ISSN: 1863-5598

ZKZ 64717
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Bodo´s Power Systems®

Electronics in Motion and Conversion

December 2024

ROHM SEMICONDUCTOR

2-in-1 SiC Modules reduce the size of xEV inverters

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

Also suitable for 3-phase inductors

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

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

AVAILABLE MODELS

Model	max. test current	max. pulse energy
DPG10-100B	0.1 to 100A	1350J
DPG10-1000B	1 to 1000A	1350J
DPG10-2000B	2 to 2000A	1350J new model
DPG10-2000B/E	2 to 2000A	2750J new model
DPG10-3000B/E	3 to 3000A	2750J
DPG10-4000B/F	4 to 4000A	8000J
DPG20-10000B/G	10 to 10000A	15000J

Technological leader in pulsed inductance measurement for 20 years

www.ed-k.de

Content

MERRY CHRISTMAS

Season's Greetings from
the Team at

Bodo´s Power Systems®

We wish you and your family
a prosperous and successful
New Year!

Alfred Vollmer

Bodo Arlt

Holger

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

ASC audit since 09/2006

Printing by:
Dierichs Druck+Media
GmbH & Co. KG,
34121 Kassel, Germany

Is There Hope for Peace?

War continues to destroy the future of people, and we face enough man-made disasters with climate change. All around the world heavy rain causes flooding. So, it is another tough challenge to bring war to an end. There are too many places on earth on fire.

My words a year ago are still valid: It is a pity that diplomacy could not prevent this, as history has shown us there will only be losers left at the end. The people pushing war and terrorism must be stopped. 'Please stop the War' is my message to all politicians throughout the world and stand up and work for peace.

It is tough to see so much aggression day after day on the TV. At some point, we also need to overcome religion driven aggression. Educating kids all around the world is the way to Democracy that will result in Freedom and Peace.

All these memories and past stories about war, which were told to me by my parents, return while watching the news on TV.

We have mostly grown up during the last seven decades in peace, but I personally have missed Grandpas and Uncles because they served in the military and did not return home from World War I and II. Wars definitely destroy the resources needed to save our environment. We need to stop global warming too. Allocating electronic manufacturing resources to defense projects weakens our fight against global warming, with all of the bad side effects. We are all losers in the end, but mainly it will be the wider population who will suffer the most. It will have an impact on all of us. My hope is that all of our children and grandchildren will grow up in peace and that war will not escalate in all areas and set the world on fire. Working to stop the war must be our most important task. There are never winners after wars.

I have once again donated 1.000 € to UNICEF to help the children in the war zones. We usually spend this amount sending out Christmas cards and have donated this for the past two years. In my opinion, this is more worthwhile, and I would like to encourage my readers and contributors to offer similar help.

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:
For your vacation, why not discover your own country rather than fly to far destinations. This is a great alternative and will lower your CO_2 footprint.

Merry Christmas and
a Happy New Year

Events

Thermal Management Expo 2024
Stuttgart, Germany December 3 – 5
www.thermalmanagementexpo-europe.com

IEEE IEDM 2024
San Francisco, CA, USA December 7 – 11
www.ieee-iedm.org

SEMICON Japan 2024
Tokyo, Japan December 11 – 13
www.semiconjapan.org

NEPCON Japan 2025
Tokyo, Japan January 22 -24
www.nepconjapan.jp

DesignCon 2025
Santa Clara, CA, USA January 28 – 30
www.designcon.com

PLECS Conference 2025
Zurich, Switzerland March 4 – 5
www.plexim.com/events

embedded world 2025
Nuremberg, Germany March 11 -13
www.embedded-world.de

APEC 2025
Atlanta, GA, USA March 16 – 20
www.apec-conf.org

AMPER 2025
Brno, Czech Republic March 18 – 20
www.amper.cz

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Call for Proposals for Innovation Award & Young Engineer Award

The Semikron Danfoss Innovation Award and the Semikron Danfoss Young Engineer Award are given for outstanding innovations in projects, prototypes, services or novel concepts in the field of power electronics in Europe, combined with notable societal benefits in form of supporting environmental protection and sustainability by improving energy efficiency and conservation of resources. The prizes are awarded in cooperation with the European ECPE Network. With the award Semikron Danfoss wants to motivate people of all ages and organizations of any legal status to deal with innovations in power electronics, a key technology of the 21st century, in order to improve environmental protection and sustainability by energy efficiency and conservation of resources. The Semikron Danfoss Innovation and Young Engineer Prizes 2025 will be awarded in the frame of the ECPE Annual Event in April 2025. A single person or a team of researchers can be awarded. Semikron Danfoss Innovation Award includes prize money of EUR 10,000, while the Semikron Danfoss Young Engineer Award for researchers who have not yet completed their 30th year of age includes prize money of EUR 3,000. The award targets at projects, prototypes, services and novel concepts developed in Europe, which did not yet appear on the market, which are used in a novel application, or which form an absolute novelty, and therewith fulfil the requirement to be extraordinary and remarkable. To apply for the awards own applications as well as proposals from third parties are welcomed. The deadline for submission ends on 31.01.2025.

www.semikron-danfoss.com

Consulting for Startup Company

Foxy Power announced a new partnership with DL Consulting. This collaboration is based on technological business development paired with industry-wide market analyses to enable faster success in the market. By combining the expertise of both companies, it will allow for superior consulting experience and will give the common customer base access to the specialist from the industry. In its consulting services DL Consulting specializes on wide bandgap solutions like SiC and GaN including market research, power electronics design, acquisition services, go-to-market strategies and advisory to institutional investors. The company will deliver its know-how and services to Foxy Power's customer base to enable a better customer journey. Foxy Power, an advocate for startups as well as other companies at the forefront of disruptive technologies by delivering worldwide business development, sales, and strategy services. Driving the concept of product value maximization, Foxy Power enhances manufacturers' sales outreach, emphasizing an application-centric approach.

www.consulting.liesabeths.de

The World's thinnest Silicon Power Wafer

Infineon Technologies has reached a breakthrough in handling and processing the thinnest silicon power wafers ever manufactured, with a thickness of only 20 µm and a diameter of 300 mm, in a high-scale semiconductor fab. The ultra-thin silicon wafers are only a quarter as thick as a human hair and half as thick as current state-of-the-art wafers of 40-60 µm. According to Infineon this will "significantly help increase energy efficiency, power density and reliability in power conversion solutions for applications in AI data centers as well as consumer, motor control and computing applications". Halving the thickness of a wafer reduces the wafer's substrate resistance by 50 percent, reducing power loss by more than 15 percent in power systems, compared to solutions based on conventional silicon wafers. For high-end AI server applications, where growing energy demand is driven by higher current levels, this is particularly important in power conversion: Here voltages have to be reduced from 230 V to a processor voltage below 1.8 V. The ultra-thin wafer technology boosts the vertical power delivery design, which is based on vertical Trench MOSFET technology and allows a very close connection to the AI chip processor, thus reducing power loss and enhancing overall efficiency. This was achieved by applying a unique wafer grinding approach, since the metal stack that holds the chip on the wafer is thicker than 20 µm. The technology has been qualified and applied in Infineon's Integrated Smart Power Stages (DC/DC converter) which have already been delivered to first customers.

www.infineon.com

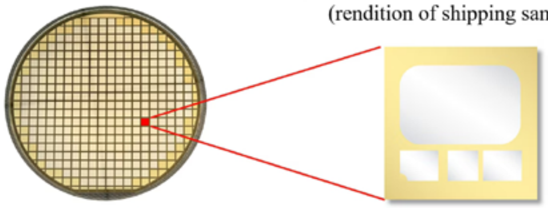
The next Generation of HIL Compatible Digital Twin

ABB has partnered with Typhoon HIL to create the DriveLab ACS880 HIL compatible digital twin. This collaboration is intended to bring a realistic, scalable, and easy to use real-time simulation platform to a wide range of industrial applications. DriveLab ACS880 is the next generation of Hardware-in-the-Loop (HIL) simulation technology. It is specifically tailored and geared towards simplifying the integration of ABB variable speed drives (VSD) systems. It will enable users to test and validate the system via a test automation capability which is a key component of top-tier customer support. HIL simulation is used to validate both component and system-level behavior of the drives and drive systems in real-world applications ranging from compressors, conveyers, and cranes to large scale energy storage, microgrids and more. The DriveLab ACS880 serves as a digital twin, integrating the control hardware, firmware, and software of the ACS880 drives with Typhoon HIL's high-fidelity digital models. These digital models virtually represent the ACS880 drive's hardware, including its connected components, such as the grid, motors, filters, batteries, protection devices, and the electro-mechanical elements.

www.typhoon-hil.com

Shipping Samples of SiC-MOSFET Bare Die for xEVs

Mitsubishi Electric Corporation announced that it will begin shipping samples of a silicon carbide (SiC) metal-oxide-semiconductor field-effect transistor (MOSFET) bare die for use in drive-motor inverters of electric vehicles (EVs), plug-in hybrid vehicles (PHEVs) and other electric vehicles (xEVs) on November 14. Mitsubishi Electric's first standard-specification SiC-MOSFET power semiconductor chip will enable the company to respond to the diversification of inverters for xEVs and contribute to the growing popularity of these vehicles. The SiC-MOSFET bare die for xEVs combines a proprietary chip structure and manufacturing technologies to contribute to decarbonization by enhancing inverter performance, extending driving range and improving energy efficiency in xEVs.


Layout of SiC-MOSFET bare die for xEVs
(rendition of shipping sample)

Wafer with SiC-MOSFETs for xEVs
(rendition)

Mitsubishi Electric's new power semiconductor chip is a proprietary trench SiC-MOSFET that reduces power loss by about 50% compared to conventional planar SiC-MOSFETs. Thanks to proprietary manufacturing technologies, such as a gate oxide film process that suppresses fluctuations in power loss and on-resistance, the chip achieves long-term stability to contribute to inverter durability and xEV performance.

www.mitsubishielectric.com

PCIM Expo 2025 with more Exhibition Space

The growing demand for power electronics is increasing the need for information and dialog within the industry. Therefore, the PCIM Expo will expand from four to six halls in 2025 to create even more space for development potential. With the new halls 4 and 4A, the Nuremberg exhibition will therefore, for the first time, extend over six exhibition halls. Event visitors will thus have access to a wider range of companies, products, and interaction opportunities, which is key to shaping the further development and future of power electronics.

https://pcim.mesago.com

Early Bird Registration Now Open for the 40th Annual APEC 2025 in Atlanta

Early bird registration is now open for the 40th Annual Applied Power Electronics Conference (APEC), running March 16-20 at the Georgia World Convention Center in Atlanta. The APEC 2025 conference and exposition gathers power electronics engineers, academics and students from all over the world to learn about the latest research, technologies and products. Early bird registration ends Jan. 13, 2025. Full registration includes access to the APEC Technical Program. Comprising nearly 800 paper presentations, sessions and seminars, the conference offers a broad scope of content: APEC Plenary Session (visionary talks by distinguished speakers), Technical Sessions (lecture sessions and dialogue sessions based on peer-reviewed papers), Industry Sessions (presentations showcasing work in all areas of power electronics), Professional Education Seminars (in-depth seminars on practical aspects of power electronics), Debate – formerly RAP – Sessions (expert panelists identify three hot topics for friendly debate) as well as Exhibitor Presentations (exhibitor companies highlight new products and technologies). Also included in the full registration package is admission to the APEC 2025 Exposition and Special Events. The 2025 exposition will gather nearly 300 exhibitors to the sold-out exhibit floor. With its lively, interactive trade show environment, APEC 2025 offers participation in such events as the MicroMouse contest, the FIRST Robotics demonstration and the Wednesday evening Social Event celebrating APEC's 40th anniversary.

www.apec-conf.org

3D Power Design and Manufacturing Symposium (3D-PEIM) 2025

The PSMA Packaging and Manufacturing Committee announce its Fifth International Symposium on 3D Power Electronics Integration and Manufacturing (3D-PEIM-20235). 3D-PEIM will take place July 8–10, 2025 at the National Renewable Energy Laboratory (NREL) in Golden, Colorado. The symposium is designed for any engineer or manager involved in the design and manufacturing of high-density power sources using 3D technology. It will feature key speakers and technical sessions focused on increasing the power density and performance of power solutions. Plenary presentations will include: "Beyond 2030: Powering the E-Powertrain with High-Value and High-Efficiency Power Conversion Systems - A BorgWarner Perspective", presented by Harsha Nanjundaswamy, BorgWarner, "Advanced Packaging to System Integration - Trends and Challenges", presented by Devan Iyer, IPC and "The Power Delivery and Energy Storage Challenge in Advanced Packaging", presented by Subramanian Iyer, University of California Los Angeles. Attendees are also invited to tour the power electronics facilities of the National Renewable Energy Laboratory.

www.3d-peim.org

Strategic Partnership for Onboard Chargers and more

Nexperia has entered into a strategic partnership with Kostal, which will enable it to produce wide bandgap devices that more closely match the exacting requirements of automotive applications. Under the terms of this partnership, Nexperia will supply, develop, and manufacture WBG power electronics devices which will be designed-in and validated by Kostal. The collaboration will initially focus on the development of SiC MOSFETs in topside cooled QDPAK packaging for onboard chargers in electric vehicles.

www.nexperia.com

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WIND

High Power next Core (HPnC)

with Fuji Electric‘s X series - 7G IGBT and SiC

MAIN FEATURES for traction & industrial applications

- **Latest chip technology**
  - Fuji Electric‘s X series IGBT and FWD with low losses
- **SiC – MOSFET: Super low switching loss energies**
- **High reliability**
  - CTI>600 for higher anti-tracking
  - High thermal cycling capability with ultra sonic welded terminals
  - MgSiC base plate for traction version
  - 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

www.fujielectric-europe.com

Fuji Electric
Innovating Energy Technology

Where Has All the Power Gone?

Control your Energy Efficiency

Energy efficiency is essential for creating a low-emission or even carbon-neutral future. It plays a crucial role in the transition from combustion engines to electric vehicles and in minimizing the energy impact of power-hungry AI applications in data centers. Understanding where power is lost – whether in converters, motors, or data centers – is key to unlocking significant efficiency gains and addressing the growing demand for energy usage.

A power analyzer calculates the system efficiency of motors, inverters, or transformers by measuring both the main active power and power harmonics. Main active power is the portion used for productive output, like driving motors and powering devices, while harmonic power is lost as vibration, noise, and heat. Reducing harmonics is crucial for engineers to minimize energy losses.

Measuring Harmonics Accurately

When measuring harmonics at high frequencies and high currents, current sensors are required. However, these sensors must maintain accurate performance over the entire frequency band to ensure precise power measurement. To achieve this, the power analyzer must know the phase shift value of the current sensor and ideally, the sensors must be designed to have the same time delay over the whole frequency band.

If such a power analyzer and current sensor combination isn't optimized for high-frequency measurements, efficiency readings can be misleading. For example, measuring an inverter with a 50 kHz carrier frequency may produce unrealistic efficiencies, sometimes over 100%. While such extremes are clear red flags, smaller discrepancies, like showing 96% instead of the true 94%, are difficult to detect. These inaccuracies often occur because standard power analyzers typically ignore current sensor effects at higher frequencies.

Perfectly Fitting Current Sensors

In motor systems, high-frequency harmonic power primarily converts to heat within the motor. Due to the motor's inductive nature, high-frequency power is difficult to measure: at high frequencies the phase angle between voltage and current approaches 90°. Since active AC power is calculated as Voltage × Current × cos(θ), any phase error pushing the phase angle beyond 90° incorrectly results in a negative measured power loss – appearing as a false gain.

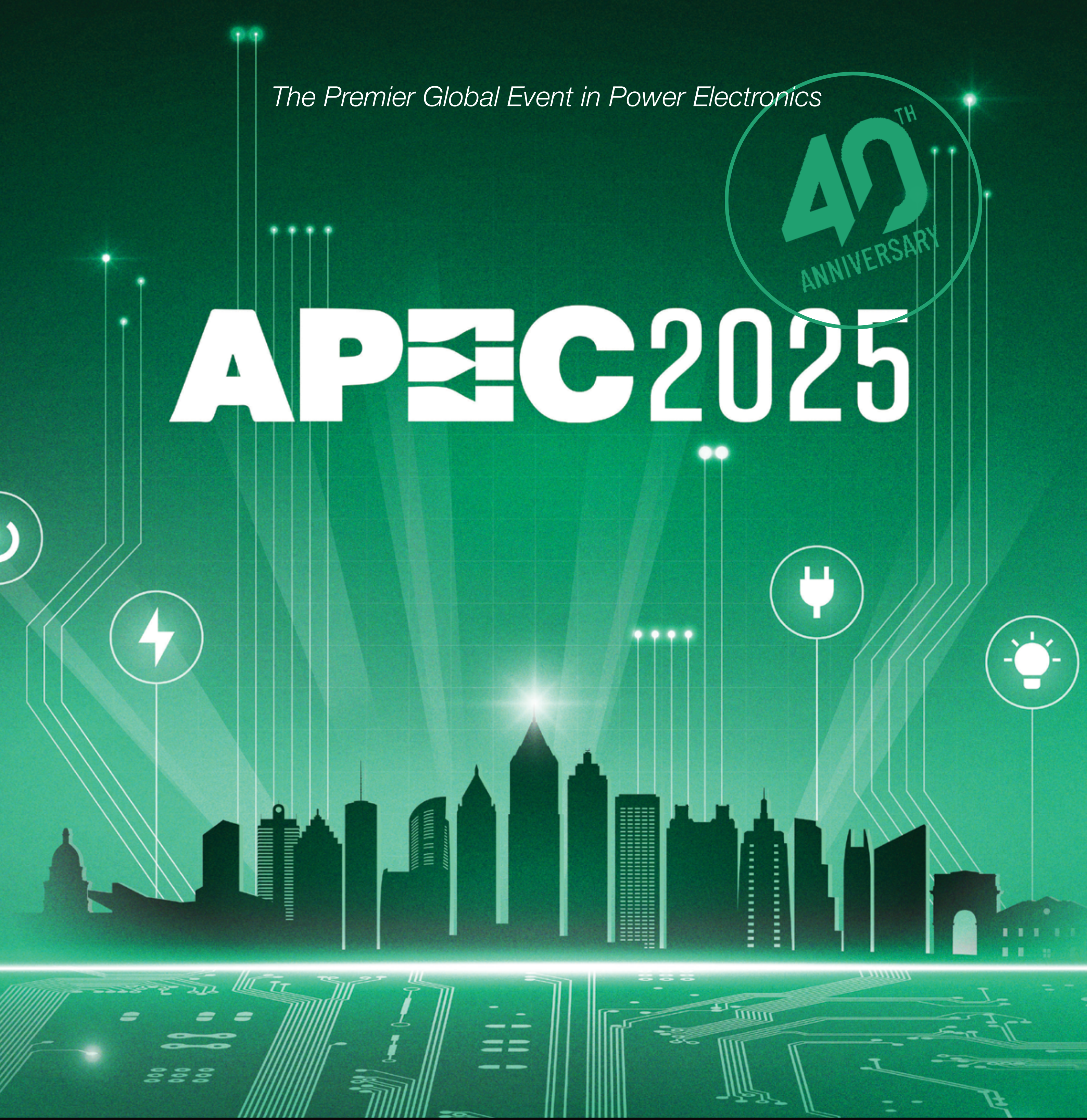
The right combination of a power analyzer such as the PW8001 and HIOKI current sensors ensures accurate power measurements, particularly for high currents and high frequencies – enabling engineers to determine power losses precisely.

Comprehensive Power Analysis Across All Frequencies

Power analyzers offer various methods to identify the frequencies where power is lost. Traditional harmonics analysis, based on the main frequency, is limited to around 100 kHz. For a view over the complete frequency range, advanced power spectrum analysis (PSA) is required. PSA, as used in HIOKI's PW8001 analyzer, applies FFT up to 5 MHz covering the whole frequency range of the power analyzer.

Since HIOKI designs both its power analyzers and current sensors, they are optimized for each other with accurate analysis features like PSA and sensors that maintain a consistent, flat amplitude response across the frequency range. This integration ensures accurate insights into power losses, helping engineers take measures to improve efficiency in their applications.

www.hioki.eu



SAVE THE DATE

ATLANTA, GA | MARCH 16–20, 2025

www.apec-conf.org

IAS IEEE INDUSTRY APPLICATIONS SOCIETY Linking Research to Practice

IEEE Advancing Technology for Humanity

pels IEEE POWER ELECTRONICS SOCIETY Powering a Sustainable Future

PSMA

2-in-1 SiC Modules reduce the Size of xEV Inverters

High power density thanks to integration of 4th generation SiC MOSFETs in a compact housing

Silicon carbide (SiC) power components are becoming increasing popular when developing electrical drive systems. Until now, however, it has been difficult to achieve low losses while maintaining a compact size. ROHM is addressing this challenge in the field of drive trains with its TRCDRIVE pack™.

By Imane Fouaide, Application Marketing Manager, ROHM

Mobility is a key part of our daily life. The rapid move to carbon-neutral and energy-efficient means of transport is making an important contribution to a greener future. Development of electric drives that are more compact, efficient and also lighter has a key part to play here - not only in promoting greater interest and use of the next generation of electric vehicles (xEVs), but also hitting environmental targets such as carbon neutrality. Improved drive inverter efficiency is extremely important in this regard, particularly for electric vehicles, as this allows the range to be extended and the size of the on-board battery to be reduced.

The importance of silicon carbide in the automotive industry is undisputed. Sales figures from the last few years confirm that the transformation towards electric mobility is continuing to drive growth, particularly in the European and Asian automotive industry. ROHM supports this transformation on a sustainable basis through multiple confirmed cooperations with manufacturers of vehicles and traction inverters.

Two-year development cycle promotes innovation

To support the progress of innovation in the automotive industry, ROHM has announced that it will be reducing the development cycle of its SiC generations to two years. However, components will definitely not be phased out because of this. Thanks to ROHM's production capacities, older generations can continue to be produced. Depending on the life cycle of the products, this means that the requirements can still be met with regard to component availability for long-term industrial applications.

ROHM adopts the "brownfield" approach to ensure success when producing newly developed products. Thanks to retrofitting and modernisation of existing factories, such as the Miyazaki facility, production of 8-inch substrates is already set to begin this year. This reduces the construction time of production sites by two years over a new building, since the infrastructure already in place can be used. ROHM will then able to increase production of modules by a factor of 30 over conventional SiC housing modules. Production will run on the 8-inch substrates from the fifth generation of SiC MOSFETs, which will increase production capacities significantly.

In addition to this, ROHM and Toshiba have announced a cooperation for the manufacture of power semiconductors. The Japanese Ministry of Economy, Trade and Industry (METI) is supporting this plan, the aim of which is to ensure a stable and secure supply of semiconductors. Both companies are investing intensively in the production of silicon carbide (SiC) and silicone (Si) power semiconductors in order to improve their supply capacities, as well as make optimum use of one another's production capacities.

SiC as a key component in the field of electric mobility

However, ensuring low losses while maintaining a compact size represents a major challenge for SiC power components. ROHM solves this dilemma with its TRCDRIVE pack™.

TRCDRIVE pack is a trademark for SiC modules from ROHM that have been developed specifically for traction inverter applications and feature a reduced size thanks to a unique structure for maximising the heat dissipation surface. Integration of ROHM's 4th generation SiC-MOSFETs with low ON resistance offers industry-leading power density, which is 1.5 times higher than with conventional SiC modules. At the same time, it makes a significant contribution to the miniaturisation of inverters for xEVs.

The TRCDRIVE pack modules from ROHM are half-bridge modules that are equipped with 4th generation SiC FETs. These modules are designed in such a way that they offer high current density and low switching losses. Modules such as these support the automotive industry in driving forward the technological change and supplying highly efficient drives.

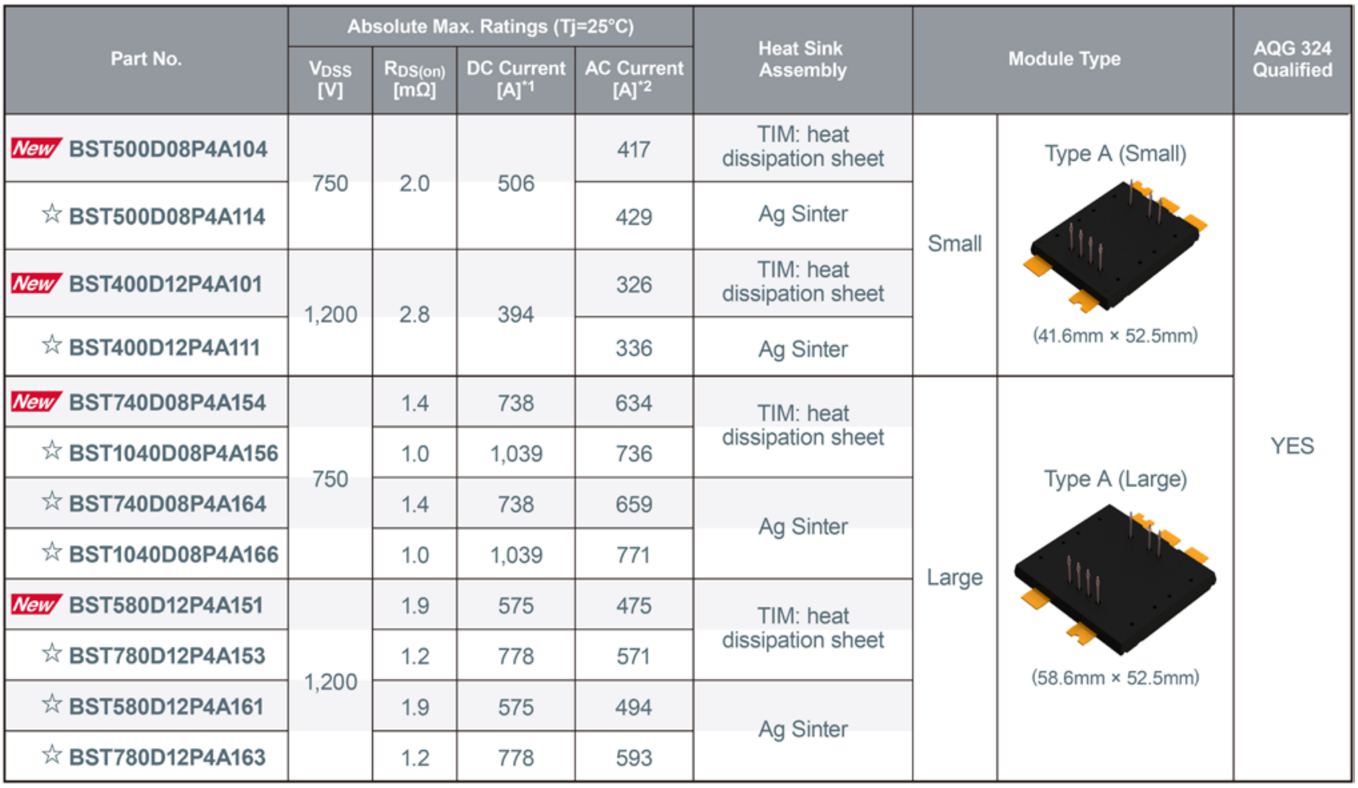
Figure 1: TRCDRIVE pack is a compact module offering high current density with heat dissipation on one side that has been developed for controlling traction inverters and is based on ROHM's proprietary module technology

The TRCDRIVE pack excels through its performance. A one-sided, highly thermally conductive housing ensures easy installation and a high current density. An optimised internal arrangement allows a very low inductance of just 5.7 nH to be achieved. This is made possible by a two-layer busbar structure, which maximises the current path. Thanks to a very low ON resistance ($R_{DS(on)}$), an industry leading current density of 19.1 Ampere/cm² can be achieved. The modules are available for voltages of 750 V and 1,200 V.

Offering power of up to 300 kW and outstanding power density, the module contributes to satisfying the most important requirements of traction inverters in terms of miniaturisation, greater efficiency and lower development costs. The modules have control signal terminals with press-fit pins, which facilitate easy connection by simply being plugged into the gate driver board from above.

Product range

TRCDRIVE pack will be integrated in a series of twelve models in various housing sizes (small / large) and mounting patterns (TIM: heat deflection plate / Ag sintering) by March 2025. In addition to this, ROHM is developing a 6-in-1 product with integrated heat sink. This facilitates a fast design process for drive inverters, as well as early market launch of models that are tailored to handle a large number of design specifications.



Part No.	Absolute Max. Ratings (Tj=25°C)				Heat Sink Assembly	Module Type		AQG 324 Qualified
	V_{DSS} [V]	$R_{DS(on)}$ [mΩ]	DC Current [A]*1	AC Current [A]*2				
New BST500D08P4A104	750	2.0	506	417	TIM: heat dissipation sheet	Small	Type A (Small) (41.6mm × 52.5mm)	YES
☆ BST500D08P4A114				429	Ag Sinter			
New BST400D12P4A101	1,200	2.8	394	326	TIM: heat dissipation sheet			
☆ BST400D12P4A111				336	Ag Sinter			
New BST740D08P4A154	750	1.4	738	634	TIM: heat dissipation sheet	Large	Type A (Large) (58.6mm × 52.5mm)	
☆ BST1040D08P4A156		1.0	1,039	736				
☆ BST740D08P4A164		1.4	738	659	Ag Sinter			
☆ BST1040D08P4A166		1.0	1,039	771				
New BST580D12P4A151	1,200	1.9	575	475	TIM: heat dissipation sheet			
☆ BST780D12P4A153		1.2	778	571				
☆ BST580D12P4A161		1.9	575	494	Ag Sinter			
☆ BST780D12P4A163		1.2	778	593				

☆ : Under Development

*1: T_c=60°C, V_{GS}=18V *2: T_f=65°C, V_{DC}=800V/500V, fsw=10kHz, Modulation=0.9, Power factor=0.9

AQG 324 is a qualification standard for automotive power modules established by ECPE (European Center for Power Electronics).
European automakers are required to comply with this standard when considering adoption.

Figure 2: TRCDRIVE pack product range

Comprehensive user support

ROHM offers extensive support at application level, including use of its in-house motor testing equipment. In addition to this, the company makes a large number of auxiliary materials available. These include simulations and thermal designs that facilitate rapid evaluation and introduction of TRCDRIVE pack products. Two evaluation kits are also available: one for double pulse tests and the other for 3-phase full bridge applications. These facilitate evaluation under similar conditions as practical inverter circuits.

The evaluation kit for double pulse tests comes with pre-welded, screw-retained external connections. This eliminates any need for additional welding of the terminals. No special capacitors are required, which in turn allows evaluations to be performed in various standard environments. The device driver board is supplied with 24 V as standard, while the maximum switching frequency is 20 kHz. The operating voltage is also independent of the withstand voltage of the respective capacitor/component.

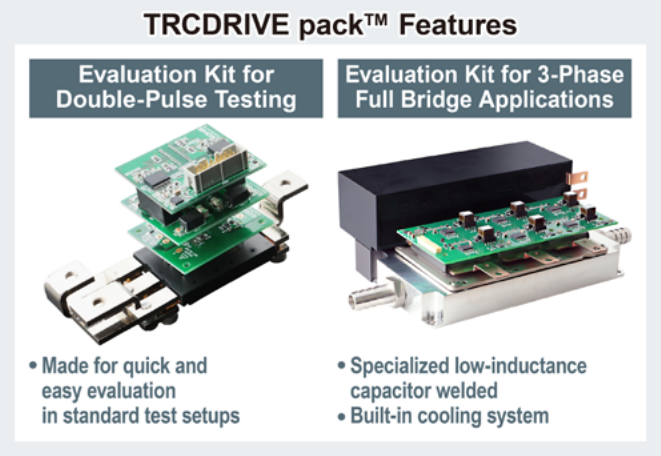


Figure 3: Two evaluation kits facilitate quick evaluation and introduction of TRCDRIVE pack products

The evaluation kit for 3-phase full bridge applications also comes with pre-welded, screw-retained external terminals, as well as pre-welded capacitors and an integrated cooling system. Further specifications include a gate driver board power supply (typically 24 V), a switching frequency of up to 20 kHz and an operating voltage of up to 900 V.

EcoSiC™ for greater efficiency and reliability

Although electric vehicles are generally considered sustainable, it is still important to ensure that the components used in the vehicles are also designed on a sustainable basis. As the world's first provider, starting mass production of SiC MOSFETs back in 2010, ROHM continues to enjoy a leading role in the development of SiC component technology. These components are marketed under the EcoSiC™ brand and cover an extensive range, including bare chips, as well as discreet components and modules.

EcoSiC stands for silicon carbide products with enhanced efficiency and reliability, particularly those used in high-performance applications such as electric vehicles, industrial equipment and systems for renewable energies. With the introduction of EcoSiC, ROHM is positioning itself as a provider of advanced and sustainable technologies that target higher switching frequencies, lower losses and environmentally friendly properties. The EcoSiC logo symbolises the connection between the ecosystem and technological excellence. It is part of the superordinate "Power Eco Family" concept, which aims to maximise the efficiency and compactness of electronic applications. Production of the EcoSiC modules is already being performed on a CO_2-neutral basis.

EcoSiC

Summary

With its TRCDRIVE pack range, ROHM has developed compact modules with heat dissipation on one side that offer a high current density. These modules have been optimised for xEV traction inverters and are based on ROHM's proprietary module technology. The modules make a valuable contribution to overcoming the most important challenges in terms of miniaturisation, greater efficiency and lower development costs. ROHM will also continue to expand its range of SiC MOSFETs in various housings and with even lower ON resistances. The objective here is to reduce power consumption in various devices and thereby make a contribution to achieving societal objectives such as environmental protection. TRCDRIVE pack™ and EcoSiC™ are brands or registered trademarks of ROHM Co., Ltd.

About the Author

Imane Fouaide started as Field Application Engineer at ROHM in 2019, taking care of automotive customers with a focus on SiC power devices in discrete and power modules. Since October 2023 she is responsible for application marketing of e-powertrain products to support European customers.

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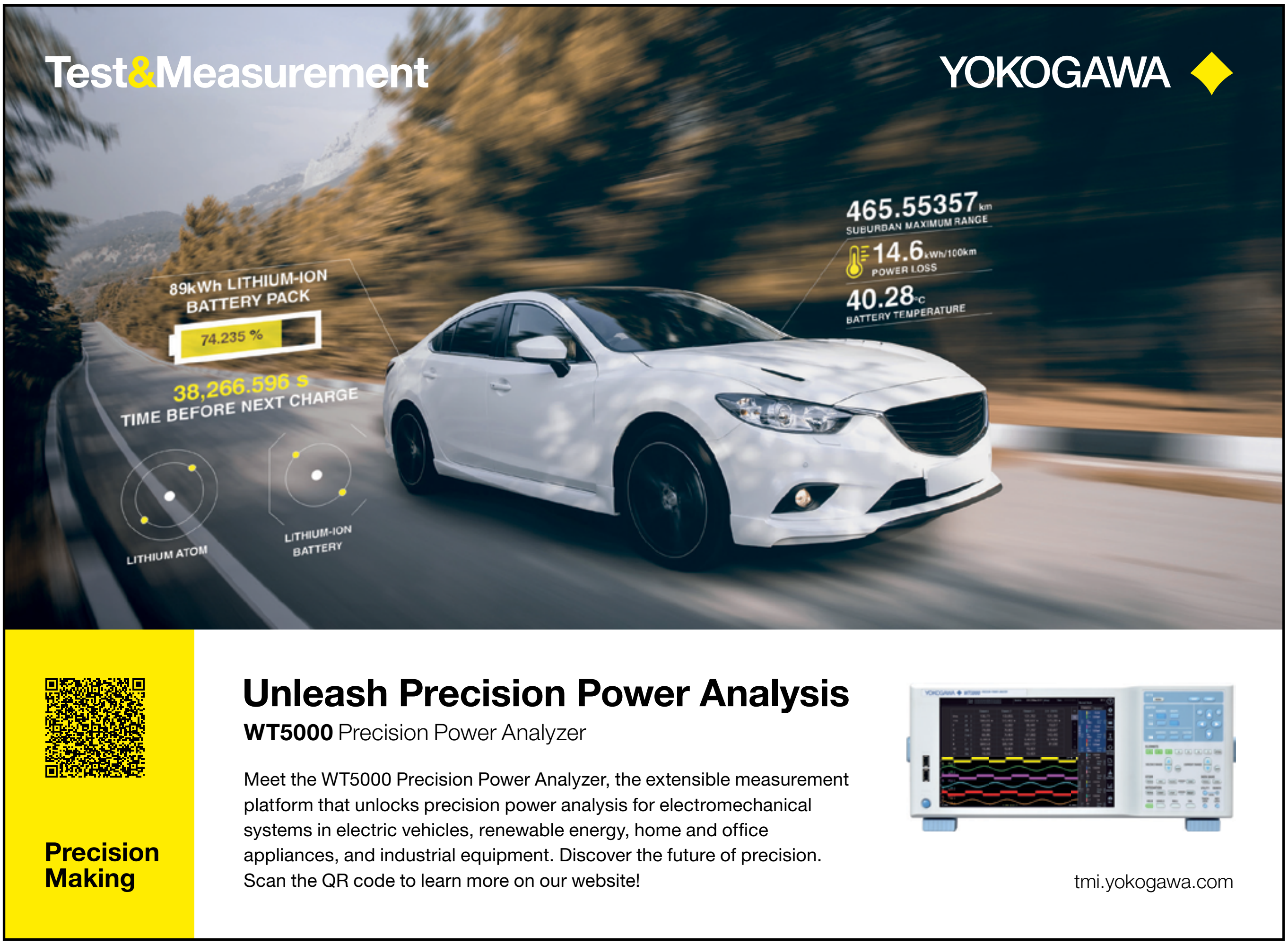

Mega-Watt-Level Power Stack Design with LV100 Package

Mitsubishi Electric introduces the reference design of power stack, assembled with 3-parallel IGBT modules (1.7kV/ 1200A) in LV100 package. The solution for 690 Vac / 1100 Vdc 2-level inverters systems in wind power application is designed by electrothermal simulation, and the experimental results support the effectiveness of the design methodology. The information in this article about the power stack and some design concepts may support power-device users.

By Zheng-Feng Li, Nobuya Nishida, Mitsubishi Electric Corporation, Fukuoka, Japan
Koichi Masuda, Nils Soltau, Mitsubishi Electric Europe B.V., Ratingen, Germany

Introduction

In recent years, demands for power semiconductors, key devices for contributing to realize a decarbonized society, have been rapidly expanding. The reason is that the path toward renewable energy grids involve significant integration of inverter-based resources (IBRs), which are composed with a huge number of small IBRs to adjust frequency and voltage for obtaining higher system performance [1]-[2]. Therefore, the significant growth of wind power (WP), photovoltaics (PV), hydrogen and energy storage system are expected [3]. The power rating of a large inverter for WP or central PV inverters could be somewhat below 10 MW approximately [4]. Wherein, the key manufactures design the utility-scale solutions using 1.5 MW to 2.5 MW with paralleled-connections to achieve the required output power. In order to reduce customers' developed workload, Mitsubishi Electric starts to provide data about a power stack, which is a single-phase inverter solution composed of 3 paralleled industrial IGBT modules in LV100 package.

The LV100 has a footprint of 100 mm × 140 mm. It has become popular for high-capacity inverter systems as shown in Figure 1. The stack design includes evaluation and selection of various other components. Moreover, current balancing, skin effect, temperature rising, as for example, needs to be considered. Moreover, to verify the electro-thermal design under different cooling condition, both of liquid and forced-air cooling could be suitable to the power stack with changing the heatsink. This paper introduces the performance and key thermal design information of the power stack, and its specification as listed in Table 1. Hence, the maximum current is designed to 1800A for 3-phase connection to achieve 2MW of output power, and the current imbalance ratio could also be controlled within 5%.

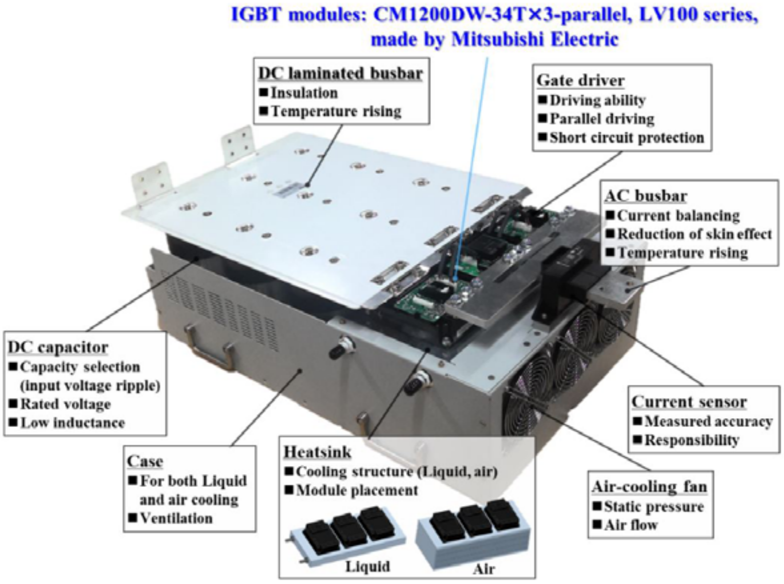

Figure 1: Illustrate of power stack and technical points.

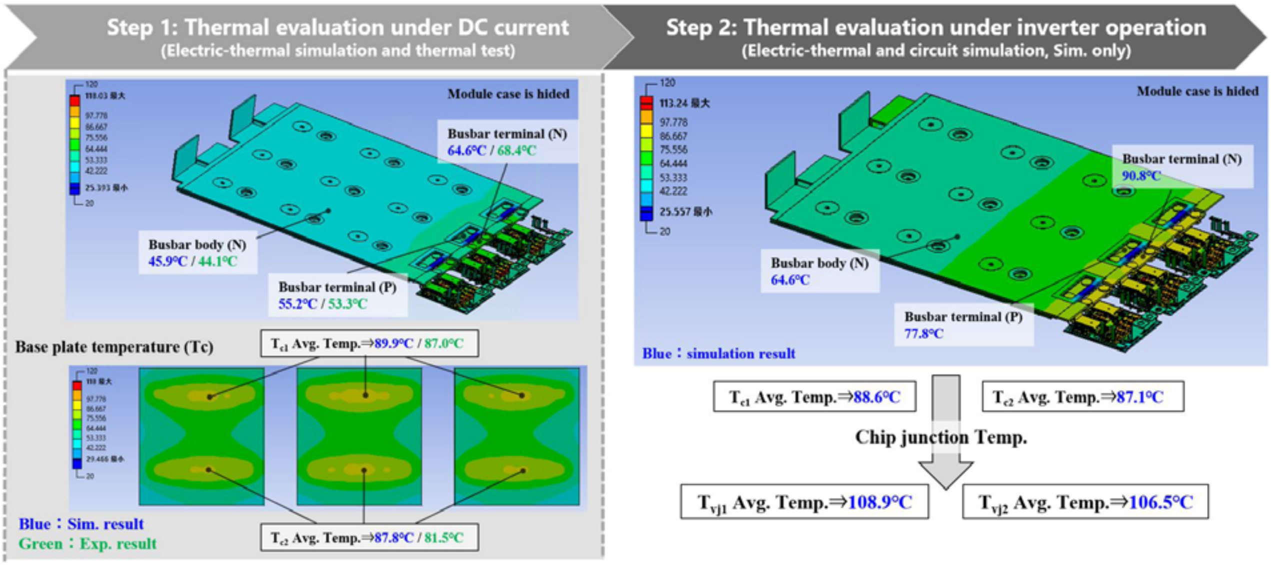

Figure 2: Thermal evaluation methodology of power stack.


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Design Methodology and Output Capacity of Power Stack

The proposed power stack is designed by electro-thermal co-simulation using computer-aided engineering (CAE) software: Q3D and Workbench, Ansys. There are two steps for evaluating the output capacity of power stack as shown in Figure 2, the ambient and water inlet temperature are set at 25°C, and heat generating of DC capacitors is not considered. In step 1, thermal evaluation has been done under 1800 A of DC current and temperatures at DC busbar and IGBT case ($T_{c,x}$) is measured. Wherein, the $T_{c,1}$ and $T_{c,2}$ represent baseplate temperature just under high- and low-side IGBT chip, respectively. Heat-transfer coefficient (HTC) for simulation was adjusted to meet with experimental results for achieving less than 10% error. In step 2, loss of DC busbar and IGBT modules was simulated considering space-vector pulse-width modulation (SVPWM) (by power loss calculator, Melcosim made by Mitsubishi Electric. Condition: V_{DC}=1100V, Modulation index=0.9, Power factor=0.95, 2.5kHz). Wherein, the thermal model is same to Step 1 and chip junction (T_{vj}) was calculated from thermal resistance and simulated T_c. Then the temperature distribution under inverter mode could be estimated.

Item	Specification
Topology	2 level
Size (L×W×H)	795×423×289 mm
Weight	About 65 kg
Output power	2 MW
DC Voltage	1100 V
Current	AC：1800 Arms @fs: 2.5kHz
Current imbalance ratio	Within 5%
Max. driving fs	2.8kHz

Table 1: Specification of power stack.

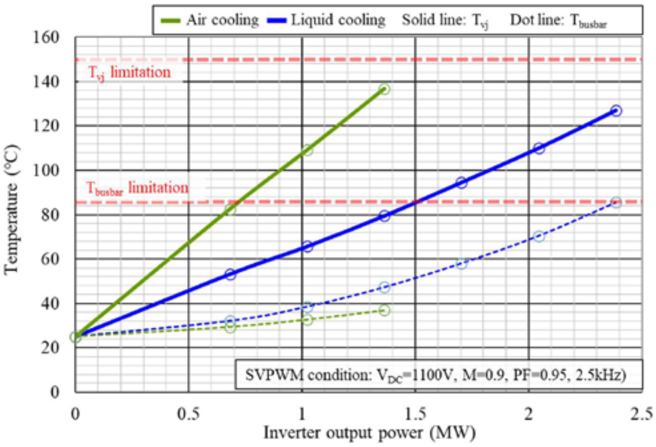


Figure 3: Relationship between T_{vj} and T_{busbar} under different output power and cooling method.

Figure 3 shows the estimated output power under inverter condition for air and liquid cooling by setting different conditions of generating loss and HTC, the solid and dot line represent the Tvj and busbar temperature Tbusbar, respectively. The output power of 2 MW could be achieved for liquid cooling. Air-forced cooling results in output power of 1.4 MW with gentle temperature rising of busbar.

Improvement of Stack Performance

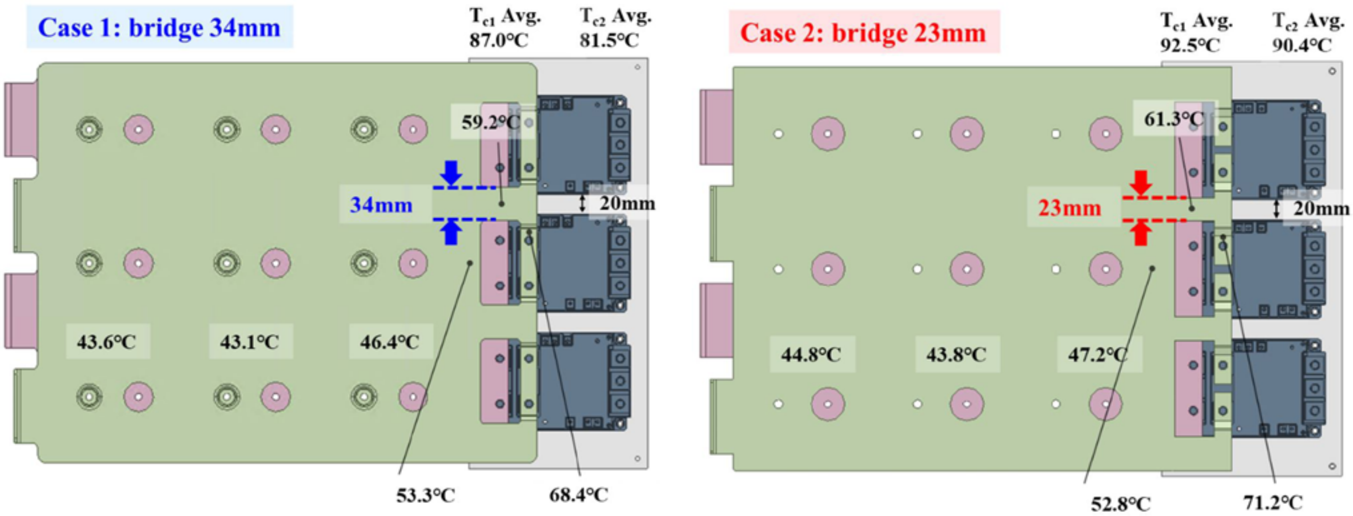
For MW-level power stack design, the power modules are usually used in paralleled connection while considering current balancing, driving synchronization, short circuit protection and temperature rising. Wherein, the design concept of current balancing is to equalize the impedance among parallel paths proposed in [5], this paper focuses on the temperature rise of components with explaining the heat dissipation under different design approach.

1) Bridge width effect of DC busbar:

Figure 4 shows experimental results of temperature distribution with different bridge width of DC busbar under 1800 A of DC current and 3 mm of layer thickness. In doing so, the 20 mm of pitch distance among paralleled IGBTs is fixed. Since IGBT modules dissipate heat via the heatsink and the DC busbar, a narrow bridge width causes higher IGBT temperature due to increase of thermal resistance.

2) Flow direction of forced-air cooling:

In the forced-air cooling, the flow direction affects significantly the system performance. Each IGBT module should receive equal air flow to achieve minimum temperature imbalance in parallel condition. Hence, the air-flow direction of the proposed power stack could be separated into two cases as shown in Figure 5. In the case 1, forced-air flows through the heatsink and gets heated up by the IGBTs. Afterwards, the warm air flows to the DC busbar and the capacitors. The front-side IGBT whose case temperature is the Tc2 receives maximum cooling flow, but the cooling of peripheral components and even the back-side IGBT whose case temperature is the Tc1 become worse due to higher ambient temperature. Whereas, air-flow direction of the case 2 would be better with considering system performance.



a) Bridge width=34mm

b) Bridge width=24mm

Figure 4: Temperature distribution under different bridge width.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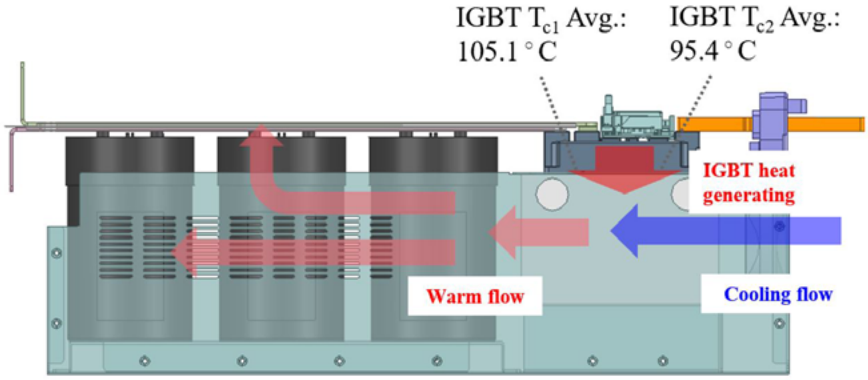
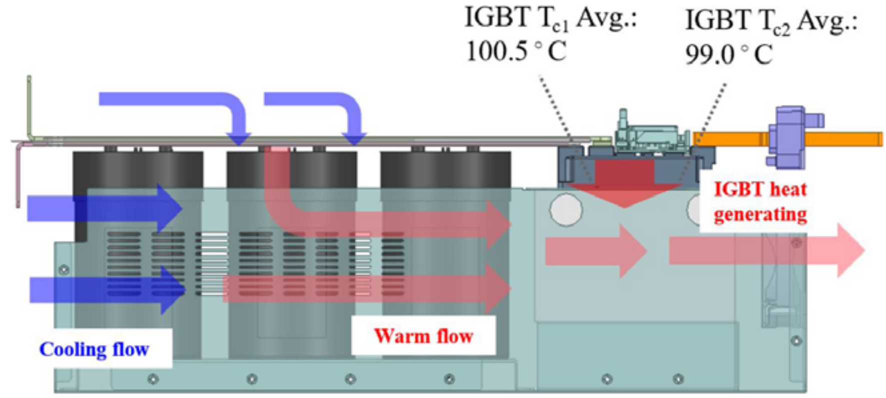


a) Case 1



b) Case 2

Figure 5: Different Air-flow direction for power stack. (Side view)

Conclusion

This study indicates influence factors on temperature rising: DC busbar and direction of air flow. The thermal management is a cross coupling issue. Hence, the design and selection of peripheral components should be optimized. The IGBT modules with LV100 package is a suitable solution for such a power stack due to its easy paralleling and low inductance. This reduces design difficulty for achieving better system performance on thermal management, current balancing and lower voltage spike. Especially, the symmetric chip layout simplifies the heatsink design and reduces the thermal cross coupling between IGBT modules. The line-up of LV100 package is shown in Table 2. LV100 for industrial application covers voltage ratings of 1200V, 1700V and 2000V. The package is based on the SLC packaging technology with a thermal cycle failure free packaging technology by matching thermal expansion coefficients [6]. A LV100 package for railway applications is available for 1700V and 3300V and uses MCB baseplate [7].

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Line-up		 **LV100 (Industrial)**				 **LV100 (Traction)**			 **HV100**	
Application		Renewable, Industrial				Traction, Power transmission				
Footprint		100mm×140mm×40mm								
V_{isol}		**4kVrms**				**6kVrms**			**10kVrms**	
Rated Voltage		1.2 kV	1.7 kV	2.0kV	2.5kV 1)	1.7 kV	3.3 kV		3.3 kV	4.5kV
Rated Current	**Si**	800A 1200A 1800A 1)	800A 1200A	1200A	1200A 1)	1200A	450A 600A		450A 600A	450A
	Hybrid SiC	-	-			-	600A		-	-
	Full SiC		-			-	750A 375A 185A	800A 2) 400A 2) 200A 2)	-	-

1) Under development
2) SBD-embedded

Table 2: Line-up of IGBT module with LV100 package.

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Designing Robust Power Electronics with SiC in Extreme Thermal Conditions

Staying Cool While Getting Hot

High power densities lead to high operating temperatures, but what does this mean for SiC MOSFETs in terms of critical parameters like $V_{GS(th)}$, $R_{DS(on)}$, I_{DSS} or I_{GSS}? This story provides some guidelines regarding these critical parameters at temperatures up to 175 °C.

By Abdus Sattar, PhD, Nexperia

Achieving maximum power density is an increasingly important requirement for applications like DC/DC power converters, onboard chargers (OBC) in electric vehicles (EV), industrial motor drives, solar inverters, and traction inverters. This requirement increases system operating temperatures, necessitating the use of components that can function safely at temperatures up to 175 °C. Devices based on wide bandgap materials like silicon carbide (SiC) meet this requirement and are increasingly popular in such applications. However, at elevated temperatures, even SiC MOSFETs exhibit complex behavior that can be attributed to subtle variations in critical parameters like $V_{GS(th)}$ (gate threshold voltage), $R_{DS(on)}$ (on-resistance), I_{DSS} (drain-source leakage current), and I_{GSS} (gate-source leakage current). These variations, if not carefully accounted for, can cause power electronics systems to fail unexpectedly. Manufacturer's device datasheets typically do not contain information detailing the interdependence of these various parameters, especially at higher operating temperatures. This article addresses this deficiency by providing guidelines on using these critical parameters when designing a SiC-based DC/DC power converter required to operate at temperatures up to 175 °C.

Using the SiC Advantage

SiC MOSFETs offer significant advantages over traditional Silicon MOSFETs and Insulated Gate Bipolar Transistors (IGBTs) in high voltage and temperature, making them ideal for automotive, renewable energy, and industrial applications [4].

Engineers usually test their devices in application conditions and try to push the performance boundaries of the device to get maximum performance, keeping all the derating factors; the thermal design is one such boundary.

Nexperia comprehensively tests the performance parameters of its devices by using industry-standard test methods. Figure 1(a) is one such setup of double pulse setup used to test the device parameters such as RDSON, $V_{GS(th)}$, I_{GSS}, and I_{DSS}, and evaluates switching performance.

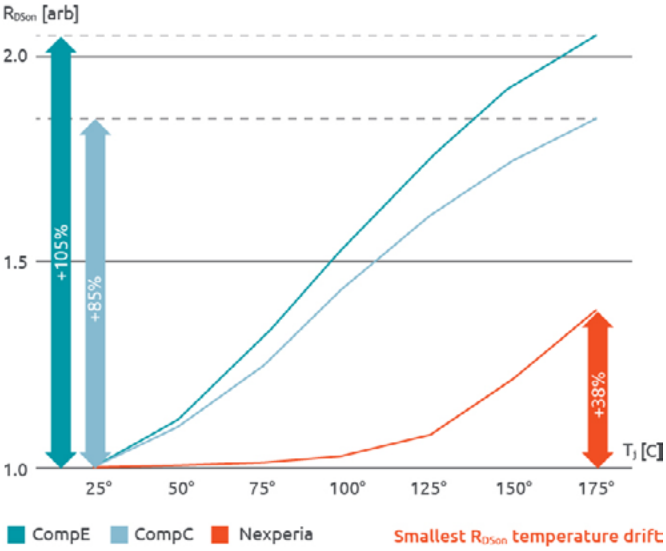
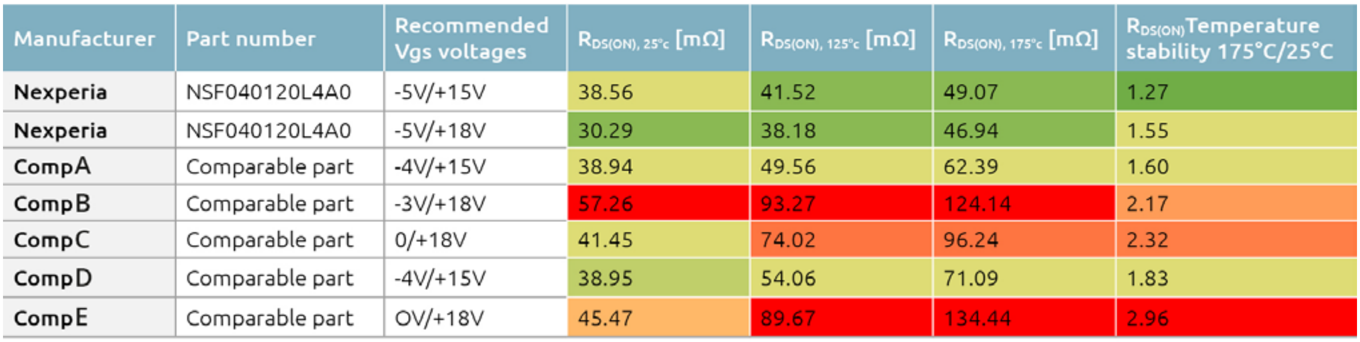


Figure 1: $R_{DS(on)}$ comparison with competitors.

IV curves are generated using Keysight 505 Power Analyzer. To push the converter operation at a high temperature, the first parameter to consider for design is the $R_{DS(on)}$ of the device. The below section will compare Nexperia devices with regards to a few competitors and variations of $R_{DS(on)}$ parameters within its tight control manufacturing process to show the superior $R_{DS(on)}$ stability of Nexperia devices. Figure 1 shows the variation of $R_{DS(on)}$ with regarding to temperature and compares it with industry competitors to understand the variation. The red line, representing the Nexperia component, shows a 38% increase in $R_{DS(on)}$, while the blue lines, corresponding to competitors C and E, indicate increases of over 180% and 210%, respectively. An increase in $R_{DS(on)}$



Manufacturer	Part number	Recommended Vgs voltages	$R_{DS(ON), 25°c}$ [mΩ]	$R_{DS(ON), 125°c}$ [mΩ]	$R_{DS(ON), 175°c}$ [mΩ]	$R_{DS(ON)}$ Temperature stability 175°C/25°C
Nexperia	NSF040120L4A0	-5V/+15V	38.56	41.52	49.07	1.27
Nexperia	NSF040120L4A0	-5V/+18V	30.29	38.18	46.94	1.55
CompA	Comparable part	-4V/+15V	38.94	49.56	62.39	1.60
CompB	Comparable part	-3V/+18V	57.26	93.27	124.14	2.17
CompC	Comparable part	0/+18V	41.45	74.02	96.24	2.32
CompD	Comparable part	-4V/+15V	38.95	54.06	71.09	1.83
CompE	Comparable part	OV/+18V	45.47	89.67	134.44	2.96

Note: The test condition used for RDSON measurements are IDS=40 A, recommended positive Vgs

Table 1: Measured $R_{DS(on)}$ drift versus junction temperature variations

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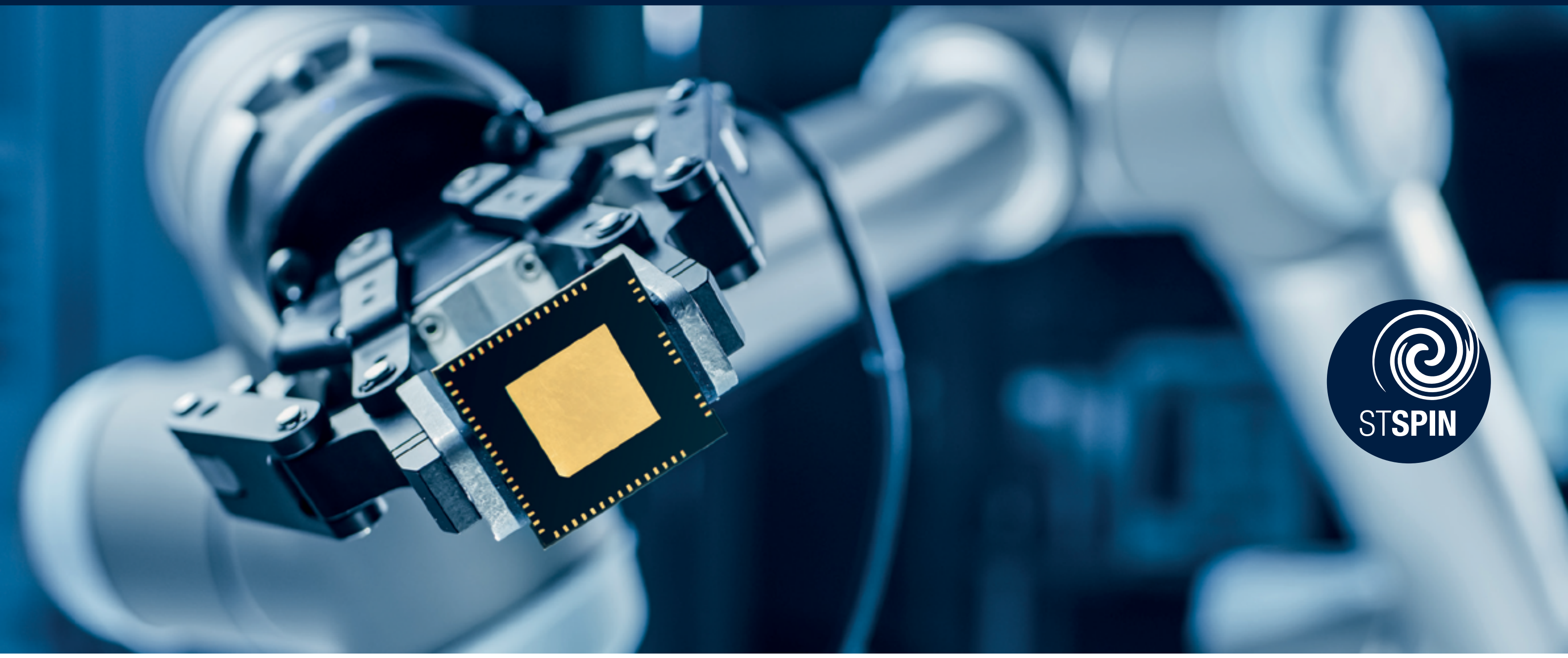

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directly correlates with higher conduction power loss, as expressed by the following equation,

$P_{Conduction\ Loss} = I^2 \times R_{DS(on)}$ (1)

If $R_{DS(on)}$ doubles, the conduction losses also double, resulting in greater heat generation within the device, potentially driving the device closer to its thermal limits and heightening the risk of failure [5].

Table 1 shows the $R_{DS(on)}$ experimental measurement results of several 1200 V, 40 mΩ SiC MOSFETs including Nexperia and five competitors (Comp A-E). The data reveals that Nexperia's 40 mΩ SiC MOSFET demonstrates the most stable $R_{DS(on)}$ performance across a temperature range from 25 °C to 175 °C, with increases of 1.27 and 1.55 times—lower than those of its top five competitors [6].

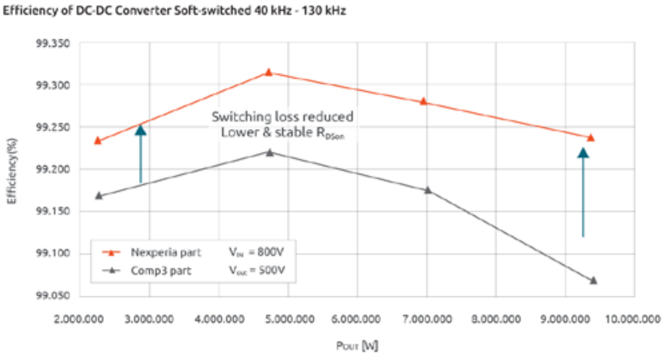

Figure 2: Efficiency comparison between Nexperia and competitor.

From a practical perspective, significant increases in R_{DSON} at elevated temperatures can greatly affect a system's power loss and efficiency, as shown in Figure 2, efficiency measurement at high temperature, thereby impacting its overall reliability. This $R_{DS(on)}$ stability underscores the superiority of Nexperia's components in maintaining higher efficiency under demanding conditions [6].

Figure 3 (a) illustrates $R_{DS(on)}$ behavior across temperatures, with the x-axis showing $R_{DS(on)}$ in milliohms and the y-axis indicating the percentage change from the 2nd to the 98th percentile. Tests were conducted on 25 DUTs at V_{GS} = 15 V, covering temperatures from -55 °C to 175 °C. Each line represents a specific temperature, highlighting $R_{DS(on)}$ variability. At higher temperatures, $R_{DS(on)}$ stability improves, with standard deviations around 1.20 mΩ from 125 °C to 175 °C, ensuring consistent performance under thermal stress, reducing power loss risks. This high temperature $R_{DS(on)}$ stability contribute to improved power efficiency shown in Figure 2.

The second parameter of interest is $V_{GS(th)}$. A tight control of this parameter translates into static and dynamic current sharing between different devices. Figure 3(b) offers a detailed visualization of $V_{GS(th)}$ behavior across a wide temperature range (-55 °C to 175 °C), with the x-axis representing $V_{GS(th)}$ values in millivolts and the y-axis depicting the percentage change in $V_{GS(th)}$ from the 2nd to the 98th percentile. Each colored line in the graph corresponds to a specific temperature result, clearly comparing how $R_{DS(on)}$ varies with temperature. The average value and standard deviation are labeled as Av and S. The more stable threshold voltage was found at 175 °C test with the lowest standard deviation, S= 56.26 mV. The highest variation in $V_{GS(th)}$ happened at -55 oC with standard deviation, S= 85.78 mV [8, 9]. More detailed explanation will be given in the full paper. Figure 4(a) and (b) show the ongoing testing of I_{DSS} and I_{GSS} with 75 DUTs and the notable differences of test data between the lower temperatures (-55 °C, 25 °C and up to 125 °C) and higher temperatures (150 °C or 175 °C) due to the temperature dependence of the leakage currents. At temperatures up to 150°C tests, I_{DSS} values are very low <200 nA among 72 samples and at 175 °C, I_{DSS} values are between 400 nA and 800 nA which are within device ratings. Similarly, I_{GSS} test data at 175 °C are <10 nA which are within device ratings [9[.

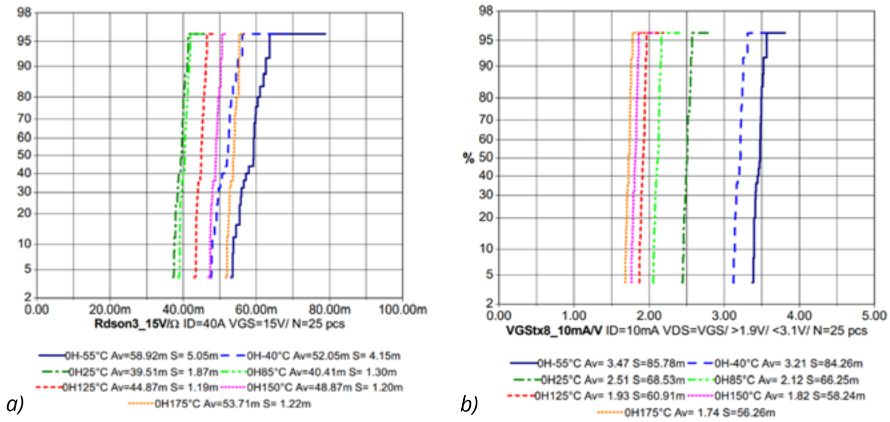

Figure 3: (a) R_{DSON} measurement and (b) $V_{GS(th)}$ measurement at -55 °C and 175 °C.

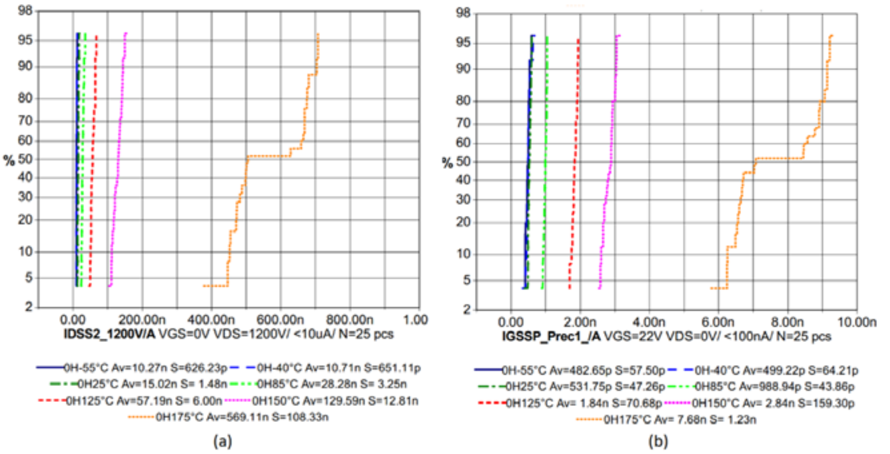

Figure 4: (a) I_{DSS} measurement and (b) I_{GSS} measurement from -55 °C to 175 °C.

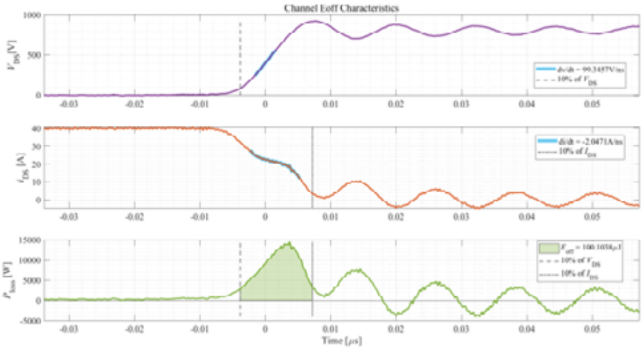

Figure 5: DPT Turn-on and turn-off transitions of Nexperia's devices.

Analyzing the dynamic switching behavior is crucial for evaluating the performance of the devices at 175 °C. To achieve this, the same devices listed in Table 1 were tested using a double pulse configuration, with their respective recommended gate-to-source voltage levels and external gate resistances (RGext) as specified in the datasheets. Figure 5 presents typical turn-on and turn-off waveforms for Nexperia's 40 mΩ device.

Conclusions and Future Work

At elevated temperature, mainly 150 °C or 175 °C, Nexperia's 1200 V SiC MOSFETs demonstrate $R_{DS(on)}$ stability, low variations in $V_{GS(th)}$, I_{GSS}, and I_{DSS}, lower switching losses and higher efficiency in the DC/DC converter shown in Figure 2. This consistency is particularly beneficial in demanding applications such as electric vehicle traction inverters, aerospace power systems, power grids, industrial motor drives, and other high-temperature scenarios where performance stability is paramount.

Ongoing testing for 17, 30, 60, and 80 mΩ, 1200 V SiC MOSFETs includes static characteristics, dynamic switching and DC/DC converter testing to show efficiency improvement at 175 °C. The goal is to build a comprehensive static and dynamic performance dataset. This analysis will guide further optimization of these devices, making them suited for high-temperature applications where consistent performance, power efficiency, and reliability are paramount.

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Next-Gen Bipolar Modules: Thermally Advanced and Sustainable Design

Bipolar modules remain a robust and cost-effective solution for industrial line-frequency applications. While the basic operation of such circuits has not changed, the packaging technology in the power modules continues to improve.

By Paul Drexhage, Sr. Technical Marketing Manager, Semikron Danfoss

Since it's invention in 1975, the SEMIPACK isolated baseplate rectifier module has grown into an extensive product line covering a wide range of currents and topologies. It has become the standard in 50/60Hz rectifiers and AC controllers and is widespread in markets such as motor drives, UPS systems, and process control.

The SEMIPACK product line (Figure 1) now covers six different housings containing diodes and/or thyristors with nominal currents ratings from 60A (SEMIPACK 1) to beyond 1300A (SEMIPACK 6). These modules are configured for uncontrolled (diode/diode), half controlled (thyristor/diode), and fully controlled (thyristor/thyristor) rectification. Thyristor/thyristor modules are also easily configurable for AC control (anti-parallel connection). Construction of these modules varies across the range. Lower power modules have wire-bonded and soldered connections and larger types have a pressure construction similar to capsule devices.

Each of the six housing sizes has gone through individual revisions. The original type, SEMIPACK 1, has gone through five generational changes to maintain its position as the market leader. Now, the 6th generation, SEMIPACK 1.6, is available with the full range of current ratings. This brings the highest performance and current capability to all bipolar applications.

Module Construction

The SEMIPACK 1 module utilizes the well-established construction of lead frame, chip-on-substrate, and baseplate. The use of a copper baseplate in these 20mm-wide modules improves thermal spreading as well as providing a robust mounting surface across different heatsink types. For the 6th generation SEMIPACK 1, the internal construction has been changed. These changes improve thermal performance and reduce materials, significantly improving the cost/performance ratio.

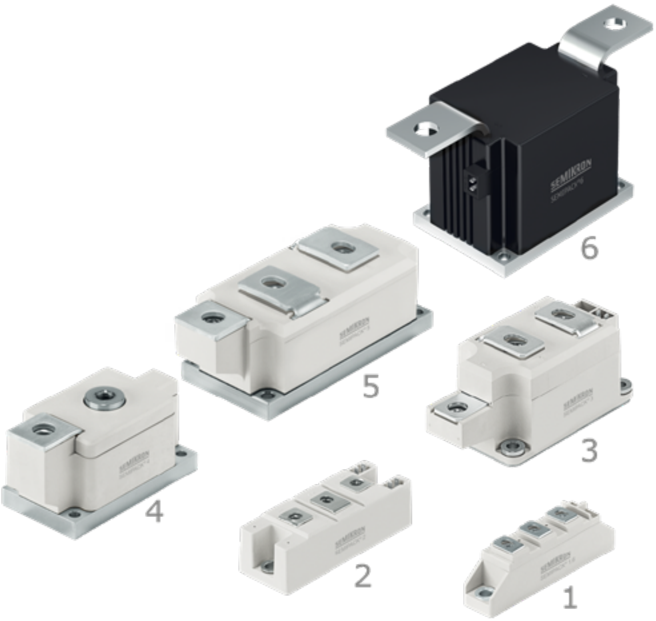


Figure 1: SEMIPACK Family

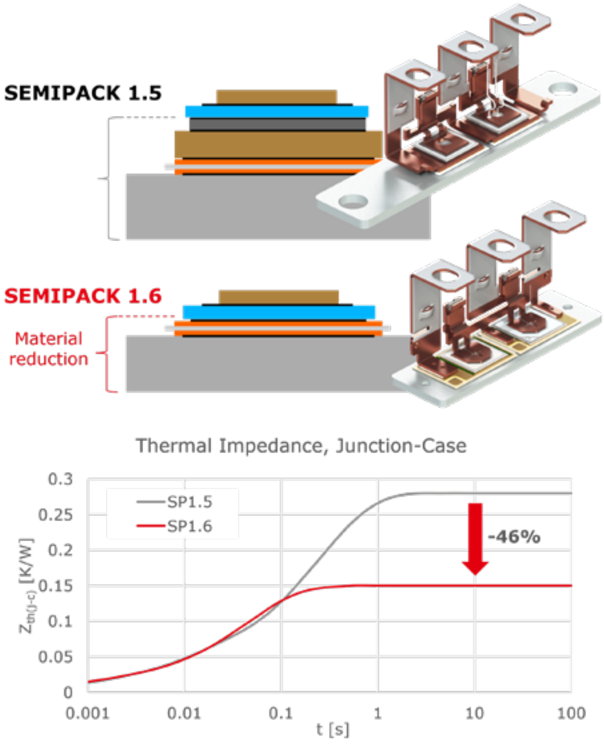
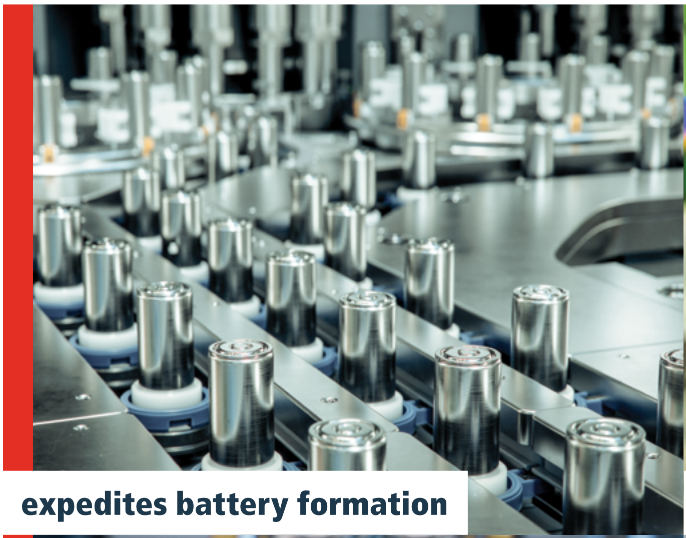


Figure 2: Comparison of internal construction

First, the material stack-up beneath the bipolar semiconductor chip has been drastically simplified (Figure 2, top). This greatly reduces the thermal resistance from chip to baseplate ($R_{th(j-c)}$). The SEMIPACK 1.6 exhibits a 46% reduction in steady state thermal resistance from semiconductor junction to case over the previous generation (Figure 2, bottom).

Second, the baseplate in the SEMIPACK 1.6 has been reduced in size. Obviously, this conserves valuable copper, with a total weight reduction of the module from 95g to 75g (-18%). But in previous SEMIPACK generations, this baseplate also had screw holes and provided mounting pressure to hold the module to the heatsink. This required a complex bend in the baseplate to ensure uniform contact to the heatsink after mounting. In the "hybrid" design of the SEMIPACK 1.6, the reinforced plastic housing encases the baseplate and provides mounting pressure. This allows for much simpler baseplate geometry to greatly increase effective contact area to the heatsink underneath the chips. The improved metal-to-metal contact area between baseplate and heatsink

High density power conversion



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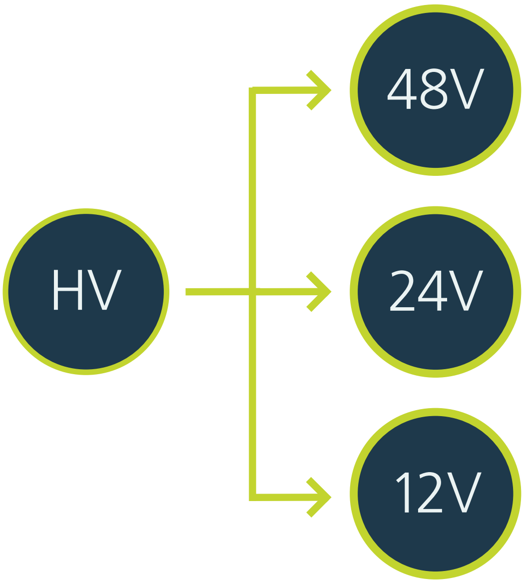
withstands the rigors of recycling

using fixed-ratio converters



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also means less thermal interface material is required. The SEMIPACK 1.6 reduces the overall case-to-sink thermal resistance, $R_{th(c-s)}$, by 35% (Figure 3) over the previous generation, with a typical value of 0.09K/W.

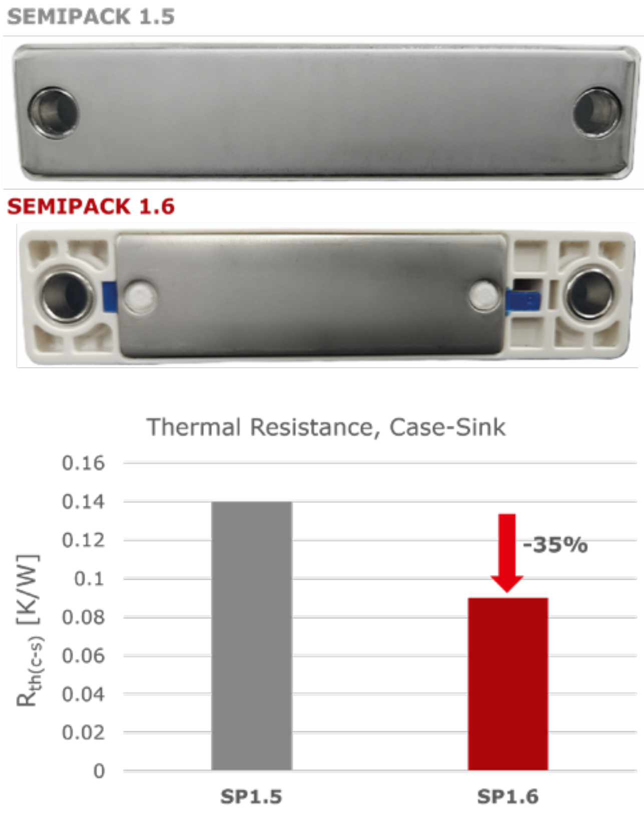

Figure 3: Comparison of external construction

Despite these changes to the construction, the external dimensions, mounting locations, and electrical terminals all remain the same as in previous SEMIPACK 1 generations. This means that existing mechanical designs can benefit from higher performance. As an industry standard package, the SEMIPACK can also replace outdated rectifiers in the same footprint.

Application Performance

The improved thermal performance of the 6th generation is clear when looking at the resulting semiconductor junction temperature during operation in a typical electrical circuit. One of the most common industrial circuits is the line-fed, 3-phase bridge rectifier. This is easily constructed with three SEMIPACK 1 modules on a single heatsink. The input to the bridge is typical line voltage (e.g. 400VAC, 50Hz), with the DC output being filtered to provide current to a typical load (e.g. inverter). Such a circuit can be easily simulated using the online SemiSel simulation tool, accessible through the Semikron Danfoss website. This free-to-use tool includes models of all the SEMIPACK types and quickly gives the semiconductor junction temperature for a given set of conditions. For this example, the previously described three SEMIPACK modules on a heatsink are forced-air cooled with 45°C inlet air. If it is assumed that the inverter on the output of the rectifier is driving a motor, then it is typical to consider a 3s, 180% overload as well.

With these conditions in mind, the dual-diode (SKKD) SEMIPACKs of the 5th and 6th generations can be compared (Figure 4). Each 5th generation SEMIPACK 1 is first simulated with the rectifier bridge output current that results in the junction temperature reaching the recommended operating limit during an overload condition. As is common for design across the industry, this recommended operating temperature limit is 10°C below the maximum junction temperature listed on the datasheet.

For example, the SKKD 81 (5th generation) nearly reaches the recommended operating limit (115°C) when the output current of the 3-phase rectifier is 207A_{DC} (3s overload condition). However, under the same operating conditions and output current, the equivalent 6th generation device (SKKD 95) only reaches a junction temperature of 103°C. Furthermore, the release of the 6th generation of SEMIPACK has given the opportunity to qualify the devices to a maximum junction temperature, $T_{j,max}$, of 130°C. This represents a 5°C increase over nearly all the devices in the 5th generation. With the previously mentioned 10°C operating margin applied, this means that 6th generation devices are capable of operating continuously up to 120°C.

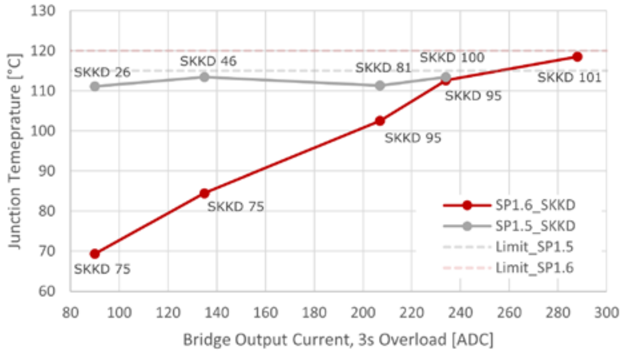

Figure 4: SEMIPACK 1.5 vs. 1.6 (diode/diode configuration)

Portfolio

The new SEMIPACK 1.6 portfolio (Figure 5) covers the existing current range of the 5th generation while expanding the upper current limit. The improved design allows for an I_{FAV} = 143A at T_c = 85°C for the dual-diode equipped packages. In the case of the thyristor-equipped packages (SKKH and SKKT), the current rating of I_{TAV} = 145A at T_c = 85°C is the highest current rating on the market for 20mm packages. The surge current capability is also best in class, with I_{TSM} = 2210A @ T_j = 130°C.

Given the widespread use of 400/480V networks, all SEMIPACK 1.6 are equipped with a reverse blocking voltage of 1600V. However, 1800V devices will also be offered.

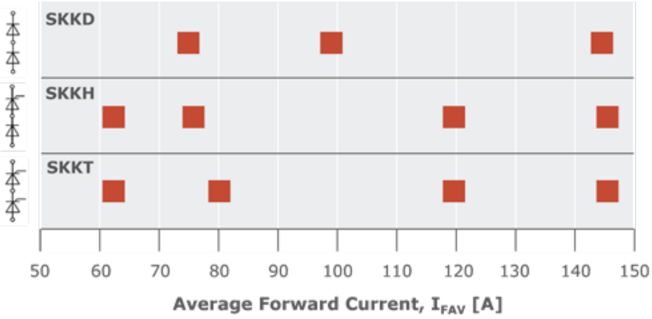

Figure 5: SEMIPACK 1.6 Portfolio

Summary

The 6th generation SEMIPACK 1 continues the tradition of innovation started with the original isolated power semiconductor module. By utilizing less materials, the SEMIPACK 1.6 contributes to efforts to improve sustainability in the electronics industry, while simultaneously improving thermal performance. With each new SEMIPACK generation the cost/performance ratio improves, ensuring that it remains the rectifier module of choice for all industrial applications.

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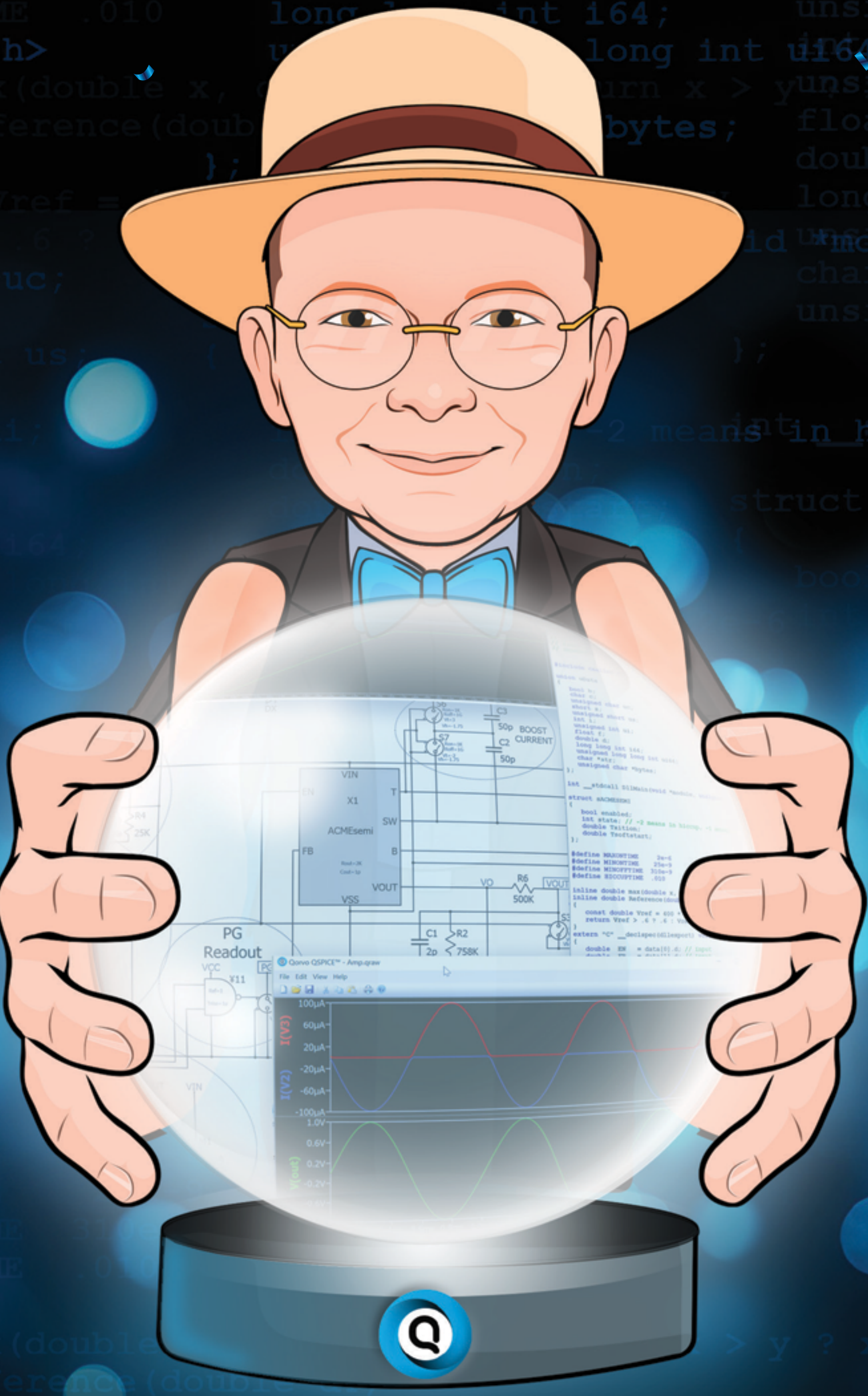

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VSS
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R2
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50p
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Readout

Monitoring System for Current Collector Devices

Real Time Insight to Shoe vs. Third Rail Intimate Contact

Electrical systems specialist, Mersen has developed a monitoring system adapted for current collector devices used in subway and metro systems.

By Simon Landrivon, Marketing Communications Manager, Mersen

The third rail is just as essential for subways and metros as the overhead wire is for long-distance and high-speed trains: both supply electrified trains with electricity. Running along the railroad line, the third rail carries the current while the current collector collects it when sliding along the power rail. The current drawn is transferred to the rail vehicle by a collector shoe usually made of copper impregnated graphite. Two rugged coil springs fitted on the current collector ensure constant contact of the shoe against the power rail.

This physical contact paired with a voltage of 750 V, the often-considerable speed of the trains, and places of unevenness on the third rail contact surface are all factors responsible for the significant wear sustained by the collector shoes fitted on every train.

“The shoes are generally replaced every six to twelve months. However, Mersen’s shoes do last longer”, explains Mersen Sales Manager François Trama. Nevertheless, the shoe represents 70 percent of the total cost of ownership of the entire current collector device (CCD) during its lifespan.

The new Digital Current Collector Device (D-CCD) from Mersen will improve the comprehension of the CCD’s performance on duty

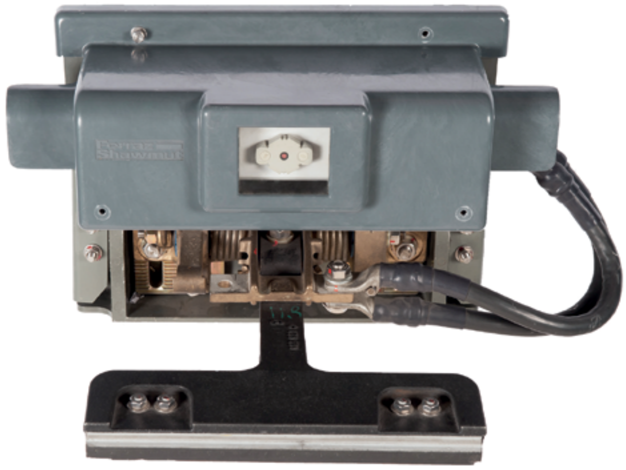
Boosting efficiency and sustainability

“After investing nearly four years of hard work, our project team has now devised a solution that will dramatically improve the comprehension of the CCD’s performance on duty”, declares Mechatronic Engineer Bilal Naim. Mersen’s solution to the problem is the D-CCD, the Digital Current Collector Device. This device is used for realtime monitoring of the contact force between the shoe and the power rail.

The clearly visible portion of the D-CCD is a black box, which is attached to the arm of the current collector and houses the so-called MAT, the Module Acquisition & Transmission. The MAT is composed of the readings recorder (strain gauge and temperature sensor) and of an electronic system that is in charge of processing the signals, storing the data and providing the wireless communication. The measured variables are

- the temperature rise in the current collector (if one collector of the car is off),
- the force applied on the third rail by the shoe (N),
- the shocks and vibrations applied to the current collector during its course and
- Optical sensors.

The optical sensors serve as arc detection where one can detect the peak of lights generated by arcs taking place at the shoe vs. power rail contact.



The Digital Current Collector Device allows realtime monitoring of the contact force between the shoe and the power rail

All these data serves as indicators for the condition of the collector shoe, the collector overall and indirectly of the third rail. “This information allows us to find out if the shoe is still operational or will have to be replaced shortly. It gives a clear insight of the quality of the third rail”, reveals R&D Department Manager Olivier Dosda.

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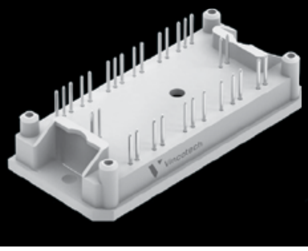

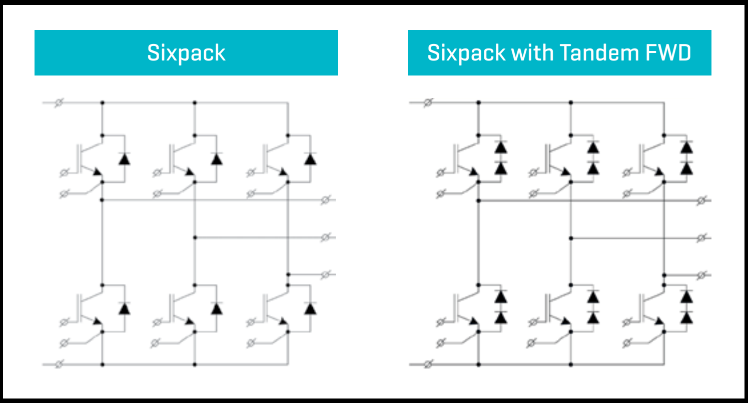

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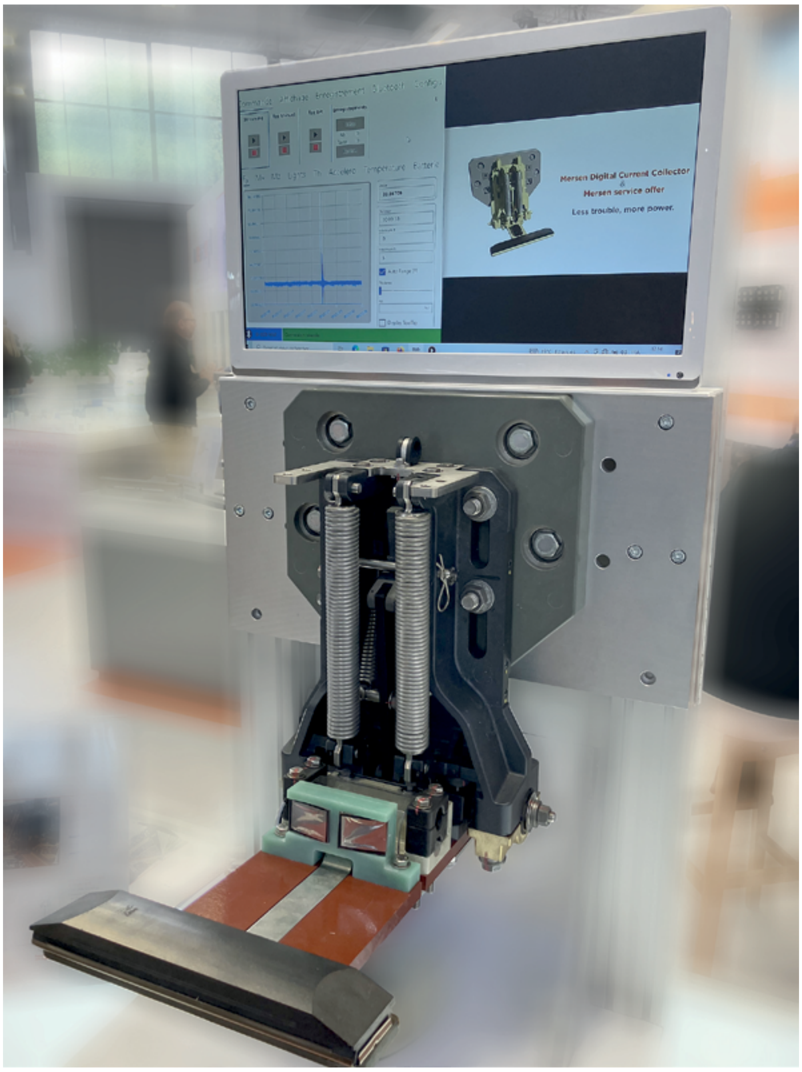
Challenges during development

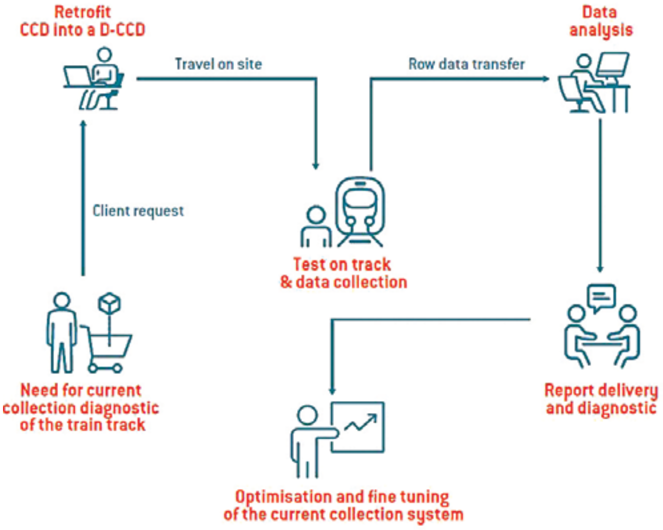
The development of the measuring technology for the MAT posed a tremendous challenge to Mersen's engineers. "The goal to measure the contact force with the greatest possible accuracy required us to be as close to the contact point as possible, but the voltage of 750 V also made it necessary to provide for dependable insulation", explains Olivier Dosda. "Two objectives hard to combine." Similarly challenging was the development of an electronic module capable of working reliably in a difficult environment marked by high voltage, high level of shocks and vibrations, and electromagnetic effects.

The solution developed by the engineering team features a specially designed strain gauge technology using thick-film strain gauges. Patented in 2018, this advanced technology detects deformations in the current collector arm during operation. Thanks to its electrical isolation properties, it can be safely applied to electrified current collectors, allowing precise characterization of impacts occurring between the current collector shoe and the electrified third rail during operation.

The MAT module is battery-powered and designed with its own data storage. "These properties make it a stand-alone unit without any connection nor interference with the train, which was of great importance to us", underlines Olivier Dosda. Its power supply and data capacity are enough for one day of operation. Customers who wish to test-drive the system for a day and check the condition of their power rail / current collectors can be accommodated by Mersen with a workable solution that can easily be integrated into Mersen current collectors via plug-and-play.



The D-CCD in a live monitoring simulation



Mersen service offer for preventive maintenance and reduced total owner cost

Analyzing wear behavior

Those interested in monitoring their current collectors continuously will require to connect the train network to the MAT via an ethernet cable and a 24 V supply voltage. This interface that the MAT calculator provides will transfer the data directly to the train system and extend the real time measurement as long as it needs to.

"This long-term monitoring feature in particular is what creates the best prerequisites for analyzing the wear behavior of the current collectors and for drawing the appropriate conclusions", states Olivier Dosda. "We aim to eventually arrive at predictive maintenance including plannable maintenance intervals, which will allow our customers to operate their trains with improved reliability and reduces total cost of ownership." And as far as the benefits for themselves are concerned, Mersen is hoping that the data collected by the D-CCDs will help them optimize the design of their current collectors.

High-efficiency solution

As a global expert in electrical energy and advanced materials in high-tech industries, Mersen ranks among the world's leading suppliers of current collectors for use in subways and metros. "With the D-CCD, we are now offering our customers an exceedingly appealing high-efficiency solution that will give them an insight of what is going on between the 3rd rail and the carbon shoe which is the stepstone towards shoe life extension."

Mersen unveiled the Digital Current Collector Device in September 2024 at InnoTrans in Berlin, where it managed to "electrify" the visitors of the world's leading trade fair for transport technology. It was also met with great interest at a roadshow through Southeast Asia. This is also the region that placed the first customer order. A manufacturer from Korea will build the D-CCD into trains operating in the service of the Singapore subway system. "The wait for the first feedback from use in the real world is keeping us at the edge of our seats", announces Olivier Dosda.

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Pathways to SiC Perfection

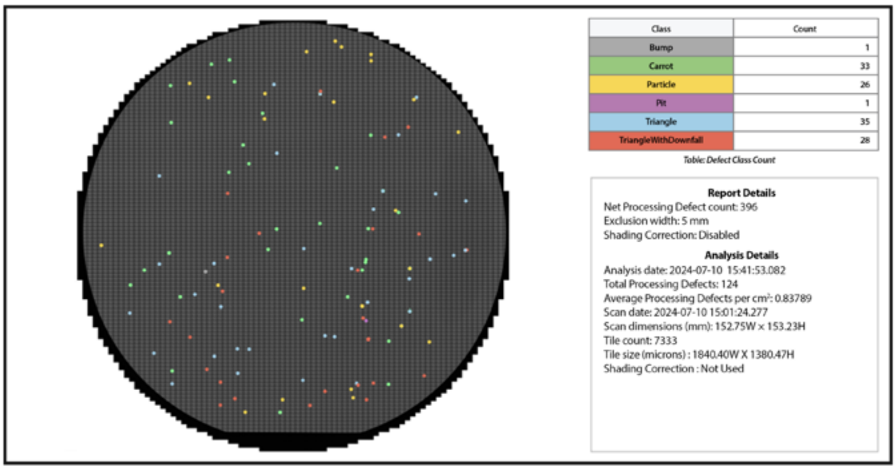
How improvements to SiC wafering and epitaxy are delivering affordable high-efficiency power semiconductors

From renewable energy to electric mobility, silicon carbide (SiC) power semiconductors have become critical to the pursuit of sustainability through electrification.
While the technology delivers a valuable efficiency advantage over silicon alternatives, SiC components remain relatively expensive due to manufacturing challenges. Overcoming these holds the key to producing commercially viable components.

By Tony Witt, Device Scientist, and Timothy Han, President, SemiQ Inc.

Growing SiC Crystals
Silicon carbide has a complex crystal structure with many different polytypes. It displays extreme hardness - two properties not well suited to fabricating precision electronic components with sub-micron feature sizes. While silicon ingots for wafer production can be produced routinely with close-to-perfect results, a SiC ingot, or boule, typically contains several types of defects resulting from imperfect growth.

Figure 1 shows the results of defective site analysis on a wafer of suitable quality for high-yield diode production.



Class	Count
Bump	1
Carrot	33
Particle	26
Pit	1
Triangle	35
TriangleWithDownfall	28

Table: Defect Class Count

Report Details
Net Processing Defect count: 396
Exclusion width: 5 mm
Shading Correction: Disabled

Analysis Details
Analysis date: 2024-07-10 15:41:53.082
Total Processing Defects: 124
Average Processing Defects per cm^2: 0.83789
Scan date: 2024-07-10 15:01:24.277
Scan dimensions (mm): 152.75W × 153.23H
Tile count: 7333
Tile size (microns) : 1840.40W X 1380.47H
Shading Correction : Not Used

Figure 1: Defective site analysis of SiC wafer.

Among the most severe defects, basal plane dislocations (BPD) caused by misalignment of atoms can introduce strains that affect the overall integrity of the crystal lattice. On the other hand, defects such as screw dislocations (SD) form around an axis and can produce visible defects in the surface after epitaxy. Improving control over crystal-growth conditions, as well as applying post-growth treatments, can help to mitigate SD.

Carrot defects, conical or carrot-shaped inclusions in the SiC crystal, happen when screw dislocations intersect the surface of the crystal during growth, providing a channel for impurities to be incorporated into the crystal, causing carrot-shaped inclusions. There can also be hollow core dislocations, referred to as micropipes. Other potential causes of defects include irregular crystal stacking, missing atoms, extra atoms, and grain boundaries that can extend through the crystal lattice.

Wafering and Epitaxy Challenges
After the boule is grown, wafers are cut by sawing with diamond-encrusted wire saws and then ground and polished. These processes are time-consuming and expensive due to SiC's extreme hardness, yet some defects inevitably remain in and below the substrate surface. When epitaxy is applied, these imperfections can impede layer growth leading to step bunching, effectively slowing the formation of steps and causing interference and unwanted changes in the step height. Imperfections below the crystal surface affect device parameters such as the body diode characteristics and the interface quality with gate oxide.

In addition, local site flatness is much more difficult to achieve after grinding and polishing than ordinary silicon. However, a flat surface is critical for device fabrication to permit proper focusing of the lithography equipment and thus achieve accurate device dimensions, directly affecting the electrical parameters.

The stepper tries to focus on the center of each site. Because the depth of field of the lithographic equipment is relatively shallow, wafer shape variation means the image can be less sharply focused in some places. Subsequently, the reactor causes variations in epitaxial doping and thickness, resulting in a spread of device parameters. The breakdown voltage (BVDSS) of SiC MOSFETs is known to be particularly strongly affected (figure 2). Severe defects at some sites on any given wafer may produce some dies that cannot function at all.

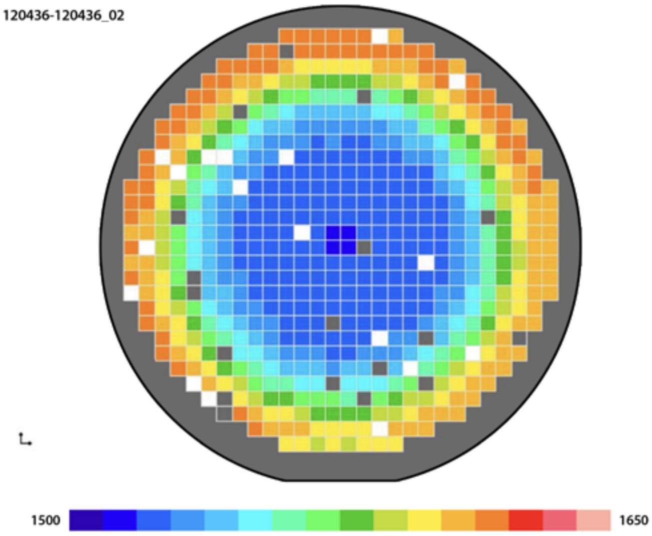


Figure 2: Measured BVDSS of MOSFETs fabricated at different sites across the wafer surface, showing radial variation due to epitaxial doping and thickness.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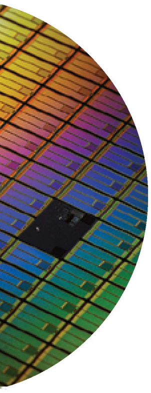

Defining Wafer Quality

The extent of imperfections in a wafer significantly affects the number of good dies the wafer will yield. More imperfections imply a lower yield that effectively drives up the per-unit component price. On the other hand, setting a high specification can raise the price of bare wafers.

When arranging the supply of SiC epiwafers, chip makers must specify the acceptable level of imperfections. The industry has had to learn how to establish workable specifications, enabling suppliers to deliver suitable quality cost-effectively while allowing device manufacturers to produce enough functional dies to remain commercially viable.

Epiwafer suppliers provide a certificate of analysis (CofA) that confirms conformance with the agreed specification. As understanding of the issues has grown, device manufacturers have requested epiwafer suppliers to provide more information in the CofA.

Early in SiC's history, suppliers and device makers focused on only a few wafer parameters. Historically, for example, only the total count of defects on the wafer surface has been monitored. It is now common for the CofA to specify the percentage of sites that must be defect-free, with specific limits on defects of serious concern, such as BPD. The percentage of sites that have zero BPD defects is most important in wafers intended for MOSFET production.

Surface flatness, also, was typically stated for the entire wafer. Experience has shown that device manufacturers need assurances about flatness in more localized areas across the wafer surface. Accordingly, local site flatness has become a typically requested parameter.

Figure 3 shows a sample of parameters from a typical SiC epiwafer CofA. In this list, local site flatness is expressed as the SBIR, or (S)ite (B)ackside (I)deal Focal Plane (R)ange. Considering the surface topology as a set of peaks and troughs above and below the center point of the site, SBIR is the sum of the highest peak height and the lowest trough depth. Although an SBIR value of 2µm has been considered adequate, 1.2µm is a more acceptable range to minimize flatness deviation as a cause of defects in fabricated devices.

Processes and Equipment

Increasing knowledge of the types of defects in epiwafers, their causes, and their effects on component quality and performance has driven improvements in the processes and equipment available for wafer production.

SiC's extreme hardness presents challenges from the earliest stages of wafering. Cutting discs or diamond-encrusted wire saws used to cut wafers from the boule face a high risk of breakage. Laser cutting allows more substrates to be wafered from the expensive boule and will likely be preferred shortly. Also, laser dicing can narrow the wasted "street" between adjacent dies and increase the die per wafer.

In addition, work is ongoing to minimize so-called edge exclusion and allow processes to be applied closer to the wafer edge. Better data about the material characteristics within 4-6mm of the wafer edge can help to increase utilization of this area to produce more usable dies and lower the per-unit device cost.

Commercialization is also driving improvements in reactor design. Multi-wafer reactors become more economical as volume demand rises. On the other hand, processing a single wafer provides greater flexibility to perfect the setup. In addition, advancements in photolithographic motion control permit smaller step sizes that minimize and reduce instances of defects. The typical step size now is about 25% of the size in previous equipment generations.

Moreover, the depth of field is typically greater, allowing extra tolerance for surface flatness. Sites with larger SBIR can now yield devices with parameters that are within the acceptable range. Improvements that optimize the dopant vapor flow and wafer movement in the reactor also minimize the differences in device properties produced at different sites on the wafer by ensuring more uniform epitaxial doping and thickness.

In addition, best practices are adapting, such as regular reactor cleaning. As particles accumulate on the reactor's internal components and mechanisms, removing these prevents downfall that can otherwise produce faults of various shapes and sizes in the wafer surface.

Conclusion

SiC is a far more challenging substrate than silicon at every stage of component manufacture, from ingot or boule production, through wafering, epitaxy, lithography, and dicing. Understanding and overcoming these challenges has defined the technology's journey from research projects to today's commercial position. The technical justifications for adopting SiC in high-efficiency converters and drives are clear. The economic argument is becoming more persuasive with each improvement in production processes, equipment, and practice.

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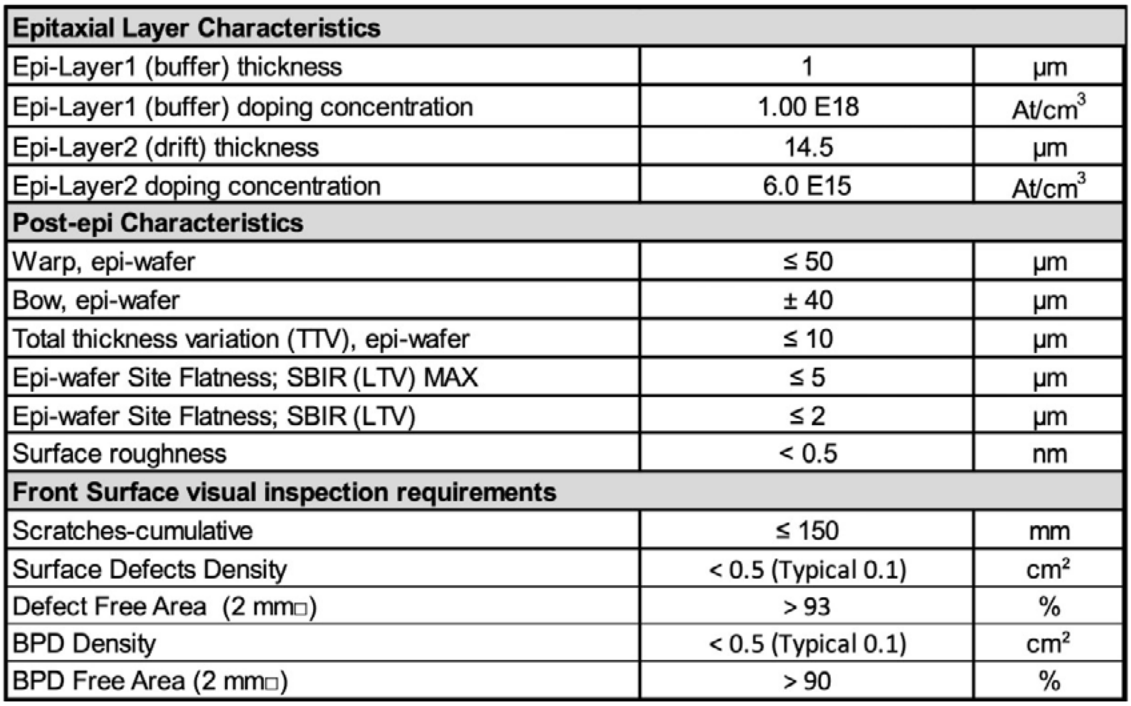
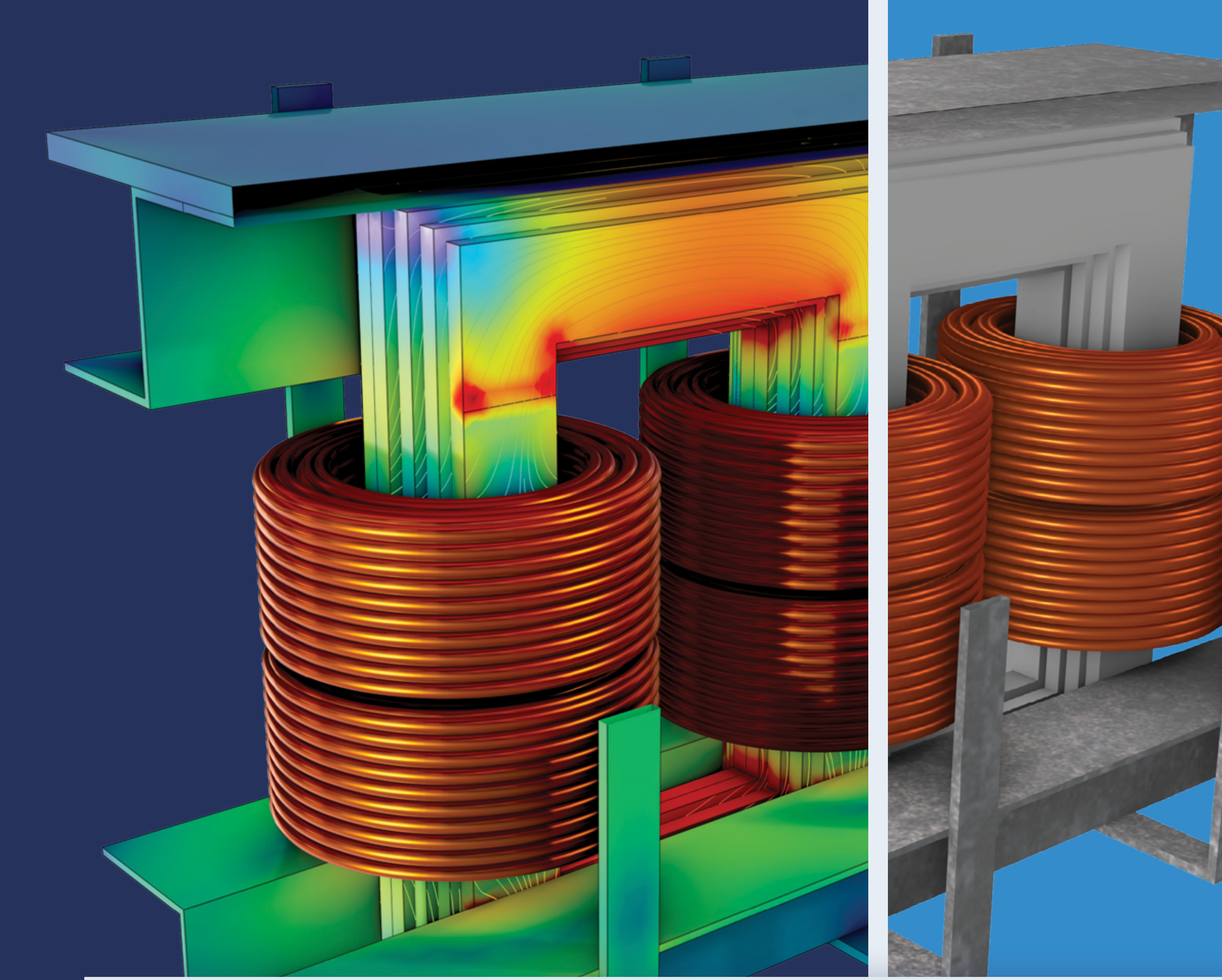


Epitaxial Layer Characteristics		
Epi-Layer1 (buffer) thickness	1	µm
Epi-Layer1 (buffer) doping concentration	1.00 E18	At/cm^3
Epi-Layer2 (drift) thickness	14.5	µm
Epi-Layer2 doping concentration	6.0 E15	At/cm^3
Post-epi Characteristics		
Warp, epi-wafer	≤ 50	µm
Bow, epi-wafer	± 40	µm
Total thickness variation (TTV), epi-wafer	≤ 10	µm
Epi-wafer Site Flatness; SBIR (LTV) MAX	≤ 5	µm
Epi-wafer Site Flatness; SBIR (LTV)	≤ 2	µm
Surface roughness	< 0.5	nm
Front Surface visual inspection requirements		
Scratches-cumulative	≤ 150	mm
Surface Defects Density	< 0.5 (Typical 0.1)	cm^2
Defect Free Area (2 mm□)	> 93	%
BPD Density	< 0.5 (Typical 0.1)	cm^2
BPD Free Area (2 mm□)	> 90	%

Figure 3: Key parameters specified in the CofA.



A Switch-Mode Power Supply Quiet Enough to Directly Power Noise-Sensitive Devices

Historically, switch-mode power supplies (SMPS) have been too noisy for noise-sensitive A/D converters, requiring a separate LDO regulator. Recent advancements in SMPS technology, have reduced EMI emissions and output ripple voltage. This allows for a single SMPS device with noise suppression techniques to be placed near noise-sensitive devices without affecting the ADC's signal-to-noise ratio (SNR).

By Adam Huff, Senior Design Engineer, and George (Zhijun) Qian, Senior Design Manager, Analog Devices

Have you ever experienced unexpected output from an ADC with slight variations and random changes? This is likely caused by noise within the ADC system. One common source of noise is the supply rail of a voltage-controlled oscillator (VCO). The noise on this rail can introduce jitter to the clock signal, which is then used as the sampling clock for the ADC. If the jitter is significant, it can lead to conversion errors and unexpected data from the ADC.

SMPS are known for their inherent noise due to the switching required for voltage conversion. If an SMPS is used for the clock's supply rail, it can introduce noise into the ADC system. To minimize errors, LDO regulators with noise suppression capabilities are typically used to power noise-sensitive devices.

Technologies such as Analog Devices' LTM8080 buck regulator SMPS integrate post regulation dual LDO regulators with noise suppression technologies. This SMPS device can provide a clean supply rail similar to the standalone LT3045 LDO regulator.

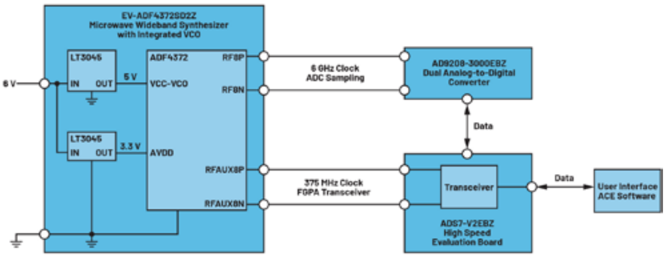


Figure 1: Basic block diagram of a VCO/ADC setup.

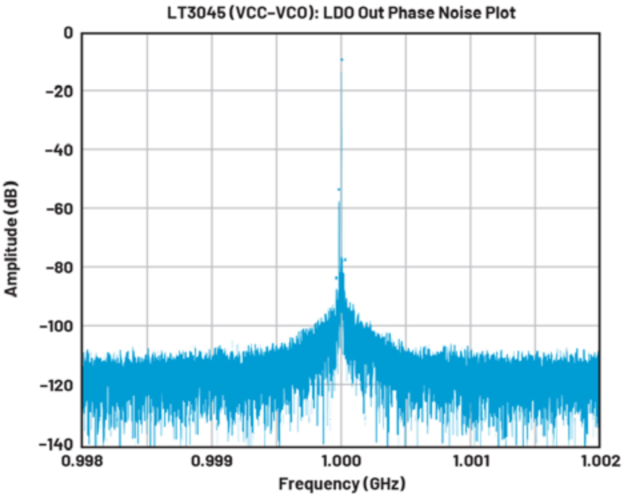


Figure 2: Phase noise plot of the baseline LT3045 (1 GHz with 2 MHz span).

Why Does Supply Rail Noise Matter?
Supply rail noise is a crucial factor that can significantly impact the performance of a system. In Figure 1, the LT3045 LDO regulator is utilized as a clean supply rail to power the VCO of the ADF4372 synthesizer. The ADF4372 then generates clock signals for the AD9208 ADC and FPGA boards. Figure 2 presents a phase noise plot obtained from the output of the LT3045 LDO regulator, serving as a reference for comparing alternative supply rail solutions.

If a noisy supply rail is employed instead of the baseline design, Figure 3 demonstrates an example of a suboptimal noise spectral plot, with slightly elevated sidebands. When these sidebands reach a certain level, they can introduce jitter to the rising edge of the ADC's sampling clock (Figure 4). Consequently, the ADC samples the analog input signal at unexpected time points, leading to unexpected data words with bit errors.

The occurrence of bit errors can have tangible consequences, particularly if they are significant. Deviations between the actual data word from the ADC and the expected data word can trigger unexpected behavior in the system. For instance, if the data word indicates a higher input voltage than the actual voltage, it could prematurely activate a device before the system is ready. In safety-critical applications, this unexpected state could disable safety features.

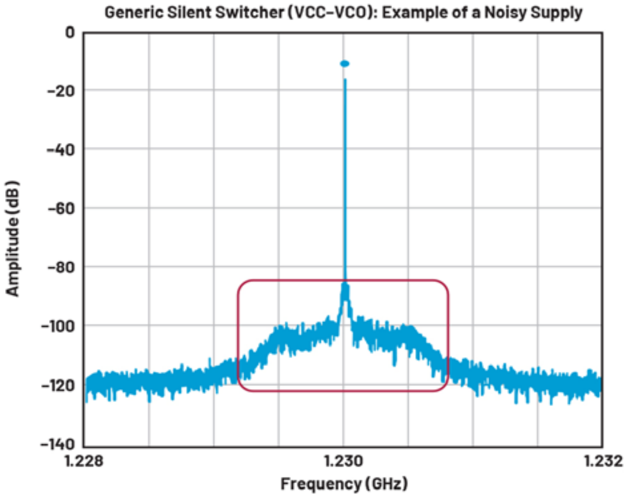


Figure 3: Example phase noise plot of a noisy SMPS (1.23 GHz with 2 MHz span).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With the advent of the EMI noise shield technology specifically, an SMPS can now be placed within close proximity to an LDO regulator without coupling switching noise to the output of the LDO regulator. If the SMPS and LDO regulator are packaged together, additional benefits beyond reduced noise can be achieved. See Table 1.

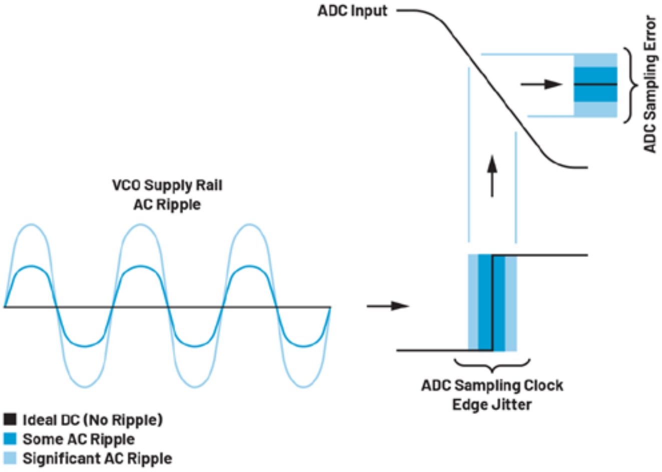


Figure 4: A noisy VCO supply rail to ADC sampling clock edge jitter (VCO output) to ADC sampling error.

Design Feature	SMPS + LDO Regulator	LDO Regulator
Input supply flexibility	Wide input range (3.5 V to 40 V) Standard input voltage rails	Narrow input range Unique input voltage rails
PCB layout simplicity	Noise-sensitive routing is internal to the device Only basic PCB routing techniques are required Device can be placed near other noise-sensitive devices	Specific routing required to minimize noise More advanced PCB routing techniques are required
PCB space saving	Direct voltage conversion from a 12 V/24 V rail to an LDO regulator output voltage No need for uncommon intermediate bus voltages	May require an additional regulator to convert a 12 V/24 V rail to a specific intermediate bus voltage
Design simplicity	Design has been fully tested and optimized User can plug-and-play	More upfront design/testing required to minimize noise
Potential system efficiency improvement	Less parasitic losses Optimized LDO regulator headroom The buck regulator portion could power additional external LDO regulators directly	

Table 1: SMPS + LDO Regulator Benefits over Standalone LDO Regulator

A device that combines a switching buck converter (SMPS) with an LDO regulator offers several advantages. It can be powered from standard rails like 12 V or 24 V, providing input supply flexibility. Additionally, an intermediate bus can be designed to maintain a specific voltage above the LDO regulator's output, even when the device is powered from higher voltages. This voltage input-to-output control (VIOC) feature ensures a set headroom for the LDO regulator by controlling the output of the upstream SMPS. VIOC is crucial for maximizing efficiency while maintaining power supply rejection ratio (PSRR).

The SMPS plus the LDO regulator device enables noise-sensitive routing within its internal circuitry. Therefore, basic routing techniques at the PCB level are sufficient to optimize the device's noise performance.

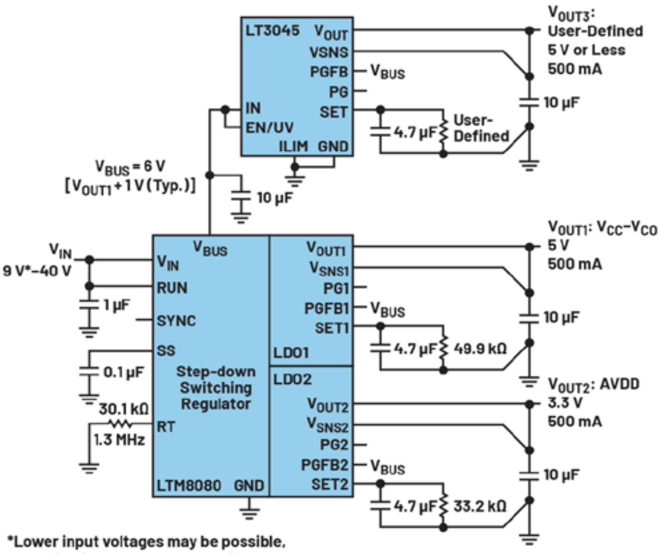
Furthermore, the device benefits from a fully integrated EMI noise shield. Instead of allowing the on-board SMPS' noise emissions to radiate in all directions, an EMI noise shield redirects the radiated noise emissions away from the LDO regulator. This technique allows the placement of the switching regulator in close proximity to the LDO regulator without compromising the noise suppression capability of the LDO regulator. As a result, the fully integrated device can be placed in areas that were previously considered unsuitable for an SMPS due to noise concerns.

If the SMPS portion of the device can deliver more current than the LDO regulator's rating, multiple LDO regulators can be integrated into the package. Additionally, an external LDO regulator can be connected to the intermediate bus, providing further flexibility in the user's design.

To ensure compliance with the specifications mentioned in the device's data sheet, the manufacturer conducts thorough testing on the fully integrated SMPS plus the LDO regulator device. This guarantees that the device meets the specified requirements.

A Switching Buck Converter as Quiet as an LDO Regulator

The LTM8080 offers greater input supply voltage flexibility, while minimizing power loss when compared to a baseline LDO regulator solution. Figure 5 illustrates an example solution using the LTM8080 and demonstrates its design flexibility. The LTM8080, along with the copackaged buck regulator and LDO regulators, incorporates an EMI noise shield that redirects radiated noise



*Lower input voltages may be possible, but switching pulses may be skipped or frequency may be reduced.

Figure 5: An LTM8080 solution replaces the two LT3045 LDO regulators on the ADF4372SD2Z evaluation board plus allows an optional user-defined third LDO regulator output for greater system flexibility.

When comparing the noise suppression capabilities of the LTM8080 and the LT3045, the measurements show nearly identical results. Table 2 provides a comparison of the SNR and Figure 6 displays the phase noise plot. Therefore, the LTM8080 can be used as a replacement for the LT3045 while still minimizing bit errors and ensuring effective noise suppression.

Conclusion

Test results clearly demonstrate that an SMPS device, equipped with advanced noise suppression technology such as the EMI noise shield, can effectively replace an LDO regulator in powering noise-sensitive supply rails. Although the proof of concept focused on a VCO supply rail, the design flexibility offered by an integrated SMPS plus LDO regulator solution can benefit numerous other noise-sensitive applications as well.

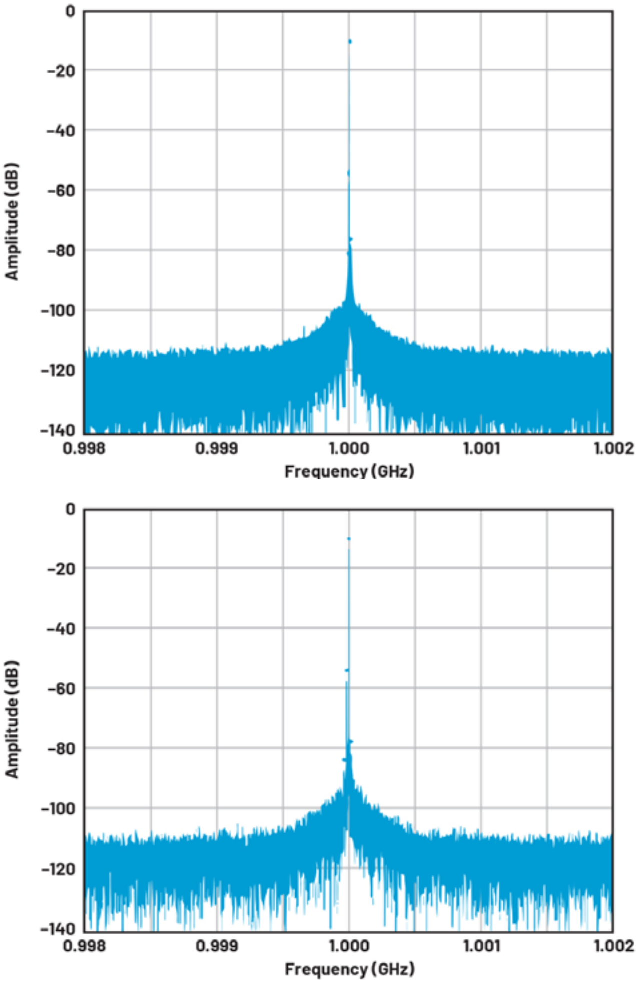


Figure 6: Phase noise plots of LTM8080 (top) vs. LT3045 (bottom).

ADF4372: 5 V PLL Clock Supply	SNR: AD9208
LT3045 (Baseline)	53.6 dBFS
LTM8080	53.6 dBFS

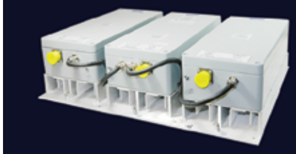
Table 2: SNR Comparison: LTM8080 vs. LT3045

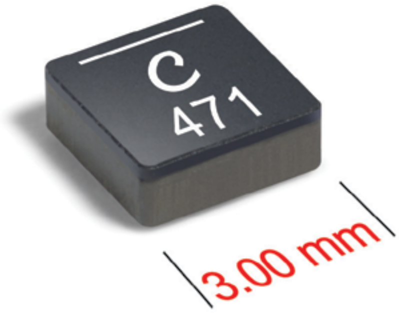
About the Authors

Adam Huff is a senior design engineer for the Power Modules Group in Analog Devices. He has held various roles within the Power Modules Group since joining ADI in 2005. He obtained a B.S. degree in electrical engineering from Purdue University.

Zhijun “George” Qian is a senior design manager for power modules in Analog Devices. He obtained his B.S. degree and M.S. degree from Zhejiang University, and a Ph.D. degree from University of Central Florida, all in power electronics. He joined ADI in 2010.

www.analog.com





Analog and Mixed-Signal Platform

onsemi introduced the Treo Platform, an analog and mixed-signal platform built with Bipolar-CMOS-DMOS (BCD) process technology on an 65 nm node. This platform provides the foundation for a range of power and sensing solutions from the manufacturer including high-performance and low-power sensing, high-efficiency power management, and purpose-built communications devices. Using this single, scalable solution, users can accelerate product development for existing applications, and respond to emerging market opportunities.

The Treo Platform features a modular, SoC-like architecture with a set of ever-evolving IP building blocks that make up the compute, power management, sensing, and communications subsystems. It offers digital processing capabilities and "better analog IP performance". With these capabilities, the platform can deliver local intelligence and compute for flexible configuration, as well as improve performance and accuracy in end applications. Additionally, the platform supports "the industry's widest voltage range of 1-90 V and operating temperatures up to 175 ° C", which allows engineers to integrate a range of low-to-high power functionality.

Initial product families built on the Treo Platform are sampling now, including voltage translators, ultra-low-power AFEs, LDOs, ultrasonic sensors, multi-phase controllers, and single-pair Ethernet controllers. Through 2025, the semiconductor manufacturer will deliver new family members including: high performance sensors, DC/DC converters, automotive LED drivers, electrical safety ICs, connectivity, and more.

www.onsemi.com

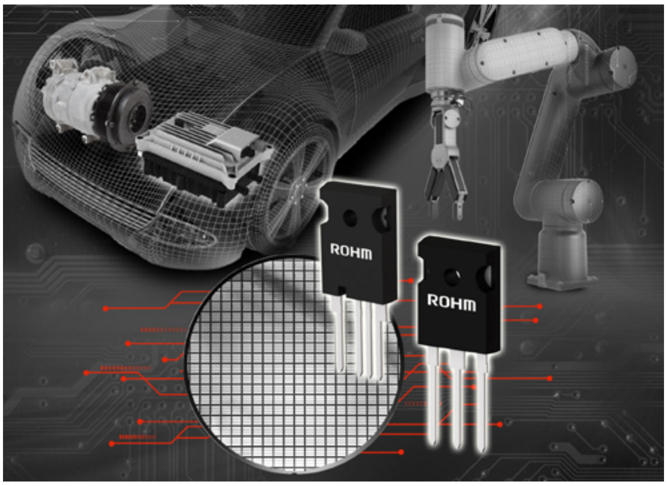
1700 V GaN Switcher IC replaces 3 SiC Transistors

Power Integrations introduced a new member of its InnoMux™-2 family of single-stage, independently regulated multi-output offline power supply ICs. According to the company the device features "the industry's first 1700 V gallium nitride switch, fabricated using the company's proprietary PowiGaN™ technology". The 1700 V InnoMux-2 IC supports 1000 VDC nominal input voltage in a flyback configuration and achieves over 90 % efficiency in applications requiring one, two or three supply voltages. Each output is regulated within one percent accuracy, eliminating post regulators. The GaN device replaces SiC transistors in power supply applications such as automotive chargers, solar inverters, three-phase meters and a wide variety of industrial power systems. Radu Barsan, vice president of technology at Power Integrations, said, "Our rapid pace of GaN development has delivered three world-first voltage ratings in a span of less than two years: 900 V, 1250 V and now 1700 V. Our new InnoMux-2 ICs combine 1700 V GaN and three other recent innovations: independent, accurate, multi-output regulation; FluxLink™, our secondary-side regulation (SSR) digital isolation communications technology; and zero voltage switching (ZVS) without an active-clamp, which all but eliminates switching losses."

www.power.com

1200 V IGBTs for Automotive and Industrial Applications

ROHM has developed automotive-grade AEC-Q101 qualified 4th Generation 1200V IGBTs for vehicle electric compressors and HV heaters as well as industrial inverters. The current lineup includes four models - RGA80TRX2HR / RGA80TRX2EHR / RGA80TSX2HR / RGA80TSX2EHR - in two discrete package types (TO-247-4L and TO-247N), along with 11 bare chip variants - SG84xxWN - with plans to further expand the lineup in the future. In case of a short circuit these devices provide a withstand time of 10 µs (Tj=25 °C) together with low switching and conduction losses while maintaining a withstand voltage of 1200 V. Its TO-247-4L package features 4 terminals, can accommodate an effective voltage of 1100 V in a 'Pollution Degree 2 environment' by ensuring adequate creepage distance between pins. High-speed switching is achieved by including a Kelvin emitter terminal, resulting in even lower losses. In fact, when comparing the efficiency of the new TO-247-4L packages with conventional and standard products in a 3-phase inverter, loss is reduced by about 24% compared to standard products and by 35% over conventional products.



www.rohm.com

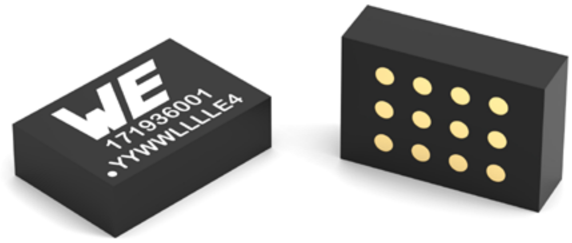
AC programmable Power Sources

The GENESYSTM AC (GAC) and GENESYSTM AC PRO (GAC-PRO) series of 2 kVA and 3 kVA rated programmable AC power sources from TDK-Lambda are claimed to provide the highest power density for a fully featured programmable AC power source with a 1U chassis height. They offer the ability to allow AC, DC, or combined AC+DC operation while allowing full-rated power and current in DC modes, as well as advanced functions such as waveform generation and harmonics analysis as standard. The GENESYS AC PRO also includes real-time analog control functionality necessary for more complex test scenarios, such as hardware in the loop (HIL). Other applications include automated test equipment, avionics airborne equipment, aircraft electrical power, defence (RTCA, Boeing, Airbus Standards), automotive, e-mobility, and power source testing. 2 kVA and 3 kVA units may be user-combined for additional power and to provide multiple phase outputs. The front panel controls can be made through the use of a capacitive touch display. Multiple languages are catered for, including, Chinese, English, French, German, Japanese, Korean, and Spanish. As standard, LAN, USB, RS232, RS485, and Analog Programming / Monitoring are provided, with optional IEEE / GPIB. The included remote GUI software allows the user full control, sequence programming, plus the option to use pre-programmed test standards for common IEC, aerospace, and marine tests.

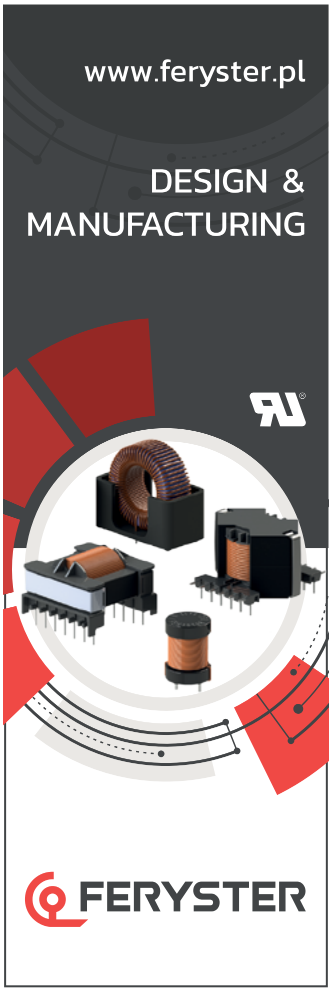
www.emea.lambda.tdk.com

60-V Variant of Power MicroModule Series

There's another generation of MagI^{3}C-VDMM power modules from Würth Elektronik: The input voltage range gives the new MicroModule a resistance to voltage transients on the 48 V bus. The adjustable output voltage ranges from 0.85 to 6 V with currents up to 0.3 A. The extended input voltage range of the Variable Step Down MicroModule from 3.5 to 60 V now covers bus voltages from 5 to 48 V, opening up applications from Point of Load (PoL) to direct 48 V bus voltage connection. So the MagI^{3}C-VDMM series is suited as a replacement for linear regulators, for example in the power supply of interfaces, sensors, microcontrollers, microprocessors, DSPs and FPGAs. Operational areas include industrial, testing and measurement technology, medical devices and point-of-load DC/DC applications. Its efficiency of up to 86 percent supports "cool design", allowing its use in a temperature range from -40 to +105 °C. To save energy, the power module can be set to sleep mode using an additional pin, and the quiescent current is up to 3 µA. The integrated sync feature allows multiple Micromodules to synchronize to an external frequency while simultaneously meeting the requirements of EMC standard EN55032/CISPR32 Class B for radiated and conducted interference with verified filter combinations. The selectively controllable "spread spectrum" feature improves the EMC behavior.

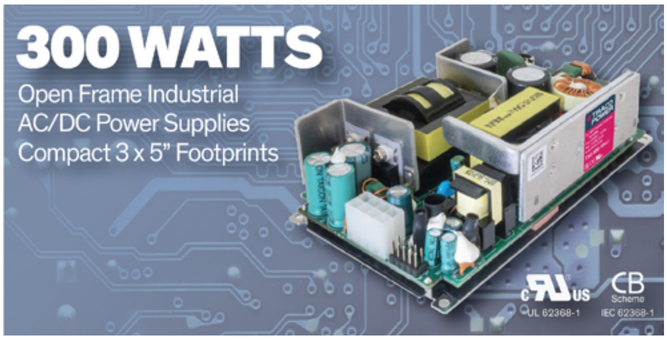


www.we-online.com



300 W Power Supplies in 3” x 5" Packages

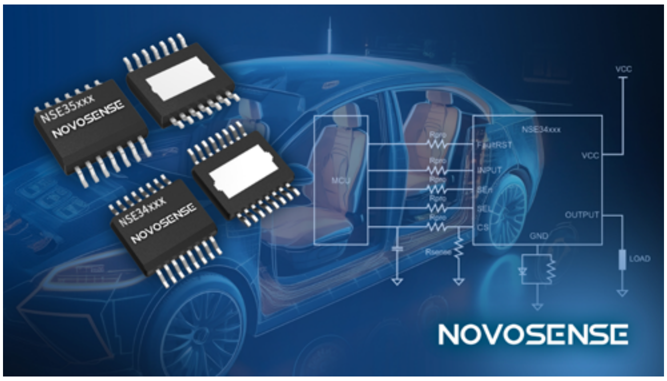
TRACO Power announced TXO 300, a compact 300 W AC/DC Power supply in an 3” x 5” open-frame construction. The TXO line specifically focuses on industrial power supplies. With an efficiency of up to 92 % these models are designed to meet the ErP directive (< 0.3 W no load power consumption). Features include internal EN55032 class B filter, as well as EMC characteristics dedicated for applications in industrial/automation and test & measurement fields. While the input range is 85-264 VAC it is full load convection cooled from -20 °C to +50 °C, and protection class II prepared. The supply units offer 3000 VAC reinforced I/O isolation, an internal EN55032 class B filter, short circuit and overvoltage protection. They are EN 61000-3-2 compliant and according to IEC/EN/UL 62368-1 safety-approved.



www.tracopower.com

Automotive-Grade High-Side Switches for BCMs and ZCUs

Novosense has announced a range of high-side switches for driving traditional resistive, inductive, and halogen lamp loads in automotive body control modules (BCM) as well as large capacitive loads commonly found in the first-level and second-level power distribution within zone control units (ZCU). At time of launch, the NSE34 and NSE35 families includes 26 single-, dual- and quad-channel devices developed for operation across 11 separate load currents intervals (11 A to sub-2 A). These devices have an $R_{ds(on)}$ resistance range from 8 mΩ to 140 mΩ and feature diagnostic and protection functions such as over-current protection and over-voltage clamping protection. All devices in the two families are fully compliant with multiple automotive standards, including AEC-Q100, AEC-Q100-006, AEC-Q100-012 Grade A, ISO7637, ISO16570 and CISPR25-2021 Class 5.



www.novosns.com

100 V Automotive-Grade Devices for Automotive LiDAR

Innoscience has added two 100 V automotive-grade GaN devices. The company’s INN100W135A-Q ($R_{DS(on),max}$ = 13.5 mΩ) and smaller package INN100W800A-Q ($R_{DS(on),max}$ = 80 mΩ) are both certified to AEC-Q101 and optimized for LiDAR as well as for high power density DC/DC converters, and Class D audio applications in the automotive sector.

The INN100W135A-Q and the ultra-compact INN100W800A-Q, with a WLCSP package measuring 2.13 mm x 1.63 mm and 0.9 mm x 0.9 mm respectively, offer advantages in terms of size and power efficiency. Both devices are specifically tailored for the requirements of L2+/L3 assisted driving systems, with switching speeds up to 13 times faster and pulse widths reduced to one-fifth of those of silicon solutions. Parameters like Q_g and Q_{OSS} are also improved by 1.5 to 3 times over their silicon counterparts. This results in medium to long-range recognition capabilities of 200/300m.

100V Automotive GaN devices

INN100W135A-Q and INN100W800A-Q are both certified to AEC-Q101 and optimized for LiDAR applications

Switching speeds up to 13 times faster than Si
Pulse widths reduced to one-fifth with respect to Si
Qg and Qoss are 1.5 to 3 times smaller than Si

Devices are optimized for LiDAR as well as for high power density DC-DC converters, and Class D audio applications in the automotive sector.

Parameter	Unit	INN100W135A-Q	INN100W800A-Q
$V_{DS,max}$	V	100	100
$R_{DS(on),max}$ @ V_{GS} = 5 V	mΩ	13.5	80
$Q_{G,typ}$ @ V_{DS} = 50V	nC	3.2	0.75
$I_{DS,Pulse}$(T_A = 25°C)	A	75	17
Q_{OSS}@ V_{DS} = 50V	nC	20	4

www.innoscience.com

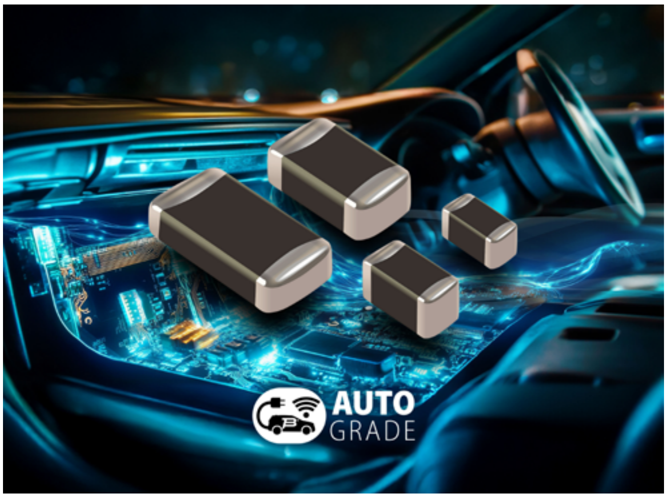
www.innoscience.com

8-Channel Driver and Photo Receiver Amplifier IC

Apex Microtechnology announced two devices in their Precision IC product line: an 8-channel driver and a photo receiver amplifier IC. The devices provide supply voltages of up to 350 V and feature multi-channel architectures. Typical applications are e. g. piezoelectric transduction, capacitive actuation and LED drivers. The AIC1513 is a rigid general purpose high voltage driver IC with 8 high voltage push-pull outputs to drive capacitive and resistive loads such as piezoelectric transducers, electroluminescent devices and micro-mechanical actuators. The maximum operating voltage is 300V, and each output can handle currents up to 40 mA. The device has been designed for harsh industrial applications. The AIC1638 is an integrated receiver amplifier designed for high-sensitivity photo diodes used in applications like light barriers, smoke detectors, light curtains etc. Filtering out ambient light and amplifying the detected pulses from a photo diode, the conditioned signals are used for driving a current mirror output stage. Implementing an integrated polarity protection, the device can be used in a multiplexed configuration, simplifying the wiring of the application. It is suited for light sensing applications ranging from a few millimeters to several meters.

www.apexanalog.com

AEC-Q200 Compliant, Automotive Grade Multilayered Varistor Series

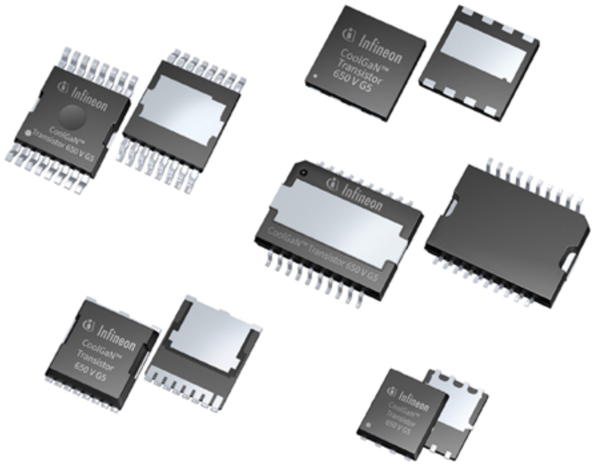


Bourns announced its Model BVRA Series AEC-Q200 compliant, automotive grade multilayered varistors. These low voltage varistors feature transient energy absorption due to improved energy volume distribution and power dissipation. Designed specifically for use in automotive circuits requiring surge protection, the new series can also be applied to protect other integrated circuits and components such as power supplies, entertainment electronics as well as CAN, LIN and Flexray-based modules. The Model BVRA Series is available with working voltages from 5.5 to 85 VDC and provides a response time of less than 0.5 ns to help ensure prompt energy diversion during transient events. Offered in a range of compact 0402, 0603, 0805 and 1206 SMD packages, the new varistors have an insulator overcoat designed to help enhance efficiency and streamline integration. In addition, these models meet the IEC 61000-4-5 standard, and deliver stable leakage current for a high reliability, consistent overvoltage protection solution.

www.bourns.com

Next Generation of GaN Power Discretes

Infineon Technologies launched a family of high-voltage discretes, the CoolGaN™ Transistors 650 V G5. Target applications for this new product family range from consumer and industrial switched-mode power supplies (SMPS) such as USB-C adapters and chargers, lighting, TV, data center and telecom rectifiers to renewable energy and motor drives in home appliances.



The latest CoolGaN generation is designed as a drop-in replacement for the CoolGaN Transistors 600 V G1, however, with improved figures of merit. Compared to key competitors and previous product families from Infineon, the CoolGaN Transistors 650 V G5 offer up to 50 percent lower energy stored in the output capacitance (E_{oss}), up to 60 percent improved drain-source charge (Q_{oss}) and up to 60 percent lower gate charge (Q_g) improving both hard- and soft-switching applications. This leads to a significant reduction in power loss compared to traditional silicon technology, ranging from 20 to 60 percent depending on the specific use case.

The members of the high-voltage transistor product family offer a wide range of $R_{DS(on)}$ package combinations. Ten $R_{DS(on)}$ classes are available in various SMD packages, such as ThinPAK 5x6, DFN 8x8, TOLL and TOLT. In the future, CoolGaN will transition to 12-inch production.

www.infineon.com

Galvanically isolated Gate Drivers provide Protection for IGBTs and SiC MOSFETs

STMicroelectronics’ STGAP3S family of gate drivers for silicon-carbide and IGBT power switches provide a reinforced capacitive galvanic isolation between the gate-driving channel and the low-voltage control and interface circuitry, withstanding 9.6 kV transient isolation voltage (VIOTM) with 200 V/ns common-mode transient immunity (CMTI). Suited for motor drives for industrial applications such as air conditioning, factory automation, and home appliances the drivers are also used in power and energy applications including charging stations, energy storage systems, power-factor correction (PFC), DC/DC converters and solar inverters. The STGAP3S product family includes different options with 10 A and 6 A current capability, each of them available with differentiated Under Voltage Lock-Out (UVLO) and desaturation intervention thresholds. This helps designers select the best device to match the performance of their chosen SiC MOSFET or IGBT power switches. The Desaturation protection implements an overload and short-circuit protection for the external power switch providing the possibility to adjust the turn-off strategy using an external resistor to maximize the protection turn-off speed while avoiding excessive overvoltage spikes. The undervoltage-lockout protection prevents turn-on with insufficient drive voltage. The driver’s integrated Miller Clamp architecture provides a pre-driver for an external N-channel MOSFET. The available device variants allow a choice of 10 A sink/source and 6 A sink/source drive-current capability with desaturation-detection and UVLO thresholds optimized for IGBT or SiC technology. The fault conditions of desaturation, UVLO and overtemperature protection are notified with two dedicated open drain diagnostic pins.

www.st.com

Electronic Fuses (eFuse ICs) for HV Power Management

Toshiba Electronics has launched two additional electronic fuses (eFuse ICs) named TCKE903NL and TCKE905ANA, which are reusable, thereby reducing maintenance costs and recovery time for equipment repairs, and support various functions to protect power supply line circuits. The eFuses are suited for a wide range of power management applications while operating with a switch ON resistance of typically 34 mΩ and an output current of up to 4.0 A. The products are suited for electronic slew rate control and power supply line circuit protection in industrial applications such as servers, professional kitchen equipment and more. The TCKE9 series of 25 V input voltage eFuse ICs offers two product types: an auto-retry type that allows the eFuse IC to automatically recover the circuit itself, and a latch type that is recovered by an external signal. Two different clamping voltage levels are available, i.e. 3.8 V and 5.7 V. The current limit and voltage clamp functions of the TCKE9 series protect the circuit against overcurrent and overvoltage conditions, including over temperature and short-circuit protection features to protect the circuit by immediately shutting off when abnormal heat is generated in the circuit or an unexpected short-circuit condition occurs. As Toshiba intends to obtain IEC 62368-1 certification, the international safety standard for ICT and AV equipment, the eFuse ICs will also simplify and accelerate certification testing process of the end equipment. The TCKE9 series is available in a thin and compact WSON8 package measuring 2.0 mm × 2.0 mm x 0.8 mm.

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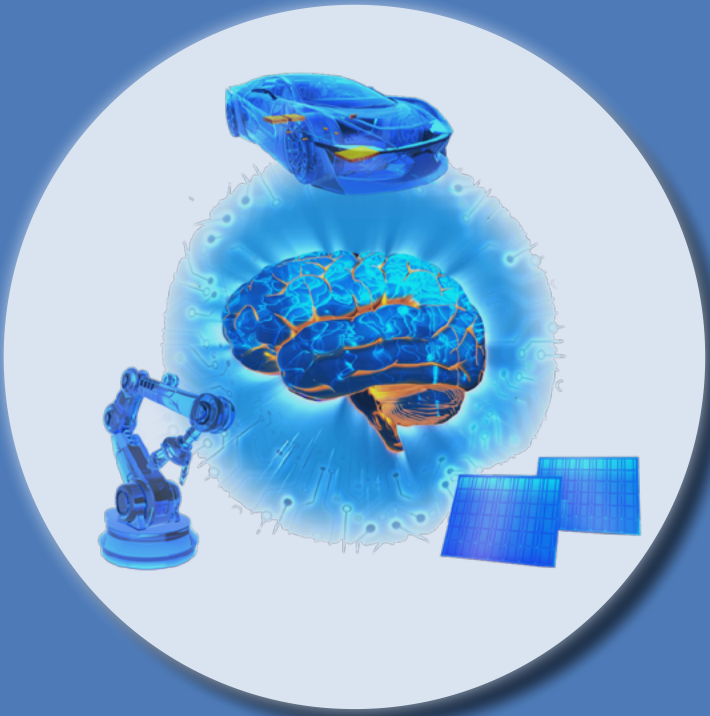

Power as a core competence

for designing electronic components and systems

- Digital power control since 2008
- Wide band gap semiconductors since 2011
- Support of the entire development process

Application competence

- Automotive, industry and renewable energy
- Wireless or conductive battery charging technology
- Bidirectional converters – conductive and inductive
- Power classes up to 100kW

Services

- Circuit design and layout
- Mechanical design
- Electrical, magnetic, thermal, mechanical and EMC simulations
- Prototype construction and commissioning
- Support with qualification and series production

Quality assurance

- ISO 9001: 2015 and ISO 26262
- Automotive SPICE Level 3
- Software and hardware design up to ASIL C
- Laboratory verification for electrical safety
- EMC – Pre-Compliance & Debugging

CUSTOM-TAILORED DEVELOPMENT

industrialization and certification

consulting & training

concept-studies

thermal and electrical simulation

magnetic calculations

layout

construction

firmware

prototyping

We wish you a merry christmas.
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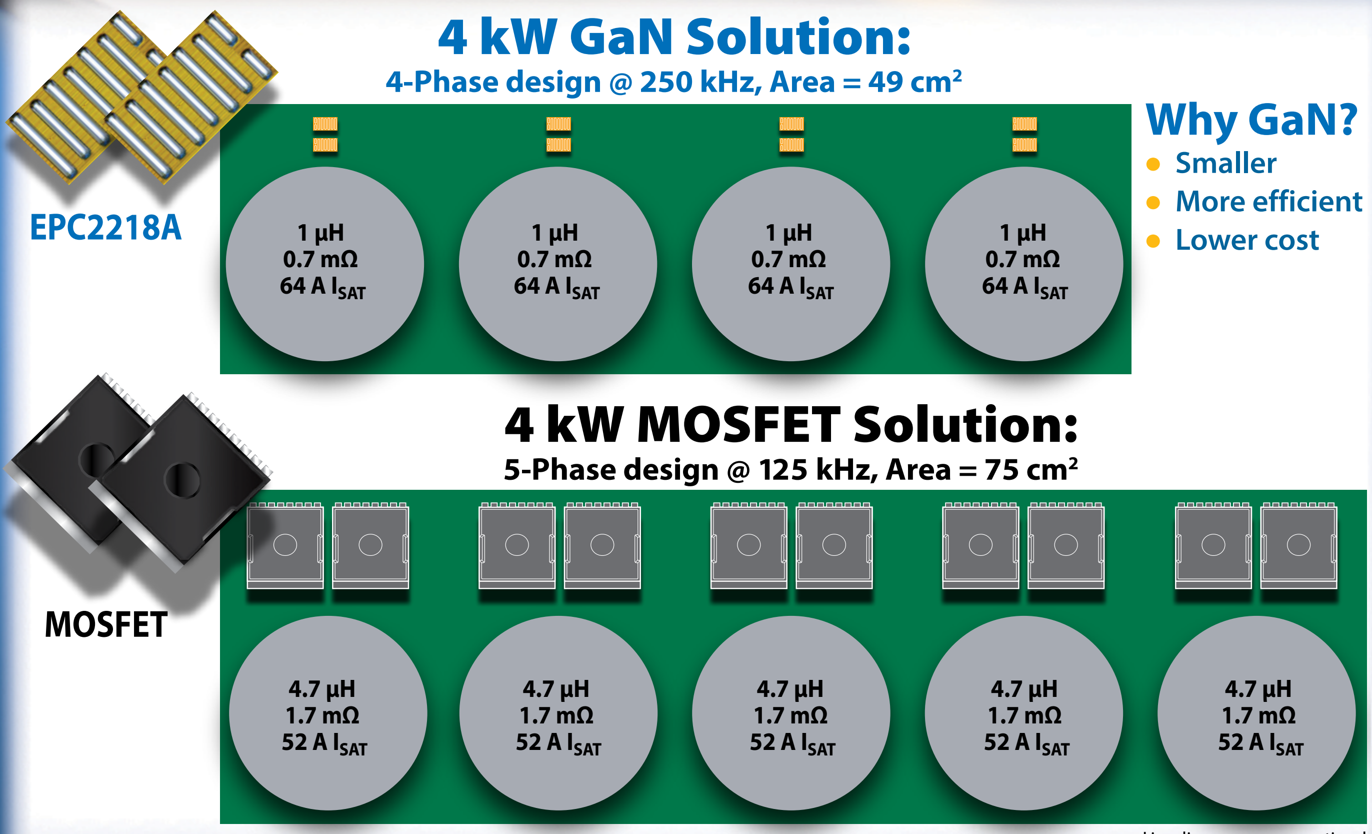
GaN for 48 V Automotive Systems

... Leave Silicon in the Rearview Mirror



4 kW GaN Solution:

4-Phase design @ 250 kHz, Area = 49 cm²

EPC2218A

1 µH
0.7 mΩ
64 A I_{SAT}

1 µH
0.7 mΩ
64 A I_{SAT}

1 µH
0.7 mΩ
64 A I_{SAT}

1 µH
0.7 mΩ
64 A I_{SAT}

Why GaN?

- Smaller
- More efficient
- Lower cost

4 kW MOSFET Solution:

5-Phase design @ 125 kHz, Area = 75 cm²

MOSFET

4.7 µH
1.7 mΩ
52 A I_{SAT}

4.7 µH
1.7 mΩ
52 A I_{SAT}

4.7 µH
1.7 mΩ
52 A I_{SAT}

4.7 µH
1.7 mΩ
52 A I_{SAT}

4.7 µH
1.7 mΩ
52 A I_{SAT}

Line diagrams are proportional

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