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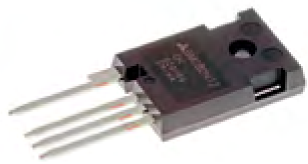
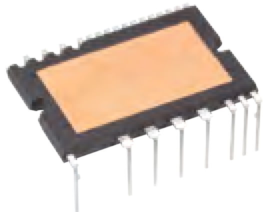
Bodo´s Power Systems®

Electronics in Motion and Conversion

December 2020



22mΩ / 1200V
SiC MOSFET



25A / 600V
SiC Super-Mini DIPIPM

400A / 1200V
Full-SiC 4-in-1 Module

800A / 1200V
Full-SiC Dual Module

1200A / 1200V
Full-SiC Dual Module

750A / 3300V
Full-SiC Dual Module

Mitsubishi Electric
Highly Efficient SiC Power Devices for Wide Application Range

MITSUBISHI ELECTRIC
Changes for the Better

CONTENT

Viewpoint 4
Christmas is Coming!

Events 4

News 6-12

Product of the Month 14
Second Generation Isolated Oscilloscope Probes

Blue product of the Month 16
IC Reduces Volume of AC-DC Converters by Up to 40%

Cover Story 18-25
Towards a Greener Future: Highly Efficient SiC Power Devices for Wide Application Range
By René Spenke, Mitsubishi Electric Europe B.V., Ratingen, Germany
Nils Soltau, Mitsubishi Electric Europe B.V., Ratingen, Germany
Toru Matsuoka, Mitsubishi Electric Corporation, Fukuoka, Japan

Driver 26-27
Coreless Transformers Isolate SiC Gate Drivers for EV & Industrial Applications
By Mitch van Ochten, Sr. Applications Engineer at ROHM USA

Power Management 28-31
Pulse Current Systems up to 35kA
By Michael Rost, Project Manager, IRS Systementwicklung GmbH

Wide Bandgap 32-35
Reducing Size, Noise, and Field Failures of Transportation APUs
By Kevin Speer, Nitesh Satheesh, and Marc Rommerswinkel, Microchip Technology

Driver ICs 36-39
Achieving Fast Switching with a High-Voltage Isolated Driver IC
By Vladimir Scarpa, Jan Svetlik, and Michele Lauria, STMicroelectronics

Power Modules 40-42
Chip Embedded Technology Enables High Current Density Power Modules
By Tony Ochoa, Director, Faraday Semi, a TDK Group Company

Wide Bandgap 43-45
Interpreting and Validating Dynamic Characteristics for Wide Bandgap (WBG) Power Device Data Sheets
By Ryo Takeda – Keysight Solution Architect, Bernhard Holzinger – Keysight Technical Architect, Michael Zimmerman – Keysight R&D Engineer, Mike Hawes – Keysight Power Solution Consultant

Power Supply 46-48
Bipolar Power Solutions for Precision Test and Measurement Systems
By Alan Walsh, System Applications Engineer, Analog Devices

Technology 49-51
How Hard is Soft Saturation?
By JC Sun, Bs&T Frankfurt am Main GmbH

New Products 52-56

Bodo´s Power Systems®

The Gallery

Changes for the Better

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Events

E|DPC 2020
Online December 8-9
www.edpc.eu

Power Electronics Conference 2020
Online December 8-9
www.power-conference.com

IEEE IEDM 2020
Online December 12-18
www.ieee-iedm.org

PEMD 2020
Online December 15-17
https://events2.theiet.org/pemd

Christmas is Coming!

December is always a good time to reflect on the passing year. The world is facing covid-19, global warming and plastic pollution in the oceans. We must be more careful how we travel and what we consume.

We are looking forward to Joe Biden bringing a better understanding of critical issues, for a better America, and a better world. Joe Biden was born in Scranton - a Pennsylvania town that I visited quite often in the 90s when I worked for Harris and had business at the nearby factory in Mountaintop. Landing at the Wilkes Barre - Scranton Airport was always interesting, with its view of the woods in the Pocono Mountains, and before that the Delaware River. Especially during an Indian Summer, it was great to see the forest turning red. Hopefully, corona will soon be under control and we will be able to travel again and see our business partners and friends.

So we look forward to a better 2021. We hope that a vaccine will become available to protect us from covid19. Until that happens we need to keep the curve of infections flat by limiting contacts and events. We have learned to do virtual events which help to keep us stay safe. I think that mouth and nose coverings will stay long term as we learn to understand their benefits in stopping the infection. We have learned to keep our distance in public areas and washing our hands was already important and this is now even more important.

Wide band gap semiconductors will change the world to a more efficient one - it is all about losses in power electronics. If we are more efficient, we will reduce heat dissipation. This is a very simple statement, but with a lot of implications. Passive components and measurement equipment must adapt to the higher switching speeds possible with wide band gap semiconductors. So, we will include articles and products from such companies in our publication.

In December, our fourth Wide Band Gap Conference will take place in Munich, again in cooperation with AspenCore handling the administration. The program is finalized - a record of over thirty papers – from important leaders in power electronics talking about their progress. A high-quality audience is guaranteed. Due to corona it will be a virtual conference. Besides the presentations and the live chats, networking directly with the companies will be of great value.
Visit www.power-conference.com to see the abstracts. and to book your “ticket”, even at the last minute. All presentations will be online a day ahead to give you the option to watch parallel sessions ahead of time. I am looking forward to seeing you at our conference and chatting about your progress.

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 serving 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:
See what toys you have saved from your childhood. Trains always attract my grandchildren.

Some of my locomotives are 60 years or older. After I inspect them, they run as well as new ones – and the world of make-believe is still the same for my grandchildren.

The smarter route to Electric Vehicle metering

DCBM Series

Smart and compact, the Direct Current Billing Meter (DCBM) gives charging station providers the ability to deliver a ‘gas station’ like experience, using an LCD display to show real time measurements, energy, alarms and legal data.

An excellent solution for retrofit and new DC Fast charging stations from 25 to 400 kW, the DCBM uses industry standard data protocols. The result is secure, authentic billing, easy connectivity to Cloud services and a faster certification process.

www.lem.com

- **400 A - 600 A maximum current**
- **1000 V nominal voltage**
- **Class B accuracy**
- **Billing Meter in compliance with VDE-AR-E-2418-3-100**
- **Ethernet communications supporting the HTTPS/REST protocol**
- **Signed billing data sets according to the S.A.F.E OCMF**

LEM

Life Energy Motion

Packaging Research for Power Electronics

Palomar Technologies and the Fraunhofer Institute for Integrated Systems and Device Technology IISB in Erlangen, Germany, announced their joint research initiative in the area of high-quality, void-free power module packaging for electric vehicles.

"We are delighted to be working with Fraunhofer IISB within this new initiative," said Bruce Hueners, CEO and President for Palomar Technologies and SST Vacuum Reflow Systems. "Palomar Technologies works with research institutes around the world to contribute to the development and advancement of techniques and technologies key to microelectronics packaging for the semiconductor industry. The work with these institutes results in new processes, new products, or new applications for industry." Fraunhofer IISB conducts applied research and development in the field of electronic systems for application in, e.g., electric mobility, aerospace, Industry 4.0, power grids, or energy technology. In this connection, the institute uniquely covers the entire value chain – from basic materials to whole power electronic systems.

"The packaging technologies are essential for cost effective and reliable power electronics. They offer the potential for improvements in every single domain. This cooperation will allow us to create significant progress in the field of solder materials and processing," explained Andreas Schletz, head of the department for devices, packaging, and reliability at Fraunhofer IISB.

www.iisb.fraunhofer.de

www.palomartechnologies.com

Focus on Silicon Carbide and Gallium Nitride

Cree announced that the Company has entered into a definitive agreement to sell its LED Products business unit ("Cree LED") to SMART Global Holdings for up to $300 million, including fixed upfront and deferred payments and contingent consideration. Under the terms of the agreement, which has been approved by the Company's board of directors, Cree expects to receive an initial cash payment of $50 million upon closing and $125 million to be paid upon maturity of a seller note issued by SMART to Cree due August 2023. Cree also has the potential to receive an earn-out payment of up to $125 million based on the revenue and gross profit performance of Cree LED in the first full four quarters post-transaction close, also payable in the form of a three-year seller note.

"We are pleased to announce the sale of our LED Products business to SMART, which represents another key milestone in our transformational journey to create a pure-play global semiconductor powerhouse," said Cree CEO Gregg Lowe. "This transaction uniquely positions us with a sharpened strategic focus to lead the industry transition from silicon to silicon carbide and further strengthens our

financial position, which will support continued investments to capitalize on multi-decade growth opportunities across EV, 5G and industrial applications. SMART has a strong platform and a solid track record of successfully acquiring and integrating technology businesses."

www.cree.com

Call for Proposals for Innovation and Young Engineer Award

The SEMIKRON Innovation Award and the SEMIKRON Young Engineer Award is given for outstanding innovations in projects, prototypes, services or novel concepts in the field of power electronics in Europe, combined with notable societal benefits in form of supporting environmental protection and sustainability by improving energy efficiency and conservation of resources.

Both prizes have been initiated and are donated by the SEMIKRON Foundation which is awarding the prizes in cooperation with the European ECPE Network. With the award the SEMIKRON Foundation wants to motivate people of all ages and organisations of any legal status to deal with innovations in power electronics, a key technology of the 21th century, in order to improve environmental protection and sustainability by energy efficiency and conservation of resources. The SEMIKRON Innovation and Young Engineer Prizes 2021 will be awarded in the frame of the ECPE Annual Event in March 2021 in Erding/Muinch. A single person or a team of researchers can be awarded. The Innovation Award includes prize money of EUR 10,000.00, the Young Engineer Award for researchers who have not yet completed their 30th year of age includes prize money of EUR 3,000.00. The deadline for submission ends on 18.01.2021! Please send your proposal resp. your application with the reference ´SEMIKRON Innovation Award´ by email to Thomas Harder, General Manager of ECPE e.V., thomas.harder@ecpe.org. The receipt of your proposal will be confirmed by email immediately. Your proposal comprising 3-5 pages in total should be structured according to the headline given below and submitted in English language.

www.semikron.com

SMALLER
STRONGER
FASTER

ROHM
SEMICONDUCTOR

REDUCES STANDBY POWER
FOR ALWAYS-ON CONSUMER PRODUCTS

ROHM’s BM1ZxxxFJ integrated zero cross detection IC series is optimized for home appliances such as vacuum cleaners, washing machines, and air conditioners. The device provides designers a turn-key zero cross detector without the need for a complex design using discrete components. Additionally, this integrated solution does not use a photo-coupler typically used in other solutions, and therefore, it further reduces standby current consumption and increases long-term reliability.

KEY FEATURES

- Breakthrough photocoupler-less zero cross detection circuit design minimizes application standby power consumption
- Contributes to improved reliability and efficiency in home appliances in a variety of countries and regions
- Easily replace conventional zero cross detection circuits
- Integrated voltage clamp function protects the downstream MCU

CONSUMER

www.rohm.com

ECCE 2021 - IEEE Energy Conversion Congress and Exposition

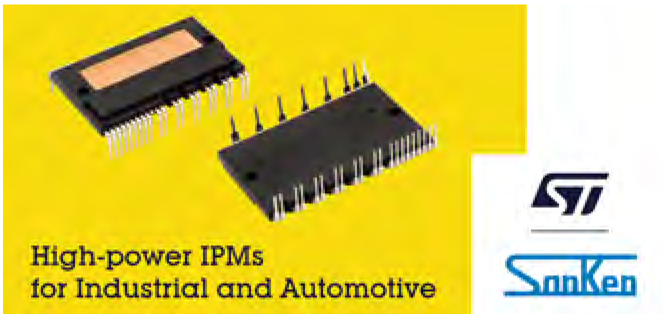
The Thirteenth Annual IEEE Energy Conversion Congress and Exposition (ECCE 2021) will be held in Vancouver, British Columbia, Canada, from October 10 to October 14, 2021. ECCE is a pivotal international event on energy conversion. ECCE 2021 will feature both industry-driven and application-oriented technical sessions as well as an exposition. The conference will bring together practicing engineers, researchers and other professionals for interactive and multidisciplinary discussions on the latest advances in areas related to electrical energy conversion. Technical papers are solicited on any subject pertaining to the scope of the conference. The submission deadlines for the paper digests, tutorials, and special sessions are Jan 15, Feb. 12, and Mar. 31, 2021, respectively.

www.ieee-ecce.org/2021

Strategic Partnership to Develop Intelligent Power Modules

STMicroelectronics and Sanken Electric have collaborated to unleash the performance and practical advantages of intelligent power modules (IPM) in high-voltage, high-power equipment designs.
The two companies are developing and will jointly market 650V/50A and 1200V/10A industrial modules, which simplify design challenges and shrink the bill of materials for HVAC systems, industrial servo drives, industrial washing machines, and general-purpose inverters over 3 kW. The ST/Sanken IPM product roadmap will continue with 650V/50A automotive-grade modules for high-voltage compressors, pumps, and cooling fans.
“With ST and Sanken contributing their strengths, we can bring these new high-voltage, high-power IPMs to industrial and automotive markets, ensuring superior performance, efficiency, and reliability,” said Masao Hoshino, Director and Head of Device Business Corporate Headquarters of Sanken.
Marco Monti, President, Automotive and Discrete Group, STMicroelectronics, said, “These new devices extend our established STPOWER SLLIMM™ portfolio with a High-Power (HP) product line to address applications over 3 kW and introduce our first automotive-grade IPMs that permit sleeker designs and greater reliability.”

IPMs let designers replace traditional power circuits built using discrete components with a compact, integrated device that simplifies circuit layout and PCB design. This helps accelerate time to market and improve cost-effectiveness and reliability. Leveraging easier manufacturing, faster assembly, and bill-of-materials savings, designers of high-voltage equipment can create new generations of power products that are space-saving, economical, energy-efficient, and robust.



www.st.com

Testing Methodology for Power Stamp Users

The Power Stamp Alliance (PSA), which is creating collaborative solutions for 48V-to-low-voltage on-board DC-DC power converters, announced that LoadSlammer, designers and manufacturers of transient load testing devices, has joined the Alliance to bring the option for a consistent, standardized testing methodology to users of power stamps. This is the first time that a multi-vendor alliance around dc-dc power conversion has agreed a testing methodology and tools. Design engineers will be able to use a common, consistent, and repeatable load to significantly reduce validation and integration time, speeding their end-product to market and reducing risk in the design process. LoadSlammer estimates up to 30 per cent saving in development time depending on the user’s specific configuration.

Power Stamp Alliance Founding Members, Advanced Energy, Bel Power Solutions, Flex, and STMicroelectronics have created and shared a specification for a standard product footprint and functions to create a multi-vendor ecosystem. This assures practical levels of alternate source capability to server and storage system manufacturers, while encouraging a competitive supply chain through differentiation in topology, circuitry, and performance from multiple, independent manufacturers. Power Stamp Alliance 48V direct conversion DC-DC modules – or ‘power stamps’ – primarily target advanced IT and supercomputing equipment and large data processing installations.

www.powerstamp.org


Shape the Future
High Voltage
IGBT
Full SiC 3.3kV Power Module in nHPD2
Hitachi Europe Limited, Power Device Division
Email pdd@hitachi-eu.com +44 1628 585151
HITACHI
Inspire the Next

Partnership for the Service of PCB and Engineered Solder Materials

The partnership with RENEX expands Indium Corporation's existing market reach in Poland as it continues to deliver world-class products and technical service; including solder paste, preforms, ribbon, flux, wire, kits, spheres, and thermal interface materials (TIMs). "We are excited to work with RENEX to enhance our delivery of world-class products and technical service to manufacturers in Poland," said Brian Craig, Managing Director of Indium Corporation's European Operations. RENEX has been serving Poland's electronic industry with machines and materials as well as tech expertise, being an IPC and ESA training center, for the past 30 years. Its network of 150 dedicated employees, along with its Technology Center, provides deep process and quality training sessions.

www.indium.com

ECPE Events

ECPE Online Tutorial 'Testing Automotive Power Modules according to the ECPE Guideline AQG 324'
20 - 21 Januar 2021, Digital Event via Webex

ECPE Online Tutorial 'Drivers and Control Circuitry for IGBTs and MOSFETs'
23 – 24 February 2021, Digital Event via Webex

ECPE Workshop 'ECPE SiC & GaN User Forum – Potential of Wide Bandgap Semiconductors in Power Electronic Applications'
2 – 3 March 2021, Erding/Munich, Germany

ECPE Tutorial 'EMC in Power Electronics'
11 - 12 March 2021, Eindhoven, Netherlands

www.ecpe.org

IC Sales Surpass One Billion Units

Power Integrations announced that shipments of the groundbreaking InnoSwitch™ family of ICs have surpassed one billion units. Launched in 2014, the InnoSwitch family was the first to incorporate Power Integrations' innovative FluxLink™ communication technology, which provides highly accurate secondary-side control without the need for an optocoupler, resulting in exceptional energy efficiency, reliability and robustness. InnoSwitch ICs, including the InnoSwitch3 family which launched in 2017, support a diverse range of power-supply applications including USB PD chargers, consumer electronics, PCs, displays, servers, appliances, industrial devices and automotive. Commenting on the billion-unit milestone, Power Integrations' president and CEO Balu Balakrishnan said: "The InnoSwitch family set a new standard in power-conversion technology and hailed a paradigm shift in power-supply design. The expensive, complicated method of combining a primary-side controller and associated MOSFETs with a synchronous rectification controller has given way to a more highly integrated architecture that is simple, elegant, more reliable and more efficient. We are delighted by the market's response to InnoSwitch ICs and proud to have shipped more than one billion units."

www.power.com

7th Generation X series

Top Class in Power Density and Reliability

MAIN FEATURES

- 7G IGBT & FWD
- New internal layout
- Higher reliability
- Improved silicone gel
- Solder or press-fit pins
- Advanced bond wire design
- High thermal conductive ceramic substrate
- Package material with CTI > 600
- V_{iso} up to 4 kV
- Lower V_{cesat}
- Lower voltage overshoot
- Lower oscillations / lower EMC issues
- Available in various package types from low to high power ranges

Downsizing of IGBT Modules

Increment of Losses	Rise of Temperature	Deterioration of Reliability
Low Loss IGBT & Diode	High Heat Dissipation Packages	High Reliability Packages

Our Solutions
(The 7G IGBT Modules Concepts)

\+

Expansion of continuous T_{vjop} up to 175 °C

Tim Brown Joins as Sales & Marketing Manager

Amantys Power Electronics Ltd. is delighted to announce the appointment of Tim Brown to the Senior Management Team as Sales & Marketing Manager. A graduate of the Universities of Manchester and Staffordshire, Tim has a wealth of technical knowledge and experience in the Power, Power Quality and Power Electronics industries, along with sales and business development expertise.

Tim will be focusing on Amantys' range of world class gate drive units, supporting leading Power Conversion specialists with the Junction Temperature Estimation technology and Condition Monitoring capabilities of Amantys' products, and offering NRE/consultancy services. Dr Keith Ferguson, General Manager of Amantys commented, "We are extremely fortunate to welcome Tim to our team. With his proven success in sales management and business development, he will be a significant asset to Amantys and our customers".

www.amantys.com

Expanding Supply Base for Silicon Carbide

Infineon Technologies and GT Advanced Technologies (GTAT) have signed a supply agreement for silicon carbide (SiC) boules. The contract has an initial term of five years. With this supply contract, the German semiconductor manufacturer adds a further element to secure its growing base material demand in this area. SiC is the basis for power semiconductors that are particularly efficient, robust, and cost-effective at the system level. Under the brand name CoolSiC™ Infineon now already markets the industry's largest product portfolio for industrial applications and is rapidly expanding its offerings towards consumer and automotive products. "We are seeing a steadily increasing demand for SiC-based switches, especially for industrial applications," says Peter Wawer, President of Infineon's Industrial Power Control Division. "However, it has become clear that the automotive sector is quickly following suit. With the supply agreement we have now concluded, we ensure that we will be able to meet the rapidly growing demand of our customers with a diversified supplier base. GTAT's high-quality boules will provide an additional source for competitive SiC wafers fulfilling the best-in-class material standards now and in the future. This supports our ambitious SiC growth plans, making good use of our existing in-house technologies and core competencies in thin-wafer manufacturing."

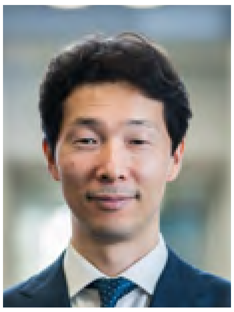
www.infineon.com

Stefan Werkstetter Appointed as Director of Sales for EMEA

To support the continued adoption of gallium nitride (GaN) FETs and Integrated Circuits in the European market, Efficient Power Conversion Corporation (EPC) is pleased to announce the appointment of Stefan Werkstetter as Director, Sales EMEA. Based near Munich, Germany, Stefan brings many years' experience working in the power electronics market, particularly the automotive and industrial automation sectors. In his new role he will focus on developing new and existing accounts with major OEM and key account customers based in Europe. Stefan holds a degree in electrical engineering and joins EPC from Skeleton Technologies where he was Head of Strategy and prior to that spent many years working at Maxwell Technologies. His experience includes strategy, product management, business development, sales and applications engineering. "Working with EPC and GaN is really exciting and I am looking forward to developing both new and existing business in EMEA. There is great potential to assist customers in choosing to adopt GaN and I'll be focussed on increasing these application and sales opportunities," commented Stefan on joining EPC.

www.epc-co.com

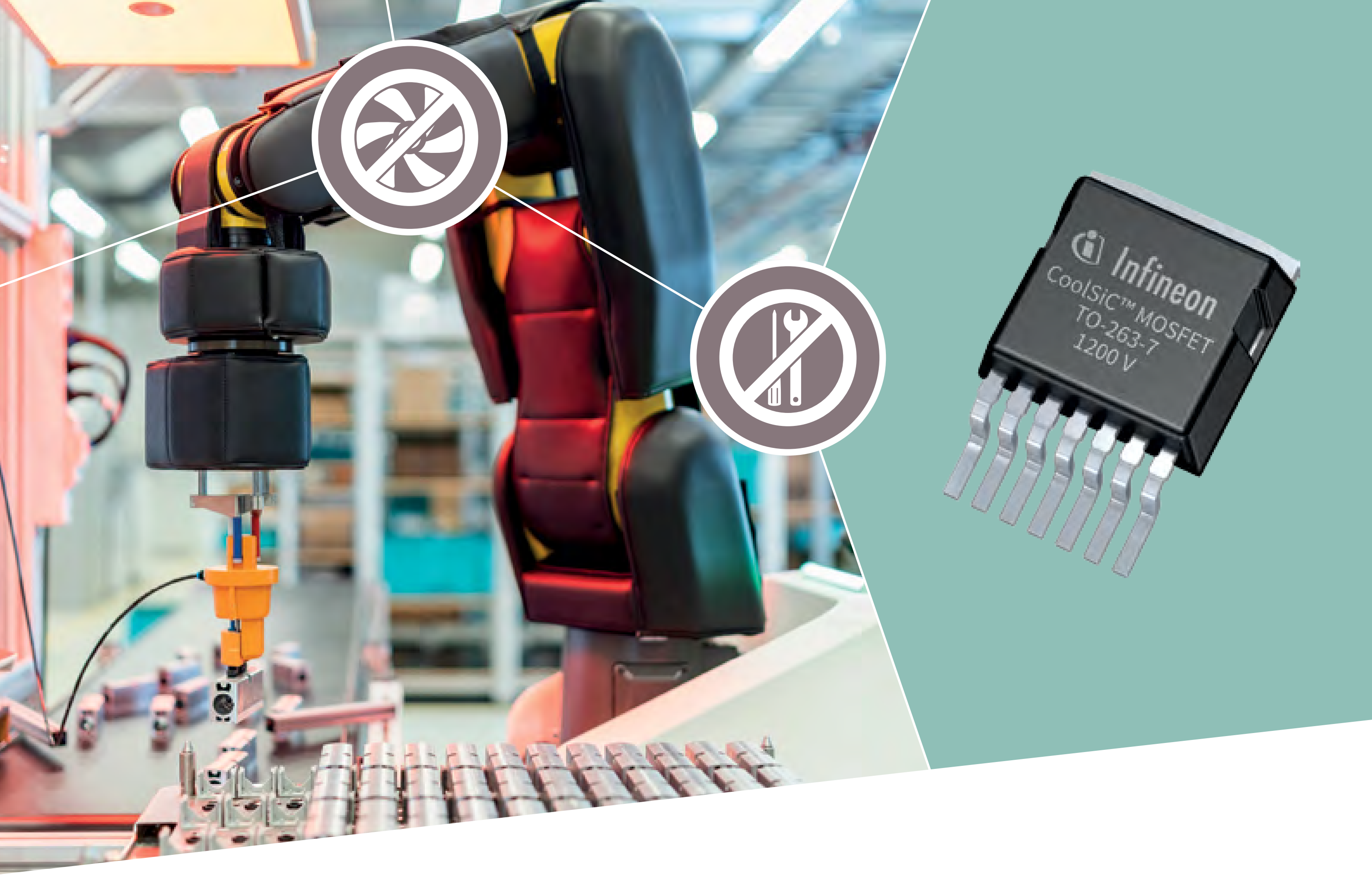
GSA Appoints Hidetoshi Shibata to Board of Directors



As the semiconductor industry navigates an unprecedented year with projections of steady growth, the Global Semiconductor Alliance (GSA) expands its board of directors with the appointment of Hidetoshi Shibata, President and CEO of Renesas Electronics Corporation.

"As the voice of the global semiconductor industry, GSA offers leaders a neutral platform to collaborate and advance technology for a positive societal and economic impact. Our board's vision, dedication and passion has led to the GSA being a strong, influential association representing companies across the world," said Jodi Shelton, CEO of GSA. "We are pleased to welcome Hidetoshi as our newest board member and look forward to his contributions as we further progress our industry." "Semiconductors are essential technology enablers that power most of the intelligent devices we use today," said Hidetoshi Shibata, President and CEO at Renesas. "I am proud to join the GSA Board of Directors and add our expertise to the development of innovative solutions in the global collaboration effort, with industry leaders of GSA, which is critical for success in today's fast-paced and competitive markets." The GSA welcomes Renesas, a global leader in the semiconductor industry focused on the IoT, industrial, infrastructure and automotive markets, onto its board of directors with the collective goal of increasing the profitability and sustainability of the global semiconductor ecosystem and improving the worldwide economy.

www.renesas.com


Infineon
CoolSiC™ MOSFET
TO-263-7
1200 V

Second Generation Isolated Oscilloscope Probes

Tektronix announced its second-generation IsoVu™ Isolated Oscilloscope Probes, the TIVP Series, which significantly advance the capabilities of the ground-breaking probes first introduced in 2016. The second-generation IsoVu probes extend the applications for isolated probe technology to the entire power system design market with a smaller size, improved ease of use, and enhanced electrical performance.

Making accurate measurements on high-speed ungrounded systems can be nearly impossible using traditional differential probes. Engineers working with wide-bandgap technologies such as SiC and GaN face difficult challenges to accurately measure and characterize devices due to the higher frequencies and switching speeds involved. By galvanically isolating the probe from the oscilloscope, IsoVu probes have completely changed how power researchers and designers make wide bandgap power measurements. “When first introduced, the IsoVu probes represented a true breakthrough for our customers because they could gain actual insight into the performance of the high side of their half-bridge designs, eliminating a significant blind spot,” said Suchi Srinivasan, general manager of Tektronix mainstream solutions. “With this second generation of IsoVU, we are making this cutting edge isolated measurement technology accessible to a broader range of customers for such tasks as product level R&D, validation and EMI troubleshooting.”

IsoVu Gen 2 Features and Options

Like the first generation, the IsoVu Gen 2 probes use patented electro-optical technologies to capture signals and power the probes without the need for an electrical connection to the oscilloscope. Compared to traditional high voltage differential probes, IsoVu probes offer a unique combination of high bandwidth, dynamic range and best-in-class common-mode rejection ratio (CMRR) over the probe’s full bandwidth. Non-isolated probes’ CMRR ratings derate quickly as frequency increases, making higher frequency measurements impossible. The use of optical cables also allows for long cable lengths and makes the probes largely immune to EMI. “IsoVu technology has been critical in our support of customers adopting our Power Conversion technology in their designs.” says Cam Pham, Global Automotive Field Application Engineer Leader, Wolfspeed, a Cree Company. “With its galvanic isolation capability, IsoVu technology enables us and customers to accurately characterize high side events with confidence”

www.tek.com/isolated-measurement-systems


Texas Instruments
MORE POWER.
BETTER THERMALS.
SMALLER FOOTPRINT.
Your partner in solving
power density challenges
Learn More
https://www.ti.com/power-management/overview.html
TI POWER

IC Reduces Volume of AC-DC Converters by Up to 40%

MinE-CAP device reduces the input bulk capacitor size, reduces in-rush current by up to 95% and eliminates NTC thermistors and associated losses

Power Integrations announced the MinE-CAP™ IC for high power density, universal input AC-DC converters. By halving the size of the high-voltage bulk electrolytic capacitors required in offline power supplies, this type of IC enables a reduction in adapter size of up to 40%. The MinE-CAP device also reduces in-rush current making NTC thermistors unnecessary, increasing system efficiency and reducing heat dissipation.

Comments Power Integrations' product marketing director, Chris Lee: "The MinE-CAP will be a game-changer for compact chargers and adapters. Electrolytic capacitors are physically large, occupy a significant fraction of the internal volume and often constrain form factor options – particularly minimum thickness – of adapter designs. The MinE-CAP IC allows the designer to use predominantly low voltage rateding capacitors for a large portion of the energy storage, which shrinks the volume of those components linearly with voltage. USB PD has driven a major market push towards small 65 W chargers and many companies have concentrated on increasing switching frequency to reduce the size of the flyback transformer. MinE-CAP provides more volume saving than doubling the switching frequency, while actually increasing system efficiency."

The MinE-CAP leverages the small size and low RDSon of PowiGaN™ gallium nitride transistors to actively and automatically connect and disconnect segments of the bulk capacitor network depending on AC line voltage conditions. Designers using MinE-CAP select the smallest high-line rated bulk capacitor required for high AC line voltages, and allocate most of the energy storage to lower voltage capacitors that are protected by the MinE-CAP until needed at low AC line. This approach dramatically shrinks the size of input bulk capacitors without compromising output ripple, operating efficiency, or requiring redesign of the transformer.

Conventional power conversion solutions reduce power supply size by increasing switching frequency to allow the use of a smaller transformer. The innovative MinE-CAP IC achieves just as significant overall power supply size reduction while using fewer components and avoiding the challenges of higher EMI and the increased transformer/clamp dissipation challenges associated with high-frequency designs. Applications include smart mobile chargers, appliances, power tools, lighting and automotive.

Said Bhaskar Thiagaragan, Director of Power Integrations India Ltd.: "MinE-CAP ICs are excellent for all locations with wide ranging input voltages. In India we often design for voltages from 90 VAC to 350 VAC, with a generous surge de-rating above that. Engineers here often complain about the forest of expensive high-voltage capacitors required. MinE-CAP dramatically reduces the number of high-voltage storage components, and shields lower voltage capacitors from the wild mains voltage swings, substantially enhancing robustness while reducing system maintenance and product returns.

www.power.com/products/MinE-CAP

Power Electronics for Wind Turbines

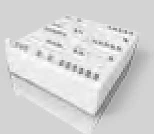
www.semikron.com

SEMIKRON's portfolio includes a wide range of products for wind energy applications, from small to medium power modules for pitch and yaw drives to high power components for multimegawatt power converters.

Features

- Supply chain safety with industrial standard package designs
- Inverter topologies: Half-bridge, sixpack, NPC, ANPC
- Reduce time-to-market with enhanced driver cores that meet $1500V_{DC}$ and handle the complex shutdown patterns for NPC
- Covering air and water cooled multimegawatt applications with the SKiiP high power IPM
- Excellent application support

SEMITOP® E1/E2
0.4kW - 30kW



MiniSKiiP®
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Towards a Greener Future: Highly Efficient SiC Power Devices for Wide Application Range

In various applications, SiC devices are used today to achieve highly efficient and compact converters. Applications range all power ratings, from air conditioners, to battery chargers, to industrial drives and even railway propulsion.
This article discusses the demands from different applications, highlights the MITSUBISHI ELECTRIC SiC power devices available in different voltage and power classes and gives insights in latest developments.

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Nils Soltau, Mitsubishi Electric Europe B.V., Ratingen, Germany
Toru Matsuoka, Mitsubishi Electric Corporation, Fukuoka, Japan

Introduction
The reduction of carbon dioxide and the responsible use of electric energy are main drivers for a more sustainable future society. Silicon Carbide (SiC) and its superior physical properties shall save even more electric energy and make power-electronic converters more compact, which reduces the consumption of valuable materials and resources.

The main difference between SiC semiconductors and classical silicon is the higher band gap. This allows 10-times higher critical field strength in the SiC material. Consequently, for the same blocking-voltage capability, SiC chips can be made thinner. Hence, electrical resistance and power losses are decreased.

Furthermore, due to the higher band gap, SiC MOSFETs or SiC Schottky Barrier Diodes can be produced even for higher blocking voltages (e.g. 3300 V or 6500 V). Due to high switching speed, these unipolar devices have low switching losses and enable high switching frequencies. In many applications, the higher switching frequencies yields power-density increase of other system components, like filters, transformers or motors. Hence, the power-electronic converter becomes more compact and saves material and related costs.

Since the 1990s, Mitsubishi Electric has gained comprehensive experience about the production and application of SiC devices and power modules. SiC power semiconductors have successfully completed the technology hype cycle and Mitsubishi Electric SiC products are widely available. Today, we find SiC products in various applications: from chargers for electric vehicles, to air conditioners, to uninterruptable power supplies, to industrial drives and even railway traction drives. These different applications result different requirements to the SiC device. This article demonstrates the variety of demands and the according SiC solution.

The Core of our SiC Devices: Next Generation of SiC chips
The newest SiC devices feature Mitsubishi Electric's 2nd generation of SiC chips. These chips are manufactured on the new 6-inch SiC wafer line. As shown in Figure 1, the 2nd generation has an enhanced planar MOSFET structure. The special JFET doping profile enables improvement of the specific electric resistance $R_{on,sp}$ while reducing the MOSFET cell width as demonstrated in Figure 2. The excellent electric resistance of this enhanced planar MOSFET technology is highly competitive against other trench gate structures as shown in Figure 3. Moreover, the JFET doping lowers the reverse transfer

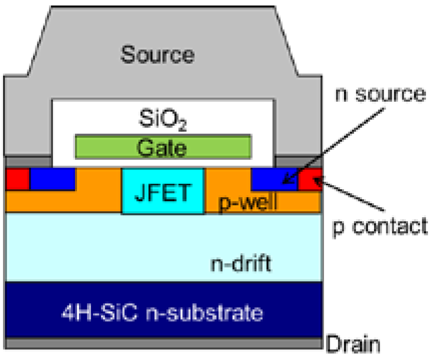


Figure 1: Structure of 2nd Generation SiC MOSFET Chip

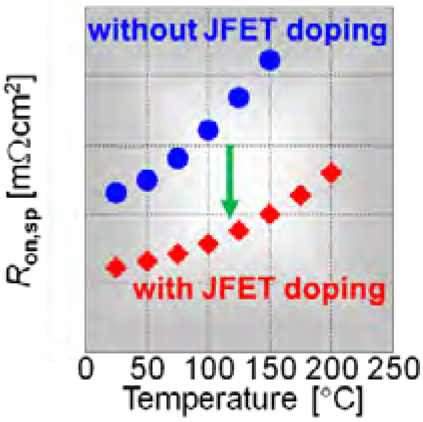


Figure 2: Unique JFET doping improves $R_{on,sp}$

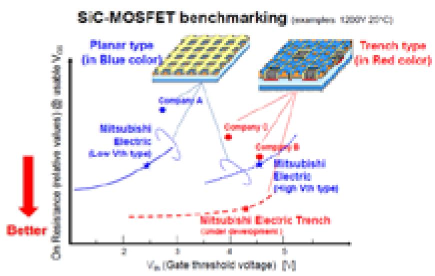
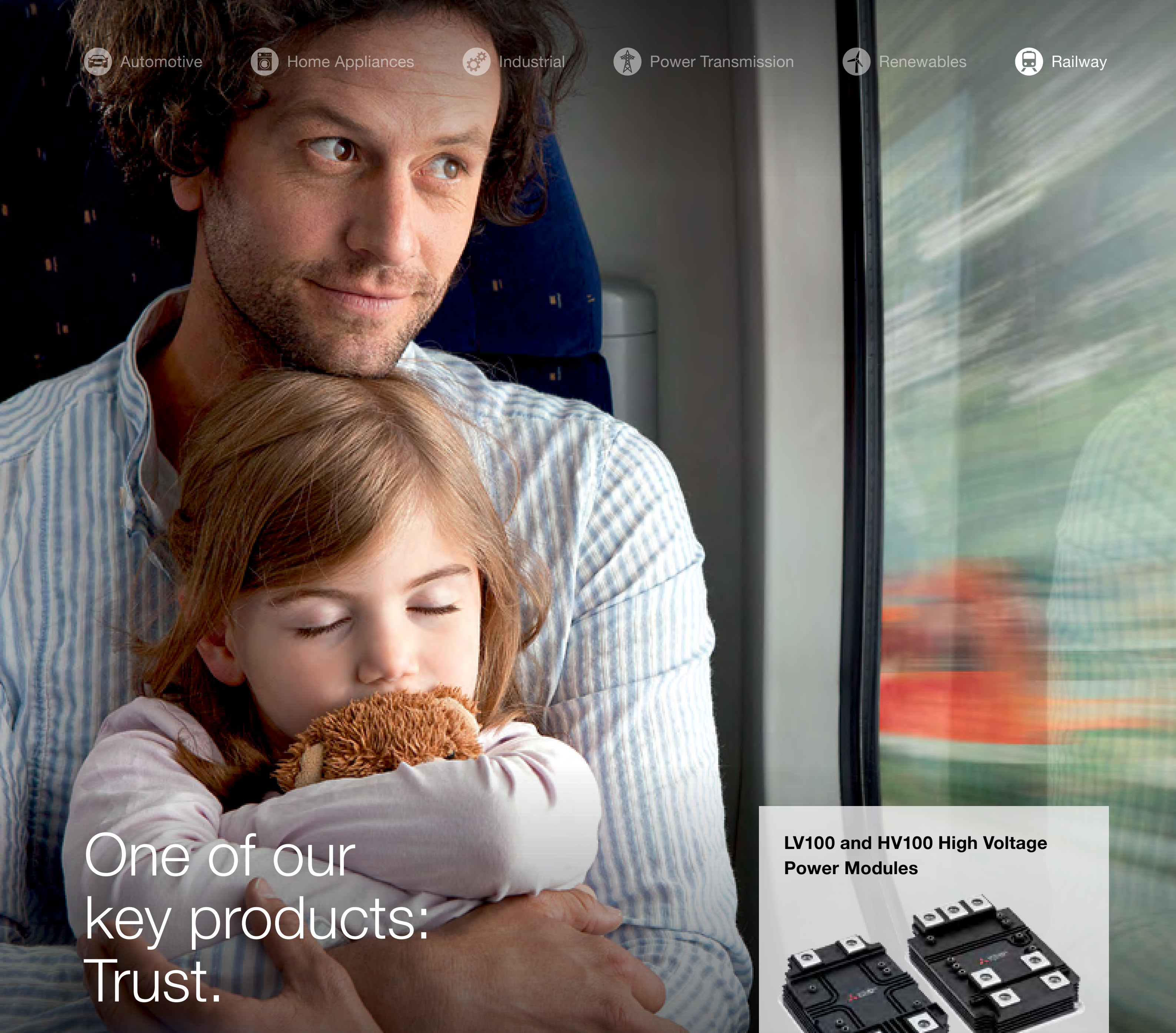


Figure 3: Comparison between different Planar- and Trench-Gate SiC MOSFET technologies



Power Devices from Mitsubishi Electric.

Demanding applications like railway, wind energy and medium-voltage drives require efficient semiconductor modules with high power density. Since 60 years Mitsubishi Electric offers continuous innovation in development and production of power semiconductors. Packaging as well as Si and SiC chip technology reach most ambitious targets for high reliability, compact design and high power density.

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capacitance C_{rss}. This capacitance affects the switching speed of the SiC device. The smaller C_{rss} allows higher switching speeds and improves robustness against parasitic turn-on as explained further below.

SiC Discrete Devices for Automotive Battery Chargers, Air Conditioners or Heat Pumps

Applications like battery chargers, air conditioners or heat pumps demand high-volume production capacity, a compatible package among different suppliers and current ratings of up to 100 A.

For such applications, our solution is Mitsubishi Electric's N-Series 1200 V 2nd generation SiC discrete power devices in the industry standard TO-247 package [1] [2]. This type of devices is still the preferred choice in many low- to medium-power applications, due to their flexibility: Discrete devices consist of only a single MOSFET switch, making it possible to build any type of converter topology. Due to the simpler package (cf. Figure 4) and high volume production, they can offer a cost effective introduction of the SiC technology. Besides the 3-terminal package, Mitsubishi Electric also offers a 4-terminal version of TO-247. It has further improved switching characteristics and achieves 30% less switching loss [3]. Table 1 shows the line-up of the N-Series SiC MOSFET devices. All are tested according to Mitsubishi high quality standards, fulfilling the requirements of industrial applications. Additionally, all discrete devices are available in a version qualified according to the standard AEQ-Q101 for the use in automotive applications.

Due to their low losses, the industrial N-Series SiC MOSFETs are ideally suited for example to improve the efficiency of residential solar inverters and reduce the size of bulky and costly passive components. In fast battery chargers the SiC technology enables more compact and at the same time efficient systems.

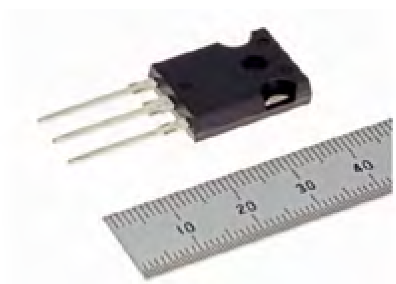
In electric vehicles, the AEQ-Q101 qualified SiC MOSFETs can reduce the size and weight of auxiliary components such as on-board battery chargers or DC-DC converters.

Besides those examples, Mitsubishi Electric's discrete SiC devices can be used also in various other applications.

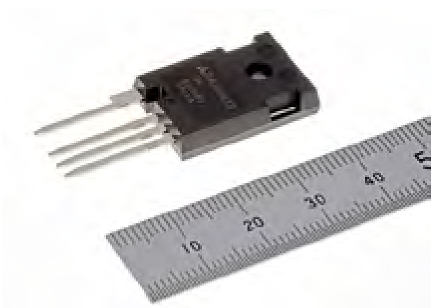
Key Features:

The N-Series SiC MOSFETs use Mitsubishi Electric's 2nd generation of planar SiC technology with JFET doping. This technology offers several advantages as compared to previous generations of SiC technologies.

The high breakdown field strength of SiC material has enabled power MOSFETs in the 1200 V class with a low drift layer resistance (R_{drift}). But another significant part of the specific on resistance is caused by the parasitic JFET between the p-wells of the MOSFET structure. With the introduction of the JFET doping in the 2nd generation SiC technology, the specific on resistance is improved making smaller MOSFET cells possible.



(a) N-Series with 3 terminal package (TO-247-3)



(b) N-Series with 4 terminal package (TO-247-4)

Figure 4: N-Series 1200 V SiC-MOSFET

Model	BM080N120S(J)	BM040N120S(J)	BM022N120S(J)
V_{DS}	1200 V		
$R_{DS(on)}$	80 mΩ	40 mΩ	22 mΩ
$I_{D,max@25}$	38 A	68 A	102 A
Package	TO-247-3		
Size	15.9 × 41.0 × 5.0mm		

Table 1: Line-Up of Mitsubishi Electric's N-Series

An important factor for the MOSFET switching behavior is the ratio between the input capacitance (C_{iss}) and the reverse transfer capacitance (C_{rss}). The fast switching transients of discrete SiC power MOSFETs can cause a parasitic turn-on of a MOSFET and in worst-case could lead to a catastrophic arm shoot through failure. By reducing C_{rss}, a figure of merit of 1450 mΩ·nC is achieved, which is defined as the product of the on-resistance and the gate-drain charge. As visualized in Figure 5, this improves the robustness against parasitic self-turn-on by around 14 times as compared to conventional devices and therefore enables high switching speeds and reduced switching losses [1].

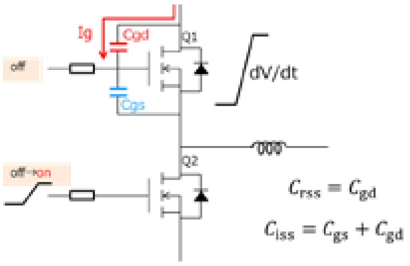


Figure 5: Parasitic turn-on effect – The turn-on of the low side MOSFET Q2 causes a dV/dt at the high side MOSFET Q1. As a result, the gate current I_g flows via the reverse transfer capacitance C_{rss} of Q1 into the gate. If this current causes a sufficient voltage drop at the gate resistor to exceed the gate threshold voltage $V_{gs(th)}$, MOSFET Q1 is turned-on parasitically. The current I_g is proportional to C_{rss} and dV/dt.

Discrete SiC MOSFETs are typically specified and initially compared by the $R_{DS(on)}$ resistance measured at T_j = 25 °C. However, under real application conditions with typically T_j = 100 °C and above, the $R_{DS(on)}$ of power MOSFETs increases. Mitsubishi Electric's N-Series power MOSFETs show comparably low $R_{DS(on)}$ increase of only about 10 % at T_j = 100 °C. This reduces the conduction losses in the application and allows converter designs for higher output power than with comparable devices specified with the same $R_{DS(on)}$.

In addition to the discrete N-Series SiC MOSFETs, Mitsubishi Electric also offers a line-up of matching SiC Schottky-Barrier Diodes (SBD). SBD typically offer lower forward voltage V_F drop than bipolar diodes. However, a trade-off exists between low V_F and high forward surge current capability. To optimize both, Mitsubishi Electric developed the so called Junction Barrier Schottky Diode structure, where in addition to the Schottky contact a pn-junction is integrated in parallel for handling high surge currents as demon-

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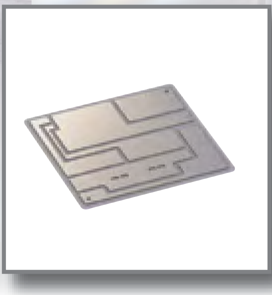

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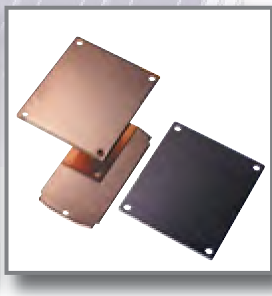

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strated in Figure 6 and Figure 7. The line-up consists of 600 V and 1200 V diodes with current ratings of 10 A and 20 A in different discrete package variants (TO-247, TO-220FP-2, TO-263S) [4].

Integrated SiC DIPIPM power module solutions increasing the efficiency of air conditioners

For the lower power inverters, Mitsubishi Electric introduced SiC DIPIPM power devices with blocking voltage capability of 600 V and two different current ratings: 15 A and 25 A. This class of intelligent power modules contains the relevant components such as six switches and gate driver ICs to build compact inverters (cf. Figure 9). The intelligence of these products are the integrated protection functions, such as short-circuit protection, under-voltage lockout or over-temperature protection. As shown in Figure 8, the modules are manufactured using transfer molded technology, which allows to secure high productivity and robustness against influence of aggressive environments. Especially applications running almost 24 hours per day, such as air conditioners or pumps, can benefit from the increase of efficiency by applying SiC. Figure 10 shows a comparison to conventional silicon device and how 70% of converter power loss can be saved under regarded operating conditions.

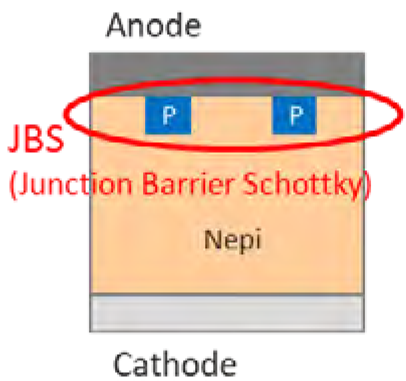

Figure 6: Structure of Mitsubishi Electric's Junction Barrier Schottky Diode

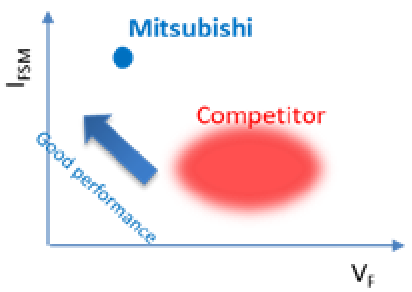

Figure 7: Diode Trade-off comparison (V_F vs. I_{FSM})

SiC Power Modules for Uninterruptable Power Supplies, Fast Chargers and Efficient Feed-In of Renewables

Applications like uninterruptable power supplies, fast chargers or the feed-in of renewable energy sources usually require much higher current ratings than discussed before. Therefore, Mitsubishi Electric has developed SiC power modules, that also feature the 2nd generation chip technology [5]. These modules offer the benefits of SiC technology to industrial applications requiring high currents, beyond the capability of discrete devices. Available are voltage classes of 1200 V and 1700 V and a wide line-up of current ratings up to 1200 A. As shown in Figure 11, the 2nd generation power modules are package-compatible to the 1st generation, allowing our customers an easier development based on their existing designs.

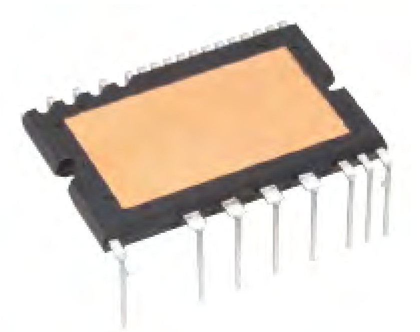

Figure 8: Super Mini Full SiC DIPIPM

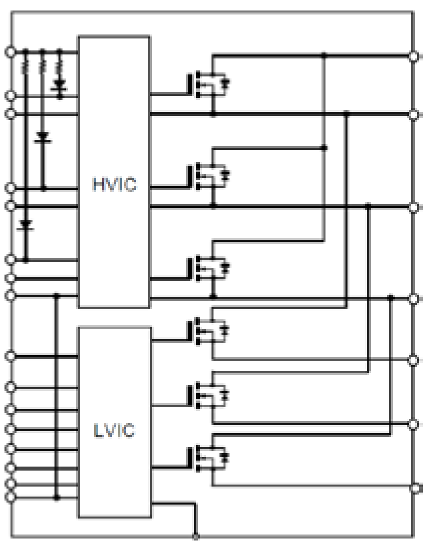

Figure 9: SiC DIPIPM internal block diagram

Key Features:

With 122 x 79.6 mm², the footprint of the modules is the same as Mitsubishi Electric's NX-series power modules. However, to reduce the parasitic loop inductance of the package significantly, the terminals were re-arranged, allowing a better utilization of the benefits of the SiC technology. Additionally, the design of the baseplate and the

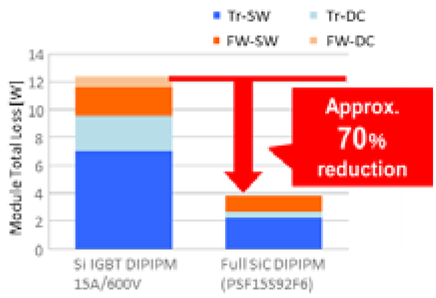

Figure 10: SiC DIPIPM benchmark (V_{cc}=300V, V_D=18V(SiC) /15V(Si), f_c=15kHz, PF=0.95, M=0.8, I_o=1.5Arms, T_j=125°)

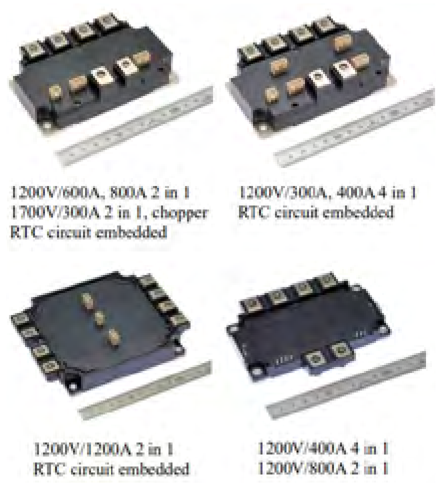

Figure 11: Industrial SiC power modules' line up

Model	Rated Voltage	Rated Current	Circuit Structure	RTC circuit	Size
FMF400BX-24B	1200 V	400 A	4 in 1	No	121.7 x 92.3
FMF800DX-24B		800 A	2 in 1	No	
FMF300BXZ-24B		300 A	4 in 1	Yes	122 x 79.6
FMF400BXZ-24B		400 A		Yes	
FMF600DXZ-24B		600 A	2 in 1	Yes	
FMF800DXZ-24B		800 A		Yes	
FMF1200DXZ-24B		1200 A		Yes	122 x 152
FMF300DXZ-34B	1700 V	300 A	2 in 1	Yes	122 x 79.6
FMF300E3XZ-34B		300 A	Chopper	Yes	

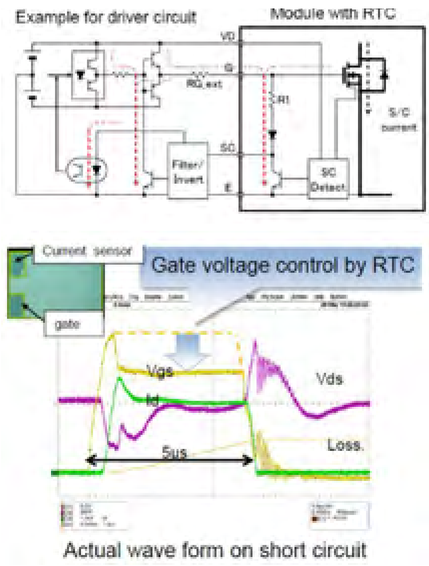

Figure 12: Efficient short circuit detection by RTC function

Figure 13: 3.3 kV Full-SiC power module in LV100 package with 6 kV insulation voltage

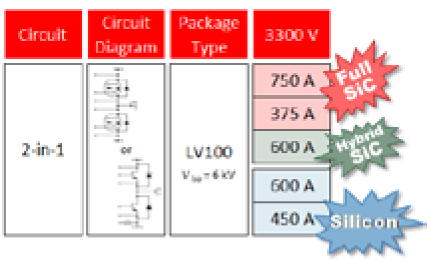

Figure 14: Lineup of 3.3 kV SiC and Si power modules in LV100 package

placement of the SiC-MOSFET and SiC-SBD chips was optimized to improve the heat spreading inside the package

The 2nd generation with the previously described JFET doping technology offers lowest overall losses. Compared to the 1st generation, both, the conduction and the switching losses were further reduced [6].

Mitsubishi Electric's Real-Time Control (RTC) function eases the design of short circuit protection. The design of short-circuit protection is a challenge when changing from IGBTs to SiC MOSFETs, as methods such as desaturation detection cannot be applied in the same way. To overcome these constraints, the RTC function detects a short circuit using current sensors integrated into the MOSFETs. When a short circuit is detected, the gate voltage is automatically reduced to limit the current and increase the short-circuit withstand time. This gives enough time to the driver circuit to react on the short circuit signal from the RTC function.

High-Voltage SiC Modules for Railway and Grid Applications

In this bullet train operation, SiC power modules allow a more efficient and more compact traction system. As an example, SiC power modules have enabled 20% weight savings in the Shinkansen drive train, leading to a more flexible railroad car designed. The volume of the traction inverter itself was reduced by 50% which was enabled by the lower losses of SiC devices leading to a simpler cooling system [7].

Besides traction inverters, auxiliary converters, railway battery chargers and dc-dc converters especially benefit from the switching frequency increase enabled by SiC power modules. The increasing switching frequency typically allows the size reduction of passive components (like transformers, inductors or capacitors). Moreover, the higher switching frequency might allow the use of different soft-magnetic core materials. It gives the potential for efficiency increase and cost reduction [8] [9].

With increasing voltage and power ratings, railway and grid applications demand for best performance and highest reliability. Mitsubishi Electric offers commercial high-power SiC modules for voltages up to 3.3 kV for high-reliability application. Already in 2015, Mitsubishi Electric has applied 3.3 kV Full-SiC semiconductor modules in high-speed bullet trains [10]. Hence, the robustness of these devices has been demonstrated under real conditions by several years of field operation.

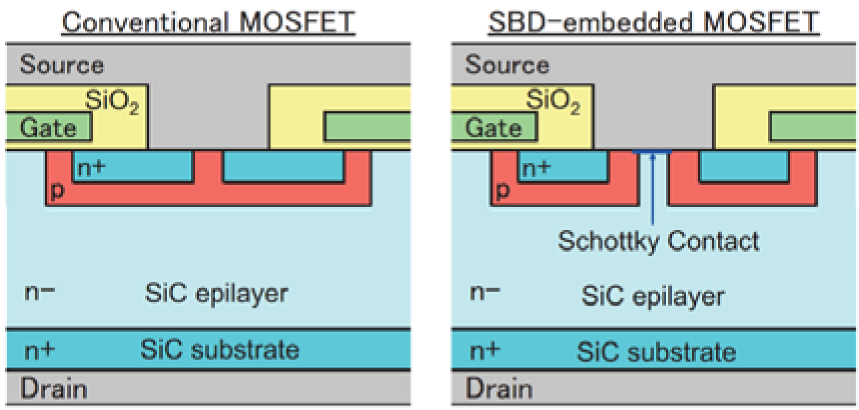

Figure 16: Structure of a conventional MOSFET and one with embedded SBD [12]

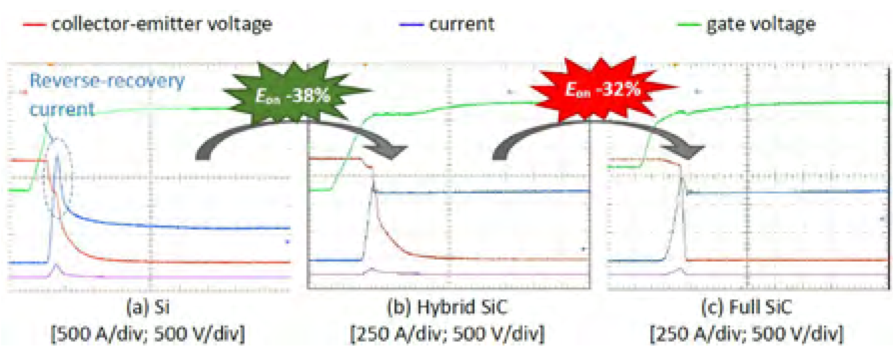

Figure 15: Comparison of turn-on waveforms between silicon (Si), hybrid SiC and Full-SiC (V_{cc} = 1800 V, I_C = 600A, T_j = 150 °C, L_s = 65 nH)

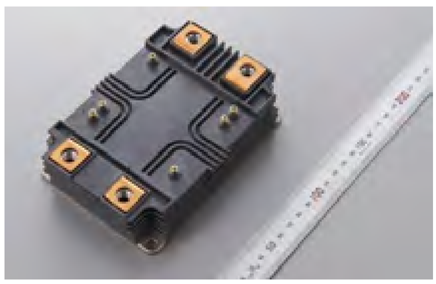

Figure 17: 6.5 kV Full-SiC power module in HV100 package with 10.2 kV insulation voltage

Mitsubishi Electric offers its 3.3 kV SiC power modules in the LV100 package as depicted in Figure 13. As shown in Figure 14, two different Full-SiC products are available with current ratings of 375 A and 750 A.

Additionally to Full-SiC Power Modules, Mitsubishi Electric also offers Hybrid-SiC modules. In the same LV100 package, a 600 A Hybrid-SiC module for 3.3 kV is available. This device combines an silicon High-Voltage IGBT of the latest X-Series generation with a SiC diode. Compared to the Si diode, the SiC diode is reverse-recovery free. Hence, the switching losses in the diode are much smaller. Moreover, the losses in the IGBT are reduced as well due to the absence of the reverse recovery current. As shown in Figure 15, IGBT turn-on losses are 38% lower. This makes the hybrid SiC power module the ideal candidate for relatively high switching frequencies (e.g. around 2 kHz). If higher switching frequency and lower losses are required, then Full-SiC power modules are the perfect choice.

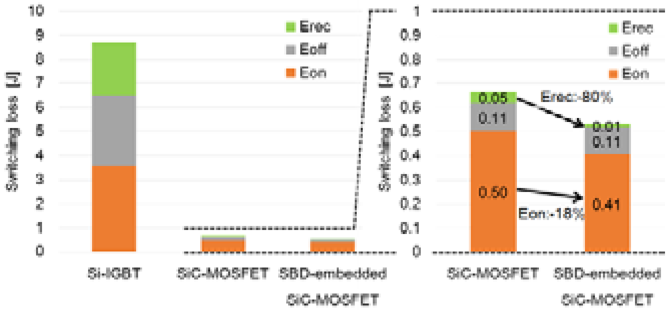

Figure 18: Comparison of switching loss between Si-IGBT at 150°C, SiC-MOSFET and SBD-embedded SiC-MOSFET at 175°C [13]

Beyond existing SiC products, Mitsubishi Electric is further developing SiC technology to become even more competitive in future. One research topic is related to the integration of the SiC SBD diode in the MOSFET structure. Generally, the SBD diode is required to avoid bipolar current flow through the body diode of the MOSFET. Hence, degradation effects like stacking faults are suppressed. To achieve this in today's SiC power modules, dedicated SBD diode chips are connected in parallel to the MOSFET chips. In future, the SBD structure is integrated into the MOSFET chip as shown in Figure 16. Additional benefits, besides avoidance of stacking fault, are lower switching losses and the omission of dedicated diode chips [11] [12].

The technology of embedding the SBD is also utilized in the 6.5 kV Full-SiC prototype [13]. This prototype utilizes the HV100 package as show in Figure 17 and is rated for 400 A. As shown in Figure 18, the switching losses of this device are less than 1/10 compared to a Si IGBT. This gives 6.5 kV SiC devices enormous potential for high-switching frequency applications.

Conclusion

This article has shown that today many applications benefit from the advantages of SiC devices, which result in more efficient and more compact power converters. All these different applications make different demands on the SiC devices. It has been shown that Mitsubishi Electric offers particular SiC products for nearly every application.

Acknowledgement

This work was supported by the New Energy and Industrial Technology Development Organization (NEDO).

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Coreless Transformers Isolate SiC Gate Drivers For EV & Industrial Applications

Along with requirements for higher voltage operation and greater efficiency, the latest EV and industrial power system trends push for greater integration and safety of power system devices. A key element in enabling these features are isolated gate drivers. Of the few methods of isolating a gate driver, the latest innovations of coreless transformer technology are paving the way for compact and efficient gate drivers for high voltage systems.

By Mitch van Ochten, Sr. Applications Engineer at ROHM USA

Conventional isolated gate driver technology, including discrete transformer, opto isolated, and capacitive methods, though viable in some applications, present challenges for the latest EV and industrial power systems. For instance, discrete transformers are low cost, but only allow for one-way communication from the microcontroller to the power device, and don't allow for communication of information back to the microcontroller such as temperature and overcurrent/short circuit. In the case of opto-isolators, this method suffers from LED output drop from higher temperature operation and aging, which requires higher current input over time and temperature to compensate for the LED output degradation. Lastly, capacitive gate drivers require a sine wave signal input to turn the output on, which may cause electromagnetic interference with wireless communications, such as WiFi.

Coreless Transformers Transform SiC Gate Drivers

Coreless transformer gate drivers, on the other hand, don't pose any of the challenges of other isolated gate driver technologies, and with innovative design, can provide several system enhancing features. Though there are a variety of coreless transformer implementations, ROHM's coreless transformer technology is built using three internal slabs with a low voltage section that provides a silicon interface with a DSP or microcontroller and a high voltage section that drivers the IGBT or MOSFET. The copper coils of ROHM's coreless transformers are separated by a slab of silicon dioxide, which is a very robust dielectric with a very high melting temperature and with similar properties to quartz. The low voltage section operates with 3.3 V to 5 V signals, compatible with a wide range of either 3.3 V or 5V microcontrollers or DSPs.

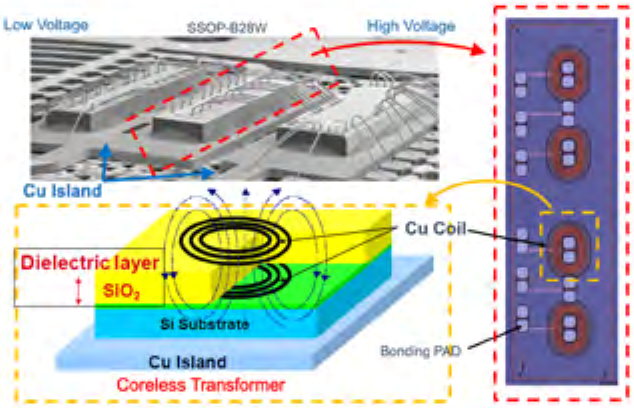
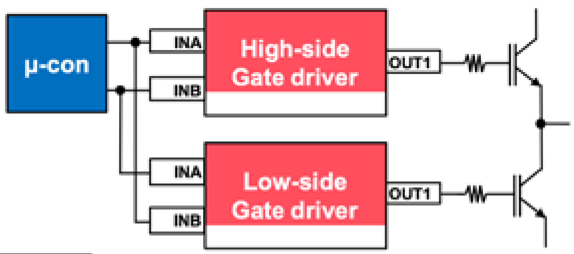


Figure 1: Coreless transformer gate drivers provide system-enhancing features

Unlike opto-isolator gate drivers, coreless transformer gate drivers exhibit a relatively flat turn on and turn off times over temperature. Opto-isolator gate drivers tend, on the other hand, to change behavior substantially with temperature variations with a much longer difference between turn on and turn off times, which equates to reduced efficiency due to larger dead times.



INA	INB	OUT1
L	H	L
L	L	L
H	L	H
H	H	L

Only one configuration of the two output INA and INB on the 4 possible gives output HIGH, this excludes the cross conduction when are connected like in the picture.

Figure 2: Exclusive OR configuration

Key Coreless Transformer Gate Driver Features

HS LS Cross Conduction Prevention With XOR Function

Cross wiring the XOR inputs of a half-bridge gate driver prevents both the low-side and high-side from turning on simultaneously, which is a key advantage of coreless transformer gate drivers over opto-isolator based drivers as this isn't viable with opto-isolators. Without this feature it is possible to enter a destructive mode where both the high-side and low-side are on simultaneously, which may even lead to a small explosion in addition to device failure.

Desaturation Detection Prevents Excessive Power Damage

A nominally operating power device will have roughly a 3 V difference between the source and the drain. However, during a major malfunction in the load, such as a shorted motor or power supply, the current passing through the device may reach 10 to 20 times that of the nominal operating current range. The result of this excessive current is greater than a 3 V difference between the source and drain, which results in large amounts of dissipation across the power device and puts the device at risk for overtemperature.

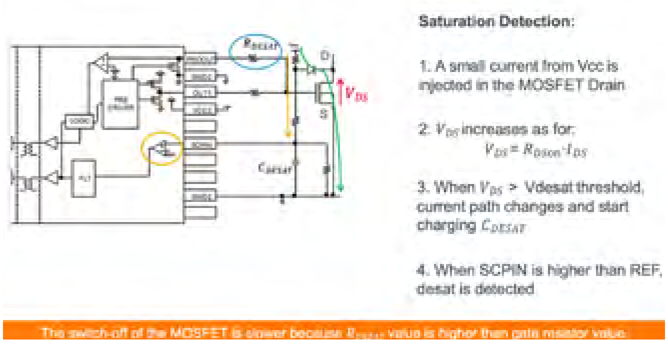


Figure 3: Desaturation circuitry

A method of addressing this is the use of desaturation detection and soft switch-off. Desaturation detection monitors the voltage across the device, and in the case of overvoltage, softly switches the device off preventing damage from excessive power.

Temperature Monitoring Flexibility With PWM Temperature Signal

Typical power device temperature monitoring uses a negative temperature coefficient thermistor where the resistance changes as a function of the device temperature. These thermistors are driven using a secondary side feed with a constant current through the thermistor, and the voltage across the device provides a voltage as a function of the thermistors temperature coefficient.

In the case of catastrophic device failure, it is not unknown for the failure to create a conductive plasma that could lead to an overvoltage of the thermistor. Power device bond wires or the DC bus traces may even separate from their pads and make contact with a thermistor traces or the thermistor itself leading to overvoltage events. The result of a thermistor overvoltage event could be failure of the device, which makes mitigation challenging without the necessary temperature information from the thermistor.

ROHM's solution to this with the coreless transformer technology is to use pulse-width modulated (PWM) signals to carry the temperature signal, where the signal is modulated based on the temperature profile. This allows for isolation from the primary side, and enables continuous monitoring of the baseplate temperature with less risk from catastrophic failures.

Integrated Miller Clamp Mitigates Transients

For typical half-bridge power devices, a very sudden dv/dt of 10s of nanoseconds from 0 to 800 V is experienced when the low-side device is shut off and the high-side device is engaged with the drain voltage of the low-side spiking toward the power rail. This is problematic as the intrinsic gate to drain capacitance of the low-side device may become charged and develop a voltage bump that exceeds 2 V to 2.5 V, which approaches the turn-on voltage for the lower device. This situation could lead to shoot through issues where both low-side and high-side of the half-bridge power device is on simultaneously.

Using a positive and negative voltage is a method of preventing this occurrence, as is the use of a Miller clamp. As there are additional costs and design complexities associated with use of a negative supply, the preferred method for many applications where it is viable is the use of a Miller clamp.

A Miller clamp is a transistor designed to provide a low resistance path from the gate of the mosfet source which clamps transient voltages, preventing too high a voltage being developed form the gate to the drain of the low-side device. In some power devices a Miller clamp is built in, or there is a port open in the gate driver to introduce a Miller clamp. ROHM's coreless transformer gate drivers include an integrated, active Miller clamping function with a gate control pin for the active miller clamp along with a power supply pin for the driving MOSFET for the Miller clamping function.

Conclusion

ROHM's latest Coreless Transformer Gate Drivers bring many features and performance advantages to the latest EV and Industrial power system applications. Along with extremely high isolation voltages, ROHM's gate drivers, such as the BM6112FV-C, also include many value added features that reduce a driver BOM and ensure the safety, efficiency, and monitoring of critical power circuit parameters.

www.rohm.com

Pulse Current Systems up to 35kA

The testing of safety elements under short-circuit conditions is an important safety aspect in the development of new electric vehicles.

By Michael Rost, Project Manager, IRS Systementwicklung GmbH

Introduction

The voltages of traction batteries in electric vehicles today are typically in the range of 400 to 800V and may in future aim at values of 1500V, since higher voltages can achieve higher performance with lower losses. The energies in these accumulators are enormous and can cause considerable damage in case of failure. Safety devices in electric vehicles ensure that the high voltages and energies in the high-voltage batteries do not endanger people - neither the driver, passengers nor first-aiders in the event of rescue after an accident.

Figure 1: IRS Systementwicklung GmbH and GvA Leistungselektronik GmbH develop in close cooperation pulse power sources for up to 35kA.

Even in the event of a crash, it must be ensured that no dangerous voltage can reach the body of the vehicle. To this end, fuses are used that very reliably disconnect the energy storage system before live parts can bend and make contact. Assuming that a short circuit nevertheless occurs in the vehicle as a result of the crash, currents of several kiloamperes must be reliably separated. This is done, for example, with the aid of so-called pyro-fuses, which break the electrical connection with a small blast, similar to the ignition pills used in airbags, which are common in the automotive industry. Pyrotechnic fuses are a safety-relevant component and must therefore be tested intensively.

In order to prove the triggering behavior of such a component under simulated short-circuit conditions, a current source is required that can supply several kiloamperes of current for a few milliseconds. In addition, it must generate a realistic battery voltage of up to 1500V while the fuse is tripping.

IRS Systementwicklung GmbH and GvA Leistungselektronik GmbH develop in close cooperation pulse power sources for up to 35kA. This cooperation combines the long and solid experience of GvA for power electronics, high current design and system manufacturing and IRS for software, safety and measurement technology.

On the one hand, the systems are used for design validation by manufacturers and testing institutes. In addition, random sample tests in production ensure the reliability of products with pyro-fuses.

Technical Description

Currents of 35kA at voltages of 1500V mean a peak power of more than 50 megawatts for short time. This amount of power may not be easily drawn from an even powerful industrial plant, not to mention from a standard laboratory socket outlet - the energy must be stored to be made quickly available at an instant.

The energy storage device is a capacitor, which is charged by power supplies up to a predefined voltage. The current pulse occurs when the capacitor is discharged via the device under test and an additional adjustable resistor in series. A semiconductor high speed high current switch defines the time

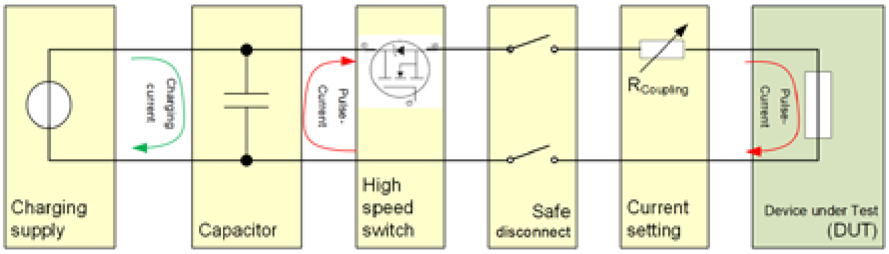


Figure 2: Simplified block diagram of the surge system

Key Facts

- Peak Currents up to 35kA
- Voltage Range up to 1500V
- Pulse Duration approx. 5ms @ 35kA
- Single or optional multi-pulse capability with IGBT technology

Applications

The surge testers from GvA and IRS can be used to test various switching devices in the automotive sector. The current focus is clearly on the separation of traction batteries in the event of a crash, but applications in the energy sector also have similar requirements.

of discharge, while mechanical contactors provide a safe disconnection during maintenance. The resistor and the voltage setting define the test current.

Energy Storage

Realistic battery voltages are already in the range of 400...800V today and will aim for 1500V in the future. Therefore capacitors with high dielectric strength must be used. Furthermore, the capacitors need high capacitances of more than two farads to keep the voltage within certain limits while the high pulse current flows. Such voltage-proof capacitors with high capacitance require a lot of space - between 3 and 8 cabinets, depending on the expansion stage.


It's not you, Mark.
I just need more space.


WOW!

To charge the capacitors up to 1500V within a few minutes, DC power supplies in the range of 10...50kW are used - depending on the required interval of firing. Furthermore, the power supplies must also be robust against possible overvoltages in the kilovolt range, which can be caused by inductive components. Finally, it is recommended to use units with mains feedback to efficiently feed back excess energy into the mains after the test.

Figure 3: Huge capacitor banks from GvA buffer the necessary energy

Pulse unit

If the capacitor is charged, the current is fed into the test object via the pulse unit at a defined time. This is initially done via the fast semiconductor switch, which is available in two versions depending on the requirements:

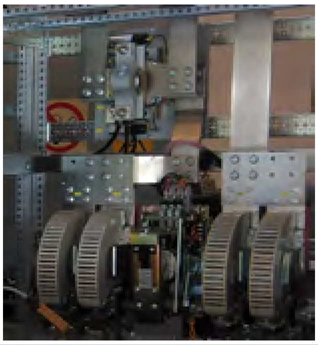
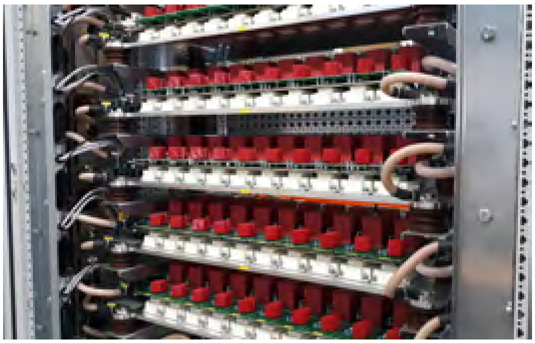
Thyristor	IGBT Stack
	
• Single shot • Reliable standard component • Cost effective solution	• Multi-shot with on/off function • complex IGBT array • for any timing in µs resolution

Figure 4: Semiconductor switches from GvA in comparison: cost-effective vs. complex timing

Figure 5: Current setting via resistance matrix and/or monitored jumper

While thyristor solutions can trigger a single current pulse at a precise point in time due to their DC voltage structure, the complex IGBT stack can be switched on and off at any time. This increases the flexibility of the system, e.g. to test closing switching elements with pulse current.

The test current is determined by the voltage applied to the capacitor and an adjustable resistance. Various solutions are in use in which configurable resistance matrices and, optionally, additional inductors simulate the internal resistance of the battery. If the resistance can be easily selected manually by the user via jumpers, it is possible to monitor this connection optically to exclude operator errors.

Measuring and control unit

The power section of the impulse system must be safely controlled and measurement data must be recorded in order to perform an analysis and evaluation later. Compact RIO from National Instruments is used in combination with IRS modules for precise timing and measurement. On the one hand, this platform enables powerful measurement and control technology in the µs range with a combination of processor with real-time operating system and FPGA. On the other hand there is a seamless connection to Windows systems to analyze the measurement data with familiar tools.

While current and voltage pulses are recorded at high sampling rates, interference in the harsh environment of high magnetic fields must be suppressed. Hardware and software from IRS ensure that clean test results are available for further processing.

Figure 6: Time-precise control via fiber optic cables and analog measurement

The control of the power electronics (thyristor or IGBT) is galvanically isolated via IRS Compact-RIO optical interfaces. This ensures that the measuring system can be placed safely separated from the power electronics and that disturbing influences remain minimal. The measuring system is also galvanically isolated from the operating computer via fiber optics. Thus, the measuring technology and the control system in the operating room are additionally spatially separated from dangerous voltages.

User Interface

The system is controlled by an industrial PC with an IRS user interface, which makes it easy for the plant operator to create and execute test configurations. The status of the current source is always visualized and it is possible to process the measured data and waveforms for further analysis.

Safety engineering

Last but not least, safety is a critical issue in the operation of pulsed power systems. Safety controllers monitor the status of door contacts and interlocks, insulation and voltage monitors and control door interlocks, discharge contactors, load and ground switches to ensure that people are not endangered at any time. After all, touching voltages of up to 1500V is life-threatening. It must be ensured that the system is only in operation when all safety circuits are working without errors, doors are closed and all system states are plausible. Only when the energy has been almost completely dissipated, all accessible connections are automatically grounded and access to the test room is granted. At the same time, power supply units with mains recovery guarantee the efficient recovery of excess stored energy.

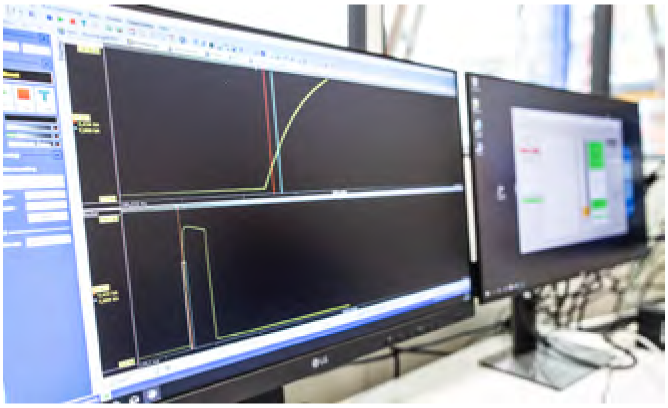


Figure 7: User software for easy configuration and visualization

Figure 8: Safety control to avoid dangerous situations

But electrical hazards are not the only ones from which employees and visitors must be protected, because in the event of a fault, a test specimen can burst. It should be noted that more than 2 megajoules of energy are stored in a fully charged system.

If only 1% of this energy were to be converted into the movement of a mechanical component of a bursting test specimen, this part would get the force of a 12mm projectile. Spatial separation of the test specimen and safe software is therefore essential for the operation of such a system.

A safety control always monitors the condition of the system as well as that of the higher-level test field - independent of the software used to operate the system.

Technical data

Different variants of surge current systems have been developed and built - depending on customer requirements. The following data represent the parameters of a fully developed version according to the current status. Smaller or larger variants can be supplied individually according to customer requirements.

	Min	Typ	Max	Unit
Voltage range	10		1500	V
Output current	0,1		35	kA
Charging power	15		45	kW
Timing resolution (control and measurement)		1		µs
Pulse duration (@35kA) Depending on capacitance and voltage drop		5		ms

www.irs.systems

www.gva-leistungselektronik.de

Reducing Size, Noise, and Field Failures of Transportation APUs

Designers are finally able to extract disruptive system-level benefits of SiC technology to shrink the size, noise, and field failures of auxiliary power units (APUs) in transportation vehicles.

By Kevin Speer, Nitesh Satheesh, and Marc Rommerswinkel, Microchip Technology

As vehicle electrification proliferates the consumer EV segment other forms of transportation are also chasing the global macrotrend, including railway, aircraft, delivery trucks, off-highway vehicles, and more. Common across all forms of electrified vehicles are two electrification systems: the traction power unit (TPU), which provides vehicle propulsion; and the auxiliary power unit (APU), which supplies power for all other on-board loads, from lighting and doors to air conditioning and power outlets.

Unlike consumer EVs which put a premium on range-per-charge other transportation use cases may have different priorities addressed through improvements in the APU. Cabin space comes at a premium in light rail, for example, as free space allows more paying passengers. Field reliability is paramount for mining vehicles, where downtime is measured in millions of dollars per day. And across all use cases, passenger comfort is critical in a market served by competitive OEMs targeting choosy buyers.

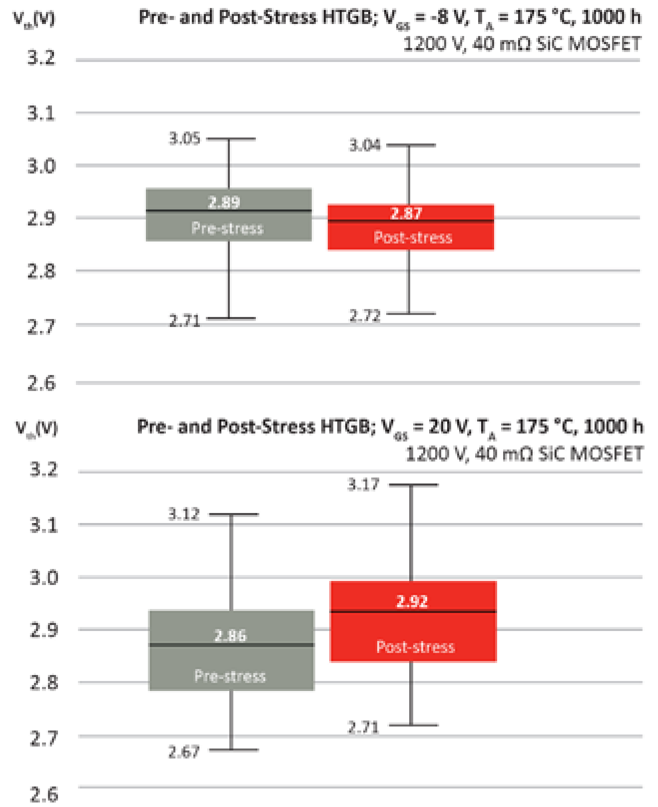


Figure 1: Threshold voltage of production-grade SiC MOSFETs before and after (top) negative and (bottom) positive high-temperature gate bias stress

The high switching losses of silicon IGBTs have blocked transportation APU improvements. By limiting switching frequency, IGBTs fix the minimum size of the APU's largest physical components, the isolation transformer and heatsink. With SiC, one can drastically downsize the isolation transformer by switching at higher frequencies; and with switching losses reduced by 80% or more, heat sinks shrink in turn. In addition, APU switching frequencies can extend beyond the audible range, eliminating the high-pitched whine that is tiresome for passengers. Last, efficiency is essential because the APU is continuously operating, often under light load; the conduction losses of SiC MOSFETs are lower than competing IGBTs under light load conditions.

SiC Up to the Task?

The toughness of the SiC MOSFETs across wide-ranging conditions is essential for APUs that power both convenience and emergency loads. One must verify: 1) the stability of the MOSFET's gate oxide, a known issue for SiC MOSFETs; 2) the lifetime of the gate oxide; 3) the stability of the MOSFET's body diode; and 4) failure toughness measures such as avalanche ruggedness and short circuit survival.

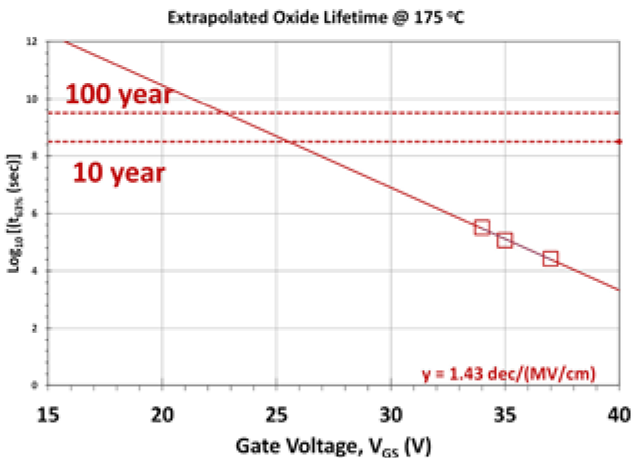


Figure 2: Example of extrapolated oxide lifetime of production-grade SiC MOSFET from Microchip

Gate oxide integrity

Should the threshold voltage shift, device performance changes (e.g., increased on-resistance), leading to erratic system behavior and possible APU failure. Figure 1 shows how Vth data for production-grade SiC MOSFETs should exhibit no meaningful change after 1000 h of stress at 175 C.

One can predict gate oxide lifetime by accelerating samples to failure using elevated temperature and electric field. Activation energy is extracted for each failure mode, and an Arrhenius equation is used

to extrapolate oxide lifetime (see Figure 2). A production-grade SiC MOSFET gate oxide can last well beyond 100 years at high stress, ensuring confidence in routine, reliable APU operation beyond the designed service lifetime.

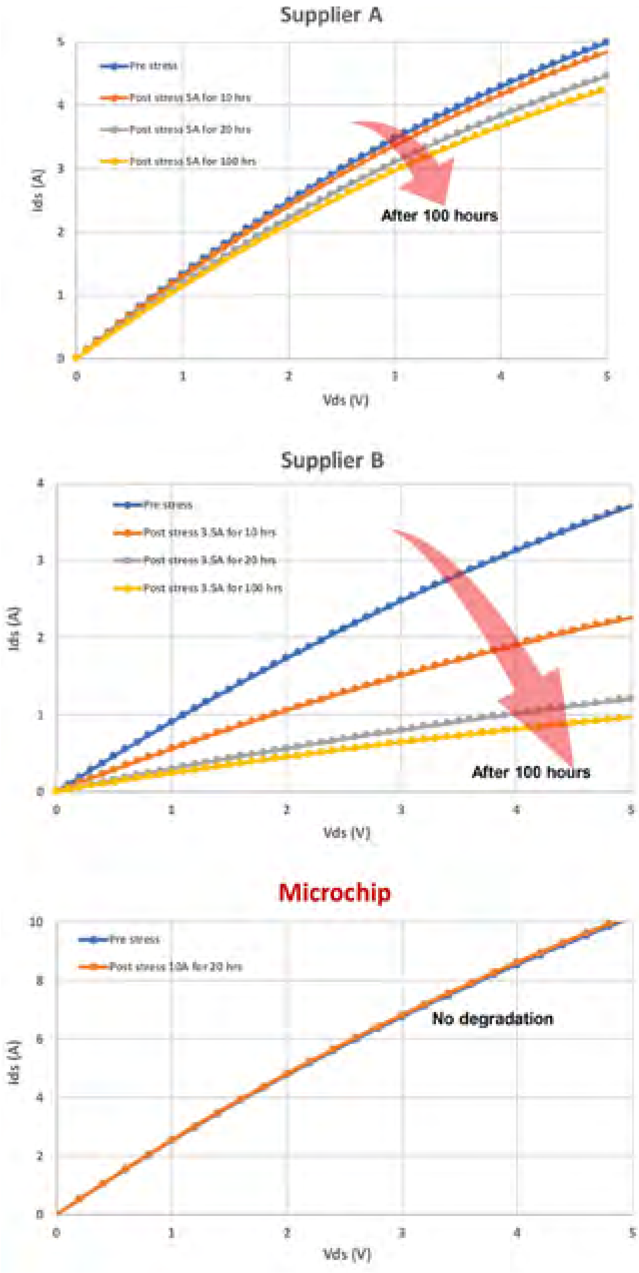


Figure 3: Pre- and post-stress R_{DSon} for commercially available SiC MOSFETs, revealing varying quality of the intrinsic body diode from three suppliers [1]

Body diode stability

Unlike the IGBT, the SiC MOSFET can conduct reverse current using its intrinsic body diode. In some devices, this diode degrades over time, leading to an increased RDS,on and more heat than designed. Figure 3 shows body diode I-V curves and MOSFET ON-state drain–source resistance (RDSon) after many hours of constant forward current stress [1]. Wide variation was seen across suppliers. One supplier had noticeable degradation; another became unusable. Selected devices should show no perceptible shift. Using a SiC MOSFET with stable body diode enhances reliability and cuts cost by eliminating the antiparallel diode.

Field survival: Short circuit and Avalanche

Transportation APUs are susceptible to a variety of fault conditions, demanding SiC MOSFETs designed to safely ride through these events and maintain consistent performance before and after faults.

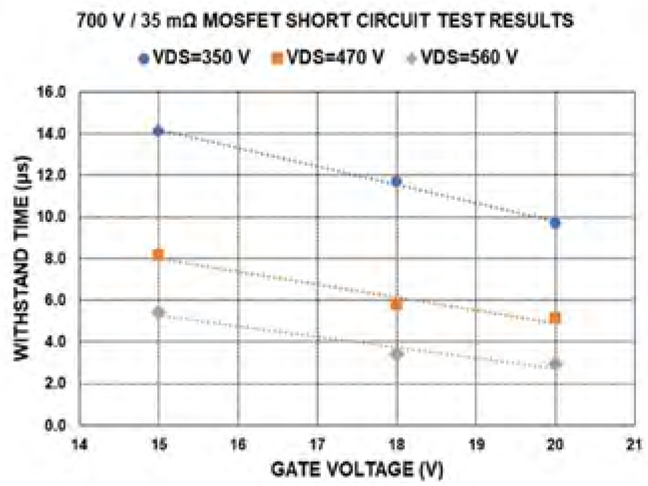


Figure 4: Short circuit withstand time for production-grade SiC MOSFETs from Microchip

Short circuit withstand capability measures the MOSFET's ability to survive an instantaneous short of the dc link across its drain-source terminals. The MOS channels are enhanced, allowing a properly designed device to safely distribute peak currents across the MOSFET die area. Figure 4 shows short circuit withstand times (SCWTs) for production-grade SiC MOSFETs – the Microchip example is between 3 and 14 microseconds, with dependence on dc link voltage and applied VGS. This is sufficient for many commercially available gate drivers. An advanced driver, such as that described in the next section, adds intelligence to short circuit detection.

Avalanche ruggedness is even more demanding: the load current is suddenly dumped into the MOSFET, forcing the drain-source voltage to rise to breakdown. Unlike short circuit, the MOS channels are not enhanced; avalanche current crowds the die edge, rapidly taking the device to its thermal limitations.

Repetitive unclamped inductive switching (R-UIS) is used to evaluate a device's avalanche ruggedness. Figure 5 shows time-dependent dielectric breakdown (TDDB) for commercial SiC MOSFETs before

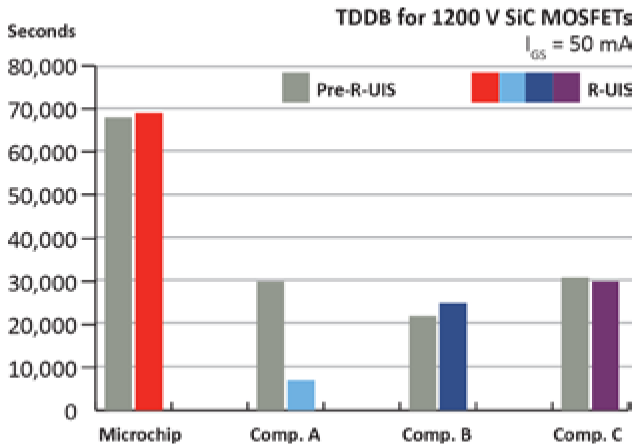


Figure 5: Time-dependent dielectric breakdown before and after repetitive avalanche failure for commercially available SiC MOSFETs from four suppliers

and after 100,000 cycles of R-UIS. Many suppliers maintain oxide strength but the ability to demonstrate up to four times the toughness alongside stability in R_{DSon} and drain-source leakage [2] reinforces the SiC MOSFETs' ability to safely ride through the most demanding electric overstress conditions.

Switch Faster with Low-inductance Packaging

Combined with high edge rates, problematic inductances in a power system cause higher switching losses, excessive overshoot voltages, non-compliant EMI, and potentially, APU failure. The preventative measures designers must take to slow down the MOSFETs' speed may leave them wondering what happened to SiC's value proposition.

Microchip's low-inductance SP6LI package illustrates how these problems can be solved. The phase leg-configured format inserts less than 3 nanohenries of parasitic inductance to the power loop. Internally, layout optimizations have been made to ensure identical timing and current sharing. Thermal performance can be improved with the use of silicon nitride ceramics (aluminum nitride also offered), and baseplate options include copper and AlSiC. Externally, the power terminals allow a low-inductance connection to the dc link and optimal paralleling in two orientations. The SP6LI allows the designer to drive the SiC MOSFETs at higher speeds with maximum efficiency and reduced EMI, shrinking APUs while precluding EMI-related failures.

Gate Drivers Keep APUs on Track

APU performance and reliability can also be optimized using digital programmable gate drivers that enable overshoot voltage and switching losses to be fine-tuned on the fly. This allows designers to reduce APU cost and size with lower-voltage parts and smaller heat sinks – and eliminating hours with a soldering iron and bin of gate resistors.

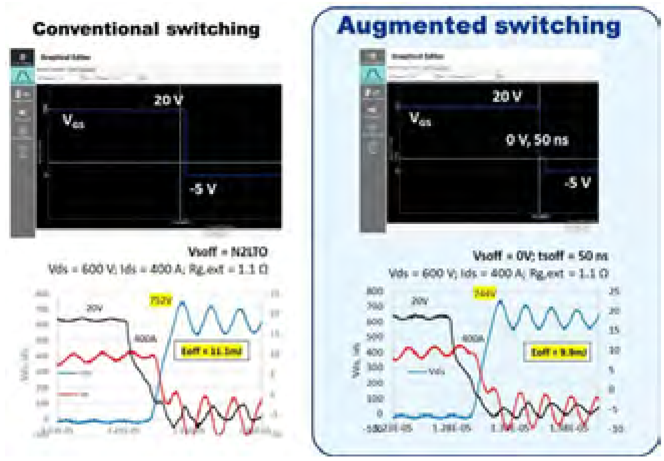


Figure 6: Graphical user interface for programmable AgileSwitch™ gate driver and turn-off waveforms using (left) conventional switching and (right) augmented switching

Figure 7: Demonstration of how augmented switching (right) can reduce peak voltage and peak current during short circuit event compared to conventional switching (left)

The impact of augmented switching may be seen in Figure 6. Unlike conventional turn-off (left), augmented turn-off begins with an on-stage voltage of 20 V, moves to a user-programmed intermediate level for a specified dwell time, and finally to the off-state of -5 V. The effects are modest due to the SP6LI's extraordinarily low inductance; results are published elsewhere showing more pronounced influence [2,3]. In addition, short circuit events are quickly arrested, reducing peak voltage and current by 60% and 10%, respectively (Figure 7).

Total SiC System Solution

Designers wishing to streamline from double-pulse evaluation through volume production will need accelerated development kits that unify all three pieces into the total SiC system solution for transportation APUs: rugged SiC power devices, low-inductance power package and intelligent gate driver. Figure 8 shows how Microchip's solution may be dropped into an APU circuit.

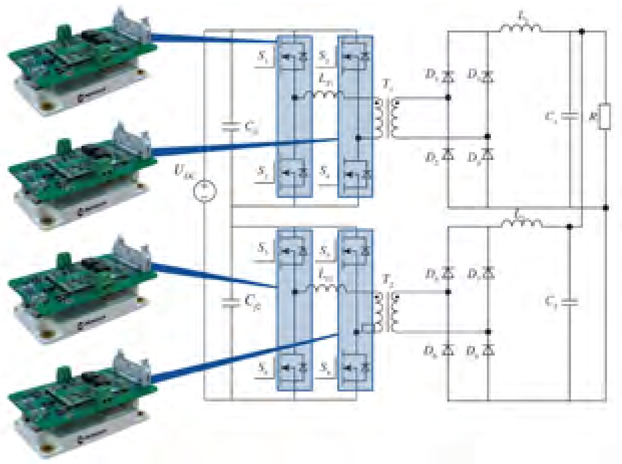


Figure 8: Proposed phase-shifted full bridge implementation of the Microchip ASDAK+ in the DC-DC section of a transportation APU [4]

Summary

The use of SiC MOSFETs in auxiliary power units for transportation vehicles offers disruptive benefits over silicon IGBTs with respect to the APU's size, weight, efficiency, and noise. However, these benefits may only be realized with high field reliability using rugged SiC MOSFETs, low-inductance packaging, and a gate driver intelligent enough to take control of SiC's agile performance. Designers can now solve the challenges with total SiC system solutions that simultaneously enable a reduction in size, noise, and field failures.

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www.microchip.com

Achieving Fast Switching with a High-Voltage Isolated Driver IC

Industrial systems have struggled in recent years with the need of high efficiency, combined with the need of more compact systems. This also influences the choice of the gate drivers associated to high speed switches, like Silicon Carbide (SiC) MOSFETs. STMicroelectronics has recently launched the STGAP2, a family of isolated gate drivers focused on the industrial power market. Its portfolio includes different isolation voltages and functionalities.

By Vladimir Scarpa, Jan Svetlik, and Michele Lauria, ST Microelectronics

Isolated gate drivers are widely used in industrial power applications. In high switching frequency applications, the high commutation slopes of the power switches require immunity against high levels of common mode noise. In addition, isolation capability and very short signal propagation delay are also typically required.

The STGAP2S product family [1] [2] , from STMicroelectronics, offers isolation through a coreless transformer, with propagation delay of 80 ns. In addition, it has an immunity against common mode above 100 V/ns. The isolation between primary and secondary sides is tested up to 1.7 kV. All this in a very compact package: the single channel driver is available in SO-8N package, while the STGAP2D - dual channel – is available in SO-16N package. The is offered in two variants: one STGAP2SCM, with active Miller clamp (AMC), and STGAP2SM, with separated on- and off- outputs. The comparative table of all devices from STGAP2 technology is shown below in Table 1.

The devices from the STGAP2S family have 4 mm creepage distance between primary and secondary sides. For some applications, there might be the need of higher creepage distances, depending on pollution degree and maximum humidity levels.
In these cases, STGAP2HS [3] family is indicated. It is offered in an SO-8W package, with 8 mm creepage, allowing the gate drivers from this family to be tested with 6 kV.
In addition, this family also includes dedicated part numbers for operation with SiC MOSFETs, namely STGAP2SiCS [4] . They have increased values of under voltage lockout (UVLO) to couple with the higher operation gate voltage of those switches.

Common Mode Transient Immunity
Fast power switches applied in industrial applications can present slew rates above 50 V/ns. This is a desired feature to reduce dynamic losses and achieve higher system efficiency. Fast transients can generate disturbances in the associated gate driver though. In high side drivers, the fast transient in the secondary side can generate oscillations in the primary ground. In the worst case, this may cause glitches in the input signal, and consequently, the unwanted switch on of the SiC MOSFET.

Figure 1 shows experimental results with the STGAP2S device during very fast transients, both positive and negative, with a DC voltage V_{dc}=1500 V. The waveforms demonstrate that, even for slew rates in the order of 120 to 130 V/ns, the gate driver was able to properly operate and maintain the desired output state.

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Coupling Through Miller Capacitance
High slew-rate transients in the Drain to Source voltage can also cause oscillations in the gate through the Miller capacitance (MC) i.e. the parasitic capacitance between Drain and Gate of a MOSFET. To

2. Part number	# Channels	Package	Isolation[1]	UVLO[2]	Output Conf.
STGAP2SM	Single	SO-8N	1.7 kV	9.1 V	Separated on/off
STGAP2SCM					Miller Clamp
STGAP2D	Dual	SO-16N			Single Output
STGAP2HSM	Single	SO-8W	6 kV	9.1 V	Separated on/off
STGAP2HSCM					Miller Clamp
STGAP2SiCS				15.5 V	Separated on/off
STGAP2SiCSC					Miller Clamp

Table 1: Product portfolio of STGAP2 Technology.
[1] more details on the isolation voltage in a dedicated section.
[2] referred as the typical value of the turn-on threshold, as stated in the datasheet.

Figure 1: Measured positive and negative transients in the STGAP2S, V_{DC}=1500V.

minimize it, one of the variants of the STGAP2S, the STGAP25CM, offers an active Miller clamp (AMC), see Figure 2.

The AMC is a recommended functionality for use with SiC MOSFETs in applications where fast hard-switching transients are expected. Figure 3 depicts idealized waveforms of a half-bridge inverter using the SCTW35N120G2V, a 650V rated SiC MOSFET from STMicroelectronics [6] . As the output current is assumed positive, the low side switch (S2) is turned-on during the free-wheeling time. After a short dead-time after the turn-off of S2, the high side switch S1 is turned-on. When this happens, the V_{DS} of S1 goes to zero, causing the V_{DS} of S2 to increase. Both transients have same slew-rate. The gate voltage V_{GS} of S2, which was in OFF voltage, is now pulled up by the coupling through Miller capacitance. In the same way, V_{GS} is pulled down when S1 turns off. Symmetrically, the same kind of oscillations are expected in S1 when output current is negative.

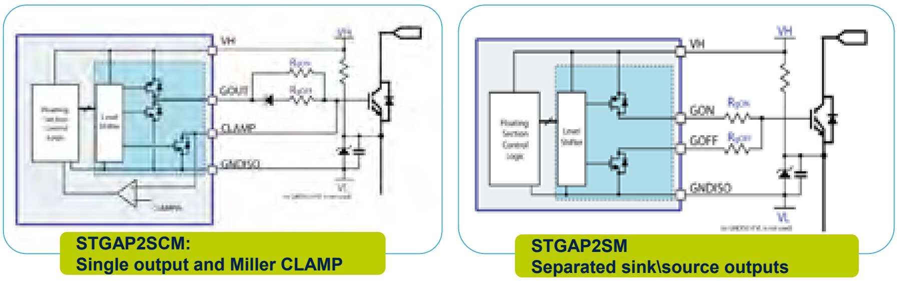
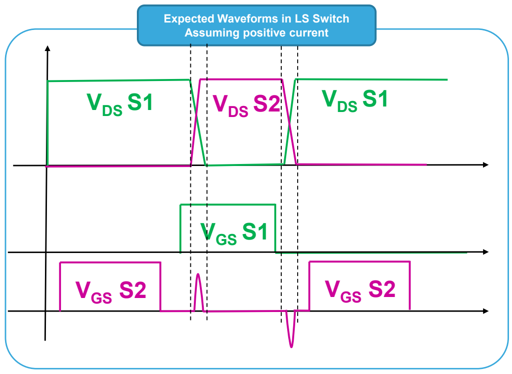


Figure 2: Available options of the STGAP2S.



Device	Description
S1 & S2	SCTW35N65G2V (55 mΩ, 650 V SiC MOS)
Gate Driver	STGAP2S, in both versions AMC and SO

Figure 3: Half-Bridge inverter with SIC MOSFETs, and idealized waveforms of V_{DS} and V_{GS}.

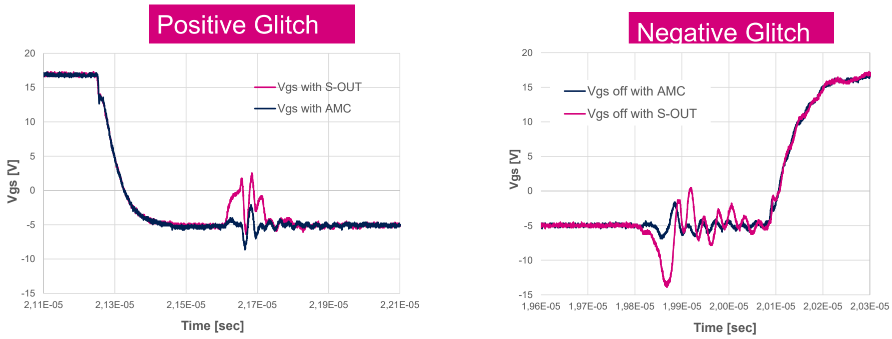


Figure 4: V_{GS} waveforms in the half-bridge inverter, using two variants of the STGAP2S.

Maximum Operating voltage in application

Partial Discharge Test
Done on 100% production

Maximum "Temporary overvoltage"
Used in many IEC standards
Usually expressed in peak value

Surge (Impulse voltage test)

Isolation Voltage
"UL 1577"
Usually expressed in rms value

Isolation Voltage Test
"UL 1577"
Done on 100% production
Usually expressed in rms value

Ability of package to avoid arching. The higher, the better

Related to CTI.
Can be I, II, II or IV
The higher, the better

Conform with VDE 0884-11 and UL1577 standards

Parameter	Symbol	Test Conditions	Characteristic	Unit
Maximum Working isolation Voltage	V_{IORM}		1200	V_{PEAK}
Input to Output test voltage	V_{PR}	Method a, Type and sample test $V_{PR} = V_{IORM} \times 1.6$, t_m= 10 s Partial discharge < 5 pC	1920	V_{PEAK}
		Method b, 100% Production test $V_{PR} = V_{IORM} \times 1.875$, t_m = 1 s Partial discharge < 5 pC	2250	V_{PEAK}
Transient Overvoltage	V_{IOTM}	Type test; t_{ini} = 60 s	6000	V_{PEAK}
Maximum Surge isolation Voltage	V_{IOSM}	Type test;	6000	V_{PEAK}
isolation Resistance	R_{IO}	Type test; V_{IO} = 500 V at T_S	> 10^9	Ω
Isolation Withstand Voltage	V_{ISO}	1 min. (type test)	3535/5000	$V_{rms\ /\ PEAK}$
Isolation Test Voltage	$V_{ISO,test}$	1 sec. (100% production)	4242/6000	$V_{rms\ /\ PEAK}$

Parameter	Symbol	Value	Unit	Conditions
Creepage (Minimum External Tracking)	CPG	8	mm	Measured from input terminals to output terminals, shortest distance path along body
Comparative Tracking Index (Tracking Resistance)	CTI	≥ 400	V	DIN IEC 112/VDE 0303 Part 1
Isolation group		II		Material Group (DIN VDE 0110, 1/89, Table1)

Table 2: Voltage characteristics of the STGAP2H devices in SO-8W package.

Both positive and negative oscillations in V_{GS} during OFF state can have a negative impact on the device and the system. Positive oscillations can cause parasitic turn-on of the MOSFET, and consequent shot-thru of the entire half-bridge. On the other hand, negative oscillations may bring V_{GS} outside of the safe operation area (SOA), and trigger degradation mechanisms in the device.

As can be seen by the waveforms in Figure 4, the ACM is able to reduce both positive and negative spikes of V_{GS} during off state, down to safe values. As it can be shown, when driven by the STGAP2SM, the V_{GS} of a SiC MOSFET can achieve positive values, with the consequent risk of parasitic-turn-on. With the STGAP2SCM, the same configuration presents much lower spikes, which never reach positive values.

In the same way, the negative oscillations in the right side of Figure 4 are also reduced. The configuration with the STGAP2SM presents negative peaks below the absolute minimum gate voltage, which lays at $V_{GS,min}$=-10 V for the SCTW35N65G2V. With the STGAP2SCM, the negative spikes never reach $V_{GS,min}$.

Isolation voltage

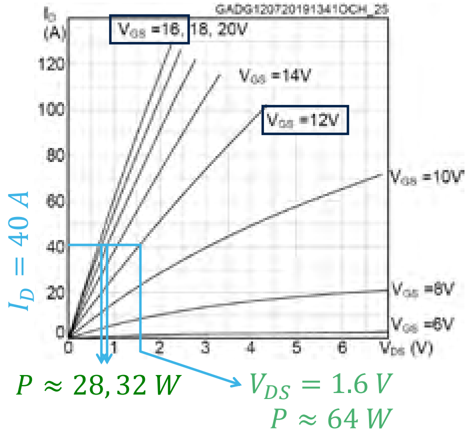
The gate drivers inside the SO-8W package – refer to Table 1 – have an isolation of 6 kV. This voltage is related to the test voltage during production, in accordance to UL1577.
More details on the voltage characteristics of the STGAP2H family in SO-8W package are shown in Table 2.

Undervoltage Lock-out (UVLO)

The undervoltage lock-out (UVLO) is a protection feature, present in all STGAP2 devices. It prevents the power switch from being driven with a voltage below its requirements. The UVLO protection is activated when the supply voltage of the secondary side, i.e. the voltage between pins VH and GNDISO, drops below a certain value.

IGBTs and super-junction MOSFETs operate with gate voltages between +12 V and +15 V. Below this range, the on-resistance of the MOSFET – or the saturation voltage of the IGBTs – starts to increase, and with it the conduction losses of the switch. The switch could also start to operate in linear mode, leading to thermal runway and to device failure. The same can also occur in SiC MOSFETs. However, due to the required higher voltage on the gate – from +18V to +20V, - the value at which the UVLO is activated needs to be increased accordingly.

Figure 5 presents the output characteristics of the STW90N65G2V [5]. The V-I curves on the graph are obtained for different values of gate-to-source voltages V_{GS}, at room temperature. The values below the graph are the calculated power dissipation due to current conduction, at a drain current of 40 A. For V_{GS} = 18 V, the nominal value for this device, the resulting dissipation is around 28 W.



STGAP2SiCS UVLO Values

	Min	Typ.	Max
$V_{HL(ON)}$ [V]	14.6	15.5	16.4
$V_{HL(OFF)}$ [V]	13.9	14.8	15.7

Figure 5 – Output characteristics of SCTW90N65G2V SiC MOSFET, and calculated conduction losses for different gate-to-source voltages.

If the power supply on the gate driver drops, this will affect V_{GS} as well. On the graph we have the example for V_{GS} = 12 V, that would already increase the conduction losses almost double. Going even further down will cause the MOSFET to operate in linear mode. The extremely high associated losses can cause the MOSFET to fail due to overheating.

To avoid that, the UVLO of the STGAP2SiCS [5] devices has been increased to 15.5 V. This guarantees proper protection even if bipolar drive is applied to the MOSFET. As an example, if a negative off voltage of -3V is applied to the MOSFET, this will bring the effective activation voltage down to +12.5V, still safe enough for SiC MOSFETs.

Summary

The devices in the STGAP2 technology family enable operation at very high switching speeds, and in turn, enabling high power density of industrial systems. Among their very interesting features are CMTI above 100 V/ns, typical propagation of 80 ns, and active Miller clamp functionality. The newest STGAP2HS is offered in an SO-8W package, which allows a higher isolation voltage of 6 kV. Specifically designed for combination with SiC MOSFETs, the STGAP2SiCS has an increased UVLO value, to guarantee its proper protection function.

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3. https://www.st.com/resource/en/datasheet/stgap2hs.pdf
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Chip Embedded Technology Enables High Current Density Power Modules

3D Design Approach Delivers 1 Watt per Cubic Millimeter

DC-DC power modules in the past 10 years have evolved into new emerging, chip embedded technologies with newly enhanced thermal packaging techniques that allow for higher-density module designs in smaller form factors. Power modules today incorporate: 1) DC-DC converters including FETs and drivers, 2) integrated inductors, 3) passives for Vcc and Boot start up, and 4) in some cases communications for advanced power functionality.

By Tony Ochoa, Director, Faraday Semi, a TDK Group Company

3D design techniques can help reduce parasitic losses, and improve thermal performance while also reducing the PCB footprint. These key factors benefit DC-DC applications requiring compact design and the highest levels of current density and power delivery.

The New Technology

The needed paradigm shift for near future micro-point-of-load power (µPOL™) modules requires leading-edge technologies and a cross-functional approach:

- Packaging design to address thermal and regulation performance
- Innovative integrated circuit (IC) design for compact regulator design with extreme accuracy
- Paralleled magnetic and discrete component development
- Three dimensional design approach of all on-package components
- Manufacturing technology development for sustainability and reliability

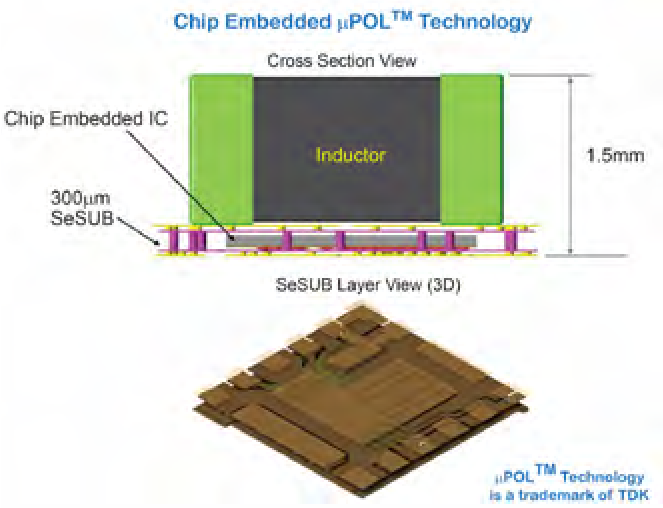


Figure 1: Chip Embedded Power Module Technology

Figure 1 shows an example of the latest developments in chip embedded power module technology. The IC containing the DC-DC regulator circuit is embedded into a thermally enhanced packaging technology called Semiconductor Embedded in SUBstrate (SESUB). The embedded IC die and the SESUB technology includes a patented technology implementation of copper heat sink layers and a 3-dimensional construction of metal and laminate materials, creating reduced thermal resistance paths to the bottom-side of the package substrate. The module substrate, with the embedded die, is 300 µm thick maximum. The SESUB technology eliminates the need for wire bonds which greatly reduces unnecessary parasitic losses while increasing the mechanical package strength. Historically wire bonds are prone to breakage during heavy vibration and drop tests. End product testing has demonstrated that all industry standard mechanical (up to 50G) and thermal stress tests are met utilizing the SESUB technology.

The low profile substrate is then populated on its top mounting surface with an industry leading thin film power inductor, thus yielding an overall thickness of 1.5 mm height. At 1.5 mm, this technology opens the door for low profile DC-DC solutions that enable PCB board layouts to have the power in closer proximity to the load. This is key for upcoming 7 nm ASICs, SoCs, FPGAs and multi-core ARMs covered by height limiting heatsinks under 3 mm.

Examples of 3D Chip Embedded Power Modules

Figure 2 showcases complete high density power modules delivering 15W (FS1406) and 30W (FS1412), at 3.3mm x 3.3mm x 1.5mm height for 6A and 4.9 mm x 5.8 mm x 1.6 mm for 12A, respectively. The 6A device delivers 650 A per cubic inch current density, while the 12A device delivers in excess of 1000 A per cubic inch, with both being two to four times more than current DC-DC power module technologies. These numbers will increase in the near future with the development of 25A to 200A current sharing modules, and at 3 mm to 4 mm height profiles. These will be ideal for high current density core voltages in upcoming artificial intelligent (AI) SoCs and ASICs for small form factor applications.

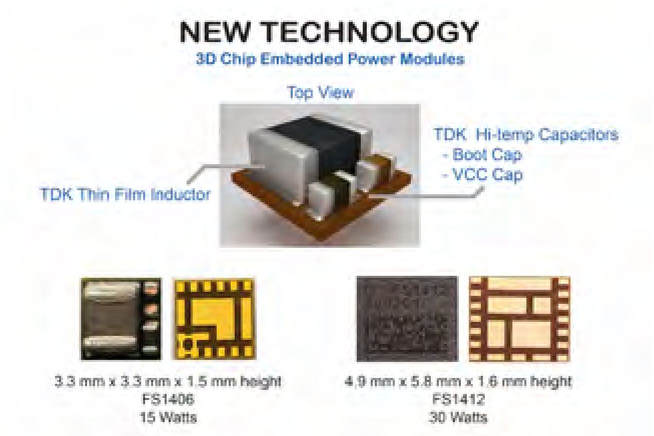
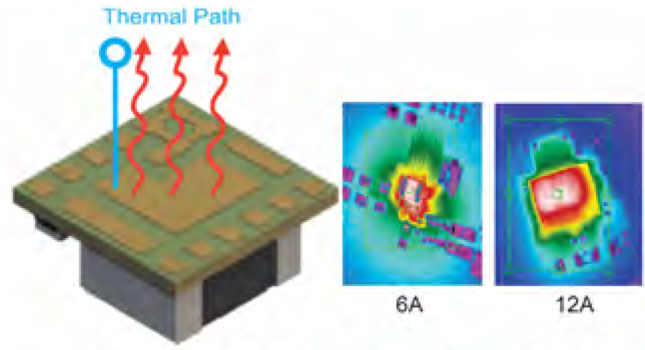


Figure 2: 3D Chip Embedded Power Modules (compliments of TDK)



Thermal Performance 12V input to Vout, No Air Flow, 25°C ambient*

Output Current	Output Voltage	Temperature	Temperature Rise
4A	1.8V	50.7°C	24.7°C
5A	1.8V	57.8°C	31.8°C
6A	1.8V	67.1°C	41.1°C
6A	2.5V	78°C	53°C
12A	1.0V	78°C	30°C *

*12A device measured at start ambient of 46°C

Figure 3: Thermal Performance 3D Chip Embedded Power Modules

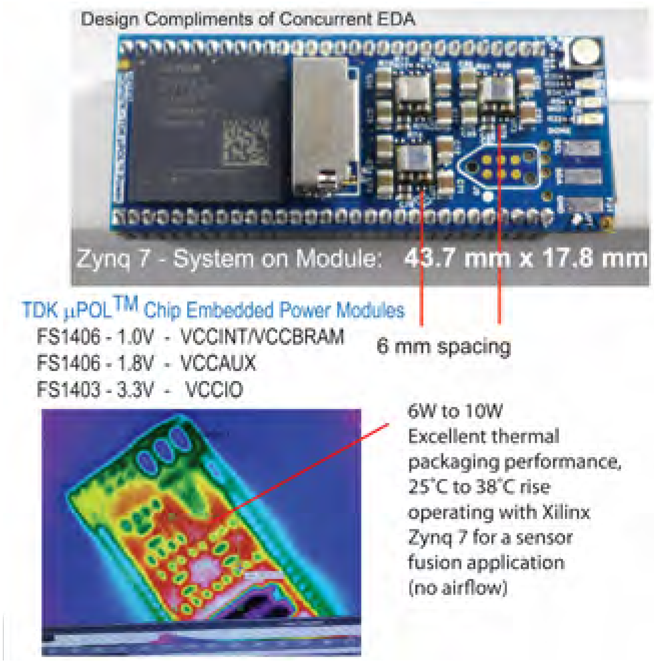


Figure 4A: Practical Design Using 3D Chip Embedded Power Modules for High Density

Pushing the Barrier of Performance

The new 3D technology comes in both exposed and encapsulated top packaging at highly sustainable production yields and excellent thermal performance, thereby lessening the need for output current derating at higher temperature ambient conditions. It is common for smaller, older power module technology solutions to reduce output current by as much as 40% when the ambient board temperature approaches 60°C to 90 °C, which is rarely the case with the new µPOL 3D technology power modules. Figure 3 lists the measured thermal performance from 3A to 12A at different output voltages and at ambient temperature without airflow convection. The thermal path from the hottest sections of the die through the thermal vias of the SESUB packaging approach proves out the capabilities of the TDK µPOL™ 3D chip embedded technology.

This data confirms that the technology enables an astounding current density of 1 watt per cubic millimeter!

Translating this to practical applications, the FS1406, 6A power module, delivers a full current rating to 80°C at 12V input to 1V output, needing little or no output current derating with zero airflow (operating range -40°C to +125°C) providing the headroom for higher ambient board temperatures. This can help reduce the space and weight of cooling costs in industrial and communication applications.

Putting It All Together for Practical Applications

Figure 4A showcases the results of a System on Module (SoM) design using a Xilinx Zynq 7 with 3 µPOL 3D power modules. The total DC-DC solution is 6W to 10W power delivery with each module and off-module output capacitors in 49mm^2 footprints directly next to the

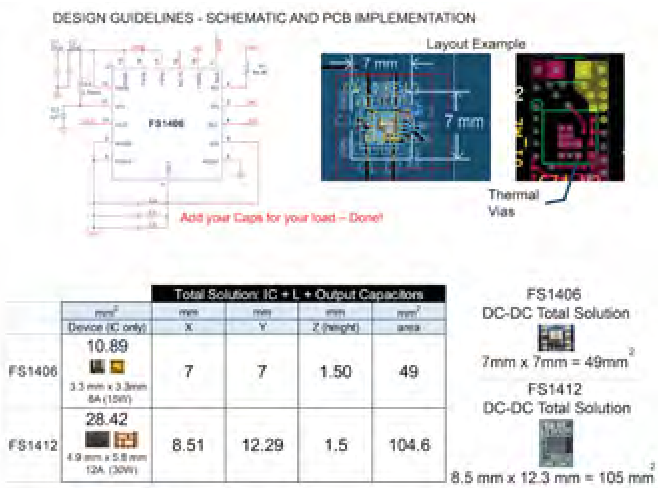


Figure 4B: Typical PCB Design Footprints – Total Solution

FPGA. The simplicity of the power modules requires minimum output load capacitors, eliminating traditional compensation components and additional voltage divider resistors which further reduces the space and cost. Using PCB thermal vias from 0.5 to 2 ounce of copper and proper board layout delivers excellent thermal performance with only a +13°C rise (without airflow) between the three power modules separated by 6mm. The embedded approach downsizes the SoM card to only 43.7 mm x 17.8 mm, which is up to a 30% reduction of board space over similar solutions.

The table in Figure 4B shows the typical design footprints to calculate board spacing advantages using these high current density power modules. They are ideal for placing DC-DC power solutions in the nooks, crannies and voids between and around the FPGAs, ASICs, memory; and under the hoods of heat sinks and/or on the top or bottom sides of mother boards and daughter cards for design flexibility. The power delivery summary: 6A (15W) power delivery with the FS1406 in a 49mm^2; and 12A (30W) with the FS1412 in 105 mm^2.

Industrial Test and Reliability of Performance

The 3D chip embedded technology and the ability to produce sustainable, long term availability is now realizable at high production yields. Extended reliability tests include: 1) JESD22-A108 for high temperature (up to 125°C) at higher voltages with no failures, 2) JESD22-A104 for the 3000 power cycling test with no failures, and 3) mechanical vibration and shock test. Further information is available on EMI performance such as CISPR-11 performance.

Conclusions

The next generation of new technology power modules are already on-going and are now commercially available. The benefits of the Chip Embedded 3D power modules, or TDK's µPOL™, are:

- Higher current/power density
- Smaller form factor solutions targeting today's power challenges
- Low profile (height) packaging for emerging trends of system design
- Improved thermal performance
- More ruggedized package solution

These factors will open new doors for overall higher PCB board density and downsizing, power delivery line loss reductions and weight reduction of the complete power plus thermal solution.

Tony Ochoa is the director of marketing engineer, supporting mixed signal analog in both precision and power. He has over 30 years of industry experience, and has worked for Analog Devices, National Semiconductor, Infineon, and several other start-up in the Silicon Valley area. He holds a BSEE and MBA from the University of California. When not working on engineering, you will find him in the waves in Oceanside, California.

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Interpreting and Validating Dynamic Characteristics for Wide Bandgap (WBG) Power Device Data Sheets

Do you find it frustrating trying to measure dynamic characteristics of WBG devices and correlate them with published data sheet results? With the advent of Wide Bandgap (WBG) devices, older test methods and standards don't address the capabilities of these new semiconductor technologies. Therefore, you see so many 'typical' specifications used in data sheets for WBG devices. In this article, we will provide some practical considerations for measurement and extraction of dynamic power semiconductor parameters, which can offer explanations to correlate measured results and data sheet results.

By Ryo Takeda – Keysight Solution Architect, Bernhard Holzinger – Keysight Technical Architect, Michael Zimmerman – Keysight R&D Engineer, Mike Hawes – Keysight Power Solution Consultant

In previous articles, we've described many of the challenges to obtain repeatable and reliable dynamic measurements and extractions from your Double Pulse Test (DPT) systems. As designers of power converters, it is also important to be able to correlate data sheet dynamic specifications with the results obtained by measuring and characterizing power devices. There are many dynamic characteristics given in Silicon Carbide (SiC) and Gallium Nitride (GaN) power device data sheets. We will focus on switching characteristics [$t_{d(on)}$, t_r, $E_{(on)}$, $t_{d(off)}$, t_f, E(off)] and reverse recovery characteristics [t_{rr}, I_{rrm}, Q_{rr}]. Gate charge parameters and $R_{ds(on)}$ measurements and extractions will be discussed in later articles.

Electrical Characteristics (T_C = 25˚C unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions	Note
E_{on}	Turn-On Switching Energy (SiC Diode FWD)		3.05		mJ	V_{DS} = 800 V, V_{GS} = -4 V/+15 V, I_D = 50 A, $R_{G(ext)}$ = 5Ω, L = 65.7 μH, T_J = 175ºC	Fig. 26, 29
E_{off}	Turn Off Switching Energy (SiC Diode FWD)		1.67				
E_{on}	Turn-On Switching Energy (Body Diode FWD)		4.65		mJ	V_{DS} = 800 V, V_{GS} = -4 V/+15 V, I_D = 50 A, $R_{G(ext)}$ = 5Ω, L = 65.7 μH, T_J = 175ºC	Fig. 26, 29
E_{off}	Turn Off Switching Energy (Body Diode FWD)		1.58				
$t_{d(on)}$	Turn-On Delay Time		142		ns	V_{DD} = 800 V, V_{GS} = -4 V/15 V, $R_{G(ext)}$ = 2.5 Ω, L = 65.7 μH, Timing relative to VDS, Inductive load	Fig. 27
t_r	Rise Time		27				
$t_{d(off)}$	Turn-Off Delay Time		72				
t_f	Fall Time		25				

Figure 1: Data Sheet Switching Characteristics.
(source: page 2, C3M0021120D Datasheet – Rev. -, 08-2019)

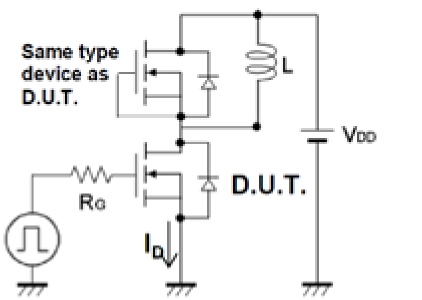

Figure 2: Simplified DPT Setup. (source: Fig 3-1: SCT2080KE Datasheet - 2015 ROHM Co., Ltd.)

Switching Characteristics

Figure 1 shows typical switching characteristics from a 1200V SiC MOSFET datasheet.

The first thing to determine is the DPT setup and test conditions. Because DPT setups are not standardized, the device manufacturer will typically show a simplified diagram of the test setup (Figure 2).

There are many things to consider when comparing your DPT setup with the manufacturer's setup.

- **What device is used for the 'high side' in the DPT setup?**
  The purpose of the high-side device is to 'freewheel' the current stored in the inductor during the off state, allowing the current to immediately flow through the DUT as the second pulse begins. Either the same device (denoted: Body Diode FWD in Figure 1), assuming a body diode is present, or a simple diode (denoted: SiC Diode FWD) is used. Because the output capacitance (C_{oss}/C_{ds}) of the 'high side' device will resonate with the power loop inductance during turn-on, it is sometimes advantageous or necessary to use a simple diode to get clean enough waveforms to extract the switching parameters. In addition, the reverse recovery current (I_{rrm}) of a high side device will add to ID at the beginning of the second pulse distorting the DUTs switching performance (i.e. increasing the turn-on switching losses).

- **Is the switched load resistive or inductive?**
  Older switching tests were often done with resistive loads. With the advent of IGBTs and WBG devices, higher frequency switching creates more challenges for the designers. Inductive loads more accurately simulate real loads (e.g. motor windings) and have become the norm for switching characterization. Sometimes the load

inductor (e.g. L = 65.7μH) is mentioned in the test conditions. This load inductor is used to provide the specified current, ID and is not part of the power loop.

- **What operating conditions are used to test the device?**
  In the example in Figure 1, one sees the typical specified parameters:
  - V_{DD}/V_{DS} = 800V
  - I_D = 50A
  - $R_{G(ext)}$ = 2.5Ω
  - V_{GS} = +15/-4V
  - Temperature = 25˚C/175˚C

What is rarely, and if so briefly, included in the test conditions, are the parasitic impedances in the DPT system (Figure 3). These parasitics have significant impact on the performance of the DPT system to provide accurate characteristics of the DUT. If the DPT system designer doesn't consider these parasitics, the measured waveforms are often measuring the characteristics of the DPT system in addition to the characteristics of the DUT. Therefore, these parasitics are often the reason for discrepancies between measured results and data sheet results, even if the other test conditions are consistent between your DPT system and the data sheet.

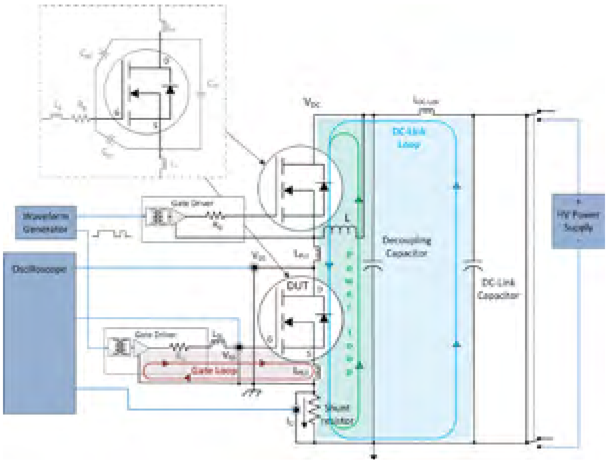

Figure 3: DPT Diagram with device and system parasitics.

As we've mentioned in previous articles, it is difficult to measure these parasitic impedances. However, there are some common ways that the industry uses to determine the power loop inductance ($L_{PL} = L_{PL1} + L_{PL2} + L_{shunt}$). One method is to extract L_{PL} by using the simple formula for the voltage across and inductor (V = L * di/dt), solved for L (L = V/(di/dt)). By taking the measurements of V, di/dt from the first dip in V_{DS} during a turn-on event, one can calculate the approximate L_{PL} for the DTP system (Figure 4).

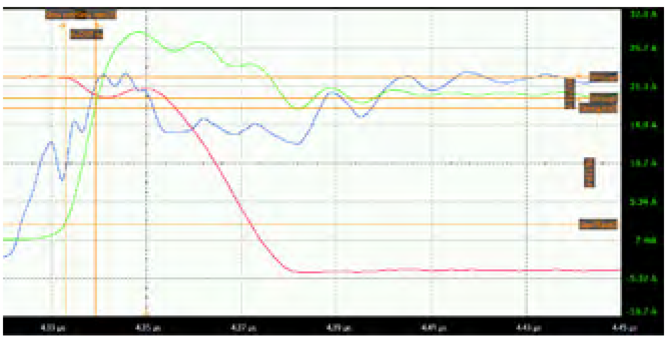

Figure 4 – Parasitic power loop inductance (L_{PL} = 87.27V/(16.16A/6.43ns) = 35 nH) extraction.

One additional test condition parameter is used to help minimize the ringing caused by the parasitics in the system.

- **What external gate resistor (R_G) is used?**
  R_G is used to slow the gate drive signal and therefore, minimize the 2nd order ringing caused primarily by L_{PL} and the output capacitance (C_{OSS}). The higher the R_G, the slower the turn-on and turn-off events and therefore, less ringing. However, the consequence is slower switching times and larger energy loss. This makes the switching characteristics in the data sheet appear worse. So, you often see many different R_G values specified as device manufacturers find the optimized situation where the ringing still allows repeatable parameter extractions, without slowing down the turn-on and turn-off of the device too much. In addition to R_G, the gate drive ICs and supporting circuit, also impact the turn-on and turn-off times.

The other necessary step to determine the dynamic characteristics is to extract the desired parameters from the waveforms on the oscilloscope. Again, there are more than one way to extract parameters from the waveforms and data sheets will often diagram the method used (e.g. Figure 5) or reference a standard (e.g. IEC 60747-8).

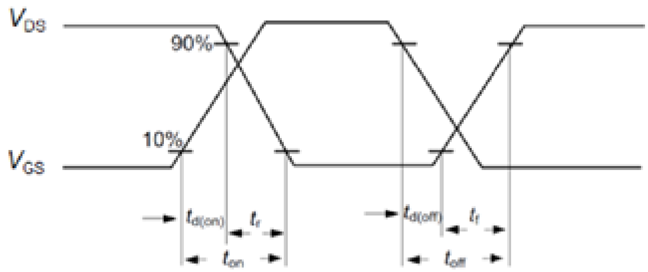

Figure 5: Switching parameter extraction method.

Even then, there is still interpretation left to the test engineer. Because of ringing, it is possible to have multiple crossings of an extraction threshold (Figure 6). So, how would you interpret t_r in Figure 6? The definition for tr is 90% V_{DS} → 10% V_{DS}. However, that could be ~ 41 ns if you use the first crossing of the 90% threshold (shown with top horizontal orange marker) or ~23 ns if you use the third crossing of the 90% threshold. The standard definitions for parameter extractions, don't always lead to consistent results when real waveforms have ringing and render the standard extraction ambiguous. New standards need to be developed, considering the inevitable ringing in the switching waveforms, so parameters extractions can be more consistent.

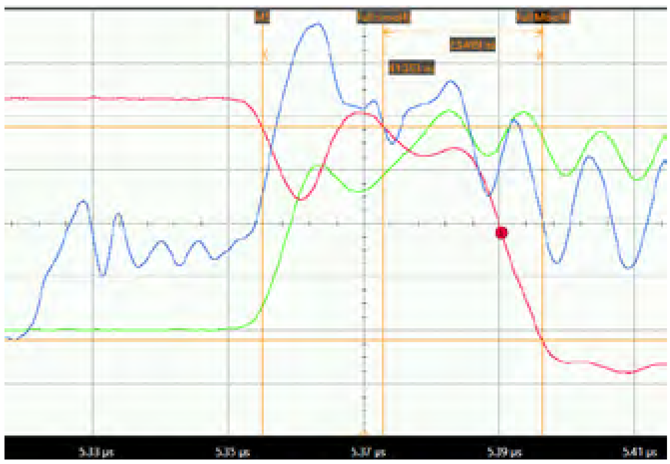

Figure 6: Turn on event (V_{DS} – red, I_D – green, V_{GS} – blue).

Reverse Recovery Characteristics

Now let's investigate reverse recovery characteristics. Figure 7 shows a typical section from a 1200V SiC MOSFET data sheet describing some reverse recovery specifications.

Reverse Diode Characteristics (T_c = 25˚C unless otherwise specified)

Symbol	Parameter	Typ.	Max.	Unit	Test Conditions	Note
V_{SD}	Diode Forward Voltage	4.6		V	V_{GS} = -4 V, I_{SD} = 25 A, T_J = 25 °C	Fig. 8, 9, 10
		4.2		V	V_{GS} = -4 V, I_{SD} = 25 A, T_J = 175 °C	
I_S	Continuous Diode Forward Current		90	A	V_{GS} = -4 V, T_C = 25˚C	Note 1
$I_{S,pulse}$	Diode pulse Current		200	A	V_{GS} = -4 V, pulse width t_P limited by T_{jmax}	Note 1
t_{rr}	Reverse Recover time	81		ns	V_{GS} = -4 V, I_{SD} = 50 A, V_R = 800 V, dif/dt = 1000 A/µs, T_J = 175 °C	Note 1
Q_{rr}	Reverse Recovery Charge	879		nC		
I_{rrm}	Peak Reverse Recovery Current	19		A		

Note (1): When using MOSFET Body Diode V_{GSmax} = -4V/+19V

Figure 7: Data Sheet Reverse Recovery Characteristics.
(source: page 2, C3M0021120D Datasheet – Rev. -, 08-2019)

Reverse Recovery Time (t_{rr}), Reverse Recovery Charge (Q_{rr}), and Peak Reverse Recovery Current (I_{rrm}) are the most common parameters specified in data sheets. In many DPT setups, the load inductor (L) is connected to the ground reference and the body diode in the DUT (low side device) is tested. The low side device is turned off, and the high side device is pulsed to energize L with the specified current. Some data sheets show the test setup, but others leave it to your decision and just provide test conditions.

There are common operating conditions specified for reverse recovery characteristics, similar to what is specified for switching characteristics:

- V_{DD}/V_{DS} = 800V
- I_D = 50A
- Temperature = 175˚C

However, V_{GS} has a different meaning in reverse recovery. In the example in Figure 7, the V_{GS} = -4V refers to turning off the DUT with the body diode that is getting tested. Note (1) specifies the maximum values (V_{GSmax} = -4v/+19V) for driving the 'high side' MOSFET in the DPT configuration. The 'high side' MOSFET drives the double pulses to test the reverse recovery of the DUT (MOSFET that is turned off). The reason only a maximum is given will become evident shortly.

The final test condition is the dif/dt (1000 A/µs), which requires us to look at how the waveform is extracted to interpret what is meant. There are multiple standards in the industry which define the reverse recovery parameter extractions, so it is important to understand which is being used. And as mentioned above, data sheets will often provide a diagram to show how they are extracting the parameters (Figure 8).

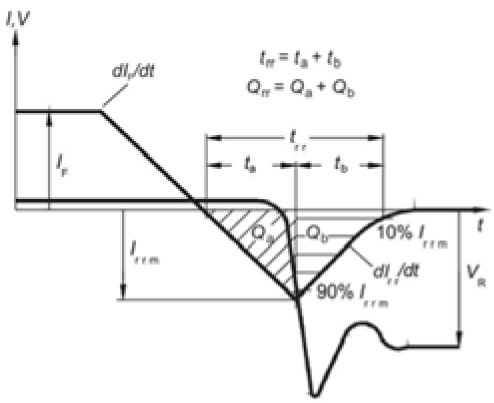

Figure 8: Reverse Recovery Extraction Method.
(source: Figure C., IMW120R045M1 Datasheet – Rev. 2.5 2020-06-12)

I_F is the forward current flowing through the body diode (reverse polarity for the MOSFET) that is generated when the body diode is freewheeling the current between the two pulses. When the second pulse starts, the current flows through the other MOSFET, 'turning -off' the current in the body diode, enabling the reverse recovery to be measured. The current descends toward 0 A at a rate of di_F/dt. As the current becomes negative, the reverse recovery phenomenon starts as shown in Figure 8.

One might think di_F/dt is an input you can specify in your test system, because it is specified in the test conditions. However, di_F/dt is controlled by two other test conditions you control:

- The external gate resistor (R_g) used to drive the MOSFET.
- The gate to source voltage (V_{GS}) that is used to drive the high-side MOSFET. Now the meaning of Note 1 becomes clear.

So, the process of measuring reverse recovery parameters is iterative. One must choose a value for R_g and V_{GS} and run a DPT to see what di_F/dt is achieved. If the value is lower than the required test condition, then R_g can be reduced to speed up the response, or V_{GS} can be increased to speed up the response. Then a second DPT is run to see how the changes in Rg or VGS affected the resultant di_F/dt. This process iterates until a the desired di_F/dt is achieved. In practice, one typically uses R_g as a coarse adjustment for di_F/dt, until the slope is close to the desired value. Then it is easier to change V_{GS} as the fine control to tune di_F/dt to the desired value.

Finally, the extraction of di_F/dt can be done in different ways. One standard specifies that it should be calculated from 50% of I_F to 75% of I_{rrm}. While other extractions will differentiate the current across the declining slope of I_F/I_r and take the maximum of this differentiated value as di_F/dt. Therefore, care must be taken in extracting the appropriate di_F/dt to expect correlation with data sheet values.

Conclusion

Interpreting and validating dynamic characteristics of power semiconductors in data sheets is not easy. As we have discussed, there are many aspects of the measurement setup, that are not included in the test conditions that significantly impact the results. As well as, approaches to extracting the parameters from the switching and reverse recovery waveforms. To help create standards for WBG devices, the JEDEC JC-70 standards was initiated in September of 2017 to develop industry standard tests for GaN and SiC. For each subcommittee, there are task groups focused on 'Reliability and Qualification Procedures', 'Datasheet Elements and Parameters', and 'Test and Characterization Methods'. Keysight is a contributing member to the JC-70 standard for both GaN and SiC subgroups.

Keysight designed the PD1500A Dynamic Power Device Analyzer as a complementary dynamic characterization solution to the B1505A/B1506A Power Device Analyzers you have learned to count on. We focused on providing repeatable and reliable dynamic DPT measurements for discrete Si/SiC based power semiconductors. We are continuing our R&D investment in state-of-the-art measurement techniques for DPT solutions. Recently we introduced a customized GaN FET Test board, that works with the standard PD1500A system (see October's edition of Bodo Power Systems). The PD1500A test methods are following the standards being create by the JC-70 standard. To learn more about Keysight's PD1500A Dynamic Power Device Analyzer, please visit the website (https://www.keysight.com/find/PD1500A). Look for future articles from Keysight, with more discussion regarding repeatable and reliable Double-Pulse Test results.

Bipolar Power Solutions for Precision Test and Measurement Systems

In order to ensure high accuracy, precision test and measurement systems require power supply solutions with low levels of ripple and radiated noise so as not to degrade the performance of high resolution converter signal chains. In these test and measurement applications, generating system supplies that are bipolar and/or isolated poses a challenge to system designers in terms of board area, switching ripple, EMI, and efficiency.

By Alan Walsh, System Applications Engineer, Analog Devices

ADC signal chains without being corrupted by spurious ripple tones from switching supplies. Source measure units and dc sources/power supplies have similar requirements for minimizing spurious output ripple on high resolution DAC signal chains. There is also a trend toward a higher channel count in precision test and measurement instruments for increased parallel testing. In electrically isolated applications, these multichannel instruments have an increasing need for channel-to-channel isolation where power must be generated on a per channel basis. This is driving solutions that require a smaller and smaller PCB footprint while maintaining performance. Implementing low noise power solutions in these applications can result in larger than desired PCB footprints and/or poor power efficiency from excessive use of LDO regulators or filter circuits.

For example, a switching power supply rail with 5 mV of ripple at 1 MHz would need a combined power supply rejection ratio (PSRR) of 60 dB or greater from an LDO regulator and powered ADC to reduce the switching ripple seen at the ADC output to 5 µV or less. This would be a fraction of an LSB for a high resolution 18-bit ADC. Luckily there are solutions that are simplifying this task through higher levels of power solution integration with µModule® devices and components that deliver greater efficiencies while reducing radiated noise and switching ripple such as Silent Switcher® devices and high power supply rejection ratio (PSRR) LDO regulators.

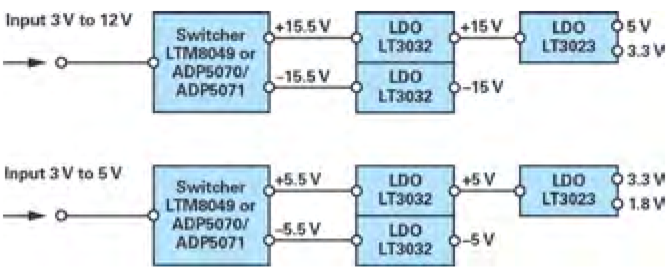

Figure 1: Power solution for a nonisolated bipolar supply system (±15 V and ±5 V) with low supply ripple.

Many precision test and measurement instruments such as source measure units or power supplies require multiquadrant operation to source and measure both positive and negative signals. This requires the generation of both negative and positive supplies from a single positive supply input with low noise and in an efficient manner. Let's consider a system that requires bipolar supply generation from a single positive input supply. Figure 1 shows power solutions that generate ±15 V and ±5 V and use positive and negative LDO regulators to filter/reduce the switching ripple as well as generate additional rails like 5 V, 3.3 V, or 1.8 V for powering signal conditioning circuitry or ADCs and DACs.

The power rail solutions shown here were designed using the system designer found in LTpowerCAD®. The LTpowerCAD® design tool is a complete power supply design tool program that can significantly ease the tasks of power supply design with many power products.

The LTM8049 and ADP5070/ADP5071 allow us to take a single positive input, boost it to the required positive supply, and invert it to generate the negative supply rail. The LTM8049 is a µModule solution that greatly simplifies the number of components needed to do this—we just need to add the input and output capacitors. As well as simplifying the design challenge in terms of selecting components and board layout for switching regulators, the LTM8049 also minimizes the PCB footprint and bill of materials needed for generating bipolar supplies. Where efficiency at lighter loads (<~100 mA) is required, the ADP5070/ADP5071 is a better choice. Although the ADP5070 solution requires more external components, like inductors and diodes, it allows for more customization of the power solution. Both the ADP5070 and LTM8049 have sync pins that can be used to synchronize the switching frequency with the clock of an ADC to avoid switching the internal FETs during sensitive time periods for an ADC. The high efficiency of these regulators at a load current of a few 100 mA makes them ideal for precision instrument supplies.

The LT3032 incorporates both a positive and negative low noise LDO regulator in a single package with wide operating range. The LT3023 incorporates two low noise, positive LDO regulators with a wide operating range. Both LDO regulators are configured to operate with minimal headroom (~0.5 V) to maximize efficiency while also delivering good ripple rejection from the switching regulator stage. Both LDO regulators are available in small LFCSP packages that reduce the PCB footprint and simplify the bill of materials. If much higher levels of PSRR are required from the LDO regulator to further reduce the switching ripple in the MHz range, then LDO regulators like the LT3094/LT3045 should be considered. The choice of how much PSRR is required in the LDO stage will depend on the PSRR of the components, like ADCs, DACs, and amplifiers that are powered from the supply rails. Generally, higher PSRR LDO regulators are less efficient due to higher quiescent current.

CN-0345 and CN-0385 are two examples of reference designs that implement this solution by using the ADP5070. These designs are for precision multichannel data acquisition using precision ADCs such as the 18-/20-bit AD4003/AD4020. In CN-0345, an LC tank circuit is used to filter the switching ripple from the ADP5070 instead of using an LDO regulator as shown in Figure 1. In reference design CN-0385, positive and negative LDO regulators (ADP7118 and ADP7182) are used after the ADP5070 to filter the switching ripple. An example for powering a bipolar 20-bit precision DAC like the AD5791 with the ADP5070 can be found in an evaluation board user guide.

These examples show how high levels of precision performance can be maintained while using switching regulators like the ADP5070 to generate bipolar supplies in applications such as data acquisition and precision power supplies/sources.

Isolated Bipolar Power Supplies

When a precision test and measurement instrument needs to be isolated for safety reasons, this brings challenges in delivering sufficient power efficiently across the isolation barrier. In multichannel isolated instruments, channel-to-channel isolation means a power solution per channel. This necessitates a compact power solution that can deliver power efficiently. Figure 2 shows a solution for delivering isolated power with bipolar rails.

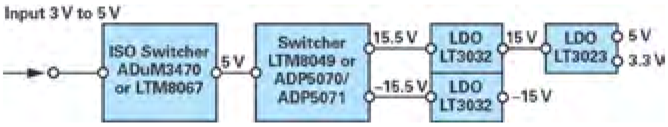

Figure 2: Power solution for isolated bipolar supply system with low supply ripple.

The ADuM3470 and LTM8067 allow us to deliver power over the isolation barrier up to ~400 mA at 5 V isolated output with high efficiency. The LTM8067 is a μModule solution integrating the transformer and other components that simplify the design and layout of the isolated power solution while minimizing the PCB footprint and bill of materials. The LTM8067 isolates up to 2 kV rms. For even lower output ripple, the LTM8068 incorporates an output LDO regulator that reduces the output ripple from 30 mV rms to 20 μV rms at the expense of the lower output current of 300 mA.

The ADuM3470 family uses an external transformer to deliver isolated power while also integrating digital isolation channels for data transfer and control of ADCs and DACs. Depending on how the isolation solution is configured, the isolated power output can be followed with a power solution similar to Figure 1, as shown in Figure 2 to generate ±15 V rails on the isolated side from a single positive supply. Alternatively, the ADuM3470 design can be configured to generate bipolar supplies directly without the need for an extra switcher stage. This results in a smaller PCB area solution at the expense of efficiency. The ADuM3470 isolates up to 2.5 kV rms, but the ADuM4470 family can be used for higher levels of voltage isolation up to 5 kV rms.

CN-0385 is an example of a reference design that implements the ADuM3470 solution, as seen in Figure 2. The ADP5070 is used on the isolated side to generate the bipolar ±16 V rails from an isolated 5.5 V. This reference design makes use of the digital isolated channels also included in the ADuM3470. A similar design that uses the ADuM3470 is CN-0393. This is a bank isolated data acquisition system based on the ADAQ7980/ADAQ7988 μModule ADC. In this design, the ADuM3470 is configured with an external transformer and Schottky diode full wave rectifier to generate ±16.5 V directly without the need for an additional regulator stage. This allows for a smaller footprint solution at the expense of lower efficiency. A similar solution is shown in CN-0292, which is a 4-channel data acquisition solution based on the AD7176 ∑-Δ ADC, and CN-0233, which highlights the same isolated power solution of a 16-bit bipolar DAC.

These examples show how to deliver isolated power for precision levels of performance in isolated data acquisition or isolated power supplies while maintaining a small PCB footprint or high levels of power efficiency.

Silent Switcher Architecture to Efficiently StepDown with Low Noise

In the power supply scheme shown in Figure 1, an LDO regulator is used to step down from 15 V to 5 V/3.3 V. This is not a very efficient way of generating these low voltage rails. A solution to improve the efficiency of stepping down to lower voltages using the Silent Switcher, μModule regulator LTM8074 is shown in Figure 3.

The LTM8074 is a Silent Switcher, μModule step-down regulator in a small, 4 mm × 4 mm footprint BGA package capable of delivering up to 1.2 A with low radiated noise. Silent Switcher technology cancels stray fields generated by the switching currents, thereby reducing conducted and radiated noise. The high efficiency of this µModule device with its very low radiated noise makes it a great choice for powering noise sensitive precision signal chains. Depending on the PSRR of the components connected to the output supply such as amplifiers, DACs, or ADCs, it may be possible to power them directly from the Silent Switcher output without the need for an LDO regulator to further filter the supply ripple as is needed for traditional switchers. Its high output current of 1.2 A also means it could be used to power the digital hardware in a system such as an FPGA if needed. The LTM8074's small footprint and high level of integration make it a great fit for space constrained applications while simplifying and speeding up the design and layout of a switching regulator supply.

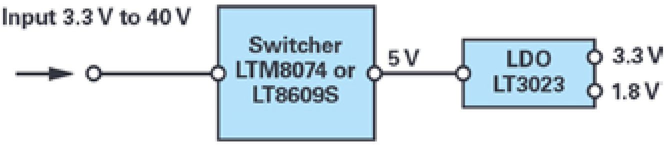

Figure 3: Power solution for stepping down to lower voltage rails with low EMI.

If greater customization is needed at the expense of PCB area, then a discrete implementation of a Silent Switcher device can be achieved by using a product like the LT8609S. These products include a spread spectrum mode to spread the ripple energy at the switching frequency over a frequency band. This reduces the amplitude of spurious tones showing up in a precision system from the supplies.

Silent Switcher technology combined with the high levels of integration found in µModule solutions solve the challenge of increasing density needs for precision applications, such as multichannel source measure units, without compromising the high resolution levels of performance that system designers need to achieve.

Conclusion

Generating bipolar power supply systems with isolation for precision electronic test and measurement can be a balancing act between system performance, maintaining a small footprint, and power efficiency. Here we have shown solutions and products that help meet these challenges and allow the system designer to make the right trade-offs.

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How Hard is Soft Saturation?

Within the development process like inductor design, numerous questions can arise. "How large is the linear area of a certain magnetization curve?", "How hard is soft saturation?" or "How lossy is a magnetic component?" Without answers, these questions can needlessly slow down the development process.

By JC Sun, Bs&T Frankfurt am Main GmbH

Without answers, these questions can needlessly slow down the development process. However, to get answers one needs to go to a so-called "expert" with "experience". Bs&T is here to deliver the answers, the data, the exact numbers in an open and transparent way.

High power density and high efficiency are two major technical requirements for magnetic component. Each soft magnetic material has saturation, and the ideal magnetic material is supposed to have linear area to perform virtual inductive design within circuit simulation. There are two commercial available solid materials with relatively high saturation flux density, and high Curie temperature on the market, they are "metal alloyed powder core" and "stress annealed metal-metalloid tape wound core".

Metal alloyed powder cores consist of highly permeable metal grains, isolated with inclusion. These cores are macroscopically homogenous and magnetically isotropic [1]. The metal-metalloid tape wound core on the other hand is rapid solidified and annealed in combination of uniaxial anisotropy with controlled tensile stress along the ribbon direction. These cores are highly versatile and provide desired levels of linear permeability. An additional transversal magnetic annealing can be applied as post treatment which reduces coercivity within the so called Rayleigh area. Not having discrete air gaps guarantees homogenous thermal loading especially during long term excitation. This makes these cores extremely reliable.

This article will analyze the challenge of measuring the saturation roll off and introduce the BsT-pulse which attempts to solve this problem. We will present a case study of two common examples and end on a technical discussion of the proposed solution.

Challenge and solution of quantify the softness of saturation
The (re)magnetization curve has saturation and it limits the linear working area, for each inductor cored regardless with metal alloyed powdered or rapid solidified and stress annealed one. The roll off of differential permeability and its approaching to saturation can be characterized by the width of anisotropy distribution, determined by the Baradiaran method [3]

$p(H_K)$=-H d^2J/dH^2

The second deviation of B and H is, by definition, the differential permeability for each particular current amplitude along the demagnetization curve.

Current validation method for such low permeable material is performed by small signal ac excitation at given frequency and small enough ac magnetization, with increasing dc biased with DC sources, the particular measurement delivers incremental permeability [4], it is very sensitive, especially at "sharp" roll up area, approaching to saturation. Because the infinitesimal ac interval is systematically enhanced the drop off with increasing dc bias. A principle description of incremental permeability is given by IEC 62024 edition 2, as well as the operation difficulty of such measurement; however description of measuring condition in quantity is dismissed.

Complementarily, BsT-Pulse delivers differential inductance on demagnetization curve quickly [1], directly and not sensitive by operational condition. And so does the differential permeability.

The BsT-pulse micro is based on thyristor technology, the working principle is described as following: Pulse energy, storage in capacitor, is discharged at desired voltage, and the device under test and capacitor formulate a LC resonance circuit, the full reversal current enables characterization of damping behavior and the transient large current amplitude drives device under test into saturation. [4] With given effective length and cross section, and number of turns, the impulse amplitude permeability and demagnetization curve can be found in the material analysis page of the data processing.

Further depiction of the HK vs. H/Hm can be described accordingly, Gaussian distribution at HA quantifies the stiffness or so called "softness" of the roll off to saturation. Sharp Gaussian distribution with curvature R, defined as ratio of the field strength, at which the linear working area ends, and the local maximum of differential permeability takes place. The high number of R differentiates the hardness of saturation behavior. [5]

Demonstration with two examples:
Now we have selected two typical commercial available examples, the one inductor under test (with courtesy of company: Fuss EMV) is constructed with metal alloyed powder core, shaped as 2 pieces E6527 in stack, the material in use is XFlux $FeSi_{6.5}$ 040 (company Mag-Inc), and wound with solid wire with number of turns as 139. And the other one is stress annealed finemet type nanocrystalline $Fe_{73.5}Si_{13}B_9Nb_3Cu_1$ tape wound core (with courtesy of company AmorNano in Beijing).

1. Metal alloyed powder core XFlux R ~0,26

Metal alloyed particles are compacted and annealed, wound with solid wire [1]

The characteristic point is located at HA~ 13000A/m, the differential permeability (starting with ~ 54) ends to 13000 A/m, and saturation flux density of 1,6 T is seen at 50000 A/m, the curvature is calculated as 0,26. The initial magnetic permeability is 54 by data processing, the Rayleigh constant is 0,125, the Ms is calculated as 1,2 MA/m, Néel constant is -5859 Joule.

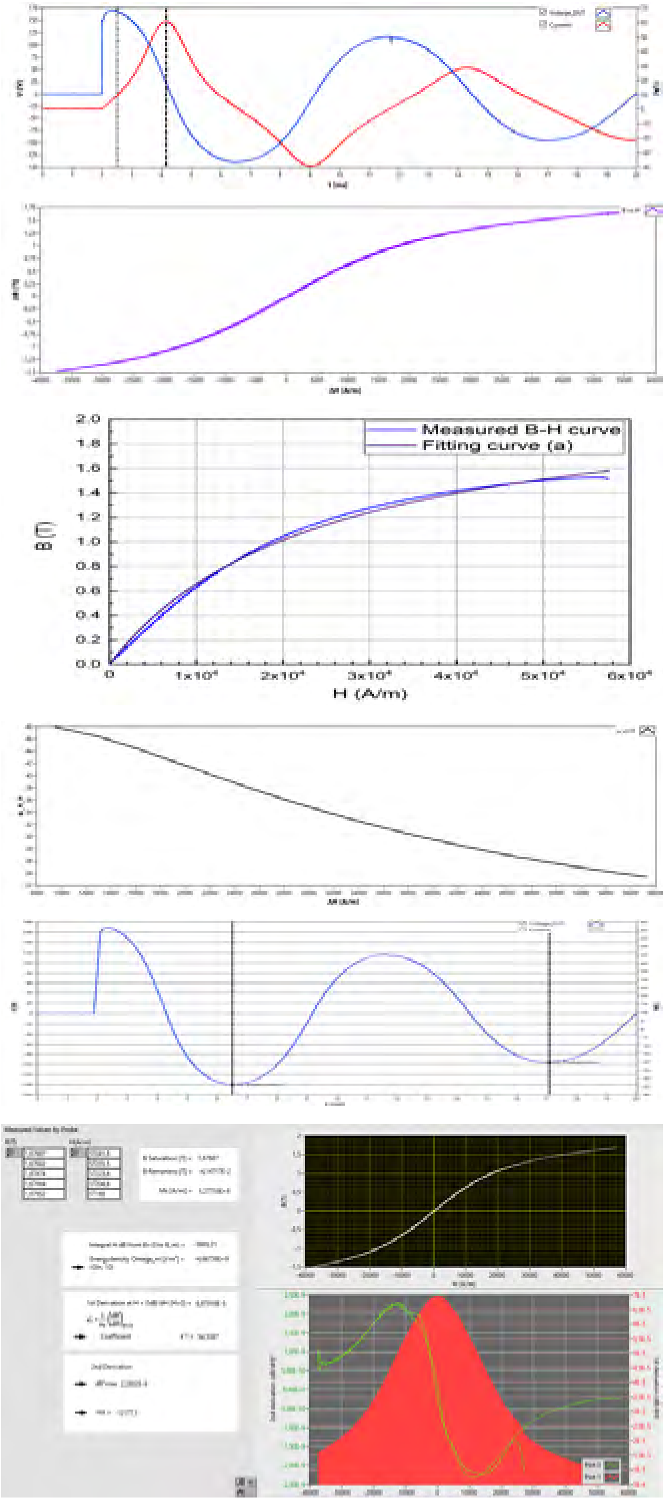

Figure 1: Powder core XFlux, wound with solid wire with number of turns 139, pulsed at discharge voltage of 300 V

- voltage current decay DUT
- BH curve of bipolar excitation
- rebuild of BH curve (zoom part) with Rivas coefficients [6]
- $\mu_{\pi,a}$ vs. H IEEE389
- Q factor $\omega L_s/R_s$ is calculated as 0,08, and the insertion loss among 6,5 ms and 17 ms is 3,285 dB
- distribution of anisotropy as differential permeability (green) [3]

As shown in the Figure 1 the B-H curve can be re-built according to Rivas [6]

$$\begin{cases} B = \mu_0(H + M) \\ M = \dfrac{a_0 + a_1 H + a_2 H^3}{1 + b_1 H + b_2 H^2} \end{cases}$$

And the coefficients can be calculated by

$$\begin{cases} a_0 = 0 \\ a_1 = \chi \\ a_1 = \dfrac{\lambda \cdot M_s + \chi^2}{M_s + \alpha \cdot \chi} \\ b_1 = \dfrac{\lambda \cdot \alpha + \chi}{M_s - \alpha \cdot \chi} \\ b_1 = \dfrac{\lambda \cdot M_s + \chi^2}{M_s \cdot (M_s + \alpha \cdot \chi)} \end{cases}$$

where the factors: M_s, χ, λ, and α can be found by parameters of the materials as following description.

First, the χ is actually the initial relative permeability of the material and read directly from the datasheet, alternatively obtained from initial differential permeability of DUT; the M_s is the M value when the $H \rightarrow inf.$, thus is defined as the maximal magnetic flux density during damping process, which can be as $\frac{B_s}{\mu_0}$, the factor λ is considered as Rayleigh constant, by definition:

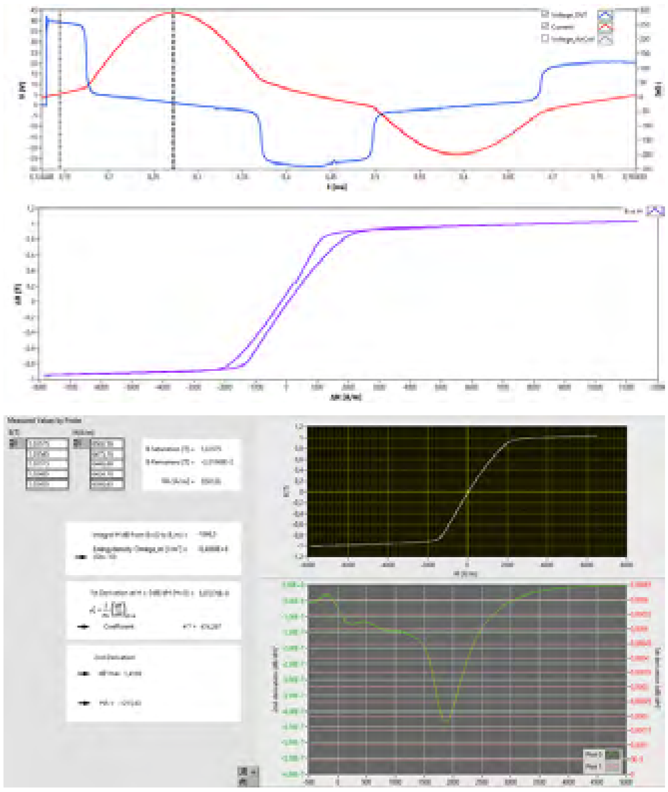

Figure 2: Stress annealed finemet type nanocrystalline, pulsed with discharge voltage of 70 V

- voltage current decay DUT
- BH curve of bipolar excitation
- distribution of anisotropy as differential permeability (green) [3]

$$\lambda = \frac{\mu_{r,H=H_c} - \mu_{r,H=0}}{H_c}$$

, therefore by H_c is read between the neighboring cross zero points of flux density, right from pulse testing, at last, the is considered as Néel constant, it is the intercept of the linear function $M\ H$ of H, defined as

$$\frac{y - M_s}{H - H_s} = \frac{M_s - M_t}{H_s - H_t}$$

And the curve must cover the point when the $M = M_s$ and point (H_t, M_t). In this exercise of fitting, the α is selected as 8000 A/m and then the can also be calculated based on the pulse testing data.

2. Stress annealed tape wound nanocrystalline core R 0,67

Finemet type nanocomposite is made as ingot, rapid solidified as plan amorphous ribbon, despoolt through continuous kiln under strain loading, and respoolt to tape wound core, the whole process is automatically performed, afterward boxed in plastic cover, labor cable (0,5 m) is wound over the core, the number of turns is 8. The inductor is right connected on the two terminals of BsT-pulse micro, and formulated with the storage capacitor as LC resonance circuit.

The curvature R (~ 0,67) is independent on permeability performed by stress annealing [5], the characteristic point is located at HA~ 1200A/m, ending with linear area. The local maximum of differential permeability is illustrated with pronounced peak at field strength of 1800 A/m. The discharge voltage is 70 V, the H_c and B_r are read as 115 A/m and 70 mT.

Discussion and Conclusion

BsT-pulse enables the differentiation of softness of saturation behavior, and the full reversal current enables the articulation of loss (insertion loss) behavior with limit values for serious specification. It can be embedded into monitor system to ensure reliable operation. The rebuilt magnetization curves and loops are quick and intuitive. Those fitting coefficients with physical interpretation can be then used for simulation routine in numerical way.

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GaN-FET Based Laser Diode Drivers

Schulz-Electronic (SE), and the Swiss laser electronics specialist Meerstetter Engineering announced to start sales and joint development of versatile and cost-efficient premium laser diode driver solutions in early 2021. The highly flexible, high power solution will be based on Meerstetter's powerful LDD-1137 GaN-FET diode driver platform. The experts for individual, professional power supply solutions from Schulz-Electronic offer many years of experience in the field of laser power supplies. With LDD-1137 they are expanding their DC/DC driver portfolio in the high-power and high-current range - as well as in the segment of fast, pulsed CW applications and analogue modulations into up to Kilohertz rate. The laser diode driver LDD-1137 is footprinted on small 171 x 118 mms. It is designed to serve as a universal platform for a vast number of new driver models. The basic parameters of the pulsable CW multi-phase driver range up to max. 70 amps output current and max. 70 volts output voltage. Thanks to the latest GaN-FET technology, rise times in pulsed operation of < 500 nanoseconds at output powers of up to several kilowatts can be realised. Up to three LDD-1137s can already be connected in parallel to increase the output current.

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DC Meter Solution for Electric Vehicle Chargers

LEM launches its DC meter solution, a DC Billing Meter (DCBM) fully compliant with the German “Eichrecht” regulation. The DCBM is a smart and compact billing solution that will help electric vehicle charging stations take advantage of the benefits of DC charging. Offering a power measurement range from 25kW to 600kW, the DCBM is a legal and certified meter that provides accurate billing of DC chargers. The German “Eichrecht” regulations state that consumers should only be charged for the DC power supplied. Standards are being established not only at the European level but also at the international level and more particularly in the USA in the state of California. The DCBM has been developed to meet market demands for inter-operability and data security, easy and fast retrofitting of charging stations already deployed, and the ability to provide high power at up to 600A/1000V. Designed to meet future connectivity needs, the DCBM offers Ethernet communications, supporting the HTTPS/REST protocol to allow quick integration and deployment within charging stations. The DCBM also integrates the Signed billing data sets according to the S.A.F.E OCMF protocol, allowing billing data to be transmitted with an extremely high level of security and providing total interoperability for cloud service operators.

www.lem.com

Expanded Schottky Diode Portfolio

UnitedSiC has announced four Junction Barrier Schottky (JBS) diodes to complement its FET and JFET transistor products. The UJ3D 1200V and 1700V devices are part of the company’s 3rd generation of SiC Merged-PiN-Schottky (MPS) diodes. Possessing a VF x Qc figure of merit (FoM) that is at least 12-15% better than what diodes from other manufacturers can achieve, these SiC SB diodes are highly optimized for power system designs requiring elevated efficiency levels and ultra-fast switching speeds. Having a >8.8mm clearance between the anode and the cathode means they are better at coping with high pollution environments where voltage transients are likely to be present. In high current situations, the novel PN junction arrangement featured enables the injection of additional charge carriers. Thanks to this, the diodes can withstand much higher surge currents than competing devices (up to 12x the rated current). There is a 1700V 25A-rated option, plus three 1200V devices in 10A, 20A and 50A-rated options. Fully compliant with the AEC-Q101 automotive standard, all SiC diodes come in a compact TO247-2L package format and in die form. Applications that will benefit most from these new SiC diodes include fast-charge electric vehicle (EV) charging access points, industrial motor drives and solar energy inverters. As Anup Bhalla, VP Engineering at UnitedSiC, explains: “Through the unique characteristics of the UJ3D1725K2, we can provide our customers with reliable, space-saving, cost-effective SiC diodes that have substantially better performance levels and assured quality, supported by high volume manufacturing.”

www.unitedsic.com

Modular Capacitor Concept for DC Link Applications

TDK has implemented a modular and versatile power capacitor concept for DC link applications. This, combined with the latest-generation of IGBT modules, allows compact converters for applications in traction, renewable energies and industrial to be brought swiftly to market readiness.
Increasingly, tougher requirements are being placed on converters and the required DC link capacitors. They include a high energy density under compact dimensions, control over fast switching operations, a large current capability, high admissible operating temperatures, mechanical compatibility with IGBT modules and a long service life. To fulfill all these demands and thanks to its long-standing expertise in power capacitors with ModCap™, TDK has developed a new modular, standardized and scaleable concept for DC link capacitors. In contrast to most conventional DC link capacitors, a cubic design with plastic housings is involved. It is available in two versions with dimensions of 243 x 169.5 x 90 mm or 258 x 215 x 115 mm.
ModCap is constructed from parallel interconnected flat windings filled with Polyurethane resin. Thanks to this design, the capacitors can be fitted very near to the IGBT modules, thus producing very short lead lengths. This, combined with a very low 14 nH self-inductance of the capacitors, stops any substantial voltage overshoot at the IGBT modules when the current is shut off. As a result, generally, no snubber capacitors are needed. This in turn, reduces the space requirement and costs of new converter designs.

www.tdk-electronics.tdk.com

Thyristor Modules

Proton-Electrotex is happy to announce the launch of a thyristor and thyristor-diode module

MT3-700-18-A2 with increased power density. This module is based on its predecessor MT3-540-18-A2. The higher power density was achieved by upgrading the semiconductor element with minimal changes to other design elements. Specifically, the module was designed with a new topology increasing the active cathode area by 10%, reduced thickness of the diffusion element and improved diffusion profile. The extensive research and testing program behind these changes allowed to achieve previously unavailable parameters. The module features lower losses in open state, lower thermal junction-case resistance, and higher surge current. Mean current in open state ITAV increased by 20% to 700A. Repetitive peak off-state and reverse voltage VDRM/ VRRM values are 1400-1800 V.

www.proton-electrotex.com

Gallium Nitride Transistors for a Wide Range of Power Levels

Efficient Power Conversion Corporation advances the performance capability while lowering the cost of off-the-shelf gallium nitride transistors with the introduction of the EPC2059 (6.8 mΩ, 170 V) eGaN FET. This device is the latest in a family of 100 V – 200 V solutions suitable for a wide-range of power levels and price points. They are

designed to meet the increasing demands of 48 V – 56 V server and data center products as well as an array of consumer power supply applications for high end computing, including gaming PCs, LCD/LED TVs, and LED lighting. The EPC2059 is ideal for DC-DC secondary-side synchronous rectification in AC/DC adaptors, fast chargers, and power supplies with power ranges between 100 W and 6 kW. The performance advantage of gallium nitride devices helps designers achieve the demanding efficiency requirements for 80 Plus Titanium power supplies, while providing smaller, faster, cooler, and lighter systems with lower system costs then currently available solutions. According to Alex Lidow, EPC's co-founder and CEO, "There are very significant performance advantages gained from using GaN in the secondary-side synchronous rectification socket of AC/DC adaptors. In a 400 V to 48 V conversion, switching at 1 MHz, GaN has shown to have one-sixth the losses and run 10 degrees cooler than a silicon MOSFET with equivalent on resistance. This enables designers to meet the latest stringent energy efficiency standards for high-end computing, where growth is exploding for multiple applications, such as artificial intelligence (AI), cloud computing, and high-end gaming systems."

www.epc-co.com

Reliability in Industrial and Utility Applications

In industrial and utility applications, uptime is often one of the most critical aspects of operations – right after safety. ABB is helping to ensure reliable, efficient power in these mission critical industries with its Integritas industrial battery charger. The wall-mounted system features switch-mode rectifier technology that provides transformer-less, efficient power conversion in a compact footprint – providing true N+1 or N+N redundancy in a single battery charger.
"Ensuring reliable, efficient AC-to-DC power and battery backup is essential in applications such as utility power, oil and gas, and process control – to name a few – where downtime can be critical," said Mark Lloyd, senior product manager with ABB. "Having reliable, efficient backup power in a single charger with high power density helps ensure these critical applications remain up-and-running while also reducing the footprint of the power equipment needed – freeing up valuable floor space."
ABB's versatile industrial battery charger supports the critical DC power and battery charging needs of various rigorous industrial applications – from utilities and manufacturing to pharmaceuticals and petrochemicals. It provides up to 18 kilowatts (kW) of output power at 125 volts DC (VDC) from a direct, three-phase, 480-volt AC (VAC) input feed.

www.electrification.us.abb.com

GaN FET with Integrated Driver, Protection and Power Management

Texas Instruments expanded its high-voltage power management portfolio with the next generation of 650-V and 600-V gallium nitride (GaN) field-effect transistors (FETs) for automotive and industrial applications. With a fast-switching, 2.2-MHz integrated gate driver, the families of GaN FETs help engineers deliver twice the power density, achieve 99% efficiency and reduce the size of power magnetics by 59% compared to existing solutions. TI developed these FETs using its proprietary GaN materials and processing capabilities on a GaN-on-silicon (Si) substrate, providing a cost and supply-chain advantage over comparable substrate materials such as silicon carbide (SiC).
Using TI's automotive GaN FETs can help reduce the size of electric vehicle (EV) onboard chargers and DC/DC converters by as much as 50% compared to existing Si or SiC solutions – enabling engineers to achieve extended battery range, increased system reliability and lower design cost. In industrial designs, the new devices enable high efficiency and power density in AC/DC power-delivery applications where low losses and reduced board space are important – such as hyperscale and enterprise computing platforms as well as 5G telecom rectifiers.
"Wide-bandgap semiconductor technologies like GaN inherently bring firmly established capabilities to power electronics, especially for high-voltage systems," said Asif Anwar, director of the Powertrain, Body, Chassis & Safety Service at Strategy Analytics. "Texas Instruments leverages over a decade of investment and development to deliver a uniquely holistic approach – combining internal GaN-on-Si device production and packaging with optimized Si driver technology to successfully implement GaN in new applications."

www.ti.com

Bidirectional Power Supply with Integrated SiC-MOSFETs

Testing is a critical part of bringing any electric drivetrain into production. Traditional test setups require a dedicated DC source and electronic load in parallel to deal with bidirectional energy flow.
The power supply PSB 10000 of EA Elektro-Automatik offers a bidirectional solution for this application. It simplifies the test setup and reduces test time. Additionally, it offers great potential for savings in both acquisition and maintenance costs. Thanks to the discrete 1200 V CoolSiC™ MOSFETs from Infineon Technologies the system operates with efficiencies of over 96 percent. Used as an electronic load, the energy is fed back into the power grid, and only a small amount of energy is dissipated in the form of heat. The power density is industry-leading with 30 kW in a single 4U 19" housing.
The device series PSB 10000 features an output stage with an extended scope of operation. Typical programmable DC sources offer full output power only at maximum voltage and current. The devices from EA Elektro-Automatik, on the other hand, offer full power from as little as one-third of the output voltage or output current. Charging or discharging a vehicle battery can serve as a good example. Even if the battery voltage rises or falls, the current automatically adjusts and thus provides full power. The flexibility of the devices can save a lot of equipment when testing different electronic components.

www.elektroautomatik.com

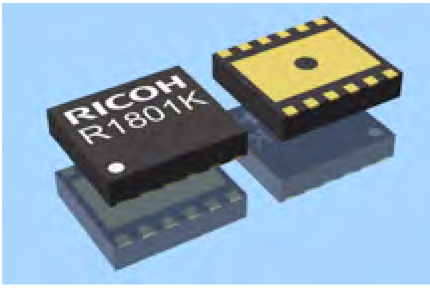
Automotive Primary DC/DC Converters

ROHM has developed a lineup of twelve automotive primary DC/DC converters. The BD9P series are optimized for ADAS (Advanced Driver Assistance System) sensors, cameras, and radars, along with car infotainment and instrument clusters. The need for fast response to provide stable operation and higher power conversion efficiency are crucial, which have been difficult to meet with conventional power supply ICs. The product adopts an original advanced power supply technology, Nano Pulse ControlTM* which enables high speed operation at 2.2MHz that will not interfere with the AM radio band (1.84MHz max.) while achieving high step-down ratio. The BD9P series ensures stable operation during battery input voltage fluctuation, reducing output overshoot to less than 1/10th of that of conventional products. This eliminates the need for additional output capacitors typically required as countermeasure against overshoot. Additionally, adopting a new control method makes it possible to achieve both high efficiency and fast response (which typically represent a tradeoff). Not only does this provide a 92% power conversion efficiency at heavy loads (at 1A output current), but 85% efficiency at light loads (1mA) as well, ensuring leading-class efficiency across the entire load range. As a result, low power consumption is enabled both when driving and when the engine is stopped (standby current can be reduced). Furthermore, combining the product with the BD9S series of secondary DC/DC converters connected to the subsequent stage leads engineers to faster design of more efficient automotive power supply circuits.

www.rohm.com

Buck DC/DC Converter for Energy Harvesting Applications

Ricoh Electronic Devices in Japan has launched the R1801 Buck DC/DC Converter, designed for use on the Internet of Things ecosystem by extracting energy from PhotoVoltaic or PiezoElectric cells. It is used to power small devices in applications such as wireless sensors, home and building automation, remote monitoring, presence detection and industrial equipment controls as well as wearables and fitness sensors. The R1801 makes small energy autonomous devices protecting the environment by reducing the use and waste of primary batteries, while eliminating the impact of cabling cost and maintenance to replace batteries regularly.



A vast amount of these devices is to be deployed in environments such as offices, buildings, hotels, industrial sites, airports, malls, remote monitoring infrastructures and wearable fitness / healthcare devices.

The DC/DC converter converts energy and stores it in battery or super capacitor storage elements. An ultra-low quiescent current of 200 nA allows to use the harvester circuit even in a low-illuminated environment when the generated level of energy is moderate. As soon as there is sufficient energy available on the input side, the buck DC/DC Converter will be enabled to transfer energy from input to output until the energy drops below a threshold. This process repeats and increases the voltage in the energy storage device until the required level is reached.

www.ricoh-usa.com

SiC-MOSFETs for Power Conversion Applications

GeneSiC Semiconductor announces the availability of 6.5kV SiC MOSFET bare chips – G2R300MT65-CAL and G2R325MS65-CAL. Full SiC modules utilizing this technology are soon to be released. Applications are expected to include traction, pulsed power, smart grid infrastructure and other medium-voltage power converters. GeneSiC's innovation features a SiC double-implanted metal oxide semiconductor (DMOSFET) device structure with a junction barrier schottky (JBS) rectifier integrated into the SiC DMOSFET unit cell. This leading-edge power device can be used in a variety of power conversion circuits in the next generation of power conversion systems. Other significant advantages include more efficient bi-directional performance, temperature independent switching, low switching and conduction losses, reduced cooling requirements, superior long-term reliability, ease of paralleling devices and cost benefits. GeneSiC's technology offers superior performance and also has the potential to reduce the net SiC material footprint in power converters. "GeneSiC's 6.5kV SiC MOSFETs are designed and fabricated on 6-inch wafers to realize low on-state resistance, highest quality, and superior price-performance index. This MOSFET technology featuring an on-chip integrated JBS diode promises exemplar performance, superior ruggedness and long-term reliability for medium-voltage power conversion applications" said Dr. Siddarth Sundaresan, VP of Technology at GeneSiC Semiconductor.

www.genesicsemi.com

Cylindrical Hybrid Supercapacitors

More power and high reliability: The HS/ HSL Hybrid Supercapacitors impress with a power density that is up to three times higher than that of lithium-ion batteries. In a 3.8 V hybrid cell, they have an energy density up to eight times higher than conventional EDLCs (Electric Double Layer Capacitor).
Hybrid supercapacitors are energy storage devices that combine the advantages of electric double layer capacitors and lithium-ion technology to achieve higher energy densities and longer life. In the hybrid supercapacitors, a lithium-doped carbon electrode replaces one of the carbon-based electrodes. With more than 250,000 charging cycles at 20°C ambient temperature and a maintenance-free service life of up to 20 years, the hybrids score points over conventional batteries. At operating temperatures of down to -25°C (HSL) and up to +85°C (HS), the hybrid supercapacitors work without any problems. While HSL supercapacitors are optimized for lower temperatures down to -25 °C, HS supercapacitors have an extended range up to +85 °C and are optimized for higher temperatures.

Thanks to their low self-discharge, they act as stand-alone energy storage devices or are used in addition to battery systems to optimize system costs, service life and runtimes. This makes them particularly suitable for emergency power supplies in server rooms or in medical environments, IoT energy storage, smart metering, tracking of commercial vehicles / containers, but also for impulse and hybrid power supply systems.

www.rutronik24.com

LED Drivers in DFN Package with Side-Wettable Flanks

Nexperia announced a range of LED drivers in the space-saving DFN2020D-6 (SOT1118D) package. This case style features side-wettable flanks (SWF) which facilitate the use of AOI (automated optical inspection), and improve reliability. This is the first time LED drivers have been available in this beneficial package. The leadless devices join Nexperia's wide range of LED drivers in leaded packages offering equivalent performance yet reducing PCB space by up to 90% compared to SOT223. With a footprint of just 2x2 mm and a low profile of 0.65 mm, the DFN2020D-6 LED drivers are available in NPN technology. They feature an output current of up to 250 mA (NCR32x types) and a maximum supply voltage of 40 V. Their high thermal power capability is at least equal to any other package for LED drivers. The use of side-wettable flanks not only enables AOI techniques to be used - which is especially important for automotive customers – but also improves reliability. Devices with side-wettable flanks exhibit a greater resistance to shear forces, and can handle greater board flexing without cracking than devices without side-wettable flanks.

Commented Frank Matschullat, product group manager at Nexperia: "The new DFN2020D-packaged parts with SWF address the concerns of various sectors – size, performance, ruggedness – so they are a perfect match for many diverse applications in general lighting, white goods and automotive. Nexperia is committed to deliver industry's broadest discrete portfolio in DFN technology, so introducing LED drivers in this rugged, space-saving package is a natural step. However, parts are also available in leaded SMD styles so customers can choose which to use."

www.nexperia.com

Advertising Index

ABB	47	Infineon	13	Rutronik	C3
CALY Technologies	41	LEM	5	Saker	27
Cornell Dubilier	29	MinDCet	31	Semikron	17
DOWA	21	Mitsubishi Electric	19	Texas Instruments	15
Electronic Concepts	1	MRC Components	51	UnitedSiC	33
EPC	C4	PCIM Europe	42	Vincotech	23
Fuji Electric Europe	11	PEMD	48	Wolfspeed	39
GvA	C2	Plexim	37	Würth Elektronik eiSos	3
Hitachi	9	ROHM	7		