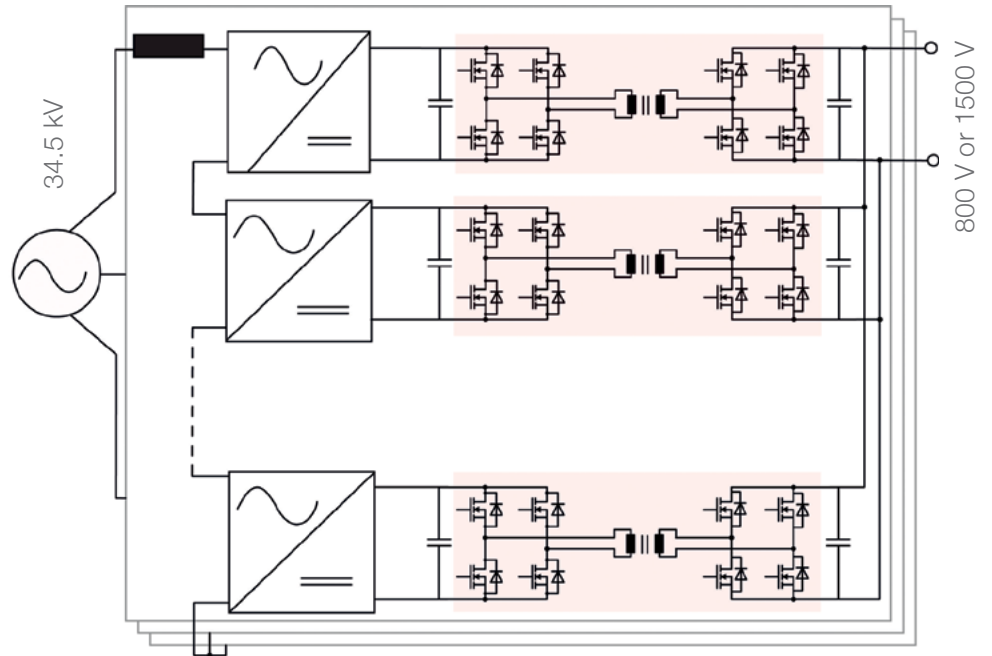


Bodo's Power Systems®

Electronics in Motion and Conversion

September 2026

SiC Modules for High Power Data Centers



Built into the Future





POWER CHOKES TESTER DPG10/20 SERIES

Inductance measurement from 0.1 A to 10 kA

KEY FEATURES

Measurement of the

- **Differential inductance** $L_{diff}(i)$ and $L_{diff}(\int U dt)$
- **Amplitude inductance** $L_{amp}(i)$ and $L_{amp}(\int U dt)$
- **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 <i>new model</i>
DPG10-2000B/E	2 to 2000A	2750J <i>new model</i>
DPG10-3000B/E	3 to 3000A	2750J
DPG10-4000B/F	4 to 4000A	8000J
DPG20-10000B/G	10 to 10000A	15000J

INTRODUCING

3PH SERIES THREE PHASE PACKAGE

sales@ecicaps.com | sales@ecicaps.ie
ecicaps.com



Three-phase packaged capacitor module featuring a rectangular enclosure with integrated mounting flanges. Engineered to handle high RMS currents, ideal for demanding power factor correction and AC harmonic filtering applications. Available in both wye and delta configurations, with flexible terminal options including male or female connections to suit a wide range of system requirements.



Content

Viewpoint	4
Let's electrify the World!	
Events	4
News	6
Product of the Month	14
Single-port bidirectional source/sink USB-C PD MCU	
VIP Interview	16
Why the Materials Used in the Package are Becoming as Important as the Power Semiconductor Itself	
By Holger Moscheik, Publisher, Bodo's Power Systems	
Cover Story	18
From Grid to GPU: Enabling Multi-Megawatt SST Architectures with High-Current SiC Power Modules	
By Narendra Lakshmanan, Karthik Debbadi and Nils Soltau, Mitsubishi Electric Europe B.V. (based in Ratingen, Germany) and Ryo Tsuda, Mitsubishi Electric Power Devices (based in Fukuoka, Japan)	
Motion Control	26
High-Frequency 100 V GaN Motor Drives Push Low-Voltage Motion Control to the Next Level	
By Maurizio Di Paolo Emilio, Marcom Director, and Marco Palma, Vice President of Motor Drive Marketing and System Engineering, Efficient Power Conversion (EPC)	

Wide Bandgap	30
GaN Technology now with 2200 V Rating	
By Andrew Smith, Director of Technical Outreach, Power Integrations	
Magnetic Components	36
Rethinking Inductor Sizing: The High-Gain Magnetic Illusion	
By Udi Levy, Power Electronics Expert, SolarEdge Technologies	
Power Modules	40
DC Anti-Backflow: Comparing Active ORing and Diode ORing for Reverse Current Protection	
By the engineering team of RECOM Power	
Driver ICs	42
Preventing Under and Overdamping Through Optimized GaN Gate Switching Waveforms	
By Huojun LONG, Application Engineer, NOVOSENSE Microelectronics	
Protection	46
The Arc across the Contacts:	
Switching Inductive Loads with a Mechanical Switch	
By Liu Junxiong, R&D Engineer, Swiclick	
New Products	51

Bodo's Power Systems®
Electronics in Motion and Conversion



Follow us on LinkedIn:
linkedin.com/company/bodo's-power-systems

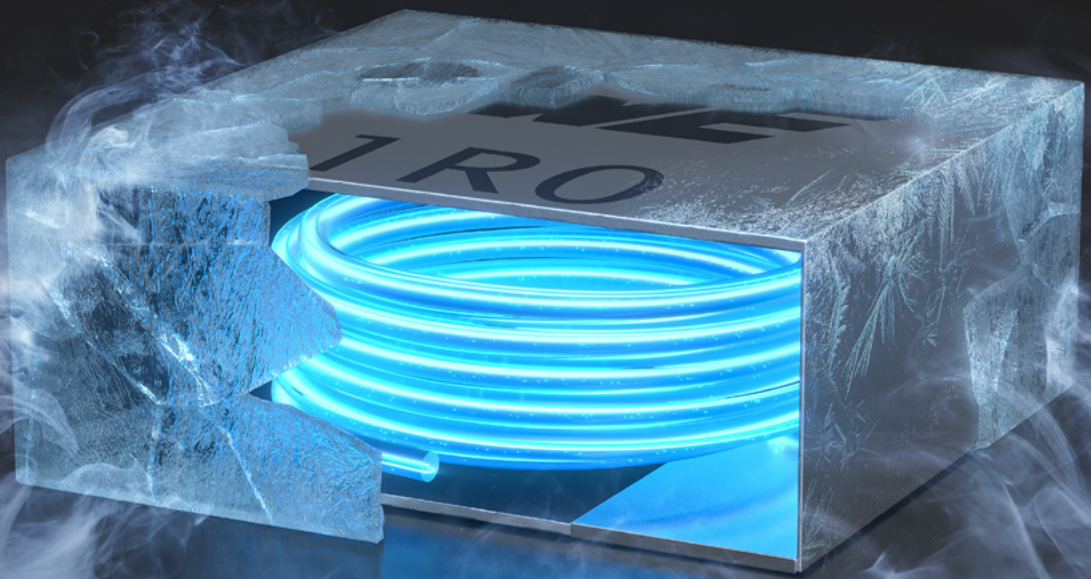
Supporters & Friends



WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

ULTRA LOW LOSSES

WE-MXGI



WE meet @ electronica
Hall B6 - 101

With the WE-MXGI Würth Elektronik offers the newest molded power inductor series. It combines an innovative iron alloy material that provides high permeability for lowest R_{DC} values combined with an optimized wire geometry.

Ready to Design-In? Take advantage of personal technical support and free samples ex-stock.

www.we-online.com/WE-MXGI

Highlights

- Extremely high power density
- Ultra low R_{DC} values and AC losses
- Magnetically shielded
- Optimized for high switching frequencies beyond 1 MHz

#UltraLowLosses

A Media

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

Founder

Bodo Arlt, Dipl.-Ing.
bodo@bodospower.com

Editor in Chief

Alfred Vollmer, Dipl.-Ing.
alfred@bodospower.com

Correspondent Editor Bavaria

Roland R. Ackermann, Dipl.-Ing.
roland@bodospower.com

Editor China

Min Xu
xumin@i2imedia.net

US Support

Rusty Dodge
rusty@eetech.com

Creative Direction & Production

Bianka Gehlert: b.gehlert@t-online.de

Publisher

Holger Moscheik
holger@bodospower.com
Phone: +49 4343 4285017

Printing

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

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

Free Subscription to qualified readers**Disclaimer**

A Media and Bodo's Power Systems assume no liability for any loss or damage resulting from errors or omissions in the material contained herein, regardless of whether such errors or omissions result from negligence, accident or any other cause whatsoever.

AI-generated content

Authors, contributors and advertisers are responsible for ensuring that AI-generated or AI-manipulated content submitted to Bodo's Power Systems is appropriately identified in accordance with applicable legal requirements.

Copyright

© 2026 Bodo's Power Systems. All rights reserved. Reproduction or redistribution of editorial content, in whole or in part, requires prior written permission.



Let's electrify the World!



Immediately after my graduation as an electrical engineer I moved to Munich where I also visited the picturesque Königsee (King's Lake) at the southernmost tip of Bavaria.

I was immediately fascinated of course by its beauty, but also by the boats on the lake which are all electric, actually since 1909! Riding in silence while gliding electrically-powered over this lake and watching the alpine mountains around is an almost breathtaking experience.

My first visit to the Königsee was in the days of lead-acid batteries. Now, we live in the age of lithium-enabled rechargeable batteries with for example cable-free gadgets and power tools. This year I spent my vacation driving through parts of Scandinavia. While visiting Sweden, I was fascinated by the well-established EV charging infrastructure for cars and the closer I travelled to Gothenburg, the more EVs were on the roads.

Shortly after crossing the border (no checkpoint at all, just a road sign "Welcome to Norway") I came to the town of Halden, where I saw a parking lot with many public transport buses charging. I discovered, that since 2022 all the 30 public buses in this area operate 100 % electric. Even in Oslo, the capital, more than 85 % of the buses run on electricity only.

A few kilometers further, there was a hydraulic excavator, which was fully electric. Nearby was a pop-up high-performance charger. It makes sense to operate the hydraulic pumps with electrical motors, because diesel-powered excavators idle the motor a lot of the time, while an electric motor just stays silent without needing energy during idle times.

Then I proceeded to the busiest ferry in Norway crossing the Oslo Fjord from Moss to Horten, within about 30 minutes of cruising time. It was a great experience to ride almost silently without significant vibration on a 100 % electric ferry carrying lots of trucks, cars, RVs and bicycles. The giant power connectors of the chargers were connected for less than 12 minutes before the RoRo ferry took off again for its next 10 km trip across the Fjord. Also, a Swedish company has demonstrated a fully electric 160 nautical miles (almost 300 km) ferry ride from Gothenburg to Oslo, which is intended more for commuter traffic. Check out youtu.be/5fqnbSKTAJl for more fascinating details.

Omitting the fossil fuel guzzling motors can open up new market opportunities and bring new levels of convenience and cost. So let's electrify the World! We at Bodo's Power Systems will support you during this electrification journey – in the future additionally with stories featuring rechargeable batteries and the power-related electronics in and around these energy storage devices.

For more than 20 years Bodo's magazine has been delivered by post 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. And don't miss our Chinese version at bodospowerchina.com. An archive of every issue of the magazine is available for free at our website bodospower.com.

My green tip of the month:

Whenever possible, ride the electric way or use a bicycle.

Events

ECCE Europe 2026
Valencia, Spain September 14 – 18
www.ecce-europe.org

electronica India 2026
Bengaluru, India September 16 – 18
<https://electronica-india.com>

WiPDA Europe 2026
Aalborg, Denmark September 20 -22
www.energy.aau.dk

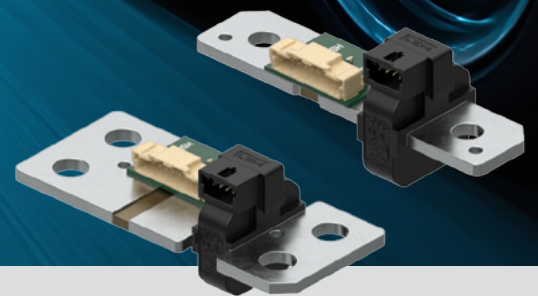
INTELEC 2026
Nuremberg, Germany September 20 – 23
www.intelec.org

ESREF 2026
Vienna, Austria September 21 – 24
www.esref2026.org

embedded world NA 2026
Anaheim, CA, USA September 22 - 24
www.embedded-world.de



Combine highest SoC estimation accuracy with ASIL D readiness



HSU Series

The main challenge that high-voltage battery experts are trying to solve is how to improve the battery autonomy while operating in the safest environment for the driver. How to translate this challenge at the sensor level?

The new HSU is the first hybrid sensor on the market. It combines two technologies, shunt + hall, in a standard shunt footprint. It offers gain on space, weight and cost and has been designed to minimize integration effort for a faster time-to-market while allowing ASIL D compliance at system level.

- **Non-heterogeneous redundancy**
- **Galvanic isolation on Hall part**
- **Separated communication lines (shunt signals and digital bus for Hall)**
- **NTC signal for shunt T°C compensation**
- **2 references sizes of standard shunts**

www.lem.com

LEM

Life Energy Motion

Berlin Startup Secures €2M for Gallium Oxide Epitaxy



NextGO Epi, a Berlin/Germany-based deep tech startup and spin-off of the Leibniz Institute for Crystal Growth (IKZ), has closed a pre-seed funding round totaling 2 million euros. This was also enabled by the European Commission's Chips Act 2.0. The company produces gallium oxide epitaxial wafers for next-generation power electronics. Its process creates a semiconductor material that aims to cut the manufacturing costs of power semiconductors by up to 75 percent. NextGO Epi claims to be Europe's only company producing industrial-grade gallium oxide epitaxial wafers with diameters of up to 4 inches. The material forms the electrically active layer of the next generation of power semiconductors: gallium oxide-based com-

ponents can withstand higher voltages and operate more efficiently than the silicon carbide or gallium nitride commonly used today. The fresh capital will be used to accelerate product development, expand the team, and strengthen the company's commercial presence in Europe and on global markets. The founding team brings together more than ten years of experience in gallium oxide research and epitaxy, backed by two international patents and over 30 scientific publications. Gallium oxide is ten times more energy-efficient, can handle up to six times higher voltage density, and can be manufactured at up to 75 percent lower cost than GaN or SiC.

www.nextgoepi.com

Strategic Acquisition increases Medium Voltage Expertise

Tamura Corporation has entered into a share transfer agreement, through its subsidiary Tamura-Europe Limited, to acquire EMG Power Electric S.r.l. This strategic acquisition marks another important step in Tamura's "One TAMURA for Next 100" Medium-Term Management Plan, strengthening the Group's capabilities in medium-voltage power technologies and supporting growth in key markets including renewable energy, industrial electrification, AI-driven data centers and critical power infrastructure. Following the completion of the transaction, EMG will serve as the Tamura Group's Global Center of Excellence for medium-voltage dry-type transformer technologies, supporting engineering development, manufacturing excellence and technology transfer across the Group's worldwide operations. By combining EMG's expertise with



Tamura's global engineering and manufacturing network across Japan, Europe, the United States, Mexico, China and Malaysia, the Group aims to strengthen its ability to deliver advanced power conversion solutions to customers worldwide.

www.tamuracorp.com

Joining the Current/OS Partner Network to Advance the Future of Direct Current Microgrids

Power Innovations International (Pii) has joined the Current/OS Foundation to advance the adoption of Direct Current microgrids and support industry efforts to establish standards for the next



generation of energy systems. As electrification accelerates across transportation, data centers, industrial facilities, airports, and distributed energy applications, direct current (DC) is becoming an increasingly important foundation for modern power systems. Current/OS is committed to addressing the challenge of defining and implementing standards for designing, deploying, and operating DC systems at scale by bringing together technology leaders dedicated to creating the frameworks and best practices needed to accelerate DC adoption.

www.powerinnovations.com

Zait Akcam appointed as Managing Director of GVA



GVA Leistungselektronik has appointed Zait Akcam as its new Managing Director. Mr. Akcam is already well known to many customers and partners through his many years as Head of Sales at the Mannheim/Germany-based company. With more than 30 years of experience in the semiconductor industry and his knowledge of international markets, he brings considerable industry and

management expertise to his new role. In his new position, Akcam will drive the continued development of GVA, with a particular focus on the needs of customers and partners. One of his key priorities will be the ongoing development of the company's product and service portfolio. The aim is to further strengthen GVA's position as a trusted partner in power electronics and to continue providing customers with innovative solutions combined with the high level of service they have come to expect.

www.gva-power.de

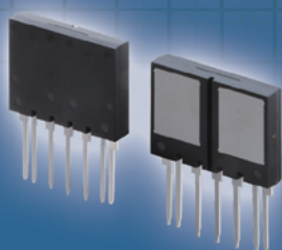
Meeting your needs. Portfolio expansion. SiC Power Modules

HSDIP20



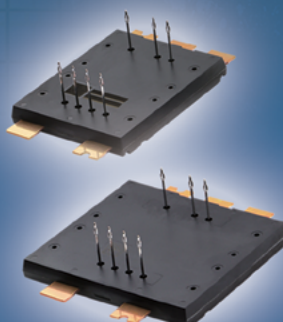
- Compact 4-in-1/6-in-1
- Circuit-oriented element layout (4-in-1, 2-in-1, etc.)
- Improved heat dissipation characteristics

DOT-247



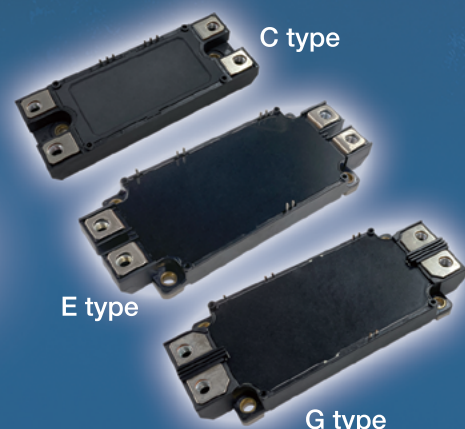
- 2-in-1 TO-247-4L
- Improved heat dissipation performance
- Half-bridge/source common

TRCDRIVE pack™



- Parallel multi-chip configuration provides high current capability
- Low Ls improves switching performance
- Reduced size through improved heat dissipation performance

Case type



- Parallel multi-chip configuration provides high current capability
- Gel encapsulation in case



TRCDRIVE pack™ and EcoSiC™ are trademarks or registered trademarks of ROHM Co., Ltd.

PCIM Visitors enable Charity Donation

Vincotech raised € 12,500 for Plan International Germany's climate resilience project in Zambia through an interactive charity activity



at this year's PCIM Europe trade fair. Every visitor, who took part in a reaction game, contributed to the donation. Vincotech has made community fundraising a tradition at PCIM Europe, using interactive attractions to engage visitors while supporting charitable causes. Over the years, attractions including wall climbing, Sudoku challenges, virtual reality experiences, and, most recently, a fast-paced reaction game have delighted attendees. This year's crowd favorite drew around 500 participants, all playing for a good cause. This year's charity initiative will benefit a Plan International Germany's project in Zambia that supports communities in responding to the effects of climate change. The project focuses on practical measures such as sustainable agriculture, green business development, hydroponics, and environmental protection. It also helps young people and farming families improve food security, gain new skills and create more stable sources of income.

www.vincotech.com

Collaboration on DC Power Solutions for AI Data Centers

Infineon Technologies and LS ELECTRIC have signed a Memorandum of Understanding (MoU) to collaborate on high-efficiency direct current (DC) power infrastructure solutions for AI data centers and next-generation power grids. The collaboration will focus on key DC infrastructure areas, including power conversion systems for energy storage systems, solid-state transformers (SSTs) and solid-state circuit breakers (SSCBs). SSTs are advanced, semiconductor-based power conversion devices that can be up to 30 percent smaller and lighter while offering higher efficiency compared to conventional copper and iron-based transformers. SSCBs use semiconductors and smart algorithms to protect electrical circuits from damage caused by short circuits or overloads. They interrupt the flow of current and operate on the microsecond scale to improve system stability and protection. These semiconductor-based solutions are becoming increasingly important in high-density power environments such as AI data centers. The collaboration aims to improve power and voltage conversion efficiency while enhancing the stability and reliability of next-generation DC power systems. Under the provisions of the MoU, Infineon will support the development of high-efficiency, high-performance DC power infrastructure systems with its semiconductor portfolio that includes power



semiconductors, microcontrollers and power control solutions. LS ELECTRIC will leverage its expertise in power systems and industrial automation to drive system-level integration and implementation. Together, the two companies will align technology roadmaps and advance co-development efforts to capture growth opportunities in the next-generation energy infrastructure market.

www.infineon.com

“Engineer Social Hub”: Engineers supporting Engineers

ROHM launched the English-language version of Engineer Social Hub, an online platform designed to make the company's technical information, know-how, and support more accessible to engineers. Engineer Social Hub brings together ROHM's technical content related to semiconductor products and solutions in one place. Through product-specific FAQs and discussions, as well as a chatbot, users can search for solutions to technical questions and obtain direct support from ROHM engineers. Previously, when users encountered technical challenges, they often needed to contact ROHM individually or make inquiries through distributors. Via the Engineer Social Hub, users can now access ROHM's technical information and know-how online – anytime and from anywhere. FAQs and discussions on the site can be read and searched without logging in. If users are unable to find the information they need, they can register as members and post questions in discussions, enabling them to explore solutions in greater depth. The site also provides documents and videos explaining how to use Engineer



Social Hub. Going forward, ROHM will continue to evolve Engineer Social Hub into a community in which not only ROHM and users, but also users themselves, can communicate with one another to generate new ideas and solutions. Through this initiative, ROHM aims to contribute to solving engineers' technical challenges by creating a site where engineers connect, create, and collaborate.

www.rohm.com

CAPACITORS BUILT TO ENDURE THE EXTREME.



INTRODUCING

3PH SERIES

THREE PHASE PACKAGE



Three-phase packaged capacitor module featuring a rectangular enclosure with integrated mounting flanges. Engineered to handle high RMS currents, ideal for demanding power factor correction and AC harmonic filtering applications. Available in both wye and delta configurations, with flexible terminal options including male or female connections to suit a wide range of system requirements.



Please visit us at
BOOTH #203



CONTACT US

ecicaps.com

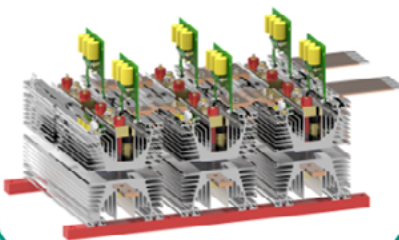
sales@ecicaps.com | sales@ecicaps.ie

WE BUILD
POWER STACK

AC/DC

Press-pack

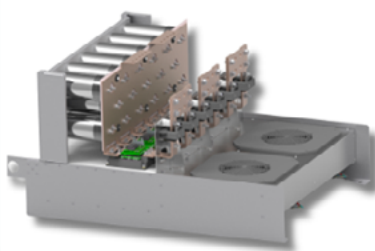
1000A – 400Vac (B6C)



DC/AC

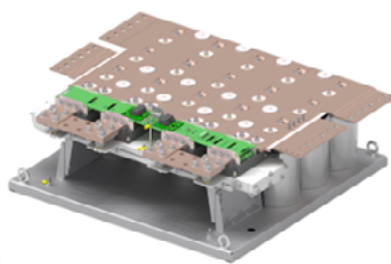
3ph Inverter

1500A – 400Vac (B6CT)



DC/DC

2000A – 800Vdc (L1CT)



UPCOMING EXHIBITIONS

InnoTrans



BERLIN

22 - 25 September 2026

Hall 9 Booth 110



PARIS

3 - 6 November 2026

Booth A67

Second Managing Director appointed

The German custom magnetics company Schmidbauer Transformatoren und Gerätebau has appointed Florian Ehgartner as an additional managing director. He will lead the company alongside the managing director, Dominik Reichl. As a managing director with sole power of representation, Florian Ehgartner will assume responsibility in particular for operational areas, including materials management and IT. Dominik Reichl will in future focus more closely on product development, sales and the company's strategic direction.

www.schmidbauer.net



Strategic Partnership to Accelerate HV and UHV Silicon Carbide Adoption

Navitas Semiconductor and Magnachip Semiconductor, a designer and manufacturer of analog and mixed-signal power semiconductor platform solutions, announced a strategic partnership to accelerate adoption of SiC technologies in high-voltage (HV) and ultra-high-voltage (UHV) power markets. Under the terms of the agreement, Magnachip will license Navitas' GeneSiC™ Trench-Assisted Planar™ (TAP) technology to enter the HV and UHV SiC markets. The license covers 1200 V, 2300 V, 3300 V and higher voltage GeneSiC technologies, enabling Magnachip to build on Navitas' SiC device platforms for next-generation power conversion applications. Magnachip will also gain access to Navitas' SiC supply chain and materials eco-



system, supporting faster market entry. At the same time, the technology is planned to be ported, qualified, and internalized at Magnachip's fab in South Korea. The companies also stated that the agreement encompasses broader engagement beyond SiC.

www.navitassemi.com

President of Danfoss Power Electronics appointed

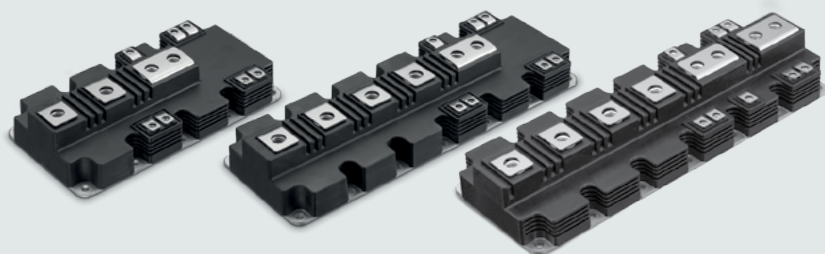


Danfoss Power has appointed Kern Jain as President of Danfoss Power Electronics. He most recently served as Segment CFO of Danfoss Power Electronics and Drives and brings more than 20 years of experience in global technology and pharmaceutical companies. Mr. Jain has started in his new role as President of Danfoss Power Electronics on 1 August 2026. He succeeds Dominic Dorfner, who has left the company at his own request. Over the past months, the two worked closely together to ensure a smooth handover, allowing Jain to meet customers and colleagues ahead of his official start. The Danfoss business unit develops and markets power electronics products and solutions under the established Semikron Danfoss brand. The leadership transition coincides with the renaming of the business unit from Semikron Danfoss to Danfoss Power Electronics, reflecting being part of the Danfoss Group's core electrification business. The established Semikron Danfoss brand will be retained for products and solutions. Within the Danfoss Group, the Power Electronics and Drives segment operates two distinct businesses: Danfoss Drives and Danfoss Power Electronics.

www.semikron-danfoss.com

PrimePACK™ IGBT Modules

Upgrading to 1200 A/1200 V in PP2,
2400 A/1200 V & 2400 A/1700 V in
PP3+ with RC-Technology

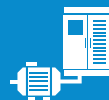


MAIN FEATURES

- Optimized IGBT, FWD & RC-IGBT design
- Improved solder material for higher reliability
- Higher lifetime at same ΔT_j
- Increased output power
- Lower conducting and switching losses
- 2nd label with $V_{CE(sat)}$ and V_F classification for easier paralleling

PrimePACK™ is registered trademark of Infineon Technologies AG, Germany.

MV-INV



SOLAR



WIND



Acquisition for expanding Analog and Mixed-Signal Portfolio

Diodes Incorporated (Diodes) has entered into a definitive agreement to acquire ElevATE Semiconductor, Inc. (ElevATE) in an all-cash transaction for \$250 million. ElevATE is a fabless semiconductor company based in San Diego, California that specializes in the development of integrated circuits for the Automated Test Equipment (ATE) industry. The transaction is expected to close during the second half of 2026.

www.diodes.com



Custom Magnetics Research and Development Center opened in Northern Germany

Bourns has opened a research, development, and design center for its custom magnetics operations in Rosdorf near Göttingen/Germany. The facility brings together the full 44-person engineering, prototyping, and design team — the same group that has been developing custom magnetic components at this site since Bourns acquired Kaschke Components in 2021 — in a renovated 3,000-square-meter building. Production of inductive components continues at Bourns' manufacturing sites in Tunisia. The move comes after Bourns wound down ferrite production at the team's previous location, leaving it in a building that was too large for an engineering and design operation. Rather than adapt the old space, Bourns chose to start fresh. The center includes a prototype workshop with separate areas for measurement technology and qualification equipment — tools the engineering team needs to move from concept to tested design without leaving the building. After renovating there are now 17 offices where each engineer has a permanent desk, a soundproof booth for uninterrupted work, two meeting rooms, and a work café — all designed with the home office as the benchmark to beat. Heating and cooling come from a geothermal system feeding two heat pumps. Rainwater drains into a surrounding basin and two on-site ponds rather than the municipi-

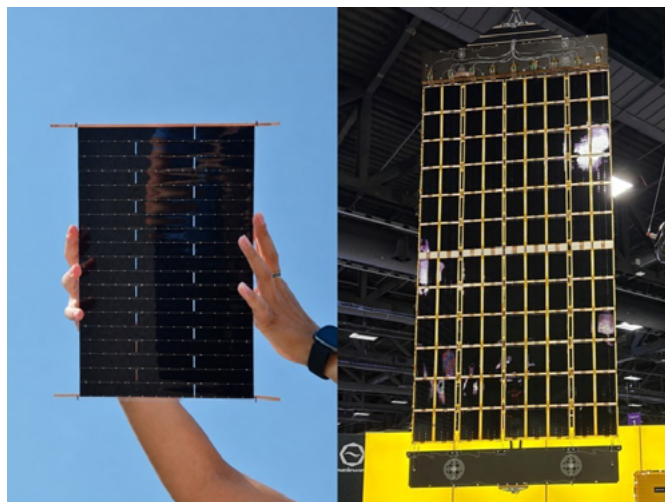


pal system. Bourns also added electric vehicle charging stations for employees. All renovation work — interior fit-out, electrical, painting, fire safety — was handled by local companies based in the German federal state of Lower Saxony.

www.bourns.com

Silicon Photovoltaics Make Power Generation in Space More Cost-Effective

Source Energy and the Fraunhofer Institute for Solar Energy Systems ISE have jointly developed a product line for space satellites based on silicon solar cells. The solar arrays are using a special interconnection technology. Combined with inexpensive silicon solar cells, this enables modules at much lower costs compared



to standard III-V technology that currently dominates the space sector. The high cost and limited availability of solar cells based on III-V materials are major constraints for commercial missions, particularly Low Earth Orbit (LEO) satellites. The resulting solar modules are compact and lightweight: 64 grams and 629 square centimetres, (321 by 209 millimetres). The average power output of the prototypes was 15.6 W – with modules achieving 16.1 W – and an average active area efficiency of 18.8 % (AM0 at 25 °C). At 252 W/kg, the module's specific power is competitive with other silicon modules in its class. The silicon solar cells are interconnected using shingle-matrix technology, where individual solar cells are cut into strips and arranged with certain overlap and spacing relative to one another, like brickwork. An electrically conductive adhesive bonds the solar cells together.

The machine manufacturer M10 Solar Equipment GmbH has developed an industrial stringer for shingle-matrix technology.

If the solar panel is damaged – for example, by a small meteorite or space debris – the matrix arrangement of the solar cells allows the current to simply flow around the damaged area. Rows and columns of solar cells in the layout can be flexibly adjusted depending on the satellite's voltage and current requirements.

www.ise.fraunhofer.de/en

Japanese precision since 1935

HIOKI



Precision Current Clamps for every application



2 to 2000A max

DC to 2MHz

Ø 50mm max

up to 0.07 % accuracy



shop.hioki.eu/current-clamps



HIOKI EUROPE GmbH | Helfmann-Park 2 | 65760 Eschborn | hioki@hioki.eu



Single-port bidirectional source/sink USB-C PD MCU

A solution that is ready-to-use for USB-C applications up to 140 W

Driven by European Commission mandates and consumer demand for flexible charging, versatile USB-C connectors are rapidly replacing legacy and proprietary alternatives across industries. USB-C, being a universal interface, scales effortlessly from smartphones and laptops to highpower devices like cordless vacuums and eBikes, offering users reversible designs, accelerated data transfers, and up to 240 W of power delivery. However, upgrading a device using discrete architecture introduces severe design bottlenecks, including complex high-voltage power sequencing, state-machine management, and stringent on-chip security requirements. Traditional topologies demand deep USB-PD protocol stack expertise and inflate Bill of Materials (BOM) costs by requiring separate host micro-controllers, physical layer (PHY) transceivers, and discrete power management ICs (PMICs).

EZ-PD™ PMG1-S4 supports a wide input and output voltage range (4 V to 28 V). It is a programmable USB PD solution with an on-chip 32-bit Arm® Cortex®-M0 + processor, 2x64 KB flash, and 12 KB SRAM. It also includes various analog and digital peripherals such as ADC, PWMs, serial communication blocks (UART/I2C/SPI), and timers. The MCU is available in a compact 32-QFN package (5 mm × 5 mm) with a pitch of 0.50 mm, enabling designs with reduced sizes. Being suited for an industrial temperature range of -40°C to 85°C with a maximum operating junction temperature of 125°C, EZ-PD™ PMG1-S4 ensures a robust and reliable design.

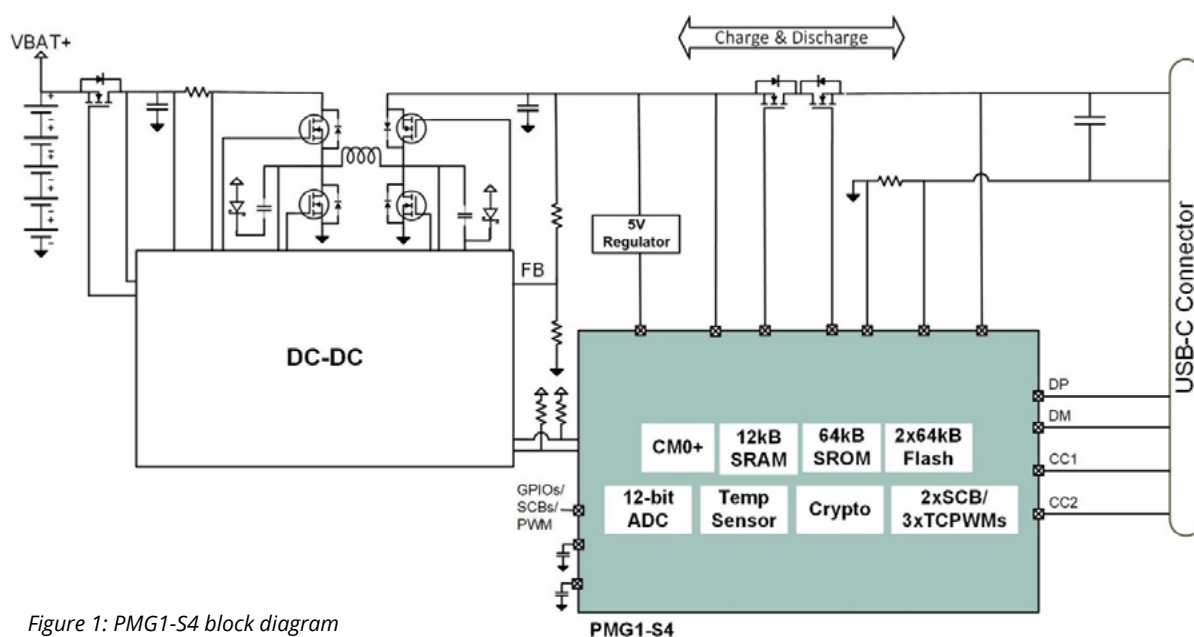


Figure 1: PMG1-S4 block diagram

To mitigate these layout complexities and optimize PCB space, Infineon's EZ-PD™ PMG1 portfolio integrates a high-voltage, programmable Arm® Cortex® MCU and a fully compliant USB Type-C PD controller onto a single monolithic die. This system-on-chip (SoC) architecture features integrated high-voltage regulators, gate drivers, and hardware cryptographic accelerators, eliminating the discrete peripheral logic usually required for power arbitration. By serving as a direct drop-in replacement for the application's legacy host processor, the PMG1 allows hardware teams to implement native USB-C power negotiation while minimizing hardware-firmware overhead and accelerating development cycles.

Continuing the legacy, Infineon introduces EZ-PD™ PMG1-S4 USB Power Delivery MCU, serving higher power embedded systems requiring USB Power Delivery's Extended Power range (EPR) up to 28 V, 5 A. EZ-PD™ PMG1-S4 integrates a bidirectional NFET gate driver to control the USB-C PD port as a power source or sink using the same power path. The part also integrates a dead battery Rd and an LDO for battery applications.

Additionally, there are built-in integrations such as an I/O subsystem, analog blocks, and programmable digital blocks to simplify the design. The 16 GPIOs can be used for interactions with switches and LED lights, whereas the I2C, UART, SPI, and the TCPWM can be used to manage the control of humidity, temperature, accelerator, and communications with external battery charger or battery management system (BMS). Moreover, the built-in 12-bit ADC can be used to sense the built-in temperature sensor, battery voltage monitoring, and VBUS voltage/current monitoring.

Infineon is one leader in the USB-C market, offering various portfolios for different market segments. With the EZ-PD™ PMG1-S4, USB PD high-voltage microcontrollers now offer a device that supports bidirectional battery applications like power banks, power tools, drones, or speakers, and can extend the charging rate from ≤100 W standard power range (SPR) to 140 W extended power range (EPR) applications. To learn more about PMG1-S4 and to order samples, visit www.infineon.com/pmg1-s4



Vincotech

MAXIMIZE POWER DENSITY

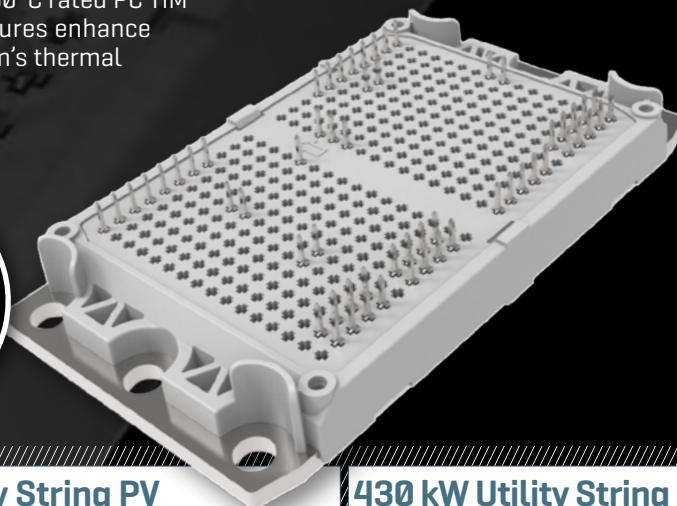
Unlock higher performance for PV and ESS

Vincotech's *flow* E3BP⁺ extends the proven *flow* E3BP platform, raising the module operating temperature to 175°C while maintaining the compact 110 mm × 62 mm footprint. Optional Si₃N₄ substrates reduce thermal resistance by 26 % versus Al₂O₃ DCB and comprises more than double the PCsec reliability.

The design includes a CTI600 housing with isolation flaps for 2 kV insulation and optional 12 or 15 mm mounting height with press-fit or solder pins. A 3 mm convex copper baseplate ensures uniform heatsink contact and stable long term thermal performance.

Together with the recommended 150°C rated PC TIM [available pre-applied], these features enhance robustness, and extend the platform's thermal capability keeping its form factor.

ORDER
YOUR
SAMPLE
NOW

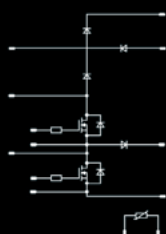


465 kW Utility String PV

Booster

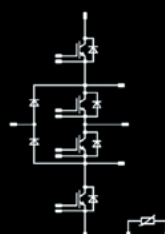
30-EX14B2A007WS01-PS29F28Z

2x



Inverter

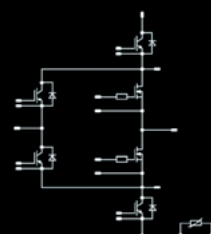
30-EX14NIA560H701-PS59F86Z



430 kW Utility String ESS

Inverter

30-E312NAA003MS13-PS48F75Z



Read more

EMPOWERING YOUR IDEAS

Why the Materials Used in the Package are Becoming as Important as the Power Semiconductor Itself

As power semiconductors continue to advance, packaging technologies are increasingly determining how much of their potential can be realized in practical applications. In this interview Shinichiro Kitaoka, Product Manager, Silver-based Bonding Materials, TANAKA PRECIOUS METAL TECHNOLOGIES Co., Ltd., and Takekazu Tanaka, General Manager, Bonding Wire, TANAKA ELECTRONICS Co., Ltd., explain how bonding materials, interconnect technologies, and package design are evolving to meet the demands of SiC, GaN, EVs, industrial systems, and AI data centers, while highlighting the growing importance of reliability and system-level optimization.

*By Holger Moscheik, Publisher,
Bodo's Power Systems*

Holger Moscheik (HM): Many power electronics engineers focus primarily on the semiconductor die itself. Why should they pay more attention to packaging materials and bonding technologies?



Shinichiro Kitaoka

Shinichiro Kitaoka (SK): The semiconductor die is certainly at the center of power device performance, but the package determines how effectively that performance can be utilized in a real system.

As power density continues to increase, the electrical, thermal and mechanical stresses around the die become much more severe. Packaging materials and bonding technologies directly influence current carrying capability, heat dissipation paths, and long-term reliability. In this context, packaging is no longer just a passive structure. It is an essential performance enabler. Even if the semiconductor die itself has excellent characteristics, the overall system performance can be limited by the surrounding materials and interconnections. Therefore, engineers should evaluate the package and interconnect as an integrated part of system design from the early stage.

HM: As SiC and GaN devices continue to improve, where are today's packaging bottlenecks shifting?

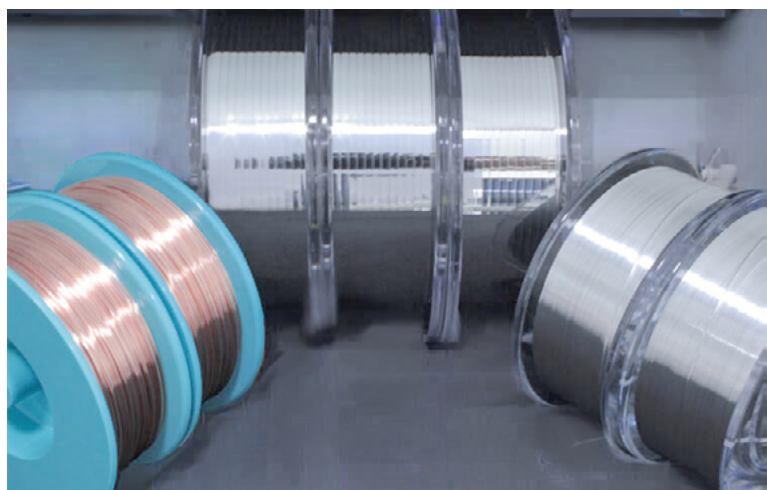
SK: As SiC and GaN technologies continue to mature, packaging and interconnect technologies are also evolving to meet their specific characteristics. Packaging approaches that were originally developed for silicon MOSFETs and IGBTs cannot always be applied directly to SiC and GaN devices. These wide bandgap devices have different electrical, thermal, and structural characteristics, which require optimized packaging solutions. In addition, the higher operating temperatures, switching speeds, and power densities associated with SiC and GaN can increase the demands placed on bonding wires, substrates, and interface materials. As a result, areas such as thermal management, parasitic effects, current handling capability, and long-term reliability are receiving increasing attention throughout the industry.



Takekazu Tanaka

HM: What are the key trade-offs between aluminum and copper bonding wires in modern power semiconductor packages?

HM: What are the key trade-offs between aluminum and copper bonding wires in modern power semiconductor packages?



Aluminum and Copper Bonding Wires and Ribbons for Power Devices
(Courtesy of TANAKA)

TANAKA's A: Aluminum and copper bonding wires each offer different advantages, and the optimal choice depends on the application. Aluminum wire has a long track record and provides stable processability, making it suitable for many established applications. Copper wire, on the other hand, offers significantly higher electrical and thermal conductivity. In practice, electrical resistance can be reduced by approximately 40% compared to aluminum, which enables higher current capability and improved electrical efficiency. This is especially important in high-power applications such as SiC-based modules. However, copper is approximately three times harder than aluminum, which increases the risk of chip damage during bonding. This often requires more robust chip metallization, leading to additional cost. At the same time, the higher mechanical strength of copper improves resistance to wire deformation and fatigue, and power cycling reliability can be enhanced significantly, often by an order of magnitude compared with conventional solutions. Therefore, the trade-off is not simply material selection, but a balance between electrical performance, process control, reliability, and overall system cost.

HM: Which failure mechanisms are becoming increasingly important in high-power applications such as EV traction inverters, industrial drives and data center power systems?

Takekazu Tanaka (TK): In high-power applications, thermal and mechanical stress-related failure mechanisms are becoming in-

creasingly important. These include wire lift-off, heel cracking, bond interface degradation, and metallization fatigue caused by repeated thermal expansion and contraction during power cycling.

As current density and temperature increase, these effects become more pronounced. In automotive applications, resistance to thermal cycling and vibration is critical, whereas in data center applications, stable operation under continuous high current becomes more important. Therefore, material optimization and bonding process control are essential to ensure long-term system reliability.

HM: How are SiC and GaN devices changing the requirements placed on packaging and interconnect materials?

TK: The increasing adoption of wide bandgap devices such as SiC and GaN is creating new opportunities for package and interconnect optimization. As device performance continues to improve, electrical losses within the package become increasingly important. This has increased interest in low-resistance interconnect technologies, including copper bonding wires, which can contribute to improved current carrying capability and lower electrical resistance. At the same time, different device technologies place different priorities on package design. For example, high-voltage applications may emphasize insulation and reliability, while high-frequency operation places greater importance on minimizing parasitic effects. In addition, reliability remains a key consideration across all applications. As packaging and interconnect technologies continue to evolve, material selection and package optimization are becoming increasingly application-dependent.

HM: Will traditional wire bonding remain dominant, or do you expect alternatives such as clip bonding and advanced interconnect concepts to gain market share?

TK: Wire bonding will continue to play a major role due to its maturity, flexibility, and cost-effectiveness. Alternative approaches such as clip bonding can provide very low resistance and inductance, but they typically involve more complex processing steps and reduced design flexibility. As a result, they are often limited to specific flagship or high-end applications. Therefore, rather than one technology replacing another, we expect multiple interconnect technologies to coexist. Wire bonding, in particular, will continue to evolve through improved materials and process technologies.

HM: AI data centers are creating unprecedented power demands. Are their packaging requirements different from those of automotive applications?

SK: There are clear differences between automotive and AI data center requirements, although both require high reliability and high efficiency. Automotive systems must withstand harsh environmental conditions such as temperature cycling and vibration, with long-term reliability as the highest priority. In contrast, AI data centers require extremely high-power density, continuous operation, and maximum efficiency, where even small improvements in electrical resistance can have a large system-level impact. Therefore, while automotive applications emphasize robustness, data centers emphasize efficiency and current capability.



*Silver Sintering paste for Die-bonding
(Courtesy of TANAKA)*

HM: What is one packaging-related aspect that design engineers often underestimate during the early stages of system development?

SK: One often underestimated aspect is the relationship between material selection and long-term reliability. Engineers tend to focus on device performance and electrical rating in the early design stage, but the final system reliability is strongly influenced by how different materials interact under thermal and mechanical stress. In particular, bonding wires should not be expected to contribute significantly to heat dissipation. Thermal performance is mainly determined by the die attach and substrate structure. Technologies such as transient liquid phase (TLP) bonding and sintered silver offer advantages in this area, as they form stable intermetallic structures with high thermal conductivity. TLP bonding also avoids issues such as chip tilt seen in liquid-phase soldering processes, contributing to improved reliability. Therefore, packaging and material considerations should be integrated from the very early stage of system development.

HM: I would like to thank TANAKA for taking the time to share their expertise and valuable insights with our readers. It was a pleasure discussing the future of power semiconductor packaging and interconnect technologies with their team.

<https://tanaka-preciousmetals.com>

LET ITG POWER UP YOUR POWER SUPPLY SYSTEMS

**PFC CHOKES FROM ITG.
REVOLUTIONIZE YOUR POWER.**

Power up your power systems with ITG PFC Chokes. Our chokes are hi-efficiency, space-saving, and provide industry leading power density. ITG delivers performance-driven solutions to meet your specific requirements, and a range of options for different applications. Transform your magnetics!

Engineering Electronics Partnership since 1963



Trusted Innovation
Magnetics & EMI Filters

www.ITG-Electronics.com



Scan for more information

From Grid to GPU: Enabling Multi-Megawatt SST Architectures with High-Current SiC Power Modules

AI-driven data centers require power-supplies with high efficiency, power density, and reliability. Solid-State-Transformer (SST) architectures based on SiC power modules enable direct conversion from 34.5 kV medium-voltage grids to 800 V and future 1500 V data center DC-infrastructure. This article highlights how high-power SSTs and high-current, highly reliable SiC modules can support multi-megawatt hyperscaler applications while improving efficiency and the key AI performance metric: “Tokens per Second per Megawatt.”

*By Narender Lakshmanan, Karthik Debbadi and Nils Soltau,
Mitsubishi Electric Europe B.V. (based in Ratingen, Germany)
and Ryo Tsuda, Mitsubishi Electric Power Devices (based in Fukuoka, Japan)*

The electricity demand of datacenters is set to increase by at least two fold until 2030 [1]. Moreover, large scale data centers (Hyperscalers) will be a key driver for the overall electricity demand [2]. Today, 72% of the datacenters have a power demand of more than 50 MW [3] and blueprints for 100 MW installations are available [4]. Trends indicate that future Hyperscalers demand power in the GW range [5].

Today, electrical power and the connection to the electricity grid is considered to be the ultimate constraint for AI infrastructure [6]. Therefore, “performance per Watt” or “Tokens per Second per Megawatt” are considered key indices for evaluating AI throughput. AI infrastructure is power hungry, and any improvement in efficiency translates into “tokens” and finally into revenue. Considering the trajectory of power demand for AI infrastructure and the improvements to “Tokens per Second per Megawatt”, it can be summarized that power supply for AI infrastructure will require solutions which can innovatively combine high power densities and high operational efficiency while maintaining a certain level of modularity to scale output power.

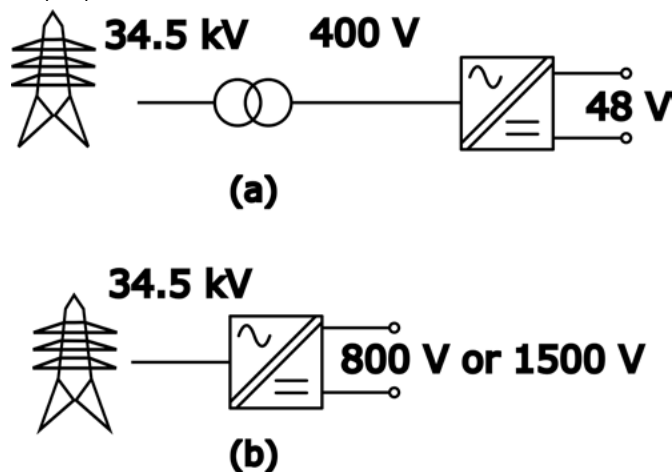


Figure 1: (a) Conventional approach with Low Frequency Transformer (LFT) and multi-stage AC to DC conversion at low voltage with isolation. (b) SST based power delivery to datacenter at DC-voltages of 800 V or 1500 V.

From LFT to SST

As illustrated in Figure 1, the power architecture to supply the server racks has transitioned from a 48 V DC-bus to 800 V. Referring to Figure 1 (b), an AC-to-DC conversion stage is employed with galvanic isolation to energize the 800 V DC-bus directly from the 34.5 kV distribution network. Such a power-conversion system is commonly referred to as Solid-State-Transformers (SST). Replacing the conventional system, based on low frequency transformers (LFT), with an SST offers several advantages especially including higher efficiency, increased power density, and enhanced design flexibility and modularity [7]. Particularly, modular SST architectures are considered attractive for Hyperscalers due to their scalability and suitability for multi-megawatt power levels [8]. The power supply architecture can be developed using multiple AC/DC and isolated DC/DC conversion cells (refer to Figure 2).

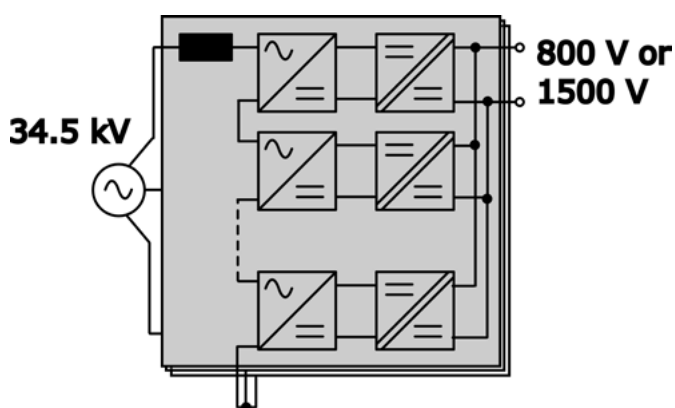
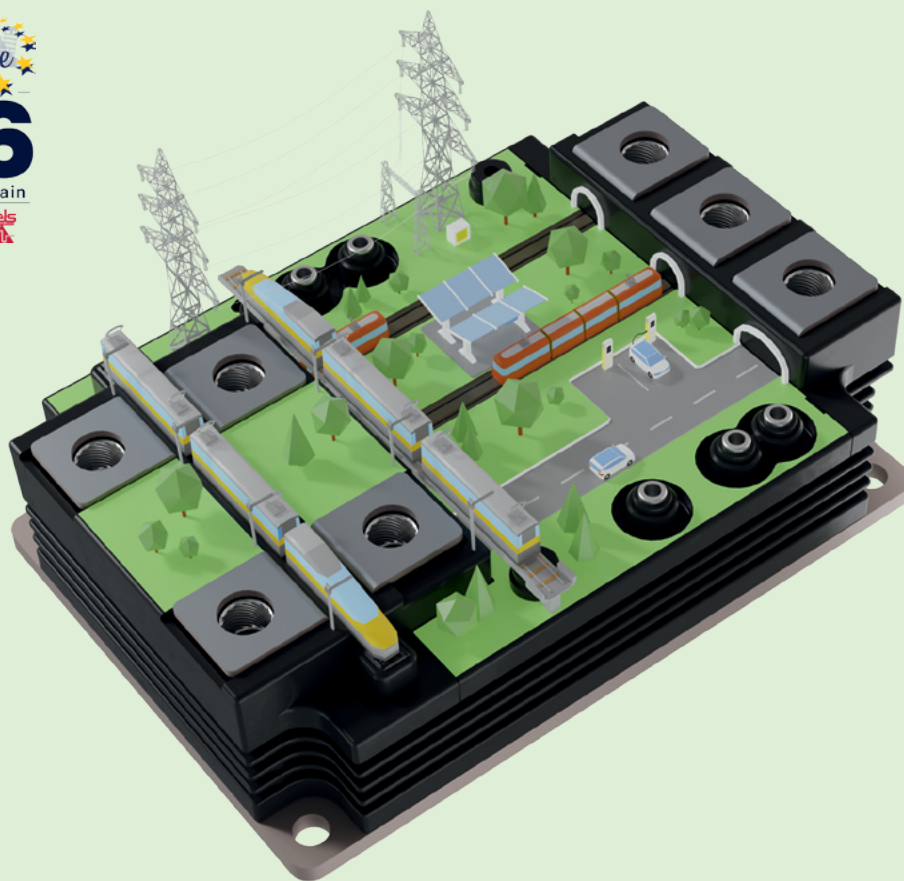


Figure 2: Simplified SST architecture with multiple cells being connected in series at their input.

Topologies and Solutions

Today 800 V DC-bus systems are state-of-the-art for server-rack supply. However, motivated by the significant increase in power demand, higher system voltages like 1500 V are being discussed [9]. For PV inverters and battery-energy-storage systems, 1500 V is the widely accepted DC-voltage level as it represents the upper-limit of the European Low Voltage Directive (IEC). In the following, both, the 800 V and 1500 V use cases shall be analyzed in more details.



YOU CAN BUILD ON IT.

POWER SEMICONDUCTORS
FOR CLEAN TECHNOLOGIES

LV100 High Voltage Power Modules

- // Standardised dual packages with 6 kV and 10.2 kV insulation voltage
- // IGBT chips with latest generation CSTBT™ technology and RFC diodes
- // Robust main terminals suitable for doubling the rated module current in case of using SiC-chips
- // High power density and low thermal resistance by new MCB (Metal Casting direct Bonding) technology
- // High robustness / resistance against environmental influences due to the newly developed SCC (Surface Charge Control) process
- // Option of Unifull™ SiC MOSFET with embedded SBD for 91 % switching loss reduction compared to a Si power module

More Information:

semis.info@meg.mee.com

www.meu-semiconductor.eu



Experience the Unifull™
SBD-embedded SiC-MOSFET
for superior power, efficiency
and reliability

The focus of the evaluation is limited to the isolated DC-to-DC conversion stage inside each cell of the SST. In this example, a dual-active bridge topology is considered as depicted in Figure 3. At the input side, which is connected via an AC/DC converter to the medium-voltage distribution network, 1800 V DC-link voltage is considered. Due to the comparable high operating voltage, grid voltages like 34.5 kV can be achieved with a reasonable number of cells, which limits system complexity. In the following analysis, 16 cells are considered per phase.

800 V DC-voltage output system

For the isolated DC/DC converter from 1800 V to 800 V, the considered Mitsubishi Electric SiC MOSFET power modules are for the primary side the FMF800DC-66BEW (3.3kV/800A) in the LV100 housing, and for the secondary side the FMF600DXE-24BN (1.2kV/600A) in the NX housing with 2 devices in parallel. The operating conditions are listed in Table 1. The virtual junction temperature is estimated on the devices based on liquid cooling with the thermal resistances from heatsink to water of around 16 K/kW and 30 K/kW for LV100 and NX packages, respectively. The remaining parameters are taken from datasheets.

Switching frequency f_c	10	kHz
Output power P_{out}	550	kW
DC input voltage V_{in}	1800	V
DC output voltage V_{out}	800	V
Turns ratio N	2.25	
Stray inductance L_σ	25	μ H
Water temperature T_W	40	$^{\circ}$ C
Primary side power module	FMF800DC-66BEW	
Secondary side power module	FMF600DXE-24BN	

Table 1: Simulation conditions for a power supply system with a DC voltage output of 800 V.

As shown in Figure 4, for the operating conditions in Table 1, the maximum virtual junction temperature of the primary side and secondary side power modules reaches 127 $^{\circ}$ C and 150 $^{\circ}$ C, respectively.

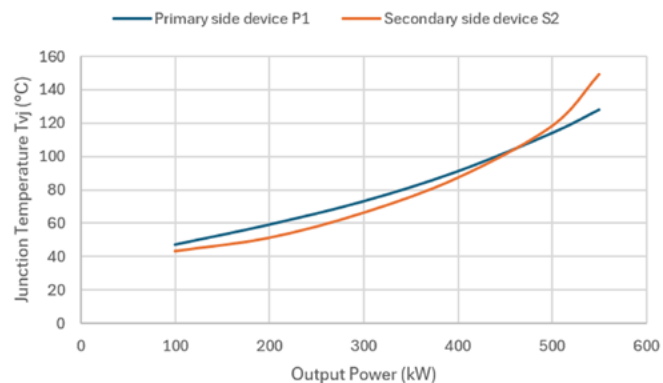


Figure 4: Simulation results showing maximum output power versus maximum junction temperature of the power module for DC-output = 800 V.

1500 V DC-voltage output system

For the isolated DC/DC converter from 1800V to 1500V, the considered Mitsubishi Electric SiC MOSFET power modules are, for the primary side the 2 FMF800DC-66BEW in parallel, and for the secondary side the 2 FMF1600DC-50CW (2.5 kV/1600 A) in parallel.

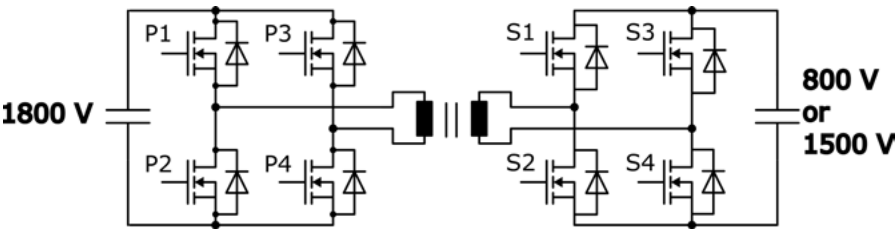


Figure 3: SST solution based on a Dual-Active-Bridge topology.

Both devices use the LV100 housing. Table 2 shows the operating conditions. The virtual junction temperature is estimated on the devices based on liquid cooling with the thermal resistances from heatsink to water as around 16 K/kW for the LV100 devices. The remaining parameters are taken from datasheets.

Switching frequency f_c	10	kHz
Output power P_{out}	1.3	MW
DC input voltage V_{in}	1800	V
DC output voltage V_{out}	1500	V
Turns ratio N	1.2	
Stray inductance L_σ	5	μ H
Water temperature T_W	40	$^{\circ}$ C
Primary side power module	FMF800DC-66BEW	
Secondary side power module	FMF1600DC-50CW	

Table 2: Simulation conditions for a power supply system with 1500V_{DC} output.

As shown in Figure 5, for the operating conditions in Table 2, the maximum virtual junction temperature of the primary side and secondary side power modules reaches 136 $^{\circ}$ C and 150 $^{\circ}$ C, respectively.

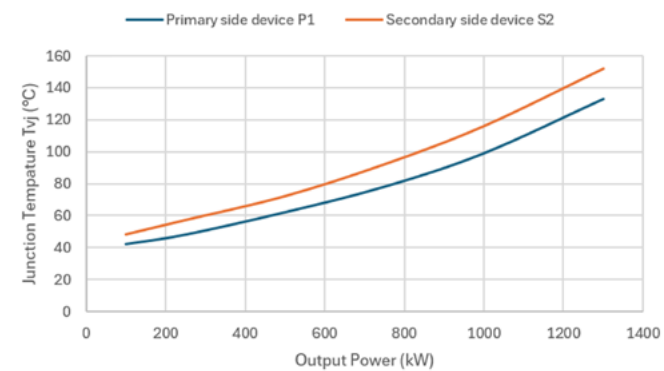


Figure 5: Simulation results showing maximum output power versus maximum junction temperature of the power module for DC-output = 1500 V.

The simulation results show that 550 kW and 1.3MW are realistic targets for a 800 V and 1500 V system. As stated above, for the connection to the 34.5kV distribution network, 16 cells are considered per phase, resulting in 48 cells for the three phases. Delivering 1.3MW per cell using Mitsubishi Electric SiC power modules results in a system output power of 62 MW. It becomes evident that high-power SST and high-current SiC power modules are the crucial components to current data center power requirements of 50MW and higher. At the same time they are providing a scalable path to support future growth and improving “Tokens per Second per Megawatt”.

„WHERE INNOVATION GOES IN SERIES: GVA”

Our Development, Production and Quality departments are separated by one floor and two flights of stairs – nothing else. Because all GVA experts share the same systemic understanding and the latest know-how. That’s why we are able to mass-produce innovative developments in the shortest possible time. With guaranteed quality – and gladly also for you!



Your GVA expert:
Daniel Bonanno
+49 (0)621 / 78992-27
d.bonanno@gva-power.de



Power modules considered in this analysis

The primary side requires power modules with 3.3 kV SiC MOSFETs while the secondary side power modules are either 1.2 kV SiC MOSFETs for 800V output or 2.5 kV SiC MOSFETs for the 1500V output. Each power module is a half-bridge consisting of 2 switches in a package. While the 1.2 kV power module is available in the NX housing, the 2.5 kV and 3.3 kV power modules are available in the LV100 housing.

1.2 kV SiC MOSFETs

Power module package compatibility is a key aspect which system designers need to consider when new solutions are being developed. Widely utilized conventional packages have been developed based on Si IGBT devices, and incorporating SiC devices in these conventional (but widely accepted) packages are challenging. SiC MOSFETs switch faster than Si IGBTs and require special power module design consideration with regards to internal current balancing of parallel connected MOSFET dies and overall internal parasitic inductance. The NX package is a widely adopted power module housing for several applications including uninterruptible power supplies, photovoltaic, battery storage systems and motor drives for output power in the range of several hundred kilowatts. A usual disadvantage of a conventional NX package is its high internal parasitic inductance in the range of 15 to 20 nH. The reason for this is the layout of the chips and the internal busbar design. High internal inductance presents a challenge for SiC adoption as it prevents the user from taking advantage of high switching speeds.

The special NX module for SiC adoption

This problem was solved by introducing a special NX module (Figure 6) designed for SiC adoption [10]; its internal busbars are organized in a laminated structure (Figure 7). The SiC MOSFET dies were internally placed for optimum current sharing. The overall parasitic inductance of the NX SiC module is about 9 nH. The package utilizes an AlN ceramic substrate and offers 4 kV of isolation between the terminals and the baseplate.



Figure 6: SiC MOSFET power module FMF600DXE-24BN in the NX package.

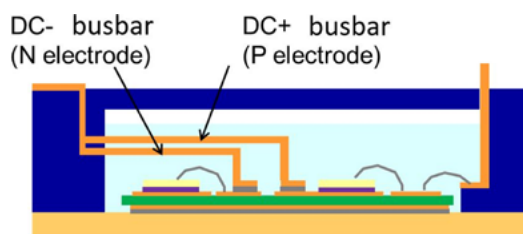


Figure 7: Cross-section of the NX SiC power module showing laminated busbar design.

The NX SiC modules are currently available in the ratings of 1.7 kV / 600 A (FMF600DXE-34BN) and 1.2 kV / 600 A (FMF600DXE-24BN) and are provided with the second generation Mitsubishi SiC chip technology. The low inductance package design allows the user to extract maximum performance from the advanced second generation (G2A) SiC MOSFET chips.

The simulation results in Figure 4 indicate that the secondary side device FMF600DXE-24BN is the thermal bottleneck. By utilizing power modules with lower $R_{DS(on)}$ and higher current rating, it is possible to extend the overall output of the power stage.

Referring to Table 3, the NX SiC power module line-up is being extended towards higher current ratings. Additionally, a new chip generation (G2B) is also under development to further optimize overall electrical performance (refer to Figure 8).

Rating	$R_{DS(on)}$ [mΩ] at 150 °C	Status	Chip Technology
1.2 kV / 600 A	2.68	Mass production	G2A SiC
1.2 kV / 600 A	2.4	Under development	New G2B SiC
1.2 kV / 800 A	1.8		
1.2 kV / 1000 A	1.43		

Table 3: Line-up of the 1.2 kV NX SiC power modules currently under development.

Reliability of SiC power modules

While power density and efficiency play a direct role in determining the revenue generation capability of the installed AI infrastructure, reliability and preventing down-time due to failures is an often-overlooked aspect in the overall cost-benefit calculation. There are several known degradation modes for SiC MOSFETs. The stability of the $V_{GS(th)}$ is one key aspect, and Mitsubishi SiC power modules have demonstrated good $V_{GS(th)}$ stability (refer to Figure 9). Another topic which is important for long term is the so called "bipolar-current-degradation" [11]. Referring to Figure 10, it can be understood that, for 5 % increase in $V_{DS(on)}$, the estimated probability at the module level is about 100ppm, indicating robustness towards bipolar current degradation.

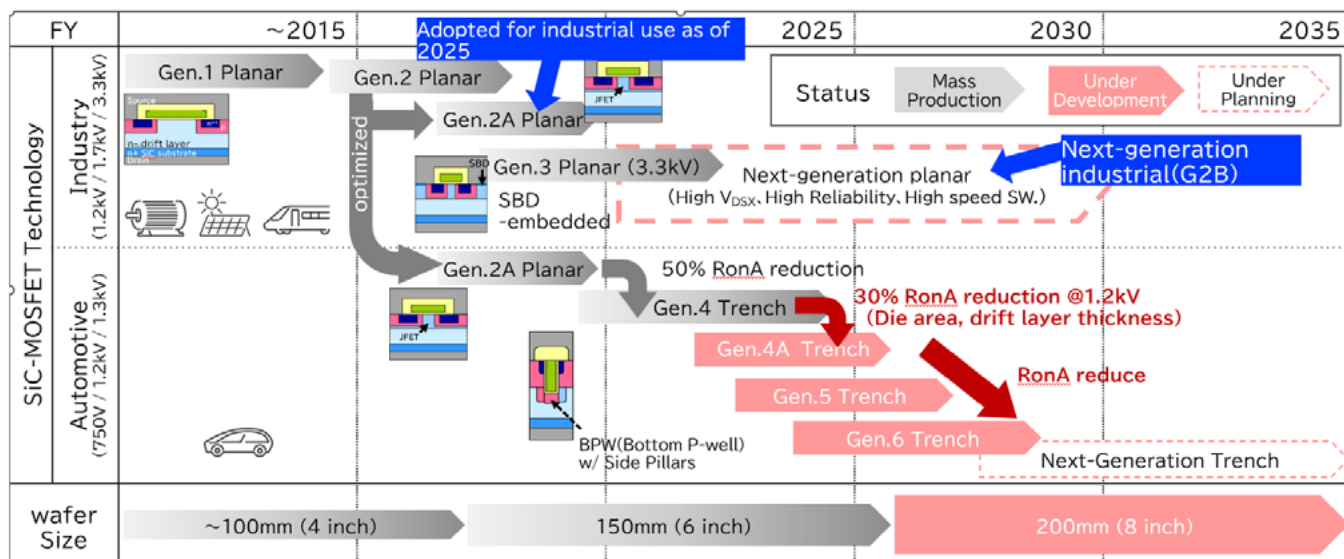
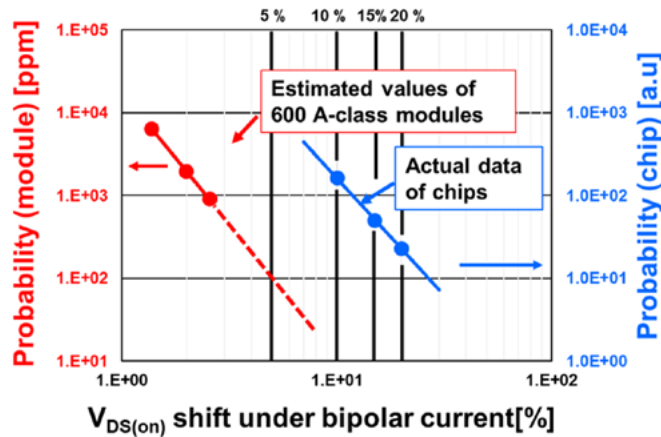
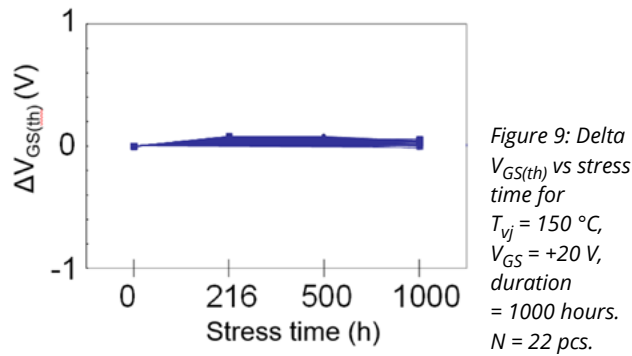


Figure 8: SiC Chip technology roadmap.



2.5 kV and 3.3 kV SiC MOSFETs

Table 4 presents the line-up of the 2.5 kV and 3.3 kV SiC power modules which are applicable for the datacenter power supply application. The devices are available in the LV100 package (refer to Figure 11), which is accepted as the industry standard for high power applications. The LV100 modules are widely adopted in megawatt level PV, BESS applications as well as traction applications. The LV100 package was developed considering SiC adoption for high power applications and is therefore already optimized with regards to internal busbar layout and the internal chip placement. The LV100 module shown in Figure 11 utilizes an AlSiC baseplate for high thermal cycling capability and has an isolation voltage of 6 kV between terminals and baseplate. Table 4 shows the line-up of the available SiC LV100 modules.



Figure 11: The LV100 package for the FMF1600DC-50CW and FMF800DC-66BEW.

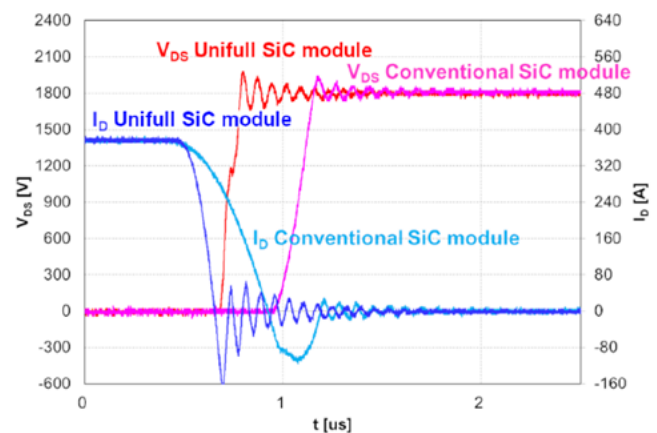
The 2.5 kV / 1600 A SiC LV100 (FMF1600DC-50CW) has been specifically developed for PV and BESS applications requiring 1.5 kV DC-link. For such applications, the best trade-off between cosmic ray FIT and electrical loss performance is required while maintaining sufficient margin for switching over voltages, which is relevant while utilizing SiC high switching speed operation. Since the module utilizes the latest G2B SiC chip technology, it is optimized for best electrical loss performance (R_{rr} reduction using proton irradiation), and the module has a target FIT of less than 100 for 1500 V.

Type Name	Blocking Voltage [V]	Rated Current [A]	$R_{DS(on)}$ at 150 °C [mΩ]
FMF1600DC-50CW	2500	1600	1.75
FMF200DC-66BE	3300	200	17.25
FMF400DC-66BEW	3300	400	8.63
FMF800DC-66BEW	3300	800	4.31

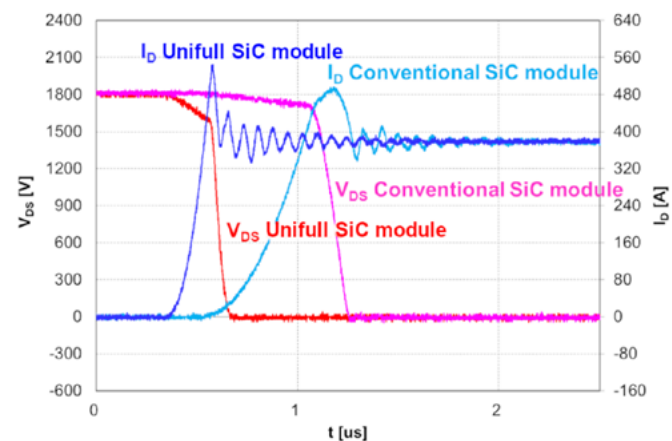
Table 4: The line-up of the 2.5 kV and 3.3 kV SiC LV100 modules.

3.3 kV SiC MOSFET

In 2024, Mitsubishi Electric has released the Unifull™ SiC power modules with embedded Schottky Barrier Diode (SBD) [12][13]. The embedded SBD effectively solves the issue of bipolar degradation by deactivating the internal body diode of the SiC MOSFET. Furthermore, as the body diode is deactivated, Unifull SiC power modules have no reverse recovery losses and reduced turn-on losses. Exemplary switching waveforms shown in Figure 12 demonstrate the absence of recovery charge and the higher switching speed of the Unifull power modules. Overall, switching losses of Unifull 3.3 kV SiC MOSFETs are reduced by 58 %, compared to the previous 3.3 kV SiC generation as shown in Figure 13.



(a) diode reverse recovery



(b) MOSFET turn on

Figure 12: Switching waveform comparison between conventional 3.3 kV SiC MOSFET (FMF375DC-66A) and Unifull™ 3.3 kV SiC MOSFET (FMF400DC-66BEW).

Mitsubishi Electric has specially developed Unifull 3.3 kV SiC power modules for high reliability applications like railway traction and grid applications. 6 kV isolation voltage and partial-discharge free design according to IEC 61287-1 make this device suitable for direct operation at the high-voltage electricity grid. In case of unforeseen events, surge current and I_{t} values are specified with 5.9 kA and 180 kA²s, respectively.

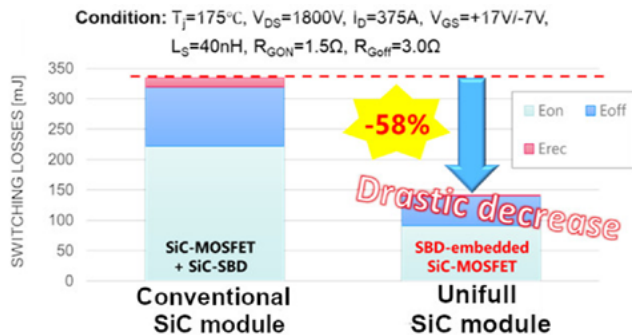


Figure 13: Switching loss reduction of Unifull™ 3.3 kV SiC MOSFET (FMF400DC-66BEW) compared to conventional 3.3 kV SiC MOSFET (FMF375DC-66A).

Unifull power modules use sintering to attach the SiC dies to the substrates. This increases the power-cycling capabilities compared to conventional soldering technology. To provide even higher power-cycling capability for especially demanding applications, Unifull™ Plus technology has been developed [14] recently. As visualized in Figure 14, enhance bond-wire material and chip metallization is utilized for Unifull Plus. Measurements confirm that Al-alloy wire and enhanced metallization achieve approximately 5 times higher power-cycling capabilities than the original Unifull bond-wire material (refer to Figure 15).

High efficiency, fast switching speed and high ruggedness make Unifull Plus power modules especially suitable for SSTs with direct grid connection.

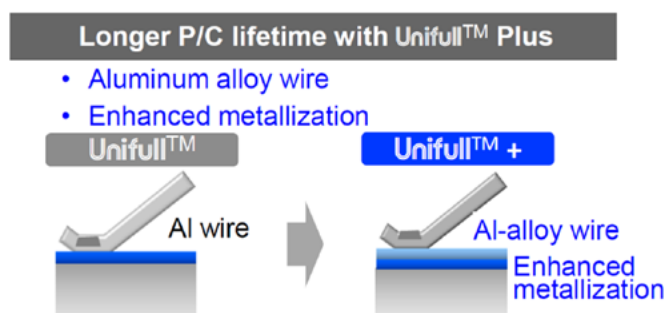


Figure 14: Unifull™ Plus uses enhanced bond wire and chip metallization to increase power-cycling capabilities.

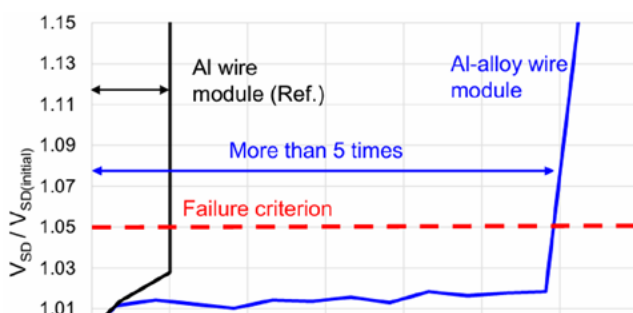


Figure 15: Al-alloy wire and chip metallization, as used in Unifull™ Plus technology, allow 5 times longer power-cycling-lifetimes.

Conclusion

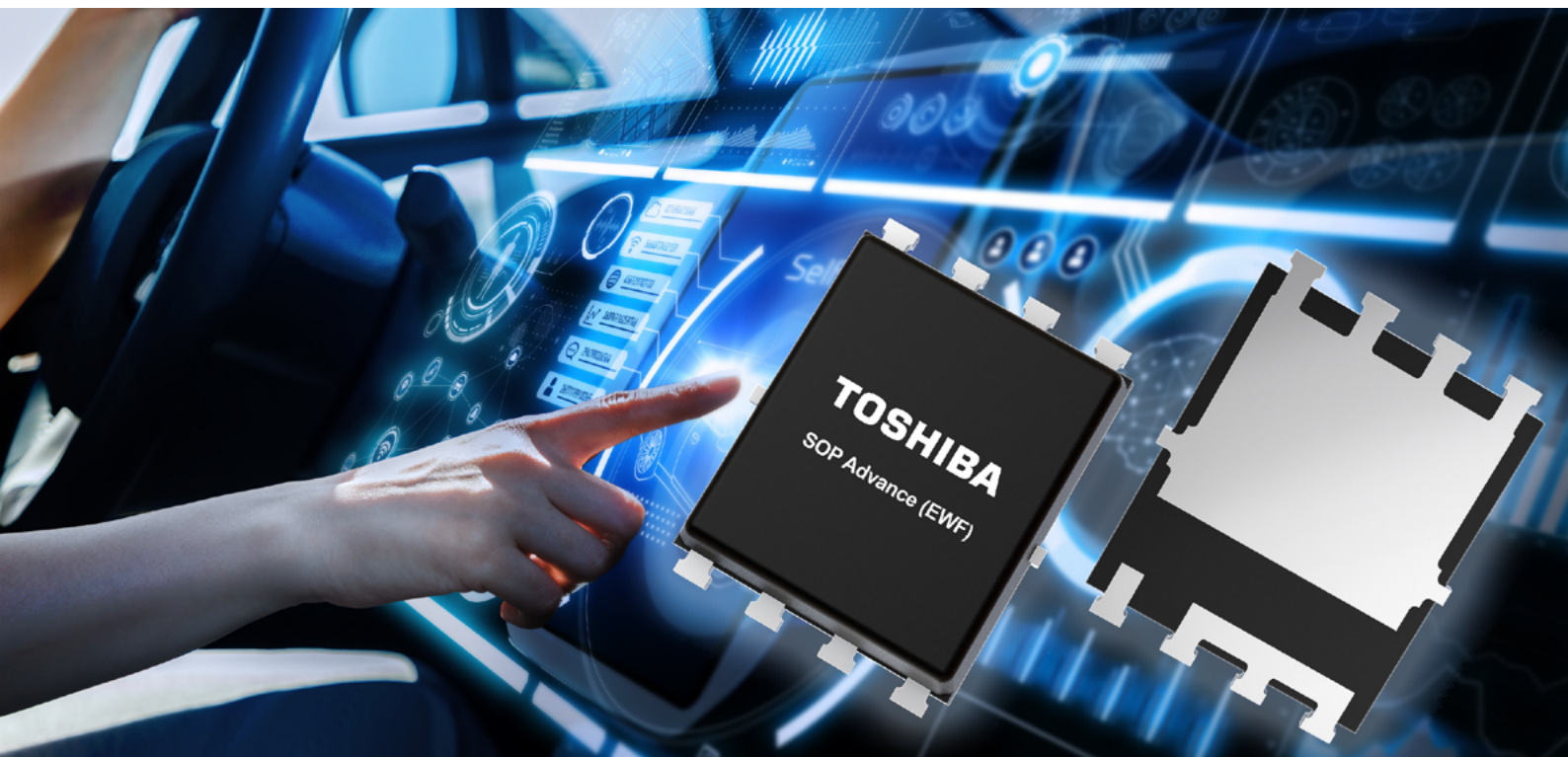
AI-driven datacenters require power-supply solutions that combine high efficiency, power density, scalability, and reliability. SST architectures based on SiC power modules can achieve these requirements, while allowing direct conversion from the medium-voltage distribution network to 800V and future 1500V DC datacenter infrastructures while supporting these requirements.

The analysis shows that 550 kW and 1.3 MW are realistic targets for 800V and 1500V SST cells, respectively. For a 34.5 kV distribution network considered in this work, the resulting SST can achieve more than 60 MW of power capability. High-power SSTs utilizing high-current SiC power modules therefore represent a scalable solution for current and future hyperscale datacenters while improving the key AI efficiency metric: "Tokens per Second per Megawatt."

References:

- [1] IEA (2025), Energy and AI, IEA, Paris <https://www.iea.org/reports/energy-and-ai>, Licence: CC BY 4.0
- [2] AI power: Expanding data center capacity to meet growing demand, McKinsey & Company, March 25, 2026.
- [3] Bloom Energy, 2026 Data Center Power Report: When Power Defines Growth: How Power Availability Is Reshaping the Data Center Industry, Bloom Energy, Jan. 2026. [Online]. Available: <https://www.bloomenergy.com/wp-content/uploads/2026-power-report.pdf>. Accessed: Jul. 30, 2026
- [4] Siemens, Report "DATA CENTERS 100 MW Hyperscale AI Blueprint", URL: https://assets.new.siemens.com/siemens/assets/api/uuid:ccfd2c1e-4e8b-423c-bec3-17333e651cde/Data-Center-Reference-Architectures-100MW-Blueprint_original.pdf
- [5] Deloitte, Article "AI data centers jolt power demand", URL: <https://action.deloitte.com/insight/4718/ai-data-centers-jolt-power-demand>
- [6] Scaling Token Factory Revenue and AI Efficiency by Maximizing Performance per Watt, NVIDIA. URL: <https://developer.nvidia.com/blog/scaling-token-factory-revenue-and-ai-efficiency-by-maximizing-performance-per-watt/>
- [7] Predescu, D.-M.; Roşu, Ş.-G. Solid State Transformers: A Review—Part I: Stages of Conversion and Topologies. *Technologies* 2025, 13, 74. <https://doi.org/10.3390/technologies13020074>
- [8] J. Huber and J. W. Kolar, "Next-Generation Solid-State Transformers for Powering Artificial Intelligence Data Centers: A Survey of Emerging Topologies," in *IEEE Industrial Electronics Magazine*, vol. 20, no. 2, pp. 42-54, June 2026, doi: 10.1109/MIE.2026.3684540.
- [9] Open Compute Project, Report "Data Center Facility – Low Voltage Direct Current Power Distribution", 30 March, 2026. URL: <https://www.opencompute.org/documents/dcf-power-distribution-lvdc-white-paper-version-1-0-final-pdf-1>
- [10] R. Goto, Y. Miyazaki, N. Lakshmanan, K. Masuda and E. Motto, "Advanced PKG technology for SiC in the NX Package," *PCIM Europe 2023; International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management*, Nuremberg, Germany, 2023, pp. 1-6, doi: 10.30420/566091120.
- [11] K. Ishibashi et al., "Prediction of the Bipolar Degradation in 1200V 4H-SiC MOSFETs by Inspection in Device Fabrication Process," *PCIM Europe 2023; International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management*, Nuremberg, Germany, 2023, pp. 1-5, doi: 10.30420/566091021.
- [12] N. Soltan, D. He, R. Tsuda, and S. Yamamoto, "How a Unifull SiC Power Module Reduces Carbon Emissions in the Transportation Sector," *Bodo's Power Systems*, September 2024, pp. 16-21
- [13] Y. Hironaka, S. Okimoto, M. Matsuo, S. Saito, K. Hatori and N. Soltan, "3.3 kV SBD-Embedded SiC-MOSFET Module for Traction Use," *PCIM Europe, Nuremberg, Germany, 2024*, pp. 699-706
- [14] D. Yoshio et al., "Investigation of Power Cycling Lifetime: Extension from Si to SiC and Enhancement of SiC Module Lifetime by Advanced Materials," 2025 Energy Conversion Congress & Expo Europe (ECCE Europe), Birmingham, United Kingdom, 2025

Next Generation MOSFET Packaging



Toshiba's new SOP Advance(EWF) package for Automotive MOSFETs improves product on-resistance performance by increasing the mountable chip size and reducing package resistance.

Package highlights

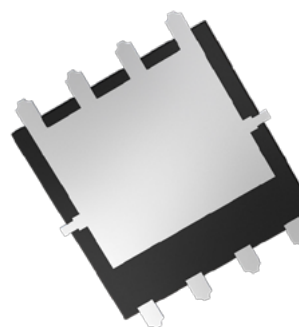
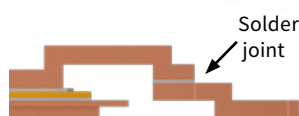
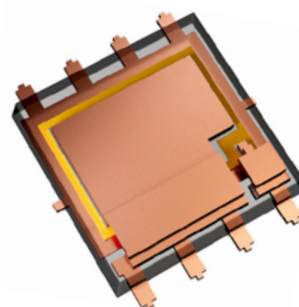
- 38% reduction in channel-to-case thermal impedance ($Z_{th(ch-c)}$) vs. SOP Advance(WF)*
- Reduced package resistance achieved through improved post structure and source terminal design
- 20% Improvement in drain-current (I_D) rating vs. SOP Advance(WF)*
- Enlarged mountable chip size and improved chip bed frame design
- Compatible with SOP Advance(WF) and other popular 5 x 6mm packages

Featured products with 40V drain-source (V_{DS})

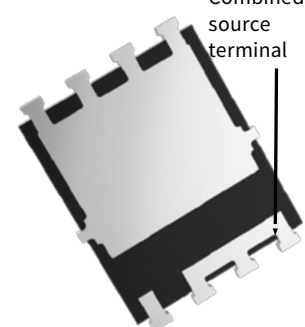
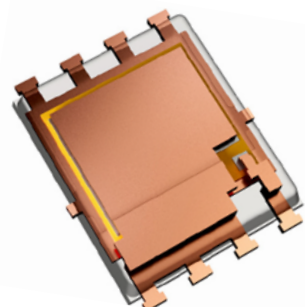
Part number	Drain current I_D	Drain source on-resistance (Max) $R_{DS(ON)}$
XPMR5904PB	180A	0.59m Ω
XPMR7004PB	160A	0.70m Ω
XPMR8504PB	140A	0.85m Ω

* Comparison between current XPHR7904PS and the new XPMR5904PB

Current SOP Advance(WF)



New SOP Advance(EWF)



High-Frequency 100 V GaN Motor Drives Push Low-Voltage Motion Control to the Next Level

100 V GaN motor drives enable high-frequency switching up to 100 kHz, delivering greater efficiency, power density, dynamic response, and lower noise than silicon-based designs. Integrated sensing, optimized dead-time control, and robust thermal performance make them well-suited for robotics, automation, drones, and precision motion systems. Two evaluation boards facilitate the design process.

By Maurizio Di Paolo Emilio, Marcom Director, and Marco Palma, Vice President of Motor Drive Marketing and System Engineering, Efficient Power Conversion (EPC)

Rapid growth in industrial automation, collaborative robots, autonomous mobile robots (AMRs), drones, and precision servo systems is driving the need for a new generation of low-voltage motor drives to deliver higher efficiency, greater power density, and improved dynamic performance. In the past, silicon MOSFETs were the most common switching technology for this voltage range, but nowadays, gallium nitride (GaN) power devices enable inverter architectures that can operate at much higher switching frequencies, improving motor efficiency without the efficiency penalties traditionally associated with silicon.

Motor drive design requirements are different from data center power converters, as they must simultaneously optimize several performance parameters. In addition to efficiency, design optimization must also account for low torque ripple, low acoustic noise, high current-loop bandwidth, low electromagnetic interference (EMI), complex thermal management, and overall reduced system size. Recent 100 V GaN power stages show the possibility to simultaneously meet these objectives by carefully optimizing the power devices as well as the surrounding system architecture.

This evolution is exemplified by evaluation platforms like the EPC91124 and EPC91125. Based on the latest generation of 100 V enhancement-mode GaN FETs, these three-phase BLDC inverter platforms run from 18 V to 80 V, allow PWM frequencies up to 100 kHz (150 kHz maximum), and offer continuous phase currents of 30 to 35 A_{RMS} depending on the power stage selected. Rather than just power boards, they are a small development platform for evaluating high-performance motor control, integrating gate drivers, sensing circuitry, house-keeping power supplies, and controller interfaces.

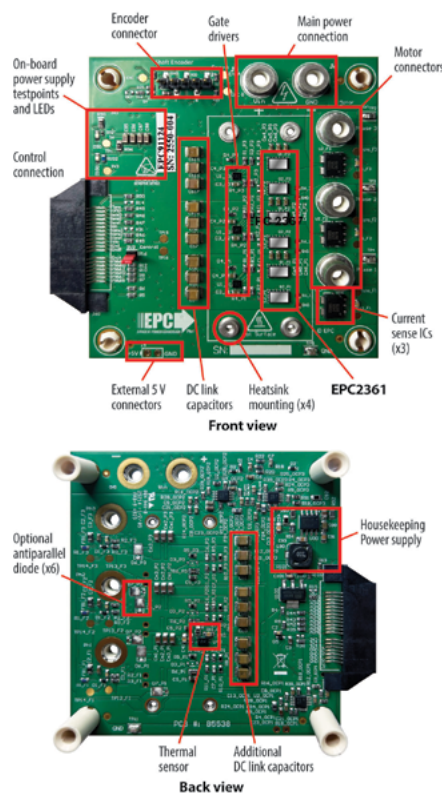


Figure 1: Photo overview of the EPC91124 evaluation board highlighting the main sections.

Moving Beyond the 20 kHz Barrier

Most industrial motor drives continue to operate at switching frequencies between 10 and 20 kHz because switching losses increase rapidly in silicon MOSFETs as frequency rises. Although this operating range is well established, it imposes several compromises. Larger magnetic components and DC-link electrolytic capacitors are required, current ripple increases, control bandwidth is limited, and audible motor noise often remains within the human hearing range.

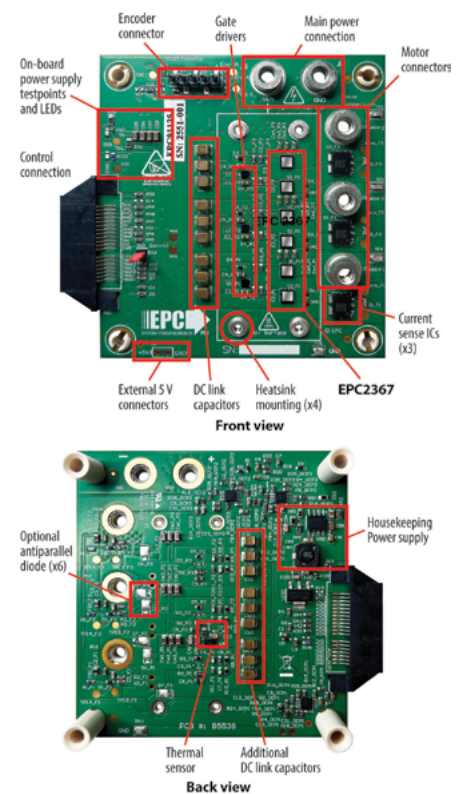
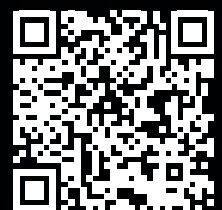


Figure 2: Photo overview of the EPC91125 evaluation board highlighting the main sections.

GaN devices substantially change this design tradeoff. Thanks to their extremely low gate charge and output capacitance, 100 V eGaN FETs enable efficient operation at PWM frequencies around 100 kHz, allowing designers to reduce passive component size while improving current regulation and transient response. Higher switching frequencies improve the motor efficiency by reducing the phase-current ripple, lowering torque ripple and acoustic emissions—important characteristics in collaborative robots, precision servo drives, medical equip-

Redefine what's possible in battery management

Learn how EIS is enabling the future of battery monitoring



ment, and high-speed industrial automation. GaN allows designers to improve overall system performance, increasing efficiency while simultaneously reducing inverter size.

Optimizing Switching Speed for Motor Drives

One of the most prevalent misconceptions in GaN technology is that switching transitions should always be as fast as possible. Indeed, controlled switching speeds (dv/dt less than 10 V/ns) are used in motor drive applications with optimal results.

Very fast voltage transitions (dv/dt higher than 50 V/ns) may cause higher common mode currents through motor cables and bearings, resulting in electromagnetic compatibility problems and potential winding insulation failure resulting in a short circuit. Thus, practical GaN motor drive designs often deliberately reduce the switching voltage slopes.

The inverter platforms discussed here are designed to exhibit dv/dt values below about 10 V/ns, which is a good compromise between efficiency and EMI performance.

Integrated Measurement and Control

As switching frequencies increase, accurate sensing becomes increasingly important. High-bandwidth current feedback is essential for implementing field-oriented control (FOC), and advanced torque-control algorithms.

Both inverter platforms integrate current sensing on all three phases using Hall-effect sensors with a 13.2 mV/A sensitivity, 250 kHz bandwidth, and a measurement range of approximately ± 125 A, allowing accurate current reconstruction at elevated switching frequencies. Voltage monitoring is provided for all motor phases and the DC bus through resistor-divider networks with a gain of 29.22 mV/V, while analog outputs remain within the standard 0–3.3 V range used by modern microcontrollers.

The boards integrate three-phase voltage sensing, DC bus voltage monitoring, onboard temperature sensing, regulated 5.2 V and 3.3 V housekeeping power supplies, quadrature encoder / Hall-sensors interface, under-voltage protection and comprehensive test points for power-stage characterization.

The controller logic interface accepts standard 3.3 V PWM input signals, features approximately 50 ns propagation delay, and supports minimum input pulse widths of 120 ns, making it suitable for high-frequency digital motor-control implementations.

An additional advantage is compatibility with several widely used controller ecosystems, including Microchip dsPIC, Texas Instruments C2000, STMicroelectronics STM32, and Renesas RAX platforms, allowing engineers to evaluate identical power hardware using different digital control strategies.

Dead-Time Optimization Becomes More Important

Migrating from silicon MOSFETs to GaN does not only mean replacing the switching devices. In conventional Si-inverters relatively long dead-times are used to avoid cross-conduction. Long dead-times are safe but increase reverse-conduction losses and cause waveform distortion.

GaN devices do not have an intrinsic body diode, enabling the dramatic reduction of dead-times as they can conduct reverse current. Values of about 50 ns minimize reverse-conduction losses and improve phase-current quality at the same time.

Interestingly, the inverter platforms have optional antiparallel silicon diodes. These are not required for normal operation of GaN but provide additional protection when designers accidentally evaluate the board with firmware originally designed for silicon MOSFET inverters that employ longer dead times. This design decision highlights one of the practical considerations in GaN adoption: best performance depends on hardware choice as much as on firmware optimization.

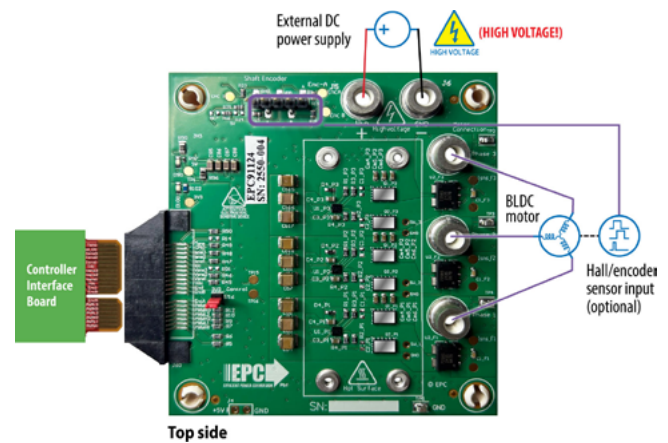


Figure 3: Connection diagram of the EPC91124 configured as a motor drive inverter.

Thermal Performance Under Dynamic Conditions

Rarely are operating conditions of modern robotic or industrial systems described only by continuous current ratings. Motion control applications often face fast-changing load profiles, including acceleration, deceleration, and short torque peaks. The evaluation platforms have been thermally characterized in real operating conditions with a 48 V_{DC} supply, 100 kHz PWM frequency, 50 ns dead time, and at 26 °C ambient temperature.

The higher-current platform is capable of ~30 A_{RMS} continuous operation without a heatsink, and 35 A_{RMS} with passive cooling, with pulsed torque testing showing current peaks of ~65 A_{pk} during short transient events. Similar tests on the second platform confirm good transient capability even with a lower continuous current rating. These results highlight the significance of transient thermal impedance evaluation instead of just steady-state specifications.

The thermal solution is really important. The backside of the GaN device is not electrically isolated; thus, the thermal interface insulating material must simultaneously exhibit excellent thermal conductivity, high dielectric strength, and sufficient mechanical compliance. Proper thermal interface materials enable passive heatsinks to increase continuous current capability without loss of electrical isolation or long-term reliability.

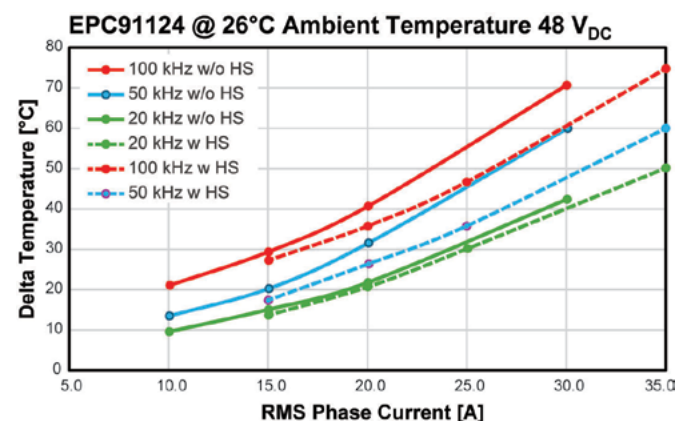


Figure 4: EPC91124 eGaN FET temperatures increase vs. the ambient temperature (26 °C). Measurements were taken at various PWM frequencies.

Selecting the Appropriate Power Stage

Although the two inverter platforms share the same PCB dimensions (79 × 80 mm²), sensing architecture, controller compatibility, and software ecosystem, they target different operating points.

The EPC91124 employs the 3 x 5 mm² 100 V EPC2361 eGaN FET, featuring a typical $R_{DS(on)}$ of 0.75 mΩ. It supports 35 A_{RMS} continuous current and 45 A_{RMS} peak, making it suitable for larger servo motors, industrial actuators, and robotics applications requiring higher torque.

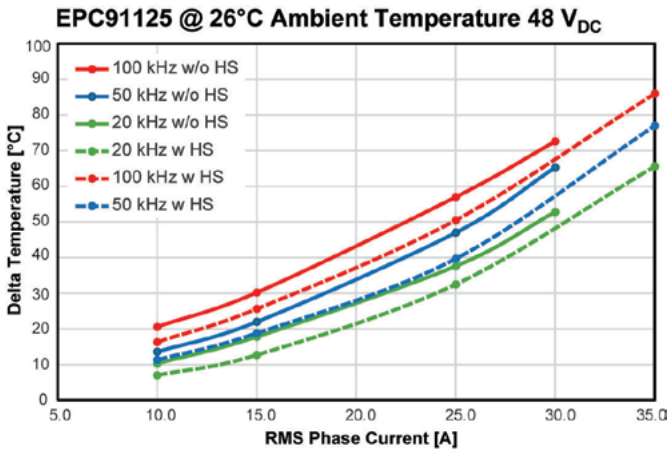


Figure 5: EPC91125 eGaN FET temperatures increase vs. the ambient temperature (26 °C). Measurements were taken at various PWM frequencies.

The EPC91125 mounts the 3.3 x 3.3 mm² 100 V EPC2367, offering a typical $R_{DS(on)}$ of 1.2 mΩ while delivering 30 A_{RMS} continuous and 40 A_{RMS} peak current capability. This provides a cost-performance alternative without changing firmware, controller hardware, or board architecture.

Looking Ahead

In low voltage motor drives, GaN adoption is no longer just about higher efficiency. Rather, it is a more holistic system-level opti-

mization where the switching devices, sensing, PCB layout, thermal management, and digital control software are designed as one platform.

Parameter	EPC91124	EPC91125
GaN device	EPC2361	EPC2367
Maximum device voltage	100 V	100 V
Maximum $R_{DS(on)}$	0.75 mΩ	1.2 mΩ
Input voltage	18–80 V	18–80 V
Recommended PWM frequency	20–100 kHz (150 kHz max.)	20–100 kHz (150 kHz max.)
Continuous phase current	35 A _{RMS}	30 A _{RMS}
Peak phase current	45 A _{RMS}	40 A _{RMS}
Current sensor bandwidth	250 kHz	250 kHz
Current sensor sensitivity	13.2 mV/A	13.2 mV/A
Voltage sensing gain	29.22 mV/V	29.22 mV/V
Board dimensions	79 x 80 mm ²	79 x 80 mm ²

Table 1: EPC91124 and EPC91125 Parameters.

These contemporary GaN inverters switch at 100 kHz, which translates to smaller passive components, reduced acoustic noise, improved current regulation, and higher power density, while being compatible with established motor-control ecosystems. Robotics, industrial automation, drones, and intelligent motion systems will continue to require faster dynamic response in increasingly compact form factors, and high-frequency 100 V GaN platforms are expected to become an important reference architecture for the next generation of precision motor-control systems.

www.epc-co.com



Custom AC/DC & DC/DC Power Modules

For Mission-Critical Applications



Aviation



Defense



Space



Ground Systems



Designed in Prague
Trusted Worldwide

www.gejetlab.com



GaN Technology now with 2200 V Rating

The release of 2200 V PowiGaN™ technology marks the next major step in high-voltage GaN power conversion. Power supply engineers grappling with the challenge of higher power density in EV, AI data centers, BESS and photovoltaic converters (among others) will be able to stop designing around the voltage limit problem inherent with conventional GaN switches.

By Andrew Smith, Director of Technical Outreach, Power Integrations

The release of 2200 V PowiGaN™ technology marks the next major step in high-voltage GaN power conversion. Power supply engineers grappling with the challenge of higher power density in EV, AI data centers, BESS and photovoltaic converters (among others) will be able to stop designing around the voltage limit problem inherent with conventional GaN switches.

GaN-on-silicon HEMTs have a maximum commercially available operating voltage of 900 V. GaN-on-sapphire is the technology differentiator employed to create PowiGaN™ switches – a proprietary approach to GaN switches developed and owned by Power Integrations. The potential effect of 2200 V GaN was recently described by Roy Dagher, PhD, Technology & Market Analyst, Compound Semiconductors at Yole Group, as follows: “GaN’s voltage ceiling has kept it out of the main power path, ceding that ground to SiC. A 2200 V rating changes this, giving margin for single-stage topologies and future-proofing emerging 1500 V data center and EV designs...”

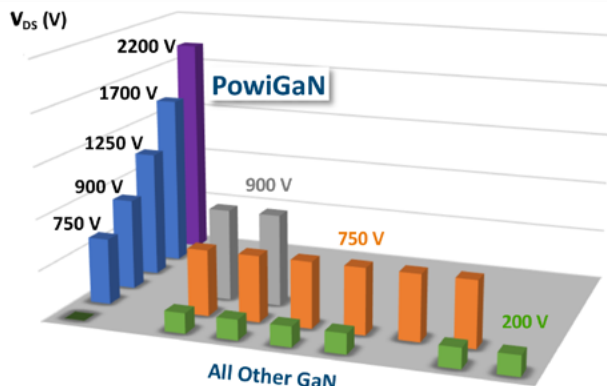


Figure 1: A comparison of the V_{DS} rating of different lateral GaN power switch technologies available in the market today. PowiGaN Uses a GaN-on-sapphire process to achieve high voltage devices, whereas the other GaN in the market employs GaN-on-silicon.

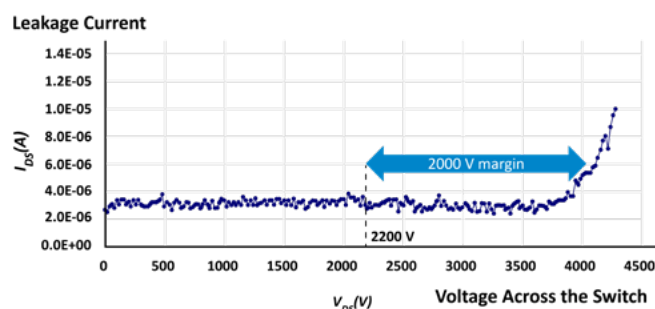


Figure 2: Leakage current (I_{DS}) measured across a 2200 V PowiGaN switch. Note the substantial margin (>2000 V between rated voltage and rise in leakage current) which demonstrates the robust nature of the barrier at rated voltage. Increasing leakage margin is a key constituent in achieving high reliability (PowiGaN cascoded-HEMT technology has a FIT number of less than 1).

The insulating nature of sapphire substrate enables a markedly different high voltage performance compared to silicon. This in turn leads to an epitaxy-substrate boundary that can support much higher voltages – significantly in excess of the 2200 V described in the title. Not only does this allow high voltage GaN devices to be created, but it also allows for the addition of substantial margin (more than 2000 V) above this rated voltage (see figure 2).

The Cascode Advantage – Robust Operation, Simplified Control, Higher Efficiency

Moving PowiGaN switch technology into a cascode arrangement also overcomes GaN sensitivity with respect to gate voltage. A low-voltage silicon MOSFET is paired with the normally-on PowiGaN HEMT to provide a normally-off (enhancement mode) switch with a robust gate structure that is easy to drive and very reliable. This increased gate drive robustness and reliability factors into the long lifetime (1 FIT) noted above and has resulted in automotive qualification for PowiGaN devices.



Figure 3: Cascode structure – the GaN HEMT is allowed to operate in its natural depletion mode and provides the low $R_{DS(ON)}$ and voltage isolation that characterizes GaN switches while the low voltage, low $R_{DS(ON)}$ series MOSFET provides robust gate drive inversion for the HEMT to create a normally-off (enhancement mode) switch.

At higher power levels, vertically stacked die architectures will be necessary to create a practical cascode structure which will be married to the higher voltage GaN devices; the approach is potentially stackable into systems in the order of 20 kW, subject to topology, frequency, cooling and paralleling assumptions.

High Voltage GaN simplifies Design Challenges

In the 800 V Bus (and higher) space, bias supplies typically employ a flyback converter that must withstand high voltage. The worst-case voltage stress seen by the power switch can be approximated to the sum of three main sources. The maximum bus voltage (typically 10 % higher than the headline value) is the first and largest contributor. The second contribution is from the output voltage reflected back onto the primary side of the converter (termed VOR) – this is the output voltage multiplied by the transformer turns ratio and can be in the order of 200 V for a (commonly required) 48 V output. The third voltage stress adder for the primary switch is caused by leakage inductance. Leakage inductance is the magnetic flux in the flyback transformer that is not coupled to the secondary side.

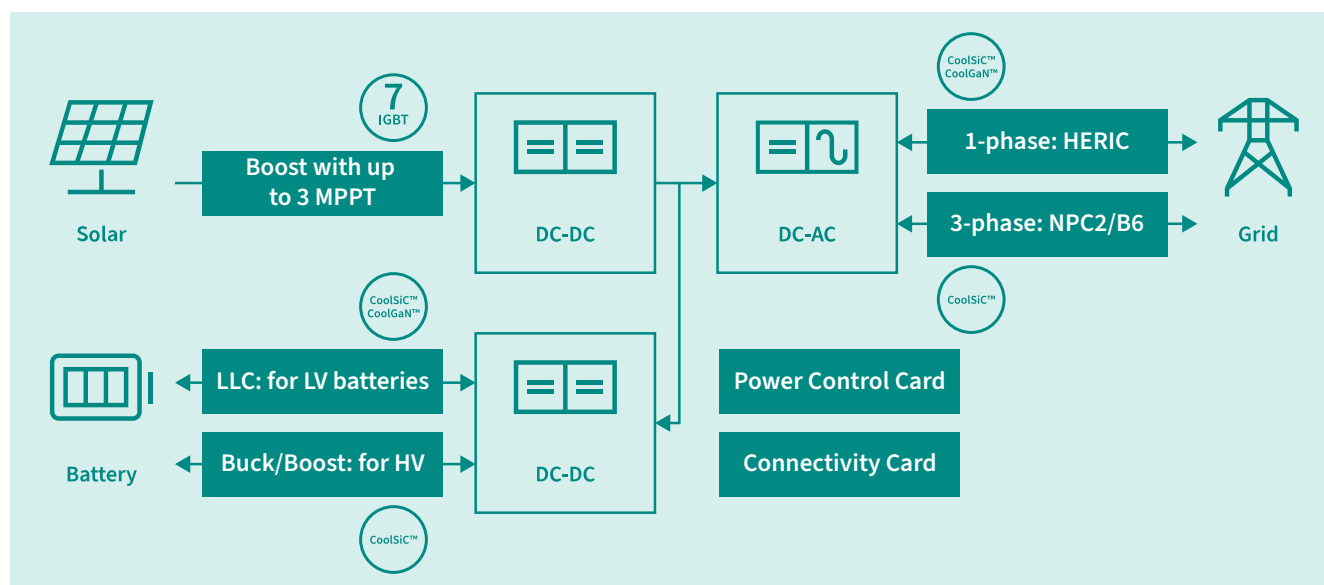


Modular hybrid inverter design platform

Take the fast lane to your own prototype



Infineon has developed a modular portfolio of power conversion, control, and connectivity building blocks that enables the fast prototyping of grid-tied 1- and 3-phase residential and small commercial hybrid inverter solutions:



Customers can flexibly combine state-of-the-art technologies such as CoolSiC™, CoolGaN™ and IGBT7, together with advanced packaging innovations like QDPAK, to implement a wide range of inverter and converter topologies, including HERIC, NPC2 and LLC.

Main benefits: maximum efficiency, high power density, and optimized system design – proving that high performance and low cost per kilowatt no longer have to be a compromise.



Scan the QR Code for more information
www.infineon.com/mhi



When the transformer turns off, magnetizing inductance energy (the energy that is coupled to the output windings) is commutated and discharged to the output. Leakage flux has nowhere to go. Leakage current that has built up during the primary switch on-time, cannot fall instantly to zero. Instead, the energy trapped in the leakage flux is discharged as a high voltage spike that appears on top of the primary rail at the moment the primary switch turns off. The leakage spike can be in the order of 80 - 150 V depending on the transformer design and the size of the snubber circuit added to clamp it. A stylized flyback primary switching waveform with these three voltage elements identified is shown in figure 4. The combination of these voltages describes the voltage stress on the primary switch.

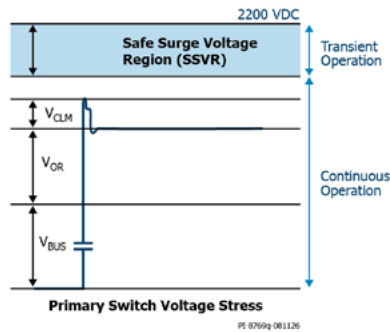


Figure 4: Simplified primary switch voltage waveform for a flyback converter showing the voltage stress on the power switch which is set by bus voltage (V_{BUS}), reflected voltage (V_{OR}), and the amplitude of the leakage inductance clamp voltage (V_{CLM}). The sum of these three elements describes the withstand voltage the switch must be able to support in normal operation. The voltage must remain below the Safe Surge Voltage Region (SSVR) during continuous operation. In the SSVR recoverable $R_{DS(ON)}$ shift begins to occur, and this voltage region is reserved for short duration rather than continuous operation. A typical design margin (perhaps 20 %) is applied to the maximum stress seen on the switch in normal operation and is compared to the switch voltage rating that bounds the top of the SSVR.

For the resonant half-bridge that typifies higher power conversion, the maximum primary-switch voltage-stress is given by:

$$V_{DS(PEAK)} = V_{BUS} + V_{CLM} + V_{TRANSIENT} + V_{RING}$$

Where:

$V_{DS(PEAK)}$: Maximum voltage across each primary switch

V_{BUS} : Maximum DC input voltage to half-bridge circuit

V_{CLM} : Clamp voltage

$V_{TRANSIENT}$: Voltage overshoot on the primary switch caused by C_{OSS}

V_{RING} : Oscillatory (ringing) component caused by LC resonance of parasitic elements

The half-bridge circuit imparts less voltage stress than the flyback, but for a 1500 V BUS application, the 2200 V rating of the new PowiGaN process is ideal.

VOR is Limited by the Voltage Rating of the Secondary Side Rectifier

A significant challenge of high efficiency flyback power supplies is designing a practical circuit that operates within the drain-to-source voltage limit of the logic-level SR MOSFET (or GaN) typically used. A device limit of 150 V is typical. To limit the voltage stress on the SR MOSFET, designers can opt to increase the turns ratio of the transformer. This will increase VOR (and hence voltage stress on the primary switch). A similar argument can be made for voltage stress on the SR MOSFETs in a resonant half-bridge circuit.

The 2200 V rating demonstrated for PowiGaN provides the engineer with more design freedom to balance the voltage stress be-

tween the primary switch and the secondary side SR MOSFET by adjusting the turns ratio of the transformer.

Switching Frequency Benefits with PowiGaN compared to SiC

800 V systems for EV and data center market spaces are already embracing GaN despite the availability of SiC devices and the voltage limitations of existing (750 V) high power GaN switches. In both these application types, minimizing size is a critical requirement. Higher switching frequency results in a smaller switching transformer and is a first order effect. Figure 5 describes the relationship between switching frequency and the cross section (A_e) of the switching transformer. While SiC devices can switch at frequencies up to 500 kHz, device capacitances mean that switching frequency for practical SiC-based converters are often constrained below this range. GaN devices exhibit much lower capacitances for equivalent on-resistance (see table 1), making them ideal for higher frequency switching. Resonant (soft) switching means that the EMI effects of a higher switching frequency are minimized, Power converters up to 20 kW are able to use a switching frequency in the 500 kHz to >1 MHz range.

The relationship between switching frequency and transformer cross section for a Half-Bridge power supply is described in the following formula, where A_e equals the effective core cross-sectional area (m^2) and f = switching frequency (Hz), B_{PK} = peak flux density (T), which is typically limited to less than 300 mT (3000 Gauss), V_{pri} = DC voltage applied to the transformer primary, N = primary turns:

$$A_e = \frac{V_{pri}}{4NB_{pk}f}$$

The lower transformer cross section translates to lower power converter height, especially when planar magnetics are utilized. The effects of WBG switch parasitic effects on resonant circuit performance can only be summarized here, but they demonstrate why design engineers looking for highest efficiency and smallest size are already embracing GaN technology even when low voltage capability necessitates the use of multiple series connected HEMTs.

Parameter	650-V GaN FET	650-V SiC MOSFET
C_{ISS}	200-1000 pF	1000-5000 pF
C_{OSS}	20-200 pF	100-1000 pF
C_{RSS}	1-20 pF	10-100 pF
Q_G	5-20 nC	20-100 nC

Table 1: Comparison of parasitic circuit elements for different WBG technologies.

For a high-frequency resonant half-bridge, C_{ISS} controls gate charge Q_G and therefore gate charging current from the driver - Q_G controls gate-driver loss and indirectly affects switching speed. C_{RSS} controls switching transition loss - less important in resonant circuits. C_{OSS} controls the resonant commutation current and is critical for light load efficiency (very important in EV applications).

$$\frac{1}{2}L_r I_r^2 > C_{OSS} V_{BUS}^2$$

where I_r is resonant commutation current

At frequencies above 500 kHz, minimizing Q_{GD} and C_{OSS} can be as important as, or more important than, $R_{DS(ON)}$ conduction losses.

Higher Efficiency from a 2200 V Cascode in Half-Bridge Applications

Efficiency is critical in many emerging applications. In half bridge cascode-based PowiGaN switches offer lower loss in 3rd quadrant operation than can be achieved with conventional GaN devices. A summary of this is shown in Figure 5.

Beyond the Limits of SiC · GaN Power Semiconductors

Innovative Low-Temperature Sintering Die Attach Paste Solution for Next-Generation Power Modules

Optimized for SiC & GaN

Advanced Die & Module Attach Solution for
High-Power Semiconductors

Next-Generation EV Module Solution

Reliable Bonding Performance for Large-Area
Modules

Exceptional Thermal Conductivity

Superior Heat Dissipation for Enhanced
Module Reliability

Excellent Process Flexibility

Full Compatible with Pressure & Pressureless
and Wet & Dry Placement.

ParonTAC[®]

High Thermal Conductive Silver Paste

ParonTAC[®] series are high thermal conductive
pastes for power electronic applications.



High Thermal Conductivity

Excellent heat dissipation
performance



Reliable Bonding

Strong adhesion and
reliable sintering
performance



Halogen-free & No-clean

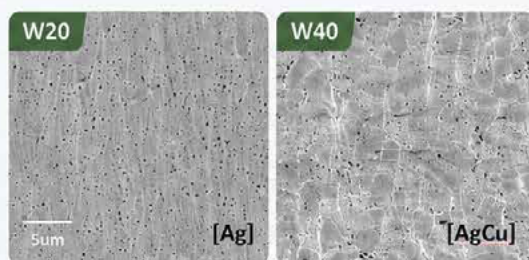
Environmentally
friendly and
process-friendly



Various Options

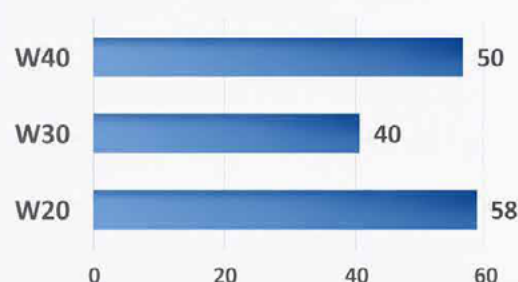
Optimized solutions
for diverse
applications

Cross Section (200°C, Pressure)



* Cross section after sintering

Bond Strength (MPa)



* Measured after sintering (typical values)

Product	Filler	Sintering	Process	Thermal conductivity
ParonTAC [®] W20	Ag : 78%	Pressure	200 ~ 250°C >9MPa, 3min	> 200 W/mk
ParonTAC [®] W25	Ag : 85%	Pressure		> 200 W/mk
ParonTAC [®] W40	AgCu	Pressure		> 150 W/mk
ParonTAC [®] W30	Ag	Pressureless	200°C, >1hr	> 150 W/mk

* The data shown above are typical values.

Application Space for High Voltage GaN Switches

Practical circuit testing shows that the 2200 V process is robust – exhibiting resistance to charge-trapping - dynamic $R_{DS(ON)}$, and current collapse effects. The technology is ready to be deployed in main power switching circuits and auxiliary power supplies in half-bridge and flyback configurations, respectively.

SiC owns the switching market space above 800 V today. However, there are applications already in place that require the unique capabilities of high voltage GaN devices. SiC MOSFETs are limited to applications where small size is not a requirement.

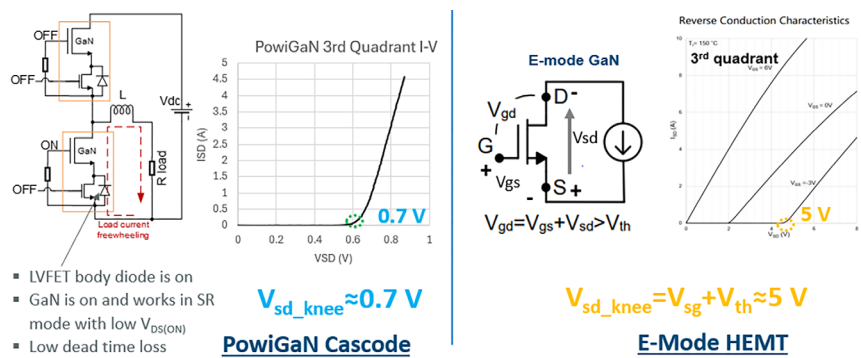


Figure 5: In a half-bridge application, during 3rd quadrant (diode conduction) operation, the normally-on PowiGaN cascode presents a lower voltage drop compared to conventional E-mode devices - increasing circuit efficiency.

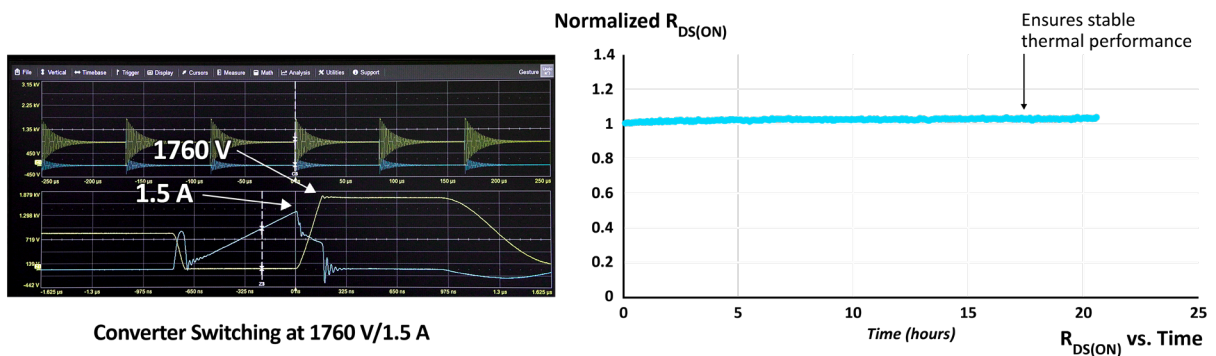


Figure 6: Dynamic High Temperature Operating Life (D-HTOL) testing of 2200 V PowiGaN showing normalized $R_{DS(ON)}$ measured in a flyback architecture shows no significant dynamic $R_{DS(ON)}$ effects in the GaN switch.

This is because SiC devices have a relatively low maximum switching frequency (typically described as being in the order of 250 kHz). Higher frequency would allow a move to smaller magnetics, so for applications such as On-Board-Charging (OBC) in EVs and AI data centers the benefits are readily apparent due to the very limited space available. Indeed, data centers are already embracing GaN switches, where multi-level architectures are currently being employed to overcome the voltage limits of conventional devices (as shown in figure 7).

Higher voltage allows more power, so for data center 1500 V bus architectures are being actively pursued. To meet derating requirements, main power switches will need the 2200 V rating.

Automotive manufacturers in the US and EU are exploring 1200-1500 V for commercial vehicle charging and are sizing their power delivery systems accordingly. In China, BYD has decided to push for super-fast battery charging and are proposing a 1 MW charger to deliver ultra-fast charging for electric vehicles using their Super e-Platform. Higher EV charging speed will require an increased voltage bus, and 1150 V has already been identified as a new standard. This voltage level is not fully supportable with even the 1700 V PowiGaN – especially for auxiliary power systems running from flyback converters. 2200 V will be required to support this environment. Finally, HVDC transmission and utility scale Battery Energy Stor-

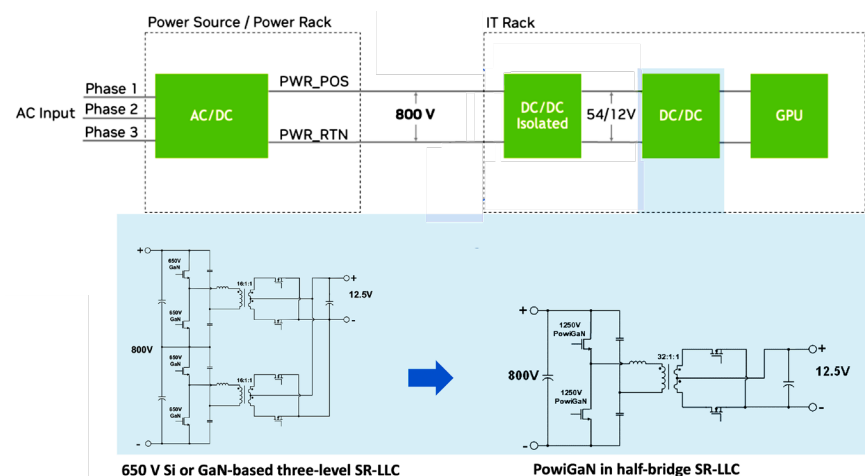


Figure 7: To meet the power distribution challenges of AI data centers, multi-level architectures are being employed for 800 V systems. The move to 1500 V systems to meet ever-increasing higher power requirements has already been discussed. High voltage PowiGaN-based devices allow the move to a simplified single-level switching architecture – reducing circuit cost, design complexity, and solution size.

age Systems (BESS) already employ a 1500 VDC rail architecture and will benefit from higher power density.

Industry is replete with SiC manufacturing capacity today which has lowered pricing for the technology and allowed its adoption in an increased range of applications. Because of this, Higher voltage GaN will initially be deployed in areas that will significantly benefit from the smaller size and enhanced efficiency that the technology provides. In the long term, high voltage GaN - which can offer a compelling path where switch-

ing frequency, architecture simplicity and power density will outweigh the maturity and current pricing of SiC.

2200 V PowiGaN will enable the design of smaller, more efficient, and robust power converters from flyback auxiliary power up to 20 kW resonant half-bridge circuits. The introduction of vertical GaN - still some way off, may also provide a pathway into the highest power switching applications, (> 20 kW), but that is a discussion of another time.

FOR GALVANICALLY ISOLATED MEASUREMENT 4000 ARMS

Compact precision fluxgate AC/DC current transducer



MBC4000I • Nominal current 4000A

Total accuracy 0.05% (-40 to +85°C) • Large aperture 121 mm

Overall, 10 times better than Hall effect closed loop

DANISENSE

Rethinking Inductor Sizing: The High-Gain Magnetic Illusion

Two common design intuitions frequently mislead engineers when selecting inductors for DC-DC converters: first, that inductor size scales linearly with processed power; and second, that cascading Boost stages improves magnetic utilization in high-gain applications. By defining a formal Utilization Factor (UF) metric and anchoring it against physical core data, this article debunks both myths. We demonstrate why high-gain Boost topologies are inherently poor magnetic utilizers and offer a strategic architectural framework for volume optimization.

By Udi Levy, Power Electronics Expert, SolarEdge Technologies

Physical Law: Size Follows Energy, Not Power

A persistent industry misconception assumes that a power increase of X translates to a magnetic volume increase of X, or that multiplying the input voltage enables proportional power processing through the same core.

From first principles, the physical volume (*Ve*) of an inductor is bound by its maximum magnetic energy handling capability:

$$E = \frac{1}{2} \cdot L \cdot I^2$$

restricted by core saturation (*B_{max}*):

$$E = \frac{1}{2} \cdot L \cdot I_{max}^2 \propto Ae \cdot le \cdot B_{max}^2 \propto Ve$$

Empirical Catalog Validation

To bridge the gap between textbook physics and hardware realities, physical volume (*Ve*) and energy handling capacity (*LI²*) data were mapped across four decades of core sizes from Magnetics' Kool Mμ toroid catalog.

We can clearly see that the manufacturer uses the Energy to be handled (X-axis) as the prime factor for selecting a core.

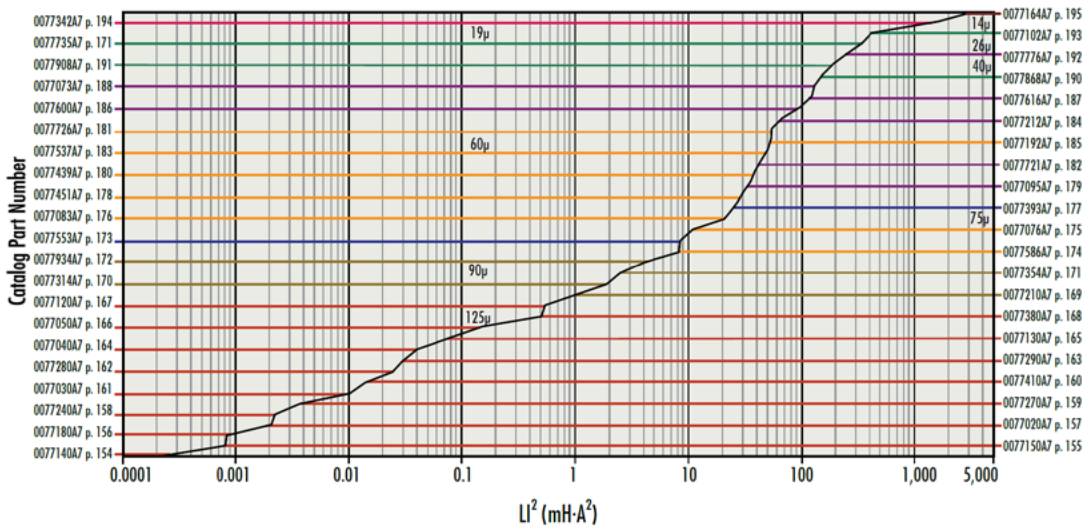
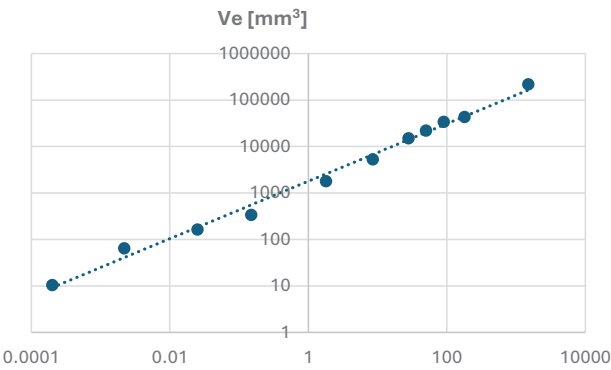


Figure 1: Magnetics' Kool Mμ catalog data: Core volume vs. energy handling capacity (*L · I²*).

Let's extract the volume of the vertical axis, using the datasheet.

P/N	LI2 [J]	Ve [mm3]	a=Ve/LI ²
0077140A7	0.0002	10.5	52500
0077240A7	0.0022	64.9	29500
0077280A7	0.025	164	6560
0077050A7	0.15	340	2267
0077314A7	1.8	1800	1000
0077553A7	8.5	5,340	628
0077451A7	28	15,100	539
0077537A7	50	22,000	440
0077600A7	90	33,900	377
0077908A7	180	43,400	241
0077342A7	1500	220,000	147



Ideally, you'd stick to PLECS

But sometimes reality needs a little SPICE



Now you can use SPICE models in PLECS

A log-log fit of this data yields an exceptionally tight slope of **0.62** ($R^2 = 0.99$), demonstrating a clear scaling law. For medium-to-large 60μ cores, a reliable volumetric design baseline is established at: $V_e \approx 300 \cdot E$ [mm^3/mJ]

note: While this analysis explicitly tracks core volume (V_e), total winding volume scales proportionately under equivalent copper loss limits, preserving the same law's system-level validity.

Defining the Utilization Factor (UF)

To evaluate how effectively a topology utilizes its magnetic volume, we define the Utilization Factor (UF) as the ratio of average power processed to peak stored energy:

$$UF \triangleq \frac{P}{E} \left[\frac{\text{W}}{\text{J}} \right]$$

By maintaining a fixed proportional peak-to-peak ripple current ratio ($k = \Delta I / I \leq 0.1$) under continuous conduction mode (CCM), closed-form UF expressions can be derived across various topologies:

Single-Ended (SE) Boost vs. Dual Floating Outputs (DFO) Boost

In a standard single-ended (SE) Boost converter, mapping duty cycle (D) to the voltage conversion ratio ($M = V_o / V_{in}$) yields:

$$UF_{Boost} \approx \frac{2 \cdot k \cdot F_s}{D} \approx 2 \cdot k \cdot F_s \cdot \frac{M}{(M-1)}$$

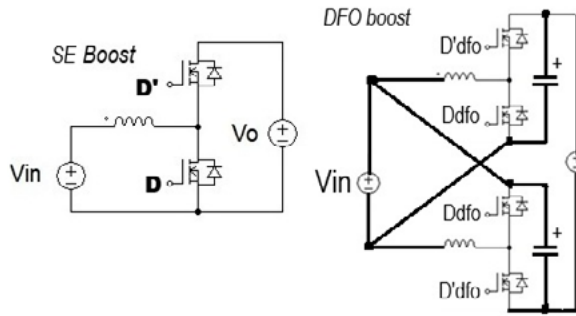


Figure 2: Evaluated non-isolated converter topologies.

Engineers often hope that alternative topologies like the Dual Flying Outputs (DFO) Boost can shrink magnetics due to a lower operating duty cycle. However, because DFO-Boost has a lower duty ratio compared to SE Boost for the same operational conditions, we must write the UF as a function of the conversion ratio M to perform an accurate comparison.

An energy-balance derivation reveals that for two equal, uncoupled inductors:

$$UF_{DFO} \approx 2 \cdot k \cdot F_s \cdot \frac{M}{M-1}$$

Conclusion: The total magnetic volume of a DFO Boost exactly equals its single-ended counterpart ($UF_{SE} = UF_{DFO}$); splitting the phase provides zero volumetric advantage for the core.

Buck and Buck-Boost Topologies

Applying the identical framework to Buck and Buck-Boost circuits highlights completely different magnetic behaviors:

- Buck:** $UF_{Buck} \approx 2 \cdot k \cdot F_s \cdot \frac{1}{1-M}$ (As $M \rightarrow 1$, $UF \rightarrow \infty$, meaning magnetic utilization becomes highly efficient near unity conversion).
- Buck-Boost:** $UF_{BB} \approx \frac{2 \cdot k \cdot F_s}{1+k} \approx 2 \cdot k \cdot F_s$ (The metric is perfectly flat – utilization remains strictly independent of the voltage ratio M).

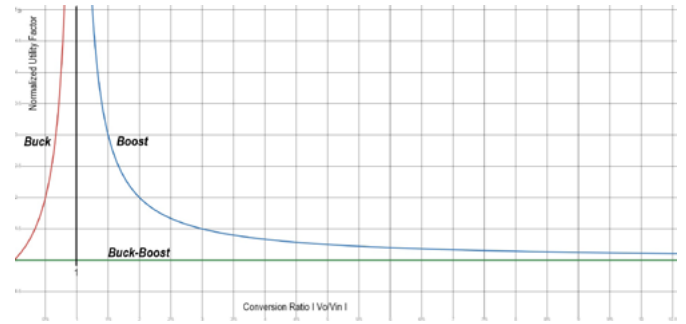
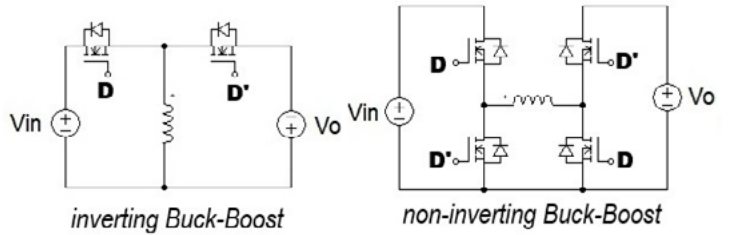


Figure 3: Normalized Utilization Factor (UF) vs. conversion ratio (V_o/V_{in}).

The High-Gain Illusion

The UF curve for a Boost converter reveals an alarming structural trap: beyond a conversion ratio of $M = 5$, the utilization factor rapidly plateaus near its floor ($\approx 2kF_s$)

Faced with a high-gain requirement (e.g., $10V \rightarrow 400V$, $M_{tot} = 40$), a common instinct is to cascade multiple stages ($m = 3$) under the assumption that smaller per-stage gains ($m = M_{tot}^{1/n} = 3.42$) will relieve magnetic stress.



The Mathematical Penalty of Cascading

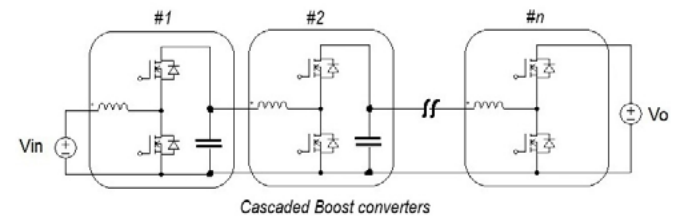


Figure 4: Multi-stage cascaded Boost converter architecture.

For n cascaded lossless Boost stages processing equal power (P), total stored energy is the sum of individual stage requirements:

$$E_{tot} = \sum_{i=1}^n \frac{P}{UF_i} \propto \sum_{i=1}^n \frac{M_i - 1}{M_i}$$

By substituting $x_i = \ln M_i$, the objective function turns into maximizing $\sum e^{-x_i}$ under a strict sum constraint ($\sum x_i = \ln M_{tot}$). Because $f(x) = e^{-x}$ is strictly convex, Jensen's Inequality dictates that the minimum total energy state occurs only when all stages share an identical gain split ($M_i = M_{tot}^{1/n}$). At this mathematically optimal split, the system-level utilization factor becomes:

$$UF_{tot} = \frac{UF_{stage}}{n}$$

This proof uncovers a harsh reality: while cascading lowers the per-stage gain and minorly ticks up individual stage UFs, **dividing the entire system efficiency by n mathematically dominates**. Consequently, adding stages always forces a total stored energy penalty.

Case Study: $10V \rightarrow 400V$ ($100W$, $100kHz$, $k = 0.1$)

- Single Stage ($n = 1$, $M = 40$): Processes the power with a total magnetic energy storage of 5.36 mJ
- Three Stages ($n = 3$, optimal $m = 3.42$): Each stage stores an identical 3.89 mJ, culminating in a total system energy requirement of 11.68 mJ.

Cascading tripled the number of components while more than doubling the total physical volume and cost of the magnetics (11.68 m) vs 5.36 m)!

PSIM simulation circuits (below) and their corresponding waveforms shown below validate this analysis.

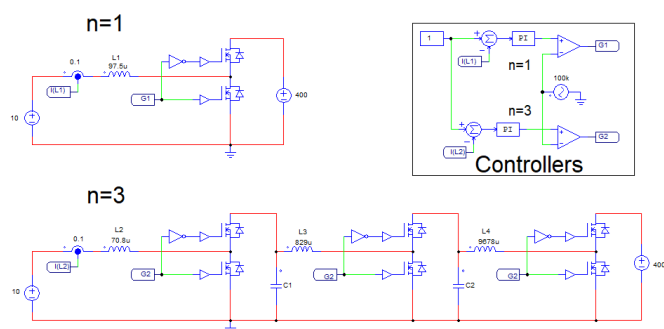


Figure 5: PSIM simulation schematics ($n=1$ vs. $n=3$).

Sizing Conclusions & Practical Takeaways

When a converter operates in the “flat zone” ($M \gg 5$), attempting to force a Boost architecture – whether single-stage or cascaded – is

fundamentally flawed for magnetic volume optimization. Cascading should only be chosen to resolve switch voltage stress or component limitations, never optimizing core size.

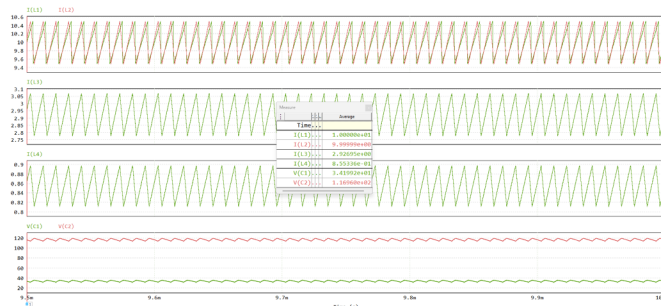


Figure 6: PSIM simulation waveforms validating currents and stored energy.

The Engineering Solution: For high-gain conversion, implement a decoupled two-stage architecture:

- 1. First Stage:** A non-isolated converter (e.g., Buck-Boost or moderate Boost) operating at a highly favorable, low conversion ratio ($M < 3$) to step up to an intermediate rail.
- 2. Second Stage:** A transformer-based isolated topology (such as an LLC or Phase-Shifted Full Bridge) to efficiently absorb the heavy high-gain requirements via turns-ratio scaling rather than massive inductive energy storage.

By keeping both stages firmly inside their magnetically efficient zones, total inductor volume is minimized. This framework was validated in practice, where the proposed topological shift successfully drove a substantial reduction in physical hardware size.

www.solaredge.com



WiPDA
2026

The 13th IEEE Workshop on
Wide Bandgap Power Devices & Applications
BURLINGTON, VT, USA | OCTOBER 26-28, 2026

FROM MATERIALS TO MEGAWATTS

Connect with the people advancing
wide bandgap power electronics





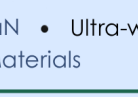
IEEE



PSMA



**ELECTRON
DEVICES
SOCIETY**

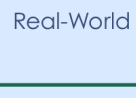


**IEEE POWER
ELECTRONICS SOCIETY**
Powering a Sustainable Future

October 26 - 28, 2026
Burlington, VT, USA



Explore the latest developments in:



SiC • GaN • Ultra-wide
Bandgap Materials



Power Devices • Packaging
Reliability



Converters • Gate Drives
Real-World Applications

Technical
Sessions

Panel
Discussions

Poster
Sessions

Industry
Exhibits

Register Now

wipda.org



DC Anti-Backflow: Comparing Active ORing and Diode ORing for Reverse Current Protection

Reverse-current protection has become an integral part of overall power-system architecture. Selecting the appropriate ORing strategy requires balancing efficiency, thermal behaviour, reliability, maintainability and installation requirements. The goal is to develop redundant DC power systems that are more efficient and more robust throughout their operational lifetime.

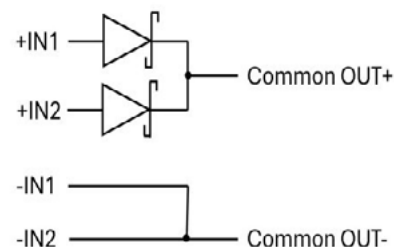
By the engineering team of RECOM Power

As industrial DC power systems continue to increase in power density, redundancy has evolved beyond a simple means of improving system availability. Modern control cabinets, telecommunications infrastructure and industrial automation systems are expected to maximise uptime while simultaneously reducing energy consumption, cabinet temperatures and maintenance effort. These changing design priorities have brought renewed attention to one aspect of redundant power architectures that often receives little consideration during the early stages of system design: reverse-current protection.

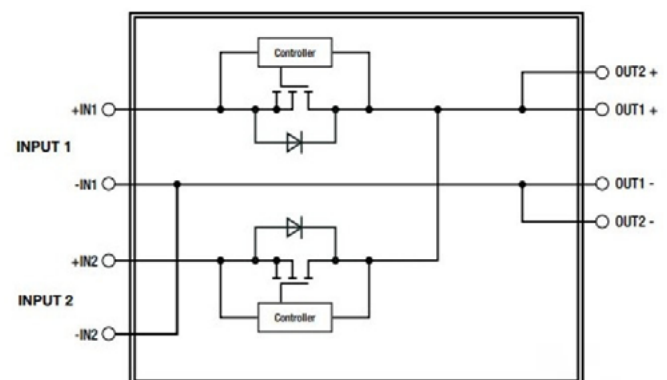
Connecting multiple power supplies in parallel is a well-established method of increasing available output current or implementing N+1 redundancy. Under normal operating conditions, the supplies share the load and operate transparently. During a fault, however, the situation changes. If one supply fails low or develops an internal short circuit, healthy supplies can feed current back into the failed unit. Instead of supporting the load, the faulty supply becomes an additional load itself, increasing stress on the remaining power sources and potentially destabilising the complete DC bus.

Preventing this reverse current is the purpose of DC anti-backflow protection, commonly implemented through ORing circuits. Although the concept is straightforward, the choice of ORing technology has a significant influence on efficiency, thermal behaviour and long-term system reliability. What was once considered a relatively simple protection circuit has therefore become an important engineering decision in modern high-power DC installations.

Traditional diode ORing has served industry reliably for decades. Its popularity comes from its simplicity: a diode placed in series with each power supply naturally blocks reverse current whenever the source voltage falls below the common bus voltage. The solution requires very few components, operates without control circuitry and offers predictable behaviour across a wide range of applications.



(A) Schottky diode reverse current protection



(B) Recom RACPRO01-RD40 redundancy module



Figure 1: RECOM RACPRO1-RD40 redundancy module for DIN-rail mounting

Figure 2. Simple Schottky ORing circuit (A, upper part), and (B, lower part) more efficient MOSFET-based ORing module

However, every diode introduces a forward voltage drop. While this loss may appear modest, its effect becomes increasingly significant as output current rises. The resulting power dissipation generates additional heat inside the control cabinet, reduces overall efficiency and may require larger copper areas, heat sinks or forced-air cooling. Consequently, the design challenge extends beyond electrical protection and becomes part of the system's thermal management strategy.

These limitations have accelerated the adoption of active ORing solutions. Instead of relying on a semiconductor junction, active ORing uses low-resistance MOSFETs controlled as ideal diodes. Because conduction losses are primarily determined by the MOSFET's on-resistance, voltage drop and heat generation can be reduced dramatically compared with conventional diode solutions. Lower losses improve efficiency while also reducing thermal stress on surrounding components and allowing more compact cabinet layouts.

Beyond efficiency, active ORing offers advantages that are increasingly valued in industrial environments. Modern controllers can detect reverse-current events, react rapidly to fault conditions and provide diagnostic information that supports maintenance and system monitoring. As industrial systems become more connected and greater emphasis is placed on predictive maintenance, these additional functions can contribute to higher overall system availability.

In practice, the decision between diode and active ORing is rarely determined by a single parameter. Current level, efficiency targets, available installation space, cooling concept, maintenance philosophy and expected service life all influence the final architecture. For lower-current systems where simplicity and cost remain the primary objectives, conventional diode ORing often continues to represent the most appropriate solution. Where power density and efficiency become dominant design criteria, active ORing offers measurable benefits.

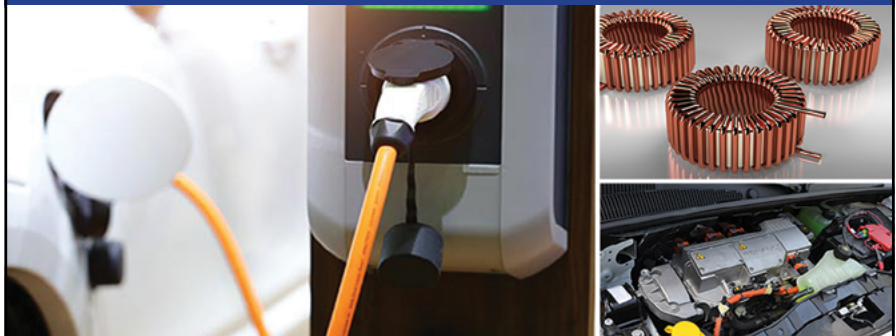
Mechanical integration also plays an increasingly important role. Industrial designers are expected to maximise the available DIN-rail space while simplifying installation and future maintenance. Compact redundancy modules with flexible mounting options, direct installation alongside compatible power supplies and tool-less wiring help reduce installation effort and improve serviceability without increasing cabinet size.

One practical implementation of this approach is RECOM's RACPRO1-RD40 redundancy module. Rather than focusing solely on reverse-current protection, the module demonstrates how MOSFET-based active ORing can be integrated into a compact DIN-rail solution for modern 12 V, 24 V and 48 V systems. A wide input range, high efficiency, low voltage drop and straightforward installation illustrate how current engineering requirements for electrical performance and practical usability can be addressed within a single industrial product.

Ultimately, reverse-current protection should no longer be viewed simply as a protective accessory. It has become an integral part of overall power-system architecture. Selecting the appropriate ORing strategy requires balancing efficiency, thermal behaviour, reliability, maintainability and installation requirements. By considering these factors together rather than in isolation, engineers can develop redundant DC power systems that are not only more efficient, but also more robust throughout their operational lifetime.

www.recom-power.com

Electromagnetic Coils utilizing our tape wound cores provide high precision and reliability for critical applications



Our coil assemblies meet the stringent specifications and performance requirements that are vital for these applications:

- EV Power & Propulsion Systems
- Aerospace/Military Launching and Defense Systems
- Medical Diagnostic and Monitoring Equipment
- Energy Generation and Distribution Systems
- High-Voltage Power Management Products & Systems

Rely on Magnetic Metals to deliver maximum electromagnetic properties for components used in:

- electric motors,
- transformers,
- generators,
- battery packs,
- EV charging stations,
- power supplies,
- inductors,
- circuit boards,

Magnetic Metals

- sensors
- and more...

Technical and Customer Support

We can customize advanced grades of soft magnetic alloys, enhancing their frequency, permeability and pulse properties to meet your unique requirements.

Our competitors' price structure may initially appear lower, but we can guarantee the long-term higher quality that adheres to ANAB ISO 9001:2015, AS9100:9100:2016, ITAR, and USFCR requirements.

Contact Us Today!

**75+ YEARS
OF CUSTOMER
SERVICE**

Phone: (856) 964-7842 Fax: (856) 365-8723
www.magneticmetals.com

© 2025 Magnetic Metals Corporation



**MADE IN
USA**



Preventing Under and Overdamping Through Optimized GaN Gate Switching Waveforms

Enhancement-mode GaN HEMTs feature fast switching speed, low on-resistance, and high power densities. As such, they are ideally suited for use in high-frequency, high-efficiency power conversion and RF circuits. However, due to their small gate capacitance, low gate threshold voltage (typically between 1V and 2V), and limited voltage tolerance (usually -5V to 7V), steps need to be taken to prevent device failure through unintended turn-on and oscillation during switching. In particular, special attention must be paid to gate driver.

By Huojun LONG, Application Engineer, NOVOSENSE Microelectronics

This article seeks to address this challenge by providing an in-depth analysis of the oscillation mechanisms in GaN HEMTs during turn-on and turn-off. It also demonstrates how strategies, such as proper gate resistance configuration and the addition of an RC damping network between gate and source, can be deployed to effectively suppress oscillations and overshoot.

During testing for the article, validation of optimization results under various device and parameter combinations has been undertaken using NOVOSENSE NSD2622N high-voltage half-bridge GaN HEMT driver, which has enabled a stable and reliable high-frequency driver design to be used.

Oscillation Mechanisms and Driver Design Considerations in GaN HEMT Switching

A typical GaN HEMT driver circuit can be seen in Figure 1, with resistors R1 and R2 used to respectively adjust the turn-on and turn-off speeds. The driver loop can be regarded as a series LRC circuit and during turn-on, the gate voltage may exhibit oscillations or overshoots due to the high drain dv/dt and the Miller capacitance (C_{GD}) and the current path illustrated as I_{src} .

HEMT (C_{GS}) with the following formula used to calculate the minimum the total equivalent gate resistance during turn-on ($R_{G(eq)}$):

$$R_{G(eq)} \geq 2 \times \sqrt{\frac{L_G}{C_{GS}}}$$

Similarly, the gate voltage may experience excessive negative overshoot or oscillation during turn-off, with this caused by parasitic inductance in the driver loop and the gate turn-off speed. Here, the result is gate breakdown or false turn-on, with the current path in Figure 1 shown as I_{sink} . Again, special attention should be paid during design to prevent these potentially catastrophic side effects.

As can be observed in Figure 1, the current paths I_{src} (turn-on) and I_{sink} (turn-off) differ, which results in different total equivalent parasitic inductances and resistances. More specifically, during turn-on, L_G includes parasitic inductance from the power supply path, whereas during turn-off, L_G does not. This distinction must be considered during analysis and calculation.

Methodology

To better understand the influence of different gate drive resistors on GaN HEMTs, validation tests are conducted using the NSD2622N dual-channel half-bridge GaN HEMT driver from NOVOSENSE in conjunction with two different GaN HEMTs. The tested devices and corresponding results are briefly described below.

NOVOSENSE NSD2622N is a high-voltage half-bridge GaN HEMT driver in a 5x7 mm QFN package. Its functional block diagram and pin definitions are shown in Figure 2 and Figure 3, respectively and the device adopts mature capacitive isolation technology, which enables it to meet the requirements of high-voltage applications. Both its high- and low-side drivers integrate dedicated positive/negative voltage regulators to provide adjustable positive voltage from 5V-6.5V and fixed negative voltage of -2.5V, ensuring reliable negative-voltage turn-off for GaN HEMTs.

While the driver features low propagation delay and high drive current (peak source/sink currents of 2A/-4A), satisfying the requirements of diverse systems. It also provides undervoltage lockout (UVLO), over-temperature protection, and dead-time interlock capabilities. It should be noted that the dead-time interlock function can effectively prevent shoot-through in bridge-leg configurations. Additionally, the driver provides a 5V LDO output, offering greater system design flexibility.

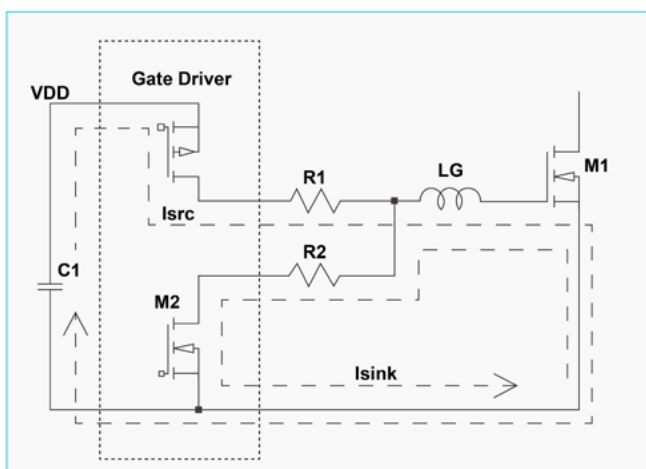


Figure 1: GaN HEMT Driver Circuit

In this, excessive oscillations or overshoots can, at best, increase GaN HEMT power loss or, at worst, cause device failure. To prevent this, we need to consider the total equivalent parasitic inductance during turn-on (L_G), and the equivalent gate capacitance of the GaN

Additionally, two high-voltage GaN HEMTs in TOLL packages with Kelvin source pins were used in the validation tests: INNO65TA080BS and GS0650306LL. Key parameters for these devices are listed below.

A double-pulse test setup, as shown in Figure 4, was used to measure gate waveforms of the GaN HEMTs under different gate resistances. The drive loop reference ground of the HEMT driver was connected to the GaN HEMT Kelvin source pin.

The total parasitic inductance of the gate drive loop during turn-on was approximately 38nH. Using the C_{ISS} value from the GaN HEMT datasheet, the equivalent gate resistance $R_{G(eq)}$ during turn-on should be no

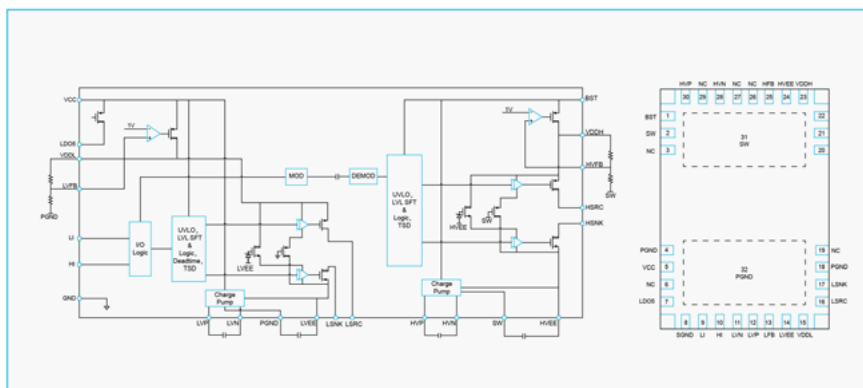


Figure 2: NSD2622N Functional Block Diagram and Pin Definitions

less than 26Ω . To directly observe the effects of underdamping, R_1 values of 10Ω and 27Ω were tested. The measured waveforms for each of these variables can be seen in the table below, with the blue trace representing the GaN HEMT drain voltage, the green being the inductor LM current, and the yellow being the GaN HEMT gate voltage.

As we can see, when $R_1 = 10\Omega$, the turn-on drive loop operates in an underdamped mode. At a bus voltage of around 50V, both GaN HEMTs exhibit high-frequency oscillations in gate and drain voltages, rendering the system inoperable.

Parameter	INNO65TA080BS	GS0650306LL	Unit
V_{DS}	650	700	V
I_D	29	40	A
V_{GS}	-6~7	-10~7	V
V_{th}	1.7	1.7	V
$R_{DS(on)}$	60	40	m Ω
C_{ISS}	225	235	pF
C_{OSS}	70	70	pF
C_{RSS}	0.5	1.6	pF
Q_{RR}	0	0	nC

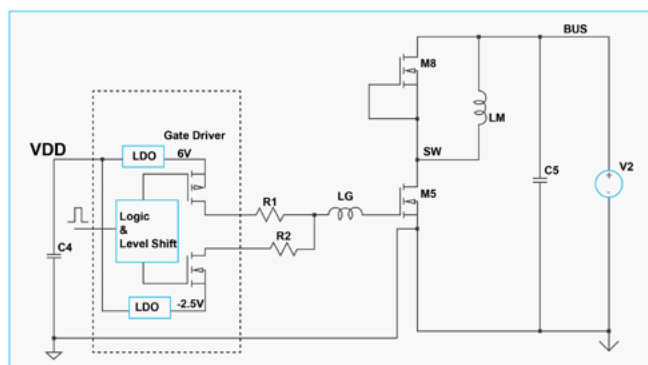


Figure 3: Double-Pulse Test Setup



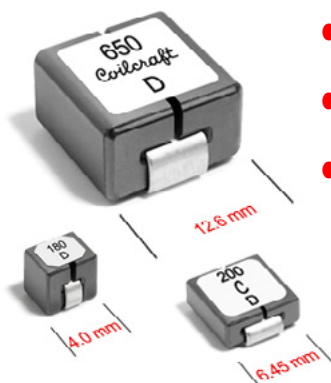
Figure 4: Measured waveforms at 10Ω and 27Ω



SLZ Family

High Current Ferrite Beads

Coilcraft



- Designed for high-current power line EMI filtering (5 A to 50+ A)
- Optimized for CISPR 25 EMC compliance across 30 MHz to 3 GHz
- Wirewound surface mount construction for broadband impedance characteristics across frequency, DC current, and temperature

Request Free Samples @ coilcraft.com

November 10–13, 2026

Empowering the All Electric Society

Get your
ticket now!
[electronica.de/
tickets](https://electronica.de/tickets)

Smart synergy sparks intelligence.

The clever integration of industrial AI with solutions for drive and sensor technology, software, and industrial communication is driving automation forward with unerring precision.

Track down a world of possibilities at the
SPS – Smart Production Solutions, the international trade fair
for automation.

Create the Future with Automation

Messe Frankfurt Group

mesago

sps

24 – 26.11.2026
NUREMBERG, GERMANY

**Spot the
World of
Industrial AI**

See you at the SPS!



sps-exhibition.com

Conversely, when $R_1 = 27\Omega$, both GaN HEMTs operate normally at 400V, but INNO65TA080BS exhibits severe high-frequency oscillation in gate voltage during turn-on. This primarily results from the differences in parasitic inductance of the internal source and di/dt during turn-on between the two GaN HEMTs, which leads to distinct gate ringing characteristics.

To mitigate such oscillations, we both increased R_1 to 33Ω , and implemented an RC snubber ($20\Omega + 1\text{nF}$) in parallel between the gate and source. These two methods both reduced the turn-on speed of GaN HEMTs and di/dt during turn-on and the corresponding waveforms can be seen below.

As we see in figure 5, at a 400V bus voltage, both adjustment methods enable normal operation, with significantly improved gate voltage oscillation and overshoot. Compared with simply increasing R_1 , connecting an RC snubber in parallel between the gate and source results in a smoother gate voltage without obvious overshoot, but with longer turn-on delay and increased power dissipation. This should be taken into consideration during design.

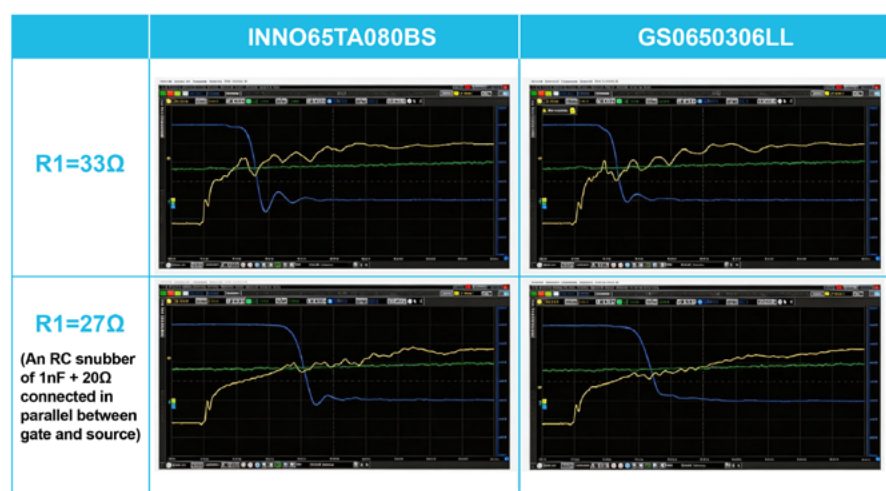


Figure 5: Turn-On Waveforms After Parameter Adjustment

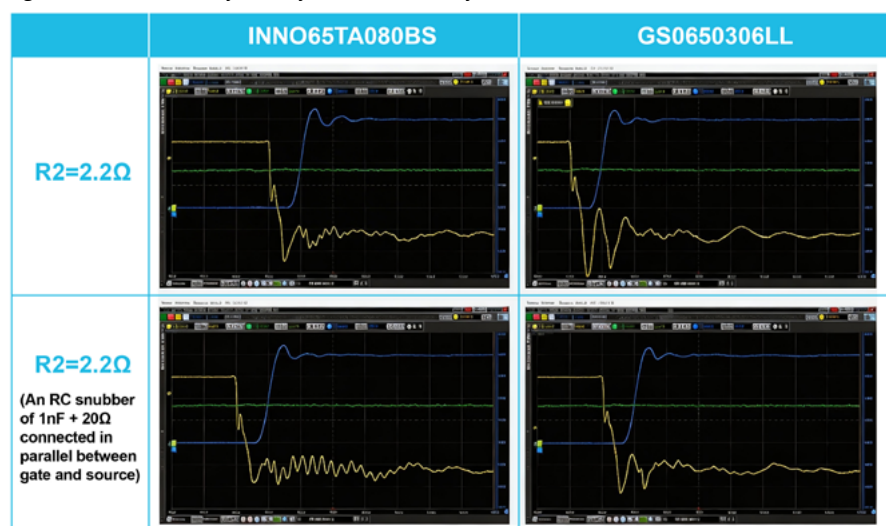


Figure 6: Gate Waveforms During Turn-Off



Do it the Bavarian way!

Need magnetics that really propel your designs?
Then stop tinkering around.
Visit our website. And get in touch.

SCHMIDBAUER
A member of Sumida Group

www.schmidbauer.net

From figure 6 we can also see that during negative-voltage turn-off, significant negative overshoot and oscillation occurred at the gate, but no false turn-on was observed.

When the RC snubber is absent, the negative overshoot exceeded -5V. After adding the RC snubber, the amplitude of negative overshoot was clearly reduced. The negative overshoot and oscillation during turn-off can be further optimized by adjusting the value of resistor R_2 or the RC snubber parameters.

Conclusions and Recommendations

Test results confirm that proper gate drive resistance ensures stable and reliable operation of GaN HEMTs. They also highlight that excessively small gate resistance can easily lead to gate voltage oscillation, and with it the potential for system malfunction or failure. Therefore, for enhancement-mode GaN HEMT driver design, the gate drive resistance needs to be tightly defined to prevent gate-source voltage overshoot and oscillation during turn-on, using the equation:

$$R_{G(eq)} \geq 2 \times \sqrt{\frac{L_G}{C_{GS}}}$$

When calculating L_G , parasitic inductances from both PCB traces, as well as the chip in the driver loop should be taken into full consideration. And for different GaN HEMTs, an appropriate RC snubber can be connected in parallel between the gate and source to effectively suppress oscillation spikes during switching. For high-voltage GaN HEMTs, negative-voltage turn-off can also prevent unintended turn-on during turn-off. Additionally, the driver ICs should be placed as close as possible to the GaN HEMT to minimize parasitic inductance in the driver loop, and GaN HEMTs with Kelvin source pins are recommended.

www.novosns.com

The Arc across the Contacts: Switching Inductive Loads with a Mechanical Switch

A mechanical switch's headline current rating is a resistive rating. Switching an inductive load is a different problem, set by the flyback voltage, the arc it strikes, and the contact erosion that follows.

By Liu Junxiong, R&D Engineer, Swiclick

Power engineers spend a good deal of effort on the energy stored in inductance. Freewheeling paths, avalanche ratings, snubbers, and clamps are routine parts of any switching design, because the voltage a collapsing field produces will destroy a semiconductor left unprotected from it. The same energy reaches a mechanical switch when one is used to make and break an inductive load, and it does its damage in a way that is easy to overlook. A micro switch or relay contact rated at, say, 6 A 250 V AC carries a resistive rating. Put it in series with a motor, a solenoid, a transformer, or a contactor coil, and its useful life can fall by an order of magnitude. The clue is on the data sheet. A typical micro switch of this class is rated for around 100,000 mechanical operations but only about 10,000 electrical operations at its full 6 A 250 V AC load. The mechanism is not wearing out ten times faster. The contacts are being eroded by an arc, and the arc is struck by the load's own stored energy.

The flyback voltage and the arc

When the contacts separate and interrupt the current in an inductance, the inductor resists the change according to $V = L \, di/dt$. Contact separation forces di/dt to a large value in a very short time, so the voltage across the opening gap rises far above the supply, often to several times it. The gap between the parting contacts is tiny, and its breakdown strength is low while it is small, so the rising voltage soon exceeds it, ionises the air, and strikes an arc. Current then keeps flowing across that arc as the contacts move apart, until the stored energy is spent or the gap grows long enough to quench it.

An arc does not sustain at any voltage. It needs a minimum, together with a minimum current, both set by the contact metal; for silver the figures are roughly 12 V and a few hundred milliamps. Below them no arc can hold, which is why a logic-level switch making and

breaking a few milliamps never arcs, and why arc erosion is a problem of real loads rather than of signals. Above them, the supply decides how hard the arc bites. On AC the current passes through zero twice per cycle and the arc has a natural chance to extinguish at each zero crossing, so AC inductive loads are the more forgiving case. On DC there is no zero crossing. The arc can be broken only by stretching and cooling it as the gap opens, so a DC inductive load holds an arc longer, drives more energy into the contacts, and is markedly harder on them.

How the arc erodes the contacts

Erosion begins before the arc does. As the contacts part, the current crowds into the last shrinking point of contact, which heats, melts, and draws out into a fine molten bridge that ruptures as they separate. That bridge alone transfers a little metal on every operation, which is why material transfer appears even in low-voltage DC switching below the arc threshold. Above the threshold the arc adds its own damage. An arc is a plasma at several thousand degrees, and at its roots it melts and vaporises the contact metal, so the surface loses material and the contact slowly erodes away. On DC the transfer runs in a consistent direction, building a projection on one face and a matching pit on the other; this pip and crater can eventually interlock or bridge and hold the contacts closed. Arc heat also oxidises and contaminates the surface, which raises contact resistance and drives local heating higher still. The end of contact life is some combination of these: resistance climbed out of specification, intermittent making, or a weld that will not release. It is the reason the electrical rating sits so far below the mechanical one. Under load, the arc rather than mechanical fatigue sets the life.

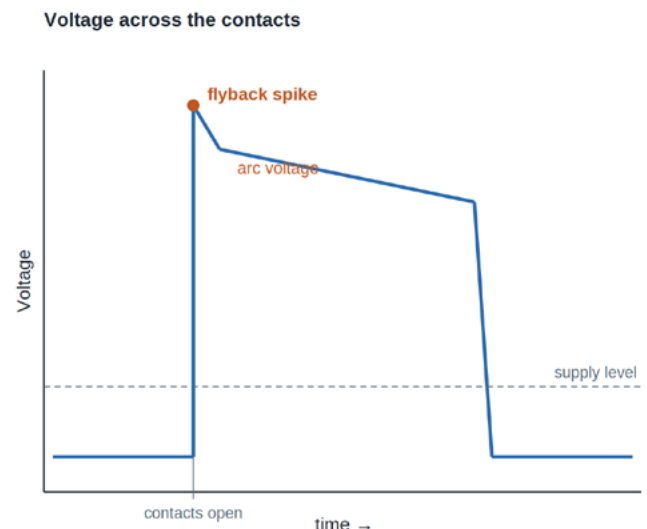
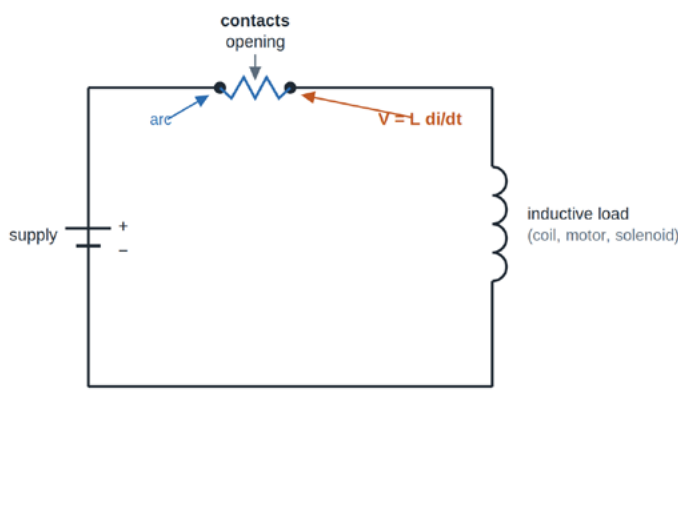


Figure 1: Opening an inductive load.

The collapsing field drives the contact voltage far above the supply and strikes an arc across the parting contacts.

Contact material

The contact material is the first defence, chosen before any external protection. Fine silver has the lowest resistance but erodes and welds readily under arcing. Silver alloys and silver metal-oxide materials, such as silver nickel or silver tin-oxide, give up a little conductivity for much better resistance to material transfer and welding, which is why contacts meant for real loads are usually made from them rather than from pure silver. The micro switch referred to here uses a silver alloy contact for exactly this reason. Material sets the baseline, but on its own it does not remove the arc. For that the design has to handle the energy.

Giving the energy another path

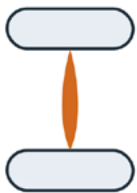
Protecting a contact that switches an inductive load means giving the inductor's stored energy, $\frac{1}{2}LI^2$, a path other than the arc, or holding the gap voltage below the level at which an arc strikes.

Three networks cover most cases, and they are the same tools used to protect semiconductors.

An RC snubber, across the contacts or across the load, slows the rate at which voltage rises across the opening gap. The capacitor absorbs energy and limits dV/dt so the gap can widen past the arcing distance before the voltage breaks it down, while the series resistor limits the capacitor's discharge current when the contacts close again. As a starting point the capacitor runs to a fraction of a microfarad per amp of interrupted current and the resistor to an ohm or so per volt of supply, with the resistor chosen above all to keep the make-discharge within the switch's rating. A snubber suits both AC and DC.

A freewheeling diode across a DC inductive load gives the current a path to circulate and decay after the switch opens, clamping the

1 Parting



2 Arc



3 After many operations

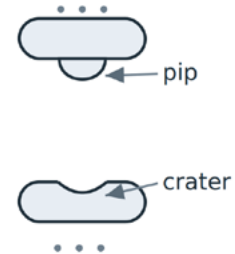


Figure 2: Contact erosion. A molten bridge transfers metal as the contacts part, the arc melts and vaporises more, and over many operations a pip and crater form while the surface oxidises.

3/5 power electronics

Innovation • Quality • Partnership

YOU ARE FIRED!

MADE IN GERMANY

G2S

THERE IS A BETTER CHOICE.

GaAs Power Diodes

**OUTDATED
MORE LOSSES
HIGHER COSTS**

**G2S
GaAs POWER DIODES**

WHY G2S GaAs POWER DIODES?

- ULTRA LOW Qrr**
temperature-independent,
much lower than Si
- LOW CAPACITANCE / LOW Cj**
up to 25x lower Cj
vs. SiC for highest efficiency
- HIGH TEMPERATURE**
Reliable operation
up to 175°C
- RUGGED & ROBUST**
High dv/dt capability
& cosmic ray robust
- COST EFFECTIVE**
Si-like price,
SiC-like performance

LOWEST PRICE

SCAN ME!

PV & SOLAR
HIGH EFFICIENCY

EV & E-MOBILITY
MORE RANGE

INDUSTRIAL POWER
MAX RELIABILITY

RAIL & TRANSPORT
BUILT TO LAST

SPACE & DEFENSE
RADIATION PROVEN

3-5pe.com

g2s.3-5pe.com

voltage to about a diode drop above the supply. It is the simplest and most effective protection for DC coils such as relays and solenoids. It cannot be used on AC, where it would conduct every half cycle. The coil current then decays with the circuit's L/R time constant, and because a plain diode adds almost no resistance, that decay, and so the coil's release, is slow; a series Zener or resistor raises the effective resistance and speeds the release at the cost of a higher clamp voltage.

A voltage-clamping device, a metal-oxide varistor or a transient-voltage-suppressor diode across the contacts or the load, conducts above a set voltage and holds the spike to a safe level. A varistor is bidirectional and suits AC, but it absorbs energy on every operation and degrades over its life, so it has to be rated for the cumulative duty.

Choosing by load type

The network follows from the load. For an AC inductive load, an RC snubber or a varistor across the load is the usual answer. For a DC coil, a freewheeling diode is the default, with a series Zener where the release has to be fast, and an RC snubber is a sound alternative. The network can sit across the contacts or across the load: across the load keeps the transient at its source and avoids dumping the capacitor into the contacts as they close, while across the contacts is simple and common, and either way it is sized so the make-discharge stays within the contact rating. None of this removes the need to choose the switch well. The rating that matters for an inductive load is the electrical rating, not the resistive headline, and the electrical-life figure still has to be read against the real duty once suppression is added.

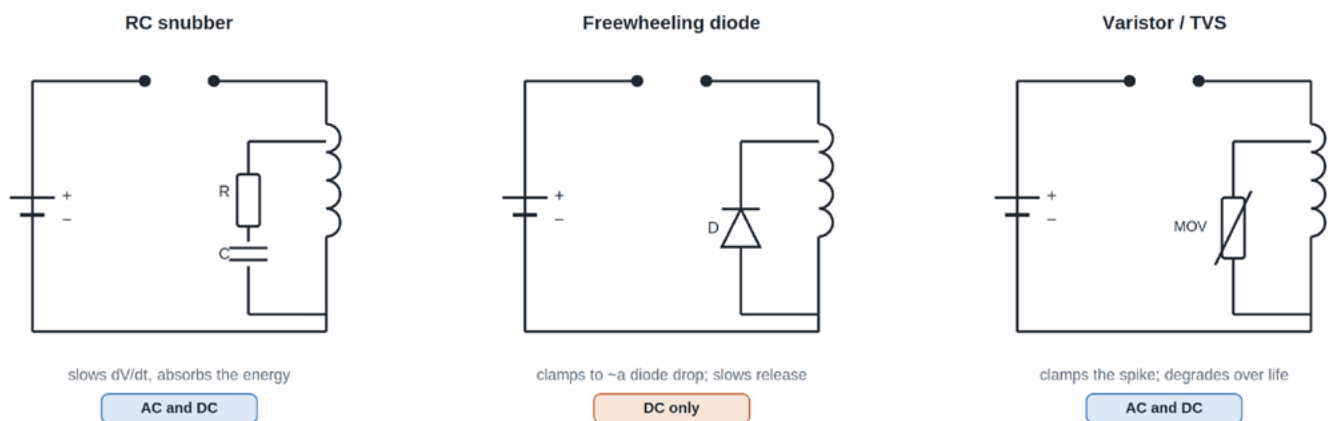


Figure 3: Three suppression networks and where they apply: an RC snubber (AC and DC), a freewheeling diode (DC coils), and a voltage clamp (AC and DC).

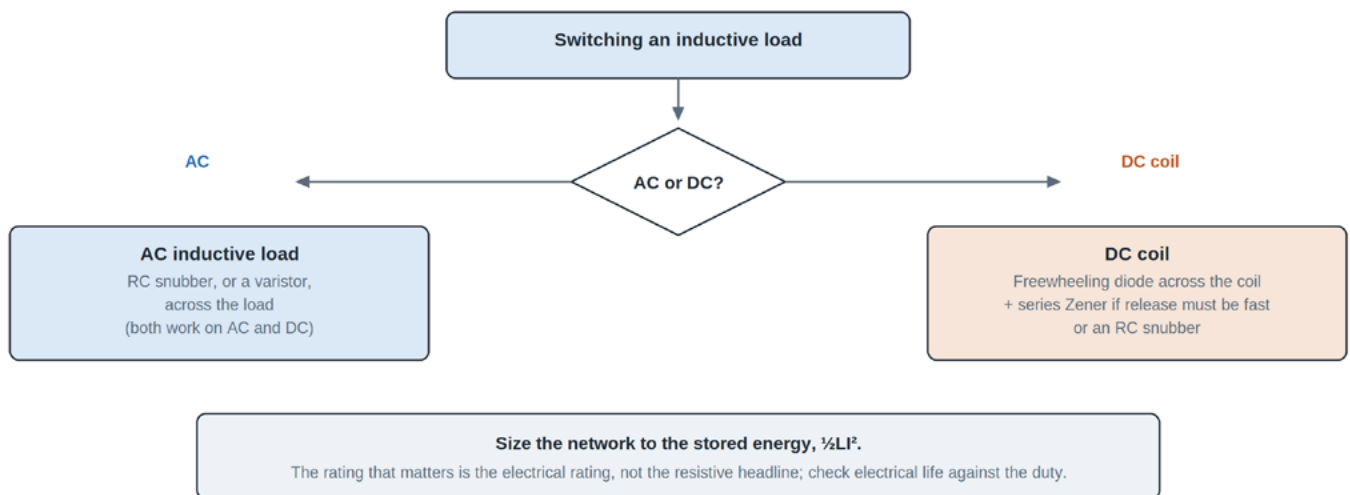


Figure 4: Matching the suppression to the load, sized to the stored energy.

Conclusion

A switch's headline rating describes the resistive case. The inductive case is a question of energy: the field that collapses when the contacts open strikes an arc, and the arc, with the molten bridge that precedes it, erodes the contacts and fixes the electrical life well below the mechanical one. Handle that energy, with an arc-resistant contact and a suppression network chosen for AC or DC and sized to $\frac{1}{2}LI^2$, and the electrical life stops being the limit it first appears to be.

About the Author



Liu Junxiong is an R&D engineer at Swiclick, where he leads switch mechanical design and project management. His work focuses on the tactile and electrical performance of miniature and micro switches, including contact materials, contact reliability, and switching performance under real loads.

HITACHI



HiPak Next generation 3300 V and 6500 V

HiPak IGBT modules are renowned for their high performance in traction, industrial or renewable energy applications. Now the performance has moved up a gear with the arrival of the Trench TSPT⁺ for 3.3 kV 1800 A and Enhanced Planar SPT⁺⁺ for 6.5 kV 1000 A IGBTs. With TSPT⁺, Hitachi Energy offers the next generation IGBT cell featuring a further 30 percent reduction in losses and opening up the possibility to increase current density.



hitachienergy.com/semiconductors

The Premier Global Event in Power Electronics

SAVE *the* DATE

March 7-11, 2027



New Orleans, LA

Ernest N. Morial Convention Center

APEC 2027



Advert

TVS Diodes for 48 V Automotive Systems

TP5.0SMD-FL in SMC



TP1KSMB-FL in SMB



Littlefuse announced the TP5.0SMD-FL (5 kW) and TP1KSMB-FL (1 kW) Series FlatSuppressX™ TVS Diodes, designed to protect 48 V automotive electronics from transient overvoltage events while delivering low and stable clamping performance. Engineered for next-generation 48 V systems in compliance with ISO 21780, the TVS diodes address a critical challenge in automotive design: protecting increasingly sensitive ICs - such as DC/DC converters and gate drivers - without exceeding their absolute maximum ratings. Using Littelfuse's proprietary FlatSuppressX™ technology, the devices maintain a near-constant, low clamping voltage during fast transients and high-energy surge events. The TP5.0SMD-FL Series provides up to 5000 W peak pulse power capability in a DO-214AB (SMC) package. At the same time, the TP1KSMB-FL Series delivers 1000 W in a DO-214AA (SMB) package. Both series are AEC-Q101 qualified.

www.littelfuse.com

2200 V GaN Technology

Power Integrations announced that PowiGaN™ gallium-nitride (GaN) technology is now rated at up to 2200 V, which is according to the company "far exceeding the voltage capabilities of all other commercially available GaN technologies". You can read all the details in the article at page 30.

www.power.com

Angst+Pfister
SENSORS AND POWER

Experts on Design-In

Customization is our daily business

- Fast evaluation, sampling and pricing process
- Guaranteed high quality
- Drop-in replacement designs
- Dedicated engineering support

Current Sensors

Transformers and Inductors

And many more...please contact us.

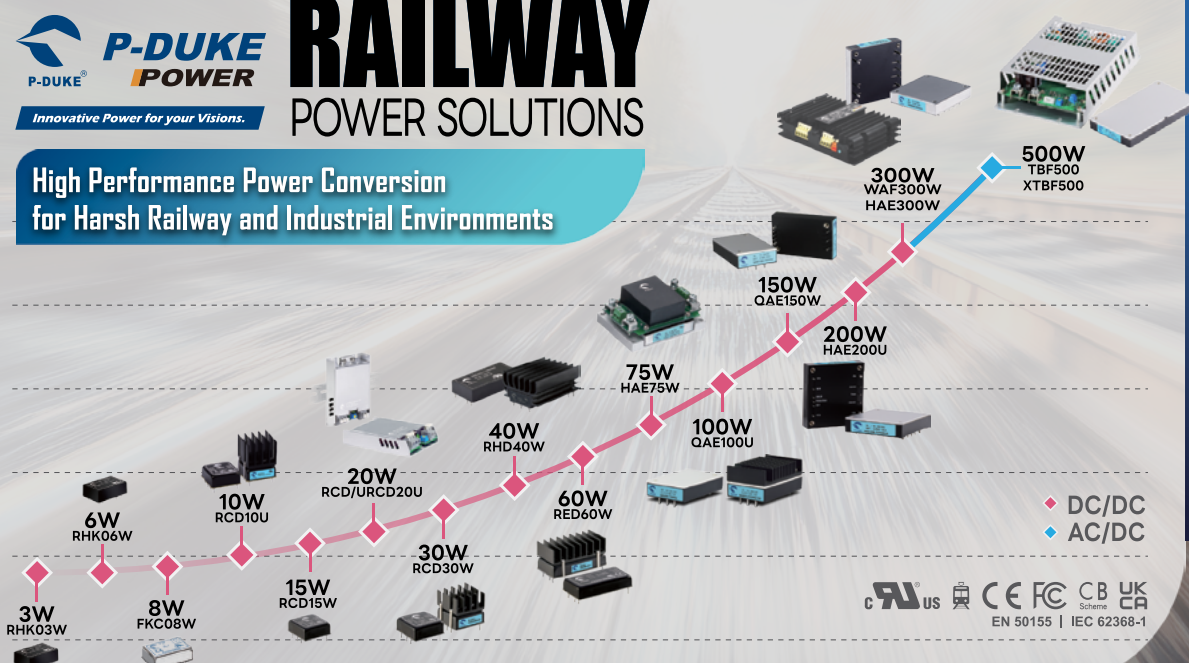
2200 V PowiGaN™



Innovative Power for your Visions.

RAILWAY POWER SOLUTIONS

High Performance Power Conversion for Harsh Railway and Industrial Environments



Innovative Power for your Visions.

AC/DC · DC/DC
Power Solutions

22-25.9.2026

Hall 17 - 130

VISIT US!



www.pduke.com | sales@pduke.com

High-Precision Power Analyzer

Yokogawa introduced the WT1500 power analyzer for high-voltage, multi-functional measurement within the renewable energy and xEV markets as well as for semiconductor and battery applications. Operating with an input voltage of 2000 V_{DC}, its four measurement channels fit within a 2U (approx. 88 mm), 19-inch chassis, making it suitable for the rack-mount and PC controlled test environments. Resolver signal input support enables engineers to conduct motor evaluation tests without needing additional equipment, while multi-unit synchronization capabilities will later allow up to 5 units to connect, for a maximum of 20 power channels. The WT1500 achieves a total power accuracy of $\pm 0.038\%$ (DC, 50/60 Hz) and low-power-factor accuracy of $\pm 0.07\%$ of S at 50/60 Hz and supports two types of input elements, High Voltage (HV) and Wide Bandwidth (WB). The HV element supports direct measurement up to 2000 V_{DC} and 300 kHz, well-suited for high-voltage PCS and ESS applications. The WB element supports up to 1000 V with a 2 MHz bandwidth, crucial for measuring the complex, high-frequency waveforms generated

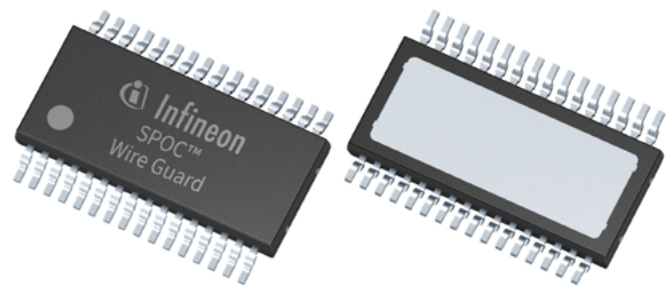


in today's xEV motors. Both inputs share a common sensor input and can be mixed in a single unit. The instrument supports four power measurements and four motor evaluations, including both encoder and resolver signal inputs, IEEE 1588 time synchronization, and data output to CAN/CAN-FD buses and low-latency data transmission via UDP communication. Featuring several interfaces for remote control via PC, external monitor or tablet up to five WT1500 units can be synchronized, enabling 20-channel power measurement.

www.tmi.yokogawa.com

12 V Automotive eFuse supports Software-defined Vehicles

Infineon Technologies has expanded its automotive power distribution portfolio with the SPOC™ Wire Guard BTS80009 SWPx 1ES, a 12 V automotive eFuse with SPI interface. As the first member of a smart power switch family, it combines a protected high-side switch with integrated I²t wire protection, software configurability, and advanced diagnosis. It is designed for new E/E architectures that support SDV concepts with over-the-air updates. The SPOC Wire Guard BTS80009 SWPx 1ES automotive eFuse provides failure isolation within μ s as well as current sensing, avoiding overdimensioning of the wire diameter compared with traditional melting fuses. For permanently powered loads, the product features a dedicated idle mode with a power consumption of a few μ A while maintaining full protection. Its 24-bit SPI interface is daisy-chain-capable. Supporting platform reuse across vehicle variants, the configuration and protection parameters can be adjusted in software for each variant. In addition, SPOC Wire Guard devices provide real-time status, pre-warning indicators, and other diagnostics. SPOC Wire Guard also addresses growing needs for features supporting ADAS and enables fail-operational capabilities for L2++ to L5. It is offered as



a Safety Element out of Context (SEooC) for use in systems up to ASIL-D in accordance with ISO 26262, with an integrated non-volatile memory (NVM) to configure an application-specific safe state. It can autonomously react to supply-voltage drops caused by load faults to protect the supply and is available in four variants with a scalable feature set (A, I, P, and F) supporting currents up to 34.5 A.

www.infineon.com

Software for Three-Phase Power Analysis on MXO Series Oscilloscopes

Rohde & Schwarz has introduced the R&S MXO-K333 software option for three-phase power analysis on its MXO series oscilloscopes. The software adds in-depth measurement and analysis functions for testing and debugging three phase power systems, drives and inverters. Available for all four and eight channel models of the MXO 3, MXO 4, MXO 5 and 5C oscilloscopes, it supports the analysis of voltage and current signals in three-phase AC systems. This test solution keeps the captured waveforms visible during measurement, allowing engineers to review power values and check transient behavior in the same instrument. Other oscilloscope functions such as math, spectrum analysis, measurement tracking and zone trigger remain available for further analysis. A guided setup wizard assigns the oscilloscope channels to the voltage and current probes used for the three-phase analysis. It verifies the wiring and supports common two-wire, three-wire and four-wire configurations (2V2A, 3V3A and 3VN3A). After setup, the software provides cycle-by-cycle calculations for RMS values, power factor, active power, reactive power and total power. By defining the input and output configuration, users can also calculate the system's three-phase efficiency. Additional analysis views include phasor display, harmonic analysis and THD measurements in line with IEC 61000-

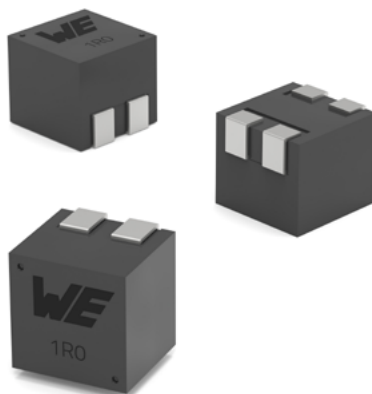


3-2 and MIL-STD-1399. As an oscilloscope-based solution, the R&S MXO-K333 enables engineers to correlate three-phase power results directly with the underlying voltage and current waveforms in real time. This is especially valuable during R&D and debugging, when power behavior often must be analyzed alongside switching events, transients, control signals and communication activity.

www.rohde-schwarz.com

Harnessing Leakage Inductance

Würth Elektronik is expanding its WE-MCRI product series with the 1090HL variant (HL = High Leakage), a coupled inductor specifically designed to improve the performance of SEPIC, ZETA and Čuk converters. This double choke takes an unconventional approach by deliberately harnessing leakage inductance, which is normally treated as a parasitic element in conventional designs. The coupled inductor enables more effective filtering for improved EMC performance with a far more compact design. By using the molded double choke, which measures $11 \times 10 \times 9 \text{ mm}^3$, ripple current reduction can be achieved with a lower inductance value. Cost and space are reduced compared with using two separate inductors. This special component also requires a smaller AC coupling capacitor, without sacrificing efficiency while enabling a



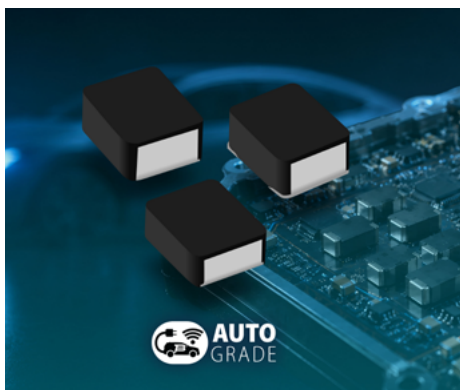
more compact design. As a molded coupled inductor, this component delivers temperature-stable and soft saturation performance.

www.we-online.com

Shielded Power Inductors for High-Current, Automotive and DC/DC Designs

Bourns introduced the SRP2010PA, SRP-2510PA, and SRP2512PA Series of shielded power inductors designed to support high current operation in space-constrained electronic designs. This series combines a metal-alloy powder core with shielded construction to reduce magnetic field radiation while maintaining a low-profile package. The devices are AEC-Q200 compliant and suitable for automotive-grade applications. Typical applications are automotive systems, DC/DC converters and miniature electronic devices.

www.bourns.com

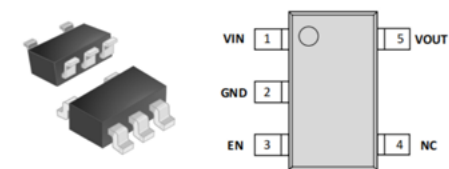


Ideal Diodes Enhance System Efficiency

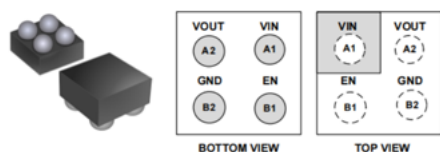
Available in SOT23-5L (GLF1800) and WLCSP (GLF1800T & GLF1800AT) packages; GLF1800 Series of ideal diodes replaces Schottkys with

low-loss MOSFET-based architecture to significantly reduce forward voltage drop and heat generation. GLF Integrated Power introduced its GLF1800 Series of ideal diodes. Designed to deliver efficient power-path protection in compact, battery-powered systems, GLF's ideal diodes feature a low static current (I_Q), low turn-off current (I_{SD}), and a low forward voltage drop (GLF1800: 117 mV and GLF1800T/AT: 73 mV). These ideal diodes feature an SOT23-5L package, or a WLCSP package. The GLF1800AT EN pin has an internal pull-up resistor connected to V_{IN} . Supporting an input voltage range of 1.8 V to 5.5 V and providing up to 1.0 A or 1.5A of continuous current, GLF1800 Series diodes are well-suited for use in wearables and other low-voltage electronics. They can replace traditional Schottky diodes. The GLF1800 Series integrates multiple protection features - including reverse-current blocking, inrush control and seamless power-source switching.

www.glfpower.com



GLF1800: SOT23-5L



GLF1800T:
0.77 mm x 0.77 mm x 0.35 mm Thin WLCSP

WÜRTH ELEKTRONIK
MORE THAN YOU EXPECT



HEAT OUT. PERFOR- MANCE IN.

Heatsinks for optimal thermal management

Stop thermal bottlenecks before they start. The new Würth Elektronik WE heat sink portfolio combines optimized aluminum geometry, black anodized surface and matching mounting hardware for optimal thermal management.

www.we-online.com/heatsinks



Highlights

- Heat sinks for various applications like TO220/247 or IC
- Also available with interface materials for easy assembly
- Free samples & personal technical support for fast design-in

© e505

WE meet @ electronica
Hall B6 - 101

POWER SUPPLIES

Heavy-Duty
Industrial

Cost-effective
solutions to tough
design challenges



ABSOPULSE
ELECTRONICS LTD.

www.absopulse.com
Since 1982

Power Operational Amplifier Family

Apex Microtechnology released three precision power operational amplifiers - the PA167, PA168, and PA169 - delivering up to 20 % higher thermal performance than previous generations. The PA167 is a high-voltage MOSFET operational amplifier featuring a monolithic amplifier core designed for applications requiring high output voltage or output current density. Operating up to 205 V, the device delivers 1 A of continuous output current in the standard version and 2 A in the A-grade version, with up to 6 A peak current and 33 W of internal power dissipation. The PA168 operates up to 200 V with 8 A of continuous output current, 12 A peak current, and 52 W of internal power dissipation. Separate power supplies for the amplifier core and output stage allow designers to optimize voltage swing and overall system efficiency. The PA169 integrates two independent high-voltage amplifier channels into a 52-pin QFP package, delivering dual 200 V, 2 A continuous (6 A peak) amplifier channels with up to 52 W of internal power dissipation for applications requiring multiple high-performance amplifier channels in a single package. All three devices utilize Apex's monolithic MOS technology and incorporate integrated protection features including temperature-compensated current limiting with



over-current flag indication and amplifier disable functionality. Housed in a 20 mm × 20 mm PQ package, the devices are targeted towards applications like high-density voltage and current sources, electrostatic transducers, beam and mirror deflection systems, deformable mirror focusing, piezoelectric positioning, and other precision motion control applications.

www.apexanalog.com

Current Probe for Measurements up to 1000 A

Teledyne LeCroy expands its portfolio of current measurement solutions with the CP1000 AC/DC current probe, which has been specifically designed for precise measurement of high currents in applications such as traction inverters, motor drives, fast charging stations, energy storage systems, and industrial power electronics. With measurement capability up to 1000 A_{rms} and 1400 A peak current, the CP1000 combines 1000 A continuous current capability with 1.5 MHz bandwidth. This capability is particularly important for SiC- and GaN-based power circuits as well as for efficiency and



power-loss measurements. It fills the gap between traditional high-current transformers and high-bandwidth laboratory current probes. The probe features a 33 mm core opening in combination with a 6-meter cable, enabling measurements on large conductors and busbars without interrupting the circuit. Through Teledyne LeCroy's ProBus® interface the probe is automatically recognized and scaled. Functions such as Auto-Zero and Degauss can be controlled directly from the oscilloscope.

www.teledynelecroy.com

Family of 1200-2300 V SiC Power Modules

WeEn Semiconductors has launched a family of AC/DC and DC/DC SiC power modules to target the growing range of solid-state

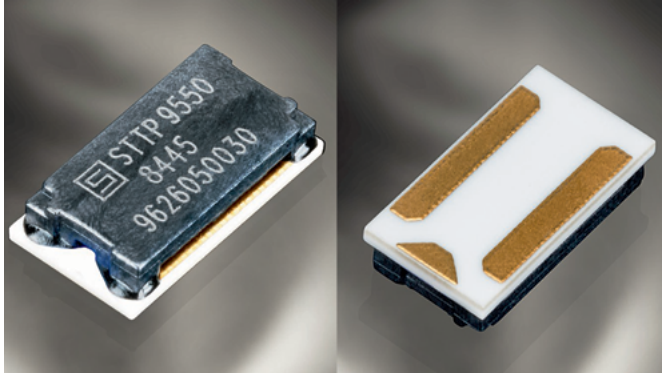
transformer (SST) applications, as well as EV super chargers and smart-grid/renewable applications. The semiconductors are available in an array of packages and with voltages ranging from 1200 to 2300 V, $R_{DS(on)}$ values as low as 1.5 mΩ and customer-specific configurations can also be created. Module configurations have been created to cater for a huge array of SST applications, including grid PFC for the latest generation of AI racks, enabling conversion from 35 kV_{AC} to 800 V_{DC} in a single stage. This includes 3-level topology modules for enhanced EMI performance (e.g. WMSC5R0N17B3T), and 2-level devices, for easier control and smaller footprints (e.g. WMSC5R0F23B3T). Similarly, half bridge modules for LLC/DAB primary and secondary applications have also been announced with packaging options that include B2, B3 and 62 mm screw mount housing.



www.ween-semi.com

Intelligent Fuse Technology for Battery Systems

The STTP 9550 from Schurter combines overcurrent protection with active overcharge protection in a compact 3-terminal fuse. Using its integrated trigger function, the charge and discharge paths can be disconnected even if the protection IC or FET fails. This makes the STTP 9550 suitable for lithium-ion batteries used in energy storage,



industrial and mobility applications. These three-terminal fuses STTP 9550 combine conventional overcurrent protection with an actively triggered overcharge protection function, providing an additional layer of safety for lithium-ion battery systems. In addition to current-dependent interruption, the integrated trigger terminal enables controlled activation in critical operating conditions. This allows reliable disconnection of charge and discharge paths even in the event of protection IC or FET failure. Gold-plated terminals ensure low and stable contact resistance, high signal integrity and corrosion resistance. The package supports high-power-density battery pack designs ranging from 1 to 24 cells. Typical applications include energy storage systems, power tools, UPS equipment, e-bikes, e-scooters, and automated guided vehicles (AGVs). Supported by UL approvals and designed for redundant protection architectures required by the battery safety standards, three-terminal fuses provide a robust and intelligent protection solution for advanced energy systems.

www.schurter.com

35 W to 350 W AC/DC Power Supplies

XP Power announces the LBA series of low-profile enclosed, chassis-mount, single-output AC/DC power supplies, covering power levels from 35 W to 350 W within the operating temperature range



of -30 °C to +70 °C. Designed for cost-sensitive industrial technology applications, the series provides a platform for engineers developing industrial automation, security and surveillance systems, lighting control, smart home and building control equipment. The LBA series offers regulated single output voltages from 5 V to 48 V_{DC} (model dependent) with output adjustment capability to compensate for system tolerances or voltage drops. This output voltage trim allows engineers to ensure accurate voltage delivery at the point of load and improve overall system performance and reliability. A universal 90 to 264 V_{AC} input range and active PFC are standard in this series, which provides an efficiency of up to 90%. In lower power ratings, the LBA series offers a footprint of 99 mm x 82 mm x 30 mm (35 W and 50 W models) and 99 x 97 x 30 mm³ (75 W). Models up to 200 W feature convection-cooled, fanless operation, designed for noise-sensitive environments. The 350 W variant incorporates fan cooling. A wide ensures reliable performance in harsh environments.

www.xppower.com

LOW PROFILE HIGH PERFORMANCE

Introducing

PLANAR POWER TRANSFORMERS

Advanced magnetic solutions
for compact industrial power electronics

www.sirio-ic.com



5 ÷ 25 kW

POWER
RANGE

from 100 kHz

SWITCHING
FREQUENCY

99%

MEASURED
EFFICIENCY

°C

EFFICIENT
COOLING

<60 mm

ULTRA LOW
PROFILE

5 kVrms

INSULATION
VOLTAGE

pC

PARTIAL
DISCHARGE
FREE

Fast 1200 V Rectifiers

Vishay Intertechnology expanded its Gen 7 platform of 1200 V FRED Pt® Hyperfast rectifiers with six additional devices in the eSMP® series SMPC HV package. Suited for industrial, automotive, and energy applications, the 1 A, 2 A, and 3 A rectifiers aim to offer the best trade-off between reverse recovery charge (Q_{rr}) and forward voltage drop for devices in their class, but also to provide the lowest junction capacitance and recovery time. The rectifiers released include the VS-E7SX0112-M3V, VS-E7SX0212-M3V, and VS-E7SX0312-M3V, and AEC-Q101 qualified VS-E7SX0112HM3V, VS-E7SX0212HM3V, and VS-E7SX0312HM3V. To reduce switching losses and increase

efficiency, the devices combine a recovery time of 50 ns with Q_{rr} down to 105 nC typical, forward voltage drop down to 1.45 V, and junction capacitance down to 7.25 pF. The rectifiers offer non-repetitive peak surge current up to 70 A in a compact package measuring 4.3 mm x 6.5 mm with a 1.1 mm profile, which is footprint-compatible with the TO-277A. Combined with a minimum 5.4 mm creepage distance and molding compound with a comparative tracking index (CTI) ≥ 600 (Material Group I), the devices reduce component counts and lower BOM costs based on IEC 60664-1 requirements for high voltage applications. The devices will serve as clamp, snubber,



and freewheeling diodes in flyback auxiliary power supplies and high frequency rectifiers for bootstrap driver functionality. Typical applications for the devices include industrial drives and tools, on-board chargers and motors for electric vehicles (EV), energy generation and storage systems, and more.

www.vishay.com

Current Transducer with PPM-Class Precision

Danisen announced a high-precision DP121P current transducer designed for isolated DC and AC current measurement in demanding PCB-mounted power electronics applications. Based on the company's closed-loop compensated fluxgate technology, the DP121P series combines ppm-class accuracy with a maximum linearity error of 10 ppm and high long-term stability in a PCB-mount package featuring a form factor of 32 mm and weighing 250 g. This allows for integration into 1U power supplies and

other space-constrained equipment. The transducer supports current measurement



up to 18 A and accommodates measurement resistors up to 100 Ω at full scale. It uses fixed excitation frequency and second harmonic zero-flux detection for current measurement. Typical applications include magnet power supplies for particle accelerators, stable precision power supplies, precision servo drives for motion control, battery test benches, battery emulators, and power measurement and power analysis systems.

www.danisen.com

AEC Q101 compliant 40 V N-channel MOSFETs

Toshiba Electronics Europe has launched the XPJ1R504PB, an automotive-compliant 40 V, 120 A N-channel power MOSFET housed in the S TOGL™ package, expanding its lineup for 12 V systems. Target applications include inverters, semiconductor relays, load switches, and motor drives. By adding this 40 V MOSFET to its existing lineup in the S TOGL™ package, which includes the XPJR6604PB and XPJ1R004PB, Toshiba has expanded its product options to meet a range of applications and performance requirements. The S TOGL™ package employs gull wing leads that help relieve mounting stress, thereby improving the mechanical



reliability of the soldered connections. In addition, the package features a post less structure that integrates the chip's source-electrode connection and outer leads,

thereby reducing parasitic resistance and achieving an on resistance ($R_{DS(ON)}$) of 1.54 m Ω (max.) at a gate-source voltage (V_{GS}) of 10 V. The use of a thick copper frame in the S TOGL™ package lowers the transient thermal impedance between the channel and the case ($Z_{th(ch-c)}$) to 0.76 K/W, reducing conduction loss and suppressing heat generation, thereby improving overall system efficiency. Furthermore, a multi-pin structure for the source leads enhances current distribution, enabling high current capability.

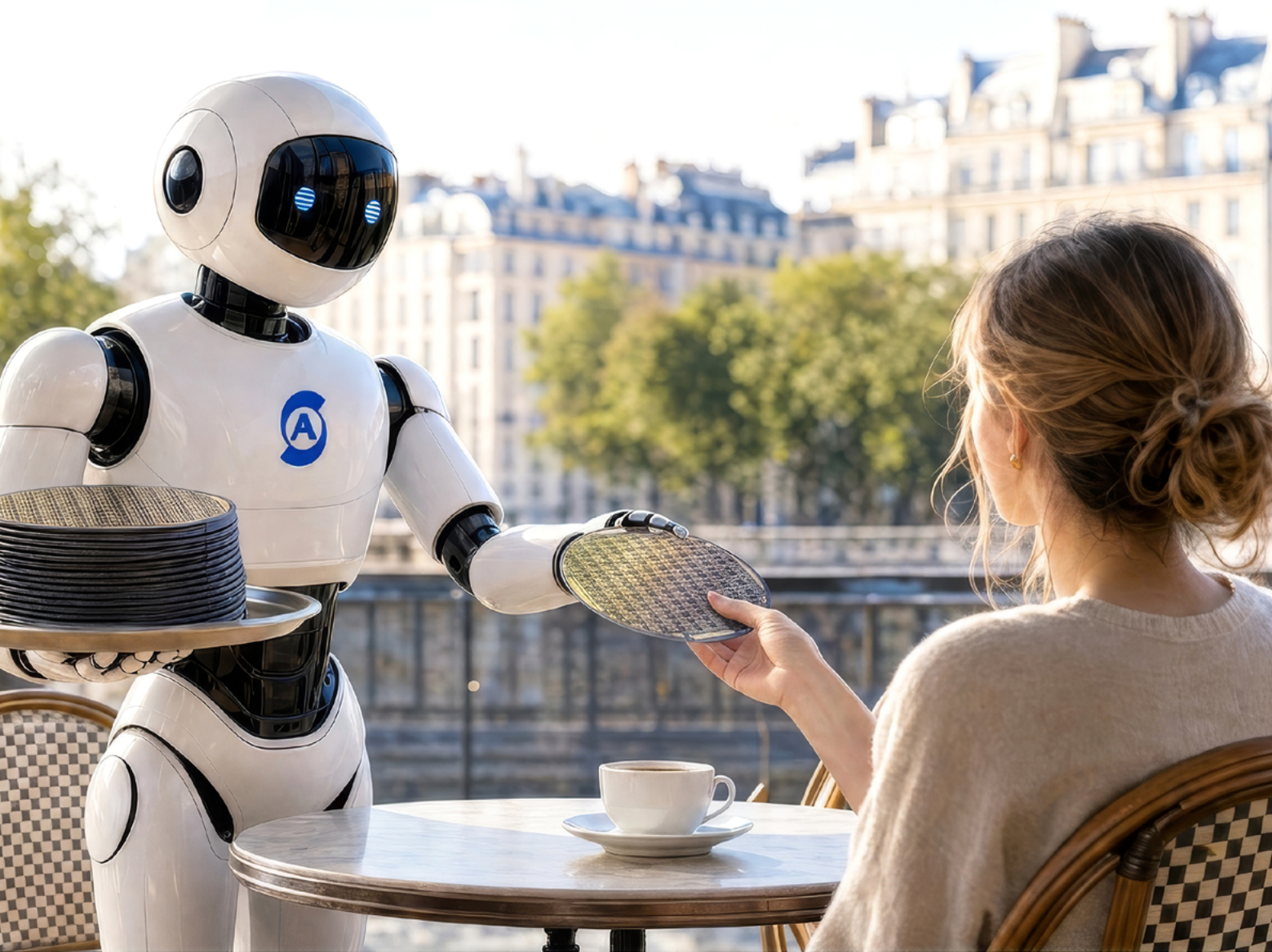
www.toshiba.semicon-storage.com

Advertising Index

3-5 Power Electronics	47	Fuji Electric Europe	11	ROHM	7
Absopulse	54	Goncharov Electric Jet	29	Sanan	C3
Angst+Pfister Sensors and Power	51	GVA	21	Schmidbauer	45
APEC	50	HIOKI	13	SIRIO ELETTRONICA	55
ARCEL	10	Hitachi Energy	49	sps	44
Chang Sung Corporation	33	Infineon	31	Texas Instruments	27
Coilcraft	43	ITG Electronics	17	Toshiba	25
Danisen	35	LEM	5	Vincotech	15
ed-k	C2	Magnetic Metals	41	WiPDA	39
Efficient Power Conversion (EPC)	C4	Mitsubishi Electric	19	Würth Elektronik eiSos	3, 53
Electronic Concepts	1, 9	P-Duke	51		
electronica	44	Plexim	37		

Your One-Stop Manufacturing Partner for WBG Innovation

SiC and GaN
150mm, 200mm and 300mm



www.sanan-semiconductor.com/en



sales.europe@sanan-ic.com



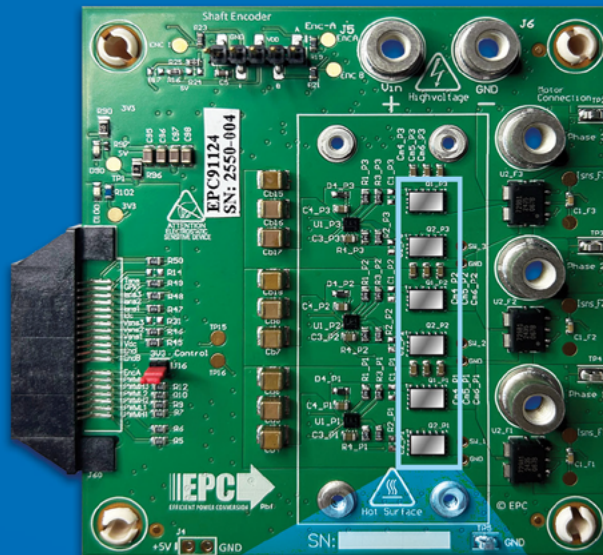
45/40 A_{RMS} 3-Phase BLDC Motor Drive Inverter Evaluation Boards



EPC91124

45 A_{RMS}

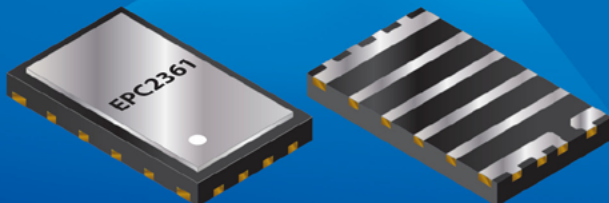
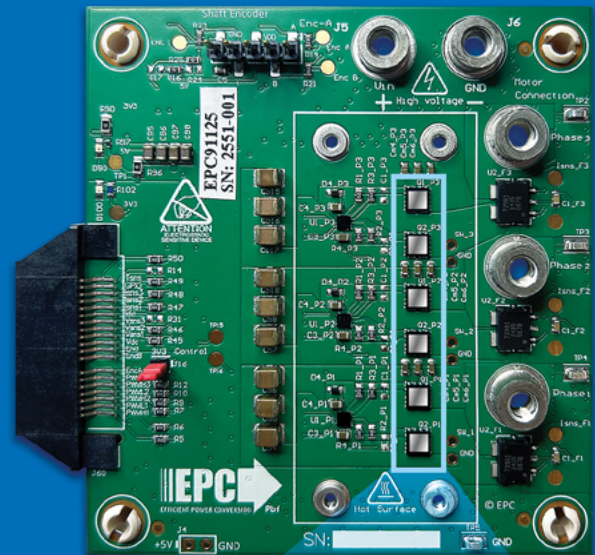
in 79 x 80 mm
(includes connector)



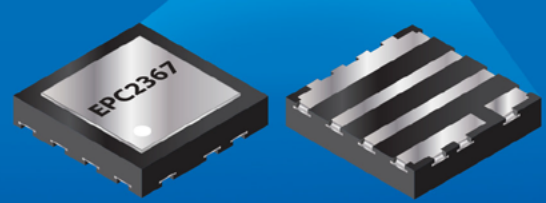
EPC91125

40 A_{RMS}

in 79 x 80 mm
(includes connector)



EPC2361
100 V, 0.75 mΩ



EPC2367
100 V, 1.2 mΩ



epc-co.com