ISSN: 1863-5598

ZKZ 64717
05–22

Bodo´s Power Systems®

Electronics in Motion and Conversion

Mai 2022

PULSED INDUCTANCE MEASUREMENT

POWER CHOKE TESTER DPG10/20 SERIES

Inductance measurement from 0.1 A to 10 kA

KEY FEATURES

Measurement of the

- **Incremental inductance** $L_{inc}(i)$ and $L_{inc}(\int Udt)$
- **Secant inductance** $L_{sec}(i)$ and $L_{sec}(\int Udt)$
- **Flux linkage** $\psi(i)$
- **Magnetic co-energy** $W_{co}(i)$
- **Flux density** B(i)
- **DC resistance**

Also suitable for 3-phase inductors

WIDE RANGE OF MODELS

7 models available with maximum test current from 100A to 10000A and maximum pulse energy from 1350J to 15000J

KEY BENEFITS

- Very **easy and fast** measurement
- **Lightweight, small and affordable price-point** despite of the high measuring current up to 10000A
- **High sample rate and very wide pulse width range** => suitable for all core materials

APPLICATIONS

Suitable for all inductive components from **small SMD inductors** to **very large power reactors in the MVA range**

- **Development, research** and **quality inspection**
- **Routine tests** of small batch series and mass production

Technological leader in pulsed inductance measurement for 18 years

www.ed-k.de

ISSN: 1863-5598
ZKZ 64717
05–22

Bodo´s Power Systems®

Electronics in Motion and Conversion

May 2022

ROHM SEMICONDUCTOR:
Increasing presence in the global power semiconductor sector

ROHM Semiconductor: Increasing presence in the global power semiconductor sector

Founded in 1958 in Kyoto, Japan, the ROHM Group is now a global player and supplier to the electronics industry.
The company produces a wide range of electronic solutions – including power integrated circuits, SiC MOSFETs, diodes and modules, silicon power transistors and diodes, LEDs and resistors. As a vertically integrated semiconductor manufacturer, ROHM is largely independent of suppliers and can respond more flexibly to market changes. The company leads the industry in technological development. At the same time, ROHM is working with an integrated production system to improve production efficiency by increasing wafer diameter and using state-of-the-art equipment, while also reducing environmental impact.

ROHM's development strategy for power components

ROMH makes an important contribution to society through its products. To clarify its mission in the new social infrastructure, ROHM formulated its management vision in 2020: "We focus on power and analog solutions to meet our customers' needs for energy savings and downsizing of their products," explains Wolfram Harnack, President of ROHM Semiconductor Europe. In 2021, the company formulated its "Environmental Vision 2050". Based on the three themes of "climate change", "resource recycling" and "coexistence with nature"ww, ROHM supports the core requirement of net zero emissions by 2050, while at the same time protecting biodiversity.

Investment in new plant increases production capacity for SiC power semiconductors

ROHM is increasing its production capacity for SiC power semiconductors with the completion of a new building at its Apollo plant in Chikugo, Japan. The new building is a state-of-the-art, environmentally friendly factory that uses a range of energy-saving technologies in its production facilities, with 100% of its electricity coming from renewable energy sources. In addition, ROHM has strengthened its business continuity management system by introducing various disaster prevention measures. The company is installing production equipment and building a manufacturing system to meet the growing demand for SiC power semiconductors in the medium to long term.

Furthermore, SiCrystal GmbH is to be operated entirely with renewable energy from the previous fiscal term (ending in March 2022). The aim is to reduce CO2 emissions from purchased electricity at the plant to zero.
All major production processes for SiC wafers will then be operated with environmentally friendly renewable energy.

www.rohm.com

Content

ADVENTURES OF OHM
HALL OF DREAMS
OHM, WHAT'S IN THIS ROOM?
DO NOT OPEN THAT DOOR!

Supporters & Friends

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

Publisher
Bodo Arlt, Dipl.-Ing.
editor@bodospower.com

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

Editor China
Min Xu
Phone: +86 156 18860853
xumin@i2imedia.net

US Support
Rusty Dodge
Phone +1 360 920 7825
rusty@eetech.com

Creative Direction & Production
Bianka Gehlert
b.gehlert@t-online.de

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

Printing by:
Westdeutsche
Verlags- und Druckerei GmbH
Kurhessenstraße 4 - 6
64546 Mörfelden-Walldorf
Germany

Looking Forward to Being Back

After more than two years, I am finally planning to travel to a live event this month. Actually, it is three events, as PCIM Europe, Sensor + Test and SMTconnect are all taking place at the same time and place in Nuremberg. While preparing for the event, I realized that there are many people that I work together with on various projects now and in the past, that I have not yet met in person. So more than ever, the statement “looking forward to meeting friends” is true this year. And although not everyone will be able or allowed to come to Nuremberg, it will be a pleasure for me to meet new people as well as those I already know. I’m sure, I still have the ability to socially interact and so hopefully three days will be sufficient for all of my meetings.

When it comes to personal interaction, I remember seeing, on social media, the buttons that were used at APEC in March. They signaled in a clever way, how the person prefers to act: handshake (green color), elbow/fist-bump (yellow) or still distance (red). I really like this idea and think it is something that should be adopted for future events as it helps to avoid difficult situations when walking towards someone. I’m not sure who has the copyright on this idea, the organizers, or the ones I saw carrying them, but I don’t think that matters, as it really helps everybody! We are team yellow, visit us in hall 6, booth 266!

As mentioned in his April viewpoint, Bodo is holding his podium discussion in Nuremberg again. All visitors and conference attendees are welcome to join the podiums at the Industry Forum for:

SiC on Wednesday,
May 11th at 1:10 p.m. CEST,

GaN on Wednesday,
May 11th at 2:15 p.m CEST, and again

SiC on Thursday, May 12th
at 1:45 p.m. CEST

This month’s issue also shows how hot this technology is. I can’t remember when we had so many articles on SiC, GaN and related topics in a previous magazine. This demonstrates how huge the potential is and I’m very sure PCIM will have a lot of interesting highlights to explore. Most of the contributing companies have a booth at PCIM, so maybe some of the authors will be here too. That way you can get your update first-hand and maybe have the chance to ask some questions directly. If not, this opportunity will come in one of Bodo’s upcoming quarterly WBG Expert Talk. We had the 5th edition a few weeks ago, this format has developed very nicely!

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 our clients in North America. If you speak the language, or just want to have a look, don’t miss our Chinese version at bodospowerchina.com. An archive of my magazine with every single issue is available for free at my website bodospower.com.

My Green Power Tip for the Month:
Save the electric power for air purifiers at you trade fair booth within huge halls. The effect is going to be near zero! Ask your visitors to wear a mask instead, that’s much more effective and I’m very sure the majority will do.

Best regards

Events

CWIEME Berlin 2022
Berlin, Germany May 10 – 12
www.berlin.coilwindingexpo.com

SMTconnect 2022
Nuremberg, Germany May 10 – 12
https://smt.mesago.com

PCIM Europe 2022
Nuremberg, Germany May 10 – 12
https://pcim.mesago.com

Sensor + Test 2022
Nuremberg, Germany May 10 – 12
www.sensor-test.com

The Smarter E 2022
Munich, Germany May 11 - 13
www.thesmartere.de

Battery Tech Expo 2022
Silverstone, UK May 12
www.batterytechexpo.co.uk

AMPER 2022
Brno, Czech Republic May 17 – 20
www.amper.cz

IPEC ECCE Asia 2022
Himeji, Japan May 15 – 19
www.ipec2022.org

PEDG 2022
Kiel, Germany June 26 – 29
www.pedg2022.org

Joining Forces

SEMIKRON and Danfoss Silicon Power announced a merger to create a joint business specialized in Power Electronics focusing on power semiconductor modules. With an existing workforce of more than 3,500 dedicated power electronic specialists, the new SEMIKRON-Danfoss will provide technology expertise as the leading partner in Power Electronics. The merger comes with a firm commitment to future investments, paving the way for green growth and a more sustainable, energy efficient and decarbonized future. SEMIKRON-Danfoss will be a central enabler of this transition.

The newly formed SEMIKRON-Danfoss joint business will be owned by the current owner-families of SEMIKRON and the Danfoss Group, with Danfoss being the majority owner. The joint business SEMIKRON-Danfoss will be managed by one common leadership team. It will be operated in the accustomed manner, retaining existing production facilities, customer and supplier relationships and distribution channels. SEMIKRON-Danfoss will retain the two main locations in Germany, Nuremberg and Flensburg. The current factories and sales offices of Semikron and Danfoss Silicon Power will continue operations as usual.

Danfoss President & CEO Kim Fausing, said:
"The new SEMIKRON-Danfoss builds on a strong long-term partnership and more than 90 years of combined technology leadership in Power Module packaging, innovation, and customer application expertise. With electrification driving the green transition, SEMIKRON-Danfoss aims to become the preferred decarbonizing partner for customers. We have the passion, competences and technologies to more than double our business in five years."

SEMIKRON CEO Karl-Heinz Gaubatz added: "This really is an exciting moment. Based on close, trusting conversations over the last months we have identified that SEMIKRON and Danfoss are a unique fit with complementing assets, a strong team and shared values. By combining SEMIKRON's expertise as a pioneer for semiconductor technology with more than 70 years of experience in the development of top-class power modules and systems and the strength, innovativeness and fast-paced operations of Danfoss Silicon Power and the Danfoss Group we are positioned ideally to become one of the strongest players in power electronics."

www.danfoss.com

Fiftieth Anniversary of Foundation

Avnet Abacus announced its 50th year in business, since the setup of its forerunner company Abacus Electronics, which was founded in 1972 with headquarters at Newbury, Berkshire in the UK.

Abacus Electronics grew quickly over the decades from an embryonic start-up to become a $500 million UK stock-exchange listed electronics distribution company, building up via a combination of organic growth and acquisitions of other specialist component distributors. By the time of its merger with Avnet Time in 2009, Abacus Electronics had approximately 1100 employees based in 44 offices in 11 European countries, an office in Hong Kong and five distribution warehouses.

"This year marks our fiftieth in the electronics business, growing from a small start-up company to become one of the largest component distributors across Europe and the EMEA region," said Rudy Van Parijs, President at Avnet Abacus. "It is a moment to take stock and celebrate our 50 years in business and to look at how our company has met the many challenges in our target markets over the past five decades, largely driven by global external forces from the oil crises of the 1970s to the financial crisis of the late 2000s and the global pandemic of the past two years from which we are still slowly emerging. But it also a moment to consider how we will continue to drive forward within the Avnet umbrella of its family of companies, and how we can best channel our past endeavours and our resources to better serve our customers, suppliers, partners and, very importantly, our employees, and drive forward to continued success in the coming years."

www.avnet.com

'Tech for Good' Award Celebrates Women in Technology

RS Components (RS) has sponsored the 'Tech for Good' category at the FDM everywoman in Technology Awards 2022, which celebrate the achievements of women in technology. This sponsorship showcases the company's commitment to developing a sustainable and inclusive future through people and innovation. The annual RS 'Tech for Good' award is presented to a woman who is driving forward an initiative that uses technology to make a positive difference, whether as part of a social enterprise, diversity and inclusion, a focus on sustainability, or any other area of impact.

This year, 'Tech for Good' category finalists showed a clear focus on developing applied, innovative, technology-led solutions to real world problems, using technology for good in the world. The everywoman in Technology Awards 2022 were held in London. Claire Rose, Director of New Venture Development at RS, commented: "The strength of applications in the 'Tech for Good' category this year was remarkable. It was great to see ambitious game-changing technologies being developed, delivered, and advocated with passion, intellect, compassion, and intelligence; aiming to deliver technology for good on a global scale and with impact. Well done to all the applicants.

"RS is a strong advocate for equality, diversity, and inclusion. As a global engineering and technology-led business, we are proud to support everywoman and applaud their movement for gender parity in the workplace."

www.rs-online.com

ISPSD 2022 Will Bring Together Authorities on Power Devices and ICs

The 34th International Symposium on Power Semiconductor Devices and ICs (ISPSD 2022) will be held in hybrid format with the in-person portion held in Vancouver, Canada from May 22 – 25, 2022. ISPSD brings together the experts on power devices and power integrated circuit technologies and applications. The conference venue rotates annually through regions of the world with an average attendance of about 450 engineers, scientists, students, and professors. ISPSD 2022 will open with an all-day short-course lecture series on May 22 with six exciting topics. This will be followed by three full days of technical sessions (May 23 – 25). A total of 84 oral and poster technical papers will be presented. Sessions will run sequentially, with no parallel sessions, enabling participants to listen to, and to ask questions of, every presenter. In recognition of the reality that not all authors will be able to attend in person, the conference has been shortened by one day for 2022 and we will modify the format of the conference to include video-on-demand presentations as well as two extended roundtable discussion sessions with on-line authors to enhance the experience for in-person attendees. All oral and poster presentations will be pre-recorded and available on-demand for all attendees. The technical program will consist of more than 84 presentations on novel power device concepts, process integration, device modeling, power ICs, packaging and integration, and power electronics applications. In addition, exhibition booths will provide an opportunity for attendees to learn about the equipment and services of companies that support the power electronics industry.

www.ispsd2022.com

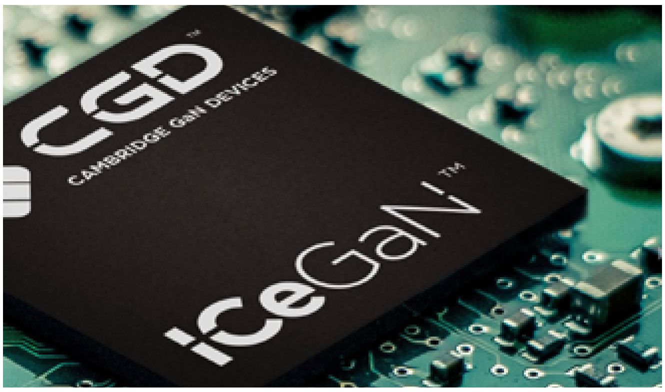
Heading Into the Future of Electronics - Sustainably

electronica 2022, which takes place from November 15 to 18, will once again bring the international electronics industry together at the Munich exhibition grounds under the motto "Driving sustainable progress." Through their products and solutions, exhibitors at the world's leading trade fair, ranging from start-ups to global corporations, will show what role electronics plays in paving the way for sustainable technologies for future societal topics. A comprehensive supporting program with conferences and forums offers room for personal and professional exchange. After electronica 2020 took place as a purely virtual event, electronica 2022 is once again registering high interest from exhibitors and will fill 13 halls on the Munich exhibition grounds. As a co-located event, SEMICON Europa will take up an additional hall. "The exhibitors, top decision makers and thought leaders want to discuss innovations and trends in person again at last and they're already looking ahead to the fall with confidence," says Dr. Reinhard Pfeiffer, Deputy CEO of Messe München. "For them, electronica is the world's most important industry get-together and the only one this year that seamlessly covers the complete spectrum of electronics." To ensure a secure visit to the trade fair, the organizers are relying on a detailed safety and hygiene concept which has already been proven at the likes of productronica in fall 2021.

www.electronica.de

Debut with First Commercial Products at APEC

Fabless semiconductor company Cambridge GaN Devices Ltd. (CGD) has emerged from stealth mode to announce the launch of its first portfolio of products capable of reducing power losses by up to 50%. Marking the company's debut appearance at APEC, CGD has launched the ICeGaN™ 650 V H1 series comprising four 650 V products that utilise the power of Gallium Nitride-based technology. Spun out of Cambridge University, CGD has spent the past six years in R&D to design, develop and commercialise products that tackle some of the world's most pressing energy consumption challenges. Since 2016 the company has built a portfolio of 39 patents and applications, 20 of which are distinctive inventions, focused on faster, smaller and more economical devices designed to drive widespread adoption of GaN technology in consumer electronics and beyond. The 650 V H1 product series represents CGD's commercial launch, enabling the use of standard MOSFET drivers and no external components needed for protection. Engineers will be able to use CGD's GaN-based technology in applications currently run with silicon-based devices or with other GaN solutions, while CGD is set to tap into a power semiconductor market estimated to be worth over $50 billion by 2027.



www.camgandevices.com


HITACHI
Inspire the Next
IT'S IN OUR
DNA
When you need efficiency, performance is mandatory.
Our High Voltage IGBTs, are developed to meet the demanding requirements of our customers - meeting the highest quality standards and a lifetime guarantee.
Our robust products pave the way for future convenience while extending better protection of our environment.
Discover more on our High Voltage IGBTs today:
More Information:
pdd.hitachi.eu / pdd@hitachi-eu.com

Design Center Launched in Dallas, TX

Nexperia announced the official launch of its new design center in Dallas, Texas. Having recently celebrated its 5th anniversary as an independent company, this development marks another major step towards Nexperia's stated goal of becoming a world leader in essential semiconductors by 2030.

The Dallas design center is Nexperia's first research and development facility in North America and will focus on the development of analog signal conversion and power management ICs. According to Irene Deng, general manager business group, Power and Signal Conversion at Nexperia, who will head up the new center: "The Dallas design center represents an important company milestone for several reasons. It demonstrates Nexperia's commitment to establishing R&D activity in North America and it will also enable Nexperia to expand and strengthen the analog IC portfolio, power management ICs and signal conditioning ICs."

Nexperia has ambitious plans for its new center and is aiming for a sixfold increase in the numbers of employees located there by the end of 2023. "Upon presenting this investment proposal to the CEO of Nexperia, Xuezheng Zhang, it received near immediate approval, as entering the analog market delivers on our strategy to transition the Nexperia portfolio towards more differentiated, unique and combined products. Having worked in the semiconductor industry for over 30 years, I have seldom encountered such ambitious growth plans" says Dan Jensen, general manager of Nexperia's business group, Analog & Logic ICs.

www.nexperia.com

Innovation Award and Young Engineer Award 2022

This year the jury has decided to give the SEMIKRON Innovation Award to Stephan Wirths and the SiC R&D group of Hitachi Energy Ltd. Semiconductors team led by Lars Knoll in Lenzburg, Switzerland for their innovation regarding 'High-k SiC Power MOSFETs for the Next Generation of E-mobility Power Modules'.

The team has developed a novel MOS gate stack technology based on high-k dielectrics for SiC Power MOSFETs replacing today´s SiO2 gate oxides. The conventional gate oxide is a weak point of today´s SiC MOSFETS as it suffers from highly defective oxide/SiC interfaces and the intense electric field across the gate oxide negatively impacts device performance as well as reliability. The innovation has been successfully verified and demonstrated by fabricating fully functional vertical high-k power SiC MOSFETs for several voltage classes, namely 1.2kV, 1.7kV and 3.3kV. The on-state performance could be improved by 35% compared to devices with SiO2 gate oxide, and improved threshold voltage stability could be demonstrated.

This year's SEMIKRON Young Engineer Award is given to Michael Basler from Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg, Germany for his work on 'Monolithic Integration for GaN Power ICs'.

The researcher has pushed the GaN-on-Si technology by pioneering concepts and demonstrated two innovative monolithic-integrated GaN power ICs with outstanding performance, a synchronous buck converter with half-bridge, driver and control for highly-compact DC-DC conversion as well as an active rectifier diode with power switch, control and auxiliary power supply for highly-compact AC-DC rectification.

www.semikron.com

High Power next Core (HPnC)

with Fuji Electric‘s X series - 7G IGBT

MAIN FEATURES

Latest chip technology
- Fuji Electric‘s X series IGBT and FWD with low losses

High reliability
- CTI>600 for higher anti-tracking
- High thermal cycling capability with ultra sonic welded terminals and MgSiC base plate
- Improvement of delta T_j power cycle capability by using 7G Package Technology

RoHS compliance
- Ultrasonic welded terminals
- RoHs compliant solder material

Over temperature protection
- Thermal sensor installed

Easy paralleling
- HPnC module has a minimized current imbalance
- Easy scalability

Honored for Supply Competence and Strategic Cooperation

Hyundai Motor Group (HMG) has honored Infineon Technologies as “Partner of the Year 2021” with the “Special Award for Supply Competence.” The global automaker recognized Infineon’s efforts to stabilize uncertain supply chains despite the challenges posed by COVID-19 and the global semiconductor shortage. In particular, Infineon was honored for its excellent risk management working with HMG. Infineon Korea and Infineon Headquarters have provided flexible and strategic cooperation to manage the difficult situation in the market. For example, by providing the silicon carbide (SiC) based power module HybridPACK™ CoolSiC™ Drive, Infineon demonstrated product quality and its ability to respond to new requirements.

“Infineon is a reliable partner. We are honored that our efforts to maintain our delivery capabilities in a very challenging environment are valued and appreciated by our customers,” said Peter Schiefer, President of the Automotive Division at Infineon. “With the rapid momentum towards green mobility, semiconductor solutions are in high demand. We are driving the transformation toward electromobility with high-quality products, leading technology and system expertise, along with a global production network.”

HMG has been awarding the “Partner of the Year” award since 2002.

In early 2019, Infineon was the first semiconductor manufacturer to receive this award. It was awarded in recognition of outstanding achievements in just-in-time supply and contribution to strengthening the overall competitiveness of the Hyundai Motor Group.

www.infineon.com

Expansion of AC-DC GaN Power Module Family

Transphorm confirmed that power supply manufacturer TDK-Lambda has expanded its GaN-based PFH500F product line. As with their GaN-based predecessor, these latest supplies deliver various GaN benefits to end applications including a six percent efficiency increase in a 13 percent smaller device package. Combined, these advantages yield a 38 percent power density improvement when compared to the PFE500SA-12 and PFE500SA-48, TDK-Lambda’s incumbent silicon-based 12V and 48V modules. The PFH500F series

uses 72 mΩ, 8×8 PQFN GaN FETs from Transphorm. These power transistors’ high power density enabled TDK to cool the GaN power supplies via thin baseplates. In turn, TDK was able to produce a leaner, tightly contained power module capable of supporting a wide variety of broad industrial applications operating in harsh environments.

The 12V and 48V modules were designed by the TDK-Lambda Americas Dallas, TX team and deploy a bridgeless totem pole PFC configuration. While the flagship 28V GaN power supply took about three plus years to design, TDK’s engineering team was able to adapt its learning to produce these latest models in a year.

“TDK’s decision to launch the PFH500F product line as a GaN line was the result of carefully considering what our customers want and need,” said Jin He, Vice President of Engineering at TDK-Lambda Americas. “And, what our customers require are reliable power systems for use in rugged applications that can’t afford to fail. By using Transphorm’s GaN, we are able to confidently deliver that in increasingly smaller, higher performing PSUs that can also inspire end system innovation.”

www.transphormusa.com

Tatsuo Bizen Appointed CEO

pSemi Corporation announced the appointment of Tatsuo Bizen as CEO effective April 1, 2022. Succeeding interim CEO Takaki Murata, Bizen joins pSemi from parent company Murata, where for more than 30 years he has served in a variety of global leadership roles in the United States, Japan and Europe. He brings an extensive background in RF and power management, and a passion for driving innovation.

A Murata employee since 1985, Bizen served as vice president of the power module division. From 2012 to 2015, he was president and CEO of the Murata Power Solutions subsidiary headquartered in Massachusetts. Bizen spent the three years prior as head of Murata’s global corporate marketing. From 2007 to 2009, he was president and CEO of SyChip, Inc., a Texas-based Murata subsidiary that provided RF chip-scale modules. His earlier experience includes involvement in the development of RF modules such as electronic TV tuners and circuit modules for wireless communication, and product management for RF components and modules in Germany, the Netherlands and Sweden.

“I am honored and eager to lead pSemi to new heights as CEO. Since the Murata acquisition in 2014, I have worked closely with pSemi employees, who have always impressed me with their hard work, can-do attitudes and inventive ideas. I look forward to working together with my pSemi colleagues to create innovative semiconductor solutions for the connected world.” Tatsuo Bizen said.

www.psemi.com

Production Site for Factory Automation Control System

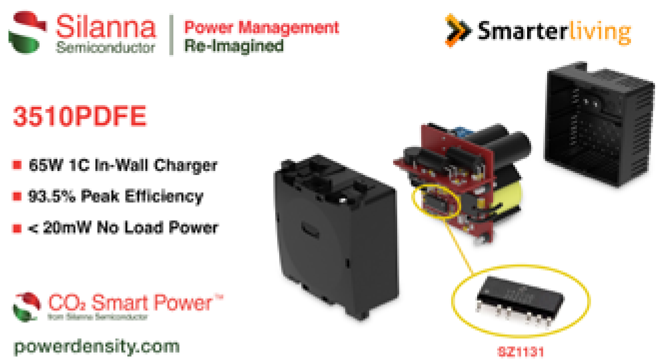
Mitsubishi Electric Corporation announced that it has acquired 42,000 square meters of land in Owariasahi City, Aichi Prefecture, Japan to establish a production site for the manufacture of factory automation (FA) control system products from April 2025.

Demand from the manufacturing industry for FA products is expected to show a medium- to long-term growth, particularly in digital sectors, such as semiconductors, electronic components and data centers, as well as for decarbonization-related areas such as lithium-ion batteries. To meet this increasing demand, Mitsubishi Electric will invest approximately 13 billion yen (approx. 110 million USD) to establish a new production site in Owariashi City, which neighbors Nagoya, where the company's main FA production site, Nagoya Works, is located. The factory will utilize several advanced technologies, such as 5G communication, allowing simultaneous connection of various machines, human workers and automatic guided vehicles (AGVs) as they perform their manufacturing tasks. In parallel, high-speed, real-time data acquisition throughout the factory will provide data sets on all aspects of the production cycle for AI-based analysis to realize a safe and flexible production environment. Additionally, the factory, which will be a three-floor, earthquake-resistant building with a total floor area of 33,600 square meters, will incorporate Mitsubishi Electric's digital manufacturing solution "e-F@ctory". This advanced digital approach strongly impacts both the supply chain management (SCM) and engineering chain management (ECM) systems.

www.mitsubishielectric.com

Collaboration on In-Wall 65W GaN Charger

Silanna Semiconductor and smart socket outlet specialist Smarter Living, have announced a 65W in-wall GaN (gallium nitride) fast charger. Measuring just 42mm x 42mm x 30mm, the 3510PDFE charger is built around Silanna's SZ1131 active clamp flyback (ACF) controller and is the first in a series of small form factor wall sockets that Smarter Living will be providing for global markets. Discussing the launch of the charger, Smarter Living CEO Jean-Paul Otto, comments: "The demand for wall-mounted USB charging outlets is growing rapidly and customers are expecting increasingly higher output powers in the smallest form factors. Partnering with Silanna Semiconductor allows us to rapidly develop a series of charging sockets that address these requirements by offering high-performance, efficient and compact charging solutions that can quickly and easily be deployed across a variety of markets."



Mark Drucker, Silanna Semiconductor's CEO, adds: "The SZ1131 ACF controller is designed to help manufacturers deliver the high-performance fast charging demanded by power-hungry mobile phones, tablets, notebooks and gaming consoles with the smallest form factor and the lowest energy requirements. By working closely with Smarter Living, we have been able to bring these benefits to the world's smallest wall-mounted 65W GaN charger."

www.powerdensity.com

20-Year Warranty for GaN ICs

Navitas Semiconductor has announced a 20-year limited warranty for its GaNFast technology – 10x longer than typical silicon, SiC or discrete GaN power semiconductors – and a critical accelerator for GaN's adoption in data center, solar and EV markets.

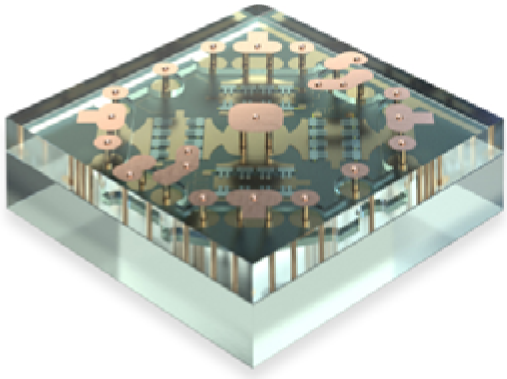
GaN is a semiconductor technology that runs up to 20x faster than legacy silicon chips. Navitas' proprietary GaNFast™ power ICs integrate GaN power (FET) and GaN drive plus control, sensing and protection. The result is easy-to-use, high-speed, high-performance 'digital-in, power-out' building blocks that deliver up to 3x faster charging in half the size and weight, and with up to 40% energy savings compared with earlier silicon solutions.

The unprecedented 20-year limited warranty is founded on Navitas' holistic approach to product reliability through design, testing, characterization and certification. As the pioneer in GaN power ICs and a founding member of the industry's JEDEC JC-70.1 GaN standards committee, Navitas developed proprietary high-speed production and qualification testing to set new standards in GaN reliability.

"As leading-edge customers like Enphase (solar), Brusa (EV) and Compuware (data center) confirm GaN's technical and environmental benefits over legacy silicon chips, they are laser-focused on critical, long-term reliability," said Gene Sheridan, CEO and co-founder of Navitas. "GaN power ICs have a 6x-lower FIT rate (failures in time) than silicon, and this 20-year limited warranty puts Navitas front and center in the next-generation semiconductor revolution."

www.navitassemi.com

Series C Funding and Scale-up of Product Portfolio



Menlo Microsystems announced its $150 million Series C, bringing Menlo Micro's total cumulative funding to over $225 million. Vertical Venture Partners and Tony Fadell's Future Shape led the round with participation from new investors Fidelity Management & Research Company, DBL Partners and Adage Capital Management along with existing investors, Standard Investments, Paladin Capital Group, Piva Capital, and PeopleFund.

Menlo Micro will use the funding to expand the company's domestic manufacturing and supply chain for the Ideal Switch, the most disruptive technological innovation in the electronics industry since the advent of the transistor.

"Today's funding milestone underscores the confidence our investors have in Menlo Micro's transformative technology to fuel the electrification of everything and modernize the $100+ billion market for RF communications, power switching and protection devices in the 21st century," said Russ Garcia, Menlo Micro CEO. "It will enable us to expand our manufacturing in the U.S. and accelerate the development of our power roadmap to solve some of the world's most pressing challenges. We're positioned to enable the upgrade of the world's aging power grids, modernize smart buildings and factories, and eliminate many of the inefficiencies in our legacy electrical infrastructure."

www.menlomicro.com

Collegiate Competition Challenging Multidisciplinary Student Teams

The Research Triangle Cleantech Cluster (RTCC) announced the winners in the Carolinas Regional Explore Event of the EnergyTech University Prize, an initiative of the Office of Technology Transitions at the U.S. Department of Energy with total cash prizes of $250,000. Ten student teams from universities in North Carolina and Virginia were tasked with identifying an innovative energy technology, assessing its market potential, and proposing a strategy for commercialization.

The overall winner of the regional competition was a team from Virginia Tech, with a self-powered autonomous robot (SPAR) for overhead powerline inspection, providing electric utilities a compact, energy-efficient, cost-effective way to provide simultaneous vibration control and condition monitoring of powerlines. The SPAR adapts to wind conditions and provides optimal vibration suppression.

"Overhead power lines frequently experience premature structural failure caused by wind-induced vibration, vegetation encroachment, and other hazards, resulting in tens of billions of dollars of losses each year. SPAR was developed to deliver a cost effective, sustainable power line maintenance solution," explained Andrew Choi, graduate research assistant and captain of the Virginia Tech student team.

Selected as a finalist in the Solar Energy Technology Office (SETO) bonus competition was Solar Shepherds – Agrivoltaics Solutions from Appalachian State University. They were awarded a $2,000 cash prize, and will join the SPAR team to compete in the national finals. Solar Shepherds were also named the Carolinas Regional Runner-Up, and received the Audience Choice Award. Solar Shepherds developed an innovative, scalable agrivoltaics model to generate renewable solar energy on active farmland, generating revenue, and increasing property values.

www.researchtrianglecleantech.org

Small Cell Solutions to Power the 5G Transition

ABB's rectifier, high-voltage DC/DC converter and downstream converter address power needs to support the small cell network buildout required for wide-spread 5G deployment.

With wider-spread 5G implementation and deployment taking place and expected to continue picking up momentum in 2022, powering next-gen networks reliably and efficiently will be essential. To help power its customers' 5G transition, ABB Power Conversion has expanded its solution offerings with its CC1600 rectifier, CC1600 high-voltage DC/DC converter, and a line power solution – its QS200 downstream converter.

"With 72% of today's global tech leaders planning to transition to 5G within the next two years1, the time is now to build out or bolster network infrastructure to support the rising bandwidth demands that will come along with 5G deployment," said Raj Radjassamy, 5G and wireless segment leader for ABB Power Conversion. "Wide-spread 5G adoption will require an influx of small cells to both support demand and expand network coverage. And energizing the newer radio equipment needed for 5G will require innovations at the power supply and component level as well."

In fact, according to ABB's recent survey of 204 Fortune 1000 CIOs and CTOs, of the criteria being used to evaluate 5G infrastructure providers, the highest priorities identified were product features (including power levels and efficiency) at 34% and reliability at 23% – further emphasizing the need for new power solutions to help enable the 5G transition. ABB is addressing this need with its latest small cell power supplies.

The CC1600-SC55 conduction-cooled rectifier provides reliable power in a sealed and weatherized enclosure that can be mounted on a pole, the side of a building, or various other outdoor locations that are vulnerable to the elements, making it ideal for powering 5G equipment. The 1600-watt (W) power supply also is available as a high-voltage DC/DC converter (CC1600SC54HV) that offers similar outdoor installation capabilities but is fed by a +/- 190-volt (V) DC input instead of the 240V AC input found on the CC1600 rectifier. It also can remotely power small cells from a centralized location with battery backup.

The QS200 is a sealed, 380V-to-48V submersible downstream line power converter that extends from a centralized power location to the load device through a twisted pair of copper cables. Designed for outdoor operation, the four-circuit converter can be strand, pole, or ground-mounted regardless of potential water saturation, making it ideally suited for low-power, outdoor distributed loads such as DSL-type broadband applications as well as small cell and 5G applications.

"With our vast experience in the wireless telecommunications space, we're able to anticipate the needs of the industry and develop solutions to our customers' toughest power challenges," Radjassamy added.

www.abbpowerconversion.com

Retrofit of a Superstar for More Sustainability and Performance: The EconoDUAL™ 3 Black Series

The Infineon EconoDUAL™ 3 (ED3) has been in use since 2005 in key applications such as general-purpose drives (GPD), electric buses and trucks, solar and wind systems, uninterruptible power supplies (UPS), chargers, and traction. It is available today with a variety of IGBT technologies and topologies as well as with integrated shunts. After 15 years, it is now time for a retrofit - to adapt this package to modern market requirements.

By Klaus Vogel, Jan Baurichter, Vitali Weiss, Christian Steininger, Fabian Severin, Torsten Methfessel, Infineon Technologies

This article introduces the features of the new EconoDUAL 3 Black Series, combined with the advantages of the tried and tested former model. With respect to sustainability and the economical use of natural resources, the copper content of the new component has been significantly reduced without compromising the performance of the device.

The new device FF600R12BE7_B11 (BE7) was tested using the 1200 V TRENCHSTOP™ IGBT7 and the emitter-controlled diode EC7 technology.

Mechanical design

The mechanical design of the EconoDUAL 3 Black Series was improved with respect to the predecessor model to further simplify production at the customer's site, and to prepare the housing for future chip generations. Also, in terms of sustainability and to ensure that natural resources are used sparingly, the copper content of the new component was reduced by eliminating the copper baseplate. This provides more stable prices as a result. To compensate for the baseplate removal, a new substrate and housing concept was developed with a sophisticated solution for heat-sink connections.

Automated inverter production

To simplify automated inverter production, the new EconoDUAL 3 Black Series is equipped with four reference elements, two on the top and two on the bottom side, see figure 1, left side.

These new reference elements enable the module to be accurately positioned on the inverter manufacturer's automated production tool. The elements form the system of reference for the device, and are the best positioning aid for the customer. To take advantage of this feature, standard dowel pins, as per ISO 2338, can be used in customers' handling grippers, heat sinks and in any production process: manual, semi-automated or highly automated. Moreover, inverter manufacturers can use less expensive bus bars with higher tolerance owing to the high-precision positioning of the module.

Fit for the new IGBT generation

New generations of IGBTs are usually developed for higher operating temperatures as compared to former generations. As a first step, the EconoDUAL 3 Black Series will be equipped with the 600 A, 1200 V Trenchstop IGBT 7 technology. The materials (plastic, gel, ceramic and terminal material) were selected bearing in mind the expected thermal load of current and future chip generations.

Press-in process

Fifteen years ago, the conventional way to build an inverter in the medium-power range was to screw copper bus bars to the AC and DC terminals, and to solder the driver PCB to the auxiliary terminals. This required manual work, as these production steps were

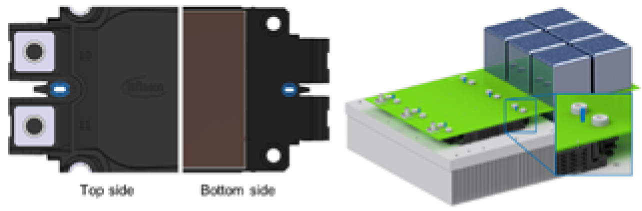


Figure 1: Left side: EconoDUAL 3 Black Series: two of four reference elements are visible in blue. Right side: Three EconoDUAL 3 Black Series (black) and capacitor bank (grey-blue) connected via the press-in process (auxiliary terminals) and screws (main terminals) to a high-current PCB (green). Positioning of the PCB using dowel pins (blue) and the new reference elements. Power module is screwed on an air-cooled heat sink (grey).

challenging for the automation process. With the arrival of the press-in process, which replaced PCB soldering, and the introduction of high-current PCBs as a substitute for single bus bars, the automation process now has fewer assembly steps, and has become simpler for inverters in the ED3 power range. For a 3-phase configuration, up to three modules are pressed into the PCB, and screwed down to the heat sink. The drawing in figure 1, right side, depicts examples of three modules connected to a high-current PCB and heat sink, including DC-link capacitors.

The four new reference elements mentioned in Section 1.1 are helpful for the press-in process, since the positioning between modules, and between the module and the high-current PCB or driver board, is performed with high precision. Machines are able to perform the assembly process, as all component positions are relative to each other, and clearly defined mechanically. A further point to consider is the tolerance of the height of the four devices connected to the PCB and to the heat sink. The devices must be of similar height to avoid mechanical stress between the connected parts, and to guarantee that every pin is properly connected to the PCB. For the new EconoDUAL 3 Black Series, the module height is determined by the plastic housing, resulting in very few height differences between the different modules.

Single substrate with high mechanical robustness

The substrate has to fulfil many different requirements. It must protect the inside of the module, support the chips, and insulate the heat sink against electrical potential. Additionally, providing a good connection to the heat sink will ensure low thermal junction-to-heat sink resistance (R_{TH_JH}). Some of the above-mentioned functions can be controlled by the material and thickness of the substrate.

For the EconoDUAL 3 Black Series, the selected substrate ensures the lowest thermal junction-to-heat sink resistance for this concept, as well as high mechanical robustness. To demonstrate its mechanical robustness, a test was performed in which high force was applied simultaneously to the standard ED3 and to the ED3 Black Series, using the test setup shown in figure 2.

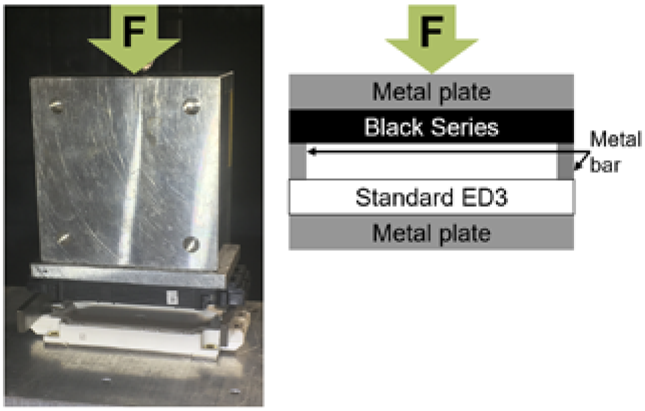


Figure 2: Left side: robustness test setup. Right side: sketch of the test-setup showing EconoDUAL 3 (bottom side) and EconoDUAL 3 Black Series (top side) in the mechanical robustness test. Modules connected via metal bar on the main terminals and force applied from top center (green arrow).

The test applies forces that are much higher than those allowed in the specification to demonstrate the high resilience of the new module compared to the former device, which is in itself highly robust. More than 4000 N is applied until breakdown of the EconoDUAL 3 device. The new EconoDUAL 3 Black Series shows no failure, demonstrating its high robustness. Figure 3 shows the device and the results of the module analysis after the test.

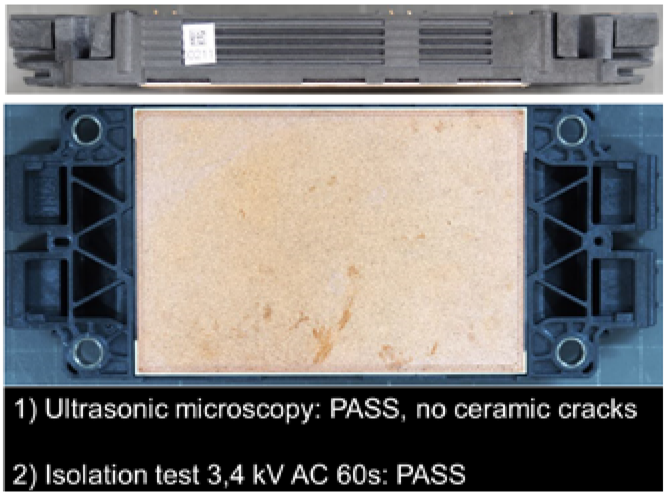


Figure 3: Photo of the EconoDUAL 3 Black Series after mechanical robustness test. No damage is visible and the substrate is intact.

It clearly shows that the new module withstands the rigorous robustness test without damage. With its high mechanical robustness and the new presented features, the new EconoDUAL 3 Black Series is suitable for all types of inverter production, whether fully automated or manual.

Thermal interface material

Owing to the selected module materials, the substrate can be very flat. Therefore, it is important to carefully observe the process of applying thermal grease to prevent the wrong amount of grease from affecting performance. Also, the material used has a big impact on the thermal performance. Figure 4 demonstrates the impact on thermal resistance using three different types of thermal grease.

For Infineon datasheet values, a thermal grease with 1 W/mK is used to define R_{TH_JH}. Using Infineon's TIM [1] or higher thermal-conductivity grease improves the R_{TH_JH} by 12 percent, respectively 24 percent.

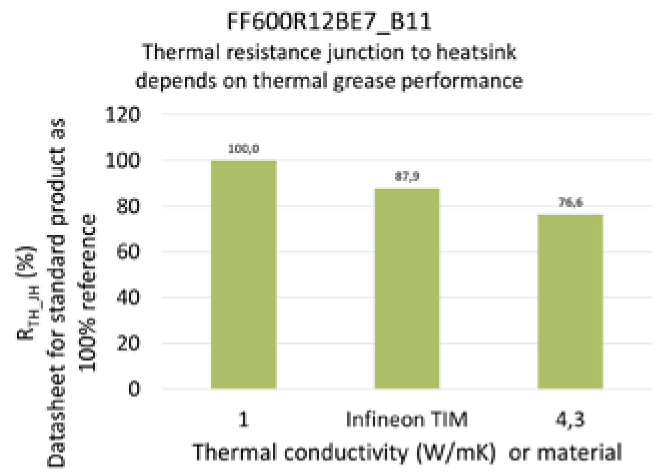


Figure 4: Comparison of thermal resistance, junction to heat sink, using different thermal grease materials

Module qualification

For the new module concept, a dedicated module qualification procedure was developed. Besides the industrial qualification tests, which are based on the well-known IEC standards, and include, among other things, tests for storage, power cycling, thermal cycling, TST and vibration, three other types of tests were created and conducted.

To evaluate the stability of the thermal resistance, an additional storage test was introduced, which was based on the lifetime model of the material. The press-down force, which is applied to the DCB by the package, changes with temperature and time. These changes in force were evaluated, the results of which were used to conduct an active thermal-cycling test in a special module design. The special design enabled the press-down force to be varied, as per the results of the above-mentioned evaluation. Under the cycling conditions, the thermal resistance remained stable even with a varying press-down force.

Additionally, several module samples were tested under applications conditions. Here, tests were conducted with air and water-cooled heat sinks using a wide range of electrical parameters to stress the IGBTs and diodes. Even when the inverter was put in a chamber at -40°C during the test break, there was no impact on the performance of the new device after it was restarted. In total, over 800 hours of application testing was conducted. Figure 5 illustrates the test strategy.

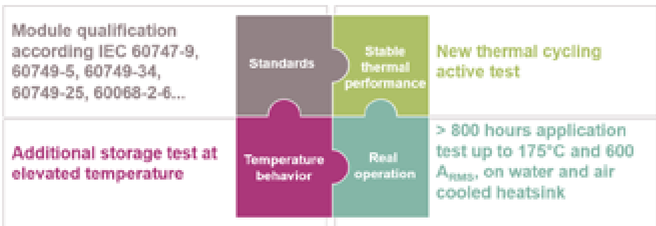


Figure 5: Illustration of the qualification strategy for the EconoDUAL 3 Black Series

Electrical aspects

The following section compares the new FF600R12BE7_B11 device, equipped with a 600 A and 1200 V IGBT 7 chipset, with the predecessor FF600R12ME4_B72 device. The removal of the copper baseplate and the reduction of chip size [2] were compensated for by a smart DCB design and a new IGBT technology aimed at achieving good thermal spreading and low switching and static losses.


Erik Rehmann, GVA expert for Quality Management
MEET THE EXPERTS:
pcim
EUROPE
10. – 12. May 2022 in Nuremberg
Hall 9 · Stand 304
gva-power.de
„WHERE INNOVATION GOES IN SERIES: GVA"
Our Development, Production and Quality departments are separated by one floor and two flights of stairs – nothing else. Because all GVA experts share the same systemic understanding and the latest know-how. That´s why we are able to mass-produce innovative developments in the shortest possible time. With guaranteed quality – and gladly also for you!
Your GVA expert:
Jürgen Kolasinski
+49 (0)621 / 78992-22
j.kolasinski@gva-power.de
GVA
POWER ELECTRONICS EXPERTS
in
YouTube

Electrical losses

In the new module, a single substrate is used to accommodate the complete circuit. Compared to solution with two or three substrates, the new solution does not waste space on system bond wires, which in turn reduces parasitic inductance and resistance. The chips can be positioned with a high degree of freedom. The placement of the IGBTs and diodes is improved in the new ED3 Black Series package, leading to a faster IGBT turn-on, and thus, lower IGBT losses. The new generation device enables faster switching without being affected by oscillation up to a $du/dt_{10..90}$ of 7 kV/µs. In [4], the switching performance of the new 600 A is presented in detail and compared with the former 600 A device. The FF600R12ME4_B72 device is able to operate up to 4 kV/µs $du/dt_{10..90}$ without oscillations at 60 A and 25°C. The FF600R12BE7_B11 is able to switch up to 7 kV/µs without oscillations, giving users a high degree of freedom if the application allows for faster switching. A detailed explanation on this subject can also be found in [2].

The described advantages, improved static losses and module lead resistance $R_{CC`EE`}$ are summarized in figure 6.

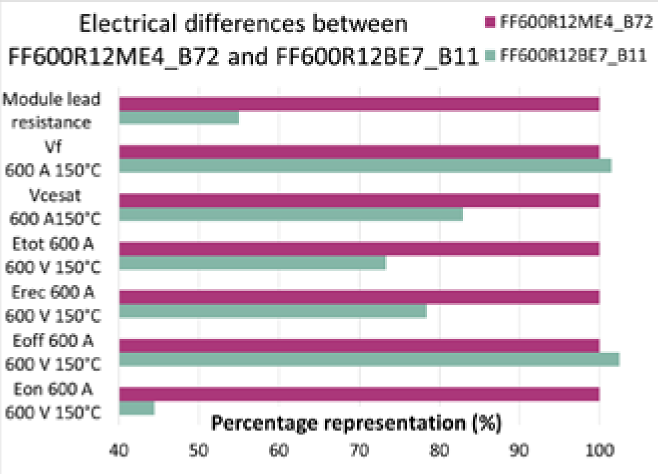


Figure 6: Switching loss comparison between ME4_B72 and BE7_B11 (gate resistor adjusted at maximum switching speed without oscillations at 25°C and 60 A); additionally, static loss and module lead resistance ($R_{CC'+EE'}$) comparison

With the new IGBT 7 and the single-DCB solution, chips are positioned in such a way that the turn-on losses can be reduced by more than half compared with the former generation. Even the recovery losses were reduced by over 20 percent, while the diode static losses at 150°C stayed the same. The turn-off losses remained at the same level, while IGBT static losses improved by 18 percent. Additionally, the single-DCB solution, combined with ultrasonically welded terminals, enabled a reduction of module lead resistance from 1 mΩ to 0.55 mΩ. For an application current of 450 A, this would result in 92 W lower losses to be dissipated via the heat sink. This results in more environmentally friendly products with lower energy consumption in operation.

Main terminals

In the first decade of the 21st century, the IGBT 3 was the state-of-the art semiconductor, which worked well in combination with the then newly developed EconoDUAL 3. In the meantime, the current density of successor chip technologies has enabled the nominal current for this device to double. However, as chip performance improves, the main terminals of the module may become a limiting factor in terms of current capability. For the EconoDUAL 3 Black Series, the best available technology is used to reduce the electrical resistance of the main terminals without changing the outer dimensions. This is done by using copper terminals that are ultrasonically welded to the substrate, instead of connections via bond wires between substrate and main terminal. At the same time, ultrasonic welding improves cooling in this part of the device. The terminal base area on the substrate has increased by 350 percent compared to a bond wire solution. The impact on performance will be presented in the next section.

Application performance

To evaluate the performance in an inverter application, the old and new designs are both tested during operation. As the EconoDUAL 3 Black Series features a lid, which is part of the DCB press-down concept, a thermocouple measurement is used to gauge the IGBT and diode temperature. An infrared camera is used to check the temperature of the module terminal. For the performance test, the modules are placed on an air-cooled heat sink. The gate resistor for the FF600R12ME4_B72 was 1.5 Ω and for the FF600R12BE7_B11 0.5 Ω. This represents the maximum switching speed for both devices according to the criteria described in Section 2.

First, the temperature reduction at the terminals was evaluated under DC conditions, and then presented in figure 7. The new terminals significantly reduced temperature inside and outside the module. At the same time, the maximum measured temperature was now at the inverter bus bar and not inside the IGBT module. In a second step, an application AC test was performed, and the chip temperature was measured with thermocouples placed at the center of the hottest IGBT. The results shown in figure 10 represent the "hot spot" of the hottest chip. The test conditions were as described in the title of figure 8.

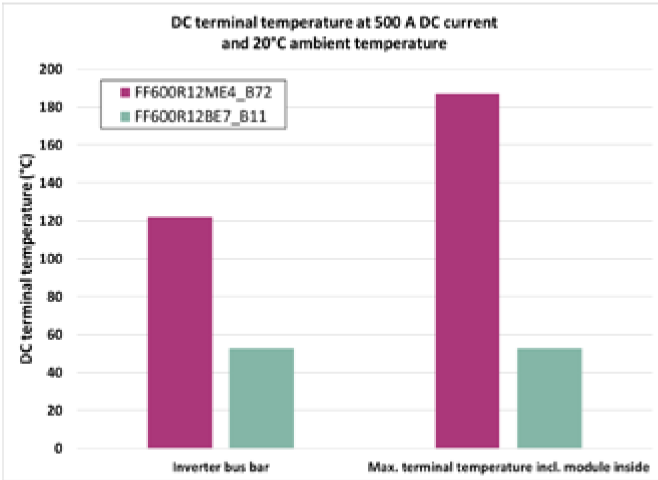


Figure 7: Temperature of the main terminal evaluated at the DC-link bus bar at the module terminal position. Left column: Inverter bus bar at module terminal position. Right column: Maximum temperature of the terminal including inner module.

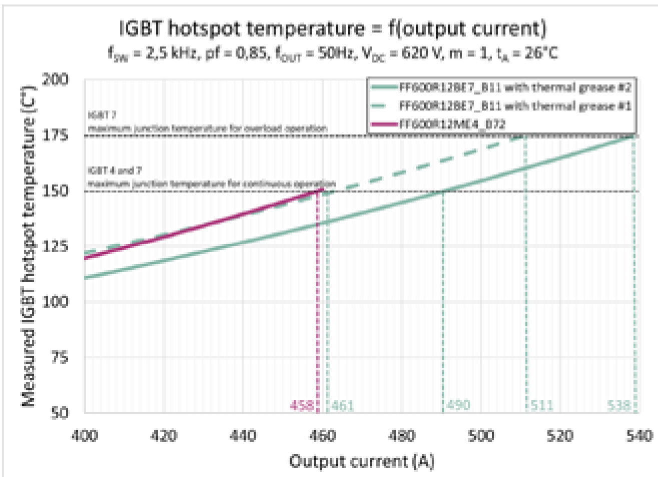


Figure 8: IGBT junction temperature as a function of the current under air-cooled inverter operation (for further test details, see diagram title)

The new EconoDUAL 3 Black Series performs in a similar way to the FF600R12ME4_B72, and is able to achieve the same output current at 150°C IGBT hot-spot temperature. The reduction of chip size and the removal of the baseplate could be compensated for by the module concept and new chip technology. If the application allows the use of the IGBT 7 overload specification [3], the BE7_B11 outperforms the predecessor generation by 9 percent. Further improvement in output current can be achieved by applying thermal grease with high thermal conductivity. Here, the performance improvement allows for 53 A (+6.5 percent) and 80 A (+17.5 percent) more output current for continuous and overload operation, respectively, compared with the ME4_B72 device.

Summary

The new EconoDUAL 3 Black Series is equipped with many new features to meet the latest market requirements without relinquishing any of the key benefits of the EconoDUAL 3 package. The new device has been developed for high-accuracy positioning, and therefore for fully automated inverter production. At the same time, the new package enables a robustness level that can withstand any manual production line.

Combining the new IGBT 7 and EC7 technology with a smart DCB design, efficient heat-sink connection and a clever selection of materials, the new EconoDUAL 3 uses fewer parts and less copper compared to the former generation. The high performance of the ED3 can be achieved, or even surpassed, depending on conditions. To highlight its superior robustness and reliability, a new qualification strategy based on the module concept was developed and successfully implemented.

Moreover, the new technology reflects modern trends towards resource conservation and sustainable living. The inverter manufacturer also has an economic advantage over the previous generation: a better price/performance ratio.

References

[1] AN2012-07, Module with pre-applied thermal interface material, https://www.infineon.com/dgdl/Infineon-AN2012_07_Modules_with_pre_applied_Thermal_Interface_Material-AN-v02_01-EN.pdf?fileId=db3a30433af3614c013af3c70cf10025

[2] Jan Baurichter, et al., Higher output performance despite chip shrinkage: New FF600R12ME7_B11 outperforms former generation, PCIM Europe, Nuremberg, Germany, 2021

[3] Klaus Vogel, et al., New, best-in-class 900-A 1200-V EconoDUAL 3 with IGBT 7: highest power density and performance, PCIM Europe, Nuremberg, Germany, 2019

www.infineon.com

SiC MOSFETs Push the Boundaries of Power Electronics

ROHM's 4th generation SiC MOSFETs offer improved characteristics compared to the older generation, and at lower prices. Several applications in both, the industrial and automotive sectors can benefit from this.

By Felipe Filsecker, Group Manager Application Engineer, Application and Technical Solution Center at ROHM Semiconductor Europe

For those who are not familiar with the latest developments in power electronics, it may sound a little strange that there are now components that are no longer manufactured on the basis of silicon, but are made of silicon carbide. The material itself and the resulting production of semiconductors such as MOSFETs is significantly more demanding than in the case of silicon. However, SiC MOSFETs have established themselves in the market as a high-performance alternative to IGBTs and Si MOSFETs, despite all the technological hurdles that were initially present. They are used in various power electronic circuits that rely on high efficiency or where volume is a major consideration. Typical applications include: Switching power supplies, photovoltaic systems and motor drives for electric mobility. Especially for the latter, which have a great demand for semiconductors and performance, the requirements are being pushed ever higher. ROHM, one of the market leaders in the field of SiC MOSFET technology, is introducing a new generation that meets the increased requirements.

ROHM expands its portfolio of power semiconductors: The 4th generation SiC MOSFETs offer improved characteristics than the previous generations, and at lower prices. Several applications can benefit from this.

This is not only about the introduction of new MOSFET power semiconductors, but also the expansion of facilities for their production. With the new semiconductor plant at the Apollo Chikugo plant in Japan and the expansion of SiCrystal in Nuremberg, where silicon carbide semiconductor wafers are produced, ROHM is increasing the production capacity significantly. This is also supported by increasing the wafer diameter from 100 to 150 mm. With these forward-looking steps, ROHM anticipates future needs in order to offer a solid foundation for technical progress.

New generation of SiC MOSFETs

SiC MOSFET technology has constantly developed over the last few years and the hurdles seen in the early years are long gone. After ROHM was the first company to launch a SiC Trench MOSFET on the market in 2015, the further development of it now follows: the 4th generation. This shows clear advantages compared to the old technology: The increased current density leads to smaller chips (Rds,on -40% for the same chip area compared to the 3rd generation). In addition, ROHM has adapted the internal capacitances so that the component can switch faster and with less loss. The result: a modern component that meets the demands of our time.

The products planned with this technology cover a wide range. From unpackaged chips with different metallisations to discrete components in classic TO packages to modern and compact modules for electromobility. An overview of the newly developed products is shown in Table 1. This list is constantly being expanded to cover as many applications as possible in both the industrial and automotive sectors. The items listed are discrete components intended for either through-hole or surface mounting. Of these,

750V MOSFET

Part No.	$R_{DS(on)}$ typ. (mΩ)	I_D (A)	Package
SCT4045DE *	45	34	TO-247N
SCT4026DE *	26	56	
SCT4013DE	13	105	
SCT4045DR *	45	34	TO-247-4L
SCT4026DR *	26	56	
SCT4013DR	13	105	
SCT4045DW7 *	45	31	TO-263-7L
SCT4026DW7 *	26	51	
SCT4013DW7	13	98	

* Automotive qualified variant planned

1200V MOSFET

Part No.	$R_{DS(on)}$ typ. (mΩ)	I_D (A)	Package
SCT4062KE *	62	26	TO-247N
SCT4036KE *	36	43	
SCT4018KE	18	81	
SCT4062KR *	62	26	TO-247-4L
SCT4036KR *	36	43	
SCT4018KR	18	81	
SCT4062KW7 *	62	24	TO-263-7L
SCT4036KW7 *	36	40	
SCT4018KW7	18	75	

* Automotive qualified variant planned

Table 1: Product range of 4th generation silicon carbide MOSFET

packages with a source auxiliary connection, such as TO-247-4L and TO-263-7L are advantageous over the TO-247N package because the MOSFETs are optimally driven by the availability of the additional auxiliary connection, leading to a reduction in switching loss. The TO-263-7L is a great choice for an SMD mountable package. It offers a significantly reduced parasitic inductance and enables automated mounting in the SMD assembly process. If an extended creepage distance is desired in the package, the TO-247-4L package is the right one. This allows the creepage distance requirements according to the IEC 60664-1 standard to be met without any further measures such as potting.

Safe short-circuit detection possible without problems

One of the limiting factors in reducing the Rds,on value is the short-circuit ruggedness of the MOSFET. Smaller Rds,on values for the same chip size mean a higher load on the MOSFET in the event of a short circuit, unless countermeasures are taken at chip level. In the case of the 4th generation, the semiconductor structure was changed so that good short-circuit ruggedness of the components is achieved, which give commercially available fast gate driver ICs with DESAT function enough time to detect and safely switch off a short circuit.

Figure1 shows the current and voltage levels of the MOSFET SCT-4036KR during a hard short circuit. In this case, the gate driver IC BM6112FV-C was used, which offers a short-circuit detection function via the drain-source voltage (classic DESAT method). The time to short-circuit detection in this case is 860 ns. In total, the short circuit takes approx. 1.6 µs until it is completely switched off without causing damage to the MOSFET. Thus, short-circuit shutdown can be performed safely and quickly with these components.

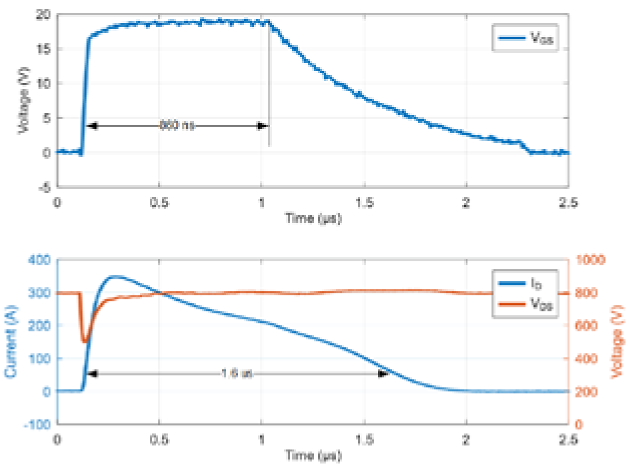


Figure 1: Safe short-circuit shutdown in less than 2 µs for the SiC MOSFET SCT4036KR using the integrated DESAT method of the BM6112FV-C gate driver.

Evaluation kits for the new components

New technologies also bring new challenges when it comes to making the best use of them. For this reason, ROHM offers corresponding evaluation kits (EVKs). As the half-bridge configuration is one of the most common topologies in power electronics, two EVKs have been developed to deal with it. The surface mount version is shown in Figure 2. This is a simple circuit. It contains: MOSFETs, gate drive, back-up capacitors and terminals. One EVK is designed for MOSFETs in THT packages (variants for TO-247-4L- & TO-247N), the other for SMT packages. The layout and component selection can be used as a reference for further designs. In the case of fast-switching components, special care must be taken to ensure that the layout, gate drive and support capacitors are optimally selected and arranged. If this is not the case, the components will be less efficient.

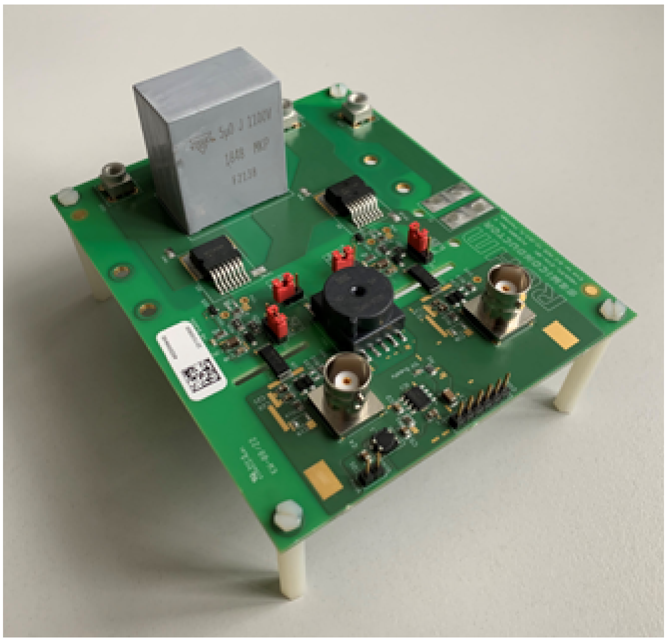


Figure 2: Evaluation kit for discrete SiC MOSFETs in a half-bridge configuration, here in the surface mount variant.

The EVKs offer the possibility to operate the switches as buck and boost converter, or as single-phase inverter. Of course, it is also possible to operate only in pulsed mode to explore the dynamic behaviour of the components under certain conditions. The gate control was realised with a simple IC, BM61x41RFV-C, which offers isolation, Miller-clamp and UVLO functionality. There are two different approaches for the auxiliary power supply: With individual flyback converters per switch based on the BD7F200EFJ-BE2 (THT EVKs), and with a self-oscillating half-bridge and transformer with separate secondary windings based on BU4S584G2 and BD62120AEFJ (SMD EVK). In both EVKs, it is possible to detect current characteristics of the switches by means of Rogowski coil or coaxial shunt resistor.

Operation at high efficiency

ROHM used the EVK for SMD switches as a buck converter to investigate the performance of the MOSFETs. The aim of this investigation was to determine what efficiency can be achieved when the SCT4062KW7 MOSFETs are operated at a switching frequency of 45 kHz. The input voltage was 800 V, the output voltage 400 V. The efficiency curve of the DC/DC converter at different output power is shown in Figure 3. It can be seen that an efficiency of just under 99.0 % is achieved at 2500 W.

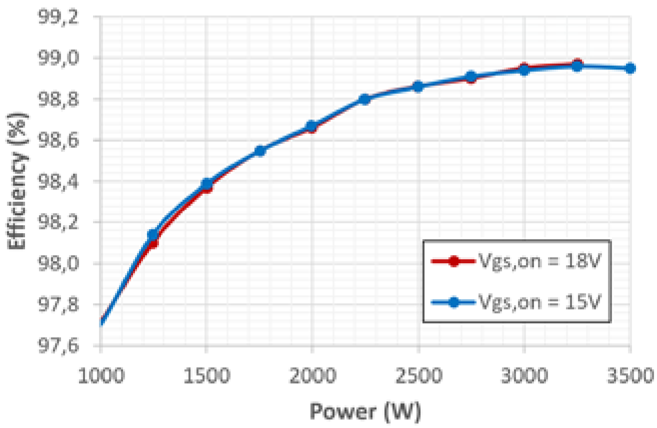


Figure 3: Efficiency of SCT4062KW7 in a buck converter (Vin = 800V, Vout = 400V, Rg = 5.1 Ω, fsw = 45 kHz, CCM)

Two variants were tested: In the first configuration, a gate-source voltage of 18 V was used, as recommended in the data sheet. In addition, the measurement was repeated for a voltage of 15 V. Based on the curves, it can be seen that both modes of operation hardly differ from each other. Only the measured case temperature is slightly higher in the case of 15 V gate-source voltage. This means that the new generation of SiC MOSFETs can be used more flexibly because they do not necessarily need to be driven with +18 V, as was the case in the past.

Summary

The increasing market acceptance of silicon carbide MOSFETs shows that these components are an essential part of the technological development in power electronics. With the 4th generation, ROHM is contributing to this trend. Due to the improved properties of these MOSFETs, it is now possible to achieve even higher efficiencies and to realise more compact designs. In addition, ROHM's latest generation offers more flexibility in the choice of control voltages compared to the previous generation.

To simplify the introduction of this technology, ROHM offers different evaluation kits. The designs included in them are also a good basis for developers who want to design circuits with these components. Short-circuit protection should also not be a problem for the developers, as this can be realised with common gate driver ICs.

www.rohm.com

GaN vs Silicon Smackdown

One way to tell when a new technology has passed the tipping point of adoption is by the voices advocating the status quo. The more conservative voices tend to cite older information that, given the fast change of trajectory that occurs at a tipping point, can lead to poor decisions for new designs.

By Alex Lidow, CEO and Co-founder, Efficient Power Conversion

In the world of GaN power devices the tipping point occurred in the past two years when the rate of new GaN-based designs started to double year-on-year, and the legacy MOSFET designs started to face critical supply shortages due to their finely tuned, but less flexible supply chains. GaN devices, on the other hand, have remained in stock at most major distributors due to their relatively new and flexible supply chains utilizing older silicon foundries, but affording these foundries a new and vibrant future.

In this article we will address some of the common misconceptions still showing up in articles and at conferences, usually presented by advocates of the status quo.

Prices and Cost

Lower voltage GaN device prices have been matching silicon MOSFETs for a few years. Figure 1 is a table of prices for 100 V GaN transistors from Efficient Power Conversion compared with the popular MOSFETs with similar on-resistance. This data was taken in February 2022 and used medium volume pricing data from distributors. GaN devices are not the cheapest, nor are they the most expensive. This comparison ignores the fact that the GaN transistors are 10 times faster and 10 times smaller than the silicon counterpart, thus delivering much more value for the price.

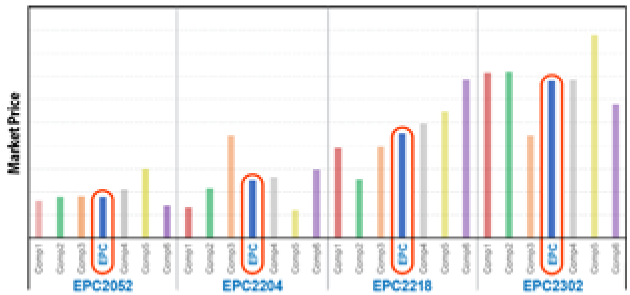
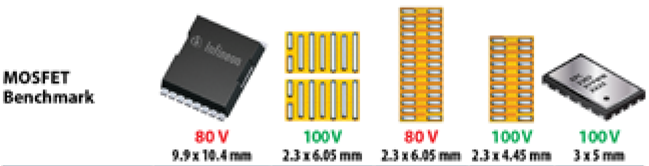


Figure 1: Comparison of market prices for 100 V GaN transistors and Si MOSFETs with similar on-resistance.

Thermal Efficiency

GaN transistors are much smaller than their silicon counterparts. This size difference is a major contributor to their lower manufacturing cost as well as their faster switching performance. One very common question that arises from the diminutive size is whether this makes it harder to extract the heat. The answer has two dimensions; (1) GaN devices tend to generate less heat due to lower conduction and switching losses, and (2) GaN devices have been designed to be extremely efficient thermally. As evidence of this second point, in figure 2 is a comparison between a popular MOSFET and several comparable eGaN® FETs from Efficient Power Conversion. Note that all the eGaN devices – even the one in a package on the far right – have much lower thermal resistance from the junction to the heatsink despite being six to 10 times smaller in size.



Parameter	IAUT200N08S5N023 (@ 10 V_{GS})	2 x EPC2218 (@ 5 V_{GS})	EPC2206 (@ 5 V_{GS})	EPC2071 (@ 5 V_{GS})	EPC2302 (@ 5 V_{GS})
$R_{DS(on)}$	2.3 Ω	1.6 Ω	2.2 Ω	2.2 Ω	1.8 Ω
Q_G typ (40 V_{DS})	36 nC	23.6 nC	15 nC	22 nC	18 nC
Q_{GD} typ (40 V_{DS})	28 nC	3.2 nC	3 nC	1.9 nC	3 nC
Q_{RR} typ	110 nC	0 nC	0 nC	0 nC	0 nC
Device size	103 mm²	14 mm²	13.9 mm²	10.3 mm²	10.3 mm²
R_{th} junction to heatsink	~0.7 °C/W	0.4 °C/W	0.4 °C/W	0.3 °C/W	0.2 °C/W

Figure 2: A comparison of 80 – 100 V GaN and MOSFET devices with similar on resistance. Note that, despite the smaller size of the eGaN FETs, they are significantly more thermally efficient.

Integration

One of the great advantages of GaN-on-Si technology is the ability to integrate multiple high voltage power devices onto one chip. This has enabled the development of monolithic power stages such as the one shown in figure 3. This device has essentially the same functionality as the Si-based lower voltage multi-chip "DrMOS" but with higher current and voltage capability, as well as better thermal properties. To illustrate the advantages of monolithic integrations, in figure 4 is a comparison between the efficiency in a 48 V – 12 V buck converter using the monolithic chip in figure 3 (green lines) and the equivalent discrete GaN transistors (blue lines). The additional efficiency is due to the virtual elimination of the common source, gate loop, and power loop parasitic inductances that are unavoidable when assembling multiple discrete elements on a PCB. The best MOSFET efficiency is also shown on this graph with a black "X".

Efficiency and Power Density

Thermal and electrical efficiency can be combined into a superior system power density. GaN power devices have consistently been

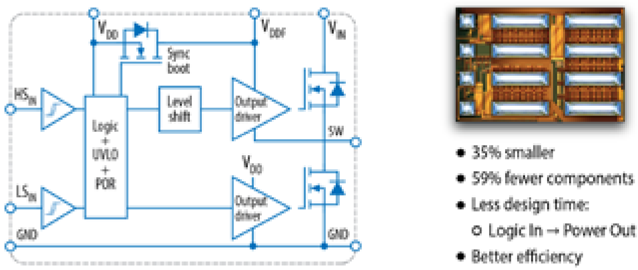


Figure 3: The EPC2152 is a monolithic power stage. The block diagram is on the left, and the 10 mm2 GaN chip is shown on the right.

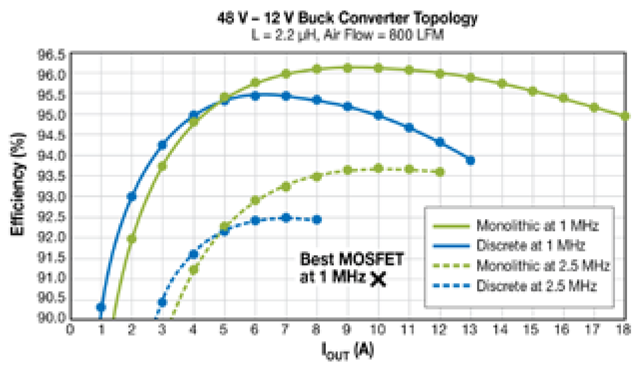


Figure 4: A comparison of efficiency in a 48 V – 12 V buck converter between a monolithic EPC2152 and comparable GaN discrete devices with a silicon driver IC. The IC is 35% smaller in size and is significantly more efficient. Note the maximum efficiency of a MOSFET-based buck converter is significantly worse.

the devices of choice at the power density benchmarks in 48 V converters. In figure 5 is shown the evolution of power density in 48 V – 12 V unregulated converters over the past 7 years. The latest benchmark has a power density of over 5,000 W/in3 compared with the benchmark MOSFET-based converters prior to GaN adoption at about 350 W/in3.

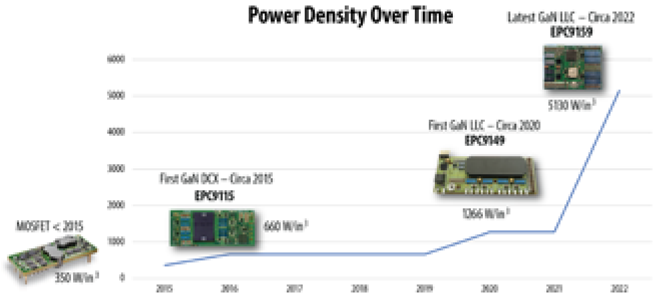


Figure 5: Since 2015 the benchmark power density for a 48 V – 12 V DC-DC converter has increased by a factor of eight.

Setup	Inverter 20 kHz, 500 ns dead time 400 RPM, 5 A_{RMS}	GaN inverter 100 kHz, 14 ns dead time 400 RPM, 5 A_{RMS}
Input Inductance	2.7 µH	None
Input capacitor	660 µF electrolytic	44 µF ceramic
Pin	121.3 W	113.3 W
Pout	119.6 W	111.3 W
$\eta_{inverter}$	98.50%	98.20%
Speed	42.25 rad/s	41.94 rad/s
Torque	1.876 Nm	1.940 Nm
Pmech	79.3 W	**81.36 W**
η_{motor}	66.30%	73.10%
η total efficiency	65.30%	**71.80%**

Figure 6: Using three EPC2152 GaN power stage ICs to create a BLDC motor drive operating at 100 kHz instead of the traditional MOSFET-based inverter at 20 kHz improves overall system efficiency by 10% while shrinking the size by a factor of two.

Brushless DC (BLDC) motor drives also benefit from improved power density due to the superior properties of GaN. In this case, the absence of reverse recovery charge (QRR) in an enhancement mode GaN transistor allows for a significant reduction in deadtime and a significant increase in the optimal operating frequency on the motor drive. Figure 6 is a comparison between a 20 kHz BLDC drive with 500 ns deadtime (needed to accommodate MOSFET Q_{RR}) and a 100 kHz drive with 14 ns deadtime. Both motor drives are running at 5 A_{RMS} and 400 RPM, and the GaN-based drive uses just three of the ICs in figure 3 coupled with a simple microcontroller to create a very low component count motor drive. Surprisingly, the 100 kHz drive has about the same inverter efficiency but can deliver 10% more torque to the motor shaft, and therefore 10% more range for an e-bike. This is a result of the elimination of a sixth harmonic signal that is derived from the long deadtime needed to accommodate the MOSFET diode recovery. This harmonic causes a significant acoustic noise as well as a counterforce to the motor. By going to the higher frequency there is also a reduction in EMI, and the designer can go to ceramic instead of electrolytic capacitors. The reduced size makes it easier to incorporate the entire drive inside the motor housing thus reducing costs and EMI even further.

Future Generations

GaN power devices have been around in volume for more than 12 years, yet the technology is far from achieving its theoretical capability. The latest generation GaN transistor technology is still 300 times larger than prescribed by the physical limits of the crystal. This means that GaN technology will continue to improve in performance and cost while the aging silicon MOSFET stagnates at the silicon crystal limits reached several years ago. GaN integrated circuits are just coming on the scene in volume applications such as fast chargers for cell phones, ebike motor drives, and lidar systems for cars and robots. Designers can look forward to many years of upgrade possibilities once they take the plunge into GaN-based power conversion.

www.epc-co.com

Innovative Power Semiconductors for Your Application

Our power electronics journey started in Switzerland over 100 years ago with the production of mercury-arc rectifiers. We continue to push the boundaries of what is possible, using silicon (Si) and silicon carbide (SiC) technology to drive innovation for the next generation of power electronics devices.

By Tobias Keller, Head of Global Product Management Semiconductors, Hitachi Energy
Dr. Virgiliu Botan, Global Product Manager BiMOS Semiconductors, Hitachi Energy
Christian Winter, Global Product Manager BiPolar Semiconductors, Hitachi Energy
Roc Blumenthal, Global Product Manager Low Voltage Semiconductors, Hitachi Energy

Our advanced semiconductor technology delivers unprecedented precision and control to HVDC transmission systems. We are the heart of traction converters that drive high speed trains, metros and diesel-electric locomotives. Industrial pumps, fans, roller tables, hoists and winches rely on us, and the world enjoys greener mobility because we power the next generation of electric and hybrid-electric vehicles.

Renewable energy transformation - Photovoltaic Inverters
To address the accelerating transition to renewable energy and the significant interest in semiconductors for photovoltaic (PV) applications, we are introducing the 1200V 600A x 2 LoPak module, which joins the 900A x 2 LoPak module introduced in 2021 and the original 1700V LoPak family. This 600A module takes advantage of the same upgraded LoPak package used for the 900A x 2 version.

The mechanical design has a major influence on the performance and reliability of an IGCT device. By applying an outer gate ring structure, it was possible to use a monolithic cathode side moly. This allows for more efficient and homogeneous wafer cooling on the cathode side compared to previous generations of the IGCT. By applying an asymmetric anode and cathode-side pole piece, the total thermal impedance was lowered. The result is a device with significantly improved thermal performance and increased reliability.

A 10kV device is the simplest and most cost-effective way to increase system voltage while using a familiar converter topology. Hitachi Energy has developed a new platform consisting of 10kV RC- and Asymmetric IGCT and a companion diode, which allows our customers to design using compact, highly reliable and cost-optimized semiconductors tailored for their specific configuration and application.

Hitachi Energy's 1200 V LoPak	Temperature	$V_{CE,sat}$	V_f	E_{off}	E_{on}	E_{rec}	IGBT short circuit SOA	Short circuit current
600 A x 2	175 °C	1.83 V	1.65 V	115 mJ	267 mJ	34 mJ	6 µS	2500 A
900 A x 2				178 mJ	171 mJ	46 mJ	6 µS	3350 A

Figure 1: 1200V module key parameters.

The bond wire material has been changed to copper (Cu) for the DBC/DBC and DBC/power terminal to support the very high current levels. The number of wires were also increased and a coated Cu power terminal supports the increased power rating. The increased performance is delivered in a module with unchanged form and function unchanged from the other members of the LoPak family, and there is an option to have a pre-applied Thermal Interface Material (TIM) installed on the base plate to improve thermal conductivity (Rth).

Renewable energy transformation - Offshore Wind
To connect 15MW offshore wind turbines as energy sources to the grid, we offer an extensive portfolio of reverse conducting and Asymmetric IGCTs. Our most recent products are the new 3rd generation 4.5kV Reverse conducting- and Asymmetric IGCT in L size housing with a pole piece of 85mm.

The new devices are available in two variants. One is optimized for converters with a medium switching frequency, which are often used in offshore wind turbines or medium voltage drives. A second variant optimized for low switching frequencies is intended for multi-level converters. The new Asymmetric IGCT has a turn-off current of 6500A, a record value for a device in this class, enabling the user to further optimize the converter design in terms of cost, size, efficiency and performance.

	Generation 1	Generation 2	Generation 3
Parameter	5SHY 35L4520	5SHY 55L4520	5SHY 65L4521
Status	Product	Product	Ramp-up
Tjmax (°C)	125	125	140
ITGQM (kA)	4 kA (@2.8kV)	5 kA (@2.8kV)	6.5 kA (@2.8kV)
Rthjc (K/kW)	8.5	8.5	6.8

Figure 2: Key device parameter comparison for 4.5kV Asymmetric IGCT generations

Renewable energy transformation - HVDC & FACT
In HVDC and FACTS, converters are used that operate at dozens of kilovolts. To function at this very high voltage, many semiconductors need to be connected in series. The converters in the most common topology used today - the MMC - are required to have high blocking voltage capability; low on-state losses; high capability to deal with fault cases (SOA and Surge Current); and outstanding reliability to guarantee an operating lifetime of more than 30 years. To ensure these requirements are met, Hitachi Energy has developed a package specifically for HVDC & FACT applications, the StakPak. Importantly, the semiconductor chip inside, the Bimode IGBT (BIGT), best meets the requirement of high SOA and Surge

TURNING THE EV MARKET UPSIDE DOWN

Our new **750V Gen 4 SiC FETs deliver $R_{DS(on)}$ from 6mΩ to 60mΩ**, the industry-best Figures of Merit, and come in 13 different $R_{DS(on)}$ and package combinations. Power designers can now pick their target power levels, then optimize their design for efficiency, cost, and thermal performance. It's all about delivering performance leadership and design flexibility.

▶ unitedsic.com/gen4

UJ4C/SC Series
750V Gen 4 SiC FETs

FETJet™
CALCULATOR

Find Your FET Match
Test these new FETs in 26 different power topologies.

▶ info.unitedsic.com/fet-jet

UnitedSiC Is Now qorvo®

Current. In the last year, we launched the next generation of this chip, the BIGT2.

The BIGT2 improves on the the previous generation by increasing current density by roughly 30%. This is achieved by redesigning the Termination (Figure 3); optimizing the cell and the pitch; and optimizing the crucial design of the back side integration.

An important design criterion of the converters is - fault capability, and the - BIGT2 provides an improvement of over 30% versus the original BIGT. Even more impressive is the Surge Current Capability, with BIGT2 having a capability 9kA (10ms pulse) in a module with the same footprint as the previous generation.

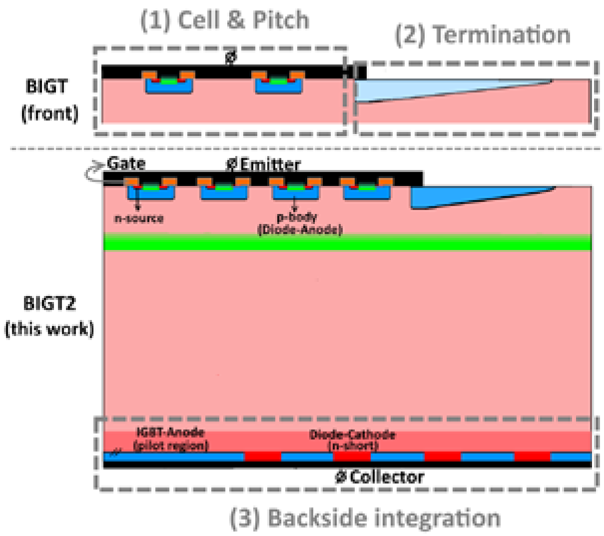


Figure 3: Schematic cross-section comparing the BIGT and BIGT2 chip with the improved areas highlighted accordingly.

Moving people across the world – e-Mobility and Charging

After ramping up the production of the LV LinPak platform during 2016, with the first products operating at 1700V and 3300V, Hitachi Energy now offers state-of-the-art 3.3kV, 4.5kV and 6.5kV modules with 10.2kV isolation voltage. For trains operating on 3kV DC lines like those in Italy, Poland and parts of Czech Republic, a two-level converter with 6.5kV IGBT modules or three-level converter with 3.3kV is available. Depending on the earthing scheme, 10.2kV isolation for the three-level converter with 3.3kV modules may be needed.

In designing these modules, great care was taken to optimize the electromagnetic behavior during switching and short circuiting. This ensures a smooth switching behavior with minimum oscillations, enabling high switching speeds. Moreover, since the modules are smaller than the standard HiPak modules used previously in Traction applications, the design was optimized for parallel operation. This enables converter designers to take a modular approach, selecting the number of devices to be paralleled based on the power level required. To meet the needs of the highest reliability Traction applications, a 10us short circuit capability will be offered (Figure 4a). By using the latest generations of chips, current ratings of 600A, 450A and 300A are offered for the 3.3kV, 4.5kV and 6.5kV respectively HV LinPak.

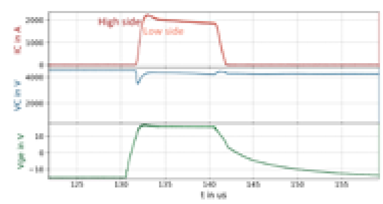


Figure 4a: Short circuit behavior for the 6.5kV 300A HV LinPak
Figure 4b: HV LinPak

RoadPak is our SiC and Si power module optimized for xEVs, e-busses and e-trucks. After the introduction of the 1200V 580A, 780A and 980A and the 750V 660A, 880A, 1100A modules with the lowest stray inductance of 5nH and highest load cycling performance (up to 6'000'000 cycles), we are adding a smaller module with 1200V 450A and 1700V 440A to our RoadPak family. These products extend the superior behavior to a lower power range.

Increasing productivity – Industrial applications

We offer a complete thyristor product portfolio from small size low voltage to high voltage and 6" diameter.

Our latest product is a 6.5 kV thyristor in a 100 mm package. This is the first product based on the latest, next-generation industrial thyristor, which significantly improves device current performance. The 6.5 kV device offers more than 30% greater average current capability compared to other products in same voltage class. It achieves this, in part, by using the leading Snowflake gate design structure and latest backend technology features.

Along with the thyristor we have developed a new rectifier diode with the same size and voltage rating that offers impressive performance at an increased voltage rating of 6.5 kV compared to previous generations that supported 5.5 kV.

	Device / Target rating	Itavm [A]	Vrrm [V]	ITSM [kA]
Thyristor	New: 5STP 40N6500	3780 +31%	6500	75 +15%
	Ref: 5STP 26N6500	2880	6500	65
Rectifier Diode	New: 5SDD 57N6500	5850 +28% / +39%	6500 +18% / +8%	110 +51% / +55%
	Ref: 5SDD 50N5500	4570	5500	73
	Ref: 5SDD 50N6000	4210	6000	71.2

Figure 5: Comparison of ratings for Thyristors and Rectifier Diodes

After successfully launching IGBT medium power modules in 2017, we are now introducing a bipolar power module, the 60Pak, which perfects the art of ultimate reliability. The first product to be launched is a diode device with a 60 mm industry standard housing.

For the best cycling performance and reliability, our modules are based on pressure contact technology. The 60 mm housing is an industry standard that is footprint compatible with existing products in the market. Optimal heat transfer, highest insulation level and very low losses ensure the best performance in demanding applications.

Voltage (V)	Ampere (A)	Configuration
1800 2)	542	TT, DT, TD
2200 1)	890	DD
5000	650	DD
6000	480	DD

1 Product qualified
2 Samples

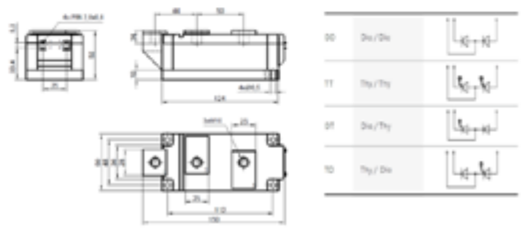


Figure 6: BiPolar Module Portfolio

www.hitachienergy.com

Eliminating Power Conversion Trade-Offs by Moving to 1700V SiC MOSFETs

Designers of high-voltage power systems have struggled to meet customers' needs for continued innovation when using silicon MOSFETs and IGBTs. The desired reliability is often not possible without sacrificing efficiency, nor can silicon-based solutions meet today's challenging size, weight and cost requirements. With the arrival of high-voltage silicon carbide (SiC) MOSFETs, however, designers now have an opportunity to improve performance while solving all the other challenges.

By Xuning Zhang, PhD, Senior Staff Strategic Applications Engineer, Microchip Technology
Kevin Speer, PhD, Senior Manager of SiC Solutions, Microchip Technology

Today's 1700V SiC products build on the success of SiC power devices rated from 650V to 1200V that have seen growing adoption over the past 20 years. The technology has already enabled significant advancements to end equipment; and now, with power devices rated at 1700V, it is extending SiC technology's myriad benefits into new end market segments, including electrified commercial and heavy-duty vehicles, light rail traction and auxiliary power, renewable energy, industrial drives, and more. Designers can maximize the benefits offered by 1700V SiC MOSFETs with the right power packaging and proper gate driving. This increases their advantages over the incumbent silicon solutions across the widest possible range of power levels.

Benefits at Lower Power Levels

The benefits of 1700V SiC MOSFET transistors begin at power levels as low as tens to hundreds of watts. SiC technology is the ideal solution for the auxiliary power supply (AuxPS) that is used in virtually every power electronics system Without an AuxPS, there is no way to get power to gate drivers, sensing and control circuits, or cooling fans. Because of its mission-critical functions, reliability is the top priority for AuxPS applications.

One of the ways 1700V SiC MOSFETs help mitigate AuxPS failures is through their high breakdown voltage, lower specific on-resistance, and fast switching speed. Together, these attributes enable a more simplified circuit design using the single-switch flyback topology (see Figure 1). In comparison, silicon-based solutions either have too low a voltage rating for this topology (which necessitates a two-switch architecture and doubles failure risk), or they sacrifice performance for voltage rating. They also are not available from enough suppliers and are more expensive than SiC devices.

By enabling the single-switch flyback topology, 1700V SiC MOSFETs make it easier for today's low-power, isolated, switch-mode power supplies to support diverse input and output requirements. They can accept a wide-ranging, high-voltage dc input (300V to 1000V) and output a low-voltage (5V to 48V) source. The single-switch flyback topology improves simplicity while reducing component count and associated overall cost.

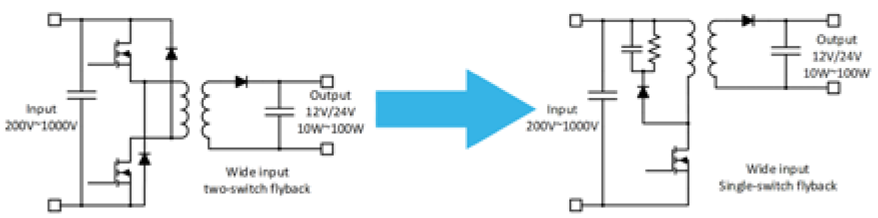


Figure 1: The ubiquitous auxiliary power supply is shown above, using the wide input single-switch flyback topology.

Beyond their improved reliability, less complex control scheme, reduced component count and lower cost, an AuxPS utilizing 1700V SiC MOSFETs can also be more compact. The area-normalized on-state resistance, also called specific on-resistance ($R_{on,sp}$), of SiC MOSFETs is a fraction of what silicon MOSFETs exhibit. This means smaller packages may be used for the smaller die, and conduction losses are reduced which can ultimately result in reducing (or eliminating!) the size and expense of heat sinks. SiC MOSFETs also have lower switching losses, providing an avenue for shrinking transformer size, weight, and cost by increasing the switching frequency.

Figure 2 shows the degree to which various available SiC devices improve efficiency vs. output power. With today's most efficient devices, it is even possible for system designers to implement passive cooling, i.e., no heat sink is required.

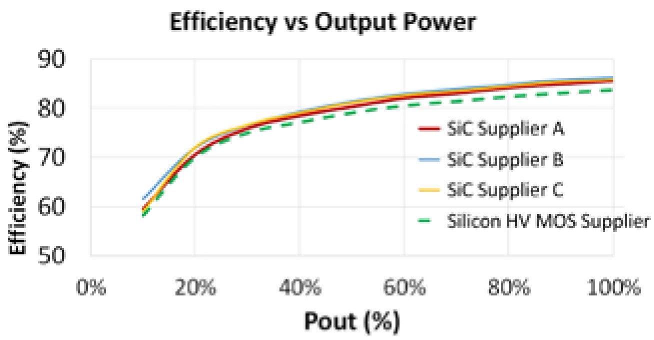


Figure 2: Comparison of efficiency vs. output power for multiple SiC options and one silicon high-voltage MOS device.

Benefits Grow as Processed Power Increases

The impact of SiC technology's faster, more efficient switching increases as the processed power increases. Move up the power scale to tens or hundreds of kilowatts (kW), there are many applications for SiC technology. Figure 3 shows a multi-kW three-phase inverter (75 kW in this example) and its topology. It can be found in EV traction, EV chargers, solar inverters, UPS, motor drives and more.

Figure 4 compares the efficiency of this inverter design using 1700V power modules in a low-inductance package to that of alternative power semiconductors. The SiC module demonstrated a peak efficiency of 99.4% at 10 kHz. Even when the switching frequency was tripled to 30 kHz, the SiC module still offered higher efficiency than the silicon IGBTs. This makes it possible to shrink heavy, expensive filter components to just one-third their original size.

In general, MOSFETs reduce switching losses by an average of 80% as compared to the silicon IGBT, which enables converters to increase switching frequency while reducing the size, weight, and cost of bulky, expensive transformers. The conduction losses of SiC MOSFETs and silicon IGBTs are similar under heavy loads, but it is more important to consider so-called "light-load" conditions under which many applications spend most of their service lifetimes operating. These include solar inverters located under a shade structure or on cloudy days; wind turbine converters operating on still days; and train doors that are only periodically opened/closed by transportation auxiliary power units (APUs). SiC MOSFETs reduce conduction losses compared to silicon IGBTs in these use cases, which complements their reduced switching losses. The combination of lower conduction and switching losses enables designers to reduce or eliminate heat sinking or other thermal management measures.

As with lower-power AuxPS applications, SiC MOSFETs used in this higher power range improve reliability by empowering designers to use a more simplified circuit topology and control scheme. This, in turn, reduces component count and associated costs. In these applications, the higher-power delivery needs of medium-power converters requires the use of a higher dc bus voltage, typically between 1000V and 1300V. To maximize efficiency, designers using silicon transistors at these high dc link voltages have traditionally had to choose from among a few complex, three-level circuit architectures. Examples include the diode neutral point clamped (NPC) circuit, the active NPC (ANPC) circuit and the T-type circuit. This changes with 1700V SiC MOSFETs, which allow designers to use the two-level circuit with half the device count and significantly more streamlined control. As an example, a system that previously used silicon IGBTs in a three-level circuit topology could use half (or fewer) 1700V SiC MOSFET modules in a more reliable two-level topology.

Figure 5 shows the dramatic extent to which designers can reduce total part count for NPC, ANPC and T-type circuits with SiC technology. Without even considering the benefits of multiple parts being connected in parallel at each switch position, the various circuit architectures used with IGBTs have 4 to 6 times more components than a SiC solution. As the part count is decimated, so, too, is the gate driver count, and the control scheme is simplified.

Moving to Megawatt-Scale Applications

Megawatt-scale applications range from solid-state transformers (SSTs) and medium-voltage dc distribution systems to traction power units (TPUs) in commercial and heavy-duty vehicles. Other applications include central solar inverters and offshore wind converters, as well as shipboard power conversion systems. Figure 6 provides an example of a modular multi-level converter.

In applications within this multi-megawatt power range, a converter for a solid-state transformer as shown above uses multiple levels of series-connected power cells to meet voltage requirements. Each cell could be a half-bridge or a full-bridge cell. Some designers even opt for three-level architectures. Using modular solutions based on a basic unit cell improves scalability while minimizing maintenance. These unit cells, sometimes referred to as power electronic building blocks or sub-modules, are configured as cascade H-bridge converters or modular multi-level converters (MMCs).

To implement these unit cells, designers historically have used 1200V to 1700V silicon IGBTs. When they are replaced by 1700V SiC MOSFETs at the unit cell level, there is the same effect as described in lower-power applications: better power handling capability and electrical performance. The lower switching losses of 1700V SiC MOSFETs enable switching frequency to be increased. The size of each unit cell is dramatically reduced, and the high blocking voltage of 1700V reduces the number of unit cells required for the same dc link voltage. This ultimately increases system reliability through the reduced cell count while reducing cost by using fewer active

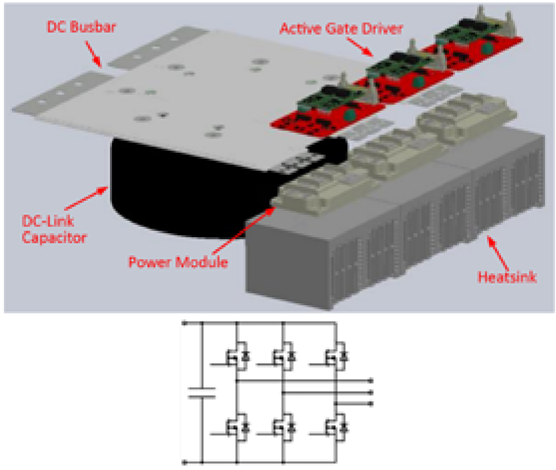


Figure 3: In order, the key priorities for the multi-kW three-phase inverter shown above (including functional sections and topology) are efficiency, reliability, and power density (size and weight reduction).

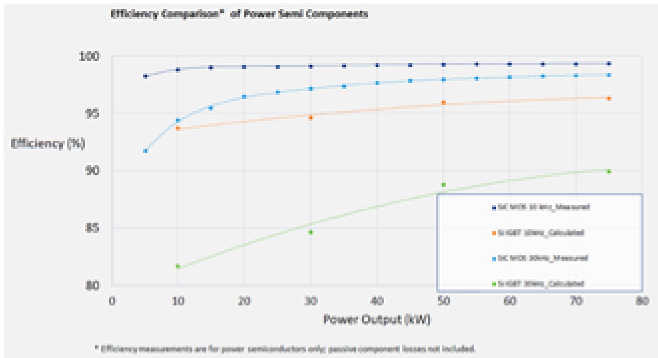


Figure 4: The efficiency of SiC solutions is compared to that of silicon IGBTs at 10 kHz and 30 kHz switching frequencies.

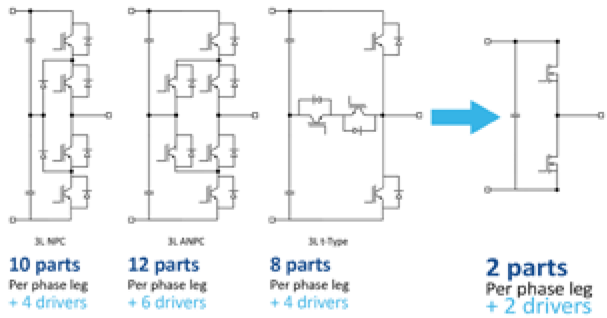


Figure 5: SiC technology increases efficiency and power density while enhancing reliability through the ability to use simpler two-level topologies. This enables a 75 kW three-phase inverter to be built with as few as two parts per phase leg plus two drivers, as shown in the NPC, ANPC and T-type circuit examples above.

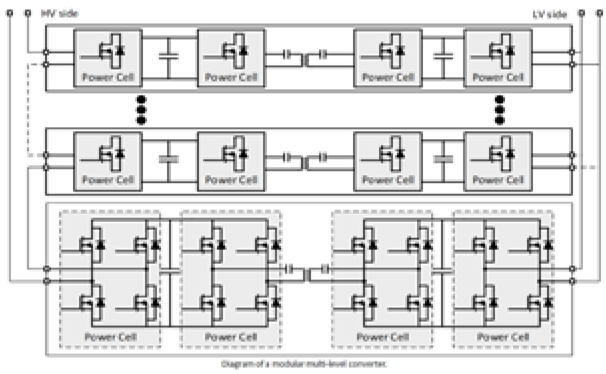


Figure 6: Modular multi-level converter.

switches and gate drivers. As an example, when a 1700V SiC solution is used in a solid-state transformer operating on a 10 kV medium-voltage distribution line, the number of series-connected cells can be reduced by 30 percent as compared to those using silicon alternatives.

Importance of Power Packaging and Proper Gate Driving

Because SiC MOSFETs can switch high levels of power at very high speeds, there are secondary effects that must be mitigated, including noise and electromagnetic interference (EMI), as well as limited short circuit withstand time and overvoltage caused by parasitic inductance and overheating. The typical medium-power converter turns off hundreds of amperes across a 1000V – 1300V bus in under a microsecond.

Figure 7: Designers have many package options with today's SiC modules, including half-bridge options with stray inductance as low as < 2.9 nH as shown above.

Microchip has SiC MOSFET module packaging options available that significantly reduce parasitic inductance. These include half-bridge packages with as little as < 2.9 nanohenry (nH) of stray parasitic inductance, which maximizes current, switching frequency and efficiency (see Figure 7). These types of packages also offer higher power density and a compact form factor, enabling lower quantity of modules in parallel to achieve complete systems, which helps to further downsize equipment.

In addition to minimizing package inductance and optimizing system layout, designers also can use a new method of gate driving designed specifically to mitigate the secondary effects of SiC MOSFETs' faster switching speeds. Today's configurable, intelligent, and fast-acting digital gate drivers cut drain-source voltage (VDS) overshoots by up to 80 percent as compared to the traditional analog approach and reduce switching losses by up to 50 percent. They also cut time to market by up to six months and provide new augmented switching capabilities.

These capabilities enable designers to explore configurations and re-using them for different gate driver parameters such as gate switching profiles, system-critical monitors, and controller interface settings. They can quickly fine-tune gate drivers to support many different applications without making any hardware modifications, reducing development time from evaluation through production. They also can change control parameters throughout the design process, and change switching profiles in the field as required and/or if/when SiC MOSFETs degrade.

Today's SiC MOSFET offerings should also be part of a comprehensive SiC ecosystem that provides a direct path from evaluation to production. This includes customizable module options as well as digital gate drivers that allow users to optimize system performance and reduce time to market with the click of a mouse. Other ecosystem elements should include reference module adapter boards, an SP6LI low-inductance power module, mounting hardware and connectors to the thermistor and DC voltage, plus a programming kit for the configurable software. Companion discrete products round out the ecosystem.

A Continuum of Benefits

Across a continuum of power conversion applications, from watts to megawatts, high-voltage SiC MOSFETs are moving designers beyond the compromises of silicon solutions to drive innovation in power conversion system development. They increase reliability while reducing cost and simultaneously shrink the size and weight of more efficient power converters and power systems. When used with intelligent digital gate driving, 1700V SiC MOSFETs deliver their greatest possible value. Microchip offers a broad portfolio of rugged and reliable SiC components in the form of die, discretes and power modules, as well as digital gate driver solutions, that allow the designer to adopt SiC with ease, speed, and confidence.

www.microchip.com

Finding the Right Technology to Solve the Datacenter Power Challenge

Digitization and the rapid deployment of cloud services have boosted the growth of datacenters worldwide. Datacenters consume close to one percent of global electricity, a number that is only expected to grow. Industry trends, such as metaverse and augmented and virtual reality, will continue to demand more energy than the planet can sustainably produce.

By Anuj Narain, Director Power Platforms, Wolfspeed

While increasing renewable energy contribution is a step in the right direction, it is not enough, and energy efficiency is another area of focus that targets the nearly 40 percent of datacenter operational costs due to energy consumption by servers and their cooling systems.

Global standards for datacenter power supplies also continue to evolve toward higher efficiencies. The Open Compute Project (OCP) 3.0 offers further optimization of hardware that lowers energy consumption, and the 80 Plus Platinum and Titanium certification requirements as well as EU's Ecodesign in Europe (ErP) Lot 9 regulations continue to evolve (Table 1). The next update to Lot 9 is already scheduled for January 2026.

Power architecture evolution

As processor and server power is increasing, datacenters are using more power per rack. They now need 2-4 kW discreet blocks with the industry trending toward even higher power densities. Distributing this power at the first-generation 12 V levels means having to handle much higher currents. To provide 1 kW to a server rack, the traditional 12-V architecture needs to deliver 83 A of current. To control I2R losses and address safety concerns, more copper would be needed in the wiring harness of such a system.

A one-percent efficiency improvement can result in saving kilowatts at datacenter level and second-generation power architectures, using 48 V (Figure 1), result in 16-times lower I2R losses while still being below the UL-60950-1 standard 60 V DC Safety Extra – Low Voltage (SELV) limit beyond which additional insulation, spacing, and testing are required. To meet new energy efficiency requirements, the enterprise datacenter power sector is therefore adopting a 48 V architecture.

Generation 2 rack systems, built out as discrete 2-4 kW power blocks, replace the massive high-voltage Uninterruptible Power Supply (UPS) and Power Distribution Units (PDUs) from Generation 1 with smaller UPSs per rack that are charged using a 48 V DC supply. The AC-DC and DC-DC supplies not only operate each server board but charge the UPS battery. The removal of load sharing and redundancy from Generation 1 leads to the requirement for each power supply to operate at close to full (100%) load.

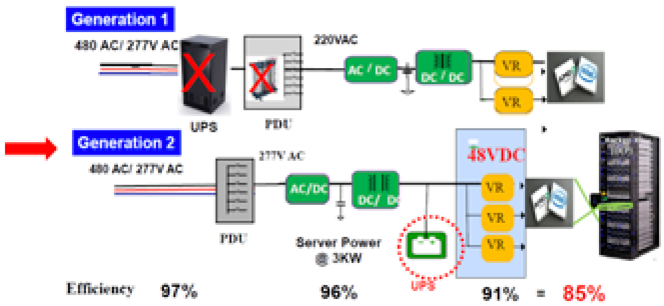


Figure 1: The global energy savings from Generation 2 power architectures can be equivalent to 27 1-GW nuclear power plants. Source: Fred Lee, Power Architecture for the Next Generation of Datacenter.

Challenges to server PSUs

Apart from the challenges due to the changes discussed above, it is worth noting that the OCP 3.0, Open Rack V.2 (ORV) and Bitcoin/mining power supply units (PSUs) require a move beyond 2 kW to the 3-4 kW range. Rack manufacturers continue to call for small form factors and low profiles of 40 mm (height), high power density, effective and low-cost thermal management, and EMI design to manage the high-speed switching that reduces size of the magnetics. In addition, there is requirement for full digital control and design flexibility from using power MOSFETs mounted on a daughter card.

In considering semiconductor device technologies to solve these challenges, differences must be noted in terms of bandgap, critical electrical breakdown, electron mobility, and thermal conductivity, all of which affect the peak operating temperature, voltage, efficiency, and thermal management requirements of the system.

The semiconductor solution

Although silicon (Si) is the most familiar technology, its smaller bandgap limits operating temperature, its low breakdown electric field restricts its use to lower voltages, and its low thermal conductivity limits power density compared to wide bandgap materials, like gallium nitride (GaN) and Silicon Carbide (SiC).

		Efficiency				Power Factor				80Plus	
Requirement	**Output/ Load**	**10%**	**20%**	**50%**	**100%**	**10%**	**20%**	**50%**	**100%**	**230 V non-redundant**	**230 V redundant**
Lot 9 (March 2020)	Multi	—	88%	92%	88%	—	—	0.90	—	Gold	Gold
	Single	—	90%	94%	91%	—	—	0.95	—	Platinum*	Platinum
Lot 9 (Jan. 2023)	Multi	—	90%	94%	91%	—	—	0.95	—	Platinum*	Platinum
	Single	90%	94%	96%	91%	—	—	0.95	—	Titanium	Titanium

Table 1: Lot 9 and 80Plus have similar requirements with 80Plus Titanium applications demanding a >98.5% PFC peak efficiency.

For the efficiencies needed in datacenter power supplies, it is important to compare switching and conduction losses. Conduction loss, which is the device's I2R loss, is lower when the ON drain-to-source resistance ($R_{DS(ON)}$) is low and changes less with temperature.

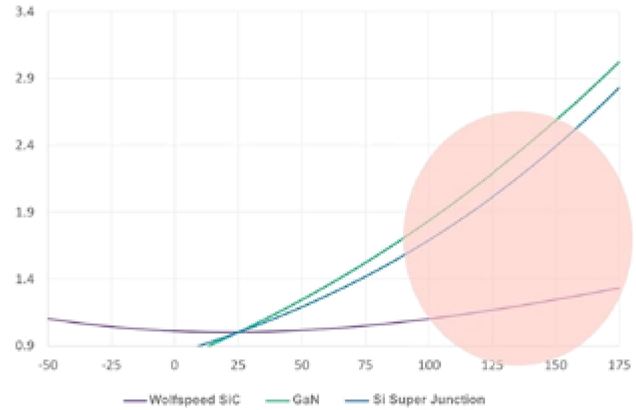


Figure 2: A generic chart showing typical MOSFET RDS(ON) (normalized) change over temperature.

Figure 2 shows normalized $R_{DS(ON)}$ plotted against temperature for the technologies that many designers consider using to meet Gen 2 datacenter PSU requirements — SiC, GaN, and Si Super Junction (SJ). It is interesting to note that both GaN and SJ devices boast a lower $R_{DS(ON)}$ below 25°C, which are temperatures not quite practical for datacenter power supplies. As datasheets for GaN and SJ devices often specify $R_{DS(ON)}$ at 25°C, it can mislead engineers into assuming that specification at the much higher operating temperatures for which systems are normally designed.

Another interesting characteristic to note in Figure 2 is the change in $R_{DS(ON)}$ over temperature. SiC's curve remains nearly flat, and although the other technologies both show a significant increase in $R_{DS(ON)}$, this change is particularly dramatic for GaN. Since designers have to use $R_{DS(ON)}$ at real-world junction temperatures of 120°C to 140°C, a 60-mΩ SiC device would be 80-mΩ "hot," while a 40-mΩ Si SJ or GaN device would really be significantly >80-mΩ hot.

GaN's low switching loss ≠ low total loss

GaN's high electron mobility is the property that enables its well-known and unmatched efficiency at very high switching frequencies. Among the technologies discussed here, GaN offers the lowest switching loss (Figure 3).

Wolfspeed compared their 60-mΩ SiC device with a 50-mΩ GaN device in a totem pole PFC simulation to find that although GaN had slightly lower switching losses over the entire power range, any gains were offset by the increased conduction losses with power and consequently junction temperature increase. This requires GaN devices to be made oversized to compensate for higher conduction losses regardless of switching frequency.

The GaN testing had to be stopped at 3 kW due to power limitations of the device. The study clearly demonstrated that SiC results in significantly lower total losses, especially at the high power levels at which wide bandgap semiconductor use is most compelling, such in as datacenters. The various device-level performance specs of the three semiconductor technologies are compared in the radar chart in Figure 4.

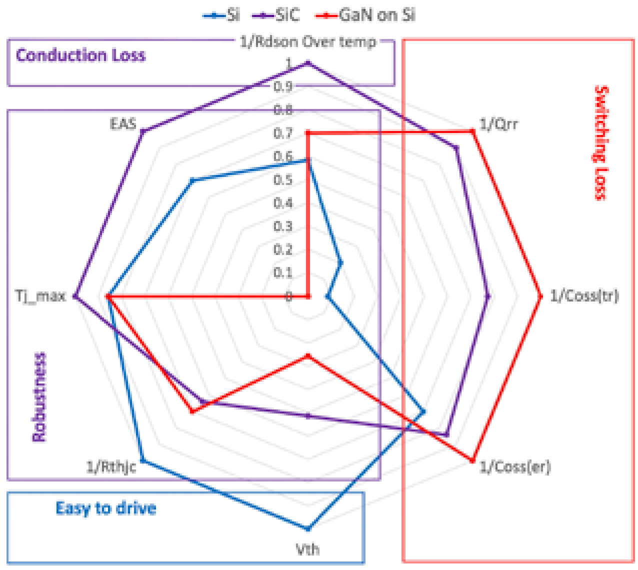


Figure 4: Silicon Carbide excels in high-voltage, high-power and high-temperature applications, such as datacenter power supplies.

At first glance, we notice GaN's benefits are the lowest reverse recovery charge Q_{rr} for the lowest switching loss in continuous conduction mode (CCM) synchronized rectifier, the lowest time-related output capacitance $C_{oss(tr)}$ for low dead time, and high frequency and efficiency, and the lowest energy-related output capacitance $C_{oss(er)}$ for minimum switching loss in hard-switched topologies. Notice that SiC trails close behind GaN in these attributes, while Si lags significantly.

Silicon wins include the lowest junction-to-case thermal resistance R_{thjc}, which confers better thermal performance, and the highest threshold voltage V_{th}, which offers better immunity to noise and makes Si devices easier to drive. Note that GaN has an extremely low V_{th}.

The maximum junction T_{j_max} and the avalanche energy, single pulse E_{as} indicate device robustness. SiC is the most robust as shown, while GaN has no E_{as} capability. SiC also has the lowest

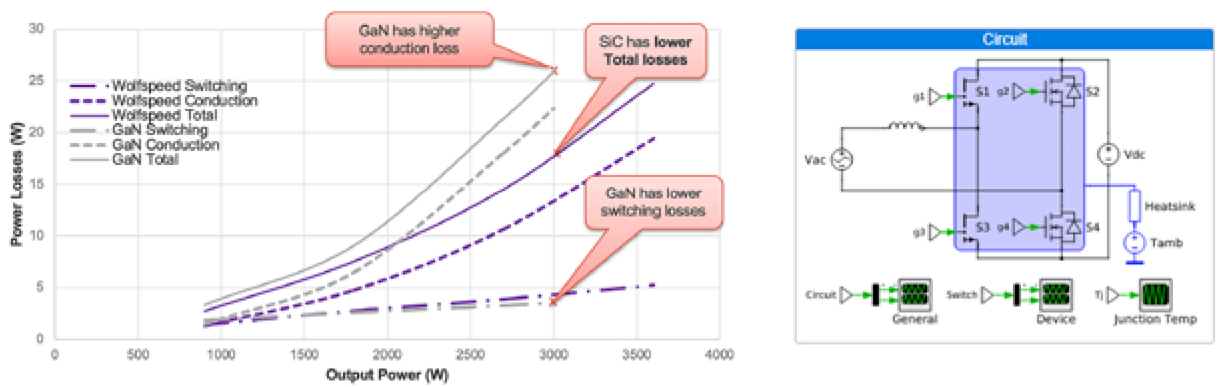


Figure 3: A study comparing a Wolfspeed 60-mΩ Silicon Carbide with a 50-mΩ GaN device in a totem pole PFC simulation. Power loss vs output power left, circuit right.

$R_{DS(ON)}$ change over temperature, which results in low conduction loss at high temperature. This is where GaN lags considerably to undo all gains from low switching loss.

Put together, SiC's strengths help deliver the highest efficiency at higher power levels, as well as high power densities required for enterprise datacenters and similarly demanding applications.

The package point of view
Since Wolfspeed developed the SiC technology for a successful transition from Si, many of the common surface-mount and through-hole packages are available for SiC products. GaN, on the other hand, faces unique challenges toward package standardization.

For instance, GaN through-hole packaging is uncommon because products need to have lower parasitics and allow very-high-frequency switching to best utilize the material's strengths. GaN is often either offered in large QFN or custom packages. Large QFN suffers from board-level reliability concerns and custom packages lack multisource availability as well as tooling capability at subcontractors.

GaN's power device package challenges do not end here. Other common concerns include:

- Kelvin source pins, widely adopted in SiC for better switching control, are not feasible in cascode GaN since other internal parameters like the cascode FET and capacitances go unaccounted. The common source cannot be eliminated and the cascode GaN is limited to TO-247-3 (three-lead) package in which the vulnerability to gate oscillation limits switching speeds.
- Some custom packages on the market are so thin, they constrain the space available for a heatsink.
- Another custom package on the market has a top-side cooled drain, which requires thermal interface materials (TIMs) with high thermal conductivity to extract heat away from the device.
- Yet another TO-Leadless (TOLL) package for GaN places the gate and the Kelvin source in a direction different from standard Si, which makes transition from the latter technology cumbersome.

As the market moves towards high-power density design and tighter space constraints, the TO-Leadless (TOLL) package offers advantages of low height and smaller footprint, and its leadless form results in low lead inductances that would otherwise become a concern in high frequency operation. The package's larger drain tab area addresses thermal performance concerns from small packages.

TOLL is a relatively new package for the datacenter and server power supply market. Wolfspeed is, however, supporting that market with product development in this direction, such as with new TOLL package variants for datacenter and server power.

A system-level comparison
Compared with Si-based H-bridge, SiC-based CCM totem pole PFC can have not only higher efficiency but higher power density at similar or lower cost. A comparison of efficiency between technologies clearly shows that while both SiC- and GaN-based CCM totem pole PFCs can achieve >99% efficiency, GaN has the efficiency advantage only at very light loads. As discussed earlier, GaN's much higher $R_{DS(ON)}$ change over temperature (Figure 2) results in its dramatically drooping efficiency curve at higher power/loads. In applications, like datacenters, that operate at or near full load 24/7, GaN therefore fails to meet efficiency requirements.

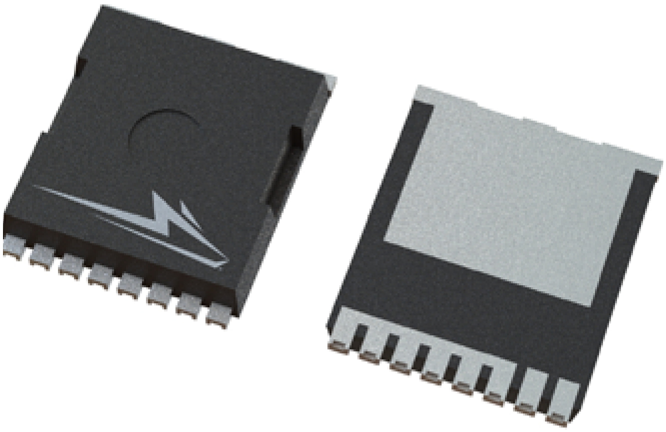


Figure 5: Wolfspeed's TOLL package is significantly smaller than the standard TO-263 and enables low-cost surface-mount assembly.

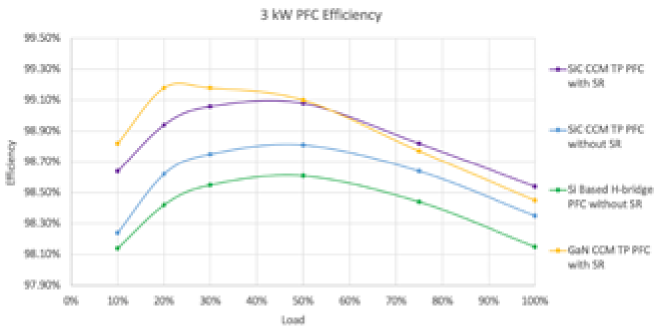


Figure 6: Silicon Carbide is the best choice in a totem pole PFC, especially for high reliability applications

SiC, on the other hand, provides an efficiency similar to that of GaN at half load and better efficiency at full load (Figure 5).

	# PFC Choke	# Power Semiconductor	Power Density	Peak Efficiency	Cost	# Control	# Gate Drive
SiC CCM Totem Pole Semi-BL PFC	1	4	Highest	98.8%	Medium	2	2
SiC CCM Totem Pole bridgeless PFC	1	4	Highest	99.1%	High	3	3
GaN CCM Totem Pole Semi-BL PFC	1	4	Highest	98.8%	High	2	3
GaN CCM Totem Pole bridgeless PFC	1	4	Highest	99.2%	Highest	3	4
GaN CRM Totem Pole bridgeless PFC	2	6	Medium	99.1%	Highest	4	5

Table 2: Topology and component analysis of Silicon Carbide- and GaN-based bridgeless PFCs.

Taking a broader look to include power density, the number of components, and relative cost of SiC- and GaN-based CCM totem pole PFC (Table 2), it is noted that SiC is better than GaN not only in terms of efficiency in high-power density applications, but also in terms of gate drive complexity, control, and cost.

In yet another comparison of real-word wide-bandgap demonstrator designs from various companies, Wolfspeed SiC shows clear advantages (Table 3). Some key points to note are:

- Many of the existing reference designs require impractical thermal management and restrict design flexibility.
- GaN FET-based totem-pole designs have lower efficiency at full load due to the high temperature coefficient of $R_{DS(ON)}$.
- As expected, SiC's low temperature coefficient of $R_{DS(ON)}$ results Wolfspeed's design to exhibit a nearly flat efficiency curve from half load to full load.
- While SiC and GaN meet requirements for bridgeless PFCs in the 2-4 kW range, high conduction losses make GaN thermal design challenging beyond 4 kW.
- System frequencies of the reference designs are limited to the 45-47 kHz and 60-67 kHz ranges to keep harmonics under 150 kHz for CE's EMI requirements. This negates GaN's advantage from low switching losses.

Wolfspeed's 3.6 kW solution

Wolfspeed's new 3.6 kW totem-pole PFC reference design (Table 3, last row) is aimed at solving the datacenter and server power supply challenge with >99% efficiency at half load and >98.5% full load, achieving 80 Plus Titanium and ErP Lot 9 requirements.

The design also offers the flexibility to tradeoff some of the high efficiency for lower cost, while still meeting the efficiency standards mentioned above (Table 4). The lower cost option replaces two of the MOSFETs in the low-frequency (LF) leg of the design with diodes, while retaining them in the high-frequency (HF) leg.

A two-daughter-card design concept gives customers the flexibility to choose the right option depending on their system design priorities.

	4 x MOSFETs	2 x MOSFETs in HF leg + 2 x Diodes in LF leg
MOSFET cost %	55.6%	27.8%
Diode cost %	0.0%	8.7%
Gate drive cost %	37.0%	18.5%
PCB, Heatsink	3.7%	3.7%
Assembly cost	3.7%	3.7%
Efficiency @ 50%	99.1%	98.6%
Efficiency @ 100%	98.9%	98.5%
Total cost %	100.0%	62.4%

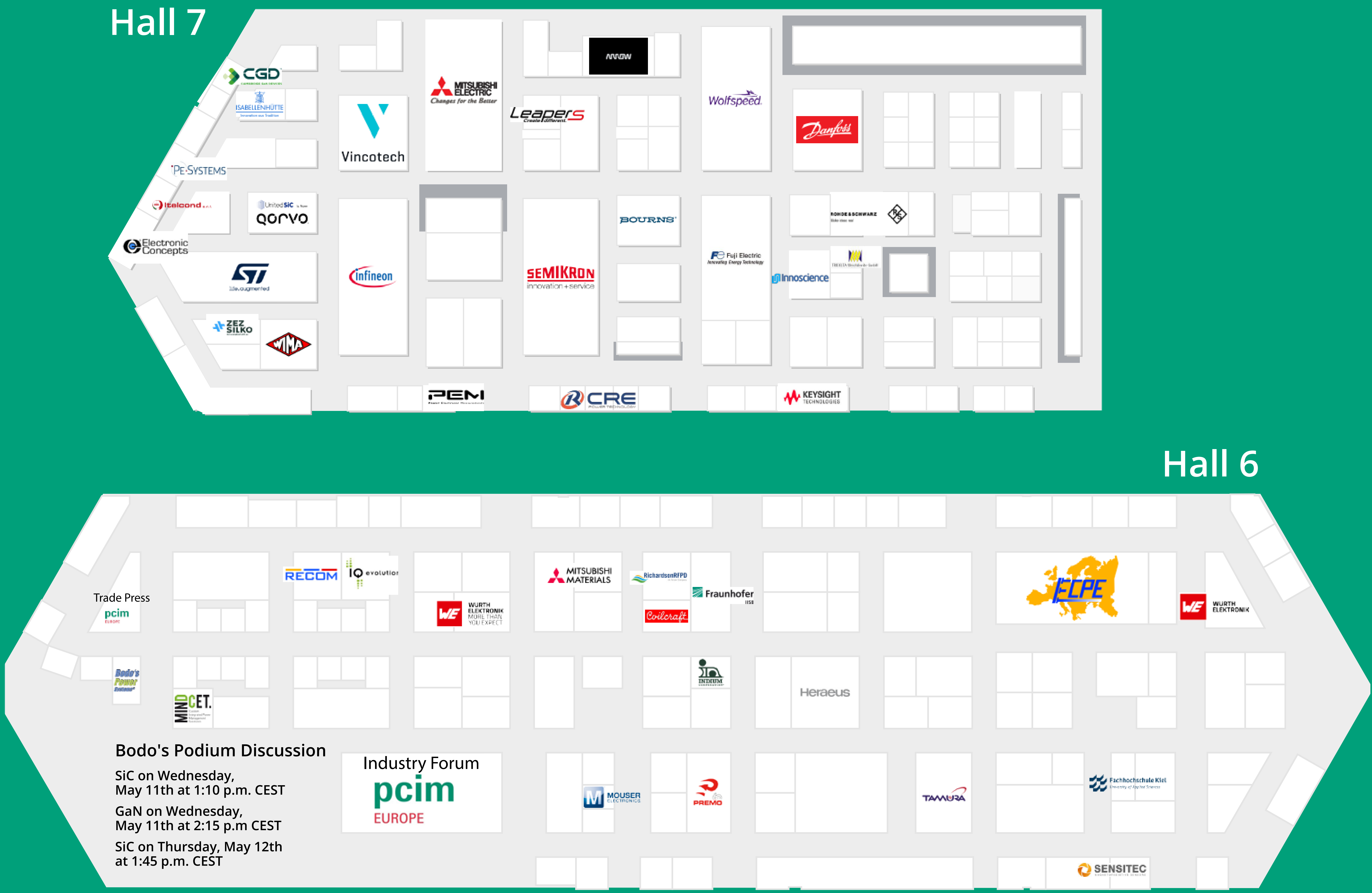
Table 4: The efficiency and cost comparison of four- and two-MOSFET options available for Wolfspeed's 3.6 kW design.

In developing such solutions, Wolfspeed uses its extensive experience building a broad portfolio of the most field-tested SiC and GaN on SiC solutions on the market. With a semiconductor team that best understands the strengths and future potential of both technologies, Wolfspeed is uniquely qualified to target the technology most suited to any given application.

www.wolfspeed.com

	Peak Efficiency	Full-Load Efficiency	HF Switch	LF Switch	Height (mm)	Power Density (W/in³)	Efficiency Standard	Physical Standard	Comments
Company A 2.6kW	99.14%	98.70%	GS66516B 32mΩ **GaN**	IXFH60N65X2	40	78	80+ Titanium/ ErP Lot9	None	SMD GaN
Company B 2.5kW	99.2%	98.50%	IGO60R070D1 70mΩ **GaN**	IPT65R033G7	45	/	80+ Titanium/ ErP Lot9	None	eGaN, limited to 2.5kW by 70mΩ
Company B 3kW	98.9% (50% load)	98.5%	IMZA65R048M1H 65mΩ 650V **SiC**	IPW60R017C7 (SJ MOS)	40	32	80+ Titanium/ ErP Lot9	OCPv3	PFC SiC primary & Si secondary, LLC Si. No daughter card.
Company C 4kW	99%	98.55%	GAN041-650WSA 41mΩ **GaN**	STY139N65M5	50	/	80+ Titanium/ ErP Lot9	None	Cascode GaN
Company D 3.6kW	97.7%	97.10%	SCTW35N65G2V 55mΩ **GaN**	TN3050H-12GY	57	/	80+ Titanium/ ErP Lot9	None	SiC, SCR, low efficiency
Company E 4kW	98.73%	98.57%	LMG3410R050 50mΩ **GaN**	STY139N65M5	35	**123**	80+ Titanium/ ErP Lot9	None	GaN, interleaved, switching at 115 kHz (in CE band)
Company F 3.3kW	99%	98.55%	TP65H050WS 50mΩ **GaN**	STY139N65M5	50	/	/	None	Cascode GaN
Wolfspeed 2.2kW	98.79%	98.68%	C3M0060065J/K 60mΩ **SiC**	FRED diode	64	20	80+ Titanium/ ErP Lot9	None	SiC, no SR
Wolfspeed 3.6kW	>99% (50% load)	>98.5%	C3M0045065L 45mΩ **SiC** TOLL	VS30CDU06H M3 (diode)	40	**92**	80+ Titanium/ ErP Lot9	OCPv3	SiC primary with SR option, daughter card concept

Table 3: A competitive analysis of wide bandgap reference designs on the market.



Hall 7
CGD
ISABELLENHÜTTE
PE-SYSTEMS
Italcond
United SiC
QORVO
Electronic Concepts
ST
ZEZ SILKO
WIMA
Vincotech
Infineon
MITSUBISHI ELECTRIC
Changes for the Better
PEM
Leapers
SEMIKRON
innovation + service
CRE
BOURNS
Wolfspeed
Fuji Electric
KEYSIGHT TECHNOLOGIES
Danfoss
ROHDE & SCHWARZ
Innoscience
Hall 6
Trade Press
pcim
RECOM
IQ evolution
WE
WURTH ELEKTRONIK
MORE THAN YOU EXPECT
MITSUBISHI MATERIALS
RichardsonRFPD
Coilcraft
Fraunhofer
ECPE
WURTH ELEKTRONIK
Bodo's Power
CET
INDIUM
Heraeus
Bodo's Podium Discussion
SiC on Wednesday,
May 11th at 1:10 p.m. CEST
GaN on Wednesday,
May 11th at 2:15 p.m CEST
SiC on Thursday, May 12th
at 1:45 p.m. CEST
Industry Forum
pcim
EUROPE
MOUSER ELECTRONICS
PREMO
TAMURA
Fachhochschule Kiel
SENSITEC

Hall 9


BASiC
Navitas
A.L.M.T. Corp.
YAGEO
Group
DOWA
cefem
APEX
MERSEN
WeEn
TIGRIS
MICROMETALS
MAGNETICS
Littelfuse
EBV Elektronik
DYNEX
nexperia
starpower
ROGERS CORPORATION
Kendeil
Hitachi Energy
GVA
ROHM SEMICONDUCTOR
power integrations
TDK
HITACHI
Inspire the Next
LEM
amantys
YOKOGAWA
EPC
plexim
VisIC
TECHNOLOGIES

Drive Safe: Isolated Gate Drivers for High-Power Applications

New technological and market trends are constantly pushing for smaller solutions with higher power capabilities. The advancement of electric vehicles, renewable energy microgrids, massive energy storing, and high-power telecom applications have significantly increased power density requirements.

By Tomas Hudson, Applications Engineer, Monolithic Power Systems – MPS

Voltage and power levels that were previously reserved for specific, high-power applications are becoming more and more commonplace in day-to-day applications, which means that previously forgiven performance issues are now unacceptable. The main limitation for these applications has traditionally been power switching technology — specifically, the performance limitations of silicon semiconductors. Recently, wide-bandgap (WBG) semiconductors have started to solve this issue, enabling high-voltage, high-frequency power converter designs.

However, the combination of high power and fast operation has created a new set of issues that designers must face when designing their converters. One of the main issues — which will be discussed in this article — is the dangers of unwanted coupling between the high voltages in the power conversion block and the weak, small-signal circuitry of the control block.

The Need for Isolated Gate Drivers

Gate drivers are common elements in most power converters. Since the control circuitry operates at low voltages, controllers cannot provide sufficient power to quickly and securely open or close the power switch. As a result, the signals from the controller are sent to the gate driver, which can withstand much higher power and can drive the MOSFET's gate as needed.

When working in high-power or high-voltage applications, the elements in the circuit are subject to large voltage shifts and high currents. If there is a current leak from the power MOSFET to the control circuitry, the high voltages and currents involved in the power conversion circuit could easily cause a massive breakdown of the control circuit by frying the transistors. In addition, high-power applications require isolation between the input and output to protect both the user and any other devices connected downstream from the converter.

Isolation can be implemented using a variety of mechanisms and materials, each with its own set of advantages. However, the most commonly used method today for high-performance systems is capacitive coupling, because it takes up much less space than inductive isolation, is more reliable than optocouplers, and offers unrivaled isolation capacity. Figure 1 shows an isolated driver.

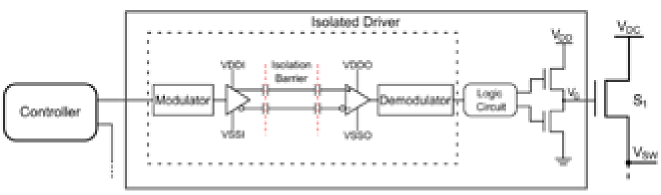


Figure 1: Isolated Driver Schematic

Capacitive isolators are based on two capacitors connected in series. These capacitors are built on the silicon die and use silicon oxide as a dielectric. By building these capacitors with a thick dielectric, they can withstand very high voltage peaks without breaking down. The isolator works by modulating the PWM signals coming from the controller into high-frequency signals, and then generating a differential voltage pair to send this information across the capacitors. This way, the modulated signal can pass through the isolation barrier without losing any data. After passing the barrier, the signals are demodulated before interacting with the driver circuit.

The main benefit of capacitive isolation is that the entire isolated driver can be easily integrated into a single chip. This is because the capacitors are built using the same standard microelectronic processes as the rest of the driver components. It is even possible to implement ICs with drivers for both the high-side and low-side power switches, such as the MP18831, an isolated half-bridge gate driver.

Important Specifications: Isolation and CMTI

One of the key parameters for isolated gate drivers is its isolation voltage rating. Having the right isolation rating is crucial for protecting the user from potentially harmful current discharges, as it aims to avoid unexpected voltage transients from destroying other circuits connected to the supply. In addition, this rating can maintain signals within the converter free from the interferences caused by noise or unexpected common-mode voltage transients.

Isolation is usually expressed as the amount of voltage the isolation layer can withstand. In most datasheets, the isolation voltages are introduced as parameters such as the maximum peak isolation voltage, working isolation voltage, and RMS isolation voltage.

However, due to increased voltages and frequencies, gate drivers face high-amplitude voltage shifts with very large slew rates. If these voltage transients are fast enough, certain high-frequency components in the voltage may not be blocked by traditional isolation methods. Common-mode transient isolation (CMTI) protects the circuit by stopping these high-frequency voltage components from coupling past the isolation barrier.

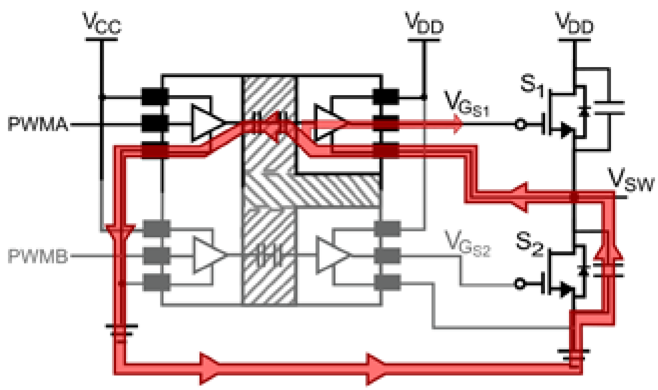


Figure 2: Charge Coupling through the Driver Due to Insufficient CMTI

As bus voltages and switching frequencies continue to increase, CMTI is becoming more and more important in gate drivers. If the CMTI is not sufficiently high, the high-power noise could be coupled across the isolated gate driver, generating a current loop and causing charge to appear at the switch gate. If this charge is large enough, it could cause the gate driver to misinterpret this noise for a driving signal, causing a severe circuit malfunction due to shoot-through. Figure 2 shows how charge can be coupled across the isolation barrier due to insufficient CMTI.

Isolated Gate Driver Protections: Miller Clamp and DESAT Protection

Parasitic coupling past the isolation barrier may not be the only cause of shoot-through. Voltage from the switch node may also be coupled to the transistor's gate via parasitic coupling within the transistor itself. This coupling usually occurs through the MOSFET's equivalent parasitic capacitor, called the Miller capacitor. However, the Miller capacitor can cause serious problems during high-frequency, high-voltage switching.

Due to the natural high-pass behavior of capacitors, high-frequency voltages are coupled through the Miller capacitor, bypassing the isolation barrier between the MOSFET's gate and channel.

This means that a current flows across the gate node, charging the gate and potentially triggering the switch. If this occurs, a direct path is established between the bus voltage and GND, causing shoot-through current and a loss in converter efficiency.

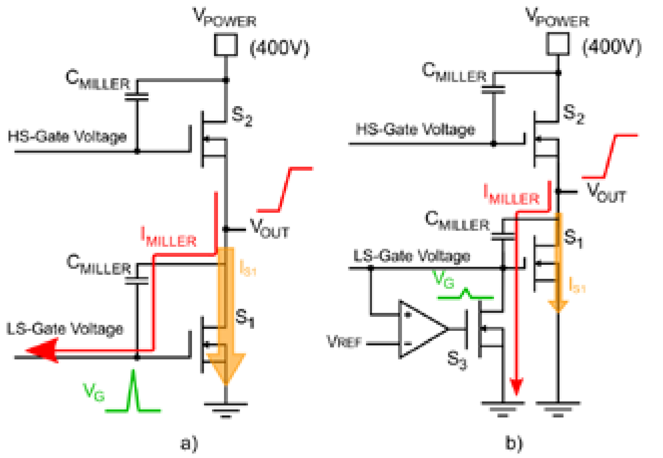


Figure 3: Switching Half-Bridge Transient Cross-Conduction Principle

The active Miller clamp is a low-impedance path consisting of a comparator and an additional MOSFET, which connects the gate of the low-side FET to ground when the high-side FET is turned on. This process redirects the current through the Miller capacitor from the gate to the ground, which reduces the charge at the gate and avoids unwanted gate driving. Figure 3 shows the switching half-bridge transient cross-conduction principle with and without a Miller clamp. Figure 3a shows the principle without a Miller clamp, while Figure 3b shows the principle with a Miller clamp.

This charge accumulation at the gate can also cause other issues, such as desaturation. Desaturation is the process of a MOSFET involuntarily entering the nonlinear region. This operation region is highly inefficient, and is therefore never used for power conversion. Due to the increased power dissipation, not only will the system lose efficiency, it may even lead to the switches being destroyed. To avoid this, the DESAT protection circuit senses the voltage across the switch and stops powering the gate if it surpasses the desaturation threshold (see Figure 4).

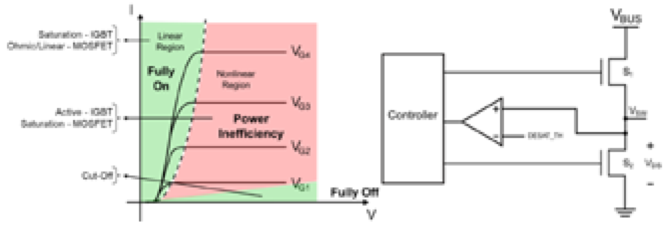


Figure 4: MOSFET Operation Regions and Desaturation Protection Schematic

Conclusion

The increased switching frequency brought about by the introduction of WBG semiconductors paired with increased power requirements has made isolation a key factor in power converter design. High isolation and CMTI ratings are key to ensure that users and devices connected to the power supply are not harmed by accidental current leakage. Protections features such as desaturation protection and active Miller clamps keep the MOSFETs operating safely.

MPS offers a wide variety of isolated gate drivers such as the MP18831, a dual-channel driver specifically designed for half-bridge converter topologies with configurable dead-time control.

www.MonolithicPower.com

SiC MOSFET Enhances Stability Under Real Application Conditions

The recently launched 1200 V CoolSiC™ MOSFET M1H comes with a variety of new features and improvements from which the targeted applications will benefit. One highlight is the much improved stability of the threshold voltage under real application conditions.

By André Lenze and Dr. Paul Salmen, Infineon Technologies

Introduction

The drift of threshold voltage ($V_{GS(th)}$) under real application conditions has been a SiC-specific focus in the last couple of years.

Infineon first discovered the drift phenomenon in $V_{GS(th)}$ under long-term stress caused by dynamic operations and presented recommendations for an operation gate voltage area to minimize drift over the lifetime. [1]. After ongoing research and subsequent optimization, the newly launched CoolSiC™ MOSFET M1H now shows a significant improvement in $V_{GS(th)}$ stability with a negligible impact of the drift effect in almost all cases.

Phenomenological Description

$V_{GS(th)}$ drifts are typically characterized by high-temperature gate bias stress tests (DC-HTGS) that follow the test guidelines defined in standards such as JEDEC. Recent findings indicate that bipolar AC gate stress including < 0 V can lead to a higher threshold voltage drift than corresponding static gate-stress tests would imply (DC-HTGS). This finding presents a new perspective in SiC MOSFET device reliability [1,3].

Figure 1 shows the different impact of AC & DC stress conditions. The data of the change in $V_{GS(th)}$ (ΔVth) was derived using maximum conditions from the data sheet [1]. Two different slopes are visible, the first corresponding to a typical DC-like drift behavior ("DC fit"). The second larger slope is due to the bipolar AC stress effect ("AC fit") also referred to as gate switching instability (GSI).

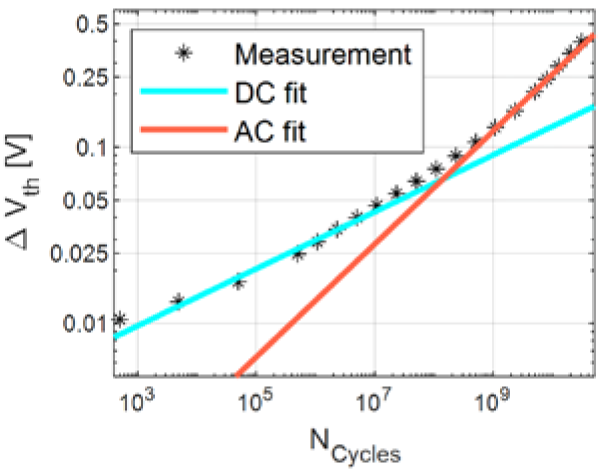


Figure 1: Drift during continuous gate switching stress: = 20 V; = −10 V; = 150 °C and = 500 kHz. [1]

We conclude that under stress conditions exceeding 10^8 switching cycles, the AC drift is the main contributor to stress, while the DC drift is the main cause of stress for fewer switching cycles.

The data shows that switching stress leads to a slow $V_{GS(th)}$ increase over time. Due to the increase of the threshold voltage $V_{GS(th)}$ an increased channel resistance (R_{ch}) can be observed. This phenomenon is described in equation (1), where L is the length of the channel, W is the width of the channel, μ_n is the electron mobility, C_{ox} is the gate oxide capacitance, $V_{GS(on)}$ is the on-state gate voltage, and $V_{GS(th)}$ is the threshold voltage of the device [1].

$$R_{ch} \approx \frac{L}{\mu_n \cdot C_{ox} \cdot W \cdot (V_{GS(on)} - V_{GS(th)})} \qquad (1)$$

The total $R_{DS(on)}$ is determined by the sum of the single resistances. These are namely channel resistance (R_{ch}), the resistance of the junction field-effect transistor (R_{JFET}), the epitaxial layer resistance of the drift region (R_{epi}), and the resistance of the highly doped SiC substrate (R_{Sub}). The entire chain for the total $R_{DS(on)}$ is described in equation (2).

Thus, the increase of $V_{GS(th)}$ causes slight increases in the channel resistance, followed by the $R_{DS(on)}$, and in the on-state losses over time.

$$R_{DS(on)} = R_{ch} + R_{JFET} + R_{epi} + R_{Sub} \qquad (2)$$

Gate Switching Stress

To secure and predict long-term electrical parameter stability of our CoolSiC™ MOSFETs during typical switching operation, we have developed and applied a new qualification stress test: the gate switching stress test (GSS). This test enables you to directly determine electrical parameter drifts that typically run in bipolar mode (positive $V_{GS(on)}$ for turn-on and negative $V_{GS(off)}$ for turn-off) under application-like gate switching conditions. This test is a must for qualifying SiC MOSFETs, as it enables developers to quan-tify the new failure mechanism described above.

The GSS test covers all important drift phenomena, including those that occur during normal device operation. Except for the missing load current, which itself does not alter the observed drift behavior [3], we mimic the application as closely as possible by keeping gate switching characteristics, such as voltage slopes, similar to typical application conditions (see figure 2) [1]. To cover potential impacts of over- and undershoots in the gate signal, which are common in real SiC MOSFET applications, we apply worst-case conditions by stressing at the allowed maximum gate voltages from the data sheet and the maximum static junction temperatures ($T_{vj,op}$).

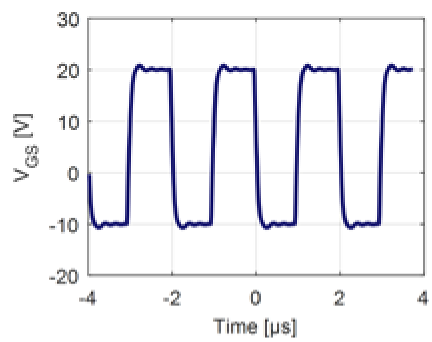


Figure 2: Typical GSS gate source stress signal at a frequency of f=500 kHz [1]

The testing under worst-case conditions makes customers feel confident that they can use the device over the entire specification range without ever exceeding the drift limit. Hence, the approach guarantees excellent device reliability combined with easy calculation of safety margins. Besides $V_{GS(th)}$, other parameters like the gate leakage current are also measured, and remain constant over time for the tested hardware [1].

Assessment of Worst-case end-of-life Drift and Impact on the Application

One of the main tasks during the development of an inverter is to predict the lifetime of the device. Therefore, it is necessary to have reliable models and information available. After extensive tests under various operating conditions, we were able to develop a predictive, semi-empirical model that describes the change in threshold voltage as a function of the relevant mission profile parameters such as stress time (t_S), gate bias low level ($V_{GS(off)}$), gate bias high level ($V_{GS(on)}$), switching frequency (f_{sw}) and operation temperature (T) ($\Delta V_{GS(th)}(t_S, V_{GS(off)}, V_{GS(on)}, f_{sw}, T)$) [3].

Based on the model, we have established a method of assessing the threshold-voltage drift with a worst-case end-of-application profile (EoAP) to calculate the relative drift. For applications that run at an arbitrary frequency for certain times, we calculate the total number of switching cycles (N_{Cycle}) until EoAP. N_{Cycle} can then be used to read out the relative drift.

The number of cycles depends on the switching frequency and the operating time. Typical hard-switching industrial applications, such as solar string inverters, make use of a switching frequency between 16 to 50 kHz. Inverters that use resonant topologies often switch faster than 100 kHz. The lifetime targets of these applications are typically between 10 to 20 years, while the real operating time is often between 50 percent to 100 percent.

The following example shows a sample evaluation:
- Targeted lifetime [years]: 20
- Real operation time [percent]: 50 => 10 years
- Real operation time [s]: 315360000 s (10 years)
- Switching frequency [kHz]: 48
- Cycle duration [s]: 1 / switching frequency = 0.0000208
- Number of cycles at end of life: operating time / cycle duration = ~1.52E+13

For a turn-on voltage of 18 V, a relative $R_{DS(on)}$ change of less than 6 percent at 25°C and less than 3 percent at 175°C can be expected, as shown in figure 3.

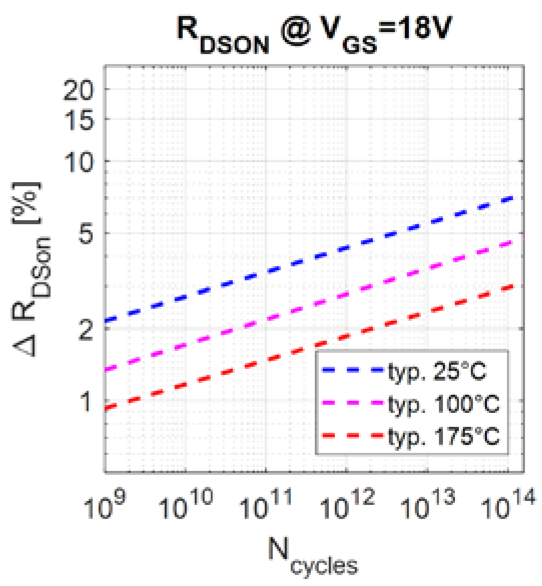


Figure 3: Relative $R_{DS(on)}$ change at $V_{GS(on)}$ = 18 V, $T_{vj,op}$= 25°C, 100°C & 175°C [2]

The example shown in figure 4, based on the recently launched EasyPACK™ FS55MR12W1M1H_B11 (six-pack configuration in a DC-AC inverter), illustrates the impact of the predicted change in $R_{DS(on)}$ [4]. The example shows applications in which conduction losses (P_{con}) represent a big portion of the loss distribution. $T_{vj,op}$ rises only by 2 K from an initial 148°C to the worst-case EoAP of 150 °C. The result confirms that a slight change in $R_{DS(on)}$ leads to a negligible increase in $T_{vj,op}$ even after 20 years' lifetime.

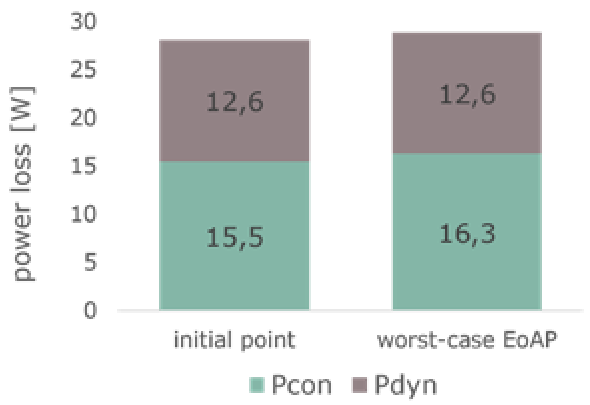


Figure 4: Worst-case EoL assessment: V_{dc}: 800 V, I_{rms}: 18 A, f_{out}: 50 Hz, f_{sw}: 50kHz, cos(φ): 1, T_h = 80 °C.

This approach implies that the largest drifts should be expected under the worst-case conditions described. With the new M1H hardware, customers will be able to choose the parameter set from the data sheet's specification range that best fits their application. Parasitic overshoots and undershoots in the gate signal will not impact the drift and do not need to be considered on customer side. Therefore time and effort can be saved.

Note that applications that run at well-controlled gate bias levels much below data-sheet maximum limits, e.g. +18 V / -3 V, yield even lower change in $R_{DS(on)}$ for the same number of switching cycles.

Conclusion

The characteristics of the threshold voltage under real application conditions have been studied by performing long-term tests under various switching conditions. We have developed and applied a stress test procedure to determine worst-case EoAP parameter drifts under realistic, application-oriented switching conditions to provide our customers with a reliable model for prediction.

In addition to other key improvements, the recently launched 1200 V CoolSiC™ MOSFET, called M1H, shows great stability and diminishes the impact of the drift phenomenon.

References

[1] Infineon Application Note 2018-09
[2] P. Salmen, M. W. Feil, K. Waschneck, H.Reisinger, G. Rescher, T. Aichinger: A new test procedure to realistically estimate end-of-life electrical parameter stability of SiC MOSFETs in switching operation; 2021 IEEE International Reliability Physics Symposium (IRPS) (2021)
[3] Infineon: Whitepaper 08-2020: How Infineon controls and assures the reliability of SiC-based power semiconductors 11–21;
[4] Data sheet FS55MR12W1M1H_B11

www.infineon.com

Methodology for Specifying Bus Bars in High Density Power Converters

The evolution of high-density power converters brings harsher constraints to the converters inducing technical issues for bus bar designers. This article presents a methodology developed to collect the electrical, thermal, and magnetic design constraints of laminated bus bar (LBB), through Bus Bar Calculator™, a software derived from GT-PowerForge (GT-PF).

By Simon DARIO, PhD, R&D Engineer – Laminated Bus Bar Specialty, Mersen

The power conversion industry is under increasing pressure in terms of product performance, cost, and manufacturing quality. This trend brings challenging technical constraints on the converter sub-assemblies resulting in a degradation of efficiency, reliability, and cost-effectiveness.

An appropriately designed LBB for interconnection can effectively mitigate overshoot voltage, electromagnetic interference, switching loss and thermal stress for high power converters. This step is mandatory to avoid critical faults that could lead to converter failure. (Figure 1)

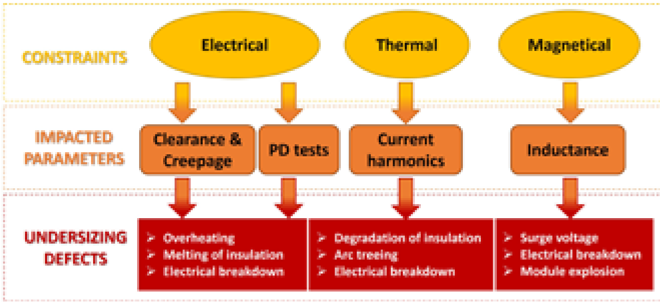


Figure 1: Effect of undersized elements on converter quality

As the voltage level raises, the multilevel converter topologies are a solution to limit the dv/dt stress, but that complicates the mechanical design and the definition of electrical interactions between each conductor.

Determining these parameters reliably and accurately is critical for compactness, safety, electrical robustness, thermal, and magnetic performance concerns.

Bus Bar Calculator™, result of a collaboration between MERSEN, LBB manufacturer, and GAMMA TECHNOLOGIES, GT-PowerForge software developer, is a software proposing an innovative methodology to collect the operating conditions of the converter quickly, efficiently, and accurately.

In the first part, the main LBB design constraints are detailed. In a second part, how a software-based solution can help gather the constraints is detailed.

Bus bar constraints

The switching devices operate at various frequencies inducing voltage peaks that are increased proportionally to the total stray series inductance of the Commutation Current Loop (CCL), as explained in Figure 2. To prevent converters to exceed the breakdown voltage, the stray inductance needs to be minimized. This parameter depends on the geometry and the structure of the interconnection, such as the bus bar, as illustrated in Figure 3.

Switching frequencies, from few to several hundreds of kHz, generate current harmonics that need to be identified for thermal concern. Indeed, these harmonics could, due to skin and proximity effects, overheat the system if the LBB conductors aren't well cooled or designed.

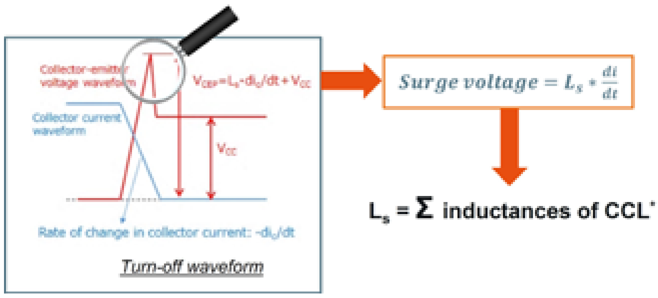


Figure 2: Inductance impact on surge voltage

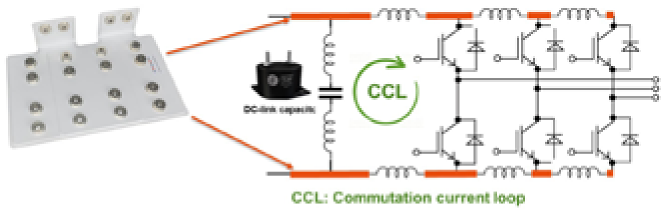


Figure 3: Electrical diagram of converter

To illustrate this phenomenon, the Figure 4 shows the current density mapping, thermal heating, and temperature as a function of the current frequency passing through a copper bar, at 70 °C.

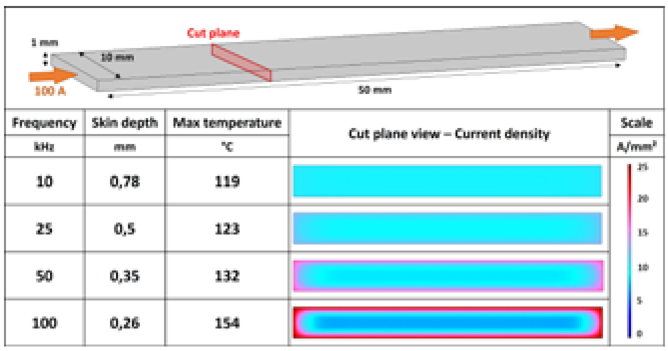


Figure 4: Skin effect on current density and thermal heating at different frequencies

These results are from Comsol Multiphysics®, a cross-platform finite element analysis, solver and multiphysics simulation software.

As it can be observed, the current density at the edges is higher at high frequency than low and it induces an increase of the temperature by 35 °C in the hotspot's areas, which could delaminate the LBB, and eventually lead to short-circuit conductors.

More generally, the trend of dv/dt increases induce critical events, like partial discharges (PDs) and electrical breakdown. Hence, it is necessary to refer the right standard for the right application


CDE
ENERGIZING IDEAS
CORNELL DUBILIER
IF IT'S NOT THE HEAT,
~AC
ALH SERIES
DC ⎓
BLH SERIES
IT'S THE HUMIDITY
Meet the 1,500-hour THB-rated ALH/BLH capacitors
At 85°C and 85% relative humidity, with rated voltage applied, our new inverter-grade film capacitors are tested 50% longer than the industry standard requirements for Temperature-Humidity-Bias. Improve the reliability of your power electronics design with outstanding capacitor performance at high humidity.
cde.com/harsh-environments
1,500 HOURS
85°C
85% RH
AEC-Q200

to correctly define the electrical test voltages, and the insulation coordination, including clearance and creepage distances.

A differentiation must be made between clearance and creepage, as shown in Figure 5. Having enough insulation distances prevents an ionization of the air gap and a subsequent flashover or electrical tracking failures over lifetime.

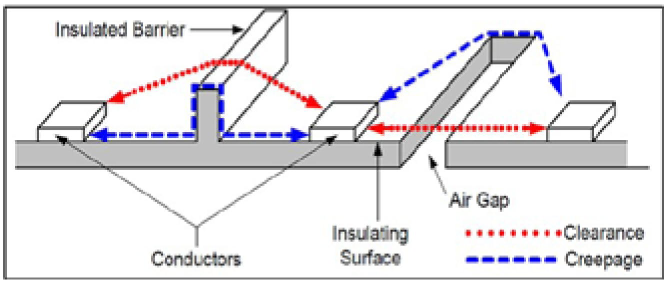


Figure 5: Representation of clearance & creepage distance

All these key elements (inductance, thermal heating, PDs, insulation distances) in the LBB design process, lead to opposite requirement and a special attention should be given to the compromise between thermal, electrical, and magnetic constraints. Any kind of deviation could induce an immediate or delayed malfunction of the converter, potentially posing human risks.

Currently no converter design tool considers all the elements interconnecting passive and active components together for a better design process and optimization.

With Bus Bar Calculator™, the complete operating conditions of the converter and the technical and environmental interconnection requirements can be filled as input conditions to calculate the converter outputs needed to design the LBBs. It strives to standardize and communicate the busbar technical requirements through all the stakeholders of its complete design and considers the constraints at the start of the design phase. The whole is explained in the next section.

Mersen Bus Bar Calculator™

What is the GT-PF add-on, Bus Bar Calculator™?

The presented bus bar application, Bus bar Calculator™ is based on GT-PF, a multiphysics solver developed by GT, handling electrical, thermal, and magnetic physics to cover the complexity of a power converter design.

STANDARDS	APPLICATIONS							
	Test equipment	Wind	Solar	Battery cells	Auto	Industrial	Railway	Naval
MIL-DTL-917F								✖
EN 50124-1							✖	
UL 840					✖	✖		
IEC 61010-1	✖							
IEC 60664-1				✖	✖	✖		
IEC 61800-5-1						✖		
IEC 62109-1			✖					
IEC 62477		✖	✖					
IEC 62497-1							✖	
Mersen fall back proposal*	IEC 61010	IEC 62477	IEC 62477	IEC 60664	IEC 60664	IEC 61800	IEC 62497	DTL-917F

Figure 6: Standards for bus bar applications

MERSEN adds on GT-PF the Bus Bar Calculator™ application, computing the key electrical specifications of LBB, providing all the values to help designer make bus bar in a wide variety of converter topologies, within few tens of seconds.

Input conditions in Bus Bar Calculator™

To design a LBB in the most optimized way, all the necessary operating parameters for the design must be collected, starting with the application area of the converter. As an example, a converter for railway application is considered. Through the analysis and classification of all the standards for bus bar application in Figure 6, the appropriate standard can be selected for the correct definition of the insulation coordination and qualification tests.

Except for aeronautic, each application has at least one dedicated standard allowing the definition of:

- ➢ Clearance and creepage distance
- ➢ Dielectric test
- ➢ Clearance test
- ➢ Correction factor depending on altitude

Depending on the application the device doesn't suffer from the same environmental constraints and design requirement changes. For example, at 5 kV, and overvoltage category 3, the clearance distance can vary with a x4 ratio as illustrated in Figure 7.

Standard	61010	62477	61800	62497	DTL-917F
Application	Test equipment	Wind / Solar	Industrial	Railway	Naval
Clearance	18 mm	25 mm	39 mm	40 mm	68 mm

Figure 7: Clearance calculation for different applications

For aeronautic devices, a correction factor is applied on clearance to consider the altitude (or pressure), but no dedicated standard helps to define electric tests at low pressure atmosphere to qualify the products. For high test voltages (> 5 kVrms) the standards are not self-sufficient, and the design must be adapted to reinforce the insulating part of LBBs, through internal design rules.

Then, the electrical operating parameters of the converter are essential for the correct dimensioning of the interconnection of the switching components. The converter topology and switching frequency must also be filled to allow the software to correctly calculate the voltage and current in each branch. (Figure 8)

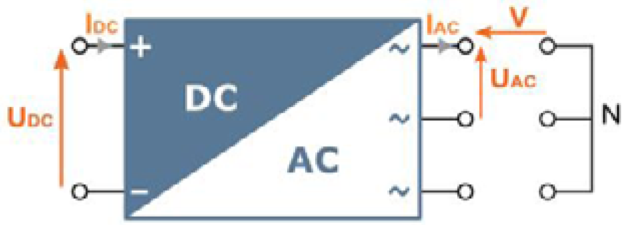


Figure 8: Electrical operating parameters of 3-phase DC/AC converter topology

In this example:

- ➢ Udc = 2000 V + Uac = 400 V
- ➢ Power = 200 kW
- ➢ Switching frequency = 20 kHz
- ➢ 3-level T-type converter topology

The conductors composing the LBB, and the converter environment must be filled to consider all the constraints together, from the very beginning of converter design phase, and thus optimizing the complete system. (Figure 9)

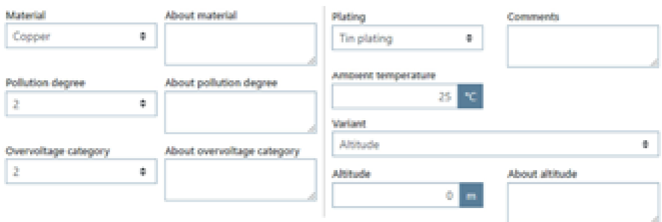


Figure 9: Bus bar design elements for 3D model definition

The compilation of inputs in Bus Bar Calculator™ takes only 10 to 30 seconds. The first information displayed is the electrical schematic of the converter in Figure 10.

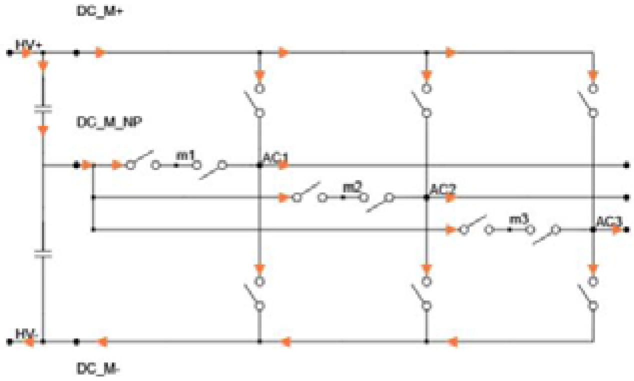


Figure 10: Electrical schematic of 3-level T-type converter topology generated by GT-PF

Outputs from Bus Bar Calculator™
Clicking on each node, AC and DC voltage and current passing through the considered node are provided. It also displays RMS current values passing through each conductor as illustrated in Figure 11 and Fourier transform, really mandatory to take into account skin and proximity effects on the thermal heating.

Component	Irms [A]
Capacitor_1	166
Capacitor_2	166
DC_M+	194
DC_M-	274
DC_M_NP	194
HV+	100
HV-	100

Figure 11: RMS current table value through all conductors

The maximum and repetitive peak voltages between each conductor in the interconnection, used for the calculation of insulation distances and electrical tests, are summed up in a table to ease and speed up the design phase, as illustrated in Figure 12.

To introduce the PD test, the addressed standard for PD test calculation and graph test is proposed in Figure 13 to explain the electrical constraints that will be applied on the LBBs.

Max Voltage [V]	Repetitive peak voltage [V]								
	AC1	AC2	AC3	DC_M+	DC_M-	DC_M_NP	m1	m2	m3
AC1		2600	2600	2600	2600	1300	1300	2650	2650
AC2	2000		2600	2600	2600	1300	2650	1300	2650
AC3	2000	2000		2600	2600	1300	2650	2650	1300
DC_M+	2000	2000	2000		2600	1300	1300	1300	1300
DC_M-	2000	2000	2000	2000		1300	2650	2650	2650
DC_M_NP	1000	1000	1000	1000	1000		1300	1300	1300
m1	1000	2050	2050	1000	2050	1000		1300	1300
m2	2050	1000	2050	1000	2050	1000	1000		1300
m3	2050	2050	1000	1000	2050	1000	1000	1000	

Figure 12: Voltages between each conductor of converter

Considering the voltage between conductors and the converter application, the 2 steps of PD test voltages can be calculated informing the user whether the test is mandatory. (Figure 14)

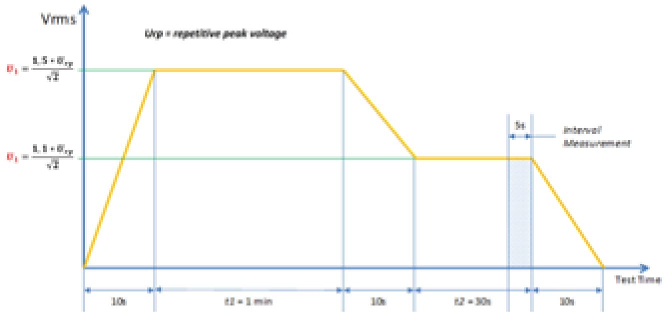


Figure 13: Partial discharges standard and graph

Test name	Repetitive peak voltage [V]	Partial discharge values [V]	
		U1 (1.5 factor)	U2 (1.1 factor)
DP1*	**2650**	2811	2061
DP2*	**2600**	2758	2022
DP3	1300	1379	1011

*Tests noted with an asterisk are mandatory

Figure 14: Partial discharges test voltage calculation

With this last information the LBB insulation design can be finalized.

At the end of the day, by this process, through the consideration of skin and proximity effects, PD and dielectric tests requirement, the application and the environment of the converter, conductor and insulation designs are covered and can be used to optimize the busbar early in the converter development. The user will only need to create an account, accessing to www.busbarcalculator.com.

Conclusion
This work has resulted in the enhancement of a support tool for converter designers, engineering, and sales teams into a common basis of understanding summarized in a single document provided directly by the customer.

It allows all constraints from the converter to be defined on interconnecting LBB early in the converter design phase, minimizing errors and optimizing converter performance and cost.

With this process, thermal, electrical, and magnetic issues are brought to light and helps to create a common language across actors in the development process.

Later, other stakeholder products like capacitor, fuse, or cooling, can be added to this process to continue the optimization of the converters and move towards a complete converter development where all the actors would share the design constraints of each block and work together for a better optimization which will become essential to take better advantage of the new emergent technologies.

https://ep.mersen.com

Safer Linear Mode Operation with Wide SOA MOSFETs

STMicroelectronics (ST) has introduced a 100V power MOSFET manufactured with advanced STPOWER STripFET F7 technology and housed in an H2PAK package. The device is designed for rugged operations with forward bias safe operating area (FBSOA), where high power levels are required in the event of high drain-source voltage (V_{DS}) drops [1].

By Filippo Scrimizzi and Giusy Gambino, STMicroelectronics, Catania, Italy

The new STH200N10WF7-2 power MOSFET is suitable for industrial and motor drive applications and can be used for linear motor controllers and inrush current limiters, where the current flow is set by tuning the gate-source voltage (VGS) of the MOSFET and high capacitive loads require a heavy charge phase at constant current.

The device is able to provide high immunity to the thermal runaway better than advanced planar devices under linear mode working conditions. The wide SOA capability is the result of the optimization of the STPOWER STripFET F7 technology in terms of setting the gate-source voltage (V_{GS}) to obtain modulated threshold voltage (V_{th}) and transconductance (G_{fs}) values for the device [2]. In this way, the MOSFET becomes more robust in linear mode and thermally stable for a wider range of operating conditions in the safe operating area (SOA).

The STH200N10WF7-2 for Linear Motor Control

The wide SOA MOSFET (STH200N10WF7-2) offers an excellent performance in linear motor control systems, such as the fan control. The HVAC (Heat Ventilation Air Conditioning) system can usually be accomplished according to the block diagram shown in Figure 1.

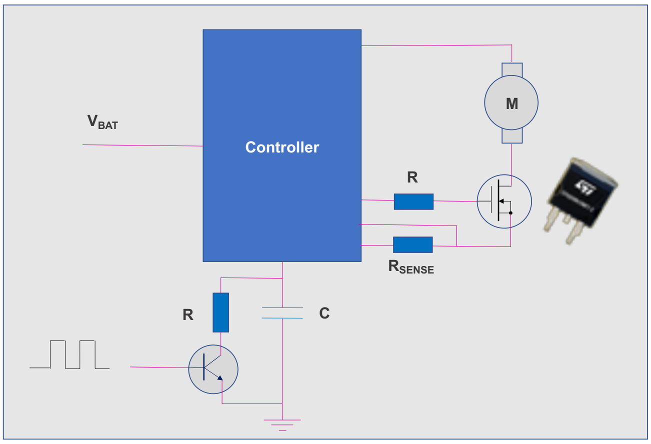


Figure 1: Block diagram of a linear motor control system.

The gate-source voltage (V_{GS}) of the MOSFET can be changed by adjusting the duty cycle of the bipolar transistor, so it is possible to change the current through the motor and its speed. The current is set by the equivalent resistance provided by the MOSFET, when biased under FBSOA working conditions. In this case, the STH200N10WF7-2 has to withstand a very stressful condition as high-power levels are required with a high drain-source voltage (V_{DS}) drop. The waveforms measured in steady state working conditions are shown in Figure 2.

The above figure shows the main signals of the power MOSFET when the application works at a fixed operation point. The green trace represents the current flowing through the motor and then the MOSFET with an average value of about 6.5A. The red trace is the drain-source voltage drop across the MOSFET and the dark blue curve is the gate-source voltage which drives the device. A low gate-source voltage value just above the MOSFET threshold allows the setting of the equivalent resistance which is connected in series to the motor. In this way, the amount of current flowing through the motor is defined and the motor speed regulated. The dark green trace represents the power dissipation in the device defined as the product of the drain source voltage drop and the current.

Additional measured waveforms showing the power dissipation at start-up when the duty cycle is set at 50% are reported in Figure 3.

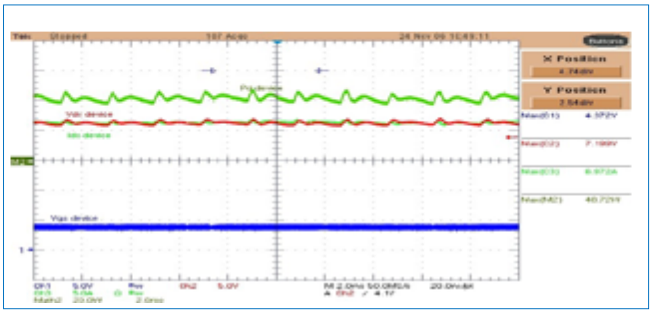


Figure 2: Measured waveforms in steady state conditions.

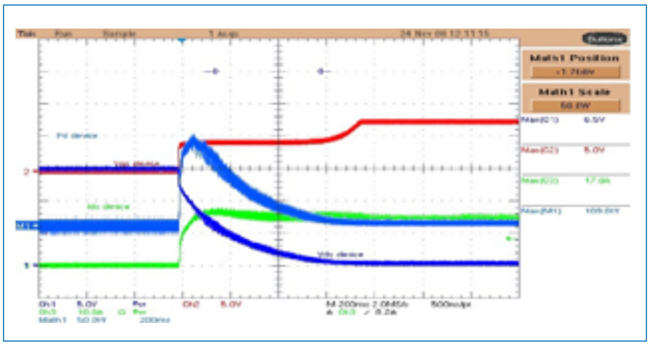


Figure 3: Measured waveforms at start-up.

Due to the stalled condition of the motor at start-up, the peak inrush current reaches nearly 18A. This peak is related to the back EMF (Electro-Magnetic Force) that, for a DC brushed motor, is zero when the motor is not running. This transient condition implies a temporary inductive short circuit used to overcome the mechanical inertia. Once the motor starts running, the current returns to the steady state condition with a much lower average value. The maximum power dissipation at start-up is about 110W, as shown by the dark blue trace in the above figure.

The STH200N10WF7-2 MOSFET

The wide SOA MOSFET can achieve much better thermal stability in linear mode operation than the standard trench device and assure quite a self-balanced current, as shown in Figure 4.

The simulated drain current curves over time for ST's standard and wide SOA device show excellent stability for the STH200N10WF7-2.

This feature makes this device suitable for linear controller fan motor application. In fact, due to the flat output current with respect to the V_{DS} voltage (as shown in Figure 5) at DC operating condition is easier to manage the tuning of the V_{GS} and ID for protecting the system from unwanted thermal instability and device failures.

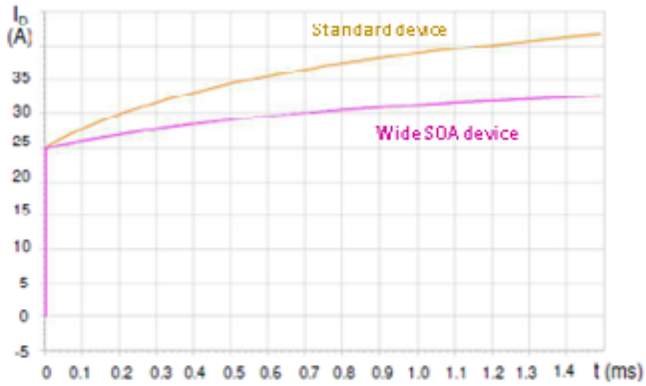


Figure 4: Simulated drain current stability over time.

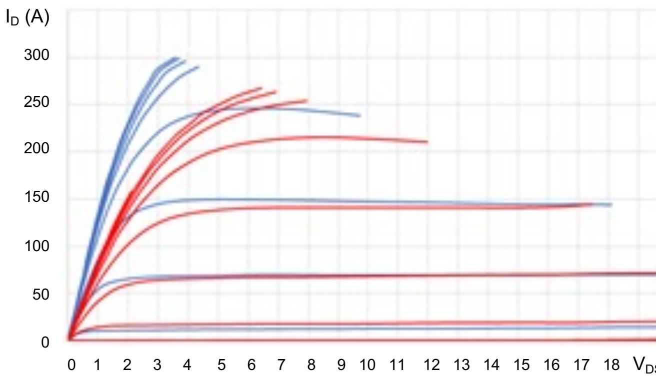


Figure 5: Output characteristics of the STH200N10WF7-2 (at different temperatures).

The key parameter to select the proper MOSFET for linear mode motor control application is then the thermal coefficient of the drain current (TC) [1]:

$$TC = \frac{\partial I_D}{\partial T}$$

which defines the power capability and relevant stability of a MOSFET working in linear mode, as shown by the following equation:

$$\left.\frac{\partial I_D}{\partial T}\right|_{I_D=const} = \frac{1}{V_{DS} \cdot R_{thJA}}$$

The external application conditions determine the V_{DS} voltage drop and the junction-ambient thermal resistance (R_{thJA}) of the system while the thermal coefficient is intrinsic to the device technology. The condition of equilibrium defined in the above equation (2) establishes the boundary condition to trigger the thermal instability [3].

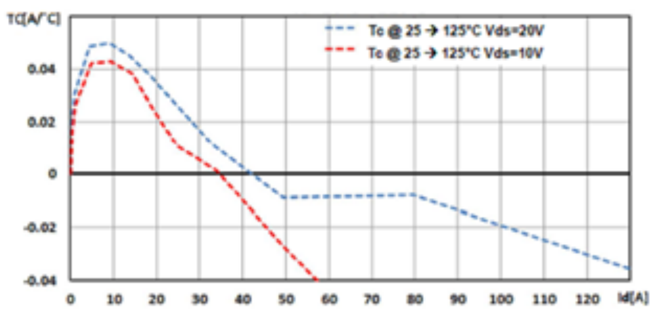


Figure 6: Thermal coefficient of the wide SOA STH200N10WF7-2 at different V_{DS}.

To be effective and robust under FBSOA permanent working conditions, the MOSFET has to exhibit a thermal coefficient with a small peak and a rather narrow range of positive values (Figure 6) [2].

The new device can even exceed the performance of advanced planar MOSFETs in linear mode operation due to its thermal stability for a wider range of operating conditions within the SOA, as illustrated in Figures 7, 8.

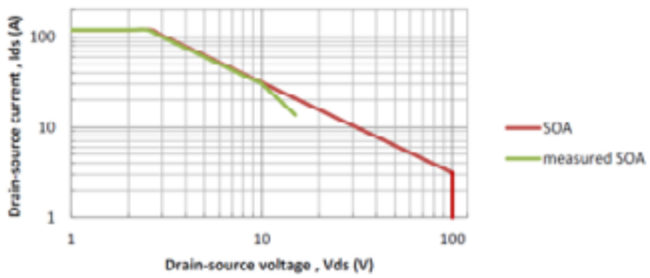


Figure 7: Measured and theoretical curves for an advanced planar device.

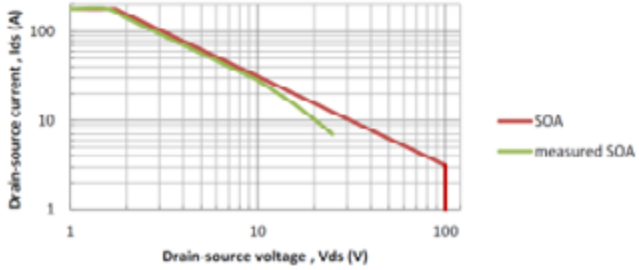


Figure 8: Measured and theoretical curves for the wide SOA device.

The green curves represent the real SOA measured on an advanced planar MOSFET and the wide SOA device. For the wide SOA MOSFET, the experimental data show that the measured curve is closer to the theoretical curve (red trace) for a wider voltage range [3].

As a consequence, the new advanced trench device is able to withstand the linear mode operation up to 25V, while the advanced planar device starts to trigger the instability region for V_{DS} > 15V. The relevant thermal pictures at V_{DS} = 15V (for planar device) and VDS = 25V (for wide SOA device) are shown in Figure 9.

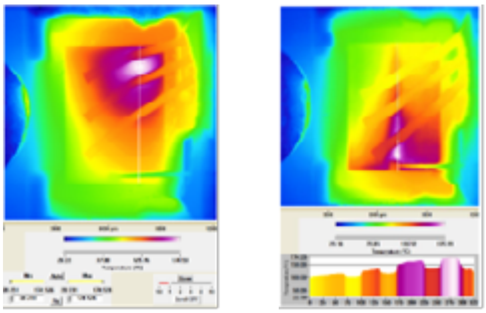


Figure 9: Thermal pictures for the planar device @ V_{DS} = 15V (left) and wide SOA device @ V_{DS} = 25V (right).

The thermal picture shows how in linear mode operation the active area of the wide SOA MOSFET involved in managing the power dissipation is reduced at higher VDS voltage drops and is concentrated in a limited hotter area only.

Measured Linear Mode Performance

The linear mode ruggedness of the STH200N10WF7-2 was experimentally verified and compared with a standard trench technology MOSFET using the test circuit shown in Figure 10.

Turning on the controller MOSFET, the source pin of the D.U.T. goes to ground, therefore the bias voltage provided by V_{cc} is fully applied to the drain of the D.U.T. The Zener diode (Dz) clamps the voltage at its limit value and allows a current flowing through R1. The voltage drop on R1 turns on the D.U.T. in linear mode. The C capacitor provides an extra current capability to the power supply in order to feed the circuit during the power pulse.

The following test conditions have been considered:

V_{CC} = 40 V – 44 V
R_G = 47 kΩ
C = 2 x 47000 µF.

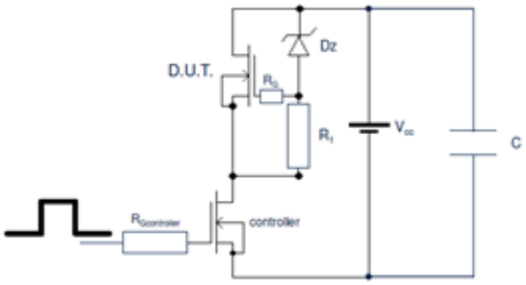


Figure 10: Testing circuit for linear mode ruggedness.

The external RG resistor connected to the gate is used to slow down the fast-rising edge of the current when the MOSFET is turned on and, by doing so, the maximum current capability of the MOSFET can be increased [3].

The measured waveforms relevant to the standard and wide SOA devices just before failure are shown in Figure 11.

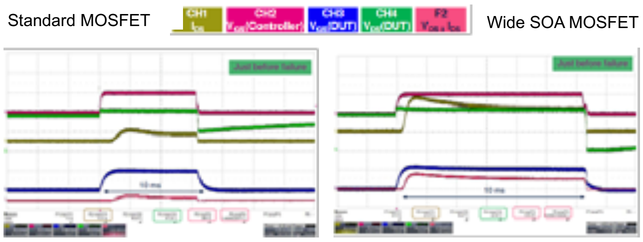


Figure 11: Measured waveforms for the standard and wide SOA device.

The standard trench device exhibits much lower current capability than the relevant wide SOA solution with same die size and thermal resistance. In fact, the standard trench device fails with a 10ms pulse when the drain current reaches 4.3A, whereas the new wide SOA MOSFET can properly work at the same conditions with a current up to 27.6A.

The above reported bench measurements at both application and device level to verify the linear mode ruggedness demonstrate that the STH200N10WF7-2 is robust under DC FBSOA working conditions and therefore suitable for linear mode motor control applications.

References

[1] A. Consoli, F. Gennaro, A. Testa, G. Consentino, F. Frisina, R. Letor and A. Magrì, "Thermal instability of low voltage power MOSFET's", IEEE Transaction on Power Electronics, vol. 15, no. 3, May 2000.

[2] G. Consentino and G. Bazzano, "Investigations on Electro-Instability of Low Voltage Power MOSFETs: Theoretical Models and Experimental comparison results for different structures", PET 2004 Conference, Chigaco 2004.

[3] F. Scrimizzi, C. Mistretta, G. Gambino, "Wide SOA MOSFET technology for hot swap and inrush current limiter solutions", IEEE Xplore, Jan. 2022.

www.st.com

How Buck Regulators with Integrated Capacitors Help Lower EMI and Save Board Space

It's a challenge to create highly efficient and compact designs while also adhering to strict electromagnetic interference (EMI) requirements imposed by groups such as Comité International Spécial des Perturbations Radioélectriques (CISPR). Therefore, component selection becomes a critical part of the design process.

By Harrison Overturf, Application Engineer, Texas Instruments

As with most design decisions, choosing between different components almost always comes down to an assessment of tradeoffs based on your most critical design goals. Known for high efficiency and good thermal performance, buck regulators are not typically considered low-EMI options. Fortunately, you have several options for reducing the EMI generated by such regulators. To aid further discussion, Figure 1 shows a simplified buck regulator schematic.

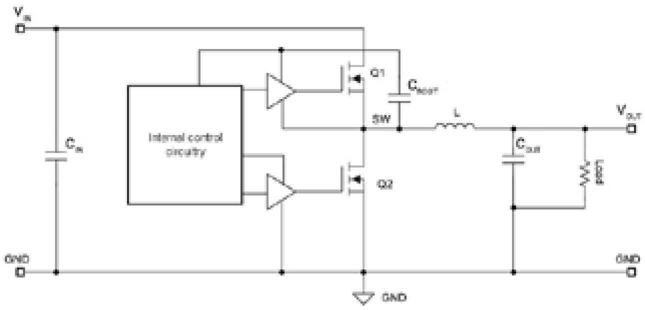


Figure 1: Simplified buck regulator schematic

Board layout considerations

Beyond selecting proper passive component values to ensure a functional design, board layout should be your first consideration when your design must fall under EMI limits. There are two general rules that can help minimize generated EMI with all buck regulator board layouts:

- Minimize high transient current (di/dt) loop areas by bringing the input capacitor and boot capacitor as close to the VIN and GND pins of the integrated circuit as possible.
- Minimize the surface area of high transient voltage (dv/dt) nodes by minimizing the area of the switch node.

In instances where board layout optimization is not possible, there are other options. Learn more about them in the technical article, "How Device-Level Features and Package Options Can Help Minimize EMI in Automotive Designs."

Integrated input capacitors

As I mentioned, reducing the area of high di/dt current loops is very important when designing switching regulators to remain under EMI limits. In a buck regulator, it's important to consider the input-voltage-to-ground loop from an EMI perspective. A buck regulator steps down a higher DC voltage to a lower one by switching the connection to the supply on and off, resulting in high-side metal-oxide semiconductor field-effect transistor (MOSFET) (Q1) current, shown in Figure 2.

The MOSFET switches on and off rapidly, creating very sharp, almost discontinuous currents supplied by the input capacitor. Some devices, such as TI's 3-A LMQ66430-Q1 and 6-A LMQ61460-Q1 36-V buck regulators, integrate high-frequency input capacitors inside the package, resulting in the smallest possible input current-loop area. Reducing the area of this input current loop results in smaller parasitic inductance at the input, which reduces the amount of electromagnetic energy emitted.

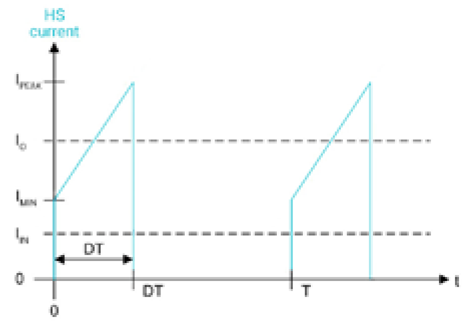


Figure 2: Input current waveform to a buck regulator

Integrated boot capacitor

Another high di/dt current loop that you should consider is the boot capacitor loop. The boot capacitor is responsible for supplying charge to the high-side MOSFET gate driver during the on-time. Internal circuitry refreshes this capacitor during the off-time. The source terminal of the high-side MOSFET connects to the switch node rather than GND. Referencing the boot capacitor to the source pin of the MOSFET ensures that the gate-to-source voltage (VGS) is high enough to turn on the MOSFET. With most buck regulators, you will have to leave some switch node area available on the board to connect the bootstrap capacitor, although this can be counterproductive when trying to minimize the area of the switch node for EMI. By integrating the boot capacitor inside the package, the LMQ66430-Q1 follows the two rules that I mentioned earlier, while also reducing the need for an external component.

Conclusion

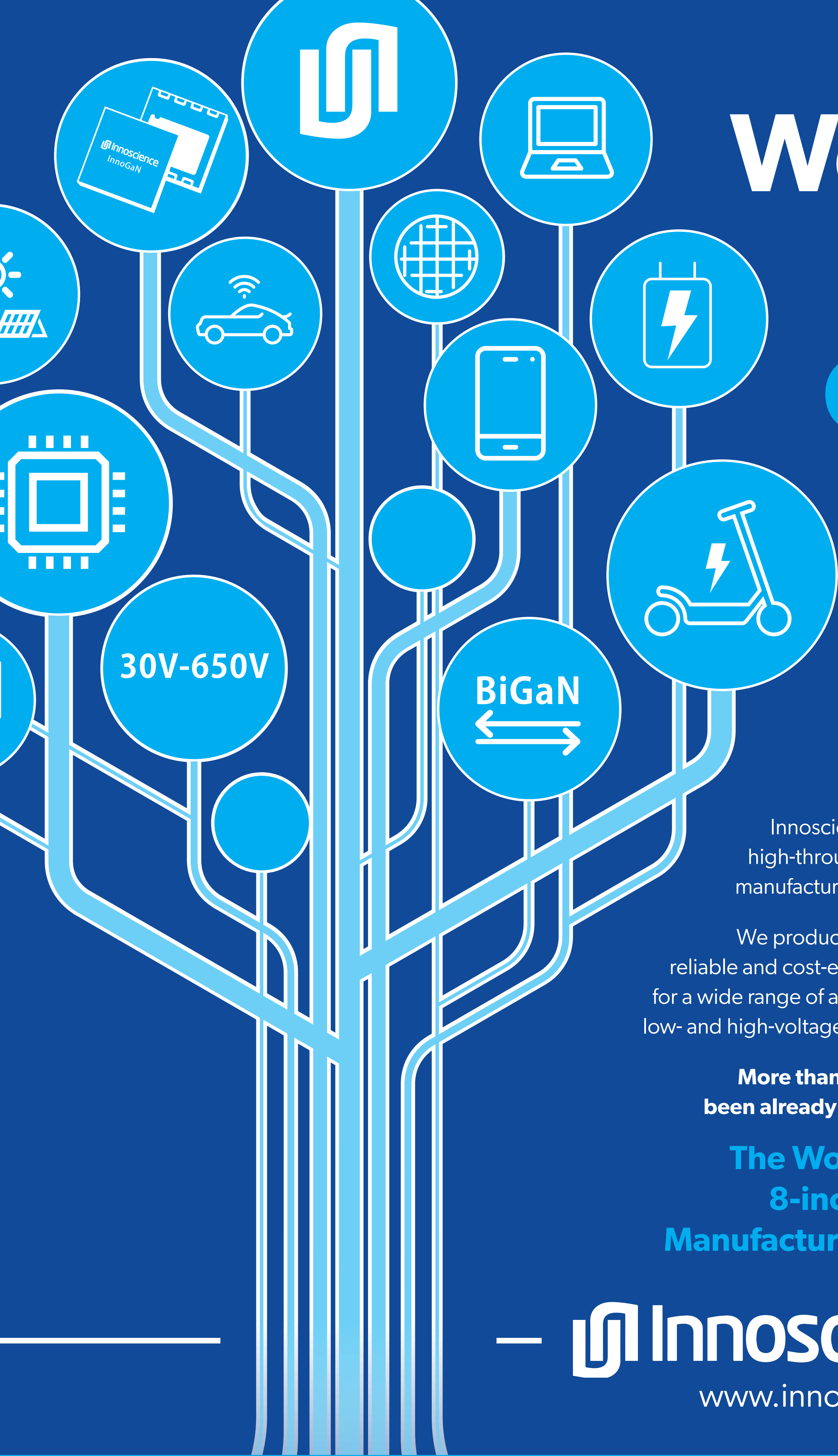
It can be difficult to design compact power-supply designs capable of remaining under strict EMI limits. Buck regulators with integrated capacitors can make the process of EMI-compliant designs easier, while also helping reduce the overall external component count.

Additional resources

Check out these technical articles:

- "How a DC/DC Converter Package and Pinout Design Can Enhance Automotive EMI Performance."
- "Lowering Audible Noise in Automotive Applications with TI's DRSS Technology."
- For a comprehensive overview of all things related to low EMI, read the e-book, "An Engineer's Guide to Low EMI in DC/DC Regulators."

www.ti.com


30V-650V
BiGaN

Power Module Dynamic Test Solution Suitable Also for WBG Devices

Evaluation of power modules is important for power electronics engineers, as well as power module manufacturers, to design efficient, small form factor, and reliable power converters. There are multiple challenges for these engineers to overcome when evaluating power modules, especially for power modules made with WBG devices.

By Ryo Takeda, Michael Zimmermann, Takamasa Arai, Bernhard Holzinger, and Mike Hawes, Keysight Technologies

The challenges of power module dynamic test

Power modules typically have higher power density than discrete power devices, incorporating multiple field-effect transistor (FET) chips to increase current. High current, such as 400 A, is necessary for some EV applications where silicon carbide (SiC) devices are being used to increase voltage and reduce charging time. Therefore, high current with high bandwidth is required for WBG power module testing.

Most power electronics applications require half-bridge structures as the basis for inverters and converters. Depending on the application, 2-in-1, 4-in-1, or 6-in-1 configurations are used. Two-in-1 configurations are half-bridge structures, 4-in-1 configurations are typically H-bridge structures, and 6-in-1 configurations are used for 3-phase power converters. In the case of discrete power devices, such as in TO-247 packages, it is possible to evaluate an individual device by placing it at the low-side in a double-pulse test (DPT) setup. However, it is necessary to perform measurement on both the low-side and the high-side device to characterize a half bridge module, because you cannot assume the high-side device behaves exactly as the low-side device. The voltage potential at the junction between the high-side device source and low-side device drain in a half-bridge configuration, dynamically changes with large voltage swings (e.g., 0V to 600 V) as the half bridge is switched. This makes the measurement of the high-side FET very challenging, especially for small gate voltages. Measurement of a 10 V to 20 V gate voltage, while the reference for this measurement (i.e., the source) switches up and down, hundreds of volts with fast slew rates is very difficult, unless you have high common mode rejection (CMR) probing technology.

When measuring high-side V_{gs}, the industry tends to think high CMR is the only necessary parameter to make accurate measurements. However, the bandwidth and noise specifications of the probe are also critical factors for accurate measurement.

Power modules come in a variety of form factors. Emerging WBG devices drive even more variations because of their high-power density and potential to make the module more compact. When evaluating power modules, the associated PC board layout needs to be carefully designed. Double-pulse test (DPT) boards typically integrate almost all DPT components, such as the connection to the power module, gate drivers, decoupling capacitors, and current measurement. The power module is often soldered to the test board to minimize the stray inductance. However, the need to solder and unsolder multiple power modules makes the evaluation of the power module time consuming and inefficient.

Many R&D engineers in the industry either use an older production-type dynamic power module tester for silicon (Si) power devices or a custom set up made in-house by integrating a function generator, power supply, oscilloscope, and probes with a custom made DPT board. The former solution provides DPT capability, but is not suitable for detailed evaluation of faster WBG-based devices. Because these systems typically require tedious programming to setup and execute tests, the process can be inefficient and cumbersome. This makes it difficult to apply various test conditions for comprehensive analysis of the power module. The cost to purchase and maintain these production-type systems can also be excessive. The latter solution often lacks repeatable results, ease-of-use, safety, and correlation with the other in-house test systems. The next DPT system design is improved creating different versions of DPT test systems, leading to inconsistent results and additional support and maintenance issues.

Providing temperature dependence measurements for the power module's dynamic characteristics is critical as the applications often require harsh environments, such as hot deserts, humid tropical forests or extreme cold with heavy snow fall. Testing power modules in such temperature conditions using a thermostatic chamber is not easy, especially for dynamic characterization.

Extending the Dynamic Power Device Analyzer Portfolio

Introduced in 2019, Keysight's PD1500A Power Device Dynamic Analyzer/Double-Pulse Tester has been used by many power semiconductor manufacturers and users around the world. Leveraging Keysight's success with the PD1500A as well as measurement science knowledge and RF test expertise, enabled the company to develop a power module DPT solution with unprecedentedly clean, repeatable, and reliable waveforms and extractions. The same 'ease of use' and compliance to safety regulations as the PD1500A are well accepted by power electronics engineers.

Keysight introduced a new DPT system called the PD1550A Advanced Dynamic Power Device Analyzer by expanding the PD1500A's capabilities to test power modules. The system is valuable to automotive OEM and Tier 1 power converter designers. Understanding power module behavior and characteristics is critical to designing safe and reliable power circuits for automotive appli-

Figure 1: More than 500 A I_d test results on SiC power module (FF2MR12KM1P).

cations. Some of the key features solve the challenges for power module testing described above.

Current capacity is increased from 200 A to 1000 A while still using a coaxial shunt as a current sensor to maintain high bandwidth current measurements.

Depending on the current level and required accuracy, users can select and attach a 5 mΩ or a 50 mΩ coaxial shunt resistor. Each shunt is characterized to flatten the frequency response to the specified bandwidth. RF compensation data is supplied for each shunt and is applied to the raw measurement data to produce accurate results by eliminating unwanted bandwidth variation of the current shunts. Figure 1 shows example test results for I_d > 500 A measured with the new PD1550A. Figure 2 shows the effectiveness of RF compensation, which makes the waveform accurate and consistent regardless of the bandwidth of the shunt resistor which is used.

Figure 2: Effect of RF compensation on drain current.

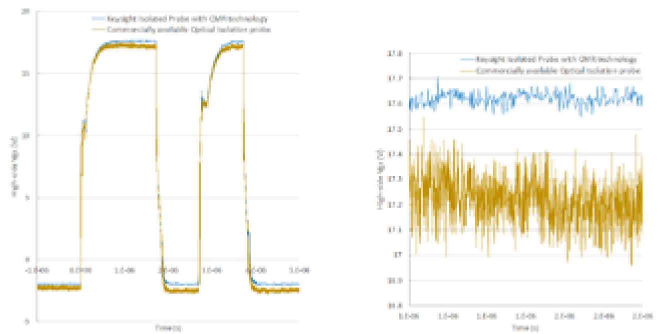


Figure 3: High-side V_{gs} measurement results comparison.

A big challenge to test gate voltage characteristics on the high-side device is solved by newly developed "true pulse isolated probe technology". Specially designed probing, fully isolated from the other probes, allows accurate V_{gs} measurement for the high-side device in a half-bridge configuration power module as shown in Figure 3. It clearly shows the newly developed "true pulse isolated probe" has sufficient CMR and superior noise performance (gold waveform) compared to the commercially available optically isolated probe (blue waveform).

The PD1550A inherits its modular architecture from the PD1500A, allowing Keysight to leverage the test system software framework that provides features such as the easy-to-use user interface. By just filling in test conditions for V_{ds}, V_{gs}, I_d, 2nd pulse width, off time, and temperature (optional), the user is only a mouse-click away from performing fully automated tests. The user can sweep V_{ds}, I_d, and even temperature, allowing hundreds of tests to be automated, enabling lots of repeatable and reliable data for statistical analysis. Presentation of the test results has many options, such as extracted parameters, DPT waveforms, or switching locus, and gate charge graphs. The "Measurement History" function allows quick search and recall of measured data for deeper analysis, duplicating tests applying the same test condition to a different device, or troubleshooting a test setup.

An interface board that attaches to the power module is the only component required to be customized, depending on the power module's layout. Keysight application experts can provide thorough design services to create these customized boards. An example of an interface board is shown in Figure 4. These customized boards incorporate technology that makes it easy to attach the board to the power module without soldering, which allows repeated use of the board for many DUTs, while creating a solder-like connection. The gate resistor (R_g) is an important component when characterizing the power module. A small gate resistor module is also shown in Figure 4. Each gate resistor module has an EEPROM which contains the resistor value. The PD1500A software recognizes the resistor value automatically and uses the value for testing. An EEPROM is also used on other DPT components, such as the interface board and the gate driver board, reducing the chance of having operator error and further enhancing the reliability of the system.

As we previously mentioned, another critical evaluation factor is temperature dependency. The PD1550A supports two types of thermal management techniques. One is a hot plate which allows

The PD1550A is capable of the following V_{ds}, I_d, and V_{gs} ranges, which cover a variety of power modules:

- Drain voltage (V_{ds}): 1.36kV (force), 2kV (measure with differential probe)
- Drain current (I_d): 1kA (force), 2kA (measure)
- Gate voltage (V_{gs}): -28V to +28V with no Under Voltage Lock Out (force)

These ranges apply to both low-side and high-side device testing.

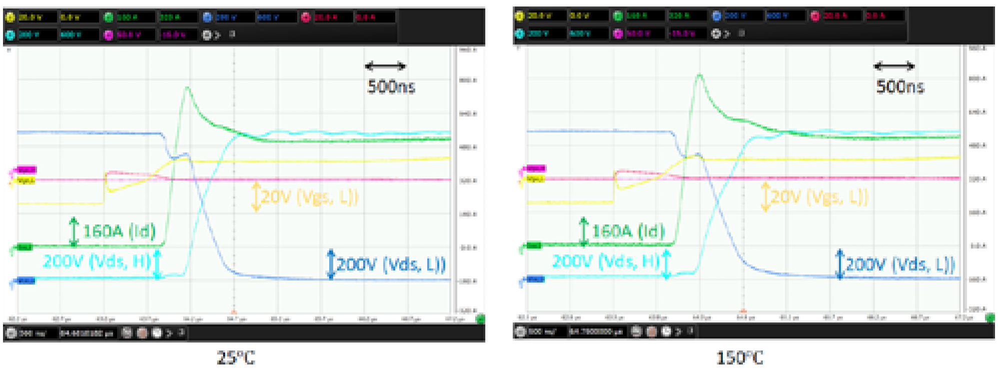
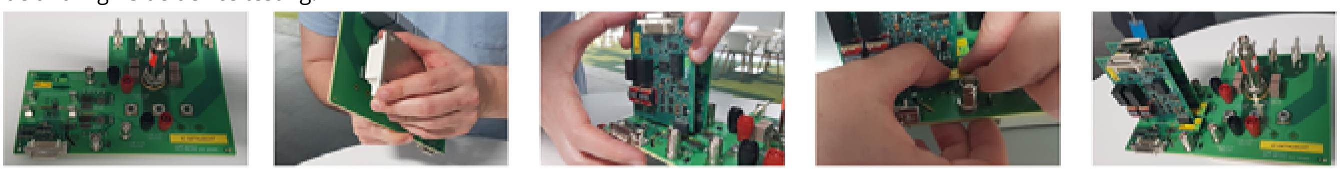


Figure 5: IGBT power module test result examples (25 °C & 150 °C).



(a) Interface board for 62mm module

(b) Attaching 62mm SiC power module

(c) Attaching gate driver boards

(d) Attaching a small gate resistor module

(e) Ready to plug into test fixture in 2 minutes

Figure 4: DUT interface board and gate resistor module.

a temperature range from room temperature to 200 °C. The other technique is a ThermoStream® that can make measurements in cold ambient down to -40 °C, as well as high temperatures up to 200 °C. The thermal test equipment is automatically controlled by the system software making it simple to obtain temperature dependent characteristics.

The Keysight PD1550A also complies with international safety regulations such as Compliance, Safety, Accountability (CSA), CE, and KCC. You will be ensured to test your device safely.

Summary

Keysight's PD1550A Advanced Power Device Dynamic Analyzer is a newly developed DPT characterization solution for power modules. The first version provides measurement and extraction of the double pulse test parameters you are used to measuring with the PD1500A, including some additional high-side parameters.

The PD1550A will soon be enhanced to measure discrete devices as well as other reliable test applications such as short circuit and UIS. The PD1550A was designed with the same goal as the PD1500A, to provide repeatable and reliable dynamic characterization of WBG devices. Key features, include larger voltage and current ranges, True Pulse Isolated Probe, RF characterization and compensation of each current sensor, interface board with solderless contacts, and easy-to-use software will contribute to significantly improve productivity on power device and power module evaluation.

www.keysight.com

Efficient Power Supplies Cut CO_2 Emissions

Worldwide electricity use is responsible for a quarter of all carbon dioxide (CO_2) emissions. However, by taking simple steps companies and consumers can cut down the usage of electricity–especially coming from burning coal or gas–to save billions of dollars while reducing millions of tons of CO_2 emissions.

By Steve Roberts, Innovation Manager, RECOM Power

These changes include replacing toxic fluorescent and inefficient incandescent light bulbs with LED lamps that use significantly less electricity, using energy efficient appliances at home, going solar, driving electric vehicles (EVs) to name a few.

Advanced power electronics and power supplies are a critical part of enabling these solutions – as efficient, high performance power supplies drive these technologies forward while accelerating their adoption rate. All this translates into saving millions of kWh energy, in turn positively impacting consumer savings and the environment.

Advanced Technologies for a Greener Future
Take for example LEDs, which require highly efficient drivers to get the maximum output from these solid-state devices at low cost. Inefficient drivers defeat this purpose. RECOM has developed the best-in-class constant current source and constant voltage drivers that deliver the reliability and efficiency needed to help LED technology fulfill its promise and transform the lighting industry. RECOM AC/DC and DC/DC LED drivers have helped to save millions of kWh of electricity consumption worldwide, cutting tens of millions of tons of CO_2 emissions.

Until recently, major manufacturers of AC/DC adapters and chargers for a variety of consumer devices were flaunting the high efficiency at full load, while minimizing the somewhat poor performance at low or no load. As a result, millions of AC/DC power supplies in standby mode are simply wasting power, consuming between 5%-10% of the device's total electricity consumption. With the average home having upwards of 40 mains-powered devices today, these losses are staggering. In response to these issues, regulatory authorities have introduced standards for standby as well as full load losses.

The main energy efficiency regulations for external power supplies standby (no load) power consumption are Energy Star (≤ 0.30 W up to 10W; ≤ 0.5 W up to 250W), China Energy Conservation Program (≤ 0.30 W up to 10W; ≤ 0.5 W up to 250W), EU EcoDesign (Energy related Products- ErP) (≤ 0.30 W for non-PFC; ≤ 0.5 W for PFC), and Australia Energy Efficiency(≤ 0.5 W up to 180W). Likewise, external battery charger power supplies have stricter limits (0.075W up to 50W, 0.15W up to 250W) as it is assumed that they will be left plugged for most of their time in standby mode.

AC/DC converters have to operate efficiently over the entire load range, including no-load conditions. Recognizing these industry challenges, RECOM has developed AC/DC power supplies with special focus on no-load and light-load efficiency.

Transitioning to Renewables
In the last decade or so, renewable resources, which include wind, solar, hydropower, geothermal and biomass, have made remarkable progress in capturing the global energy supply market. Today's higher efficiency power electronics with high-power density alongside lower costs are key factors driving the adoption rate of renewables.

Figure 1: Renewable resources like solar, wind, and hydropower are making progress

In 2021, according to IEA report, the share of renewables in the electricity generation mix was an all-time high of 30%. That means 70% of the global electricity today is still generated by GHG and carbon producing fossil fuels.

Consequently, the further expansion and growth of renewables in the power generating world is more important than ever. Though prices for PV panels and wind turbines have fallen substantially in last ten years, high performance cost effective power supplies, both DC/AC inverters and DC/DC converters, are needed to accelerate this adoption. RECOM is at the forefront of this application, offering high performance inverters and converters that can be easily integrated with smart grids and renewable energy sources at cost effective prices.

Electrification of Transportation
Transportation is another sector playing a critical role in the reduction of CO_2 emissions to meet the goals of the standards set by the International regulatory agencies. By replacing fossil fuel-based transport with electrically powered vehicles and other modes of transportation, we can significantly reduce CO_2 emissions and dramatically improve the quality of our air. Understanding the direct link between e-mobility and reduction in emissions, the automotive and transportation OEMs are slowly phasing out ICE powered vehicles and increasing the production of EVs. GM, for instance, is committed to putting every driver in an EV on a scale previously unseen and bringing the USA to an all-electric future.

Toward that goal, GM has announced an investment of US$2.2 billion. Likewise, Ford Motor Company has announced plans to bring EVs at scale to American customers with two new massive, environmentally and technologically advanced campuses in Tennessee and Kentucky that will produce the next generation of electric F-Series trucks and the batteries to power future electric Ford and Lincoln vehicles. Meanwhile, Tesla is looking for higher sales for its EVs as gas prices soar amidst Ukraine crisis and Russian sanctions.

Similarly, in Europe and Japan, car OEMs are promising to phase out gas powered vehicles and increase production of EVs. The worldwide drive towards e-mobility solutions continues at a rapid rate.

Figure 2: Electric vehicles are on the rise

To further accelerate the adoption of EVs around the world, the automotive and transportation industries are encouraging global and state-level regulatory bodies to deploy policies promoting the use of energy-efficient EVs. The sale of new fossil-fuel burning vehicles will be banned in European countries from 2035.

In the U.S., for example, President Joe Biden's administration has passed USD $1.75 trillion infrastructure bill, which includes EV tax incentives up to USD $12,500 per vehicle to spur consumer demand for EVs and USD $7.5 billion for EV charging infrastructure network. Similar incentives are also underway in Europe, Japan, and China. Battery powered EVs require automotive qualified traction inverters and DC/DC converters that are efficient, compact, rugged and can operate over a wide temperature range. RECOM has readied such solutions that can be easily deployed in EV battery charging stations, drivetrains, and conditioning applications.

Buildings and Industrial Plants

Commercial, industrial and government buildings account for some 40% of global emissions, according to Forrester Consulting. Decarbonization has been rather slow in this sector but there is hope as sincere efforts are underway to optimize buildings with latest technologies that can deliver substantial energy savings with a corresponding drop in CO_2 emissions and 100% renewable electricity. To meet the emerging demands of smart building applications, RECOM extends its existing low-power RAC series with new household certified AC/DC converters at lower cost.

Conclusion

The race to decarbonization is earnestly underway and there is light at the end of the tunnel. But the bottom line is that power electronics is the enabler for all these efforts.

Power electronics will continue to advance to further accelerate the adoption of LEDs, renewables worldwide, electrify all types of transportation, and make buildings, data centers and manufacturing plants around the world cleaner to meet the net zero goal of 2050. And RECOM is ready to help with innovative power supplies made to power LEDs, renewables, e-mobility, smart buildings, data centers and manufacturing plants around the world.

About the Author

Steve Roberts was born in England. He obtained a B.Sc. in Physics and Electronics at Brunel University, London before working at University College Hospital. He later moved to the Science Museum as Head of Interactives, where he completed his M.Sc. at University College, London. Eighteen years ago he made his own personal Brexit and moved to Austria, becoming Technical Director for the RECOM group in Gmunden. He is the author of the RECOM DC/DC & AC/DC book of knowledge.

www.recom-power.com

Improving Efficiency and Reducing Size of Low-Power AC/DC Conversion

In this article, Eggtronic CEO Igor Spinella considers conventional low-power conversion architectures based on quasi resonant (QR) and active clamp flyback (ACF) topologies in the context of high-performance AC/DC converters, and introduces a novel architecture that guarantees ZVS from light load to full load.

By Igor Spinella, Eggtronic

Applications ranging from fast chargers and travel adapters to power supplies for loudspeakers and smart home assistants rely on low-power (sub-100 W) AC/DC conversion. A fundamental point when choosing the power conversion architecture is the extent to which it delivers zero voltage switching (ZVS) as this has a significant impact on efficiency, EMI performance and reliability. Not all conventional topologies are able to reach ZVS, and none has yet been able to deliver ZVS at light load.

Any piece of electronic equipment that plugs into a wall outlet requires some form of AC/DC converter to rectify the voltage and reduce it to the lower level that the equipment requires. Many modern devices we find in our homes and offices fall into the low-power category, requiring less than 100 W of power. In fact, with the exception of appliances, the majority of devices that we have in our homes are likely to be classified as low-power.

In some cases, such as computer monitors or battery chargers, the AC/DC converter will be embedded in the product itself. However, many devices use a dedicated external power supply - including smart home assistants and computer peripherals such as disc drives, all of which require power while in use. In addition, AC/DC conversion is fundamental to the adapters used to charge mobile phones, tablets and other portable devices.

While the low power nature of these applications might imply that efficiency is not a huge concern, nothing could be further from the truth. Given the billions of these devices that are in use and that are often left plugged in 24 / 7 the impact on global energy consumption and subsequent emissions is significant. Making AC/DC converters more efficient is, therefore, at the top of the power engineer's design agenda.

Topologies and Techniques for Low-Power AC/DC Conversion

Low-power AC/DC converters rated below 75 W are generally not subject to power factor correction (PFC) requirements as their effect upon the mains grid is considered to be minimal. This simplifies the design and reduces component count – both of which are ideal for these tiny power solutions.

The flyback topology is extremely popular in low-power designs due to its versatility, performance and simplicity. This topology has been in use for over 70 years and generally consists of a primary-side MOSFET, output (secondary) rectifier diode, output capacitor and flyback transformer – as well as a few other minor components.

Power designers are constantly seeking to improve topologies to enhance efficiency or performance or, ideally, both. As a result, the quasi-resonant (QR) flyback architecture has become very popular due to its ability to reduce switching losses. This is achieved by lowering the drain-source voltage of the primary MOSFET before the turn-on pulse which has the effect of reducing the peak current and switching frequency, ensuring that the MOSFET turns on at the first 'valley'.

The efficiency gains from QR operation are primarily realized in full-load conditions. However, the hard-switching nature of this topology means that at light loads, efficiency is generally much lower.

The QR flyback design can be further improved by the implementation of zero-voltage switching (ZVS). In a normal QR flyback design the MOSFET is switched in a 'valley' which implies that the drain-source voltage (VDS) is at a minimum, but not necessarily zero. By implementing ZVS (or soft switching), VDS falls to zero (rather than just a minimum) before the MOSFET is switched which eliminates any overlap between the voltage and current, thereby minimizing losses. This also reduces EMI, an additional benefit that allows designers to meet stringent EMC regulations more easily.

A further development is the active clamp flyback (ACF) topology that differs from conventional flyback designs in that it re-uses the energy stored in the transformer's leakage inductance that would have been dissipated in a passive clamp snubber resistor. Delivering this 'recycled' energy to the load improves converter efficiency and significantly reduces the peak voltage across the MOSFET during turn-off.

Additionally, the QR 'valleys' in an ACF design are significantly lower, often achieving near-ZVS operation, thereby delivering the reduced switching losses and enhanced EMI.

Improving and Extending ZVS Performance

A new approach to flyback conversion with the ability to further enhance performance, efficiency and reliability is QuarEgg®, an innovative and proprietary power architecture developed by Eggtronic that is specifically intended for sub-100 W AC/DC designs. This new architecture significantly improves the efficiency and reduces the size of AC/DC converters that would normally have been based upon ACF and QR flyback topologies. Unlike other approaches, the architecture operates with ZVS under all load conditions to give very flat efficiency curves. Typical efficiencies

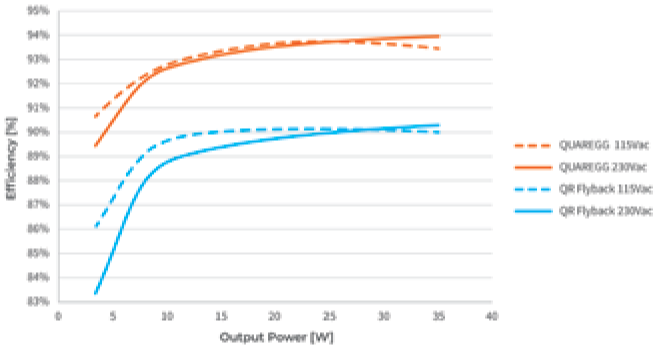


Figure 1: QuarEgg shows a significant efficiency improvement over a generic QR flyback converter right across the load range

achieved are up to 95% at full load and up to 92% at light load and, when in standby mode, a QuarEgg-based design consumes less than 18 mW.

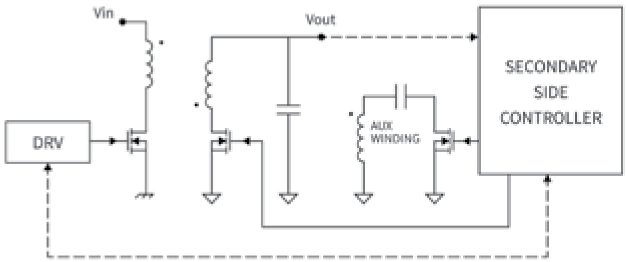


Figure 2: Simplified schematic of the QuarEgg topology.

Compared to a generic QR flyback topology, the new approach adds an auxiliary winding to the main transformer along with a flying capacitor and a low-voltage, low-cost MOSFET connected in a forward configuration on the low side. However, the elimination of a high-voltage, high-side clamping MOSFET reduces overall component count and improves reliability. The main QuarEgg controller is on the secondary side of the converter so as to enhance regulation of the output voltage.

The auxiliary MOSFET is primarily included as a means of actively forcing the ZVS conditions for the primary power MOSFET across all load conditions. While the converter is switching, the secondary side controller senses the VDS of the primary MOSFET via the auxiliary winding. When each crest occurs, the auxiliary MOSFET turns on and discharges the drain node so VDS becomes zero, thereby ensuring a ZVS turn-on of the primary MOSFET.

The corresponding waveforms are shown below.

The new approach is suitable for use with all types of MOSFET switching devices, including legacy silicon and wide bandgap (WBG) materials such as gallium nitride (GaN) and silicon carbide (SiC). With improved performance compared to conventional ACF and QR topologies, QuarEgg-based power converters are up to seven times more efficient and three times smaller than traditional silicon converters and up to three times more efficient and twice as small as already high-performance GaN converters.

To support designers using Eggtronic technology, a range of development boards, integrated power controllers and proprietary magnetic components - as well as detailed technical support - are available.

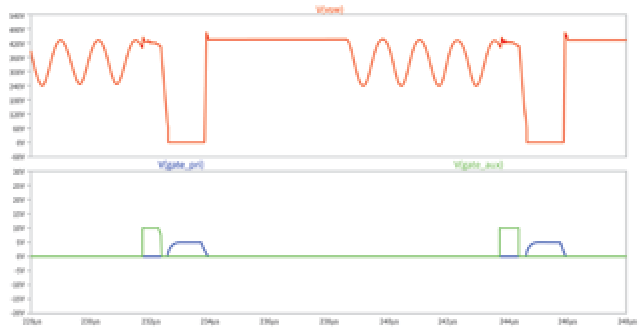


Figure 3: Waveforms for the QuarEgg topology.
Red: VDS of primary MOSFET; Green: Vg of auxiliary MOSFET;
Blue: Vg of primary MOSFET.

Summary

Efficiency from no load to full load is an increasingly important consideration for low-power AC/DC power supplies, chargers and adapters that are likely to be left plugged in 24 hours a day, seven days a week. Until now, many designs have been based upon the flyback topology that has been in use for decades, albeit with more recent enhancements such as QR, ACF and ZVS.

As a member of Eggtronic's EcoVoltas® family, QuarEgg is specifically developed to deliver smaller, higher efficiency power conversion and help engineers to meet performance, cost, size, weight and sustainability goals.

By actively forcing ZVS operation, the new architecture not only increases efficiency but flattens the efficiency curve to address poor performance at light loads. The technology also allows a reduction in components, further improving power density and reliability.

www.eggtronic.com

Optical Excitation of Super Cascodes

The GaN HEMT as well as the SiC-JFET are promising wide bandgap power semiconductors. By their structure, HEMTs resp. JFETs, are normally-on and the manufacturers make efforts to give them normally-off characteristic. One possibility to achieve this is the use of a normally-on device together with a normally-off Si-MOSFET in a cascode configuration. This can be extended to a super cascode to provide a higher blocking voltage and to make the blocking voltage scalable. However, the required Si-MOSFET is a low voltage type. Therefore, it needs only a small gate charge to switch it on and off. This small charge could be generated by a photodiode. This gives a power device with optical turn-on and -off!

By J. Ranneberg, Professor, HTW Berlin

Introduction

Today controllable power electronic devices e.g. MOSFETs or IGBTs need appropriate driver stages. However, these driver stages need their own power supply that has to be potentially isolated. In addition, the control signals must become isolated, e.g. via optocouplers or optic fibres. An advantage would be a power switch that can become turned-on and -off by the optical signal itself. This can be realised in the way of a light controlled cascode (LCC) or light controlled super cascode (LCSC), they were described in detail in [1] [2] [3]. Here new measurements with the LCSC are shown, the impact of the photodiode on EMC of the demonstrator are described in detail and more detailed explanations and calculations of the turn-on and turn-off transitions are given.

Normally-on Devices

Today, wide bandgap (wbg) semiconductor materials are under fast development. One of these promising materials is GaN; the typical device made of GaN is the HEMT. Another promising Material is SiC, a common device made of SiC is the JFET. Unfortunately, these HEMTs resp. JFETs have normally-on characteristics which has to be avoided for safety reasons. One possibility to "convert" this is the cascode or supercascode circuit [5] [6] [7]. Within these a low voltage normally-off Si-MOSFETs controls one or more normally-on GaN-HEMT or SiC-JFETs. Because the low-voltage MOSFET controls the on- and off-condition of the cascode, the driver requirements are defined by this low-voltage normally-off Si-MOSFET.

RQ-Figure of merit

By theory, it can be shown that for n-MOSFETs the RQ-figure of merit is limited to

$$Q_{Ch} = \frac{4 * V_{DSS}^2}{R_{DSon} * \mu_n * E_{crit}^2} \qquad (1)$$

with the blocking voltage V_{DSS}, the electron mobility µn and the maximum field strength E_{crit}. Therefore, the charge Q_{Ch} required to control the R_{DSon} depends on semiconductor parameters and the square (!) of the blocking voltage.

In the cascode or supercascode for T0 (see figure 1) a blocking voltage of about 15 V to 20 V is sufficient, regardless the blocking voltage of the complete (super) cascode! This is the crucial aspect of optical excited (super) cascodes.

Therefore, by an e.g. 20 V MOSFET T0 controlling a 650 V normally-on T1 the required gate charge can become reduced by approx.

$$\frac{V_{DSST1}^2}{V_{DSST0}^2} \approx \frac{(650V)^2}{(20V)^2} = 32{,}5^2 = 1056 \qquad (2)$$

resp. by three orders of magnitude even for the same semiconductor material!

This small charge can be generated for turn-on by a photodiode (D_R in figure 1) and consumpted for turn-off by a resistor. However, a single Si-photodiode will generate only about 500 mV, which is not enough. Therefore, in conventional Opto-MOS usually several Si-photodiodes are connected in series. A wbg-semiconductor photodiode would also be promising. Due to the difficulty to purchase an appropriate wbg-photodiode, a blue InGaN-LED was used inversely for D_R. In the experimental set-up, it provided 2,29 V in open loop and 278 µA in short circuit. The transmitter LED D_T was of the same type.

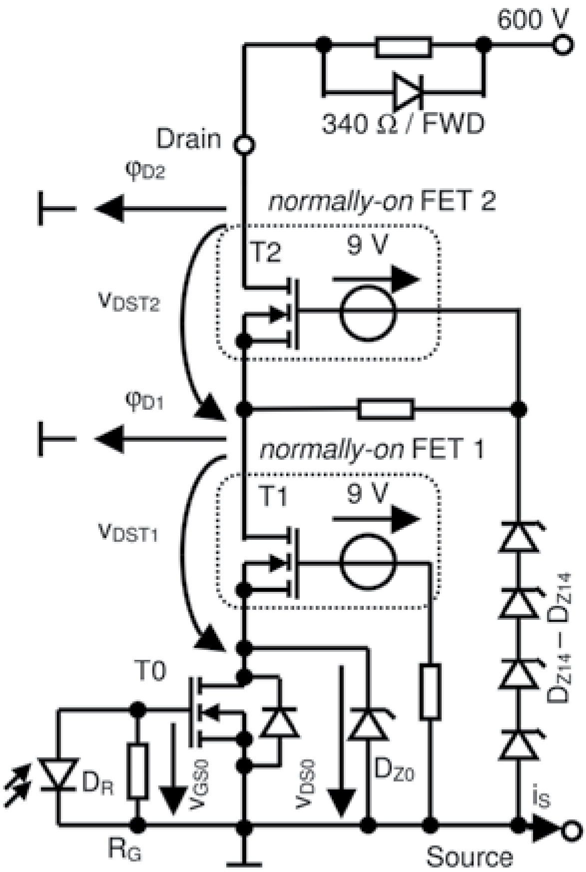


Figure 1: Schematic diagram of the LCSC feasibility demonstrator, T1 and T2 with gate biases to provide normally-on characteristic used for experimental purpose only, EMC components not shown

Light Controlled Super Cascode

The cascode circuit was used originally for HF applications. In recent time it became interesting for power applications too because it „converts" a normally-on FET, e.g. a GaN-HEMT with a high blocking voltage into a normally-off type by additionally use of a normally-off low-voltage FET. The low-voltage FET, e.g. a Si-MOSFET, controls the cascode. In on-condition both R_{DSon} are added, in off-condition nearly all the blocking voltage remains across the GaN-HEMT. Furthermore, the driver circuit is defined by the low-voltage Si-MOSFETs requirements and a variety of driver circuits is available.

The supercascode adds one or more high-voltage normally-on devices and the blocking voltage of the cascode is even higher, scalable by the number of normally-on FETs. The schematic of a supercascode with two normally-on FETs T1 and T2 is shown in figure 1. In the supercascode, one (or more) Zener- or suppressor-diodes are used to stack the individual blocking voltages of T1 and T2.

Feasibility Demonstrator

The schematic of the experimental set-up is also shown in figure 1. Unfortunately, there were problems to get appropriate devices (normally-on GaN-HEMTs or SiC-JFETs for T1 and T2, wbg-photodiode for D_R) needed for the experimental set-up.

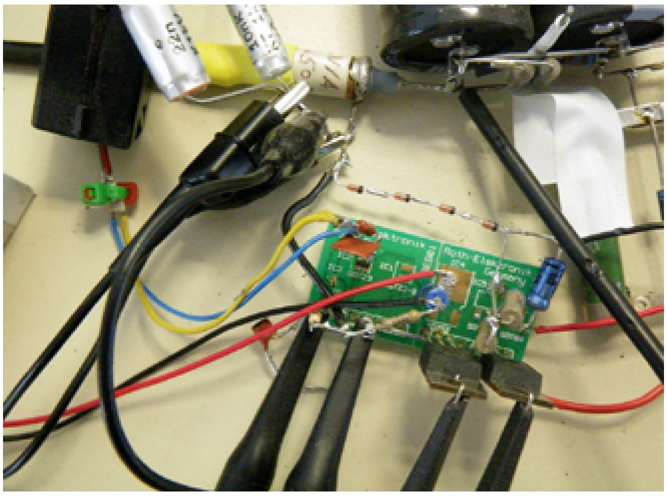


Figure 2: Experimental set-up of the Light Controlled Super Cascode

Therefore, the normally-on FETs T1 and T2 were replaced by normally-off Si-n-MOSFETs with a battery to provide a gate bias. With normally-on GaN-HEMTs, these batteries were not needed!

For the same reason an inversely used LED replaced the photodiode D_R (see figure 3). For D_T and D_R the same InGaN-LED was used. By its dominant wavelength [4] a bandgap of 2,6 eV was calculated which is consistent with an open-circuit voltage of 2,29 V [1] [2]. For practical purposes, the use of an optic fibre between D_T and D_R would be advantageous. This fibre would minimize the stray capacity C_σ (see figure 4). However, due to its dampening of the light pulse it will also reduce the current driven by D_R. Therefore, it was omitted in the experimental set-up.

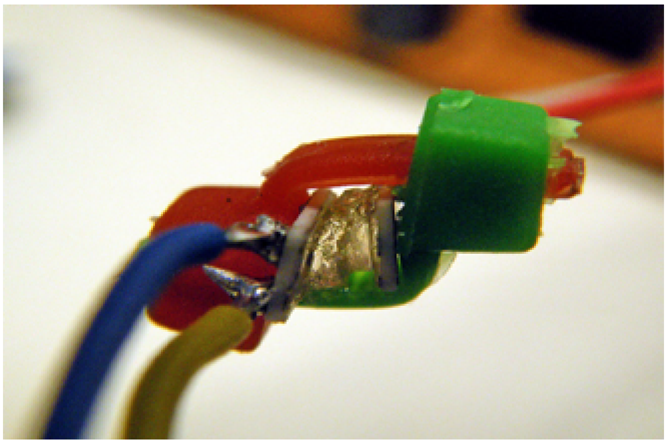


Figure 3: The two identical blue LEDs D_T (right) and D_R (left) attached closely forming an optocoupler

The 300 V Zener diode was realised by a series connection of four 75 V Zener diodes, D_{Z11} to D_{Z14}. Because a capacity mismatch of T0 and T1 or an increased blocking current through T1 can cause an avalanche of T0 [6] the 15 V Zener diode D_{Z0} was implemented. Therefore the blocking voltage of T0 is limited below the max. 20 V

Impact of poor Photodiode on EMC of Demonstrator

Due to the difficulty to purchase an appropriate wbg-photodiode for the demonstrator, a blue LED was used inversely. Together with D_T it provides 2,29 V in open loop but only 278 µA in short circuit. This gives an impedance of

$$R_{source} = R_G = \frac{2{,}29V}{278\mu A} = 8{,}2k\Omega \qquad (3)$$

as value of R_G to match source and load impedance. Because this high impedance of the gate-source voltage vGS0 additional EMC measures were necessary to provide a reliable operation of the demonstrator.

C_σ represents the parasitic capacity of the „optocoupler" consisting of D_T and D_R. A rough estimation by area, distance, and an assumption for ε_r gives approximately 0,1 pF for C_σ. This seems to be quite low but due to the high impedance cited above even a moderate dv / dt across C_σ will force a significant current through C_σ.into the gate of T0. The EMC-measures in the demonstrator are:

- A capacity of 10 nF || 22 nF = 32 nF was installed for C_Y. For measurement this capacitor was not shorted, therefore the voltage waveforms of v_{DT} shown below are AC-coupled
- The ferrite core across the wires from pulse generator to D_T builds a common mode choke
- The 100 Ω 33 pF RC-pair from D to G of T0 gives a negative feedback whereas
- The 47 Ω 330 pF RC-pair from D_R to T0 is a low pass. This low pass gives an additional delay of t = 47 Ω * 330 pF = 15,5 ns to the turn-on and therefore which is very small, However, this RC-pair should be omitted in further set-ups.

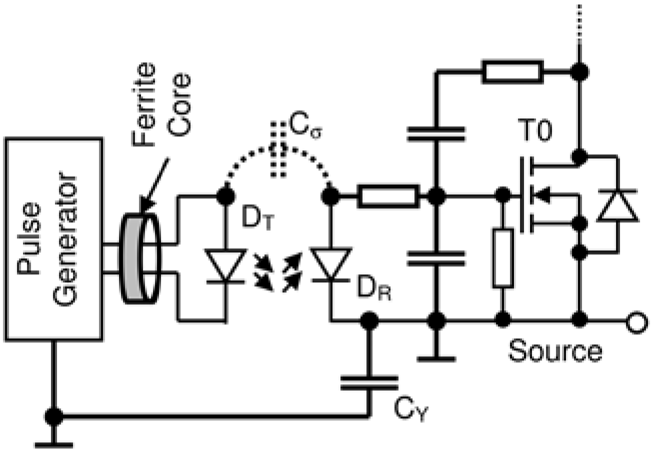


Figure 4: Additional EMC components (thick lines) to provide reliable operation of demonstrator

For practical purposes, an optic fibre between D_T and D_R would give more flexibility for the positions of driver circuit and LCSC as well as a reduction of C_σ . However, the damping of the fibre would reduce the short circuit current of D_R . Therefore, a better wbg-photodiode is crucial for further improvements. This wold reduce the "driver" impedance and therefore the effort for EMC.

Measurements: Single 200µs Pulse

A complete pulse of 200 µs length of the LCSC with a 340 Ω load resistor at 600 V dc voltage is shown in figure 5. These conditions give a power of 1 kW, which was turned-on and –off optical. The voltage v_{DT} across D_T was measured via C_Y , therefore it is AC coupled in spite of not being mentioned on the scope screen.

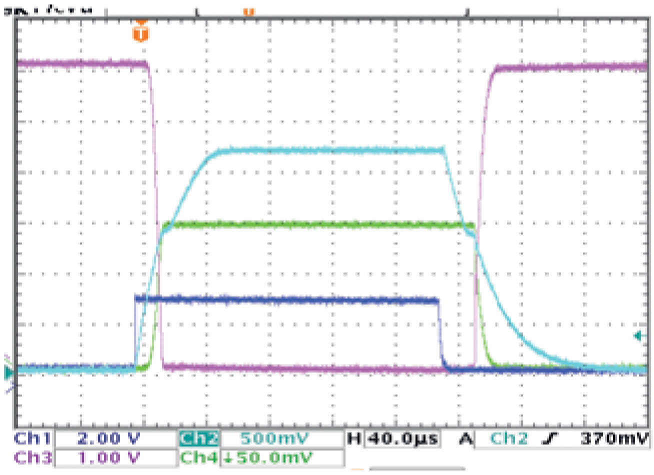


Figure 5: 200 µs pulse with 1kW at 600 V
Ch1 v_{DT} 2V / Div. (AC coupled)
Ch2 v_{DR} 500 mV / Div.
Ch3 φ_{D2} 100 V / Div.
Ch4 i_S 500 mA / Div.

Due to the supercascode circuit, there is a difference between the potentials φ_{D2} and φ_{D1} and the voltages v_{DS2} and v_{DS1}:

$$v_{DST2} = \varphi_{D2} - \varphi_{D1}$$
$$v_{DST1} = \varphi_{D1} - v_{DST0} \qquad (4)$$

(see figure 1, figure 6 and figure 7). It is shown that the switching waveforms of the demonstrator are very slow (horizontal axis 40 µs / Div.). However, the feasibility is demonstrated.

Detailed Turn-on

A detailed view (horizontal axis 10 µs / Div.) on the turn-on transition is given in figure 6.

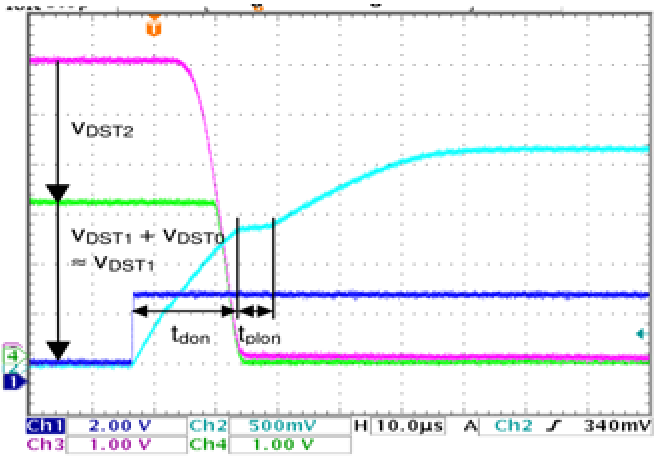


Figure 6: Turn-on with 1kW at 600 V
Ch1 v_{DT} 2 V / Div. (AC coupled)
Ch2 v_{DR} 500 mV / Div.
Ch3 φ_{D2} 100 V / Div.
Ch4 φ_{D1} 100 V / Div.

It can be seen that after applying a voltage across D_T the voltage v_{DR} across D_R which is also the gate-source voltage of T0 starts rising with ≈ 100 mV / µs. Under the assumption that D_R still delivers 278 µA (s. above) a total capacity of about 3.6 nF results. This is the input capacity of T0, the RC-pair from Drain to Gate (see figure 4) as well as the RC-pair from D_R to the gate. Because the mentioned dv / dt is prior to the plateau voltage the miller effect has not started. For a faster switching, a photodiode with a higher short circuit current as well as a smaller capacity would be necessary. Also with a better photodiode, the input RC-pair should be omitted. When v_{DR} reaches about 1,3 V the plateau voltage is achieved and the LCSC turns on. As shown in figure 6 the time t_{don} to reach this plateau after exciting D_T lasts about 17 µs and therefore longer than the plateau itself which lasts t_{plon} of about 5 µs. Keep in mind that the voltage across D_T is AC coupled (see above).

Because the MOSFET T0 accumulates gate charge, the current of D_R limits only the switching speed and not the maximum current switched by the LCSC.

Detailed Turn-off

A detailed view (horizontal axis 10 µs / Div.) on the turn-on transition is given in figure 7. Immediately after the voltage across D_T is turned-off the voltage v_{DR} across D_R sinks in exponential way as expected for a RC-pair. By drawing a tangent a time constant of about 32 µs can be derived. Together with the 8.2 kW resistor from gate to source a capacity of about 3.9 nF will be calculated. This is slightly above the value estimated at turn-on. However, both figures are not very precise and can give only an estimation. After t_{doff} of about 19 µs the gate-source voltage v_{DR} has decreased to the plateau level the LCSC turns off. Also at turn-off it takes longer to reach this plateau than the plateau itself, which lasts t_{ploff} off about 4 µs. As shown the drain potential φ_{D1} will be clamped by D_{Z1} to 330 V, therefore the blocking voltage across T1 is also limited to about 300 V. So there is more blocking voltage installed than usable, this is a drawback of the supercascode circuit.

Voltage Scalebility

The blocking voltage of the LCSC is scaleble by the number of normally-on FETs in the supercascode [8]. Because the voltage of the inner FETs (T1 in figure 1) is limited by the Zener-diode D_{Z1} it would be possible to use chips for the inner FET that slightly fail the blocking voltage test in manufacturing and therefore could not be sold otherwise.

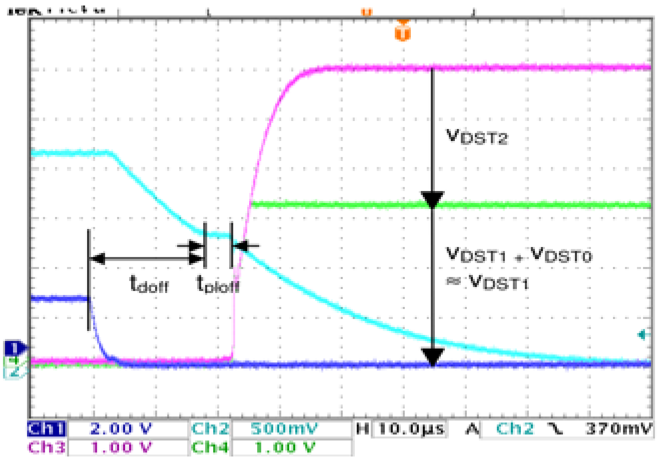


Figure 7: Turn-off with 1kW at 600 V
Ch1 v_{DT} 2 V / Div. (AC coupled)
Ch2 v_{DR} 500 mV / Div.
Ch3 φ_{D2} 100 V / Div.
Ch4 j_{D1} 100 V / Div.

Remaining Topics for Improvement

One step would be normally-on GaN HEMTs or SiC-JFETs instead of biased Si-MOSFETs for T1 and T2.

A better wbg photodiode instead of the inversely used LED will increase the short circuit current to deliver the gate charge. This would improve the switching speed at turn-on but also at turn-off because RG (see figure 1 and equation (3)) can be reduced.

The normally-off MOSFET T0 can become better matched for this purpose. A normally-off FET made from wbg needs even smaller gate charge. GaN has the same electron mobility as n-Si but an 11 times higher critical field strength [1] [2]. By equation (1), it can be shown that for GaN instead of n-Si the required channel charge of T0 can be reduced by ≈ 100 or two orders of magnitude. Therefore, the charge needed for the parasitic capacity of D_R would be higher than the required gate charge of T0!

Light Controlled Cascode as Single Chip

A first step but also a tremendous leap forward would be a light controlled cascode (LCC) on one single chip made of wbg-material. Such chip consisting of

- D_R ("real" photodiode with higher efficiency),
- R_G (matched to open loop voltage divided by short circuit current of D_R),
- T0 (low voltage normally-off) and
- T1 (high voltage, normally-off) and if necessary
- D_{Z0} (see figure 1)

could be mounted in a housing appropriate to receive an optic fibre. This would reduce C_σ. and R_G significantly, therefore the EMC-measures cited above should become unnecessary. Also, with normally-on T1 and T2 the batteries shown in figure 1 are not required anymore! Together with an appropriate transmitter LED D_T in a second housing prepared to insert the other end of the optic fibre it would give a power electronic switch with potential isolation. However, this will need semiconductor technology not available at HTW.

Summary

The proposed circuit (or device) is similar to a photovoltaic relais or an Opto-MOS but with

- A (super) cascode instead of a MOSFET for the full voltage.
- A "real" wbg-photodiode instead of a series connection of several Si-photodiodes.
- The use of a normally-off GaN-HEMT or SiC-JFET for T0.
- The option of an optic fibre between D_T and D_R for flexible arrangement.

The feasibility of an optical excitation of supercascodes is demonstrated with a load of 1 kW at 600 V. Due to difficulties getting appropriate devices for the demonstrator some compromises were necessary. The switching occurs very slowly due to the lack of an appropriate wbg-photodiode. However, the shown topology can be used to increase the blocking voltages of photovoltaic relais to build a power device with optical turn-on and –off with scalable blocking voltage.

References

[1] Ranneberg, Light controlled (super) cascode, LC(S)C, a power device with optical turn-on and –off, EPE-Journal on-line, https://doi.org/10.1080 / 09398368.2019.1701308, Dec. 2019

[2] Ranneberg, Light controlled (super) cascode, LC(S)C, a power device with optical turn-on and –off, EPE-Journal Vol. 30 no. 1 March 2020

[3] Ranneberg, Schaltungsanordnung für ein optisch steuerbares, leistungselektronisches Bauelement und Verwendung, patent application WO2018/ 184607A1, 7. April 2017, disclosure 11. Oct. 2018

[4] N.N., Technical Datasheet LXML-PB01-0023, Philips Lumileds Lighting, 20. July 2009

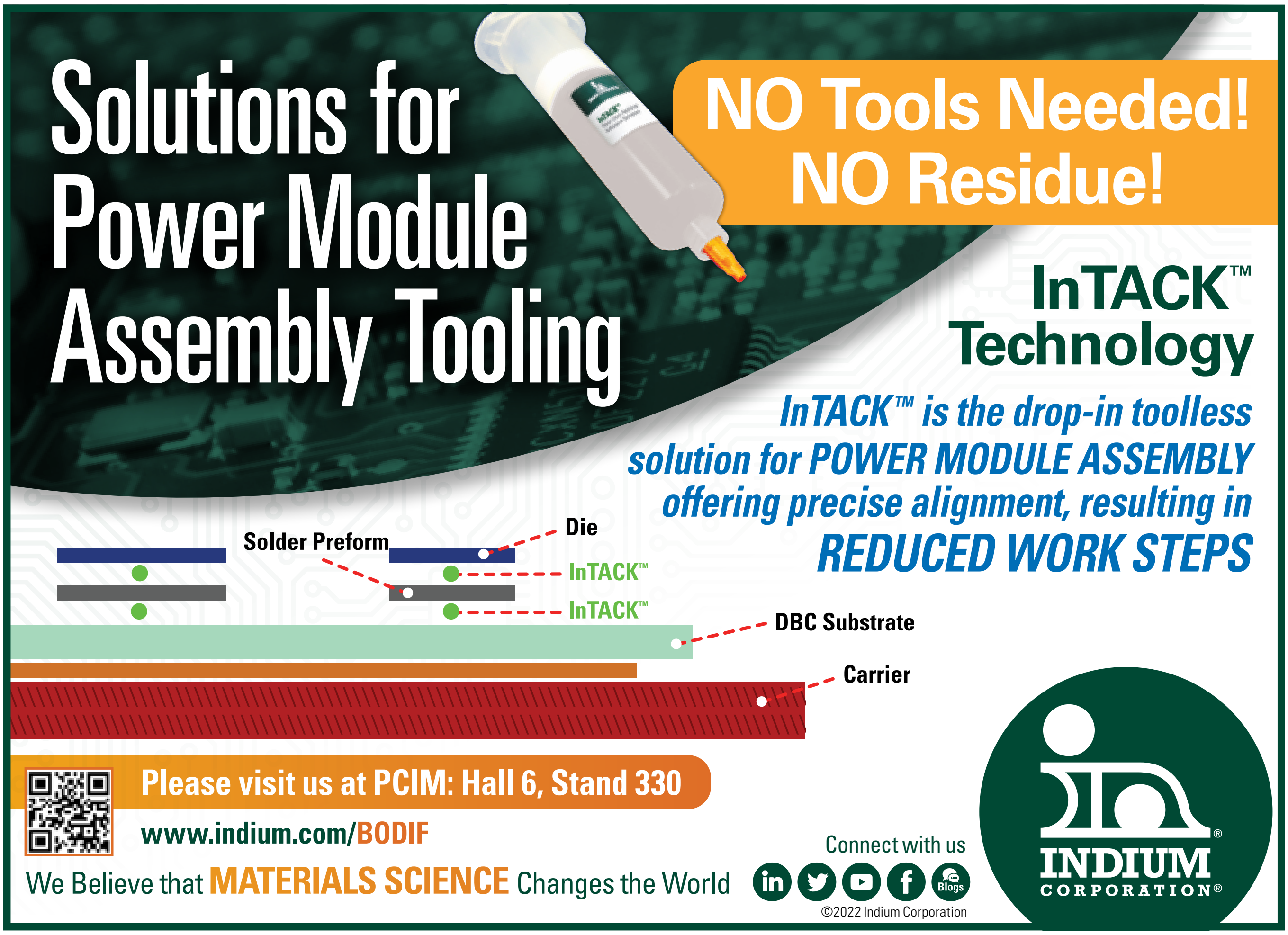
[5] B. Gao et al., 6.0kV, 100A, 175kHz Super Cascode Power Module for Medium Voltage, High Power Applications, IEEE Applied Power Electronics Conference APEC, 4 – 8. March 2018, San Antonio, Texas

[6] Lee FC, et al. Characterization and enhance-ment of high-voltage cascode GaN devices. IEEE Transactions on Electron Devices, Vol 62 No. 2, Feb. 2015

[7] J. Bendel. Cascode Configuration Eases Challenges of Applying SiC JFETs, Application Note USCi_AN0004, United Silicon Carbide, March 2016

[8] J. Ranneberg: Anordnung für ein leistungs-elektronisches Bauelement, patent application WO2017/092722A1 2.12.2015, disclosure 8. June 2017

www.htw-berlin.de


Solutions for Power Module Assembly Tooling
NO Tools Needed! NO Residue!
InTACK™ Technology
InTACK™ is the drop-in toolless solution for POWER MODULE ASSEMBLY offering precise alignment, resulting in REDUCED WORK STEPS
Solder Preform
Die
InTACK™
InTACK™
DBC Substrate
Carrier
Please visit us at PCIM: Hall 6, Stand 330
www.indium.com/BODIF
We Believe that MATERIALS SCIENCE Changes the World
Connect with us
Blogs
©2022 Indium Corporation
INDIUM CORPORATION®


Higher voltage, more power.
Outputs up to 30kV @ 60W and 125W
Fast Charge Time
Low Overshoot
High Stability
High Efficiency
Competitive Pricing
Dean Technology's new UMR-HPC Series of high voltage power supplies is a form-fit-function replacement for industry standard modules at a competitive cost. All models come standard with voltage and current monitoring and can be upgraded to include buffered monitors and current regulation.
pcim EUROPE Booth #9-250
Contact DTI today to discuss your high voltage design.
DEAN TECHNOLOGY
+1.972.248.7691 II www.deantechnology.com

High Performance Impedance Measurements

With a family of high performance LCR meters, the frequency range of impedance measurements provided by Rohde & Schwarz test equipment is extended to cover AC components operating from 4 Hz to 10 MHz, supporting all practical applications. The R&S LCX family of LCR meters serves all established impedance measurements plus specialized measurements for selected component types and provides both, the high accuracy required in R&D, and the high speed needed in production test and quality assurance. For engineers selecting suitable capacitors, inductances, resistors, and analog filters to match the device application, the R&S LCX models provide high precision impedance values with high accuracy. Equally, higher speed measurements at production-use accuracy for quality control and monitoring are also supported. All the essential software and hardware required for production environments is available, including remote control and result logging, as well as rack mounting for the instrument, and a full range of test fixtures for handling components.

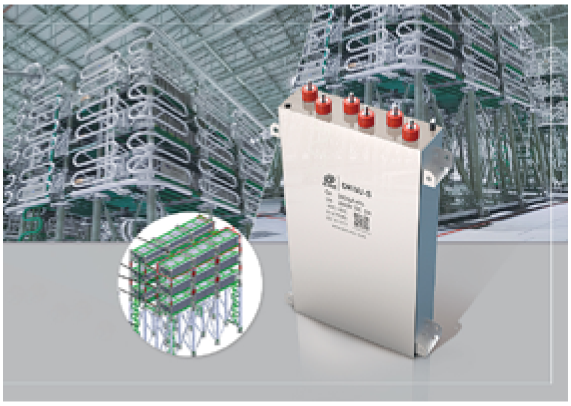
The auto-balancing bridge technology used by the R&S LCX supports conventional impedance measurements by measuring the AC voltage and current for the device under test, including the phase shift. This is then used to calculate complex impedance at any given operational point. As a general purpose LCR meter, the R&S LCX covers many applications, such as the measurement of equivalent series resistance (ESR) and equivalent series inductance (ESL) of electrolytic capacitors and DC-link capacitors.

www.rohde-schwarz.com

DC Support Capacitors For Flexible DC Power Transmission

Recently, the "DC support capacitor for flexible DC transmission" developed by Wuxi CRE New Energy Technology Co., Ltd. has successfully passed the damage test in the company's in-house laboratory. By now, CRE's flexible DC support capacitors have successfully passed all the tests required by the IEC standard (International Electrotechnical Commission), marking the successful birth of CRE's flexible DC support capacitors with its own technology.

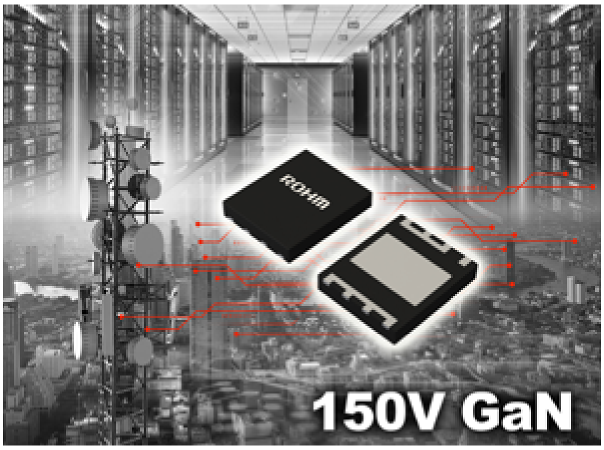
The flexible DC support capacitor, also known as a DC-LINK capacitor, is one of the key components of a flexible DC converter valve. By supporting DC voltage and absorbing ripple current, it can stabilize them, and then provide security for the stable operation of IGBTs in the converter group. Because of its long service life, low leakage current and good explosion-proof stability, it provides a strong driving force for the development of new energy industries.



CRE's successful development of this product marks a further breakthrough in capacitor technology and broadens the application areas. CRE will continue to focus on film capacitors for power electronics applications, providing highly reliable capacitor solutions for new energy vehicles, photovoltaic/wind power applications, inverters, and various industrial equipment.

www.cre-elec.com

GaN HEMTs Featuring 8V Withstand Gate Voltage

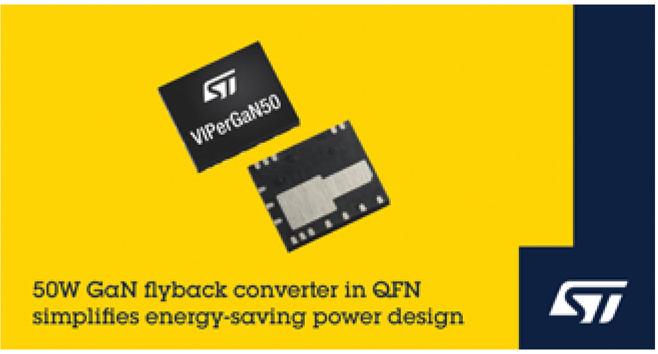


ROHM 150V GaN HEMTs, GNE10xxTB series (GNE1040TB) increase the gate withstand voltage (rated gate-source voltage) to 8V – ideally to be applied in power supply circuits for industrial equipment such as base stations and data centers along with IoT communication devices. These products utilize an original structure that raises the rated gate-source voltage from the conventional 6V to 8V. As a result, degradation is prevented, even if overshoot voltages exceeding 6V occurs during switching - contributing to improved design margin and higher reliability in power supply circuits. The GNE10xxTB series is offered in a highly versatile package featuring superior heat dissipation and large current capability, facilitating handling during the mounting process. ROHM has trademarked GaN devices that contribute to greater energy conservation and miniaturization under the name EcoGaN™, and is working to expand the lineup with devices that improve performance. Going forward, ROHM will continue to develop control ICs that leverage analog power supply technology such as Nano Pulse Control™ and modules that incorporate these ICs, along with power solutions that contribute to a sustainable society by maximizing the performance of GaN devices. EcoGaN™ refer to GaN devices that contribute to energy conservation and miniaturization by maximizing the low ON resistance and high-speed switching characteristics of GaN, with the goals of reducing application power consumption, miniaturizing peripheral components, and reducing design load along with the number of parts required.

www.rohm.com

50W GaN Converter for Consumer and Industrial Applications

The STMicroelectronics VIPerGaN50 simplifies building single-switch flyback converters up to 50 Watts and integrates a 650V gallium-nitride (GaN) power transistor for superior energy efficiency and miniaturization. With its single-switch topology and high integration, including current-sensing and protection circuitry also built-in, the VIPerGaN50 comes in a compact and low-cost 5mm x 6mm package. The speed of the integrated GaN transistor allows a high switching frequency with a small and lightweight flyback transformer. Minimal additional external components are needed to design an advanced, high-efficiency switched-mode power supply (SMPS).



The VIPerGaN50 helps designers leverage GaN wide-bandgap technology to meet increasingly stringent ecodesign codes that target global energy savings and net-zero carbon emissions. It is suited to consumer and industrial applications such as power adapters, USB-PD chargers, and power supplies for home appliances, air conditioners, LED-lighting equipment, and smart meters.

The converter operates in multiple modes to maximize efficiency at all line and load conditions. At heavy load, quasi-resonant (QR) operation with zero-voltage switching minimizes turn-on losses and electromagnetic emissions (EMI). At reduced load, valley skipping limits switching losses and leverages ST's proprietary valley lock to prevent audible noise. Frequency foldback with zero-voltage switching ensures the highest possible efficiency at light load, with adaptive burst mode operation to minimize losses at very low load. In addition, advanced power management cuts standby power to below 30mW.

www.st.com

Bidirectional and Regenerative Programmable DC Power Products

Elektro-Automatik introduces its 10000 series enhanced and expanded line of EA-PS and EA-PSI programmable DC power supplies, EA-PSB bidirectional DC power supplies, and EA-ELR regenerative DC electronic loads. The 10000 series includes over 180 models offering a greater range of power from 0 – 600 W to 0 – 30 kW. The models provide extended voltages from 0 – 10 V to 0 – 2000 V, a significant increase over prior 9000-series power instruments, and provide output current as high as 1000 A.

All 10000 series instruments operate on the same firmware and have the same touchscreen user interface. The physical layout is the same, and all instruments have similar input and output characteristics. The common programming and user interface saves test development and setup time when building test systems that have requirements for multiple power instrumentation.

All 10000 series instruments employ an autoranging output (input if an electronic load) characteristic. Autoranging enables the instrument to have a higher voltage capability at lower currents and a higher current capability at lower voltages than a power supply or load with a conventional rectangular output/input characteristic. Furthermore, an instrument with autoranging output/input can deliver/accept full power output over a significant portion of the instrument's operating range. This is in contrast with an instrument with a rectangular output characteristic which has maximum power only at its maximum voltage and current.

www.elektroautomatik.com

High Power Capacitor Charging High Voltage Power Supplies

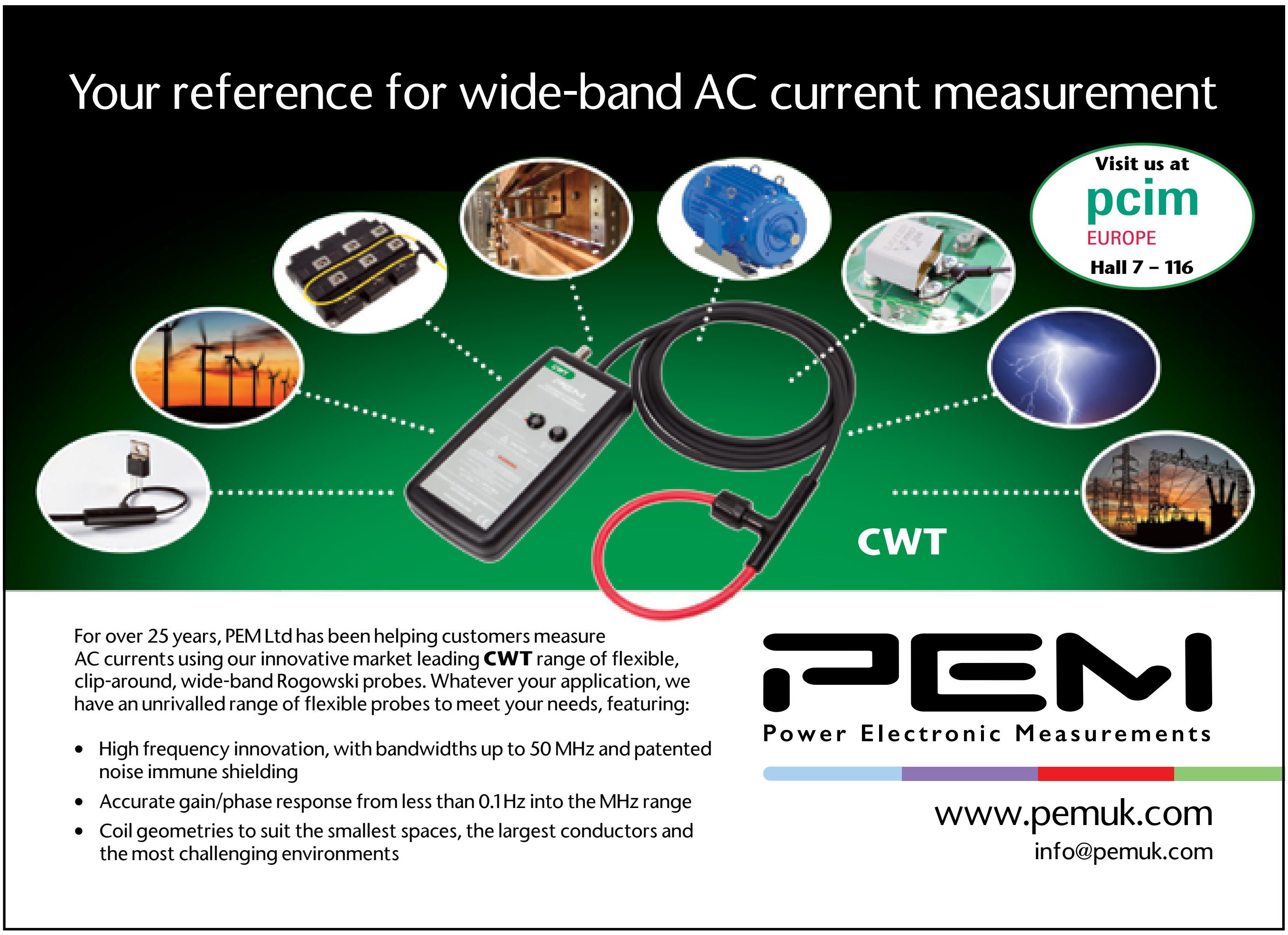
Dean Technology announced the introduction of a series of high voltage power supplies designed specifically for exceptional performance in capacitor charging applications requiring higher voltage and higher power. The UMR-HPC series, which is an extension of the existing UMR Collection of power supplies, offers output voltages up to 30kV at either 60W or 125W.

UMR-HPC modules are form-fit-function replacements for industry standard units and come in three package sizes based on voltage. They offer low overshoot and fast rise time while maintaining high efficiency. All models come standard with voltage and current monitoring and can be upgraded to include buffered monitors and current regulation. In addition, higher power units up to 250W, and bipolar models up to 125W, are in late stages of development and available for early prototyping.

"The addition of higher power and higher voltage modules to our UMR product line gives our customers larger ranges for their more demanding power applications," said Scott Wilson, Sales and Product Development Manager for Dean Technology. "Our focus has been on expanding and augmenting our power supply product line while maintaining our commitment to high quality and high performance. The UMR-HPC units fulfills a significant customer need with more models releasing soon."

www.deantechnology.com


TRACO POWER
Reliable. Available. Now.
Ruggedized Power Solutions
DC/DC converters
3–300 Watt
EN 50155: Isolation and EMC immunity
EN 45545-2: Fire protection
EN 61373: Shock and vibration immunity
Input voltage range: 2:1/4:1/12:1
3-years warranty
For more information, datasheet and certifications please visite our website
www.tracopower.com
RAILWAY DC/DC CONVERTERS
SIP
3 – 6 W
DIP
3 – 200 W
Off-board
20 – 300 W
SURGE FILTER
DIP, 1.6 × 1
1 – 300 W
1
10
200
300
PERFORMANCE IN WATTS

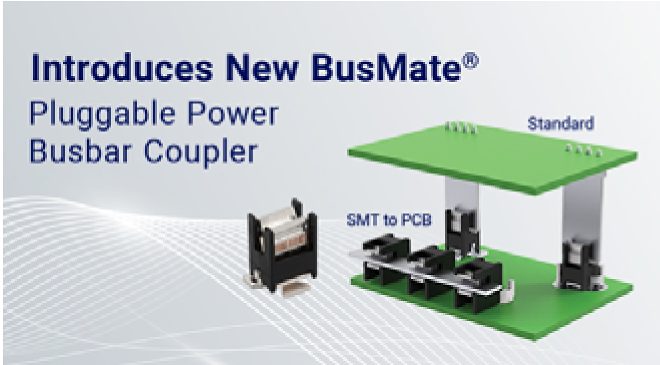

Your reference for wide-band AC current measurement
Visit us at
pcim
EUROPE
Hall 7 – 116
CWT
For over 25 years, PEM Ltd has been helping customers measure AC currents using our innovative market leading CWT range of flexible, clip-around, wide-band Rogowski probes. Whatever your application, we have an unrivalled range of flexible probes to meet your needs, featuring:
High frequency innovation, with bandwidths up to 50 MHz and patented noise immune shielding
Accurate gain/phase response from less than 0.1 Hz into the MHz range
Coil geometries to suit the smallest spaces, the largest conductors and the most challenging environments
PEM
Power Electronic Measurements
www.pemuk.com
info@pemuk.com

Pluggable Power Busbar Coupler

Interplex has announced availability of the BusMate® Power Busbar Coupler, which is designed to maximize configuration options for product engineers to integrate busbars in power devices.

BusMate® provides a compact, pluggable, and economical interface for connecting busbars to a variety of small PCBs, using either SMT or Press-Fit configurations. The technology can support a wide range of designs, including blade-to-blade, molded connectors, busbar-to-SMT and other applications. This gives engineers a highly reliable and assembly-friendly solution for new power designs. According to Joe Lynch, Product Portfolio Director, "As smaller and more powerful product designs require compact, efficient, and reliable busbar interconnects for higher power densities, the BusMate® Power Busbar Coupler is giving designers new options. BusMate®'s design flexibility and Floating Contact Technology enables usage across a wide range of requirements, while assuring excellent electrical performance and cost-effective assembly."

BusMate® is especially helpful for applications such as motors & pumps, hybrid vehicle power systems, electric power steering, charging systems, power mechatronics, Brushless Servo Motor

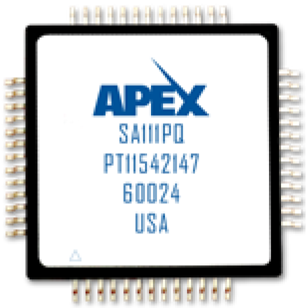


(BLDC) systems, Traction-Drive Inverter Busbar systems and other emerging power applications. These applications span a variety of industries including Electric Vehicles, e-Mobility, Charging Stations, Energy, Transportation, Industrial, Information & Communications Technology, and Medical & Life Sciences.

www.interplex.com

Power Density in Compact Surface-Mount Package

Created with Silicon Carbide (SiC) technology the SA111 is expanding the boundaries of thermal efficiency and power density in analog modules. In a surface mount package and with a body of just 20mm x 20mm, the SA111 can provide continuous output currents of 32A, manage supply voltages of up to 650V, and achieve switching frequencies of up to 1MHz. This thermally efficient package utilizes top-side heat sinking, allowing the user to maximize board layout. The SA111's Silicon Carbide MOSFETs enable the device to withstand higher thermal stress, managing junction temperatures of up to 175°C. The SA111 SiC power module offers a fully integrated solution allowing for increased device control and protection,



featuring an integrated gate driver, under-voltage lockout, and active Miller clamping.

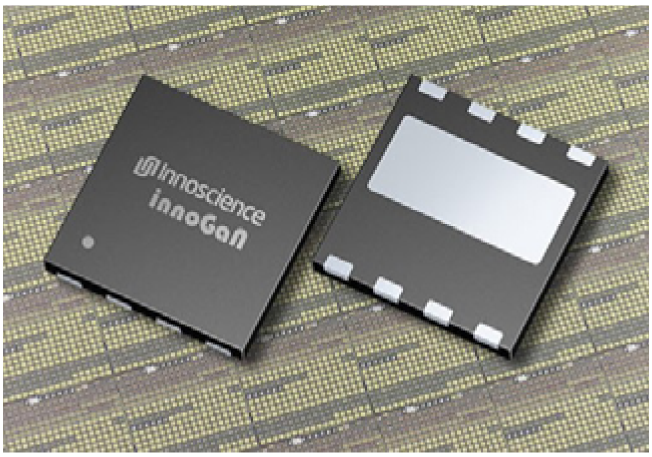
"The SA111 underlines again Apex Microtechnology's ability to provide leading-edge high power solutions in a very compact footprint.", says Director of Business Development, Jens Eltze. "Apex's patented PQ package addresses the demand from the market for surface mountable devices with top-side cooling."

With the surface mount package style and exceptionally compact size, designers are afforded the ability to maximize board real estate, allowing for the use of multiple devices in circuit designs with high power requirements. A wide range of target applications include MRI gradient coil-drive, magnetic bearings, motor drive, test equipment, server-fans, Power Factor Correction (PFC), and AC/DC and DC/DC converters.

www.apexanalog.com

140W Power Supply Design Using High- and Low-Voltage GaN Switches

Innoscience Technology announced an 140W power supply demo that uses the company's high- and low-voltage GaN HEMT devices to achieve efficiencies of over 95% (230VAC; 5V/28A). Measuring just 60x60x22mm (2.4x2.4x0.9in) the PSU has a power density of 1.76W/cm3 (29W/in3). Dr. Denis Marcon, General Manager of In-



noscience Europe and Marketing Manager for the USA and Europe, explained: "By using GaN switches for both the high- and low-voltage functions on this design, we are maximizing efficiency rather than compromising it with lossy silicon devices. This is possible thanks to Innoscience's cost-effective and high-volume manufacturing processes and capabilities."

The 140W 300kHz AC/DC adapter uses a CRM Totem Pole PFC + AHB topology. It features Innoscience's INN650DA140A, a 650V /140mΩ GaN HEMT in the 5x6mm DFN package, for switches S1 and S2, the 650V/240mΩ, 8x8mm DFN-packaged INN650D240A for S3, and the INN650DA240A, a 5x6mm DFN 650V/240mΩ device for S4. S5 and S6 are delivered by the INN150LA070A, a 150V/7mΩ, 2.2x3.2mm LGA part within Innoscience's low-voltage GaN HEMT range.

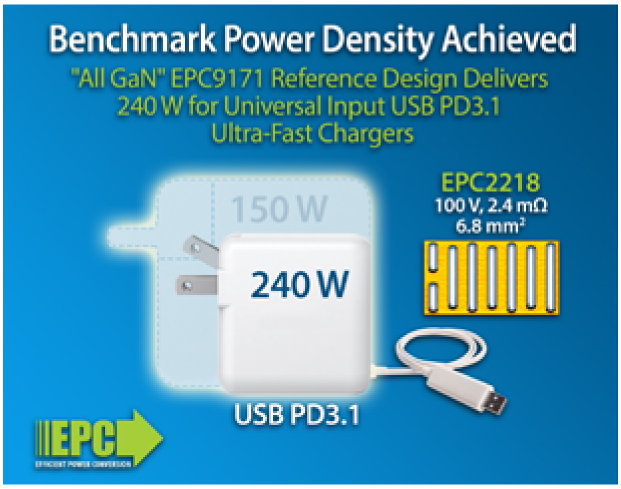
Yi Sun, General Manager of Innoscience America and Sr VP of Product and Engineering adds: "This design, which targets USB PD3.1 notebooks and power tools, is a full 2% more efficient than silicon designs; this proves what can be achieved if GaN FETs are used everywhere, even in a relatively simple design."

www.innoscience.com

"All-GaN" Design for Universal Input USB PD3.1 Ultra-Fast Charger Reference Design

EPC announces the availability of the EPC9171, a 90 V – 260 V universal AC input to 15 V – 48 V DC output power supply designed for USB PD3.1 ultra-fast chargers. This reference design can deliver 240 W maximum output power at 48 V output voltage and 5 A load current. A power density of about 1.1 W/cm3 is achieved by employing gallium nitride (GaN) power switches operating at high switching frequencies in both the primary and secondary circuits. This 240 W reference design measures a mere 83.7 mm by 83.7 mm and shows 79% higher power density, which is more than recently released 140 W USB PD3.1 slim chargers, while providing 240 W of output power – 100 W more power!

The power supply topology used in the design of the EPC9171 consists of a two-phase interleaving boost converter power factor correction (PFC) stage and an isolated LCC resonant power stage. Unlike the well-known LLC resonant power stages, which suffer from limited output voltage range, the LCC resonant converters are ideal for wide output voltage range multi-point applications.



The EPC9171 is an "all-GaN" solution using GaN devices for PFC, LCC and secondary synchronous rectification. The GaN solution switches at two to three times the frequency of standard silicon MOSFET solutions, which enables the very high-power density.

www.epc-co.com

MOSFETs 650 V in D²PAK for Lowest Losses

Infineon Technologies introduces a family of CoolSiC™ 650 V silicon carbide (SiC) MOSFETs to deliver reliable, easy-to-use, and cost-effective top performance. The devices build on Infineon's SiC trench technology and come in a compact D 2PAK SMD 7-pin package with .XT interconnection technology. They target high power applications including servers, telecom, industrial SMPS, fast EV charging, motor drives, solar energy systems, energy storage, and battery formation.

The products offer improved switching behavior at higher currents and 80 percent lower reverse recovery charge (Q rr) and drain-source charge (Q oss) than the best silicon reference. The reduced switching losses allow high-frequency operations in smaller system sizes, enabling higher efficiency and power density. The trench technology is the basis for superior gate oxide reliability. Together with an improved avalanche and short-circuit robustness this ensures the highest system reliability even in harsh environments. The SiC MOSFETs are suitable for topologies with repetitive hard commutation as well as for high temperature and harsh operations. Thanks to a very low on-resistance (R DS(on)) dependency with temperature they show an excellent thermal behavior.

Featuring a wide voltage from gate to source (V GS) range from -5 V up to 23 V and supporting 0 V turn-off V GS and a gate-source threshold voltage (V GS(th)) greater than 4 V, the family also works with standard MOSFET gate driver ICs. Additionally, the products support bi-directional topologies and full dv/dt controllability, offering reduced system cost and complexity, as well as ease of adoption and integration.

www.infineon.com

High-Voltage Flat Wire Inductors

ITG Electronics has introduced a line of High Current Flat Wire Inductors for industrial and rugged environments, including automotive applications. Offering a vastly superior power rating – higher inductance and current – compared with conventional flat wire inductors, the box-shaped item features denser magnetic materials allowing custom-level power in a standardized product. Among other benefits, the result is reduced weight and saved space.

For example, one of the series' inductors, the ITG L201316Q, offers an inductance range from 1.00H to 105uH, and high-power capabilities of 11.6uH 75 Amp / 105uH 25 Amp. This represents 2-4 times the power capabilities offered by leading competitors. The L201316Q is an alloy powder-based DIP Inductor with lower core loss and no thermal aging concerns.

Comprising AEC-Q200 compliant components for automotive applications, the ITG L201316Q utilizes exceptionally high-power density magnetics materials to achieve a the most powerful density inductor available in a standard product offering. Custom designs also are available. The series also is RoHs & HF compliant, and has a consistency-minded operating temperature range of -55°C to 150°C.

www.itg-electronics.com

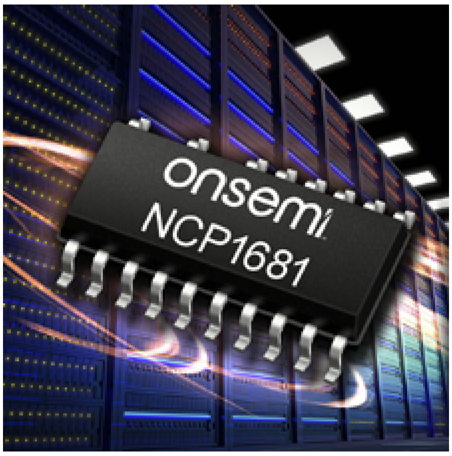
Quasi-Resonant PFC IC with 750 V GaN Switch

Power Integrations announced the HiperPFS™-5 family of power-factor-correction (PFC) ICs with an integrated 750 V PowiGaN™ gallium-nitride switch. With efficiency of up to 98.3 percent, the ICs deliver up to 240 W without a heat sink and can achieve a power factor of better than 0.98. HiperPFS-5 ICs are ideal for high-power USB PD adapters, TVs, game consoles, all-in-one computers and appliances. The capacitors and inductors used in power supplies generate a phase change between current and voltage, causing losses in the apower lines and potentially disrupting other equipment

connected to the AC mains. Many countries require power supplies over 75 W to adjust for this effect with so-called power factor correction, or PFC. While there are many PFC solutions available, HiperPFS-5 ICs with PowiGaN technology and a quasi-resonant (QR) control scheme represent the pinnacle of the art and science of off-line power quality enhancement. HiperPFS-5's innovative QR discontinuous conduction mode (DCM) control technique adjusts the switching frequency across output load, input line voltage and input line cycle. QR DCM control ensures low switching losses and permits the use of a low-cost boost diode. The variable frequency engine allows the reduction of boost inductor size by more than 50 percent compared to conventional critical-conduction-mode (CRM) boost PFC circuits.

www.power.com

High Power Totem Pole PFC Controller



onsemi introduced its latest mixed-signal controller dedicated to bridgeless totem pole PFC (TP PFC) topology. The NCP1681 targets ultra-high density offline power supplies. Building upon the success of theNCP1680, which is suited for designs up to 350 W, the controller extends the power capability into the kilowatt range.

In the past, TP PFC designs required the use of an MCU that added design complexity and the need for coding. However, with the NCP1681, only a few external components and no coding is needed to be added for a fully-featured TP PFC solution, thereby saving time, cost and space.

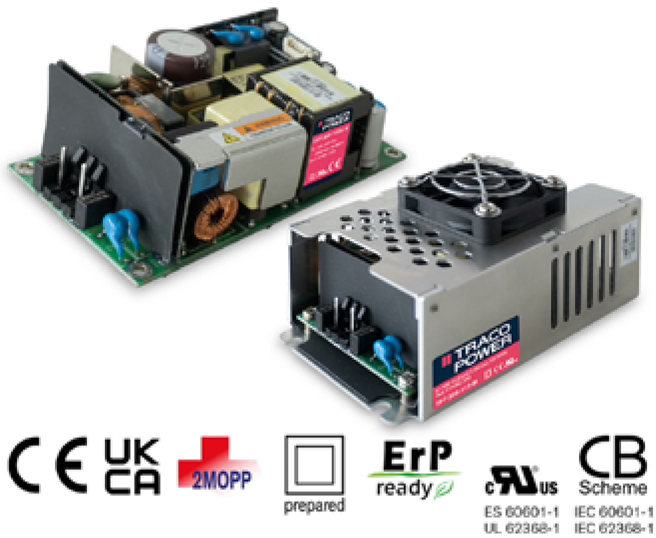
Commenting on the release, Robert Tong, Senior Vice President & General Manager of Computing and Cloud Division at onsemi said "The NCP1681 extends the benefits of code-free TP PFC design into higher power. This allows our customers to continue to enhance the efficiency of their design while reducing design time and cost, thereby delivering solutions to market quickly."

The NCP1681 can be configured to work in either fixed frequency continuous conduction mode (CCM) or multi-mode operation, where the controller naturally transitions between CCM and critical conduction mode (CrM) for optimal performance across power levels.

www.onsemi.com

AC/DC Power Supplies for Industrial & Medical Applications

The TPI 300 (industrial grade) & TPP 300 (medical grade) series are a set of encapsulated AC/DC power supplies coming as open frame and encased versions. They feature a reinforced double I/O isolation (3000 VAC) system according to latest medical or industrial safety standards respectively. With focus on the medical market the TPP series also has a low leakage current of <100 µA which makes the units suitable for BF (body floating) applications.



The efficiency of up to 93% allows a high power-density and compact design (4" x 2" for open frame and 4.6" x 2.44" for encased version). The operating temperature range is –40°C to +85°C with derating above 50°C. In natural convection operation these power supplies deliver 180 Watt going up to 300 Watt with forced air cooling. Additionally, they can deliver 360 Watt peak power for 5s.

The EMC characteristic is dedicated for applications in industrial and medical fields. High reliability is provided by using high quality components and an excellent thermal management making the TPI 300 & TPP 300 an ideal solution for industrial and medical devices and for demanding safety and space critical applications.

www.tracopower.com

SiC Power Modules at PCIM Europe

Wuxi Leapers Semiconductor (Leapers Semiconductor) will present full silicon carbide (SiC) power module portfolio during PCIM Europe 2022 in Nuremberg, Germany. On May 10-12, 2022, the representatives of the company will join the event to showcase their latest SiC power module portfolio designed for applications like new energy vehicles, smart grid, solar and wind power generation, motor drives, medical equipment, traction, etc. By using innovative advanced packaging material and processing technology, Leapers Semiconductor provides comprehensive module application solutions for miniaturization, efficiency and light weighting of electrical drive systems and inverters of new energy vehicles. Besides SiC product line Leapers Semiconductor will present IGBT modules portfolio in the industry recognized footprint designed for high power switching applications. All participants and visitors are invited to stop by Leapers Semiconductor booth 520 in Hall 7 to learn more about company, SiC and IGBT module portfolio, and future products under development.

This year PCIM Europe will return to face-to-face format and welcome the visitors from around the world in the halls 6, 7 and 9 on the Messe Nürnberg event grounds. The international power electronics industry will meet again after nearly two years of predominantly digital exchange. As in previous years, visitors of the leading exhibition and conference for power electronics can expect product innovations and a top-class lecture program.

www.leapers-power.com

Qi 1.3 Wireless Charging with Authentication

In order to ensure high quality wireless charging power transmitters, the Wireless Power Consortium (WPC) has released the Qi® 1.3 specification with the extended power profile. This specification created demand for high security silicon authentication devices for full-service support. In response, Microchip Technology is announcing the industrial grade TrustFLEX ECC608 and the automotive grade Trust Anchor TA100 combined with Microchip secure key provisioning services for Qi 1.3 power transmitters. This offering is an all-in-one secure storage subsystem that includes key provisioning for consumer and automotive systems.

The Qi 1.3 specification now mandates the addition of a secure storage subsystem with secure key provisioning including X.509 certificates to cryptographically verify the source and quality of the certified power transmitter. When a receiver, e.g. in a cell phone is placed on a Qi 1.3 power transmitter, it may initially accept a 5W charge or no charge at all. Then after a successful X.509 based ECC authentication proving the charger is an approved, “do no harm” device, the phone will then safely accept a 15W charge significantly reducing charging time.

Microchip is now a WPC licensed manufacturing Certificate Authority (CA), not only offering pre-configured secure storage subsystem solutions that reduce complexity and development time, but also lowering the technical barrier of entry by handling the entire key ceremony with the WPC root certificate authority on behalf of Microchip customers.

www.microchip.com

Advertising Index

OUTLOOK:
ROHM's 4th Generation SiC product line

ROHM has set itself the goal of achieving strong growth in automotive sectors and markets worldwide over the next ten years. For example, the company is increasing its SiC device and gate driver production capacity significantly. In addition, ROHM will continue to invest in these technologies aggressively. SiCrystal is preparing to support 8-inch wafers. The Apollo plant already has a production line that can be converted to 8-inch wafers.

ROHM's 4th Generation SiC MOSFETs are currently available in 1200-V and also 750-V versions, and are being offered in a variety of forms including discrete packages, bare chips, and modules. Discrete package product lines are available in the market. Bare chips for traction inverters for bulk EVs are currently being adopted for customers' mass production.

There will also be a new module for the industrial market in 2022.
Then, there should be another molded type of module for the automotive and industrial market.

ROHM's 5th Generation SiC MOSFETs are also under development. According to ROHM, there are still further optimization opportunities that need to be exploited.
The company has not yet reached a point here where it is approaching theoretical limits, as it has with Si IGBTs.
With the next generation, ROHM is aiming for a further 30% reduction in Rdson compared to the 4th Generation.
Mass production is targeted for 2025.

For more ROHM SiC power devices information, visit:
www.rohm.com/products/sic-power-devices

SEMI AMERICAS EVENTS

Technology Leadership Series of the Americas Events

ISS
INDUSTRY STRATEGY SYMPOSIUM
APRIL 3-6, 2022
HALF MOON BAY, CA

MEMS & SENSORS TECHNICAL CONGRESS
APRIL 26-27, 2022
BERKELEY, CA

SEMICON WEST
JULY 12-14, 2022
SAN FRANCISCO, CA

FLEX at West
JULY 12-14, 2022
SAN FRANCISCO, CA

ASMC
ADVANCED SEMICONDUCTOR MANUFACTURING CONFERENCE
MAY 2-5, 2022
SARATOGA SPRINGS, NY

SMC
STRATEGIC MATERIALS CONFERENCE
OCT 3-5, 2022
SAN JOSE, CA

MEMS & SENSORS EXECUTIVE CONGRESS
OCT 10-12, 2022
SAN DIEGO, CA

ITPC
INTERNATIONAL TRADE PARTNERS CONFERENCE
OCT 30-NOV 2, 2022
HAWAII

The **Technology Leadership Series** of the Americas is a collection of eight major events representing the various technology communities in our industry. These programs connect 2,400+ member companies and over 1.3 million global professionals to advance the technology and business of electronics manufacturing and the design-supply chain.

There are numerous ways for you to participate in these events to connect with the industry and grow your business.

ATTEND | PRESENT | SPONSOR | EXHIBIT

SAVE THE DATES
FOR THESE 2022 EVENTS

Explore these upcoming programs and fill out the Interest Form on each website to get connected for the latest event updates.

www.semi.org/semi-americas