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Bodo´s Power Systems®

Electronics in Motion and Conversion

July 2023

PULSED INDUCTANCE MEASUREMENT

POWER CHOKE TESTER DPG10/20 SERIES WITH 3-PHASE EXTENSION UNIT

Inductance measurement on 1~ and 3~ reactors from 0.1 A to 10 kA

3-PHASE EXTENSION UNIT

- Easy and quick measurement of 3-phase inductors
- Automatic measurement of all windings without reconnecting the terminals
- The software considers the different magnetic flux conditions in the core with 3-phase sinusoidal currents and corrects the measurement results
- The measurement result is equivalent to a conventional measurement with 3-phase sinusoidal mains voltage

KEY BENEFITS

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

APPLICATIONS

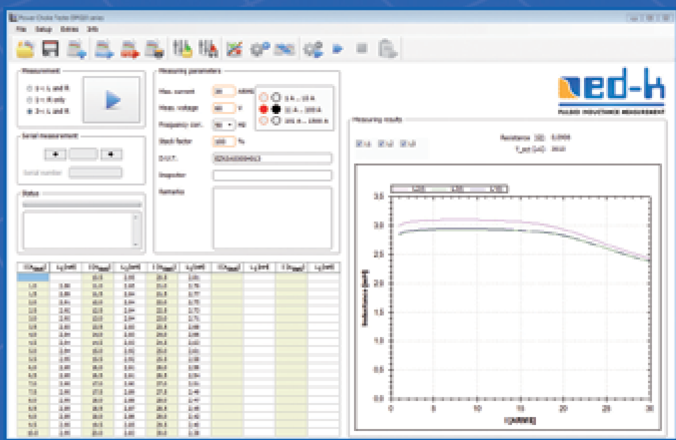
Suitable for all inductive components from **small SMD inductors** to **very large power reactors in the MVA range**

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

KEY FEATURES OF THE DPG10/20 SERIES

Measurement of the

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



Technological leader in pulsed inductance measurement for 18 years

www.ed-k.de

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Supporters & Friends

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- Automotive series WE-MAIA available AEC-Q200 Grade 0&1

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Highlights

- High current ratings up to 15 A
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- Excellent temperature stability from -55° to +150 °C
- Innovative Design
- Excellent EMI behavior

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The Big Summer Slump

It is interesting to see how every year, once PCIM Europe is over, our industry almost instantly goes into vacation mode. Of course, following-up after the event keeps many people busy, but it is noticeably quieter. It feels like the end of the event is almost the unofficial start of the summer break. The phones are noticeably quieter, there are significantly fewer emails and less press releases. And this phenomenon seems even stronger in non-Electronica years, as someone mentioned in a recent call to me. Also, if you look at the event calendar below, it is only events from the US and Asia and the next European event will be EPE'23 ECCE in early September.

Does this mean that we are lazier in Europe? At least not here at Bodo's! The return of the in-person Wide Bandgap Event to Munich in December will be another highlight for 2023 and is keeping us busy. There is no public call for papers, instead, Bodo will be sending personal invitations to the speakers, and I will help him as much as possible. If your company is somehow involved in SiC or GaN, you can be sure you're on our radar! However, should we somehow miss you, please contact us and we'll see what we can do. The provisional programme, with the companies we'll be inviting, will be on bodoswbg.com soon.

On another note, I couldn't think of a better place to live, especially in the summer, than on the Baltic coast. We have a constant breeze, which makes for a pleasant climate during the hot days. I have heard that it is apparently now the trend for people from the south and centre of Germany to move to the northern states because of the nice climate. If this is the case, it seems to make a lot of sense to me, especially since many professionals today are no longer tied to one location. Remote working has become normal in many areas, even being a criterion for some people when looking for a new role. Personally, I have not yet found the real benefit of working from home. I also think we should always remember the people who can only imagine having this kind of "lifestyle", such as the people who keep the wheels turning, like nurses, doctors, plumbers, construction workers or grocery shop clerks, to name a few.

Bodo's magazine is delivered by postal service to all places in the world. It is the only magazine that spreads technical information on power electronics globally. We have EETech as a partner serving our clients in North America. If you speak the language, or just want to have a look, don't miss our Chinese version at bodospowerchina.com. An archive of my magazine with every single issue is available for free at my website bodospower.com.

My Green Power Tip for the Month:
Fill your refrigerator with as many beverage bottles as possible. They help maintain the temperature better than air.

Kindest regards,

Holger Moscheik

Events

DAC 2023
San Francisco, CA, USA July 9 – 13
www.dac.com

electronica China 2023
Shanghai, China July 11 – 13
www.electronicachina.com

SEMICON West 2023
San Francisco, CA, USA July 11 – 13
www.semiconwest.org

IPFA 2023
Penang, Malaysia July 24 – 27
www.ipfa-ieee.org/2023

EMC+SIPI 2023
Grand Rapids, MI, USA July 31 – August 4
https://emc2023.org

Experience Power 2023
Savannah, GA, USA August 14 – 17
www.experience-power.com

WiPDA Asia 2023
Hsinchu, Taiwan August 27 – 29
www.wipda-asia2023.org

PCIM Asia 2023
Shanghai, China August 29 – 31
www.pcimasia-expo.com

EPE'23 ECCE Europe
Aalborg, Denmark September 4 – 8
https://epe2023.com/

Appointment of Lars Fox as Director of R&D

Danisense announced that Lars Fox has joined the company as Director of R&D. Lars Fox has held various management positions in industrial, electronics and technology driven market segments and brings with him more than 20 years of experience in R&D, operations and product commercialization.

Comments Henrik Elbæk, CEO at Danisense: "Danisense has already introduced many high performance transducers to the market but new and exciting opportunities lure on the horizon. This calls for innovation, new products and close collaboration with customers. I am sure that together with our new Director of R&D Lars Fox, we will be able to accelerate our strategy forward as we continue to expand our operational capabilities and portfolio of products."

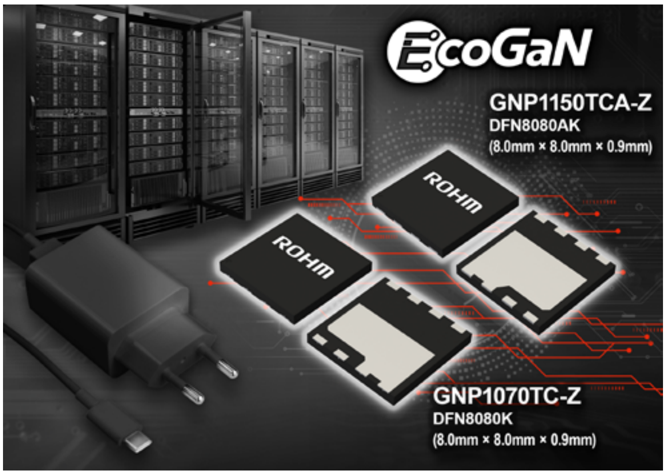
He continues: "We are confident Lars is the right person to further propel the development of our products, supply chain and R&D processes, while continuing to drive our mission of providing top notch current transducers to the market."

"Bridging product development with customers' commercial demands are important steps for scaling the business. My focus will be on realizing the company's potential by setting new goals and standards together with colleagues and customers. Being able to work in a company with research-related activities and being involved with the development of new products for the current transducer market, appeals to me very much. On top of this, it is very satisfying that Danisense develops innovative product solutions for high precision electrical power measurement applications, which support the increasing global demand for distribution and use of clean renewable energy" remarks Lars Fox.

www.danisense.com

Mass Production of 650V GaN HEMTs Started

ROHM has started with the mass production of 650V GaN (Gallium Nitride) HEMTs optimized for a wide range of power supply systems applications. These products are jointly developed with Ancora Semiconductors, an affiliate of Delta Electronics, that develops GaN devices.



Improving the efficiency of power supplies and motors, which account for most of the world's electricity consumption, has become a significant hurdle to achieving a decarbonized society. The adoption of new materials such as GaN and SiC are key to improving the efficiency of power supplies.

After initiating mass production of 150V GaN HEMTs – featuring a gate breakdown voltage of 8V in 2022 – in March 2023 ROHM established control IC technology for maximizing GaN performance. This time, ROHM developed 650V GaN HEMTs featuring market-leading performance that contributes to higher efficiency and smaller size in a wider range of power supply systems.

The GNP1070TC-Z and GNP1150TCA-Z deliver performance in terms of $R_{DS(ON)} \times C_{iss}$ / $R_{DS(ON)} \times C_{oss}$, a figure of merit for GaN HEMTs, translating to higher efficiency in power supply systems. At the same time, a built-in ESD protection element improves electrostatic breakdown resistance up to 3.5kV, leading to higher application reliability. GaN HEMTs' high-speed switching characteristics also contribute to greater miniaturization of peripheral components.

www.rohm.com

Alan Lee Appointed Chief Technology Officer

Analog Devices announced the appointment of Alan Lee to the position of Chief Technology Officer (CTO). He and his team will collaborate closely with ADI customers, universities, research organizations, and other strategic partners to incubate novel technologies and develop the ecosystems to support their market entry. "I am delighted to join ADI and continue its legacy of technology leadership at the boundary between the physical and digital domains," said Alan. "ADI has long been synonymous with innovation, and I am looking forward to working with the company's incredible technology talent to further extend ADI's leadership in the years and decades to come."

Alan is a well-known industry leader, currently chairing both the CTO Committee for the Semiconductor Industry Association (SIA) and the CTO Council for the Global Semiconductor Alliance (GSA). He has served on the Board of Directors for the Semiconductor Research Corporation and the Board of Trustees for the NSF Institute for Pure and Applied Mathematics. Alan will report directly to ADI's CEO and replaces ADI's former CTO, Dan Leibholz, who now serves as ADI's Senior Vice President, Digital Business Unit.

www.analog.com

300mm Semiconductor Manufacturing Facility in France

GlobalFoundries and STMicroelectronics announced the conclusion of the agreement to create a jointly-operated, high-volume semiconductor manufacturing facility in Crolles (France), which was announced on 11 July 2022.

"I would like to thank Minister Le Maire, the French Minister of the Economy and Finance, and his team for their support and the dedication for the last 12+ months that have made celebrating today's milestone possible," said Dr. Thomas Caulfield, president and CEO

Credit - Hamilton de Oliveira MEFSIN

of GlobalFoundries. "In partnership with ST in Crolles, we are further expanding GF's presence within Europe's dynamic technology ecosystem while benefiting from economies of scale to deliver additional capacity in a highly capital efficient manner. Together we will deliver GF's market leading FDX technology and ST's comprehensive technology roadmap, in alignment with customer demand which is expected to remain high for Automotive, IoT, and Mobile applications over the next decades."

"Today marks an important milestone for ST, for GF as well as for Europe. This could not have been achieved without the support of the French government as well as of the European Commission," said Jean-Marc Chery, President and CEO of STMicroelectronics. "We will further reinforce the European and French FD-SOI ecosystem, building more capacity for our European and global customers in complex, advanced technologies for key end-markets including automotive, industrial, IoT and communication infrastructure, as they transition to digitalization and decarbonization. This new manufacturing facility will support our $20 billion+ revenue ambition."

www.gf.com

PCIM Europe 2023 Continues on the Road to Success

A wider audience – greater knowledge – even more networking: From 9 – 11 May 2023, the PCIM Europe once again gathered the experts of power electronics in Nuremberg, further pushed its meaning as an important exchange platform and thus once again confirmed its relevance for the industry.

The exhibition and conference demonstrated that power electronics is an essential topic for technological progress and, as a key technology, makes a major contribution to future-oriented trend topics. These include hot subjects such as electromobility and energy storage. In 2023, the PCIM Europe is again proven to be a relevant industry meeting place and networking platform, which is reflected in the positive feedback and results.

The parallel conference once again showed the close connection between industry and science within the PCIM Europe. In 377 top-class presentations on current research and development topics, 895 participants from 36 countries expanded their expertise. This year, the three Special Sessions again focused on particularly relevant industry topics, such as the session on "Power Electronics for E-Mobility". The three keynotes at the beginning of each conference day were also very well attended.

At the exhibition, these application areas were focused within the new E-Mobility & Energy Storage Zone and Stage, enabling interested parties to exchange information and ideas with each other. Presentations highlighted current trends and challenges in the value chain in this segment and these were discussed afterwards in more detail in the networking area.

Next year, the PCIM Europe will be held around one month later from 11 – 13 June 2024 at the Nuremberg Exhibition Center.

https://pcim.mesago.com

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Celebrating 50th Anniversary

Rutronik Elektronische Bauelemente GmbH announced its 50th year in business. Helmut Rudel founded Rutronik in 1973 in Ispringen, near Pforzheim, Germany. The expertise of the independent family-owned company lies in the distribution of semiconductors, passive and electromechanical components, embedded boards, storage and displays, as well as wireless products. The distributor's customers drive high-growth future markets around Industry 4.0, (I)IoT, Future Mobility, and Energy & Power.

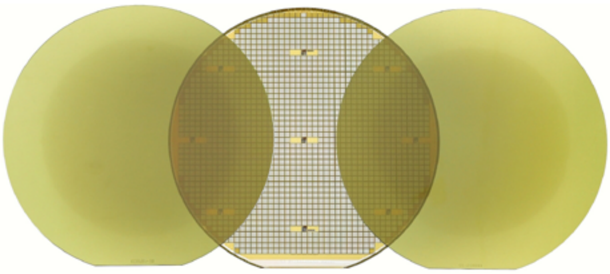
In the 1970s, color television became increasingly popular in Germany, especially because of the 1972 Olympic Games and the Soccer World Cup in 1974. Exactly in the period between these two major sporting events, in 1973, Helmut Rudel founded Rutronik, which was specialized on the distribution of passive components. Rutronik is now one of Europe's largest electronics distribution companies and generated sales of 1.28 billion euros in 2022. Worldwide, the family-owned company now employs more than 1,900 people in over 80 offices, as well as logistics centers in Europe, Austin (Texas), Shanghai, Singapore, and Hong Kong. "We are happy and proud to celebrate our 50th anniversary in the electronics industry this year," said Thomas Rudel, CEO and chairman of the board at Rutronik. "From a small family business that I founded in a double garage in Ispringen in the early 1970s with great support of my wife, we have become a leading distribution company for electronic components within 50 years," added Helmut Rudel, founder and president of Rutronik.

www.rutronik.com

SiC Long-Term Supply Agreement and Invest in Capacity Expansion

Vitesco Technologies and onsemi announced a 10-year long-term supply agreement worth $1.9 billion (€1.75 billion) for silicon carbide (SiC) products to enable Vitesco Technologies' ramp in electrification technologies. Vitesco Technologies, a leading international manufacturer of modern drive technologies and electrification solutions, is providing an investment of $250 million (€230 million) to onsemi for new equipment for SiC boule growth, wafer production and epitaxy to secure access to SiC capacity. The equipment will be used to produce SiC wafers to support Vitesco Technologies' growing SiC demand. In parallel, onsemi, a leader in intelligent power and sensing technologies, will continue to invest substantially into end-to-end SiC supply chain.

In addition, Vitesco Technologies and onsemi will collaborate on optimized customer solutions for Vitesco Technologies. onsemi's EliteSiC MOSFETs will be used by Vitesco Technologies to execute the recent orders as well as future projects for traction inverters and electric vehicle drives.

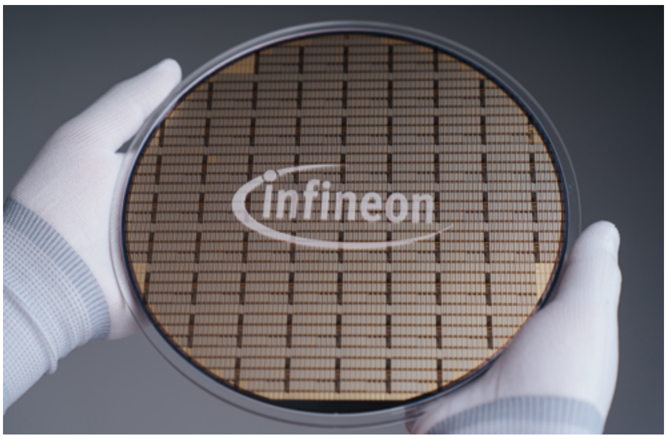


"Energy-efficient silicon carbide power semiconductors are at the beginning of a big surge in demand. That is why it is imperative for us to get access to the complete SiC value chain together with onsemi. With this investment we have a secure supply of a key technology over the next ten years and beyond." said Andreas Wolf, CEO of Vitesco Technologies.

www.vitesco-technologies.com

EU Projects for Power Electronics and Artificial Intelligence

To tackle the climate crisis, Infineon in Villach is launching two European research projects with enormous thrust: The "ALL2GaN" project is about easily integrated energy-saving chips made of gallium nitride. They have the potential to improve energy efficiency by 30 percent in a wide range of applications and thus save an extrapolated 218 million tons of CO_2 worldwide. The "AIMS5.0" project focuses on artificial intelligence (AI) to create resource-efficient manufacturing across industries as well as optimize supply chain management in Europe. The projects, worth a total of 130 million euros, bring together 98 partners from 18 countries. Both projects will run for three years and are funded by industry investments, grants from the individual countries involved, and the European Key Digital Technologies research program.



The research project "ALL2GaN" (Affordable smart GaN IC solutions for greener applications), led by Infineon Austria, brings together 45 partners from twelve countries with a total budget of around 60 million euros. The aim is to fully exploit the energy-saving potential of highly efficient power semiconductors made of the semiconductor material gallium nitride (GaN), to integrate them easily and quickly into many applications, and thus to reduce emissions.

Following the development of cost-efficient GaN chips at Infineon-Villach, the research team is now working on a crucial milestone: the novel GaN power semiconductors will be modular and easily embedded in many applications through the integration toolbox. The research extends from individual chip elements, high-performance GaN modules, to chip designs and novel system-on-chip approaches. The advantage: variably adaptable GaN system solutions mean faster integration into applications, energy efficiency increases, and CO_2 emissions decrease.

www.infineon.com

PrimePACK™ 7G IGBT Modules

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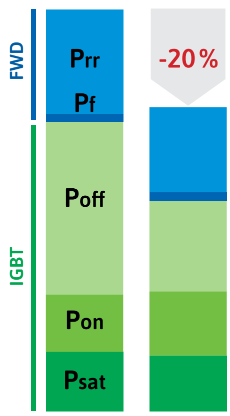

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www.fujielectric-europe.com
www.americas.fujielectric.com/us-semiconductors

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Innovating Energy Technology

Advancing Silicon Carbide Ecosystem in China

STMicroelectronics and Sanan Optoelectronics announced that they have signed an agreement to create a 200mm silicon carbide device manufacturing Joint Venture ('JV') in Chongqing, China. The SiC fab is targeting to start production in Q4 2025 and full buildout is anticipated in 2028, supporting the rising demand in China for car electrification as well as for industrial power and energy applications. In parallel, Sanan Optoelectronics will build and operate separately a new 200mm SiC substrate manufacturing facility to fulfill the JV's needs, using its own SiC substrate process.

The JV will make SiC devices exclusively for STMicroelectronics, using ST proprietary SiC manufacturing process technology, and serve as a dedicated foundry to ST to support the demand of its Chinese customers.The total amount for the full buildout of the JV is expected to be about $3.2 billion, including capital expenditures of about $2.4 billion over the next 5 years, which will be financed by contributions from STMicroelectronics and Sanan Optoelectronics, local government support, and loans to the JV.

"China is moving fast towards electrification in Automotive and Industrial and this is a market where ST is already well-established with many engaged customer programs. Creating a dedicated foundry with a key local partner is the most efficient way to serve the rising demand of our Chinese customers. The combination of Sanan Optoelectronics' future 200mm substrate manufacturing facility with the front-end JV and ST's existing back-end facility in Shenzhen, China will enable ST to offer our Chinese customers a fully vertically integrated SiC value chain," said Jean-Marc Chery, President and CEO of STMicroelectronics.

www.st.com

Industry Tech Days to Partner with electronica

EETech has announced that this year, its virtual event, Industry Tech Days will partner with electronica as 'Marketing Sponsors'. As a five-day free digital conference and trade show hosted on the All About Circuits website October 2 to 6, the event hosts live sessions, keynote forums, and provides technical content for electrical engineers and electronics industry experts across all areas of the electronics industry. With previous years regularly generating 40,000 unique visitors in its own right, the electronica tie will no doubt be a huge draw and boost this considerably, as electronica undertakes promotion for the event.

www.allaboutcircuits.com

Ranked Number One Start-Up Accelerator

Imec announced that it was placed first by UBI Global in its biennial ranking in the category World Top Business Accelerator - Linked to University. The 2023 ranking was announced at the World Incubation Summit.

The ranking is based on the UBI Global World Benchmark Study, the world's largest screening of (university) incubators and accelerators. In the past three editions of the ranking (in 2015, 2017, and 2019) imec's start-up accelerator program secured a spot in the top five. This year's edition counted 1,895 participants. 109 programs from 56 countries were selected based on a comprehensive list of more than 50 parameters mainly classified into three categories: impact on the ecosystem, performance of the program, and performance of the portfolio start-ups. Imec was ranked number one.

"This result is a great recognition of what we have achieved in the past years together with our entrepreneurs, start-ups, spin-offs, partners, and the broader ecosystem. It's also the first time since the launch of the UBI ranking that the global number one position

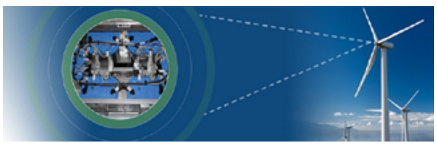
originates from a 'small' region. We are extremely proud to further position our region on the world map. Despite our characteristic Flemish modesty, which also makes entrepreneurs often think too small, we are capable of realizing grand things," says Sven De Cleyn, program director at imec.istart, imec's start-up accelerator program.

www.imec-int.com

Hybrid Ultracapacitor UPS System for Power Management Systems

Richardson Electronics is pleased to announce a patent pending Hybrid Ultracapacitor Uninterrupted Power Supply (UPS) for wind turbine control systems and other industrial applications where reliable low voltage ride through and safe shut down are safety critical. This is the latest patent pending product adding to the Company's growing portfolio of engineered solutions. The ULTRAUPS3000™ is designed for operation in harsh environments unlike other energy storage solutions such as lead acid or lithium-based UPS systems. With the wider operating temperature of Richardson Electronics hybrid ultracapacitor solution, the product will help solve issues related to the short life of other technologies.

Greg Peloquin, Executive Vice President, and General Manager of Power Microwave and Green Energy Solutions Group stated, "This is another major achievement from our team in our ever-increasing portfolio of power management products. The potential of the ULTRAUPS3000™ meeting

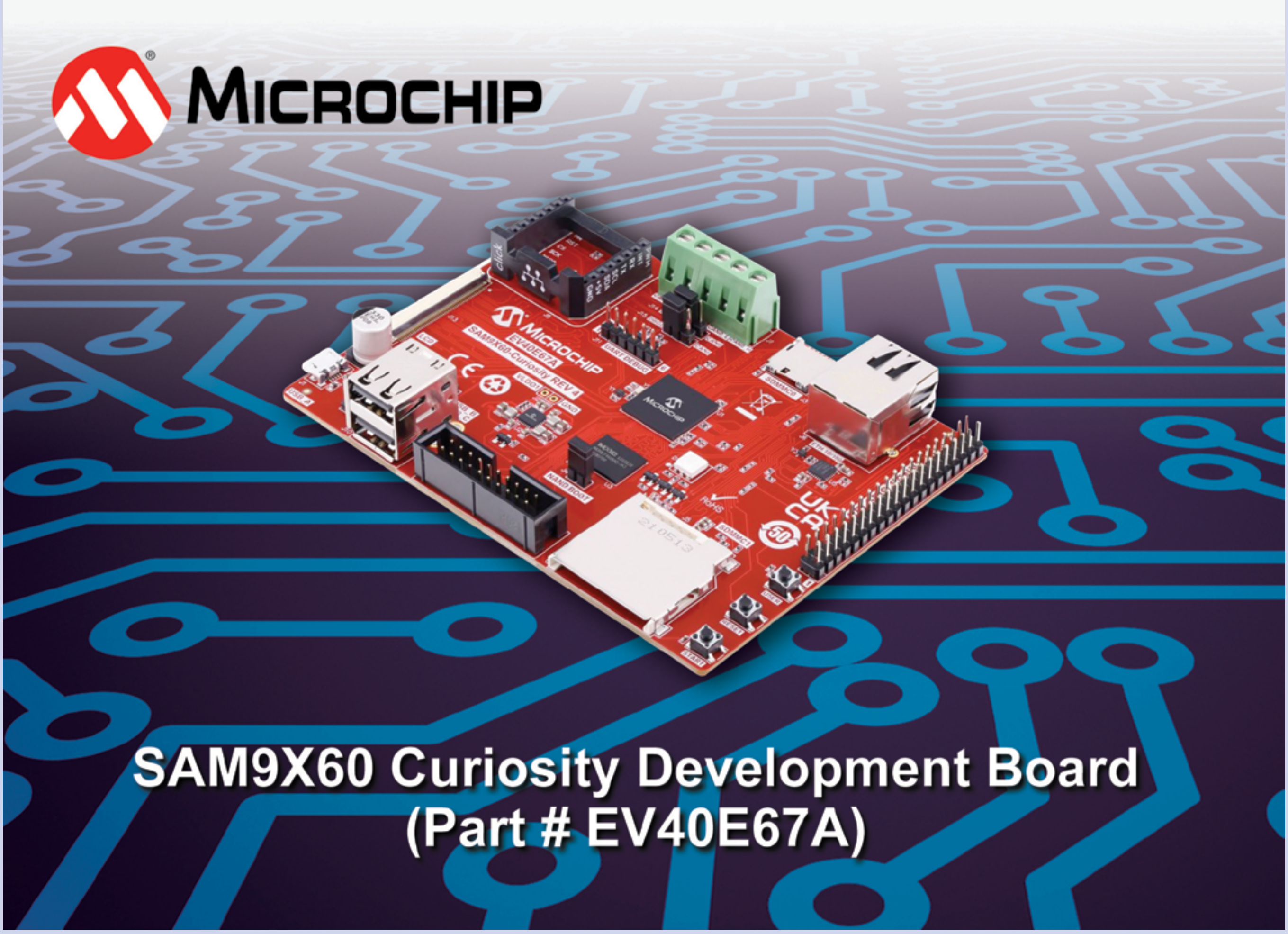


the needs of our customers in the wind turbine industry and many other industries is exponential. This patent reinforces our commitment to innovation and engineered solutions."

www.rell.com

Win an SAM9X60 Curiosity Development Board

Win a Microchip SAM9X60 Curiosity Development Board (EV40E67A) from Bodo's Power and if you don't win, receive a 15% off coupon for this board, plus free shipping.



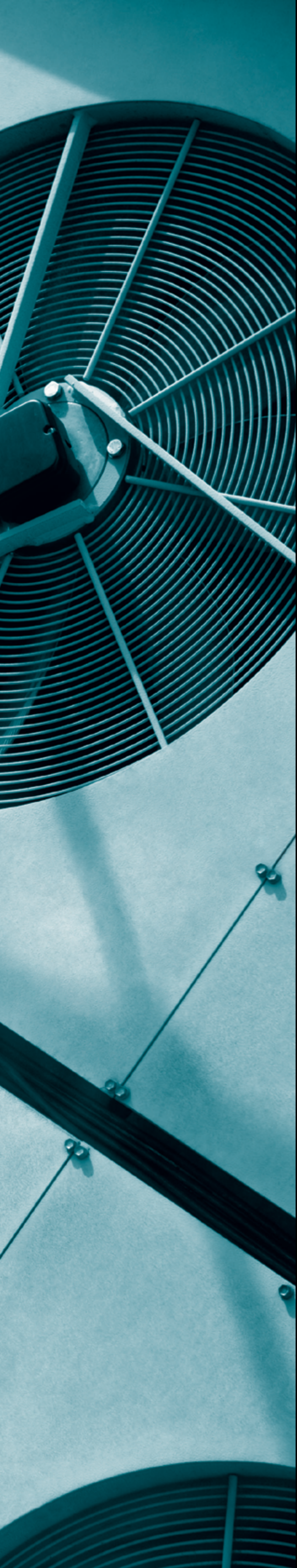
The SAM9X60 System on Module (SOM) is intended for graphical and communications applications spanning various industries such as medical equipment, electric vehicle chargers with a display, security panels, industrial and home automation control and more.

The SAM9X60D1G is a high-performance, ultra-low-power ARM926EJ-S CPU-based embedded microprocessor (MPU) running up to 600 MHz, with 1Gbit integrated DDR2 memory. The device integrates powerful peripherals for connectivity and user interface applications. It offers State-of-the-Art security functions such as Secure Boot capability with on-chip secure key storage (OTP), high-performance crypto accelerators (SHA, AES and TDES) as well as tamper pins.

Coupled with Ensemble Graphics Toolkit or MPLAB® Harmony Graphics Suite, the SAM9X60-SOM is particularly well-suited for low-power, low-cost RTOS or embedded Linux applications that still require high-performance graphics.

For your chance to win a SAM9X60 Curiosity Development Board or receive a 15% off coupon for this board, plus free shipping., visit https://page.microchip.com/Bodo-SAM9.html and enter your details in the online entry form.

www.microchip.com



The Genesis of GeneSiC and the Future of Silicon Carbide

Pioneers of SiC technology lead system efficiency with paramount focus on reliability and ruggedness

For almost 20 years, GeneSiC has pioneered high-performance, robust, and reliable silicon carbide (SiC) power devices for automotive, industrial and defense applications. As one of the first SiC device companies, GeneSiC developed cutting edge SiC technologies for government bodies[i], focused heavily on performance and robustness, and released several generations of both SiC diode and MOSFET technologies with ratings up to 6.5 kV, in various packages as well as bare die.

By Llew Vaughan-Edmunds, Senior Director Product Marketing – SiC, Navitas Semiconductor

In 2022 Navitas Semiconductor acquired GeneSiC Semiconductor, creating the industry's only pure-play, next-generation power semiconductor company, focused wholly on SiC and GaN. Dr Ranbir Singh, who founded GeneSiC in 2004 and is now Navitas' Executive Vice-President of SiC, has a rich history in SiC power technology, beginning with his research into the first SiC power devices at North Carolina University (NCSU). In 2022, to mark this pioneering work, Dr. Singh was inducted into the NCSU Electrical and Computer Engineering (ECE) Alumni Hall of Fame.

With the industry's broadest voltage range – stretching from 650 V to 6.5 kV - GeneSiC MOSFETs and Schottky MPS™ diodes have been at the forefront of SiC technology. The company has been involved with over 60 government-agency projects, pushing the boundaries of SiC performance, ruggedness and reliability. These include the development of 6.5 kV SiC thyristors for energy-storage, grid-tied inverters for the Department of Energy (DoE); 15 kV MOSFET and PiN Diodes for defense applications; 500°C monolithically-integrated SiC super-junction transistor-JBS diode (MIDSJT) for NASA's Venus exploration missions, and monolithically-integrated, radiation-hardened SiC gate drivers for 1200 V SiC DMOSFETs and 6.5 kV SiC thyristors, for the US Navy.

The SiC Market

The silicon carbide (SiC) market has expanded rapidly in the last few years thanks to a growing acceptance of the technology among engineers and increased understanding of how to maximize the benefits of using wide bandgap power devices. Yole Développement forecasts that the SiC device market will grow beyond $6 billion by 2027, from only $1 billion in 2021[ii]. A significant proportion of this growth will come from solutions for the automotive sector, plus solar / energy storage systems, and industrial applications.

In 2022, EV sales in the United States surpassed 5% of the total passenger vehicle market[iii], joining 18 other countries that have achieved this threshold for mass adoption. However, there are still two main concerns for consumers wanting to transition to electric – range anxiety and charge times. Gasoline and diesel cars take less than five minutes to fill-up, whereas with first-generation charging, EVs take at least 25 mins to charge up to 80%.

To address this issue, EV manufacturers are transitioning from 400 V to 800 V batteries, matched with roadside superchargers, with peak charging powers of 350 kW. Now, EVs such as the Genesis GV70 SUV using a Level 3, 800V 350 kW DC charger can power from 10–80% in only 18 minutes. As well as higher power delivery, the increase in voltage also reduces I^2R transmission power losses, lowering heat dissipation and reducing both cable weight and cost. To address the higher voltages, increased insulation is required in both the cables and motor windings, and the inverter system must be designed to match. Thanks to their increased efficiency and performance improvements at higher voltages, 1,200 V SiC MOSFETs are ideally suited to addressing this requirement.

Using an EV to Power Your House

The average battery size in an electric vehicle is 40 kWhr [iv]. Being four times the size of an average residential battery energy storage system (BESS)[v], this means an EV can quite easily deliver the energy needed by a typical house for the whole day. Offering this alternative 'vehicle-to-home' (V2H) approach will become a disruptive driver in the industry and change the way we use energy in the future. Accessing power from the EV will save electricity costs and reduce strained demand on the grid, while re-charging the EV when demand and costs are low drives down household bills and supports better grid stability. What's more, the EV can also provide energy back to the grid (V2G) when the demand is high. This has the potential to transform the utility grid, to make it more intelligent and dynamic with electricity transferred and stored at a macro scale.

With this in mind, EV manufacturers are now starting to introduce bi-directional on-board chargers (OBCs), which provide a two-way street of power delivery for V2H, V2G, and vehicle to load (V2L). The Nissan Leaf, Ford F-150 Lightning, Hyundai Ioniq 5, Kia EV6 and the Mitsubishi Outlander PHEV all offer this capability today.

Such next-generation integrated and holistic power solutions are increasingly reliant on SiC power devices. SiC MOSFETs such as those in the GeneSiC family, for example, can provide the high-temperature, high-speed performance that these applications demand, while GeneSiC merged-PIN Schottky (MPS) SiC diodes must sustain excessive surge currents with low leakage while offering low forward-voltage drop and fast-switching characteristics.

Fast Charging Stations

The GeneSiC history to address the needs of the automotive sector also includes the development of solutions for the fast-charging stations that are essential to the rapid adoption of EVs. Take, for example, SK Signet's recent design for a 350 kW-rated fast charger that converts 277 V_{AC} mains electricity to a carefully-controlled 200-950 V_{DC} for both 400 and 800 V-rated battery-powered electric vehicles. Each fast charger uses 168 x 1,700 V-rated GeneSiC diodes in the input power-factor correction (PFC) and output-rectifier stages to provide efficient, robust operation. The high-performance GeneSiC components operate up to 12 °C cooler than competing devices due to extremely-low threshold voltage (V_{TH}) characteristics, which maximizes energy savings and supports longer lifetime operation.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POWER ELECTRONICS EXPERTS

Fast charging is also a key requirement in the industrial sector where, again, GeneSiC technologies are being deployed to address application-specific challenges. Exide Technologies[vi], for example, has adopted new, leading-edge GeneSiC power semiconductors to ensure reliability, safety, ease-of-use and optimal charging in its next-generation of high-frequency fast chargers for industrial materials-handling equipment.

Exide's 2100-series fast chargers convert 220 V AC power to a battery-level voltage between 24 and 80 V for automated guided vehicles (AGVs) and manned material handling equipment such as forklifts and pallet trucks. Each 7 kW module uses GeneSiC 750 V MOSFETs and MPS Schottky diodes with frequency-optimized architecture. The same platform can be upgraded to 10 kW, with four modules in parallel to provide 40 kW of reliable fast-charging power.

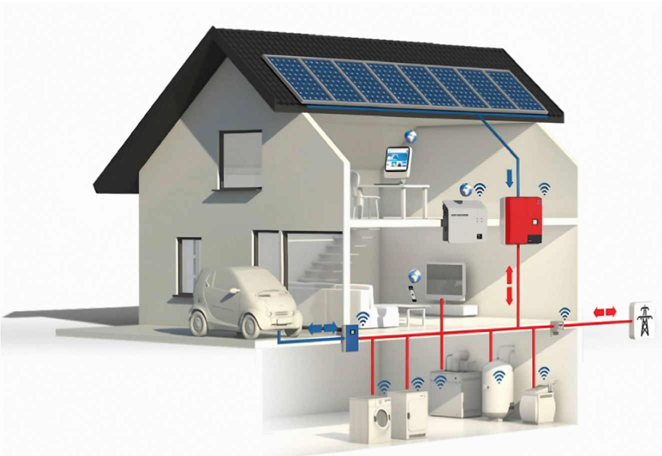


Figure 1: Residential homes can be powered from solar energy, BESS, an electric vehicle, and the grid.

Solar Energy

Another significant growth driver for SiC is energy management in areas such as solar conversion, wind energy, heat pumps, and energy storage.

In recent years, we have seen an increased number of power outages due to weather conditions and climate change. In 2021, there were 350 million outages worldwide and in the United States approximately 83% of reported major outages were attributed to weather-related events[v]. With the stability of the grid in question, customers are resorting to installing solar power and BESS technologies in their homes and businesses. Indeed, the US 'attach rate' for battery storage capability sold with solar panels has increased from 9.5% to 17.1% in only 18 months. Having energy independence and being able to live off-grid not only provides security but also allows customers to optimize and manage energy storage and usage for lower electricity bills – an increasingly important issue in a market where utility costs keep increasing.

GeneSiC has been established in the solar market for several years and its technologies can be found in a variety of inverters including KATEK's Steca coolcept fleX series [vii], which convert DC power from a string of solar panels into 4.6 kW AC power for use in the home, returning to the grid, or being stored locally for later use.

Each inverter uses sixteen GeneSiC 1200 V, 75 mΩ-rated SiC MOSFETs to provide a two-level converter, with bi-directional boost converters and an H4-topology for AC voltage output. As well as delivering the performance and reliability needed by this application, the increased switching frequency of the SiC technology allows the size and weight of passive components to be reduced, which optimizes the KATEK unit in size and weight compared with legacy silicon-based inverters.

Energy Storage

The average US home uses 29 kWhr per day [viii], a demand that typically requires 20-25 solar panels. Assuming the roof receives four hours of sunlight each day and each panel provides 350 W of power, then 22 panels would be required. The problem is that approximately 30% of electrical usage happens during solar production hours. Midday has the strongest daylight and provides the most power, yet the majority of homeowners are at work and not able to use this free energy.

Storing this energy from the sun for later use means that when a homeowner arrives home in the evening - which is when electricity costs from the grid are at a peak - they can switch over to the battery system. This reduces utility bills and optimizes how the energy is distributed.

There are several ways to store energy into the BESS, including solar energy, grid connection and, as mentioned previously, energy from an EV.

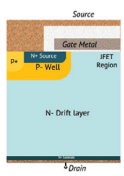
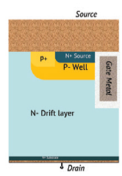
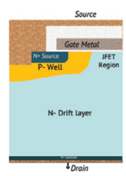
	Planar 	***Trench*** 	***GeneSiC*** 
Manufacturability	» *Repeatable* » *High yield* » *Low cost*	» *Inconsistent trench etch* » *Lower yields* » *High cost*	» *Repeatable* » *High yield* » *Low cost*
Performance	» *High $R_{DS(ON)}$ / area* » *Slow switching* » *High $R_{DS(ON)}$ / Δ temp*	» *Lower $R_{DS(ON)}$ / area* » *Faster switching* » *High $R_{DS(ON)}$ / Δ temp*	» *Lower $R_{DS(ON)}$ / area* » *Fastest switching* » *Lowest $R_{DS(ON)}$ / Δ temp*
Reliability	» *Rugged gate oxide (stable V_{TH})*	» *Failures due to non-uniform gate oxide* » *Lower short-circuit capability*	» *Highest 100% tested avalanche* » *Long short-circuit withstand time* » *Rugged gate oxide (stable V_{TH})*

Figure 2: GeneSiC trench-assisted planar-gate technology enables leading-edge performance with high-yielding manufacturing.

A BESS consists of a battery module, battery management system (BMS), energy management system (EMS), and a power conversion system (PCS). Typical systems range between 10-20 kW, which translates to powering a home for anything between eight and 16 hours. Wide bandgap devices, such as SiC MOSFETs and GaN power ICs are used in the inverter and buck-boost stages of these systems to convert AC-DC (from grid to battery), DC-DC (from solar to battery), and DC-AC (from battery to grid or battery to home).

SiC Technology Update - MOSFETs

The imperative to deliver ever-higher performance and more efficient energy conversion and control while supporting environmental sustainability through the electrification of our world and the reduction of CO_2 emissions is driving the ongoing development of SiC solutions for mass market applications. Take, for example, GeneSiC trench-assisted planar gate MOSFET technology.

While SiC MOSFETs offer superior conductivity and switching performance compared to silicon due to their wide bandgap characteristics and high electric-field strength, traditional designs using planar or trench techniques have had to compromise between manufacturability, performance, and/or reliability. The patented GeneSiC trench-assisted planar-gate design, however, is a no-compromise, next-generation solution that supports high-yield manufacturing, fast and cool operation, and extended, long-life reliability. Combined with the industry's lowest $R_{DS(ON)}$ at high temperatures and lowest energy losses at high speeds, these devices enable unprecedented, industry-leading levels of performance, robustness and quality.

The issue of $R_{DS(ON)}$ and temperature is particularly important. In real-life applications, the ambient temperature in a system can be up to 80 °C, with device power cycling further elevating junction temperature. GeneSiC MOSFETs were designed with this in mind and support the industry's lowest $R_{DS(ON)}$ temperature co-efficient. In datasheets, $R_{DS(ON)}$ is typically rated at 25 °C, but depending on temperature coefficient, this can significantly increase at elevated temperatures. In tests, a GeneSiC 1200 V, 40 mΩ SiC MOSFET in a D2PAK was compared against the comparable leading SiC MOSFET technology and the equivalent gate drive and conditions were realized to reveal a true comparison. The results demonstrated that GeneSiC MOSFETs operate with a 25 °C cooler case temperature, which results in significantly lower losses and higher system efficiency. From a reliability standpoint, 25 °C cooler operation translates into three times longer device lifetime.

Other important 'figures of merit' for evaluating SiC MOSFETs are on resistance and area and on resistance and gate charge.

The latest Yole SystemPlus SiC Transistor 2022 Report compared twelve SiC MOSFET technologies for $R_{DS(ON)}$*Area and $R_{DS(ON)}$*Q_G and the results show that GeneSiC's novel MOSFET technology outperforms all competition, including trench-gate structures, whilst keeping the benefits or planar gate ruggedness, short circuit capability and simpler manufacturing processing.

In 2019, GeneSiC collaborated with Sandia National Laboratories and DoE to create a state-of-the-art, leading edge monolithically integrated SiC double-implanted metal oxide semiconductor (DMOSFET) device structure with a merged PiN Schottky (MPS) diode. This product was later awarded Green Tech special recognition at the 100 R&D Awards. Integrating a JBS diode within the MOSFET provides more efficient bi-directional performance, temperature independent switching, low switching and conduction losses, reduced cooling requirements and superior long-term reliability. Typical applications are 'medium-voltage' power conversion systems, such as traction, pulsed power and smart grid infrastructure.

Monolithic integration of the MOSFET and diode enables low conduction losses during the operation of the free-wheeling diode without an externally connected Schottky diode. Furthermore, the built-in P-Well/N-

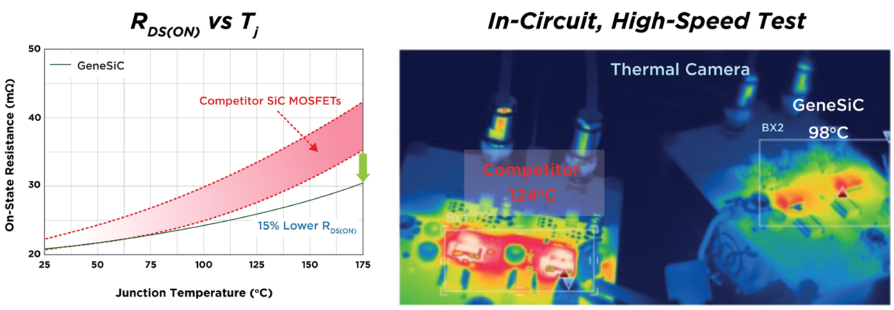


Figure 3: Operating temperature comparison.

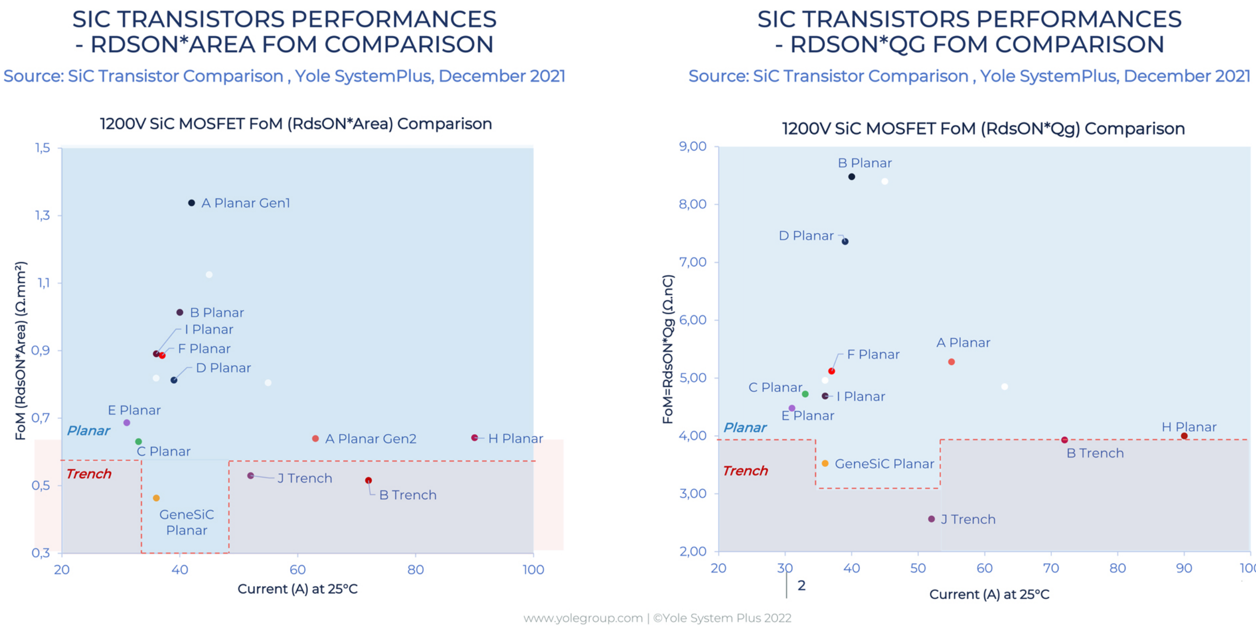


Figure 4: GeneSiC's pioneering MOSFET technology leads the industry and proven by third party evaluation.

Drift body diode of the MOSFET structure is bypassed, which can lead to faulting of the basal plane dislocations (BPDs) present within the N- drift layer of the MOSFET.

The benefits that this technology offers can be seen by considering the implementation of a medium voltage (MV) grid-to-battery energy storage system in which the MV grid is connected to the BESS by an isolated topology, such as a dual active bridge (DAB) and an active front-end converter (AFEC). A three-level, neutral-point clamped (NPC) inverter reduces filter requirements compared to a two-level topology, lowering the voltage stress across the SiC MOSFETs.

A series connection of the SiC 3.3 kV MOSFET-diode devices is possible, depending on the grid voltage (Figure 7), while the low-voltage side is supported by 1200 V SiC devices. The medium frequency transformer switching frequency can range from 10 - 20 kHz. Single or a three-phase topology can be used depending on the power requirements. Using single 3.3 kV SiC MOSFET-diodes as a replacement to several 1.2 - 1.7 kV MOSFETs or IGBTs connected in series has significant advantages, including easier gate driving, lower parasitic inductance, reduced conduction losses and higher system efficiency. Cooling requirements can be substantially reduced, alongside system size and weight.

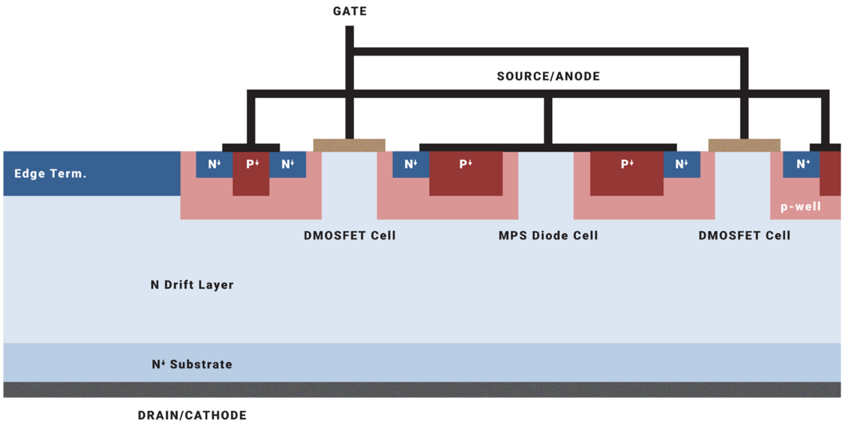


Figure 5: GeneSiC MOSFET with monolithically-integrated MPS diode increases efficiency in 3rd quadrant operation and significantly improves reliability.

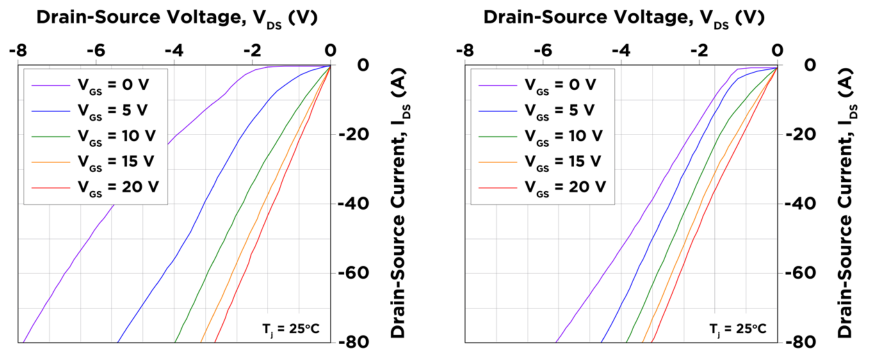


Figure 6: 3.3 kV Monolithic MOSFET with MPS diode has significantly lower voltage drop in third quadrant operation compared to a discrete SiC MOSFET.

SiC Technology Update – Diodes and Modules

At PCIM 2023, Navitas announced the 5th generation of merged-PIN Schottky (MPS™) diodes with low-built-in voltage biasing technology, offering superior FOM and highest robustness to provide industry-leading efficiencies in SMPS PFC applications across all load situations. The novel design of the MPS diode combines the best features from both PiN and Schottky diode structures, producing the lowest forward voltage drop (V_F), high surge-current capa-

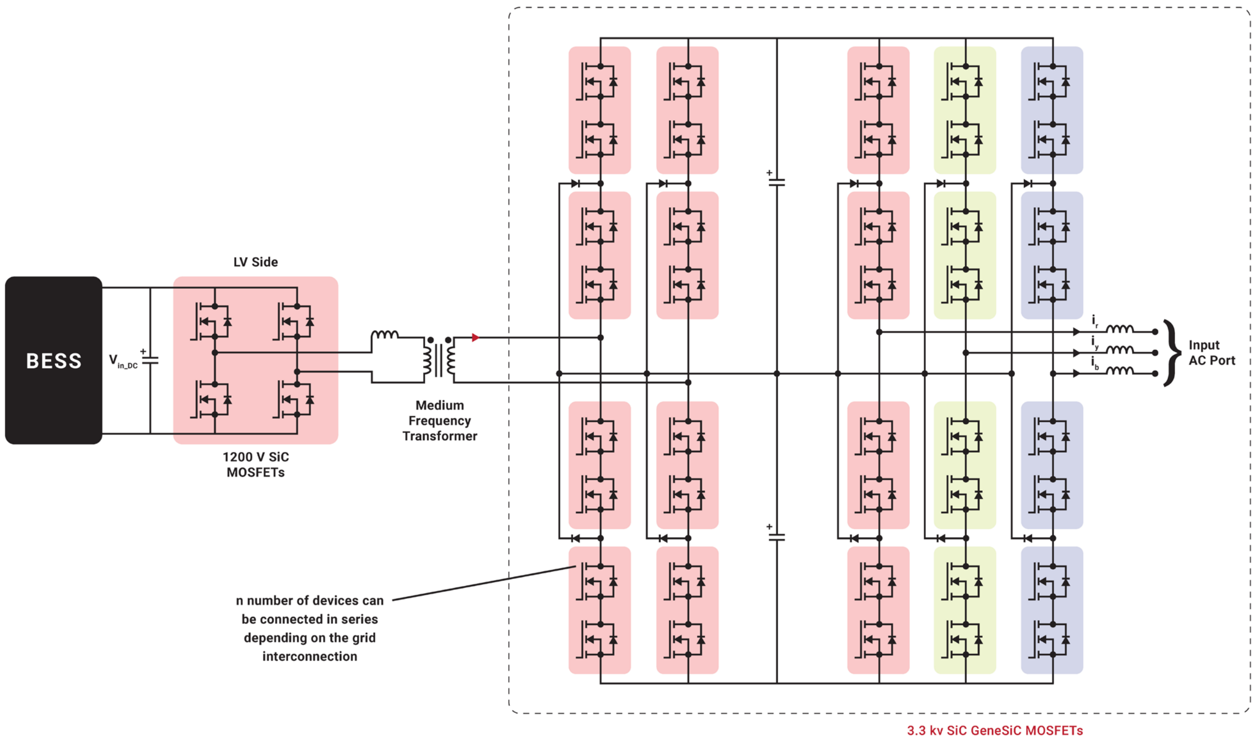
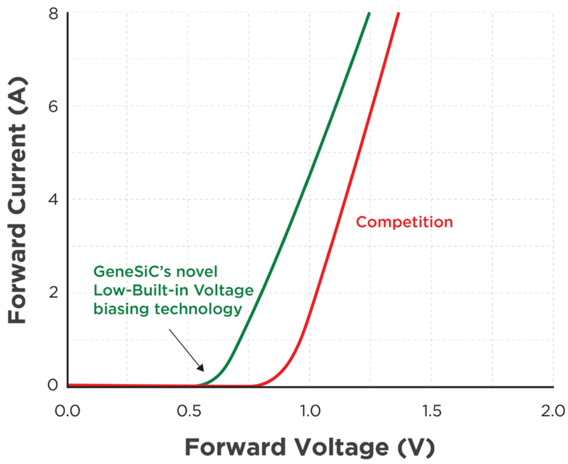


Figure 7: Using 3.3kV SiC MOSFETs with integrated Diode reduces the number of devices in series, improves system efficiency and reliability, while reducing weight, size and cooling requirements.

bility (I_{FSM}), and minimized temperature-independent switching losses. Proprietary thin-chip technology further reduces V_F and improves thermal dissipation for cooler operation.

Additionally, the Gen 5 MPS diodes have been designed for best-in-class robustness and ruggedness, for applications demanding high surge current and avalanche capability, critical for fail-safe designs. All GeneSiC devices are 100% avalanche (UIL) production tested to ensure the highest level of ruggedness in over-voltage conditions.

These devices are ideal in PFC circuits in continuous current mode (CCM) due to excellent figures of merit, comprising of a low V_F of 1.3 V and minimized capacitive charge (Q_C). In addition, zero reverse recovery charge improves PFC MOSFET turn-on performance. The result is a cooler, more reliable system.



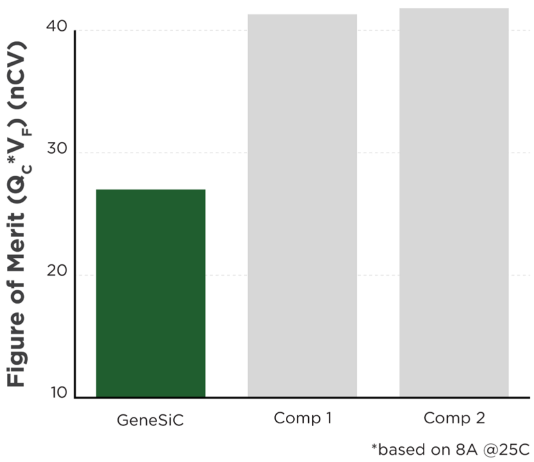


Figure 8: GeneSiC Gen 5 650V diodes has a novel structure enabling low-built-in voltage biasing, while providing excellent figure of merit (QC.VF).

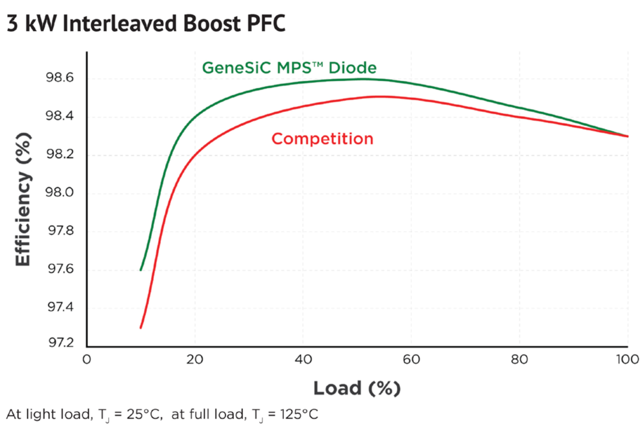


Figure 9: In a 3 kW Interleaved Boost PFC, GeneSiC diodes offer highest system efficiency across light and full load due to superior FOM.

SiCPAK™ SiC MOSFET Modules

Navitas has also announced the availability of its module packaging portfolio, starting with the SiCPak module[ix]. These industry standard press-fit modules have been designed with performance, reliability, and ruggedness at the forefront. The G3 1200V MOSFETs range from 6mOhms upwards in half-bridge configurations. The SiC MOSFETs are Ag sintered to provide superior thermal dissipation and reliability. Additionally, the Direct-Bonded Copper (DBC) substrates are manufactured by Active Metal Brazing (AMB) on silicon nitride (Si3N4) ceramics ideal for high power cycling applications. The excellent bending strength, high fracture toughness, and excellent thermal conductivity make silicon nitride (Si3N4) well suited for power electronic substrates.

Conclusion

Growth markets such as electric vehicles, renewable energies, and energy storage are driving higher system efficiency requirements that only SiC power devices can enable. Navitas' GeneSiC portfolio offers leading-edge performance and robustness up to 6.5 kV, to delivery clean, highly efficient energy conversion that will accelerate the adoption to "Electrify Our World™".

To learn more about the high-performance GeneSiC range, and how dedicated Navitas Design Centers can provide complete platform designs to upgrade and accelerate your design, visit navitassemi.com.

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Increasing Power Density of 4.5 kV IGBT Power Modules

The requirements of future power-electronic converters are increasing constantly. Power density and converter efficiency have to increase further. Output power shall be adaptable for various projects and end customers. And yet, the converter still needs to be cost competitive. This article demonstrates how a new 4.5 kV power module can fulfil these converter requirements in applications such as railway, medium-voltage drives or electric power systems.

By Kazuto Mikami and Kenji Hatori, Mitsubishi Electric Corporation, Fukuoka, Japan

Victor Tolstopyatov and Nils Soltau, Mitsubishi Electric Europe B.V., Ratingen, Germany

Introduction

In 2020, Mitsubishi Electric has announced the availability of HV100 power modules with X-Series chipset and a voltage rating of 3.3 kV [1]. The HV100 package, as shown in Figure 1, offers high flexibility by easy parallel connection, low commutation stray inductance and 10.2 kV isolation voltage. Offering such features, this package has been originally designed to fulfill the requirements of future railway converters [2]. Most recently, Mitsubishi Electric further released another HV100 power module, which is rated for 4.5 kV and achieves a nominal current rating of 450 A. This article introduces this new device with the type name CM450DE-90X, explains the advantages compared to previous power modules and shows key features for applications like railway, medium-voltage drives or electric power systems.

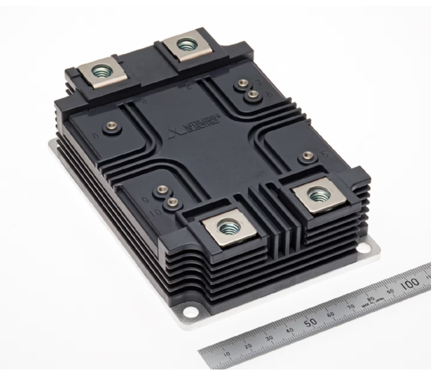

Figure 1: Power Module in HV100 Package

Inside CM450DE-90X, Mitsubishi Electric uses its latest 4.5 kV X-Series chip generation including CSTBTTM (III) and RFC diode. This ensures low losses, smooth switching waveforms and high robustness in case of over-current.

The structure of the HV100 package is shown in Figure 2. The two DC terminals are located at one side of the power-module, whereas two AC terminals are located at the opposite side. It allows low-inductive connection of the DC-link capacitor and a clean converter setup. In its center, the HV100 offers space for the gate-driver board. When HV100 power modules are connected in parallel, terminals are still easy to access and well sorted. For the gate driver in parallel connection, a PCB may be mounted just on top of the paralleled modules and control all of them. Also such design can be easily scalable by increasing (or decreasing) the number of paralleled modules to adjust the output power.

The HV100 package uses the famous MCB baseplate (Metal Casting direct Bonding). It allows lower thermal conductivity for remarkable power density. Compared to a classical package structure with AlSiC baseplate, the thermal resistance from junction to case is about 30% lower with MCB baseplate. Moreover, the MCB baseplate avoids substrate solder, which was originally a limiting factor of thermal-cycling lifetime in conventional power-module packages.

Increased Power Density

In the following, the achievable output power of CM450DE-90X is compared with conventional 190 x 140 mm² power modules. The comparison considers for example two CM1350HG-90X single modules in conventional packages with three paralleled CM450DE-90X dual modules, which corresponds to the same nominal current rating for one half-bridge. Even though the nominal current rating is same, Figure 3 shows that the HV100 power modules occupy about 20% less area on the heatsink.

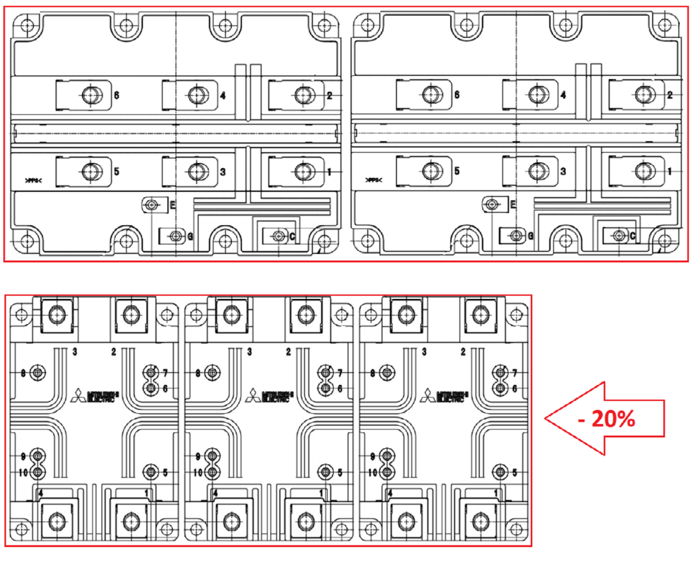

Figure 3: Size comparison for one half bridge with HV100 and conventional packages at same nominal current rating

Stray inductance between the dc-link and the semiconductor chips is one of the main characteristics of a power module, which can influence significantly its switching behavior. High parasitic inductance protracts turn on and off processes as well as leads to higher overvoltage spike during turn-off. Both mentioned phenomena overall increase switching losses of the module. Since the HV100 achieves lower stray in-

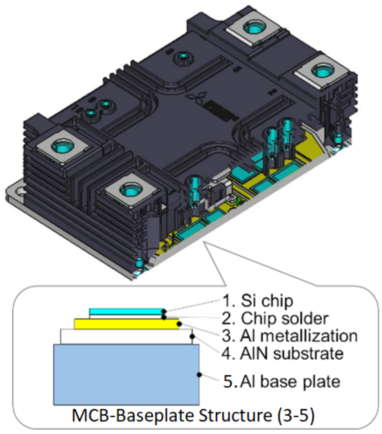

Figure 2: Cross section view of HV100 power module including MCB baseplate structure

ductances, faster switching speeds and lower switching losses are enabled. Compared to the conventional package, the 4.5kV HV100 can reduce total inverter losses by 17% in acceleration mode (i.e. positive power factor Figure 4a) and 18% in braking mode (i.e. negative power factor Figure 4b) [3].

Using MelcoSim ver.5.4.1 [4], the achievable output current is calculated for three CM450DE-90X in parallel compared to CM1350HG-90X and CM1200HG-90R (previous R-Series). The results are shown in Figure 5. Compared to the previous R series HVIGBT modules, the X series can contribute to lower losses, improved thermal resistance and increased maximum allowed operating temperature to Tj=150°C. By those mentioned factors the possible output current in CM1350HG-90X module might be increased by around 17% in comparison to CM1200HG-90R. A further 12% increase may be achieved by using new HV100 dual modules CM450DE-90X (three in parallel). This is achieved by the lower switching losses and the improved thermal resistance due to the MCB baseplate.

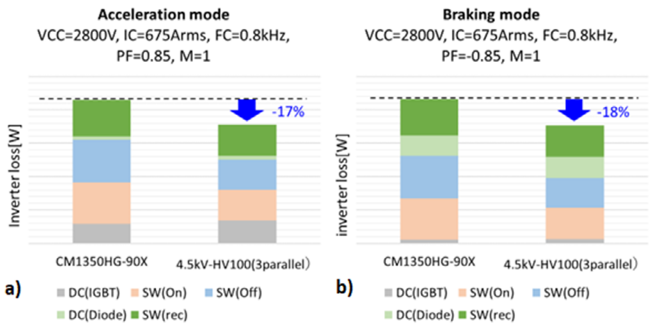

Figure 4: Inverter Loss Calculation Result

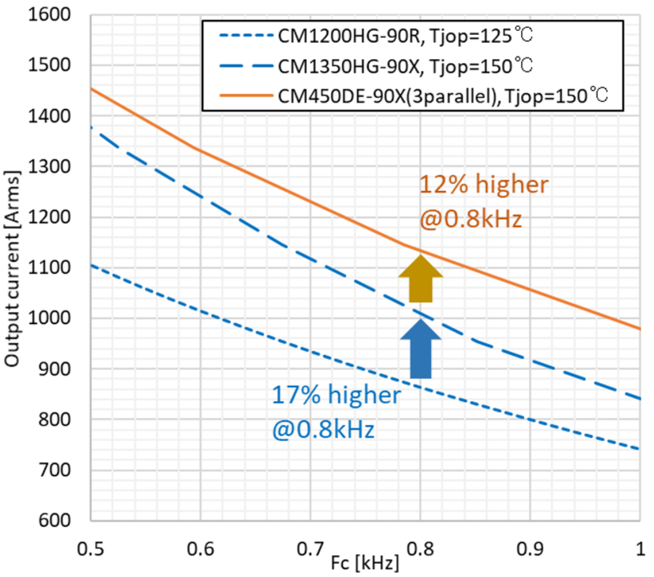

Figure 5: Relationship between output current and carrier frequency for R series HVIGBT, X series HVIGBT and 4.5kV HV100 (Condition: Sinusoidal, V_{CC}=2800 V, P_F=+0.85, M=1, T_S=80°C, T_j = T_{jop})

Parallel Operation

As previously mentioned, the HV100 package is designed for simpler parallel connection. Hence, even for parallel connections, the terminal layout allows straight forward connection of the dc-link capacitors and the AC output. In the following, the current sharing among two parallel-connected CM450DE-90X is measured. Figure 6 shows the test setup. With it, the individual currents of the N-side IGBTs are measured. The tests have been performed at room temperature, V_{CC} = 2800 V, a total current of $I_{C,total}$ = 900 A (450 A per power module), and a gate voltage of V_{GE} = ± 15 V.

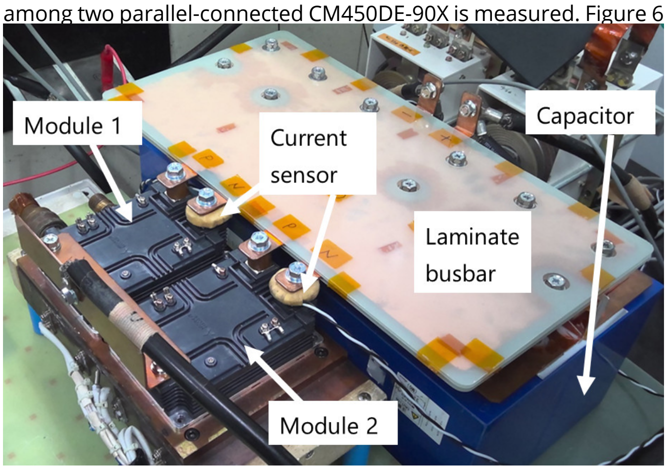

Figure 6: Test setup to measure the current sharing between two CM450DE-90X connected in parallel

Figure 7 (a) and (b) show the current sharing between the two power modules during turn-off and turn-on respectively. The measurements show that the current is distributed evenly between the two power modules, leading to a very good utilization of available chip area.

It should be noted that the two modules used in the evaluation have been selected to have small differences in their individual characteristics. Regarding the influence of power module parameter variations on the parallel connections, please refer to [5].

Switching with High Stray Inductance

Switching with low DC-link stray inductance LS is recommended to reduce switching losses and overvoltage during turn-off switching. However, converter design with low LS might not always be possible. In some cases, for example in multi-level converters, the power module should also be able to operate safely even under higher LS conditions. Figure 8 shows a comparison of switching waveforms at LS=100nH and 400nH for 4.5kV HV100 during turning-off. As it can be seen, even at LS high as 400nH the maximum VCE voltage reaches only around 3600V. For further measurement results at high stray inductance, please see [3]. In summary, CM450DE-90X can operate even with high stray inductance having enough margin to VCES and without oscillations.

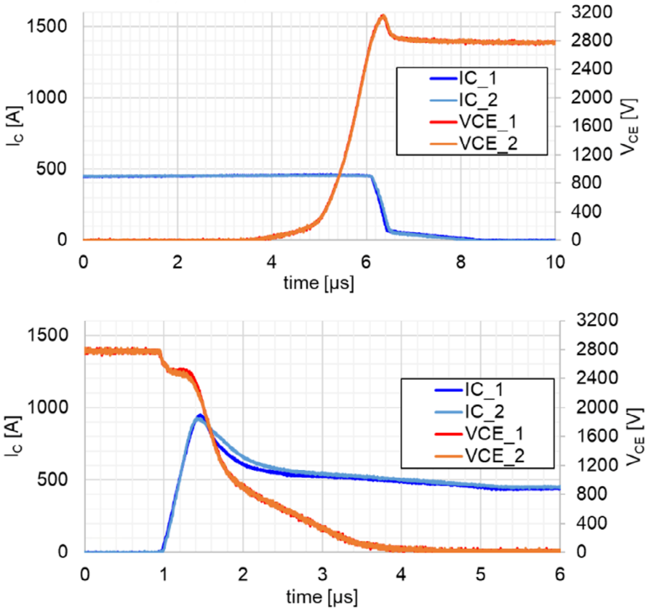

Figure 7: Current sharing of two parallel-connected CM450DE-90X (Conditions: V_{CC}=2800V, $I_{C,total}$=900A, V_{GE}=±15V, T_j=25°C, N-side)

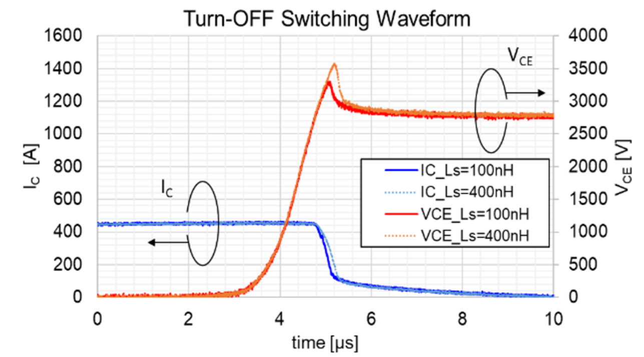

Figure 8: Comparison of switching waveform of 4.5kV HV100 between L_s=100nH and L_s=400nH (Condition: V_{CC}=2800V, I_C=450A, V_{GE}=15 V, T_j =150°C)

Ruggedness in Over-Current Events

Robustness of power modules is one of the main required feature especially for such a responsible applications as railway or electric power systems. Defining RBSOA (Reverse Bias Safe Operation Area) is the typical approach to evaluate the robustness of IGBT module. This characteristic shows the ability of a power module to withstand certain voltage and current during IGBT turn-off. In Figure 9, the specified RBSOA for CM450DE-90X is shown with black color. In same picture, real type-test measurement results are shown with

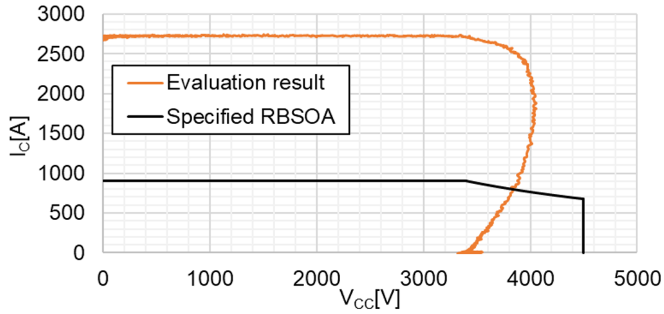

Figure 9: Specified RBSOA and evaluation result (V_{CC}=3400V, T_j=150°C)

orange. It has been confirmed that the CM450DE-90X sample has not failed even at 2700A which is 6-times rated current. This difference demonstrates the ruggedness of CM450DE-90X and potentially gives additional safety margin to the converter manufacturers and end-users in case of unexpected over-current events.

	LV100		HV100	
Dimensions	100 mm x 140 mm x 40 mm			
Isolation Voltage	6 kV_{rms}		10.2 kV_{rms}	
Rated Voltage	1.7 kV	3.3 kV	3.3 kV	4.5 kV (new!)
Rated Current	1200 A	450 A, 600 A	450 A, 600 A	450 A
Model	CM1200DA-34X	CM450DA-66X CM600DA-66X	CM450DE-66X CM600DE-66X	CM450DE-90X

Table 1: Line-up of HV100 and LV100 power modules

Conclusion

This article has introduced the new 4.5 kV / 450 A power module in the HV100 package, named CM450DE-90X. The power module provides 10.2 kV isolation voltage and remarkable performance enabled by its MCB baseplate and latest chip generation. It has been shown that CM450DE-90X fulfills future converter requirements. In particular, power-density increase, simple parallel-connection, and high ruggedness in case of over-current have been discussed.

The new CM450DE-90X is extending the line-up of the LV100 / HV100 product family. Besides CM450DE-90X, there are additional power modules for 1.7 kV and 3.3 kV rated voltage available. Table 1 shows the complete LV100 / HV100 line-up.

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One Product Family Fits All: Gate Driver Solutions for Si, SiC, and GaN

Features and benefits of the new generation of dual-channel galvanically isolated gate driver ICs

This product family spans multiple under-voltage lockout (UVLO) variants, isolation levels, and package options to provide a comprehensive solution for various applications. The new portfolio combines robust isolation technology that meets the latest isolation standards with excellent electrical parameters and protection features to deliver high efficiency and reliable operation over a wide temperature range, extending the design's lifetime. These drivers can be used in a wide range of applications, including server and telecom SMPS, solar inverters and energy storage systems, motor drives and battery-powered applications, EV charging, and high-performance computing.

By Carmen Menditti Matrisciano, Staff Product Definition Engineer, and Dr. Diogo Varajao, Head of Technical Marketing of Isolation ICs, both at Infineon Technologies

Isolators are used today in a wide range of applications, from telecom and server switch-mode power supplies (SMPS) [1] to solar inverters, industrial AC motor drives, and EV charging. They are primarily used to offer the required protection from injury and electrical shock to the operators interfacing with HMI or connectors, as well as safeguard sensitive and expensive low-voltage components, such as controllers, against failures in the high-voltage power stage [2].

Often isolation is used to interrupt disruptive ground loops, eliminating displacement currents and high-frequency noise injected back into the control units.

Digital isolators and isolated gate driver ICs have become the technology of choice in the market thanks to their unquestionable benefits compared to traditional solutions such as pulse transformers [2] and optocouplers.

This article presents the features and benefits of the new EiceDRIVER™ 2EDi family of dual-channel isolated gate driver ICs. The new generation features DSO 14-pin packages for extended channel-to-channel creepage, dead-time, and shoot-through protection, faster start-up time, robust isolation technology meeting the latest isolation standards (VDE 0884-11, IEC 60747-17), as well as small LGA 4x4 packages enabling 36 percent space saving in low-voltage applications. With multiple under-voltage lockout (UVLO) variants, package options, and isolation levels, this family meets most design needs in several applications for the different switch technologies (see Table 1).

Isolation technology with excellent MFI and CMTI that meets the latest standard requirements

The new EiceDRIVER™ 2EDi generation exploits magnetic isolation with proven Infineon's Coreless Transformer (CT) technology. A repetitive working voltage of 1767 VRMS is ensured over 20 years

		Galvanic isolation			Output stages			Control inputs			
Package	Product name	Rating	Certification	CMTI	Sink/Source currents	UVLO on (nom.)	UVLO start-up	Channels	STP/DTC option	DIS/EN	Use case examples
WB DSO-16 300 mil DSO, 16-pin 2.5 mm Ch-Ch creepage	2EDS7165H	V_{ISO} = 5700 V_{RMS}	• UL1577 Single protection • EN 62368-1 Reinforced isolation • GB4843.1 Reinforced	150 V/ns	1 A / 2 A	4 V	5 µs	INA, INB	-	DIS	• Telecom and server SMPS, primary-side of HV DC-DC stage (e.g., LLC) with need of reinforced isolation • Solar microinverters and DC-DC power optimizers • EV off-board chargers
	2EDS8165H					8 V					
	2EDS8265H				5 A / 9 A	8 V					
	2EDS9265H					13 V					
	2EDR8259H	V_{ISO} = 5700 V_{RMS} V_{IOTM} = 8000 V_{pk} V_{IOSM} = 6875 V_{pk}	• VDE 0884-11 • IEC 60747-17 Reinforced isolation • UL1577 Single protection • EN 62368-1 Reinforced isolation • GB4943.1 Reinforced	150 V/ns	5 A / 9 A	8 V	2 µs	INA, INB	yes	DIS	
WB DSO-14 300 mil DSO, 14-pin 3.3 mm Ch-Ch creepage	2EDR7259X					4 V					
	2EDR8259X					8 V					
	2EDR9259X					15 V					
	2EDR8258X					8 V				EN	
	2EDR9258X					15 V					
	2EDR6258X					12 V					
NB DSO-16 150 mil DSO, 16-pin 2.5 mm Ch-Ch creepage	2EDF7175F	1500 V_{DC}	• functional	150 V/ns	1 A / 2 A	4 V	5 µs	INA, INB	-	DIS	• Telecom and server SMPS (e.g. totem-pole PFC, Vienna rectifier) • Low-voltage drives with ground bounce issues (LEVs, gardening tools, fork-lifters)
	2EDF7275F				5 A / 9 A	4 V					
	2EDF8275F					8 V					
	2EDF9275F					13 V					
	2EDB8259F	V_{ISO} = 3000 V_{RMS} V_{IOTM} = 4242 V_{pk} V_{IOSM} = 6000 V_{pk}	• UL1577 Single protection • GB4943.1 Basic	150 V/ns	5 A / 9 A	8 V	2 µs	INA, INB	yes	DIS	
NB DSO-14 150 mil DSO, 14-pin 3.3 mm Ch-Ch creepage	2EDB7259Y					4 V					
	2EDB7259Y					8 V					
	2EDB9259Y					15 V					
LGA 5x5 13-pin 1 mm Ch-Ch creepage	2EDF7275K	1500 V_{DC}	• functional	150 V/ns	5 A / 9 A	4 V	5 µs	INA, INB	-	DIS	• Non-isolated inverted buck-boost brick • Isolated dc-dc bricks • Low-voltage drives with ground bounce issues (LEVs, gardening tools, fork-lifters)
	2EDF7235K					4 V			DTC		
	2EDB7259K	V_{ISO} = 2500 V_{RMS} V_{IOTM} = 3535 V_{pk} V_{IOSM} = 6000 V_{pk}	• UL1577 Single protection • GB4943.1 Basic	150 V/ns	5 A / 9 A	4 V	2 µs	INA, INB	yes	DIS	
	2EDB8259K					8 V					
LGA 4x4 13-pin 0.75 mm Ch-Ch creepage	2EDB7259E	V_{ISO} = 2250 V_{RMS} V_{IOTM} = 3181 V_{pk} V_{IOSM} = 4000 V_{pk}				4 V					
	2EDB8259E					8 V					

EiceDRIVER™ 2EDi (Previous Gen.) EiceDRIVER™ 2EDi (New Gen.)

Table 1: Product overview of the new and previous generations of the EiceDRIVER™ 2EDi product family.

lifetime, fulfilling the time-dependent dielectric breakdown (TDDB) requirements of VDE 0884-11 and IEC 60747-17, the latest component standard for magnetic and capacitive couplers.

A proprietary double coil on-chip transformer also ensures high magnetic field immunity (MFI), fulfilling the most stringent test levels according to IEC 61000-4-8, IEC 61000-4-9, ISO 11452-8, and MIL-STD-461G-RS101 standards. It also provides an excellent common-mode transient immunity (CMTI) of more than 150 V/ns, fundamental for driving wide bandgap devices (WBG) such as SiC and GaN.

Robust insulation to electrical overstress (EOS) in the power stage
The robustness of the insulation in overstress scenarios is often of concern, particularly when it comes to potential failure and damage of the power stage across the reinforced isolation barrier.

Figure 1 depicts one of the worst-case scenarios, i.e., when the EiceDRIVER™ 2EDRx259X galvanic isolated gate drivers are used in an LLC topology, and one power switch fails with a gate-drain short circuit while the other is conducting.

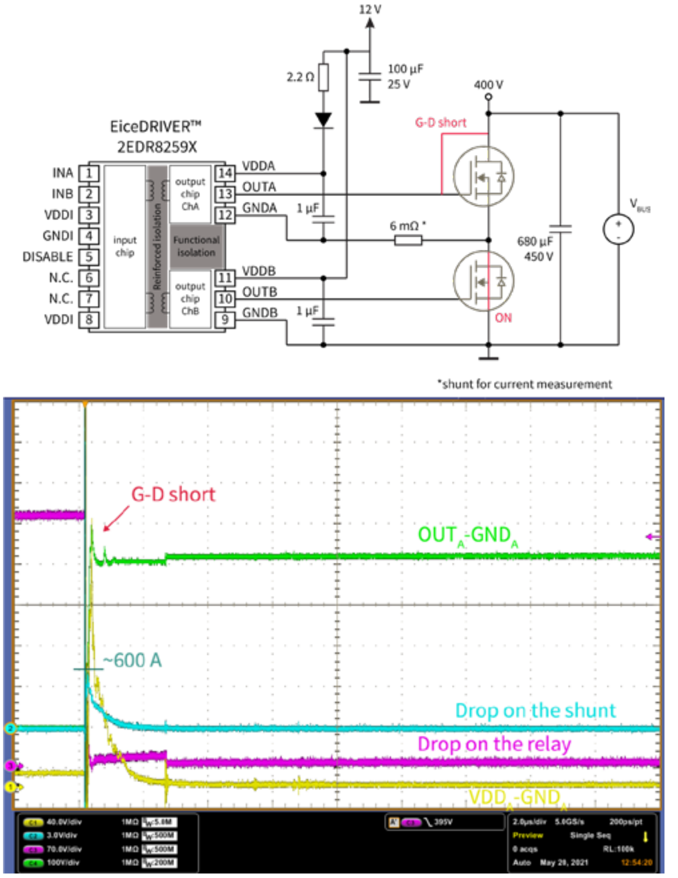

Figure 1: A critical EOS event in the power stage that could break the isolation barrier Despite the high energy injected into the driver (up to 600 A current flowing into OUT$_A$ until bond-wire evaporation and package explosion), the EiceDRIVER™ 2EDRx259H guarantees the fully reinforced isolation integrity.

Without a protection diode between the driver output and its ground, a significant amount of energy is transferred from the bulk capacitor (680 µF in this example) directly into the driver leading to electrical failure of the output chip ChA and package destruction with open bond wires. The EiceDRIVER™ 2EDRx259X ensures total isolation even after high electrical overstress, thanks to the robust insulation built on the primary-side chip. Competitors 2 and 3, using a capacitive isolation technology, fail the Hi-Pot test after EOS stress.

Table 2 shows the summary results of the Hi-Pot test at rated V_{ISO} voltage after EOS stress.

Product	Pass high-voltage Hi-Pot test* after EOS stress
2EDRx259X/H	Yes
Competitor 1	Yes
Competitor 2	No
Competitor 3	No

*V_{ISO} = 5700 V_{RMS} for t = 60 sec, V_{ISO} = 5000 V_{RMS} for competitors 1, 2 as per datasheet specification

Table 2: Isolation robustness against output-side EOS after Hi-Pot test at rated V_{ISO}.

Fast UVLO timing

A bootstrap circuit is often used to supply the high-side MOSFET due to its simplicity and low cost. However, it can hide several complications because, by nature, the bootstrap supply and the low-side supply are unavailable during start-up. Consequently, the supply voltage in the high-side channel becomes available after some delay, depending on the size of the bootstrap capacitor and resistor.

Many gate driver ICs on the market show a UVLO start-up time in tens of µs (left of Figure 2), meaning several high-side pulses are skipped while the low-side MOSFET turns on and off in normal operation.

This can lead to several consequences, e.g., it can create unbalance in the two resonant capacitors of an LLC topology. If not properly controlled, this can generate severe hard commutation issues. On top of that, it can create voltage asymmetry on the main transformer with a saturation of the core. The new EiceDRIVER™ 2EDi generation features an industry benchmark UVLO start-up time lower than 2 µs ensuring high-side activation in less than one pulse (Figure 2).

Figure 2: UVLO start-up time of a competitor driver with slow bootstrap channel activation (top) vs. the new EiceDRIVER™ 2EDi with the fastest output-side activation time (bottom).

Fast active output clamping to avoid shoot-through

Another potential issue hidden in the bootstrap system can arise when induced noise on the high-side gate is not effectively clamped by the driver that is still "inactive," being the charging bootstrap supply below the UVLO level.

One example is the start-up in LLC with split resonant capacitors (see Figure 3). If no special start-up sequence is considered, the high-side MOSFET is OFF until (and after a certain delay) the bootstrap supply approaches the UVLO, creating voltage unbalance on the resonant capacitor and an unwanted change of the switching node (in green). Each negative dV/dt of the switching node charges the gate of the high-side power switch (in magenta) via the Miller effect.

The new EiceDRIVER™ 2EDi generation includes a special active clamping circuit to quickly clamp the output noise even if the channel is "inactive" (output supply below UVLO), thus avoiding dangerous shoot-through events, as shown in the right-hand side measurements of Figure 3.

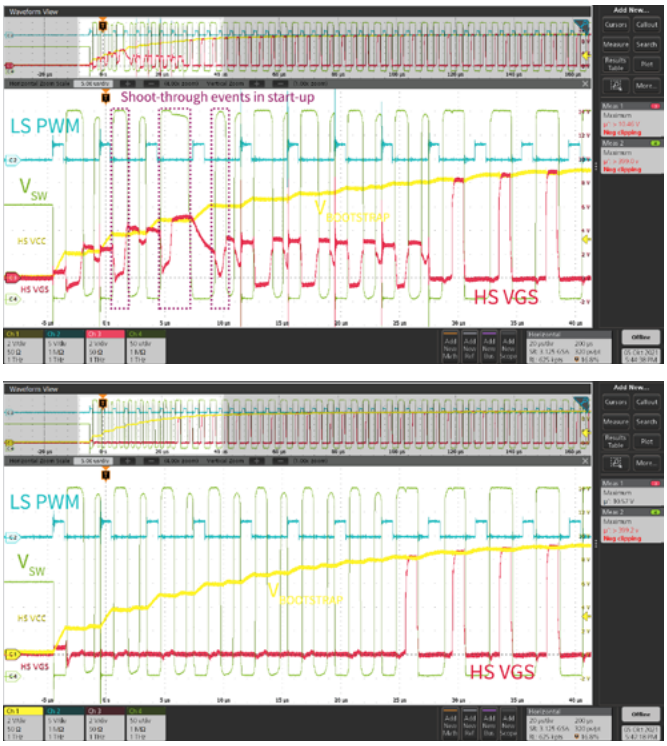

Figure 3: A critical shoot-through when using a driver with a slow output clamping for supply below UVLO (top). The outperforming clamping behavior of the new generation of EiceDRIVER™ 2EDi gate driver ICs (bottom). Both measurements are related to a start-up condition in an LLC circuit with split resonant capacitors and with bootstrap.

Accurate timing and Dead-time control (DTC)

The new EiceDRIVER™ 2EDi generation includes features that fulfill the needs of fast-switching applications employing WBG devices. Excellent propagation delay matching and dead-time accuracy (see Table 3) ensure perfect timing synchronization of the gate signals (e.g., in diagonal driving) and dead-time optimization with huge benefits on system reliability and efficiency performance.

Feature	Values
Part-to-part propagation delay turn-on	6 ns (max)
Part-to-part propagation delay turn-off	8 ns (max)
Ch A-to-Ch B turn-on propagation delay mismatch	-4 ns – 4 ns
Ch A-to-Ch B turn-off propagation delay mismatch	-5.5 ns – 3 ns
Channel turn-off to turn-on prop. delay mismatch	-5 ns – 1 ns
Pulse width distortion	-5 ns – 5.5 ns

Table 3: Tight timing specifications enable WBG driving.

Furthermore, important second-level safety mechanisms are configurable shoot-through protection (STP) and dead-time control (DTC) built into the gate driver IC hardware.

The EVAL_2EDB_HB_GaN evaluation board (Figure 4) combines an EiceDRIVER™ 2EDB8259Y dual-channel isolated gate driver with Infineon's discrete GaN HEMTs. This board allows testing in different operating modes and with different driving supply approaches (unipolar or bipolar, isolated or non-isolated with bootstrap).

The test results obtained with gate injection transistor (GIT) HEMTs demonstrate a reliable operation at MHz and kW range [3]. The board also includes a flexible bias supply configurable for bipolar or unipolar operation with different voltage levels and an option for one percent voltage regulation, which is particularly important while driving Schottky gate (SG) GaN HEMTs. Detailed information about a universal gate driving circuit for both 650 V GIT and SG GaN HEMTs is described in [4].

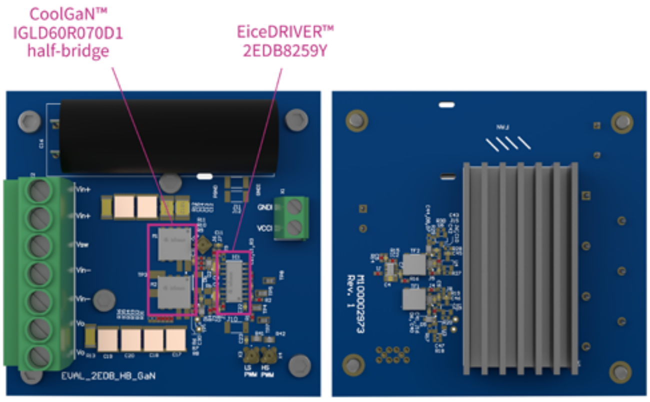

Figure 4: EVAL_2EDB_HB_GaN CoolGaN™ GIT HEMT half-bridge evaluation board.

Conclusion

The new EiceDRIVER™ 2EDi generation combines the benefit of robust isolation technology with outstanding electrical parameters. The features of this new product family can support system requirements to achieve high efficiency and reliable operation over a wide temperature range and with a longer lifetime.

Infineon's broad product portfolio includes different packages and isolation ratings, providing a comprehensive offering adapted to the needs of different application use cases and topologies.

For a deeper understanding of the new EiceDRIVER™ 2EDi generation, we invite you to delve into the wealth of information provided in the dedicated application notes [3] and product webpage. Scan the QR code below to find out more.

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Carmen Menditti Matrisciano is currently employed as an application engineer at Infineon Technologies. In her role, she works in the Technical Marketing team for the product segment Isolation ICs. Her main responsibilities include defining the best-in-class Gate Driver ICs, driving go-to-market activities, and providing technical product support to customers worldwide. Carmen holds a Bachelor's and a Master's degree in Electronic Engineering from the University of Naples.

Dr. Diogo Varajao is leading the Technical Marketing organization for the product segment Isolation ICs at Infineon Technologies, responsible for the Gate Driver ICs, Digital IO, and Digital Isolators portfolio. The System and Application Engineers develop their activities at the Infineon headquarters in Munich (Germany) and the global competence center for power electronics in Villach (Austria). He holds a Ph.D. degree in Electrical and Computer Engineering, with a specialization in Power Electronics, from the Faculty of Engineering of the University of Porto, Portugal. His research was conducted at the Smart Grids and Electric Vehicles Laboratory (SGEVL) of INESC TEC Institute, where he collaborated on several national and international projects. He has been granted patents in the US, Europe, and Japan for the ACDC CUBE technology. Dr. Varajao is an IEEE Member with more than 12 research papers published in peer-reviewed journals and international conference proceedings.

Voltage Regulators for Automotive Designs

To achieve best-in-class performance in power management integrated circuits (ICs), ROHM has combined years of expertise along with a vertically integrated design and manufacturing process to develop Nano Technology. This technology leverages advancements in circuit design for high speed and low power, optimizes the layout to reduce both parasitic effects and size, and carries out semiconductor processing for maximum yield and reliability.

By Nobuyuki Ikuta, Senior Design Engineer, ROHM Semiconductor

Original Nano Technology

All three of the above domains contribute to a product portfolio of DC/DC converters, LDOs, and PMICs that provides unmatched performance for today's automotive needs. The Nano Pulse line consists of single-chip solutions for 48V electric vehicle (EV) designs. For example, the Nano Energy series reduces quiescent power consumption to achieve unprecedented battery life, while the Nano Cap line eliminates the need for large output capacitors to deliver excellent performance in a compact form factor.

ROHM's Nano Technology also incorporates many secondary requirements into the primary power management IC. These multifunction chips save space and cost by eliminating the need for supervisory circuits such as watchdog timers, voltage monitors, and even communication bus drivers.

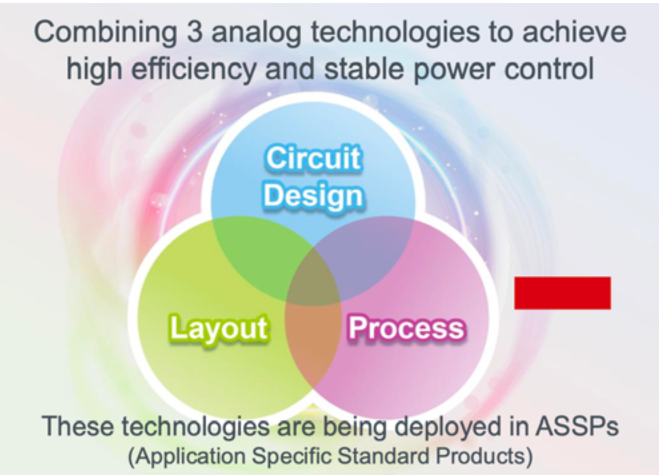

Figure 1: ROHM's Nano Technology

Nano Pulse for Electric Vehicles

Unlike traditional 12V lead-acid battery vehicles, hybrid EVs primarily use a 48V lithium ion battery to deliver greater efficiency. In both cases, engine control units and peripheral electronics demand lower supply voltages, typically 2.5-3.3V. However, as converting 48V to 3.3V is no simple task, conventional solutions

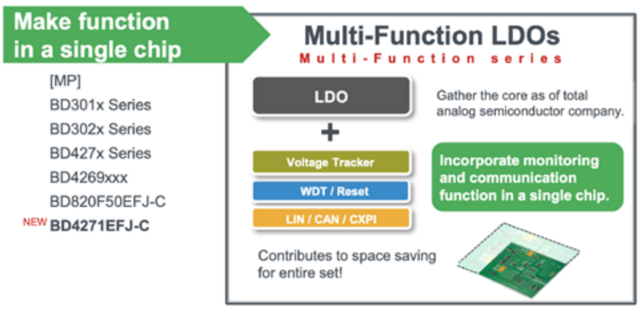

Figure 2: Multifunction ICs Developed Using Nano Technology

typically employ two stages (two ICs). The first stage steps down to an intermediate voltage such as 12V, with an easily achievable ratio of 4 to 1. The second stage provides the final output voltage by again dividing down by about 4 to 1. To save space, cost, and efficiency, it is preferable to derive the final 3.3V output voltage directly from the 48V source in one step. This difference is shown in the following figure.

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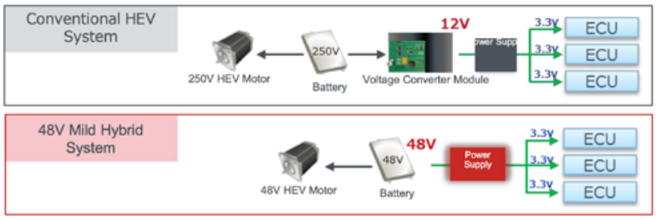


Figure 3: Single- and Two-Stage Step-Down Topologies

To accomplish high ratio single-stage conversion, ROHM's Nano Technology reduces the DC/DC switching minimum on-time to an unprecedented 9ns. This is the shortest switching time in the industry and a breakthrough accomplishment, considering that the typical value is around 120ns. This enables step-down operation

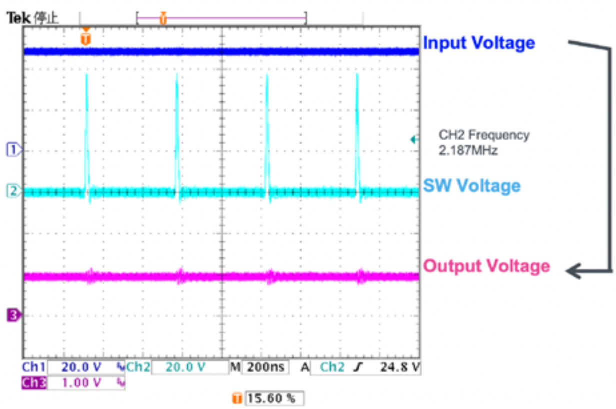
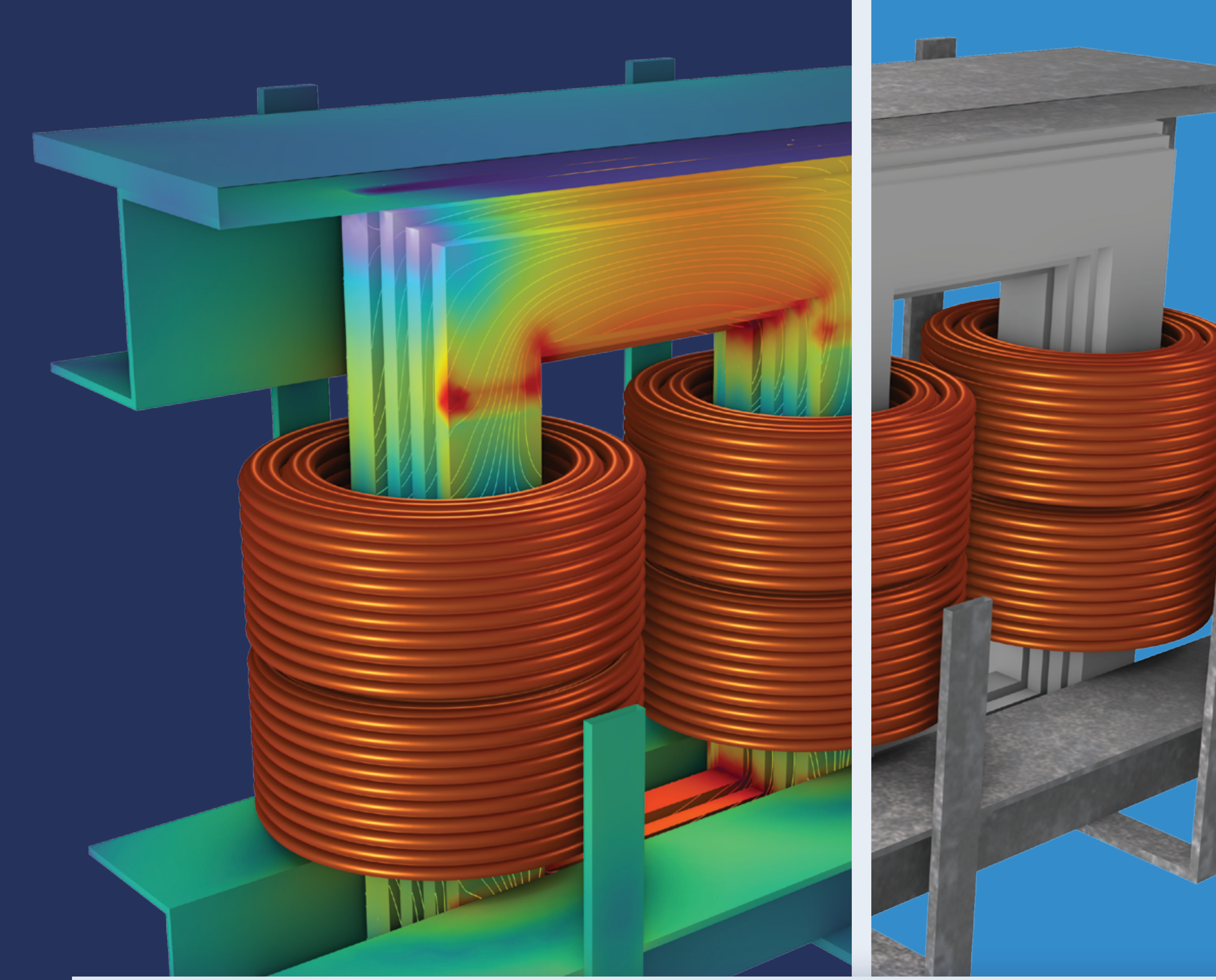


Figure 4: Industry leading switching speed enable high ratio DC/DC conversion



from 60V to 2.5V using the BD9V100MUF monolithic buck DC/DC converter with integrated MOSFET. The figure below depicts the switching waveform in a representative circuit.

Such a short switching time further enhances performance by minimizing the size of the required inductor. Up to a 70% reduction in overall design size compared to conventional two stage configurations can be achieved using a single chip Nano Pulse solution with small inductor.

Nano Energy for Automotive Subsystems

It may seem counterintuitive that automotive electronics might require ultra-low power consumption, yet several subsystems fall into this category. As shown in the figure below, a variety of automotive modules operate continuously when the vehicle is not running, including clocks, alarms, keyless entry, and infotainment systems. Whether powered by the main vehicle battery or an isolated coin cell, these devices must reliably operate for extended periods of time across a wide range of temperatures.

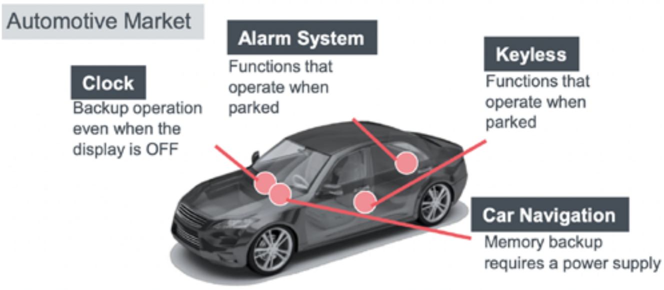


Figure 5: Energy-Sensitive Automotive Subsystems

To address these needs, ROHM developed breakthrough Nano Energy technology that decreases standby power consumption. Nano Energy Automotive LDO's feature a best-in-class quiescent current consumption of only 850nA. Products designed around Nano Energy, such as the BD7xxLx and BD7xxL05 Series, deliver twice the battery drive time of conventional products and greatly improve overall energy efficiency. As shown in the figure below, these devices outperform the competition by a wide margin.

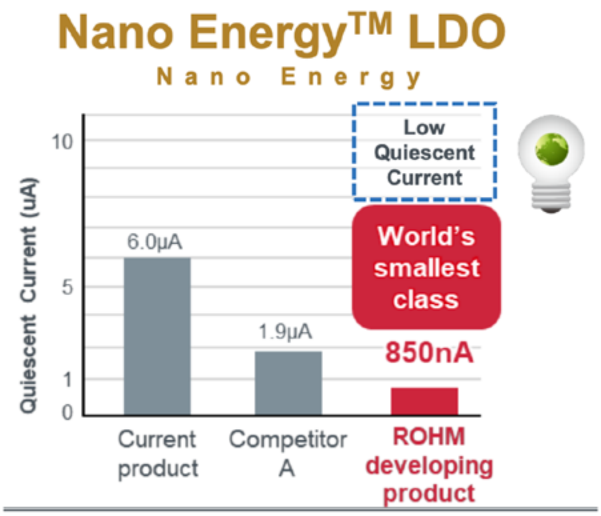


Figure 6: Nano Energy Automotive LDO with 850nA quiescent current

Nano Cap for Automotive Sensors

Many automotive electronic modules are highly space constrained, with every component in the system optimized for area and volumetric efficiency. Examples include radar distance units, video cameras, and any number of embedded peripheral sensors for safety and self-driving systems. Each of these subsystems contains a voltage regulator that requires large input and output capacitance for both stability and ripple performance.

ROHM's Nano Cap technology alleviates this constraint by improving the transient response of the on-chip analog circuits to guarantee linear regulator output stability. This also minimizes parasitic factors related to wiring and amplification, making it possible to reduce the output capacitance to less than 1/10th the size of conventional solutions.

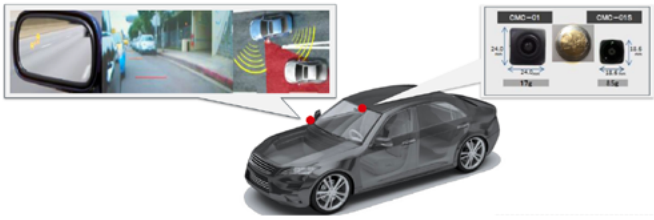


Figure 7: Space Constrained Automotive Subsystems

In practical terms, circuits composed of a linear regulator and microcontroller (MCU) typically require a 1uF capacitor at the output of the linear regulator and 100nF at the input of the MCU. But with ROHM's Nano Cap™ linear regulator technology, designers can achieve stable operation using just one 100nF capacitor at the MCU side.

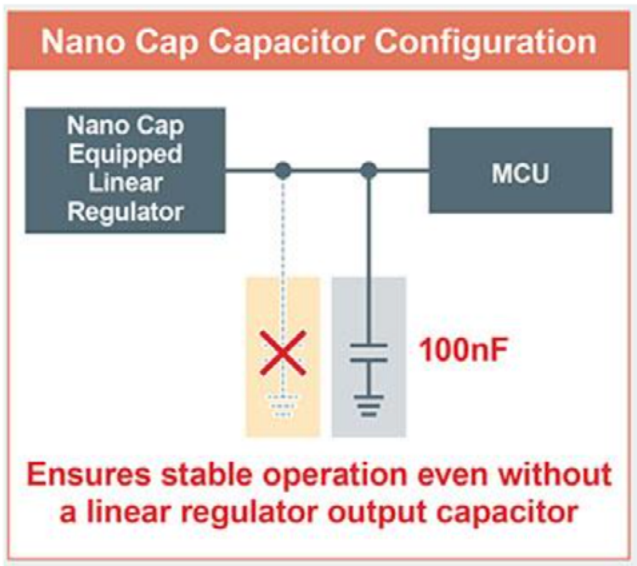


Figure 8: Nano Cap Technology Eliminates the Need for Large LDO Output Capacitors

Eliminating a passive component not only shrinks PCB area but also greatly simplifies design load. When every cubic millimeter matters, Nano Cap technology presents an indispensable asset in the automotive designer's tool box.

Conclusion

ROHM's Nano technology portfolio that includes Nano Pulse, Nano Energy, and Nano Cap devices addresses a variety of needs in the automotive industry by leveraging breakthrough performance along with a dedicated, vertically integrated design and manufacturing process. In addition to qualification under the AEC-Q100 standard, these power management and control IC's are offered in a variety of packages with a host of features.

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SMPD: An Advanced Isolated Package to Keep the SiC MOSFET Chip up to 75°C Cooler

The advanced isolated package from Littelfuse, the SMPD, fills the gap between modules and discretes, by offering the performance of a power module with the flexibility of a discrete.

By Aalok Bhatt; Umme Kulsoom; Francois Perraud; Martin Schulz; Levi Gant, Littelfuse

ISOPLUS - SMPD and its Advantages

The SMPD stands for Surface Mount Power Device. This top side cooled isolated package was first pioneered by IXYS (Littelfuse) in 2012. The SMPD as displayed in Figure 1, offers several key advantages:

- The integrated isolation provides excellent reliability under power and temperature cycling environment.
- Isolation voltage rating of minimum 2.5 kV AC, 1 minute.
- Lower junction-heatsink thermal resistance and higher power handling capability compared to discrete device using an external isolation foil.
- Allows fully automated pick & place and standard reflow soldering for the ease of manufacturing.

The SMPD is a revolutionary package which simplifies the way engineers address the system integration, thermal and assembly challenges of their power semiconductor designs. The SMPDs are already available with standard topologies such as rectifier, buck, boost, phase-leg in a variety of technologies such as Si/SiC MOSFET, IGBT, Diode, Thyristor, Triac, or other tailored solutions with voltage classes ranging from 40 V to 3000 V.

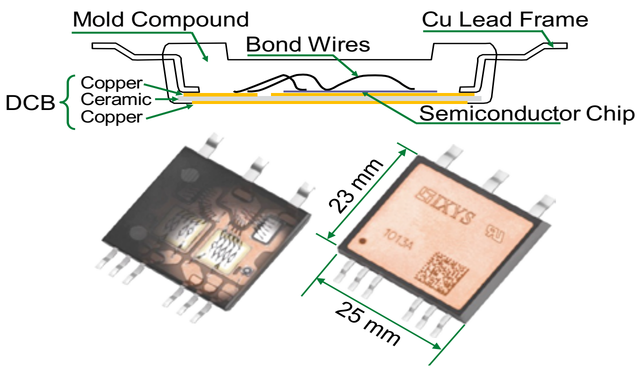

Figure 1: SMPD internal construction and size

Performance advantages of SiC based SMPD compared to standard discrete

The electrical performance advantages of SiC MOSFET based SMPD compared to standard discretes were highlighted in Bodo's power magazine article, October-2022 [1]. The article also emphasized on the applicational advantages including the power loop optimization when using the SMPD.

Thermal performance comparison between SiC based SMPD and standard discrete

Most of the standard discrete power semiconductor packages have an electrically conductive mounting tab. It is typically desired to electrically isolate the device mounting tab from the heat sink due to safety concerns and due to the need to mount multiple discrete devices with different tab potentials on the same heat sink frame. External thermally conductive electrical isolation foil between the package tab and heatsink has become a widely used approach in the industry for such a purpose. However, this approach comes with the major penalties of increased junction-heatsink thermal resistance, R_{thJH}, reduced power and current handling capability and complex thermal management with significant assembly efforts [2]. In contrast, the DCB-isolated SMPD doesn't require an external isolation foil, thus improving its thermal performance significantly when compared to conventionally isolated discretes. Thermal measurements were carried out to demonstrate the improved thermal performance and power handling capability of the isolated SMPD compared to externally isolated standard discretes. Littelfuse has developed the SMPD with a high-performance ceramic which further reduces the junction-case thermal resistance, R_{thJC}, and junction-heatsink thermal resistance, R_{thJH}, consequently improving power handling capability even further [3]. Thermal measurements incorporating 1200 V SiC MOSFET chips were conducted in three different packages as shown in Figure 2: the standard TO-247, the SMPD with alumina ceramic, and the SMPD with high performance ceramic.

	TO-247	SMPD	SMPD
Isolation	External, Thermally conductive foils with thermal conductivity 4.5W/mK and 6.5W/mK	Internal, Alumina ceramic	Internal, High performance ceramic
SiC die	Same in all three packages		
$V_{(BR)DSS}$ [V]	1200	1200	1200
$R_{DS(on)}$ [mΩ]	25	25	25
I_{D25} [A]	90	55	77
R_{thJC} [K/W]	0.27	0.7	0.45

Figure 2: Devices for thermal performance comparison featuring SiC MOSFETs

Thermal measurement results for the 1200 V, 25 mΩ SiC MOSFET chip in different packages at heating current, I_H=40 A are illustrated in Figure 3.

As evident from Figure 3, the SMPD with high performance ceramic can improve the thermal resistance, R_{thJH}, by up to 56% when compared to the TO-247 with the same chip. This directly translates into increased power handling potential and lower chip temperature at the given current. It was observed that the SiC chips in the SMPD package with improved ceramic stays up to 75°C cooler when compared to the TO-247 device with external isolation at I_H=40 A. The SMPD with high performance ceramic enables therefore nearly a 58% reduction in temperature swing ΔT_{JH} compared to the standard discrete. However, it is worth mentioning that the practical zone for T_{vj} within an application is usually only up to 130°C to ensure safe operation. By comparing the SMPD's performance to the TO-247 with 6.5 W/mK foil at this junction temperature, the SMPD with high performance ceramic improves thermal resistance, R_{thJH}, by 48% and offers 45% lower temperature swing, ΔT_{JH}. Compared to conventional alumina ceramic based SMPD, the high-perfor-

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mance ceramic based SMPD offers 30% lower R_{thJH} and 40% lower temperature swing, ΔT_{JH} with the same SiC chip. The SMPD package thus can contribute to significantly improving the device's lifetime and in turn the reliability of the application under realistic application conditions.

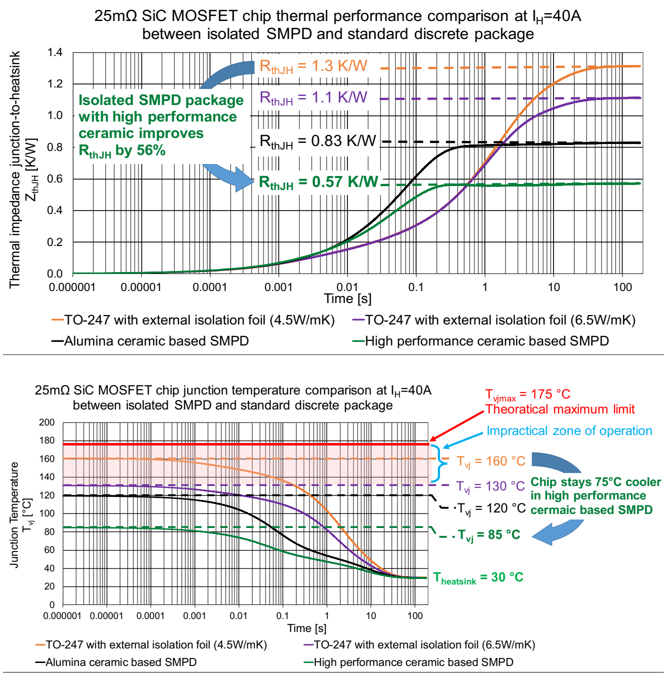


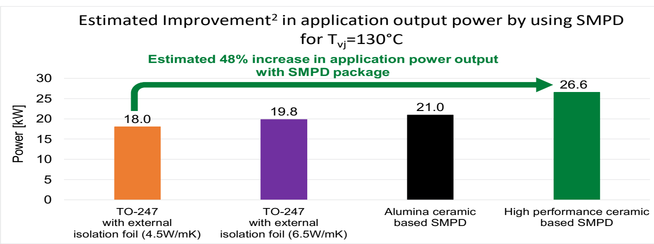
Figure 3: Thermal measurement comparison results on devices featuring SiC MOSFETs

Application power output increase by 48% using SMPD

The reduction in overall thermal resistance and chip junction temperature by using the SMPD package may lead to significant increase potential in application power output. To demonstrate this fact, thermal measurements were performed such that the SiC MOSFET chip will reach the junction temperature of 130°C for the different packages listed in Figure 4. The SMPD with the high performance ceramic could handle 28% higher heating current and 130% higher power dissipation as compared to conventionally isolated discrete solution. The thermal measurement results can be interpreted in terms of percentage power output increase potential of an application by using the SMPD. Let's consider an 18 kW power converter operating at 800 V DC-link voltage, designed with TO-247 discrete and external isolation foil. Replacing the standard discretes with the SMPD will not only reduce the number of necessary power components but also, for the given junction temperature limit of 130°C, the SMPD can push the theoratical DC power output of an 18 kW application by 48% to 26.6 kW.

Thermal Measurement Results at T_{vj} = 130°C

	I_H [A]	R_{thJH} [K/W]	P_{DJH} [W]
TO-247 with 4.5 W/mK isolation foil	37.7	1.31	77
TO-247 with 6.5 W/mK isolation foil	40	1.11	91
SMPD with Alumina ceramic	41.4	0.83	122
SMPD with High performance ceramic	48.4	0.57	177

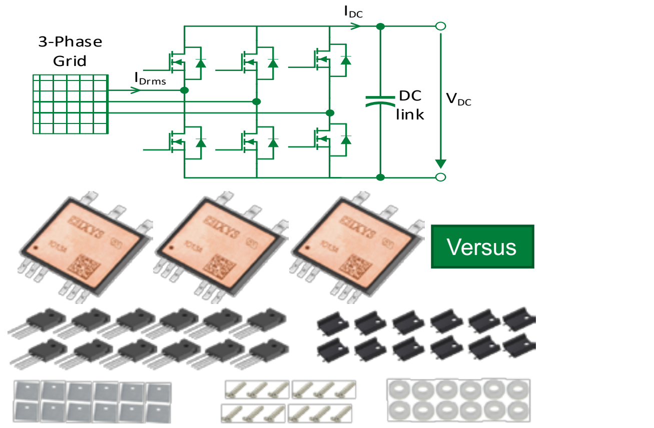


²Calculated based on the thermal measurement results @T_{vj}=130°C for theoratical 18 kW application with 800 V DC-link voltage.

Figure 4: Potential increase in application power output using SMPD

System level cost saving by using the SMPD

The SMPD offers significant indirect cost saving opportunity at system level in the application thanks to its pick & place compatibility, reduction in potential warranty claims by eliminating isolation foil, and reduced space and size on the PCB. Figure 5 illustrates the system level direct cost saving opportunity in the application using the SMPD versus standard discrete using the example of a 22 kW active front end converter for DC charger.



	SMPD	TO-247
Total number of device	3	12
No. of isolation pad	No need	12
Mounting efforts	Simplified [2]	12 screw, washer, heat-sink, man power, tooling
Minimum required PCB area	2400 mm²	5000 mm²

Figure 5: System level cost saving opportunity by using the SMPD in application

Summary

By comparing the thermal performance of the Littelfuse SMPD with standard TO-247 discrete having the same SiC MOSFET chip, it was observed that the SMPD package offered thermal resistance R_{thJH} reduction by up to 56% and temperature swing ΔT_{JH} reduction by up to 58%. The SiC MOSFET chip in the SMPD package could stay up to 75°C cooler at given DC power. The usage of SMPD in application reduces mounting efforts, enables space saving, provides integrated isolation, increases power density and efficiency along with simplified thermal design compared to the standard discrete packages. The Littelfuse SMPD product portfolio can be checked and inquired at Littelfuse web page [4].

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[2] Application Note: 'Mounting and Cooling Solutions for SMPD Packages'; www.littelfuse.com.

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[4] Littelfuse SMPD product offering; https://www.littelfuse.com/products/power-semiconductors.aspx

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Powering the Control of Modern Energy Systems

The reduction of CO_2 emissions has become a worldwide goal and has led to the development and research of many new technologies. Higher efficiencies in the complete power chain and new ways to store energy are needed.

By Clyde Chang, Vice Chief Engineer, P-DUKE

To replace fossil fuels with renewable energy sources, there is the possibility of using the energy of the sun, wind, water, biomass as well as geothermal energy. While biomass and geothermal energy provide a constant energy yield, this is not the case with energy generated from the sun, wind, or waves. Solar energy generated during the day must be stored for the night. The same applies to wind energy, as the turbines no longer supply energy during a wind calm.

All these new technologies require electronic control circuitries, which need to be powered from the various sources. The following article will explain challenges and solutions.

One of the growth markets is e-mobility, and the EU has decided, for example, that no new vehicles with a classic combustion engine may be sold after 2035. Other regions have decided similar bans and the change to e-cars will require many public and private charging stations supplied from the different worldwide AC grids (figure 1).

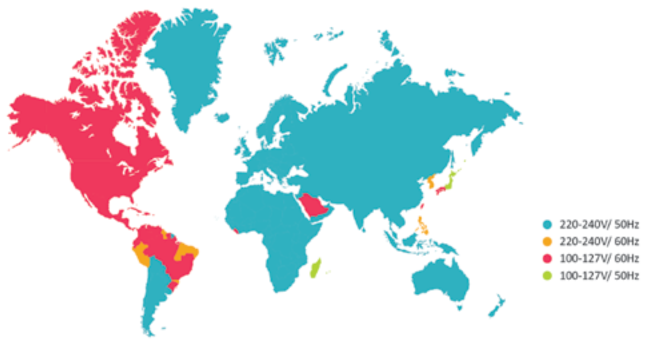

Figure 1: worldwide AC mains single phase voltage and frequency levels without tolerances

The worldwide AC mains voltages range from 85Vac up to 264Vac and many power supplies today can work over this full range.

An additional challenge in energy applications comes from the fact, that equipment like power chargers or wall boxes are hard wired directly to the fuse panel. This means they are more exposed to transients on the grid than equipment connected to an outlet by cables and plugs and therefore have to be compliant to overvoltage category III (OCV III) with isolation barriers of 4kVac (figure 2). This also applies to the auxiliary power supplies used inside the chargers or wall boxes.

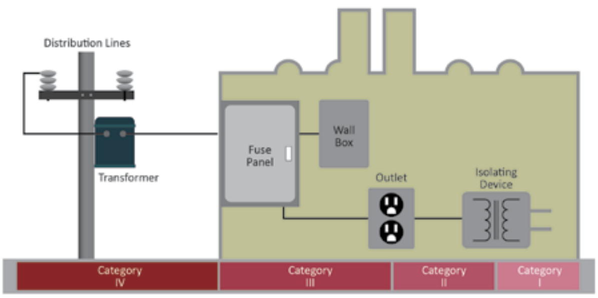

Figure 2: Overvoltage Categories

These systems also have to be tolerant to faults in the mains wiring or the neutral. A phase accidentally connected incorrectly during installation, or a break in the neutral even in the neighborhood can lead to unbalanced systems and therefore higher voltages. The mains input voltages are therefore monitored to disconnect the expensive high-power stages in case of such a failure.

This monitoring circuitry must work under all circumstances and P-Duke therefore offers a series of small AC/DC converters not only compliant to OVC III but also operating over the extremely wide range of 85 to 530Vac. Even if a phase is connected to neutral by error, the auxiliary supply and the monitoring circuitry work and can protect the power stage.

Modern systems should be ready for the integration in a smart grid or smart home environment. This allows controlling the system to match the actual availability of power in a grid. Car batteries can be charged when a surplus of energy is available and work as energy buffers stabilizing the grid. Household appliances with high energy consumption will be switched on only when there is enough energy available.

This means more interphases to communicate with the grid or smart home controller. Supply voltages for interphases, displays, touch panels or relays can range from 3.3V up to 24V and can be generated from the auxiliary supply voltage bus with small isolated or non-isolated converters (figure 3).

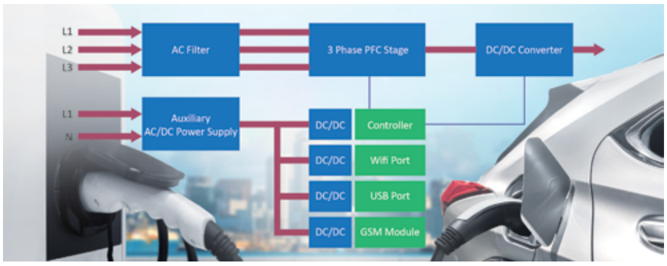

Figure 3: simplified block diagram of a typical EV car charger. P-Duke offers the lower power auxiliary AC/DC and the various DC/DC converters.

As mentioned at the beginning of the article, the integration of renewable energies also requires an expansion of storage options due to the non-constant energy flow. Hydroelectric power plants are already used for this purpose today by pumping water back into the reservoir when there is a surplus of energy. However, their capacity is limited and the most obvious way to store energy would be to use batteries.

Lead-acid batteries have been used for decades but they are heavy, energy density is relatively low, the charging process is slow, and they can only be charged about 300 - 600 times.

Lithium batteries have several advantages over lead-acid batteries. For example, they are not only much lighter and smaller than lead-acid batteries, but they can also be charged faster and reach several thousand charge cycles. This makes them ideal for use in mobile devices as well as e-vehicles.

But they require materials whose availability is limited and some of which are obtained under problematic conditions. Per kilowatt-hour of capacity a typical e-car battery needs not only 120 – 180 grams of lithium but also some other materials with limited availability. According to a study from ADAC, a German automobile club, the 50kWh battery of a-car contains around 4kg lithium, 11kg manganese, 12 kg cobalt, 12kg nickel and 33kg graphite.
To change mobility away from combustion engines to e-drives, hundreds of thousands of tons of these materials will be needed in the future. Methods to recycle this material are complex and according to experts partly still in the development or testing phase. Therefore, alternatives are being sought, not only in battery technologies but also in the way electrical energy is stored.

You may have heard of batteries based on aluminum - sulfur, sodium ions, carbon - copper, or iron - oxygen. Not available yet for the mass market, these are options to use material that is available in large quantities and is also less problematic to mine.
For a non-mobile application, size and weight of the batteries are also not so important. In the base of a wind turbine tower, there is plenty of space even for larger batteries. When there is a surplus of energy in the grid, the energy generated by the turbine could be stored there and fed into the grid when there is an energy shortage. Often, energy only needs to be temporarily stored in a grid for a period of 12 to 24 hours.

But each battery technology has different voltages, a real challenge if someone wants to design future-proof systems compatible to the different battery technologies and number of cells used in an application. Power supply manufacturers like P-Duke therefore offer converters with input voltage ranges from 2:1 up to 12:1. With these converters it is possible to cover many different battery technologies.
Supercaps are an interesting alternative to batteries as they offer longer lifetimes, up to 1 million charging cycles and very high charging currents. Unlike batteries, supercaps are not damaged by a deep discharge. They are ideal for applications with power demands of less than 1-2 minutes but a very high number of charging cycles. Why not using supercaps on a transport robot in a warehouse that only travels short distances and can then be recharged in seconds. Unlike batteries, the output voltage of supercaps depends very much on the state of charge. As most electronic loads need a stable voltage, DC/DC converters with very wide input ranges are needed.

And there are many other ways to store energy. With electrolysis hydrogen can be obtained from air. In a further process step methane, the main component of natural gas can be produced. Both gases can be stored, transported, and used as fuel, e.g., in a fuel cell, another strongly emerging technology. Even drones are using fuel cells nowadays. Other ways to store mechanical energy for later use are gas pressure and flywheel storage devices. Over 15 years ago a start-up in the USA wanted to use compressed air for wind turbines but it was never realized because the solution was too complex and inefficient. But there are still projects working on storing excess energy from wind turbines in compressed air.
First gyro buses came to the market in 1950, where able to recover the braking energy but needed a charging station every 4-6 kilometers, not suitable for modern public transport. Today flywheel storage devices are mainly used to deliver high power for a short time, for example to stabilize a grid.

These were just a few examples; the energy market is complex, there are thousands of options and new ideas and technologies appear almost daily, each placing different requirements on the power supplies needed. In addition, for energy-efficient, wide-spread use, modern systems must communicate with each other. All these systems need regulated supply voltages to be generated from a wide variety of sources. The AC grid voltage levels and transient specifications are set for many years now and companies like P-Duke offer a wide variety of AC/DC power supply solutions meeting the various requirements (figure 4, P-Duke's AC/DC solutions)

Figure 4: P-Duke's range of highly efficient/ compact AC/DC power supplies from 6W to 500W

For DC sources the situation is more complex also because new systems are expected to come to the market. But solutions are available today. In the telecom and the railway market different battery voltages had been used for decades. System manufacturers in these markets want to offer one solution and therefore power supply manufacturers like P-Duke designed converter families covering even the extremely wide input ranges of 16V up to 160V in railway applications and achieving power levels up to 200W. With their standard output voltages from 5V up to 53V, these converters can be used for many different battery voltages in all types of energy market applications.

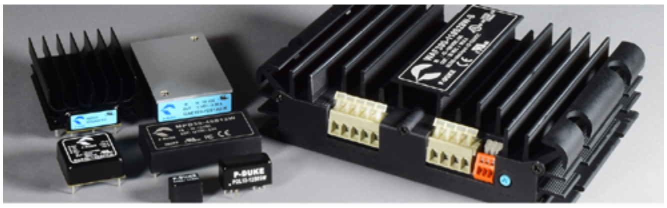

Figure 5: DC/DC converter modules from P-Duke are available in different housings

LAN, WLAN, GSM and other communication modules, safety and monitoring devices, displays, touch panels or relays, they all need regulated supply voltages, with or without isolation from the internal control circuitry. Withing the broad range of converters it should be easy for a designer to find a ready-to-use solution. (figure 6)

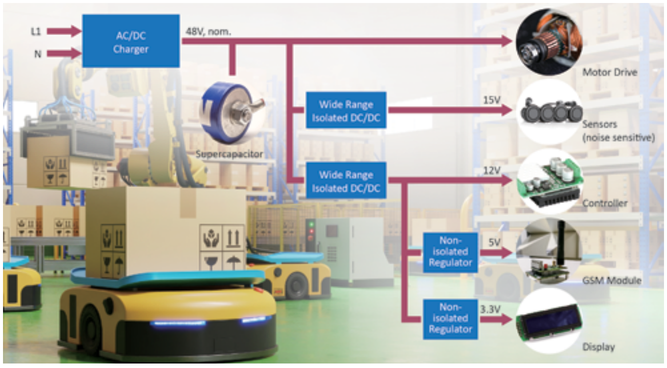

Figure 6: simplified block diagram of the power chain in an automated guided vehicle for warehouse applications. Two Isolated, wide range converters are used to cover the wide voltage range of the supercap array and to protect the sensitive electronics from electric noise coming from the motor drives. The other, low power voltages are generated by non-isolated regulators.

All these converter modules are easy to deploy and therefore plug-and-play solutions not only during the design phase but also in case of later changes in the input, output or power specification of a system. This makes every design future proof and ready for an emerging market with many new opportunities but also still many unknowns.

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Optimum GaN Gate Control for Greater Performance Gains

When designing power applications with gallium-nitride (GaN) wide-bandgap technology, proper control of the gate-driving circuit is essential to maximise efficiency, space savings, and reliability.

By Mike Wens (CEO & co-founder), Jef Thoné (CTO & co-founder) and David Czajkowski (Strategic Business Development Manager), MinDCet NV, Belgium

As the world looks to electrification to help utilise energy efficiently and switch to renewable sources, the time is right for wide-bandgap semiconductor technologies like gallium nitride (GaN). The performance of traditional silicon MOSFETs and IGBTs is now close to the theoretical limits of the material and further development is realising only small improvements, slowly and at high cost. GaN transistors permit a significant and instant increase in power-conversion efficiency and can deliver additional advantages including smaller size and greater reliability.

Accordingly, these devices are pervading new designs for important applications like power adapters and wall chargers, electric-vehicle charging systems, industrial and medical power supplies, and motor drivers. End users will experience this revolution as new generations of equipment enter the market in slimmer form factors that are easier to carry and that run cooler than their predecessors. GaN technology also delivers advantages in class-D audio amplifiers, including longer battery runtime and smaller size in portable and mobile applications, as well as the potential for superior audio quality.

Several important benefits of GaN transistors derive from their generally lower parasitic effects compared to silicon equivalents. In particular, lower values of gate-source and gate-drain capacitance (C_{GS}, C_{GD}) translate into lower energy losses during switching. Figure 1 compares the efficiency of 48V-3.3V buck converters implemented using silicon and GaN technologies, showing a significant efficiency advantage for GaN that becomes even larger at higher output current.

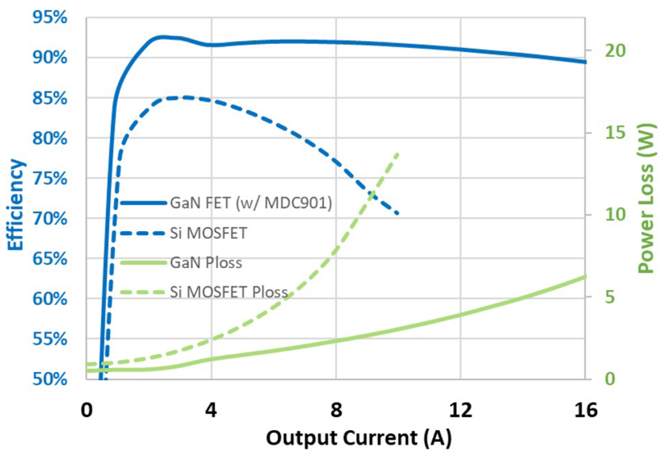

Figure 1: Efficiency comparison between GaN and silicon technologies in a buck converter.

In addition, faster charging and discharging of the capacitances results in shorter delay and transition times, allowing engineers to design applications for switching frequencies into the MHz range. This permits the use of smaller storage passives, with a direct effect on increasing power density. In class-D amplifiers, high switching frequency enables increased audio fidelity. Moreover, a low value of CGS enhances switching control in applications that call for a low duty cycle, such as buck regulators with a high step-down ratio.

Unlocking GaN Advantages

Power is nothing without control, and the principle applies well in relation to driving GaN transistors in switching circuits. The role of the gate driver is critical in maximising the efficiency advantages of GaN transistors, while also protecting the device structure to ensure reliability.

MinDCet has created the MDC901 driver IC with features that are specially designed to ensure secure, fast, and efficient GaN switching to maximize performance and energy savings, leveraging experience producing high-performance, high-reliability ASICs and systems for demanding applications, including rad-hard space-ready components. Figure 2 highlights that the PCB area required by the MDC901 gate controller is five times smaller than the external components needed for a comparable gate driver solution.

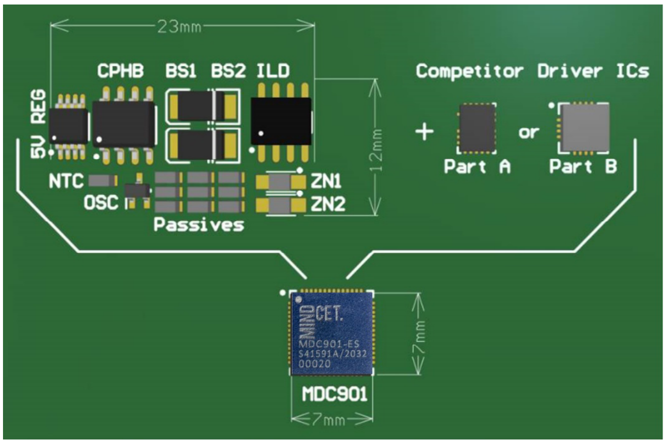

Figure 2: The PCB area used by the MDC901 gate controller is five times smaller than the required external components for an equivalent competitor gate driver solution.

Overcharging Protection

The gate oxide in GaN transistors is relatively fragile and can be damaged by excessive voltage. The behaviour of parasitic inductance in the gate loop, charging/discharging of transistor capacitances during switching, and induced voltages appearing on signal lines are all factors that can expose the low-side transistor to potentially damaging excessive gate-source voltage (V_{GS}).

There are various ways to protect the gate against overvoltage. One is to add external clamping circuitry. However, this tends to increase the power consumption and circuit footprint. Its effectiveness is also limited by PCB parasitic effects. Alternatively, protection can be built into the GaN transistor, at the cost of increased device complexity and cost. MinDCet's MDC901 half-bridge gate driver protects the GaN gate by integrating true floating voltage linear (LDO) regulators for both high-side and low-side driver circuits. These LDOs tightly regulate the voltage at a level that can be programmed to either 5V or 6V. Hence the driver is effective in preventing overvoltage while allowing designers a broader choice of GaN transistors without internal protection.

Dead-Time Control
To realise the full efficiency gains that GaN technology can deliver in power conversion, designers need to understand the behaviour of parasitic capacitances and the physics that permit transistor reverse conduction when VGS = 0V. Whereas an ordinary silicon MOSFET has an intrinsic body diode that conducts freewheeling current, the GaN transistor has no body diode. The device self-commutates when reverse biased with VGS = 0V so that the freewheeling current passes through the transistor drain-source channel. This has several advantages, including eliminating the losses associated with body-diode reverse recovery and internal noise generated during diode turn-on.

On the other hand, the voltage drop across the transistor is greater than the corresponding voltage across the body diode of a silicon MOSFET. In a half-bridge, the loss due to this voltage drop is incurred during the transistor dead time. Hence, a short dead time helps to minimise these losses and enhances efficiency. On the other hand, insufficient dead time incurs losses as drain-source capacitance is discharged through the complementary transistor.

Effectively, the ideal dead time is application dependent. Hence, dead-time control is a desirable feature of a suitable GaN driver to help designers optimise performance and efficiency. Moreover, control also ensures that the deadtime is known and constant for the lifetime of the application.

The MDC901 provides digital inputs that allow setting the dead time for both the turn-on and turn-off phases of half-bridge operation. The driver can also set the dead-time automatically if required. Closed-loop sensing of the GaN gate voltages provides a failsafe by ensuring either the high-side or low-side transistor can only turn on when the complementary device is off.

Output Drive Strength
A key strength of GaN technology comes from its ability to transition quickly between the OFF and ON states and thereby minimise dissipation. Achieving a short switching transition time is dependent on providing adequate gate current. The MDC901 has maximum gate-drive strength of 10A, which maintains the ability to ensure fast switching transitions even where multiple GaN transistors are connected in parallel.

While fast switching is typically a priority, care must be given to moderate the speed to avoid ringing. This is typically achieved using resistors that are chosen according to the inductance of the gate circuit and the transistor gate capacitance. It is common for the driver to integrate these resistors to facilitate control of the turn-on/turn-off current.

The MDC901 takes a different approach that emphasises the use of external resistors, which moves power dissipation outside the driver IC thereby easing thermal management and enhancing reliability. The driver provides separate pull-up and pull-down outputs for gate-drive tuning. In addition, the driver is designed to operate with output voltage down to -4V to ensure correct operation when the voltage swings below the supply ground, which can be caused by a combination of source inductance and load conditions.

High Duty Cycle
Another important advantage of GaN transistors' fast switching capabilities is their ability to operate efficiently at very low duty cycles. This can be the case in applications such as power conversion with a large step-down ratio. GaN makes it possible to convert a 48V bus directly to 1V, at the point of load (POL), with high efficiency and with no intermediate stage required. This enables bill of materials (BoM) savings and a smaller circuit footprint, as well as eliminating intermediate-conversion losses. The GaN transistors' ability to minimise switching losses by performing fast transitions can raise the overall conversion efficiency by 10-15% compared to equivalent silicon MOSFET technology at the same switching frequency.

Conversely, GaN's fast switching capability also makes the technology suitable for applications that require extremely high duty cycles. These include class-D amplifiers and motor drivers, particularly when operating at high rpm. When operating at sustained high duty cycle, the bootstrap voltage and thus the voltage applied to the GaN transistor gate can become reduced due to leakage effects and through biasing other loads in the system. To combat this, the MDC901 driver integrates a charge pump to sustain the necessary gate-drive bias. This enables operation at up to 100% duty cycle thus permitting the high-side switch to be held on for extended periods. The MDC901 also integrates bootstrap diodes that help ensure adequate gate-drive strength.

Figure 3 shows the driver's internal features, including the charge pump, dead-time generator, and floating regulators. Essential system-safety features are also integrated, including die-temperature monitoring, gate-signal output monitoring, and gate undervoltage lockout (UVLO).

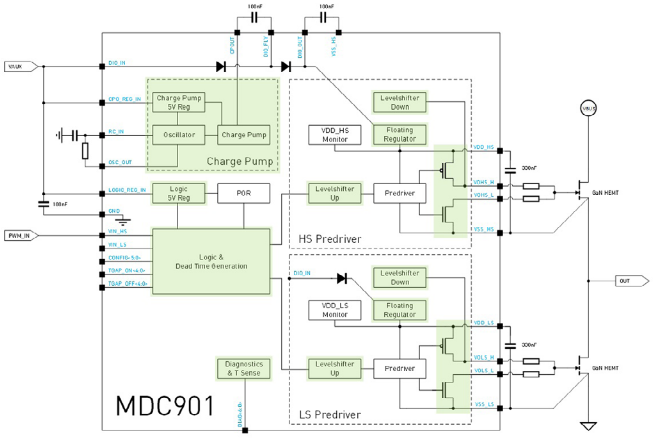

Figure 3: Block diagram of MDC901 GaN gate driver IC.

To accelerate development, MinDCet has created three half-bridge evaluation boards. The MDC901-EVKHB, MDC901-15I-EVKHB and MDC901-2E-EVKHB combine the MDC901 driver with GaN Systems' 100V GS61008P GaN HEMTs, Innoscience's 150V INN150LA070A FETs, and EPC2215 200V eGaN FETs, respectively, in a buck-converter topology. A fourth half-bridge evaluation board MDC901-15N-EVKHB using Nexperia's 150V GAN7R0-150LBE GaN FET is under development and will be available soon. Each board measures 80mm x 90mm and is ready for use out of the box, delivering a compact solution ready for testing.

Conclusion
GaN transistors can drop directly into established power-conversion topologies and deliver advantages including greater energy efficiency, higher power density, more compact product dimensions, cooler operating temperatures with easier thermal management and greater reliability.

Maximising these benefits requires some re-engineering, particularly in the way the transistors are controlled. Ideal gate-driver characteristics include a large current-sink capability to control multiple GaN devices in parallel, configurable dead-time, and protection against gate-overcharging. With additional functions including an integrated charge pump to serve applications that require a high duty cycle, as well as built-in system protection features, the MDC901 addresses demanding, energy-conscious applications in medical, industrial, consumer, and automotive markets.

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Bi-Directional Topologies for Fast Charging of EVs: Options to Optimize for Size, Power, Cost or Simplicity

Dc fast chargers for electric vehicles (EVs) under development now have to meet a more demanding set of specifications than today's installed base of chargers. This high requirement stems from two market pressures: first, to provide for faster charging of the higher-capacity batteries embedded in the latest EVs. And second, to enable bi-directional power flow, supporting new vehicle-to-grid (V2G) and vehicle-to-building (V2B) applications – technology that will help to balance the power grid as more energy is generated from fluctuating sources such as wind and solar power.

By Riccardo Collura, EMEA Vertical Segment Manager (Power), Future Electronics

Charger manufacturers can build flexibility into their designs by implementing dc fast chargers as modular building blocks: multiple modules can be connected in parallel to scale up the power output to as high as 300 kW. This means that when multiple modules are stacked in a charger's enclosure, the power density of the module becomes a key issue, as does thermal management.

In answer to these challenges, EV charger manufacturers have turned to silicon carbide (SiC) power switches, which can switch faster than equivalent silicon MOSFETs or IGBTs with much lower switching losses: this enables the use of smaller magnetic components, and resulting in higher system power density. SiC technology also provides an answer to the thermal problems of high-density power designs, because of its higher efficiency and toleration of higher operating temperatures than silicon devices, enabling the use of a smaller heat-sink while reducing thermal stress on the system's components.

There is today a small number of semiconductor manufacturers with the technical capability and manufacturing capacity to supply SiC devices in volume to charger manufacturers: leading the group are Infineon, onsemi and STMicroelectronics. Many EV charger designers will therefore look to these companies to provide the reference design boards with which they can evaluate the performance of various SiC power switches, and assess their suitability for their application.

These reference designs provide implementations of some of the most appropriate topologies for bi-directional dc fast chargers, both at the PFC stage and the dc-dc converter stage. An understanding of these topologies, and their benefits and drawbacks, will help the designer to work out which best fits the requirements of their application. Let's look first at the choice of topologies for an EV charger's active front-end PFC stage.

Active front-end PFC stage of a dc charger module

The ac-dc stage converts a (normally) three-phase input in the range 380 V-415 V ac into a stable dc link voltage of around 800 V. All the topologies examined in this article are for bi-directional systems, so the conversion will also go the other way, from dc to ac.

SiC devices are particularly well suited to bi-directional converters, which are based on a half-bridge configuration. Usually bi-directional systems perform repetitive hard commutation: in this case, a silicon power switch's long reverse-recovery time at the device's body diode will lead to high power dissipation and low efficiency, as well as higher thermal stress and lower system reliability. So a bi-directional converter requires low or even zero reverse-recovery time, a feature of SiC MOSFETs (see Figure 1).

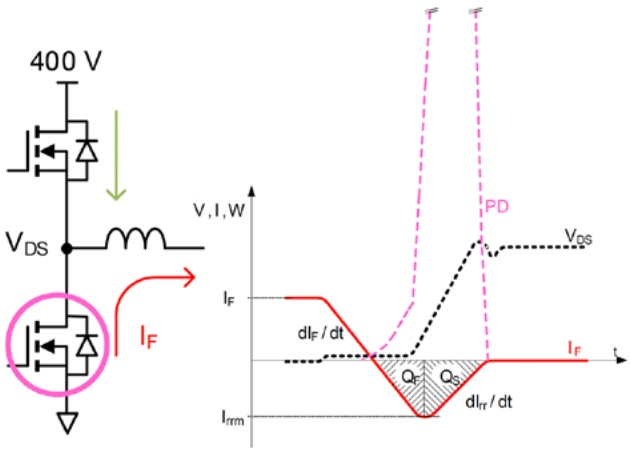


Figure 1: Low body diode reverse-recovery time is essential in bi-directional converters, which have a half-bridge configuration and are exposed to repetitive hard commutation

There are three topologies worth considering for the active front-end PFC stage of three-phase bi-directional dc chargers:

- Two-level PFC
- Three-level neutral point clamped (NPC)/active NPC (ANPC)
- Three-level T-type NPC

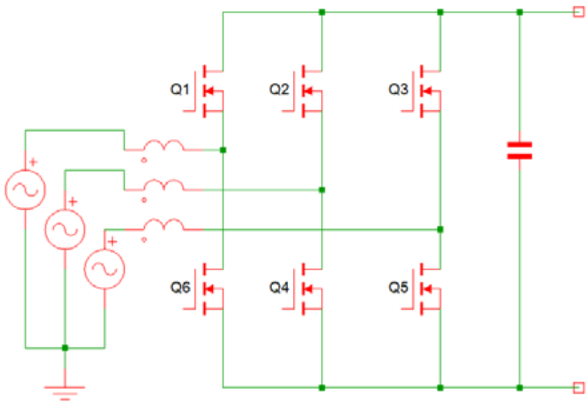


Figure 2: The two-level PFC topology

Two-level PFC topology
The six-switch boost-type rectifier of the two-level PFC topology is a very simple circuit that is easy to control (see Figure 2). It facilitates bi-directional power flow and can achieve a high power factor with reasonable efficiency. Compared to a three-level topology, it results in a lower component count and an easier PCB layout.

On the other hand, it requires switches with a high voltage rating to block the entire dc link voltage. For example, in an 800 V dc application, a SiC MOSFET with a 1,200 V blocking capacity is required.

An additional drawback of this topology is the bulky filter inductor, which is required to minimize the total harmonic distortion (THD) at the input current. Three-level topologies, which do not require so much inductance, enable lower power density.

Another factor to consider is the high peak-voltage stress, which compromises the lifetime of the semiconductor and other passive devices.

Finally, the converter's EMI performance is substantially lower than that of the multi-level PFC topologies described below.

Three-level NPC/ANPC PFC topology
In the three-level NPC/ANPC topology, each switch only needs to be capable of blocking half the bus voltage, so MOSFETs with a lower voltage rating can be used, and the voltage stress on devices is much lower (see Figure 3). This means that this topology can be easily scaled across multiple platforms for implementation with SiC, GaN and silicon power switches to meet the needs of applications with different power, cost and efficiency requirements.

In an 800 V application, 600 V-rated MOSFETs may be used. As well as offering lower switching losses than 1,200V MOSFETs, 600 V MOSFETs can support much faster switching frequencies.

In the NPC topology, lower ripple is observed in the output current, and the output-voltage transient is 50% lower. This reduces the requirement for filtering and isolation, and allows for the use of a smaller filter inductor. With less inductance needed to regulate THD in the current waveform, the design can achieve higher power density. This multi-level converter topology's output voltages also suffer very low disturbance, which minimizes the dv/dt stresses across devices, and improves EMI performance.

While the NPC topology offers lower switching losses and higher efficiency at switching frequencies higher than 50 kHz than the two-level PFC, it does require more switches, and each switch needs its own gate-drive circuit. This means that control is more complex, and the bill-of-materials (BoM) cost is higher.

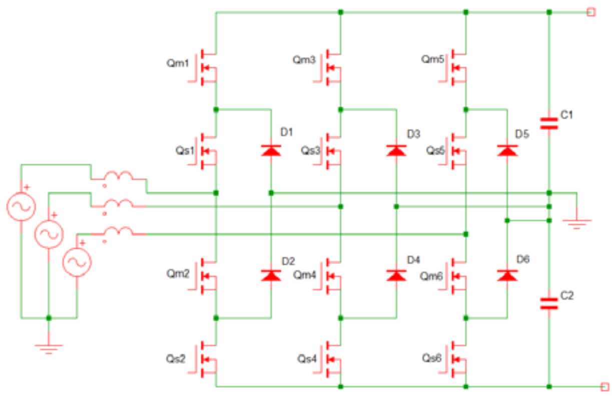


Figure 3: Three-level NPC PFC topology

In addition, this topology uses both active semiconductor switches and diodes, and the resulting unsymmetrical distribution of losses across the power stage can make thermal management difficult. Some designers prefer a more symmetrical distribution of losses, so replace the diodes of the NPC topology with active switches in an ANPC converter (see Figure 4).

It is useful in both NPC and ANPC topologies that the reduced blocking voltage across all switches means that high-efficiency gallium nitride (GaN) switches can be used to improve efficiency and power density.

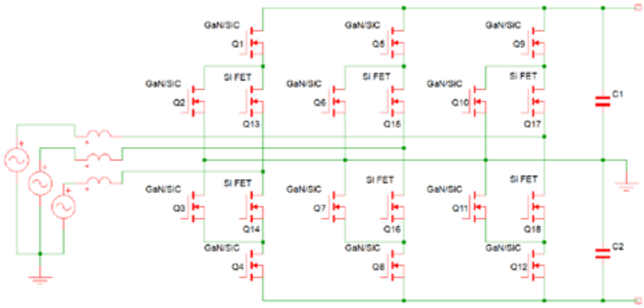


Figure 4: Three-level ANPC PFC topology

Three-level T-type NPC PFC topology
In three-level T-type NPC PFC converters, the conventional two-level voltage source converter (VSC) topology is extended with an active, bi-directional switch to the dc link midpoint (see Figure 5). For 800 V dc link voltages, 1,200 V IGBTs/diodes would normally operate on the high and low sides on each phase, as the full voltage has to be blocked. But in the T-type configuration, the bi-directional switch to the dc link midpoint only needs to block half of the voltage. This means it can be implemented with lower-voltage devices, for example two 600 V IGBTs that include antiparallel diodes.

Due to the reduced blocking voltage, the middle switch generates very low switching losses and acceptable conduction loss. Unlike the three-level NPC topology, the T-type NPC topology does not connect devices in series that must block the whole dc link voltage.

In the NPC topology, switching transitions made directly from a positive to a negative dc link voltage, and vice versa, are usually avoided, as they might cause an uneven share of the voltage to be blocked momentarily when both FETs connected in series turn off at the same time. This undesirable effect cannot occur in the T-type topology. Therefore it is not necessary to implement low-level routines which prevent such transitions, or to provide for transient voltage balancing across series-connected IGBTs.

An additional benefit of using single 1,200 V devices to block the full dc link voltage is reduced conduction losses. Whenever the output is connected to positive or negative, the circuit is exposed to the forward voltage drop of only one device; in the NPC topology, two devices are always connected in series. This considerably reduces conduction losses, making the T-type topology valuable in applications that switch at a low frequency.

Overall, conduction losses are significantly lower than those of the NPC topology, but switching losses are high because of the devices that block the full dc link voltage. So the T-type rectifier is best suited for applications switching at up to 50 kHz, while the NPC topology performs better at frequencies higher than 50 kHz.

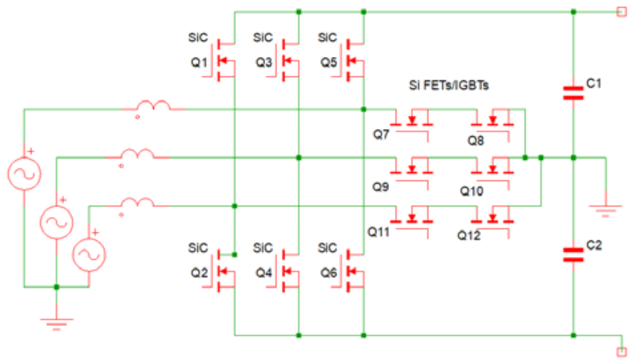


Figure 5: Three-level T-type NPC PFC topology

Table 1 shows a high-level comparison of the advantages and drawbacks of the three PFC stage topologies described above.

	Two-level PFC	Three-Level NPC	Three-level ANPC	Three-level T-type NPC
Power Density	Low	Higher	Higher	Highest
Efficiency	Low	Very high at high frequencies	Highest	High
Conduction Loss	Low	High	High	Mid
Switching Loss	High	Low	Low	Mid
Peak Voltage Stress	High	Low	Lowest	Low/(high blocking voltage)
Cost	Low	High	Highest	Mid
Control	Easy	Mid	Mid	Mid
Input Inductor	Large	Small	Small	Small
Number of Active Switches	6	12	18	12
Number of SiC Diodes	0	6	0	0

Table 1: Summary of features of PFC topologies

Dc-dc converter stage of a dc charger module

The dc-dc stage is the galvanic isolated converter which converts the incoming dc link voltage of 800 V to a regulated dc output voltage for charging the EV's battery (bypassing the vehicle's on-board charger, which is used only when connecting to an ac charger).

The topology for the bi-directional dc-dc stage can be implemented in one of two ways:

- Dual active bridge
- Dual active bridge in CLLC mode

The dual active bridge topology

The dual active bridge (DAB) converter consists of a full bridge with active switches on both the primary and secondary sides, connected via a high-frequency transformer (see Figure 6). Because of the inherently lagging current in one of the bridges, the current discharges the output capacitance of the switches of one bridge at a time. While the secondary side switches are discharged, some switches on the primary side enable zero-voltage switching turn on. Loss-less capacitive snubbers can also be used across the switches to reduce turn-off losses.

The main advantages of this converter topology are:

- Bi-directional capability, which is achieved by controlling the phase angle between the two bridges
- Modularity, which allows for it to be scaled to higher power levels

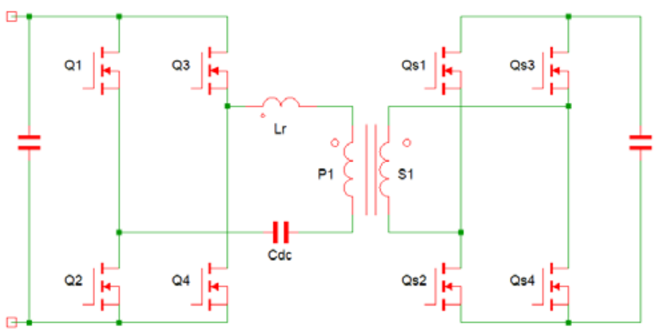


Figure 6: Dual active bridge dc-dc converter topology

In single-phase shift modulation, the DAB topology is simple to control. For extended, dual- or triple-phase shift modulation, however, the control scheme becomes complex. This topology may be used to cover a wide range of battery voltages with single-phase shift modulation, but circulating currents in the transformer rise to elevated levels, which greatly reduces efficiency.

With advanced modulation schemes such as triple-phase shift modulation, however, the converter can theoretically perform zero-voltage switching over the entire operating range. The ratio of output power to the transformer's KVA rating is high in this topology. The output capacitance required to handle ripple currents is also low.

Overall, this converter is ideal for applications in which power density, cost, weight, isolation and reliability are critical factors, because of its range of attractive features:

- Relatively low component count
- Soft-switching commutation
- Low cost
- High efficiency

It is worth noting, however, that the DAB converter often requires an additional shim inductor to support zero-voltage switching: this increases the size of the circuit and reduces power density.

DAB topology in CLLC mode

The CLLC circuit configuration performs all the functions of the classic LLC, but has the added advantage that the use of active switches across the secondary side enables bi-directional power transfer (see Figure 7).

This converter operates in zero-voltage/zero-current switching mode, resulting in high efficiency. When there is room to vary the bus voltage by a margin of 10%, this converter can cater for a widely varying battery voltage while maintaining good efficiency. With a fixed bus voltage, however, this topology has a very limited range of operation.

The presence of capacitors on both the primary and secondary sides eliminates the risk of saturation of the transformer's core.

The DAB converter in CLLC mode is actually best suited to ac-dc onboard chargers. It can though be used at power levels higher than onboard chargers handle – up to 15 kW. But scaling to higher power levels and paralleling can be difficult, as it requires a highly symmetrical tank structure and synchronization of multiple modules – a difficult task.

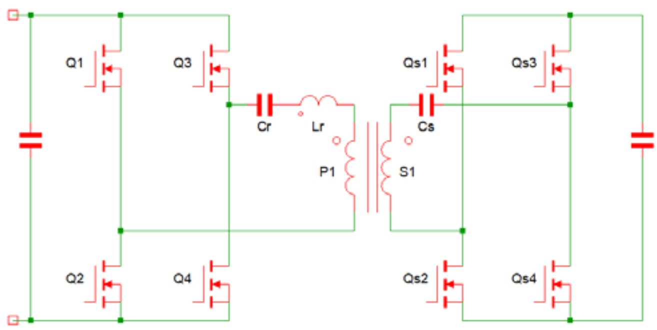
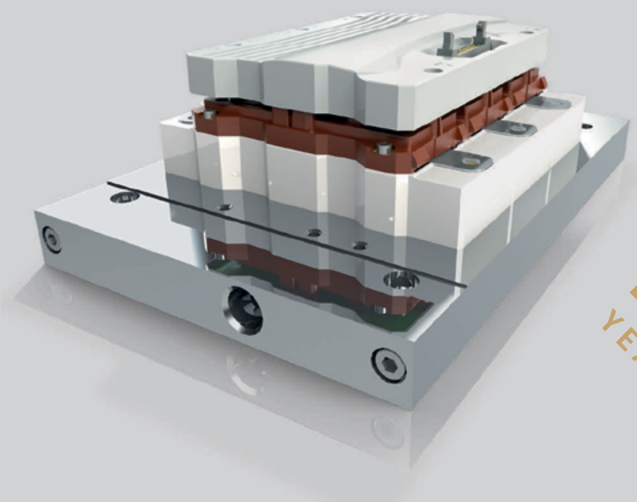


Figure 7: DAB topology in CLLC mode

Both the DAB and DAB in CLLC mode topologies are commonly used in 800 V isolated dc-dc converters. The voltage conversion ratio controls the connection for the converter terminals, which affects the breakdown voltage rating required for the switches: a high-voltage converter could be connected in series or in parallel in one terminal, while another remains connected in parallel. This means that there are four possible configurations for the topology's connections.



Two examples of the DAB topology in CLLC mode are shown: Figure 8 shows a series input configuration, and Figure 9 a parallel input configuration for an 800 V bus voltage with a wide output-voltage range of 200 V to 1 kV.

The advantage of the series-input full-bridge CLLC is its narrow resonant-frequency range over a wide output-voltage range, resulting in lower switching losses; here, a 650 V device could be used. But this calls for more complex control of the dc bus capacitor voltage in series on the dc bus side. In addition, to achieve a given efficiency, a device with lower on-resistance is required than in a single full bridge using 1,200 V devices.

The advantage of the parallel-input full-bridge DAB converter in CLLC mode is that, for a given efficiency, the circuit can use devices with a higher on-resistance, while the control scheme is easier. A wide resonant-frequency range is required to support a wide output-voltage range.

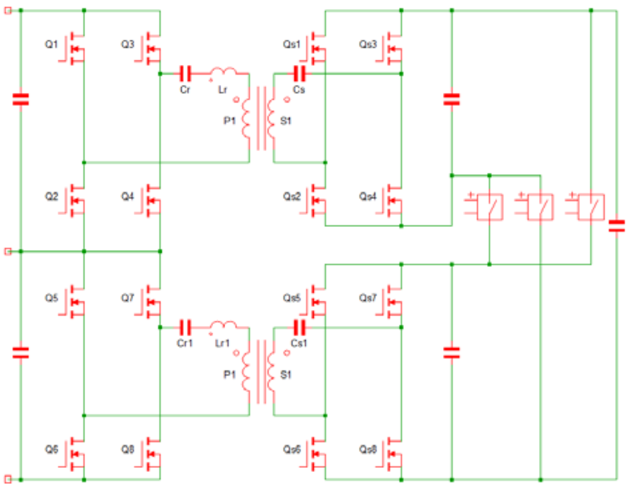


Figure 8: DAB converter in CLLC mode with series input

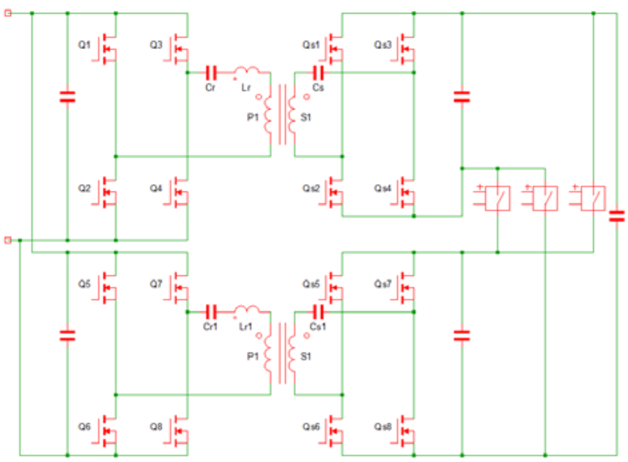


Figure 9: DAB converter in CLLC mode with parallel input

The advantages and drawbacks of the two dc-dc stage topologies are shown in Table 2.

Reference designs accelerate implementation of new dc charger circuits

The leading SiC MOSFET manufacturers supply reference designs that provide a blueprint for new high-power dc charger designs, either in part or in whole.

The STMicroelectronics STDES-PFCBIDIR 15 kW bi-directional PFC stage converter implements the T-type NPC topology (see Figure 10). Digitally controlled, it converts between 400V ac and 800 V dc. Efficiency is almost 99%. ST has optimized the passive components for both size and cost, and the converter offers high power density.

	DAB	DAB in CLLC mode
Peak Device Stress	Low	High
Switching Frequency	High	Very High
Control	PWM (simple)	Frequency (moderate)
Wide Battery Voltage Range, Fixed Bus Voltage	Yes (with reduced efficiency)	Limited range
Input RMS Currents	Low	High
Conduction Losses	Low	Medium
Turn-on Switching Loss	ZVS	ZVS
Turn-off Switching Loss	High (device turn off at peak leakage inductor current value)	Low (primary-side turn-off decided by magnetizing inductor current, secondary-side turn-off is zero to ZCS)
Total Losses	Medium	Low
Efficiency	High	Very High
Paralleling Modules	Easy	Difficult
Number of Active Switches	8	8

Table 2: Summary of the features of two dc-dc stage topologies

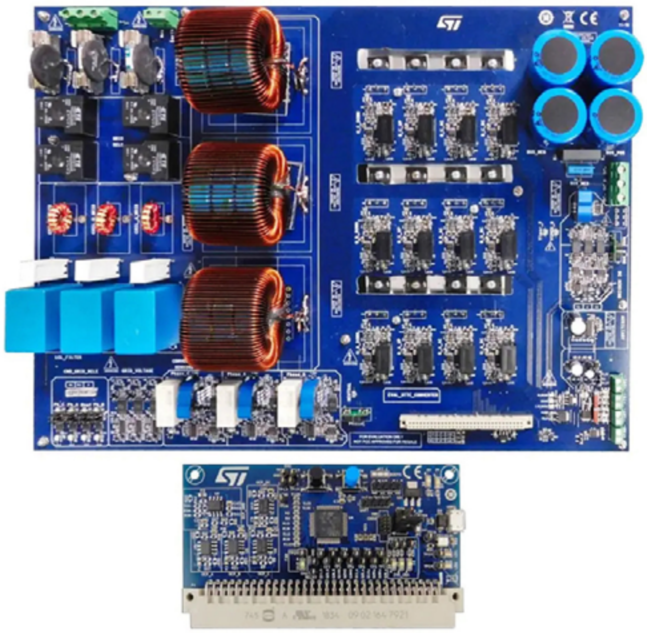


Figure 10: The STDES-PFCBIDIR PFC reference design from STMicroelectronics is notable for its high efficiency and power density

A pairing of the STDES-PFCBIDIR with ST's 25 kW STDES-DABBIDIR provides a complete solution for a bi-directional EV charger. The STDES-DABBIDIR implements the DAB topology switching at 100 kHz with a SiC MOSFET power module in an ACEPACK 2 package (see Figure 11). Digital control is performed by an STM32G474RE MCU. Soft-switching operation is managed by adaptive modulation techniques, which respond to variations in the load and voltage.

The Infineon REF-DAB11KIZSICSYS is a bi-directional dc-dc converter stage that implements the DAB topology in CLLC mode (see Figure 12). It provides an output of up to 11 kW at 800 V, at higher than 97% efficiency.

Based on IMZ120R030M1H CoolSiC™ MOSFETs driven by the Infineon 1EDC20I12AH gate driver, the board combines high power density and reliability at low cost.

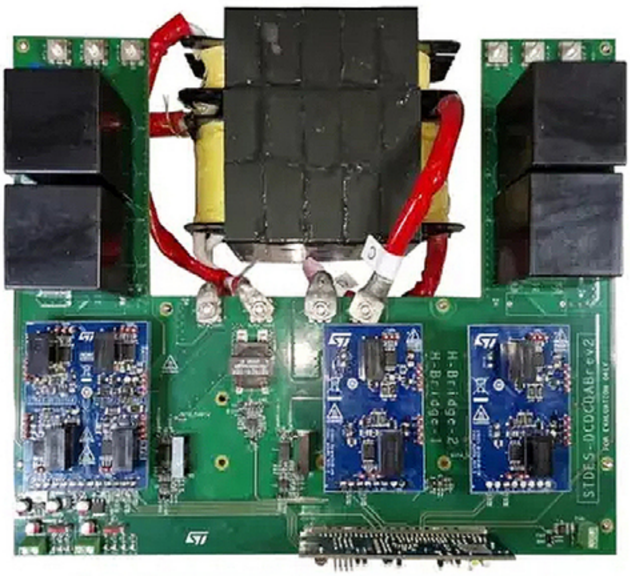


Figure 11: The STDES-DABBIDIR dc-dc converter reference design board has a power rating of 25 kW

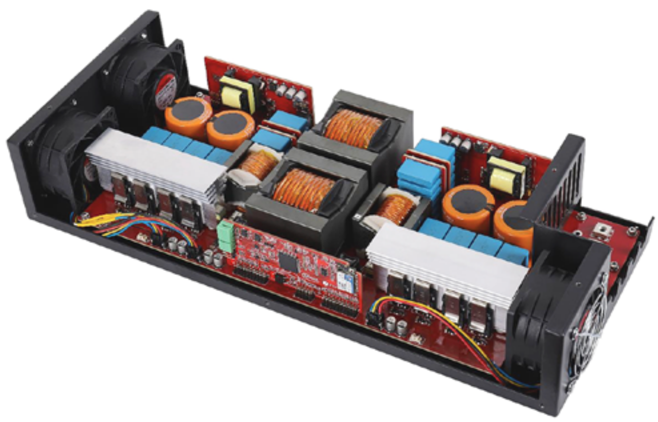


Figure 12: The Infineon REF-DAB11KIZSICSYS reference design board has an 11 kW output rating

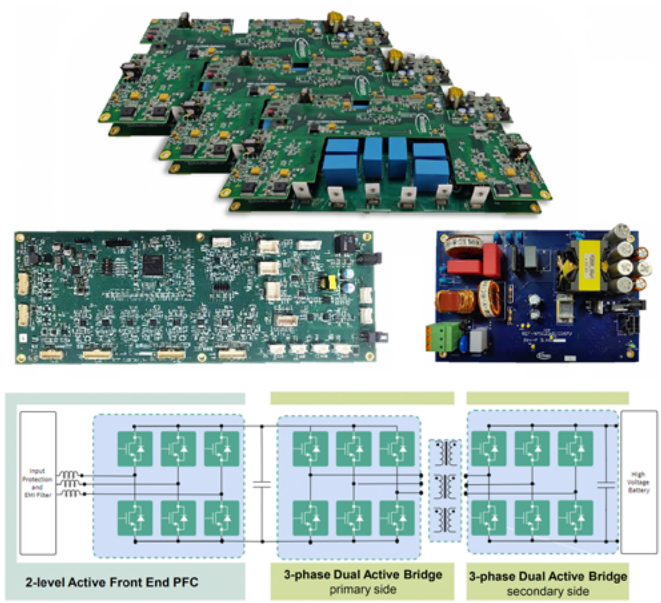


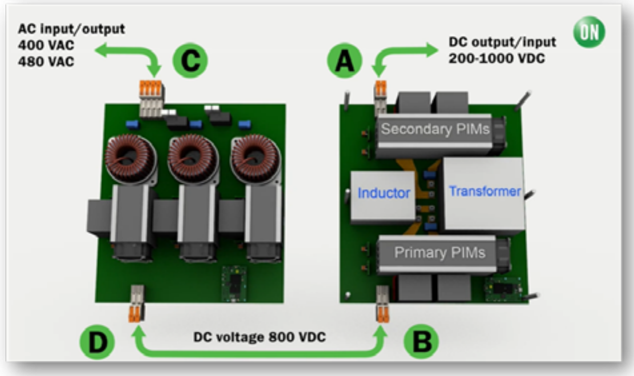
Figure 13: The REF-EV50KW2SICKIT from Infineon implements a complete dc-dc fast charger

Infineon has also developed a complete dc-dc charger reference design, the REF-EV50KW2SICKIT, which was due for imminent release as at March 2023. This 50 kW dc charger sub-unit is intended for use as a module in stacked high-power charging systems (see Figure 13).

The design achieves a power factor of higher than 0.95, and maximum efficiency of 96%.

On release, Infineon will offer fully assembled boards that fit into a 19" 4U rack. A power control card plus software with GUI will also be available.

Another complete dc-dc charger design is supplied by onsemi. The SEC-25KW-SIC-PIM-GEVK is a 25 kW charger which implements the two-level PFC and DAB topologies (see Figure 14).



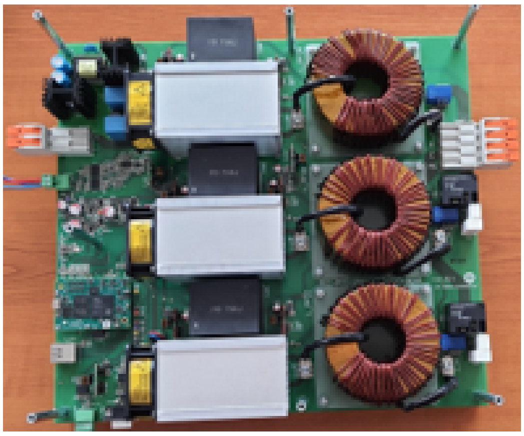


Figure 14: SEC-25KW-SIC-PIM-GEVK reference design from onsemi is a 25 kW dc-dc charger

The SEC-25KW-SIC-PIM-GEVK features multiple NXH010P120MNF1 half-bridge SiC modules which have a breakdown-voltage rating of 1,200 V. Notable for their very low on-resistance of 10 mΩ and low parasitic inductance, these SiC modules substantially reduce conduction and switching loss. Conversion operations are controlled by a powerful universal controller board based on a Zynq®-7000 SoC FPGA. The output-voltage range is 200 V to 1,000 V, and efficiency is up to 96%.

Multiple SEC-25KW-SIC-PIM-GEVK boards can be stacked together in a single cabinet to supply the output power required by the application.

Conclusion

The choice of topologies in the PFC and dc-dc converter stages of bi-directional EV fast chargers gives the designer the choice of optimizing for size, cost, efficiency, output power, component count, and ease of control.

The availability of high-performance reference designs from the leading SiC device manufacturers gives designers a head start in implementing some of these topologies.

www.futureelectronics.com

Silicon Carbide E-Fuse Demonstrator

High-voltage electrical subsystems throughout Battery Electric Vehicles (BEVs) and Hybrid Electric Vehicles (HEVs) require a mechanism to protect the high-voltage distribution and loads in the event of an overload condition. To provide BEV and HEV designers with a faster and more reliable high-voltage circuit protection solution, Microchip announces the E-Fuse Demonstrator Board, enabled by silicon carbide (SiC) technology, available in six variants for 400–800V battery systems and with a current rating up to 30 amps.

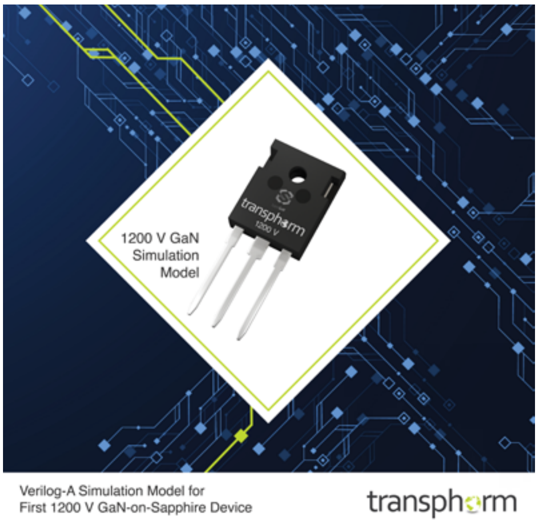
The E-Fuse demonstrator can detect and interrupt fault currents in microseconds, 100–500 times faster than traditional mechanical approaches because of its high-voltage solid-state design. The fast response time substantially reduces peak short-circuit currents from tens of kilo-amps to hundreds of amps, which can prevent a fault event from resulting in a hard failure. With the E-Fuse demonstrator's resettable feature, designers can easily package an E-Fuse in the vehicle without the burden of design-for-serviceability constraints. This reduces design complexities and enables flexible vehicle packaging to improve BEV/HEV power system distribution.

OEMs can accelerate development of SiC-based auxiliary applications with the E-Fuse demonstrator because of the built in Local Interconnect Network (LIN) communication interface. The LIN interface enables the configuration of the over-current trip characteristics without the need to modify hardware components, and it also reports diagnostic status.

www.microchip.com

Simulation Model of 1200 V GaN-on-Sapphire Device Released

Transphorm announced availability of its 1200 V FET simulation model and preliminary datasheet. The TP120H070WS FET is the only 1200 V GaN-on-Sapphire power semiconductor introduced to date, making its model the first of its kind. Its release indicates Transphorm's ability to support future automotive power systems as well as three-phase power systems typically used in the broad industrial, datacom, and renewables markets. These applications will benefit from the 1200 V GaN device's higher power density and reliability along with equal or better performance at more reasonable cost points versus alternative technologies. Transphorm recently validated the GaN device's higher performance ability in a 5 kW 900 V buck converter switching at 100 kHz. The 1200 V GaN device achieved 98.7% efficiency, exceeding that of a similarly rated production SiC MOSFET.



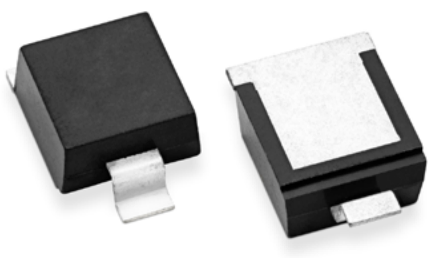
The innovative 1200 V technology also underscores Transphorm's leadership in GaN power conversion. Vertical integration, epitaxy ownership, and patented process paired with decades of engineering expertise enable the company to bring to market the highest performing GaN device portfolio with four additional major differentiators: Manufacturability, Drivability, Designability, and Reliability.

Transphorm's 1200 V technology is anchored in proven process and mature technology, satisfying customer confidence requirements. The GaN-on-Sapphire process is in volume production today in the LED market. Additionally, the 1200 V technology leverages the fundamentally superior, normally-off GaN platform used in Transphorm's current device portfolio.

www.transphormusa.com

High Power TVS Diodes in Surface Mount Package

Littelfuse announced the release of its latest product, the LTKAK2-L Series High Power TVS Diodes. This surface mount solution addresses the market demand for automated PCB assembly process-compatible TVS diodes with a high surge rating. By using one LTKAK2-L in place of either four or eight 15KPA or 30KPA axial-leaded TVS diodes, electronics designers can save 60% and 80% of PCB space respectively. The LTKAK2-L Series TVS Diodes offer a compact, surface mount package compatible with automated PCB assembly processes. The smaller solution in a modified SMTO-218 package allows designers to achieve robust circuit protection with less



PCB space than the available axial leaded solutions. The 2 kA surge current rating enables designs to comply with IEC-61000-4-5 Level 4 requirements, which protects numerous high-reliability AC and DC power supplies and their applications.

“This new product helps solve the key problem of high surge rating TVS diodes being in larger sized, axial leaded packages, which are not compatible with automated PCB assembly processes,” said Ben Huang, Senior Product Marketing Manager at Littelfuse. "The LTKAK2-L Series provides a compact surface mount solution that protects AC and DC power supply to achieve high reliability. This automated PCB assembly process-compatible TVS diode is a significant step towards making high-power TVS diodes more accessible to designers."

www.littelfuse.com

Highly Integrated Wireless Charging Transmitter IC 50 W

Infineon´s WLC1150 wireless charging transmitter IC expands the portfolio of wireless charging (WLC) controller ICs by offering a highly integrated, easy-to-design, and cost-effective solution to address applications requiring higher wireless power transfer.

The transmitter´s design caters to the crucial requirements of such applications with its capacity to offer high efficiency, flexible ther-mal management options, minimal electromagnetic interference (EMI), built-in adaptable foreign object detection (FOD), inverter control, and numerous other functionalities.

It supports 50 W wireless power transfer using a high-power pro-prietary charging protocol and a wide input voltage range (4.5 to 24 V). The integrated buck controller for the fan enables thermal management by cooling the interface surface during high-power delivery.

In addition, it integrates a USB-C power delivery (PD) controller that supports the latest USB-PD 3.1 version featuring a programmable power supply (PPS) mode. WPC Qi 1.3 with extended power profile (EPP), basic power profile (BPP), and proprietary power delivery extension (PPDE) are supported.

WLC1150 is based on a programmable on-chip 32-bit Arm® Cortex®-M0 processor with 128 KB Flash, 16 KB RAM and various peripherals. By leveraging Infineon's ModusToolbox™ software, WLC1150 programmable features enable the development of unique and scalable wireless charging solutions for proprietary protocols as well as the latest Qi specification.

The WLC1150 transmitter can be paired with the upcoming WLC1250 receiver IC to realize end-to-end proprietary wireless power transfer solutions. Its functionalities can be tested with the dedicated solution board: REF_WLC_TX50W_N1.

www.infineon.com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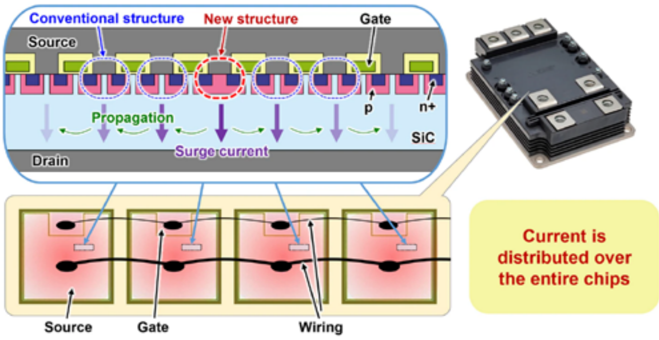
cde.com/harsh-environments

SBD-Embedded SiC-MOSFET for Power Modules

Mitsubishi Electric Corporation announced that it has developed a new structure for a silicon carbide metal-oxide-semiconductor field-effect transistor (SiC-MOSFET) embedded with a Schottky barrier diode (SBD), which the company has applied in a 3.3 kV full SiC power module, the FMF 800 DC -66 BEW for large industrial equipment such as railways and DC power systems. The chip's new structure is expected to help downsize railway traction systems, etc. as well as make them more energy efficient, and contribute to carbon neutrality through the increased adoption of DC power transmission. SiC power semiconductors are attracting attention with their capacity to significantly reduce power loss. Mitsubishi Electric, which commercialized SiC power modules equipped with SiC-MOSFETs and SiC-SBDs in 2010, has adopted SiC power semiconductors for a variety of inverter systems, including air conditioners and railways. The chip integrated with a SiC-MOSFET and a SiC-SBD can be mounted on a module more compactly compared to the conventional method of using separate chips, thus enabling smaller modules, larger capacity, and lower switching loss. It is expected to be widely used in large industrial equipment such as railways and electric power systems. Until now, the practical application of power modules with SBD-embedded SiC-MOSFETs has been difficult due to their relatively low surge-current capability, which results in the thermal destruction of the chips during surge-current events because surge currents in connected circuits concentrate only in specific chips.

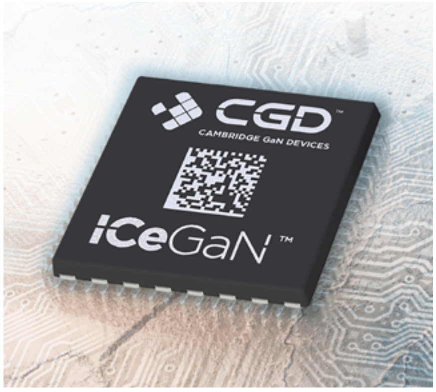


www.mitsubishielectric.com

Second Series GaN ICs Deliver Robustness, Ease-of-Use and High Efficiency

Cambridge GaN Devices (CGD) launched the second series of its ICeGaN™ 650 V gallium nitride HEMT family, delivering robustness, ease-of-use and maximised efficiency. H2 Series ICeGaN HEMTs employ CGD's smart gate interface that virtually eliminates typical e-mode GaN weaknesses, delivering improved overvoltage robustness, higher noise-immune threshold, dV/dt suppression and ESD protection. Like previous generation devices, the 650 V H2 ICeGaN transistors are driven similarly to Si MOSFETs, eliminating the need for complex and inefficient circuits, instead using commercially available industry gate drivers. Finally, H2 ICeGaN HEMTs feature a QG that is 10x lower than silicon parts and QOSS is 5x less, This enables H2 ICeGaN HEMTs to greatly reduce switching losses at high switching frequencies, reducing size and weight.

ICeGaN H2 Series feature an innovative NL3 (No Load and Light Load) Circuit, integrated on-chip alongside the GaN switch, resulting in record-low power losses. An advanced clamping structure with integrated Miller Clamp – also on-chip - eliminates the need for negative gate voltages, achieving true zero-volt turn-off, and improving dynamic RDS(ON) performance. These e-mode (normally off) single chip GaN HEMTs include a monolithically-integrated interface and protection circuit for gate reliability and design simplicity. Finally, a Current Sense function reduces power dissipation and allows direct connection to ground for optimised cooling and EMI.

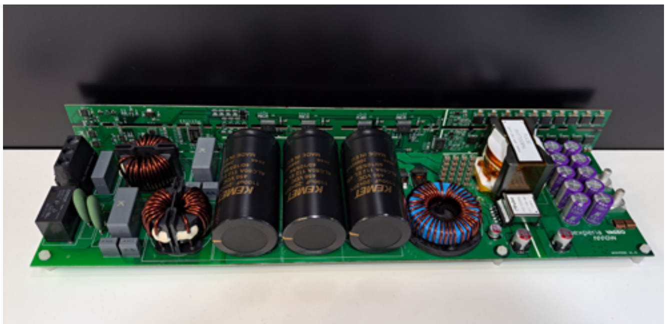


www.camgandevices.com

4kW GaN Power Supply Reference Design

Arrow Electronics, working with franchised suppliers Nexperia and Yageo, has completed an AC/DC power supply (PSU) reference design to unleash gallium nitride (GaN) efficiency and power-density advantages in applications up to 4kW. The reference design is available with complete supporting documentation including bill of materials.

Customers can integrate the GaN-based PSU directly in their own products and are free to modify if needed. Typical applications include solar and wind energy conversion, industrial robots, HVAC equipment, fluid pumps, ATM machines, and general industrial automation and power supplies, including UPS. With its compact form factor, it is also ideal for e-bikes, power tools, and professional audio equipment. “Our 4kW reference design is at the forefront of the current trend to adopt GaN wide-bandgap transistors in applications above 1kW,” said Vitali Damasevich, director engineering – Eastern Europe and engineering solutions center, EMEA, Arrow Electronics. “By leveraging the latest GaN FETs and customized passive components, we have achieved a significant increase in efficiency, power density, and device miniaturization over traditional silicon-MOSFET-based solutions. In addition to supplying the reference design, we can also help customers to develop their own highly efficient PSUs, as well as integrate the solution in their applications for optimal form, fit, and function.”



To realise the advanced PSU design, Arrow’s team chose the latest GAN039-650NTB GaN power transistors from Nexperia and worked with Yageo to develop specifications for the flyback transformer and resonant-circuit inductor.

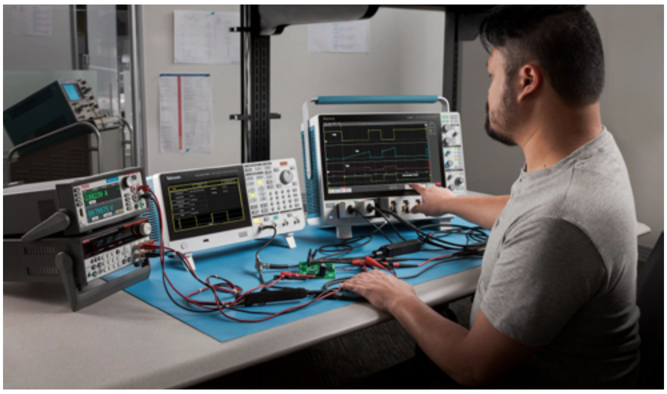
www.arrow.com

Oscilloscope-Based Double Pulse Test Solution

Tektronix announced a release of its Double Pulse Test solution (WBG-DPT solution). With new wide bandgap switching devices enabling significant advances in electric vehicles, solar energy and industrial controls, the Tektronix WBG-DPT solution has the ability to provide automated, repeatable, and accurate measurements on wide bandgap devices such as SiC and GaN MOSFETs.

Designers of next-generation power converters will now be able to utilize the WBG-DPT solution to optimize their designs confidently and quickly. With the ability to run on Tektronix 4, 5 and 6 Series MSO oscilloscopes, integrating seamlessly into the measurement system of the oscilloscopes, the WBG-DPT Solution boasts several industry-first measurement capabilities, such as an automatic WBG deskew technique, and reverse recovery timing plots, making it easier for engineers to see reverse recovery details for multiple pulses overlaid on a single display. Measurements are also designed to align with JEDEC and IEC standards for double pulse testing and diode reverse recovery.

“Tektronix customers are the designers of the next generation of cutting-edge power electronics technology, and their designs must be optimized to balance efficiency, size and reliability,” shares Daryl Ellis, Tektronix Mainstream Portfolio General Manager. “We are confident that the design of the Tektronix WBG-DPT Solution will allow for simplified debugging, repeatable measurements (per JEDEC and IEC standards) and a faster learning curve. Test automation reduces test times and retesting errors, ensuring our customers meet their project timelines and time to market plans.”



www.tek.com

1200V, 120A Silicon Carbide Power Modules

Solitron Devices is pleased to announce the introduction of the SD11911 and SD11912 1200V Silicon Carbide (SiC) Power Modules. Both modules feature two independent, high current MOSFETs.

Solitron power modules maximize the benefits of SiC, with a unique robust and cost-effective packaging format. The 37mm x 25mm x 9mm outline is a fraction of the size and weight of competitive modules. The integrated format maximizes power density while minimizing loop inductance with a pin configuration to allow simple power bussing.

The SD11911 and SD11912 provide two independent MOSFET configurations. The SD11911 includes two 1200V, Ultra low RDS(on) 8.6mΩ SiC MOSFETs while the SD11912 has two 13mΩ MOSFETs. The pinout configuration separates the power bus from the gate and source controls to ease and simplify board layout. The independent outputs allow maximum flexibility to customize configurations such as half bridge, full bridge, H-bridge and many other topologies. Both devices feature continuous drain current of 120A. Both modules include an integrated NTC temperature sensor.

www.solitrondevices.com

DC EMC/EMI Filters for EV Charging Stations

Astrodyne TDI has developed a range of EMI/EMC filters for fast and ultra-fast DC chargers. The RP695H DC EMI filters combine high performance and compact factors. These filters are designed to improve cost and shorten the time-to-market for DC charger OEM.

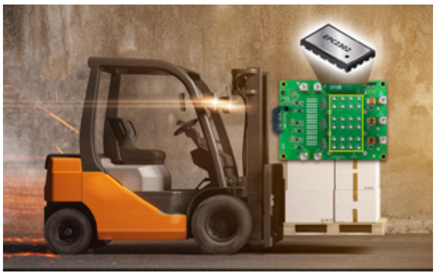
With electric vehicles (EVs) becoming more popular, there is an ever-growing need for faster-charging options. Due to this, the demand for DC ultra-fast charging infrastructure has skyrocketed. To meet this increasing demand, EV charger manufacturers are working on newer high-power designs. The need for more power, shorter development time frames, and compact designs has also made the agency compliance process a lot more challenging, especially, on the radiated spectrum. The primary contributor to radiated emissions failure is radiated noise on the EV charger output (DC side). This has given rise to a need for high current, high voltage, high-performance DC filters in a compact form factor.

Astrodyne TDI's RP695H series is a dual-stage DC EMI/EMC solution that operates up to 1500 VDC. For performance, cost, and weight optimization, this design features a hybrid extruded-molded construction. These features are especially important for ultra-fast DC Charger applications where space and weight are critical. The RP695H filters are offered in 450 A, 600 A, 1000 A, and 1600 A-rated currents and selectable Y-capacitor values from 0 to 2000nF. To ensure peace of mind, Astrodyne TDI can provide a "no-charge" on-site pre-compliance testing to minimize unexpected costs and time to market.

www.astrodynetdi.com

150 ARMS Motor Drive Reference Design with GaN FETs

EPC announces the availability of the EPC9186, a 3-phase BLDC motor drive inverter using the EPC2302 eGaN® FET.



The EPC9186 supports a wide input DC voltage ranging from 14 V to 80 V. The high-power capability of the EPC9186 supports applications such as electric scooters, small electric vehicles, agricultural machinery, forklifts, and high-power drones.

The EPC9186 uses four EPC2302 FETs in parallel per switch position and can deliver up to 200 Apk maximum output current. The EPC9186 contains all the necessary critical function circuits to support a complete motor drive inverter including gate drivers, regulated auxiliary power rails for housekeeping supplies, voltage, and temperature sense, accurate current sense, and protection functions. The boards can also be configured for multiphase DC–DC conversion and support both phase and leg shunt current sensing. Major benefits of a GaN-based motor drive are exhibited with this reference design, including lower distortion for lower acoustic noise, lower current ripple for reduced magnetic loss, lower torque ripple for improved precision, and lower filtering for lower cost.

EPC provides full demonstration kits, which include interface boards that connect the inverter board to the controller board development tool for fast prototyping that reduce design cycle times.

"GaN-based inverters increase motor efficiency and can increase power capability without increasing size", said Alex Lidow, CEO of EPC. "This enables motor systems that are smaller, lighter, less noisy, have more torque, more range, and greater precision for a wide range of consumer and industrial applications."

www.epc-co.com

Interactive Datasheets Put MOSFET Behavior Analysis at Engineers’ Fingertips

Nexperia announced a raising of the bar in semiconductor engineer design support with the release of interactive datasheets to accompany its Power MOSFETs. By manipulating interactive sliders within the datasheets, users can manually adjust the voltage, current, temperature and other conditions for their circuit application and watch how the operating point of a device dynamically responds to these changes.

These interactive datasheets effectively offer a type of graphical user interface to a circuit simulator, using Nexperia’s electrothermal models to calculate the operating point of a device. In addition, they allow engineers to visualize immediately the interaction between parameters such as gate voltage, drain current, RDS(on) and temperature. Their collective contribution to the device behavior is then displayed dynamically in tables or graphs. As a result, Nexperia’s interactive datasheets can increase productivity by eliminating the time needed for an engineer to perform manual calculations or set up and debug a circuit simulation.

The technology powering these datasheets is the same as that used in Nexperia’s successful precision electrothermal MOSFET models, which demonstrate how the behaviour of discrete MOSFETs changes with temperature. The new interactive datasheets are offered in addition to the traditional static datasheets and operate in any standard web browser without the requirement of additional software for device simulation.

www.nexperia.com

1TB 65W GaN Charging Cube & Backup Storage

Vinpower, through a strategic alliance with Phihong Technology and Silanna Semiconductor, has developed the first universal charging cube, which offers the ability to charge the battery and provide extended memory for virtually all mobile smartphones, tablets, and laptop computers, called the iXCharger. The patented iXCharger is a compact 65W up to 1TB storage power charger, using a specialized third-generation semiconductor GaN technology and ACF controller to provide higher power density and ensure fast heat dissipation in a smaller package, to enable fast, secure, and more efficient charging for mobile phones, tablets, and laptops. However, the iXCharger offers more than superior charging capabilities, it also utilizes an added large-capacity storage component that creates a 2-in-1 solution for both charging and storage.

The charger is compliant with the new EU USB-C mandate, offering an environmentally sustainable ESG product. It further reduces unnecessary waste by reducing the burden of redundancy to a single compact device that can act as both an energy efficient power charger and a large capacity backup storage solution for a wide range of mobile devices and laptop computers, including Apple iOS, Android, MacOS, Windows laptops, ChromeOS, and many other similar devices. This makes the iXCharger the ideal replacement for portable device manufactures planning to eliminate power chargers with their new offerings.

www.vinpowerdigital.com

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