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July 2021

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Bodo’s WBG Event

As announced in my May viewpoint we have decided to hold Bodo’s WBG Event as a pure virtual conference from November 30 to December 3 this year. Although vaccinating the population is making very good progress, the safety of the attendees and contributors is still our top priority. Having now seen a few of virtual events, we know what works virtually and what to concentrate on. We will focus on presentations and live sessions with the industry experts. All presentations will be available on demand in advance, and we will cover four topics:

- **Silicon Carbide - SiC on Nov 30**
- **Gallium Nitride - GaN on Dec 1**
- **Passives and Magnetics on Dec 2**
- **Test, Measurement and Simulation on Dec 3**

Invitations will go out to the industry experts and companies in July, interesting sponsorship packages will also be available. Free registration for visitors will open soon, so please look out for the announcements in the magazine, eNewsletter, on our website and our social media channels.

Unfortunately, this means that social networking will have to wait until we can meet again in person. For me, this is something that virtual events cannot replace, and I have spoken to many people who feel the same. So, we will not try to reinvent the wheel here, but stay focused on content. This means that probably we will end a second year without any business trips at all. I can only imagine the impact that this

is having on so many people and whole industries such as events, constructors, catering, hotels...

Bodo’s magazine is delivered by postal service to all places in the world. It is the only magazine that spreads technical information on power electronics globally. We have EETech as a partner serving North America efficiently. If you are using any kind of tablet or smart phone, you will find all our content on the website www.eepower.com. If you speak the language, or just want to have a look, don’t miss our Chinese version: www.bodospowerchina.com

My Green Power Tip for the Month:
Increasingly, more products arrive in 100% recycled materials, even plastics. Watch out for these markings, it is so easy to do the right thing in everyday life!

Kind regards

Holger Moscheik

Events

IEEE DMC 2021
Bath, UK & Online July 14 - 15
https://attend.ieee.org/dmc-2021

IEEE CPE-POWERENG 2021
Florence, Italy & Online July 14 - 16
https://cpepowereng2021.com

Advancements in Thermal Management 2021
Online August 4 - 5
www.thermalconference.com

EDI CON 2021
Online August 4, 11, 18 & 25
www.ediconon line.com

World Battery Expo 2021
Guangzhou, China August 16 – 18
www.battery-expo.com

DesignCon 2021
San Jose, CA, USA August 16 - 18
www.designcon.com

SEMICON Southeast Asia 2021
Singapore & Online August 23 – 27
www.semiconsea.org

IWIPP 2021
Online August 23, 25 & 27
http://iwipp.org

EPE 2021
Online September 6 – 10
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ROHM's 'Environmental Vision 2050' contributes to achieving a sustainable society by 2050.

In addition to pursuing zero carbon and zero emissions (zero CO_2 emissions) based on the three themes of 'climate change', 'resource recycling', and 'coexistence with nature', ROHM will promote business activities in harmony with the natural cycle to protect biodiversity. ROHM's corporate objective is: 'Quality is our top priority at all times'. Since our company's foundation, we have been actively contributing to society and the progress of our culture through a consistent supply, under all circumstances, of high quality products in large volumes to the global market. The role of semiconductors – ROHM's main products – is becoming increasingly important to achieving a decarbonized society. In particular, improving the efficiency of motors and power supplies, which are said to account for the most of the world's electricity consumption, has become our major mission.

Against this backdrop, our management vision for 2020 is: 'Focus on power and analog products to solve social challenges by delivering greater energy savings and miniaturization in customer products.' In order to further contribute to society, we will clarify the direction we should take while raising awareness among all group employees.

www.rohm.com

Samsung's First MOSFET-Based Refrigerator Inverter Design

Infineon Technologies supplied Samsung Electronics with power devices to couple the highest energy efficiency with lowest audible noise. They have been integrated in Samsung's one-door fridge and French Door Fridge inverterized refrigerator. Inverterization is an emerging DC to AC conversion trend in contemporary inverter designs. It helps the application run more quietly and smoothly while the average power consumption is reduced compared to a traditional on/off control.

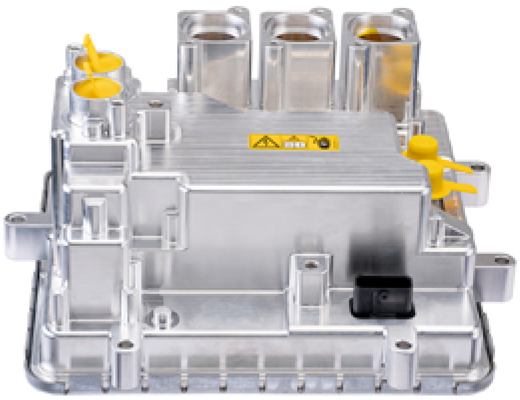
To meet Samsung's requirements towards improved efficiency and lower system cost together with a lower noise level, the Digi Touch Cool™, Curd Maestro™ features multiple power solutions from Infineon – EiceDRIVER™ gate-driver IC, CoolSET™ Gen 5 for AC/DC conversion, and 600 V CoolMOS™ PFD7 for compressor drives. This is Samsung's first refrigerator design that uses discrete devices instead of power modules in the compressor.

The 600 V CoolMOS™ PFD7 superjunction MOSFETs come with a best-in-class body diode allowing for improved soft-recovery index and the industry's fastest reverse recovery time (t rr), making them a perfect choice for home appliance motor drives. Compared to module-based designs, using MOSFETs enables lower energy consumption especially at light-load conditions and an efficiency increase as of 1.7 percent. In addition, this innovative approach allows for a heatsink-less design, a 10 percent reduction in system cost and a longer refrigerator lifetime.

www.infineon.com

Order for 800-Volt SiC-Technology in Electric Vehicles

Vitesco Technologies has won a major order with a sales volume in a triple-digit million Euro amount for an innovative high-voltage component. For the first time ever, the company will be supplying an 800-volt inverter with silicon carbide technology in significant quantities for the new electric vehicle platform of the Hyundai Motor Group. „This partnership demonstrates once again that Vitesco Technologies meets the highest requirements with innovative key components for electric vehicles. In this way, our company is contributing toward making the electric mobility of the future even more efficient, convenient and thus also more sustainable." said Thomas Stierle, Executive Vice President Electrification Technology business unit at Vitesco Technologies Up until now, most electric vehicles have used a voltage of 400-volts for the drive. Only a few battery-powered premium models and sports cars have an 800-volt architecture. The E-GMP electric car platform from the Hyundai Motor Group also works at a voltage of 800-volt. This brings several advantages for drivers of electric vehicles: For example, the doubled voltage significantly shortens the battery's charging time. Depending on capacity, it should be possible to charge the battery to 80 percent in less than twenty minutes, depending on battery capacity. In addition, the 800-volt electrical system enables a higher power output. It also significantly improves the efficiency of the electric drive.



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Using GaN Transistors to Develop DC/DC Converters

With its VALUE DC-DC product line, BrightLoop Converters is aiming to democratize access to performance and offer a range of converters dedicated to off-highway and commercial vehicles. The French player in power electronics is teaming up with Efficient Power Conversion (EPC) to deliver the upcoming VALUE product line. BrightLoop Converters has gained experience from many years of development for motorsport applications and learned to make the most out of GaN technology to deliver highly reliable, extremely light and compact converters. The company released in 2020 a PERFORMANCE DC-DC product line offering great versatility to extreme vehicle applications and motorsports. After demonstrating that GaN technology can significantly improve performance, the French company now wants to prove that using this technology does not necessarily lead to higher costs. With the launch of the new VALUE product line later this year, the strategy is clear: make performance accessible to these markets, which are now also looking for lightweight, space-saving and high-performance converters in the most cost-effective way. Florent Liffran, CEO of BrightLoop Converters commented: "We are proud to bring our expertise along with EPC's top technology to the commercial and off-highway markets. Our focus has always been to push the limits of performance further and with this new VALUE product line, our goal is clearly to bring our know-how to markets which have historically worked with heavy and bulky power electronics, making it possible for them to have a taste of outstanding performance, versatility and power density while remaining in their price range."

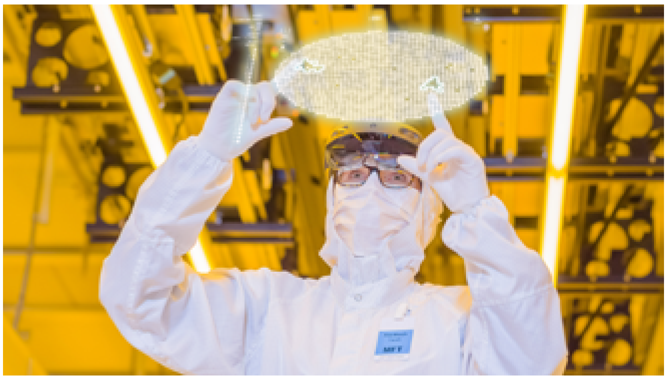
www.brightloop.fr

Wafer Fab of the Future in Dresden

In Dresden, Bosch is opening one of the world's most modern wafer fabs. Highly automated, fully connected machines and integrated processes, combined with methods of artificial intelligence (AI) will make the Dresden plant a smart factory and a trailblazer in Industry 4.0. In the virtual presence of Federal Chancellor Dr. Angela Merkel, the high-tech facility was officially inaugurated on June 7, 2021.

"The new Bosch wafer fab will boost our capacity in microelectronics. Microelectronics is the basis for nearly every promising technology, for applications of artificial intelligence, for quantum computing, and for automated and connected driving – which is also a Bosch specialty," said Federal Chancellor Dr. Angela Merkel. "The new wafer fab is the single largest investment in the company's history. This cannot be stressed too much. Its size and additional production capacity alone are impressive. The very latest methods of data-driven continuous improvement in production make the Dresden plant a smart factory. To put it another way: in this plant, natural and artificial intelligence have joined forces with the internet of things to form a productive symbiosis."

Production in Dresden will start as early as July – six months earlier than planned. From that time on, semiconductors made in the new plant will be installed in Bosch power tools. For automotive customers, chip production will start in September, and thus three months earlier than planned. The new factory will be an important part of the semiconductor manufacturing network. With it, Bosch is strengthening Germany's position as a technology and business location. On 72,000 square meters of floor space, 250 people are already working in the wafer fab in Saxony's state capital. The workforce is set to grow to roughly 700 once construction work has been completed.



www.bosch-presse.de

PCNS Registration is Now Open

3rd PCNS Passive Components Networking Symposium is now open for on-line registration. The third PCNS is organized as a hybrid event September 7-10, and it is possible to register either as live attendee or virtual attendee. Fee is equal, and early bird registration rate is valid till 16th July 2021. PCNS received 27 paper abstracts from 9 countries EU and USA (vs 19 papers at 2nd PCNS)! The papers' scope submitted by passive manufacturers, universities, material suppliers, space agencies and end users include capacitors, resistors, inductors and passive sensors in areas of aerospace, automotive or industrial. Topics are covering reliability, qualification, new materials & technologies and research. Pre-event includes workshops on reliability, life time and sustainability of passive components – open for free for all main conference symposium attendees. "We are looking forward to meet in September during this challenging year. Hopefully, we can finally meet live to enjoy multilevel exchange of experience and news within a passive industry. … meet old friend and new colleagues. Live streaming video will be available for those with travel restrictions." said Tomas Zednicek; EPCI and PCNS organising committee president.

www.passive-components.eu

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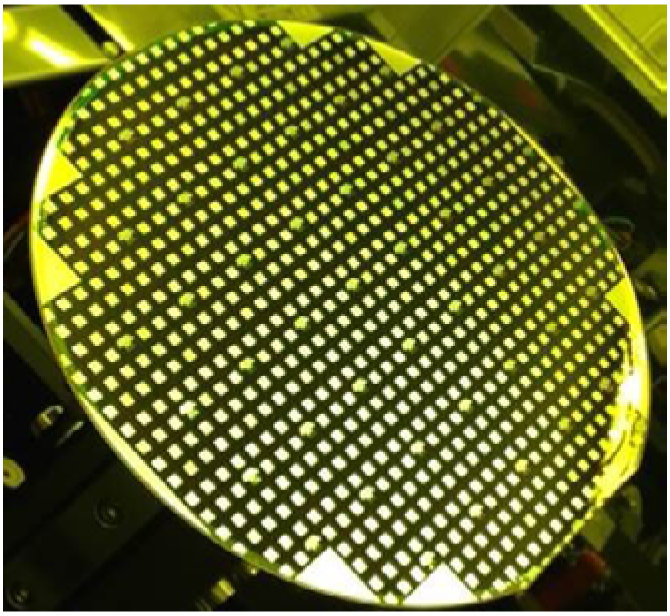
For further information on our products or services, please get in touch with one of our experts on: pdd@hitachi-eu.com

Funding for Transformational Energy Technology

NoMIS Power Group announced that it was awarded 498,000 in funding from the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E). The funding will be used to develop silicon carbide (SiC) –based power modules for power electronic applications that will deliver a step-change in efficiency and reliability to support the global energy transition.

"We are very excited to have ARPA-E support for NoMIS Power Group's transformative, enabling technology for the electrified economy and the global effort to tackle climate change," said co-founder Adam Morgan. NoMIS Power Group is a high-tech start-up company spun out of SUNY Polytechnic Institute (SUNY Poly) in Albany, NY, working to accelerate the clean tech revolution through the application of novel semiconductor devices and power packaging materials for the global power electronics market. Founded by SUNY Poly postdoc Adam Morgan, SUNY Poly Professors Dr. Woongje Sung and Dr. Shadi Shahedipour-Sandvik, as well as Ohio State University Professor Dr. Anant Agarwal, NoMIS Power Group brings together unique US-based expertise across the power semiconductor, power packaging, and power electronics fields. Notably, NoMIS Power Group's world-leading expertise in the application of SiC has made the company a go-to resource for R&D and manufacturing leaders seeking to leverage the transformative potential of this novel material.

NoMIS Power Group received this competitive award from ARPA-E's Topics Informing New Program Area's Supporting Entrepreneurial Energy Discoveries (SEED). SEED seeks to support entrepreneurial



energy discoveries, by identifying and supporting disruptive concepts in energy-related technologies within small businesses and collaborations with universities and national labs.

www.nomispower.com

Quality Award for Austrian Power Supply Manufacturer

The Austrian design-in distributor presents power supply manufacturer RECOM with the CODICO Quality Award. In addition to delivery reliability and logistics services, CODICO particularly emphasises the manufacturer's ability to innovate. Cooperation with high-performance suppliers makes a significant contribution to the long-

term success of the company. It is a basic prerequisite for CODICO's Design In concept. Every year, the distribution company evaluates its strategic suppliers worldwide according to uniform, comparable criteria: Delivery reliability, service orientation, innovativeness, cooperation, flexibility and sustainability are central elements of this assessment. Among other things, services such as sample shipments and service and quality criteria in sales support as well as reaction speed and commitment are also taken into account. RECOM, the power supply specialist also based in Austria, is pleased to accept the A-Supplier award this year. "RECOM is an important partner for us who invests a lot of commitment in the further development of complex power supply solutions and who seeks cooperation in the design of product roadmaps," says Sven Krumpel, CEO of CODICO, underlining the award. CODICO values the cooperation with dynamic and innovative suppliers. RECOM is an essential key partner for CODICO in accessing certain areas in medical technology but also in the miniaturisation of PCB modules.

www.recom-power.com

Module Market Leader announces Partnership with Berlin-Based Business Development Specialist

Power module market leader Vincotech has teamed up with Berlin-based Foxy Power, a business development company specializing in innovative power electronics. This newly forged alliance aims to maximize the value of Vincotech products, help customers optimize their products, and make the most of Foxy Power's strong industry network. Both companies bring their strengths to the table: Foxy Power excels at identifying unique value propositions for building strategic partnerships. Vincotech, known for its flexibility and reliability, designs and builds power modules for motion control, renewable energy, and power supply applications.

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3rd Generation 750V SiC MOSFETs Offer Performance and Reliability

GeneSiC expands its portfolio of 3rd generation silicon carbide MOSFETs with 750V G3R™ that offer performance, robustness and quality to realize highest levels of efficiency and system reliability

GeneSiC Semiconductor's 750V G3R™SiC MOSFETs will deliver unprecedented levels of performance, robustness and quality that exceeds its counterparts. System benefits include low on-state drops at operating temperatures, faster switching speeds, increased power density, minimal ringing (low EMI) and compact system size. GeneSiC's G3R™, offered in optimized low-inductance discrete packages (SMD and through hole), are optimized to operate with lowest power losses under all operating conditions and ultra-fast switching speeds. These devices have substantially better performance levels as compared to contemporary SiC MOSFETs.

"High-efficiency energy usage has become a critical deliverable in next-generation power converters and SiC power devices continue to be the key components driving this revolution. After years of development work towards achieving the lowest on-state resistance and robust short circuit and avalanche performance, we are excited to release the industry's best performing 750V SiC MOSFETs. Our G3R™ enable power electronics designers to meet the challenging efficiency, power density and quality goals in applications like solar inverters, EV on-board chargers and server/telecom power supplies. An assured quality, supported by fast turn-around and automotive-qualified high volume manufacturing further enhances their value proposition." said Dr. Ranbir Singh, President at GeneSiC Semiconductor.

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High Power Applications Above 5kA Demand a New Approach to Current Measurement

The power utilities business is changing globally. Where once the main provides of electrical power were coal, gas, oil or even nuclear power stations, today renewable sources of power, such as wind and solar are becoming significant. 2020 was the best year on record for wind, with 93 GW of new capacity installed globally, representing – a 53 per cent year-on-year increase. And this trend is set to continue as the world aims to achieves net zero for carbon emissions by 2050.

By Loic Moreau, VP Technical Marketing, Danisense

A new report published by the Global Wind Energy Council (GWEC) argues that the world needs to install wind power three times faster over the next decade in order to avoid the worst impacts of climate change.

This is driving huge changes in all aspects of the electrical power industry, including the methods used to measure large currents. The great advantage of traditional fossil fuel power stations is that the supply is very stable and can be controlled and regulated easily. With renewables, the source of the electrical power is volatile - power is not generated unless, for example, the wind blows. DC currents from photovoltaic installations or the power converters used in other renewables can be injected into the traditional AC grid, therefore conventional large current measurement techniques are not appropriate.

Another associated trend concerns large batteries. In order to use electrical power when it is required - not just when it is being generated - huge battery systems are being constructed. One particularly apposite example is to be found in Monterey Bay, California, where the Moss Landing Power Plant, once California's largest electric power station fuelled by natural gas, now houses the world's largest battery, storing excess energy when solar panels and wind farms produce electricity and feeding it back into the grid when they are idle. Phase 1 of the renamed Moss Landing Energy Storage Facility began operation in December 2020 with a capacity of 300MW / 1,200MWh. Phase 2 of the project, due for completion in August 2021, will add another 100MW / 400MWh. Such enormous installations also require very accurate high current measurement. Again, conventional methods have proved to be inadequate for the task.

Instead, applications requiring the measurement of currents above 5kA are increasingly looking at zero-flux techniques that use the magnetic field generated by the circulation of the current, such as Danisense's Fluxgate technology.

Zero-flux technology

To explain the operation of zero-flux technology, it is appropriate to first consider some basic principles. In Figure 1, a pick-up coil constructed around a magnetic bar is shown top left; at top right the equivalent electric circuit is shown with resistor and an inductance. When a voltage is applied, the current in the circuit is shown in the red curve. The current grows progressively, following the slope according to the value of the inductance, up to the point where the inductance saturates. At this condition, the equivalent electric circuit can be considered to be resistive only.

When creating a zero-flux current transducer, the material used for the pick-up bar has specific magnetic properties which cause the current to follow the blue curve. Initially, the current grows slowly due to a high impedance value. Then, abruptly, the inductance saturates and the current increases very rapidly to achieve the end point as previously.

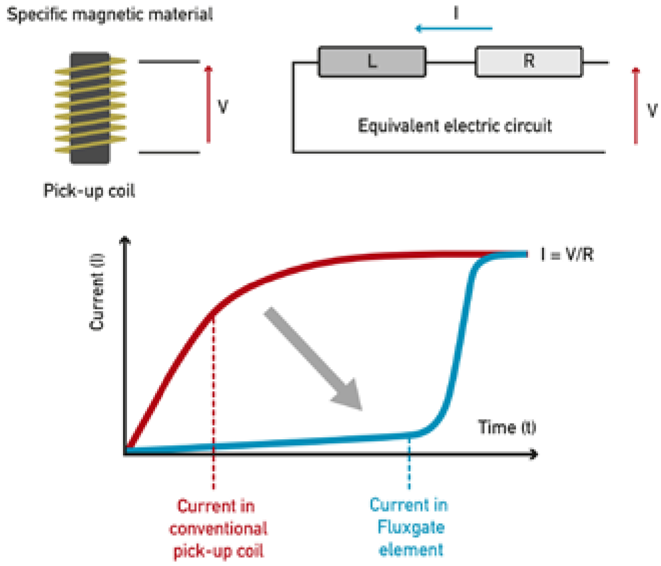

Figure 1: Basic principles of zero-flux current transducer operation.

If a square voltage signal is now applied, the profile of the current becomes a succession of positive and negative saturation and desaturation cycles. If a conductor is placed close to the Fluxgate element, the circulation of the current will create an additional magnetic field which will influence the signal by shifting the zero position (Figure 2a – blue curve). Finally, signal processing per-

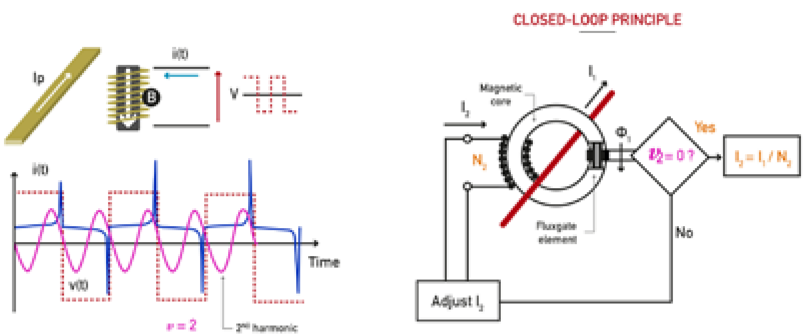

Figure 2: Shifting the zero position (2a); Closed loop principle (2b).

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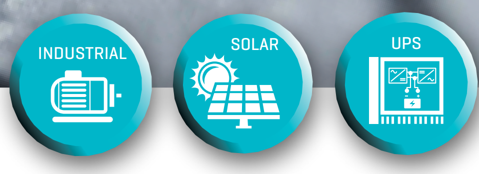

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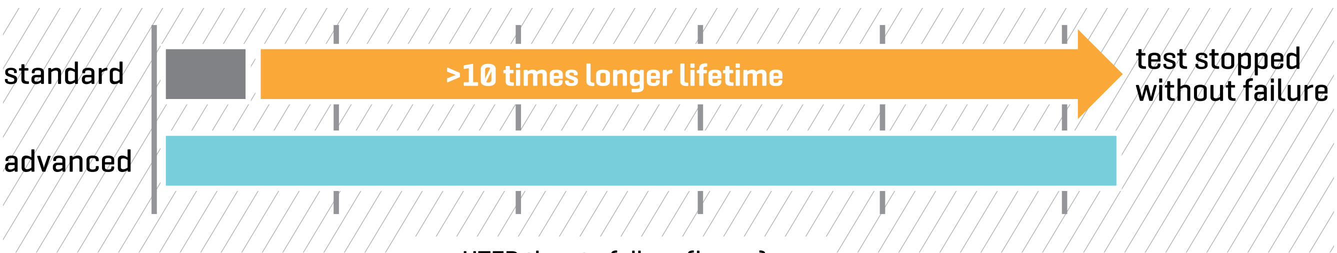

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formed on the second harmonic reveals details about the primary current (Figure 2a – purple curve).

To improve the performance of the current sense transduced even further, manufacturers often combine zero-flux technology with the closed loop principle, shown in Figure 2b. Here, the Fluxgate element is placed in the air gap and during the measurement of the magnetic field, the current output is re-injected through the secondary winding which then generates a magnetic field in the opposite direction. Using this method, the magnetic field experienced by the Fluxgate is always zero, eliminating offset and linearity issues.

Four main zero-flux topologies are currently available (Figure 3). The first (3a) is based on a magnetic core with an air gap, plus the secondary winding. It resembles a closed loop Hall Effect current transducer, where the Hall element in the air gap has been replaced by the Fluxgate. The main benefit is a good offset drift. The second topology (3b) is a single core which takes the role of the Fluxgate element. As there is no air gap, one of the key benefits is its EMC robustness and also its high resolution. But as the saturation of the core occurs quickly, the bandwidth is limited to a few Hertz. The third topology solves this issue by adding a winding core (3c) which only measures the AC signal, as with a current transformer. In that case, you get all the benefits. However, if an even higher performance is required, a 'balanced core' (3d) topology employs two identical Fluxgate elements placed in opposition. Therefore, whatever the external environment conditions – such as EMC or temperature variations - there is a natural passive compensation between the two sensing elements. Using this approach, it is possible to achieve a measurement accuracy of 1ppm, even in harsh environments.

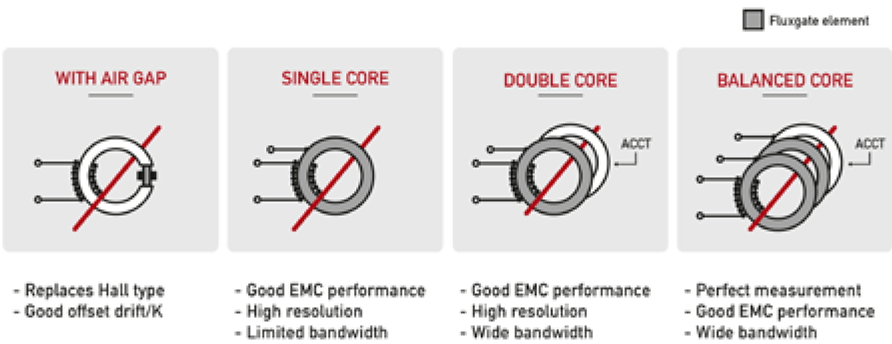

Figure 3: Zero-flux topologies.

Figure 4: Danisense's DR10000IM (11kA) current sense transducer showing the separation of passive sensing head and signal processing unit.

Fluxgate technology can be used to provide very accurate, stable and repeatable current measurement for all current levels and Danisense has developed a family of current sense transducers covering 0-600A, 600-3000A and above 3kA. For the emerging markets with very high currents as discussed in the first part of this article, Danisense has had to address new challenges, but is currently developing solutions up to 30kA and can see no theoretical limit for the Fluxgate approach.

Isolation and safety are key requirements in high power applications. The governing standard is IEC 61010. Unlike products that the company offers for lower current applications, Danisense's DR50000IM (8kA) and DR10000IM (11kA) current sense transducers (Figure 4) separate the sensing head from the electronics signal processing unit.

The sensing head is a rugged, passive device that can be positioned and left for long periods in noisy electrical environments without being affected by any interference which will inevitably be present, given the high currents involved. The complex signal conditioning and processing can be done remotely in a safe, temperature-controlled benign laboratory environment, which can be 30m away from the sensing head. By separating the functions of the current sense transducer in this way, the passive sensing head can also be made rugged enough to cope with challenging environmental conditions. Also, it is dangerous to work close to a high magnetic field environment so this approach minimizes the need for operators to manipulate the transducer – for example to connect the power supply and the output - in the magnetic field, increasing safety.

Danisense's new high current transducers also feature a low excitation frequency of 7kHz. For smaller products, a much higher excitation frequency of up to 32kHz is preferred as this improves the dynamic performance. However, for the DR series sensors saturating such big magnetic core with high frequency would require high power circuitry which can be large and expensive. By reducing the frequency Danisense has been able to achieve a good balance between dynamic performance and power level.

Figure 5 shows the Danisense's DR10000IM sensing head in a Siemens Gamesa wind turbine installation.

Figure 5: Danisense's DR10000IM sensing head in a Siemens Gamesa wind turbine installation.

A specially designed cable with multiple twisted pairs featuring individual shielding encompassed by a second overall shielding layer is used to connect the sensing head and the electronic processing stage. If the distance between the head and the processing unit is over 30 meters Danisense uses three wires for the compensated current instead of one to reduce the current value and then the impedance effect.

Figure 6: 3D render of the new 30kA sensing head which will be available shortly.

Danisense's DR50000IM and DR10000IM current sense transducers have a high bandwidth of 100kHz and are ultra-stable with a linearity error of only 1ppm. The company also offers equivalent voltage output versions of these transducers - DR50000UX (8kA) and DR10000UX (11kA)

Conclusion

With the introduction of the smart grid, utilities companies and others are having to reconsider the current measurement techniques they employ, because electrical power is being generated from a much wider range of sources that ever before. Danisense's Fluxgate technology – already employed extensively in applications such as MRI scanners, EV charging stations and large physics institutions such as CERN – is proving equally capable of handling high currents in the tens of kiloamperes, delivering accurate, stable and repeatable measurement results. Danisense knows that in the near future there will be a need to measure even higher currents, and will shortly launch a current sense transducer with the capability of measuring up to 30kA (Figure 6). This will feature a 330mm aperture - the largest ever offered by Danisense - which will also be of interest to companies which have a lower current demand but which have large diameter cables.

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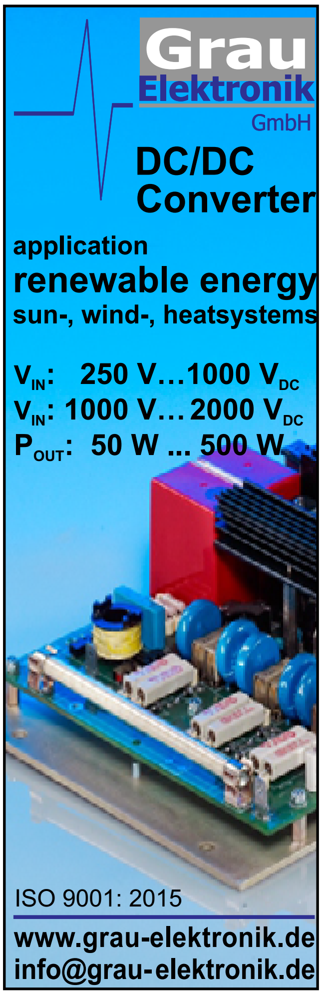

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	TEL 8WI	8 Watt	9–36, 18–75 VDC	3.3–24 VDC	DIP-16
	TEL 10	10 Watt	9–18, 18–36, 36–75 VDC	3.3–24 VDC	DIP-16
	TEL 10WI	10 Watt	9–36, 18–75 VDC	3.3–24 VDC	DIP-16
	TEL 12	12 Watt	9–18, 18–36, 36–75 VDC	5–24 VDC	DIP-16
	TEL 12WI	12 Watt	9–36, 18–75 VDC	5–24 VDC	DIP-16
Available soon	TEL 15WIN	15 Watt	9–36, 18–75 VDC	5.1–24 VDC	DIP-16

Demands by Future Railway Converters and How They Change Power Semiconductor Modules

The increase of competitiveness, robustness and efficiency of future railway converters has demanded new power semiconductor modules. Converter manufacturers particularly requested increasing power density and more flexibility for the converter design.
This flexibility shall be achieved by simpler parallel connection of power semiconductor modules, which leads to scalability of output power. This article presents the main challenges for power semiconductors in future railway converters and Mitsubishi Electric's solution: power modules in the LV100 and HV100 package.

By N. Soltau, E. Wiesner, Mitsubishi Electric Europe B.V., Ratingen, Germany
R. Tsuda, K. Hatori, H. Uemura, Mitsubishi Electric Corporation, Fukuoka, Japan

Introduction

In 2015, a consortium of train manufacturers and electric-equipment suppliers started discussions about the future of rolling stocks and radical innovations in the field of railway vehicles. The discussions, as part of the Horizon 2020 Project Roll2Rail, resulted also in technical requirements of tomorrow's power semiconductor modules. These shall provide:

- Higher power density,
- Multi-sourcing,
- Modularity and scalability,
- Readiness for SiC, and
- Ruggedness against environmental influences (temperature, humidity, vibration, …) [1].

Mitsubishi Electric's answer to the requirements from the Roll2Rail project are the packages LV100 and HV100. Today, power modules in the LV100 and HV100 package have become available for various voltage and current ratings.

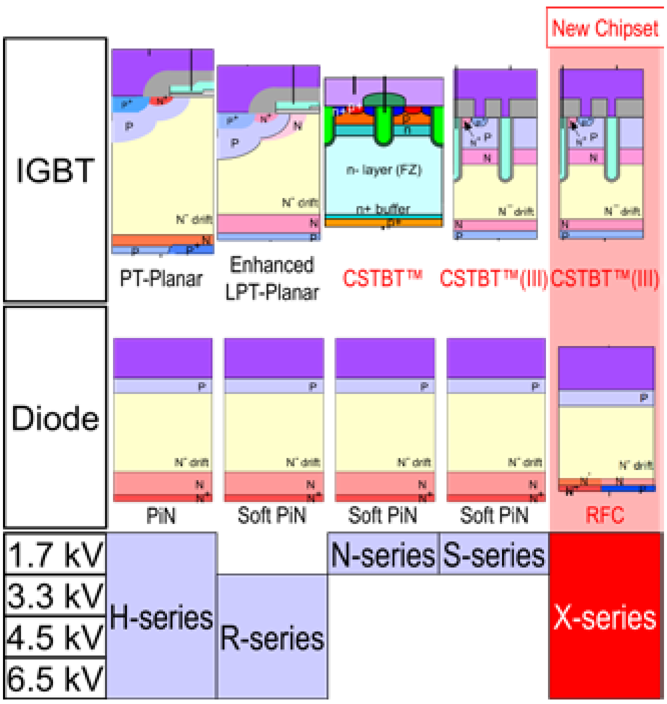

Figure 1: IGBT and diode chipset generations of MITSUBISHI ELECTRIC

The following article will introduce the silicon-based power modules of the LV100 and HV100 family. We will have a look at the advances in the chip and package technology, and measure the benefits in the application. A particular requirement of these power modules is the scalability of output power through the ability for parallel connection. The article will present a reference test setup for parallel connection and show the homogenous current distribution between paralleled modules for an optimal utilization of the silicon chip area.

Chip Technology

Mitsubishi Electric has long experience with manufacturing of the high voltage chips for railway application. The first products called H-Series addressed the entire voltage range from 1700 V to 6500 V. In the successional R-Series, the planar IGBT chip structure was optimized for lower forward voltage drop and improved device robustness. In the 1700 V class, N- and S-Series introduced the trench gate structure and CSTBT^{TM}. The diode in the R-Series, N-Series and S-Series was optimized for better performance and softness. The recently developed X-Series utilize the CSTBT^{TM} (III) technology for all voltage classes from 1700 V to 6500 V. The RFC (Relaxed Field Cathode) diode structure provides in the X-Series the balanced performance between low power losses and softness [2]. The maximum operation temperature is increased up to 150°C even for the 6500 V power modules.

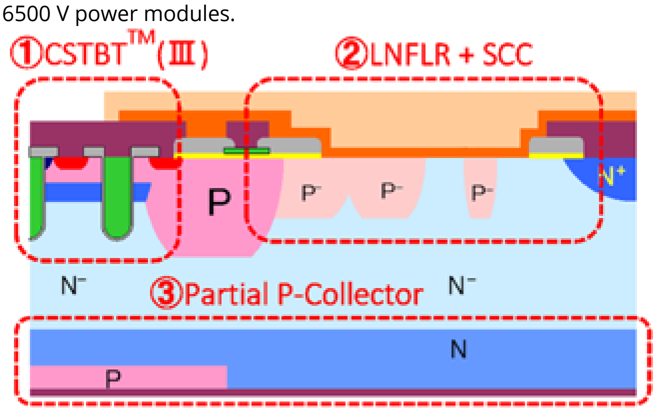

Figure 2: Structure of X-Series IGBT-chip

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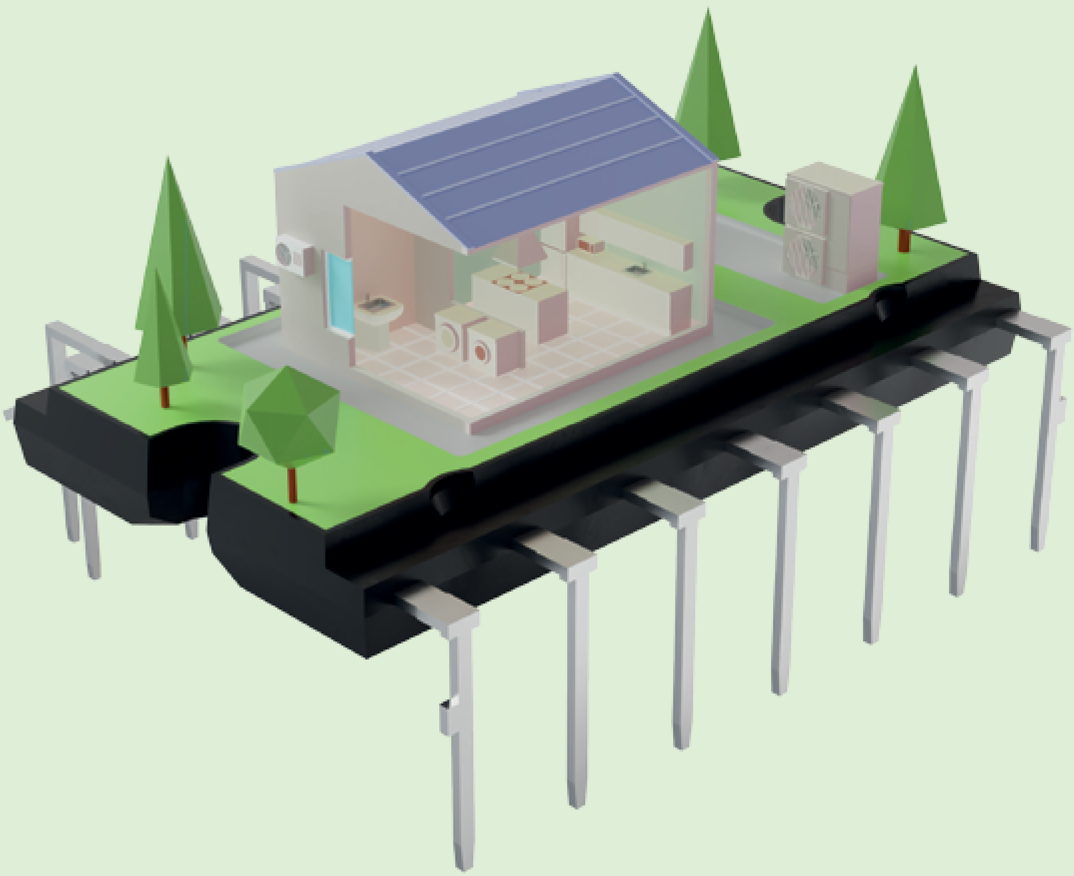

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The X-Series IGBT chip utilizes a lot of new features contributing to better module performance. The developed edge termination structure with LNFLR (Linearly-Narrowed Field Limiting Ring) allows active chip-area increase and thermal-resistance improvement. The SCC (Surface Charge Control) technology contributes to better humidity robustness [3]. The CSTBT^{TM} (III) trench structure allows higher carrier concentration at emitter side under on-state conditions. This reduces converter power losses by lower forward voltage of the device. The key criteria of the device selection in railway application is the robustness. The partial P-collector in the edge termination region minimizes the hole injection and improve the robustness during turn off event.

Package Technology

The outside appearance and the new package is the most recognizable innovation of the new LV100-HV100 power module family. As shown in Figure 3, DC and AC terminals are located on opposite sides of the package. Hence, the DC capacitors with the low inductive busbar can be placed on the one side, whereas the AC load is connected from the other side. This allows clear separation of functional building blocks in the cabinet and easier converter design. The availability of three AC terminals ensures proper connection and high current-handling capability even for 1700 V voltage class or SiC power modules.

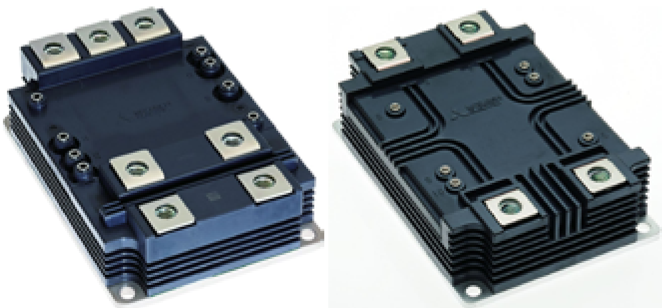

Figure 3: LV100 and HV100 packages for insulation voltage of 6 kV and 10.2 kV respectively

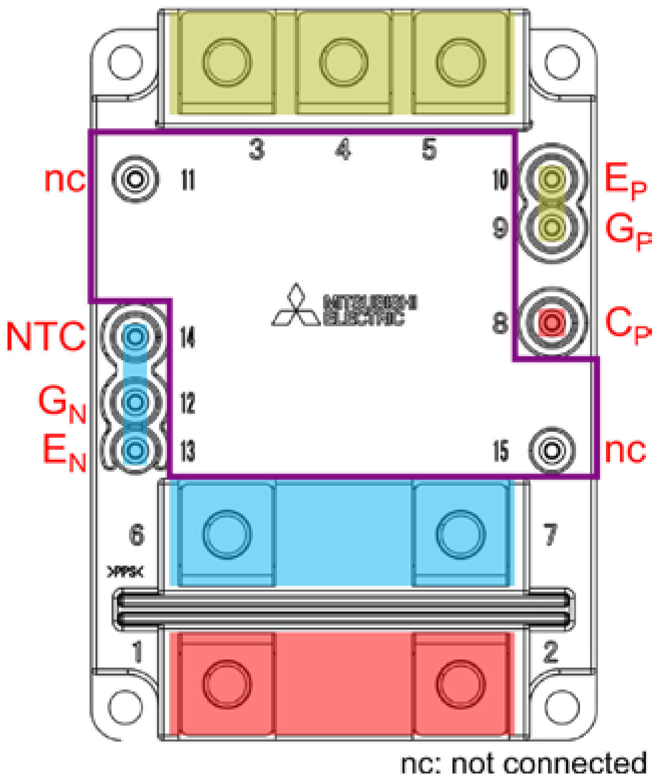

Figure 4: LV100 terminal layout with indication of the electrical potential (red: DC plus, blue: DC minus, yellow: AC) and available design space for the gate driver

The auxiliary terminals for the gate driver are located in between the DC and AC terminals. When several modules are connected in parallel, the intention is to have a large gate-driver PCB (printed circuit board) across all modules or multiple individual PCBs with short cable bridges in between. For sure, the location of gate drive terminals provides sufficient clearance and creepage distance even for parallel connected devices. At the same time however, the given layout offers maximal design space to our customers. Figure 4 shows the auxiliary terminal layout together with an indication of electrical potential by color. It is evident that the different potentials are well sorted. This allows easier insulation coordination, cheaper PCB material with lower CTI value and more design space for our customers' gate drivers.

Another innovation of the LV100 and HV100 package is the MCB (Metal Casting direct Bonding) baseplate. As shown in Figure 5, it is an aluminum-based baseplate with AlN insulation and Al metallization integrated as single structure. Compared to a classical structure, the thermal resistance is decreased leading to increased power density and easier cooling. Moreover, the substrate solder, which usually degrades in the course of thermal cycling, is omitted with this MCB baseplate. The innovative MCB technology is utilized in both the LV100 and HV100 package ensuring 6 kV and 10.2 kV insulation voltage respectively.

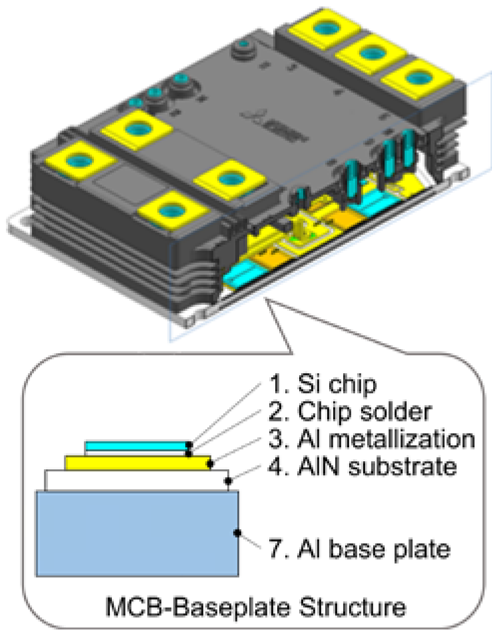

Figure 5: Package structure of LV100 and HV100 package (illustrated at the LV100)

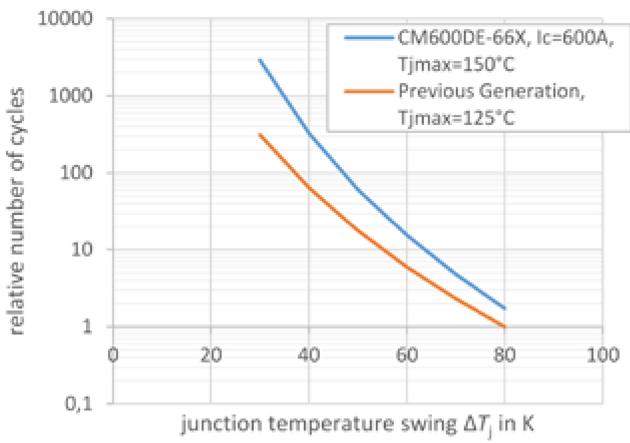

Figure 6: Improvement of power cycling capability of 3.3 kV HV100 in comparison to a previous generation 3.3 kV power module at respective nominal current

Besides electrical and thermal performance, also the robustness of the power module increases with the new package structure. Figure 6 shows the power cycling capability of the 3.3 kV / 600 A HV100 power modules (type name: CM600DE-66X). The figure compares it to a 3.3 kV power module with 10.2 kV insulation voltage of a previous generation. The numbers of cycles are given with respect to the power cycling capability at ΔT_j = 80 K of the previous-generation module. It is evident that the power cycling capability is increased drastically even though the maximal junction temperature has also been increased from 125°C to 150°C.

Parallel Connection

As mentioned in the introduction, the key requirement from the railway market for this new packages is the scalability. It allows for converter manufacturer to have flexibility at different projects to design the required output power. For example, by using the one, two or six CM600DA-66X modules, current ratings of 600 A, 1200 A or 3600 A can be achieved respectively.

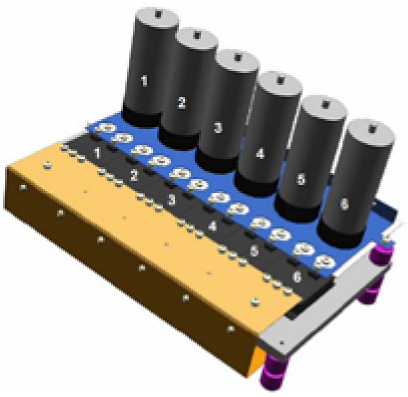

Figure 7: Reference test setup for LV100 device evaluation (Source: [4])

Advert

	LV100		HV100		
Dimensions	100mm×140mm×40mm		100mm×140mm×40mm		
Insulation	6 kVrms		10.2 kVrms		
Rated Voltage	1.7 kV	3.3 kV	3.3 kV	4.5 kV	6.5 kV
Rated Current	1200 A	450 A, 600 A	450 A, 600 A	450 A	300 A
Model	CM1200DA-34X	CM450DA-66X CM600DA-66X	CM450DE-66X CM600DE-66X	CM450DE-90X*	CM300DE-130X*
	* under consideration				

Table 1: Lineup of Si power modules

The proper operation of the module in parallel connection is needed. Due to the fact of different converter designs, the railway manufacturers agreed on the reference test setup for evaluation of the parallel connection [4]. This reference setup, as depicted in Figure 7, allows evaluation of up to six paralleled modules. The design was done with the target to minimize the influence of the external parameters on the paralleling. Mitsubishi Electric uses the reference test setup for device switching evaluation. An example of two paralleled CM450DA-66X modules is shown in Figure 8. As a benefit, the railway manufacturer can get representative and comparable results that can be easily reproduced and verified. Moreover, Figure 8 shows perfect current distribution between two in-parallel connected LV100 power modules. Hence, optimal utilization of available silicon chip area is achieved.

Lineup

Various products have already been developed by Mitsubishi Electric with standardized LV100 and HV100 packages. These products utilize the latest X-Series chip technology and cutting edge MCB baseplate. In LV100 package, 1700 V and 3300 V dual modules are

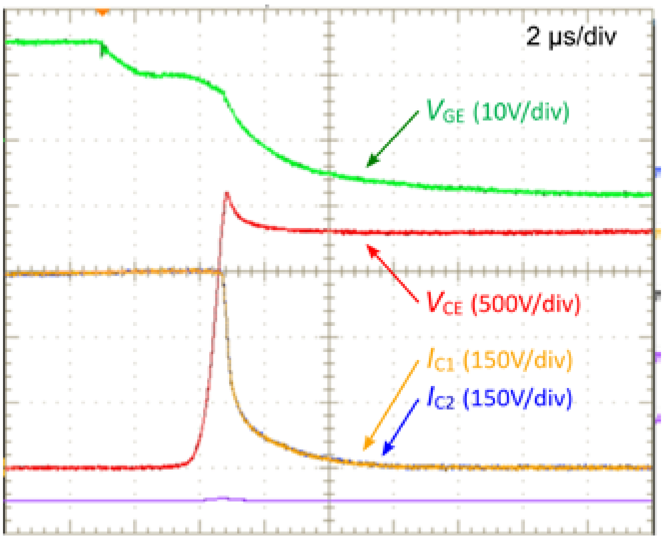

Figure 8: Turn-off of two CM450DA-66X in parallel using reference setup (Vcc = 1800V, Ic = 450A per module, Tj = 150°C)

Model	Rated Voltage	Rated Current	Technology
CMH600DC-66X	3300V	600A	Hybrid-SiC
FMF375DC-66A	3300V	375A	Full-SiC
FMF750DC-66A	3300V	750A	Full-SiC

Table 2: Lineup of SiC power modules

available. Besides the 600 A version of 3300 V module also device with lower current rating of 450 A is available. Timely for PCIM 2021, the press release of 3300 V modules in HV100 modules has been published [5]. The modules with 4500V and 6500V voltage class are under development.

Besides the available silicon-based dual power modules, Mitsubishi Electric has also developed the line-up of 3300V SiC power modules to fulfill the future demands of railway application in terms of efficiency and decarbonization. There are two current ratings of 750 A and 375 A available of Full-SiC version. Furthermore a Hybrid-SiC device with Si IGBT and SBD SiC diode with current rating of 600 A is available. It should be noted that SiC power modules use LV100 with special internal package structure. That structure is different from the silicon products, that have been explained in this article. Still, package outline and terminal locations are same.

Conclusion

This article has discussed requirements of future railway converters. The key points are increasing power density, higher flexibility and great robustness against environmental conditions. Mitsubishi Electric's solution to these requirements are the LV100 and HV100 power modules. They provide higher power densities by latest X-Series chip generation and best-in class MCB baseplate. Flexibility is achieved by elaborate package design, auxiliary terminal placement and homogenous current sharing in parallel connection. Strong robustness is ensured by the X-Series chipset and newest package technology. In particular the SCC technology achieve highest robustness against high humidity conditions. The LV100 and HV100 power modules allow highly reliable, efficient and compact converters for railways - and other applications.

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Swept Transient Frequency Response for the LLC Converter

Our last two articles showed how to generate reliable and fast control transfer functions in LTspice® using switching transient circuits [1] [2]. We demonstrated that you do not need small-signal models to study the control characteristics of your converters. Furthermore, the swept transient circuit produces more insight into design than the small-signal model. This allows us to answer important questions about pushing the performance of control loops to the limit.

In this article, we apply the same simulation approach using the RidleyBox®/AP310 emulation models to a more complex and variable circuit – the LLC converter.

By Dr. Ray Ridley, Art Nace and John Beecroft
Ridley Engineering, Inc. Camarillo, California USA

LLC Converter Test Circuit

The LLC converter has become increasingly popular over the last 20 years with the push to higher efficiencies and lower switching stress and noise. The converter works very well with a pseudo-regulated input line, and the widespread adoption of the PFC circuit provides exactly that.

There is a wealth of material available about the theory of operation of this converter, and it can be extremely confusing to follow. In particular, the small-signal model defies closed-form attempts to model it in closed-form equations. It is, therefore, a great candidate for swept control transfer functions without analysis or small-signal modeling. It is not our intent to rehash the theory of the converter, but rather to make reliable and useful control measurements.

Figure 1 shows the transient simulation circuit for a sample LLC converter with an input range of 36 – 54 V and an output of 120 W at 12 V. The lower switching frequency was designed to be 200 kHz.

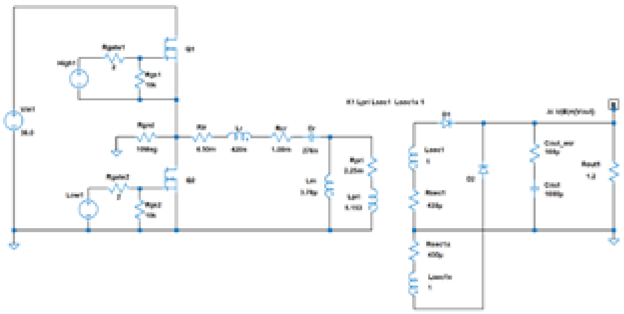

Figure 1: LLC Converter in LTspice®. Frequency Range 200-400 kHz. Vout = 12 V.

Figure 2 shows the circuit used to simulate the controller for this power stage. Notice that we chose to use an FM modulator for the VCO function, finding this to be faster to simulate than the normal ramp generation circuits. The actual implementation of the VCO differs from one control chip to another, but the basic function of converting a feedback signal into an oscillation frequency is the same.

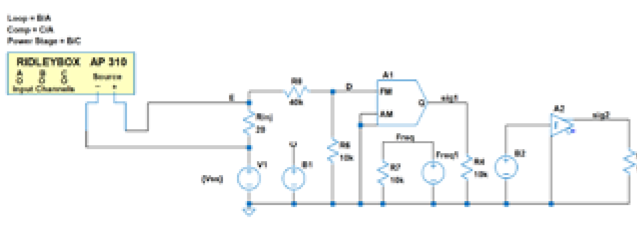

Figure 2: LLC Controller with RidleyBox/AP310 Analyzer.

The steady-state operating point of the converter is set with the input source Vss which controls the operating frequency. The RidleyBox®/AP310 component injects a small ac signal on top of this dc value to vary the switching frequency. Modulation of this signal, and measurement of the response from point C to point B of the circuit gives us the control-to-output gain of the power stage and the modulator.

LLC Converter Design Using Scaling Laws

Nicola Rosano produced a great webinar on the practical design of LLC converters which you can view in reference [3]. It is highly recommended that you watch this video to learn how to avoid endless mathematics and confusion in the design process for the LLC. Nicola has developed powerful engineering tools for generating rugged designs for the LLC using standardized curves.

We used these scaling law techniques to design the 120-W converter in this article, and the resulting component values are given in the circuit diagram of Figure 1.

The complete design process, including the curve shown in Figure 3 and two other design curves, is described in the recorded webinar. The webinar describes in detail the design process for several different diverse power stage requirements.

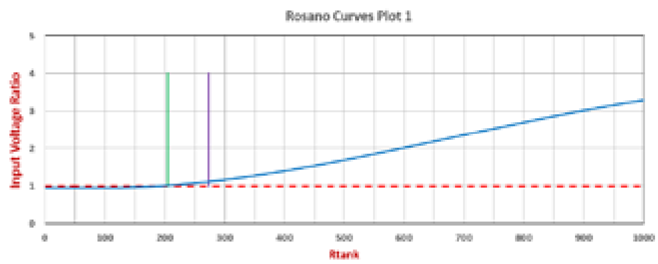

Figure 3: Impedance Curve Plot #1 of Nicola Rosano Used to Design the LLC Power Stage [3].

Simulation Settings for the RidleyBox/AP310 Emulator

The LLC converter presents many challenges to simulate cleanly, especially for frequency response characteristics. We found it essential to have the LTspice® simulation solver set to "Alternate" to be able to get meaningful results (not the default setting). We also use the following analyzer settings to produce the simulation results in this article.

The choice of 25 points per decade (from 300 Hz to 200 kHz) provided very smooth curves, although such a high number is not needed when first assessing the performance of your power stage.

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As explained in [1], choosing the correct settings for the dwell time, bandwidth, and noise reduction parameters gives a perfect balance between speed of simulation and accuracy of the plots. Don't underestimate the critical nature of these settings. If we did not have a lifetime of controlling analyzers as background experience, it is unlikely we would have been able to get LTspice® to perform as well as we have by introducing and adjusting these parameters. The complete setup of the LLC simulation circuits is fully automated by the version of RidleyWorks® [4] currently under development.

RIDLEYBOX/AP SETTINGS

SWEEP RANGE AND POINTS
.step dec param Freq 300 200K 25

SOURCE AMPLITUDE
.param Start_Amp=0.1
.param Finish_Amp=0.1
.param LFbreak=1.00K
.param HFbreak=10.00K

RECEIVER RESOLUTION
.param RidleyBoxDwell=2.00m
.param RidleyBoxBW=1
.param RidleyBoxNR=2.00K

Figure 4: RidleyBox®/AP310 Analyzer Emulator Settings for LLC Power Stage Simulation. These settings produce high resolution results. (Simulation time can be cut in half with lower resolution.)

LLC Power Stage Control Transfer Functions

Figure 5 is the LLC power stage response for the 36-V low line input. This has the characteristics of a damped double pole just below 2 kHz and additional phase delay due to a RHP zero. The zero is indicated by the fact that the phase drops well below -180 degrees while the slope of the gain curve becomes less steep.

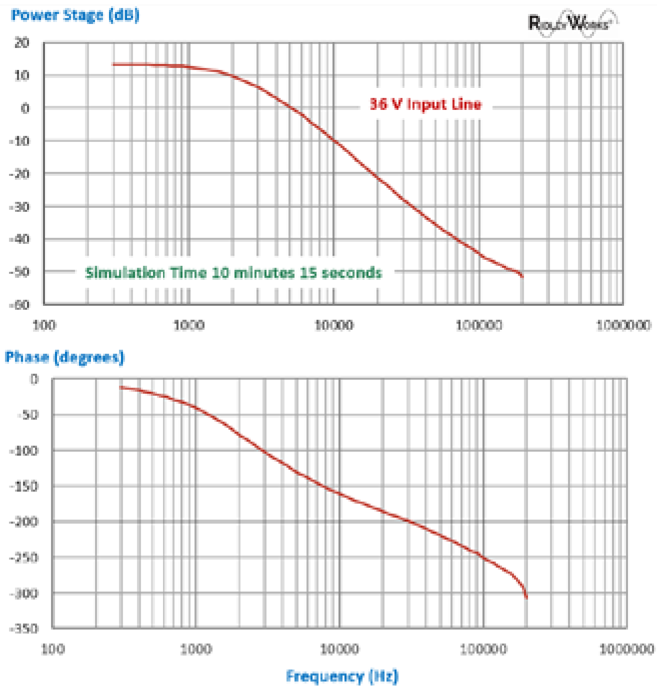

Figure 5: Frequency Response of the LLC Power Stage at Minimum Input Line.

Figure 6 shows the responses at the extremes of low and high line. In the power converter world, 36 V – 54 V is not a particularly wide range, but you can see considerable variation in response. The resonant frequency has moved out to about 8 kHz and is much less damped. You can also see that the RHP zero frequency has moved to a higher value as indicated by the improved phase and the steeper slope of the gain curve above 8 kHz. It is our intention to discuss detailed interpretation of the curves in this article. We are simply trying to demonstrate that the curves can be cleanly and accurately generated through the transient simulation.

Finally, in Figure 7 we can see the complete family of curves from low line to high line. Here you can see the smooth transition of the resonant frequency, the changing Q of the double poles and the movement of the RHP zero as the line is increased. The change in the dc gain is also quite substantial – about 15 dB for a relatively small input line change. This is what we expect from LLC power stages.

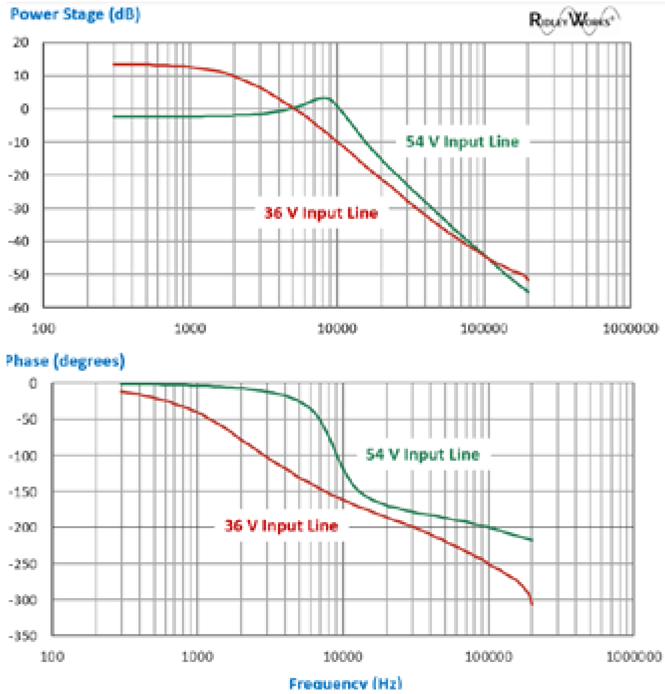

Figure 6: Frequency Response of the LLC Power Stage at Minimum and Maximum Input Line.

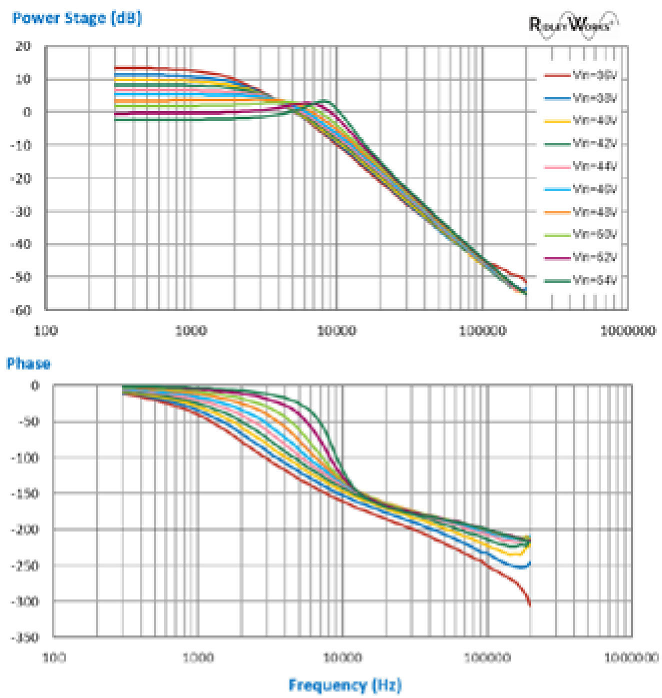

Figure 7: Frequency Response of the LLC Power Stage Over Complete Range of Input Line.

Summary

The LLC circuit has extreme variations in its control-to-output characteristics with operating conditions. Sweeping the power stage with LTspice® is a very useful tool to produce expected characteristics with minimal work. With the right analyzer settings, the simulation times are very reasonable, and we strongly encourage using this important tool for all your frequency response needs.

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3. Designing LLC Converters Using Scaling Laws Webinar by Nicola Rosano, Ridley Engineering Power Supply Design Center.
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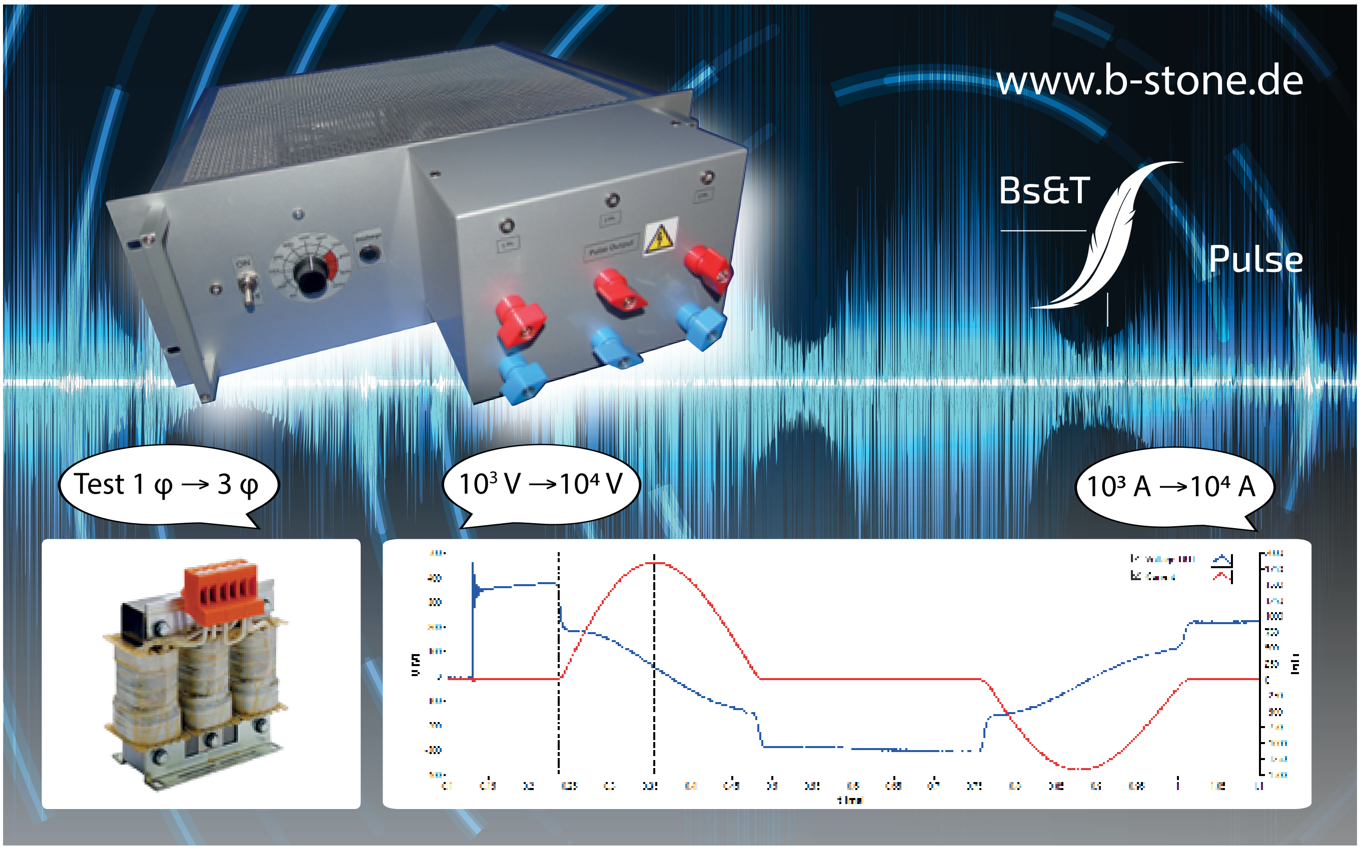
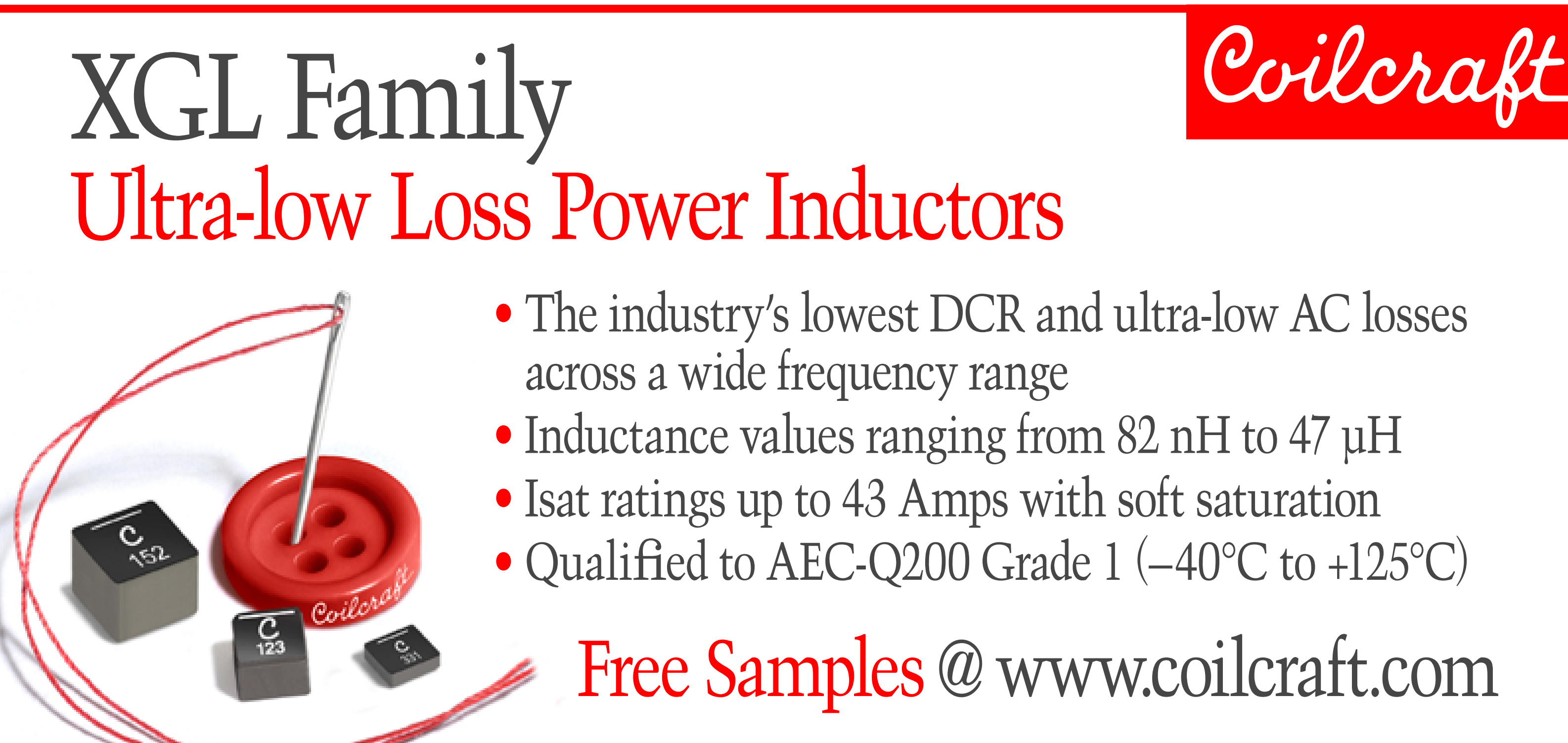




Dynamic On-Resistance Measurement Technique for GaN Power Transistors

Dynamic on-state resistance ($R_{DS(ON)}$) is critical for the reliable and stable operation of GaN power transistors. However, many engineers are struggling to evaluate dynamic $R_{DS(ON)}$ because of the difficulty in measuring it consistently with sufficient resolution. In this article, we discuss a measurement technique of dynamic $R_{DS(ON)}$ using a double pulse test system with a clamp circuit.

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

"Current collapse" behavior of GaN Power Transistors

While GaN power transistors are becoming popular in power electronics applications because of their low energy loss and high power density capability, design engineers still have some concerns about their reliability. One of the key concerns about GaN power transistors is their dynamic on-state resistance ($R_{DS(ON)}$) increase during switching operation, the phenomenon known as "current collapse". Current collapse is the result of trapped electrons in the transistor structure when a high drain off-voltage is applied. It takes time to clear out the trapped electrons during a switch on event, which is characterized by the dynamic $R_{DS(ON)}$ measurement. Increased dynamic $R_{DS(ON)}$ degrades conduction loss of the GaN power transistors and leads to higher temperature, which affects reliability of the GaN power transistor and the system overall. Although many manufacturers provide "collapse-free" GaN power transistors, engineers are still concerned about the effect of the current collapse. Therefore, not only device manufacturers, but also power converter design engineers need to evaluate dynamic $R_{DS(ON)}$ of GaN power transistors accurately.

Challenges for dynamic ON-state resistance measurement

Many engineers are struggling to evaluate dynamic $R_{DS(ON)}$ accurately. There are two main reasons: 1) overdriving, and 2) the limitation in the oscilloscopes' dynamic range.

When we measure dynamic $R_{DS(ON)}$, we would like to set the oscilloscope range just enough to monitor only on-state drain voltage ($V_{DS(ON)}$) such as 1V/div, giving us the best resolution from the oscilloscope. Unfortunately, the transistor is switching from high drain off-voltage ($V_{DS(OFF)}$) such as 400 V. The amplifiers in the oscilloscope distort the waveform if the measurement range is not wide enough to cover both $V_{DS(OFF)}$ and $V_{DS(ON)}$. This phenomenon is called "overdriving" of the oscilloscope [1] and results in saturated oscilloscope amplifiers and erroneous $V_{DS(ON)}$ measurements.

Therefore, we must set the oscilloscope range wide enough to capture both $V_{DS(OFF)}$ and $V_{DS(ON)}$ to avoid overdriving the input. However, the issue we come across this time is the limitation in the dynamic range of oscilloscopes. Even the high-end oscilloscopes, which have the highest vertical resolution in the market only have around nine effective number of bits (ENOB) at 20 MHz bandwidth (NOTE: In most cases, ENOB is the more useful parameter to use than the raw number of bits of the ADC in the oscilloscope. Often a few of the raw bits are below the noise floor of the amplifier, making them unusable). Therefore, the oscilloscope can only identify $1/2^9 = 1/512$ of full scale. If $V_{DS(OFF)}$ is 400 V, the minimum resolution will be 400/512 = 0.78 V, which is completely unacceptable resolution for dynamic $R_{DS(ON)}$ measurements.

Keysight's approach to measure dynamic $R_{DS(ON)}$

To overcome this and other challenges in testing GaN power transistors, Keysight developed a customized GaN test board to use with the PD1500A Dynamic Power Device Analyzer and Double Pulse Tester. To specifically overcome the limitation of the oscilloscope dynamic range, we developed a clamp circuit. Figure 1 shows our customized GaN test board. The newly developed clamp circuit is placed near the interface of the device under test (DUT). As we discussed in previous articles, the board also has Keysight's solderless DUT interface, low insertion inductance current sensor, and replaceable gate resistors that we call Repeatable & Reliable GaN Characterization (R^2GC) Technologies.

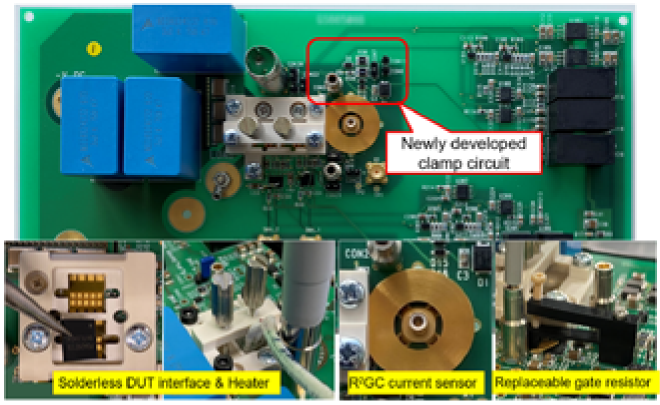


Figure 1: Keysight's customized GaN test board with R^2GC technology.

Figure 2 shows a simplified concept of the clamp circuit. This circuit is placed in parallel to the output of the DUT. For example, assume the voltage threshold (V_{TH}) of Q1 is 2 V. If the Clamp Voltage is set to 8 V, then this circuit accurately measures the voltage V_{CLAMP} up to 6 V when the V_{DS} of the DUT is below 6 V. However, when V_{DS} is

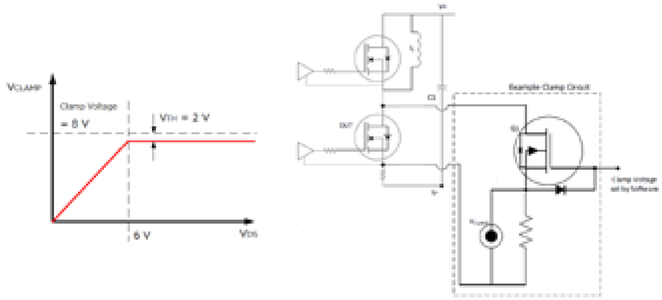
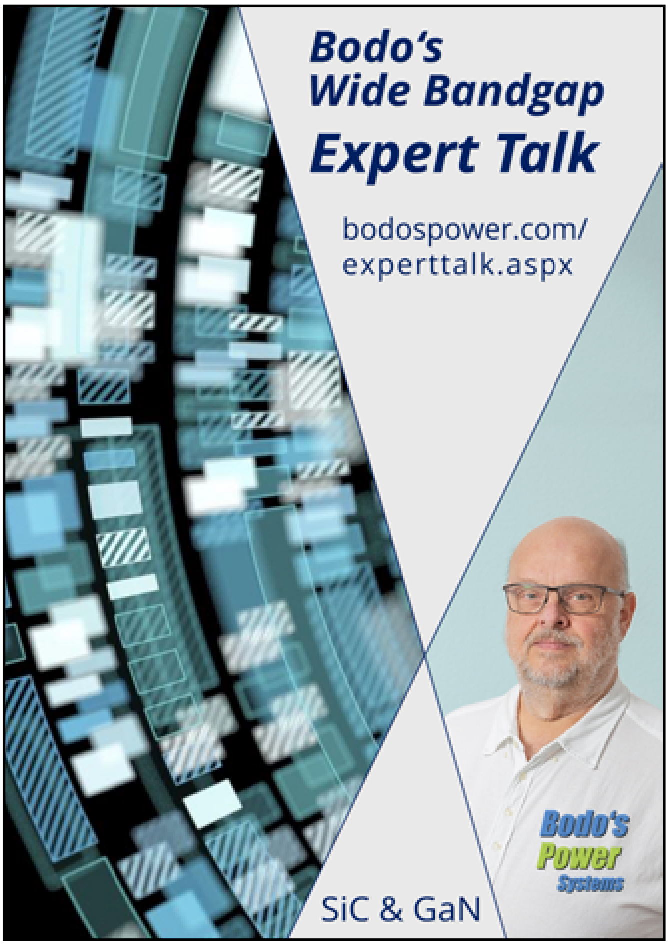


Figure 2: Simplified example of the clamp circuit.

above 6 V, then the system measures no more than 6 V. This means the oscilloscope can be set at a low-voltage range such as 1 V/div, which gives enough vertical resolution for dynamic $R_{DS(ON)}$ measurements. This test method using a clamp circuit is also suggested in JEDEC's publication JEP173 [2].

Figure 3: Turn-on switching waveform of a 650 V rating GaN E-HEMT obtained by the newly developed GaN test board with a clamped circuit.

We evaluated the performance of our customized GaN test board with a commercially available 650 V rating GaN E-HEMT (Enhancement mode High Electron Mobility Transistor). Figure 3 shows the turn-on waveforms of the GaN E-HEMT switching at $V_{DS(OFF)}$ = 400 V, $I_{DS(ON)}$ = 30 A. The yellow waveform shows clamped drain voltage



(V_{CLAMP}) and the brown line shows $R_{DS(ON)}$ calculated by V_{CLAMP}/I_{DS}, using a 20 MHz low pass filter setting on the oscilloscope. The yellow waveform shows that the measured V_{DS} is clamped at around 4.5 V and that $V_{DS(ON)}$ around 2 V is clearly measured. Peak-to-peak noise of $R_{DS(ON)}$ waveform was around 1 mΩ (30 mV in terms of $V_{DS(ON)}$), which is much more precise than the original V_{DS} resolution of 0.78 V we discussed above and sufficient to evaluate dynamic $R_{DS(ON)}$ for most GaN power transistors.

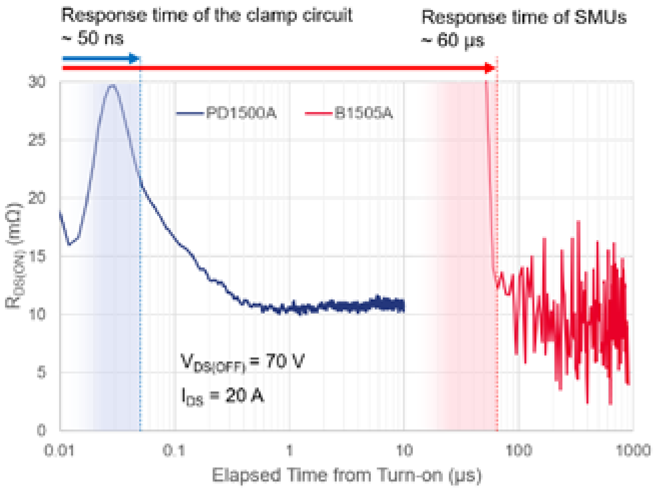


Figure 4: Measurement result of 100 V/10 mΩ GaN E-HEMT dynamic $R_{DS(ON)}$ obtained by both PD1500A (with the newly developed clamp circuit) and B1505A.

Another important characteristic for the clamp circuit is response time of the circuit. In typical power electronics applications like DC-DC converters, the switching frequency of the GaN power transistors is getting faster and faster and has become more than 1 MHz. That means the response time of the clamp circuit should be less than a few hundreds of nanoseconds to measure the dynamic $R_{DS(ON)}$ under practical operating conditions. The components of the clamp circuit like transistors and diodes intrinsically have a certain amount of junction capacitance and recovery characteristics that degrade the response time of the circuit. Therefore, getting fast response of the clamp circuit is another challenge.

Getting back to Figure 3, the clamped V_{DS} waveform (yellow) shows a negative dip for about 50 ns just after the turn on transition starts. This negative dip is attributed to the effect of parasitics of the clamp circuit. After this dip, the clamped V_{DS} shows correct $V_{DS(ON)}$ waveform. The response time of the clamp circuit in our double pulse test system proved to be less than 100 ns, which is fast enough for most applications.

We also compared our new dynamic $R_{DS(ON)}$ test method with our previous system (B1505A with N1267A HVSMU/HCSMU fast switch). Figure 4 shows the measurement result of 100 V/10 mΩ GaN E-HEMT obtained by both systems. Since B1505A is based on source measure unit (SMU) technology, it takes the measurement tens of microsecond to settle. On the other hand, PD1500A's clamp circuit has approximately 1000 times faster response time and successfully detects the fast response of the current collapse behavior which occurs within 100 ns from turn-on. The result also shows that the noise floor of the measured dynamic $R_{DS(ON)}$ is roughly ten times smaller than B1505A, proving that we did a significant improvement in the dynamic $R_{DS(ON)}$ measurement.

To explore more about our dynamic $R_{DS(ON)}$ test capability, we evaluated Off pulse length and $V_{DS(OFF)}$ dependency of the dynamic $R_{DS(ON)}$ for a 650 V rating GaN E-HEMT. In general, the dynamic $R_{DS(ON)}$ of GaN power transistors which have current collapse increases when longer and higher $V_{DS(OFF)}$ stress is applied. The effect of the current collapse can be seen by comparing $R_{DS(ON)}$ between the first pulse and the second pulse of double pulse test waveform.

Figure 5 shows the dynamic $R_{DS(ON)}$ behavior of the GaN E-HEMT during double pulse test. We extracted the deviation of $R_{DS(ON)}$ ($\Delta R_{DS(ON)}$) between 1st pulse (100 ns before V_{GS} turns off) and 2nd pulse (100 ns after V_{GS} turns on). As shown in Figure 6, $\Delta R_{DS(ON)}$ slightly increased as longer and higher $V_{DS(OFF)}$ stress was applied, confirming that our double pulse test system can evaluate the current collapse of GaN power transistors effectively.

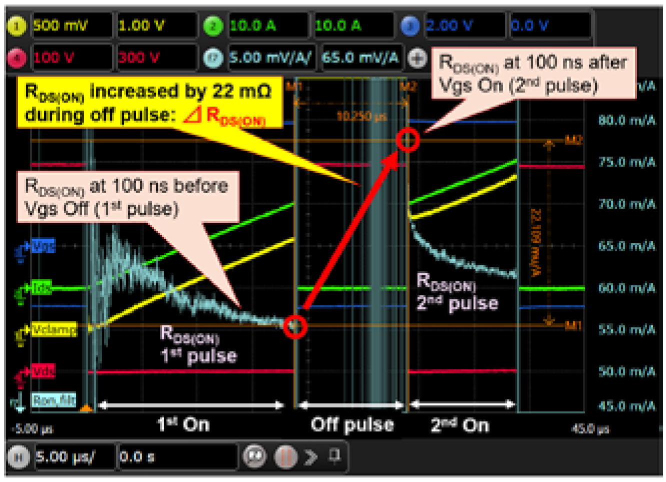


Figure 5: Dynamic $R_{DS(ON)}$ double pulse test result and $\Delta R_{DS(ON)}$ extraction of a 650 V rating GaN E-HEMT at 500 V/20 A.

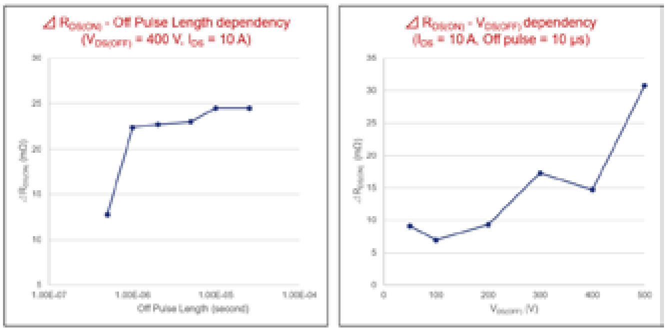


Figure 6: Off pulse length and $V_{DS(OFF)}$ dependency of $\Delta R_{DS(ON)}$ for a 650V rating GaN E-HEMT.

Summary

Current collapse is still one of the biggest concerns over GaN power transistors for many engineers, and its evaluation is very challenging due to the limitation of test instruments. As we discussed in this article, we successfully created a repeatable and reliable double pulse test system that can effectively evaluate dynamic $R_{DS(ON)}$ of GaN power transistors by employing a newly developed clamp circuit.

References

1. "Overcoming Overdrive Recovery on High-Speed Digital Storage Oscilloscopes" Application Note 5989-0068EN, Keysight Technologies
2. "Dynamic ON-Resistance Test Method Guidelines for GaN HEMT based Power Conversion Devices," Version 1.0, JEP173.

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MasterGaN* - The first 600V half-bridge driver with two integrated GaN power transistors

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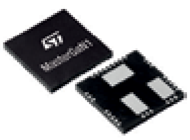
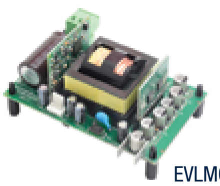
- **Faster time-to-market:** packaged solution simplifies the design
- **More robust:** offline driver optimized for GaN HEMTs for fast, effective and safe driving and layout simplification

Board area and weight are becoming limiting factors as power demands increase. Reducing size and weight can **cut the total cost of ownership** by making **installation and maintenance both easier and quicker.**

Part number	General description	Supply voltage max (V)	Key features	Output current max (A)	High side $R_{DS(on)}$ (mΩ)	Low side $R_{DS(on)}$ (mΩ)
MASTERGAN1	High power density 600V half-bridge high voltage driver with two 650V enhancement mode GaN HEMTs	11	Undervoltage lockout, interlocking function, overtemperature, Bootstrap diode	10	150	150
MASTERGAN2				6.5	225	150
MASTERGAN3				4	225	450
MASTERGAN4				6.5	225	225
MASTERGAN5				4	450	450



EVALMASTERGAN



EVLMG1-250WLLC

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20 V_{IN}, 8 A, High Efficiency, Tiny Package Step-Down µModule Device

The LTM4657 is part of the family of tiny, high efficiency, identical pin-out, step-down µModule® devices. It is designed to operate at lower switching frequencies than the LTM4626 and LTM4638 as it provides higher efficiency within its 8 A output current range.

By Timothy Kozono, Applications Engineer, Analog Devices

The LTM4657 bridges the gap between the LTM4626 and LTM4638 by combining the higher efficiency of the LTM4638 with the lower profile of the LTM4626.

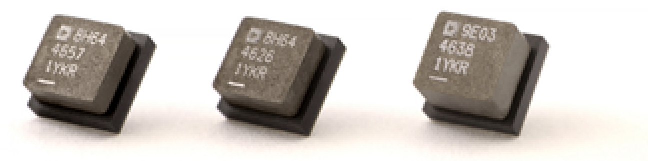


Figure 1: LTM4657, LTM4626, and LTM4638 offer different output current ratings using the same pinout. The LTM4657 and LTM4626 use lower profile inductors to reduce the overall height.

The LTM4657 provides up to 8 A continuous output current from input voltages between 3.1 V and 20 V. The LTM4657 uses the same component-on-package (CoP) design as the LTM4626 and LTM4638, which helps keep the device cool while maintaining a tiny 6.25 mm × 6.25 mm footprint. The pin compatibility and identical footprint of the LTM4626, LTM4638, and LTM4657 provide opportunities for customers to leverage previous layout designs and simply choose the µModule device that fits their need. The LTM4626, LTM4638, and LTM4657 lead the market in power density for step-down solutions. The attractive size and high efficiency of the µModule devices create flexible, turn-key solutions for a wide range of applications. The internal inductor, FETs, top feedback resistor, frequency resistor, and optional internal compensation allow for step-down solutions with minimal external components. Although capable of minimalist designs, the µModule technology offers a slew of optional features using a 49-lead BGA package to maximize the number of pins.

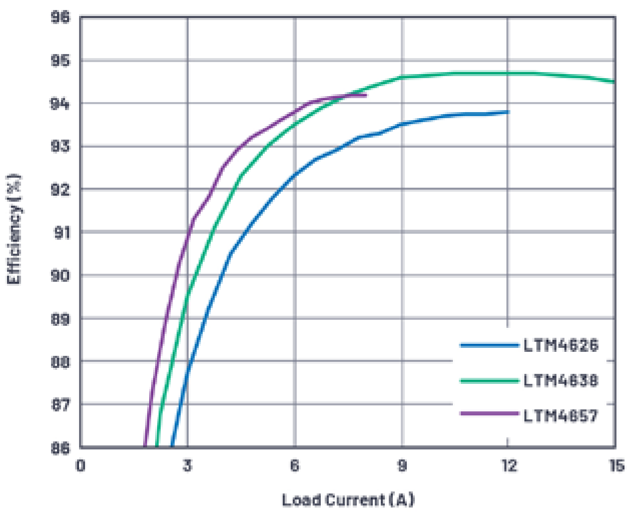


Figure 1: LTM4657, LTM4626, and LTM4638 offer different output current ratings using the same pinout. The LTM4657 and LTM4626 use lower profile inductors to reduce the overall height.

Beyond some of the more common features from the PGOOD, RUN, and TRACK/SS pins, the LTM4657 includes CLKIN, CLKOUT, and PHMODE to improve parallel and EMI operation. A differential remote sense amplifier is also included for output voltage accuracy. Temperature sensing pins are also included to supplement the internal thermal protection.

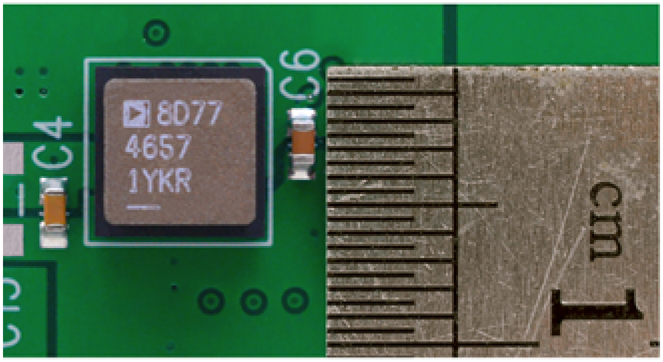


Figure 3: A tiny LTM4657 solution with input and output capacitors on a DC2989A demonstration board. A few ceramic capacitors and a resistor are placed on the back of the board.

Applications

The LTM4657 uses a higher value inductor than the LTM4626 and LTM4638. This allows the device to operate at lower frequencies to decrease switching loss. The LTM4657 is the preferred solution for high switching losses and low conduction losses, such as in applications where the load current is low and/or the input voltage is high.

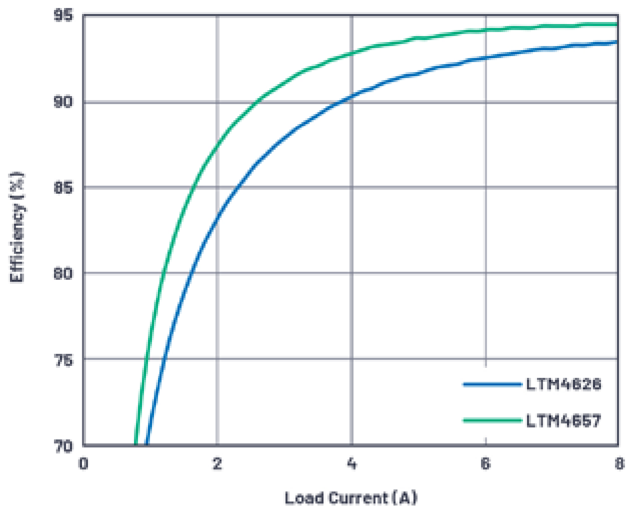


Figure 4: Efficiency comparison of the LTM4626 and LTM4657 at 1.25 MHz with the same configuration on a DC2989A demonstration board.

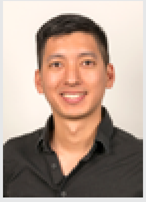
Figure 4 compares the LTM4626 and LTM4657 at the same switching frequency and with the same configuration on a DC2989A demonstration board. The 12 V_{IN}, 5 V_{OUT} configuration highlights the superior switching loss of the LTM4657. The LTM4657's higher value inductor also reduces the output voltage ripple. However, the LTM4626 can supply more load current than the LTM4657.

Conclusion

The LTM46xx family supplies a range of load currents using the same footprint and pinout. With the addition of the LTM4657, customers can optimize performance for lower load current designs. Along with the LTM4626 and LTM4638, this tiny footprint family continues to grow in flexibility and performance.

The LTM4657 offers increased efficiency for customers who want low switching loss and high efficiency solutions in low to medium load applications (up to 8 A). Offering a range of features in a tiny package, the LTM4657 can bring high efficiency to limited space designs without compromise.

About the Author



Timothy Kozono is an applications engineer in ADI's Power Products Group, focusing on μModule devices and software development. He received a B.S. and an M.S. in electrical engineering from California Polytechnic State University in San Luis Obispo in 2008 and 2010, respectively.

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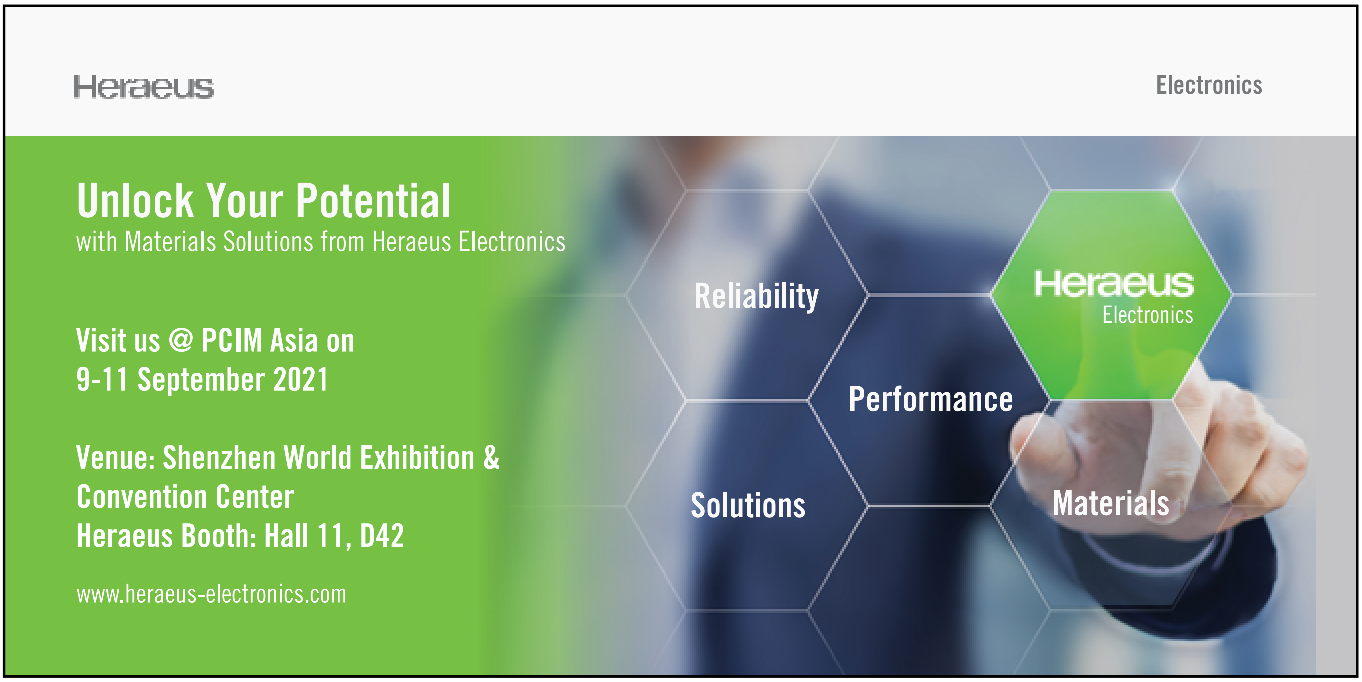

Near Chip-Scale WBG Half-Bridge

Near chip-scale Type IV µMaxPak enables higher power-density, lower inductance and lower thermal resistance, relative to benchmark Types, I & II µMaxPak, by a factor of two.

By Courtney R. Furnival, Founder, Semiconductor Packaging Solutions

Type IV µMaxPak Building Blocks

The fundamental µMaxPak Near Chip-Scale SMD architecture provides benchmark power-density while enabling minimum parasitics and minimum thermal resistance for high-power, high-speed WBG power switches. These switches accommodate high-voltage & high-current industrial products once limited to large industrial power IGBT modules. Early feasibility studies have shown that Near Chip-scale SiC Type III µMaxPak can be extended to Electric Vehicles and potential are scalable to Locomotive Traction. Such near chip-scale SMD packages are both necessary & sufficient to allow power WBG devices to operate at full performance & efficiency. Therefore, they are "Inevitable for Power WBG packaging." [1] [4]

µMaxPak near chip-scale packages uses proprietary technology protected by U.S. patent US9,214,416. It provides examples of QFN and LGA µMaxPaks. The patent and supporting technical articles, papers, and presentations show three basic µMaxPak structures, Type I, II, & III, described herein. These examples show single power FET die switches but can include multiple paralleled FETs & anti-parallel diodes and even support integration like Gate-Driver die & passive components. The single-switches (SS) can be extended to multiple "Lateral" switches like Half-Bridge (HB), Full Bridge (FB), & 3Ø-Bridges. The Type I, II & III combination can create the Stacked/Vertical Type IV µMaxPak HB. The three (3) building blocks are:

Type I µMaxPak, Standard Type with all bottom-side SMD pads contain a power FET in a QFN with die drain pad exposed on package bottom-side, and source and gate & sense pads are soldered into the bottom-side by the leadframe cavity. The leadframe extends to the bottom-side of the package, creating external connections and a secondary/parallel thermal path. The package is constructed with QFN assembly technology, contains a single-piece leadframe with no leads and wire bonds. Type I µMaxPak accommodate bump-chip integrate gate-drivers that are not shown.

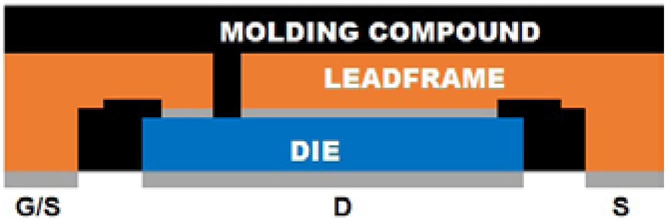

Figure 1: Type I µMaxPak

Type II µMaxPak is also built with QFN assembly technology. The die is inverted compared to Type I with all bottom-side pads. The die source, gate & sense pads are exposed on the package bottom-side. The power FET die drain is soldered into the leadframe cavity. The leadframe extends to the package bottom-side creating an external drain and second parallel paths. The package contains a single-piece leadframe with no leads or wire bonds. This µMaxPak QFN This Type II µMaxPak, in Figure 2, can accommodate horizontal integrated gate-drive IC but cannot accommodate vertical integration.

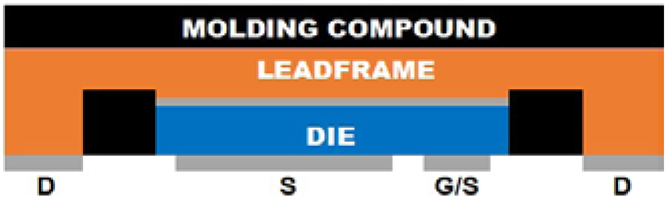

Figure 2: Type II µMaxPak

Type III µMaxPak Inverted (and Standard) die contains electrical & thermal pads on both top & bottom sides. This option is shown in Figure 3, with the die source, gate, & sense pad exposed on the bottom side. The die drain pad is soldered into the bottom-side leadframe cavity, which extends drain to bottom side pads. The top of the leadframe is exposed at the top of the package, creating the drain connection and a paralleled thermal path. This type also contains no leads or wire bonds and is built with QFN technology. The double-sided thermal package pads accommodate both top & bottom DBCs & heatsinks, cutting thermal resistance (Rjc) in half. Type III µMaxPak is ideal for higher power EV traction and scalable to Locomotive traction. [2]

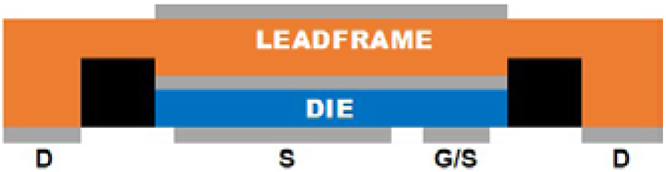

Figure 3: Type III µMaxPak

New Type IV µMaxPak HB Architecture & Performance Advantages

New Type IV µMaxPak HB is a unique Vertical/Stacked architecture. The Half-Bridge configuration contains a low-side switch in the bottom-side leadframe cavity and a high-side switch on top of the leadframe. All external pads are on the package bottom-side, except the high side drain, which is on the top-side of the package. See the cross-section of Type IV µMaxPak HB in Figure 4. It too contains all proprietary features in U.S. patent US9,214,416. The patent also extends the IP to LGA Types I, II, III & IV µMaxPak.

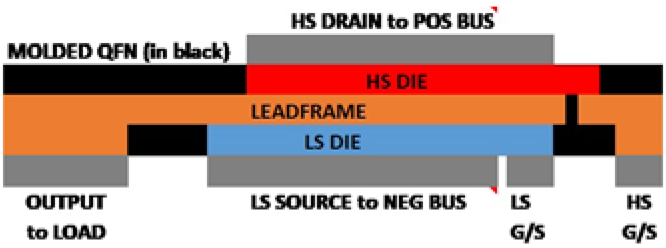

Figure 4: Type IV µMaxPak HB

This cross-section example shows a basic HB with a single SiC vertical MOSFET die for both switches. The switches can include paralleled MOSFETs die, anti-paralleled diode die, and other special devices.

Additional perspective, details, and sizes are shown in a conceptual design of 600V/350A (1200V/150A) Type IV µMaxPak 10 x 6 x 1mm HB drawing in Figure 5, which illustrates a Top X-ray view and a Cross-Section view with stacked high-side & low-side switches. The corresponding Package Outline Drawing in Figure 6 provides an external pad configuration for this Type IV µMaxPak HB example.


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The initial conceptual 650V/350A Type IV µMaxPak HB design was 650V, and 1200V products based on SiC die suitable for industrial products but may be possible for EV Traction. I_{DC}(max) was calculated based on SiC die sizes and current-densities, and rated continuous @ TJC(max)=150°C. See the results in Table1 a & b.

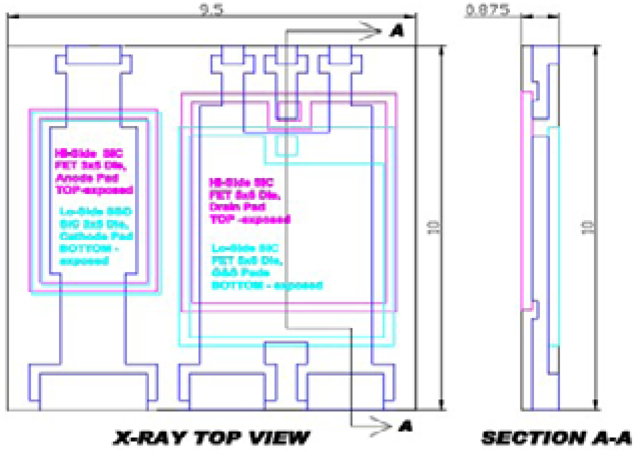

Figure 5: Type IV µMaxPak HB X-ray & Cross-Section View

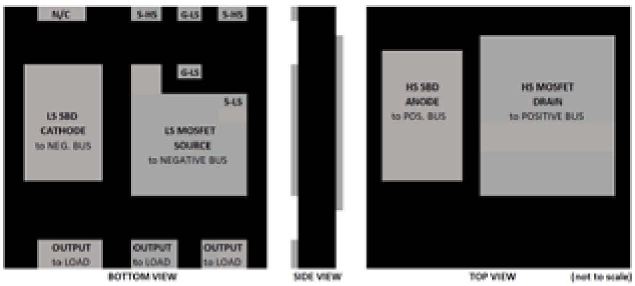

Figure 6: Type IV µMaxPak HB Package Outline Drawing

650V MOSFET DIE (mm)	650V SBD DIE (mm)	MOSFET DIE $R_{JC/RC}$ (°C/W)	Assumed Max. Current-Density @ Tj=150°C	µMaxPak HB Size (mm)	*Continuous I_{DC}(max) (A)*
5.0 x 4.0	4.0 x 3.0	0.090/9.029	14.1A/mm^2	9.0 x 8.5	225
6.0 x 5.0	5.5 x 3.0	0.060/0.019	14.1A/mm^2	10.0 x 9.5	350
7.0 x 6.0	7.0 x 3.5	0.043/0.014	14.1A/mm^2	11.0 x11.0	500
8.0 x 7.0	7.0 x 4.5	0.032/0.010	14.1A/mm^2	12.0 x 13.0	675
9.0 x 8.0	8. 0x 5.0	0.025/0.008	14.1A/mm^2	13.0 x 14.5	900

1200V MOSFET DIE (mm)	1200V SBD DIE (mm)	MOSFET DIE $R_{JC/RC}$ (°C/W)	Assumed Max. Current-Density @ Tj=150°C	µMaxPak HB Size (mm)	Continuous I_{DC}(max) (A)
5.0 x 4.0	4.0 x 3.0	0.090/9.029	7.6A/mm^2	9.0 x 8.5	90
6.0 x 5.0	6.0 x 3.0	0.060/0.019	7.6A/mm^2	10.0 x 9.5	150
7.0 x 6.0	7.0 x 3.5	0.043/0.014	7.6A/mm^2	11.0 x11.0	225
8.0 x 7.0	7.0 x 4.5	0.032/0.010	7.6A/mm^2	12.0 x 13.0	325
9.0 x 8.0	8.0 x 5.0	0.025/0.008	7.6A/mm^2	13.0 x 14.5	425

Table 1a & b: Type IV µMaxPak HB Projected Ratings

Key Type IV µMaxPak Advantages

1) Power Density is Double that of the benchmark Lateral µMaxPak HB packages, made possible by stacking high-side & low-side switches.
2) Thermal resistance (Rjc) is Half of Lateral µMaxPak HB benchmarks by dissipating heat from both the top & bottom of the package reduces the Rjc, plus added heat removal by leadframe between high- & low-side switches. This technique is most effective with a thin power die, and a higher thermally conductive SiC die.
3) The Type IV with vertically stack switches can achieve even higher I_{DC}(max) current ratings. In many HB applications, each HB switch operates at 50% duty cycle and must be de-rated for DC operations, like motor control in stall or low RPM operation. By removing heat through both the OFF & ON switches, I_{DC} & I_{AC} ratings are the same, with no de-rating is required.
4) Package Loop Inductance & Resistance is virtually eliminated (L ≤ 0.1 nH) with Vertical/Stack structures. The higher power-densities/smaller packages allow tighter packing, minimizing system interconnects, further reducing inductance & resistance.
5) Die on both sides of leadframe balances CTE mismatch between die & leadframe, minimizing warpage during die attach & operation. The balanced CTE enhances both assembly yields and reliability, making larger die possible. Leadframe & multiple die pads are essential tools to reduce stresses & warpage.

Enhanced Type IV Performance & Efficiency

The much lower Rjc(max) reduces Tj(operation), significantly reduces Rds(on) in today's WBG devices, and improving overall efficiency. A much lower loop inductance further increases switching efficiency.

When Tj(operation) is reduced for SiC from 175°C to 150°C, conventional Pb-free (Sn/Ag) solders are suitable for die attach. These soft solders develop less stress during solder processing and operation. Using standard QFN solders is simpler, requiring minimal process/material development. In principle, Sintered-Ag and Sintered-Cu die attach are possible for µMaxPak assembly but require additional design, process, and equipment development.

Long-term, Sintered-Ag and Sintered-Cu die attach for higher temperatures (Tj) SiC die attach at higher power levels. Locomotive traction and EV applications are already using Sintered-Ag die attach.

Estimated potential current ratings for Type IV HB switches vary with SiC performance, operating condition, manufacturers, and other factors. To get an approximate quantitative feel for what is possible for Type IV µMaxPak near chip-scale half-bridges products, estimates were made based SiC die sizes, Tj(operation)=150°C, Tj(max)=175°C, 99.5% efficiency @ Tj=150°C, and maximum SiC current densities for 650V and 1200V SiC. See estimates in Table 1.

Inverter Architecture with Type IV µMaxPak Half-Bridges

The µMaxPak Half-Bridge is a Double-Sided Near Chip-Scale SMD package, ideally enabling maximum system integration, providing the highest system power-density, and minimizing system parasitics, cost, size & weight. Since product applications and power levels dictate much of the systems, systems are outside the scope of this article. Still, it is possible to show some structure and process examples. Type IV µMaxPak can use SMD assembly on Power PCBs, but at higher power levels discussed herein, µMaxPaks will require assembly on DBC substrates with large heatsinks or cold-plates. DBC/AMB substrates provide HV isolation and the highest power dissipation. Power dissipation is primarily a function of thermal conductivity of DBC/AMB ceramic substrate materials (A2O3, Si3N4, or AlN) with ceramic area and thickness determining thermal resistance, case-to-sink. WBG die in µMaxPak packages generally uses smaller DBC substrates, which can often be thinner than in larger conventional modules. Thinner Ceramics reduce thermal resistance and material costs.

Power PCB are easier to assemble & interface, resulting in lower costs and easier integration. DBC substrate can provide the lowest thermal resistance but increase assembly complexity & costs. Figure 7 illustrates a single phase cross-section with Type IV µMaxPak HB (1/3 Inverter), an example of a higher power Type IV µMaxPak HB system architecture. Although 3Ø Inverter integration is possible with DBC Modules, µMaxPak packages can enable much more complex and complete system architecture, ideally with No internal Screw Terminals. Only entry & exit to the System-Enclosure would have screw terminals. Examples of such "System Enclosures" are common for EV Motor-Drives. These system boxes are large because they contain large modules with redundant internal terminals and other unnecessary mechanical structures.

Type IV µMaxPak HB and Systems described in this article assume the use of common Pb-free (Sn/Ag) solders, which can enable SiC Tj(continuous) to 150°C and Tj(max) to 175°C. Lead-free solders are ideal for many SiC & GaN power products today, with SiC Rds(on) increasing significantly above Tj=150°C. That said, very high power SiC product for applications like EV & locomotive traction already operate with higher Tj, and Tj(max) will increase as power WBG devices evolve. Higher power devices will require higher temperature die attach & package solders/materials. Sintered-Ag & Sintered-Cu are already being used for higher temperatures. These materials are compatible with µMaxPak, but require processes & equipment development.

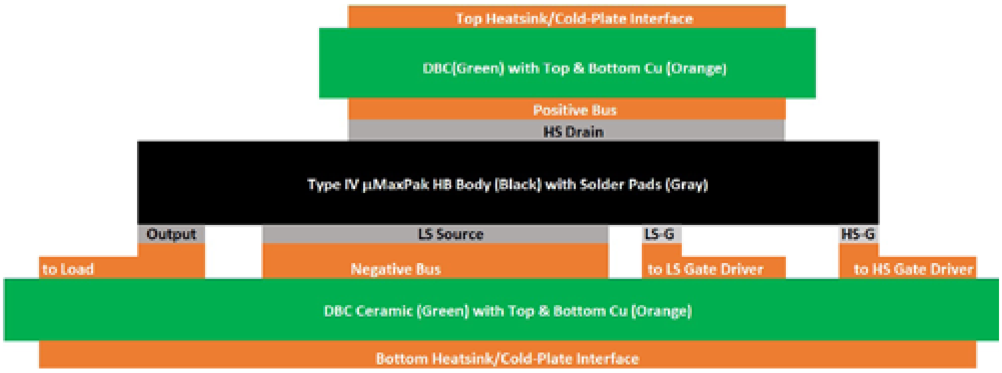

Figure 7: 1/3 Inverter with Type IV µMaxPak HB

High power-density µMaxPak enables much higher system packing density, with corresponding no leads, no wire bond, and no internal screw-terminals. These µMaxPak chip-scale SMD packages allow improvements to systems, often exceed power-density, performance, parasitics, and efficiency advantages of the µMaxPaks themselves. And significantly reduce system complexity, cost & size.

Inevitability – The long game may well be sooner than we think!
Today's Power WBG devices are evolving quickly, but products do not always keep pace. We get excited about gains relative to silicon devices, blinding us to how far we fall short of real WBG potential. Some of today's short-fall results from not selecting the best circuit topology for WBG devices, but much of the short-fall belongs to basic package parasitics and limitations.

Near Chip-Scale packages are Inevitable for Power WBG devices and a big step for Traditional Power mindset and infrastructure. Traditionally modules & systems were developed for high-voltage (HV) SCR, Thyristor, and Diode switches & bridges. These packages adapted easily to High voltage IGBT & MOSFET products. These newer Si Semiconductors improved performance and efficiency with minimum module changes, and manufacturing equipment & tooling was expensive and had proven reliability. As HV IGBT device performance, speed & efficiency increased, there were continuous incremental improvements. Although bulky and costly, these refined modules did not significantly reduce IGBT performance & reliability but pushed the limits. Power WBG (SiC & GaN) are not incremental changes and require near chip-scale packages with today's power WBG devices, and they are still evolving!

1) WBG die power density is an order-of-magnitude larger than Si die, or the die is an order-of-magnitude smaller. Power dissipation from such a small die is difficult, even if losses are reduced by 80%. Power dissipation from both sides of the die in Type I & II is helpful but insufficient in higher power products like EV and Locomotive Traction. The µMaxPak Types III & IV are necessary to remove the heat from the top & bottom of the packages.
2) Switching speeds can be a few orders of magnitude higher, requiring much lower loop-inductance and common-source inductance. The µMaxPak virtually eliminates package inductance by eliminating leads & wire bonds and enabling die to be placed closer in the package, making the end-system Much smaller.
3) Near chip-scale SMD packages reduce package and system assembly material, labor & tooling costs, and small low-profile SMD components & connectors, making systems easier to coat or pot for HV isolation, and for environmental protection.
4) Smaller size not only improves system performance, efficiency & cost, but smaller and lighter is always an advantage, especially for applications like EV & Locomotive.

The higher the power levels, the bigger payback for more efficient power Near Chip-Scale packages. However, new approaches take time for development and acceptance, especially when devices, packages, system, and application changes must occur simultaneously.

After many years designing, qualifying & manufacturing high-power IGBT modules, and designing over 100 custom QFN & LGA packages for high-power, high-voltage, RF & multi-chip products, it was clear to the author that QFN & LGA packages are a proven, flexible and economical technology platform for high power WBG µMaxPak technology is a practical implementation of near chip-scale QFN technology to replace traditional Silicon power modules.

For time to market and marketability based on proven working product, the author advises starting with the Type I & II µMaxPaks; to quickly develop industrial products, experience & confidence, and then extend it to Type III & IV higher power Industrial products and EV Traction. Pb-free (Sn/Ag) soft-solders are the most logical place to start, but as SiC moves to higher operating temperatures, Sintered-Ag or Sintered-Cu die attach will replace soft solders.

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Description of a Wrong Way

In the years 2004 to 2006 TRIDELTA Weichferrite GmbH came up with the idea of producing a ferrite material made of crushed and ground ferrite respectively, similar to iron powder materials. The idea was, since ferrite has lower losses than iron powder under the same drive conditions, to produce small cores from such material or to use this material in air gaps of cores for fringing field minimization. Furthermore it could be used for shielding.

By Klaus Seitenbecher

The material MFP (Manganese-Zinc Ferrite Powder) has been patented [1].

In order to investigate the influence of MFP material for use in air gaps to reduce the leakage flux [2], EF 25/13/7 made of Manifer 198 of the production lots 07/B17/14 and 07/B17/15 were selected in such a way that the corresponding gapless pairs of cores had approximately the same losses. These pairs were labeled according to the production lot and measuring pair.

14/6 (production lot 07/B17/14, core pair 6)

15/2 (production lot 07/B17/15, core pair 2)

15/3 (production lot 07/B17/15, core pair 3)

15/8 (production lot 07/B17/15, core pair 8)

The pair 15/10 (production lot 07/B17/15, core pair 10) was available as a reserve.

Table 1 shows the measured values of the specific core losses and B (250) in mT for the core pairs above.

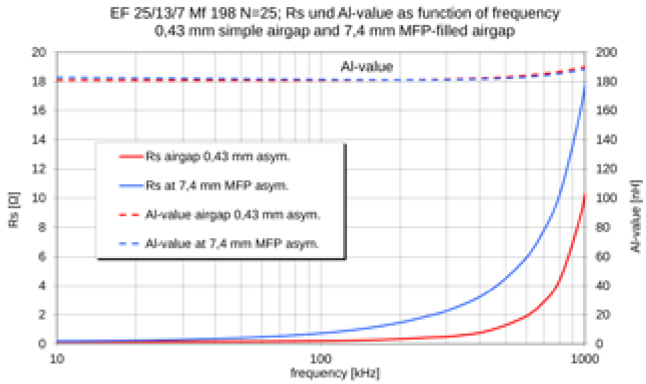

Figure 1: A_L - value and the serial loss resistance R_S

	B (250)	P_V [mW/cm³]			B (250)	P_V [mW/cm³]			
Core pair	25 °C	16 kHz 200 mT 25 °C	25 kHz 200 mT 25 °C		100 °C	16 kHz 200 mT 100 °C	25 kHz 200 mT 100 °C	100 kHz 200 mT 100 °C	100 kHz 100 mT 100 °C
14/6	437	89,5	146,6		362	60,9	102,5	639,1	95,8
15/2	446	82,7	135,1		361	59,2	100,4	636,5	93,9
15/3	446	83,2	136,2		366	59,8	101,4	638,8	93,5
15/8	440	88,3	143,3		359	62,8	104,4	643,1	96,2
15/10	442	88,8	144,2		364	60,3	101,3	628,8	92,5

Table 1: Maesured values of ungapped core pairs

For further consideration, the values marked in blue are of interest.

MFP 20 with PTFE binder was used as filling material for the air gap. The specific resistance at room temperature is 14 ohmmeters for this material.

Preparation of the samples

In one core of the pairs 14/6 and 15/2 an air gap of 7,4 mm was ground, the other core of the pair remained without air gap. MFP 20 material was glued into the air gap, after which the two cores were ground again. The measurement of the A_L - value for the asymmetrically MFP-equipped pairs yielded about 180 nH. The calculation for the air gap with the same A_L - value gives approximately 0,39 mm total air gap for the EF 25/13/7. In one core of the pairs 15/3 and 15/8 this airgap was ground and the A_L value measured. The airgap was finally ground to 0,43 mm, which also resulted in an A_L value of 180 nH.

Figure 1 shows the A_L - value and the serial loss resistance R_S as a function of the frequency for both variants. The A_L - value behavior is the same for both variants, but the loss resistance is much higher for the set with inserted MFP than for the set only with air gap, even at low frequencies.

Core pair	B (250) [mT] 25 °C	B (250) [mT] 25 °C	B (250) [mT] 25 °C		B (250) [mT] 100 °C	B (250) [mT] 100 °C	B (250) [mT] 100 °C
	airgap=0 mm	MFP=7,4 mm	airgap=0,43 mm		airgap=0 mm	MFP=7,4 mm	airgap=0,43 mm
14/6	437	62			362	66	
15/2	446	61			361	65	
15/3	446		52		366		52
15/8	440		52		359		52

Table 2: Measured flux density B at 250 A/m of core pairs with air gaps and inserted MFP material

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In the following tables, the values marked in blue are the original values of the core pairs without an air gap.

In Table 2 the measured values of B(250) = f(H=250 A/m) of the core pairs with MFP and only with air gap are shown. As supposed, the flux densities with MFP as air gap substitute and only with air gap are much smaller than with the core pairs only with ground contact air gap. Due to the MFP material, the flux density is still slightly higher than for the core pairs only with air gap.

Coil	DC - resistance at 25 °C [Ω]	DC - resistance at 100 °C [Ω]
1	0,207	0,266
2	0,20	0,254
3	0,192	0,242
4	0,193	0,240

Table 4: Coil DC resistance

Core pair	P_V [mW/cm³] 100 kHz, 100 mT 25 °C	P_V [mW/cm³] 100 kHz, 100 mT 25 °C		P_V [mW/cm³] 100 kHz, 100 mT 100 °C	P_V [mW/cm³] 100 kHz, 100 mT 100 °C	P_V [mW/cm³] 100 kHz, 100 mT 100 °C
	MFP=7,4 mm	airgap=0,43 mm		airgap=0 mm	MFP=7,4 mm	airgap=0,43 mm
14/6	1415			95,8	1375	
15/2	1447			93,9	1428	
15/3		222		93,5		171
15/8		228		96,2		169

Table 3: Measured losses of core pairs with air gaps and inserted MFP material

Core pair	P_V [mW/cm³] 100 kHz, 100 mT 100 °C	P[W]/pair 100 kHz, 100 mT 100 °C	μ_a 100 kHz, 100 mT 100 °C	I_{RMS} [A] 100 kHz, 100 mT 100 °C	$R_=$ [Ohm] Measuring Coil	Ohmic losses of the coil
	airgap=0	airgap=0	airgap=0	airgap=0	100 °C	[W]
14/6	95,8	0,286	2430	0,0535	0,266	0,00076
15/2	93,9	0,281	2770	0,0470	0,254	0,00056
15/3	93,5	0,279	2580	0,0504	0,242	0,00061
15/8	96,2	0,288	2180	0,0597	0,240	0,00086

Table 5: Maesured losses of ungapped core pairs and coil losses

Values with air gap or MFP in the air gap

Losses at 100 °C

Core pair	P_V [mW/cm³] 100 kHz, 100 mT 100 °C	P[W] 100 kHz, 100 mT 100 °C	μ_a 100 kHz, 100 mT 100 °C	I_{RMS} [A] 100 kHz, 100 mT 100 °C]	$R_=$ [Ohm] Measuring Coil	Ohmic losses of the coil
					100 °C	[W]
14/6 **MFP**	1375,3	4,112	210	0,620	0,266	0,102
15/2 **MFP**	1428,1	4,270	210	0,620	0,254	0,098
15/3 **LS 0,43**	170,6	0,510	170	0,765	0,242	0,142
15/8 **LS 0,43**	168,9	0,505	170	0,765	0,240	0,140

Table 6: Measured losses of core pairs with air gaps and inserted MFP material and coil losses at 100 °C

Cores with MFP=7,4mm Mean P = 4,191 W P (winding) = 0,10 W Loss ratio = **2,39%**
Cores with airgap=0,43mm Mean P = 0,508 W P (winding) = 0,142 W Loss ratio = **28,0%**

Losses at 25 °C

Core pair	P_V [mW/cm³] 100 kHz, 100 mT 25 °C	P[W] 100 kHz, 100 mT 25 °C	μ_a 100 kHz, 100 mT 25 °C	I_{RMS} [A] 100 kHz, 100 mT 25 °C	$R_=$ [Ohm] Measuring Coil	Ohmic losses of the coil
					25 °C	[W]
14/6 **MFP**	1415,1	4,231	210	0,620	0,207	0,0796
15/2 **MFP**	1447,2	4,327	200	0,651	0,20	0,0848
15/3 LS 0,43	221,7	0,663	170	0,765	0,192	0,112
15/8 LS 0,43	228,4	0,683	170	0,765	0,193	0,113

Table 7: Measured losses of core pairs with air gaps and inserted MFP material and coil losses at 25 °C

Cores with MFP = 7,4mm Mean P = 4,279 W P (winding) = 0,082 W Loss ratio = **1,92%**
Cores with airgap = 0,43mm Mean P = 0,673 W P (winding) = 0,113 W Loss ratio = **16,8%**

A real surprise was the measurement of the core losses, although relatively high losses in the MFP could already be expected by the R_S measurement (see figure 1).

Estimation of the ratio of ohmic losses of winding in total losses

The losses were measured with special measuring coils with 25 turns. These 4 coils were connected with short supply cables at a measuring adapter, which made it possible to measure even in the furnace at 100 °C. Table 4 shows the DC resistance of the measuring coils with N=25 including the supply cables of the measuring adapter.

The upper limit value of losses for 100 kHz, 100 mT, 100 °C (130 mW/cm³) for the core EF 25/13/7 Mf 198 only with ground contact air gap is 0.39 W / set.

To illustrate the high losses of the material MFP, the hysteresis loop on toroidal cores made of Manifer 198 and MFP was recorded with a measuring setup of Dr. Brockhaus Messtechnik, Lüdenscheid. Figure 2 shows these hysteresis loops.

Since the area of the hysteresis loop is a measure of the losses, it turns out that MFP must have much higher losses than solid Manifer 198, from which the material MFP was made. To substantiate this once again, our measuring technician, Mr. Andratschke, had the idea to prove this also calorimetrically. For this purpose, ring cores made of Mf 198, of MFP10, as well as of Pertinax with the same dimensions 25x15x10 were produced. All three ring cores were wound with 10 turns of the same stranded wire and length. The ferrite and MFP rings were controlled for 15 minutes in a small polystyrene measuring chamber with 100 kHz and 20 mT.

Parameter	Core pair with MFP=7,4mm	Core pair with airgap=0,43mm	Measuring conditions
P_V [mW/cm³]	1431	225	100 kHz, 100 mT, 25 °C
P [W]	4,279	0,673	100 kHz, 100 mT, 25 °C
P without coil losses [W]	**4,197**	**0,56**	**100 kHz, 100 mT, 25 °C**
P_V [mW/cm³]	1402	170	100 kHz, 100 mT, 100 °C
P [W]	4,191	0,508	100 kHz, 100 mT, 100 °C
P without coil losses [W]	**4,091**	**0,366**	**100 kHz, 100 mT, 100 °C**

Table 8: Measured losses of core pairs with air gaps and inserted MFP material without coil losses

The average of the losses of the 4 samples is P = 0,283 W. The mean value of the ohmic losses of the coil is P = 0,000697 W. The ratio of the total losses is approximately **0.25%**.

Evaluation of the results

The core losses increase by inserting an air gap of 0.43 mm into the core set from P = 0.284 W to P = 0.366 W (100 kHz, 100 mT, 100 °C). These values are the mean values of core pairs 15/3 and 15/8. This is a 25% increase in losses in relation to the losses at the core pairs without airgap. This can be explained by the demagnetization factor of the core pair by inserting the air gap.

At the beginning of the measurement t=0 min as well as t=5 min, t=10 min and t=15 min the chamber temperature, the total losses and the RMS current I_{RMS} were measured. To determine the influence of the temperature increase through the wire winding, a test ring made from the non-magnetizable fiber composite Pertinax with the same dimensions was made and wound with 10 turns of the same stranded wire and length. Then it was energized at 100kHz with the same RMS current I_{RMS} as in the MFP measurement in the temperature chamber for 15 min. Here also the influence of the frequency on the wire losses could be determined.

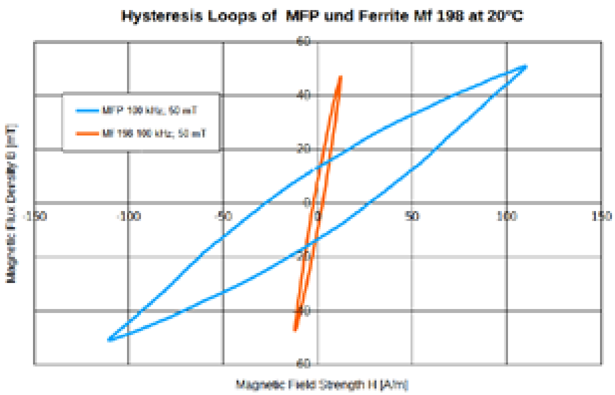

Figure 2: Hysteresis loops of MFP and Manifer 198

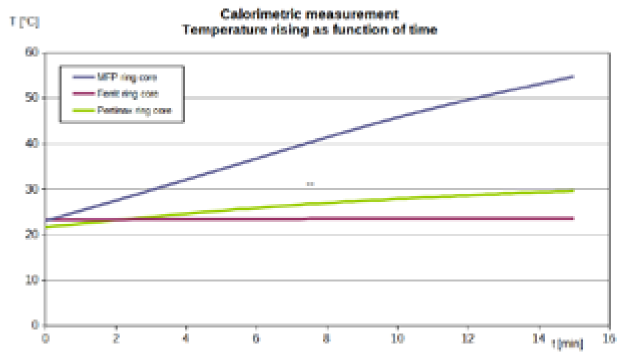

Figure 3: Results of calorimetric measurement

	Ring made of Manifer 198			Ring made of MFP µ=10			Ring made of Pertinax		
t [min]	T [°C]	I_{RMS} [A]	P_{Core} [W]	T [°C]	I_{RMS} [A]	P_{MFP} [W]	T [°C]	I_{RMS} [A]	P_{Cu} [W]
0	23,3	0,0254	0,0106	23,1	3,879	1,371	21,7	3,8	0,464
5	23,5	0,0258	0,0100	34,4	3,828	1,399	25,3	3,8	0,470
10	23,6	0,0258	0,0099	45,8	3,778	1,453	27,9	3,8	0,475
15	23,7	0,0258	0,0098	54,8	3,698	1,512	29,7	3,8	0,478

Table 9: Values of calorimetric measurement

The DC resistance of the winding at 23 °C was R_{Cu} = 0.0325 Ω. The core losses P_{Core} shown in Table 9 are calculated from measured losses minus copper losses $P_{Core} = P_{measured} - R_{Cu} \times I_{RMS}{}^2$.

The result is shown in Table 9 and Figure 3.

The temperature in the measuring chamber rose from 23.3 °C to 23.7 °C during ferrite ring measurement. This means that it has remained almost the same due to the losses of core and winding. The situation is different with the MFP. Here the temperature rose from 23.1 °C to 54.8 °C during the measurement. To estimate the influence of the 10 turns winding on the temperature increase, the same-wound Pertinax ring was operated with the same effective current as the MFP ring. There was a temperature increase of 8 °C. At the beginning of the measurement, the MFP had about 130 times the losses of the ferrite material Mf 198, from which MFP was produced.

Artikel-Nr.	Beschreibung	H_C [A/m]
2077	MnZn-Ferrit, crushed and ground [6]	1500
2077	MnZn-Ferrit, ground, sintered again, measured as a small piece *)	51
2077	The above piece ground in a mortar with a pestle to powder	110
1050	MnZn-Ferrit, jaw crushed [5], sieved > 2,5 mm	24
1050	MnZn-Ferrit, jaw crushed, sieved 0,7 mm - 2,5 mm	34
1050	MnZn-Ferrit, jaw crushed, sieved < 0,7 mm	81
1050	MnZn-Ferrit, jaw crushed, sieved > 2,5 mm, sintered again	21
1050	MnZn-Ferrit, jaw crushed, sieved 0,7 mm - 2,5 mm, sintered again	24
1050	MnZn-Ferrit, jaw crushed, sieved < 0,7 mm, sintered again	45
	Sintered pressing granule	15

Table 10: Coercive field strength of different crushed materials

Why are MFP losses higher than ferrite losses?

Coercive field strength

The material MFP or other materials witch are produced by injection moulding or casting of ferrite are made of broken and/or ground sintered ferrite. For this purpose, manganese-zinc ferrite waste is usually used. By crushing the ferrite in the jaw crusher or grinding/milling in a mill, that can be used for ceramics, a very large amount of energy is supplied to the material. The more the material is crushed or milled, the higher the energy input. This is reflected in an increase in the coercive field strength of the material. In addition, the MFP material is pressed again during production. This will probably also lead to a further increase in coercive field strength and thus to higher losses.

In the development report [3] on the material development of MFP, the ferrite fragments crushed in the jaw crusher and classified by sieve analysis were measured in a Förster coercimeter. Figure 4 shows the dependence of the coercive field strength on the size of the fragments. Investigations on this were also carried out in August 2012 by M. Becker in an internship and described in the corresponding internship report [4]. The measurement of the coercive field strength on sintered press granules of the two size classes 125 - 250 microns and 250 - 315 microns yielded 21 A/m each.

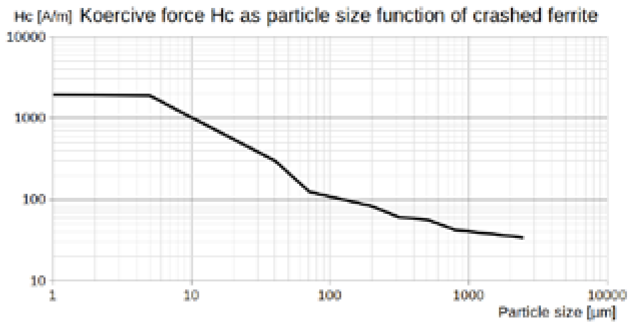

Figure 4: Coercive field strength as function of particle size

To corroborate this, the TRIDELTA Weichferrite GmbH MnZn ferrite powder grades with article numbers 1050 and 2077 [5][6] were measured (look at Table 10).

*) When the ground ferrite (2077) is sintered again under the sintering conditions of MnZn-power ferrite, it sinters together as one or more pieces and is no longer a powder. For the H_C measurement such a piece was used. Table 10 shows, that the coercive field strength can be drastically reduced by sintering a ground or crushed material again.

Demagnetization factor

But also products produced by injection moulding or casting of again sintered crushed MnZn ferrite have much higher losses than the original ferrite. The reason for this is the demagnetization factor [7] [8] of the individual ferrite fragments in these parts.

Summary

Products, e.g. chokes or parts for contactless energy transmission, which are produced by pressing, casting or injection moulding of crushed MnZn ferrite, have a partly much higher coercive field strength H_C than the original ferrite due to the energy input during the crushing/milling process. The demagnetization factor of the individual particles, which depends on the shape of the particles, their position inside the product and the course of the field in the product outside the ferrite particles, is also detrimental. Both significantly increase losses compared to the massive ferrite under equal control conditions.

However, there is another problem for such products. As MnZn-Ferrit is not registered as substance with Helsinki-based ECHA, the large-scale manufacture of products made of crushed or ground ferrite material is in breach of the European Union's REACH Regulation.

Literature:

[1] Patent DE102008026887A1
[2] Entwicklungsbericht TWKA 2008-04, TRIDELTA Weichferrite GmbH
[3] Entwicklungsbericht TWK 04 0008, TRIDELTA Weichferrite GmbH
[4] Praktikumsbericht TWK 11 0012 M. Becker, TRIDELTA Weichferrite GmbH
[5] Datenblatt MnZn-Ferritpulver-gebrochen 1050 TRIDELTA Weichferrite GmbH
[6] Datenblatt MnZn-Ferritpulver-gemahlen 2077 TRIDELTA Weichferrite GmbH
[7] E. C. Snelling: Soft Ferrites, Properties and Applications
[8] Richard Boll: Weichmagnetische Werkstoffe

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Technology for 150V GaN HEMT Devices

ROHM developed an 8V gate breakdown voltage (rated gate-source voltage) technology for 150V GaN HEMT devices – optimized for power supply circuits in industrial and communication equipment.

Existing GaN devices with a withstand voltage of 200V or less typically have a rated gate-source voltage of 6V with respect to a gate drive voltage of 5V, resulting in an extremely narrow voltage margin of just 1V. Exceeding the rated voltage can cause reliability problems such as degradation and destruction, plus the gate drive voltage requires high accuracy control, which has been a major obstacle to the widespread application of GaN devices. In response, ROHM succeeded in raising the rated gate-source voltage from the typical 6V to 8V by adopting an original structure. This triples the voltage margin during device operation, so even if a voltage overshoot exceeding 6V occurs during switching, the device will not degrade, contributing to higher reliability of the power supply circuit. ROHM's GaN device utilizes a versatile package that delivers superior heat dissipation with a proven track record for reliability and mountability. This enables easy replacement of existing silicon devices and simplifies handling during the mounting process. Furthermore, using copper clip junction packaging technology reduces

parasitic inductance by 55% over conventional packages, maximizing device performance when designing circuits for high frequency operation.

www.rohm.com

MOSFET Qualified for Commercial and Military Satellites and Space Power Solutions

Microchip Technology announced the qualification of its M6 MRH25N12U3 radiation-hardened 250V, 0.21 Ohm Rds(on), metal–oxide–semiconductor field-effect transistor (MOSFET) for commercial aerospace and defense space applications. The MOSFET withstands the harsh environments of space, extends reliability of power circuitry and meets all requirements of MIL-PRF19500/746 with enhanced performance. Microchip completed testing for

Defense Logistics Agency (DLA) review and qualification, for the device's sourcing in the U.S. military supply chain (expected JANSR2N7593U3 certification in June 2021). The M6 MRH25N12U3 MOSFET is designed for future satellite system designs as well as serving as an alternate source in existing systems. It can withstand total ionizing dose (TID) up to 100 krad and 300 krad and single event effects (SEE) with linear energy transfer (LET) up to 87 MeV/mg/cm2. It provides 100-percent wafer lot radiation hardness assurance in validation tests.

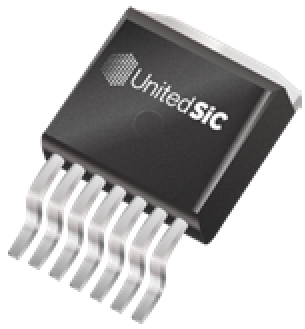
"Microchip's entry into the radiation-hardened MOSFET market reflects our long-term commitment to support our customer base and provide aerospace and defense OEMs and integrators with high-performance solutions and continuous supply," said Leon Gross, vice president of Microchip's Discrete Product Group business unit. "In addition to our proven quality and reliability, the M6 MRH25N12U3 provides a value pricing option for developers and offers them full application support."

www.microchip.com

SiC FETs in Industry Standard Surface Mount Package

UnitedSiC continues to expand its FET portfolio with the introduction of six 650V and 1200V options, all housed in the industry standard D2PAK-7L surface mount package. Available in 30, 40, 80 and 150mΩ versions, these latest SiC FETs represent another step forward in accelerating migration to SiC across applications such as server and telecom power supplies, industrial battery chargers and power supplies, EV on-board chargers and DC-DC converters. The D2PAK-7L SiC FETs support significantly heightened switching speeds, with a Kelvin source connection improving gate drive return performance, as well as offering industry-leading thermal capabilities. Through the utilization of Ag Sintering, die attachments can be done on conventional PCBs as well as complex insulated metal substrate (IMS) arrangements. In addition, they exhibit excellent creepage and clearance figures of 6.7mm and 6.1mm respectively – meaning the highest degrees of operational safety can be assured even at elevated voltages.

"Through the fast switching capabilities of these latest FETs, alongside the superior thermal performance resulting from Ag sintering, we continue to bring performance, reliability, size and layout benefits to the power designer," states Anup Bhalla, VP Engineering at UnitedSiC.



The D2PAK-7L devices are fully supported by UnitedSiC's FET-Jet Calculator™. Utilizing this free online resource, engineers can assess the different operational parameters needed for their application, carry out detailed performance comparisons and then identify which is the best SiC solution for their design requirements quickly and with confidence.

www.unitedsic.com

Reference Design Demonstrates Heatsink-Free 250W Resonant Converter

STMicroelectronics has released the first reference design for its MasterGaN power packages, demonstrating how the highly integrated devices increase power density, boost energy efficiency, simplify design, and accelerate time to market. The EVLMG1-250WLLC reference design is a 250W resonant converter with a 100mm x 60mm board outline and 35mm maximum component height. It features the MasterGaN1, which contains one half-bridge STDRIVE gate driver optimally connected to two 650V normally-off GaN transistors with matched timing parameters, 150mΩ on-resistance (Rds(on)), and 10A maximum current rating. The logic inputs are compatible with signals from 3.3V to 15V.

MasterGaN1 is suitable for high-efficiency soft-switching topologies including resonant converters, active clamp flyback or forward converters and bridgeless totem-pole PFC (power-factor correction) in AC/DC power supplies, DC/DC converters, and DC/AC inverters up to 400W.

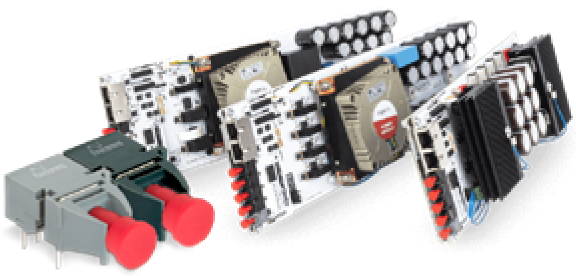
The primary side runs heatsink-free, leveraging the high efficiency of the GaN power transistors. In addition, GaN's superior switching performance allows a higher operating frequency than ordinary silicon MOSFETs, permitting smaller magnetic components and capacitors for greater power density and reduced bill of materials. Designed for a nominal 400V supply, the EVLMG1-250WLLC provides a 24V/10A output and achieves maximum efficiency above 94%. Benefiting from MasterGaN's integrated safety features, the converter output is protected against short circuit and overcurrent. There is also brown-out protection and an input-voltage monitor that permits sequencing within an array of DC/DC converters and prevents a motor from starting under low-voltage conditions.

www.st.com

Wide-Bandgap Power Converters with Inverter Development Modules

Imperix is glad to announce the implementation of the RedLink® product range from Firecomms. Imperix has grown a multi-disciplinary product portfolio on inverter modules and high-performance controllers. Such modularity brings many challenges at managing the galvanic isolation throughout the setup while complying with the various sources of EMI-induced perturbations.

Firecomms' long-term cooperation with Imperix fostered the implementation of the high-speed version Redlink transceivers within Imperix's Silicon-carbide power modules range. The high-speed, low Pulse Width Distortion (PWD), robust EMI performance, and low propagation delay skew of the 50 MBd RedLink transceivers provide simple, reliable, and galvanically isolated transmission of switching and fault signals while maintaining the time resolution provided by the Imperix B-Box RCP power electronics controller. Thanks to the simplicity and modularity provided by Imperix products supported by Firecomms technologies, the development of Silicon-carbide power inverters and drives is within reach of every electrical engineer.



"We're glad to see that our industry-proven optical communication technologies thanks to Imperix products, can accommodate and accelerate the R&D of modern converters", says Michael O'Gorman, Head of Product Development at Firecomms.
Simon Delalay, Managing Director at Imperix adds, "Thanks to Firecomms products, our customers are definitely able to develop wide-bandgap inverters as they would play with LEGO blocks".

www.imperix.com

HITACHI ABB POWER GRIDS

NEW SIC LINPAK BOOSTING THE EFFICIENCY OF HIGH-POWER APPLICATIONS

Hitachi ABB Power Grids extends the well-established LinPak family with devices based on SiC technology to deliver the highest current rating. Available at 1700 V and 3300 V, the SiC LinPak offers several benefits, including a massive reduction of switching losses, increased current density in the lowest inductance package of its class.

ABB is a registered trademark of ABB Asea Brown Boveri Ltd.
Manufactured by/for a Hitachi Power Grids company.

350kW Planar Transformer

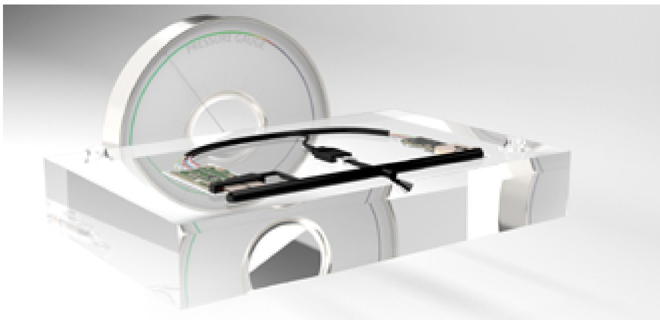
A high power design using 2 power sections of 175kW each for a total of 350kW output power. The topology is a full bridge with -55°C to 150°C operation. Power dissipation is less than 1400Watts with over 99.0% efficiency. Input voltage range is 700 to 900Vdc with output at 625V and 560Arms. Different terminal configurations can be made for a wide range of input and output voltages. Operating frequency is 50kHz with less than 1uH of leakage inductance. Is designed to be placed on a cooling plate for maximum mechanical and thermal performance. Size is L:400mm, W:400mm, H:70mm.

www.paytongroup.com

Low Pressure Molding Technology for Encapsulation of Electronics

Henkel's Low Pressure Molding technology for encapsulating electrical and electronic components in its Technomelt polyamide adhesive molding compounds is increasingly being adopted for medical, electronic components, power and industrial automation, HVAC and lighting applications. The technology offers numerous economic, process control, design and environmental advantages over alternative systems such as potting with reactive resin systems and high-pressure injection molding.

Technomelt Low Pressure Molding (LPM) technology was invented some 30 years ago by Henkel (formerly called Macromelt Molding). The technology enables the quick encapsulation of delicate components by using specialized polyamides in combination with standard processing equipment and low-cost molds. Because the material is injected at a lower pressure compared to conventional injection molding processes, and non-abrasive materials are used, risk of damage to the electronics during the encapsulation process is far lower.



The technology is particularly adept at encapsulating discrete areas in complicated assembly where wiring is attached to a printed circuit board (PCB), PCBAs and other rigid component. One reason for this is that Technomelt resins, which are all unfilled, are resistant to high stresses and at the same time very flexible.

www.henkel.com

One-step Ball Grid Array Ball-Attach Flux

Indium Corporation continues to expand its flux portfolio with WS-823—a proven, one-step ball grid array (BGA) ball-attach flux designed to eliminate the costly and warpage-inducing prefluxing step, especially on Cu-OSP substrate. While the standard ball-attach process requires two steps, especially on a Cu-OSP substrate, WS-823 is a halogen-free, water-wash flux designed for a single-step ball-attach process that eliminates the prefluxing step in order to create reliable ball-to-pad joints.

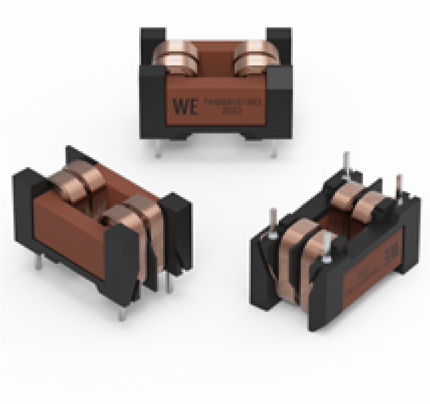
WS-823 provides:

- Tackiness suitable for holding solder spheres in place during reflow
- Solderability on a wide range of surfaces, including AuNi and oxidized Cu-OSP
- Uniform pin transfer over extended periods, eliminating changes in joint quality over time and uneven deposit sizes, which can lead to "missing ball"
- A formula engineered for low-voiding, thereby increasing joint strength
- Good cleanability with room temperature DI water, avoiding the formation of white residue

www.indium.com

Common Mode Chokes

Würth Elektronik is expanding its portfolio of common mode chokes with two models. The THT-mountable WE-FCLP for common-mode and differential-mode suppression, and the SMT data line and low-voltage common mode choke WE-CMDC. Both are available from stock without a minimum order quantity. The WE-FCLP has a compact design with a maximum height of 14.5 mm, yet achieves an inductance up to 100 mH. It can suppress common-mode interference up to 85 dB and, thanks to its high leakage inductance, it can be used not only for common-mode suppression but also for



differential-mode suppression. WE-FCLP is suitable for applications like mains-powered LED drivers, electronic ballasts, switch mode power supplies and mains filters. WE-CMDC is an AEC-Q200 Grade 1 qualified data line common mode choke. Measuring 11 × 12 × 6 mm, it is also very compact. The choke has a current-carrying capacity up to 8 A and is available with high impedances of 700, 1000 and 1500 ohms. In addition to data and signal lines, applications include low-voltage DC power supplies and DC/DC converters.

www.we-online.com

Solution for High-Performance GPUs, Server, 5G, and AI

Alpha and Omega Semiconductor announced a series of Smart Power Stages (SPS) targeting multiphase VR regulators powering high-performance GPU and CPU in desktop Add-In Graphics Cards (AICs), gaming laptops, servers, data storage, artificial intelligence, and networking equipment. The AOZ527xQI series uses AOS's latest generation of a flexible smart driver IC and Gen Alpha MOSFET technology to provide benchmark performance in an industry-standard 5mm x 6mm QFN package. The series comprises three DC current levels for multiphase voltage regulator optimization. An SPS provides current monitoring (IMON) and temperature monitoring (TMON) information. The IMON function is used to replace traditional DCR sensing schemes with improved accuracy and eliminates the external components needed for DCR sensing and tuning. The TMON pin doubles as a fault pin, reporting the power stage temperature by outputting an analog voltage of 8mV/°C. The TMON pin is an open-drain output that pulls high in the event of a fault. The AOZ527xQI uses a highly flexible and configurable driver IC to make this SPS compatible with many multiphase controllers in the market. It includes protection features such as Over-Current Protection (OCP), OverTemperature Protection (OTP), High-Side FET Source Detect (HSD), and Pre-Over-Voltage Protection (PreOVP).

www.aosmd.com

Air-Cooled Modular Power Supply

TDK Corporation announces the introduction of the TDK-Lambda brand TPF45000-385 non-isolated modular AC-DC power supply. Developed for use in distributed power architectures (DPA) and DC Microgrids, the 98% highly efficient TPF45000 provides a regulated 385Vdc output with a current of up to 117A. Low internal losses enables the use of cooling by fans, avoiding the complexity of water cooling. This industrial grade product is suitable for use in semiconductor test and burn in systems, LED based horticultural lighting and DC Microgrids. Comprising of up to ten 4.5kW modules, the series can deliver up to 45kW of output power in a less than 3U high package, and operates from a wide range Delta or Wye 360 - 528Vac three phase input. The unit can operate at full load in ambient temperatures from -10 to 50°C (-20°C start-up). The enclosure measures 450mm wide (excluding side rack mount flanges) 113mm high and has a depth of 533mm. The weight of the product is 30kg. The TPF45000 is fully featured with DC Good, dropped phase, over temperature and fault alarm signals, remote on/off and a 13 to 15V 0.5A auxiliary output. PMBus™ and USB communications interfaces allows remote monitoring of the input voltage, output voltage, output current, internal temperature, status signals and fan. In addition, the remote on/off can be programmed by the PMBus™. The power supply has 2kVac primary to ground isolation, is certified to IEC/EN/UL/CSA 62368-1 and carries the CE mark for the Low Voltage, EMC and RoHS Directives.

www.us.lambda.tdk.com

48V / 12V Bi-Directional DC-DC Converter

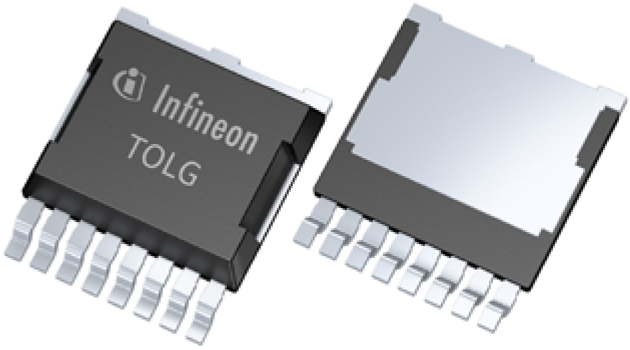
Delta recently unveiled its High Power Density Bi-Directional DC-DC Converter U50SU4P162 for data centers, super computers, and other high-tech systems. Emphasizing the requirement of high-efficiency, high-density data centers, the U50SU4P162 provides 48V / 12V bi-directional conversion, and features high power density of up to 3,000 W/inch3 with a small footprint (23*17.4*10 mm) and up to 98% conversion efficiency. The U50SU4P162 DC-DC Converter provides 48V / 12V bi-directional conversion, 800 W output power, and 1 MHz switching frequency. The ultra-high power density (up to 3,000 W/inch3) allows the U50SU4P162 to achieve 98% power conversion efficiency in a compact size of 23*17.4*10 mm. The ability of handling large load capacitance (up to 10,000 μF) and double-sided heat sink with low thermal resistance also help to ensure high-performance computing for high-density data centers. Another highlighted feature of the U50SU4P162 is the PMBus (power management bus) protocol. It allows the converter to transmit power data to system controllers for efficient monitoring and management. Delta is also outpacing others by offering customization services for power configuration and optional heat sinks to help customers build advanced systems.

With advanced functions, high power density, small footprint, and customizability, the U50SU4P162 ensures the high efficiency of data centers, super computers, and other high-tech systems.

www.delta-emea.com

Packages Offer Robustness and Thermal Performance

Applications such as e-scooters, e-forklifts and other light electric vehicles (LEVs), as well as power tools and battery management systems, demand high current rating, ruggedness and extended lifetime. Infineon Technologies addresses these requirements by offering more choices to power system designers to meet diverse design needs and achieve maximum performance in the smallest space. With the TO-Leadless (TOLL) package, Infineon now offers two OptiMOS™ power MOSFET packages in the TOLx family: TOLG (TO-Leaded with Gullwing leads) and TOLT (TO-Leaded Top-side cooling). Together, the TOLx family offers very low R DS(on) and a high-current rating over 300 A to increase system efficiency in high-power density designs.



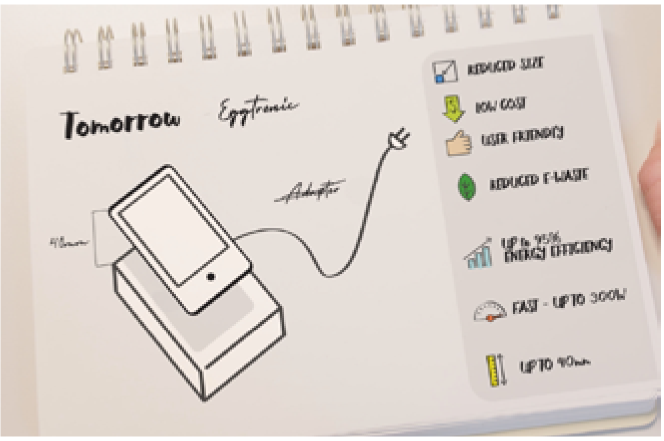
The TOLG package combines the best features of TOLL and D 2PAK 7-pin packages, sharing the same 10 x 11 mm 2 footprint and electrical performances as TOLL with added flexibility comparable to D 2PAK 7-pin. The main advantages of TOLG are particularly apparent in designs with aluminum-insulated metal substrate (Al-IMS) boards.

The TOLT package is optimized for superior thermal performance. Constructed with its lead-frame flipped to position exposed metal on the top side, the package contains multiple gullwing leads on each side for high current carrying drain and source connections. With a flipped lead-frame, heat passes from the exposed metal top side, through the insulating material, directly to the heatsink.

www.infineon.com

Wireless Power Supply Technology Offers a Route to Wireless Charging in Higher Power Applications

Eggtronic has announced E2WATT®, an AC power technology that will boost the power, efficiency, charging distance and data transmission capabilities of wireless charging applications. Offering efficiency comparable with the best conventional wired AC adapters, E2WATT provides the foundation for taking future mobile charging designs into new segments including laptops, AV equipment, and even home appliances and electric vehicles. Traditional Qi wireless power is limited by distance (usually 5 mm), and maximum power (usually up to 30 W). E2WATT technology reaches up eight times further (to 40 mm) and delivers up to 300 W - a real breakthrough for inductive standards. E2WATT wireless technology is powered directly from AC mains, without the need for an external power supply. The single-stage hybrid design minimizes losses compared with conventional double-stage wireless technologies to deliver significantly increased peak efficiencies of up to 95%.



"We developed the entire E2WATT wireless platform, from the concept to proprietary architecture and firmware, in order to overcome the limitations of standard AC power adapters and Qi wireless chargers, multiplying the number of applications and the usability of products based on Qi technology," said Igor Spinella, CEO and founder of Eggtronic.

"The industry-changing performance of E2WATT is enabled by the high-speed gallium nitride – or GaN – semiconductor technology used in GaNFast power ICs," added Stephen Oliver, VP Corporate Marketing at Navitas Semiconductor. "The Eggtronic team realized the limitations of legacy silicon chips and early discrete GaN with complex circuits and many discrete components. GaNFast power ICs are easy-to-use, 'digital-in, power-out' circuit building blocks which meant the expert team in Modena could focus on their proprietary, high-speed E2WATT topology and achieve a very fast time to market."

www.eggtronic.com

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POWERING INNOVATION – 5G AND BEYOND

The premier electronics manufacturing event in Southeast Asia, SEMICON Southeast Asia 2021, will be hosted on a virtual platform from 23-27 August. This 5-days virtual exhibition will incorporate a 3-days hybrid conference to be held in Singapore from 23-25 August.

Themed *Powering Innovation – 5G and Beyond*, SEMICON Southeast Asia 2021 will gather industry visionaries and experts to highlight the latest developments, innovations and trends in segments of electronics including Smart Manufacturing, Smart Mobility, Smart Data, AI and 5G as technology continues to reshape the way people work and live.

The virtual platform enable exhibitors to showcase technology and innovation, online networking, Meet the Experts sessions on key industry topics and a business-matching program.

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- **23-25 August 2021 – Hybrid Conference in Singapore**

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