ISSN: 1863-5598

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A Media
Katzbek 17a
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Phone: +49 4343 42 17 90
Fax: +49 4343 42 17 89
info@bodospower.com
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Publishing Editor
Bodo Arlt, Dipl.-Ing.
editor@bodospower.com

Junior Editor
Holger Moscheik
Phone + 49 4343 428 5017
holger@bodospower.com

Editor China
Min Xu
Phone: +86 156 18860853
xumin@i2imedia.net

UK Support
June Hulme
Phone: +44 1270 872315
junehulme@geminimarketing.co.uk

US Support
Cody Miller
Phone +1 208 429 6533
cody@eetech.com

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Lots of Work Ahead

This year's summer break is over (for the most of us), and so it is for Bodo and me. It was quite hard to concentrate on the daily work at our office when the temperature only knew one direction – upwards! As the "fresh air enthusiast" that he is, Bodo's first action when arriving at the office everyday was opening all windows. It was up to me to pick up and sort the paper flying all over the place…

The autumn season has started well with some shows in September - things will now become very busy. We are trying to attend as many events as possible. Beside this, autumn traditionally is the period when contracts for the following year are negotiated. I have learned a lot from my time at Bodo's, but one of the most important things is the positive impact of talking face to face. Taking care of business partners is elementary. It's always so nice to meet the people that you are in contact with over the whole year, either at an event or during a personal visit. So, if you're a marketeer and you haven't met with one of us recently, watch out – we might be just around the corner!

In December our third Wide Band Gap event will take place in Munich, again in cooperation with Aspencore. The program is nearly finalized, and we have some of the most important heads in power electronics talking about progress with these game changing materials. There is still an opportunity to participate as an exhibitor at the Tabletop – Aspencore can take care of it. If you're interested, just contact us and we will be very happy to forward your request to the right person! A high-quality audience is guaranteed. Beside the presentations and the Tabletop, networking will be very important for the visitors.

December also brings another very exciting event for us: our new website will go live. Personally, I am super excited! It took me a while to convince Bodo that this was necessary. But now he is excited too. It's a little bit comparable with seeing a baby develop. The new website will offer a very nice user experience, providing our "jewels" - the archive of over 13 years of Bodo's Power Systems magazines - along with the latest news and an up-to-date calendar with the crucial events of our industry. Stay tuned, you will love it!

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

My Green Power Tip for the Month:

Try and use the microwave as often as possible, instead of your oven. The energy consumption is significantly lower. As long as renewable energy has not taken over, every small action counts!

Best Regards

Events

Energy Storage Forum 2019
Rome, Italy; October 8-10
www.energystorageforum.com

Intelec 2019
Singapore; October 13-17
www.intelec.org

Power Electronics Moscow 2019
Moscow, Russia; October 22-24
www.powerelectronics.ru

WiPDA 2019
Raleigh, NC, USA; October 29-31
www.wipda.org

European Utility Week 2019
Paris, France; November 12-14
www.european-utility-week.com

Productronica 2019
Munich, Germany; November 12-15
www.productronica.com

SEMICON Europa 2019
Munich, Germany; November 12-15
www.semiconeuropa.org

SemIsrael 2019
Tel Aviv, Israel November 19
www.semisrael-expo.com

SPS 2019
Nuremberg, Germany; November 26-28
www.mesago.de/en/SPS

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PCIM Asia 2020: Call for Papers

At PCIM Asia Conference in June 2019, hundreds of professionals from the power electronics industry and academic from all over the world shared the latest insights and work. We sincerely invite you to be the next presenter in 2020, July 1-3, and share your latest research and experience to more than 500 experts from relevant fields. We will have a highlighted topic for PCIM Asia 2020, “E-Mobility and Infrastructure”. Also, a new topic “System Reliability” was added. Find all the topics online and select one of the topics for your abstract before 31 December 2019.

- Submission of abstracts by 31 December 2019
- Notification of acceptance on March 2020
- Submission of full paper by 30 April 2020

https://pcimasia-expo.cn.messefrankfurt.com

$24 Million to Projects to Advance Wide Bandgap Technology

The PowerAmerica Institute at N.C. State University, a member of Manufacturing USA, recently awarded $24 million in funding to 24 new member projects that will enhance wide bandgap technologies in the United States. “These projects are instrumental in fulfilling PowerAmerica’s mission of accelerating commercialization of wide bandgap power electronics. They also aim to expeditiously produce a highly skilled workforce, which is key in creating the large wide bandgap demand that spurs mass manufacturing with its cost-lowering benefits. To date, projects funded by the institute have contributed to the development of more efficient power electronics that benefit a range of applications – from electric vehicles to renewable energy and data centers,” said PowerAmerica Executive Director and CTO Victor Veliadis. The latest round of projects encompass a number of applications – from heavy duty vehicles to medium voltage motor drives to high-efficiency power conversion for transportation refrigeration unit to energy storage. Recipients include companies such as John Deere, Toshiba, General Electric Aviation Systems and more, as well as leading universities, and the projects involve many examples of collaborative partnerships. The projects were selected based on applications received through the 2018 Call for Projects and are funded by the Department of Energy and funding recipients through a cost share agreement.

www.poweramericainstitute.org

UK Gallium Nitride Consortium

To advance the UK’s automotive sector, Turbo Power Systems (TPS) has taken a collaborative role in the vertical GaNTT project led by the Compound Semiconductor Centre (CSC). Wide bandgap semiconductors such as Gallium Nitride (GaN) are becoming one of the prevailing technologies in delivering more cost-effective, compact, lightweight and efficient power electronics systems for automotive applications such as Electric Vehicles. Through GaNTT (Realisation of a mass manufacturable Vertical GaN Trench FET architecture), the consortium aims to drive the development of a new process platform to advance Automotive Power Electronics where GaN is a core element. This voltage-scalable vertical GaN process platform (200V – 600V) will be suitable for, amongst others, Electric Vehicle applications and the resulting device will be evaluated in application as part of the project. TPS will play an important role within the consortium as they will provide a Tier 1 automotive testing environment where they will assess prototype GaN devices against standard silicon by integrating them into a bidirectional DC-DC converter for EV. Dr. Nigel Jakeman, TPS Engineering & Business Development Director, commented: “Vertical GaNTT can deliver a new generation of device that can see Gallium Nitride finally being adopted in higher power applications.

We’re delighted to be part of the program and to be working with our partners, in particular to be assisting with delivery of the exciting semiconductor devices of the future.“

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Establishing Development Department

In regards to the future strategic direction and reorganization of internal departments PINK GmbH Thermosysteme founded their own development department for soldering and sintering technology on 1st of June 2019. Head of department is Mr. Christoph Oetzel, who is working for PINK since 2003. Mr. Oetzel successfully leaded the Engineering Department before and was primarily involved in many new product developments. Together with his team, consisting of well experienced engineers but also in close cooperation with the PINK Application Department, Mr. Oetzel is intensively concentrating on the latest sintering projects. The goal is to interlink both departments, Development and Application, with their concentrated expertise to further push the area of sintering in particular, but also soldering.

www.pink.de

$1,500M Financing to Fund Future Growth Plans

Nexperia announced the successful raise of USD 1,500 million equivalent of senior credit facilities. The proceeds will be used to refinance the existing outstanding debt and to partly finance the acquisition by Wingtech Technologies Co., Ltd., a listed Chinese computer and telecom equipment manufacturer. The facilities were arranged and underwritten by ABN AMRO, Bank of America Merrill Lynch and HSBC acting as Global Coordinators and were syndicated to a group of twelve global banks in total. The refinancing is fully supported by Wingtech and provides a flexible financing package at very attractive terms to support the further growth of Nexperia going forward. As a result of the Wingtech acquisition, the company is expected to capture long-term growth trends in China, further enhancing its revenues.

www.nexperia.com

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Student Travel Support Program

The joint sponsors of the Applied Power Electronics Conference (APEC) have announced the continuation of the popular Student Attendance Travel Support Program of up to $1,000 to cover a portion of the travel and conference expenses for as many as 60 students to attend APEC 2020 in New Orleans, LA, March 15-19, 2020. Interested students must apply by October 25th, 2019. In its 15h year, this popular program, initiated by the Power Sources Manufacturers Association (PSMA), is now jointly underwritten by PSMA and the other co-sponsors of the APEC conference: the IEEE Power Electronics Society (PELS) and the IEEE Industry Applications society (IAS). The recipients will be chosen by the APEC 2020 Student Travel Support Committee. Application forms are available at APEC Attendance Travel Support Application. The application criteria are:

- The applicant must be an undergraduate or graduate student enrolled in a power electronics program at an accredited institution
- Only students who have not received travel support in the past will be considered
- The recipients must be an author or co-author of a paper that was accepted for presentation at APEC 2020
- The recipient must attend APEC 2020 and submit expense receipts to the Committee for reimbursement
- Applications must be made and received by the Committee by October 25, 2019
- The recipients will be notified by the Committee by November 15, 2019

As part of the application process, students must provide information about their educational institution, degree program, the name of their faculty advisor and a brief description of their career interest and reasons for planning to attend APEC.

www.apec-conf.org

SMTconnect Technology Days: Call for Papers Opens

The Technology Days will once again be taking place in Nuremberg, Germany from 5 – 7 May 2020. The information-packed seminars are an integral part of the SMTconnect, exhibition for microelectronic components and systems. The Call for Papers is aimed at experts, who can now submit their abstracts for practice-oriented seminars on three topic areas in the assembly and interconnection technologies. Deadline for submissions is 6 November 2019.

With their participation in the Technology Days, the speakers get the chance to share their industry-specific knowledge with interested seminar participants. Furthermore, they gain access to the SMTconnect and its numerous networking opportunities. The experts can submit their abstracts for the seminars in either German or English. Each seminar lasts one hour. The papers have to focus on one of the three thematic focal points and relate it to practice. “The Technology Days enhance the exchange of knowledge between experts in the field of assembly and interconnection technologies as well as seminar participants and offer insights into the industry’s groundbreaking subject areas. This year the seminars take a closer look at three new fascinating topics with practical relevance,” says Anthula Parashoudi, Vice President at Mesago Messe Frankfurt GmbH.

https://smt.mesago.com

HV Current Transducer Calibration Lab

Danisense has set up a DC calibration test lab at its Danish headquarters and manufacturing site in Taastrup, Denmark, further strengthening the company’s reputation for flexibility, quality and accuracy of its products. A free service for its high voltage 500V and 10,000V products, units are 100% tested and shipped with a Certificate of Calibration which details the actual current error (always significantly less than the ppm values specified in the datasheet), the error without offset and the linearity error. This enables customers to have full confidence in the measurements they make.

Commented Christian Markvardsen, Project manager/R&D engineer at Danisense: “The investment means that we can assure our customers of the accuracy of our current transducers without relying on shipping parts to a third party. Most customers are happy with the DC measurements that we provide, but we may look to add an AC measurement capability in the future.”

www.danisense.com

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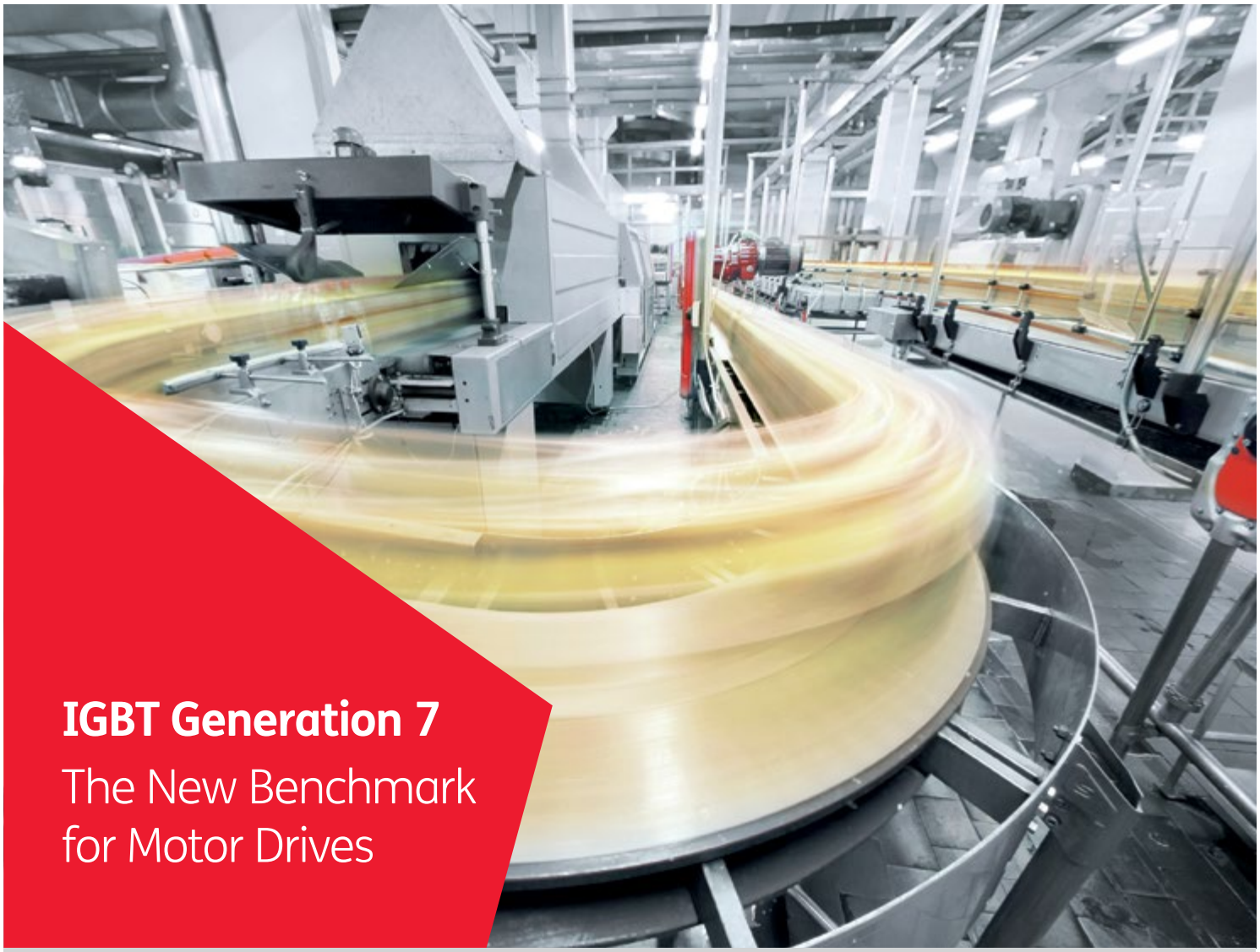

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MiniSKiiP and SEMiX 3 Press-Fit will be the first modules to feature Generation 7 IGBT technology, with SEMiX 6 Press-Fit and SEMITOP E1/E2 to follow.

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MiniSKiiP

SEMiX 3 Press-Fit

GENERATION IGBT 7

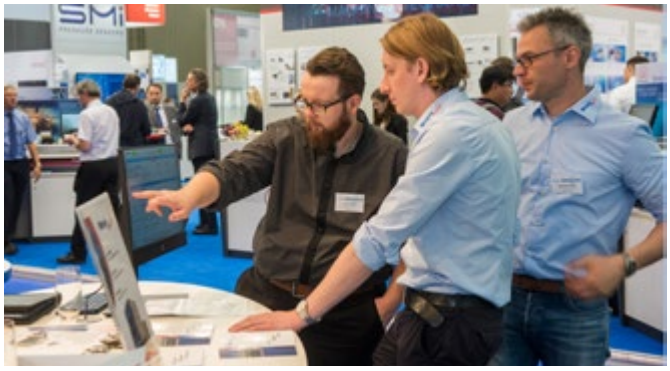
www.semikron.com

New Conferences and New Halls in 2020

The SENSOR+TEST 2019 recorded 538 exhibitors (591 the previous year), a slight decrease. Nevertheless, the share of international exhibitors remained at a very high level with approximately 40%. The overall number of visitors to the trade fair, however, 6,873 (7,879 the previous year), was to a great extent due to the hot weather during the three days of the fair. Seen from an international perspective, the show with a share of 34% international visitors, was a complete success. This was confirmed by Holger Bödeker, the AMA Service managing director, who stated, “Never before have so many international visitors found their way to the SENSOR+TEST. Such a positive development wasn’t able to compensate for the number of domestic visitors, but it does demonstrate the growing international importance of our trade fair.”

SENSOR+TEST 2020 – Two International Conferences on the Highest Level

The international conference SMSI 2020 – Sensor and Measurement Science International (www.smsi-conference.com) will take place next year for the first time parallel to the trade fair (22 – 25 June 2020) and will offer a platform for the latest research results. “The SMSI



brings together scientists and researchers from all relevant areas and ensures suppliers as well as users well-founded insights in future-oriented research results,” says Holger Bödeker about the new format, putting measuring technology and sensors for Industry 4.0 into focus.

www.sensor-test.de

High Professional and Networking Level

The PCNS symposium was attended by 63 participants from 13 European countries, USA and China and posed an ideal networking

possibilities for designers, purchasers, application engineers etc. to meet together within the group of component manufacturer industry (~50%), academia (~ 20%) and end users (~ 20% mainly automotive). Space industry was represented by presence of ESA ESTEC and Jacobs Engineering Inc/NASA. The professional program included mounting and advanced passives workshops, four keynote speeches, hot topic panel discussion and 18 technical papers. The two hour Hot Panel Discussion covered challenging topic of DC BIAS Ageing effect of MLCC and its performance in automotive applications. The discussion focused on definition of the issue, capabilities of manufacturers to measure and support suitable tools for designers.

www.passive-components.eu

eGaN FETs for Upcoming Wireless Power Platforms

EPC announces collaboration with Solace Power to enable 250-watt wireless power solutions designed for 5G, aerospace, automotive, medical, and industrial applications. Solace Power’s intelligent wireless platform use EPC’s 200 V enhancement-mode gallium nitride

(eGaN®) power transistors. This modular platform shares the same Equus™ architecture and enables up to 250 Watts of transmitted power with superior six degrees of spatial freedom.

“We’re excited to collaborate with EPC to further push the limits of our capacitive wireless power platform and to deliver previously unachievable solutions with a higher power requirement,” said Solace Power CEO, Michael Gotlieb. “Solace focuses on delivering complete, modular systems which are pre-tested for CISPR/FCC compliance and optimized in-house for rapid development in real world applications. These new solutions solve the most important challenges for applications requiring 200 watts or more.” For wireless power applications with higher power demands than traditional consumer devices, existing silicon-based transistors become inefficient. To address this limitation, Solace selected a 200 V gallium nitride-based power transistor from EPC for the 250 W solution.

“Wireless power is ready to be incorporated into our daily lives and the modular platform that Solace Power has developed, using highly efficient, low cost GaN transistors, will improve design cycle times and help new industries implement wireless power quickly and inexpensively,” commented Alex Lidow, CEO and co-founder of EPC.

www.epc-co.com

Symposium on Power Semiconductor Devices and ICs

ISPSD, to be held in Vienna, Austria, May 17–21, 2020, is a forum for technical discussion in all areas of power semiconductor devices, power integrated circuits, their hybrid technologies, and applications.

With a steadily growing attendance reaching 600 attendees this year, ISPSD has become the must-go event in power semiconductors. It is a truly international conference, rotating on a four-year cycle amongst Europe, North America, Japan and Other Areas. In 2020 ISPSD will return to Europe into the historical city center of Vienna, the capital of Austria. Vienna is a UNESCO World Heritage Site and is also described as Europe's cultural capital. The metropolis with its unique charm, vibrancy and flair, historical treasures, music and arts will give this conference a special atmosphere.
The ISPSD Technical Program Committee invites you to submit abstracts for oral or poster presentations to the conference.

www.ispsd2020.com

European Director of Automotive Business Development

Vicor Corporation announced the appointment of Nicolas Richard to the role of Director of Automotive Business Development for Europe. Prior to joining Vicor, Nicolas worked at IDT (Renesas) as Automotive Sales and Field Applications Engineer focused on technical sales in powertrain, infotainment and ADAS-based systems. His experience includes numerous engineering roles at On Semiconductor, Continental Automotive and VDO (Continental Automotive), working on projects designing DC-DC converters for hybrid and electric vehicles. Commenting on the appointment, Vicor VP of Sales for EMEA Henryk Dabrowski stated, "I am delighted to have Nicolas join Vicor as we begin projects with several leading OEMs in Europe. Nicolas will lead our initiative to deepen our engagements with these early customers and also expand our design wins to additional automotive Tier-1s and OEMs."

www.vicorpower.com

Isolated Push-Pull DC-DC Converter Delivers 1W from SOT23-6

Chinese chip maker Mornsun has created a push-pull dc-dc converter chip IC with integrated mosfets that can deliver up to 1W through an isolation transformer - and the firm offers a selection of transformers. To maximise the reliability, the chip design has incorporated three key technologies: a soft start function, output short-circuit protection and integrated over temperature protection. A range of SMD mounted transformers which can be tailored to your design is also available.

SCM1201A is actually an unregulated oscillator/power-driver, specifically designed for small form factor, isolated supplies. Being unregulated, output voltage depends on input voltage, transformer turns-ratio and, to a lesser extent, load current.

It drives a low-profile, center-tapped transformer primary with a supply rail between 4.5 and 8V wide DC power supply. The secondary can be wound to provide any isolated voltage based on transformer turns ratio, providing the voltage reflected back to the integrated mosfet drains (see diagram) is below 20V (minimum drain breakdown voltage is 27V). Minimum drain pin voltage is -0.7V. Maximum operating current is 350mA (600mA abs max peak).

To minimise the degree of magnetic biasing from the push-pull topology, the drive to the two internal mosfets is “highly symmetrical”.

Typical chip consumption is 800µA from 5V

It comes in an SOT23-6 package, and is specified for operation with its junctions between -40°C and 125°C. Soft start is included to avoid potential device harm when booting up under high current conditions. Output short-circuit protection will not be impaired by any deviation in power supply parameters, not temperature, even down to -40°C.

Over-temperature protection puts the chip into ‘sleep’ if the temperature exceeds the specified range – and subsequently self-recovers once the temperature drops below a threshold within the safe operating range. The data sheet has alternative output stage suggestions – for full-wave and half-wave unipolar and bipolar outputs, and includes two transformer examples:

TTB0505-1T is 6.5 x 8.8 x 3.6mm and designed for 5Vin and 5Vout 1W operation with what looks like 1,650Vdc isolation between input and output – operating over -40°C to 125°C. There is also a 5Vin 9Vout version. TSHT5.8-01 is 12.5 x 8.7 x 5.9mm, again for 5Vin 5Vout 1W operation.

www.mornsun-power.com

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Model Continuity: From Offline Simulation to Real-Time Testing

The dream of many engineering managers is having a single simulation model or "digital twin" for a newly developed product or application. This model shall serve as a reference for all technical aspects during design, verification and maintenance. Although working with a single model seems impossible, many benefits of a digital twin can be realized today with the right development process and an appropriate toolchain.

By Jost Allmeling, Plexim GmbH

Simulations help developers in many ways during the entire development process of a new power electronics application. The development process typically comprises the functional concept, the component selection, the mechanical design, the controller implementation and finally the test and verification under normal and faulty conditions.

Ideally, the development process refers to the familiar V-model (Figure 1), where the design and implementation follow a top-down approach and the verification follows a bottom-up approach. At each level, the developed component is verified with appropriate test tools and procedures before being integrated into a larger system.

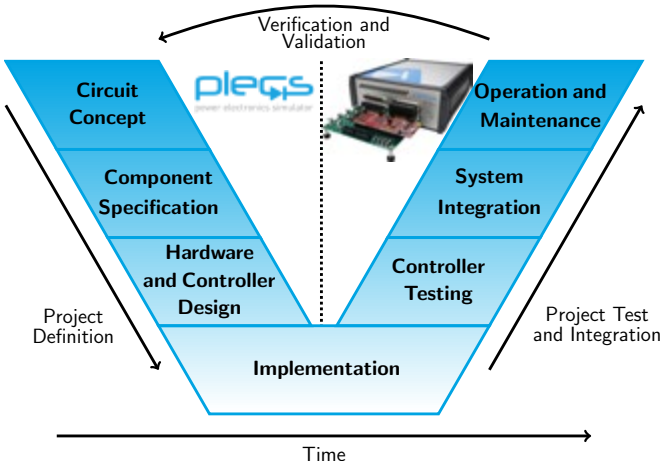

Figure 1: V-model for the development process of a power electronic system

For the verification it is important that the same specifications are used as for the design. Although the design and verification tools may use models with different levels of detail, it is important to ensure that the models produce comparable results. This article explains why a single model is not sufficient for all applications and how to ensure that multiple models deliver consistent results despite their different implementations and use cases.

Circuit concept

In the first phase of a new design, the feasibility of a particular power circuit and a proper control scheme can be assessed quickly with ideal circuit components and generic control blocks. During this conceptual phase, no manufacturer-specific information is needed to model the individual components of a power converter. Rather, power semiconductors such as MOSFETs and diodes are represented by simple on/off switches that correspond to their functional behavior. The parasitic properties of passive components like winding resistance and inductor saturation can be neglected unless they play a functional role for the circuit operation.

Likewise, the controls are represented by functional block diagrams or state machines, independent of their final implementation. These controls may later be realized as analog circuitry, digital logic, microcontroller code or hardware PWM generators.

Simulation software used in the conceptual phase must provide generic models for all types of electrical components encountered in power electronic applications. As power semiconductors are normally operated in switch mode they should be modeled as ideal switches to reduce the complexity of the simulation model. The user must be able to freely connect arbitrary components and to create his own customized components by means of subsystems.

During the conceptual phase, the system model can grow in complexity and size. In order to obtain fast transient simulations without significant integration errors, the use of a variable time-step solver is strongly recommended. A variable step solver automatically steers the time step in such a way that the maximum integration error is not exceeded and switching instants and other discontinuous events are hit exactly.

The simulation software PLECS has been designed from the beginning for the simulation of power electronic systems. One distinguishing feature is its capability to model power semiconductors as true ideal switches, which allows for fast and robust simulations of large circuits without the need to tune solver settings.

Component selection

Based on the current and voltage requirement determined by the circuit design, suitable components with specific part numbers are selected and the mechanical layout is created. In this second phase, simulations help to predict the thermal losses and the resulting temperatures. In a continuous workflow, the thermal model presents itself a new layer placed over the electrical circuit. The thermal domain computes the losses generated by the electrical circuit and models the heat transfer.

Switching and conduction losses can be simulated efficiently using a set of loss tables for each semiconductor. Tables for switching losses

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electrical engineering software

plecs

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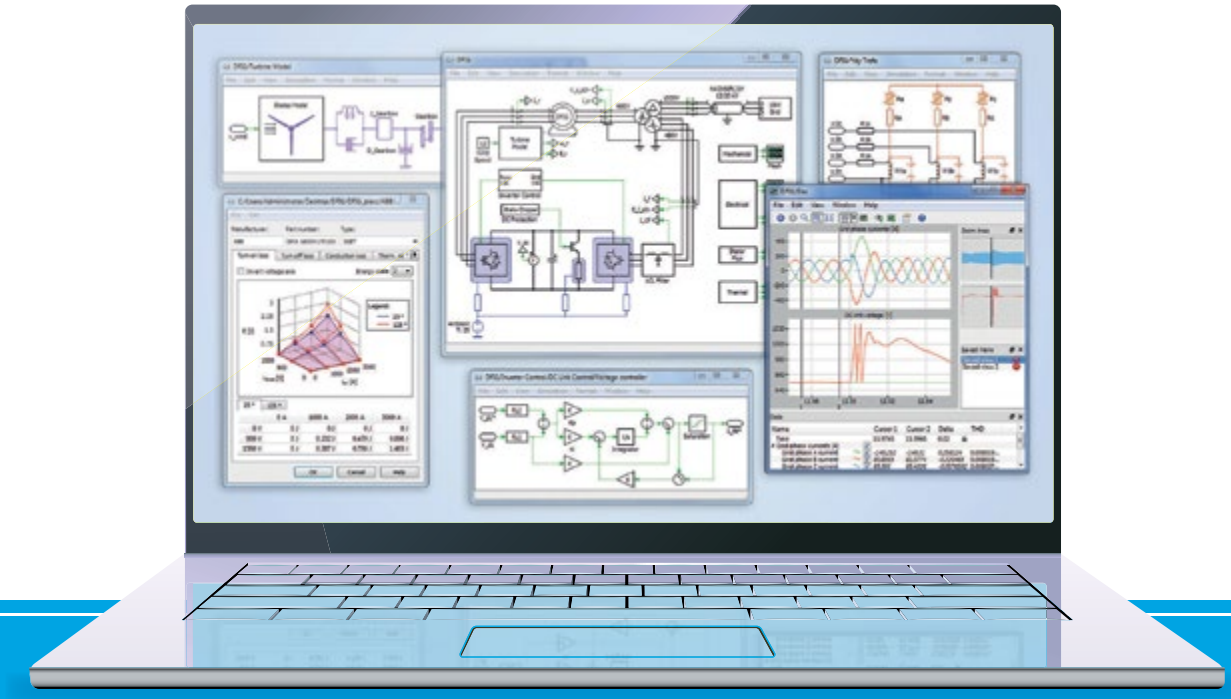

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provide the dissipated energy depending on the blocking voltage, the on-state current and the junction temperature of the device. Tables for computing conduction losses show the voltage drop as a function of on-state current and device temperature. In each simulation step, the thermal losses are calculated and fed into a thermal equivalent network that comprises the semiconductor device, the heat sink and the external cooling arrangement.

The advantage of using loss tables over simulating voltage and current transients during switching is that ideal switching and thus high simulation speed is maintained. The computation of the thermal domain just adds some extra effort to the electrical simulation based on ideal components.

Power semiconductor loss tables to be used with PLECS are readily available from a growing number of semiconductor manufacturers such as ABB, Infineon and Wolfspeed.

Mechanical design

The mechanical design, which is carried out in the next phase, includes the placement of the components, the electrical layout, the design of the cooling system and the integration into a housing.

Because CAD programs and PCB layout software require many other parameters than the ones used for system simulations, the model tool chain is typically broken at this point. In the mechanical design, the developer must adhere to the parameters used in the system simulation or modify them accordingly in the original data set.

Using the spatial layout information from the mechanical design the developer can determine the influence of parasitic inductances and EMI effects in an electrical simulation. This is only possible if detailed semiconductor models are used that accurately reproduce the switching transients. Since these models are computationally very intensive, they can only be simulated over a few switching cycles and are therefore not suitable for system simulations.

Due to the enormous effort involved in using spatial information and obtaining detailed semiconductor models, as well as the limited gain of new insights, such low-level simulation is often omitted.

Controller implementation

In a power electronics application, the development of the controls often requires more effort than the design of the power stage, especially if a microcontroller is employed. The development of the controller should therefore begin immediately after the conceptual phase has been completed, before the actual power hardware is built.

In the classical approach, experienced software developers will implement the control code for a specific target MCU according to the specifications of the controls engineers. Implementing embedded control code, though, requires continuous testing. This can be simplified by compiling excerpts of the control code into a DLL destined for the host computer instead of the target MCU. Most system simulation software can include DLLs so that the control code can be verified against a model of the controlled system. In addition, PLECS offers the possibility of pasting C code directly into the editor of the C-Script block. This code is then automatically compiled and executed along with the model.

In order to ensure that the implemented control code and the functional block diagram of the conceptual phase produce the same results, a Configurable Subsystem can be used in PLECS, one implementation of which contains the block diagram and the other the code. Simulating multiple implementations of the same functionality and overlaying the results in a PLECS Scope is a crucial test for model continuity.

A more modern approach to implementing controls on a MCU is to automatically generate target-specific C code from the functional block diagram. In addition to its offline implementation, each block must provide a method for outputting real-time capable C code. The block diagram typically contains generic signal processing blocks as well as target I/O blocks to configure the on-chip peripherals such as ADCs and PWM generators. Especially for beginners, auto-coding speeds up the development enormously, because peripheral configuration through program code is a daunting task that requires in-depth knowledge about the MCU or extensive study of the manual. With respect to model continuity, auto-coding has the advantage that the generated code always adheres to the block diagram definition. However, the responsibility for an efficient implementation of the controls is now shifted from the software developer to the controls engineer.

If the target MCU is not selected or the entire control board with the signal conditioning electronics is not yet available, the MCU can be temporarily replaced by a much more powerful real-time processing platform such as the PLECS RT Box. This approach is known as Rapid Control Prototyping (RCP) and helps to quickly get a working setup consisting of power stage and controller.

In PLECS, by switching from a particular MCU or the RT Box to a generic target, the generated code can be used instead of the original block diagram in the offline simulation. This feature allows for quick verification of the generated code by overlaying the simulation results.

Controller testing

We have seen how handwritten or automatically generated code can be verified against the block diagram definition in an offline simulation by replacing the block diagram with the compiled code. This type of verification is called software-in-the loop (SIL) testing and allows for short turnaround times since no MCU needs to be flashed. However, the proper configuration of MCU peripherals cannot be verified with SIL, nor can timing issues, processor utilization or resource corruption be detected on the target MCU.

Testing not only the control code, but the entire control hardware, including the MCU peripherals, normally requires the real power stage to be connected to the controller. However, this is often impractical because the power stage and its protection may not be fully developed before final commissioning, and certain faulty operating conditions may even damage the power stage.

To test the control hardware independently of the power stage, the controller can be connected to a real-time simulator that mimics the behavior of the power stage. This approach is referred to as Hardware-in-the-Loop (HIL) simulation as the actual control hardware is part of a closed loop-simulation. Replacing the power stage with a real-time simulation has the advantage that the behavior of the controller can be extensively tested under a large number of normal and faulty conditions.

Controller HIL testing has become very popular, because the connection at signal level provides a clearly defined interface between the controller and the power stage, and only few modifications are needed to replace the power stage with a real-time simulator.

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The challenge with HIL simulations of power electronics are the small time constants prevailing in electrical circuits. Only a short additional latency is acceptable, which is inevitably introduced by the real-time simulator. The computational latency between capturing the PWM signals and providing simulated sensor signals to the controller should be kept to a minimum, since the controller should still behave as if it were connected to the real power stage. This requires not only dedicated real-time hardware such as the PLECS RT Box, but also converter models optimized for fast and accurate execution in fixed time-step simulations.

Real-time simulations are always a race against the advancing time, since the computation of each time step must be completed within a discretization period. On a modern real-time platform, the minimum achievable time-step lies in the order of a few microseconds and may depend on the model size. Even with specialized converter models computed entirely on an FPGA the time step can hardly be reduced below 0.5 µs.

The switching frequencies of today's power converters are mostly between 10 and 100 kHz. If the PWM signals were sampled only once per simulation step, the resolution of the captured duty cycle would be insufficient. In order to capture the duty cycle more accurately, the PWM signals are usually sampled at much smaller intervals of about 10 ns and averaged over one simulation step. The average value represents the relative on-time of the PWM signal during that step.

Averaged PWM signals can accurately represent the semiconductor gate signals only if they are applied to appropriate converter models. These models are based on controllable voltage and current sources instead of ideal on/off-switches (Figure 2). Additional logic is employed to model discontinuous conduction mode and semiconductor blanking time. Since the simulation time step and thus the averaging interval is usually much smaller than one PWM switching cycle, in PLECS this modeling approach is referred to as sub-cycle averaging. Such converter models are also sometimes referred to as time-stamped bridges.

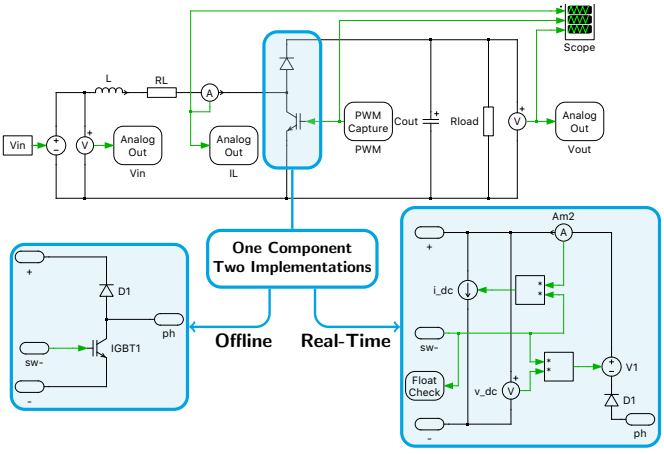

Figure 2: IGBT chopper model with two different implementations for offline and real-time simulation

While sub-cycle average models are recommended to for high-fidelity real-time applications, converter models based on ideal switches continue to be preferred in offline simulations. Because the sub-cycle averaging makes certain assumptions and simplifications, the simulation result might not always match exactly. Also, when using generated C code for fixed time-step simulations, the results can deviate slightly from the continuous-time model.

It is important that the same circuit model developed in the design phase is used when verifying the controller during HIL testing. However, a versatile offline model usually differs from a computationally efficient real-time implementation. To solve this dilemma, the power modules for various types of converter and inverter bridges in the PLECS library are all equipped with two implementations. One is based on ideal switches and the other uses sub-cycle averaging. The user can easily switch between them. To make sure that the two implementations behave the same even when discretized, the user should compare the results of the generated real-time code with the continuous model in an offline simulation as shown in Figure 3. This can already be done before uploading the code onto the RT Box.

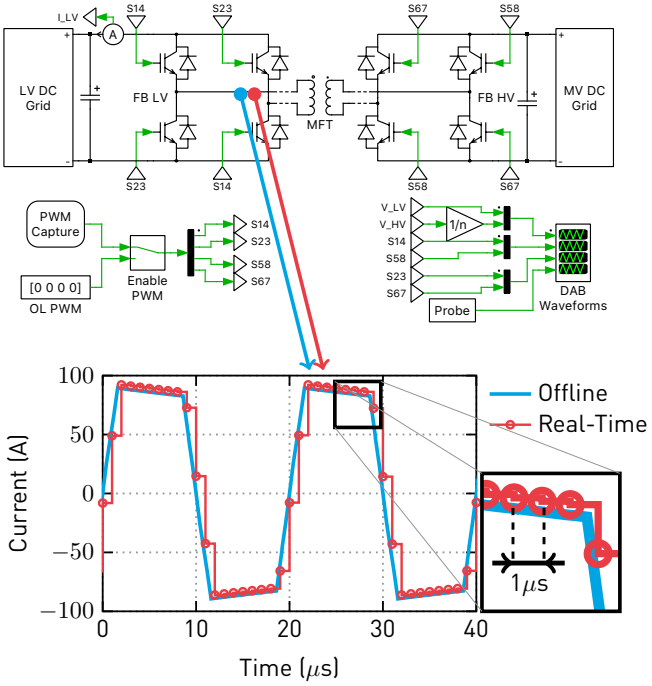

Figure 3: Verification of real-time results through offline simulation

PLECS RT Box

Real-time platforms for HIL testing are traditionally divided into universal systems based on multi-purpose CPUs and highly specialized systems for parallel computing on FPGAs. Conventional CPUs connect peripherals such as digital and analog I/Os via PCI Express, a serial bus protocol that has a communication latency of at least 10 µs. Despite their high processing power, the simulation time step is thus limited to approx. 20 µs — too much for most power electronics applications. FPGA based system, on the other hand, allow simulation time steps of 1 µs or less and can access peripherals directly. Although ideal for massive parallel computing, FPGAs perform poorly when they execute sequential code, restricting possible applications.

To address the shortcomings of conventional CPUs and FPGAs, the RT Box uses a Zynq System-on-Chip (SoC) from Xilinx that incorporates multiple ARM CPU cores on an FPGA. The tight integration of the CPU cores with the FPGA enables I/O latencies of a few 100 ns. The CPU cores can compute any simulation model, while the FPGA is employed as a co-processor for streaming tasks. With typical simulation step sizes between 1 and 10 µs for power electronic circuits, the RT Box closes the performance gap left by conventional HIL simulators.

The real advantage of the RT Box lies in its end-to-end interoperability with the PLECS simulation software. At the push of a button, a

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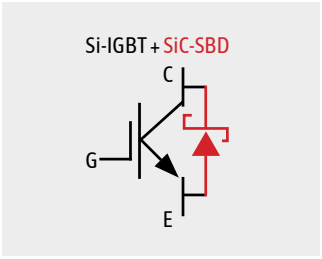

PLECS model is converted into real-time C code, compiled, uploaded and started on the RT Box. With the External Mode real-time simulation data from the RT Box can be displayed in PLECS Scopes and compared with results from offline simulations.

Plexim is currently expanding its product portfolio of RT Boxes (Figure 4). The updated RT Box 1 remains to be the most cost-effective HIL platform for power electronics and now features two CAN transceivers. The new RT Box variants 2 and 3 are deploying the next-generation multi-processing SoC from Xilinx. Besides additional connectivity for industrial communication, the RT Box 2 and 3 feature interfaces for magnetic resolvers. Compared to the RT Box 2, the RT Box 3 has twice the number of analog and digital I/Os. The main differences between the new RT Box variants are outlined in Table 1. With the new hardware offerings, Plexim will expand its position as a provider of HIL systems and offer its customers even more comprehensive solutions supporting the continuity of simulation models.

Figure 4: Plexim's new RT Box portfolio

	RT Box 1	RT Box 2	RT Box 3
Xilinx SoC	Z-7030	ZU9EG	ZU9EG
CPU Cores	2	4	4
CPU Clock Speed	1 GHz	1.5 GHz	1.5 GHz
Analog I/Os	16/16	16/16	32/32
Digital I/Os	32/32	32/32	64/64
Resolver I/Os	-	1/1	2/2
Gigabit Ethernet	1	2	2
Industrial Ethernet	-	1	1
CAN Bus	2	2	2
RS232/422	-	2	2
SSD	-	500 GB	500 GB
SFP+ Interconnects	4	8	8
DisplayPort	-	1	1
USB 2.0/3.0	1/-	-/1	-/1

Table 1: Comparison between the new RT Box variants

Conclusions

Using the same model for all simulations throughout the development process from design to verification is an ideal goal that is difficult to achieve in practice. Different aspects such as system or device behavior may require various simulation tools and models with very different levels of detail. Obtaining a single "digital twin" that resembles the entire system and using this twin as the single source of truth is therefore illusory.

Nevertheless, it is perfectly realistic to establish a development process in which all system parameters are stored in a central location and referenced by all models. This central location could be a comprehensive database or just a simple initialization script. Certain parameters will be used only by some models for simulating selected aspects. Using an integrated toolchain like PLECS helps to verify models for different purposes against each other and thus enables model continuity.

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The Intelligent Power Module Concept for Motor Drive Inverters

Designers of inverters for small AC motors in consumer and general purpose industrial applications are required to meet increasingly challenging stringent efficiency, reliability, size, and cost constraints. Classically, many of such small inverter designs utilize discrete power device packages along with the necessary auxiliary components needed to realize the interface, drive, and protection functionalities.

By Philipp Jabs and Muzaffer Albayrak,
Mitsubishi Electric Europe B.V., Ratingen, Germany

With this approach, relatively large and complex PCB designs are required to meet all of the spacing and layout requirements of the drivers and discrete power devices combination. Another equally perplexing problem is maintaining consistent performance and reliability when the characteristics of the drivers and power devices are not properly matched. An alternative solution to these problems is to use an integrated power module that contains all the required power devices along with matched gate drivers and protective functions integrated in low-voltage and high-voltage ICs (LVIC & HVIC). Finally, the fully integrated package solution allows to decrease the stock handling and reduces the assembling time compared to a discrete solution.

Building on the success of its Intelligent Power Module (IPM) approach, Mitsubishi Electric pioneered the DIPIPM™ concept in 1997 based on assembling bare power chips and LV/HVICs using a compact transfer moulded lead frame design to maintain optimized and consistent reliable performance while addressing the module's low-cost requirements.

Extending the family recently with the surface mounted SP2SK module and the high current rated Large DIPIPM+, the line-up of Mitsubishi Electric's transfer moulded IPMs covers a power range from several tens of watts up to more than 12 kW as shown in Figure 1.

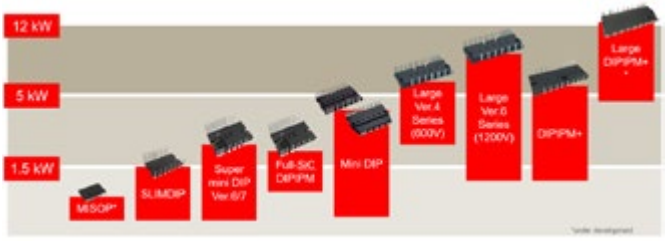

Figure 1: Current DIPIPM lineup

Topology and protection functions

Nowadays, the topologies of hard switching motor drivers in the lower power range are similar. For an optimum of costs and reliability, the amount of used semiconductors is desired to be as low as possible. The solution to be found in nearly all types of servo drives, home appliance inverters, fan inverters and pump inverters is the three phase full bridge using Insulated Gate Bipolar Transistors (IGBT). The advantage of using IGBT is the high blocking capability combined with lower conducting losses, compared to the MOSFET technology.

Figure 2 shows the topology exemplarily used in the Super Mini DIP-IPM™ series.

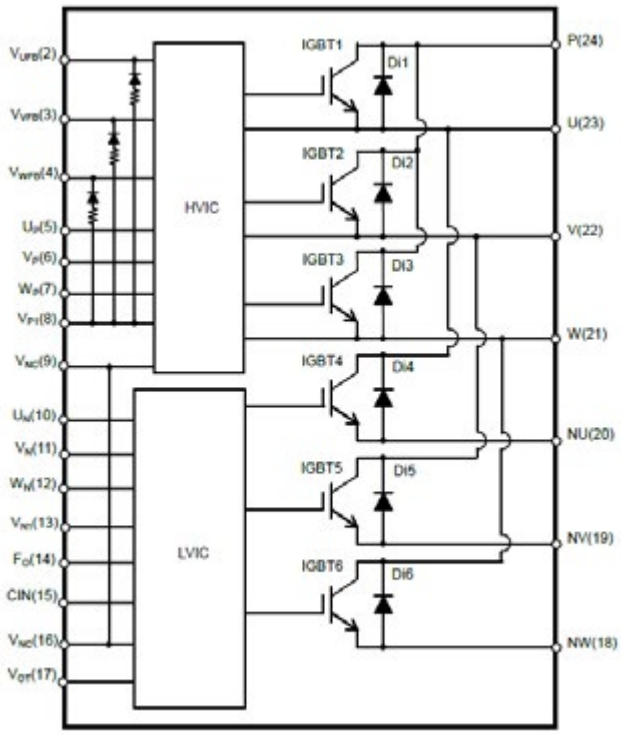

Figure 2: Topology integrated in the Super Mini DIPIPM™ series

The market for consumer and industrial products is getting more and more dynamic. Trends of smart home technologies and also industry 4.0 (IoT) requirements lead the designer to develop the next generation inverters in short time and more cost efficient. Here, Mitsubishi Electric's transfer-mould modules outperform in the market with their highly-integrated features, easy-to-implement and cost-competitive solution. They enable to shrink the inverter due to the compact module outline and sophisticated pin design with well-designed clearance and creepage distances. Furthermore, the line-up with the different series offers the possibility to design a scalable platform inverter, as several current ratings of each series are available. With offered blocking voltages of 600V and 1200V, commonly used single and

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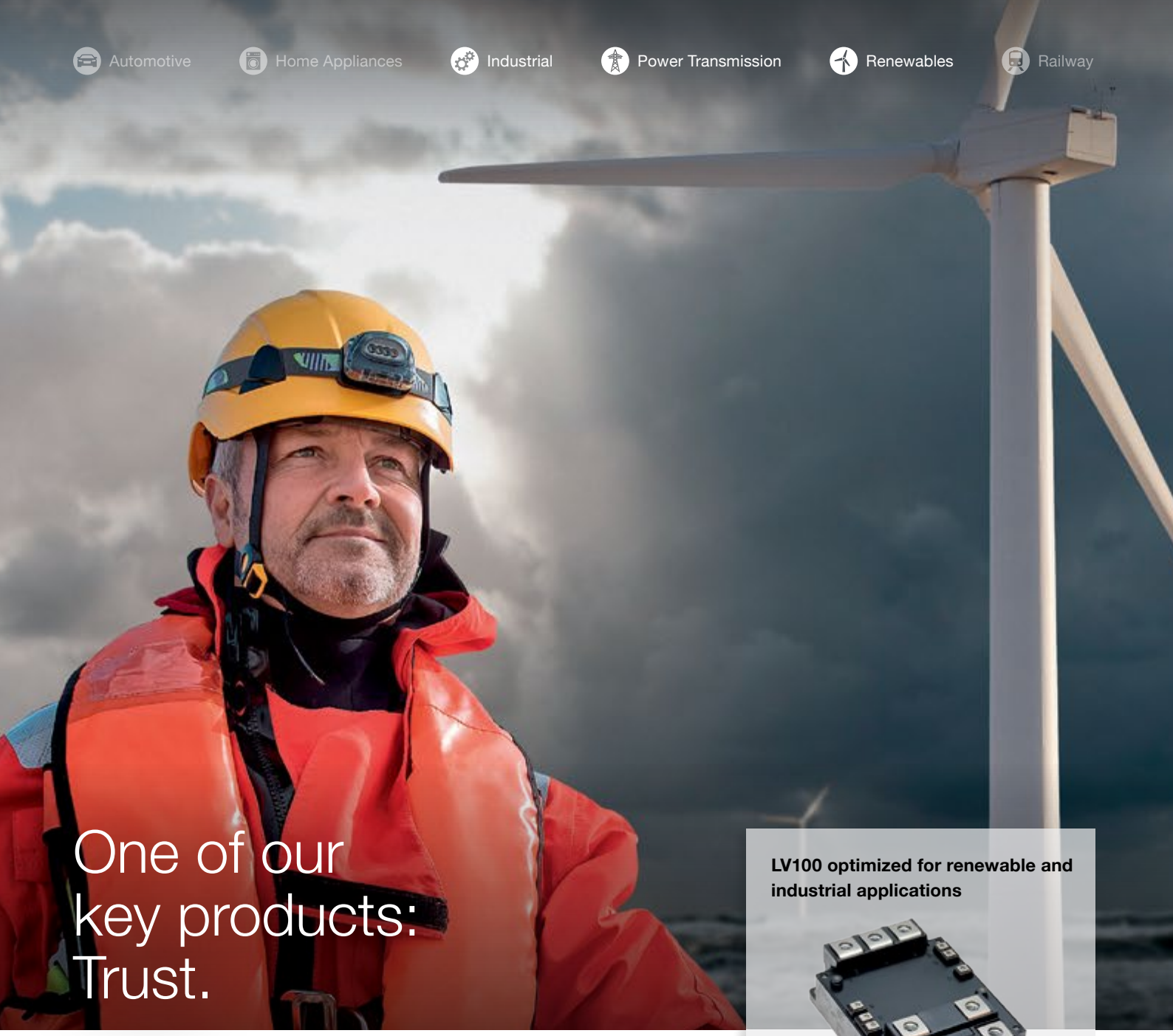

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three phase applications are covered. With the UL recognized isolated thermal interface with a rating of 2.5kV (1.5kV for the SP2SK module) and a low thermal impedance, the effort for a user-safe design is lowered, covering also the higher requirements for industrial use. Furthermore, the mechanical stress in the module is heavily decreased with the use of organic material, as the thermal expansion coefficients are better matched in comparison with ceramic materials. For high power ratings, an additional internal heatsink is moulded in the module for better heat spreading.

Mitsubishi Electric's modules consists of six IGBT with separate freewheeling diodes or six reverse-conducting IGBT (RC-IGBT). For the easy control of the IGBT, one or three high side driver ICs, a low side driver IC and, depending on the series, three bootstrap diodes with current limiting resistors are integrated. Due to the level shifter integrated in the HVIC, the transfer moulded modules from Mitsubishi Electric can be powered by a single 15V supply voltage source and can be controlled directly by an MCU without the need of galvanic isolation to control the high side switches. All dies are directly mounted on the lead frame without using a PCB inside the module, offering a market leading lifetime performance.

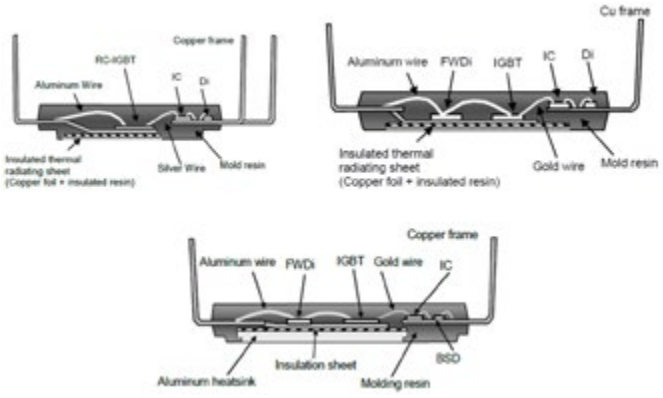

Figure 3: Internal structure (clockwise): SLIMDIP™, Super Mini DIPIPM™ and Large DIPIPM™

The emitter of the low side IGBT are open, enabling an independent current measurement of each single motor phase by the use of shunt resistors. With the possibility of detecting the three phase currents independently, state-of-the-art position-sensor less machine control can be used in the control framework of the user. The output signals of the current Measurement shunts are additionally used for the internal short circuit protection, which prevents the module to operate out of the short-circuit safe area of operation (SCSOA). Furthermore, the modules integrate a temperature output with a linear temperature-voltage dependency, resulting in an easy-to-implement condition monitoring and offering the possibility to integrate a dynamically controlled de-rating and the optional over temperature protection.

All of Mitsubishi Electric's transfer moulded modules leaving the production line are tested regarding their static and dynamic electrical characteristics and undergo a functional test with an inductive load, which help to reach a high level quality of delivered products. All results are recorded in an individual end-of-line test report in the factory.

Packages

Motor inverters are found in very different kinds of applications. Mitsubishi Electric offers different packages and herewith the optimal solution for each requirement.

The module with the smallest outline is the surface mount SP2SK module. Additionally to the common protection features of the DIP-IPM™ family, an interlock protection is integrated, preventing an arm shoot-through if high and low side switch is turned on. With the compactness of this module due to the used RC-IGBT, it is perfectly suited for low power single phase applications like dish washer or fans.

If a higher power rating is targeted, the SLIMDIP™ package is optimal. As well using the same RC-IGBT technology, it offers an outstanding compactness with through-hole technology. Matching the requirements of price sensitive platform inverters used in home appliances with a power range between 0.5kW and 1.5kW combined with a sophisticated pin design, the time-to-market is highly decreased.

With the Super Mini DIPIPM™ package, Mitsubishi Electric set a market standard for transfer mould IPM modules. It covers a wide range of current ratings, allowing the precise choice of the optimal suited module. As a highlight, additionally to the choice between silicon IGBT and silicon MOSFET models, two SiC MOSFET modules are available, based on Mitsubishi Electric's long term experience with silicon carbide.

The Mini DIPIPM™ packages allow due its bigger package an even better heat dissipation and therefore higher power rating. Moreover, the increased pin distances allow the use of 1200V IGBT in some models.

The Large DIPIPM™ package targets high power inverters where space is limited and a PCB based design is preferred. Blocking voltages of 600V and 1200V are offered with a wide current range.

The DIPIPM+™ and Large DIPIPM+™ is one of the latest developments. Based on Mitsubishi Electric's experience and knowledge, the package contains a three phase rectifier, a three phase full bridge and an optional brake IGBT. With the highest level of integration and compactness, it is the package which the user the most complete solution, shortening the component decision process and lifetime evaluation.

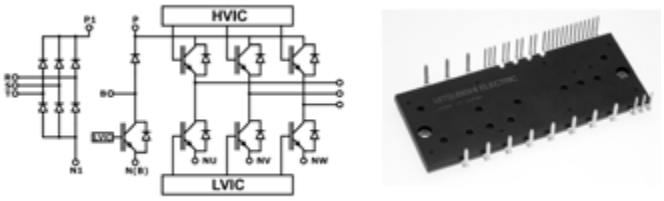

Figure 4: DIPIPM+ schematic (left) and package (right)

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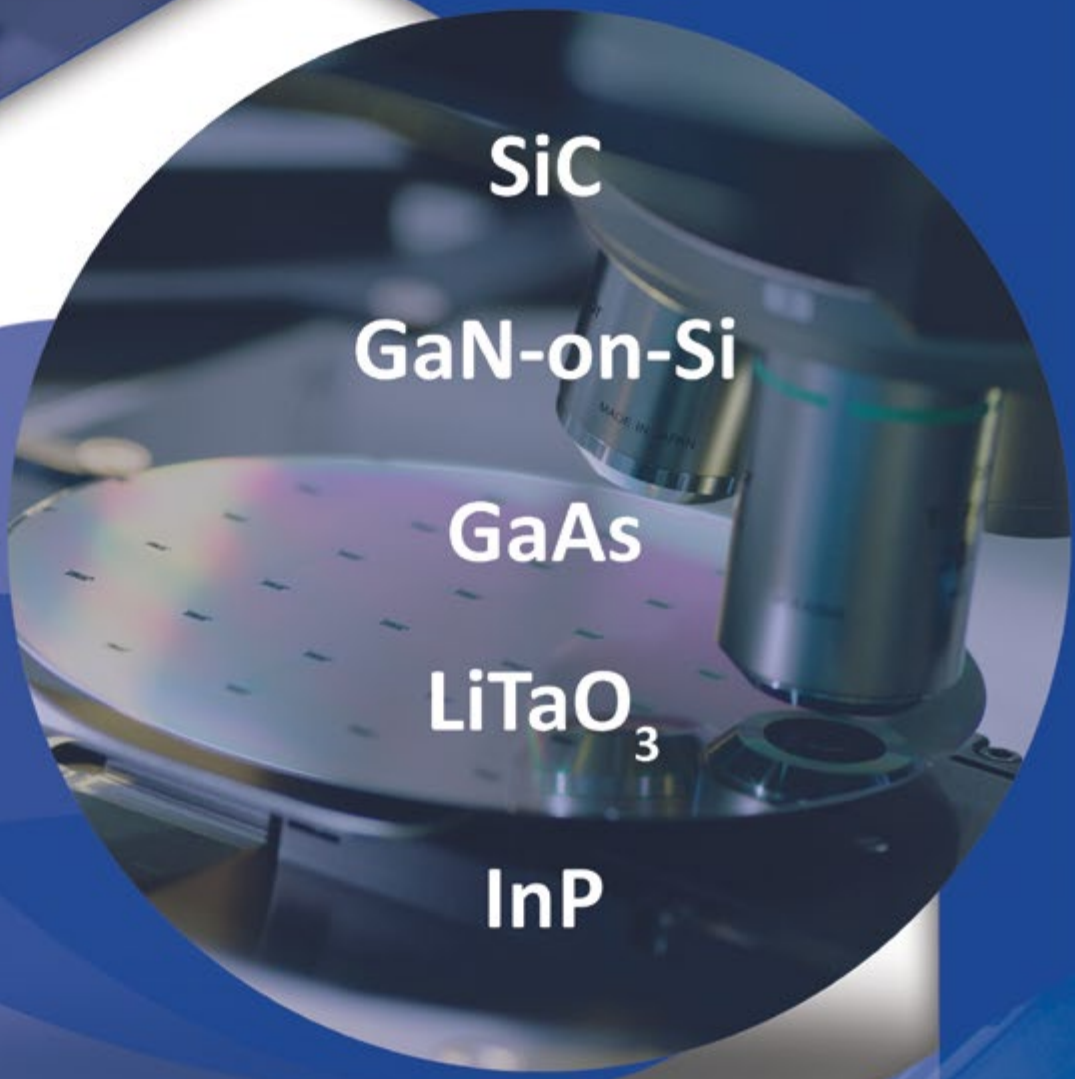

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Demystifying the Paralleling of IGBT Modules

Paralleling power devices is of general interest. It helps to increase the power rating of inverter systems very easily. Paralleling becomes even more essential for the new modular semiconductor concept of XHP™2 and XHP™3 which open up a new degree in flexibility.

By Thomas Schütze and Matthias Wissen, Infineon

This type of module supports and simplifies the design of new converters by enabling an easy scalability of the output power. Besides the power module characteristics, the system and bus bar design, the routing of the load conductor and the gate-driver characteristics have significant impact on the current sharing between paralleled devices. A certain deviation of losses, resulting in different junction temperatures among the power modules, is the result. A current derating will be defined in order to operate the paralleled power modules safely within their specification.

Below, an analytical approach will be described, which, by means of key influential device parameters, provides e.g. the maximum deviation of switching losses dependent on the number of paralleled modules. By determining the maximum current imbalance and considering the safe-operating-area (SOA) limits, a corresponding derating can be defined.

Design of experiments for n=2

In order to evaluate the most influential parameters a measurement DOE with two modules in parallel has been carried out to assess the collector-current mismatch and the difference of losses. The dependencies between device parameter deviations and resulting loss mismatches are summarized in figure 1.

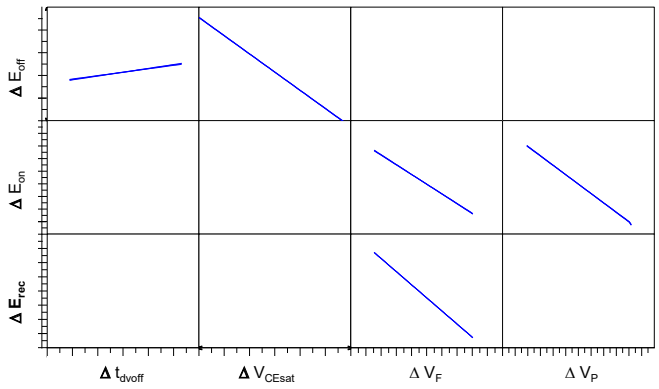

Figure 1: Differences of switching losses for two modules in parallel with respect to the most influential parameters

$$\Delta E_{rec} = f(\Delta V_F) \quad (1)$$

$$\Delta E_{on} = f(\Delta V_F, \Delta V_P) \quad (2)$$

$$\Delta E_{off} = f(\Delta V_{CE}, \Delta t_{dvoff}) \quad (3)$$

The turn-off delay time t_{dvoff} is the time between 90% V_{GE} and 10% of the rising V_{CE} during IGBT turn-off. The difference between two modules Δt_{dvoff} has only a slight impact on ΔE_{off}, but a significant impact regarding the safe operating area (SOA) of the IGBTs.

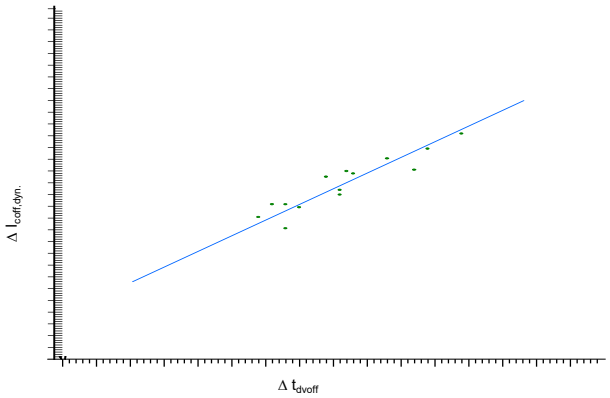

Figure 2: Difference in turn-off current DIcoff,dyn depending on the difference in turn-off delay time Dtdvoff

In figure 2 the difference in turn-off current $\Delta I_{coff,dyn}$, i.e. the current at which V_{CE} equals the DC-link voltage, is shown as a function of Δt_{dvoff}, revealing an almost linear dependency. With increasing Δt_{dvoff}, the $\Delta I_{coff,dyn}$ increases due to a voltage difference between the modules that leads to a circulating current and a corresponding current mismatch. In order to stay within the SOA, the Δt_{dvoff} has to be limited.

The set of regression functions (1) to (3) describe the differences of dynamic losses for two modules switched in parallel. The differences in conduction losses are described by the differences in output characteristics of the IGBTs and diodes. With respect to the chosen values for the selection parameters ΔV_F, ΔV_{CE}, ΔV_P and Δt_{dvoff}, and taking into account a certain duty cycle, thermal impedances and cooling conditions, the differences in total IGBT and diode losses as well as the junction temperatures can be calculated. Knowing the distribution of the parameters, they can be applied to a Monte-Carlo simulation, and their impact on switching and conduction losses quantified. Furthermore, the adherence of the SOA by mismatched currents can be verified.

Analytical approach for n≥2

Determining the current mismatch for paralleled modules with regard to their individual characteristics via a DoE is manageable as long as the number of paralleled devices is rather low. In order to predict the mismatch for multiple paralleled modules, an analytical approach is needed. A figure of merit f_X (4) has been defined describing the devia-

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tion for a given parameter X. f_X reaches its maximum for the smallest X_{avg} and the largest ΔX. The minimum X_{avg} for n modules is given by equation (5). (5) inserted into (4) results in (6), which is a universal equation for f_{Xmax} in dependence of n. For $n \to \infty$, the limiting value is obtained according to (7). Figure 3 shows f_{Xmax} in dependence of n for a difference of 5% and 10% between X_{max} and X_{min}.

$$f_X = \frac{\Delta X}{X_{avg}} = \frac{X_{max} - X_{avg}}{X_{avg}} \quad (4)$$

$$X_{avg} = \frac{X_{max} + (n-1) \cdot X_{min}}{n} \quad (5)$$

$$f_{Xmax} = \frac{X_{max} - X_{min}}{X_{min} + \frac{X_{max}}{n-1}} \quad (6)$$

$$f_{Xmax} = \frac{X_{max} - X_{min}}{X_{min}} \quad (7)$$

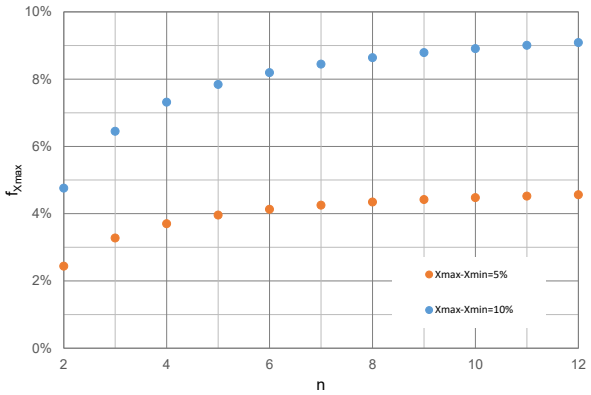

Figure 3: f_{Xmax}=f(n) describes the worst-case f_X according to (4)

The on-state current mismatch between two modules is determined by characteristics, that schematically can be simplified to a voltage source (V_0) connected in series to a resistance (R_d). In case of a positive di/dt, the voltage drop across the corresponding leg inductances of the paralleled device results in a negative feedback. The higher the positive di/dt, the higher the inductive voltage drop, and therefore, the lower the mismatch. Negative di/dt will result in a positive feedback, however, declining currents in the on-state are in general less critical in terms of losses or SOA.

Hence, for a worst-case on-state scenario, the leg inductance is negligible. According to (6), the difference in on-state currents of n modules reaches its maximum f_{imax} if (n-1) modules with R_{d1}=…=$R_{d(n-1)}$=R_{dmax} are carrying a low current in parallel to a single module with R_{dn}=R_{dmin} carrying a higher current. (6) can be rewritten as (8), an expression that depends on the individual module currents and the number of paralleled modules n.

$$f_{imax} = \frac{i_{max} - i_{min}}{i_{min} + \frac{i_{max}}{n-1}} \quad (8)$$

R_d and V_0 are sufficiently linear depending on the V_{CEsat} or V_F, and therefore can be obtained for differing on-state characteristics by a linear regression function. (8) delivers the maximum current mismatch for n paralleled modules. According to figure 3, the maximum current mismatch for n=6 modules and $\Delta i = i_{max} - i_{min} = 10\%$ amounts to $f_{imax} \approx 8\%$. Assuming a typical selection of modules with various R_d and V_0 values, the individual module currents can be calculated according to Kirchhoff's law, and the current mismatch f_i is given by (4). Once the individual R_d and V_0 have been determined, the mismatch of switching losses can be determined too.

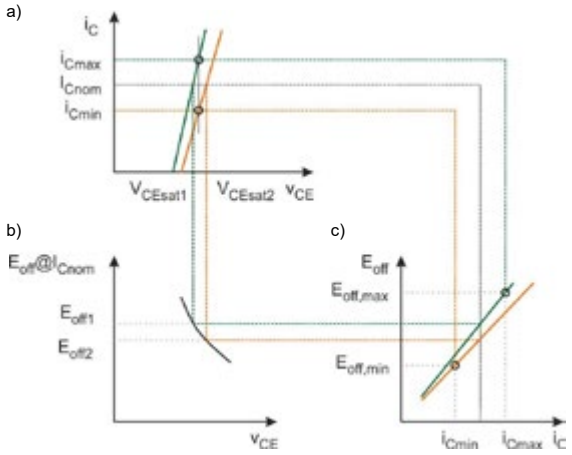

Figure 4: a) Simplified on-state characteristics for two modules with different V_{CEsat}; b) Trade-off curve; c) E_{off}=f(iC) for two modules with different V_{CEsat}

Figure 4a shows the output characteristics of two IGBTs with different V_{CEsat}, i.e. with different R_d and V_0. The difference in V_{CEsat} leads to different E_{off} values due to their trade-off characteristics (figure 4b) at the same current, e.g. I_{Cnom}. Hence, module-specific E_{off}=f(i_C) values are obtained (figure 4c). By determining the worst-case module currents of the parallel IGBTs (i_{Cmax} and i_{Cmin}), also $E_{off,max}$ and $E_{off,min}$, hence f_{Eoff} can be calculated.

This approach is sufficient as long as the desired value depends mainly on one variable. In this example, it has been assumed that E_{off} depends only on V_{CEsat}. This approach is also valid for determining ΔE_{rec} and f_{Erec}. Since ΔE_{on} depends on ΔV_F as well as ΔV_P (figure 1), a trade-off E_{on}=f(V_F, V_P) has to be considered for determining the appropriate relation E_{on}=f(i_C).

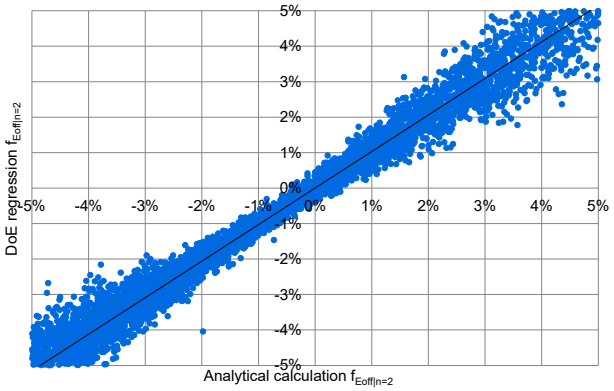

Figure 5: Correlation of f_{Eoff} for n=2 modules of the analytical approach (x axis) and the regression function obtained by the DoE (y axis). The module parameters were diced randomly according to their distribution.

In figure 5, the correlation of fEoff for n=2 of the regression function determined via the DoE and the analytical approach are shown. The slope is almost one, indicating a sufficient correlation and validity of the analytical approach. Nevertheless, the correlation reveals an increasing scattering for larger f_{Eoff}. This is due to the fact that the analytical approach does not consider the impact of Δt_{dvoff} on ΔE_{off}, which is rather low, but essential for the DoE regression function in order to

achieve a sufficiently good fit. Furthermore, the Δt_{dvoff} has not been restricted to a certain value in the diced configuration of parameters, which is required in order to stay within a defined SOA.

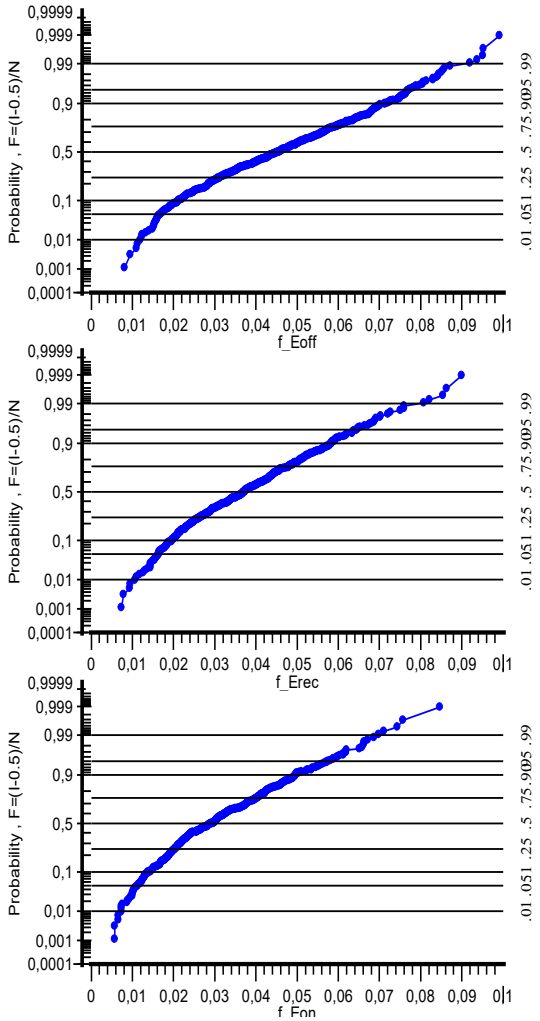

Figure 6: f_{Eoff}, f_{Erec} and f_{Eon} calculated according to (4) for sets of six module

Secondary effects, such as a circulating current between paralleled devices during switching as an effect of V_{CE} differences, cannot be considered. In measurements, they are inevitably included. Considering them is challenging, and would unnecessarily obstruct the simplicity of the suggested analytical approach.

Probability of a worst-case set of n=6 modules

Based on end test data of XHP™ 3 half-bridge modules, the probability of occurrence for f_{Eoff}, f_{Erec} and f_{Eon} has been calculated. A worst-case set of e.g. six modules is obtained, when f_X in (4) reaches the maximum, i.e. five modules have a V_{CEsat} or V_F at the lower limit while the sixth module has a respective value at the upper limit.

For the selection criteria applied here, data of sets of six XHP 3 half-bridge modules were investigated. f_{Eoff}, f_{Erec} and f_{Eon} are calculated and depicted in figure 6. The respective values on the x-axis are given in %. The analysis reveals that the difference in switching losses within the sets of six modules is always < 10%. Since the losses are distributed similar to that of a Gaussian distribution, it is possible to define an upper limit for fX to fulfil a probability of occurrence, e.g. ≤ 100 ppm. For the data shown, this is fulfilled for $f_{Eoff} \leq 11.6\%$, $f_{Erec} \leq 9.4\%$ and $f_{Eon} \leq 8.4\%$.

Beside the deviations in device characteristics, the surrounding conditions like DC busbar symmetry, placement of the load cable, gate-drive parasitics, or the cooling concept can have an impact on the mismatch among the paralleled devices. They should be carefully evaluated as well.

Summary

By means of a DoE, the most influential parameters describing the differences in module behavior due to paralleling have been determined. Besides the differences in on-state characteristics which impact static current sharing, differences in switching delay time have to be considered to comply with the SOA. All differences in voltage between paralleled devices, either in on-state or during switching, provoke current imbalances due to circulating currents among the modules. An analytical approach has enabled us to predict the behavior of multiple devices connected in parallel, and to define selection criteria to ensure the reliable use of paralleled modules. Infineon XHP™ devices for paralleling are grouped and supplied according to these criteria.

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Longer Battery Life for Tomorrow´s Design Challenges

TI Ensures Ultra-low I_Q Power Management

„As we increasingly rely on smaller, smarter and more connected devices, the demand for power grows faster than ever", stated Mike Beckman, VP and General Manager, Linear Power, of Texas Instruments during a press conference in Munich in September.

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

"As we hold power – literally – in the palm of our hands, we need devices with longer battery life. This demand for longer battery life requires low quiescent current (I_Q)."

Low I_Q plays a key role in extending battery and shelf life, enabling more functionality, increasing system lifetime and reducing system cost. In brief: Two factors drive the demand for low I_Q:

- Power systems that operate with batteries, e.g. medical devices, need low standby power to preserve battery life and provide better user experience;
- non-portable electronics, like meters, need more accurate end-of-service detection and maximum standby energy efficiency.

Texas Instruments introduced low I_Q power innovations, that can fuel engineers´ solutions to these challenges:

Ultra-LDO linear voltage regulator

The TPS7A02 is TI´s new ultra-low-power low-dropout (LDO) linear voltage regulator with the industry's lowest quiescent current (I_Q) of sub-25 nA – one-tenth that of competing ultra-small devices. The new regulator features low I_Q control at light loads even in dropout conditions, allowing engineers to at least double the battery life of their applications. In addition, it provides best-in-class transient response for faster wake-up, improving application response times and dynamic performance. The small solution footprint helps engineers design smaller, lighter, more efficient products quickly by reducing power-supply solution size, and its common industry packages allow for pin-to-pin drop-in replacement in existing designs.

Figure 1: The TPS7A02 is TI´s new ultra-low-power low-dropout (LDO) linear voltage regulator.

The TPS7A02 helps engineers solve critical design challenges in many power-sensitive, high-precision and low-power applications such as in the grid infrastructure, building automation, medical equipment and wearables markets. The device joins TI's portfolio of low-I_Q LDO linear regulators that enable designers to prolong system life. By implementing the TPS7A02 with other ultra-low I_Q devices – such as TI's family of ultra-low-power MSP430 MCUs, the SimpleLink CC2642R MCU, the TLV8802 nanopower OpAmp or the TMP1075 low-power temperature sensor – engineers can further optimize battery life and performance in their systems.

Key features and benefits of the TPS7A02:

Extended application run times, longer system lifetime: The TPS7A02's ultra-low I_Q control at light loads allows engineers to at least double the battery life for applications using a standard battery chemistry, such as lithium-ion. For example, using the TPS7A02 in wireless video doorbell and security camera designs, engineers can achieve 24 months or more of battery life (up to four times the industry standard). In addition, the TPS7A02's ultra-low shutdown I_Q of 3nA can extend battery shelf life by as much as five times in portable medical and wearable applications compared to competing devices.

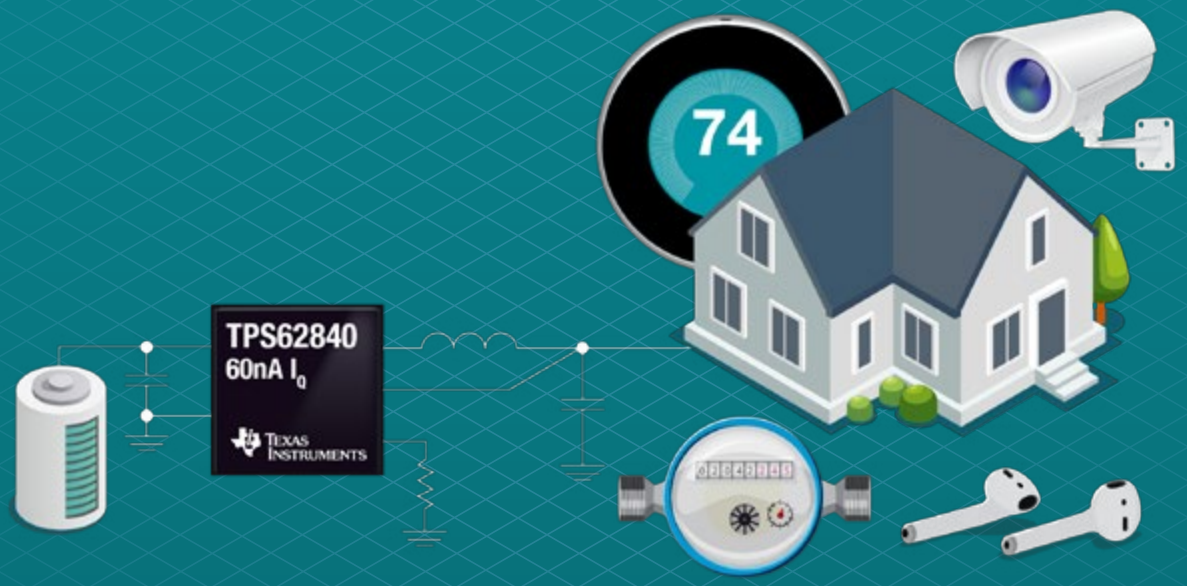
Faster wake-up, better dynamic performance: The TPS7A02 can settle in less than 5µs for 1-to-50-mA load transients – half the time of competing devices – enabling engineers to design applications with shorter response times and better dynamic performance. With the ability to quickly respond to rapidly changing loads while providing minimal variation in output voltage, the TPS7A02 can benefit high-precision, low-power applications such as wireless IoT and portable medical devices, which require clean power to accurately acquire signals from around the body.

Smaller solution footprint, faster time to market: The TPS7A02 automatically transitions from an I_Q-saving, low-load state to a high-load, fast-transient state without the need for any external circuitry or components. As a result, engineers can use the TPS7A02 to shrink the solution size by 70%, adding more functionality to their designs in space-constrained applications or lowering system cost by using smaller boards.

Pre-production samples of the TPS7A02 are now available in a X2SON package measuring 1mm by 1mm. A 5-pin SOT-23 package measuring 2.9mm by 1.6mm will become available later this year, and a 4-pin DSBGA package (0.65 by 0.65mm) will become available in early 2020.

Say hello to the world's lowest I_Q switching regulator

Texas Instruments



Extend your system's battery life with the industry's highest light-load efficiency

http://www.ti.com/product/TPS62840

60-nA I_Q buck converter shrinks solution size

The new ultra-low-power switching regulator TPS62840, a synchronous step-down converter, features the industry's lowest operating quiescent current (I_Q) at 60nA – 1/3 that of the nearest competitive device. It delivers very high light-load efficiency of 80% at 1µA load, which can enable designers to extend the battery life of their systems or use fewer or smaller batteries to shrink their overall power supply solution size and reduce cost. Additionally, the new DC/DC converter's wide VIN range of 1.8V to 6.5V supports a variety of battery chemistries and configurations.

These features plus its selectable functions enable the TPS62840 to help engineers solve critical design challenges in many battery-powered, always-on industrial and personal electronics applications – including narrow-band IoT, grid infrastructure equipment and wearables – that require more flexibility, an extended wireless range, improved accuracy and reduced EMI. The TPS62840 joins TI's portfolio of highly integrated, low-I_Q DC/DC converters that enable designers to maximize power delivery in the smallest possible solution size.

Figure 2: Synchronous step-down converter, features the industry's lowest operating quiescent current

Key features and benefits of the TPS62840

Longer battery life, very high light-load efficiency: A lower I_Q draw delivers longer battery life for systems with very light loads (less than 100µA), and those operating primarily in standby/ship mode (not switching). The low I_Q of the TPS62840 enables its 80% efficiency at a 1-µA load, which is up to 30% better than competitive devices.

Selectable modes enhance performance, lower overall cost: The TPS62840's selectable mode and stop functions improve noise performance and reduce signal distortion. These benefits can help lower the solution cost because designers can achieve system requirements without using more expensive precision signal-chain components, sensors or radio solutions to perform the same functions.

The mode pin allows for continuous conduction mode, also called forced PWM mode, to improve ripple or noise performance and lessen the impact on transmissions in sensitive radio-frequency applications.

The stop pin turns off all switching to reduce EMI or ripple, and minimizes distortions passed to precision signal-chain, measurement, sensors or wireless connectivity components.

Smaller solution size: Engineers can use the new switching regulator to cut their battery count in half or use smaller batteries in their design. For example, designers can save up to 16,980mm3 using four AAAs instead of four AAs.

Flexible VIN broadens applications: The TPS62840's wide range of 1.8VIN-6.5VIN accommodates multiple battery chemistries and configurations, such as two lithium manganese dioxide (2s-LiMnO2) cells in series, single-cell lithium thionyl chloride (1xLiSOCL2), four-cell and two-cell alkaline, and lithium polymer (Li-Po).

Pre-production samples of the TPS62840 are now available in the following packages: 8-pin SON, measuring 1.5mm by 2.0mm; 6-pin WCSP, measuring 0.97mm by 1.47mm. An 8-pin thermally enhanced package (HVSSOP), measuring 3mm by 5mm, will become available later this year.

New battery charger increases battery capacity

At the same event, Samuel Wong, Product Line Manager, Battery Management Systems, introduced a new switching battery charger IC that supports a termination current of 20mA. The three-in-one switching boost converter achieves lowest quiescent current for small medical and personal electronics applications. Compared to competing devices, which typically support a termination current higher than 60mA, the new BQ25619 enables 7% higher battery capacity and longer run time. The charger delivers three-in-one boost converter integration and ultra-fast charging, too, offering 95% efficiency at a 4.6V and 0.5A output. Additionally, with the industry's lowest quiescent current, the new charger can double the shelf life of ready-to-use electronics.

The BQ25619 charger helps engineers design more efficiently for small medical and personal electronics applications such as hearing aids, earbuds and wireless charging cases, IP network cameras, patient monitoring devices and personal care applications.

Key features and benefits of the BQ25619

The industry's lowest termination current for switching chargers: An ultra-low termination current of 20mA increases battery capacity and run time by up to 7%. The BQ25619's settable top-off timer further increases run time, enabling users to charge their devices less frequently.

Best-in-class low quiescent current: The BQ25619 reduces battery leakage down to 6µA in ship mode, which conserves battery energy to double the shelf life for the device. While in battery-only operation, the device consumes only 10µA, to support standby systems.

Three-in-one boost converter integration: The BQ25619 includes integrated charge, boost converter and voltage protection to support efficient design for space-constrained applications and eliminate the external inductor required by previous-generation charger ICs. Due to its integrated bidirectional buck or boost topology, the BQ25619's charging and discharging capabilities require just a single power device.

The BQ25619, available now, expands TI's portfolio of industry-leading battery-charger solutions, offering single- and multicell switch-mode chargers for high-capacity batteries, as well as linear chargers with high integration to extend battery run time and reduce total solution size. Offered in a 24-pin wafer WQFN package, the charger is priced at USD1.45 in 1,000-unit quantities. The 30-pin BQ25618, with similar features, will be offered in a smaller WCSP in the third quarter of 2019.

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Competing Integrated GaN and Non-GaN Technologies in USB Wall Chargers

GaN brings compelling advantages in terms of efficiency for wall chargers and other power supply products, but achieving these in a cost-effective manner can be challenging.

By Sinjin Dixon-Warren, PhD, TechInsights

Navitas has had some well-publicized GaN design wins with some recent chargers, including the RavPower RP-PC104, the Made in Mind Mu One and most recently the Aukey PA-U50, which contained an integrated GaNFast half-bridge device. Power Integrations has been making inroads, with an integrated GaN design win in the Anker PowerPort PD 1. Additionally, Power Integrations has the design win in an alternate version of the Aukey PA-U-50, with a later date code. In this case no GaN devices were found.

Aukey PA-U50 24 W USB Charger with Navitas GaNFast Technology

The Aukey PA-U50 provides a 5 V output to two USB ports, with a maximum current of 2.4 A each, corresponding to the 24 W maximum output. The main printed circuit board (PCB) from this Aukey PA-U50 with GaNFast features an 1834 date code, likely corresponding to week 34 of 2018. It contains the Navitas NV6252 integrated half-bridge device, which Navitas has been actively promoting since it was initially reported at APEC 2019.

An X-ray photograph of the 650 V NV6252 integrated half-bridge found in the Aukey PA-U50 is presented in Figure 1. The X-ray shows that the NV6252 package contains two dies, namely the NV6L002 low side die and the NV6H002 high side die, which are wired together in a half bridge configuration, as shown schematically on the X-ray image. Cross-sectional analysis confirmed they are both GaN-on-Si dies.

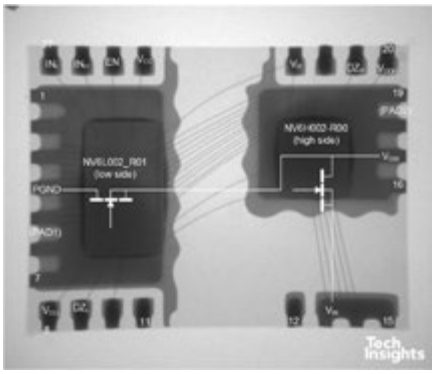

Figure 1: Navitas NV6252 Package X-ray

Manufacturer Name	Model Number	Prominent Markings	Device Type
Diodes Inc	ABS210	- + ABS210	Power Rectifier
Texas Instruments	UCC28780RTE	U28780 TI 7A8 A5HG	Other Controllers
Navitas Semiconductor	NV6252	(LOGO) Navitas NV6252 B6	GaN Power IC
CT Micro International Corporation	CT1018	CT 1018 V813K	Optocoupler
Hunteck	HGN040N06SL	(LOGO) GN040N06SL CM6A001	N-Channel FET

Table 1: Components found in the Aukey PA-U50. A transformer, two capacitors and a choke are also present on the other side of the PCB.

Figures 2 and 3 show optical photographs of the two GaN dies, after de-processing to expose their layouts at the gate level. Each features a large high electron mobility transistor (HEMT) gate array, plus a large block of peripheral analog circuitry. The integration of analog circuitry into a GaN-on-Si HEMT process is the key differentiator for Navitas' GaNFast technology. This integration is beneficial in that the device can be engineered to perform in a similar manner to a silicon MOSFET, rather than simplifying the design of the final consumer product.

Table 2 summarizes the layout of these two dies, which presents the percentage of the die devoted to the transistor gate array and to the analog circuitry. In both cases, the transistor gate array occupies about 38% of the die area. The analog circuity occupies a slightly larger percentage of the die area for the low side die as compared to the high side die. The balance of the die area, corresponding to about 20%, is unused.

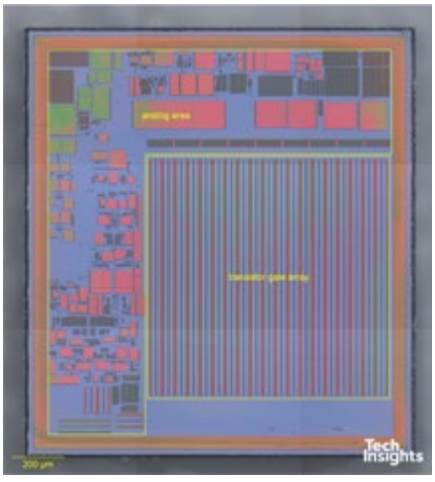

Figure 2: Navitas NV6H002 R00 High Side Die

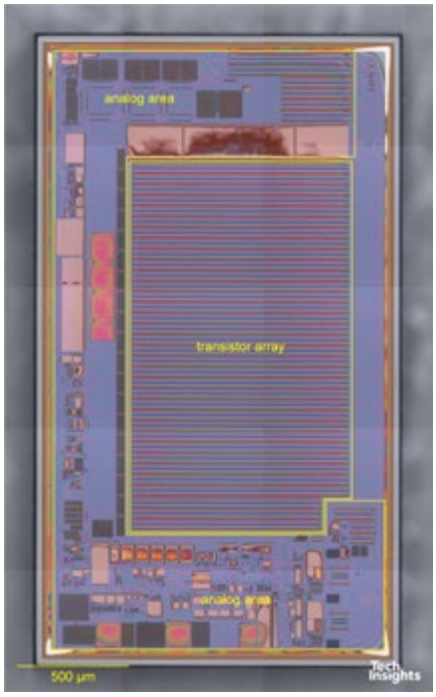

Figure 3: Navitas NV6L002 R01 Low Side Die

Navitas currently leads the market for integrated GaN technology, but they face strong competition as other existing strategies for achieving high-efficiency wall charger technology are being utilized.

Anker PowerPort Atom PD 1 A2017 USB-C 30 W Charger with Power Integrations GaN Technology Anker PowerPort Atom PD 1 is a compact 30 W USB-C charger. It delivers a range of different output voltages, including 5 V at 3 A, 9 V at 3 A, 15 V at 2 A, and 20 V at 1.5 A, as required by the USB-C power delivery standards. The PowerPort Atom PD 1 contained two PCBs. The larger PCB featured the required transformer, capacitors and a choke, while the smaller PCB featured a Power Integrations SC1933C device. Table 3 provides a list of all the devices found inside the A2017. The SC1933C appears to be part of the 650 V InnoSwitch product family.

Figure 4 shows an X-ray photograph of the SC1933C package that indicates that the SC1933C contains four dies, including the SG250F die, which was found by cross-sec-

	NV6H002 R00 High Side		NV6L002 R01 Low Side	
Block	**Area (mm²)**	**Percentage of Die**	**Area (mm²)**	**Percentage of Die**
analog area	0.94	41	2.02	46
transistor gate array	0.87	38	1.65	38
Total die utilization	1.82	79	3.67	83
Other	0.49	21	0.73	17
Total die	2.30	100	4.39	100

Table 2: Navitas NV6H002 R00 High Side and NV6L002 R01 Low Side Die Utilization

Manufacturer Name	Model Number	Prominent Markings	Device Type
Power Integrations Inc	SC1933C	SC1933C 00M7P979B (LOGO) 1	GaN Power IC
Alpha & Omega	AONS62922	(LOGO) 62922 GA8S11	Power MOSFET
Weltrend Semiconductor	WT6615F	WT6615F 000 847C 140AF	USB Controller
Diodes Inc	ABSR210	- + ABSR210 PYHDD	Power Rectifier
Excelliance MOS Corp	EMB09P03H	(LOGO) B09 P03	Transistor

Table 3: Anker A2017 Design Wins

tional analysis to be a normally-on GaN-on-Sapphire HEMT device. The DX120B3 is a silicon-based MOSFET, while the DX121C and DX002B62 are controller integrated circuits (ICs). The DX120B3 and the SG250F appear to be wired in a cascode con-figura-tion, as is commonly done for normally-on GaN transistors.

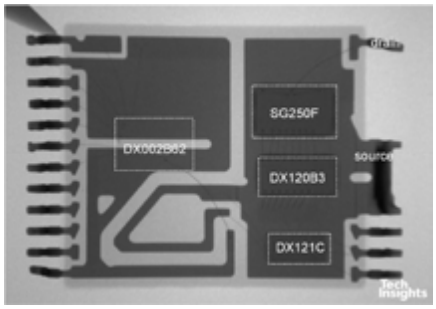

Figure 4: Power Integration SC1933C Package X-ray

Rather than integrating the driver circuitry into the GaN dies, Power Integrations have chosen to integrate conventional silicon-based driver circuitry into a single GaN-based power IC device. It is not yet clear which strategy will be more successful in the market. In the MEMS industry, some early players explored creating integrated MEMS-CMOS devices, but over time the market gradually adopted having separate MEMS and Si-based controller dies.

Aukey PA-U50 24 W Charger with Power Integrations Silicon Technology

More samples of the Aukey PA-U50 revealed that they did not contain the Navitas GaN-Fast technolo-gy found in the first sample of the PA-U50. The markings on this version are slightly different, with the earlier sample having an additional AQ145 marking; other-wise, the exterior appearance of the devices was very similar.

Manufacturer Name	Model Number	Prominent Markings	Device Type
Diodes Inc	ABS210	- + ABS210	Power Rectifier
Power Integrations Inc	INN3166C	INN3166C 13M6C672A (LOGO)	CV/CC Switcher
NCEPOWER	NCEP6080AG	(LOGO) P6080AG 1GKF1	MOSFET

Table 4: Aukey PA-U50 Design Wins

On the later Aukey PA-U50 main PCB, the date code is 1849, likely corresponding to week 49 of 2018. The Navitas NV6252 is not found on this PCB. Further inspection of the back side of the PCB shows a Power Integrations INN3166C, which is part of their InnoSwitch-CE family of devices, located beneath a capacitor. The INN3166C is an off-Line CV/CC QR Flyback Switcher IC with an integrated 650 V MOSFET. Table 4 list the devices found inside this second version of the Aukey PA-U50. This design required only three packaged silicon devices to create the charger.

Concluding Commentary

The wall charger market is an area of con-siderable innovation, largely driven by the demands of gov-ernment energy efficiency regulation, combined with a desire amongst consumers for more compact and more efficient charging technologies. Gallium nitride has potential in this market to be a disruptive technology; however, the issue is clearly not settled as silicon-based devices continue to feature prominently. The cost of using GaN in AC adapters continues to drop as the technology matures, which may help to strengthen its position and increase use in this market.

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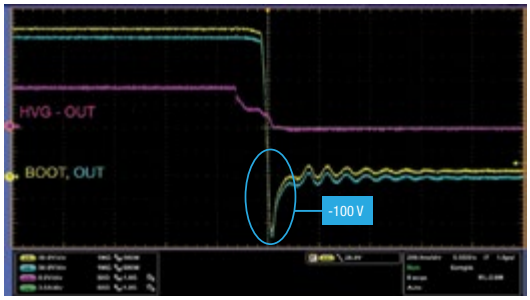
STDRIVE601	SO-28	0.35/0.20	300	9-20	3.3, 5	50	85	Integrated bootstrap diodes, smart shutdown, comparator, under-voltage lock-out, interlocking function	600



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High Voltage Family of Controllers Reduces DC-to-DC Converter Cost and Size

LTC3892 is a versatile controller, widely used in automotive and industrial applications. The main advantages of this controller are the ability to reduce power losses by adjusting the gate voltage of switching MOSFETs and extremely low quiescent current—3.6 µA at shutdown. This is a high voltage family of controllers with an input/output voltage range of 4.5 V to 60 V. It's very attractive for industrial customers because it can replace costly, bulky transformers in 48 V input rail applications with less expensive, compact step-down converters.

By Victor Khasiev, Senior Applications Engineer, Analog Devices, Inc.

High voltage controllers significantly reduce the cost of automotive electronics in 12 V and 24 V input rail applications by eliminating external transient and overvoltage protection circuitry, which simplifies the entire design.

Circuit Description and Functionality

Figure 1 illustrates a dual out, step-down converter with VOUT1 5 V at 8 A and VOUT2 12 V at 5 A. It features the LTC3892, a controller that comes in a 32-lead QFN package and that provides the following functions: selection options by the ILIM pin current sense voltage, pin VPRG1 that can set the output voltage to 3.3 V or 5.0 V without the external resistor divider, and power good pins for both outputs. LTC3892 also provides output overvoltage protection for both channels by turning on the bottom MOSFET in case of overvoltage. This chip provides protection from short-circuit conditions by implementing foldback current limiting.

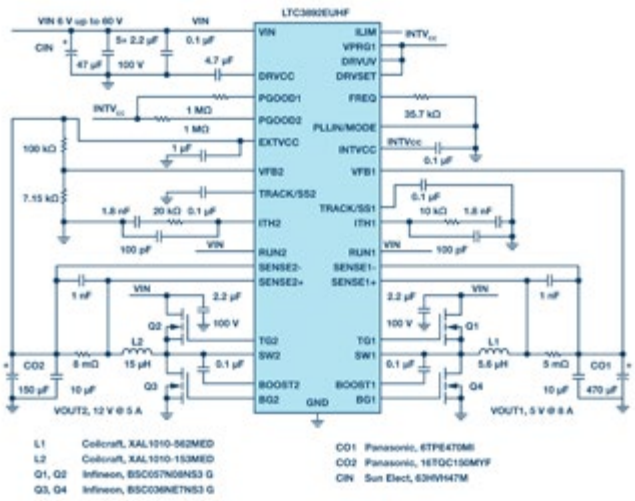

Figure 1: Electrical schematic of LTC3892 in a dual output dc-to-dc converter where VOUT1 is 5 V at 8 A and VOUT2 is 12 V at 5 A.

The power train of the first channel includes MOSFETs Q1, Q4, inductor L1, and an output filter based on CO1. The power train of the second channel includes MOSFETs Q2, Q3, inductor L2, and an output filter based on CO2. The MOSFETs are not logic level and pins DRVUV and DRVSET are tied to INTVCC to provide a 10 V gate drive. Pin VPRG1 is tied to INTVCC to select a 5 V output voltage on the first channel. Figure 2 shows the converter's efficiency. DC1998A was used for testing.

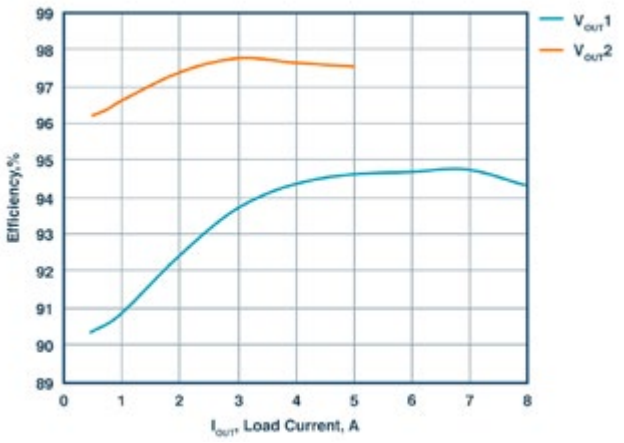

Figure 2: Efficiency curves of the dual output dc-to-dc converter.

Figure 3 illustrates a single output, dual phase step-down converter. It features LTC3892-2, a controller that comes in a 32-lead QFN package and provides features similar to those of LTC3892. However, two protection circuits are disabled: there is no overvoltage protection, nor is there protection from the short-circuit disable circuit. This chip can be used in high power battery charger applications where these protection features are not used and not desirable. Another advantage of the LTC3892-2 is its ability to support the pulse-skipping mode of operation while synchronizing to the external clock. This increases efficiency during light load operation.

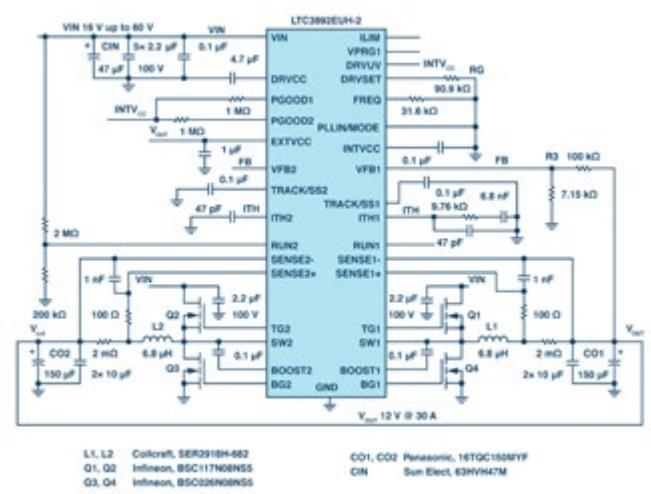

Figure 3: Electrical schematic of LTC3892-2 in a single output dc-to-dc converter where VOUT is 12 V at 30 A.

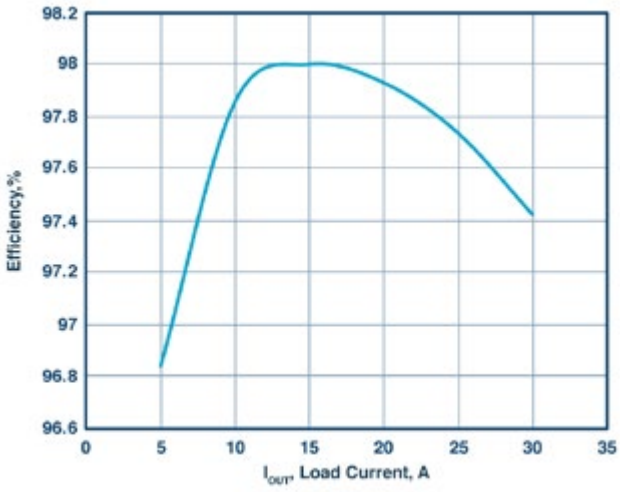

Figure 4: Efficiency curves of the single output dc-to-dc converter.

To convert the dual output controller to a single output, the ITH, FB, and RUN pins of one channel are connected to the corresponding pins of the second channel. To minimize gate losses, the gate voltage of DRVCC is selected as 9 V by setting resistor RG off the DRVSET pin. Figure 4 presents the efficiency of the single output converter. DC2493A was used for evaluation.

The last IC in the family is LTC3892-1. This chip has a smaller pin count, comes in a 28-lead TSSOP package, has no PGOOD function, and it has no selectable current limit, but it provides overcurrent and overvoltage protection.

Conclusion

The LTC3892 family of controllers can be successfully used in high input/output voltage, high power applications. LTC3892 and LTC3892-1 provide a full range of protection features needed for design fully functional dc-to-dc converters. LTC3892-2 is a good choice for employment in high power charger applications.

Victor Khasiev is a senior applications engineer at ADI. Victor has extensive experience in power electronics both in ac-to-dc and dc-to-dc conversion. He holds two patents and wrote multiple articles. These article related to ADI semiconductors in automotive and industrial applications. They cover step-up, step-down, SEPIC, positive-to-negative, negative-to-negative, flyback, and forward converters, as well as bidirectional backup supplies. His patents are about efficient power factor correction solutions and advanced gate drivers. Victor enjoys supporting ADI customers: answering questions about ADI products, the design and verification of power supplies schematics, and the layout of the print circuit boards; troubleshooting; and participating in testing final systems.

www.analog.com

Rectifier Package Development

Smaller and lower profile rectifier packages with more advanced processes achieve zero defects

Since the introduction date of the SMA/SMB/SMC rectifiers in 1990 designers have complained about their height. The SMA/B/C packages were initially Transient Voltage Suppressors (TVS) packages and their thermal design was not optimized. The rectifier industry just started using them because they were available at the time and customers wanted to avoid soldering MELFs.

By Jos van Loo, Taiwan Semiconductor Europe

The maximum possible die size in the SMA package is 1.75mm (square die). However most products sold in an SMA have a 1.25mm die. In this case the die / package size ratio is just over 10%.

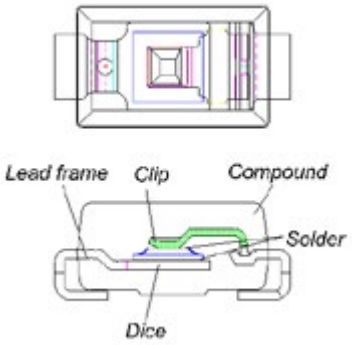

Figure 1: (a) SMA Package (b) SOD-123W package

Newer packages with flat leads and exposed solder pads transport the heat more efficiently and waste less space on a PCB. The same 50mil die from an SMA can also be manufactured in an SOD-123W package. The die / package footprint ratio is now > 20%. The heat is directly transferred out of the package. An added benefit is the height reduction of 2.5mm for the SMA to 1.02mm for the SOD-123W

So existing die and new die, currently used in SMA/B/C packages, can now be placed in smaller packages. A lot of combinations are possible, depending on the product and the application but in general the SMC package can be replaced by the TO-277A/SMPC package, the SMB can be replaced by the SOD-128 and the Thin SMA, and the SMA by the SOD-123W, and the SOD-123HE.

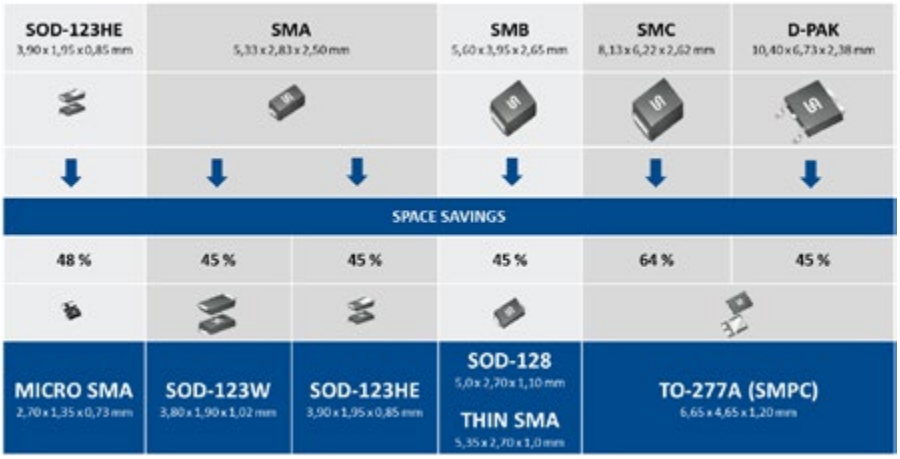

Figure 2: Smaller solutions by Taiwan Semiconductor for selected SMD-Packages

The transient thermal resistance and the thermal resistance / power dissipation in the application will determine if a size reduction is possible.

ABSOLUTE MAXIMUM RATINGS OF RECTIFIERS

Tj= Ta+ Pd*Rthj-a is the most important equation when designing with rectifiers. The absolute maximum ratings of a rectifier are the Tj (junction temperature), the Ifsm surge current and the maximum breakdown voltage. The current rating and power dissipation (as well as current derating curves) are determined by marketing and designers who choose the size of the solder pads / PCB materials (Thermal Resistance). The Junction temperature is linked to the power dissipation (Pd) and the Thermal Resistance Rthj-a. So both package design and die technology contribute. The Ifsm surge current is mainly linked to the die size and the Zth. The breakdown voltage is determined by the die. In a TVS, the maximum peak power dissipation is linked to the die and the Zth.

Transient Thermal Impedance

The Transient Thermal Impedance of a Rectifier and a TVS diode is rarely discussed. Lightning strikes, 8/20us pulses or capacitive inrush surge currents (in AC/DC conversion designs) are single pulse events, not repetitive. The product either survives or fails. The capability of a product to handle these surges is mainly dependent on the die size and the quality of the solder joint. For surges of 1ms or less, it is possible to reduce the package size without any degradation of the electrical performance if you keep the die size the same.

TVS diodes don't really follow the Tj= Ta+ Pd*Rthj-a formula if we assume that the application is a single pulse event. They have a Peak Power Rating of eg 400W linked to a certain pulse – in most cases a 10/1000µs exponential waveform. The Tj max may be briefly exceeded during this test – the product has to survive the test without damage. The product capability is determined by the die size. The new packages introduced have

a better die size to footprint ratio so product miniaturization is straightforward if you keep the die size the same.

The 1N4007 series or S1 series of standard rectifiers are some of the most common products used in low power AC/DC conversion. Billions of these rectifiers are manufactured every year. In an input bridge of a Flyback Converter < 20W, the power dissipation is quite small (<100mA) . Their limiting factor is the IFSM surge rating. When the die from an S1 is placed in a smaller package, the IFSM rating may stay the same. For AC/DC applications, the S1 can be routed on both sides of the PCB. A surprising amount of rectifiers are routed on the bottom of the PCB, on the wave soldering side, and here the lower height is most beneficial.

Thermal Resistance

The thermal resistance Rthj-a Junction to Ambient consists of 2 parts: a package related part and the contribution made by the solder pads – determined by the designer. In most designs on a single layer FR-4 PCB , the solder pads make by far the largest contribution to the total thermal resistance. This makes miniaturization difficult if a lot of power is dissipated. Very few designers use 5x5mm solder pad areas, typically used in datasheets to determine the thermal resistance. They tend to use the suggested solder pads for soldering, which are smaller (in some cases just 10-20% of the 5x5mm solder pads used to measure the thermal resistance) Expect an increase of 10 to 15K/W in Rthj-a

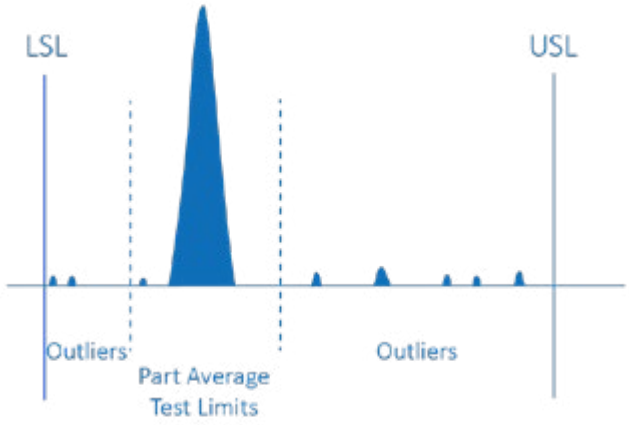

Figure 3: Part Average Testing

Two layer and 4 layer PCBs, thermal vias, and IMS substrates are options to make overall Rth less dependent on very large size solder pads. New rectifier packages with exposed pads can help in reducing board space in relation to the power dissipated. They also reduce the Tj by reducing Rthjl, improving reliability. Current ratings of especially Schottky diodes have been increasing in small packages. This does not mean that designers can use these packages at higher currents – but the power losses can be reduced by 10-20% due to the bigger die and the lower Vf. In the formula Tj = Ta + Pd * Rthj-a it becomes immediately clear that you cannot increase power dissipation without reducing thermal resistance (for a given package). Increasing the Tj would reduce your reliability. Trench Schottky technology is a major contributor to the package size reduction and increased efficiency.

Zero Defects

Rectifiers are mainly produced using GPP processes and in 4 inch fabs. Huge steps forward have been made in reliably producing rectifiers. TSC now manages a ppb level less than 10ppb on its rectifier products. Rectifiers are older components. The 1N4007 was introduced in 1965. The S1 is more than 30 years old. A very important contribution to a zero defects strategy is Part Average Testing (PAT). The test specifications on the main parameters are set to 4 or 6 sigma values by software. Especially on the leakage currents, datasheet values do not reflect the natural distribution. Even if Ir testing is reduced to 1µA instead of the 5µA datasheet value, a lot of products with potential mechanical damage, passivation problems and contamination issues can be shipped to customers. These products have a reduced reliability and may produce early HTRB or Intermittent Op Life failures. PAT testing eliminates these.

In AC/DC conversion applications, no 100% OQC test is possible to monitor Ifsm – the surge rating – of a rectifier. A Delta Vf test (measuring the Vf before and after a short current pulse) monitors the thermal resistance and eliminates the worst soldered devices. When SMA devices were first introduced they were manufactured using belt furnaces for soldering. These processes had inherent issues with solder voids and fluctuations in Ifsm surge capability. New backend soldering improvements with matrix lines / vacuum soldering eliminate these risks. The SMD packages discussed are now manufactured using fully automated equipment in a cleanroom environment. This is also a major contributor to achieving zero defects.

About the author:
Jos van Loo is a technical expert for Power Semiconductors for more than 30 years. In his role as Technical Support Engineer at Taiwan Semiconductor Europe GmbH, Jos consults customers on Rectifiers, MOSFETs and Power Management ICs.

Extended Resistance Range Opens Up New Applications

Susumu has expanded the resistance range of the RG series by using a new high-impedance material, adjusting the pattern and a more precise trimming

For applications in automotive electronics, medical technology or measuring and testing technology, high-precision and reliable resistors are required. Thin-film chip resistors are particularly suitable for applications exposed to harsh environmental conditions due to their excellent electrical properties and high long-term thermal stability.

By Ryuji Hayashi, Susumu Germany

These resistors are composed of thin metallic layers, which are usually deposited by sputtering. The layer thicknesses range from ten to a few hundred nanometers. The electrical properties of thin-film chip resistors depend on various factors.

In the case of metals that are formed into a layer on basis of a thin film process by sputter deposition, the specific resistance is not a pure material constant, but depends on the deposition process, the underlying substrate and the layer thickness.
This stands in contrast to massively processed metals. For example, the resistance and TCR of a thin film resistor depend on the conditions during and after the deposition process. Of course, the material used is also decisive for the quality of the resistance. Pure metals as well as alloys and compounds of metals are used. The temperature coefficient can be adjusted by selectively introducing external atoms, e.g. in the case of alloys.

Susumu's RG series of thin film chip resistors, launched in 2003, established a standard thanks to its exceptional resistance to high temperatures, humidity and contamination. Furthermore, the RG series features low noise, excellent long-term stability and resistance tolerances of ±0.01 % to ±0.5 %. The high precision and reliability is due to a special inorganic passivation, which Susumu, a renowned specialist for thin-film technology, introduced with this series. By skillfully adjusting various parameters, Susumu has now been able to extend the resistance range of the series. The highest value for the resistor RG2012 was 1 MΩ. Now this resistor is available with up to 2.7 MΩ. Also the limit of the RG3216 was 2 MΩ. This value was even extended to 5.1 MΩ. Moreover 10 MΩ.is now on request. Further improvements can be found in Table 1.

Product	Old absolute value	New absolute value	Extension
RG1005 (0402 inch)	100 kΩ	150 kΩ	1,5-fach
RG1608 (0603 inch)	360 kΩ	1 MΩ	2,8-fach
RG2012 (0805 inch)	1 MΩ	2,7 MΩ	2,7-fach
RG3216 (1206 inch)	2 MΩ	5.1 MΩ	2,5-fach

Table 1: Extension of the resistance range of the RG series

Susumu had already developed a special NiCr alloy for the RG series. A new high-resistance material is used for the series with higher resistance values. The length of the traces also allows determining the value of the resistance. Using photolithographic methods, Susumu is now able to produce even finer structures:

A further feature of resistors in thin-film technology is the possibility of adjusting the absolute value of the resistor by laser trimming. For this purpose, various structural patterns - from coarse to fine - are trimmed one after the other and sometimes several times in order to get closer to the desired value step by step. By skillfully adjusting these factors, Susumu has succeeded in extending the resistance value of the RG series. Although a different material was used than in the NiCr-based series, the high-impedance series has the same excellent electrical properties (Table 2). The protective, inorganic passivation already implemented in the old RG series makes this possible.

These resistors meet the needs of customers who require reliable thin film chip resistors with high precision and excellent stability. An

exemplary application is the battery management of 48-volt lithium-ion batteries in the automotive sector.

In order to meet even higher requirements, Susumu created the URG series. On the one hand, the tolerance was reduced to +- 0.01 %, whereby the TC amounts to only 1 to 2 ppm/K. The resistors available in sizes 0603 to 2512 with rated powers from 0.063 to 0.75 W at 100 to 300 V in the range - 55 to + 155 C cover the range from 10 Ohm to 200 kOhm.

At the same time, a higher reliability than known from RG is achieved according to Susumu. So the drift is less than +- 0,02 %. The main fields of application are precision measuring technology, medical technology, industrial electronics and automotive electronics.

Susumu has been offering innovative and high quality thin film resistors for all areas of the electronics industry since 1964. As a specialist in thin-film technology and one of the world's largest manufacturers, the company offers a wide range of high-quality components, including chip resistors, chip networks, precision resistor networks, chip inductors, delay lines, power inductors and current sensors.

www.susumu.de

◆Electrical Specification

Type	Power ratings			Temperature coefficient of resistance	Resistance range(Ω) Resistance tolerance(%)				Maximum voltage	Resistance value series	Operating temperature	Pakaging quantity
	Low	Regular	High	(ppm/°C)	±0.02% (P)	±0.05% (W)	±0.1% (B)	±0.5%(D)				
RG1005	1/32W	1/16W	1/8W	±5(V)	100≤R<3k				75V	E-24, E-96	-55℃ ~ 155℃	T5 T10
				±10(N)	100≤R<3k	47≤R<100k						
				±25(P)	100≤R<3k	47≤R<100k		47≤R<150k				
				±100(R)	–	–	–	10≤R<47				
RG1608	1/16W	1/10W	1/6W	±5(V)	100≤R<5.1k				100V			T5
				±10(N)	100≤R<5.1k	47≤R≤270k						
				±25(P)	100≤R<5.1k	47≤R≤270k	47≤R≤332k	47≤R≤1M				
				±50(Q)	–	–	–	10≤R<47				
RG2012	1/10W	1/8W	1/4W	±5(V)	100≤R<10.2k				150V			
				±10(N)	100≤R<10.2k	47≤R≤475k						
				±25(P)	100≤R<10.2k	47≤R≤475k	47≤R≤2.7M					
				±50(Q)	–	–	–	10≤R<47				
RG3216	1/8W	1/4W	–	±5(V)	100≤R<33.2k				200V			
				±10(N)	100≤R<33.2k	47≤R≤1M						
				±25(P)	100≤R<33.2k	47≤R≤1M	47≤R≤5.1M					
				±50(Q)	–	–	–	10≤R<47				

Table 2: Electrical specifications of the new RG series with higher resistance values

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PSMA Power Sources Manufacturers Association The Multinational Power Electronics Association

Buck-Boost DC/DC Converter

ROHM announced the availability of a buck-boost DC/DC converter with integrated MOSFET, the BD83070GWL. It combines unmatched efficiency with best-in-class current consumption, making it ideal for IoT, wearables, and portable devices. In recent years, the proliferation of battery-driven electronic devices has increased the demand for smaller components that can provide the necessary design flexibility and space for integrating new functions while minimizing power consumption to maximize battery life. In response, ROHM developed a power supply IC that meets market needs by leveraging a vertically integrated production system utilizing in-house analog design expertise and specialized power processes. At the same time, high efficiency ultra-low-power boost (BU33UV7NUX) and buck (BD70522GUL) power supply ICs are available that allow users to significantly extend the operating time of battery-powered applications. With the BD83070GWL, ROHM expands its offering with a buck-boost IC featuring industry-leading performance.

The BD83070GWL was developed to be the best-in-class product for low power eco-friendly devices used in compact battery-driven applications. The built-in low-RDS(on) MOSFET and low control current circuitry achieve an industry-leading power conversion efficiency of 97% during operation (@ 200mA load current) along with class-leading 2.8µA quiescent current consumption. This contributes to longer operating time in compact battery-driven devices, prolonging battery life by as much as 1.53 times when compared to other conventional products during standby (100µA load current). An evaluation board integrating this converter is also available.

www.rohm.com

Low-Inductance Film Capacitors

Film and foil capacitors of the Coax Cap series are designed for extremely low inductance, a very high current carrying capacity, and good self-sealing properties. The capacitor manufacturer FTCAP – part of the Mersen Group since 2018 – offers the time-proven high-current capacitors not only as the CX type for extreme perfor-

mance requirements, but also in the cost-optimized CS version. The film capacitors of the CX and CS series from FTCAP are available in five different heights from 40 mm to 100 mm and a broad selection of capacitances from 20 µF to 830 µF with voltage ratings from 600 V to 1900 V. “The classic applications include DC filters”, explains André Tausche, managing director of FTCAP. “In general these high-current capacitors, due to their low inductance coefficient, are a good choice for applications with high ripple frequencies or pulse discharges.“ For less extreme performance requirements FTCAP offers the CS version, which due to the less stringent performance requirements also offers the advantage of a lower price. Compared to the CX type these film capacitors have a lower current carrying capacity and higher inductance, which makes them a good choice for standard requirements.

www.ftcap.de

Regulated 1-3W DC/DC Converter

MORNSUN launched an ultra-compact size DC/DC converter series WRB, which features 2:1 wide input range, operating temperature range of -40°C ~+85°C, and 1500VDC isolation voltage. What’s more, the size is 40% smaller than general products. Packages are available in SMD and DIP. In addition, its continuous short circuit protection can ensure the safety performance of back-end circuits.

Widely used in communication, instruments, industrial control applications.

www.mornsun-power.com

Modules with CoolSiC MOSFETs for EV Charging and UPS

Production numbers of electric vehicles (full and hybrid) are rapidly increasing. With that, the demand for energy efficient charging solutions is also rising. Addressing the fast growing demand for Silicon Carbide (SiC) solutions in this field, Infineon Technologies AG launched two new EasyPACK modules of the 1200 V family. Both, Easy 1B and Easy 2B, integrate CoolSiC™ MOSFETs aiming not only at this market but also at UPS applications.

Coming in two different topologies the power modules enable engineers to increase their systems' efficiency for reduced cooling effort. In addition, higher frequency operation is possible. Integrated in an Easy 1B housing the four-pack topology (F4-23MR12W1M1_B11) perfectly serves the DC/DC stage of the charging station. The Easy 2B (F3L15MR12W2M1_B69) holds a three-level configuration that is well suited for the Vienna Rectifier usually implemented in this application for the PFC stage. In combination, the power modules can be used for 50/60 kW EV charging solution.

The EasyPACK standard package for power modules is characterized by an low stray inductance. This helps in building up stacked modular solutions for charging which can go up to 120/150 kW. The NTC temperature sensor, which is also featured in the Easy modules, facilitates the monitoring of the device, while the PressFIT technology reduces assembly time for mounting the device.

www.infineon.com

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600W Medical and Industrial Programmable Power Supplies

TDK Corporation announces the introduction of a ruggedised option to the GXE600 series of 600W rated programmable AC-DC power supplies. The GXE600/HD meets MILSTD810G shock and vibration and is safety certified to both the IEC 60601-1 medical and IEC 62368-1 industrial standards. These convection cooled 1U high products can be programmed digitally across a wide range using an RS-485 interface (Modbus RTU protocol) or with a 06V external voltage. Target applications are harsh environment medical and industrial equipment requiring quiet operation, fan-less cooling with constant voltage and constant current programmability.

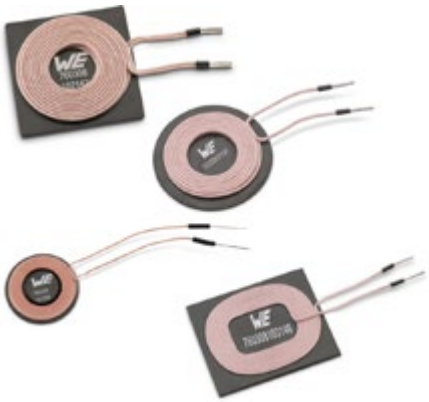
The series is available with a 24V or 48V nominal output supply and can be programmed to provide a constant voltage, constant current (CVCC) source. The voltage adjustment range is from 20 to 120% and the current from 20 to 100%. Protection and recovery parameters can be set, as can the rise time slew rate. Via the digital communications interface, the power supplies can also indicate the estimated remaining electrolytic capacitor lifetime, operating run-time and alarm history to enable remote preventative maintenance indication or fault finding.

The power supplies operate from a wide-range input of 85 to 265Vac with an earth leakage current of <300µA and dual fuses as standard. They can be used in ambient temperatures of 20°C to +70°C (40°C start up), derating linearly above 50°C to 50% load at 70°C.

www.emea.lambda.tdk.com

Charging e-Bike Batteries Without a Cable

Wireless battery charging is a comfortable and maintenance-free affair. Companies wishing to tap these advantages for the market of e-bikes and other small electrical vehicles can now turn to Würth Elektronik for development and component support. For many years now, the supplier of electronic and electromechanical components has been actively participating in many committees for the wireless power sector, and possesses one of the largest portfolios of coils for inductive power transmission worldwide. Besides standard solutions – for example according to the Qi standard – Würth Elektronik also offers solutions for many other applications, with a special focus on technology for charging battery packs for electric vehicles. Würth Elektronik emphasizes that three



popular misconceptions about wireless power are unfounded – for example, that wireless charging suffers from a low electrical efficiency. When the recommended position of the device is even only roughly adhered to – an aspect that can be enhanced by the mechanical design – then the efficiency is about 95 per cent. What's more, the fear of getting an electric shock or suffering burns is also unfounded: the industrial standards prescribe an automatic switch-off device that cuts in as soon as a foreign body gets between the charging coil and the receiver coil. The technical effort required for this is minimal.

And wireless power is not expensive: the plug and socket are replaced by wireless power coils and a slightly more sophisticated electronics, which ultimately can even result in a cost-neutral solution.

www.we-online.com

Power Capacitors Run Cool at High Power Density

Celem's co-axial, water-cooled C-Cap capacitors (distributed by Eurocomp) compensate for electromagnetic fields that significantly reduce power dissipation and increase power density, resulting in more kVAr per volume. The capacitors have a unique pattented structure that prevents the occuring of hot spots thus enabling to double the allowed power density per capacitor. Beside its low losses and double the power density, C-Cap enables easy tapping for switching between capacitance values, it features an easy mounting from one side of a very simple bus bar assembly. C-Cap comes in various values of capacitances and voltages, ranging up to 85uF in a single capacitor and up to 3600Vrms in a single capacitor. For customers who want to easily test the C-Cap benefits Celem can supply two turnkey mounting systems to mount the capacitors in parallel or in a serial-parallel combination. Both models of the mounting system allow hot-swapping of capacitors and include an integrated water cooling system. In addition, Celem has developped a very simple modular mounting system for the above mentioned capacitors. This modular assembly can accommodate from a few to a hundred capacitors in various parallel and series combinations. Logic-controlled switches can be used to switch on and off any capacitors of the modular mounting system.

www.celem.com

Simplify Power Delivery with Two USB-PD Solutions

USB Type-C has become increasingly popular, and with the introduction of Power Delivery (PD), it is now possible to charge more types of devices – and charge faster – than ever before. To remove the traditional complexity and high costs associated with implementing USB Type-C, Microchip Technology announced two solutions that simplify USB Type-C PD for a range of applications.

As one of the industry's first USB-IF-certified USB 3.1 SmartHub devices with integrated support for Power Delivery (TID1212), the USB705x family enables fast device charging and introduces unique PD implementations called HostFlexing and PDBalancing. The UPD301A is a standalone USB Type-C PD controller that significantly simplifies the implementation of basic USB Type-C PD charging functionality, making it ideal for applications from rear seat charging in vehicles to portable equipment to public charging stations. With smartphones increasingly requiring more than standard BC 1.2 power, designers of electronic systems need to be able to easily implement basic high-powered charging in systems. The UPD301A provides a simple, standalone solution for implementing USB Type-C PD charging in a variety of applications. The device supports both single- and dual-port operation and uses a pin-configurable implementation that focuses on ease of use. The UPD301 complements Microchip's expansive family of USB hubs and enables solutions from charge-only to full data, video and power management.

www.microchip.com

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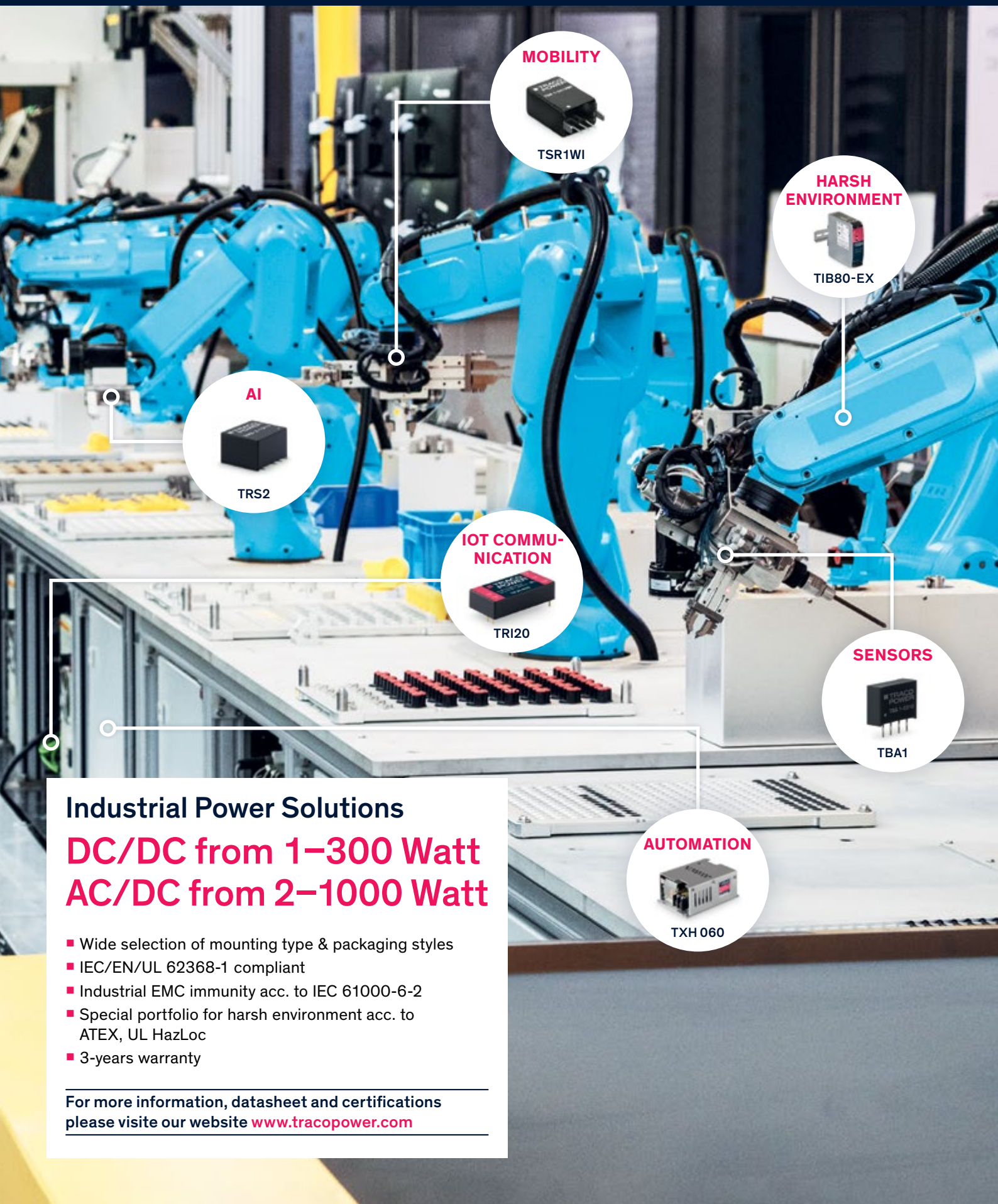

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Power Supply Reference Designs

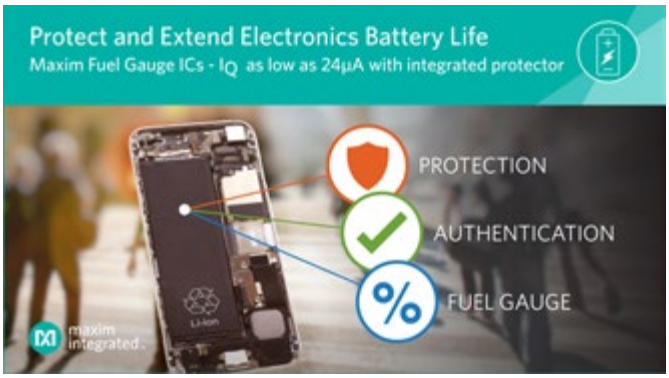
Two RECOM railway power supply reference designs, available now at Dengrove Electronic Components, solve engineering challenges including filter layout for EN 50121-3-2 EMC compliance and surge

prevention meeting the UK RIA12 specification. The R-REF04-RIA12-1 board targets high-voltage applications up to 110V, while the R-REF04-RIA12-2 is built to handle DC input current up to 10A. Both are input-side fused and can be used with single-output DC/DC converters up to 45A. The boards feature a universal pinout for 2" x 1", quarter-brick and half-brick standard case sizes, giving users the flexibility to choose from converters of various power ratings up to 240W. RIA12 surge protection is provided using an active input-voltage clamp featuring a surge-stopper IC, which acts quickly to block surge voltages up to 385VDC. The clamp circuit also provides inrush current limiting. The boards provide a nominal value of hold-up capacitance, with connectors to add extra capacitance if required. The input, output, and hold-up connections feature easy-to-use cage-clamp terminals, and there are isolated connections for fan power and system enable. Dengrove is now stocking the reference boards as well as a broad selection of applicable RECOM DC/DC converters, and can provide selection advice to support customers' projects.

www.dengrove.com

1-Cell Fuel Gauges for 2-Level Li-ion Battery Protection

Designers concerned about battery safety now have access to the most advanced battery protector with integrated fuel gauges from Maxim Integrated Products, Inc. The 1-cell, pack-side ICs in this portfolio are the MAX17301 and the MAX17311, which offer configurable

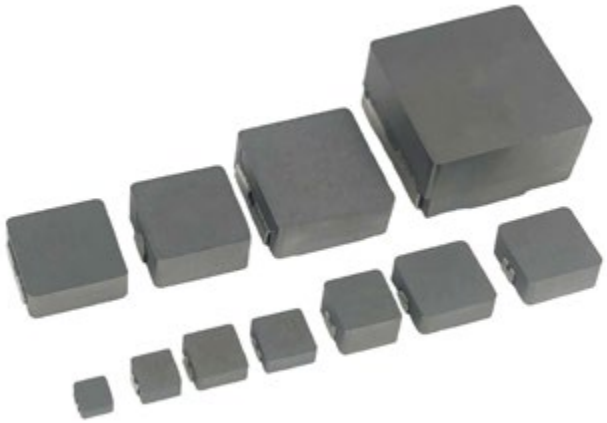


settings for battery safety and allow fine tuning of voltage and current thresholds based on various temperature zones. These ICs also offer a secondary protection scheme in case the primary protection fails. This secondary protection scheme permanently disables the battery by overriding a secondary protector or blowing a fuse in severe fault conditions. All ICs in the family are equipped with Maxim's patented ModelGauge m5 EZ algorithm that delivers highest state-of-charge (SOC) accuracy that on average offers 40 percent better accuracy than competitive offerings and eliminates the need for battery characterization. These fuel gauges also offer the industry's lowest quiescent current (IQ) – up to 80 percent lower than the nearest competitor, and feature SHA-256 authentication to safeguard the systems from counterfeit batteries.

www.maximintegrated.com

High Current Power Inductors

Power management company Eaton launched its automotive grade HCM1AV2 product line of high current power inductors designed for the transportation market to address increased power conversion and filtering requirements. The HCM1AV2 is tested beyond AEC-Q200 Grade 1 requirements for added reliability and confidence desired by most automotive engineers. "As the electronics content in vehicles continues to increase, so does the challenge to provide reliable power management with less space, more weight restrictions, and performance stability under extreme ambient conditions" said Steve Subiry, global product manager, Eaton. "The HCM1AV2 meets the stringent requirements of the automotive industry, enduring a wide temperature range, high humidity, electromagnetic interference (EMI) and increased mechanical shock and vibrations, providing enhanced reliability."



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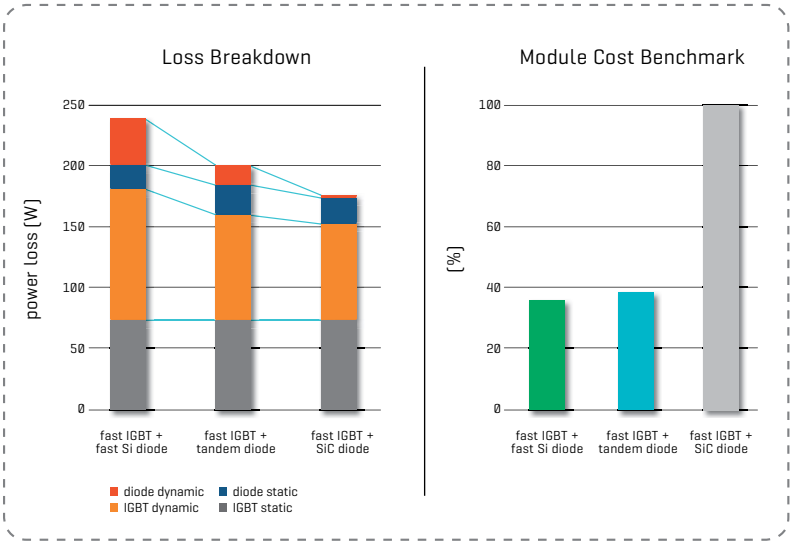
- 650 V diodes in **tandem configuration** cut the switching losses even further
- Integrated thermal sensor makes it so much easier and cheaper to measure temperature
- Kelvin emitter enhances current control and switching performance
- Standardized footprint for easier and cheaper PCB design



www.vincotech.com/pack-1

EMPOWERING **YOUR IDEAS**

High-Specification Auto-Ranging Power Supplies

RS Components (RS) has announced a series of 200W and 400W high-specification and high-quality power supply units from Keysight Technologies. The E36200 series of single- and dual-output DC PSUs has been designed for applications that will require more power than that delivered by typical benchtop power units. Primarily targeting use by engineers who are designing and testing devices that will use high currents, key applications will include: usage in electronics labs for the testing of components such as DC-DC converters, LED lighting drivers, sensors and connectors; automotive device testing at 12V, 42V and 120V; development of high-power portable devices such as power tools, robotics and industrial monitoring systems; and wide deployment in the aerospace and defence market sectors for the testing of various avionics systems, for example. Incorporating many of the advanced features of the E36300 series and offering low output ripple/noise and several layers of device protection, there are four auto-ranging DC power supplies in the 36200 series: the 200W units are the E36231A (30V, 20A) and the E36232A (60V, 10A); and the 400W units are the dual-output E36233A (30V, 20A) and the dual-output E36234A (60V, 10A). All the models are fully programmable and come with USB, LAN, optional GPIB and a digital I/O interface.

https://uk.rs-online.com

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Power Electronics is rapidly moving towards Wide Bandgap Semiconductors, as the key for the next essential step in energy efficiency lies in the use of new materials, such as GaN (gallium nitride) and SiC (silicon carbide) which allow for greater power efficiency, smaller size, lighter weight and lower overall cost.

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