flow rate of 10 L/min. The DC-link voltages were set to V_{DC} = 300 V (for CT1000CJ1B060) and V_{DC} = 600 V (for CT600CJ1B120) respectively.

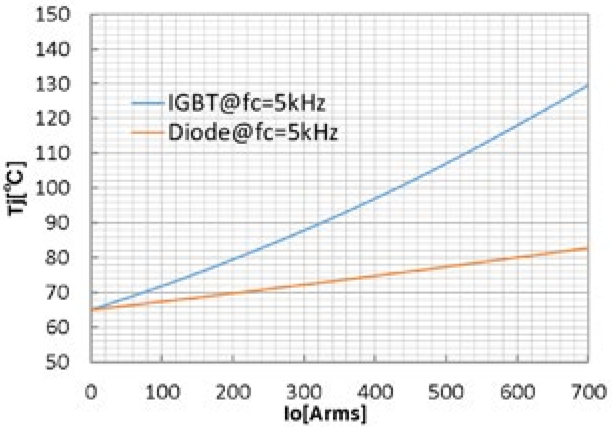

Figure 10: Inverter Mode Simulation results for CT1000CJ1B060 J1-module

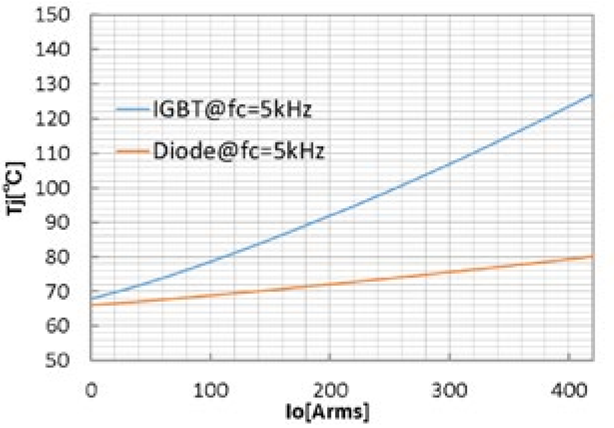

Figure 11: Inverter Mode Simulation results for CT600CJ1B120-module

The simulation shows the high current capability of both variants. The CT1000CJ1B060 can reach an output current of I_O = 700 A_{RMS} with staying significantly below the maximum continuous junction temperature, while the CT600CJ1B120 reaches more than I_O = 400 A_{RMS}.

Evaluation Kit

A complete evaluation kit can be provided together with the module for laboratory testing. It includes a cooling jacket to utilize the direct water cooling of the power module, a DC link capacitor and a driver board with a driver IC (M81605JFP) optimized to utilize the full functionality of the J1-Series by evaluating the on-chip sensors.

Summary

With the J1-Series Mitsubishi Electric provides a range of automotive grade power modules for medium to high power drivetrain applications. This article was focusing on the high power variant which is available in the voltage classes 650 V and 1200 V and was designed to meet the requirements of the automotive industry. The module achieves outstanding power density, efficiency and due to the Direct-Lead-Bonding technology also high lifetime.

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[2] "Mitsubishi Electric to Expand Lineup of J1-Series High-power Semiconductor Modules", Mitsubishi Electric Corporation press release No. 2930, Tokyo, May 12 2015

[3] "Large Capacity Power Module Packaging Technology for Automotive Inverter Applications", PCIM Europe 2018, Yuki Haka, Shoji Saito, Seiichiro Inokuchi, Shinji Hatae

[4] "High Performance 7th Generation chip installed Power Module for EV/HEV Inverters", PCIM 2015, Yosuke Nakata, Mikio Ishihara, Noboru Miyamoto, Khalid Hussein, Thomas Radke, Marco Honsberg, Shinsuke Godo

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Dynamic Load-Balancing Press-Pack IGBT for Robustness, Reliability and Ease of Use

For optimum performance of press-pack IGBT devices, it is critical that contact pressure is applied uniformly across the device. Dynex's dynamic load balancing press-pack IGBTs make this easy, ensuring robust and reliable device performance.

By Robin Simpson, Dynex Semiconductor

Introduction

Press-pack IGBTs are an alternative to isolated-base wire-bonded plastic modules, relying instead on pressure contacts. The ease with which press-packs can be stacked makes them the device of choice for applications that require series operation. Their ratings typically extend to higher currents than modules and, by using pressure contacts instead of wire bonds and solder joints, they typically benefit from higher reliability. In contrast to wire bonds, which typically fuse and render modules open-circuit in the event of failure, the use of pressure contacts ensures press-packs fail to short circuit. In the event of a high energy failure, their robust housings offer greater rupture resistance than modules [1].

Dynex's press-pack IGBT products employ a number of novel and cutting edge technologies:

- Dynamic load-balancing (DLB) technology maximises safe operating area, gives high reliability and improves ease of use compared to conventional press-pack IGBT designs.
- Silver-sinter bonding applied between the chip and adjacent molybdenum platelets ensures outstanding reliability and improved thermal performance.
- Silicone edge passivation applied to Dynex's press-pack chips and a hermetically sealed housing give robust high voltage blocking performance.
- A dedicated auxiliary emitter connection ensures synchronisation of gate drive signals between chips, mitigating the effects of power circuit di/dt on the driver circuit.

This article will focus on Dynex's DLB technology, how it differs from conventional press-pack IGBT technology and the benefits this offers users in terms of robustness, reliability and ease of use.

Importance of contact pressure uniformity

Uniform distribution of contact pressure is vital to ensure optimum sharing of electrical, thermal and mechanical stresses between the chips in press-pack IGBTs to give the largest safe operating area and the highest reliability. Conventional press-pack IGBTs, comprising a hermetic ceramic capsule housing an array of chip assemblies between rigid copper electrodes, have shortcomings in this respect.

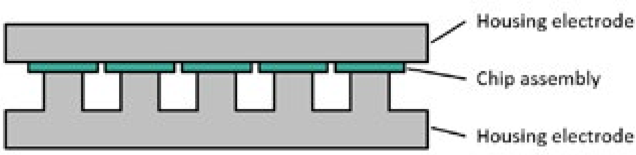

Figure 1: Cross-section of a conventional, rigid press- pack IGBT.

Figure 1 illustrates the basic construction of a conventional press-pack IGBT.

The temperature distribution that exists from chip to case within an operating press-pack IGBT drives differential expansion of the housing electrodes, causing them to distort, as shown in Figure 2. This unbalances the distribution of contact pressure and therefore thermal and electrical contact resistances, across the chips [2], [3], significantly reducing the safe operating area and reliability of conventional press-pack IGBTs. It is impossible to avoid electrode distortion, as a temperature distribution will always exist whilst the device is in operation, therefore, a press-pack IGBT design should employ a mechanism to compensate for electrode distortion.

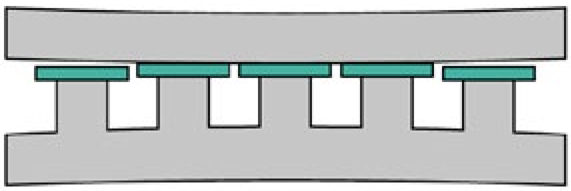

Figure 2: Thermomechanical distortion of a conventional, rigid press-pack IGBT device.

Dynex's dynamic load balancing mechanism (DLB)

Dynex's DLB mechanism replaces the rigid pillars of conventional designs with spring assemblies having far greater compliance. The springs are too resistive to form the primary load current path by themselves, so the DLB mechanism incorporates a novel current bypass mechanism, achieved using a flexible conductive diaphragm, as shown in Figure 3a.

When the device is clamped, the spring assemblies compress to the height of the spring locator plate at a pre-determined force – the threshold force - shown by label 1 in Figure 3b. The clamping force specified in the product datasheet exceeds the threshold force, with the excess force applied to the support frame. This forces pressure contacts between the diaphragm, spring locator and housing electrode - shown by label 2 in Figure 3b – creating a low resistance current path – shown by label 3 in Figure 3c.

The DLB mechanism compensates for any thermomechanical distortion that occurs, ensuring chips are uniformly pressurised, enabling Dynex press- pack IGBTs to maintain their large safe operating area and outstanding reliability, under all operating conditions.

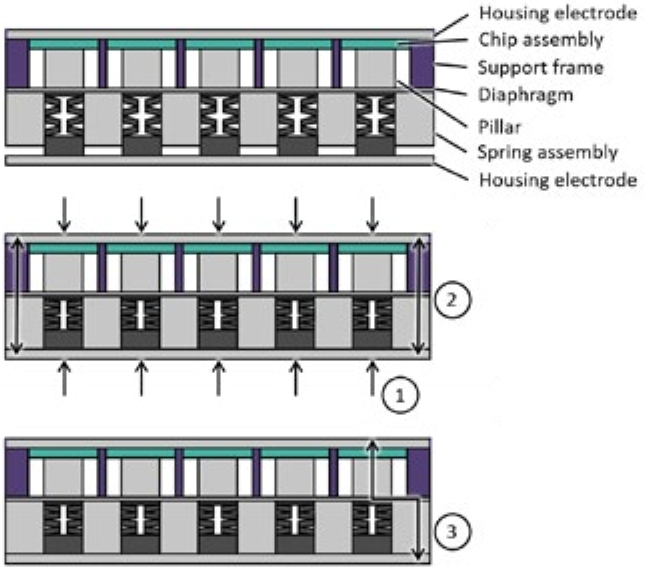

Figure 3: Illustration of the DLB (a) unclamped state, (b) clamped state, (c) current path.

In addition, the DLB mechanism gives users two further advantages. First, the enhanced mechanical compliance of the device means that heatsinks typically used with thyristors can be used and that onerous flatness tolerances required when using conventional, rigid press-pack do not need to be applied, reducing assembly costs. Second, chips in a Dynex DLB press-pack are protected from over-pressurisation – a risk with conventional press-pack IGBTs - providing extra flexibility in stack assembly procedures, where short-term over-clamping may be required.

Safe operating area robustness

Safe-operating area ratings for Dynex's 4.5kV press-pack IGBT range permit operation with line voltages up to 3.4kV and guarantee the capability of the IGBT to turn off over-currents of up to twice the product's rated current.

The products have ultimate capabilities far exceeding their datasheet ratings. To illustrate the robustness of Dynex's press-pack IGBTs, the following examples are given. Figure 4 shows a Dynex 2.1kA, 4.5kV press-pack IGBT (DPI2100P45A5200) turning off 7.4kA – 3.5 times its rated current - at a line voltage of 3.4kV and a junction temperature of 125°C. Figure 5 shows the same product withstanding a type-1 short-circuit test performed at a line voltage of 3.4kV and a junction temperature of 125°C for a duration of 40µs – 4 times industry standard. Figure 6 shows a Dynex 1.6kA, 4.5kV press-pack IGBT (DPI1600P45C3616) withstanding a type-1 short-circuit test with a gate-emitter voltage of 18V, at a line voltage of 3.4kV and junction temperature of 125°C.

Dynex press-pack IGBT product range

Dynex is able to supply press-pack IGBTs with a range of industry-standard contact diameters from 34mm to 150mm and current ratings from 120A up to 3000A at 4500V. An integrated research and development and manufacturing facility enables chips and devices to be tailored to customers' applications. Their ease of use, high reliability and robustness has made Dynex press-packs the product

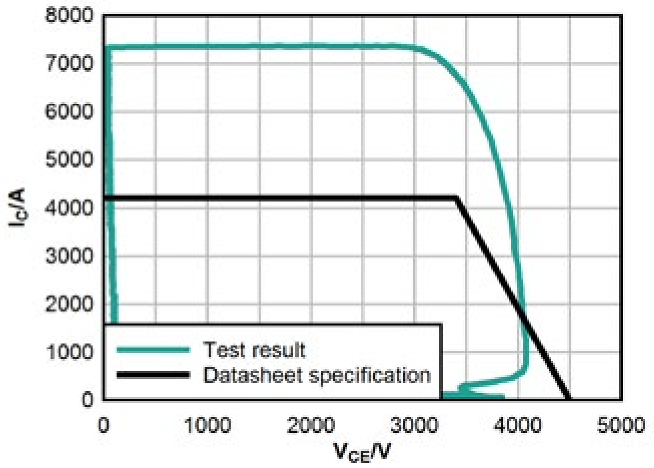

Figure 4: IGBT RBSOA robustness - successful turn-off of 7.4kA by a 2.1kA, 4.5kV device.

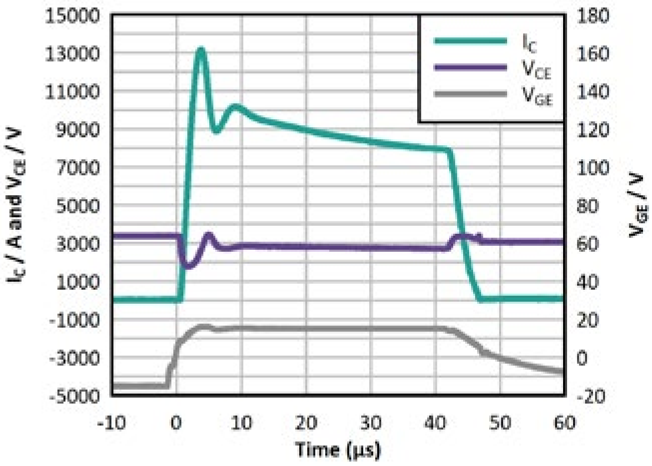

Figure 5: IGBT SCSOA robustness – a 4.5kV, 2.1kA device surviving a 3.4kV, 40µs short-circuit test.

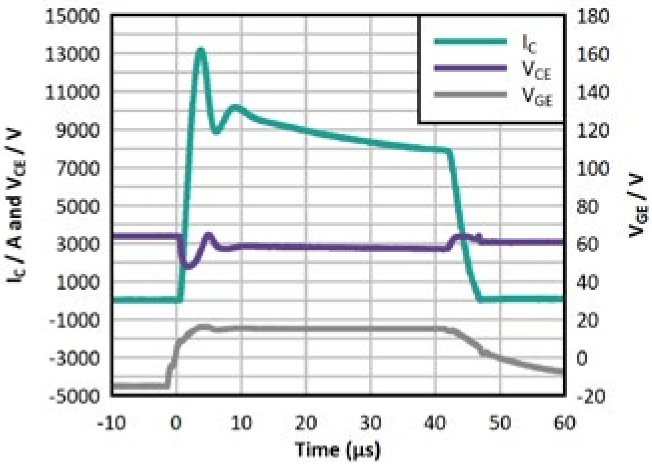

Figure 6: IGBT SCSOA robustness – a 4.5kV, 1.6kA device surviving a 3.4kV short-circuit test with a gate-emitter voltage of 18V.

of choice for a variety of applications, including HVDC and medium voltage drives. Interested parties should contact the factory with their requirements.

Conclusion

Press-pack IGBTs are an enabling technology for high current, high reliability applications. Dynex's dynamic load balancing technology elegantly overcomes the challenges in ensuring the application of uniform contact pressure, giving Dynex's press-pack IGBTs outstanding robustness and reliability and making them easier to use than conventional designs.

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Soldering Materials for Next Generation of Power Electronics

The jointing technology required for advanced power electronics requires achieving high reliability, heat resistance etc. Tamura Corporation, a global company in the field of electric and electronic technology, has developed a new jointing material as a response to these requirements.

By Tatsuya Kiyota and Seiji Shibata, Tamura Corporation

Introduction

Tamura Corporation is a global company that contributes to the electronics industry through information equipment, electronic components, electronic chemicals, and factory automation systems. As measures against global environmental problems, it is becoming more important to electrify vehicles and to secure electricity through renewable energy. Under such circumstances, power electronics, which contribute to the efficient use of electric energy (generation, transportation, consumption, etc.) is more important than ever. In power electronics, power devices and power modules used for a wide operating voltage ranging from hundreds of volts to hundreds of thousands of volts are the main components responsible for power conversion and control. High reliability is also required for power devices and power modules.

In this report, the bonding technology developed for the power electronics based on the high level jointing technology from Tamura Corporation cultivated in automotive market is introduced.

Reports about Tamura's soldering materials for power electronics

According to [1] solder composition, [2] flux type, and [3] product form, the outline of the solder material for power electronics developed by Tamura Corporation is summarized in Figure 1.

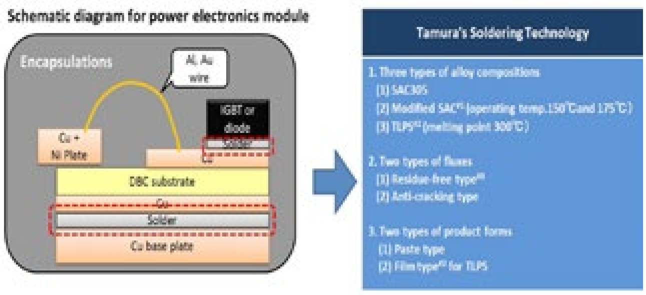

Figure 1: Tamura's Soldering Technology for die attach and substrate attach

Three types of solder composition are prepared as follows. (1) SAC305 which is standard as the lead free solder. (2) Modified SAC which improves the operating temperature up to 150°C and 175°C while setting the mounting workability to the same level as SAC305. (3) TLPS with a melting temperature of 300°C (despite heat treatment is taken place at 240°C). As the flux for power electronics, we provide two types of flux (1) a residue free type and (2) an anti-cracking type. These fluxes are applied as solder paste with solder of SAC305. In order to achieve voidless for die attachment which requires high reliability, TLPS's product form is a film type.

A solder paste of residue free type (D131-204-199-33) and a conventional type is applied on the electrode pad of PWB, and the appearance after the reflow process is shown in Figure 2. In the conventional type on the right side, there is flux residue on the solder surface after reflow, so there is a glossy feeling due to the flux residue resin.

Figure 2: Appearance of flux residue for D131-204-199-33(flux residue free type) and conventional type

On the other hand, the residue free type (D131-204-199-33) shows metallic luster of the solder itself resulted from no flux coating on the solder. This is because the residue free type flux ingredients are designed to evaporate by the heat in reflow oven at the portion not in contact with the solder. As a result, in case of bonding of die attachment, substrate, etc., the flux protruding outside the junction element evaporates in the reflow process and the flux cleaning process can be omitted.

Solder joint of 3216 chip resistors are formed on the PCB with SAC 305 alloy and Modified SAC alloy respectively. 3,000 cycles of heat cycle test is carried out at a temperature range of -40°C to 150°C. After every 1,000 cycles, solder crack in solder fillet portion on the side of the chip is observed. Figure 3 shows the results of observing the crack progress rate generated by the solder of SAC 305 and Modified SAC in each 1,000 cycles. As Figure 3 shows, durability of Modified SAC (# 287) is about 3 times higher than SAC 305 in the heat cycle test (3,000cycles@ -40°C to 150°C). Modified SAC has been improved in terms of mechanical strength and creep characteristic peculiar to solder. In addition, the suppression of enlargement of solder structure and growth of intermetallic compound at electrode interface has been taken place. Currently, we are developing a more robust solder material which can withstand heat cycle test of -40°C to 175°C.

Tamura Corporation has been developing bonding materials specialized for die attachment for Wide-Band-Gap semiconductors such as Silicon Carbide which are expected to be used at the higher junction temperatures than Silicon. Since it is assumed that the junction temperature of Silicon Carbide is about 250°C, melting temperature of solder needs to be more than 300°C for the die attachment. Recently, the sintered silver material with the silver nanoparticles is a promising candidate as the die attachment.

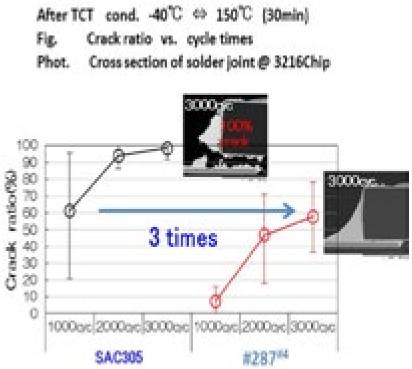

Figure 3: Comparison of crack resistance between Modified SAC(#287) and SAC305

This is mainly because this material can be bonded at temperature as low as about 250°C, although its melting temperature is about 900°C. However, in order to densely sinter the nanoparticle of silver, it is necessary to apply pressure on it during heating, and this is a problem for mass production in the field of high volume market such as automotive. Therefore, Tamura Corporation has designed and been developing new soldering material which achieves bonding with no pressure at the same reflow temperature(240°C) as SAC 305 and the melting temperature of solder material exceeds 300°C after soldering reflow treatment. The die attachment plays a role of quickly releasing heat from a semiconductor operating at high temperature. At this time, voids in the die attachment lead to the unevenness of heat flow (so called Hot spots occurred). As the results the bonding reliability is remarkably deteriorated. For this reason, it is required to form a void-free joint in the die attachment. In order to achieve void free, Tamura's TLPS has been designed in a film of preformed solder.

A cross section of the film composed of low melting point solder and copper powder is shown in Figure 4 (a). Copper (black area) and solder (white area) are uniformly formed, and voids are not observed in it. When thermally analyzing the TLPS before heat treatment, an endothermic DSC peak derived from the low melting point solder shown in Figure 4 (a) is observed on the left side of the DSC curve. On the other hand, when the solder composition obtained by heat treatment at 240°C is thermally analyzed, there is almost no endothermic DSC peak in the temperature range of 400°C as shown in Figure 4 (b).

It is considered that the melting point of the obtained solder compound exceeds 400°C. By applying Tamura's original flux to the surface of the TLPS, solder joint is formed upon the heat treatment at 240°C. A cross section of the solder composition after heat treatment at 240°C is shown in Figure 4 (b). No voids and no peeling at the interface with the copper plate are observed. In the cross-sectional structure of TLPS obtained after heating, it is found that a solder (white area) is formed on the network structure and IMC (intermetallic compound: gray area) surrounds copper (black area). In this experiment, a pressure of 0.6 MPa was applied during heating.

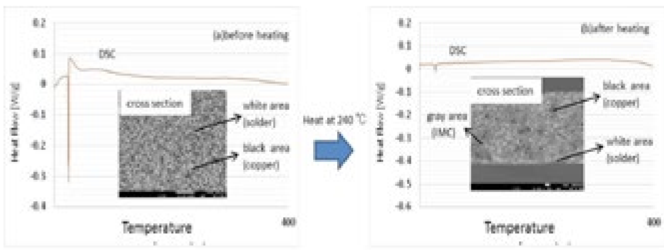

Figure 4: DSC curve and cross section of Tamura's TLPS before heating (a) and after heating (b)

Summary

Hereby we reported new soldering materials, which are developed with our original technologies, for power electronics. From now on, Tamura will develop a die attachment that is highly reliable and excellent in workability, aiming at bonding without pressure which the market and technology trend desire now and future.

Remarks

#1: Modified SAC is a SAC305 containing additional elements; Operating temp. 175°C type is under development; Operating temp. 150°C type is on the market
#2: TLPS means transient liquid phase soldering Our TLPS film is under development
#3: Under development
#4: #287 is a solder alloy composition developed by Tamura Corporation

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Expansion of continuous $Tj_{(op)}$ up to 175 °C

1000 V Output, No-Opto, Isolated Flyback Converter

Isolated flyback converters are used in automotive, industrial, medical, and telecom applications where the power supply must be reliable, easy to use, high voltage, and isolated, and they must provide excellent regulation over load, line, and temperature. LT8304-1 is an isolated, no-opto flyback converter optimized for high output voltage applications that provides outputs up to 1000 V.

By George Qian and Michael Wu, Analog Devices, Inc.

Traditionally, the regulation feedback loop requires a bulky high voltage divider to directly sense the high output voltage, along with optocouplers to convey feedback information back through the isolation barrier. The bulky resistor solution results because a 1206 resistor can handle 200 V maximum. So to sense 1000 V, at least six 1206 resistors are required, plus a small bottom resistor.

1000 V/15 mA Output, from a 4 V to 28 V Input

An LT8304-1 flyback converter design features a low component count. Figure 1 shows a complete 4 V to 28 V input to 1000 V output solution capable of supporting 15 mA loads. The output current capability increases with input voltage, reaching 13 mA when the input voltage is greater than 24 V. The LT8304-1's ability to sense the output voltage through the primary side waveform eliminates the need for a bulky high voltage divider, and no optocoupler is required.

The guidelines for calculating voltage and current stress on the components surrounding the LT8304-1 are detailed in the LT8304-1 data sheet. Notably, this 1000 V solution uses a transformer with three split-output windings on the secondary side. The primary side to secondary side turn ratio is 1:10:10:10, instead of a single-secondary winding 1:30 transformer. The 1:10:10:10 transformer enables the output voltage stress to be split among three high voltage output diodes and three high voltage output capacitors. Individual component voltage ratings need only be 1⁄3 of the total voltage, which facilitates more options for output diode and output capacitor selection.

Figure 2 shows this flyback converter reaching 90.5% peak efficiency. Even with no optocoupler, load regulation at various input voltages remains tight, typically 2% to 3%, as shown in Figure 3.

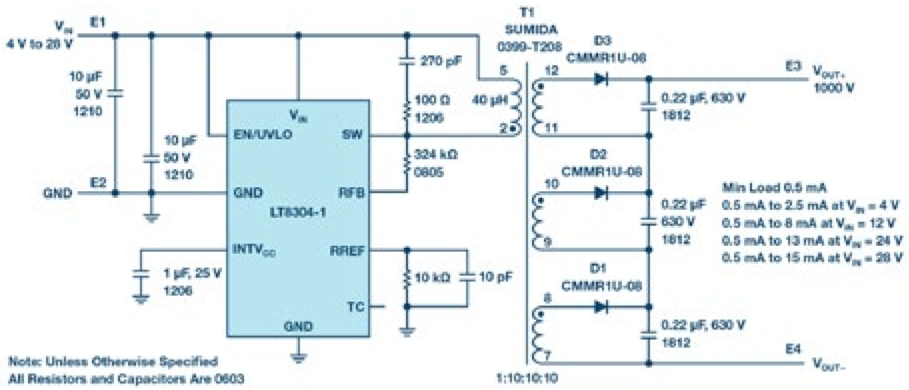

Figure 1: A complete 1000 V/15 mA isolated flyback converter from a 4 V to 28 V input.

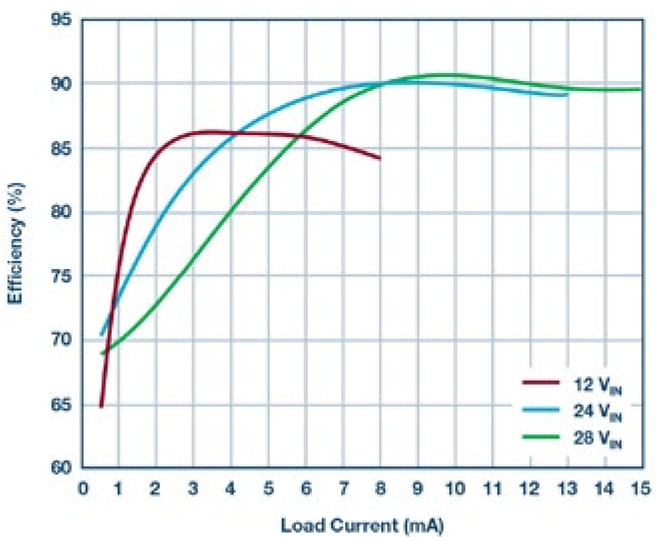

Figure 2: Efficiency of Figure 1 at various input voltages.

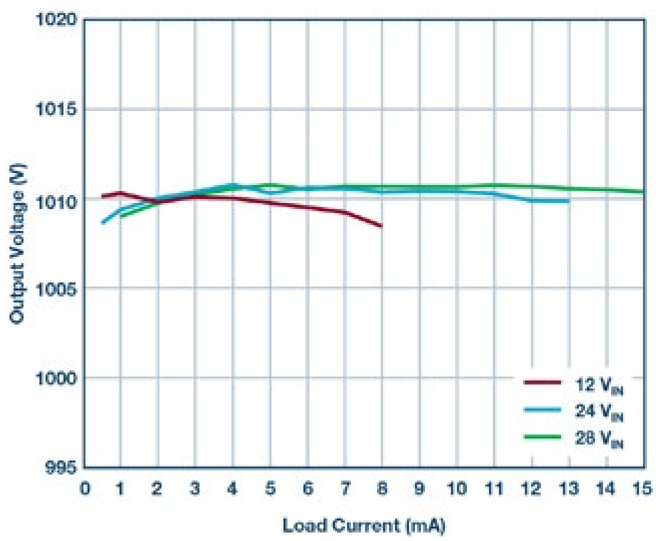

Figure 3: Load regulation of Figure 1 at various input voltages.

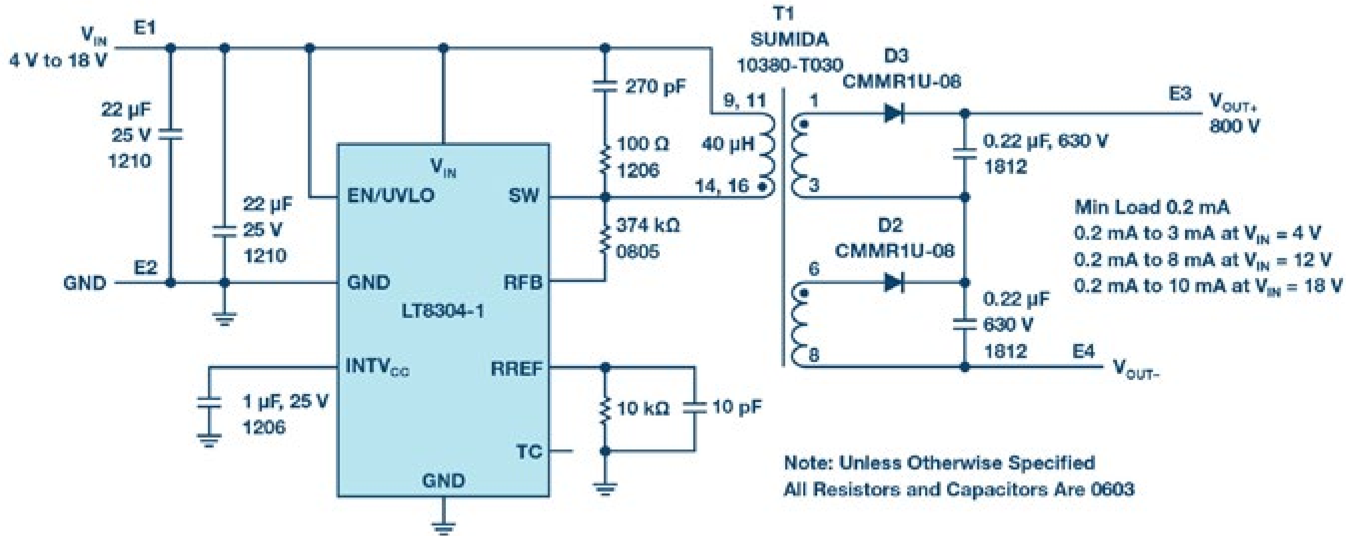

Figure 4: A complete 800 V/10 mA isolated flyback converter from a 4 V to 18 V input.

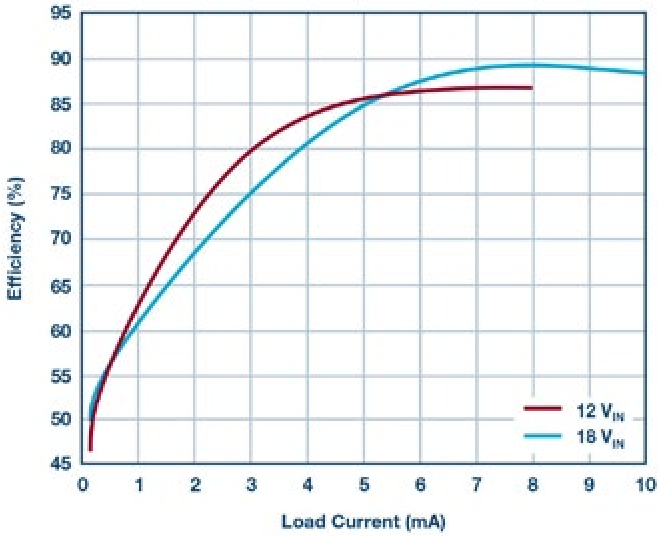

Figure 5:
Efficiency of the solution in Figure 4 at various input voltages.

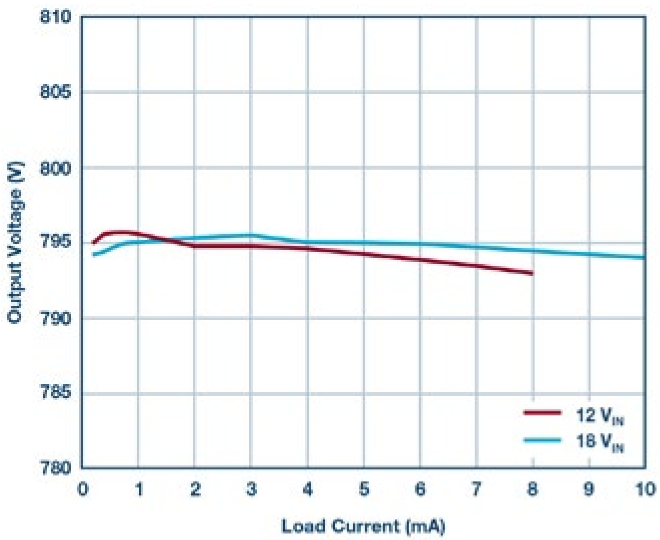

Figure 6: Load regulation of the solution in Figure 4 at various input voltages.

800 V/10 mA Output, from 4 V to 18 V Input
Figure 4 shows a complete 4 V to 18 V input to 800 V output solution capable of providing up to 10 mA output current. This flyback converter achieves 88.2% peak efficiency when the input is 18 V and the load current is 10 mA. Figure 5 shows the efficiency curve at various input voltages; Figure 6 shows the excellent load regulation. This solution also features a low component count.

Conclusion
The LT8304-1 is an easy to use monolithic micropower isolated flyback converter optimized for high output voltage applications. By sampling the isolated output voltage directly from the primary side flyback waveform, complete solutions maintain tight regulation—requiring neither an output voltage divider nor an opto-isolator.
The output voltage is simply programmed with two external resistors and a third optional temperature compensation resistor. Boundary mode operation enables a small magnetic solution with excellent load regulation. A 2 A, 150 V DMOS power switch is integrated, along with all the high voltage circuitry and control logic, in a thermally enhanced 8-lead SO package. The LT8304-1 operates at an input voltage range of 3 V to 100 V, and delivers up to 24 W of isolated output power.

About the Authors

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FIT Rates and Field Reliability

Transphorm has created an extensive body of reliability data across multiple generations of products that demonstrate the robustness of the platform; by extensive qualification testing and by having an in depth understanding of failure modes and acceleration factors.

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Introduction

Transphorm is the first company to qualify high voltage GaN devices at 600V, 650V and 900V to the JEDEC standard; is the first to qualify 650V devices at 150°C and 175°C to the AEC-Q101 automotive standard; and is the first to publish intrinsic acceleration factors, extrinsic reliability data and field reliability data. This article will discuss the application of accelerated life test data to determine the intrinsic reliability of a commercially-available automotive-qualified GaN device from Transphorm. In addition, the world's first Early Life Failure calculations and Field Reliability data for high voltage GaN power converters are presented. All tests are based on current JEDEC and AEC standards.

Device Description

Unless otherwise noted, the device used in this paper is the TPH-3205WSQA produced by Transphorm Inc., located in Goleta, California.[1] This device is a normally-off, two chip design with a D-mode GaN HEMT in series with an E-mode low-voltage Silicon FET. Vds(min)=650V, V(TR)DSSmax=800V, Rds(on)max=62mΩ, Tj max=150°C, TO-247 package. This device has been qualified to the AEC-Q101 automotive standard.

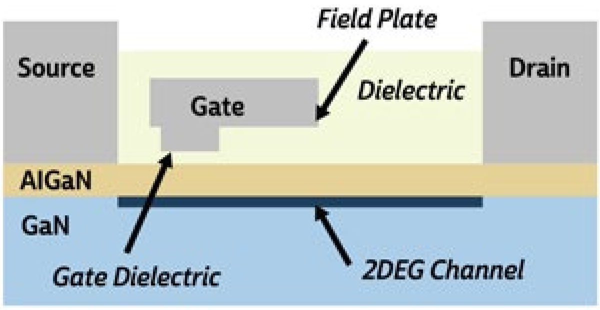

Figure 1: Cross-section diagram of Transphorm GaN device

High Temperature Reverse Bias: Off State Failure Mode and Acceleration Factors

High temperature reverse bias (HTRB) off state testing has historically been a difficult test for GaN devices to pass. The reason for this is that under this condition there are very high electric fields between gate/field plates, drain, and substrates that can cause defects in the dielectric layers and eventually result in a TDDB catastrophic failure between the field plate and drain.[2]

This failure mode dominates the off state failures regardless of whether the failure is caused by voltage or temperature acceleration. It shows up as wear-out failure (intrinsic) and also shows up as infant mortality failure (extrinsic), dielectric defect limited lifetime. The most likely explanation for early failures caused by dielectric defects sharing the same failure mode as the intrinsic failure is that defects in the dielectric and metal layers, in the wafer from the fabrication process accumulate charge and accelerate failure of the device in the region around that region due to changes in the electric field.

Voltage and temperature acceleration factors for this failure mode have been calculated.[2] Though a detailed review of the methodology is beyond the scope of this paper, what follows is a summary of the test.

Voltage acceleration was determined by testing to failure a sample of material at voltages between 1000V – 1200V. A linear time-dependent-dielectric-breakdown (TDDB) model was used, (other voltage models will give longer lifetimes, and unless there is either experimental or theoretical justification, other models should NOT be used). The Voltage Acceleration Factor (AF_V) is defined in (1), where ΔV is the difference between the stress voltage and the usage voltage. The experimentally defined value for $\gamma = .026\ V^{-1}$.

$$AF_V = e^{(\gamma \Delta V)} \qquad (1)$$

Temperature acceleration factor (AF_T) assumes an Arrhenius relationship and was generated by testing parts to failure at -20°C to +150°C at voltages ranging between 1050V and 1300V which results in an activation energy of Ea = -0.3eV. The temperature acceleration factor (AF_T) is calculated with equation (2) as referenced. Note: k is the Boltzmann's constant. The combined acceleration factor AF is simply the product of the voltage and temperature acceleration factors equation (3).[3]

$$AF_T = \exp((Ea/k) \times ((1/T_{use})-(1/T_{stress}))) \qquad (2)$$

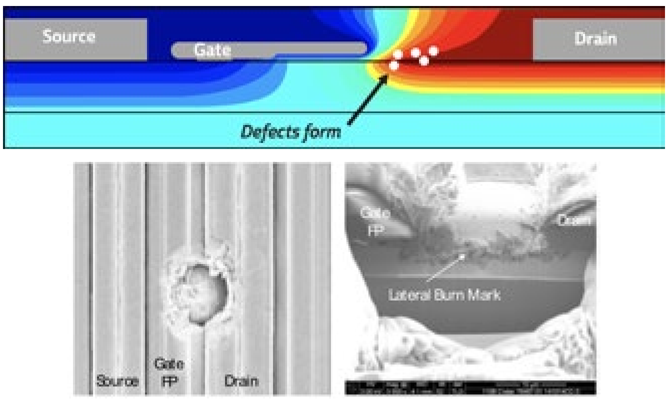

Figure 2: (clockwise from top) 1. Electric field diagram showing region of high damage. 2. Cross-section of failed device showing lateral burn mark. 3. Overhead SEM of failure showing short from gate to drain.

$$AF = AF_T \times AF_V \quad (3)$$

Intrinsic Failure Rate

Use-plot analysis gives a more complete picture of the intrinsic failure rate of the device by combining data from multiple wafers and utilizing the acceleration factors previously derived.[4] The data is then normalized to typical use conditions, using the acceleration factors defined, to calculate the wear-out lifetime of the device. A standard convention is to define wear-out of the device when the probability of failure reaches 100 ppm. The use plot calculation of the data shows that, even at 150°C @480V, wear-out of the device begins after 10^8 hours. It is important to understand that the Intrinsic Lifetime of the device is a very poor predictor of field reliability and instead one should utilize Early Life Failure Testing as defined in JESD74A.[5]

Early Life (Extrinsic) Failure

Early Life Failure Rates are used to calculate warranty risk, and to predict field failure rates. Early Life Failures include infant mortality as well as random failures during the useful life of the part (the time before the part wears out) as illustrated in the Bathtub Curve. Voltage and temperature accelerated tests on a large number of parts are used to generate an Early Life Failure Model.

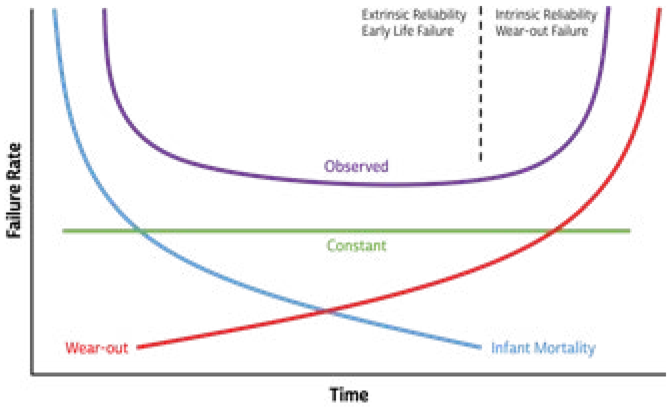

Figure 3: The Bathtub Curve demonstrates a power device's typical reliability via failure types over time.

Voltage acceleration testing can be used with GaN devices because they do not avalanche like a Silicon MOSFET. Instead leakage increases with voltage and eventually the device fails. In general, GaN can fail in one of two ways. Either laterally from the gate/field plate structure to the drain, or vertically through the insulating GaN buffer layer. This is a basic design consideration and could vary from manufacturer to manufacturer. The TPH3205WSQA device experiences vertical failure at voltages greater than 1300V, which enables Early Life Failure testing at voltages greater than the rated 650V, but well under the vertical failure voltage. It is important that all failed devices created by this test undergo analysis to ensure that the failure mode remains lateral gate to drain, and that new failure modes are not being introduced.

For this test, a total of 4,000 parts were tested. Most tests ran for 1,000 hours, though some tests were extended up to 3,000 hours. Voltages ranged from a low of 520V to a high of 900V. Temperatures ranged from a low of 25°C to a high of 175°C. A small number of parts from the 900V leg did experience failure, and these failures are included as part of the calculation. (Failures increase the chi-square statistic). Against a typical use condition of 400V/100°C, this represents over 30 billion device hours.

FIT Calculations were performed as per JESD74A.[5] (Note: FIT = failure per billion device hours)

$$\text{Early Life Failure (in FIT)} = 10^9 \times \chi^2 / 2 \times A \times N \times t_A$$

Where:
χ^2 = chi square statistic
A = acceleration factor
N = number of devices tested
t_A = test time in hours

At maximum junction temperature (T_J max = 150°C), the following FIT values were generated:

Voltage	FIT
520V	0.42
480V	0.15
400V	0.02

While there are no absolute standards for FIT (lower is always better), values in the single digits for commercial products and values less than one for automotive products are generally considered a requirement.

Field Reliability

In the end, actual field reliability statistics are the most relevant. Transphorm has shipped over 400k devices to customers in production with over 3 billion device hours in the field. In calculating field reliability, Transphorm makes a conservative calculation that assumes that only half the devices shipped are actually in the field and in use. Currently, Transphorm FIT = 2.2, or less than 20 ppm per year, which compares favorably with the FIT of other wide bandgap power semiconductors. Transphorm's FIT rate continues to decrease as it was 3.1 at the end of last year

Conclusion

The data presented shows that the TPH3205WSQA device exhibits reliability that is on par with other high voltage semiconductor devices, based upon an understanding of the physics of failure, acceleration factors, and the extrinsic reliability, and field reliability data.

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Innovations ‚Made in China‘

China is constantly developing towards technology leadership. The field of electronics is by far the largest and includes, among other things, the electronic components. China's exports have risen by a factor of 16 since 2000 [1]. The Chinese government's master plan in May 2015 for the further modernization of the industry gives further impetus to the country's innovative strength. The "Made in China 2025" strategy is the first of three steps on the way from the extended workbench to a world-leading industrialized nation in 2049 [2].

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Nine sectors of action should be given priority in order to achieve more innovation, quality and efficiency in ten key areas. Each of these areas (e.g., Artificial Intelligence, Robotics, Aerospace, Medical, Express, Hybrid, and Electric Vehicles, Electrical Engineering [3]) requires electronic components, in particular capacitors. Reason enough to take a closer look at existing and future innovations in capacitors for electronics.

Capacitors for energy storage

Energy storage is an integral part of our modern world. Be it in a smartphone, in a cordless screwdriver or in a car: many electrical devices have their own, built-in energy storage. However, capacitors are not necessarily the first technology you think of when it comes to storing large amounts of energy.

The Ragone diagram (Figure 1) shows the power density of various electrical energy storage devices versus their energy density.

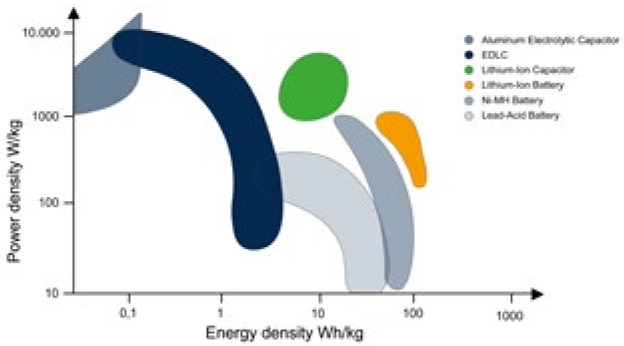


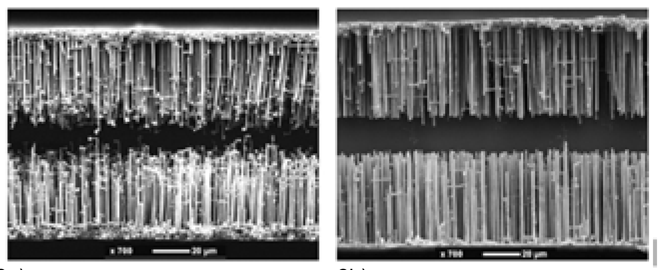
Figure 1: Ragone diagram of various storage devices for electrical energy

Depending on the application, selecting from the available storage technologies may offer a suitable solution. In the following, we will focus in particular on Jianghai aluminum electrolytic capacitors, electric double-layer capacitor and lithium-ion capacitors.

Aluminum electrolytic capacitors - workhorses of electronics

The anode foil is both in terms of value and technically the most vital pre-material of an aluminum electrolytic capacitor. The two process steps of etching and forming make the anode material from a smooth foil made of pure aluminum. Figures 2 (a) and 2 (b) show the cross-section of etched high-voltage anode foils for use in aluminum electrolytic capacitors.

With its vertical integration strategy, Jianghai has its own facilities for etching and forming the anode material and can therefore optimize the properties of the films. Improvements to the etching process result in more uniform pores (b), making better use of the available volume. This allows high specific capacitance values and thus more compact capacitors.



2a) 2b)

Figure 2: Cross-section of etched anode foils

An electrochemical process creates the dielectric layer on the surface of the roughened anode foil. The quality of this "formation" or structure and layer thickness of the dielectric are key to high reliability and electrical performance of the electrolytic capacitors in operation.

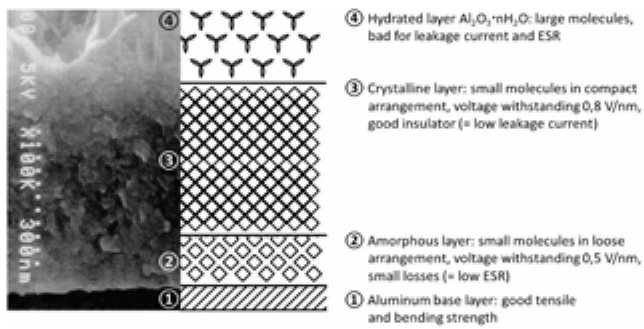


Figure 3: Layer structure of the alumina dielectric of a high-voltage electrolytic capacitor (left: electron micrograph, right: schematic representation)

Figure 3 shows the layer structure of the dielectric in cross section. The aluminum foil ① is first followed by a layer of amorphous aluminum oxide ②, followed by a crystalline ③ and finally a hydrated layer ④. One goal in the development of new anode films is a thinner hydrate layer with a thicker amorphous layer. As a result, Jianghai's novel anode films have higher current carrying capacities and lower

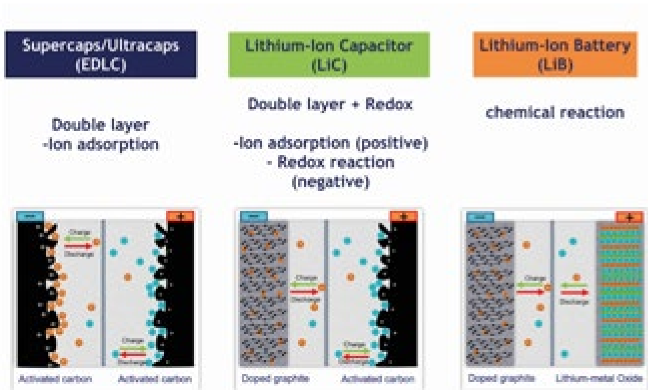
ESR values, which qualifies them as "workhorses" for power electronics applications.

"Energy capacitors" for the future

Ever since the 1950s, larger amounts of energy have been stored in double-layer capacitors (EDLC). Today, double-layer capacitors are known as Super Caps, Ultra Caps, Gold Caps and many more commercial designations. Developed further, they reach capacitance values of several hundred Farads and offer very high power densities (Fig. 1). However, high power densities alone cannot compete against the batteries and accumulators, which have also been further developed.

A technology called "Energy Capacitors" provides the energy storage in capacitors with new boost. Energy-C is based on a double-layer technology and its further development to mass production by Jianghai. The Energy-C concept makes it possible to select a suitable energy storage solution for the respective application. Energy-C basically uses two types of capacitors: the classic double-layer capacitor and the novel lithium-ion capacitor (LiC).

The EDLC technology builds the basis of both types, which offers a relatively high energy density and a very high power density (Fig. 1). Two symmetrical activated carbon electrodes carry the so-called double layer (Fig. 4 (a)).



(a) (b) (c)

Figure 4: Electrode structure of the three technologies EDLC (a), LiC (b) and LiB (c)

The second technology with a modified design allows for significantly increased energy density. A lithium-doped graphite electrode replaces one of the two symmetrical electrodes. The asymmetric construction of this lithium-ion capacitor (LiC) allows much higher energy densities but has lower power densities compared to EDLC. Both constructions have their particular strengths which recommend them for different applications.

In terms of energy and power density, the lithium-ion capacitor (LiC) is found in between the double-layer capacitor (EDLC) and the Li-ion battery (LiB) (Figure 1).

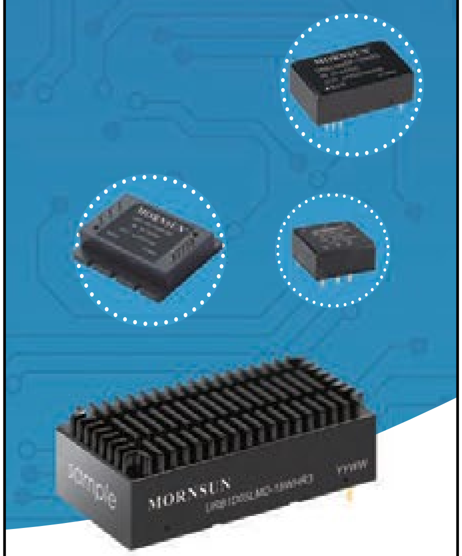
Figure 4(b) shows that the LiC has an EDLC electrode (activated carbon) and a LiB electrode (doped graphite). As a result, the lithium-ion capacitor approaches the energy density of batteries. Yet, the advantage of fast charging and discharging is maintained. This allows for many charging cycles in the minute range. For even faster charge and discharge cycles, however, the EDLC is still the better choice.

In addition to the charging times, there are other arguments for the use of Energy-Cs, which impress compared to traditional batteries:

In terms of cycle stability and lifetime, the Energy-Cs are far ahead of the batteries. While lithium ion batteries offer merely about a thousand cycles, LiC reach several tens of thousands of cycles and double layer capacitors boast with cycle values of many hundred thousand cycles.

The special design and material combination of the lithium-ion capacitor ensure stability and charge retention even at high temperatures. If both accumulators and LiC remain stable at room temperature and discharge less than 5% over 2500 h, an EDLC already loses 30% of the charge after 2000 h. At 60°C, the discharge rate increases significantly due to the accelerated chemical reactions between electrolyte and electrode material. The consequence of these chemical reactions is an increased leakage current and this leads to charge loss in batteries and EDLCs alike. While the leakage currents of the Li-C continue to be low, the lithium-ion battery now loses up to 30% of its charge after 2500 hours. For EDLCs, this happens after 500 hours. In energy harvesting applications, the Li-C offers significant advantages.

When it comes to safety and reliability, the LiC can also score: it is just as safe as an EDLC, due to the special process that firmly embeds the lithium ions in the molecular



structure of the carbon structure (“doping”). Unlike lithium batteries, no elaborate designs are needed to reduce the risk of thermal runaway with the known fire hazard. Due to the doping, there are neither metallic lithium nor lithium oxide in the capacitor. The doping method thus allows the capacitor to always be in a safe condition even with mechanical damage, high temperature, or heavy discharge.

The production of a LiC requires less than 3% of the lithium amount of a LiB of the same volume. In addition to the aspect of efficient use of resources, this results in a lower weight / smaller design as a nice side effect.

Overall, LiC technology offers many benefits as part of Jianghai’s Energy-C concept. But there is more potential in this technology. In the future, energy densities of 50 Wh / kg and power densities of more than 30 kW / kg should be achieved. Jianghai drives the research for new electrode materials, which should further increase the conductivity. Optimized electrolytes also expand the temperature range of the component while increasing the temperature stability.

The Ragone diagram (Figure 1) shows that lithium-ion capacitors open up a new range for applications that previously were not covered, neither by batteries nor by any other capacitor. The Energy-C concept represents a new technology for existing and future applications of energy storage. The capacitors described here are already being mass produced by Jianghai and have proven their superior performance under real operating conditions in the field.

Summary

China is on its way to becoming a world-leading industrial nation. Innovation, quality and efficiency are becoming increasingly important. In the production of electronic components, the development and production of the pre-materials is complementing the value-added chain. As a result, commercial and technological aspects gain in importance.

The article shows examples of some existing types of the capacitors for electronics, and which innovations exist or are to be expected for aluminum electrolytic and Energy-C capacitors. Advanced process techniques and new formulations for aluminum electrolytic capacitor anode foils ensure high reliability and superior electrical performance.

Energy-C modules use state-of-the-art materials and processes, enabling storage densities previously reserved for batteries. High temperature proof and cycle stability open up new areas of application that were previously not accessible.

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Alexander Schedlock graduated from the College of Engineering “Heinrich-Hertz-Berufskollege” in Dusseldorf as a state examined technician specializing in electrical engineering. After successfully completing his apprenticeship as an IT system electronics engineer (2010), he worked as a field service technician and was thus able to gain experience with computer terminals for various applications. In addition, he studied for four years at the technical school for electrical engineering and graduated in 2017 successfully from his state vocational school exam. Since 2018 he works in the sales team of Jianghai Europe Electronic Components GmbH as Technical Sales Manager and supports customers in technical designs throughout Europe. Mr. Schedlock is in charge of the Energy-Capacitors.

Dipl.-Ing. Ole Bjørn studied electrical engineering at the Technical University of Hannover. After completing his diploma thesis (1996) in the private sector and a time as a product manager in medical technology, he entered the technical sales department (1998) as Sales Engineer at Philips in the field of passive components. In subsequent years, his scientific profile was sharpened thanks to the close collaboration between customer developments and the production capabilities of the various plants, including the commercial responsibility under the legal successor BCcomponents, later Vishay. With the founding of Jianghai Europe Electronic Components in 2003, all experience in management, sales, marketing and technology was incorporated into the new company. In the position of Managing Director, Mr. Bjørn today coordinates the entire activities of the Jianghai Group in Europe.

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.

DC Microgrids for Commercial or Industrial Buildings

DC microgrids have become increasingly popular in recent years. Although they offer various advantages, certain challenges must be faced.

A fully operational bipolar DC microgrid with a nominal voltage of ±380 V has already been in service at the Fraunhofer Institute for Integrated Systems and Device Technology IISB in Erlangen for several years and is continuously expanded. It serves as a platform for various DC grid technologies developed at the IISB, e.g. DC/DC- or AC/DC-converters, safety components and battery storage systems. As a living lab, the platform is open for partners from research and industry.

By Julian Kaiser, Fraunhofer IISB, Roland Weiß, Siemens AG, and Jörn Burk, LEM Europe GmbH

The DC microgrid supplies large parts of the building infrastructure, from office workstations and lighting to laboratories and charging stations for electric vehicles. Power is fed from PV strings with different orientations (south and east/west) on the roof, and a maximum combined power of 43 kW. MPP tracking is performed by non-isolated custom DC/DC-converters for each string orientation; MPP voltage for the east/west strings with 20 modules is typically around 700 V, while the strings with a southward orientation and 12 modules are about 400 V. Excess energy can be stored in three lithium-ion battery systems developed in-house, each with 20 kWh energy content and a maximum power of 100 kW. Battery system voltage ranges from grid voltage up to approximately 600 V when fully charged. The batteries are coupled to the grid with non-isolated converters as well. The converters for the PV and the batteries have an efficiency of over 99 %. Bidirectional, isolating AC/DC-converters with a combined power of 96 kW can feed stored energy back into the AC grid, e.g. for peak-shaving purposes. When needed, power can be sourced from the AC grid. It is also possible to store energy as hydrogen, or in a liquid organic hydrogen carrier (LOHC). An overview of the research DC microgrid is shown in Figure 1. The grid covers well over 1000 m² of office and laboratory space in various building parts, with cable lengths up to 100 m to outdoor installations like DC charging or photovoltaic. The realization of the DC microgrid in its current state is part of the publicly funded Bavarian research project “SEEDs”.

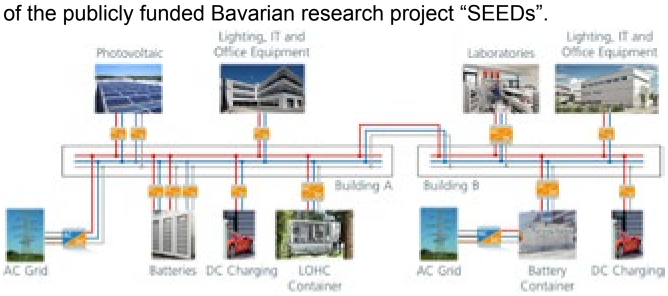

Figure 1: Schematic overview of the DC microgrid at Fraunhofer IISB

Since the microgrid is in operation around the clock, the necessary safety components and switchgear are off-the-shelf devices for DC, rather than prototypes. As one can imagine, the range of suitable products is rather easy to survey. Because the grid is solely fed from power electronic converters, the fault current in the grid is limited and mainly sourced by the output capacitors, thus limiting the fault energy to considerably small values, often insufficient to trigger conventional safety devices [1][2]. Of course, one could simply increase the fault energy by adding more capacitance between the grid’s poles. Considering fault energy as an unwanted attribute in a distribution system, a more elegant solution to the problem is desirable.

Figure 2: Mixed AC/DC-power monitoring system

Instead of relying on energy input to trigger a physical reaction, e.g. melting a fuse wire or activating a solenoid, directly measuring the current and taking appropriate action when a fault is detected yields various advantages. The sensitivity can be set closer to the low fault energy levels in DC microgrids and may also be adjusted well after installation, without the need to exchange components. This also allows for increased selectivity of protection devices, reducing the risk for downtime in the grid. Besides the improved safety function, the data from the current measurement equipment can also be used to monitor the microgrid status.

For some application areas like electric vehicle charging or smart metering, an accurate and well-defined measurement of the energy consumption is needed. Also, the efficient control of different electrical energy sources - like local photovoltaic plants, fuel cells, battery storage or the AC grid – requires a precise measurement of the electrical power flow to optimize overall efficiency and thus to reduce cost, total energy consumption and CO_2 footprint. To achieve this, an accurate AC and DC power monitoring system was developed by Siemens (see Figure 2). The key component of this monitoring system is the Sentron PAC 4200 which incorporates two important functions. First, the Sentron PAC 4200 is used, in combination with an AC current transducer (Siemens 7KT1201), to measure the power fed from the AC grid with an accuracy better than 0.2 % according to IEC 61557-12. Second, it acts as a communication gateway between any RS485 devices, e.g. the integrated DC meters (AcuDC 240) and the PC-based data storage-, handling- and visualization system, which was realized with the Siemens “Power Manager”-software. For precise measurement of the DC energy consumption, the biggest challenge is the accurate current measurement with the least possible offset to avoid an error accumulation over the long measurement periods which are necessary to evaluate the power consumption of the DC microgrid building demonstrator. It was found that only high-quality triple core fluxgate current transducers like the IT 60-S from LEM can fulfill these requirements.

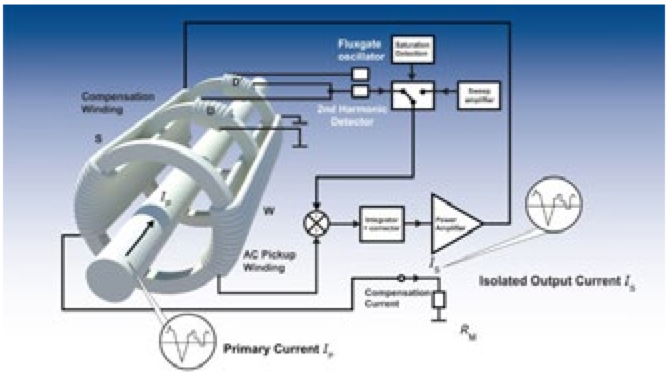

Figure 3: Block diagram of the Ultrastab IT-series fluxgate current transducer

These IT current transducers are high accuracy, large bandwidth DC-transducers using fluxgate technology without Hall generators. The magnetic flux created by the primary current IP (see Figure 3) is compensated by a secondary current. The zero-flux detector is a symmetry detector using two wound cores connected to a square-wave generator. The secondary compensating current is an exact representation of the primary current. The Ultrastab IT-series combines all the requirements for power measurement current transducers. They can measure over a wide operating temperature range from −40 to

+85 °C. Offset and linearity are excellent: over the whole temperature range, offset is between 36 and 400 ppm and linearity between 8 and 12 ppm; the values depend on the model used. An accuracy of 1 ppm is equivalent to 0.0001 %. Since the offset is so small, the transducers can be used from a few Amperes up, and just one model can cover the entire current measurement range; other transducers using different technologies would require the use of several transducers to cover the same current range while simultaneously keeping this accuracy level. This yields a non-negligible cost advantage.

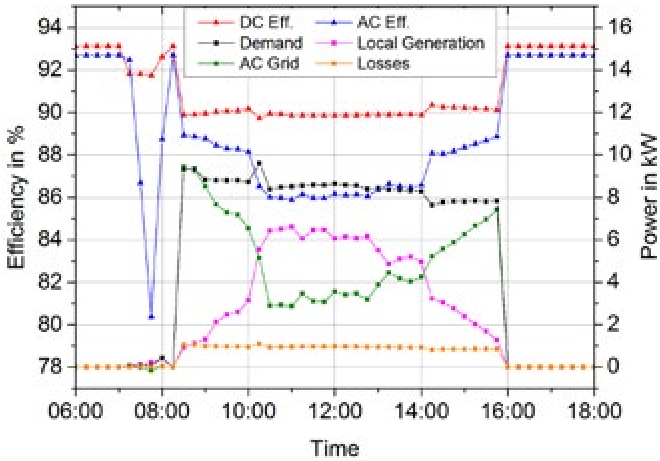

Figure 4: Comparison of AC and DC efficiency over one workday [3]

One area of application for precise current sensors with a broad operating range is monitoring and data logging for DC microgrids to evaluate their efficiency. The operation of such a microgrid is usually more efficient than a comparable AC grid. This is mainly because DC/DC-converters require a smaller number of components and less filtering, which are both a source of power losses. Since most IT and office devices, lighting or e-mobility applications are inherently DC, as well as most regenerative energy sources and storage equipment, their combined use in a microgrid seems self-evident. An example comparing AC and DC efficiency on the basis of a typical office building is shown in Figure 4. In both cases, the same type of sources and loads were used. In case of insufficient energy input from the photovoltaic plant, the DC microgrid draws power from the AC grid. Averaged over the whole day, DC operation yields a gain in efficiency of approximately 3 %. An additional percent can be gained in phases with high local power generation when input from the AC grid is low, in this case around noon.

Besides the increased power efficiency of a DC microgrid compared to an AC-grid, the easier integration of energy storage systems can add more benefits. The experimental findings presented in Figure 4 demonstrate how the extensive use of locally generated energy can lead to improved DC microgrid efficiency. To further decrease power delivered from the AC grid, any excess generated (e.g. by photovoltaic) can be stored in local energy storage and used to compensate times with reduced generation (cloudy sky, calm wind) or even AC power failures. An optimal sized battery storage allows the minimization of AC grid input for most days of the year. It is estimated that this yields an additional advantage in efficiency of approximately 1 % to 3 %. Overall, DC microgrids can help improve the energy efficiency of commercial buildings and reduce the cost of installation as fewer components are needed. Integrating current measurement with DC sensors can be beneficial for the functionality of safety devices while simultaneously providing data for grid monitoring. Efficiency, resiliency and percentage of energy own consumption can be maximized by incorporating local energy storage into the microgrid.[3]

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Optical Electric Field Sensor for Electrical Diagnostics of High Voltage Equipments

Power transmission, power plants or any high power electronics systems involve high voltage (HV) devices which have to be controlled or even monitored over significant time.

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To ensure the reliability of the power grid and the power quality of the supplied energy, the electric and dielectric behaviour of medium voltage (MV) and high voltage (HV) devices have to be carefully assessed. For that purpose, the energized cables behaviour, the insulator properties of insulators, the power semiconductors features shall be investigated experimentally. Today the measurements required for that careful investigation are essentially performed using voltage transformers such as resistive, capacitive or inductive dividers in case of contact measurement or with metallic antennas for contact-less field measurement. Such sensing techniques are limited firstly by the setting up constraints (e.g. required galvanic connection to the device under test) and secondly by their inherent poor spatial resolution and induced interference.

The aim of this article is to demonstrate the advantages of pigtailed optical sensors to perform electric (E) field characterization in the vicinity of MV and HV electrical devices. The probe used for this E-field measurement presents the following characteristics:

- Measurement of E-Field magnitude and phase of each vector component
- High electrical insulation (fully dielectric pigtailed probe)
- Spatial resolution down to 1 mm
- Fully independent of magnetic field and current (up to MA)
- Absolute field strength measurement thanks to easy probe calibration (uncertainty weaker than 1 dB)
- Time domain measurement down to subnanosecond
- Frequency bandwidth exceeding several GHz
- Compact probe
- High dynamic range (up to air breakdown field)
- Fully compatible with various environments (gases, liquids like oils, temperature and hygrometry variations)
- Single point measurement or multidimensional mapping using rotation or translation stages

Figure 1: Electro-optic probe and associated optoelectronic converter.

The optical probe is seen in the foreground of figure 1 and is here mounted on a HV compliant articulated holder. The probe consists in a dielectric optical modulator and acts as a linear transducer between the E-field component to be measured and the modulation of a laser beam. Its transverse dimension does not exceeds 5 mm and its sheath permittivity is $\varepsilon_r = 4$. This probe is plugged in an optoelectronic converter thanks to optical fibers (see background of figure 1). This converter includes both a low noise laser feeding the probe and an optoelectronic subsystem delivering an electric signal directly proportional to the E field. The setup ensures a real-time measurement of the E field over a frequency range spreading from some 10 Hz up to several 10 GHz. The link between the analog output voltage V_{out} and the actual field value E_{actual} is given by the antenna factor AF:

$$E_{actual} = AF \times V_{out} \quad (1)$$

AF is given in m^{-1}. Its numerical value is defined by the calibration of the probe. Such calibration remains valuable over a dynamic range greater than 120 dB covering field values from less than 1 V/m up to more than 1 MV/m. The air breakdown field can even be measured. The AF of the whole system is monitored all along the measurements. The output signal can be acquired using an oscilloscope for time domain measurement or a spectrum analyzer for frequency domain measurement.

The first example is dedicated to contactless diagnostic of a 100 kV hollow insulator using the same optical probe. The applied voltage is acquired and synchronized with the radial field measurement. Two configurations are compared. The insulator is firstly characterized in nominal conditions. The voltage and field measurements correspond to the blue curves of figure 2. Then, a defect is simulated using a high resistor placed inside the hollow insulator. The defect consists in a 10 GΩ, 30 cm long resistor. The measurements correspond to the red curves of figure 2. One can notice that the measured voltage does not exhibit any relevant signature of the defect.

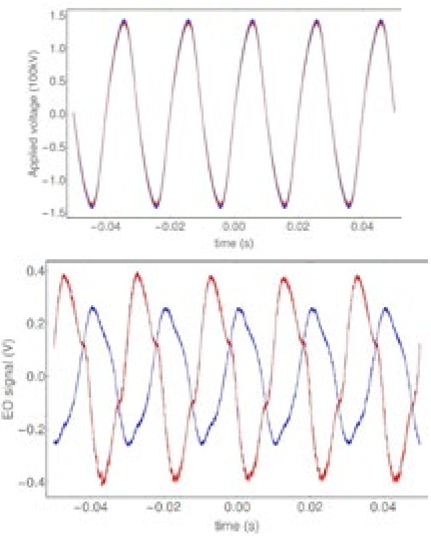


Figure 2: Voltage (top Fig.) and electric field (bottom Fig.) measurements. Blue color corresponds to the nominal behavior of the insulator. Red color corresponds to the insulator with a defect.

Thus, voltage analysis can definitely not be used as a valuable mean for diagnostics. On the contrary, the E-field temporal waveform is dramatically modified by the inner defect: both magnitude and phase are heavily modified. Indeed, the defect induces a huge phase shift of 130° and an enhancement of 50% of the magnitude.

The second example illustrates the E field mapping over a laminated busbar used in power electronics. The probe is mounted on a Cartesian robot and its position is acquired simultaneously with the field value of the component which is normal to the plane of the laminated busbar. E field mapping corresponds to a near field measurement as the probe is located less than 5 mm from the busbar surface. The spatial resolution of the measurement is 0.5 mm.

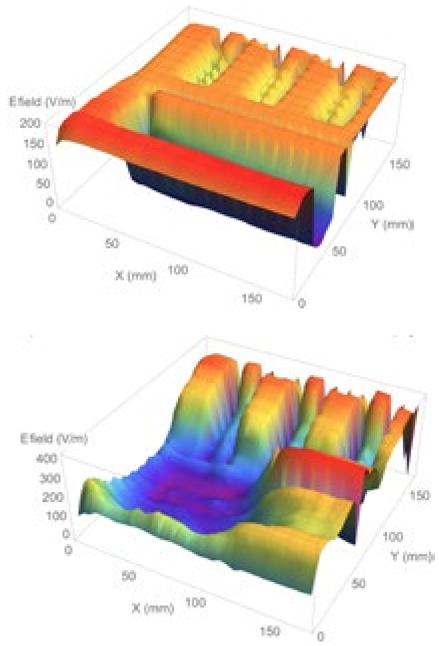


Figure 3: Measurement - 2D field mapping of the normal component in the vicinity of a laminated busbar.
Top: dry condition. Bottom: wet condition.

The result is presented in figure 3 for two different conditions: 1) dry and stabilized thermal conditions, 2) moisture and water saturated air inducing liquid droplet on the busbar.

The difference between the two mappings are significant with an increase of the field heterogeneity. As a matter of fact the field vanished down to 0 V/m in the bottom left and increased by a factor 2 on the right of the mapping. The authors point out that this result could not be assessed by numerical simulations.

The last example describes the E-field characterization in the vicinity of MV and HV devices: analysis of the field radiated by seven different 25 kV cables. This characterization concerns the apparition of partial discharges (PD) due to corrosion or contamination which can be significant for ageing cables in outdoor conditions. This kind of analysis is usually performed *a posteriori* with a visual inspection of the disassembled cable. We here propose to characterize the E-field in the vicinity of the cable to assess its behavior under voltage. The cables are here fed by a 50 Hz signal provided by a transformer delivering a voltage from 0.2 kV_{rms} to 25 kV_{rms}. The temporal waveform of the radial E-field is measured and acquired with a sampling rate of 20 MS/s for each cable and for each voltage value. The data are then analyzed (total harmonic distortion, linearity with applied voltage, residue versus pure 50 Hz signal, wavelet transform …). We here propose a multidimensional representation to compare the behavior of the 7 cables under test. On figure 4, the first axis represents the voltage threshold for the apparition of PD (PD threshold [kV]). The second axis is the over-voltage magnitude (O.V. [kV]) linked to PD. Finally, the last axis represents a phenomenological non-linearity factor ζ giving the deviation to linearity when PD appear. The characterizations of the 7 cables under test are synthesized as dots on the 3D representation given in figure 4.

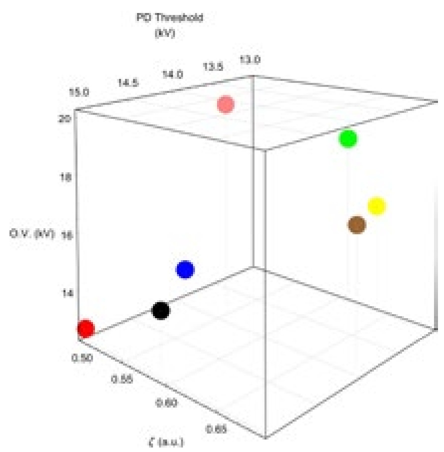


Figure 4: Multidimensional analysis of partial discharges on several 25 kV cables.

The red dot, localized at the origin, corresponds to the reference cable (new cable without ageing). For this reference cable, the voltage of PD appearance is the highest (15 kV), the non-linearity factor ζ is the lowest (0.5) and the over-voltage value is moderate (12 kV). All other cables present different ageing factors. Brown, green and yellow dots, which are far from the origin, are symptomatic of highly degraded cables that should be replaced.

Conclusion

We demonstrate via a few examples the relevance of electrooptic technology for measuring E fields. This technology is particularly adapted for near field measurements, even under HV conditions, from few tens of Hz to several tens of GHz. The electrooptic technology is of major interest for analysis of power electronics modules using SiC technology or for HV components. It is very helpful for engineers and technicians to analyze and to understand the phenomena of fatigue, ageing, contamination and corrosion as the E field appears to possess relevant and distinctive signatures of these phenomena.

www.kapteos.com

Low-Power Sub-States for Embedded and Automotive Platforms

Embedded and automotive platform designers who are seeking Peripheral Component Interconnect Express (PCIe) 3.1 Low-Power Sub-State (LPSS) L1.1 and L1.2 for power savings now have new options available from Microchip Technology Inc. The LAN7430 Ethernet bridge provides integrated power, clocks and an Ethernet physical (PHY) interface while the LAN7431 provides Reduced Gigabit Media-Independent Interface (RGMII) for alternative PHYs and switches. The LPSS L1.1 (snooze) and L1.2 (off) enables designers to reduce power consumption and improve battery life by snoozing or turning off the high-speed circuits in the PHY when not in use.

www.microchip.com

DC/DC Converter for Mobile Equipment and Industrial Electronics

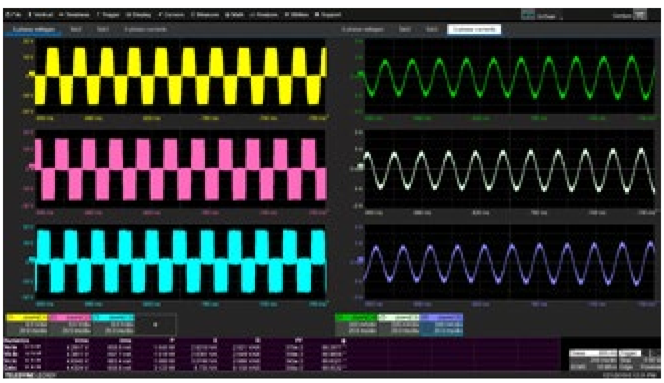
TRACO Power announces the release of their THN 15N series of 15 Watt DC/DC converters in the standard 1x1 inch package, which utilizes the latest advancements in power technology design to meet EMI Level A standards without external components and reduced no-load power consumption of 96-336mW and efficiencies up to 91 percent. These compact, high-performance 15 Watt DC/DC converters are ideal for addressing power conversion requirements in mobile equipment, instrumentation, distributed power architectures and industrial electronics applications, particularly when space is limited in PCB designs.

The THN 15N features a wide 2:1 input range of 9-18 / 18-36 / 36-75 Vin with single and dual outputs ranging from 3.3 to 24 VDC. High efficiency operation of 86 to 91 percent enables a full-load operating temperature range of -40°C to +70°C (up to 105°C with derating). These high-density DC/DC converters provide input to output isolation of 1,600 VDC and feature remote on/off control and a voltage trim function inside a 6-sided shielded metal case with an insulated base plate. All models are safety approved to IEC/EN/UL 62368-1 and are qualified to meet EN 55032 Class A conducted emissions limits and can meet Class B limits with the addition of external components.

www.tracopower.us/thn15n

3-Phase Power Analysis Software

Teledyne LeCroy launched its 3-Phase Power Analysis software package, which brings 1-phase and 3-phase static and dynamic power analysis to its HDO8000A, HDO6000A and WavePro HD 12-bit High Definition oscilloscopes. With the 3-Phase Power Analysis software package, research and development engineers can now use Teledyne LeCroy's 12-bit-resolution oscilloscopes to better understand complex power conversion system and control behaviors and hasten power conversion system-design refinements.



The rapidly growing power-conversion market now extends into applications requiring complex dynamic power analysis during time periods as short as a single device-switching cycle. Conventional power-analyzer instruments cannot perform dynamic power analysis and are limited to long power-period (e.g. 5 Hz to 500 Hz) analysis. Teledyne LeCroy's 3-Phase Power Analysis software package now enables more thorough power-conversation system evaluations and provides deep insight into complex dynamic system behaviors in applications including DC-DC power supplies, hybrid/electric vehicles, solar PV and grid-tied inverters, welding equipment, uninterruptible power supplies and HVAC systems.

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DC-DC Converter ChiP Modules

The new entries in the extensive DCM™ family are available in the 3623(36 x 23mm) ChiP (Converter housed in Package™) with an unrivaled power density of 1,032W/in3. The 80W DCM ChiPs, feature a wide-input voltage range of 9V to 75V and are available with nominal output voltages of 12V, 24V, 28V and 48V, with a voltage regulation range of ±1%.
The DCM ChiP is a DC-DC converter module that provides a proven, faster power system design option than alternate discrete solutions. DCMs operate from an unregulated, wide-range input to generate an isolated, regulated DC output. By utilizing a high frequency, zero-voltage switching (ZVS) topology, DCMs consistently deliver high efficiency across their entire input voltage range.

The DCMs are used broadly across defense and industrial applications where tighter output voltage regulation is required. These applications include UAV, ground vehicle, radar, transportation and industrial controls. The DCM ChiPs are available in M-grade, which can perform at temperatures as low as -55°C.

www.vicorpower.com

18V Synchronous DC/DC Buck Regulators and Adaptable Light Load Capability

The AOZ6662DI-01 and AOZ6663DI-01 from Alpha and Omega Semiconductor, Inc. are both available in a thermally enhanced DFN3x3 exposed pad package, delivering an output current of 2A and 3A, respectively. They offer a low on-resistant power stage, allowing cooler power conversion for a variety of consumer electronics application. The family is ideally suited for LCD TVs, set-top boxes, as well as DVD players and recorders. Products are immediately available in production quantities with a lead-time of 12 weeks. The unit price for 1,000 pieces is $0.42 for the AOZ6662DI-01 and $0.52 for the AOZ6663DI-01.

www.aosmd.com

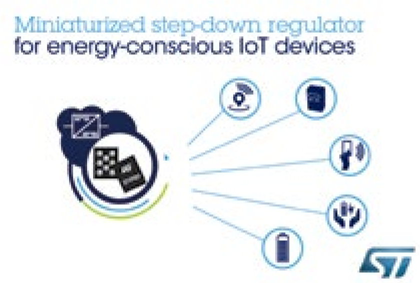
Direct Current Meter for Fast Charging Stations

Electric car owners will benefit from IEM-DCC, an innovative direct current meter for fast charging stations, in the future when fast charging their cars. It allows for the charging process to be billed by the kilowatt hour. Isabellenhütte and Innogy developed the module together. With the IEM-DCC, which is currently in the type examination procedure of the Physikalisch-Technische Bundesanstalt [national metrology institute of Germany], Isabellenhütte and innogy have responded to the legal requirement and developed a non-exclusive direct current meter that complies with calibration law. It is based on a highly-accurate shunt-based current sensor from Isabellenhütte, which is integrated into the procedure for kilowatt hour-exact billing, which is patented by innogy (used at innogy AC charging stations since 2014). The concept of the IEM-DCC includes current and voltage measurement in an extremely compact and mechanically tamper-proof housing, which is smaller than a standard household meter. So even in the smallest of spaces, current measurements up to 500 A, voltage measurements up to 1,000 V and a four-wire measurement for the compensation of charging cable losses are possible. In order to make the communication from the meter to the back-end system tamper-proof too, Isabellenhütte relies on the extended EDL 40++ from innogy, which takes into account methods for signing the meter values and methods for time synchronization for the meter. The signing of the meter values in particular is crucial for publicly accessible charging points for a number of different customers in order to ensure safe communication that complies with calibration law.

www.isabellenhuette.de

Step-Down Converters Save Energy and Space in IoT Devices

STMicroelectronics' ST1PS01 step-down converters are engineered for small size, low quiescent current, and high efficiency at all values of load current, to save energy and real-estate in keep-alive point-of-load supplies and IoT devices such as asset trackers, wearables, smart sensors, and smart meters. Leveraging synchronous rectification, efficiency is 92% at 400mA full load and 95% when delivering just 1mA. Power-saving design features keep the quiescent current to a miserly 500nA and include a low-power voltage reference. There is also a pulse-frequency counter for controlling converter



current at light load, with two high-speed comparators to help minimize output ripple. Integrated feedback-loop compensation, soft-start circuitry, and power switches ensure a space-saving solution that requires just a few small-outline passives to complete the circuit. The typical inductor value is 2.2µH. In addition, output-voltage selection logic not only saves external voltage-setting components but also gives flexibility to configure modules digitally at manufacture or let the host system change the output voltage on the fly. Eight variants, each with four optional output-voltage settings, allow a choice of regulated outputs from 3.3V to 0.625V. All models feature a Power-good indicator.

www.st.com

Filter Design Strategy for HEMP Applications

Smaller, lighter and consequently easier to install, Exxelia is the only manufacturer to solve HEMP requirements with Asymmetric filter designs, hence addressing the security challenges of tomorrow.
Exxelia pushes the limits of design with the BDP series allowing a 50% space saving in your installation while keeping high technical specifications (insertion loss of 80dB, 1250A, 300kHz to 18GHz) and complying with the MIL STD 188 125 1&2 test requirements.
Asymmetric designs allow to combine safety and miniaturization while still handling HEMP

and TEMPEST requirements. Three important benefits stand out from this conception, starting with a lower heat dissipation: as no magnetic field is generated, inductors suffer no heat dissipation. Secondly, the leakage is significantly lower thanks to a low value capacitance. Finally by using only one common inductor, these designs definitely save space.

www.exxelia.com

Code-Free FOC Sensorless BLDC Fan Drivers

Allegro MicroSystems Europe has announced the launch of the company's QuietMotion family. This family consists of the first-to-market Field Oriented Control (FOC) brushless DC (BLDC) electric motor controllers that are customer code-free. The devices are designed to provide reliable and efficient low audible noise performance while reducing design cycle time.

Whereas most FOC BLDC drivers require software developers to code the algorithm in a microprocessor, QuietMotion devices integrate Allegro's innovative FOC algorithms. These advanced algorithms allow for smooth, quiet motion while eliminating the need to write software. This significantly lowers R&D expenses and reduces time to market. With only five external components, these devices also minimise bill of materials (BOM) cost, improve reliability and reduce design complexity. The result is a quiet, easy to implement, and efficient outcome.

"This is the way of the future for motor drivers," explained Vijay Mangtani, Vice President of Allegro's Power IC Business Unit. "Our QuietMotion devices are incredibly efficient and easy to use. Flexible user interface and development boards allow customers to tune and evaluate various motors effortlessly, reduce development time and implement product designs with very few external components."

www.allegromicro.com

PSU in Miniature 3x5in Package

Fidus Power now has available a series of miniature, 3x5in PSUs that can deliver 250W when conduction-cooled or 550W fan-cooled and are approved for industrial and medical use.

Using a two-level PCB construction, the PSUs feature a baseplate with all the key semiconductors attached, allowing direct cooling into the system chassis, heatsink or cold-wall. With efficiencies to 92% and the ability to remove heat to the outside world, minimal waste-heat is generated into the system and keeping internal ambient temperature rise to a minimum.

The PSUs have a 90-264VAC input range and six models are available with 12 to 58VDC output, plus a built in 12V fan rail.

Both industrial and medical versions meet EN55032 level B; the industrial unit is also

is certified to IEC/EN/UL/CSA60950-1, while the medical unit also meets medical 4th Edition EMC levels and is certified to IEC/EN/CSA60601-1 and ANSI/AAMI ES60601-1.

Says Mark Gibbons, Engineering Manager at Fidus Power: “Whether these units are conduction-cooled via a baseplate, convection or fan-cooled, they enable system designers to manage heat generated in the system effectively, thereby increasing product lifetime. Applications include broadcast, outdoor communications, medical devices, sealed enclosures and industrial.”

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