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Electronics in Motion and Conversion

August 2018

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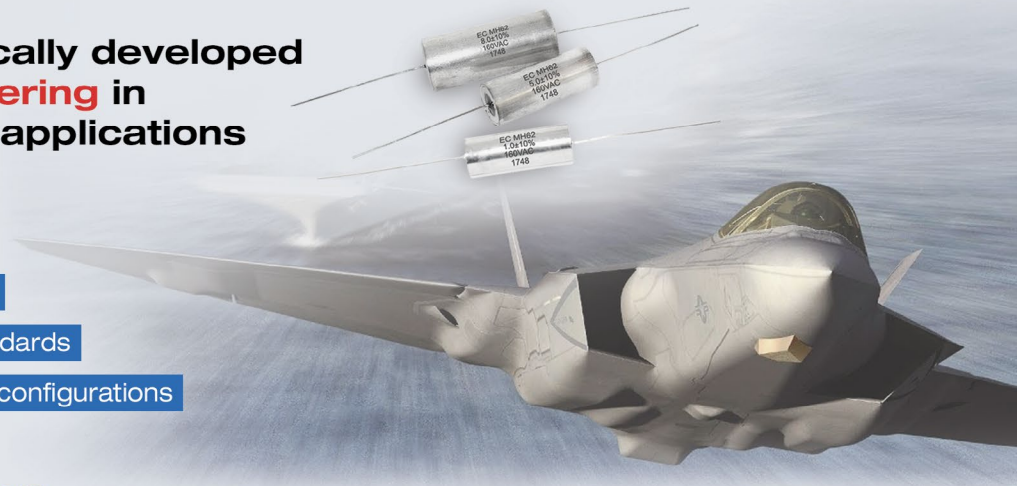

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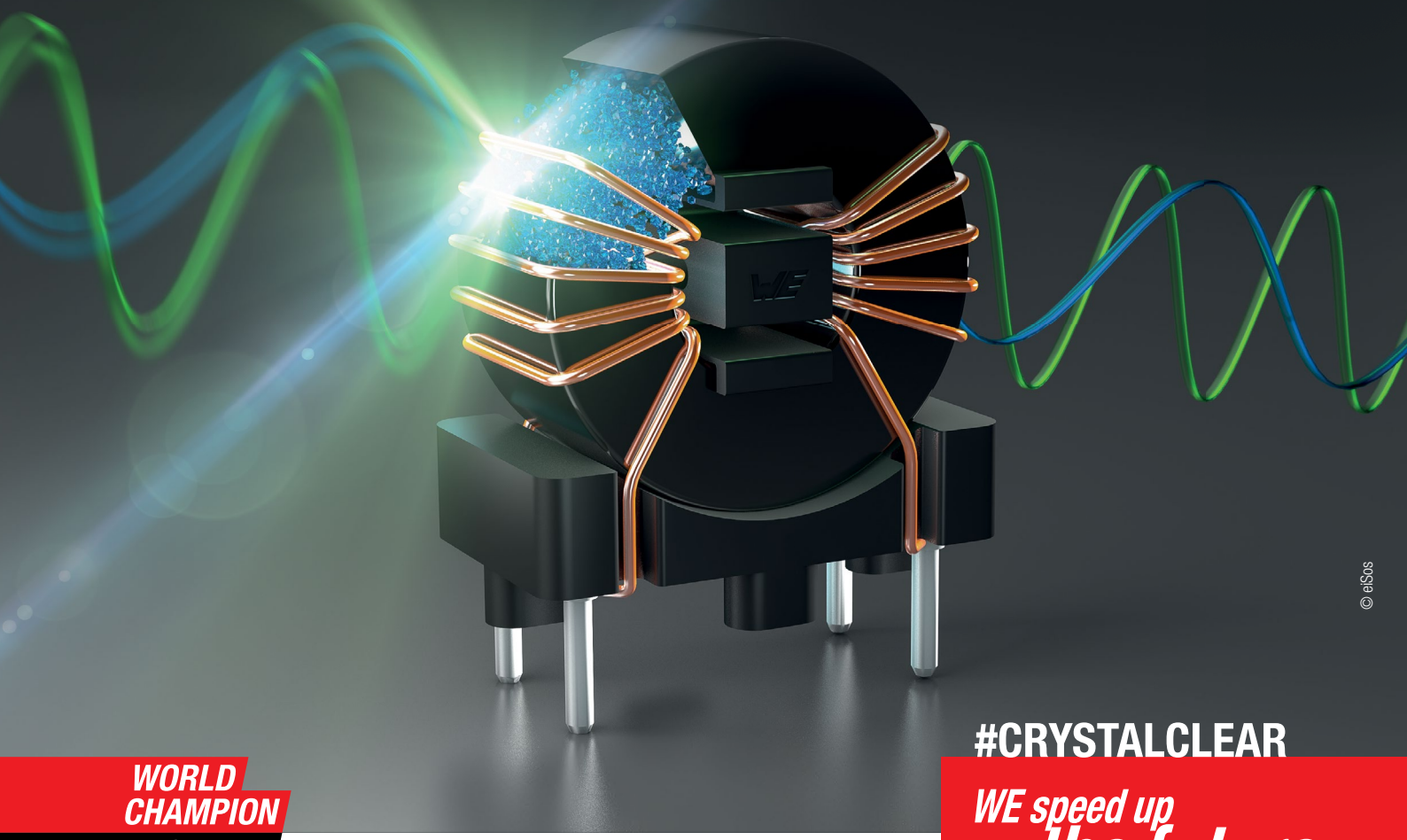
The Gallery

crystal clear
frequencies.

WÜRTH ELEKTRONIK



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NiZn
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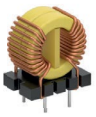
MnZn/NiZn
WE-ExB


Horizontal
WE-CMBH


High Voltage
WE-CMB HV

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Now it is Beach Time!

The weather in northern Germany has been perfect this year – we are enjoying the beach. With our new office so close, walking to work is a pleasure.

Harvesting energy in any form helps to increase efficiency. Heat itself can be a source of electrical generation. A thermoelectric generator based on half-Heusler material, a class of thermoelectric material discovered by scientists about 15 years ago, is ready for the market.

More details are in the Green Power of the Month section of the current issue.

We are starting to get ready for all the exciting conferences and exhibitions during autumn. Just to highlight a few from around the world with strong power relationships: first in September are EPE ECCE 2018 in Riga, Latvia and ECCE 2018 in Portland OR, USA; then LED Professional in Bregenz, Austria, ESREF in Aalborg, Denmark and Power Electronics in Moscow, Russia. My publication has partnered with all of these events to provide crucial information on new devices and designs, first hand.

Mark your calendar for the Wide Band Gap Conference in Munich on December 4th.

Building on last year's success, the program this year will continue and be strengthened in cooperation with ICC Media / AspenCore. See http://www.Power-Conference.com

www.bodospower.com

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 to serve North America more efficiently. If you are using any kind of tablet or smart phone, you will find all of 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 August:
Sit down in a typical German Baltic Beach Chair and make your phone calls fully relaxed. That is the new approach to a paperless office.

Best Regards

Events

Thermal Management 2018
Denver CO, USA, August 8-9
www.thermalconference.com

IEEE-PEMC 2018
Budapest, Hungary, August 26-30
www.ieee-pemc2018.org

ECSCRM 2018
Birmingham, UK, September 2-6
www.ecscrm.org

SEMICON Taiwan 2018
Taipei, Taiwan, September 5-7
www.semicontaiwan.org

EV Tech Expo 2018
Novi MI, USA, September 11-13
www.evtechexpo.com

EPE ECCE 2018
Riga Latvia September 17-21
www.epe2018.com

SPS Middle East 2018
Dubai, UAE, September 18-19
www.spsautomationme.com

ECCE 2018
Portland OR, USA, September 23-27
www.ieee-ecce.org/2018

EU PVSEC 2018
Brussels, Belgium, September 24-28
www.photovoltaic-conference.com

LED Professional 2018
Bregenz, Austria, September 25-27
www.led-professional-symposium.com

ESREF 2018
Aalborg, Denmark, October 1-5
www.esref2018conf.org

CWIEME Chicago 2018
Chicago IL, USA October 2-5
www.coilwindingexpo.com/chicago

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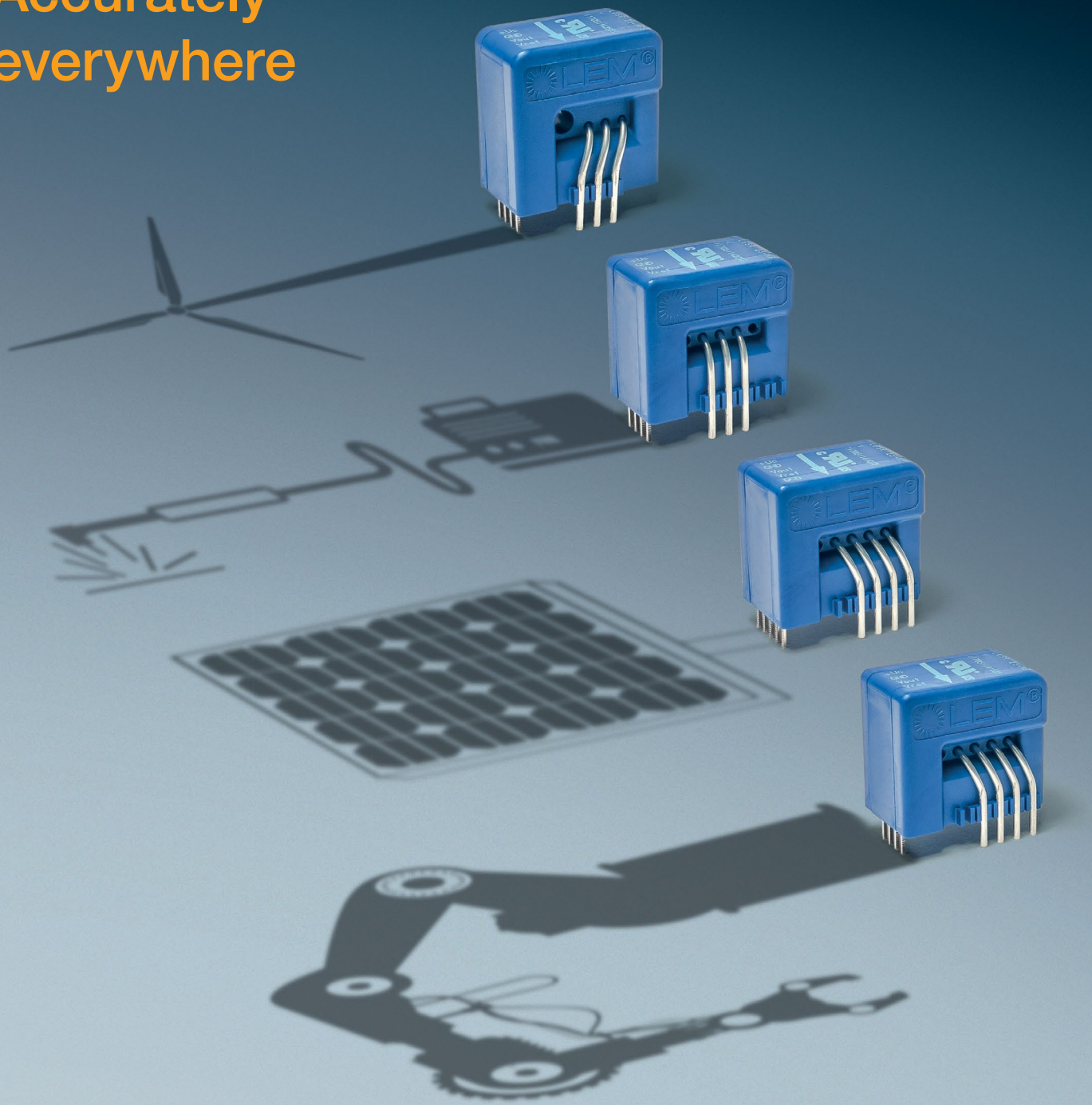


LXS, LXSR, LES, LESR, LKSR, LPSR series

New closed-loop current transducers, based on a custom Hall Effect LEM ASIC, perform at the level of fluxgate transducers, achieving the highest levels of quality and traceability using advanced manufacturing techniques. Offset drift is over four times lower than the previous generation of closed-loop transducers based on Hall cells and very similar to those using fluxgate.
There are 6 families and 22 models available with various options, such as an integrated reference (V_{REF}), footprint (3 or 4 primary pins with different layouts), with an aperture and/or with integrated primary conductors and overcurrent detection.

- 1.5 to 50 A nominal current
- PCB mounting
- Low offset drift (4 – 14 ppm/°C)
- Overcurrent detection output (LPSR models)
- -40 to +105°C operation
- 100 % compatible with previous LEM generation
- Multi-range configuration

Second Time in Sequence Awarded by Key Account Customer

PINK GmbH Thermosysteme located in Wertheim-Bestenheid and producer of void-free soldering systems is very proud being awarded again by Infineon Technologies AG. Infineon known as a worldwide leading supplier for semiconductors, which are simplifying human's work in every day's life and making it safer and more environment-friendly. For a second time in a row PINK GmbH Thermosysteme received the Supplier Award for Innovation and Cooperation, "in recognition of outstanding supplier performance" in category "Back-end High Power Equipment". The award was personally presented to Mrs. Andrea Althaus (CEO of PINK GmbH Thermosysteme) by Mrs. Andrea Fischer (Head of Strategic Purchasing Warstein, Infineon) and Mrs. Silvia Tölle (Purchasing, Infineon) during a visit at Infineon in Warstein on April 26, 2018. Both companies are cooperating in a long-term partnership for many years. PINK is very proud about this award and the herewith expressed appreciation for the whole PINK team.

www.pink.de

Gaming for Charity Drive Brings in 15000 Euro at PCIM Europe

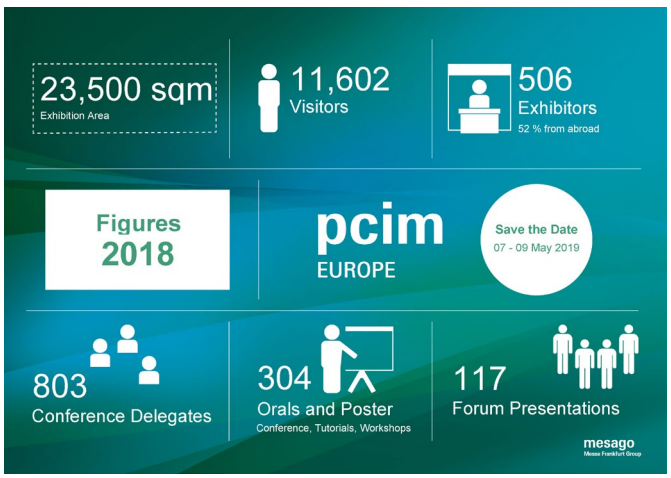
Vincotech staged a charity Sudoku challenge at the PCIM Europe show in support of Plan International Deutschland e.V. The determined efforts of Vincotech's engaged partners and the booth's staff to solve puzzle upon puzzle are now helping to make cities safer for girls.

Vincotech pledged to donate money to Plan International for every successful attempt. The funds will go to a project aimed to empower especially adolescent girls and to make large cities like Delhi, India or Hanoi, Vietnam, a safer and more inclusive place to live in. This initiative is part of Plan International's global 'Because I am a Girl' movement. The company is proud to announce that visitors stepped up to the challenge, racking up around €11.3K during the fair's three days. Vincotech matched all contributions. A €15,000 check went out to the child welfare organisation Plan International Deutschland e.V. "Vincotech has formed a firm and sustainable partnership with Plan International over the years. We are happy to sponsor development projects supporting children's rights worldwide and we monitor the progress of these projects with great interest," says Eckart Seitter / SVP Sales & Marketing. Vincotech wishes to thank everyone who supported this activity and solved the puzzle.

www.vincotech.com/charity

PCIM Europe 2018: Record Result in the Anniversary Year

After three days of pulsating exhibition and conference, the 2018 issue of the leading international event for power electronics and its applications closes with yet another record result.



"We were particularly pleased to welcome more than 500 exhibitors, for the first time in the history of the event ", reports Lisette Hausser, Vice President at Mesago Messe Frankfurt GmbH and responsible for the PCIM Europe and PCIM Asia. "The continued increase in visitor numbers as well as the high number of conference bookings further demonstrates that in the 40th year of its existence, the PCIM Europe is up-to-the-minute and a central meeting point for the international power electronics industry." In total, 506 exhibitors and 88 represented companies showcased new trends, developments and innovations from various fields of power electronics on an exhibition area of 23,500 square meters. Notable was, in particular, the high proportion of exhibitors (about 50%) that presented products designed specifically for electromobility. Over 11,000 trade visitors (a plus of 7% compared to the previous year) used the exhibition as a platform for information, networking and as a basis for investment decisions. Visitors praised aspects such as the top-quality forum program with presentations on current trends and research findings as well as the distinct focus of the entire event.

www.pcim-europe.com

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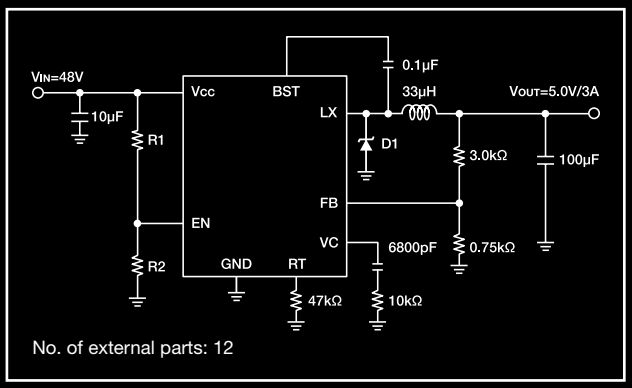

No. of external parts: 12

FEATURES

- Input voltage range: 12V to 76V (80V max.)
- Output voltage range: 1.0V to VCC V
- Reference voltage: 1.0V±1.5%(25°C)
  ±2.0 %(-40°C to 85°C)
- Operating frequency: 50 to 750kHz (typ.)
- Maximum output current: 3.0A
- EN pin threshold : ±3%
- Soft start function
- Protection Circuit: OCP, UVLO, TSD, OVP
- HTSOP-J8 package (4.9×6.0×1.0mm)

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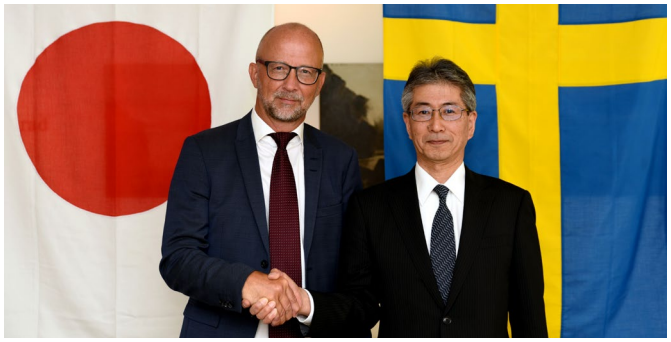
Laying the Foundation Stone for 300 mm Wafer Fab

The foundation stone laid in Dresden is a key milestone in the construction of the Bosch Group's state-of-the-art wafer fab. Construction is scheduled to be completed in late 2019, when installation of the production machinery will start. "Today we are laying the foundation stone for the wafer fab of the future, and with it the foundation for improving people's quality of life and their safety on the road," said Dr. Dirk Hoheisel, member of the board of management of Robert Bosch GmbH, at the formal ceremony in Dresden. "Semiconductors are the key technology for the internet of things and the mobility of the future. When installed in cars' control units, for example, they enable automated, efficient driving and the best possible passenger protection." In his address, Peter Altmaier, the German Federal Minister for Economic Affairs, underlined the central importance of this Bosch investment: "We are today taking an important step toward securing the future competitiveness of Germany as an industrial location. The research community in Germany and Europe is an excellent one, but we cannot afford to rest on our laurels. In the field of microelectronics, we also need engineering skills and know-how, and especially industrial-scale manufacture and application, in Germany and Europe. Today's ceremony is an important step on this route." As a supplier of technology and services, Bosch is investing roughly one billion euros in its new location in the Saxony state capital. The first associates are due to start work in the new plant in early 2020.

www.bosch-semiconductors.com/news/groundbreaking-dresden.html

Cosel Acquires The Powerbox Group

Cosel Co, Ltd announced that it has acquired The Powerbox Group. The Powerbox Group and its subsidiaries employ 120 people, with a consolidated turnover of more than €40m throughout 15 countries. With design centers in Sweden (HQ), Germany & Netherlands as well as offices throughout Europe, USA, China and Australia, they specialize in the design & manufacturing of Standard, Semi-Standard and Full Custom power supplies throughout the Industrial, Medical, Transportation & Defense sectors. "Having achieved the status as the #1 Industrial Power Supply manufacturer in Japan, and with sales in excess of $230m, our vision is to expand that success globally. By bringing the Powerbox Group in to Cosel, we gain additional design & manufacturing resources enabling us to increase our product offering to our existing customers as well as to enter new markets and acquire new customers. Cosel & Powerbox are a perfect fit, having had a business relationship for more than 30 years" says Masato Tanikawa, Cosel President and CEO." With constant growing and changing power demands, the ability to offer an even wider range of standard & semi-standard power supplies brings us closer to delivering the solutions which our customers require. With the Powerbox expertise in providing custom power solutions, we can support almost any power requirement throughout the Industrial, Medical, Transportation and Defense markets."



www.coseleurope.eu

www.prbx.com

New Building for More SiC Production Capacity

ROHM has announced plans for a new production building at the Apollo plant in Chikugo, Japan. The expanded production capacity is intended to meet the growing demand for SiC power devices.
The properties of the still relatively new material SiC promise comprehensive application possibilities in power electronics. SiC-based voltage converters have significantly less losses than conventional silicon-based converters. SiC also enables significantly smaller modules, components and systems than silicon. The increasing demand for the most energy-efficient devices possible will therefore increase the demand for SiC components in the coming years. Experts expect the global SiC market to exceed the 1 billion dollar mark by 2021.
The largest share is accounted for by power supply applications, such as power conditioners, battery chargers for electric vehicles and the power grid. However, main inverter of electric vehicles also represent a significant part of the market potential for SiC components. ROHM recognized the potential of SiC early on. In 2010 ROHM started the mass production of SiC power components such as SiC Schottky diodes and MOSFETs. In addition, ROHM was the first supplier to produce complete SiC power modules and SiC trench MOSFETs. In addition, the company has introduced a vertically integrated production system throughout the group. This means that the company covers the entire manufacturing process from the SiC wafers through the devices to the packaging.

www.rohm.com/eu

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Inspire the Next

Please read right-to-left, in respect to Akira Toriyama and Manga artists around the world. Just follow the numbers.

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Grundig in Bayreuth Continues to Rely on SMT

In order to make their production even more efficient and faster, Grundig Business Systems (GBS) has rebuilt two SMT lines in Bayreuth and equipped them with new machines worth 1 million €. A new Quattro Peak® L Plus system from SMT Thermal Discoveries is also deployed. The full convection reflow soldering system is characterised by its long machine life, high process stability and extremely low energy consumption. Especially in the field of electronic manufacturing service, the profile changeover times of the oven are critical. Therefore, the production service team at GBS had compared different ovens under technical and cost aspects in advance. The SMT-system SMT was soon the favorite. „We already have an SMT oven in operation. Thanks to the identical configuration of both lines, we can optimally use synergy effects, for example by using the same soldering profiles," says Wolfgang Fraunholz, team leader of SMT production. A second aspect were shorter profile changeover times. As an EMS provider, a wide variety of customer projects must be processed as quickly as possible one after the other. The forced cooling of the oven helps. „This saves us a lot of time when changing over from soldering profile to adhesive profile," says Fraunholz.

www.smt-wertheim.com

LpS 2018 Tackles the Disruption to the Lighting Industry

The 8th international LED professional Symposium +Expo (LpS 2018) will take place from 25 to 27 September in Bregenz, Austria. The carefully curated program for LpS2018, together with the co-hosted TiL2018, now forms a comprehensive overview of the current developments, hurdles and solutions for the disrupted and ever changing world of lighting. "We see the solution for the disruption of lighting as progression and innovation with light. This requires an understanding of technology, users and the applications. Only when all sides are understood and considered can valuable new solutions truly be created with, and in, light. We want LpS2018 to be the place that enables this process to really begin." Siegfried Luger, Event Director LpS will bring together the greatest minds in lighting to tackle this year's key 5 topics of Strategies & Technologies, Digitization, Human Centric Lighting, Quality Engineering and Technologies and Applications. There will be over 100 specialist lectures, workshops, and panel debates that will be enjoyed by more than 1,600 visitors, who will come together to discuss, debate, design and develop the "Lighting Technologies of Tomorrow".

www.led-professional-symposium.com

Final Report SENSOR+TEST 2018

Just about 8,000 visitors (last year 8,107) used the three days of the fair to obtain comprehensive information at the stands of the 591 exhibitors (last year 569) and to catch up at the forums on the state of the art of sensor, measuring, and testing technology. The number of exhibitors from abroad was the highest in the last ten years. The share of exhibitors from abroad soared to a new record of 40%. Thus, the SENSOR+TEST impressively substantiated its position as the worldwide leading event for sensor, measuring, and testing technology. Even Germany's unexpected early exit from the soccer world cup – watched live at many boothes – hardly clouded the good mood among the visitors and exhibitors. Christoph Kleye, chair of the Exhibitors' Committee, commented on the satisfaction of the exhibitors, saying, "The expectations of the exhibitors were exceeded – especially on the first day of the fair. The stream of visitors was better distributed in time and in the halls than ever before. We also noticed that visitors stayed longer at the stands, which also contributed to the relaxed atmosphere."
The SENSOR+TEST 2019 – with the special topic Sensors and Measurement for Process Automation – will be held from the 25th to the 27th of June 2019, as always at the Nuremberg Exhibition Center.

www.sensor-test.de

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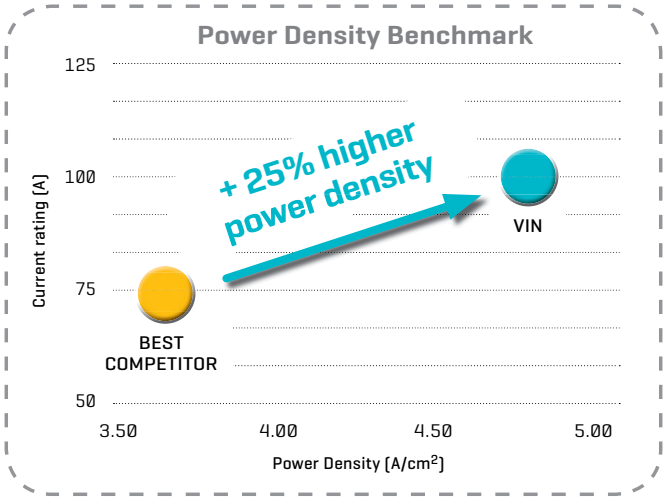
- Low-inductive packages allow downsizing of your passive components



www.vincotech.com/NPC-0-100A

EMPOWERING **YOUR IDEAS**

New Partner in France

Since April 2018 company TMI Control Plus located in St. Aignan de Grandlieu in France is one of the representatives of SMT Thermal Discoveries. „TMI Control Plus is proud to become the official distributor of SMT Thermal Discoveries products for the French Market.

SMT products will fulfill the customer requests and needs in France, the quality and the reliability of the SMT products are well known and recognized on the market. They will complete the TMI Control Plus portfolio and allows us to offer a state of the art SMT line to our customers", says Jérôme Clouet, Commercial Director of TMI Control Plus. For over 25 years TMI Control Plus distributes reflow soldering systems amongst others and offers with a team of experienced technicians best service quality, which ensure the distribution, the installation, the education and the maintenance at the present customers and at new customers.

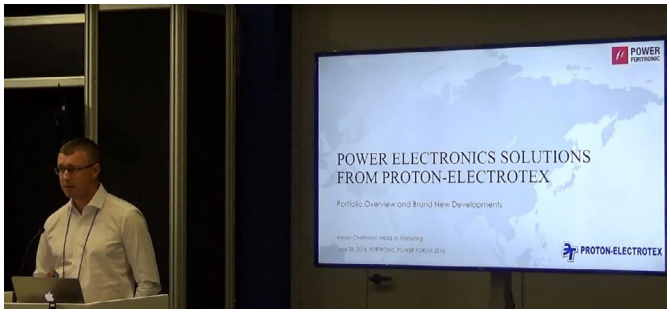
„In addition to Germany, France is the most important industrial nation in Europe. So it essential to have a strong partner on-site. We are glad that we could win TMI Control Plus for a partnership", says Florian Graf, Sales Manager Europe and Germany of SMT. SMT Thermal Discoveries headquartered in Wertheim, Germany was founded in 1987 and is a manufacturer and global supplier of equipment for thermal processes.

www.smt-wertheim.com

SiC Solutions and Other New Products

Proton-Electrotex has a long history of supplying its partners in Southern Europe with power semiconductors and related products. Italy with its extensive industrial capacity and numerous manufacturers is an especially important market, and Proton-Electrotex appreciates every opportunity to stay in touch with customers. In the end of June Proton-Electrotex joined Fortronic Power exhibition in Modena. This year's edition, just as PCIM Europe before that, clearly showed market's interest in SiC solutions and overwhelming demand for reliable and affordable e-mobility. To meet this demand engineers of Proton-Electrotex develop solutions on par with leading giants of the industry. This year Proton-Electrotex was proud to announce several brand new devices at Fortronic:

- Full-SiC module: a full-SiC module with latest generation of SiC MOSFET and SiC SBD. Features very low stray inductance (<8 nH) in standard footprint.
- Press-pack IGBT module: high power cycling resistance due to its pressure contact design, stable short-circuit mode in malfunction mode and ability for serial connection.
- IGBT modules with pre-applied thermal interface: modules with pre-applied phase-change material (PCM) boast low added cost and longer service life. PCMs ensure a low thermal resistance, but do not have issues with bleeding-out, drying and other degradation problems.



Moreover, Alexey Cherkasov, Head of Marketing in Proton-Electrotex, presented company's history overview, current state of product line and future developments during the Power Forum workshop.

www.proton-electrotex.com/eng

Distributor of the Year Awards

TTI, Inc. has been named as C&K's 2017 Distributor of the Year in both Europe and the United States. TTI Europe was also named the "Fastest Growing Distributor of the Year" for 2017. C&K is one of the world's most trusted brands of high-quality electromechanical switches covering applications spaces including the industrial, defense, aerospace and consumer electronics industries. C&K's switches and components are known for their durability and reliability, even when exposed to harsh operating conditions. The awards recognize the both companies' strong, joint global commitment to ensuring that new and existing customers have access to the reliable, high-quality and resilient switches and components they need to produce innovative new products. "TTI is a key distribution partner for C&K in Europe – and firmly deserves these recognitions for their successful, close working relationship with us," said Serge Veld, C&K's Director of Sales, EMEA. "Customers continue to benefit from TTI's detailed knowledge of switch technology solutions – and it is this commitment to customers that has driven TTI's ability to continually develop new business opportunities." Added Ros Kruger, Director, Supplier Marketing Europe – Sensors, E/Mech and Power - TTI, Inc.: "We are honored to receive both awards from C&K in recognition of our of growing partnership as 'Distributor of The Year' and for our fast sales growth in 2017. We look forward to another exciting year with the C&K team in 2018."

www.ckswitches.com

www.ttieurope.com.

On-Line Custom Catalog Generator

Many engineers have a love-hate relationship with paper catalogs. Nothing is easier to use or more accessible, but catalogs quickly become dated and most of the content doesn't relate to individual needs. For capacitors, Cornell Dubilier has the solution to that quandary with their new, on-line catalog generator that allows creation of unique PDF catalogs. It's easy to create a custom catalog that includes only the product lines or categories of interest from a menu. Just make the selections and a catalog is created, with covers, pagination and table of contents. It happens in just seconds. Optionally, a preset specialty catalog can be generated, such as for power electronics. The catalog can be saved to a drive or printed by the user. Unlike traditional printed catalogs, the generated catalogs are always current, as the content on-line data sheets are kept up-to-date. Another benefit of the tool is the ability to create documentation of capacitors that is specific to a project in development. This saves the time of pulling data sheets on every component, organizing and assembling them. No registration is required to access the Custom Catalog Generator or the website.

CDE CORNELL DUBILIER
ENERGIZING IDEAS

www.capacitorcatalog.com/cornell-dubilier

Upcoming ECPE Events

ECPE Tutorial 'Passives in Power Electronics: Magnetic Component Design and Simulation'
10 - 11 September 2018, Copenhagen, Denmark
Chairmen: Prof. G. Hurley (Nat. Univ. of Ireland), Dr. Z. Ouyan (Techn. Univ. of Denmark)

ECPE Tutorial 'Power Semiconductor Devices & Technologies'
4 - 5 October 2018, Catania, Italy (programme flyer published soon)
Chairmen: Dr. A. Mauder (Infineon), Prof. D. Silber (Univ. of Bremen)

ECPE Tutorial 'Thermal Engineering of Power Electronic Systems - Part II (thermal management and reliability)
9 - 10 October 2018, Nuremberg, Germany
Chairmen: Prof. E. Wolfgang (ECPE), Prof. U. Scheuermann (Semikron)

ECPE Tutorial 'Function and Design of Multilevel and Multicell Converters'
10-11 October 2018, Toulouse, France
Chairman: Prof. M. Hiller (KIT), Prof. T. Meynard (Univ. of Toulouse)

ECPE Tutorial 'Power Circuits for Clean Switching and Low Losses' 17 - 18 October 2018, Lyon, France
Chairman: Dr. R. Bayerer (Infineon)

ECPE SiC & GaN User Forum
26 - 27 March 2019, Erding / Munich, Germany
Chairmen: Prof. A. Lindemann (Univ. of Magdeburg), Prof. L. Lorenz (ECPE), Dr. P. Friedrichs (Infineon)
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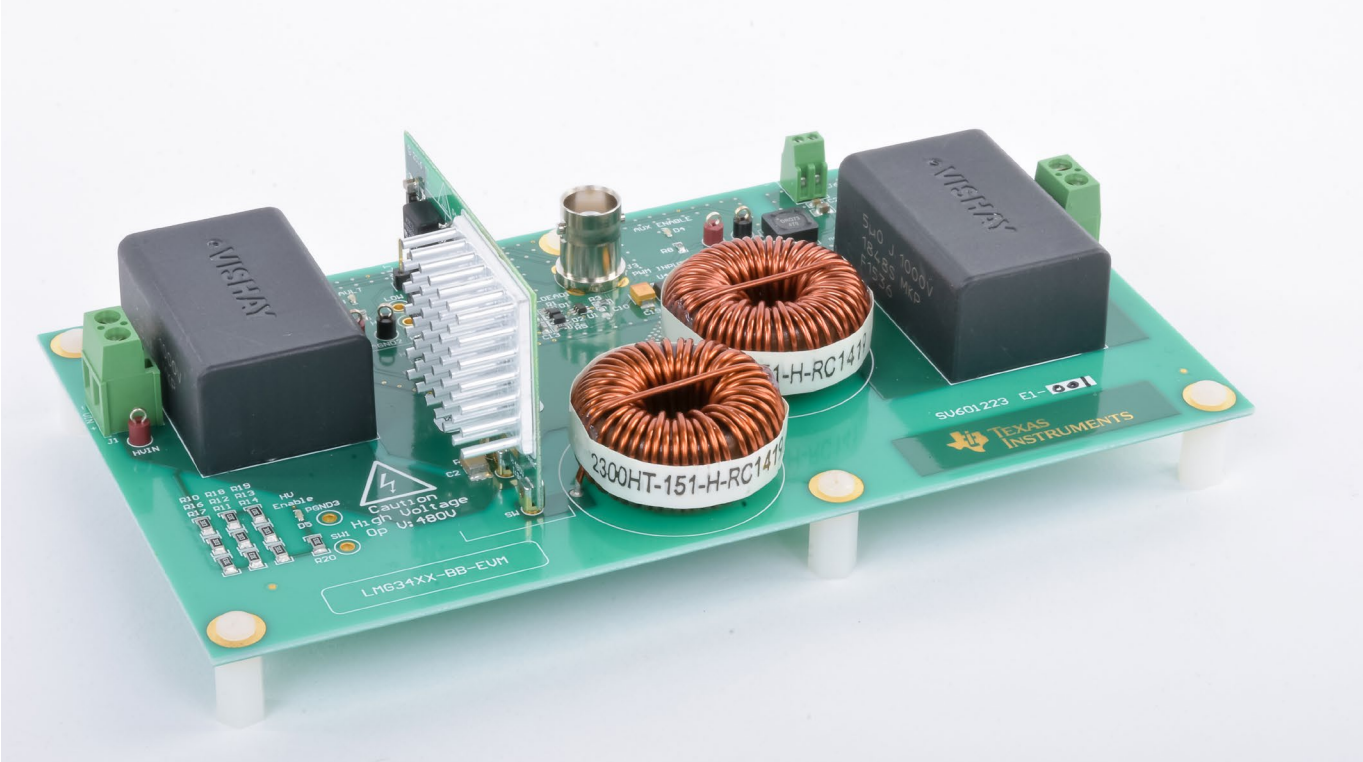

With an ever-increasing demand for higher power at much greater efficiencies, designers are exploring wide-bandgap technologies such as GaN for their next design. GaN technology continues to help designers create smaller, more efficient power converters and enable the next generation of high-density power designs that are faster, cooler and smaller.

To design high density power converters, engineers must take full advantage of GaN's inherent high switching frequency and high slew-rate capabilities. The integration of driver, protection and high voltage GaN in a single power package make this possible. With Texas Instruments' LMG3410 600-V GaN power stage, the driver integration eliminates PCB layout challenges at high switching frequencies and helps achieve zero ringing at slew rates of up to 100V/ns. And with over 10 million hours of GaN process reliability testing, TI is addressing the need for proven and ready-to-use solutions through reliable GaN products, bringing decades of silicon manufacturing expertise and advanced device-development talent to GaN technology.

Visitors to the Applied Power Electronics Conference (APEC) this year in San Antonio, Texas, witnessed the LMG3410 in action at the TI booth. Developed jointly by Siemens and TI, the 8kW Three-Phase Bidirectional Grid Link with GaN solution demonstrates a high-frequency bidirectional multilevel converter between a three phase AC grid (400V-480V) and a DC bus (650V-800V) using the LMG3410 600V GaN power stage and C2000™ dual-core Delfino™ real-time controller. With 99% peak efficiency and less than 1% THD, this solution delivers 8kW of power in grid-connected applications such as PV inverters, offline PFC, HEV/EV onboard chargers and high-voltage battery storage systems.

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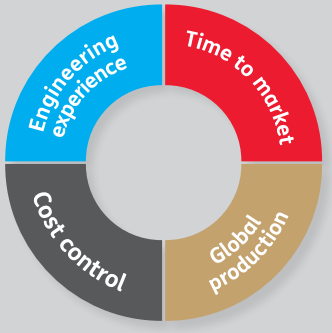

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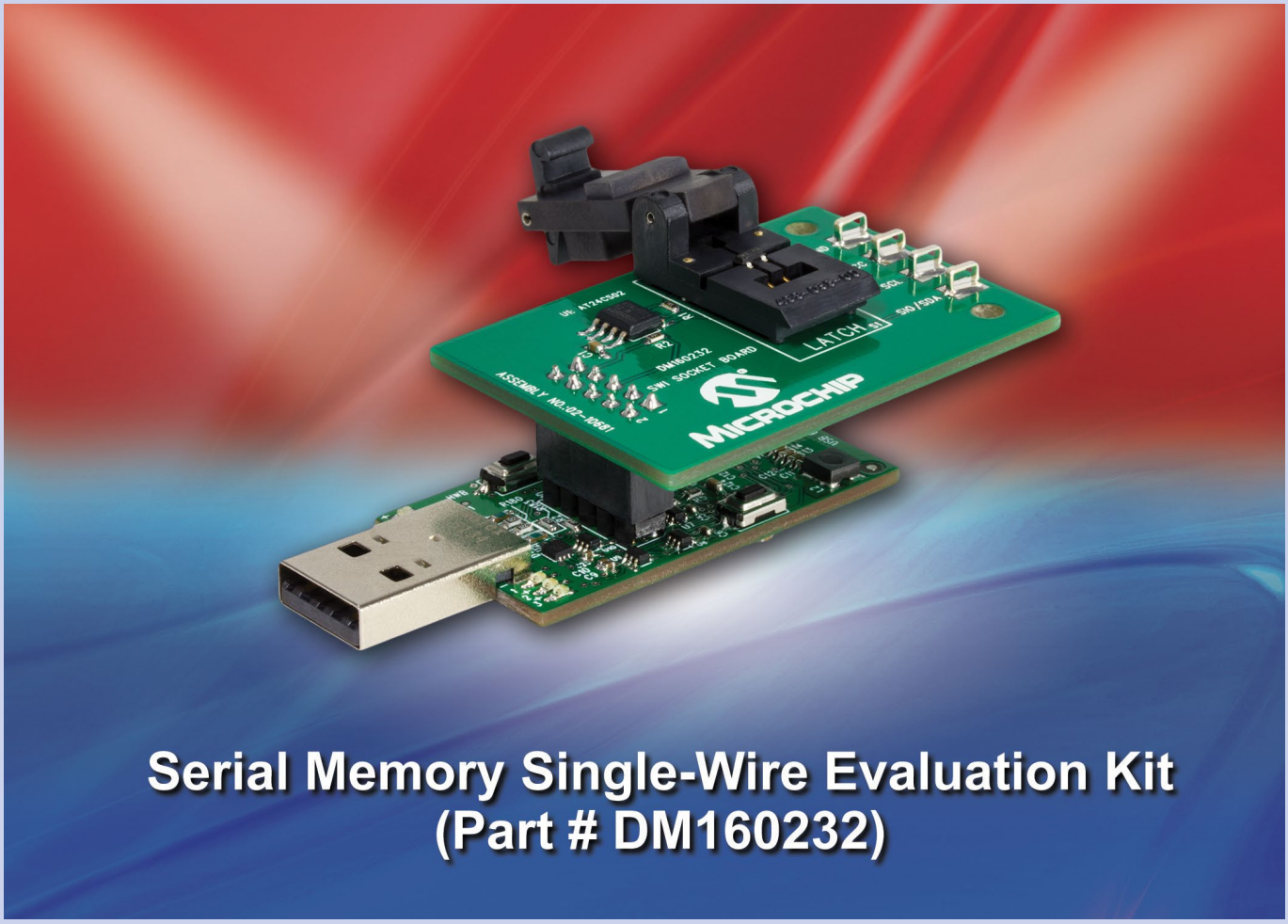
Win a Microchip Serial Memory Single-Wire EEPROM Evaluation Kit



Win a Microchip Serial Memory Single-Wire EEPROM evaluation kit (DM160232) from Bodo's Power.

The Serial Memory Single-Wire Evaluation kit is an easy to use interactive user tool, which demonstrates the best in class features, functionality and low-power operation of the AT21CS series of serial EEPROM devices.

The AT21CS Series is a family of Serial EEROMs that utilizes the Single-Wire Interface (SWI) protocol. The family software addressing scheme allows up to eight devices to share a common single-wire bus. The device is optimized for use in many industrial and commercial applications where low-power and low-voltage operation are essential. Some applications examples include analog sensor calibration data storage, ink and toner printer cartridge identification, and management of after-market consumables. The family is available in space-saving package options and operates with an external pull-up voltage on the SI/O line.

Key features of the device include: internal variable voltage from 1.7V to 3.6V, supports USB Base Board firmware update via the FLexible In-system Programming (FLIP) Software Utility and contains a AT90USB1287 and 8-bit AVR® Microcontroller. Supported devices of the Serial Memory Single-Wire Evaluation kit include the AT21CS01 and AT21CS11.

For your chance to win a Microchip Serial Memory Single-Wire EEPROM evaluation kit, visit http://page.microchip.com/bodo-eeprom.html and enter your details in the online entry form.

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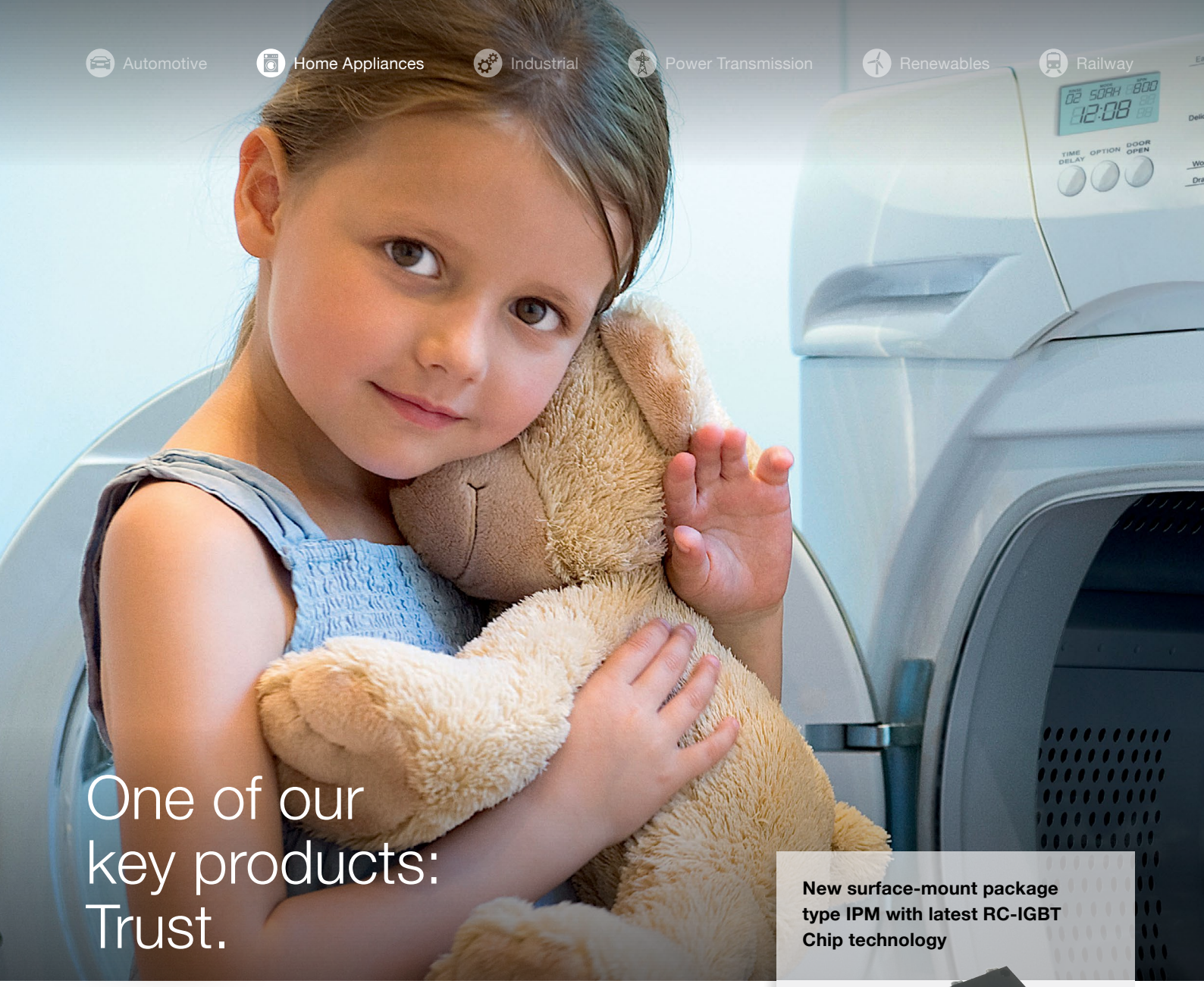

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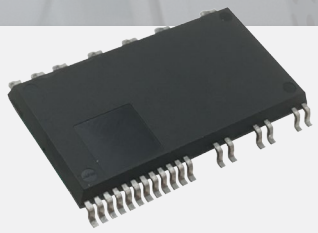
Home appliances are becoming more and more demanding regarding functionality, reliability and efficiency. In the field of Power Semiconductors Mitsubishi Electric had created the necessary basis already 20 years ago as the pioneer of the DIPIPM™ Transfer molded package intelligent power modules, followed by the continuous development and expansion of this series. Consequently, with the new MISOP™ a surface-mount package Intelligent Power Module has been added to the line-up to realise compactness and easy assembling in small power inverters for pumps and fans. Also low power servos in industrial applications can be covered. The versatile integrated features are designed to give the benefit of reduced development time for the complete inverter system.

New surface-mount package type IPM with latest RC-IGBT Chip technology



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Half-Heusler Waste Heat Conversion Reduces CO_2 Emissions of Cars

New Technology for CO_2 Reduction

In the energy debate about CO_2 reduction, Hesse's oldest industrial company, Isabellenhütte, is now making a promising contribution that is about ready to launch on the market. The basic idea: generate electricity from unused waste heat. The technology uses a new class of thermoelectric material to achieve this. The aim of the technology is, for example, to save up to 4% CO_2 emissions when used in a car.

Together with several partner companies, Isabellenhütte has now succeeded in getting the so-called half-Heusler material, a class of thermoelectric material newly discovered by scientists 15 years ago, ready for marketability. The aim of this cooperation was and is to depict the entire added value - from development to production to the specific application. The current EU project INTEGRAL* is now focusing on the construction of three pilot productions. The goal of the established pilot lines is to produce thermoelectric material in large quantities. Already at the project halfway point in May 2018, Isabellenhütte was able to successfully demonstrate the complete production process for material batches of 10 kg with its production line.

Annual production volume of 25 tons of half-Heusler material possible

A 150 m^2 production hall was built for this purpose at the company headquarters in Dillenburg, Hesse. Overall, a total of six scientists and technician are currently working on this topic at Isabellenhütte. 10 kg of thermoelectric half-Heusler material are currently being melted there per production run and processed further into functional components. This quantity is to be increased to 50 kg by the end of the project in December 2019. Theoretically, a production volume of up to 500 kg per production run is possible with the system. This corresponds to an annual production of 25 tons.

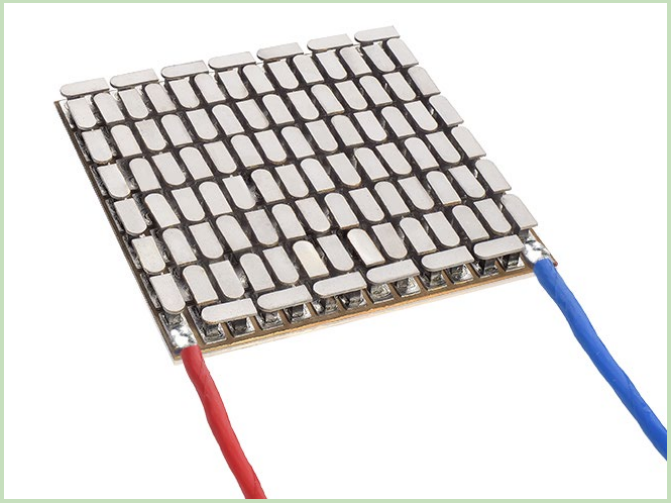

Figure 1: About 60 to 70 grams of half-Heusler material are installed in a thermoelectric generator (in the image) to convert waste heat into electricity.

Thermoelectric waste heat conversion is nearly ready for market

Thermoelectric waste heat conversion based on half-Heuslers is almost ready for market. The technology was and is already tested and tried in the exhaust gas systems of cars and trucks under realistic everyday conditions. With 60 to 70 grams of half-Heusler material, a vehicle with a thermoelectric generator (TEG) installed achieves an efficiency of up to 5% from the waste heat. This energy is converted into electricity and fed into the on-board electrical system. The effect: The fuel consumption is reduced and the CO_2 emissions are reduced per vehicle by up to 4%.

Relevant for environmental policy and competitive

The relevance of this technology is obvious. Automotive manufacturers will face strict environmental requirements in the future. This is why every gram of CO_2 saved matters. The half-Heusler waste heat conversion is also competitive from an economic point of view. The production process realized as part of the EU project generally makes it possible to achieve the market-demanded cost target of EUR 0.50/watt under mass production conditions. A half-Heusler-based thermoelectric generator that, for example, generates 400 watts of electrical energy, would cost about EUR 200.

A good mix of properties allows for use in high-temperature applications

Due to their good material properties, half-Heusler materials are suitable for high-temperature applications, such as combustion engines. They generate exhaust gas temperatures between 400 and 600°C. With the aim of reducing emissions, a half-Heusler-based recuperation is therefore recommended for continuously operating high-temperature applications in the energy, metal or chemical industries. It is also attractive for the end user, because it can also be used in fireplaces or heating systems.

This commitment from Isabellenhütte is no coincidence. The predecessor of the half-Heusler material class, the so-called Heusler alloys, were discovered over 100 years ago by Dr. Fritz Heusler, the great grandfather of today's managing director of Isabellenhütte, Dr. Felix Heusler.

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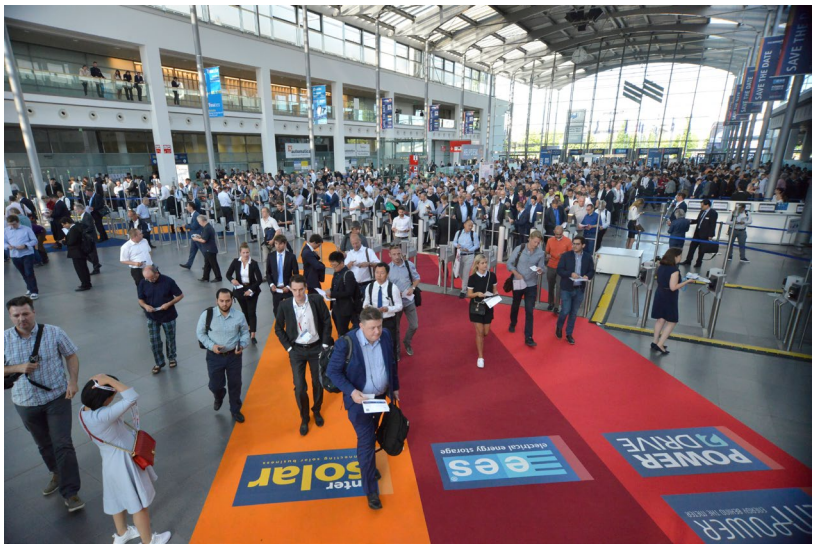
Successful Fusion of Four Exhibitions for the New Energy World in Munich: The Smarter E Europe

With 1,177 exhibitors, 86,000 square meters of exhibition space in 8 halls and around 48,000 visitors from 155 countries, the launch of The Smarter E Europe in Munich was a resounding success. This year, for the first time, the event brought together the two leading energy exhibitions "Intersolar" and "ees Europe" with two new events: "Power2Drive Europe", dedicated to traction batteries for e-mobility and topics relating to charging infrastructure, while "EM-Power" addressed intelligent energy use in industry and buildings.

By Roland R. Ackermann, Correspondent Editor Bodo's Power Systems

The innovation hub for empowering new energy solutions thus put a spotlight on the core issues in the energy world, from renewable energies to decentralization and digitalization to the coupling of the electricity, heating and mobility sectors, over three days from June 20 to 22. A wide range of innovative business models and pioneering projects were presented here and explored in greater depth at the accompanying conferences with 1,800 attendees.



New exhibition format was a hit with visitors, exhibitors and partners

The new exhibition format The Smarter E Europe met with an overwhelmingly positive response from visitors, exhibitors and partners. The success of the concept was thanks to the powerful dynamic of change, progress and vision created by recent developments in renewable energies, in energy storage and in the interconnection of the previously independent sectors with the potentials generated by digitalization.

Partners of the new The smarter E Europe in Munich were also satisfied with the outcome of the event. "The new exhibition format has been well received by the industry, because the innovation hub The smarter E Europe offers a platform to show how photovoltaic technology is making the modern energy world possible with interconnected systems, intelligent solutions and outstanding hardware," commented Carsten Körnig, CEO of the German Solar Association (BSW-Solar). "Our businesses are reporting top-level new contacts and excellent deals, which confirms our positive forecasts for photovoltaics and storage systems in 2018."

Heavy investments in renewable power

Another reason for the success of the debut of the fused exhibitions: The renewable energy market is booming worldwide. In 2017, a total of 310 billion USD were invested in the development of renewable power plants worldwide, whereas just 145 billion USD were invested in fossil fuels and nuclear power, according to the Renewables 2018 Global Status Report by REN21. Around 178 GW of new capacity were installed in the previous year, including 98 GW for photovoltaics alone. This positive development is primarily thanks to falling prices — a pleasing trend that looks set to continue.

In creating the new exhibition format, the organizers made a radical decision in order to be able to fully reflect the development of the energy industry — a major step which has won the approval of the exhibitors. "There are currently two main game changers in the energy industry: The combination of renewable energies and storage systems, and of electric vehicles and charging infrastructure, which are all part of a single ecosystem," said Leonardo Botti, Head of Global Product Management at ABB. "We're seeing an upward trend for all of these solutions — the combination of solar power and storage as well as electric vehicle charging devices."

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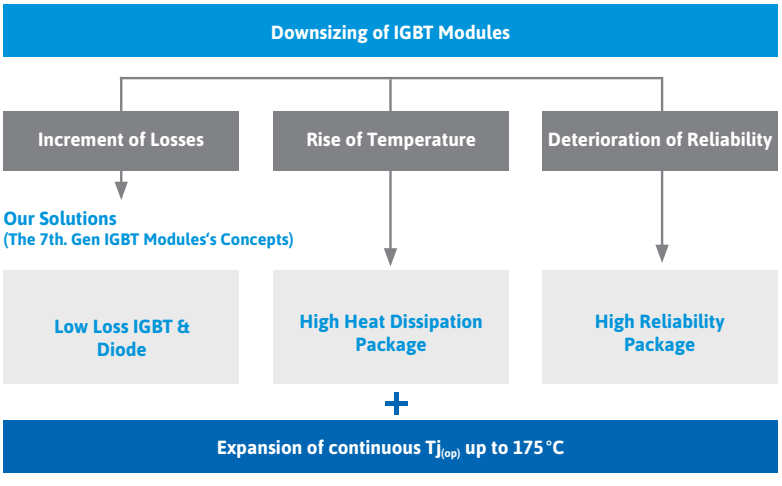

Intersolar: Inverters Present Enormous Market Potential
Inverters have become all-rounders, used not just for converting direct current into alternating current but for analysing and controlling PV installations as well as solar batteries, power-to-heat and smart home solutions. They include interfaces for digital communication and are connected with energy management systems which also incorporate electric vehicles. Inverters owe their growing versatility primarily to digitalization and the new fields of use.

Their diverse capabilities are also reflected in supply figures: 2017 was a record-breaking year, with continued growth of 23 percent over the previous year bringing inverter shipments to 98 GW, according to an analysis by GTM Research. In addition to efficiency currently approaching 99 percent, inverters are gaining entirely new innovative potential all along the energy supply chain.

Digitalization is opening up new fields of use and business models for manufacturers. For example, inverters with an integrated charging function can refuel electric vehicles up to two and a half times faster than traditional charge controllers, while at the same time cutting installation costs by removing the need for additional cables and fuses. The growing digital capabilities of inverters are also being applied in the heating sector, where they are used to control heating elements for hot water production in boilers and buffer tanks, which can be run on excess solar power. And modern PV and battery inverters even fulfill the need for solutions that contribute more to the stability of the grid. Thanks to their energy management qualities, they can supply power as and when it is needed.

ees Europe
At ees Europe, the continent's largest and most visited exhibition for batteries and energy storage systems, more than 450 suppliers of batteries, energy storage systems, grid infrastructure and solutions for integrating renewable energies were presenting their products and solutions, which are an indispensable part of a modern energy supply. Manufacturers, service providers, project developers, investors, systems integrators and research institutes from all over the world convened here, and leading experts from industry and research discussed storage markets, business models and future technologies in greater detail as part of the two-day conference program.

The boom in renewable energies in the electricity, heating and mobility sectors requires not only intelligent networks, but also and especially additional, efficient and cost-effective storage resources. "From private power generators seeking self-sufficiency to utilities looking to offer more power from renewable sources – demand for storage solutions is set to increase yet further in the future," stated Dr. Holger Hesse, head of the research group on stationary energy systems and deputy head of the Institute of Electrical Energy Storage at the Technical University of Munich (TUM) as well as a member of the conference committee. "Grid connectivity and efficient energy management have taken on new meaning this year in light of the rise of e-mobility in particular. In this context, stationary energy storage has a key role to play in the future of energy supply, not least due to the continued steep decline in the prices of lithium-ion cells and storage systems."

In battery production and energy storage, efficiency is paramount. In order to meet growing demand, capacity for battery manufacture and assembly must be expanded and costs reduced so that more battery systems can reach the market more quickly. At the same time, the energy efficiency of the components should be increased. Along with China and Korea, European companies are increasingly getting involved in cell manufacturing with the goal of mass producing lithium-ion batteries – using innovative process technologies and materials. Otmar Frey, Managing Director of the Batteries Division of the German Electrical and Electronic Manufacturers' Association, sees also Germany as a market participant that should be taken seriously: "The German battery industry has the expertise to produce ready-to-use batteries from lithium-ion cells, for example to be used in domestic storage systems for photovoltaic installations. Between 2011 and 2016, the German market grew from 1.7 to 2.8 billion euros. These figures offer clear evidence that the market can keep pace."

The future lies in cross-sector storage projects. As the energy world undergoes transformation, storage integration and new business models are shaping the market. The presentation series "Business Models or How to Make Money with Energy Storage" discussed concepts for using energy storage that have already proven economically viable. Economic viability is also a key consideration in the recycling of storage devices. The session "Environmental Impacts of Battery Storage: LCA and Recycling" covered this topic.

"The service life of energy storage devices is important not only from a technical perspective but also an economic one, particularly in terms of environmental impact," said Dr. Matthias Vetter, head of the Department of Electrical Energy Storage at Fraunhofer Institute for Solar Energy Systems ISE and chairman of the ees Europe Conference. The ees Europe Conference explored the financing and safety of storage projects, the quality of the components as well as of overall systems and many other important topics affecting the future of the industry.

Conference on decentralization, digitalization and sector coupling
The international conferences focused on the topics of sector coupling, digitalization and decentralization. Experts also discussed the latest trends and developments in the international markets. The conferences of The smarter E Europe as well as the side events attracted around 1,800 attendees this year.

More closely integrating the individual sectors via energy storage systems is of particular interest to the entire energy industry. Sector coupling will continue to grow in importance in the coming years, as is further reflected in the other conferences united under the umbrella of The smarter E Europe. The intelligent interconnection of the electricity, heating and mobility sectors must continue to advance. The digitalization of infrastructure is a crucial lever here — this was also the message of the opening address by Michael Liebreich, the founder of Bloomberg New Energy Finance (BNEF). With the session "New Energy World — Game Changers and Rising Stars", he introduced the debut of The smarter E Europe Conference.

The "Charging Infrastructure Technology" session at the Power2Drive Europe Conference, for example, was concerned with connecting local charging systems with locally generated power, while the presentation series "New Generation Power Plants/Sector Coupling" at The smarter E Europe Conference took up topics including developments in vehicle-to-grid solutions.

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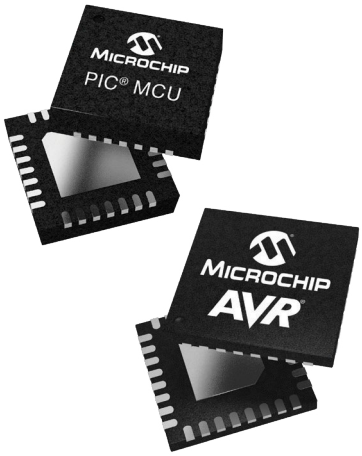

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Mature Wide Band Gap Semiconductors in Systems

We are facing more and more applications that utilize SiC and GaN semiconductors. The benefits are counting to use them to minimize losses in systems.

Bodo Arlt, Publishing Editor Bodo's Power Systems

The discussions are ongoing for years and nowadays we have reached the point that volume production is starting and applications have new design approach for systems.

As a tradition for many years we have a discussion with leading representatives from industry at PCIM Europe. This podiums discussion reflects great information what has been achieved.

I have summarized the key message from the presenters for SiC:

ROHM has a fully integrated supply chain using SiCristal as their in-house wafer source. The target is 30 percent market share. The next step for growth is the plan for the new ROHM Apollo fab in Fukuoka, Japan. This fab should start production in 2020. Construction will start in February 2019. The building will have 11000 m² of space for production.

www.rohm.com/eu

Infineon stated that the SiC Schottky diode is key for high efficiency in charging systems and 1200V SiC MOSFET for reduced part count, system simplification and power density in a charger system for electro mobility. A SiC MOSFET can reduce system size and cost. The benefits are shown as follow: Higher switching frequency means smaller transformers. Same power in smaller box size results in system size and weight reduction.

www.Infineon.com/SiC

Mitsubishi Silicon Body Diode (SBD)-embedded SiC MOSFET technology can realize smaller chip area than conventional design (MOSFET and external SBD) by embedding SBD into each unit cell of the SiC MOSFET. As a result compact SiC module design can be implemented by Mitsubishi technology.

www.mitsubishielectric.com

UnitedSiC presented the Cascode Advantages:
Ease of use: Vgsmax=+/-25V; Vth=5V typ. The device can operate from 0 to 12V, or any desired gate voltage range and is inter-operable with Si MOSFET, IGBTs and SiC MOSFETs

Robustness features:

- The gate ESD protection is 3.5KV and 100% UIS tested.
- The device is able to handle repetitive avalanche and short circuit events. (AEC-Q101)
- Performance features: JFET is lowest RdsA SiC Switch, TJMAX=175C, VTH >3V at 175C
- Enhanced thermal – low RthJC, Low RDSON and EON/EOFF and an excellent body diode VF and QRR

www.unitedsic.com

Wolfspeed showed that SiC MOSFETS have made rapid advance since 1st introduction in 2011; now the 3rd generation MOSFETs have become available at 900 and 1200 volt. For on-board charging the C3M™ SiC MOSFETs have low switching losses and superior body diode witch is ideal for the totem pole PFC topology. The high voltage rating of 1000 volt for the use of the SiC MOSFET allows operation with variable DC link to maximize efficiency. The high switching and high efficiency operation allows on board charger (OBC) to be smaller, lighter, and overall more cost effective.

www.wolfspeed.com

ON Semiconductor has focus on portfolio expansion and secure supply chain.

Unlock substrate supply, Cost @ Yield and have multiple Epitaxy supplier qualified.

To have implemented a capacity expansion for SiC MOSFET and Diode to >1k WSPW until 2020.

Enabling all ON backend facilities for SiC dicing and assembly. Establish new packaging capabilities to enable best thermal performance and low parasitic inductance.

Since 2015 the 6inch volume production is in place and SiC products available.

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Reduced size at higher efficiency using low RDS_ON SiC MOSFETs and higher switching frequency with following results: (50kHz) at higher power (10kW), >99% peak efficiency and >1.4kW/liter Power Density. The T-type inverter topology for reduced ground current in transformer-less grid-tie inverter applications and combination of SiC MOSFETs and IGBTs for performance and cost tradeoff in collaboration with Texas Instruments

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GeneSiC offers a wide range of 1200 – 3300 V SiC Diodes with best-in-class quality, performance, and robustness. These MOSFETs offer the highest continuous operating current for a given Rds,on and they are tested under UIS up to 5000 V with high UIS energies.

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For Insulation Resistance Measurement and Inrush Current Limiter Applications

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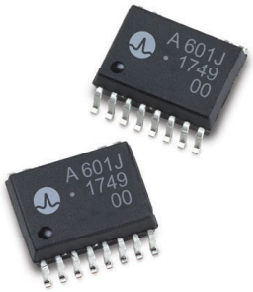

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GeneSiC's MOSFETs to be release in 2018 Q3 offer high reliability and robustness and they are AEC-Q101 qualified parts for Automotive, Industrial and light Industrial applications.

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Summarized we see significant progress in design and application using SiC devices for higher voltages. Mostly we see applications in the line voltage range and higher.

I have summarized the key message from the presenters for GaN:

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Transphorm presented the CORSAIR – 1.6 kW Titanium Gaming Power Supply.

The TPH3205WS Transphorm's GaN device is used in an Interleaved Bridgeless Totem-Pole PFC for an high end gaming application.

Another application is the Bel Power – 3 kW Titanium Server Power Supply with a Bridgeless Totem-Pole PFC using the TPH3205WS device in an datacenter.

www.transphormusa.com

Also we see significant progress in design and application using GaN devices for lower voltages. Mostly we see applications up to the line voltage range and below.

We see great acceptance for using WBG devices for new design. The question is not to compare SiC with GaN or Silicon. It is important to choose the best technical device for the given application to reach the highest level of efficiency. Doing that shows that system approach has benefits in shrinking the unit and getting smaller passive elements in place. Mostly the total cost shows that using WBG devices does not increase the system cost.

To take the barrier down for new design the engineers need the right support.

I will organize together with ICC media / Aspencore the 2nd WBG Power Conference in Munich in the Airport Hilton on the 4th of December. The last years success encouraged us to continue this event.

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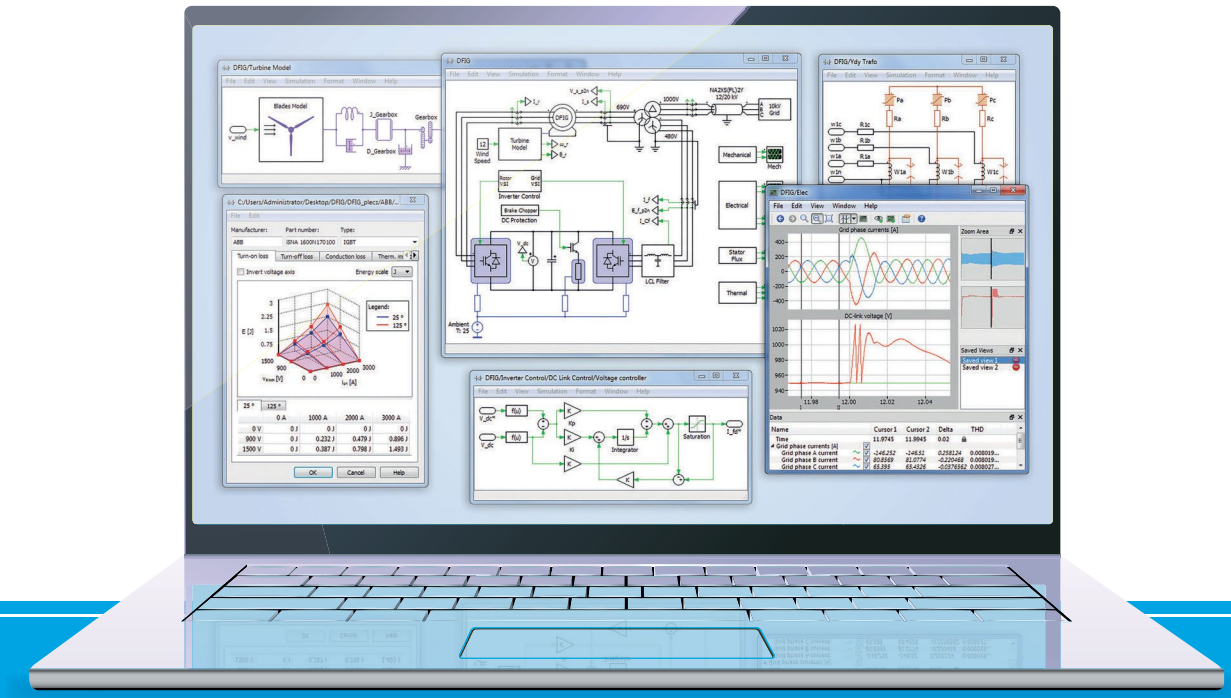

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Dual-Core dsPIC Digital Signal Controller Enables Separate Code Design and Seamless Integration

The dsPIC33CH digital signal controllers (DSC) with two dsPIC DSC cores in a single chip have been released by Microchip for high-end embedded control applications. One core within the device is designed to function as a master while the other is designed as a slave.

By Roland R. Ackermann, Correspondent Editor Bodo's Power Systems

The slave core is useful for executing dedicated, time-critical control code while the master core is busy running the user interface, system monitoring and communications functions, customised for the end application. The dsPIC33CH is designed specifically to facilitate independent code development for each core by separate design teams and allows seamless integration when they are brought together in one chip.

Figure 1: Design separately, integrate seamlessly

Higher switching frequencies allow increased power density

The dsPIC33CH family is optimised for high-performance digital power, motor control and other applications requiring sophisticated algorithms. This includes applications such as wireless power, server power supplies, drones and automotive sensors. For example, in a digital power supply, the slave core manages the math-intensive algorithms, while the master core independently manages the PMBus protocol stack and provides system monitoring functions, increasing overall system performance and responsiveness. Distributing the overall workload across two DSC cores in a single device enables higher power density through higher switching frequencies, leading to smaller components. The dsPIC33CH family was designed for live updating of the system, which is especially important for power supplies where firmware updates must be made with zero downtime.

In an automotive fan or pump, the slave core is dedicated to managing time-critical speed and torque control while the master manages the CAN-FD communications, system monitoring and diagnostics. The two cores work seamlessly together, enabling advanced algorithms to improve efficiency and responsiveness. In addition, each of the new cores in dsPIC33CH devices has been designed to provide more performance than current dsPIC DSC cores through

1. more context-selected registers to improve interrupt responsiveness,
2. new instructions to accelerate DSP performance and
3. faster instruction execution.

The dsPIC33CH family delivers unprecedented integration in a small 5 x 5 mm package and includes features such as CAN-FD communications. To reduce system costs and board size, advanced peripherals are available to each core including high-speed ADCs, DACs with waveform generation, analogue comparators, analogue programmable gain amplifiers and high-resolution PWM hardware. Having two cores, with dedicated peripherals, allows the cores to be programmed to monitor each other for functional safety reasons, facilitating robust system design.

Rich development ecosystem

The dsPIC33CH is supported by Microchip's MPLAB development ecosystem including Microchip's free, downloadable and award-winning MPLAB X Integrated Development Environment (IDE) and MPLAB Code Configurator. The dsPIC33CH Curiosity Board (DM330028), priced at $34.99 each, is a cost-effective and flexible platform enabling customers to rapidly create a feature-rich prototype. The dsPIC33CH Plug-in Module (PIM) for motor-control platforms (MA330039) is available for Microchip's MCLV-2 and MCHV-2/3 systems and is priced at $25.00 each. The dsPIC33CH PIM for general-purpose platforms (MA330040), priced at $25.00 each, is now available for the Explorer 16/32 development board (DM240001-2). The dsPIC33CH is available in eight package variants, from the 28-pin dsPIC33CH64MP202, to variants with 80 pins and variants as small as 5 x 5 mm. Memory sizes range from 64 to 128 KB of flash.

Microchip also announced the new SAM L10 and SAM L11 families of 32-bit microcontrollers (MCUs) which address the growing need for security in Internet of Things (IoT) endpoints by protecting against the increasing risk of exposing intellectual property (IP) and sensitive information. The company provides a complete life cycle, end-to-end security solution including security design partners.

With the increasing growth of IoT end points and, consequently, the increased frequency of security breaches, designers are looking for MCUs that can help reduce power consumption while adding robust security. The SAM L10 and L11 MCU family takes an innovative

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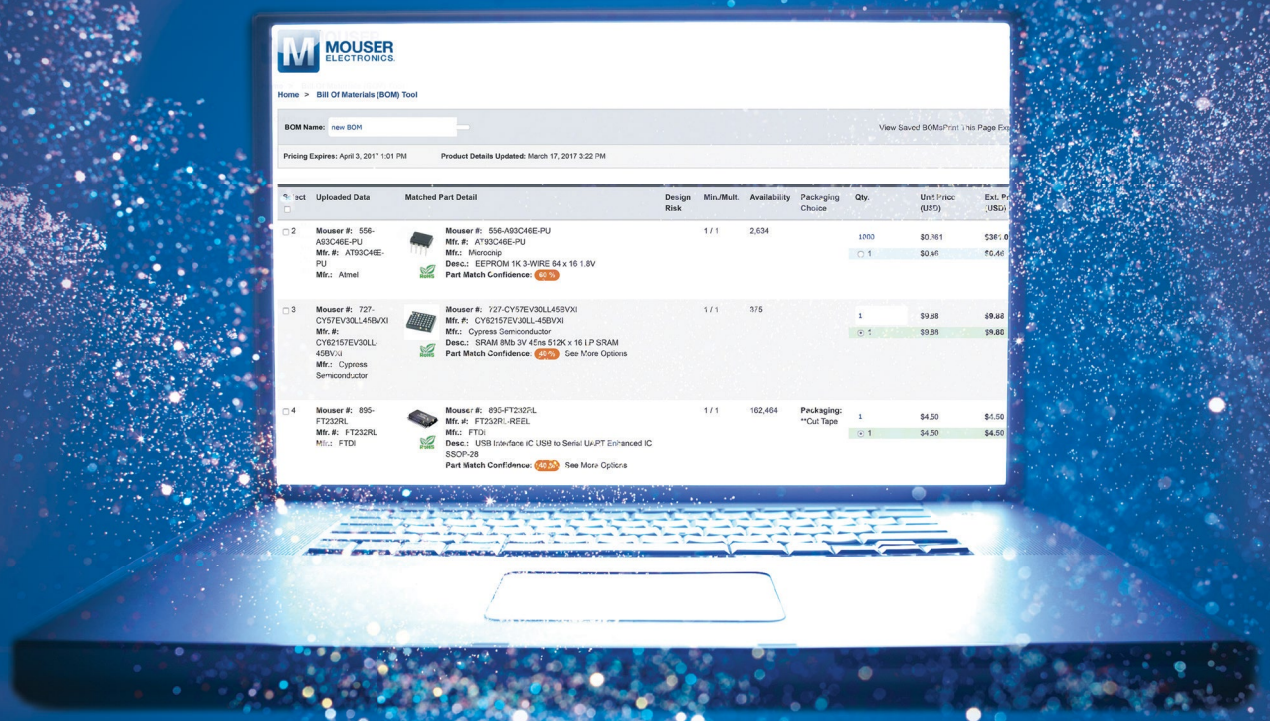

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approach to solving these challenges by integrating a wide variety of peripherals, including security features, into the industry's lowest power MCU in its class. This allows development of secured applications without the battery constraints of less power-efficient MCUs. These MCUs run at 32 MHz with memory configuration of up to 64 KB Flash and 16 KB SRAM. They come in two variant options: SAM L10 and SAM L11 and boast ultra-low power consumption as well as an enhanced Peripheral Touch Controller and advanced analogue features. The SAM L11 variant adds integrated hardware security. They both come in 24- and 32-pin package options and are targeted for use in IoT and security, low power, capacitive touch and general purpose embedded control applications.

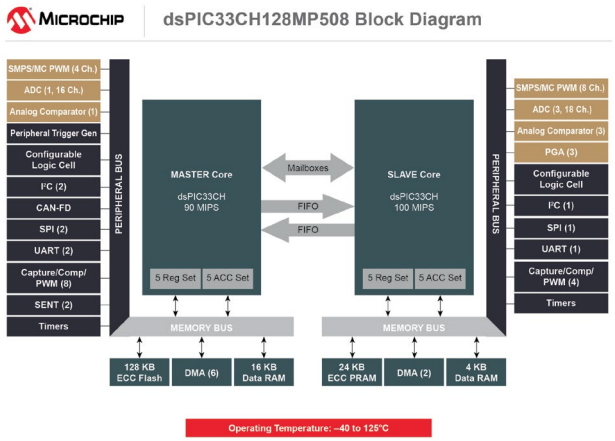

Figure 2: High-end embedded control applications with multiple software

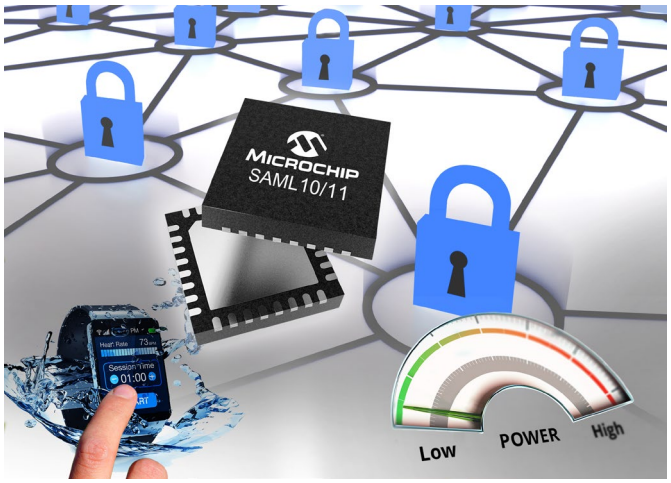

Figure 3: Industry's lowest power in its class

The new devices unite a lot of functionality with unprecedented characteristics:

- Combine industry's best-in-class low power consumption and water-tolerant, noise-immune capacitive touch
- Arm TrustZone enables hardware isolation between certified libraries, IP and application code
- Robust security enabled by chip-level tamper resistance, secure boot and secure key storage
- Eco-system of trusted partners offers a security solution framework and secure provisioning

The new MCU families – SAM L10 as the general purpose variant and SAM L11 as enhanced secure variant – are based on the 32 MHz Arm Cortex-M23 core with up to 64 KB flash/16 KB RAM, with the SAM L11 featuring Arm TrustZone for Armv8-M, a programmable environment that provides hardware isolation between certified libraries, IP and application code. Microchip enables robust security by including chip-level tamper resistance, secure boot and secure key storage which, when combined with TrustZone technology, protects customer applications from both remote and physical attacks.

Security Threats and Solutions

The SAM L11 includes numerous on-chip counter measures to ensure industry leading security in its performance class:

TrustZone and Secure Boot against software attacks like DDoS, malicious code injection, malicious access to memory/keys and Intellectual Property theft;

Secure Bootloader and Secure Storage against vulnerable firmware upgrades, malware replacing genuine program and unprotected key storage for bootloaders;

Chip-level Tamper Resistance and Silent Access against physical attacks like microprobing and side-channel attacks and

Crypto Accelerator and Secure Key Storage against communication attacks like man-in-the-middle attacks and unprotected encryption keys.

In addition to TrustZone technology, the SAM L11 security features include an on-board cryptographic module supporting Advanced Encryption Standard (AES), Galois Counter Mode (GCM) and Secure Hash Algorithm (SHA). The secure boot and secure key storage with tamper detection capabilities establish a hardware root of trust. It also offers secure bootloader for secure firmware upgrades.

Microchip has partnered with Trustonic, a member of Microchip's Security Design Partner Programme, to offer a comprehensive security solution framework that simplifies implementation of security and enables customers to introduce end products faster. Microchip has also partnered with Secure Thingz and Data I/O Corporation to offer secure provisioning services for SAM L11 customers that have a proven security framework.

Lowest Power

When benchmarked for power consumption, the SAM L10 received a ULPMark score of 405, which is over 200 percent better performance than the nearest competitor certified by the Embedded Microprocessor Benchmark Consortium (EEMBC). Microchip uses proprietary picoPower technology to provide industry-leading low power consumption in active and all sleep modes. Both MCU families offer the industry's lowest power consumption of less than 25 µA/MHz in active mode, less than 600 nA in sleep mode (full RAM retention) as well as less than 100 nA in shut down – complemented by fast wake-up times of 1.5 µs.

Touch Innovation

SAM L11 offers unprecedented touch solutions with best-in-class water tolerance against dew, sweat and rain, running water and with IP68 rated products, also improving noise immunity. Both MCU families offer Microchip's latest-generation Peripheral Touch Controller (PTC) for capacitive touch capabilities. It is four times faster than the previous generation of PTC and provides highly-responsive and ac-

curate touch sensing. It is supported by the QTouch Configurator and QTouch Modular Library which make it simple to add elegant touch interfaces to your applications.

- Enhanced peripheral touch controller
- Driven shield plus
- Parallel acquisition
- Buttons, wheels, sliders and surfaces
- Highly-responsive and accurate
- Ultra-low power
- Wake-up on touch
- IEC/EN 61000 4-6, 10 V rms

Designers can easily add touch interfaces that provide an impressively smooth and efficient user experience in the presence of moisture and noise while maintaining low power consumption. The touch interface makes the devices ideal for a myriad of automotive, appliance, medical and consumer Human Machine Interface (HMI) applications.

Evaluation Kits available

The SAM L10 (DM320204) and SAM L11 (DM320205) Xplained Pro evaluation kits, priced at $58.00 each, are available to kick-start development. They are fully supported with application demos: trusted execution environment, secure LoRa IoT node and AWS enrollment through Trustonic.

All SAM L10/L11 MCUs are supported by the Atmel Studio 7 Integrated Development Environment (IDE), IAR Embedded Workbench, Arm Keil MDK as well as Atmel START, a free online tool to configure peripherals and software for accelerated development. START also supports TrustZone technology for configuring and deploying secure applications. A power debugger and data analyser tool is available to monitor and analyse power consumption in real-time and fine-tune the consumption numbers on-the-fly to meet application needs. Microchip's QTouch Modular Library, 2D Touch Surface Library and QTouch Configurator are also available to simplify touch development.

The SAM L10 and SAM L11 devices are available today in a variety of pin counts and package options in volume production quantities.

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Electricity in the Blood

A small device with a big impact: The IVT current measuring technology from Isabellenhütte can even be found in racing cars today. Largely unnoticed by the public, the family-run company from Dillenburg in Hesse has become an FIA technology partner in recent years. It is a commitment from which Isabellenhütte has already gained valuable insights in Formula One for the mass production of precision measurement technology systems. They have now been doing this in the high-performance environment of Formula E since 2014 as well.

By Andreas Lepper and Florian Simon, Isabellenhütte

How do you actually become a technology partner of the FIA (Fédération Internationale de l'Automobile)? Andreas Lepper knows the answer. The project manager of the IVT-F development team at Isabellenhütte coordinates the cooperation with the FIA. "The cooperation essentially began almost 10 years ago," says the 37-year old electrical engineer. "That is when the McLaren Formula One team approached us. At the time, the McLaren location in Woking, England was looking for a current sensor for the first hybrid system to be used in a Formula One racing car."

How to become an FIA technology partner

Motorsports fans know this system under the name KERS (Kinetic Recovery System). A look back: The Formula One team McLaren gained an advantage already in 1998 by using the energy recovery system, but just for a single race and then it was banned again. "As we know today, however, that was not the end of KERS." For commercial and environmental reasons, the concept of the energy recovery system ultimately made sense. That is why there would be another KERS revival 10 years later. And again it was McLaren who advanced this new technology. "At the time, we were working together with a British company that specialized in prototype design and that provided the measurement technology for this purpose. McLaren also relied on its services. And that is how the first contact came about," explains Lepper.

And like in a déjà vu, McLaren also left the competition in the dust in 2009 by using the KERS again. "This was an achievement of the IVT measurement technology," explains Lepper. The other teams were less excited about it. The result: In a gentlemen's agreement, the team bosses agreed to no longer use KERS. It was first in 2011 that the FIA officially allowed the use of KERS. In 2014, it was ultimately replaced with ERS (Energy Recovery System). The advanced energy recovery system now not only converted braking power into energy, but also extracted additional power from the exhaust fumes.

IVT Measurement Technology Comes into Play

To ensure that no team could gain an advantage, the FIA required a complete and transparent data collection of the amount of energy that flows into the drive train as soon as the driver activates the ERS. Since then, energy volumes and opening times of the ERS window have been detected, recorded and issued by the IVT measurement technology in Formula One.

"During this time, we have constantly continued to develop the IVT measurement technology and have specifically designed it to meet the requirements of Formula One racing," explains Lepper. When Formula E finally starts racing in 2014, Isabellenhütte's measurement technology also experiences a tremendous development boost. The invariably battery-powered racing cars place entirely new technical and physical requirements on the measurement technology. The sensor must then be enhanced again in terms of precision, performance and compactness. The experience gained from Formula One was helpful here. The latest result of this development work is the IVT-F (F for Formula). This special design has been used in all Formula E cars since 2014.

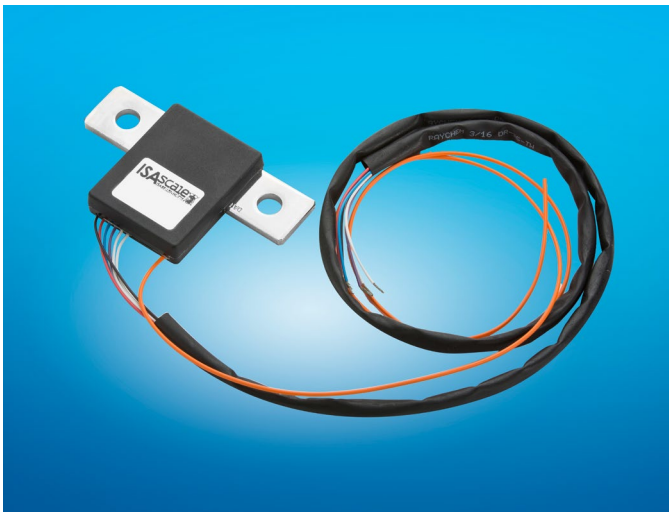

Figure 1: A small device with a big impact: After Formula One, Isabellenhütte has also been equipping all Formula E racing cars with the IVT-F current measuring system since 2014.

Working for the FIA above all means working under pressure. Within a development period of just a few weeks, the engineers of Isabellenhütte design a completely new measurement system – including the design, prototyping, tests and production. This requires a high level of expertise and lots of development power. "We are in close contact with the FIA engineers in Geneva. That is where the requirements for the performance profile and design come from." Adjustments are allowed, are carried out by the team and then approved by the FIA. That's what the rules stipulate. "Of course we provide support here with the optimal system integration, on the hardware side, for example, through structural variations in the size and installation position, and on the software side through dbc-file or support with the implementation of the communication via CANbus." This will also

be this way in the coming season when the cars will be even more powerful. It changes a lot. For Isabellenhütte too. However, Lepper is sure: “The fifth generation IVT-F will also master these challenges.”

IVT-F – “Mr. 1,000 volts” among measurement systems
The currently installed shunt-based measurement systems of the fourth generation are characterized by extreme precision and insulation strength. In order to achieve similar speeds in the racing cars as Formula One combustion engine cars, power is required that can immediately be accessed as efficiently as possible within specified limits in a corresponding amount and voltage. First and foremost this affects the so-called FanBoost. Here drivers selected by the fans get additional energy packages. They help achieve an additional performance boost during the race. The IVT-F is responsible for precisely measuring these processes and ensuring fair competition.

The Isabellenhütte team developed a new type of isolation for this purpose, which is now even used in large-scale products, such as the IVT-S. It is at 1,000 volts and uses the isolation properties of the printed circuit board itself in order to achieve the insulation strength required in the Formula vehicles. This is quite an impressive maximum value. Because: “To the best of my knowledge, there is no competitive product that has such a power capacity coupled with an ultra-compact design,” states Lepper. In addition, it comes with very good linearity, tailor-made electronics, quick scanning and in-house calibration, which lead to the measurement precision of the IVT-F. And measurement precision is indispensable in Formula E in particular, because, among other things, it provides exact information about power consumption and voltage – key values that are decisive for the race.

Constantly Demonstrating Expertise and Technology Leadership
Of course there is a very specific interest behind the Formula E commitment. Like any technology partner, Isabellenhütte strives to gain insight that its series production will benefit from. Isabellenhütte utilizes Formula E for this purpose. On the one hand, it strives to constantly demonstrate expertise and capability in a very dynamic environment, but on the other hand it strives to ensure a constant flow of expertise that the company wants to use to further expand its technology leadership within precision measurement technology. “We expose our system to the harshest conditions in Formula E. In this way, we gain valuable insights that ultimately have a positive impact on the quality, performance and design of our IVT series products,” confirms Athier Lafta, product manager for precision measurement technology at Isabellenhütte. And it’s worth it. The IVT-MOD has already benefited from detailed technological solutions that first had to prove themselves in Formula One before going into series production. This in turn led to the development of the successor IVT-S.

Figure 2: Andreas Lepper (left) and Florian Simon test the IVT-F measurement system for Formula E.

According to Lafta, it is clear that the requirements in the automobile manufacturer market will also continue to increase in terms of e-mobility and continuously improved products will be demanded, for example modules with a higher system voltage. “And Isabellenhütte can deliver these products already today, thanks to formula racing.”

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Zero Overvoltage Switching

Reduce Voltage Overshoot and Oscillations by Switching Off GaN and SiC as Fast as Possible

Turning off an electrical path is causing trouble by parasitic inductance since beginning of power electronics. Ages are spent to avoid oscillations and voltage overshoot while compromising on switching speed. Other research is focusing on low-inductive packaging technology, which is a good idea, but will not finally eliminate parasitic inductance.

By Stefan Matlok, Fraunhofer IISB

In contrast, the Zero Overvoltage Switching "ZOS" method offers a solution to unleash unlimited switching speed in real-world applications without overvoltage on the semiconductors. Moreover, in best case, it is even avoiding any subsequent parasitic oscillation. The idea is to use the intrinsic parasitic inductances and parasitic capacities to build up a resonant circuit. The turn-off event excites the resonant circuit and the free-wheeling diode stops it automatically after half a period, e.g. after a view nanoseconds. These resonant parasitic elements are thereby utilized to switch off a fixed current in a lossless, overvoltage free, and EMI compliant way. By designing the circuit and parasitics properly, there is no extra component necessary and even relaxed industrial style semiconductor housings and low-budget link capacitors can build up the circuit, as parasitic inductance is now functional part of the topology.

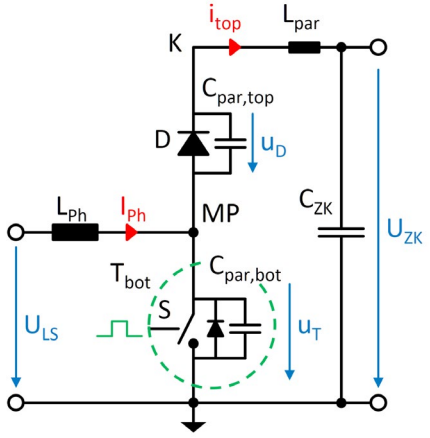

Figure 1: Boost Circuit

Explaining the Zero Overvoltage Switching Effect

The technology focuses on the transistor turn-off event. To simplify the problem, the ZOS approach is described for a boost converter, as seen in figure 1. In classic switching technology, the turn-off event is characterized by a specific turn-off switching time of the transistor T_{bot}, which causes the midpoint "MP" voltage to rise. To commutate the phase current I_L from the transistor to the diode, an additional overvoltage occurs, forcing the current through the freewheeling path's parasitic inductance L_{par}. The amplitude of the voltage overshoot is given by the parasitic inductance, switching speed, parasitic capacities and turn-off current.

Not considered in this classic description is the freewheeling diode's parasitic capacitance. While voltage at midpoint is rising, a specific current starts to flow through $C_{par,top}$. Turning off the Transistor faster increases that current. When this current is large enough, the current commutation is done during voltage is rising, even without any voltage overshoot. The ZOS waveform has three steps:

Step 1: The channel S inside the transistor turns off as fast as possible during t_1, which may also take several ns in physical devices.

Step 2: Phase current I_{Ph} charges the output capacity and thereby MP is rising. The parasitic top side capacity $C_{par,top}$ shifts the level of its cathode K over the DC link voltage U_{ZK}. Thereby current through L_{par} rises and oscillation begins.

Step 3: The oscillation ends immediately after half a period at t_3, exactly where the current of L_{par} is at its maximum. In an ideal setup, the maximum equals I_{Ph} while u_D is zero at this point. Furthermore, the oscillator is stopped by the freewheeling diode, which simply shortens $C_{par,top}$.

ZOS Cell Design

To convert the circuit into a ZOS Cell, the following design rules must apply. Figure 1 shows the parasitics, which are now part of the topology. The low side transistor T_{bot} is sketched as an ideal switch S next to additional (body-) diode and $C_{par,bot}$ and may represent a fast MOSFET for example.

- The parasitic capacitance $C_{par,top}$ of the active free-wheeling component should be near or equal to the low side parasitic $C_{par,bot}$. That is even true for typically non-linear capacities. This is easy to achieve in half-bridge configurations by default.
- On a given hardware and parasitics, the phase current I_{Ph} at the turn-off point must be set according to following equation:

$$I_{Ph} = \frac{U_{ZK}\sqrt{8\frac{C_{par}}{L_{par}}}}{\pi}$$

- The chips and the gate driver design must turn off as fast and snappy as possible. That can be achieved e.g, by switching a 25 mΩ SiC MOSFET with a gate resistor R_G of less than 1 Ω. Less speed will eliminate the ZOS effect.

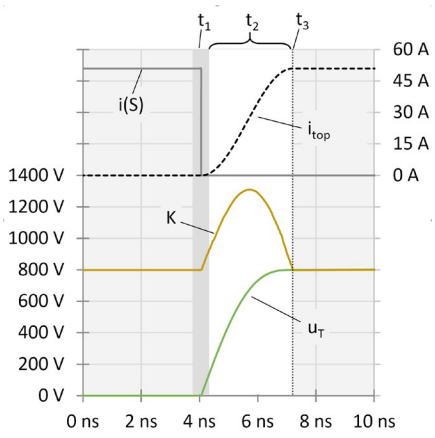

Figure 2: ZOS Switching wave form

Simulation Experiment

One ZOS showcase is a simulation experiment varying the gate resistance R_{gate}. Following classic theory, increasing the gate resistor lowers voltage overshoot. Following the rules of ZOS Cell design instead, overvoltage can be decreased against all expectations by lowering the gate resistance (and raising switching speed). By that approach, the simulated losses can be cut down to about 2 % of the nominal datasheet losses by applying an external R_{gate} of about 1 Ω additional to the internal chip resistance, instead of 20 Ω recommended. The simulation turns off the optimum ZOS current of 84 A using the 25 mΩ C2M0025120D Cree SPICE models with CPW41200S020B diodes parallel in half bridge configuration. The commutation loop inductance is 20 nH, link voltage is 800 V.

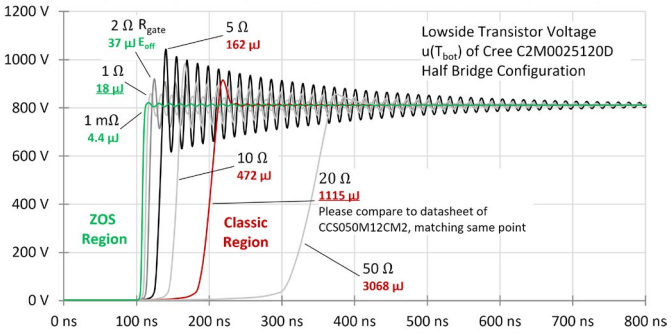

Figure 3: Voltage overshoot in classic and ZOS switching technology

Measurement Experiment

Claiming overvoltage may disappear by increasing switching speed, adding parasitic inductance and ramp up the current is a very tough job resulting in disbelieve and shaking heads. That's why a proof of concept test setup was build. The setup available has a drawback of 4,3 Ω gate resistors per chip while optimum would be below 1 Ω. To compensate this issue as far as possible, -10 V negative gate voltage (instead of -5 V) was applied to switch off faster.

A Half bridge SiC module with 4x C2M0025120D per switch and 4x 10 A SiC diodes

B Increased DC-Link inductance by adding about ~50 nH (2x100nH in parallel)

C Test voltage 400 V DC U_{ZK}

D Test phase inductor connected between MP and high side DC link

E u_T measured by Kelvin contacts

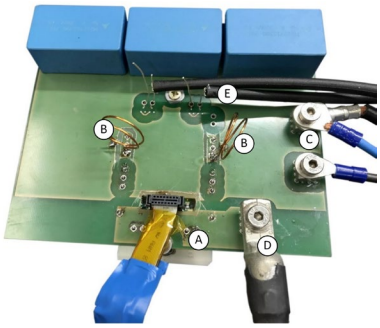

Figure 4: ZOS test platform with module-integrated gate drivers, increased link inductance and film capacitors

The current IPh was alternated by changing the on-time and thereby ramp up different current values. Figure 5 shows a turn-off current of about 48 A. In figure 6, even larger current of about 68 A is turned-off, but parameters are hitting ZOS operation point.

Channel 4 (green) shows the inductor current. Channel 2 (light blue) shows the voltage across the low-side transistor. Channel 1 (dark blue) is a trigger reference of the pulse generator input signal.

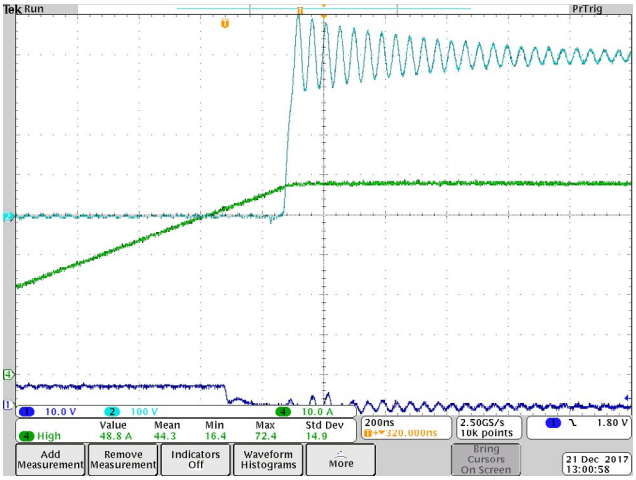

Figure 5: Turning off a non optimal current

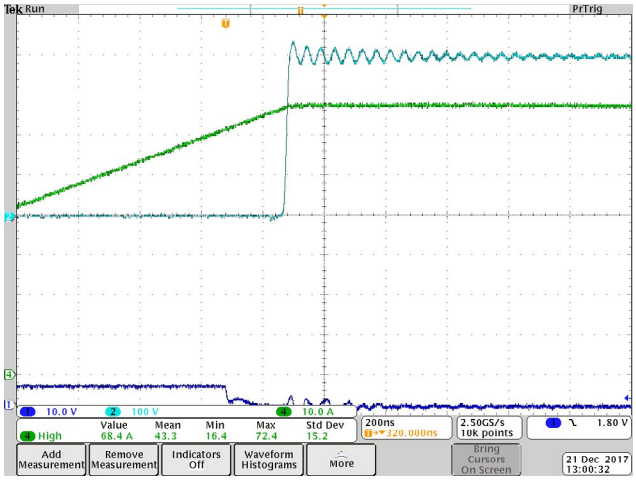

Figure 6: Turning off the ZOS optimized current

Further Key Aspects and Application

The key point of these rules is the unlimited switching speed, that allows cutting losses down to zero. Combined with classic Zero Voltage Switching (ZVS) during turn-on, it is possible to build up a real-world converter without significant switching loss at all.

Most applications need a power regulation. Several techniques allow set up average current while keeping optimum I_{Ph} at turn-off point:

- Switch off phases on multi-phase designs would allow N_{Ph}-step regulation.
- Under BCM operation, Valley Skipping can reduce power.
- Controlling power down to zero by burst-mode operation.
- Classic turn-off for small currents is still possible.

The ZOS technology can be used in every converter technology being able to control the current during the turn-off operation point. That is possible for nearly any classic isolated and non-isolated Buck-, Boost-, Forward-, Phase-shift, even Flyback- and other DC-DC converters from zero watts Point-of-Load converters to megawatt switching cells. Even load regulation is possible, implementation is more easy for constant-power applications like LED illumination or on-board chargers.

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A Charger IC, N Kinds of Applications

The MP2639A is a fully integrated and flexible battery charge management IC that can charge two cells in series from a 5V power supply. USB ports are widely used by portable devices due to their universal compatibility and reduced e-waste of in-box power supplies. Furthermore, with the increased proliferation of USB Type-C, it is now possible to draw up to 15W of power from a standard USB power supply without incurring the added cost of supporting USB power delivery.

By Min Xu, Staff Applications Engineer, Monolithic Power Systems

For its functional diversity, control flexibility, and high reliability, the MP2639A from Monolithic Power Systems (MPS) is ideal for a variety of applications, such as electrical point-of-sale (POS) machines, Bluetooth speakers, electronic cigarettes, power banks, and so on. In this article, we will introduce a variety of applications using the MP2639A.

The sophisticated features of the MP2639A include:

- Bidirectional operation for charging or discharging
- Cell balance and protection escorting for two-series cell charging
- Light-load detection for discharge mode
- Battery-current monitoring
- Input current and voltage loop control
- Integrated voltage-based fuel gauge using four LED drivers
- Other safety mechanisms, including battery temperature protection and back-up safety timers

Figure 1 shows a typical application circuit of the MP2639A.

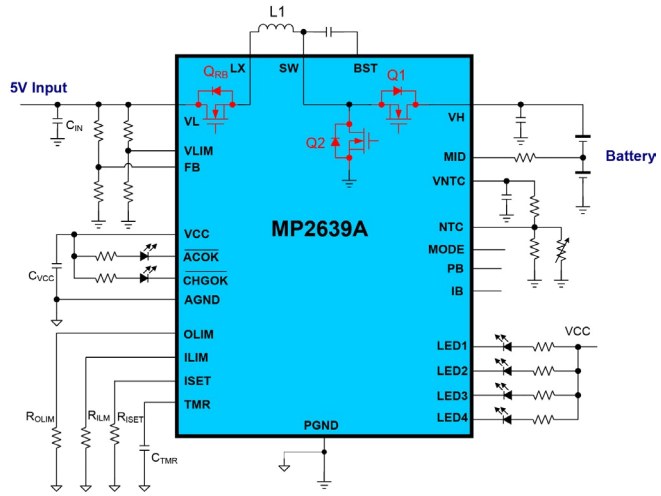

Figure 1: Typical Application Circuit

Due to its diversified features, the MP2639A can be applied to a variety of applications, such as E-cigarettes, Bluetooth speakers, POS machines, power banks, and so on.

E-Cigarette

In some high-power E-cigarettes, a battery with two cells in series is used for high instant power to atomize oil. To be compliant with the USB input, a boost charger is required. Since this application produces large peak-battery discharge current, the life span of the cells is somewhat short. As such, each cell is expected to be independently replaceable, which means the cells installed do not have matched capacity. The MP2639A is an ideal candidate for this application due to the boost charging topology and integrated cell balancing control.

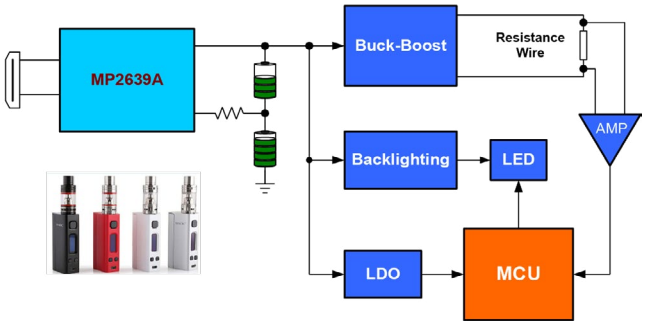

Figure 2: E-Cigarette

Bluetooth Speaker

For better sound performance and increased battery life, a battery with two cells in series is used in many Bluetooth speakers. To be compliant with the 5V USB input, a boost charger, such as the MP2639A, is required to charge the 2-cell battery. The MP2639A has a programmable input current limit and input voltage limit, which allows it to be compatible with various power inputs and the full range of USB-C current up to 3A. Furthermore, the MP2639A also features a source mode (buck) regulator, which can supply up to 5A of current for charging an externally connected smartphone. This feature is convenient for speakers with power bank mode using the USB-C port.

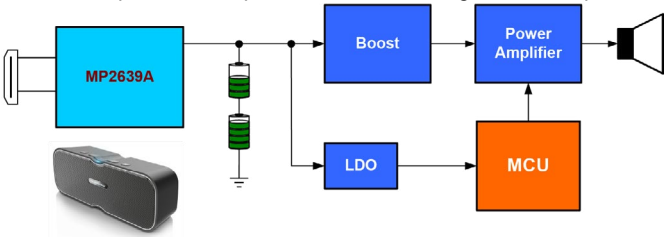

Figure 3: Bluetooth Speaker

POS Machine

In point-of-sale (POS) machines, a stepping motor is required to print receipts, typically. Two-cell batteries are used to achieve high voltage

to power the driver of the stepping motor. Therefore, a boost charger is required to charge the 2-cell battery to be compliant with the 5V USB input. The MP2639A can supply the 4-LED indication of the battery capacity, or provide a battery current monitoring output to the microcontroller (MCU) for a more accurate state of charge (SOC) by calibrating the voltage drop across the battery's internal resistance.

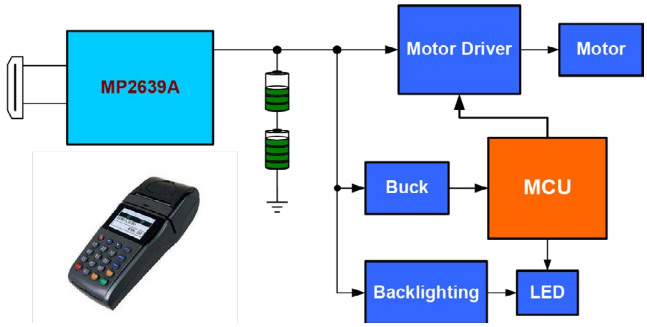

Figure 4: POS Machine

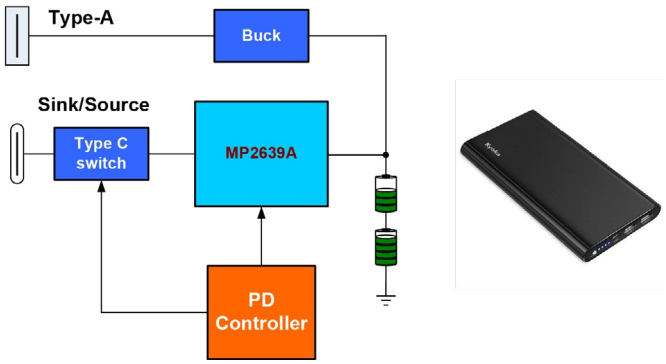

Figure 5: Power Bank

Power Bank

The MP2639A also can be used in power applications due to its bidirectional operation mode. The MP2639A can provide a 5V/5A output when it is configured in buck-discharge mode. The device can also provide simple voltage-based SOC data through the 4-LED indication and IB pin for battery current monitoring.

Conclusion

The fully integrated charger with a diverse range of programmable features make the MP2639A ideal for a wide range of USB-powered applications such as E-cigarettes, Bluetooth speakers, POS machines, and power banks. The low on resistance in the MP2639A optimizes efficiency, and the cell balance function allows customers to use initially unmatched cells to lower cost. The bidirectional power stage can operate in either sink or source (OTG) mode to charge the battery or provide power bank functionality. Together, these features make the MP2639A an excellent choice for USB-compliant, 2-cell battery applications.

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How to Hot Plug Sequence Your BMS Cell Connections

Lithium-ion (Li-ion) batteries are used in a wide variety of portable system applications, including vacuum cleaners, lawn equipment, handheld power tools, e-bikes, and energy storage systems. Li-ion batteries are smaller, weigh less, and deliver longer battery life than other battery chemistries, but require monitoring and protection for safe use.

By Robert Grist, Renesas Electronics

The main task of a battery management system (BMS) is to protect the battery pack, and the key BMS device to aid with protection is the battery pack monitor. It monitors the voltage of each pack cell, as well as overall battery pack voltage, temperature and current. Monitoring these parameters allows the BMS controller to maintain a safe window of operation for the pack and its individual cells.

While there are many aspects to BMS device operation, this article discusses hot plug sequencing and how to implement the cell connection sequences. These sequences characterize a BMS device's hot plug performance. Most engineers are familiar with the term hot plug. However, when dealing with BMS devices and developing hot plug test permutations, engineers need to keep efficacy in mind due to the many BMS connections. A single battery pack monitor can have up to 15 or more hot plug connections.

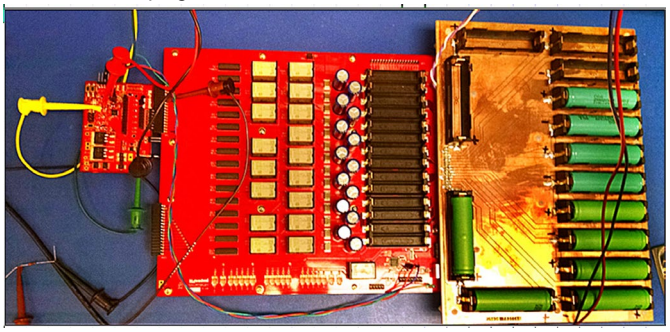

Figure 1: A hot plug test requires programmable switching for control/timing of each cell connection

Hot Plug Test Operating Conditions

Testing for BMS device hot plug robustness requires several "live" cell connections as shown in Figure 1. Because battery cells do not have an off switch, your connections will have active source/sink voltages. And given that you'll have multiple wired BMS-to-pack inter-cell connections, the BMS device must have extremely robust hot plug performance. It must be able to handle any order of connections made in production or the application environment. The BMS' controller is exposed to hot plug conditions each time you attach a new pack.
One of the main problems during hot plug is that the BMS device's various circuit blocks are receiving power before the main rails are established, which can make the circuits behave in unexpected ways. A battery pack monitor, like the ISL94203 or ISL94202, can address this issue by controlling the impedance of critical circuit nodes during the hot plug event.

Hot Plug Test Coverage Goals

Many device aberrations can occur during the hot plug process, so it's important to achieve these fault detection goals during the hot plug test process.
Corrupt POR -- improper state-machine start-up: This problem centers on the BMS control device starting before the completion of all connections. While this may not be catastrophic, it can result in ATE failures during the production process. Early POR can result in start-up failures. Therefore, new hot plug test methods include detection of early POR or device activation during the pack connection process.
Internal logic malfunction -- abnormal digital status: This occurs when digital logic levels have metastable conditions. Metastable is where logic levels are between valid voltage threshold levels. The result is digital status registers reporting abnormal bit combinations. Hence, the test apparatus must include device communications (I^2C, SPI) during hot plug testing, as shown in Table 1. Abnormal digital status can lead to ATE failures requiring a device re-start.

O	P	Q	R	S	T	U
RGO_VDC1	RGO_VDC2	0x80	0x81	0x82	0x83	CELL1
2.499	2.499	0F	0	40	0	3.855
2.499	2.499	0F	0	0	0	3.858
2.499	2.499	0F	0	40	0	3.859

Table 1: Hot plug testing records the BMS device's internal registers via I^2C or SPI communications bus

Analog bias malfunctions -- inaccurate voltage readings: This is a condition where internal analog reference or bias levels do not reach proper levels. Abnormal bias may lead to permanent offset in internal and measured analog values. These offsets can result in permanent error conditions that require a complete power re-cycle to clear.
Figure 2 shows the analog multiplexer (MUX) measurement data after the completion of a hot plug sequence.

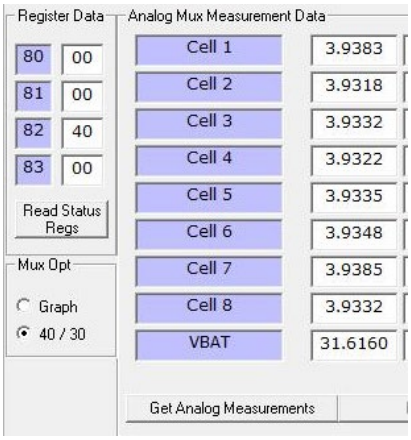

Figure 2: Analog voltage measurements enable change detection in MUX performance

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Formulating Hot Plug Connection Sequences

BMS hot plug robustness needs to address random power sequences. These sequences define the order of connection from cell measurement nodes to active cell voltages. The definition of these sequences can become a study all to itself. Previous efforts at hot plug testing suggested the need for many thousands of connection sequences. Figure 3 illustrates the switched connection sequences for a hot plug test. In developing new connection sequences, we offer a few different approaches that are the result of many years of test development.

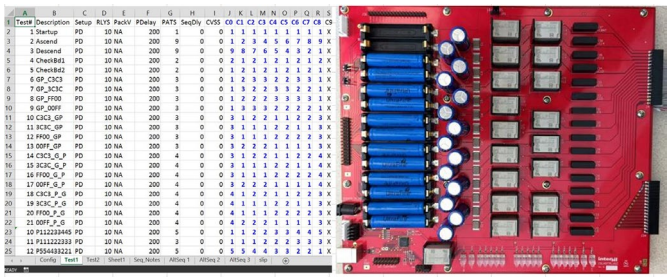

Figure 3: Hot plug tests consist of switched connection sequences

Connection Sequences Based on Memory Test Pattern Efficacy

In addition to defining your hot plug connection sequences, you'll also want to include a memory testing (pattern generation) approach. In fact, memory testing is the dynamic performance testing of the memory bank's power distribution. And, certain types of test patterns stress power distribution more than others do.

For example, a recent industrial BMS hot plug test project required the switching of nine connections made in a random fashion. The connections included VSS (pack-), VBAT (pack+) and 7-cell monitor connections. Therefore, from a memory test pattern viewpoint, there are nine bits.

Other BMS devices have up to 15 or more connections. If connection sequence design comes from a mathematical permutation viewpoint, then thousands to millions of tests are necessary. Note that each test requires the time to power down from the last test, execute the connection sequence and then confirm POR status. After completion of the hot plug sequence, each test triggers a POR cycle. The test then checks digital status registers and finally records analog measurement of all pertinent MUX channels.

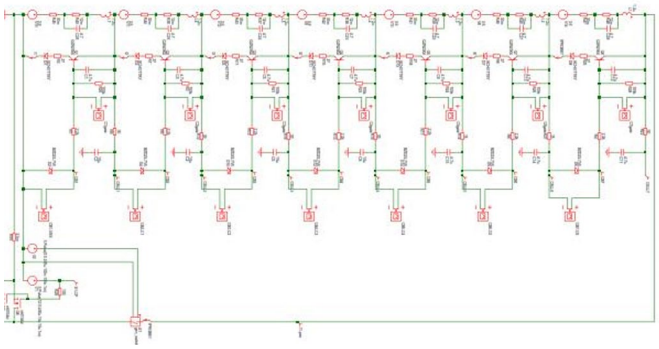

Figure 4: View of BMS hot plug connections from an overall circuit stress viewpoint

To support the memory viewpoint, let's review memory test patterns and their targeted fault detection. Here is a list of memory fault conditions:

1. SAF Stuck-At Fault
2. TF Transition Fault
3. CF Coupling Fault
4. NPSF Neighborhood Pattern Sensitive Fault
5. AF Address Decoding Fault

Reviewing these fault models, and transitioning from memory circuits to hot plug testing, some faults actually target hot plug failure mechanisms. The observation is that faults 2, 3 and 4 are pertinent to hot plug fault detection. Certainly, as different hot plug connection patterns occur, transition faults, coupling faults and neighborhood pattern sensitives are possible. Coupling and neighborhood fault detection is especially suitable for the hot plug test effectiveness.

Hot Plug Test Time using Non-Repeating Permutations Calculation

Channels	Permutations	Bleed Down	Switch Closures (100mS Delay)	POR	Digital Status Measurements	Analog Measurements	Test Step Time in Seconds	Total Minutes	Total Hours
1	1	0.30	0.10	0.25	0.30	0.25	1.20	0.02	0.00
2	2	0.30	0.20	0.25	0.30	0.50	1.55	0.05	0.00
3	6	0.30	0.30	0.25	0.30	0.75	1.90	0.19	0.00
4	24	0.30	0.40	0.25	0.30	1.00	2.25	0.90	0.02
5	120	0.30	0.50	0.25	0.30	1.25	2.60	5.20	0.09
6	720	0.30	0.60	0.25	0.30	1.50	2.95	35.40	0.59
7	5,040	0.30	0.70	0.25	0.30	1.75	3.30	277.20	4.62
8	40,320	0.30	0.80	0.25	0.30	2.00	3.65	2,452.80	40.88
9	362,880	0.30	0.90	0.25	0.30	2.25	4.00	24,192.00	403.20
10	3,628,800	0.30	1.00	0.25	0.30	2.50	4.35	263,088.00	4,384.80
11	39,916,800	0.30	1.10	0.25	0.30	2.75	4.70	3,126,816.00	52,113.60
12	479,001,600	0.30	1.20	0.25	0.30	3.00	5.05	40,315,968.00	671,932.80

Header	Description
Channels	Hot Plug Connections (Device Cell Channels)
Permutiations	Mathmatical Not Repeating Permutations
Bleed Down	Circuit Discharge from Previous Test
Switch Closures	Total time to close all channels with 100mSec delay between each closure.
POR	Typical Time for a device to POR. Devices with internal EEPROM, transfer from EEPROM to working registers.
Digital Status Measurements	I2C / SPI Register Access
Analog Measurements	Time to record analog input value (Each Cell)
Test Step Time	Time to complete one complete Hot Plug Test
Total Minutes	Test time for once complete series if test methodology is based on mathematical (non_repeating) permutations
Total Hours	Test Time calculated in hours

Table 2: Connection sequences using calculated, non-repeating permutations is not practical in a real-world lab environment

Therefore, newly designed hot plug sequences apply stress to the internal biasing of the connections. This stresses device conditions to a greater degree than the simple one at a time approach. Combinational patterns such as checkerboard add to walking 1s, and walking 0s are basic patterns used during this version of hot plug testing. As shown in Figure 4, a BMS device needs to control the impedance of the input switches during hot plug events so that the IC's input signals are also controlled.

Connection Sequences Based on Single Cell, One at a Time

These patterns have basic concepts about one at a time connection patterns. Examples are simple ascending and descending closures, and there is semi-random, one at a time sequences. The goal here is to use efficient pattern selection but limiting the quantity of these types of sequences. This keeps test runs within a reasonable length of time.

Strictly applying non-repeating permutation calculations can result in impractical hot plug testing logistics. Table 2 reveals estimated nine connection hot plug test times of more than 400 hours. This approach is not practical for device repeat testing, multiple device testing or timing variation.

Connection Sequences Based on Hardware Interconnect Design

A final consideration is the mechanical aspects of connectors. Hardware interconnect design addresses the number of connections made with each connector, and considers the overall organization of electrical distribution. Designs can use 2-, 3- and 4-cell connections with a single connector, which means that a connected battery pack involves a collection of connectors.

Also the interconnect design can include cell monitor connections made separately from the main pack- and pack+ nodes. Other designs might parallel pack- and pack+. The result is the main supply points are physically attached to two different connection points. In short, sequences based on hardware interconnects are driven by the schematic.

Connection Sequences with Interconnection Delay

Connection sequence design includes a programmable delay. Each test step, in addition to specifying the closure sequence, also includes a variable as part of the test definition. This variable is a programmable delay between closures. Therefore, in the interest of test time, early testing keeps the delay short. Follow on test runs can then increase the delay value to emulate the real-world time it takes between battery connections.

It's always better not to base sequences on mathematical permutations alone. Rather, sequences should be a combination of three types. The first type of sequence is selection of one at a time patterns. The second type is several at a time based on effective input stressing. And the third is basing sequencing combinations on connector schemes, i.e. physical contacts per plug assembly.

With a focus on sequence efficacy, reiteration of test runs is possible. This enables the testing of multiple devices. Sequence efficacy reduces test time so personnel can be on-hand from a safety standpoint. Finally, the timing within the test processes can expand to emulate delays naturally occurring in the factory/user connection process.

Conclusion

Hot plug performance is key to device qualification when you are designing battery management systems. In this article, we have reviewed many aspects of BMS hot plug testing and sequence design. We've also listed the desired failure coverage that should be followed. Along the way, we learned that focusing on connection sequencing (and timing) addresses an issue that fundamentally drives the essentials of practical hot plug testing. Engineers should consider sequence development as a continuous process. Future development will primarily be driven by the BMS-to-pack interconnect.

Test conditions also rely on reference designs and their variations.

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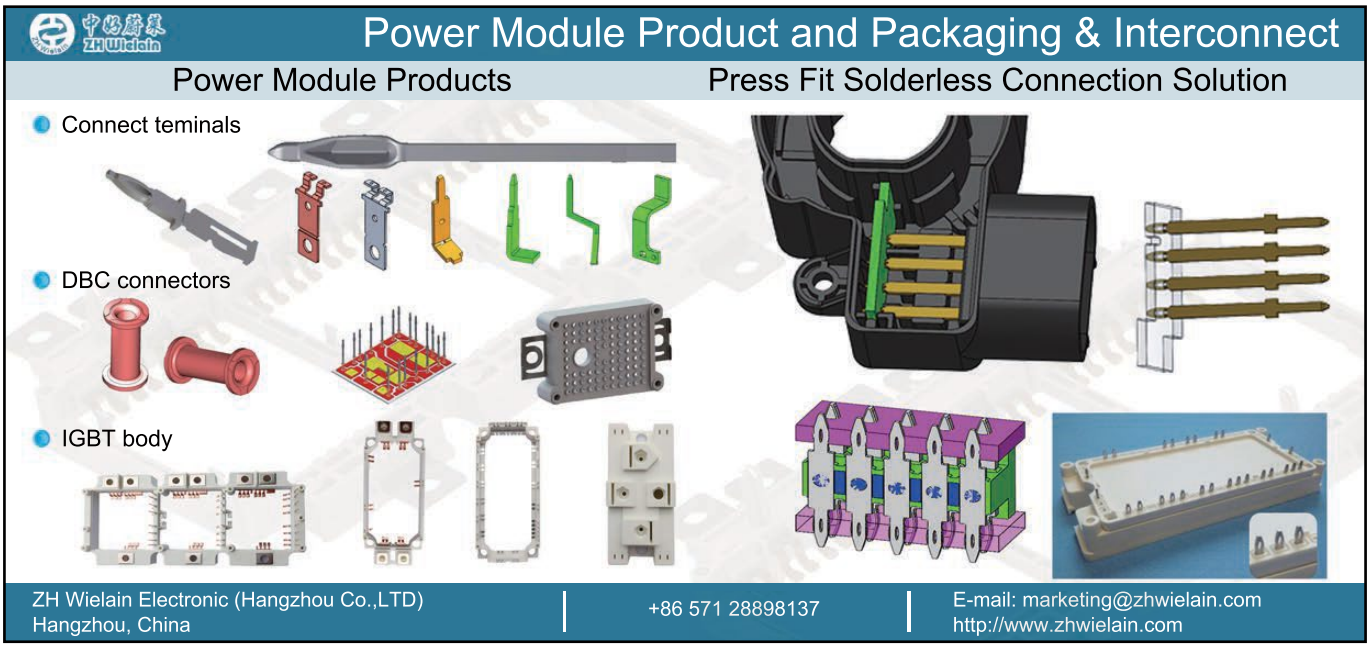
About the Author

Robert Grist is a Lead Software and Applications Engineer for the Analog and Power Products Group at Renesas Electronics.



Breakthrough in Test Procedures for Islanding Detection

New methods for Anti-Islanding Tests for Grid-tied Power Generator Equipment

The standard DIN V VDE V 0126-1-1 [1] or VDE-AR-N 4105 [2] or IEEE 1547 provides strict regulations for power generating equipment feeding the public grid. The main aim is to harmonize all important technical specifications and to prevent safety risks at "islanding" conditions.

By Bruno Ammann, B.Sc., Senior Field Application Engineer and Gabriel Schlaepfer, B.Sc., Development Engineer Hardware, REGATRON AG

Up to now test methods using passive tuned circuits require a considerable effort both in terms of expensive components as also of work time. Power circuit simulation by REGATRON TC.ACS series allows for replacing lumped component R-L-C-circuits simply by "Simulated Impedance". Furthermore the same TC.ACS device can be used to perform all necessary voltage and frequency tests based on the same test circuit, therefore the complete range of test requirements according to standard DIN V VDE V 0126-1-1 [1] is being met with a fraction of expenditures both in time as in material.

Up-to-now Standard Test in Detail

With respect to frequency and voltage the standard DIN V VDE V 0126-1-1 [1] or VDE-AR-N 4105 [2] respectively defines limits, the violation of which power equipment need to detect and then disconnect from the grid. The device under test (DUT) has to disconnect from the grid autonomously within 0.1 second when voltages either fall below 80% or exceed 115% of the nominal voltage (UN). Also frequencies (f) below 47.5 Hz and above 51.5 Hz must result in disconnection within 0.1 second. Already today in many cases a grid simulator is used to confirm the fulfillment of these requirements.

Moreover the DIN/VDE standard states that an islanding condition must be reliably detected and a disconnection from the public low voltage system has to be executed within 5 seconds.

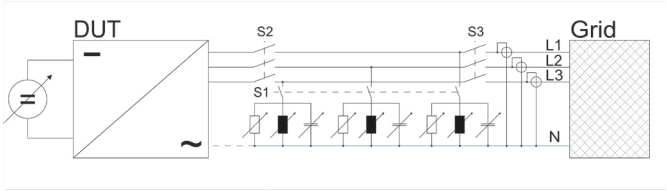


Figure 1: Test set-up for the detection of islanding operation according to VDE-AR-N 4105 [2]

In order to check the detection of islanding operation, R-L-C-circuits (see Figure 1) are connected in parallel to the DUT/grid. Each R-L-C-circuit is dimensioned to absorb the complete active and reactive power of the respective phase of the DUT. When the connection to the public system is being cut (S3), the DUT (a solar power inverter for example) has to separate from the public grid within 5 seconds. This test has to be run with P = 25%, 50% and 100% of the nominal power at the nominal frequency of ±0.1Hz and the nominal system voltage of ±3%. After each successful test run one parameter (L or C) is altered by approx. 1% within a range of approx. ±5% and the test run is repeated. Quite obviously, such a test is rather extensive with regards to material (different values of R, L and C with the corresponding ratings of voltage and current) and time. Although automated solutions are available, these are also material-consuming and expensive.

The quality factor Q of the R-L-C-circuit must be 2 at least. The active power being absorbed by the circuit must not deviate from the active power fed by the power device for more than 3%. The following relationships apply:

The test is set up as follows:

- Setting the inductivity, such that Q >/= 2
- Setting the capacity, such that the reactive power (PQ) equals that of the DUT
- Setting the resistance, such that the active power equals that of the DUT (in the case of lumped components this active power is transformed into heat!)
- Closing S1, S2, S3 and starting the DUT, the corresponding active/reactive power builds up
- Opening S3 (→ islanding starts) and measuring the time until the DUT is turned off

State-of-the-art Solution Using Simulated R-L-C-Circuit

REGATRON offers unidirectional as well as bidirectional high-performance AC/DC power supplies in different ranges of power and voltage. Beside these DC series, the TC.ACS Grid Simulator series represents a full 4-quadrant AC/AC converter with excellent dynamics and power ranges of 0 to 30 kVA or 0 to 50 kVA respectively. By ingenious paralleling techniques, a system power up to 1 MVA is achievable. TC.ACS grid simulators may be run either in Grid Simulation mode, in R-L-C-Simulation mode or in a 3-phase Linear Amplifier mode specially designed for high speed HIL applications. In the current control mode, TC.ACS is able to generate a current, which

dynamically changes according to the actual terminal voltage. By fast on-board computing techniques it is therefore possible to model complex impedance and simulate even R-L-C-circuits in real-time (see Figures 2 and 3).

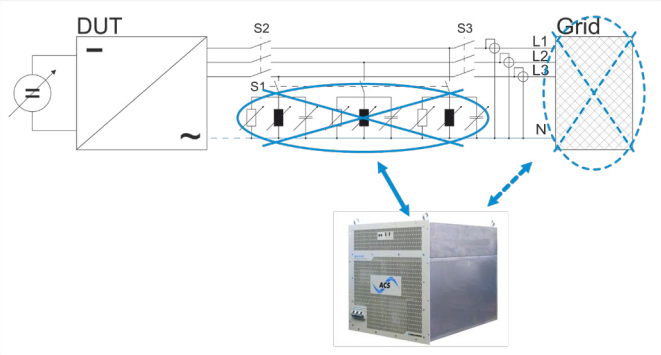


Figure 2: TC.ACS can be used to selectively simulate either the R-L-C-circuit or the public grid. This way both tests (detection of islanding and monitoring of voltage/frequency) can be carried out using the same circuitry.

In R-L-C Simulation mode the TC.ACS simulates the R-L-C tuned circuits based on pre-calculated values, while in Grid Simulation mode all voltage and frequency related tests easily may be performed.
All relevant “component values” can be adapted in full operation. A special API programming interface allows even for automatic stepwise variation of parameters according to the standard VDE-AR-N 4105 [2]. It is obvious that the “Simulated Impedance Method” simplifies the detection of islanding conditions strongly.

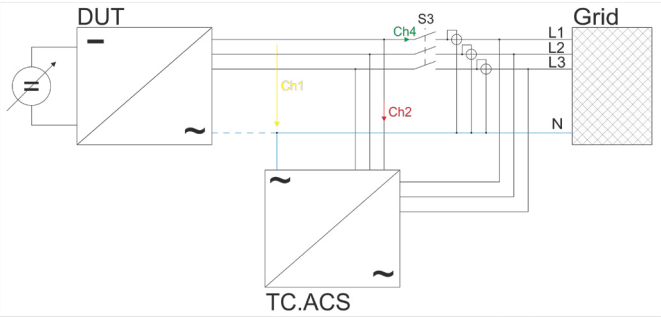


Figure 3: Test set-up using TC.ACS Impedance Simulation. For voltage and frequency related tests switch S3 stays open and the grid is being simulated by TC.ACS operated in Grid Simulator mode. For the detection of islanding switch S3 is closed, TC.ACS is operated in R-L-C-Simulation mode and the simulated R-L-C-circuits are adjusted in full operation. S3 is reopened again to test the DUT’s behavior while in islanding condition.

The use of TC.ACS in Grid Simulation mode and R-L-C-Simulation mode offers the following benefits:

- No need for a respectable component warehouse of high power R/L/C-components
- No need for a time consuming handling and recalibration of bulky and partly heavy circuit components
- Drastically simplified test circuitry
- No need for any tuning of real components and reconnecting at each test step
- Simple “component value entry” by enclosed software ACSControl
- Drastically reduced time requirements
- Simplification of tuned circuit alignment and variations in full operation

With the described test set-up it is possible to apply both single-phase as well as multi-phase blackouts to the DUT, as required by the standard. In the single-phase case an R-L-C-system is simulated only on one phase, while on the others an off-load operation is programmed.

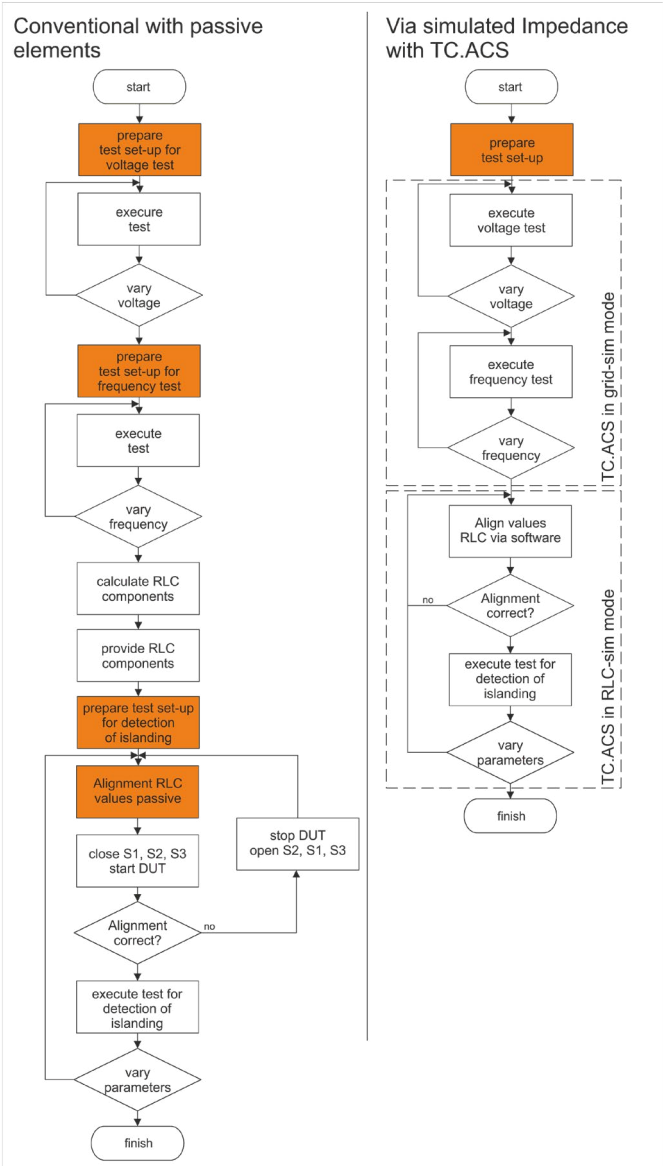


Figure 4: Flowcharts of the test sequences according to DIN/VDE regulations. On the left the conventional approach is shown with passive elements and on the right the same test using the integrated solution. The steps highlighted orange are those which require the most effort in work and material.

Use Case: Testing a DC/AC Converter for the Detection of Islanding

In order to demonstrate the capability of the R-L-C-circuit simulation, a REGATRON TC.GSS is operated in regenerative mode with a nominal power of 5 kW per phase (this is the DUT working as “Solar-inverter”). The tuned circuits are simulated by TC.ACS with the values given in Table 1. As a driving DC power source (e.g. a “Solar Array Simulation”) a further TC.GSS is being used.

Cutting the grid by S3, the circuit shows a flawless perpetuation of the islanding operation by the TC.ACS in the RLC-circuit-simulation mode. The DUT detects the islanding in turn and breaks off well within the defined period of time (see Figure 5). The values of the R-L-C-

circuit can be varied during operation in order to meet the required tolerances.

Topology	Topology no. 12 (see figure 7)
R	12.6 Ω
C	900 µF
L	11.22 mH
R2	0.1 Ω
R3	0.4 Ω
Q	3
Cut-off frequency of voltage measurement	500 Hz

Table 1: Values for testing the detection of islanding condition

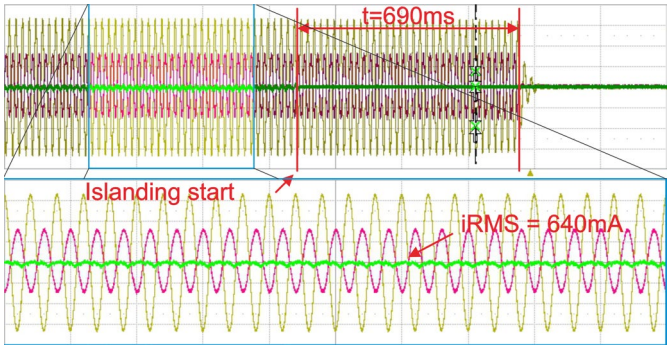


Figure 5: Behavior of the R-L-C-Simulation during an islanding detection test. 690ms after the start of the islanding the DUT shuts off.
Ch1 (yellow): Voltage L1-N at the input of the DUT
Ch2 (red): Current L1 at the output of the RLC-simulator TC.ACS
Ch4 (green): Current through S3 (current into the grid). In operating state the RMS-current into the grid is approx. 640mA and hence <3% of the nominal power.

Simple Use of the Enclosed Software

Both R-L-C Simulation and Grid Simulation modes are operated by the software ACSControl, which is included in the scope of delivery. In the GridSim mode a large variety of voltage patterns can be generated by the resident function generator.

In RLCSim mode the parameter values are set by a user interface (see Figure 6). Subsequently, a circuit analysis is performed creating a set of differential equations running in real-time onboard of TC.ACS. By this, phase currents are dynamically computed as a function of the relative phase voltage.

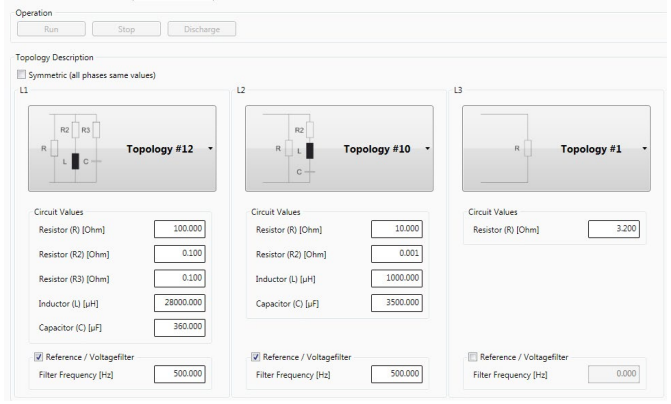


Figure 6: Graphical interface of ACSControl software: The R-L-C-topology can be set per phase.

An adjustable low pass filter restricts the bandwidth of the voltage measurement, this helps to suppress unwanted resonances within the simulation chain. At the same time voltage pulses are attenuated, preventing undesirably high currents. Moreover, an application programming interface (API) provides the possibility to access the individual parameters. Thus for instance the simulated load can variably be set via step functions, an important feature when configuring automated test sequences.

Additional Areas of Application for the RLC-Simulation

In addition to the described parallel resonant circuit above, currently further topologies are available for the simulation of complex impedance, see figure 7 below.

The R-L-C Simulation allows for definition of a wide variety of complex AC loads ranging from purely inductive to purely capacitive in a high kVA area. Also cos-j steps are possible in order to test phase shifters. Such tests are feasible not only in the 3-phase-grid, but also for each individual phase.

One-phase to three-phase loads can easily be simulated observing the TC.ACS device specifications. AC load simulation is very helpful for R+D work, AC network/grid definition and device testing as well as

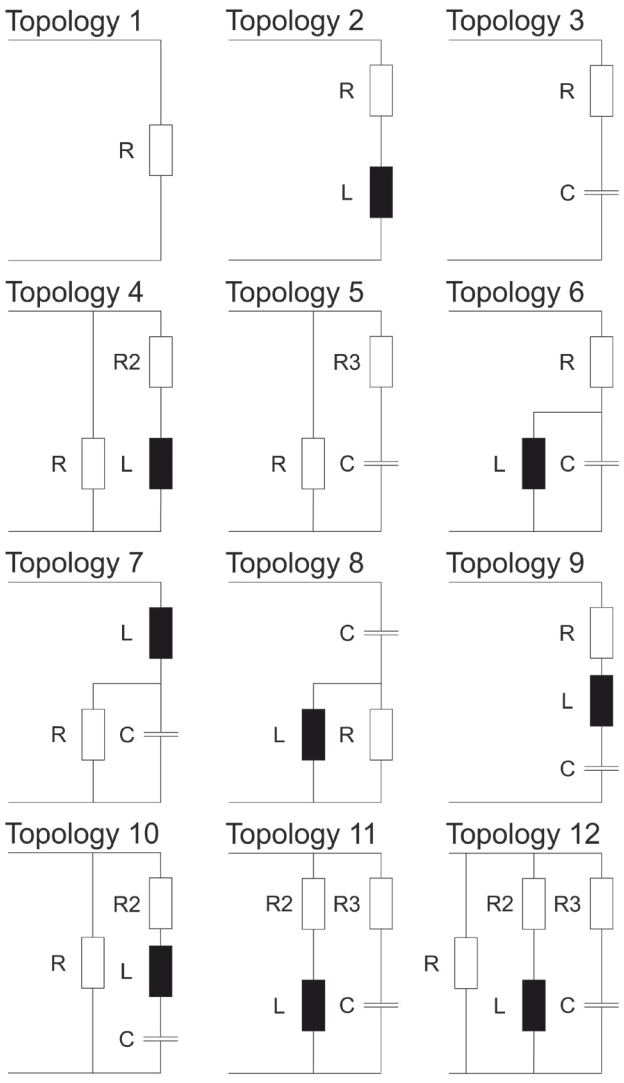


Figure 7: Overview of the RLC-topologies currently available. These can be simulated according to the system limits of the TC.ACS.

for educational purposes. Moreover, the API allows for dynamic parameter variation, opening up the way to programmable load variation, an indispensable topic for network analysis and dynamic AC device testing.

Testing devices with switch-mode output together with TC.ACS R-L-C Simulation needs sometimes a special care. Due to the complex impedance of TC.ACS output structure, unwanted AC noise may cause interference. In such cases additional filtering (i.e. notch filters) will suppress the unwanted modulation frequency. By this technique, even switch mode equipment can be tested easily in a R-L-C Simulation environment.

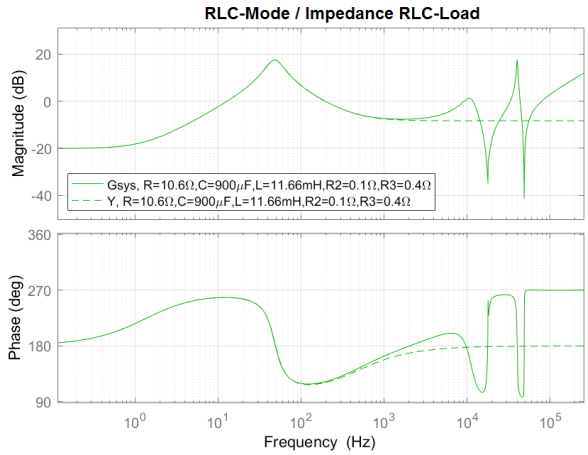


Figure 8: Comparison of the simulated (continuous) and the real (dotted) impedance according to the topology 12 of the RLC-operation with the following values: R=10.6Ω, C=900μF, L=11.66mH, R2=0.1Ω, R3=0.4Ω.
The influence of the TC.ACS output filter is clearly visible in the Wfrequency range > 1kHz.

Constraints of the Simulation

In the frequency range below 1 kHz there are only small local deviances between the real and the computed impedance due to measuring tolerances and nonlinearities in the control circuit. However, these are comparable to tolerances of real components. By adjustment of the component values it is possible at any time to tune the values such that the test requirements are met.

[1]	DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE. DIN V VDE V 0126-1-1:2013-08 Selbsttätige Schaltstelle zwischen einer netzparallelen und Eigenerzeugungsanlage und dem öffentlichen Netzspannungsnetz.
[2]	DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE. VDE-VR-N 4105:2011-08 Erzeugungsanlagen am Niederspannungsnetz - Technische Mindestanforderungen für Anschluss und Parallelbetrieb von Erzeugungsanlagen am Niederspannungsnetz.

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Research of Properties of Manganese Zinc Ferrites with Fe-Poor Composition

MnZn ferrite materials are mainly composed of Fe2O3, Mn3O4 and ZnO. General MnZn ferrite materials are basically Fe-rich composition formula, that is to say the proportion of Fe2O3 in the three main raw materials is more than 50mol%. This paper studies related characteristics of MnZn ferrites by Fe-poor composition formula.

By Yang-zhong Du, Chao-ming Wang, Xu Zhao and Fei-yu Lv;
Hengdian Group DMEGC Magnetics CO., LTD

Introduction

With the continuous development of electronic technology, especially the rapid development of digital technology, the world put forward high requirements on resistance to electromagnetic interference technology of electronic device (EMI), which requiring materials used for these devices should have excellent EMI property. Commonly used EMI ferrite materials have MnZn materials and NiZn materials. Currently, MnZn ferrite material on the market is Fe-rich composition formula, that is to say the proportion of Fe2O3 in the three main raw materials is more than 50mol%. According to the composition diagram of MnZn ferrite permeability (Figure 1), Fe3+-short composition can also obtain high permeability. In this paper, select several Fe-poor composition formula to do relevant experiment and study its related properties.

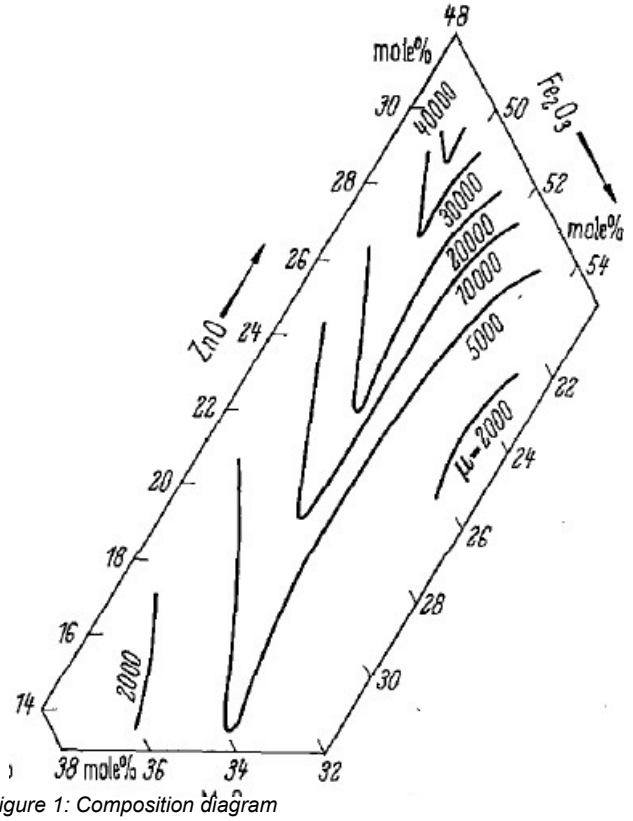

Figure 1: Composition diagram

Experimental method

According to the composition diagram of MnZn ferrite and and the influence of zinc content on the Curie temperature. The authors of this paper chose four compositions as shown in Table 1:

NO.	Fe2O3	MnO	ZnO
	mol%		
P1	49.5	26.5	24
P2	49.5	28.5	22
P3	49.5	30.5	20
P4	49.5	32.5	18

Table 1: Formulation composition

After weighing raw materials, according to conventional ceramic processing techniques to prepare material, they were mixed with a planetary ball mill. After drying, the powder was calcinated at 750~800°C in a presintering oven for 2~3hr, then add proper additives for sanding. After sanding, control average particle size of powder between 1.1~1.3 um. After drying slurry, add PVA granulating and moulding, pressing into ring core H25*15*8 and put cores in elevator kiln using different sintering program. Samples were tested with a WK6500B analyzer.

Results and discussions

The influence of ZnO content on initial permeability of material

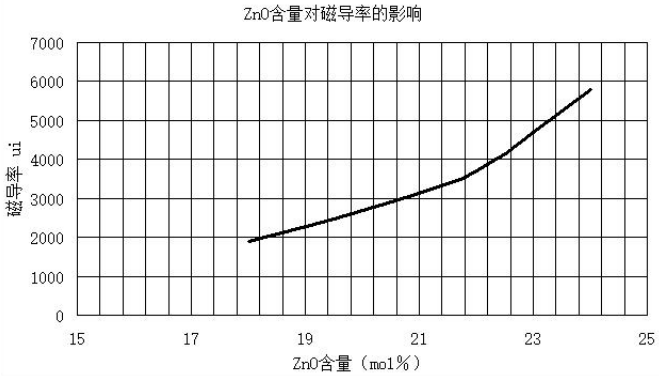

Figure 2: The influence of ZnO content on permeability

According to the formula chosen in this paper, fix Fe2O3 content 49.5 mol %, change ZnO content. As shown in Table 1, 4 different formula ring cores after sintered in certain conditions, permeability results as shown in Figure 2.

As can be seen from Fig. 2, with the increase of ZnO content, permeability shows an uptrend. When the Ratio is Fe2O3 49.5mol%, ZnO 24mol%, permeability of ring core can reach around 6000. According to magnetocrystalline anisotropy constant K1 curve (Figure 3), K1 of Fe-poor composition formula selected by this paper is less than 0. With the increase of ZnO content, K1 gets closer to 0, so you get higher permeability.

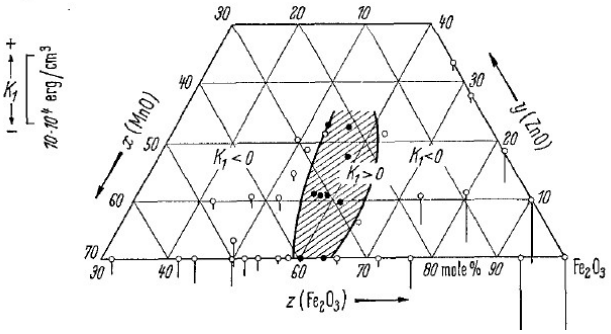

Figure 3: K1 vs MnZn composition diagram

Influence of ZnO content on Curie temperature

According to related literatures, theoretical calculation of Curie temperature of Fe-poor composition formula can be calculated as following formula:

Tc = 6.475*{ X - (2/3)*Z } - 104 [°C]

X represents Fe2O3 mol%, Z represents ZnO mol%, comparisons of theoretical Curie temperature according to calculation formula, and actual testing Curie temperature are shown in Table 2.

NO.	Theoretical calculating	Actual testing
P1	113℃	91℃
P2	121℃	102℃
P3	130℃	113℃
P4	139℃	120℃

Table 2: Comparisons of theoretical Curie temperature and actual testing Curie temperature

From above comparison, it can be seen that actual Curie temperature has some deviation from theoretical calculation of Curie temperature, which is related to the sintering process and certain addition of additives. Theoretical calculation formula of Curie temperature under certain conditions need modification.

According to the formula of Curie temperature, with the increase of ZnO content, Curie temperature of material will decrease. When ZnO content reaches 24mol% and Curie temperature is around 90°C, for actual use it makes no sense. Therefore, when choosing formula, it is necessary to consider actual application and choose proper proportion of main raw materials in the material.

In comparison to Fe-rich grades with the same permeability.

Do comparision tests of u'/u''~f, u~T characteristic, impedance characteristic and resistivity characteristic of Fe-rich composition formula and Fe-poor composition formula samples that permeability is around 4000.

From figure 4 and 5, we can see that Fe-poor composition formula samples have better properties at high frequency, what's more, impedance is higher than Fe-rich composition formula samples after 5MHz, this is due to Fe-poor composition formula samples have higher resistivity. Through testing, Fe-rich composition formula samples' resistivity is around 0.5 Ω·m, but Fe-poor composition formula samples' resistivity can reach 10 Ω·m. However, Fe-poor composition formula samples has lower curing temperature seen from figure 6.

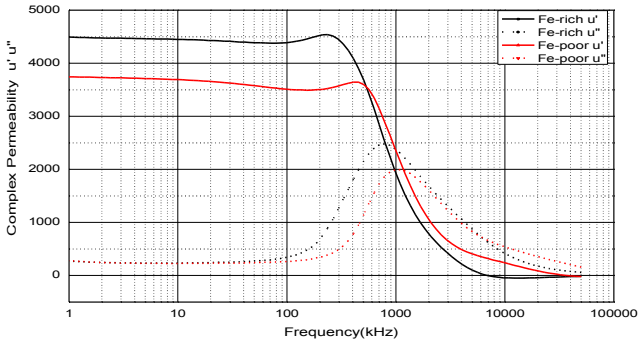

Figure 4: u'/u"~f curve

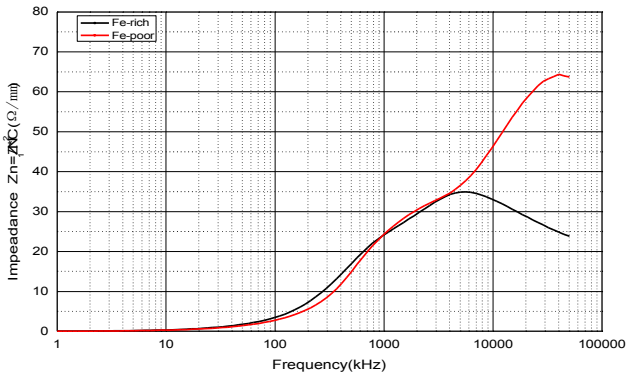

Figure 5: Impedance curve

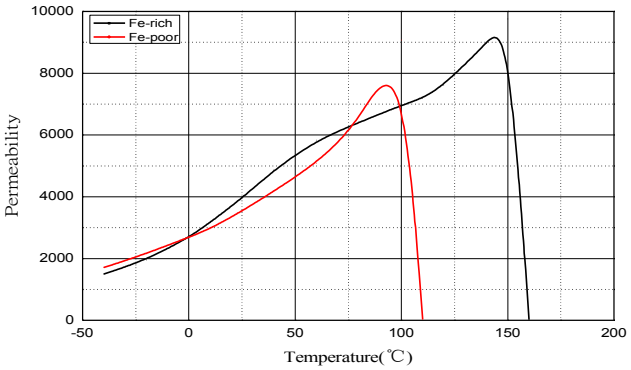

Figure 6: Temperature curve

Conclusion

MnZn ferrite with Fe-poor composition formula can also obtain high permeability, but Curie temperature is lower compared to Fe-rich composition formula. When setting formula, it is necessary to consider the actual application conditions, and choose the ratio of Fe2O3, Mn3O4 and ZnO three main raw materials rationally.

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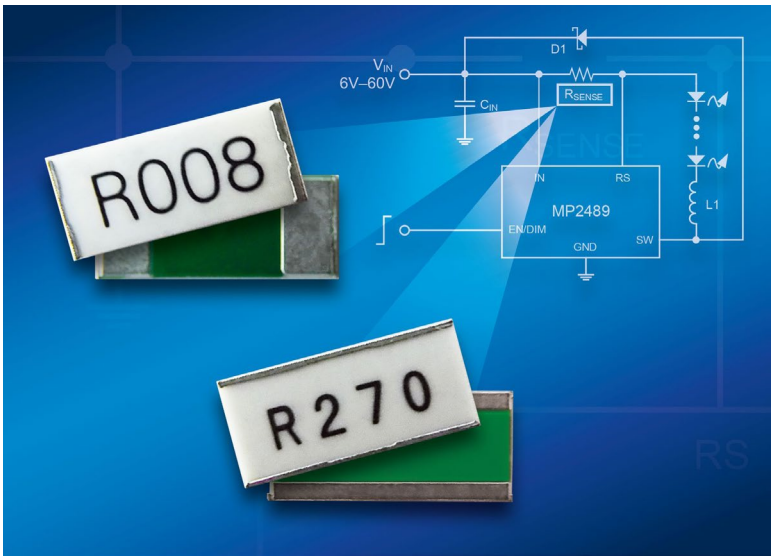
Parameters of Current–Sensing Resistors

In order to measure the current in an electric circuit, precisely kept low resistance current sensing chip resistors should be used and the voltage drop over the component is measured. The required characteristics are tight initial tolerance, small TCR, high nominal power and small size. There are however other important factors, like the affect of self heating, the material of the resistive element and on high frequencies the equivalent series inductance (ESL) to take in account. In this article we will discuss these factors and their role to be able to make a precise current measurement with SUSUMU's unique KRL series of shunt resistors.

By Tobias Jung, Senior Product manager – Passive electric parts and Zoltán Kiss, Sales manager EEU, Endrich



Low resistance current sensing chip resistors have been introduced originally as over-current protection devices in power supply circuits. Their application range has been extended and these components become important components for power management of electronic devices and used to measure or adjust current. When an engineer wants to compare different current sensing resistors' resistance stability over temperature, TCR alone would not give a precise information about the measurement accuracy due to the fact resistance is also influenced by the self-heating of the components. As there are more and more expectations towards electronics devices, the signal processing speed increases, generating a challenge for the designers to control noise caused by high frequency. In these cases, the self inductance of the resistor has a crucial affect on the behavior of the shunt. The article will detail the favorable construction of a reliable shunt resistor through the KRL current sensing resistor series of SUSUMU. This series is very popular due to its high power capability and low inductance at lower resistive range, which helps control the noise of high frequency and high speed applications of electronics devices as well as improves power dissipation capabilities due to the inverted construction and the long side terminals. These are thus suitable for current measurement in household appliances or automotive applications meeting the requirements of the standard AEC-Q200 up to the largest component package size.

First thing to take in consideration when designing-in a component to the application is the datasheet provided by the manufacturer. It is recommended however to validate the included data in real application or laboratory conditions.

In case of chip resistors - besides the usual parameters like the resistance, the nominal power and the initial tolerance of resistance at room temperature - the TCR (Temperature Coefficient of Resistance) as an indication of how the resistance changes with the temperature should be also considered.

For example, a part specifying ± 100 ppm, may have a resistance deviation from the nominal value of 0.01% per degree Celsius (or Kelvin) temperature change. At a temperature difference of 100 K, which is quite common in outdoor or automotive applications, this adds up a deviation accordingly of 1%. In most cases, the TCR information refers to the ambient temperature surrounding the component in the planned application.

Self-heating of current sensing resistors

Current sensing (shunt) resistors (see cover picture) are subject to power loss calculated by P = I2R - derived from Ohm's law. Therefore, to keep the dissipated heat low in order to avoid self heating and its affect of the resistance itself, the device manufacturers offer the range of available resistance values down to the milli- and even the micro-ohm region.

However, in order to cope with the ever-increasing currents to be measured, they must also adapt the performance specifications of the components. This is done using various technologies, such as in the construction as multi-layer resistance, with foil or curved solid metal as a resistance element.

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Depending on the technological and material-specific possibilities, these resistors are specified differently. The maximum nominal power of a component is usually determined by its thermal limitations. For this purpose, the temperature is measured, for example, at the top of the chip and / or at its contacts. When the limit temperature is reached, a derating in the power dissipation capabilities starts. The maximum power loss for which a given resistance value can be kept therefore heavily depends on the heat dissipation ability of the components. To avoid power derating the manufacturers strive to avoid so-called hotspots in the design of the resistors.

TCR and PCR

When comparing different current measuring resistors, the TCR alone would not give sufficient information about the expected accuracy over the operating temperature range, because the resistance would not only change with the ambient temperature, but also due to self-heating. Thus, another parameter comes into play: the PCR (Power Coefficient of Resistance). An inferior in terms of TCR device can deliver more accurate reading than its competitor due to the PCR effect if its self-heating is significantly lower.

An example: Basically it can be assumed that the resistance of type B would show more accurate results due to its narrower TCR. Assuming R = 100 mΩ for both types, the self-heating, depending on the structure or technology used, shows very much different values. In this example, the type B with a TCR of ± 40 ppm is heated by 100 K, while the metal foil resistor of the KRL series with TCR of ± 50 ppm would only warm up by 60 K.

The self-heating resistance is calculated according to
R = R0 TCR ΔT
100.4 mΩ for the type B respectively
100.3 mΩ for the type KRL.

One can see from this calculation example that due to lower self-heating the KRL series current sensing resistor - despite its larger temperature coefficient - provides the more accurate measurement result.

Power derating

The power rating of the resistor shows what is the maximum energy that the resistor is able to dissipate without being damaged or degraded.

Most of the manufacturers indicate their power rating at 70 °C in free airflow, above this temperature there is a degradation due to stress on the material. The temperature where the power dissipation must be derated to 0 is also indicated, this is the maximum possible storage temperature of the resistor.

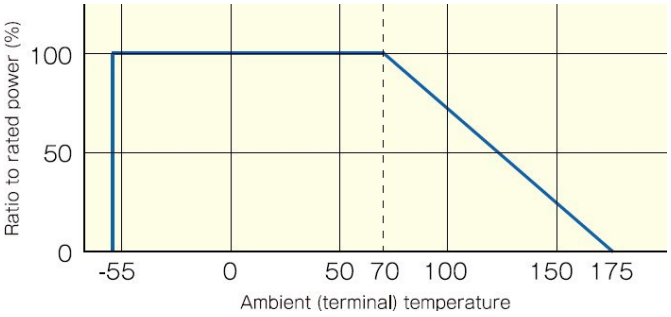


Figure 2: Indicating power rating at 70°C

Incase of SUSUMU KRL series, depending the constantan or manganin alloy used as the material of the resistive element, the power derating curve shows higher derating point, it's due to the unique construction of the component. This is the reason, that usually the KRL series could be used till higher rated power or on the same rated power in smaller case size than many other parts.

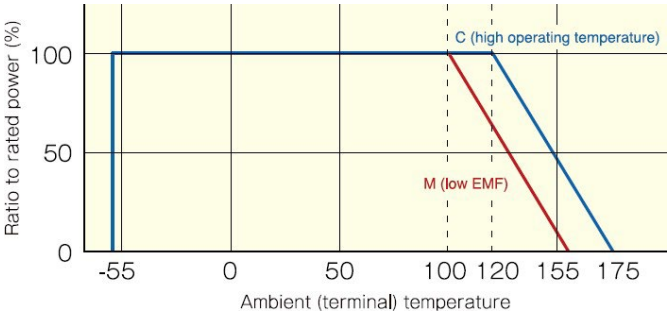


Figure 3: Curve shows higher derating point

Current measurement in practice

This reliable method of measuring currents can be found in automotive applications, but also established for example in home appliance technology. One can find such current sensing resistors in the vehicle in the trunk lid control or seat adjustment; also valve regulators or brake systems require a precise current measurement. A manufacturer of cleaning robots, such as those used in residential places, was able to solve three problems at once using the KRL resistors. The DC / DC converter of the robot's power supply requires a 10 mΩ shunt, which is specified for a power loss of at least 2 W, as currents above 10 A should be measured, and the controller requires input voltage of at least 100 mV. Usually for 2W heat dissipation a shunt with 2512 size is required, but due to limited space it does not fit. By choosing resistor with soldering terminals on its long sides (long-side terminal KRL), a smaller 2010 case size is enough, as on wider solders the heat is conducted easier and faster towards the PCB.

Material of resistive element

As current sensing is based on voltage measurement on a precisely stabile resistance, all factors that may have influence of this voltage-have to be considered. Above we detailed the TCR's and the PCR's influence, but there is a further effect that may lead to measurement mistakes. As the resistor consists of different metal materials connected together, the so called thermocouple-effect (Seebeck- effect) may also distort our measuring. When different metals are connected together at one point, and this intermetallic junction is subjected to heat, a small (microvolt magnitude) voltage may arise between the free ends, that leads to further distortion of the precise measurement. Constantan based resistive elements have higher thermo-EMF, while the manganin versions are considered to be low thermal EMF sources, therefore more stabile for precise applications.

Equivalent series inductance

There is an important factor to take in account for making precise current sensing on high frequencies, the equivalent series inductance (ESL) of the resistor, that should be kept as low as possible. Number of electronic devices require precise power management, that could be provided by using DC/DC converters. These switching devices operate on several hundred kHz frequencies. If the ESL of the current sensing resistor is large, the transition switching pulses contain noise, that affects the accuracy of the control, as the inductive impedance is proportional to the frequency and the inductivity:
Z ~ 2pfL
However, if ESL is small, such noise will become insignificant.

The inductance of conductor (non-coil) is provided by the following equation:

$L=0.002\ h(2.303\log_{10}4h/d-1+\mu/4)$

Where h: conductor length,
d: conductor width,
μ: permeability

The inductance increases with permeability of the material and length of the conductor and decreases with the width of the conductor. Therefore, when the material is fixed, low ESL can be obtained by shortening the conductor length and widening the conductor width. Susumu's long-side terminal type resistor realizes low ESL with shorter length and wider width of the resistive element by using its longer side as the terminal.

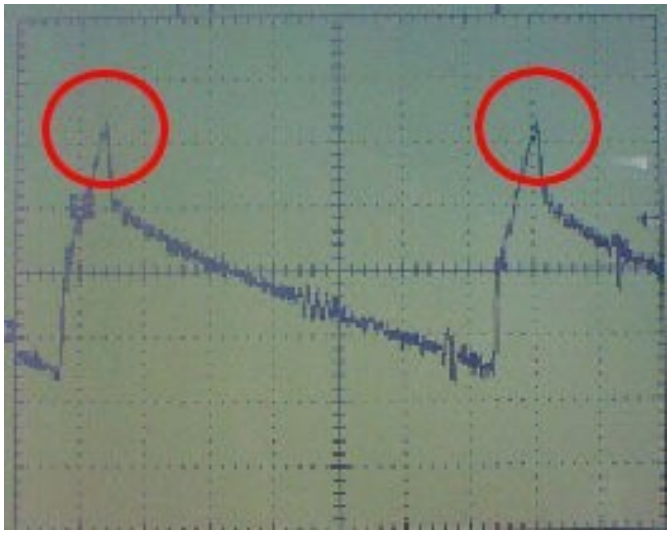


Figure 4: The shape of the waves using a short-side terminal resistor with the switching noise

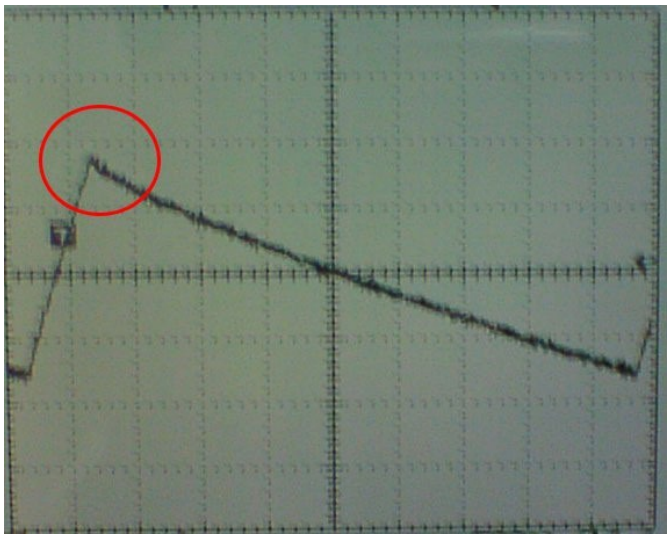
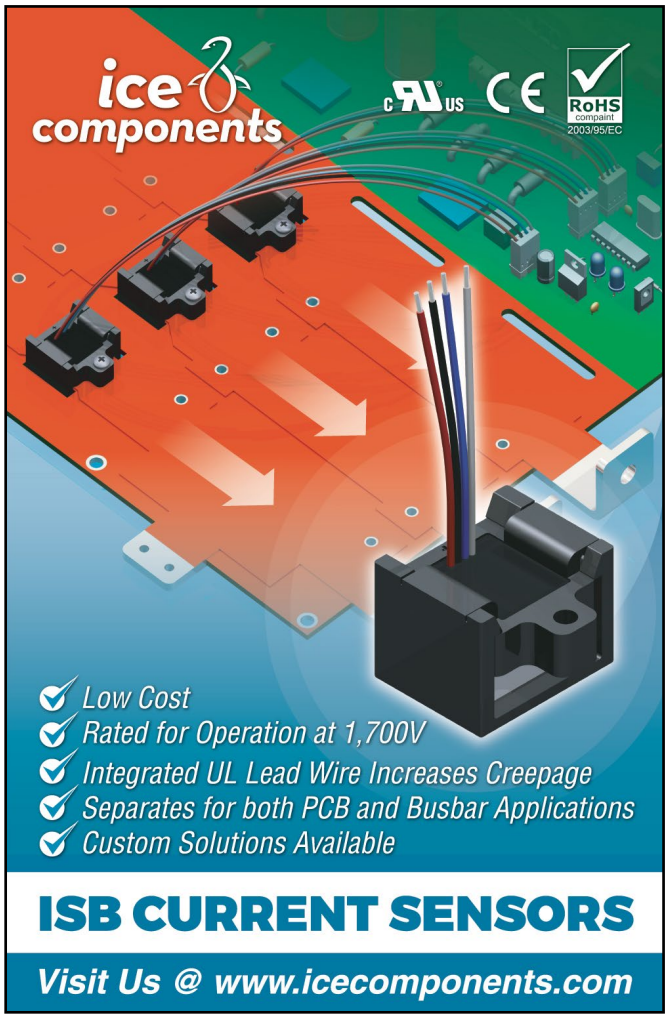


Figure 5: The same waves when using a long-side terminal resistor, demonstrating a clear reduction of the switching noise

Using such low ESL current sensing resistors, the designer can avoid the need of using additional noise reduction circuits.

Long side terminals – better heat performance, better noise reduction

Susumu's long-side terminal low resistance chip resistors were developed to increase heat dissipation. Due to this high power capability, these chip resistors have been very popular. In addition, new demand has arisen for high frequency applications, where the low ESL of the long side terminal versions also provided significant advantages. Noise suppression in combination with low parasitic inductive influences indicates the accuracy increases significantly. In the charge controller of electrical devices, near the battery, thermal properties play an important role as the electronics and battery heat up during charging and discharging. Due to the inverted structure (carrier ceramic above, resistive element below) are in the resistor, no hotspots are formed, and this is rapidly cooled, which reduces the influence of TCR / PCR on the measurement result.



KRL series of SUSUMU

The KRL resistor series of Susumu (distribution: Endrich Bauelemente) are designed for high nominal power with low nominal resistances and thus for use in current measurement. The structure with metal foil, which is attached to the underside of a carrier ceramic, promotes the uniform cooling of the component (Figure 1). Further characteristics of the KRL series are low noise, low parasitic inductances, low thermal EMF, which could falsify the measurement result, low dead weight and their robustness. The latter is due to the inverse structure - with the metal foil under the carrier ceramic. The organic adhesive layer absorbs mechanical stresses due to the different length expansion of ceramic and printed circuit board material. The components can thus clearly exceed the requirements of the automotive standard AEC-Q200 up to the largest case sizes. The KRL series is available in different layouts: with rated resistances from 1 mΩ to 1 Ω, in sizes of 0603 to 4320, in rated power classes from 0.25 to 10 W, as standard with a TCR of 50 ppm, with initial resistance tolerances of ± 1% and with short-side, long-side, 4K and gold terminals.

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Pushing the Limits of GaN-based Power Devices and Power Electronics

Latest Research Results on the EU Public Funded Project 'InRel-NPower'

The InRel-NPower research project reaches for maximum power efficiencies in power electronics' applications by exploring group III Nitride-basing power devices.

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Introduction

Power electronics demands the highest efficiency for converter and inverter applications. The continuous innovation requires the exploration of the latest GaN, AlGaN and AlN semiconductor materials. Within this context, the European Union's Horizon 2020 research and innovation programme funded the "InRel-NPower" project (Innovative Reliable Nitride based Power Devices and Applications) in order to improve functional performance and reliability of Nitride-based wide band gap power semiconductors. Generally, advances in power semiconductor technology addresses improvements in efficiency, size, weight and cost of power electronic systems. At present, IGBTs, and MOSFETs represent modern switching devices. New components based on wide band gap materials (SiC and GaN) are on the way to be introduced for next generation of advanced applications. (1)

As shown in Figures 1 and 2, wide band gap Semiconductors (WBG) such as SiC, GaN, AlN and diamond show superior material properties in comparison to Silicon.

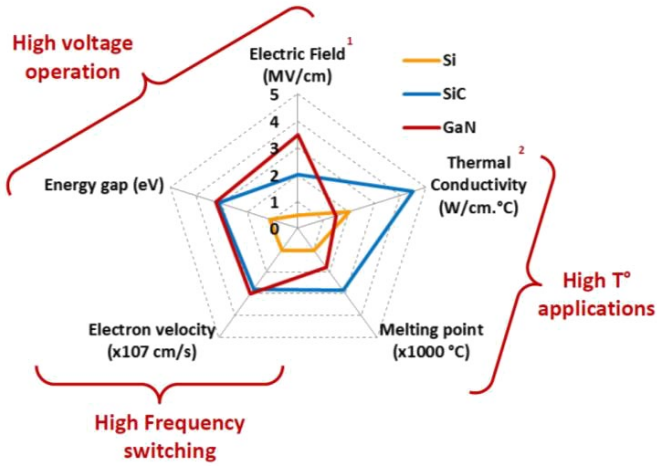

Figure 1: Superior material properties of wide band gap semiconductor material in comparison to Silicon (2).

The main strategic target of this project is to offer reliable and robust devices processed on GaN-based and AlN-based substrates (available within Europe for high and medium power application), which can help to address important and worldwide relevant social issues, like measures against climate change, sustainability in energy consumption, electrical energy savings, E-mobility and so forth. Packaging is also carefully addressed in this project thanks to two innovative packaging solutions that will allow the exploitation of the full capability of the GaN material. This requires the combination of the indicated expertise over the stages of the value-chain, paired with a physical understanding of processes and mechanisms acting inside the device. The vision is that this work and the knowledge of the partners involved will help to generate a deeper understanding of the technology issues related to semiconductor devices based on wide band gap materials. The target is to bring the European semiconductor value chain partners a step further towards the frontiers of the production and application of robust high and medium power devices.

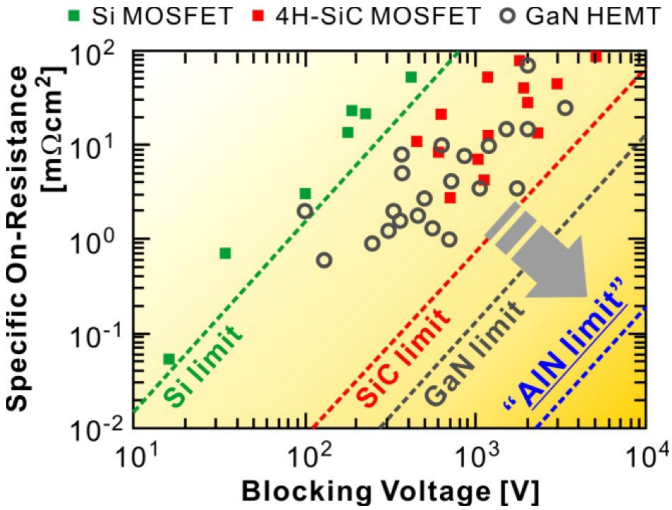

Figure 2: Superior material properties of wide band gap semiconductor material in comparison to Silicon (3), (4).

Whereas the great potential of GaN based converters has already been demonstrated at the application level there are still relatively few early adopters for this game-changing technology. The main reasons for this reluctance to switch to GaN technology is due to three factors: cost, uncertainty about long term reliability and conservatism among power converter circuit designers. InRel-NPower envisions to contribute to the medium to long term solution of the energy saving issue aspects by providing a clear reliability assessment methodology for GaN, together with convincing and improved device lifetime data, as

well as by developing two demonstrators proving the superiority (in terms of efficiency and costs) of the GaN devices developed within this project. In parallel, this project will push the boundaries of WBG technology by studying the implementation of AlN-based technology, which compared to GaN (and any other WBG semiconductor) has even better material properties.

Additionally, it shall be emphasized, that the nine InRel-NPower EU research partners are completed by two Japanese universities, the University of Mie and the University of Kyushu, as associated research members in a very special EU public funded project structure. The references (5) and (6) as examples provide an insight of their research work, tasks, contributions and results.

Improving group III-Nitride semiconductor compound material

The activities on the improvement of the GaN epitaxy and material can be roughly split in two parts: improving the HEMT heterostructure that will define the properties of the active device on the one hand and the use of different starting substrate materials together with buffer techniques on the other hand.

Due to its physical properties the GaN is probably one of the materials with the potential to develop major importance beside Silicon. However, the maturity of the fabrication processes for the most prominent novel GaN based devices, the high electron mobility transistors (HEMT), has still to improve. The HEMT structures are usually fabricated on silicon wafers with all the physical feedback and consequences a hetero epitaxial system creates. The native freestanding GaN wafers are only negligible available in small diameters and at high costs. So, the heteroepitaxy on silicon, which is available in large diameters and for low price, is the way of choice.

This is physically the more difficult situation but, epitaxy scientists all over the world have developed techniques in metal organic vapour phase epitaxy (MOVPE) for mastering the major problems arising from thermal and structural mismatch of the two materials. Although difficult, at the point in time the growth of GaN based device structures on silicon works quite successful.

The MOVPE deposition works at relatively high temperatures above 1000°C, consequently the GaN as the material with a larger coefficient of thermal expansion, shrinks faster than the Si substrate upon cooling down the system to room temperature after growth. As a result, the epitaxial layers experience huge strain and may crack. Additionally, the wafer develops an unfortunate large bow, which is not acceptable for later processing. The advanced epitaxial techniques now allow to introduce complex sequences of strain moderating layers which generate opposite strain states and thereby mitigate the bowing of the wafer.

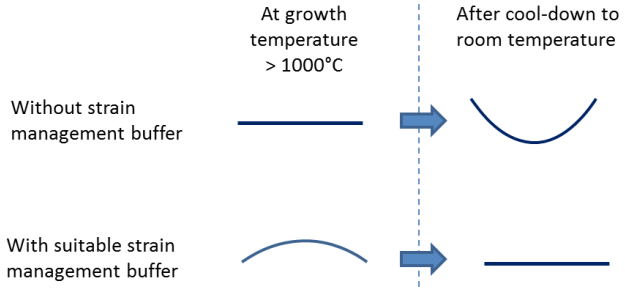

Figure 3: Mastering the wafer bow in GaN on Si heteroepitaxy.

On the other hand, the silicon substrate and the many hetero-interfaces introduced a large number of misfit dislocations because of the required strain balancing do not match structure wise. Typically, the dislocations can be drastically reduced over the height of the semiconductor layer stack. However, a remaining dislocation density in the order of 109 cm-2 in the topmost layers remains. It is the electrical behavior of these extended defects (and other point defects), which causes difficulties for the functionality of the devices, reliability and robustness.

Improving the reliability of GaN HEMTs and designing new device architectures

Reliability assessment of e-GaN devices plays a crucial role in determining long-term stability and functionality. Initial part of such assessment involves the understanding of the conduction mechanisms under both forward and reverse bias conditions for different ambient temperatures as different gate processing techniques arises different leakage conduction mechanisms, such as Poole-Frenkel, thermally assisted tunneling (TAT). As can be seen from Figure 4, Poole-Frenkel is the main conduction mechanism under reverse bias and under forward bias there are two different conduction models. Between 1.5 V and < 4 V, conduction is basically thermionic emission (TE) based and for VG > 4V to up to breakdown it is TAT. Time-dependent dielectric breakdown measurements were done on Gate-Source diodes on p-GaN-gate based e-GaN devices. Lifetime calculations, shown in Figure 5, indicate a 10 years gate life for VG > 6.5 V at room temperature using TAT model.

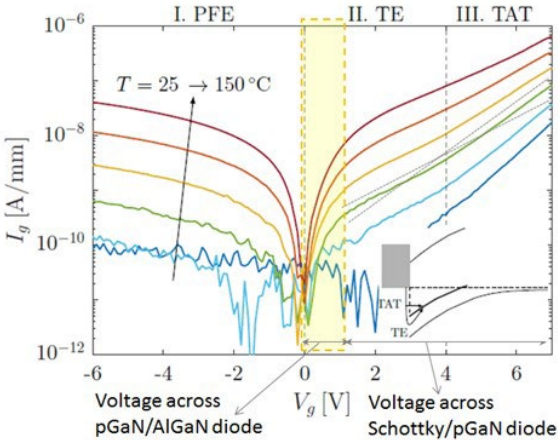

Figure 4: Figure showing the forward and reverse gate leakage characteristics for a typical pGaN gate structure as a function of temperature. Different conduction regimes are indicated.

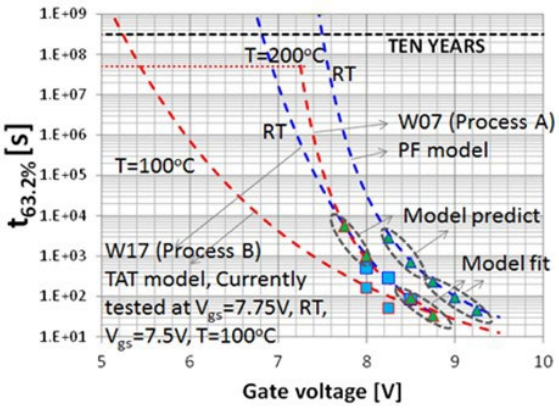

Figure 5: Operating lifetime prediction under forward bias condition at RT and 200C based on thermally assisted tunneling and Poole-Frenkel model. Measured data (blue squares) are in line with the predicted lifetime models.

GaN-on-Si transistors suffer from poor critical electrical field strength of the Si substrate together with a parasitic conduction at the buffer/substrate interface leading to device breakdown. That is why, the highest reported three-terminal breakdown voltage values for grounded substrate GaN-on-Si HEMTs defined at an off-state leakage current of 1 µA/mm are still below 1.5 kV, which is basically limited by the Si substrate and associated material quality. In order to suppress the parasitic conduction phenomenon, local Si substrate removal (LSR) was proposed in 2010. The Si substrate removal around the drain electrode enabled electrical isolation of the gate and source from the drain across the buffer layer/Si interface, leading to an enhanced blocking voltage of GaN-on-Si HEMT above 2 kV. Using this method, we recently achieved for the first time GaN-on-Si MISHEMTs with LSR under the entire device followed by a backside deposition of the ultra-wide bandgap AlN material (see Figures 6 and 7). The use of an in-situ SiN gate dielectric combined with the LSR technique together with 15 µm thick AlN layer enabled state-of-the-art GaN based HEMTs with remarkably low off-state leakage current (<1 µA/mm) up to 3 kV (see Figure 8). The next step is to apply this process to industrial high current (> 10 A) power devices in order to demonstrate the manufacturability of this approach.

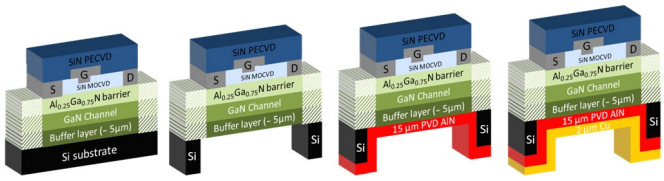

Figure 6: Schematic cross-section of AlGaN/GaN MISHEMT after the front side process, the LSR technique, 15 µm thick PVD AlN deposition, and the 2 µm Cu deposition on the back-side.

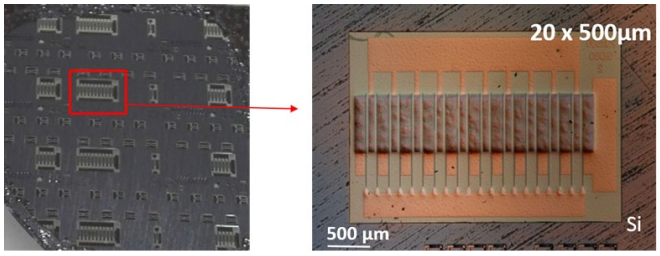

Figure 7: Optical backside image of the wafer with and without LSR removal patterns, and a 20×500 µm GaN-based MISHEMT after LSR.

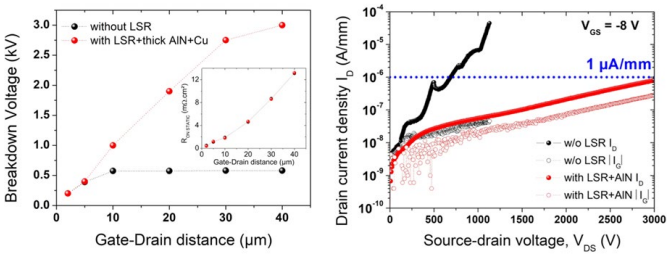

Figure 8: Evolution of LGD-dependent device breakdown and specific on resistance (inset) of AlGaN/GaN HEMTs with and without LSR/thick AlN/Cu by defining the blocking voltage at 1 µA/mm, and off-state leakage current characteristics of AlGaN/GaN MISHEMTs with and without LSR / thick AlN deposition.

Modern low-inductive power module design for GaN-HEMT

For the module designs, the selected assembly and inter-connection technologies (AIT) have to support maximal the outperformance of the wide-band-gap power semiconductors in use. For instance, this refers to maximum operating junction temperatures, maximal reachable power cycle robustness and enabling a low-inductance module characteristic. Therefor two promising module concepts with their accompanying design elements, one all ceramics substrate design and one hybrid ceramics-laminate design, are under deeper research investigation.

Due to the needed cooling performance and hot spot management, the common base substrate in both concepts will be a Si3N4-AMB (Active Metal Brazing) substrate. In addition, due to the needed power cycle robustness in hard switching inverter applications, the GaN-chip backside will be attached on this AMB-substrate in both concepts by the Silver sintering technology (or sometimes called as Low Temperature Joining Technology LTJT).

Furthermore, one has to notice: all three chip terminals – Source, Gate and Drain – have to be contacted on the chip top side due to its lateral nature as a HEMT (High Electron Mobility Transistor) device. The selected 'counter substrate' and its design has to enable the needed circuitry dissolution for a proper functionality.

All Ceramics Substrates Design

For this concept, the dissolution of the circuitry facing the top side of the GaN-chip will be realized with a multilayer LTCC (Low Temperature Co-fired Ceramics) counter substrate (see Figure 9). One very important task is the development of a double-sided Ag-sintering process for the new GaN devices: with the die-attach (as the Si-wafer backside) sintered on the AMB and the chip-terminals sintered to the LTCC. First trials towards this, while applying the Ag-sinter process on LTCC metallization, succeeded. (7)

A second important task is the design of the half-bridge. In power mechatronics for power modules in drive inverter applications the transition from topology and schematics into a concrete power module design in terms sub-components' and materials' selection, AIT processes and their order of implementation in the manufacturing line is one of the biggest challenge. A first rough sketch about this transition for the all ceramics module concepts gives Figure 9.

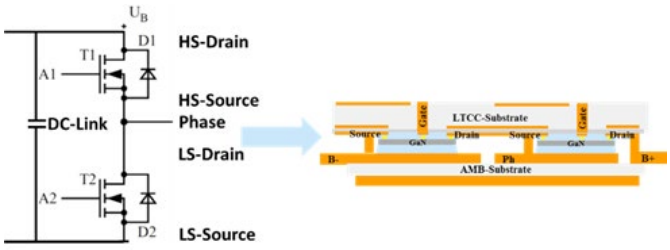

Figure 9: Rough sketch about the transition from half-bridge topology to power module design.

Ceramics-Laminate Hybrid Design

Towards the hybrid ceramic-polymer concept a compact interconnection technology replacing conventional wire bonding is being developed. For this purpose flexible planar metal interconnects on insulating layers are employed, providing the required low inductance and improved thermal management.

The packaging approach comprises

- low inductance interconnects with flexible planar interconnection and
- higher frequency drive operation
- and compact packaging with higher reliability, robustness and reduction of system size and
- includes embedded active and passive components, sensors, gate drive unit and cooling.

Figure 10 shows a draft of an integrated system applying the innovative planar packaging technology. The ceramic substrate with planar interconnect technology is embedded into a PCB with integrated passives, gate drive unit and heatsink

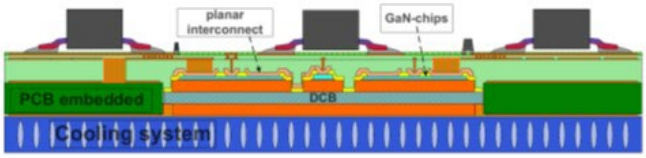

Figure 10: Compact system with planar packaging technology and improved thermal management (3D packaging).

Due to researchers' resources efficiency reasons the base substrate design strategy has been defined as to use the same AMB base substrate design and layout in both power module low-inductive concepts described above. Hence, the first step was to define which functional inputs and outputs are needed in principal for the later design flexible AMB substrate layout, e.g. like battery plus/minus, phase leg, logical connections, sensing connections etc.. The result of this consideration in terms of the defined AMB layout shows Figure 11.

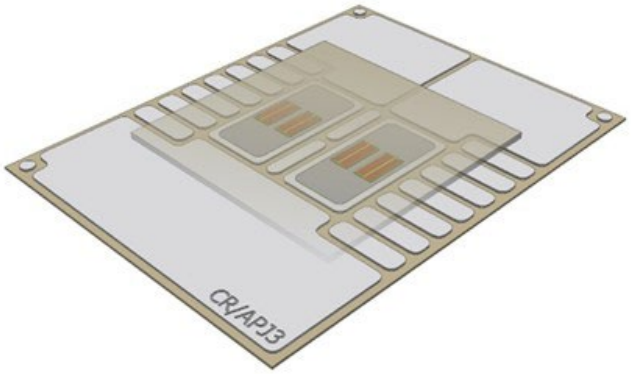

Figure 11: Defined AMB-layout: the planed position of the LTCC counter substrate is shown shaded above the chips.

The second step was to describe the thermal situation under the target characteristics of the new InRel-NPower GaN HEMT (25 mOhm RDS,on channel resistance @ 150°C maximum Tjunction) and the chosen power class of the full B6-bridge demonstrator between 20 up to 30 kW. Due to the small size of the devices, the loss density of the devices is very high. For a proper design of the distance between the devices, first simple simulations were carried out with different heat transfer coefficients. The results for a high heat transfer coefficient are shown in Fig. 12.

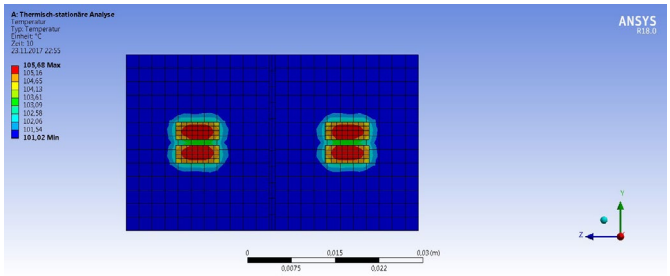

Fig. 12 Simulations of two GaN devices in parallel per switch with variation of distance on a heatsink with high cooling performance.

Summary

All power electronic systems of the future will take full advantage of the GaN-based and Al-based devices developed within this project.

These advantages include:

- Reduced heat sink requirements, lowering cooling requirements and energy saving;
- 80% reduction in system volume and weight, lowering overall system cost and material usage (due to the much smaller inductors, transformers and capacitors);
- Lower voltage drop for unipolar devices, lowering conduction losses and saving energy
- Increased output power, leading to more efficient power systems;
- Improved transient characteristics and switching speed, reducing switching losses;
- Reduced electrical noise from smaller system packages, allowing more robust circuits.

This project will focus on this lack in methodology and data, by combining the knowledge and expertise of European Centers-of-Excellence in this field and linking it to an EU-based commercial device manufacturer and substrate producers, allowing assessing large-area power devices on a large statistical sample base (rather than focusing on a few R&D samples).

Acknowledgement

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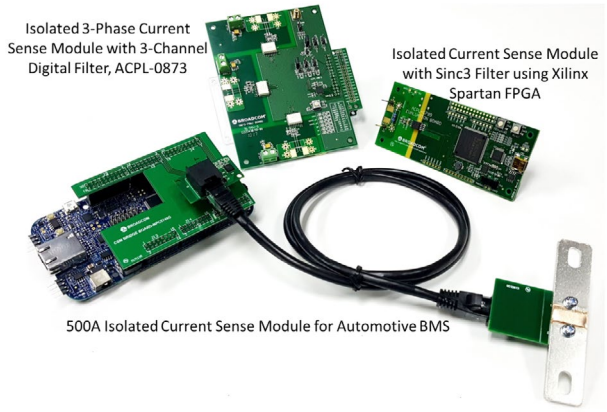
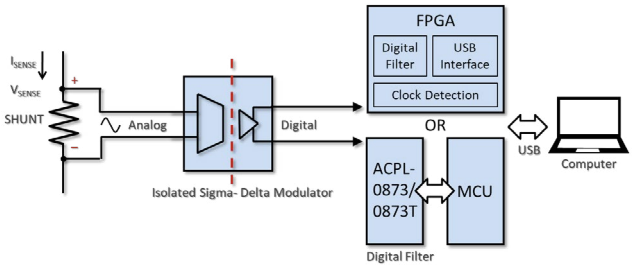
Isolated Sigma-Delta Modulator Evaluation Kits

Broadcom Inc. optically isolated sigma-delta modulator is a 1-bit, second-order sigma-delta (Σ-Δ) modulator that converts an analog input signal into a high-speed data stream with galvanic isolation based on optical coupling technology.



The analog input is continuously sampled by a means of sigma-delta over-sampling using an on-board clock. The signal information is contained in the modulator data, as a density of ones with data rate in megahertz range. The data are encoded and transmitted across the isolation boundary where they are recovered and decoded into high-speed data stream of digital ones and zeros. The original signal information can be reconstructed with a digital filter.

Combined with superior optical coupling technology, the modulator delivers high noise margins and excellent immunity against isolation-mode transients. It provides reliable reinforced insulation and high working insulation voltage, which is suitable for fail-safe designs. This outstanding isolation performance is superior to alternatives devices based on capacitive- or magnetic-coupling with narrow insulation barrier. Offered in a SSO-8 and SO-16 packages, the isolated ADC delivers reliable, small size, superior and over-temperature performance.

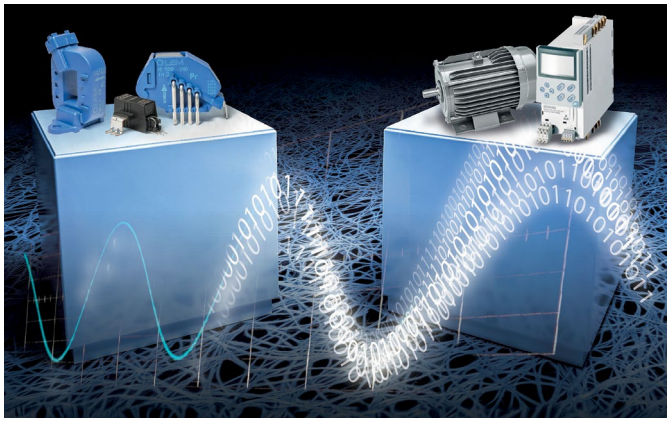


This is needed to accurately measure current at much lower price than traditional current transducers. Broadcom's internally clocked sigma-delta modulators employ single clock modulation and spread-spectrum technique to reduce EMI. This is normally observed in non-optical external clock modulators with poor PCB routing forming EMI radiating antenna at high frequency.

www.broadcom.com

Open-Loop Hall Effect Current Transducers with Digital Outputs for Drives

LEM completes its range of digital output versions of HO and HLSR open-loop Hall effect current transducers with analog to digital (A/D) conversion performed by an on-board sigma-delta modulator, giving a 1-bit serial bitstream output. These new components for nominal current measurements of 16, 32, 40, 50, 80, 100, 120, 150, 200, 250



ARMS in 4 different mechanical designs (PCB and panel mounting) provide up to 12-bit resolution with 20kHz bandwidth.
They also supply various possible digital outputs. These include, the single-bit output 2 wires CMOS (with clock in or out modes), RS422 Manchester or LVDS Manchester which minimises the connections required. Or the 4 wires mode according to the LVDS or RS 422 (Clock in or out) standards. The digital output allows the user to choose the filter used on the bitstream to optimize between resolution and response time, according to the application. Digital outputs are also intrinsically immune to noise in hostile environments.
For a typical transfer function, the average bitstream density is 50% for zero primary current, and 10% or 90% for maximum currents in negative or positive directions.
With HLSR-PW models in one mode the clock is output from the sensor at 10MHz and both the clock and the data are single-ended signals with CMOS levels. Alternatively, the output may be Manchester coded on 2 pins, meeting the RS422 standard.

www.lem.com

Intelligent GaN Power Solutions for Consumer, Industrial and Automotive Applications

Exagan, a leading innovator of gallium nitride (GaN) semiconductor technology enabling smaller and more efficient electrical converters, is accelerating the transition to greater power efficiency by launching its safe, powerful G-FET™ power transistors and G-DRIVE™ intelligent fast-switching solution, featuring an integrated driver and transistor in a single package. These GaN-based devices are easy to design into electronic products, paving the way for fast chargers that comply with the USB power delivery (PD) 3.0 type C standard while providing exceptional power performance and integration.

At PCIM Europe conference in Nuremberg, Exagan has showcased the use of its high-power-density GaN-on-silicon semiconductors to create ultra-fast, efficient and smaller 45- to 65-watt chargers. The company's exhibit demonstrates its electrical-converter expertise and how both G-FET and G-DRIVE can benefit new converter product designs and their applications.

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$R_{DS(on)}$ Automotive MOSFETs Down to 0.9 mΩ

Nexperia announced the release of the company's lowest RDS(on) automotive-qualified MOSFETs. The AEC-Q101 Trench 9, 40 V automotive superjunction MOSFETs in the rugged, electrically- and thermally-efficient LFPAK56E deliver a footprint reduction of up to 81% when compared to traditional solutions such as bare die modules, D2PAK or D2PAK-7 devices. The 0.9 mΩ, 220 A DC-rated BUK9J0R9-40H MOSFET suits applications up to 1.2 kW, and is also lower cost than larger D2PAK devices which were the previous best solution.

As well as reducing $R_{DS(on)}$ the new devices also feature an improved DC current rating of 220 A – a first for the automotive Power-SO8 footprint. This enables higher power density on a small footprint, which is especially valuable for safety-critical automotive applications that require dual redundant circuitry. The use of Superjunction technology delivers a higher Avalanche capability and Safe Operating Area for improved performance under fault conditions.

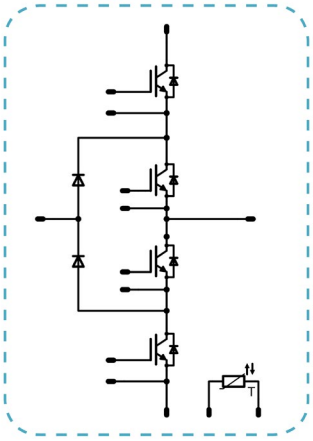
https://efficiencywins.nexperia.com/efficient-products/automotive-trench-9-power-mosfets-designed-for-performance-and-endurance.html

www.nexperia.com

Three-Level NPC Topology, Multi-Source IGBT Technology

Vincotech, a supplier of module-based solutions for power electronics, today announced the launch of new neutral-point-clamped power modules. The flowNPC 0 line features the latest IGBT technologies in a combination engineered to optimize cost and efficiency for three-phase solar and UPS applications.

Rated for 650 V / 100 A, these power modules are able to deliver switching frequencies up to 50 kHz even without SiC technology. Their chipset has been optimized to deliver the best performance at real power, yet they retain high reactive power capability to offer best-in-class power density. This enables engineers to craft lighter, more compact designs for three-phase solar and UPS applications. The ability of real multiple chip sourcing improves component supply security.



Both modules are available with Press-fit and solder pins, without adding any non-recurring engineering costs to the bottom line. Samples of the ultra-efficient flowNPC 0 modules may be sourced on demand from our usual channels.

www.vincotech.com/flowNPC-0-100A

1200V SiC MOSFET Moves Electric Vehicle Market to the Fast Lane

Wolfspeed, A Cree Company announced a performance breakthrough in the ability to power the drivetrain of electric vehicles (EVs) using its new third generation 1200V SiC MOSFET family. This switching device, which enables high-voltage power conversion, solidifies the company's leadership in solutions for the EV ecosystem. The development brings increased efficiency to the drivetrain while lowering system costs, paving the way for longer driving range and better overall EV performance for consumers.

"There is a growing global demand for more electric vehicles on the road, with nearly all vehicle manufacturers announcing new electric platforms across their fleets," said Gregg Lowe, CEO of Cree, Inc. "Cree is at the forefront of enabling this dramatic change in the automotive industry with new technologies, such as Wolfspeed's new silicon carbide MOSFET portfolio, that help foster the adoption of electric vehicles."

This marks another milestone in Wolfspeed's 30-year history of innovations in wide bandgap power conversion technology, including EV applications. Wolfspeed revolutionized the EV market in 2015 with the industry's first 900V SiC MOSFET family, which broke the cost barrier to SiC adoption in off-board and on-board chargers by delivering smaller and higher-efficiency next-generation power conversion systems at cost parity with silicon-based solutions. Today's new 1200V MOSFET extends the company's technology into the drivetrain and will enable the world's most efficient EV power converter systems.

www.cree.com

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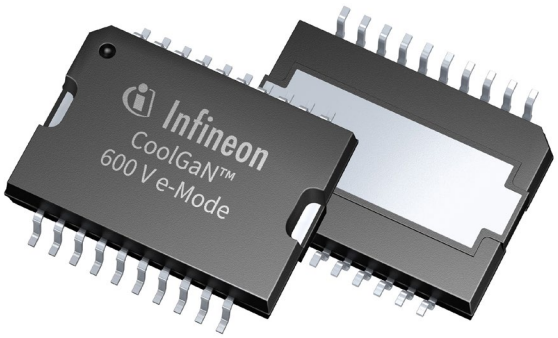
CoolGaN™ Opens up for a New Horizon in Power Management

The key benefits of gallium nitride (GaN) are, amongst others, high power density, best-in-class efficiency and decreased system costs. Infineon Technologies AG is starting volume production for CoolGaN™ products by the end of 2018, the company announced during PCIM Europe. Engineering samples of the high reliable GaN solution in the market are available now.

"Infineon is the global leader in power solutions and we truly believe that the next big thing in power management is gallium nitride," said Steffen Metzger, Senior Director High Voltage Conversion at Infineon. "Our goal is to be the first choice for customers when it comes to GaN power, and we have all assets in place to live up to this ambition. The market for GaN has been gaining a strong momentum; the advantages of using this technology in certain applications are evident. From operating expense and capital expenditure reduction, through higher power density enabling smaller and lighter designs, to overall system cost reduction, the benefits are compelling."

Infineon's CoolGaN is the one of most reliable and globally qualified GaN solutions in the market. During the quality management process not only the device is tested, but also its behavior in the application.



The performance of CoolGaN is beyond other GaN products in the market. At 100 ppm (parts per million), its predicted lifetime is about 55 years, exceeding the expected lifespan by 40 years. CoolGaN enables for example doubled output power in a given energy storage slot size, freeing up space and realizing higher efficiency at the same time.

www.infineon.com/gan

SiC Diodes for Demanding Automotive Applications

ON Semiconductor (Nasdaq: ON), driving energy efficient innovations, has announced an expansion of its silicon carbide (SiC) Schottky diode portfolio to include devices specifically intended for demanding automotive applications. The new AEC-Q101 automotive grade

SiC diodes deliver the reliability and ruggedness needed by modern automotive applications, along with the numerous performance benefits synonymous with Wide Band Gap (WBG) technologies.

SiC technology provides superior switching performance and higher reliability compared to silicon devices. The diodes have no reverse recovery current, and switching performance is independent of temperature. Excellent thermal performance, increased power density and reduced EMI, as well as decreased system size and cost make SiC a compelling choice for the growing number of high-performance automotive applications.

ON Semiconductor's new SiC diodes are available in popular surface mount and through-hole packages, including TO-247, D2PAK and DPAK. The FFSHx0120 1200 Volt (V) Gen1 devices, and FFSHx065 650 V Gen2 devices offer zero reverse recovery, low forward voltage, temperature independent current stability, extremely low leakage current, high surge capacity and a positive temperature coefficient. They deliver improved efficiency while the faster recovery increases switching speeds, thereby reducing the size of magnetic components required.

In order to meet the robustness requirements and perform reliably in the harsh electrical environments of automotive applications, the diodes have been designed to withstand high surge currents. They also include a unique, patented termination structure that improves reliability and enhances stability. Operating temperature range is -55°C to +175°C.

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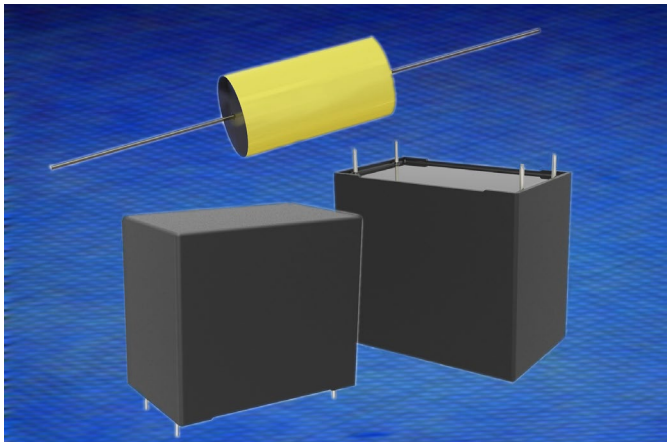
Protected Metalized Polypropylene Film Capacitors

Cornell Dubilier announces the availability of its newest metalized polypropylene film capacitors for UPS, AC power supplies and general AC filtering applications. The 951C and 953B series offer strong performance for filtering in applications where high ripple currents are encountered and benign end-of-life failure mode is essential. The

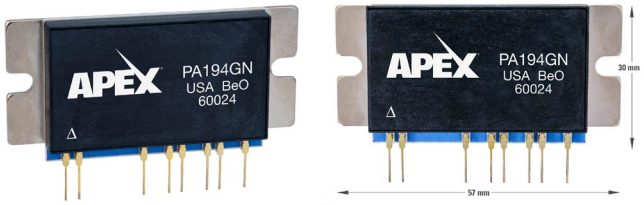


951C has a cylindrical body with axial leads, while the 953B has a rugged radial box form factor. Both capacitors offer a fused, segmented metallization pattern, providing significant circuit protection. UL 810 approval assures fail-safe operation under fault conditions. The metallization pattern is deposited on a low-loss, high-grade polypropylene dielectric. The built-in fuse-links limit capacitance loss to a small segment within the capacitor. This is in contrast to the larger areas of uncontrolled capacitance loss observed with non-segmented types. This capability is not usually available for board-mounted capacitors. The axial-leaded 951C Series is offered in values ranging from 0.825 to 40 µF, while the 953B spans 2.5 to 50 µF. Voltage ratings in both series are available at 160, 250 and 275 Vac. Both types offer -40 to +85°C performance and meet the requirements of UL 94V-0 for flammability. With a 10,000-hour service-life expectancy without derating, series 951C and 953B capacitors will excel at providing reliable filtering and smoothing for today's demanding applications in UPS systems, AC power supplies and more.

www.cde.com/news/2018/6/953b

Power Op Amp Combines 1700 V/µs Slew Rate and 900 V Supply Operation

Apex Microtechnology continues to drive the leading edge of technology innovation for high speed, high voltage power operational amplifiers that can deliver precision high voltage at fast speeds in a variety of applications were speed and accuracy are a must. The new PA194 is a refined implementation of the Apex PA94, extending slew rate capabilities by +1,000 V/µs. The PA194 has a typical slew rate of 1700 V/µs to enable fast rise and fall times on supply voltage operation of up to 900 V, and a very low noise density of ~5 nV/√Hz @ 1



kHz. The PA194 has a continuous output current capability of 100 mA and exhibits just 4 mA of quiescent current with an integrated standby mode for increased efficiency. This amplifier is available in an 8-pin power SIP package with heat tab and can dissipate up to 30 watts. "Designers looking to apply very high levels of voltage with precision and speed will certainly want to evaluate the PA194," explains Apex Strategic Marketing Director Jens Eltze. "We designed this power amplifier to operate with enhanced efficiency and reliability while lowering noise density within the electrical circuitry. The end result will be an increase in overall end-system performance." A wide range of target applications include industrial instrumentation, semi-cap test equipment and SEM analysis tools using electron beam focusing, particle deflection and piezoelectric positioning.

www.apexanalog.com/products/PA194

Bidirectional 48V/12V NBM Converter for Data Center and Automotive Applications

Vicor Corporation announced a bidirectional non-isolated fixed-ratio converter for hybrid 48V/12V power systems in data center and automotive applications.

The 2317 NBM is a bidirectional converter capable of providing up to 750W continuously at 48V from 12V, or at 12V from 48V, with over 98% peak efficiency. With up to 1kW of peak power capability (for up to 2ms) in a 23 x 17 x 7mm surface-mount package, the NBM (NBM2317S54D1464T0R) provides a complete solution with no external circuitry needed. By switching at 2MHz, the NBM provides low output impedance and fast transient response to dynamic loads. The NBM incorporates hot-swap and inrush current limiting, increasing power system density and saving valuable board space, time and money.

In data centers that are still relying on legacy 12V distribution, the NBM supports state-

of-the-art 48V input GPUs using Power-on-Package ("PoP") Modular Current Multipliers ("MCMs") driven from a 48V node sourcing a small fraction (1/48) of the GPU current. Current multiplication overcomes the power delivery boundaries imposed by traditional 12V systems that limit higher bandwidth and connectivity. In data centers that have been upgraded to a 48V infrastructure, the NBM can be used to support legacy 12V loads. In mild hybrid and autonomous vehicles using 48V, the NBM supports legacy 12V subsystems from efficient power distribution at 48V with or without dual batteries.

www.vicorpower.com

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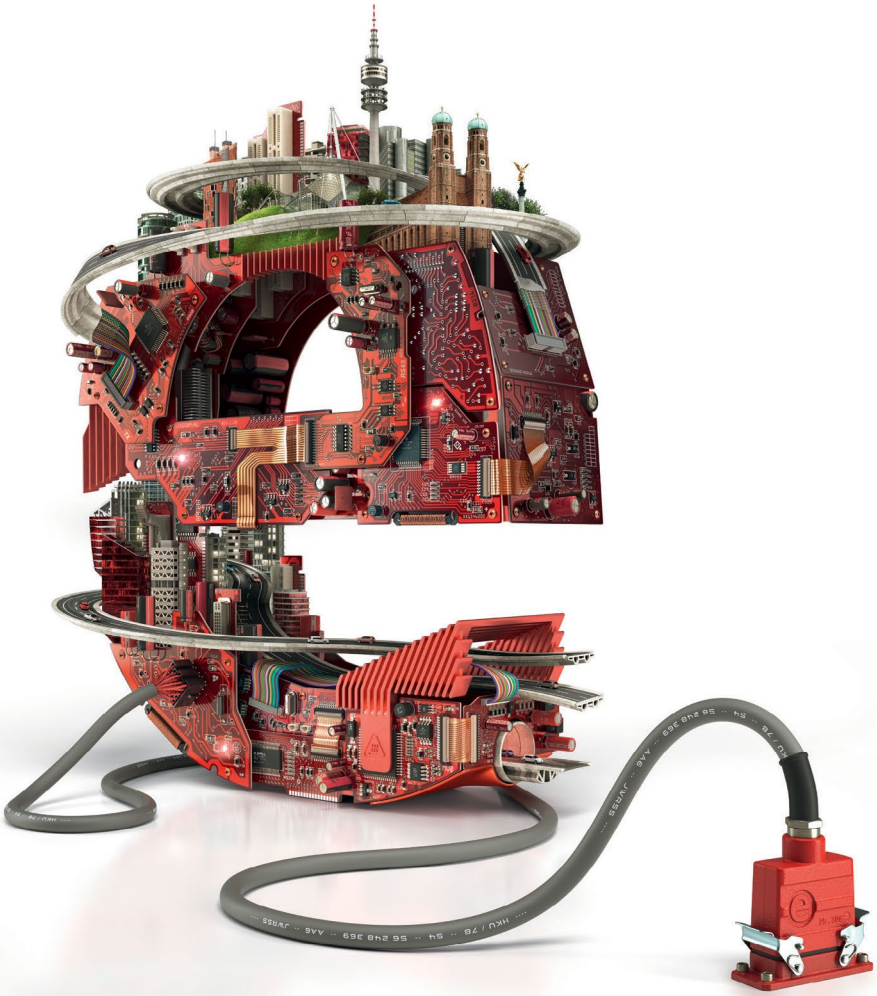

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SCALE-iDriver ICs Now Available with AEC-Q100 Certification for Automotive Use

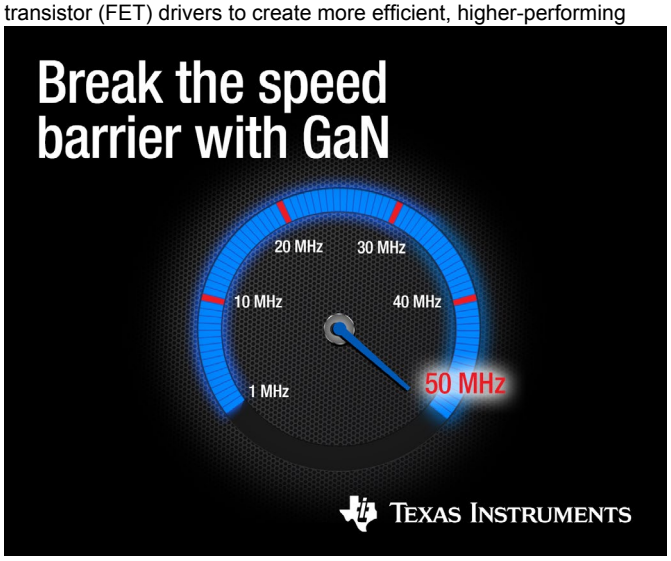
Power Integrations announced that two members of its SCALE-iDriver™ gate-driver IC family are now certified to AEC-Q100 Grade Level 1 for automotive use. The two parts, SID1132KQ and SID1182KQ, are suitable for driving 650 V, 750 V and 1200 V automotive IGBT and SiC-MOSFET modules, and are rated for peak currents of +/-2.5 A and +/-8 A respectively. The SID1182KQ has the highest output current of any isolated gate driver available and is capable of driving a 600 A /1200 V and 820 A /750 V switch.

The SCALE-iDriver family of single-channel IGBT and SiC-MOSFET driver ICs features Power Integrations' innovative FluxLink™ magneto-inductive bi-directional communication technology which ensures reinforced galvanic isolation between the primary and secondary sides, setting a new standard in isolation integrity and stability. FluxLink technology eliminates the need for opto-electronics, which suffer parametric changes with age and relentless thermal degradation that limits operational lifetime. Use of magnetically-coupled conductors locked into a homogenous thermoset, high quality insulation greatly enhances operational stability and longevity. The devices utilize Power Integrations' compact and robust eSOP package, which offers a CTI level of 600, 9.5 mm creepage and clearance distance, and easily meets automotive 5500 m requirements.

www.power.com/products/scale-idriver-ic-family/sid11x2kq/

Industry's Smallest and Fastest GaN Grivers

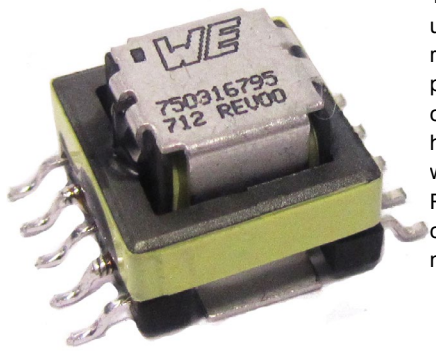
Expanding on its industry-leading gallium nitride (GaN) power portfolio, Texas Instruments announced two high-speed GaN field-effect transistor (FET) drivers to create more efficient, higher-performing designs in speed-critical applications such as light detection and ranging (LIDAR) and 5G radio-frequency (RF) envelope tracking. The LMG1020 and LMG1210 can deliver switching frequencies of 50 MHz while improving efficiency and enabling five times smaller solution sizes previously not possible with silicon MOSFETs. For more information, see www.ti.com/lmg1020-pr-eu and www.ti.com/lmg1210-pr-eu.



With an industry-best drive speed as well as a minimum pulse width of 1 ns, the LMG1020 60-MHz low-side GaN driver enables high-accuracy lasers in industrial LIDAR applications. The small wafer-level chip-scale (WCSP) package of only 0.8 mm by 1.2 mm helps minimize gate-loop parasitics and losses, further boosting efficiency. The LMG1210 is a 50-MHz half-bridge driver designed for GaN FETs up to 200 V. The device's adjustable dead time control feature is designed to improve efficiency by as much as 5 percent in high-speed DC/DC converters, motor drives, Class-D audio amplifiers as well as other power-conversion applications. Designers can achieve high system-noise immunity with the industry's highest common-mode transient immunity (CMTI) of more than 300 V/ns.

www.ti.com

Additional Current Sense Transformers in the MID-SNS Family



These surface mount transformers are designed to operate between 50khz to 500khz and sense up to 40A of current. The turns ratios offered are 1:50, 1:100, 1:150 and 1:200 with Inductances ranging from 1.4mH to 22.4mH. Compared to current sense resistors, these parts have much lower power dissipation and provide galvanic isolation. The 40A MID-SNS transformers are built on a compact platform with a footprint of 14.48mm x 20.2mm and low profile height of 10.5mm. Parts have low primary DC resistance and meet 1500Vrms dielectric between the primary and secondary windings. These transformers have an operating temperature of -40°C to 125°C and are RoHS and REACH compliant. These transformers are best suited for switch mode power supplies, precise current measurement, feedback control, circuit protection and monitoring, and high reliability equipment applications.

www.we-online.com/midcom

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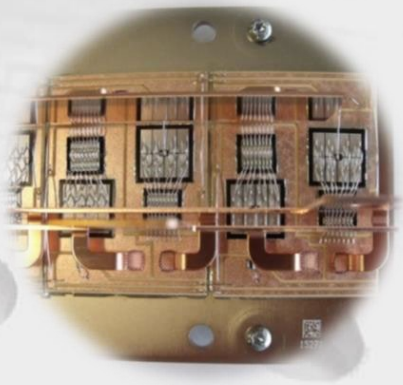

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- P. Carne Kjær (Vestas)
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- F. Altmann (Fraunhofer)
- N. Stojadinovic (Univ. of Nis)
- J. Lutz (Univ. of Chemnitz)
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- Applied robustness validation
- ECPE: Reliability in railway traction, renewables, industry
- Condition and health monitoring

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- Introduction to modern reliability based on physics and statistics
- SiC and GaN power devices reliability from the industrial perspective
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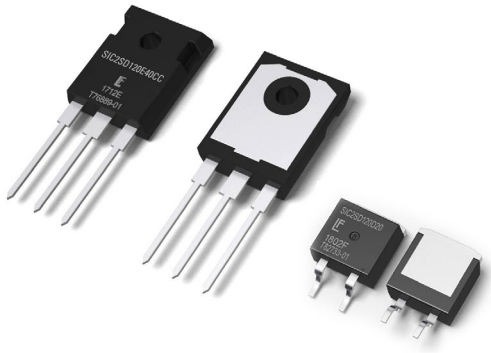
SiC Schottky Diodes Shrink Energy Costs and Space Requirements

Littelfuse, Inc. introduced an expanded portfolio of silicon carbide (SiC) power semiconductor devices with the addition of five GEN2 Series 1200 V, 3L TO-247 Schottky Diodes and three GEN2 Series 1200 V, 2L TO-263 Schottky Diodes. When compared with silicon devices, GEN2 SiC Schottky Diodes dramatically reduce switching losses and allow for substantial increases in the efficiency and robustness of power electronics systems. The product introduction was made during the PCIM 2018 Europe exhibition in Nuremberg. High-efficiency benefits that SiC technologies enable offer multiple advantages to the designers of electric vehicle chargers, data center power supplies and renewable energy systems. Because the GEN2 SiC Schottky Diodes dissipate less energy and can operate at higher junction temperatures than many alternative solutions, they require smaller heat sinks and enable a smaller system footprint. End-users will benefit from more compact, energy-efficient systems and a potential lower total cost of ownership.



www.Littelfuse.com

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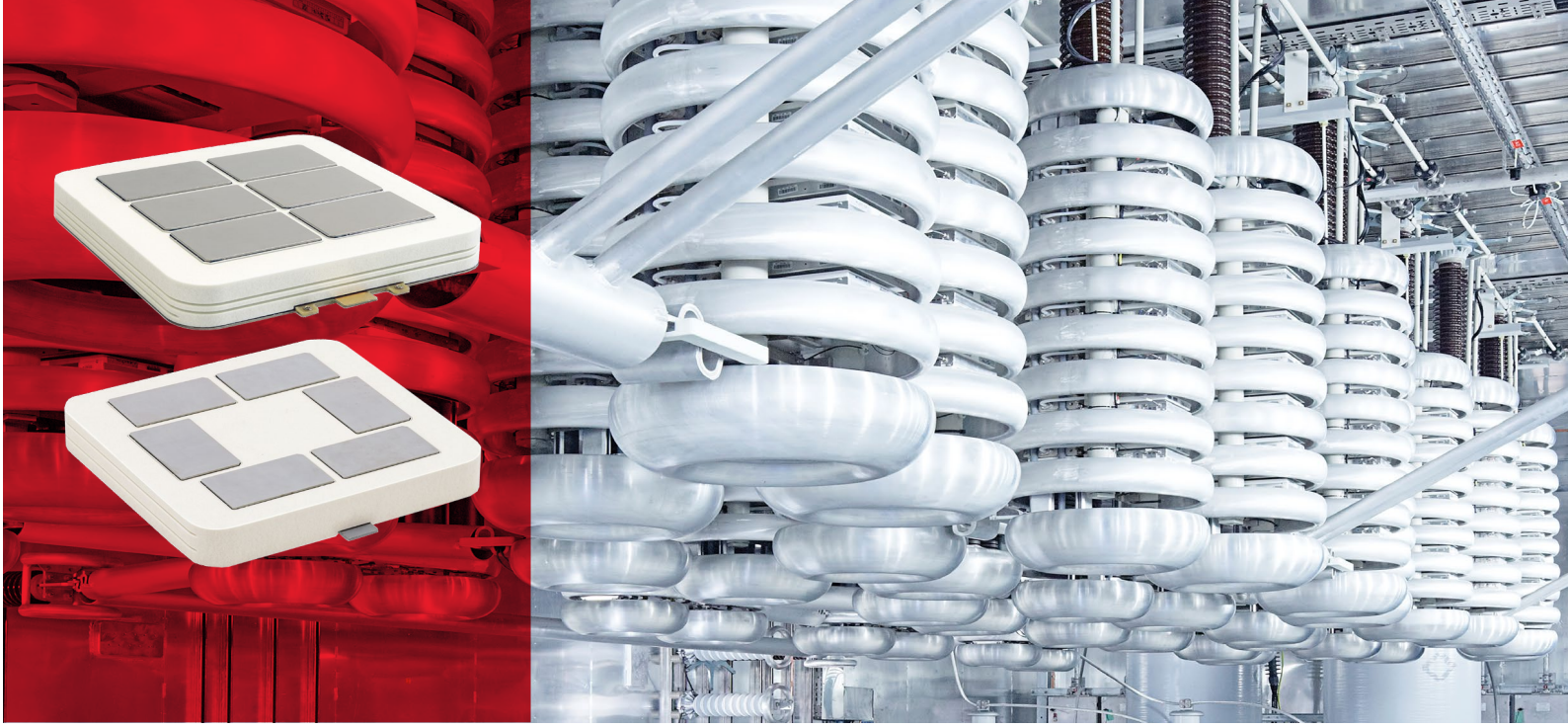

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Outstanding reliability for stable grids.

ABB Semiconductors' range of StakPak IGBT modules features an advanced modular press-pack housing that guarantees uniform chip pressure even for the largest sized modules. This ensures reliable and flawless operation over the whole lifetime of up to 40 years. Thus StakPak is the most reliable press-pack IGBT on the market and the preferred solution for demanding applications like HVDC, FACTS and others. StakPak IGBTs have an inherent ability to fail into a short circuit – an essential feature where redundancy is required and the IGBT is not allowed to explode.

abb.com/semiconductors

New 1200 V TRENCHSTOP™ IGBT6

Low conduction and lowest switching losses for best efficiency

The new 1200 V IGBT generation TRENCHSTOP™ IGBT6 is designed to meet requirements of high efficiency, lowest conduction and switching losses in hard switching and resonant topologies operating at switching frequencies above 10 kHz. It is released in two product families – low conduction losses optimized S6 series and improved switching losses H6 series. Being the first IGBT discrete ever released in 300 mm wafer, the TRENCHSTOP™ IGBT6 is now available in high volume to enable your faster time-to-market.

Features

- Low conduction losses with 1.85 V (V_{CEsat}) for S6 series
- Best combination of switching and conduction losses for switching frequency 10 – 40 kHz
- High R_G controllability
- Low EMI
- Full rated, robust freewheeling diode

Benefits

- Easy, plug & play replacement of predecessor HighSpeed3 H3 and TRENCHSTOP™ T2 series
- 0.15% system efficiency improvement when changing from H3 to S6 in TO-247-3[1]
- 0.20% system efficiency improvement when changing from H3 to S6 in TO-247PLUS 4pin[1]

[1] defined by application test in 3-phase T-type converter

www.infineon.com/igbt6-1200v