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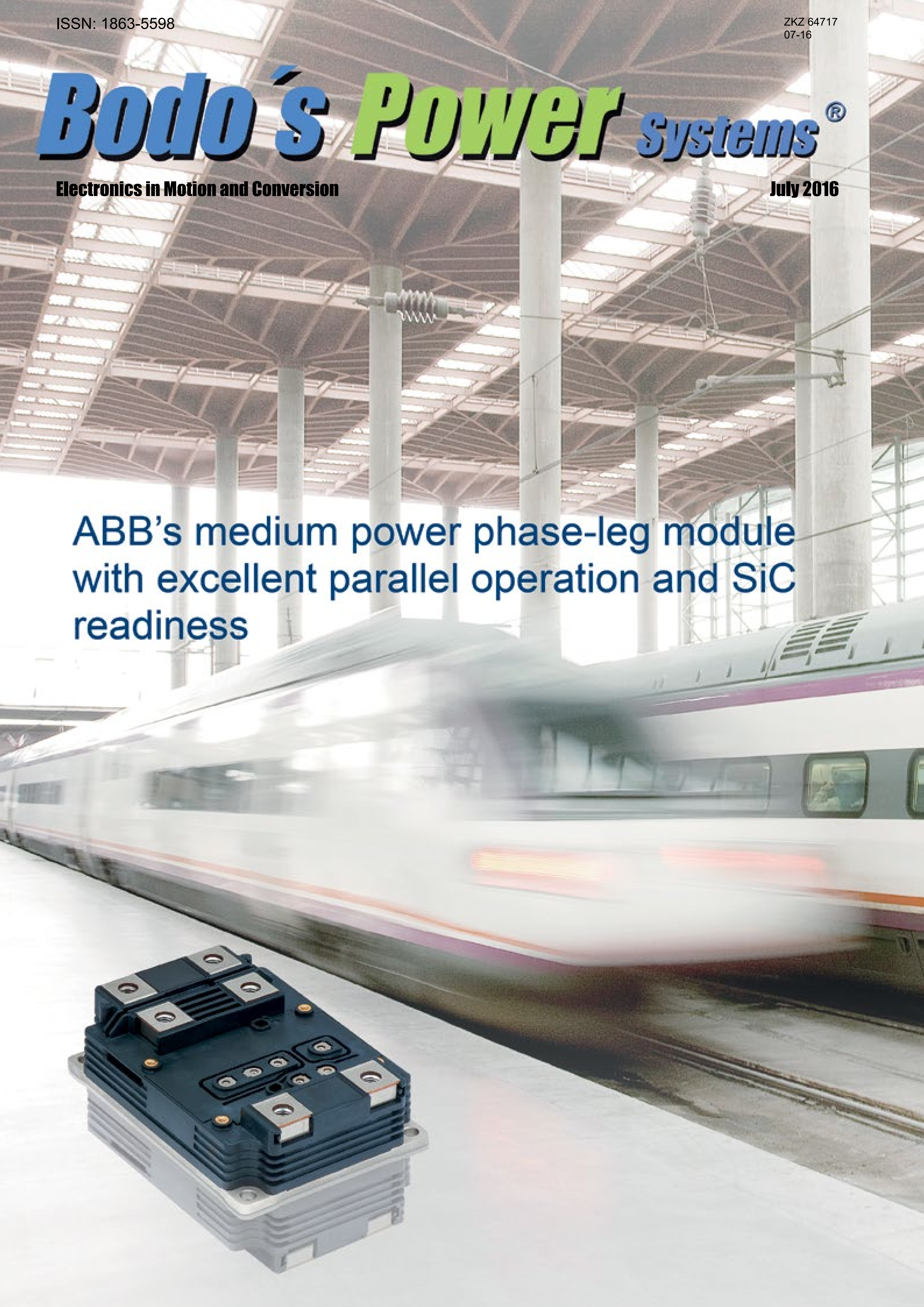
Bodo´s Power Systems®

Electronics in Motion and Conversion

July 2016



ABB's medium power phase-leg module with excellent parallel operation and SiC readiness

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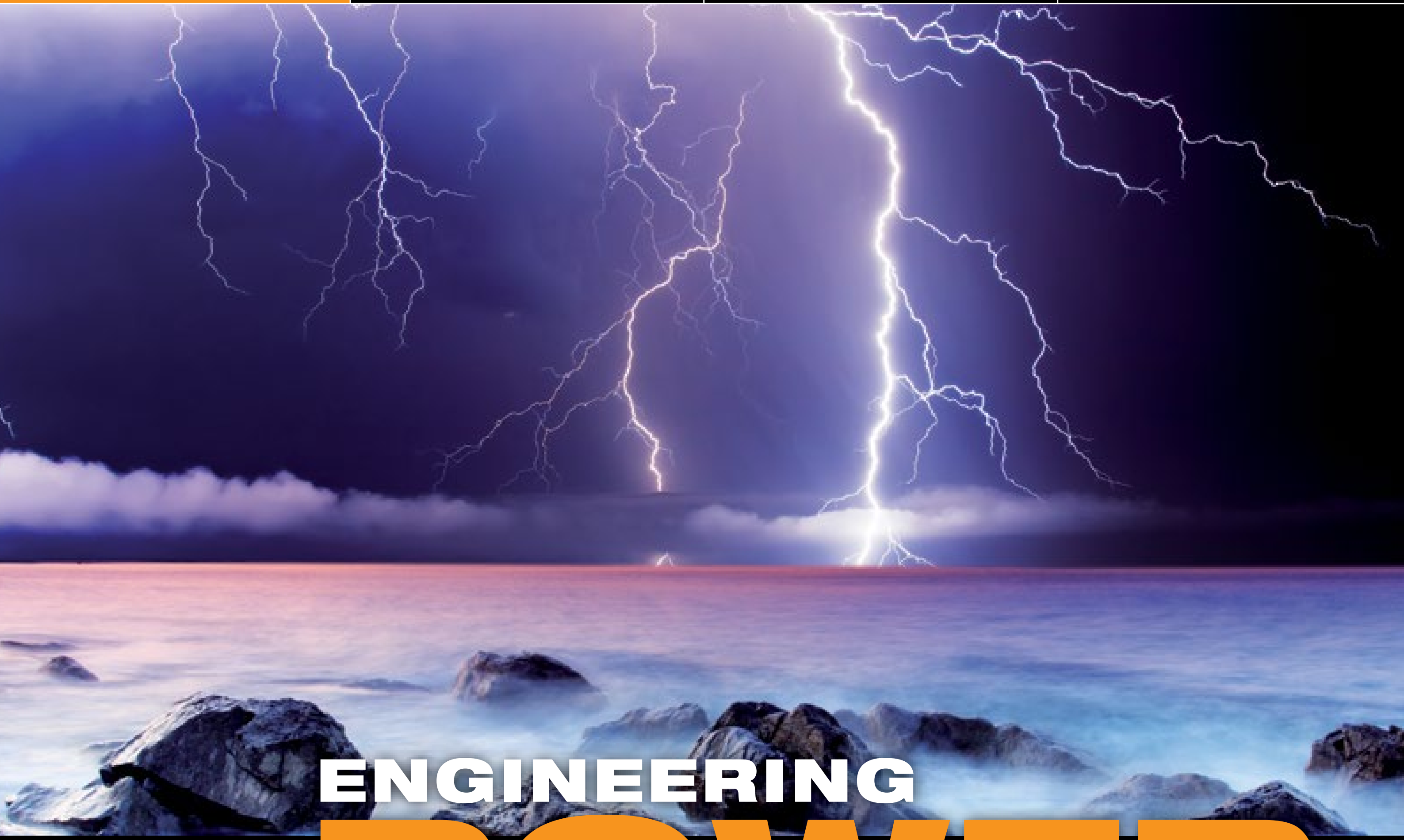

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Power Electronics

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Events

SEMICON West 2016,
San Francisco, July 14-16

EPE ECCE 2016, Karlsruhe, Germany,
September 5-9 http://www.epe2016.com/

WindEnergy Hamburg, September 27-30
www.windenergyhamburg.com/

ECCE 2016,
Milwaukee, WI USA, September 18-22
http://2016.ecceconferences.org/

INTELEC 2016, Austin TX,
October 23-27 http://www.intelec.org/

SEMICON Europa 2106,
Grenoble, France, October 25-27

electronica 2016, Munich, Germany,
November 8-11 http://productronica.com

Planning the Next Decade

Electronics is exciting in many ways. Our life would not be possible nowadays without the electronics that support us. Increasing demands for functionality have been matched by an innovative process to reduce power consumption, with the circuits involved doing more and more every day. Mobile equipment ranges from phones to computers, and smart phones combine both of these, along with a camera. The challenge now is to power these devices efficiently to operate for a reasonable length of time without having to charge the battery. I remember the days when my Nokia phone was able to serve me a week without charging. With the increased functionality and usage today, wireless charging stations are attractive. While more power would be welcomed, larger battery packs are bulky and, as such, are not practical for mobile devices.

Innovation in battery technology is a key element for the next decade, so that all of our nice toys work for us. Two decades ago, mobile phones were installed in cars and cases. Ten years ago we had portable cell phones, and the early beginnings of smart phones. With the continual growth of electronics in the medical space, a direct interface to our brain has become imaginable. What a challenge and what a risk.

The same challenge and risk faces us as cars capable of transporting us without our involvement are being developed. In the early days we joked about cruise control, and a driver whose camper crashed while he was in the rear cabin mixing a drink. He said the dealer sold him on the merits of cruise control. Automobiles of the future will undoubtedly be electric. The German postal service decided their delivery fleet of the future will run on 100% electric power. Their investment in manufacturing and design has already begun. Combustion engines will slowly become an old solution, along with their gear shift transmissions and clutches. Hybrids already achieve improved performance through optimized engine sizing, regenerative braking, and ample peak power – even in Formula 1 engines.

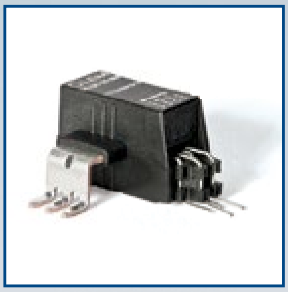
The next decade will have its challenges. The German word "Fahrvergnügen" or in English "Driving with Excitement" will have to take on a new meaning. We've always enjoyed the feeling of controlling a car and its performance. In the future we will just enjoy the trip and, from what we are told, we'll be safer than at present. Who owns the car may, however, fade in importance.

It is power electronics with GaN and SiC devices that will make these things happen. And sometime soon we will all be generating our own energy with solar cells on our roofs. Utility companies will have to adapt to a new business model of decentralized generation.

Bodo's Power Systems reaches readers across the globe. If you are using any kind of tablet or smart phone, you will now find all content available on the new web-site www.eepower.com. If you speak the language, or just want to have a look, don't miss our Chinese version: www.bodoschina.com

My Green Power Tip for July:
Consider installing solar panels on your roof and charge your own batteries. Soon you might be able to charge your electric vehicle with your own energy.

Best Regards



2015 Sales Growth Award

Cornell Dubilier Electronics, Inc. was pleased to present the 2015 Sales Growth Award, for outstanding channel partner sales growth, to Digi-Key Electronics at EDS 2016.
"In a year that could be described as challenging, Digi-Key exceeded expectations and led our sales channel with significant growth. The support at all levels has been exceptional. We have experienced substantial sales increases with Digi-Key and their inventory and sales commitments have risen significantly this past year," said Holly Good, National Distribution Manager from Cornell Dubilier. "We could not be more pleased with our partnership, and look forward to continued growth with them."
Since its founding in 1909, Cornell Dubilier has been dedicated to advancing capacitor technology for new applications. The company combines innovative products with engineering expertise to provide reliable component solutions for inverters, wind and solar power, electric vehicles, power supplies, motor drives, HVAC, motors, welding, aerospace, telecom, medical equipment and UPS systems.
A global company, Cornell Dubilier has ISO-9001 certified manufacturing and distribution facilities in Liberty, SC; New Bedford, MA; Mexicali, Mexico; and Hong Kong.

Pictured from left to right are: Chris Beeson, Executive VP of Sales and Supplier Development, Digi-Key Electronics and Holly Good, National Distribution Manager, Cornell Dubilier Electronics and Jason Simoneau, Director of Passives, Digi-Key Electronics

www.cde.com

Announcing GaN Device Sales Agreement

Richardson RFPD, Inc. announced an agreement with GaN Systems Inc. Under the terms of the agreement, Richardson RFPD will sell GaN Systems' GaN on Si power devices on a global basis, excluding Israel.
GaN Systems manufactures a range of gallium nitride high-power transistors for consumer, enterprise, industrial, solar/wind/smartgrid, and transportation power-conversion applications.
"GaN Systems adds another innovative technology to our power-conversion linecard," said Rafael R. Salmi, Ph.D., Richardson RFPD's president. "GaN Systems brings GaN industry leadership to our portfolio, which already includes silicon carbide industry leaders. This ensures we can better support our customers that want to leverage the benefits of wide-bandgap semiconductors."
"GaN Systems' products have been adopted globally across consumer, industrial, datacenter and transportation markets," said Larry Spaziani, GaN Systems vice president of sales and marketing. "To respond to the increased demand for our products and to provide the highest level of service for customers and prospects, we are pleased to partner with Richardson RFPD, a leading global distributor with a strong energy and power focus and dedicated resources in the markets we serve."

www.richardsonrfpd.com/subscribe

www.gansystems.com

3-Watt SIP4 Industrial Isolated DC/DC Converters Boost Power Density by 50%

The latest RECOM RI3 series isolated DC/DC converters, now available from Dengrove Electronic Components, pack a 3-Watt punch in the same compact SIP4 outline as the 2-Watt RI2 series.
The 11.5mm x 7.55mm x 10.2mm modules deliver market-leading power density for demanding applications such as communication equipment, industrial automation, robotic systems and distributed power architectures. Achieving up to 90% efficiency, they will deliver full power from -40°C to 85°C without a heatsink, and can operate in ambient temperatures of up to 100°C with derating. The choice of 1kVDC, 2kVDC or 3kVDC input-output isolation allows use where enhanced safety is required.
Established over 30 years ago, Dengrove provides a highly reliable and competitive component distribution service to a wide range of industry sectors.

www.dengrove.com

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Find more than 10.000 Power IC with detailed 1-page overviews.
Replace with equivalents by comparing parameters & functions.
Compare up to 7 products side-by-side.
Price and inventory check at all global online distributors.
Most functions engineers seek during a product search process are merged into a single website. This speeds up the search process, results in a significant time saving and gives engineers a real gobal market overview.

www.DCDCselector.com

North Devon Power Supply Manufacturer Celebrates Golden Anniversary in Ilfracombe

TDK Corporation is pleased to announce that TDK-Lambda UK is celebrating 50 years of manufacturing in Ilfracombe. Production first started there in 1966, under the name Coutant Electronics Ltd., occupying a 500m^2 building with first year sales recorded at £500,000. Now as a division of TDK-Lambda, the firm's two buildings total 6,179m^2, employing over 300 staff and producing more than 200,000 power supplies a year.

Coutant originally operated from a 230 m^2 unit in London with 20 people and recorded £43,000 of sales in their first year and by 1964 had moved to Reading. In the late 1950s Coutant Electronics merged with Electrotech Instruments, funded by a £25,000 investment from Unitech, a venture capitalist company. At that time, semiconductor transistor controlled power supplies were just emerging, replacing valves technology.

www.uk.tdk-lambda.com

Scaled the Amount of €15,000 at PCIM Europe

Vincotech, a supplier of module-based solutions for power electronics, arranged a charity boulder activity at the PCIM Europe show supporting Plan International Deutschland e.V. Vincotech's committed partners and its employees both tried to make as many ascents to the top of the 3-meter high boulder wall installed at the PCIM fair booth to support kids schooling in Guatemala.

Vincotech promised € 20 to Plan International for a tele-education project in Guatemala for every climber reaching the top of the wall. Thanks to their efforts, the company is proud to announce that they reached over 500 climbs during the 3 days of the fair. Vincotech then matched all contributions and a donation of € 15.000 was dispensed to child welfare organisation Plan International Deutschland e.V.

www.vincotech.com/boulder-activity

Develops Battery Concept for Lightweight Electric Car

Funded by the German Federal Ministry for Economic Affairs and Energy, the e-mobility flagship project "Adaptive City Mobility (ACM) 2" opens up new approaches with its innovative lightweight electric car CITY eTAXI especially designed for the urban living space. Due to its novel modular battery replacement system, which was specially developed for this project by Europe's leading lithium-ion battery producer BMZ, the CITY eTAXI now presented as final 1:1 design prototype – for detailed information as for the Design Launch as well as the ACM project please see annex and on www.adaptive-city-mobility.de/pressematerial/ - is able to operate completely independent of either existing or future charging stations.

www.bmz-gmbh.de

LpS 2016 –European Lighting Conference Announced

The 6th International LED professional Symposium +Expo (LpS 2016) in Bregenz, Austria, from September 20th to 22nd, has increased the conference program to 5 parallel running tracks with 100+ lectures, 4 workshops, 3 forums and 3 top-level keynotes. The three days of the symposium have been divided into a "Strategy Day" followed by a "Technology and Design Day" and ending with a "Solution Day". In addition to the outstanding conference program, over 100 exhibitors will present latest innovations and the current status of LED and OLED lighting in the 3,000 square meter exhibition area. The organizers are expecting more than 1,500 visitors from over 50 countries.

www.lps2016.com

Addressing Automotive Engine Control

STMicroelectronics, a global semiconductor leader serving customers across the spectrum of electronics applications, and Weifu High-Technology Group Co., Ltd., a leading Chinese provider of automotive electronic control systems, today announced ST's participation in Weifu's Researching and Testing Institute of Engineering and Technology. The cooperative efforts will focus on the development and study of automotive core solutions, including diesel-engine fuel injection equipment (FIE), automotive exhaust post-processing, and intake systems.

On top of the consequences of the fast growth of vehicle sales in China, the adoption of electronic control systems is mostly driven by more and more stringent emission standards for vehicles, such as the China V standard already deployed in Beijing and Shanghaï and due for national deployment by 2018. Weifu and ST are sharing their complementary talents to address the requirements of the government and the needs of the industry.

www.st.com

Argomax® 9000 Silver Sintering Preforms Wins Award in Japan

Alpha Assembly Solutions, the world leader in the production of electronic soldering materials, is pleased to announce that ALPHA® Argomax® 9000 Silver Sintering Preforms won the award under the materials category of Sangyo Times. This prestigious award was presented to Alpha by Semiconductor Device Newspaper - Sangyo Times Inc. on June 1 at the 22nd Semiconductor of the Year 2016 in Tokyo Big Sight during the JPCA show. Alpha won for No.1 share of nano-paste & improvement of customer support system. The ALPHA® Argomax 9000 Preform was selected among 34 new materials that were introduced to the market between March of 2015 and April of 2016. Backed by novel patent-pending sintering application processes, ALPHA® Argomax® 9000 preforms are uniquely positioned to fit into existing manufacturing equipment and processes to enable high volume manufacturing. "Argomax® silver die attach preforms combine unique physical properties of nanosilver powder and innovative chemical formulations into a revolutionary product," said Oscar Khaselev, Director of R & D and also the innovator of this technology. "This process produces an extremely reliable, high thermal and electrical conductivity interface when joining various electronic devices."

http://alphaassembly.com

Presenting PV Product Technologies at Intersolar Europe in Munich, Germany

Alpha Assembly Solutions, the world leader in the development of non-hazardous solder and electronic assembly materials for photovoltaic manufacturing and assembly, plans to showcase their vast product offering at the Intersolar Europe show taking place June 22 – 24 in Munich, Germany. In addition, Narahari S. Pujari, Manager of New Business Development, will be participating in Poster Session (#5BV.1.38) entitled "Compatibility of PV Ribbons and Fluxes with EVA Encapsulant Films." To learn more about Alpha Assembly Solutions, please visit us at the Intersolar Europe show at booth #A2.138 and ask about our new photovoltaic product technologies.

http://alphaassembly.com/Markets/Photovoltaic

Industrial Power Tester for IGBT Thermal Reliability in EVs/HEVs

By Roland Ackerman, Bodo's Power Systems

The Mechanical Analysis Division of Mentor Graphics Corporation announced their new MicReD Industrial Power Tester 600A which tests the reliability of power electronics for electric and hybrid vehicles (EVs/HEVs) during power cycling. This unique product extends Mentor´s total solution for thermal engineering – offering unmatched accuracy and scalability in automated simulation and test.

EVs/HEVs require tens of thousands of drive cycles over a wide range of environmental conditions. Thermally induced degradation of IGBTs due to power cycling and heating is a big issue in these vehicles resulting in wire bond degradation, metallization layer mismatch, solder fatigue or die and substrate cracks.

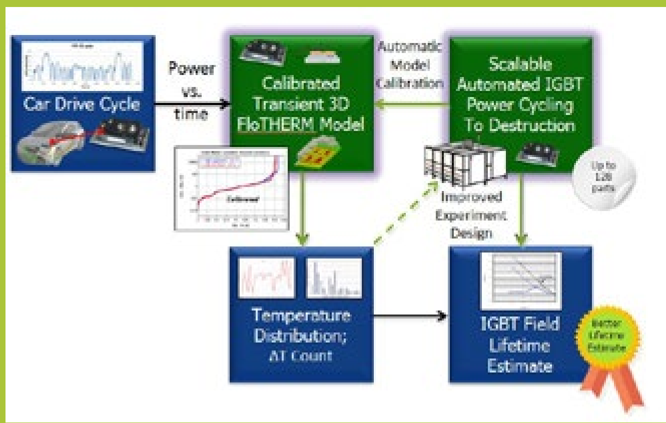
Thermal characterization testing with non-destructive diagnostics with the new Power Tester allows EV/HEV development and reliability engineers to test power electronics (such as IGBTs, MOSFETs, transistors, and chargers) for mission-critical thermal reliability and lifecycle performance. Thermal reliability issues can result in EV/HEV automotive recalls, and the ever wider adoption of electric and hybrid cars has created a specific need for this solution. Moreover, the MicReD Power Tester 600A meets the industry's need for power electronics thermal simulation and test, delivering unmatched accuracy and scalability. The end result is an improved process that offers better IGBT lifetime reliability estimates.

Reliability, Accuracy and Scalability Solve Power Electronics Thermal Issues

Designers of today's EV/HEVs are faced with significant mission-critical challenges: Foremost among these is ensuring the thermal reliability of power electronics modules; detecting potential degradation of IGBTs caused by a range of standard drive cycles; and identifying the underlying damage root causes. Mentor's MicReD Power Tester 600A provides accurate and reliable test results that scale to real-world requirements:

Comprehensive Diagnostics for Thermal Reliability: The MicReD Power Tester 600A product provides a simple reliability testing process for lifecycle estimation. Device set-up is easy and power cycles are fully automated.

The T3Ster® "structure function" feature inside the Power Tester yields non-destructive "failure-in-progress" data for each IGBT. All diagnostic information is recorded during testing, from current, voltage and die temperature sensing, to "structure function" changes that point to reasons for failures in the package structure. Package development, reliability and batch checking of incoming parts can now be tested before production.



Simulation Accuracy: The MicReD Power Tester 600A product can power IGBT modules through tens of thousands of cycles. This provides "real-time" failure-in-progress data for diagnostics, significantly reducing test time and eliminating the need for post-mortem or destructive failure analysis. Associated 3D CFD (computational fluid dynamics) simulation errors can be reduced from typically up to 20% to 0.5% for accurate thermal characterization of IGBTs and components due to Mentor's calibration technology solely found in the MicReD T3Ster product.

Scalability – Tests Up to 128 IGBTs in Series: Up to eight MicReD 600A Power Testers can be chained together to allow users to power cycle up to 128 IGBTs simultaneously in a system test. The MicReD Power Tester 600A product delivers 48V under load, and users can deal with components mounted externally on cooling systems for maximum flexibility. The MicReD Power Tester 600A also meets the needs of emerging de facto EV/HEV power electronics testing best practices such as those currently being developed for the German automotive industry.

Part of a Comprehensive Solution

Mentor Graphics is uniquely positioned as the only company that can provide a complete thermal software simulation and hardware testing solution specifically for the EV/HEV market. The MicReD Power Tester 600A can be coupled with Mentor's leading CFD simulation technologies.

Mentor's FloTHERM and FloEFD 3D CFD software provide front-loading thermal simulation of power modules. When coupled with the Flowmaster full vehicle thermo-fluid system-of-system 1D CFD modeling tool, this yields unparalleled levels of accuracy. This is done by MicReD's T3Ster technology providing CFD input material properties for automated model calibration functionality to accurately simulate the real temperature response of an EV/HEV's dynamic power input. This combination of technologies allows users to generate IGBT thermal lifetime failure estimations with the greatest accuracy possible.

"The MicReD Power Tester 600A is an extension of our total solution in automotive thermal engineering, and there is no other product like this for the EV/HEV market today," stated Roland Feldhinkel, General Manager of Mentor Graphics Mechanical Analysis Division. "We have leveraged our best-in-class products to deliver a comprehensive thermal simulation and hardware test solution that meets auto maker EV/HEV industry needs while supporting the rapid growth forecast for the market in the next few years."

Product Availability

Mentor Graphics is now accepting orders for the MicReD Power Tester 600A with shipping scheduled for summer of 2016. For additional product information, visit the company website: www.mentor.com/powertester-600a.

www.Mentor.com

LinPak, the Standard Expands to 3300V and Shows Excellent Parallel Operation as well as SiC Readiness

The LinPak module newly houses a state of the art low loss 3300V chipset. This means also applications in the medium voltage range will benefit from the record low stray inductance LinPak standard and especially from the scalability of the current rating thanks to excellent parallel operation. Also the operation of SiC switches becomes possible for larger current ratings thanks to the low overall inductance.

By Raffael Schnell, Samuel Hartmann, Slavo Kicin and Fabian Fischer, ABB Switzerland Ltd. – Semiconductors

The technical advantages and the modularity offered by the open LinPak standard are receiving very positive response from the market and it is nice to see that more manufacturers step in offering LinPak compatible solutions.
This article presents general module design considerations and first results on switching characteristics of the 3300V 2 x 450A rated LinPak module and the parallel connection of two 1700V, 2 x 1000A rated LinPaks. Furthermore, the first results with a 1200V full SiC MOS-FETs are shown.

Introduction

Today's high power IGBT modules with the typical foot print of 140mm x 190mm in single switch configuration reaches or has reached its limits. New fast switching chip sets like the 1700V SPT++ IGBT [2] or even 3300V SPT+ IGBT, that allow switching with low losses require low commutation loop stray inductance to keep the voltage overshoot small [3]. If this holds true for silicon based IGBTs, obviously SiC switches are no more useable in standard IGBT modules like 140mm x 190mm modules or similar designs. This is where LinPak steps in as the solution for the future. The LinPak power module is developed as a new open standard to overcome these limitations. The phase leg module is designed for easy paralleling. Different converter power output ratings can be achieved simply by using the appropriate number of modules in parallel. With its low module stray inductance of 10nH and the possibility to implement a low inductive bus bar equipped with DC link capacitors, the voltage overshoot during IGBT turn-off can be reduced typically by a factor of 5 compared to previous solutions using 140mm x 190mm modules like the HiPak. The amount of terminal connection area per rated current is doubled compared to HiPak, which obsoletes the need of bus bar cooling. The combination of the well established AlSiC base plate and AlN substrates with a reliable particle free ultrasonic terminal welding process makes the LinPak ideally suited for applications with demanding power cycling requirements.

Figure 1: The LinPak IGBT power module

A new feature to standard high power IGBT modules is the built-in NTC temperature sensor. It can be used to detect failures in the cooling system or to derive the chips' temperature.

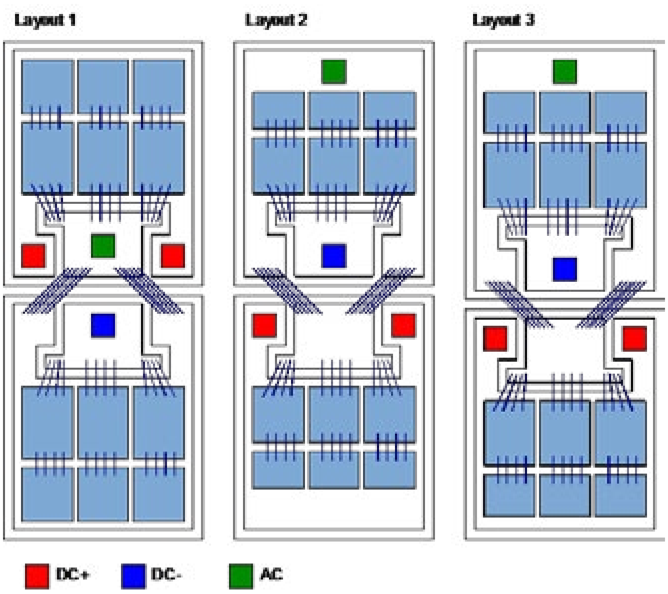


Figure 2: Three design concepts for a low inductive half-bridge module. Only two of four substrates are shown per variant.

Module design

For a pioneering power module design, many aspects need to be considered: high current rating, high reliability, good manufacturability, low cost, low thermal resistance, low inductance, stable electro-magnetic behaviour and many more. The optimum arrangement of the power terminals for easy paralleling and low inductance bus bar design is already given [1]. The LinPak power module shown in Figure 1 implements this layout. For realization of the internal power circuit layout, three concepts have been considered for the LinPak. These three layouts are shown in Figure 2. For each layout only two of four AlN substrates used within the module are shown. The further two substrates are identical and in parallel to the shown two substrates.

The first layout is used in the LinPak module. All terminal plates are connected to the substrates in the middle of the module. For the second and third layout, the AC terminal plates are connected on the AC side of the module. This allows a shorter AC path with slightly lower resistance, but additional area is needed for the AC terminal connection. In the second layout, identical substrates are used for the top and bottom side switches, therefore the same area is lost also on the bottom side switch. The third layout is realized using two different substrate layouts for the top and bottom side switches, therefore the AC terminal connection area is needed only once.

The difference in AC terminal connection area needed, strongly influences the area remaining for the power semiconductors and with it the achievable current rating. A comparison of the silicon area available is shown in Figure 3. In comparison with the Layout 1, the Layout 2 and 3 take up only 77% and 89% silicon area. With Layout 1, the LinPak achieves a current rating of 1000A based on SPT^{++} IGBT technology [1], future modules using enhanced trench (TSPT^{+}) IGBT technology have the potential to reach 1200A or more in the 1700V class.

The silicon area also influences strongly the thermal resistance. Using finite element analysis the three layouts are compared to each other (Figure 3). The Layout 1 with 27.2K/kW has a considerably lower thermal resistance than the Layout 2 with 33.6K/kW.

A further advantage of layout 1 is seen in a reliable ultra sonic welding process for connecting the power terminals to the substrates. Ultrasonic welding is known as a reliable connection when it comes to thermal cycling load, but the technology also poses two challenges: the generation of particles during the welding process and the possibility of crack formation in the ceramic insulation. The particle challenge is addressed by having all welding connections located at some distance to the semiconductor chips, which are very sensitive to particle contamination. Additionally particle removal is implemented in the welding process. The extremely low levels of particles in the LinPak would not have been achievable with layout 2 or 3, where the AC terminal feet are located very close the semiconductor chips. The insulation integrity challenge is mastered by having the welding pad

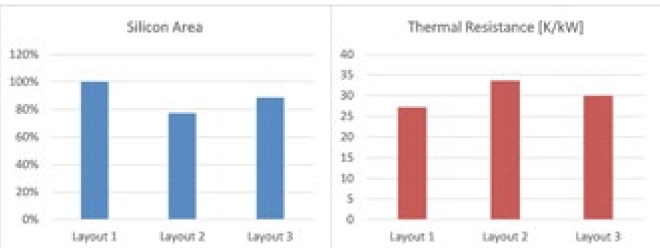


Figure 3: Comparison of the three layouts: silicon area (left) and thermal resistance for IGBT, junction to case (right).

on the substrate large enough which is reasonably possible only with layout 1. The distance between the welded terminal foot and the copper edge of the welding pad is found to be a critical design parameter. Together with carefully chosen process parameters, cracks in the aluminum nitride ceramic are successfully prevented in the LinPak module.

Easy paralleling

The scalability of the LinPak module is based on the easy paralleling capability. This means paralleling has to be possible with minimal derating. In principal, the amount of paralleled chip-area remains the same, independently whether for example three LinPak modules are paralleled or a single HiPak2 module is used. The distinct differences are:

a) the current sharing within a module (e.g. HiPak) is mainly defined by the module design and under the responsibility of the module manufacturer
b) the current sharing between modules (e.g. LinPak) depends on the circuit design of the customer and lastly
c) the current imbalance between modules can be rather easily measured, which is nearly impossible within a module.

For a) as well as b) it is clear that a proper design of the module and the circuit design including DC-link and Gate-Driving are crucial. In case of the LinPak the circuit design however is pretty much given by the module concept and with minimal effort very good current sharing between the modules can be achieved. The current sharing in case of paralleled LinPaks is better than the sharing within many existing modules available on the market. Here kicks in c), where in most cases it is very difficult to impossible for the users to measure or even estimate the internal current imbalance of the power modules. Usually just the measured overall losses or data sheet values are used for thermal calculations and no derating due to current imbalance is taken into account.

In case of the LinPak first paralleling tests have been conducted with two modules in parallel. Figure 4 shows the current sharing during IGBT turn-on at nominal conditions. The turn-on wave shape is chosen as an example since the impact of gate-emitter voltage distortion due to parasitic electro-magnetic coupling is mainly visible during IGBT turn-on. This comes from the fact that the turn-on current characteristic follows the transfer characteristic and thus, it is under influence of the gate-voltage distortion. During turn-off, the gate-voltage shape has minimal impact on the current hence even with less ideal connection symmetry usually the current sharing during turn-off is within acceptable limits.

Figure 4 shows a perfect current sharing with hardly visible current imbalance.

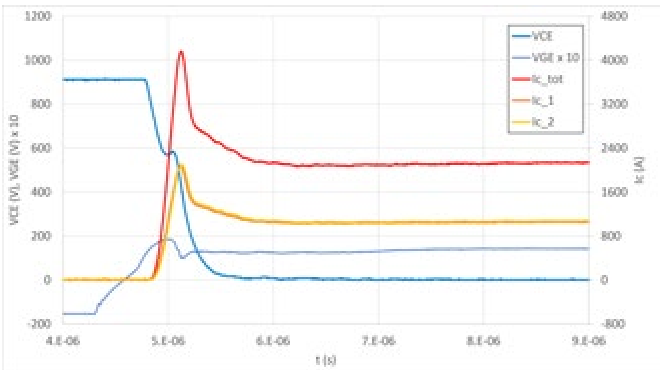
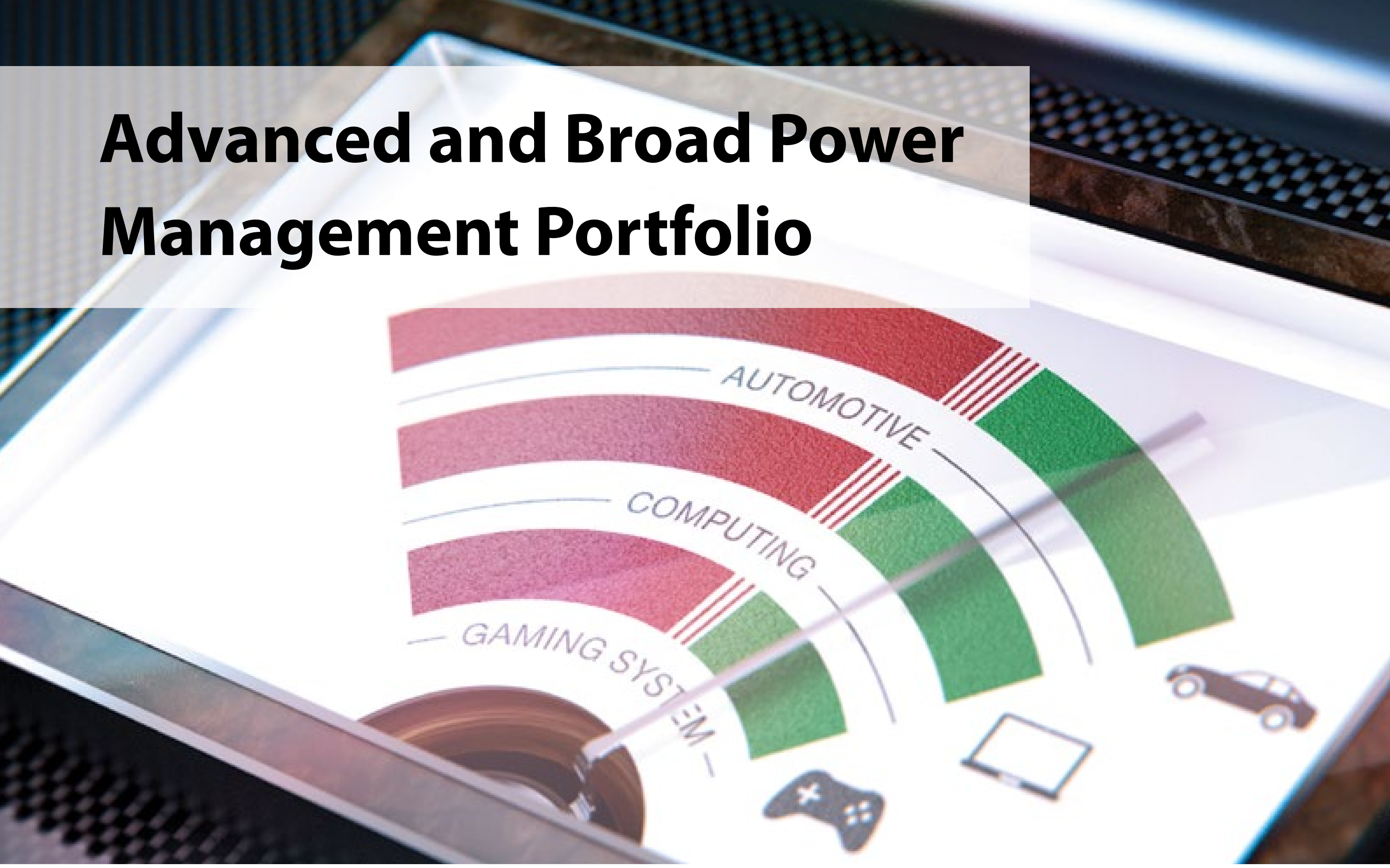
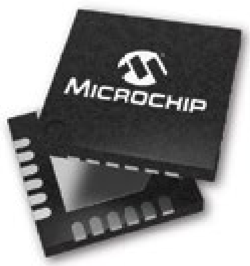


Figure 4: Paralleling of two LinPaks: Current sharing at nominal turn-on, V_{cc} = 900 V, I_{ctot} = 2000A, R_G = 0.2 Ohms, L_s = 15 nH

Advanced and Broad Power Management Portfolio



Microchip Technology has an expansive offering of power management solutions to fit virtually every type of design criteria. From the smallest form factor needed for mobile devices to complex industrial power management designs to automotive standards, you are sure to find a highly integrated solution to meet your needs. If you are looking for greater flexibility in your design, Microchip's digitally enhanced power analog devices integrate a microcontroller (MCU) or digital signal controller (DSC) for a fully programmable and flexible solution.



Applications:

- LDO and switching regulators
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- Digitally enhanced and PWM controllers
- System supervisors
- Voltage detectors
- Voltage references
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Electrical results of 3300V 2 x 450A LinPak

Results of 1700V, 2 x 1000A LinPak phase leg single modules have been already presented [1] and they showed that a reduction of up to a factor of five in turn-off over-voltage can be achieved compared to standard (190 x 140mm^2) HiPak modules.
First LinPak modules using the well established low switching losses 3300V SPT$^+$ chipset rated 2 x 450A in phase leg configuration are now available for sampling. Figure 5 shows the 3300V LinPak switching off at SOA conditions with a high DC-voltage of 2600V and a worst-case total stray inductance of 80nH. Despite the harsh condition, the turn-off event is very soft and the over-voltage is staying well below 3300V allowing for significant safety margin:

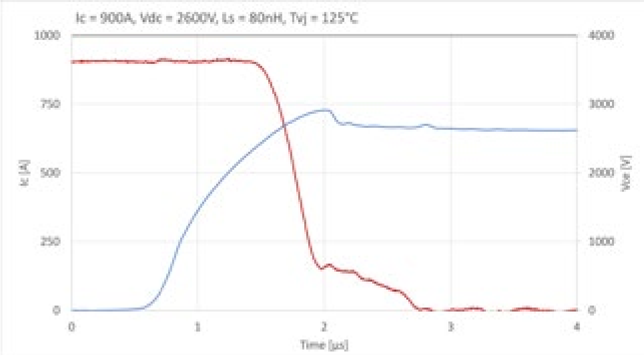

Figure 5: 3300V LinPak rated 2 x 450A, SOA turn-off at double nominal current

Electrical results of a full SiC 1200V LinPak module

In order to demonstrate the capability of the LinPak design to operate with SiC MOS-FETs a technology driver using 1200V SiC MOS-FETs, paired with SiC Schottky diodes has been built. The biggest challenge for a proper electro-magnetic homogenous design of a large current SiC module is the fact, that available SiC MOS-FETs are limited in their size and current ratings. For the demonstrator we used 12 MOS-FETs per switch, yielding in a 25°C nominal current rating of about 700A. A special substrate design was deployed to have a homogenous and low internal impedance while at the same time allowing to add a gate-resistor for each chip (Figure 6) [5].

Figure 6: Low impedance substrate design for a 1200V full SiC LinPak

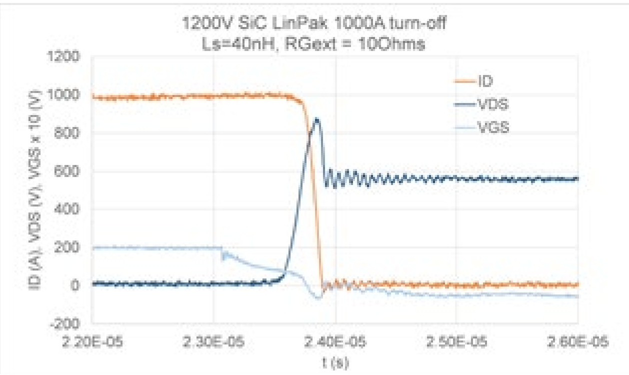

Figure 7: 1200V full SiC LinPak turn-off

First results with switching up to 1000A show that the LinPak is well suited for SiC chips. Depending on the gate-resistor value, oscillation free turn-off can be achieved. Figure 7 shows the turn-off with an external gate-resistor of 10 Ohms. The waveform is free from oscillations and the over-voltage stays well within an acceptable level. At turn-on still some oscillations persists, despite the rather high gate resistance. Further optimisation work is on-going, however for economically viable high current modules, SiC MOS-FETs with larger area are needed.

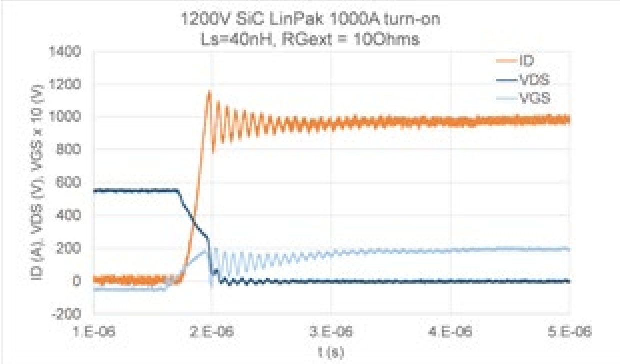

Figure 8: 1200V full SiC LinPak turn-on

Conclusions

The LinPak is an emerging package standard making optimal use of todays and future low loss silicon based IGBT chips. The LinPak allows for highly scalable converter designs thanks to its easy paralleling capability. This provides flexibility to converter manufacturers as the LinPak becomes the default building block for different ratings, resulting in less diverse bill of material per converter product. Since the LinPak standard has by now been adopted by a multitude of module manufacturers, the converter producers have a solid base for second sources making the supply chain more sustainable.
Last but not least the LinPak is future proof. We have demonstrated that the concept is capable to house silicon carbide base MOS-FET switches and that the LinPak is able to control the very fast switching devices. ABB starts to serve the market with a 1700V, 2 x 1000A rated module as well as with a 3300V, 2 x 450A rated LinPak.

Acknowledgements

Andreas Baschnagel and Daniel Prindle, ABB Switzerland Ltd., for electrical measurements.

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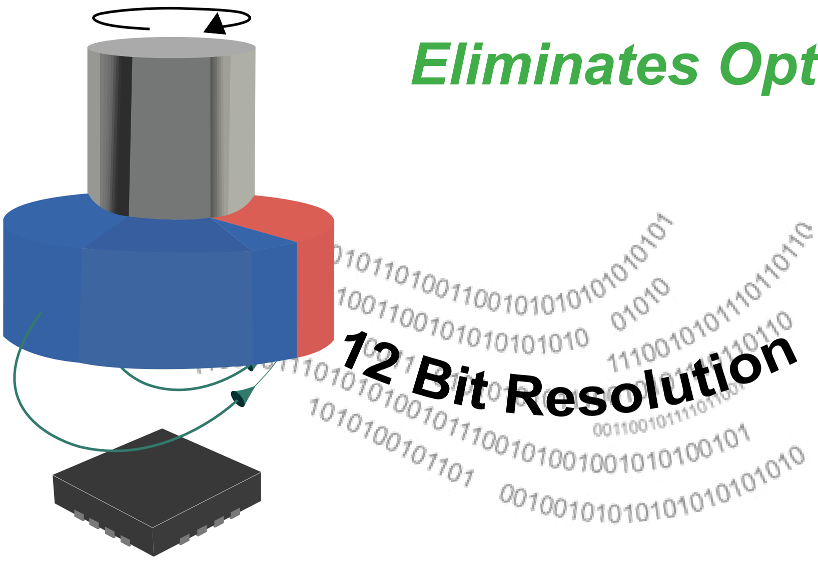

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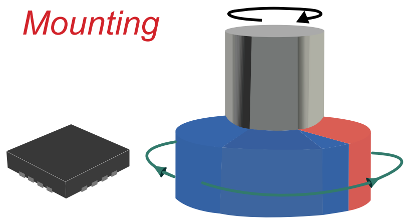

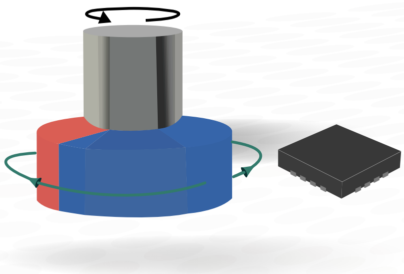

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Lifetime Analysis of PrimePACK™ Modules with IGBT5 and .XT

One of the major criterions for the reliability of power modules is the capability to withstand cyclic active thermal loads. The improvement of the die attach technology as well as the top-side interconnect and the substrate-to-baseplate solder will lead to a better thermal cycling capability and along with that, the new .XT joining technology will significant increase the lifetime of the module.

By Wilhelm Rusche and Nicolas Heuck, Infineon Technologies AG

To predict the lifetime of a power module based on a defined mission profile, lifetime models were developed for the standard packaging technologies. These models take the relative temperature swing ΔT, the mean T_{vjm}, and maximum junction temperatures T_{vjmax} as well as the duration of thermal stress (t_{on}) [1, 2] into account.

The novel joining technology .XT for PrimePACK™ power modules has been introduced to meet the future requirements of higher reliability and temperature stability. Using copper wire bonds for the top-side interconnect and silver sintered die attach layers led to a significant increase of lifetime. With the introduction of these new interconnect methods it was possible to increase the lifetime and temperature stability of power modules [3-5].

Failure Mechanisms

In general, thermally induced mechanical stresses in a chip-to-substrate or a wire bond interconnect are caused by a coefficient of thermal expansion (CTE) mismatch between the joint partners or by an inhomogeneous spatial temperature distribution during thermal cycling. Thus, the degradation and failure of the interconnects are defined by the properties of the interconnect materials themselves.

The ability of a material or interconnection to withstand a given thermally induced stress is determined by several key properties. In general, a low plastic deformation during temperature cycling results in lower mechanical damage. This indicates a higher reliability of materials with increased mechanical strength. In addition, high values for parameters such as total elongation at break point to an increased robustness against the plastic deformation.

Moreover, strong changes in the material properties caused by temperature treatment, such as a reduction of mechanical strength due to significant changes in the microstructure should be avoided within the operation temperatures. And finally, the maximum operation temperature should be low in relation to the melting temperature of the respective material, so that damage by material creeping is minimized.

The majority of existing modules is characterized by standard joining technologies such as aluminum wire bonding and soft soldering. They suffer from low inherent mechanical strength and low melting temperatures resulting in a limited reliability at operation temperatures exceeding 150°C.

Figure 1 depicts the novel joining technology .XT used in the PrimePACK module with IGBT5.

One method to increase the reliability of the top-side interconnects is to replace aluminum by copper wire-bond material. Because of its much higher yield and tensile strength combined with a lower CTE, the amount of plastic deformation for a given temperature cycle is significantly reduced compared to aluminum.

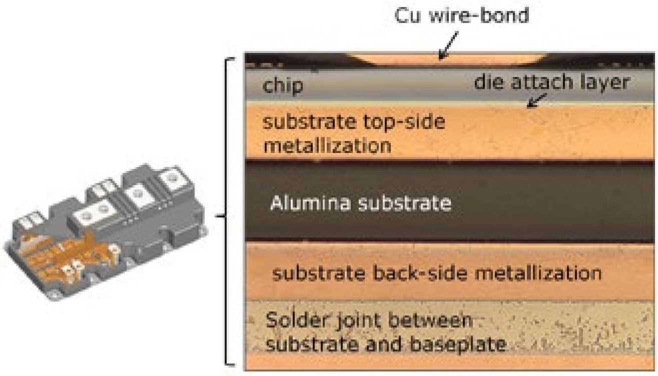

Figure 1: Power cycling sample types: PrimePACK™ modules with baseplate and the corresponding metallographic cross-section

Equally important for the module´s lifetime are novel die-attach technologies such as sintering using silver particles. Improved mechanical properties, with respect to soft solders, are also obtained for sintered Ag die attach layers. This is predominantly a result of the high melting point and the higher mechanical strength of the material.

To enhance the power terminals´ connections as well, ultrasonic welding (US) is implemented. The joint between DCB and BP is upgraded utilizing an advanced solder technology. However, compared to the other interconnect materials, a higher plastic deformation during temperature cycling and creeping fatigue cannot be excluded for the substrate-to-baseplate solder.

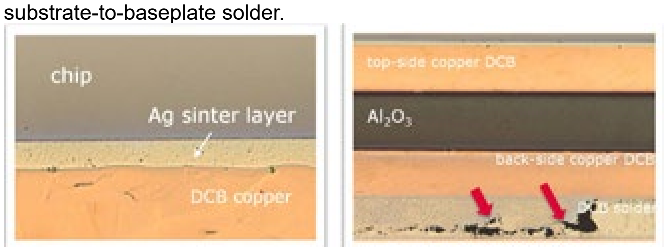

Figure 2: Failure mechanisms during power cycling (3, 4): Cracks are marked by red arrows. Samples with baseplate show degradation within the substrate-to-baseplate solder

The failure mechanisms in power modules employing improved wire-bond technologies, sintering as die attach and the improved solder

between substrate and baseplate were investigated in detail [4], they are displayed in figure 2. The degradation of the substrate-to-baseplate solder has been identified as the most prominent failure mode which is effecting lifetime.

Lifetime Analysis

Current lifetime models for power modules employing standard technologies underline the impact of the temperature difference ΔT, the mean or maximum junction temperatures T_{vjm}, T_{vjmax} and the duration of the load current t_{on} during one cycle on the estimated lifetime of a power module [1, 2]. Even though these models are empirical, ΔT, T_{jm} and t_{on} can be related to driving forces of degradation. The first lifetime model [1] presented was later extended by adding terms that describe the impact of t_{on}, the current per bond-foot, the voltage class U, with respect to chip thickness, and the bond-wire diameter D [2].

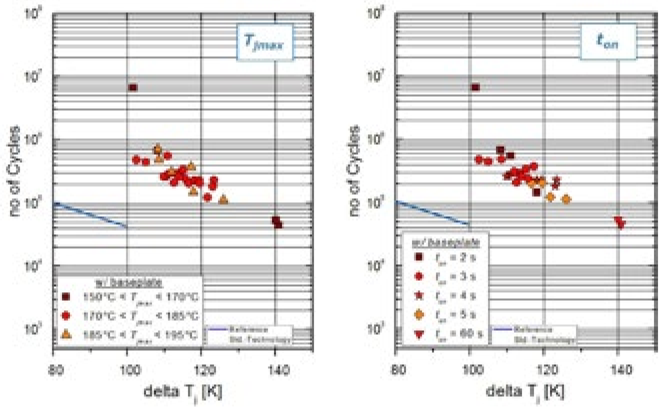

Figure 3:Power cycling results of PrimePACK™ samples employing .XT sorted by a) T_{jmax} and b) t_{on}.

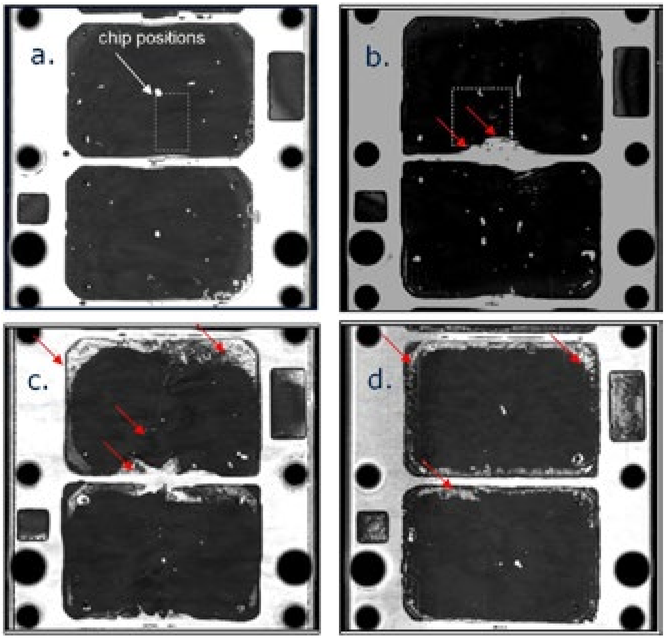

Figure 4: SAM pictures of the baseplate to DCB solder interconnect after power cycling. Red arrows mark degradation:
a) After 150.000 active cycles @ ΔT≈108 °C and t_{on} = 2 s
b) After 125.000 active cycles @ ΔT≈120 °C and t_{on} = 5 s
c) After 66.000 active cycles @ ΔT≈140 °C and t_{on} = 60 s
d) After 3000 passive thermo-shock cycles from -40 °C to 150 °C

For the development of a first lifetime model focusing on the new die attach technologies, the power cycling results presented [4] were revised. Most importantly, failure data from samples with different die attach technologies were grouped together. This is a valid approach since the failure is always related to the substrate-to-baseplate solder [5].

Figure 3 presents the excellent power cycling results of PrimePACK modules employing .XT with regard to Tvjmax and ton. For comparison, the results of standard technology are added to the graph.

The examination of the copper wire bond connection out of this PC test does not reveal degradation. Thereby it can be concluded that bond failure will not be an issue for the new joint technology .XT.

The degradation pattern in the baseplate solder can be analyzed by means of scanning acoustic microscopy (SAM). Figure 4 depicts the results and underlines the impact of t_{on}. For t_{on}=2 s, the degradation of the solder starts directly below the chip (Figure 4 a). Increasing t_{on} from 2 to 5 s leads to a higher ΔT at the edges of the substrate-to-baseplate solder joint which in turn manifests itself in additional shear forces and a more dominant degradation at the edges compared to the beginning of the test (Figure 4 b). It has to be underlined, that the sample from Figure 4a afterwards reached more than $6 \cdot 10^6$ cycles.

When ton is increased even further to 60 s, this effect becomes even more apparent as degradation is strongly accelerated at the edges of the baseplate-solder (Figure 4c). For this load, the degradation pattern bears strong resemblance to that obtained after passive thermal cycling. With the findings from [6] it can be expected that a further increase of t_{on} would lead to a complete shift of the critical degradation from below the chip to the edges of the DCB.

On the other hand, a further reduction of t_{on} is expected to result in significantly higher lifetime – independent from ΔT – as the stress in the substrate-to-baseplate solder is reduced significantly.

Summary

In contrast to standard joining technology, the wire-bond related failure loses importance as bond failure can be excluded with .XT. By increasing t_{on}, the degradation of the baseplate solders joint shifts from below the chips toward the substrate´s edges and becomes the most prominent EOL mechanism. The .XT lifetime is still dependent on T_{vjmax} and t_{on} but is shifted to much higher numbers of cycling.
Based on this and in comparison to EOL mechanism of standard joining technologies, aluminum wire-bond and soft-soldering die attach, the .XT joining technology provides a major advantage with respect to lifetime. The described results of the lifetime research will be implemented in new lifetime models of the innovative .XT interconnect technologies.

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High-Precision, Wideband, Highly Stable Current Sensing Technology

Currently, there is demand for high-precision, wideband current measurement in the power electronics field, where typical products include power conversion systems such as power conditioners and inverters. Since launching the Clamp Tester CT-300 (see Figure 1) in 1971, Hioki has supplied a variety of current sensors (see Figure 2) designed for specific measurement applications. This paper describes the features of Hioki's current sensors along with key considerations in current measurement, with a focus on high-precision, wideband current measurement.

By Kenta Ikeda, Senior Staff and Hidekazu Masuda, Senior Staff, Hioki E.E. Corporation

Detection Methods Used in Current Sensors

Current sensors utilize a broad range of detection methods. Among them, many detect current using a magnetic conversion element that is inserted into the gap of the magnetic core or a winding making up a magnetic core, depending on the current flowing in the conductor under test. That said, each detection method is characterized by its own advantages and disadvantages, making it difficult to satisfy all measurement requirements with any one detection method. Hioki provides high-precision, wideband current sensors by using the zero-flux method (also known as the closed-loop or magnetic balance method), which combines two detection techniques.

Figure 1: Current Sensor CT-300, launched in 1971

Figure 2: Hioki zero-flux current sensors

In the zero-flux method, which relies on a negative feedback circuit that includes a magnetic circuit such as those shown in Figures 3 and 4, a current is made to flow in a feedback coil so as to cancel the magnetic flux produced in the core by the current under measurement. This method has the advantage of minimizing the effects of the magnetic material's nonlinearity since the operating magnetic flux can be controlled so that it is kept to a very low level.

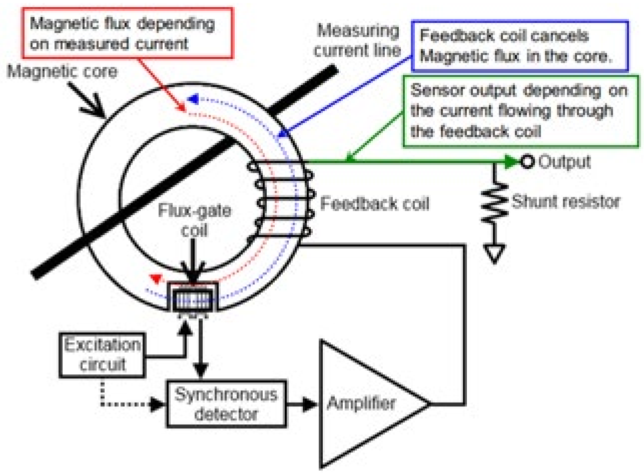

Figure 3: Zero-flux method (flux-gate type)

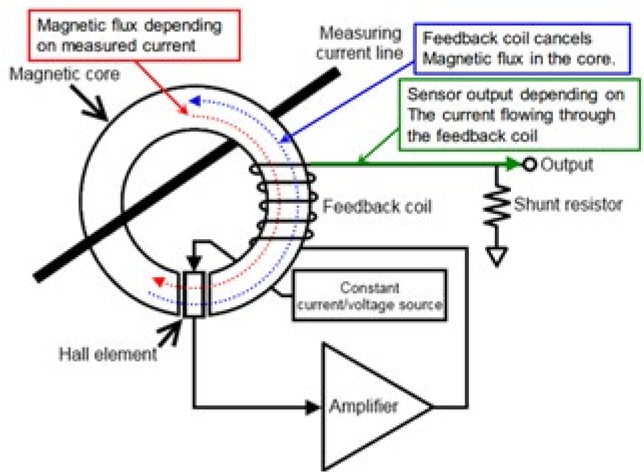

Figure 4: Zero-flux method (Hall element type)

Hioki's high-precision current sensors use the zero-flux method, which combines the flux-gate method and the current transformer (CT) method shown in Figure 3. The flux-gate method allows detection based on a DC current. Because this method does not require use of any semiconductors, it delivers the advantages of low offset voltage, high temperature stability, and excellent long-term stability. Hioki provides current sensors with 0.02% rdg. accuracy and a band of 3.5 MHz, making them some of the best-performing instruments of their kind in the world. In addition, the company takes advantage of the flux-gate method's high temperature stability to deliver products with an operating temperature range of -40°C to 85°C.

By contrast, wideband current sensors use a zero-flux design that combines a Hall element and the current transformer (CT) method as illustrated in Figure 4, providing a measurement band that extends from DC to a maximum of 120 MHz. Since Hioki produces in-house the Hall elements that serve as the key magnetic detection devices in this design with high sensitivity and low noise characteristics, these sensors are ideally suited to use in applications where minuscule current waveforms must be observed in combination with an oscilloscope.

Differences in Current Sensor architecture

Current sensors can be categorized as either through-type or clamp-type instruments based on their design. The through-type architecture eliminates any break in the surface of the magnetic core, which makes it easy to obtain uniform characteristics around the entire circumference of the core and allows construction of extremely high-precision current sensors. However, this design requires that the wire under test be disconnected so that it can be passed through the sensor, making it impossible to connect the sensor to operating equipment.

By contrast, the clamp-type architecture introduces a break into the magnetic core, allowing it to be clamped around the wire being measured. Since there is no need to disconnect the wire under test as with the through-type design, it is easy to measure operating equipment. However, the introduction of a break into the magnetic core makes it difficult to obtain uniform characteristics around the entire circumference of the core. As a result, clamp-type current sensors generally exhibit lower measurement accuracy and have a more pronounced effect of conductor position than their through-type counterparts. Consequently, they make it more difficult to obtain measurements with good reproducibility. Hioki takes advantage of expertise gained over many years of developing current sensors to offer high-precision, clamp-type current sensors. The characteristics of these instruments are described below.

Key Considerations When Choosing a Current Sensor

The most important aspect of making high-precision measurements with a current sensor is the selection of a current sensor that is appropriate for the measurement target.

Many high-precision current sensors (i.e., those with an accuracy of 0.1% or less) uses the current output method, but Hioki's high-precision current sensors uses the voltage output method. While current output is generally regarded as providing superior signal transmission quality, voltage output delivers numerous advantages as an output format for current sensors. The following sections describe key considerations when choosing a current sensor while exploring the advantages of voltage output.

Suitability of the Current Sensor's Rating and Measurement Band

To measure a given current with a high degree of precision requires a current sensor whose rating is appropriate for the magnitude of the target current. For example, if a 5 A current were measured using two current sensors with the same accuracy specifications, one with a 10 A rating and one with a 500 A rating, the results would indicate that the sensor with the 10 A rating, which is closer to the magnitude of the measurement target, is advantageous in terms of precision and reproducibility. Caution is necessary as Hioki defines rated currents for its current sensors as RMS values, whereas many current sensors do so using peak values.

In addition, it is important to verify that all frequency components of the current to be measured are included in the current sensor's measurement band.

Defined Accuracy for Amplitude and Phase in the Measurement Band

For most high-precision current sensors used in combination with power meters, amplitude accuracy is defined only for DC current and commercial frequencies (50 Hz/60 Hz), and phase accuracy is rarely defined at all. In fact, it is difficult to define the accuracy of amplitude and phase in the high-frequency region for the current output that is generally used by high-precision current sensors. Caution is necessary as many manufacturers only publish typical characteristic graphs for frequencies other than commercial frequencies. Since Hioki sensors use voltage output, it is possible to define amplitude and phase accuracy across the entire measurement band. Because both amplitude accuracy and phase accuracy are critical considerations in accurate power measurement, it is important to verify that phase accuracy has been defined when choosing a current sensor, particularly one that is to be used in power measurement.

Versatility

Current sensors that produce voltage output have the advantage of being suitable for a variety of measurement applications since it is easy to connect them not only to power meters, but also to instruments such as DMMs, oscilloscopes, and recorders.

High S/N ratio

Hioki's high-precision current sensors are designed to produce 2 V of output when measuring the rated current. For example, when using the Hioki CT6863 (rated 200 A), 2 V AC would be input to the power meter when measuring a 200 A AC. Since power meters that accept current input incorporate shunt resistors into their input circuitry, even signals from current sensors that produce current output end up being converted to voltage signals for processing. If a high-precision current sensor with a conversion ratio of 1500:1 is used to measure a 200 A AC current, the voltage measured by the power meter will be as follows for the typical shunt resistor resistance values of 0.5 Ω and 0.1 Ω:

$$133.3\ \text{mA} \times 0.5\ \Omega = 66.65\ \text{mV AC}$$
$$133.3\ \text{mA} \times 0.1\ \Omega = 13.33\ \text{mV AC}$$

The signal levels measured by the power meter would be 2 V (with Hioki's design) versus 13.33 mV to 66.65 mV (for a current output-type design), illustrating how the Hioki design yields a higher S/N ratio than current sensors that rely on current output.

Ease of Adjustment and Calibration

Since Hioki's current sensors generate voltage output, they have the advantage of being easy to adjust and calibrate. Consequently, their defined accuracy can extend to include the output cable. In addition,

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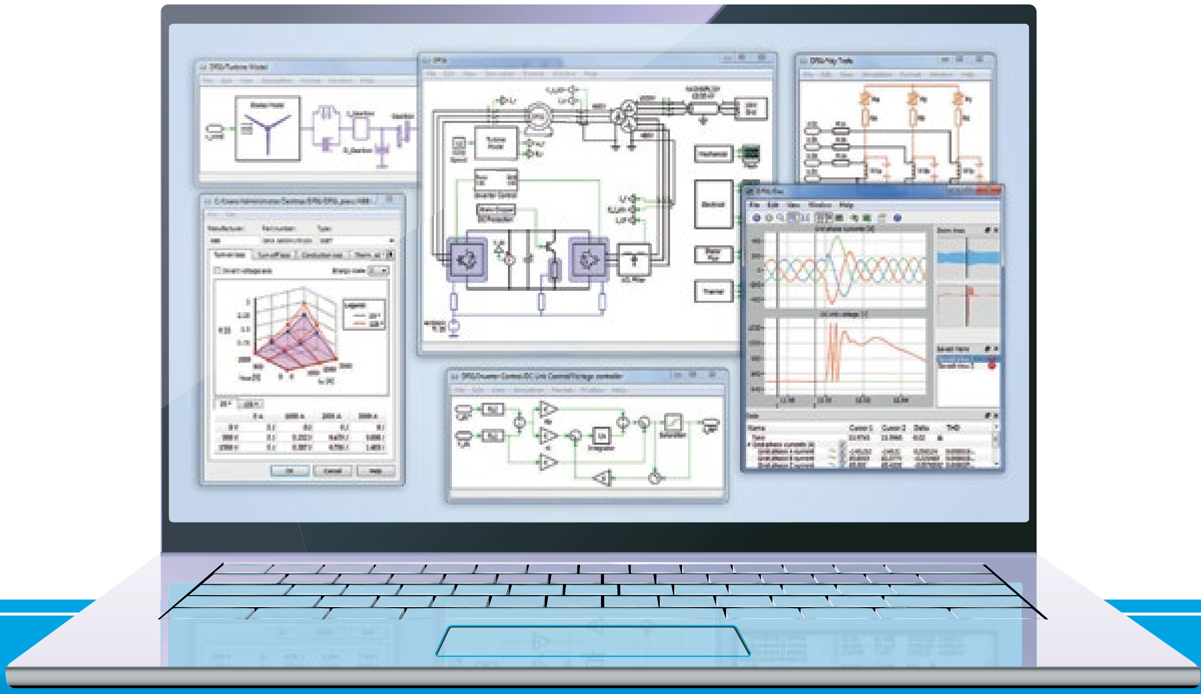

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Hioki sensors can be manufactured with custom cable lengths since the adjustment process can compensate for the minuscule voltage drop caused by the cable's resistance.

Hioki's high-precision current sensors can be calibrated not only for DC and commercial frequencies, but also for the high-frequency region. Following are some example calibration points for Hioki's current sensors (traceability is maintained for each frequency point):

Amplitude: ±DC, 50 Hz, 60 Hz, 1 kHz, 10 kHz, 100 kHz, 300 kHz, 700 kHz, 1 MHz
Phase: 50 Hz, 60 Hz, 1 kHz, 10 kHz, 100 kHz, 300 kHz, 700 kHz, 1 MHz

Precautions for High-precision Measurement
This section introduces some precautions that should be observed when using a current sensor to measure current with a high degree of precision, based on the experience Hioki has gained over many years of current sensor development.

Positioning the Conductor in the Center of the Sensor
All current sensors are prone to the effects of conductor position, and the magnitude of those effects increases with the measurement frequency. Even through-type current sensors with good characteristics exhibit significant effects at frequencies of 10 kHz and above. A current sensor's measurement accuracy is always defined at the center position of the sensor. When measuring a high-frequency current, it is particularly important to ensure high-precision, highly reproducible measurement by positioning the conductor in the center of the sensor.

Keeping Nearby Conductors away from the Current Sensor
Current sensors function by detecting the magnetic field produced when current flows through the cable being measured. As a result, they are affected in no small part by any currents that may be flowing in nearby conductors. These effects are particularly pronounced for high-frequency currents. Consequently, it is desirable to keep nearby conductors as far away as possible from the current sensor so that the target current can be measured at a high level of precision. These effects are particularly significant for high-frequency currents, and they should be considered when using all current sensors.

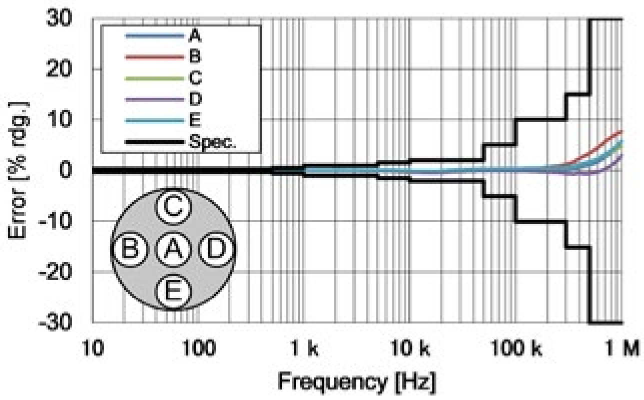

Figure 5: Frequency characteristics based on conductor position

Expressing the Accuracy of High-precision Current Sensors
The accuracy of Hioki's high-precision current sensors is defined for all frequency bands in the measurement domain. Current sensor accuracy is typically defined in the center of the sensor. However, it is no easy feat to position a conductor in the exact center of the sensor in actual practice. Figure 5 illustrates the frequency characteristics and specifications of a Hioki high-precision current sensor (Model CT6841). Accuracy has been defined for each region so that the specifications are satisfied even when the conductor position varies.

In addition, the accuracy specifications of Hioki's high-precision current sensors incorporate a sufficient margin of performance. As a result, actual performance tends to be significantly better than their specifications suggest.

High-precision Clamp Current Sensors
As described above, clamp-type current sensors generally exhibit poor accuracy and measurement reproducibility due to the break in their magnetic core. This section introduces some of the characteristics of Hioki's CT6843 high-precision clamp sensor (rated 200 A), shown in Figure 6. Figures 7 through 9 compare those characteristics to those of the CT6863, a Hioki through-type current sensor with the same rating (200 A). The characteristics of Hioki's clamp-type current sensors approach those of through-type current sensors, making them more than capable enough to be used in high-precision power measurement.

Figure 6: Hioki's CT6843 high-precision clamp sensor (rated 200 A)

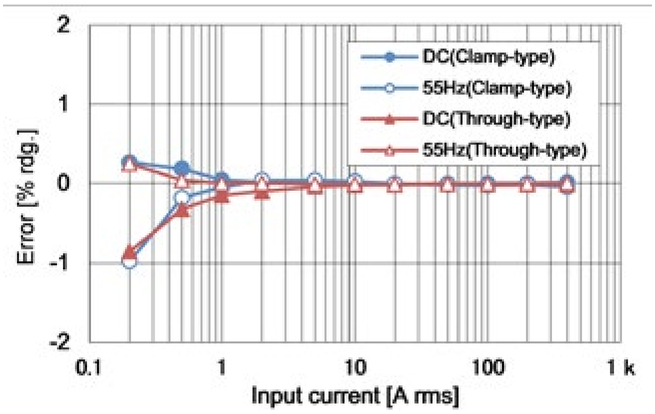

Figure 7: Comparison of linear characteristics

These clamp-type current sensors are able to deliver this level of performance because they use a uniform structure around the circumference of the magnetic core with the exception of the break and because the break in the core is designed to minimize magnetic reluctance. This construction evokes designs that deliver uniform characteristics around the entire circumference of the magnetic core as in a through-type sensor.

Hioki's clamp-type current sensors are designed to deliver excellent ease of use as well as high performance. For example, their jaws can be opened and closed, and their sensor locked in place, by means of simple, single-handed operation. Furthermore, these sensors can operate across a broad temperature range of -40°C to 85°C, allowing their use in a variety of environmental tests. As a result, they can be used without issue in harsh environments such as the hot conditions of an automobile's engine compartment.

In addition, Hioki's power meters are designed specifically to be used with its current sensors, allowing them to supply power directly to,

and automatically detect the model of, connected sensors. For this reason, Hioki's current sensors are ideal for use in conjunction with power meters in high-precision, wideband power measurement applications.

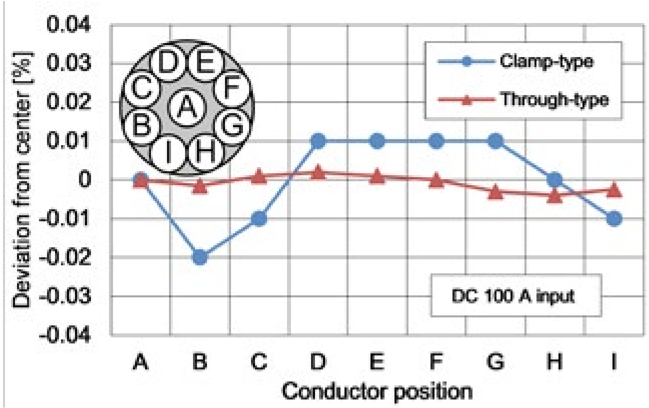

Figure 8: Comparison of the effects of conductor position

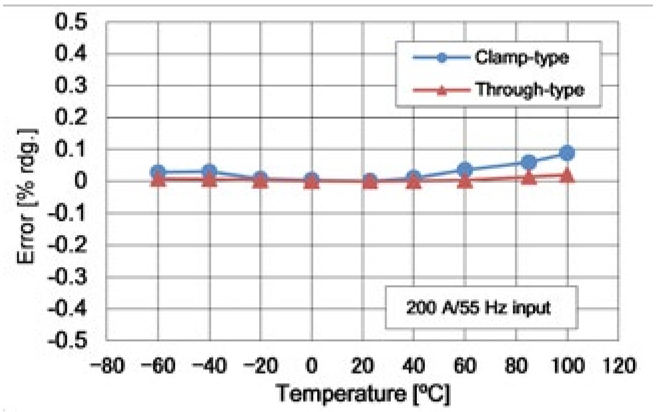

Figure 9: Comparison of temperature characteristics

Figure 10: Wideband current sensor CT6701

Wideband Clamp-type Current Sensors

Hioki's wideband current sensors feature a broader measurement band and lower noise levels than the high-precision current sensors described above. Of those products, the CT6701 (Figure 10), which has the highest current to output voltage conversion rate ("output rate") and highest frequency band (see Figure 11) of any Hioki product in its class, is ideal for use in the observation of transient response current waveforms, high-speed response waveforms such as inrush current, and minuscule current waveforms that include a variety of frequency components.

As described above, wideband current sensors use the zero-flux method, which utilizes a thin-film Hall element. Hioki has developed a thin-film low-noise Hall element, which is a key device in current sensors, to accommodate market demand for improved low-current measurement capabilities. For example, the Hioki CT6701 is able to deliver an output rate of 1 V/A (10 times the rate of its predecessor) as well as low-noise performance. Figure 12 provides a measured waveform comparison with the previous model, illustrating how the waveform of a control current flowing to an electrical part in an automobile, for example a small motor, can be more precisely observed on the order of milliamperes. Using them in combination with an oscilloscope is ideal for fully optimizing the performance of the 120 MHz (-3dB) wideband characteristics. For example, it can be used to observe the control current or load current in a switching circuit used in power conversion or motor control, the turn-on/turn-off current waveform of a semiconductor device performing high-speed switching, or ripple waveforms.

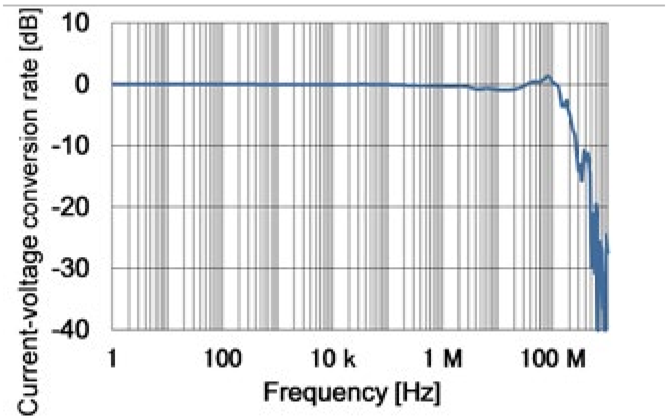

Figure 11: CT6701 amplitude-frequency characteristics (typical)

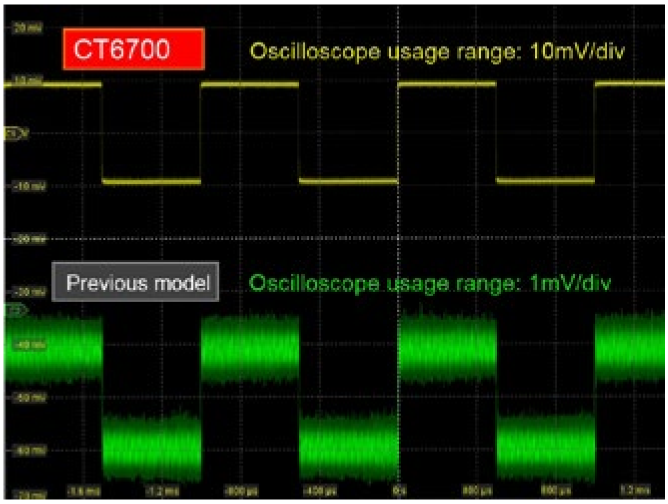

Figure 12: 20 mAp-p waveform (comparison with previous Hioki model)

Conclusion

This article has introduced the detection principle used by the zero-flux method, key considerations when choosing a current sensor, precautions when using these instruments, and some current sensor characteristics, with a focus on current sensors that have been developed by Hioki for more than 40 years. The authors hope that it will prove useful to anyone measuring current in the power electronics field, which demands high-precision, wideband current measurement.

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Thermal Management of Semiconductors

Power semiconductors are the workhorses of the electronics world. Their thermal management is crucial to the operational reliability and service life of the components. For this purpose TDK offers a wide range of EPCOS NTC and PTC thermistors that enable reliable temperature monitoring.

By Christoph Jehle, Manager Technology and Product Communication EPCOS

Power semiconductors generate thermal losses, ranging from a just a few watts to several kilowatts, which must be dissipated. Due to their need for thermal management, the enclosures of power semiconductors are designed in such a way that they can be mounted on heatsinks in order to dissipate the heat more efficiently. The conductive capability of heatsinks is measured in K/W. The smaller this value, the greater is the thermal dissipation capacity. If the maximum heat dissipation occurring in a semiconductor and the highest expected ambient temperature are known, then the required heatsink can be determined, taking into account the thermal contact resistances.

The passive thermal dissipation by convection alone soon reaches its limits. With a small chip surface and a very high power dissipation, it is impossible to guarantee sufficient cooling with this method. In addition, the size of the heatsinks hinders a compact design for the device. The only remedy here is to use systems with active thermal dissipation using fans or combined air and water-cooling using heat exchangers, which are often operated without regulation.

In many applications such as power supply units and converters or for processors in PCs and notebooks, however, power dissipation is load-related. In order to improve the energy balance and prevent generation of unnecessary noise, it is advisable in many cases only to switch on the active thermal dissipation after a defined temperature limit has been reached. EPCOS thermistors – in a host of versions for a wide variety of applications – are ideal for detecting these limit temperatures. A distinction is made in the basic thermistor technologies between positive temperature coefficient (PTC) and negative temperature coefficient (NTC) thermistors, whose resistance curves are fundamentally different (Figure 1).

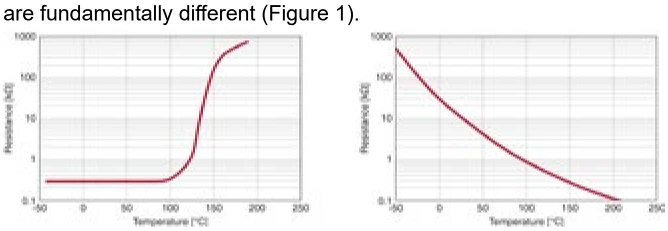

Figure 1: Resistance characteristics of PTC and NTC thermistors
On exceeding a specific temperature, PTC thermistors (left) show a very sharp rise in resistance, making them suitable as temperature limit sensors. NTC thermistors, on the other hand, exhibit greater linearity and are therefore suitable for temperature measurement.

Reliable temperature monitoring with PTC sensors

PTC thermistors with their very steep curves are very suitable for the monitoring of temperature limits and consequently for switching on a fan when a particular temperature is reached. A further advantage of the PTC temperature characteristic is that PTC thermistors can be connected in series and thus, in their function as temperature sensors, can very easily monitor several hot spots. As soon as one of these PTC sensors in a series connection exceeds the specified limit temperature, the circuit switches to the high-ohmic state. This principle can be applied, for example, in notebooks, in order to monitor the main processor, the graphics processor and any other heat emitting components using SMD PTC sensors.

A further application of PTC sensors is the thermal monitoring of the windings in three-phase motors. For this purpose, TDK offers special types that are assembled accordingly and which can be easily integrated into the windings. Figure 2 shows PTC sensors for limit temperature monitoring.

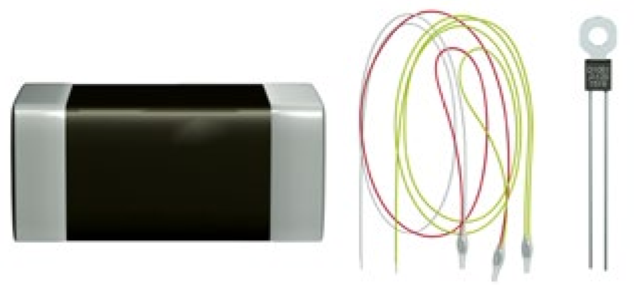

Figure 2: Different versions of EPCOS PTC sensors
From left to right: SMT-PTC temperature sensor for mounting on printed circuit boards, PTC sensors for integration in motor windings, PTC sensor with lug for mounting onto heatsinks.

Switching principle for the recording of limit temperatures

Figure 3 shows a simple circuit with two series-connected PTC sensors for the monitoring of limit temperatures. TR1 and the two PTC sensors form a voltage divider which supplies the non-inverting input of the operation amplifier that functions as a comparator. TR1 is set in such a way that its maximum value corresponds to about twice that of the resistance of the PTC series connection at 25 °C. For fine adjustment, the value of TR1 can be set accordingly. In the cold state, a potential is present at the non-inverting input which is more negative than the reference potential at the inverting input. This means that a negative voltage is present at the comparator output. If one or both PTC sensors reaches the limit temperature, the potential at the volt-

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Features

- + Optimized for Fuji modules
- + Increase lifetime of IGBT
- + Advanced IGBT power density

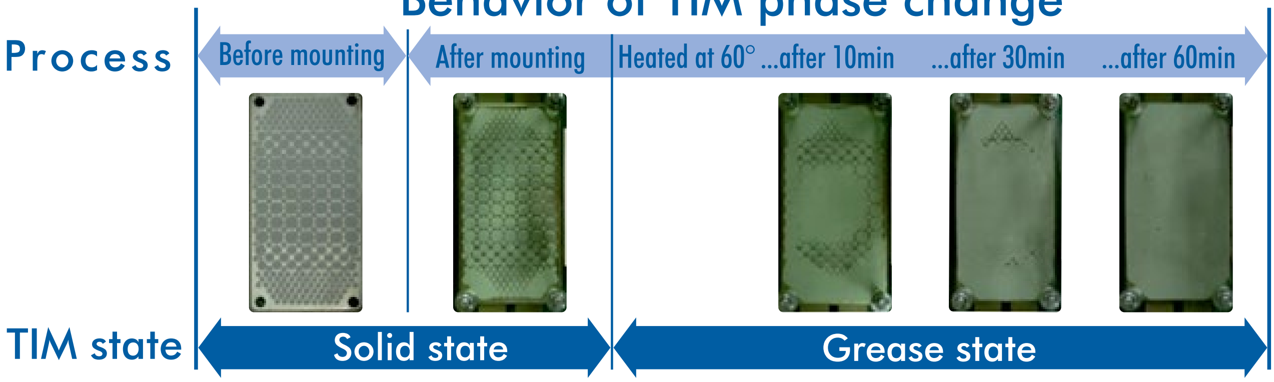
Process - Benefits

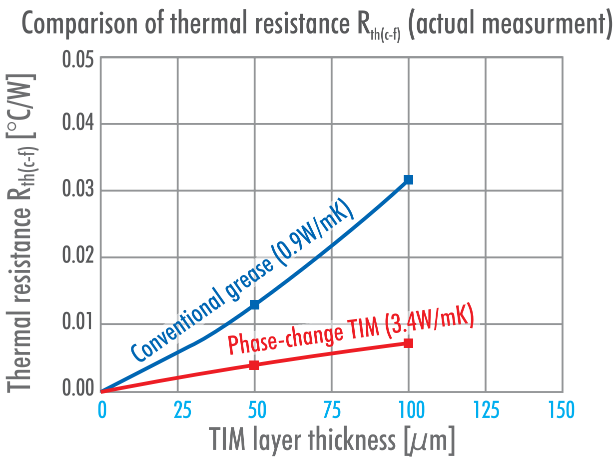
- + Outsourcing of a dirty process
- + Stable quality level
- + Increased system reliability

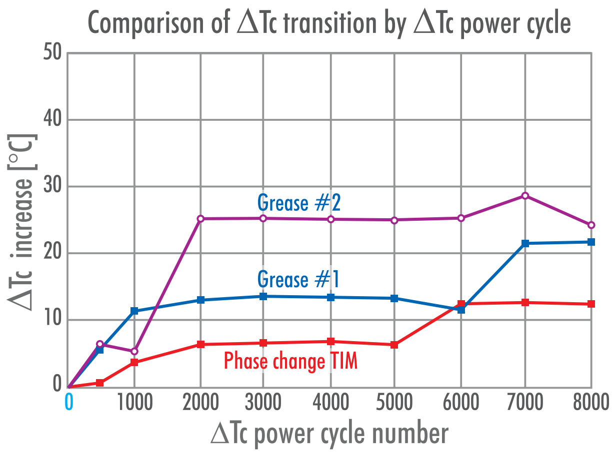
Thermal - Benefits

- + Higher thermal conductivity
- + Uniform thermal resistance
- + Higher reliability and life time.

Behavior of TIM phase change







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age divider changes and the comparator switches to a positive output signal, which trips the transistor.

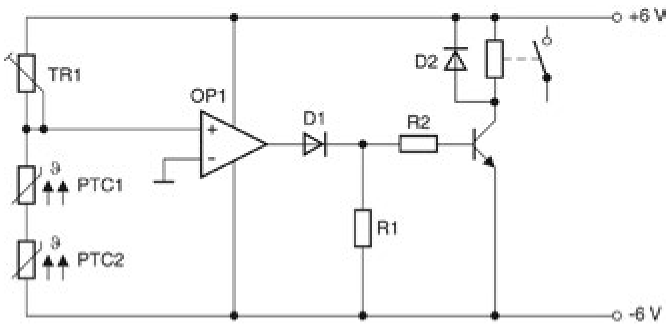

Figure 3: Circuit for monitoring temperatures with PTC sensors Circuit for monitoring two hot-spots: When the limit temperature is exceeded a fan can be switched on, for example.

Detecting two temperatures with one sensor

In addition to PTC thermistors, NTC thermistors can also be used for temperature monitoring. This applies in particular when a higher demand is made on the linearity of the characteristic.

How such a temperature monitoring is reliably implemented using NTC sensors is shown in the following practical example for the detecting of two temperatures in a high-performance audio end stage. In order to keep the housing dimensions as small as possible, the eight output transistors in TO-3 packages have been mounted together with the emitter resistors on a combined cooling fan unit. Four separate heatsinks are used here which are arranged point-symmetrically to one another. For each heatsink two power transistors have been installed (Figure 4).

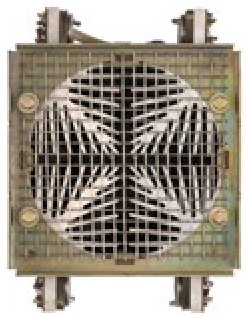

Figure 4: Combined fan/cooling unit In this design, each of the four heatsinks must be thermally monitored.

Special attention is paid to the thermal monitoring of the output transistors. Because these are located on four heatsinks that are both electrically and thermally insulated from one another, each heatsink must be monitored individually. The reason for this is that, despite adequately dimensioned transistors, the tolerances can result in a slightly uneven load distribution. The thermal monitoring must take place in two stages: as soon as one or more heatsinks reaches a temperature of 85°C, the fan must be switched on, and on reaching a temperature of about 100°C a load must be shed.

This dual function is to be performed with a single temperature sensor. The K45 or M703 series of EPCOS NTC sensors are very well suited for this purpose (Figure 5).

Thanks to the lug (left) or the threaded bolt (right), these EPCOS NTC-sensors offer a very good thermal contact with the heatsink. A K45 EPCOS NTC thermistor with an R25 of 10 kΩ was selected for each of the four heatsinks (B57045K0103K000). According to the data sheet, at 85 °C the resistance ratio RT/R25 is 0.089928, which produces an resistance of about 900 Ω. At 100 °C, this results in a value of about 550 Ω. For the dual temperature measurement a circuit with two comparators is necessary. The complete circuit as implemented is shown in Figure 6.

The reference values for the two switching thresholds are set with the two trimmers R7 and R8 (2.2 kΩ each). These are set at the levels of 900 Ω or 550 Ω already mentioned. For the eight necessary comparators (U1A – U1D and U2A – U2D) economical LM324 amplifiers have been used.

Figure 5: EPCOS NTC sensors for heatsink mounting

In a test lasting several hours under full load in jumper mode the fan switched on reliably at 85 °C. As the system is relatively slow in thermal terms, there was no need for a hysteresis circuit connection of the comparators which would normally be the case. In order to test the isolation at high temperature, the end stage was subsequently tested with the fan disconnected. The safety disconnection temperature measured was 103 °C. By means of fine adjustment with R8 it was possible to set this value to exactly 100°C.

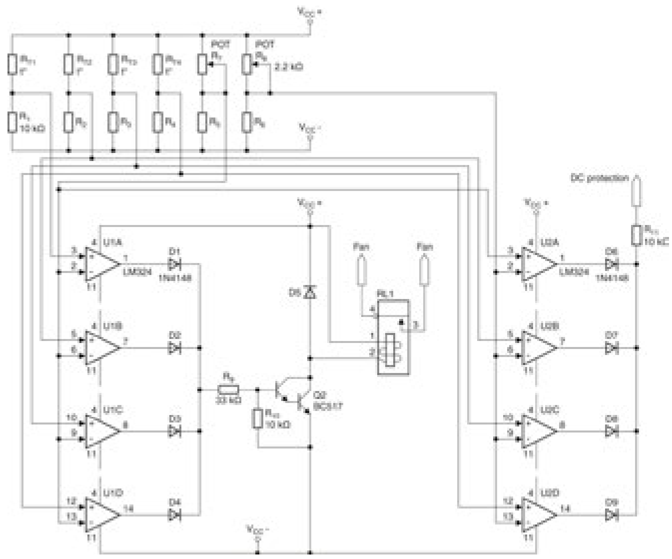

Figure 6: Double temperature protection of an audio end stage With this circuit, four heatsinks can be thermally monitored. Above a temperature of 85°C the fan is activated. If, under unfavorable conditions, temperature even reaches 100°C, the load is rejected. To do this, the DC voltage protection circuit receives a positive signal, causing its relay to trip.

Thanks to the very wide range of EPCOS NTC and PTC sensors with different characteristics and a wide variety of designs and fixing options, the thermal management of almost every conceivable application can reliably be implemented.

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20 W Low-Cost Lead-Acid Battery Charger

By Markus Zehendner and Bernd Geck, Texas Instruments

Lead-acid batteries have existed for a very long time and might be considered out of date, but they are still used in many applications worldwide. This is not only because they are more cost effective than other battery types. They are also very reliable, robust, have a decent lifetime and their characteristics are well known. Recharging batteries usually needs a dedicated charger circuit for the used chemistry. For lead-acid batteries this circuit has to fulfill the following three requirements: First of all the battery has to be charged with constant current. After reaching the typical cell voltage the charging process has to change to being constant voltage controlled and at the very end charge retention is required.

In Figure 1 two charging profiles for lead acid batteries are shown. The profile with solid lines is more complex to implement, but the time to fully charge the battery is quicker and it is also more beneficial for the lifetime of the battery. In contrast the dotted profile can be realized more cost effective. Thus the dotted profile was chosen for TIDesign PMP10081.

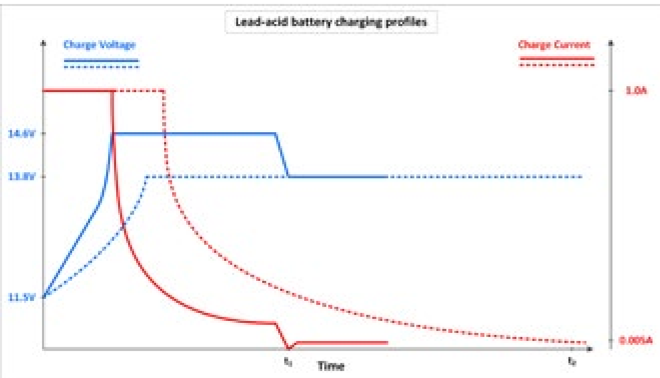


Figure 1: Two charging profiles for lead-acid batteries

Texas Instruments' TIDesign PMP10081 provides a simple and low-cost solution for charging a six-cell lead-acid battery and meeting all three requirements mentioned above. The original application behind PMP10081 is to buffer and supply industrial emergency exit lighting with a lead-acid battery. The battery charger was tested with a resistive load, an electronic load and a real battery. For testing this design under real conditions a lead-acid battery with six cells (YUASA NP 5-12, 12V, 5 Ah, AGM) was used.

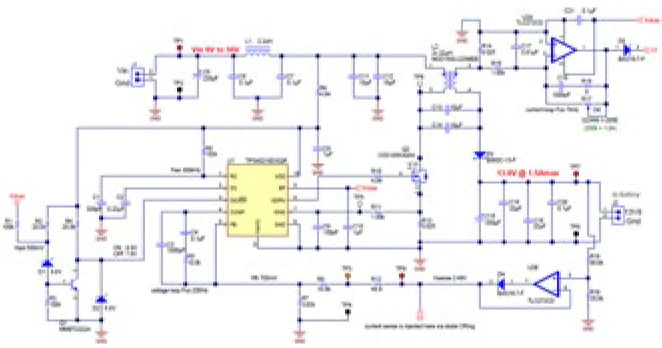


Figure 2: Schematic of TIDesign PMP10081, which is a SEPIC switch mode power supply modified for lead-acid battery charging

As lead-acid batteries have a quite simple charge profile, the necessary curves for voltage and current can be easily reproduced. This can be accomplished by adding an auxiliary sensing circuit to a switch mode power supply and connecting it to the feedback loop of the control IC. How this can be done is shown by Figure 2. The controller for this design is Texas Instrument's TPS40210. It is a low-cost non-synchronous Boost controller IC with current mode control. In PMP10081 it is configured as Single Ended Primary Inductor Converter (SEPIC) allowing the battery to be charged from lower, equal and higher supply voltages than the maximum battery voltage. The input voltage can be in a range of 9 V and 36 V and will be converted to a maximum output voltage of 13.8 V, with the maximum adjustable charge current being limited to 1.5 A.

A slight modification of the controller's feedback loop for generating two error signals enables the SMPS to operate as a lead-acid battery charger with the requirements mentioned above. The SEPIC power supply is extended by an additional dual operational amplifier circuit, which is realized with TI's TLC272. One amplifier stage is configured as a unity gain buffer for the output voltage signal. The other amplifier circuit is used for sensing the current through the output inductor. Because the average current signal through the output inductor is equal to the output current, the second amplifier circuit is configured as an integrator and the signal is provided to the feedback network of the control IC. Both amplifier outputs are connected via diode-ORing to the feedback network of the SEPIC charger. Thus one of the two signals is always dominant dependent on the active charge status of the battery.

When switched on with a discharged battery connected, the charger circuit starts with providing a constant current - which can be set and adjusted by resistor R17 in Figure 2 - to the output. This is because the external current sense signal overwrites the output voltage signal due to the diode-ORing. With higher charge of the battery its voltage will increase. When the limit of 13.8 V is reached, the charging process will be voltage controlled as the output voltage is now the dominant signal. Under this condition the output current decreases continuously until the battery is fully charged. A small trickling current will make sure that the battery does not self-discharge. For testing under real conditions with the YUASA NP 5-12 the charging current was limited to 1 A, which is 20% of the battery's maximum capacity. After the battery is fully charged, the SEPIC power supply provides a very small load current of 5 mA for charge retention. Due to that the battery will neither be damaged nor self-discharge, in case it is not disconnected from the charger.

The design can easily be adjusted for batteries with fewer or more cells by changing the feedback resistor divider (resistors R18/R19) and the charge current limit (resistor R17). As the high side resistor

R18 also affects the error amplifier gain, it is highly recommended to apply the modification to the low side resistor R19. Dependent on the new output voltage FET and diode of the design might have to be replaced as well.

Differences between testing with a resistive/electronic load and a real battery:

If a power supply is working with a resistive or electronic load, this does not automatically mean it will do the same with a lead-acid battery. A real battery has similar characteristics as a capacitor and thus behaves a little bit different than the other two loads, when connected to a power supply. In case of PMP10081 the feedback loop had to be slightly tuned because of this fact, even after already working properly with the two before mentioned loads. For charging a battery the constant current feedback network needs good dynamic behavior in contrast to the voltage control loop. For PMP10081 the current loop achieves a bandwidth of approximately 7 kHz, while the constant voltage feedback path has to be considerably slower. Its bandwidth with a resistive load is 296 Hz. With the YUASA NP 5-12 lead-acid battery connected to the output the bandwidth of the voltage control loop is in a range between 60.9 Hz and 3.9 Hz for a decreasing charge current from 900 mA to 70 mA. The current loop's behavior and bandwidth stay the same for all tested load conditions. A phase margin of more than 60° is maintained under all specified and tested conditions.

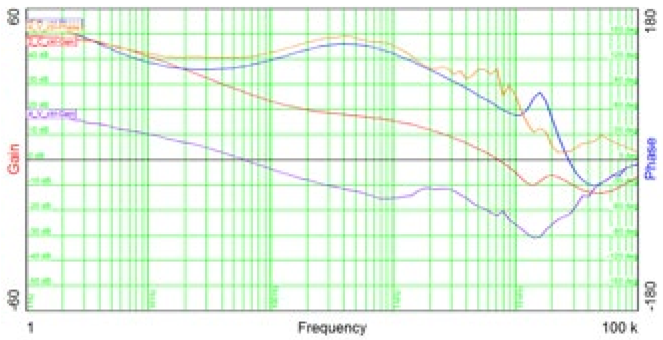


Figure 3: Frequency response for voltage controlled and current controlled charging. Red/blue graphs show the current controlled loop, purple/orange graphs show the voltage controlled loop.

Conclusion:

PMP10081 shows how a very low-cost lead-acid battery charger solution can be built. This is accomplished by adding an operational amplifier circuit and a slight modification of the power supply's feedback network. With these adjustments the battery charger circuit fulfills the general requirements of constant current and constant voltage charging, dependent on the status of the battery. Besides of that the SEPIC power supply is also able to provide charge retention. The design was built and tested. All necessary data of PMP10081 like schematic, BOM, Gerber files and test report can be found online in TI's reference design database TIDesigns under:

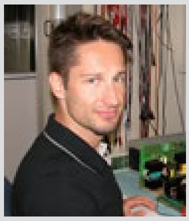
www.ti.com/tidesigns

About the authors:

Bernd Geck is heading the European Power Supply Design Services Team based in Freising, Germany. He holds a Diploma in Electrical Engineering from the University of Applied Sciences in Ulm and has more than two decades experience in electronic hardware design with focus on power management and RF. He

started the EMEA Power Supply Design Services in October 2006. Right now, he and his team are generating +200 designs per year. In addition, he educated hundreds of customers in power supply design via various seminars and workshops across Europe and Northern America. Bernd was elected as Member of Technical Staff in 2011.

Markus Zehendner is a Systems Applications Engineer in TI's



EMEA Power Supply Design Services Group since 2014. He holds a Bachelor in Electrical Engineering and a Master in Electrical and Microsystems Engineering from the Technical University of Applied Sciences in Regensburg. His design activity includes reference designs of isolated and non-isolated DC/DC converters for all application segments.

A Revolutionary Technology for Cost Tailoring Power Inductive Components

The increasing demand for more and clean energy has led to a rising need for large inductive components. This poses a challenge to providing magnetics optimized for cost, size and performance.

By Mauricio Esguerra, MAGMENT and Dr. Friedbert Schumacher, Incopa Gmbh

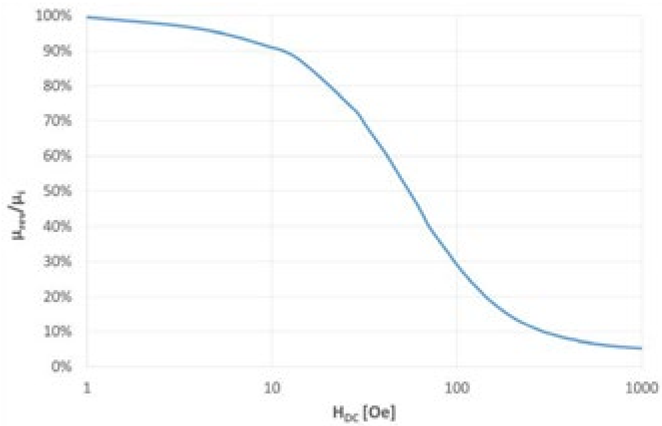
The high demand has sparked the development of both improved magnetic materials (e.g., powder cores, amorphous), winding technologies (e.g., copper foil, flat wire) and optimized core geometries. This has yield a high refinement, pushing the limits of an otherwise conventional way of making inductive components. However, advancement in small steps maybe not enough to cope with the market expectations driven by the renewables revolution.

MAGMENT power inductors and transformers are based on a disruptive technology for both a novel material and an innovative magnetic design. The material is a patented concrete with magnetisable particles embedded in a cement matrix manufactured in a pressureless process. Its features are (Figures 1 and 2):

- Permeability in the same range as powder core materials
- High DC-bias capability
- Saturation reached only at very high fields
- Very low core losses
- Very high thermal conductivity to efficiently dissipate heat
- Concrete-like mechanical robustness in a very broad temperature range

Initial permeability	μ_i	@ 25°C		40 ± 10%
Flux density	B_{max}	@25°C, 25kA/m	[mT]	350
Curie-Temperature	T_C		[°C]	> 210
Resistivity	ρ	DC	[Ω m]	20
Density	γ		[kg/m³]	3750
Realtive core losses	P_V	@50kHz, 100mT	[kW/m³]	300
Specific heat	c_p		[J/kg K]	700
Thermal conductivity	λ		[W/mK]	3
Young's modulus	E_c		[MPa]	25 000
Compressive strength	f_c		[MPa]	20
Tensile strength	f_t		[MPa]	2

Figure 1: Technical data for MAGMENT MC40 material grade



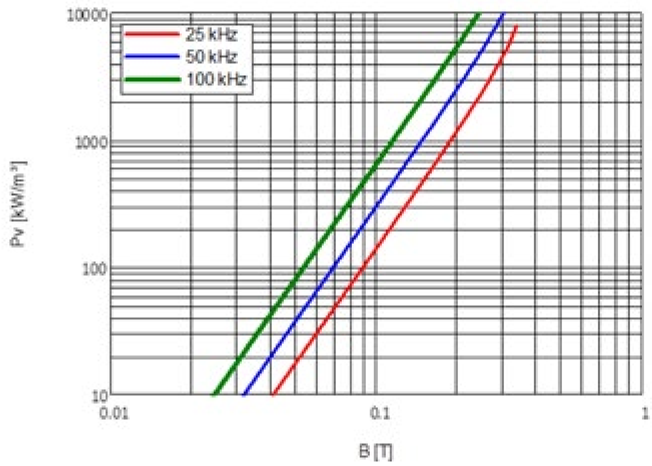


Figure 2: DC-bias vs field strength and specific core losses vs flux density

These unique and outstanding properties allow the design of rugged inductive components with a distributed air gap for minimized winding losses by completely surrounding the coil by the MAGMENT material. This ensures a complete magnetic filling of the available volume within the housing yielding maximum performance and cooling. As compared to the conventional manufacturing of winding cores and sealing with a potting material, the flowability of our concrete materials allow a "wind and magnetic pour" process, which goes along with absolute shape and size flexibility. This allows to both tailor components to minimize material utilization and to any given space constraints by a special magnetic design algorithm yielding lowest cost as compared to any other inductive technology.


Can you **engineer** Power Electronic
solutions of tomorrow?
Danfoss Silicon Power is growing!
We are looking for bright individuals to join us on our exciting journey.
Are you our new colleague?
Are you ready to engineer tomorrow´s power electronics for automotive, industrial and renewables applications?
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ENGINEERING TOMORROW
Danfoss

Figure 3 shows an example for a MAGMENT inductor and Figure 4 a comparison with a conventional inductor. The automated design process starts with the calculation of the MAGMENT inductor design parameters for given target parameters (inductance L, rated current I and DC resistance RDC). The design algorithm looks for the dimensions giving the lowest material cost and hence the most compact design. In case outer dimensions would be constrained by device space requirements, the algorithm would take this into consideration. Based on the output design parameters a suitable coil former is chosen and the winding laid out. The housing containing the inductor is then designed according to the outer dimension of the MAGMENT material block.

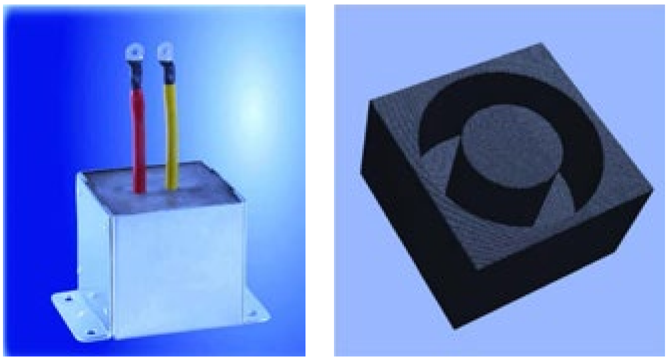

Figure 3: MAGMENT inductor (left) depicting its magnetic material shape (right)

<u>Target parameters</u>: inductance **L**, rated current **I**, resistance $\mathbf{R_{DC}}$

↓

Conventional	MAGMENT
DESIGN STEPS	
1. Select core shape (E, RM, U...)	1. Select/design coil former
2. Select core size (E25, RM8,...)	2. Layout of winding window
3. Select suitable coil former	3. Design housing
4. Layout wire in winding window	
5. Select housing	
6. Select potting material	
PROPERTIES	
Core sizes available only in steps (E55,E65...)	No shape or size limitation
Limited size availability	
Stacking for simple shapes only (E, U, R)	
Winding filling factor limited	Winding 100% surrounded by magnetic material
Partial magnetic filling of housing	Potting material = magnetic material

Figure 4: Comparison MAGMENT vs. conventional inductors: (a) design steps, (b) properties

Design case	l_e [mm]	A_e [mm²]	V_e [mm³]	No. of turns	Core loss [W]	Cost [€]
a	=	>	>	<	<	<
b	<	=	<	<	<	<<<
c	<	>	=	<<	<	<<

Figure 5: Inductor parameters relative comparison MAGMENT vs. conventional for an inductor with the same inductance value and one effective parameter:
a) magnetic path le   b) cross section Ae   c) volume Ve

The resulting magnetic effective parameters (Figure 5) show the clear advantage over conventional inductors. As a general rule and due to the complete magnetic filling of the available space the ratio Ae/le is much larger for INCOPA'S MAGMENT inductors. In a relative comparison of inductors with the same inductance and either the same (a) magnetic path, (b) cross section or (c) volume the MAGMENT inductors show always a superior performance (inductance, core and winding losses) as well as cost. Figure 6 shows a comparison corresponding to case (c) for an inductor with L=55 µH and I=60A. Notice that both the inductance is higher both for low as well as for very large currents, showing a much higher energy storage capacity.

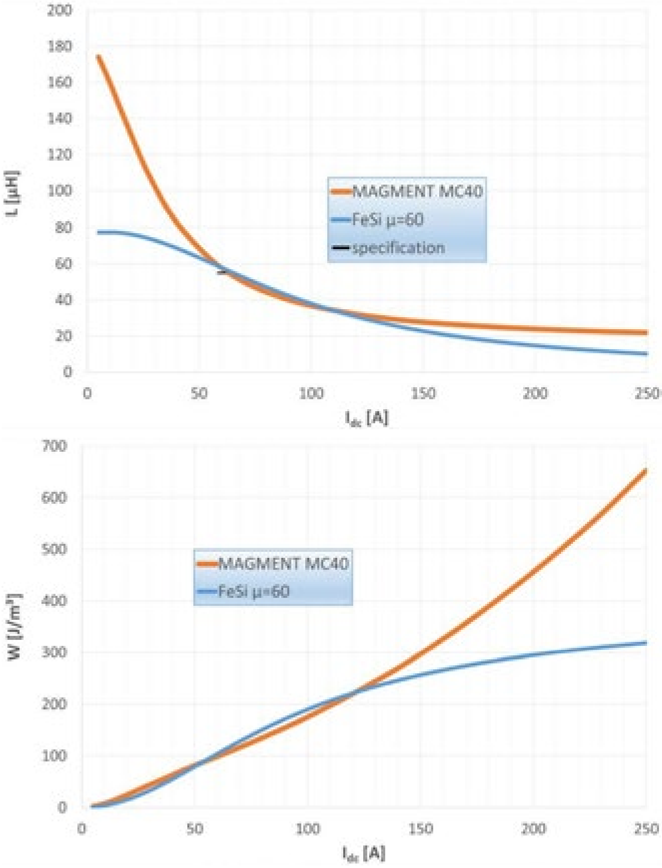

Figure 6: L=55 µH, I=60A inductor corresponding to design case (c), same effective volume for a MAGMENT MC40 and a FeSi powder core toroid with µ=60:
Inductance vs. DC-bias   b) stored energy density vs. DC-bias

Beyond the technical superiority of the product as such, there are other extraordinary aspects pertaining production and logistics. We have devised our production to have all inductor manufacturing processes under one roof. This allows to have short lead times and simplified stock holding of base materials allowing the quickest possible turnaround time from design-in to shipping. This contributes to keeping overall costs low, guaranteeing that INCOPA's MAGMENT magnetics are by far the most economical alternative for a power inductive component.

www.magment.de

5A and 3A Power Modules Offer Industry-Leading Power Density and Efficiency

Intersil Corporation announced two single-channel DC/DC step-down power modules that deliver high power density and up to 95% efficiency in a compact 4.5mm x 7.5mm x 1.85mm footprint. The pin-compatible 5A ISL8205M and 3A ISL8202M provide point-of-load (POL) conversions for FPGAs, DSPs and MCUs in a wide range of

home networking and high-end consumer products, as well as portable industrial equipment that use Li-ion batteries. The modules are complete power supplies that include a controller, MOSFETs, inductor and passive components inside an encapsulated module, simplifying system design.

With a height of 1.85mm, the ISL8205M and ISL8202M can be directly mounted on the backside of a PCB, freeing up valuable space for topside mounted components. Both devices support input voltages from 2.6V to 5.5V and offer adjustable output voltages as low as 0.6V. The pin compatibility allows engineers to start with a 3A power module and later migrate to the higher 5A output current, or design a power tree with multiple POL output rails. For battery-operated applications, the ISL8205M and ISL8202M offer unique efficiency and power saving features to extend battery life and support Energy Star® compliant products. Selectable light load efficiency, 100% duty cycle modes and 50µA quiescent current enable better efficiency and lower power consumption at light load.

www.intersil.com/powermodules

3rd Generation 1200V/180A Full SiC Module

ROHM has pioneered commercial power modules equipped with SiC-MOSFETs and SiC-SBDs and was able to successfully mass-produce the industry's first trench-type SiC MOSFETs by utilizing a proprietary structure, ensuring long-term reliability. The new module implements MOSFETs with their advanced UMOS structure going without JFET region and maximizing SiC characteristics. It provides the lowest drain source resistance together with high speed switching performance, and - thanks to the extremely low Vf and the fast recovery performance of the built-in SiC-SBDs - it has almost no recovery loss Err. As a result, the module achieves 77% lower switching loss than conventional IGBT modules and 42% lower Switching loss than planar SiC Modules utilizing a 2nd Gen SiC-DMOS structure. This not only enables high-frequency operation but also contributes to smaller cooling systems as well as smaller peripheral components which in consequence paves the way to greater energy savings and end-product miniaturization.

www.rohm.com/eu

The Alternative to Consolidated Standard Industrial Packages

SEMITOP 2nd generation fulfils the SEMIKRON target to offer a safe supply chain to the customers. The new packages represent the SEMITOP platform's natural evolution at the same high performance levels, set to offer the best footprint, a flexible architecture and high performing solutions at optimised system cost. Full compatibility with the existing standard industrial packages is ensured: modules with 12mm height, without baseplate, two lateral mounting screws coupled with a solderfree pin grid philosophy.

The latest Si and SiC chip technologies can be integrated so to offer a competitive platform. Thus able to address the power modules demanding environment where high performance, innovation and differentiation are the key winning factors. Thanks to a comprehensive portfolio with a large variety of configurations, SEMITOP E1 and E2 can address different markets like UPS, solar, motor drives, power supplies and the new emerging EV battery charger market.

www.semikron.com

ECCE 2016

IEEE ENERGY CONVERSION CONGRESS & EXPO

Sept. 18–22
Milwaukee, WI

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Important Dates

June 1, 2016
Advanced registration available

July 1, 2016
Final manuscript submission

August 6, 2016
Regular registration available

Announcement

ECCE is the foremost IEEE conference in the field of electrical and electromechanical energy conversion. ECCE2016, to be held in Milwaukee, the heartland of the North America energy conversion industry, will provide researchers, engineers and professionals from industry and academia a convivial and innovative atmosphere for interaction and networking.

Some highlights of ECCE2016 include:

- Stronger than ever industrial support including Gold or Platinum sponsorship from GM, Rockwell Automation, ABB, Eaton, Danfoss, and Wolong Electric Group.
- Keynote speeches will be delivered by prominent leaders from academia and industry:
  - "Options to Create a Sustainable Energy Future" by Prof. Arun Majumdar, Stanford University and former Director of ARPA-E
  - "Future of the Smartgrid" by Prof. Massoud Amin, Minnesota University.
  - "Intelligent Motor Control in a Connected Enterprise" by Mr. Blake Moret, Senior Vice President, Control Products & Solutions, Rockwell Automation
  - "Optimized Power Management Using Data Analytics", by Mr. Michael Regelski, SVP and Chief Technology Officer Electrical Sector, Eaton
  - "Very High Power Electronics for HVDC," by Dr. Guangfu Tang, Vice President of Smartgrid Institute of China State Grid
- A high quality technical program selected from a record setting 1715 digest submissions (10.7% over the previous record).
- 12 tutorials on interesting and relevant technical topics
- Over 60 industrial and university exhibitors to showcase the latest technologies and products
- Special sessions, industrial sessions and town hall forums
- Vibrant and enjoyable social activities to make you feel at home
- WEMPEC Open House event hosted by University of Wisconsin Madison immediately after the conference

Student travel grants available.

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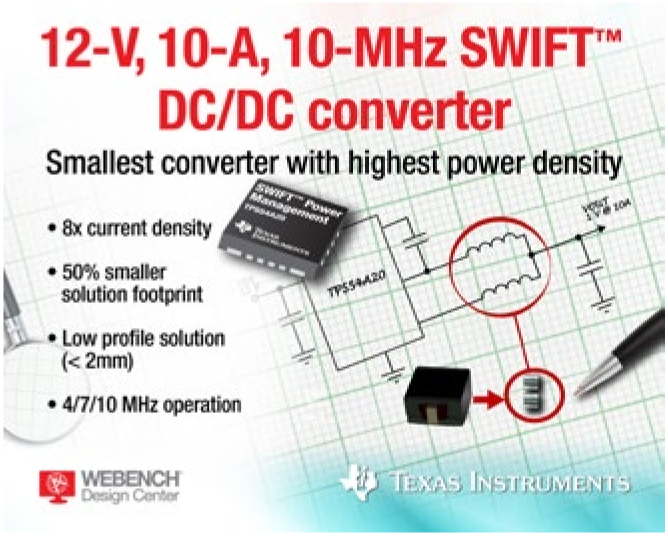
Industry's Highest Power Density 12-V, 10-A, 10-MHz DC/DC Converter

Texas Instruments introduced the industry's first 12-V, 10-A, 10-MHz series-capacitor buck converter that achieves more than 50 A/cm3 in current density, which is four times higher than any other 12 V power management component or solution available today. The unique topology of the TPS54A20 SWIFT synchronous DC/DC converter enables high-frequency operation at up to 5 MHz per phase without special magnetics or compound semiconductors, which designers can use for 8-V to 14-V input and 10-A output applications. By using the step-down converter together with TI's WEBENCH® Power Design tool, engineers can get their space- and height-constrained point-of-load (POL) telecom and networking power-supply designs to market faster.

www.ti.com/tps54a20-pr-eu



5A Gate Drive Optocouplers with Unmatched Noise Immunity

Broadcom Limited, a leading designer, developer and global supplier of a broad range of analog and digital semiconductor connectivity solutions, announced a new generation of 5A gate drive optocoupler devices, the ACPL-352J and ACNW3430, designed for a wide range of industrial applications including motor drives and power inverters. The new devices feature superb common mode transient immunity (CMTI) of up to 100 kV/μs, preventing erroneous gate driver failures in noisy environments. Both the ACPL-352J and ACNW3430 support up to 5A rail-torail output current, which eliminates the need of an output buffer circuit, enabling designers to implement cost-effective and power efficient gate driver solutions.

http://www.avagotech.com/products/optocouplers/

350W Convection Cooled Power Supply Certified for Medical and ITE Use

TDK Corporation announces the introduction of the CUS350M series of AC-DC power supplies. Rated at 350W output power, the units have both medical and ITE certification to the IEC 60601-1 and IEC 60950-1 regulatory standards. Requiring no forced air for cooling, the CUS350M is ideally suited for applications where audible noise cannot be tolerated, including hospital, dental, broadcast and professional audio equipment.

The power supplies can operate from an 85 to 264Vac input, and are initially available with 12V, 18V, 24V or 48V nominal outputs. With efficiencies of up to 94%, the CUS350M meets the ErP Directive with an average efficiency rating of greater than 87% and a stand-by power consumption of less than 0.5W. Less internal waste heat allows the product to conservatively operate at full power in -20ºC to +40ºC ambient temperatures, and up to +70ºC with derating.

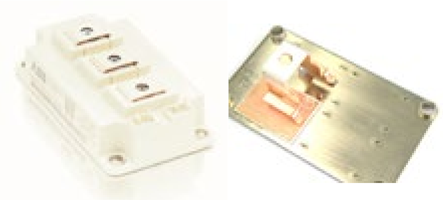
The compact CUS350M measures 190mm x 87mm, with a height of 40mm for 1U rack mounting. The preferred "/F" suffix models have a 5V 0.5A standby output, an auxiliary 12V 0.3A output, remote sense, remote on/off and an isolated DC good signal.

www.de.tdk-lambda.com/cus350m

Medium-Power IGBT Modules Released

ABB's medium-power modules family, the 62Pak, is officially released for mass production and available for unlimited sales. End of April all qualification tests have been successfully finalized and ABB is proud to present a very competitive family of medium-power modules. The 62Pak line-up consists of modules in the 1700V voltage class. Three current ratings are available in a phase leg configuration: 2 x 300A, 2 x 200A and 1 x 150A.

The ABB's 62Pak modules are designed to the highest standards with the same quality philosophy like the well-established HiPak modules. The 62Pak modules feature the state of the art 1700V SPT++ IGBT/diode chipset that offers best in class performance in terms of lowest switching losses and highest ruggedness. The package offers a long lifetime in demanding applications thanks to high power cycling performance. This has been achieved by an optimized wire-bonding process and with stamped spacers in the baseplate and main terminals. With the help of the spacers, a homogenous solder layer thickness can be ensured that offers a significantly narrowed distribution and improved power cycling performance. In addition, the 1700V SPT++ chipset offers an operation temperature range that includes full switching performance up to 175°C. This enables applications using ABB's 62Pak modules to benefit from higher over-load capability and/or improved safety margin to unexpected current surges.

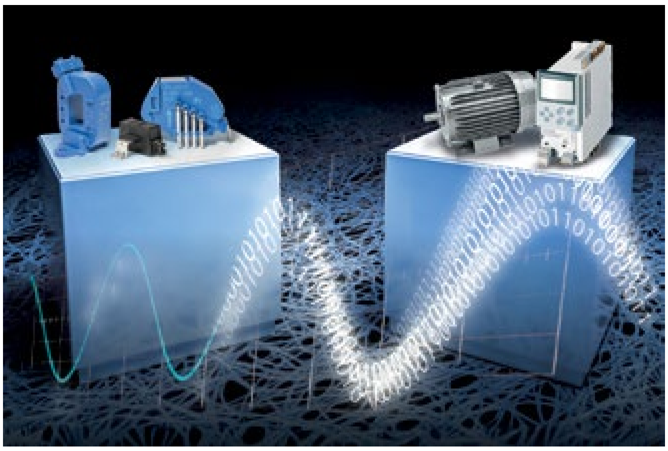


62Pak IGBT module (left), Spacers for homogenous solder thickness (right)

ABB's 62Pak IGBT modules are well suited for most power electronic applications that include low-voltage as well as medium-voltage drives, static VAR compensators, uninterruptable power supplies, induction heating and traction auxiliary converters to mention just a few.

www.abb.com/semiconductors

Open-Loop Hall Effect Current Transducers with Digital Outputs



LEM announces 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 10, 32, 50, 80, 100, 120, 150, 200, 250 ARMS in 3 different mechanical designs (PCB and panel mounting) provide up to 12 bit resolution with 20 kHz bandwidth. The single-bit output minimizes the connections required, enabling highly compact transducers, and 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 the negative or positive directions.

www.lem.com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High-Reliability SCALE-2 Driver Technology to 1200 V Applications

Power Integrations announced a family of galvanically isolated single-channel gate driver ICs ranging in output current from 2.5 A to 8 A – the industry's highest output current without an external booster. SCALE-iDriver™ ICs, optimized for driving both IGBTs and MOSFETs, are the first products to bring Power Integrations' pioneering FluxLink™ magneto-inductive bi-directional communications technology to 1200 V driver applications. FluxLink technology eliminates the need for unreliable opto-electronics and the associated compensation circuitry, thereby enhancing operational stability while reducing system complexity. In addition to combining industry-leading isolation technology, the new gate drivers incorporate advanced system safety and protection features commonly found in medium- and high-voltage applications, further enhancing product reliability. The innovative eSOP package features 9.5 mm of creepage and a CTI of 600, ensuring substantial operating voltage margin and high system reliability.

www.power.com/products/scale-idriver/

Compact Universal 100 and 150W Power Supplies

RECOM´s compact RACG100 and RACG150 were designed without compromises in reliability, efficiency or protection. These modules supply 100 or 150W, continuously without active cooling, regardless of whether they are horizontally or vertically mounted.
The RACG100 series power supplies are capable of delivering a constant 100W outputs and feature short circuit and overload protection. They can be safely operated between -20°C and +60°C and come with outputs of 5, 12, 24, or 48VDC.
With additional features, the RACG150 series have over-voltage and over-temperature protection, and are capable of delivering 150W power. They can be safely operated between -20°C and +70°C and come with 12, 24, or 48VDC outputs.

http://www.recom-power.com

Fifth Generation Deep Trench Process Superjunction MOSFETs

Toshiba Electronics Europe is set to announce the development of its next generation of superjunction (SJ) deep trench semiconductor technology for high-efficient power MOSFETs. Devices based on the new DTMOS V process operate with lower EMI noise and reduced on resistance (RDS(ON)) compared to previous DTMOS IV MOSFETs.
As with the previous DTMOS IV semiconductor technology, DTMOS V is based on a single epitaxial process involving 'deep trench etching' followed by P-type epitaxial growth. The deep trench filling process results in a narrowing of cell pitch and a lowering of RDS(ON) when compared with more conventional planar processes. Toshiba's deep trench process allows an improved thermal coefficient of RDS(ON) compared to conventional super junction MOSFETs using multi epitaxial growth process.
With DTMOS V, Toshiba has been able to reduce RDS(ON) of the DPAK TK290P60Y by up to 17% compared with the lowest RDS(ON) available from the TK12P60W DTMOS IV MOSFET. The company has also further optimised the trade-off between switching performance and EMI noise.

www.toshiba.semicon-storage.com/eu


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Compact H-Bridge Driver IC for Low-Voltage (2.5V) Drives

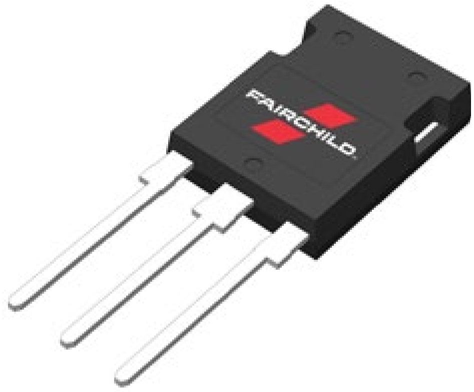
Toshiba Electronics Europe has announced a addition to its range of H-bridge [1] driver ICs for brushed DC and stepper motors. The TC78H620FNG is ideally suited to battery-powered mobile devices - such as fans and small printers - and home appliances.

The IC adopts a four-port interface control technique using the PHASE and ENABLE signals. Control is secured using just three ports, unlike previous devices that required all four ports for full step control of a stepper motor. This addresses challenges in applications where the lack of MCU control ports is an issue.

The TC78H620FNG is compatible with low-voltage drives (for motor drive: 2.5V and above, for logic control: 2.7V and above) making it suitable for mobile devices with a 3.7V lithium-ion battery drive. Either two DC brushed motors or a single stepping motor can be controlled. A maximum current consumption of 1uA in standby mode contributes to reduced power consumption.

www.toshiba.semicon-storage.com

Discrete and Bare Die IGBTs for Hybrid and All-Electric Vehicles



Fairchild expanding its growing portfolio of automotive-grade semiconductor solutions for hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV) and electric vehicles (EV) with its new discrete and bare die IGBTs and diodes.

These IGBTs and diodes are ideal for traction inverters, a core component of all HEVs, PHEVs and EVs that convert the batteries' electricity from direct current into the three-phase alternating current required by the vehicles' drive motors.

All of these new discrete and bare die IGBTs and diodes use advanced third generation Field Stop Trench IGBT technology and a soft fast recovery diode qualified to automotive-grade standards and have additional features and options.

www.fairchildsemi.com

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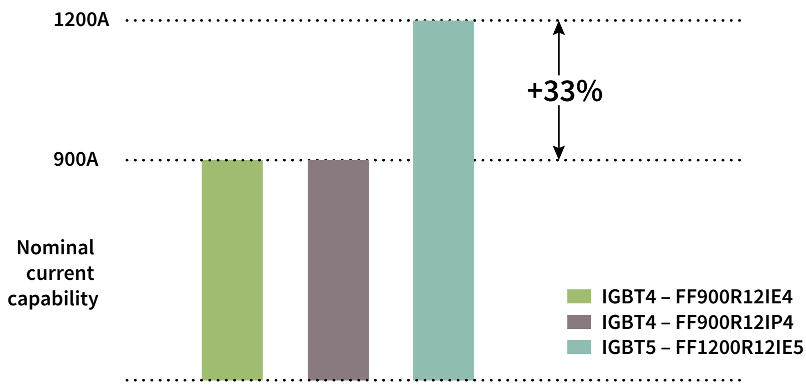
PrimePACK™ with IGBT5 and .XT

The dawning of a new era – Infineon's latest IGBT chip and interconnection technologies



www.infineon.com/PrimePACK