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Bodo´s Power Systems®

Electronics in Motion and Conversion

November 2017

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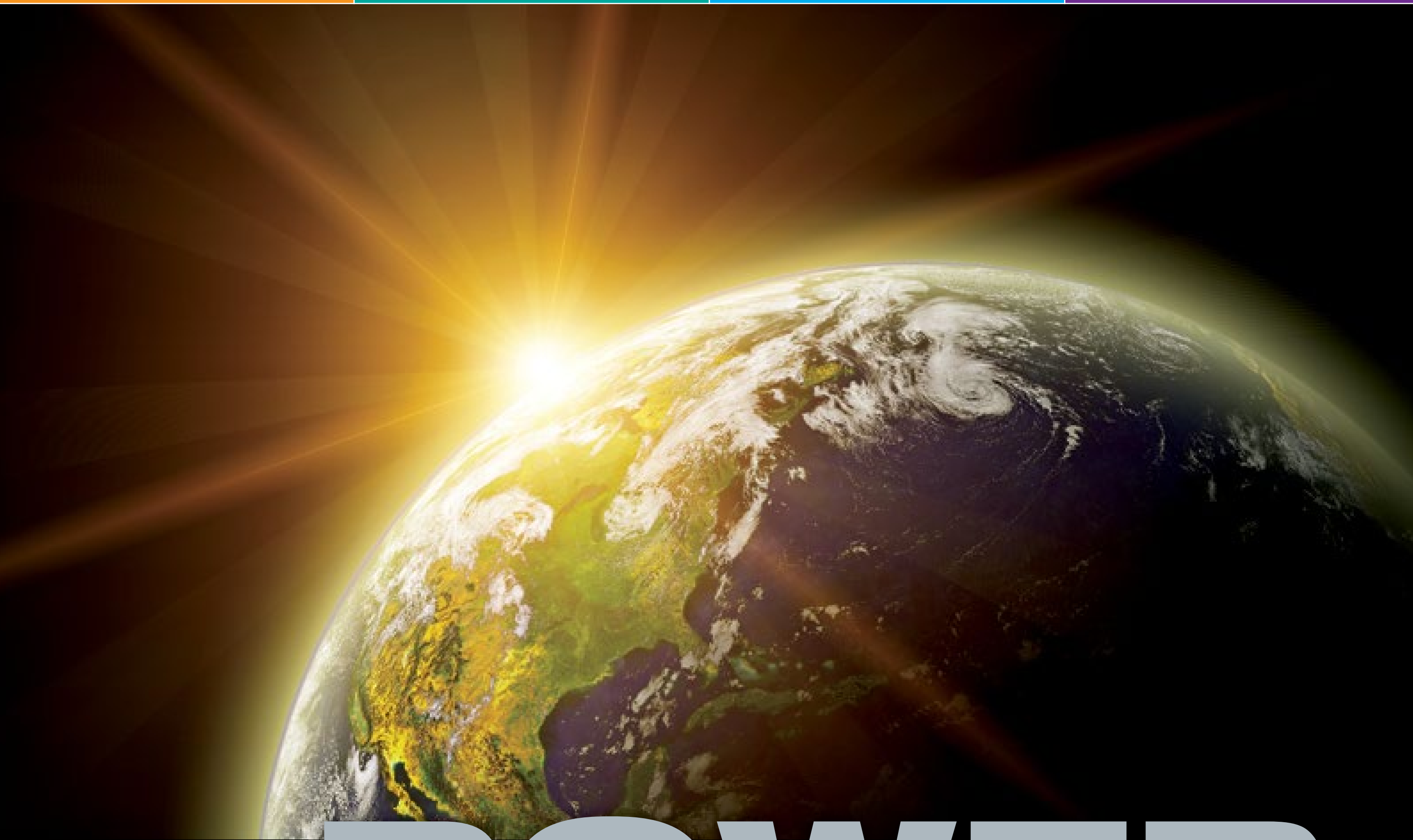

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GvA Power Electronics


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The Gallery

REDFIT IDC is a solderless reversible direct plug-in connector with SKEDD technology and insulation displacement connection. The SKEDD contacts are plugged directly into the plated through-holes of a PCB.

A complete part and a potential error source is eliminated. This results directly in higher process reliability, savings in space, material and process costs.

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- IDC Connection
- Solderless Solution
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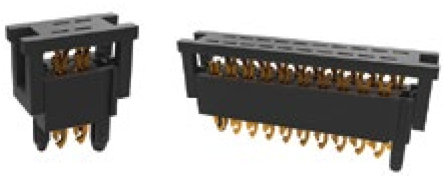
- Min. 10 Mating Cycles
- Reverse Polarity Protection

www.we-online.com/REDFIT



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Events

CWIEME Istanbul 2017
Istanbul, Turkey, November 2-4
www.coilwindingexpo.com/istanbul

SEMICON Europe 2017
Munich, Germany, November 14-17
www.semiconeuropa.org

productronica 2017
Munich, Germany, November 14-17
www.productronica.com

sps ipc drives 2017
Nuremberg, Germany, November 28-30
www.mesago.de/de/SPS/home.html

Power Electronics Conference 2017
Munich, Germany, December 5
www.power-conference.com

The Show Must Go On

Despite recent disasters, like in Houston TX, Key West FL, or the massacre in Las Vegas, we must continue to do our jobs. My condolences go to the families who lost their loved members in the Las Vegas shooting. Both disasters are man-made. Hurricanes are getting stronger through man-made global warming. We all must help to make the world a safer place. Automatic weapons must be banned everywhere in the world. This discussion is long overdue in the USA, and hopefully the recent catastrophe will bring awareness to the need to eliminate their availability.

We had just reached California to meet business friends in San Diego when the news of Las Vegas broke. Needless to say it was a shock for us all. The accused, a 64 year old man, seemed like a normal local citizen. But as Avery Brundage at the 1972 Olympic Games in Munich said: "The games must go on."

It is the same with business. We need to continue developing better solutions that reduce power consumption, while delivering the same or better performance. Our planet needs engineering innovation to survive its own slow decline. Political leaders are generally opportunistic to what people like to hear, but often not to what actually makes things better. They need our technical guidance. It is great to see wind-power and solar installations in Hawaii. Active IEEE members must be at work.

In our field, Wide Band Gap semiconductors will make their contribution in system designs with significantly reduced losses. To design with SiC and GaN is the future. For all design engineers that desire a more efficient future, I recommend attending the following event in Munich Germany.

Wide Band Gap Conference, December 5th 2017, Munich-Airport
Wide Band Gap semiconductors have become mature over the last decade. The trend is to replace silicon power switches with SiC and GaN. It is important that system design engineers get involved in advanced design work using wide band gap devices for their next project. Experts from semiconductor manufacturers and the early users will describe their experience and ease the transition to the new technology. For conference details see:
http://www.Power-Conference.com

A great group of experts will be presenting, and discussing WBG applications. Book your seat now to remain at the frontier of technology for your next design project.

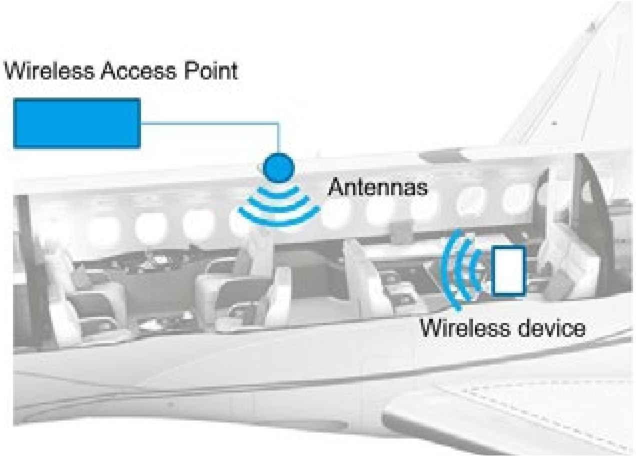
Bodo's Power Systems reaches readers across the globe. If you are using any kind of tablet or smart phone, you will find all of our content on the new website www.eepower.com. If you speak the language, or just want to have a look, don't miss our Chinese version: www.bodospowerchina.com

My Green Power Tip for November:
Do not overuse your smart phone. All that data goes through server farms, which now consume a huge amount of power. Doing video calls on the phone demands a lot of energy too. Use your voice, and trust that people will remember what you look like !

Best Regards

LETI Develops Proof of Concept to Test Wireless Systems in Aircraft

Leti, a technology research institute of CEA Tech, announced it has developed a methodology for testing high-speed wireless communications on airplanes that allows different system deployments in cabins, and assesses wireless devices before they are installed.



In a joint research project with Dassault Aviation, Leti demonstrated a channel-measurement campaign over Wi-Fi frequency in several airplanes, including Dassault's Falcon business jet. Using a channel sounder and a spatial scanner, Leti teams determined a statistic model of the in-cabin radio channel, constructed from the antenna position and the configuration of the aircraft.
A radio-frequency channel emulator and the in-cabin channel model were used to test Wi-Fi designed for passenger communication and entertainment before installation in the aircraft. In that test, two different wireless access points and different antenna configurations for Wi-Fi networks deployed in an aircraft cabin were evaluated. Based on an extensive test campaign, mean values of performance parameters, together with the operating margin, were provided according to the device configuration, kind of traffic and channel conditions.
In addition, the technology gives aircraft designers key tools to define wireless communication systems that enhance passenger experience, without aircraft immobilization.

www.leti.fr/en

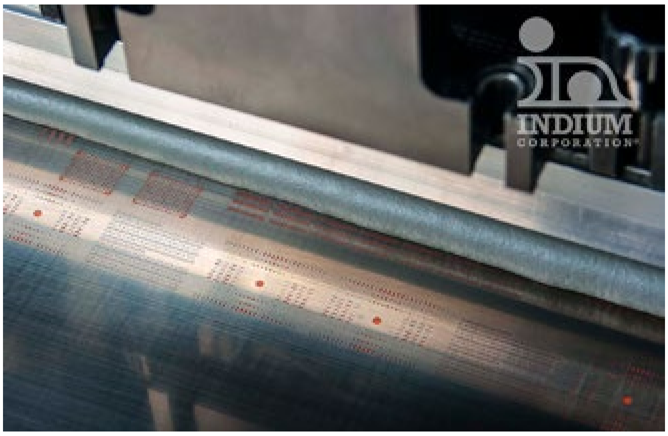
Closesing out Fiscal 2016 with €139 Million in Sales

Vincotech, a leading manufacturer of module-based solutions for power electronics, put in a remarkably successful performance in 2016/17. Total revenue was up by a phenomenal 43 % from the previous year with Vincotech strengthening its position worldwide in all core areas.
Focusing on its core motion control, renewable energies and power supply markets, Vincotech posted €138.9 million in sales at the end of March 2017. Record sales in the fast-growing, extremely dynamic Asian market accounted for a fair share of this revenue.
Sales of power semiconductor modules were up 42 % in 2016, significantly outperforming the global market growth rate of 3.5 %. According to an IHS study*, this performance in 2016 took Vincotech up to sixth place among this segment's leading manufacturers.
"I am proud that our company has been growing faster than the market for seven years now, and that we are making a valuable contribution to global energy savings with our technology. This is down to our persistent customer focus. 'EMPOWERING YOUR IDEAS' is not just a corporate claim; it is the credo of each individual employee," says Vincotech GmbH CEO Joachim Fietz.
Vincotech develops and manufactures power semiconductor modules in the 0.3 kW to 1 MW power range. A reliable partner, the company offers standard modules and application-specific solutions that serve to meet customers' needs in cost-effective and efficient ways. Vincotech sources semiconductors from eleven different manufacturers. This gives the company the strategic advantage of a chip-independent supplier.

www.vincotech.com

Featuring Stable, Low-Voiding Indium8.9HF Solder Paste Series at productronica 2017

Indium Corporation will feature its void-reducing Indium8.9HF Solder Paste Series to help customers Avoid the Void® at Productronica, November 14-17, in Munich, Germany.



The Indium8.9HF Series delivers no-clean, halogen-free solder paste solutions designed to produce low-voiding–plus improved stability–during the printing process. Under optimal process conditions, this series:

- Demonstrates consistent printing performance for up to 12 months when refrigerated
- Maintains excellent printing and reflow performance after remaining at room temperature for one month
- Delivers excellent response-to-pause even after being left on the stencil for 60 hours

The Indium8.9HF Solder Paste Series boasts a unique oxidation barrier technology that makes these pastes perfectly suited for a variety of applications, especially automotive assembly.
For more information about Indium Corporation's low-voiding solder pastes, visit www.indium.com/avoidthevoid or see Indium Corporation in hall A4 at booth 214.

www.indium.com

ABB to acquire GE Industrial Solutions

ABB announced the acquisition of GE Industrial Solutions, GE's global electrification solu-tions business. GE Industrial Solutions has deep customer relationships in more than 100 countries and an es-tablished installed base with strong roots in North America, ABB's biggest market. GE Industrial Solu-tions is headquartered in Atlanta, Georgia, and has about 13,500 employees around the world. In 2016, GE Industrial Solutions had revenues of approximately $2.7 billion, with an operational EBITDA margin of approximately 8 percent1 and an operational EBITA margin of approximately 6 percent[1]. ABB will acquire GE Industrial Solutions for $2.6 billion; the transaction will be operationally accretive in year one. ABB expects to realize approxi-mately $200 million of annual cost synergies in year five, which will be key in bringing GE Industrial Solutions to peer performance. As part of the transaction and overall value creation, ABB and GE have agreed to establish a long-term, strategic supply relationship for GE Industrial So-lutions products and ABB products that GE sources today.
"With GE Industrial Solutions, we strengthen our Number 2 position in electrification globally and ex-pand our access to the attractive North American market," said ABB CEO Ulrich Spiesshofer. "Combined with the long-term strategic supply relationship with GE, this transaction creates significant value for our shareholders."
GE Industrial Solutions will be integrated into ABB's Electrification Products (EP) division, resulting in a unique global portfolio and very comprehensive offering for North American and global customers. They will benefit from ABB's innovative technologies and the ABB AbilityTM digital offering coupled with GE Industrial Solutions' comple-mentary solutions and market access. Included in the acquisition is a long-term right to use the GE brand. ABB will retain the GE Industrial Solutions management team and build upon its experienced sales force. After closing, this transaction will have an initial dampening effect to EP's operational EBITA margin. ABB commits to returning EP to its target margin corridor of 15-19 per-cent during 2020.

www.abb.com

www.geindustrial.com

[1] 2016 GE Industrial Solutions financial information adjusted to ABB financial definition

Global Leaders Collaborate on GaN Technology

The world is challenged with unsustainable increases in power consumption, combating climate change, implementing cleantech technologies and meeting green, CO2 reduction initiatives. Taiwanese electronics manufacturers work at the forefront of these efforts. To meet these challenges, GaN Systems, the world's leading provider of gallium nitride (GaN) power transistors, and Taiwan's Ministry of Economic Affairs (MOEA) have entered into a Letter of Intent to col-laborate on expanding the economic and technical benefits of GaN technology to Taiwan's electronics companies. To further advance Taiwan's leadership role in the electronics industry, recognizing the importance and benefits of GaN, the MOEA will provide assistance to GaN Systems to extend its in-country business and representa-tion. This agreement brings together two powerful forces - the leading manufacturer of GaN transistors and the government body that oversees Taiwan's electronics industry. Working together, this alliance will collaborate to help solve some of the world's most daunting power challenges.
Ms. Mei-Hua Wang, Vice Minister of Taiwan's Ministry of Economic Affairs (MOEA), commented on the development, "As Taiwan plays a preeminent role in the Asian electronics industry, we are pleased to provide GaN Systems with the resources to continue their success with our leading manufacturers. This Letter of Intent strengthens the bonds between GaN Systems and Taiwan's electronics industry."
GaN Systems' CEO, Jim Witham, added, "GaN Systems is delighted to join forces with Taiwan's MOEA. We see this as an important demonstration of how companies and government work together to reinforce partnerships amongst industry leaders and across industry segments."

www.gansystems.com

Awarded JOSCAR Accreditation at DSEI

TTI, Inc., a world leading specialist distributor of electronic components, announces that it has been awarded JOSCAR accreditation and received its formal registration at DSEI in London, on the opening day of the world's leading defence and security exhibition. JOSCAR is the new ac-creditation system for the aerospace, defence and security sectors, and is a cross-industry collaboration initiative that reduces the time, costs, resources and duplication needed when providing information to major customers. JOSCAR holds common supplier data in a central system, and enables information to be accessed by all participating buying organisa-tions.
A formal presentation was made to TTI on its stand at DSEI by Colin Maund, CEO, Hellios Information, the supplier information and risk management company running the JOSCAR accreditation programme. Receiving its JOSCAR registration certificate, Kevin Nicholls, General Manager, UK, Ireland & South Africa, TTI said: "We are delighted to have satisfied all of the requirements necessary for full compliance and to now be accepted as a JOSCAR-registered sup-plier. This registration demonstrates the very robust and streamlined processes we have in place for supplying into defence and aero-space, one of our major and most successful market sectors, where we have been an established supplier since 1971. Our heritage and expertise in this sector is recognised by our customers and suppliers alike. JOSCAR accreditation is an additional demonstration to our aerospace and defence customers of our commitment to them going forwards."

www.ttieurope.com

Power Research Electronic and United Silicon Carbide to start strategic cooperation

Power Research Electronic, a specialist power electronics solution provider for E-mobility, renewable and energy saving applications is signing a strategic agreement with United Silicon Carbide Inc. (USCi), a leading manufacturer of SiC diodes and FETs. USCi will supply a wide range of its new Generation 3 SiC diodes and FETs into PRE's latest generation of bidirectional EV fast chargers.

"Hard switched applications using SiC MOSFETs require a SiC FWD to reduce the body diode's VF (4.6V) and thus losses. We have selected the USCi SiC Cascodes due to the low body diode VF (<2V), enabling us to remove the SiC FWD and thus saving component cost and board space" explains Menno Kardolus, CEO at PRE. "Further, the high threshold voltage (typ. 4.5V) and low gate charges enable us to use a standard low-cost gate driver with a VGS=12V/0V, also reducing gate drive losses."

Christopher Rocneanu, Director of Sales at USCi adds that the reduction of overall system cost is one of the greatest challenges for power electronics solution providers in order to partake in the upcoming E-mobility market. "The innovative chip design of USCi's SiC product family plays a crucial role in this process. We are very proud to have the Gen 3 SiC family now fully qualified under AECQ-101, offering our customers an optimized range in terms of ultra-low QRR, VF and specific RDS,on."

www.PR-Electronics.nl

www.unitedsic.com

Dialog Semiconductor to Acquire Silego Technology

Dialog Semiconductor, a provider of highly integrated power management, AC/DC power conversion, charging, and low power connectivity technology, announced that it has signed a definitive agreement to acquire privately-held Silego Technology Inc., the leading provider of Configurable Mixed-signal ICs (CMICs), for a cash payment of $276 million with additional contingent consideration of up to $30.4 million. "The acquisition of Silego brings a highly complementary technology to Dialog. What Silego has developed is truly unique – a mixed-signal platform which customers can configure to their design requirements on the fly, drastically reducing the time to bring their products to market," said Jalal Bagherli, CEO of Dialog. "With global scale and customer access, Dialog is the right platform to further accelerate industry wide CMIC adoption. Furthermore, we gain an exceptional group of talented people that will fit well with Dialog's culture. Together, we will significantly increase the value we can bring to our customers by creating a better-positioned and more-diversified mixed signal offering."

"We believe Dialog will be a great environment for the Silego team to grow as part of a much larger company serving global customers," stated John Teegen, CEO of Silego Technology. "Our proprietary and configurable approach has allowed Silego to establish leadership while creating a new market. By leveraging Dialog's technology and capabilities, I am confident we can further drive adoption of CMICs."

www.dialog-semiconductor.com

www.silego.com

ECPE Tutorials and Workshops

- **ECPE Tutorial 'Power Circuits for Clean Switching and Low Losses'**; 9 November 2017, Aalborg, Denmark Chairman: Dr. R. Bayerer (Infineon)
- **ECPE Tutorial 'Wide Bandgap User Training';** 20 - 21 November 2017, Barcelona, Spain; Chairman: Prof. E. Hoene (Fraunhofer IZM)
- **ECPE Workshop 'Reliability Engineering - 10 Years Robustness Validation'**; 24 - 25 January 2018, Stuttgart, Germany (programme will be published soon); Chairmen: Prof. E. Wolfgang (ECPE), Dr. J. Breibach (Robert Bosch)
- **CIPS 2018 - International Conference on Integrated Power Electronics;** 20 - 22 March 2018, Stuttgart, Germany in conjunction with the ECPE Annual Event 2018

www.ecpe.org

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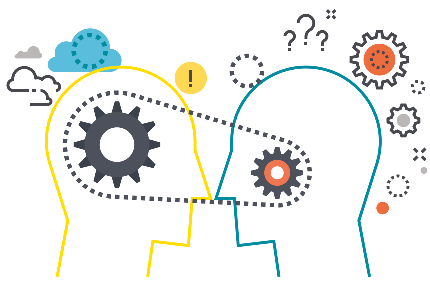

Power to **collaborate**

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Texas Instruments

Win a MPLAB® ICD 4 In-Circuit Debugger

Win a Microchip MPLAB ICD 4 In-Circuit Debugger (DV164045) from Bodo's Power. The new MPLAB ICD 4 introduces a faster processor and increased RAM to deliver up to twice the speed of ICD 3 for the in-circuit debugging of PIC® microcontrollers and dsPIC® digital signal controllers. The MPLAB ICD 4 also introduces a wider target voltage range and an optional 1 A of power via an external power supply.

For maximum flexibility, MPLAB ICD 4 features a selectable pull-up/pull-down option to the target interface and programmable adjustment of debugging speed for greater productivity The MPLAB ICD 4's significant improvement in speed is accomplished through a 32-bit MCU running at 300 MHz. Faster processing, together with an increased buffer memory of 2 MB, results in a product that is up to twice as fast as its predecessor.

Microchip's MPLAB ICD 4 is easy to use and supports many PIC microcontrollers and dsPIC digital signal controllers in Microchip's portfolio through the MPLAB X Integrated Development Environment (IDE). This simplifies the design process for customers when they choose to migrate from one PIC MCU to another to meet the needs of their application

The MPLAB ICD 4 connects to the PC using a high-speed USB 2.0 interface and is connected to the target with a debugging connector which is also compatible with the MPLAB ICD 3 or MPLAB REAL ICE™ In-Circuit Emulator systems. The MPLAB ICD 4 also works with JTAG interfaces.

- Faster and more flexible real-time in-circuit debugging
- Supports many PIC microcontrollers and dsPIC DSCs
- x2 faster than ICD 3
- Reduced wait time improves debugging productivity
- Simplifies migration between PIC MCUs

For your chance to win a Microchip MPLAB ICD 4 In-Circuit Debugger, visit the following web-site and enter your details in the online entry form:

www.microchip-comps.com/bodo-icd4


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Endless Possibilities.
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High Voltage IGBT Robust. Reliable. Reputable.
Hitachi Europe Limited, Power Device Division email pdd@hitachi-eu.com

High Density Power Amplifier IC Delivers New Levels of Performance

The PA164 and PA165 from Apex Microtechnology establish new benchmarks for power amplifier performance in a single chip design. By driving advances in packaging technology and utilizing Apex's proprietary MOSFET silicon design, the PA164 and PA165 can deliver enhanced amplifier features and combinations of continuous and PEAK output current currently not available in an IC form factor that is also rated to operate on voltage supplies up to 220 volts.

SPECIFICATION PARAMETER	PA164	PA165	PA441
Output current continuous	1A	4A	60mA
Output current PEAK	4A	10A	120mA
Supply voltage operation	220V	220V	350V
Internal power dissipation	28W	28W	12W
Onboard over current protection	Yes	Yes	Yes
Overcurrent flag and output disable	Yes	Yes	No
Built-in temperature sensor	Yes	Yes	No
Power Bandwidth	55kHz	55kHz	35kHz
RoHS compliant	Yes	Yes	Yes
Package style	QFP style, heat slug on top (hermitically sealed package as option)	QFP style, heat slug on top (hermitically sealed package as option)	Plastic, surface-mount PSOP with heat slug – or – plastic, thru-hole, hermetic PIP with alumina ceramic substrate
Package footprint measurement	20mm x 20mm	20mm x 20mm	16mm x 14.8mm – PSOP 25.4mm x 4.72mm – PIP

The PA164 provides 1 amp continuous and 4 amps PEAK of output current, while the PA165 can deliver 10 amps PEAK. At these levels of performance, thermal management for a very compact package must be managed very carefully. The design of this IC utilizes separate supplies for the amplifier core and the output stage to help optimize the overall power dissipation capabilities. In addition, both devices are housed in an QFP style package with a heat slug on top to facilitate for mounting of a heat sink over a single device or on an "arrow" pattern of these devices. As a result, the devices are capable of dissipating up to 28 watts.

"With the increased in miniaturization of circuitry designs, board space has become a highly valuable commodity. The exceptional performance potential for these ICs make them an attractive solution across a wide number of potential applications requiring high power across multiple channels when board real estate is very tight," explains Apex Strategic Marketing Director Jens Eltze. "Both the PA164 and PA165 can offer designers the opportunity to reduce the size of their overall circuitry while saving valuable design time in achieving a final layout."

Depending on the circuit design of the end system, external components can be used to set both the optimum gain and the bandwidth. Onboard system protection for these devices includes a user-defined, temperature compensated current limit and a temperature sensor output. The addition of an output disable function and an over-current flag simplify the implementation of robust failure protection on the system level.

The wide range of target applications include adjustable voltage and current sources, test equipment, piezo electric positioning, electrostatic transducers and deflection, and focusing for deformable mirrors.

In terms of electrical performance comparisons to other high performance power amplifiers, the table below stacks up the PA164 and PA165 to Apex's own next highest rated IC -- the PA441.

Pricing, Availability and Evaluation Tools

Sample units of the PA164 and PA165 are available now for qualified applications, with production volumes targeted for Q1 2018. Per unit pricing for 1K product quantities will be sub $30.00 USD. An evaluation kit for rapid prototyping is scheduled to be available in early Q4 2017. Complete product information is online at www.apexanalog.com/apex-products/PA164. For technical support, contact Apex applications engineering at 800-546-2739, or apex.support@apexanalog.com.

www.apexanalog.com/products/pa164.html

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KNOWLEDGE IS POWER

Massive power density in the smallest packages

Microchip Technology now offers an integrated switching power module designed specifically for height-constrained telecom, industrial and solid-state drive (SSD) applications. These products come in an impressive thermally-enhanced package that incorporates inductors and passive components into a single, molded power converter. The slim packages simplifies board design, saves space and eliminates concern over passive components that may introduce unexpected electromagnetic interference (EMI).

Highlights

- Variety of module package offerings (small to large, fit to application)
- High power density with integrated magnetic and passive components
- Performance (efficiency, thermal, transient response)
- Reliable (power and thermal stress tested)
- Low EMI (CISPR 22 Class B ratings on modules)

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www.microchipdirect.com

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www.microchip.com/powerpromo

94% Efficient: New Flyback Switcher ICs

InnoSwitch™3 integrated switcher ICs cut losses by 25%, deliver constant efficiency over a wide range of line and load conditions

Power Integrations announced the release of its InnoSwitch3 family of offline CV/CC flyback switcher ICs. The new devices achieve up to 94% efficiency across line and load conditions, slashing power supply losses by a further 25% and enabling the development of compact power supplies up to 65 W without heatsinks. InnoSwitch3 devices are ideal for power supplies with challenging energy consumption, footprint or thermal constraints, particularly those targeting mandatory Total Energy Consumption (TEC) specifications.

The InnoSwitch family of ICs, first introduced at electronica 2014 exhibition, combines primary, secondary and feedback circuits in a single surface-mounted off-line flyback switcher IC. The InnoSwitch IC incorporates the primary FET, the primary-side controller, a secondary-side controller for synchronous rectification and an innovative new «FluxLink" technology that eliminates the need for an optocoupler.

Power Integrations' FluxLink is a proprietary new communication technology that enables feedback information to be delivered across an isolation barrier without the use of any magnetic materials. It delivers a very high communication bandwidth which enables a much faster load-transient response. It is also highly reliable and does not suffer from the typical optocoupler degradation mechanisms. Being embedded into the package and by eliminating bulky optocouplers, it saves space and increases power density, which is particularly beneficial for adapters and chargers. Furthermore, this proprietary technology meets all global noise immunity standards. For safety, it complies not only with UL and TUV global isolation standards but also the more stringent CQC 5,000 meter Chinese safety standard.

The newly introduced InnoSwitch3 IC family is optimized into three application-specific series:

- CE: Current External. Includes accurate CC/CV regulation with external output current sense for optimum design flexibility. Targets compact single-voltage chargers, adapters, IoT and building automation.
- CP: Constant Power. Ideal for USB Power Delivery (PD), rapid charging and other applications where a dynamic output voltage is required.
- EP: Embedded Power. Features the family's highest-rated MOSFET (725 V) and provides full line and load protection with excellent multi-output cross-regulation for demanding industrial applications and appliances.

These newest flyback switcher ICs employ Power Integrations' above-mentioned innovative isolated digital communications technology, FluxLink, plus synchronous rectification, quasi-resonant switching and a precise secondary-side feedback sensing and control circuit. This results in highly efficient, accurate, reliable power supply circuits without the need for optocouplers. The new InnoSwitch3 devices, too, are CCC, UL and VDE safety-certified to bridge the isolation barrier, and the unique InSOP-24 package provides a low-profile, thermally efficient solution with extended 11.5 mm creepage and clearance between primary and secondary sides for high reliability, surge and ESD robustness.

The new devices also incorporate a host of protection features, including lossless line overvoltage and under-voltage, output overvoltage, over-power, over-current and over-temperature protection, as well as output rectifier short-circuit protection. Device sub-families are provided with either latching or auto-recovery capability, according to the typical demands of each target application space. All InnoSwitch3 ICs feature on-board high-voltage MOSFETs (rated at 650 V for the CP and CE series and 725 V for the EP series).

Mike Matthews, VP of product development at Power Integrations, comments: "InnoSwitch3 ICs represent a new state of the art in flyback power supply design. These new devices surpass the previously unrivalled efficiency of our InnoSwitch products, reducing losses by a further 25% and delivering the highest available efficiency across all line and load conditions. With unmatched system simplicity and low component count, InnoSwitch3 ICs enable exceptionally compact, reliable power supplies for a vast range of applications."

InnoSwitch3 ICs target adapters and open-frame power supplies for consumer, computer, communication and industrial applications. InnoSwitch3-CP and InnoSwitch3-CE IC samples are available now, priced at $1.11 (CE) and $1.15 (CP), in 10,000-piece quantities. InnoSwitch3-EP parts will be available in November 2017 at $1.18 per 10,000-pieces.

An online selection tool, Build Your Own InnoSwitch, is available to help designers customize device features for their particular design specifications. Technical support for InnoSwitch3 ICs, including the PI ExpertTM Online design tool, is available from the Power Integrations website at www.power.com/products/innoswitch/.

Power Integrations, Inc. is a leading innovator in semiconductor technologies for high-voltage power conversion. The company's products are key building blocks in the clean-power ecosystem, enabling the generation of renewable energy as well as the efficient transmission and consumption of power in applications ranging from milliwatts to megawatts.

https://ac-dc.power.com/products/innoswitch-family/

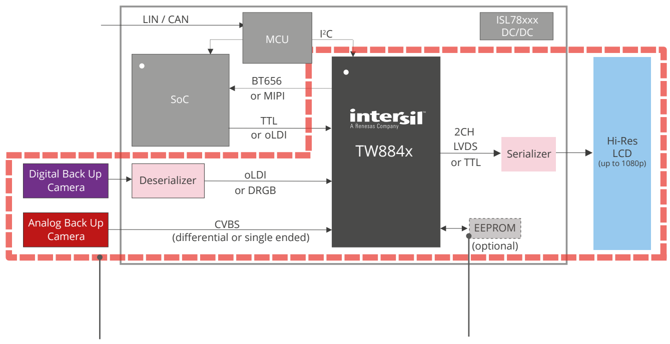
Display Rearview Camera Live Video in Less Than 500 milliseconds

Automotive Industry's First Full HD LCD Video Processor

Highly integrated TW884x instantly displays rearview camera live video, exceeding industry standard by 4x to prevent backover accidents.

- **Fast Boot**—Since some SoCs can take several seconds to boot up, the TW884x can sync to a video source and display the image on an LCD in less than 500 milliseconds.
- **Frozen Detection**—Monitors the SoC and camera output to determine if they are in a frozen or corrupted state. If the TW884x detects any issue, it bypasses the SoC and instantly displays the rearview camera video.
- **Bypass Capability**—The TW884x's rearview camera bypass architecture decouples the camera-to-display signal path from the rest of the infotainment system, which simplifies the functional safety architecture of the system.

Rear Camera Reliability System Architecture



Decouple the camera-to-display path
The TW884x provides a hardware based path that can directly drive rear camera video to the LCD.

EEPROM fast boot function enables fast boot with no external MCU needed.

For datasheets, samples, videos and more, visit
intersil.com/products/tw8844

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Module Solutions for 1500V Solar Inverters

By increasing the maximum DC Voltage of a solar inverter from 1000V to 1500V PV power plants become more cost effective. However, this voltage jump requires careful consideration when selecting power modules and converter topologies.

By Kevork Haddad, Semikron Inc. and Bernhard Eichler, Semikron Elektronik GmbH & Co. KG

PV based power plants are relatively expensive solutions in the market of energy generation technologies. Low voltage components and cabling of the arrays are significant part of the cost of the PV installations. Many studies have concluded that increase of the inverter voltage, and thus system voltage from 1000V to 1500V offers opportunities to reduce the initial PV array cost by reducing the number of low voltage components and the total cabling needed. The system also has the potential to be more efficient at the grid or the DC side. This aspect is already known from power systems that when voltage levels are increased, ohmic losses are decreased. Typical cost savings for 1500V PV installations are shown in Figure 1.

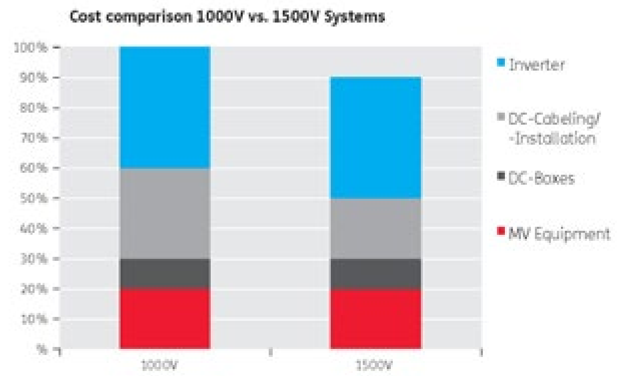

Figure 1: Cost comparison 1000V vs 1500V system

Implications to Power Modules

While 1500V is becoming the mainstream for solar inverters (central and string), this new voltage requires careful consideration with respect to creepage and clearance of the power modules and the DC link assembly as well. Also, the new requirement from solar inverter is to operate at near zero power factor. This fact needs to be accounted for when selecting the modules.

Consequences on the Inverter

Increasing the system voltage from 1000V to 1500V increases the output voltage of the inverter. While the open circuit voltage is 1500V, extracting full power or Maximum Power Point (MPP) voltage range could vary from system to system and mission profile. Hence, this will impact the selection of the appropriate topologies to meet system requirement. This in turn influences the choice of the power modules.

Various topologies are available to address higher DC voltages. Two level topology equipped with 1700V devices is the most common and basic configuration. This is shown in Figure 2.a. Its performance and limitations are well known due two level output waveform, high filtering requirement and low efficiency.

To improve the performance of the solar installations, industry standard three level topologies could be utilized. One solution consists in adopting transistor clamped topology, 3L-TNPC. This topology is obtained by inserting two switches in common emitter configuration between the AC terminal and the midpoint of the DC link referred as N, Figure 2.b Another option is the adoption of three level neutral point converter, 3L–NPC as shown in Figure 2.c This configuration has two additional clamping diodes that allow impressing half the DC link voltage across all the switches.

Three level topologies offer the following distinct advantages over two level topologies: i) synthesized AC output waveform has higher resolution (3L waveform), ii) duty cycles of the switches are distributed on various switches hence better heat distribution among the switches, iii) switching frequency doubling effect and iv) lower semiconductor losses. The reader is referred to Semikron's application note [1] for detailed overview and operation of three level converters.

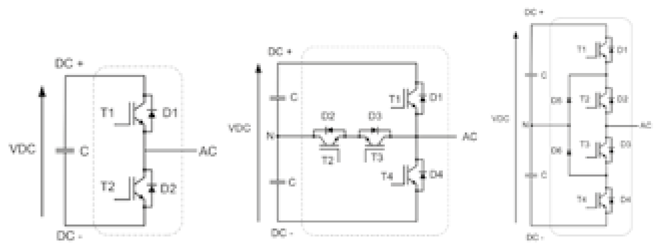

Figure 2: 2-Level (left), 3-Level T-NPC (middle) and 3-Level NPC topology (right)

Topology Selection

In this section, by way of a concrete example various topologies are compared under the same operating conditions.

Conditions are summarized as follows: Pnom=640kW, Vout =550V, cos(φ)=0.95, Vdc=900V-1200V, fsw=2-6kHz and Rth(s-a)=0.088K/W per module (air-cooled)

In this example Semikron's SEMiX® platform is considered.

SEMiX® platform is flexible and well suited to address numerous requirements in one housing. It is also an Industry standard module which allows compact inverter designs. Here, two level topology implemented in a SEMiX®3 Press-fit package, Figure 3a and three level topologies (NPC or TNPC) are realized with SEMiX®5 packages, Figure 3b. Both packages are available with press-fit pins for ease of assembly and manufacturing.

Benefits of SEMiX®:
- Optimized internal chip layout and design
- Housing features rugged molded power terminals for superior mechanical stability
- Flat 17mm package, and separated AC and DC terminal for state of the art inverter design
- Gate driver mounted directly on top of the module

Figure 3a: SEMiX®3 Press-fit

Figure 3b) SEMiX®5 modules

Set-Up:
- 2L-1700V solution: 4 x SEMiX453GB17E4p
- 3L NPC-1200V solution: 4 x SEMiX305MLI12E4p
- 3L TNPC-1700V/1200V solution : 4 x SEMiX305TMLI12E4p

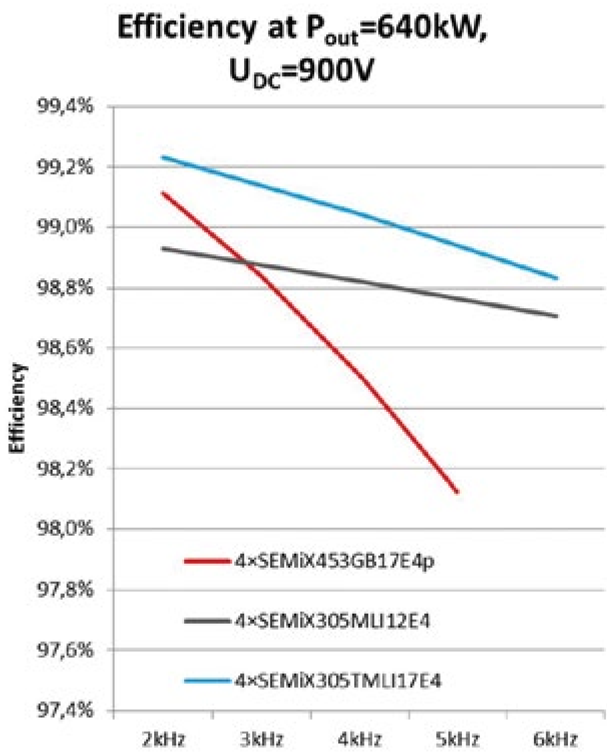

Figure 4 a): Efficiency comparison. 900VDC

The modules are equipped with Trench 4 medium power IGBTs (E4 type) and with Semikron's CAL4F Diodes. Efficiencies at 900V and 1200V DC bus are shown in Figure 4a and 4b respectively. Results show that the three level topologies have lowest semiconductor losses when switching frequency is higher than 3kHz.

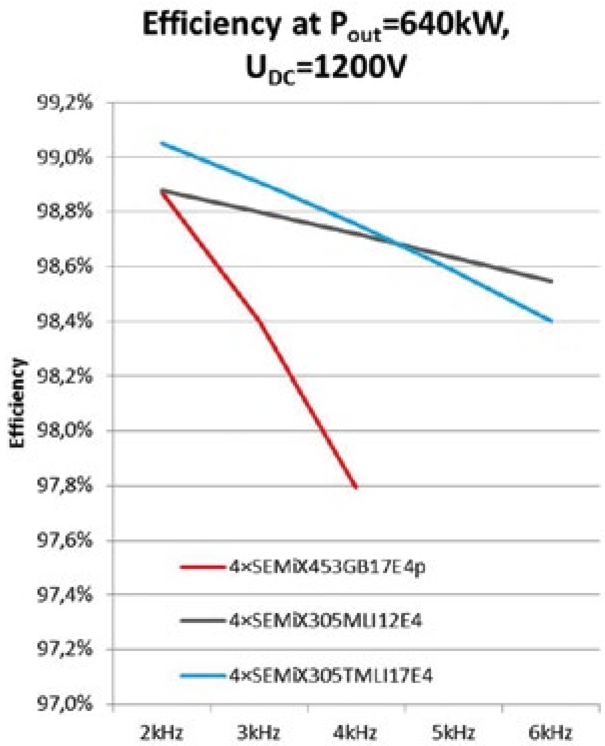

Figure 4 b): Efficiency comparison. 1200VDC.

Optimal Topology-Accounting for Cosmic Rays Failures

Unfortunately, calculating efficiencies of various configurations will not permit the design Engineer to decide which topology is optimum. This is due to the fact that mission profile is not accounted for and cosmic ray failures are excluded. Evaluating these aspects will lead to the optimal topology.

FIT rate caused by cosmic rays of Semikron's 1700V CAL4 diodes and their superior robustness compared to competitor's diodes is well documented in [2-3].

The failure rate of the inverter could be computed by considering mission profile or in another word time share of the inverter spent at a given voltage during the day. For the above example we will consider three different profiles. Profile 1 is lowest time share at the highest DC link voltage (1550V), Profile 2 is medium time share at the highest DC voltage, and Profile 3 has the highest time share at the highest DC voltage. These results are summarized at sea level and for 12 hours of operation per day. The comparison of various solutions, Table 1, shows that 3L-NPC has the lowest cosmic ray failures. This is thanks to the fact that the serial connection of four 1200V IGBTs the topology does not operate at the voltage limits of the module and the design margin is high.

It is worth to note that 2-level and 3L-TNPC inverters are operating with the same chip voltage. However, the lower cosmic ray failure rate of the TNPC compared to the 2-level system is based upon less 1700V chip area (66%) because duty cycle of the 1700V chips is lower due to additional neutral current path. Further, if the altitude is above the sea level then intensity of the cosmic rays increases and follows approximately an exponential curve. Typically, one can state that the failure rate increases by a factor of two for 1000m elevation gain. Hence, cosmic ray failure rate of solar filed installations at high altitude is significantly higher.

Topology	Profile 1	Profile 2	Profile 3
	Failure rate/FIT Failures per year @12h/d		
2L-1700V Solution	7 0.003%	12 0.005%	112 0.049%
3L TNPC-1700V/1200V solution	3 0.001%	4 0.002%	40 0.018%
3L NPC-1200V solution	<1 <0.001%	<1 <0.001%	<1 <0.001%
Average Voltage	1203 V	1245 V	1251 V

Table 1: Failure rate of inverters by cosmic ray at sea level with various topologies and different mission profiles.

Based on the above study and calculations, 3L -TNPC based systems have the best efficiency, and is characterized by simple and proven inverter design and an acceptable cosmic ray failure rate and also thanks to superior cosmic ray robustness of Semikron's CAL4F diode technology which plays an important role in further improving inverter reliability.

3L- NPC systems have high efficiency at high switching frequencies and due to the fact that cosmic ray failures can be neglected in our view is the best solution. Disadvantage of this system is a complex inverter design. However, the topology is well established in the industry and the technology is proven already. The 2-level inverter stands out due to its simple design (driver and controller) and the most cost effective solution of semiconductors (filters neglected). Disadvantages are due to its limited performances: i) lower switching frequency ii) higher cosmic ray failure rate compared to the 3-level solutions.

If the MPP range is below 1300V then 2L 1700V or 3L-TNPC 1700V/1200V solutions could be considered. On the other hand, if operating voltage exceeds 1300V then the 3L-NPC 1200V is the best choice.

In summary strength and weaknesses of each topology could be summarized as follows:

- 2L with 1700V IGBT has shortest time to market and reuse of existing assemblies is possible. However it has poor efficiency when the switching frequency exceeds 2 kHz.
- 3L NPC with 1200V IGBT has no limitations to operate up to 1500V and has excellent efficiency beyond 5 kHz switching frequency.
- 3L TNPC with 1700V/1200V IGBT is simple and has good performance at medium switching frequencies and lower DC voltages.

It follows from the discussion above that 3L-NPC 1200V should be the preferred solution from reliability point of view and when operation at higher DC voltages is required to harvest maximum energy from PV panels.

Portfolio for 1500V Solar Inverters

Semikron offers complete module portfolio for 1500V PV applications.

These modules are ready to be used in string and central inverters. Hence, a wide power range in solar installations is covered.

SEMITOP and MiniSKiiP platforms are well suited for small and medium power applications. SEMiX, SKiM and SKiiP platforms are good match for medium power converters. SEMTRANS 10 based solutions are effective for high power applications.

Innovative Approach for 3L-NPC 1200V
Semikron has recently introduced an elegant solution that overcomes the challenges associated in paralleling three level NPC inverters. This approach is suitable to build scalable and modular phase legs. Semikron's concept takes advantage of the symmetry in the NPC topology and uses two half NPC topologies referred as MLI TOP and MLI BOT. Each half MLI topology is implemented in its own module as shown in Figure 5. Two different platforms are available to implement 3L-NPC with the new approach. The first one is the use of Semikron's 2nd generation SEMITOP® module in E2 package and the second one is based upon SEMITRANS®10 package. Both modules are industry standard modules and are suitable for 1500V solar inverters.

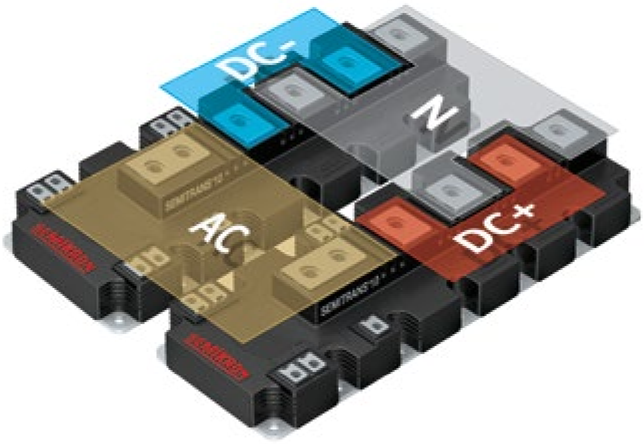

Figure 5a: 3L-NPC Inverter SEMITRANS® 10 MLI concept

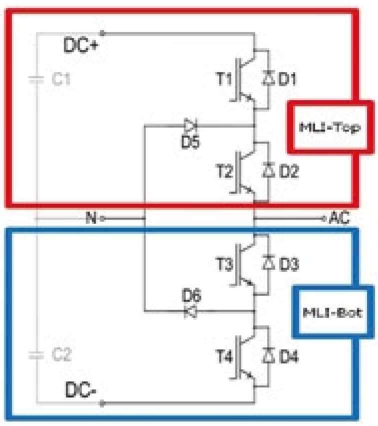

Figure 5b: 3L-NPC Inverter Split NPC topology

SEMITRANS 10 MLI for Central Inverters
In central inverters the trend is for higher DC voltages by means of over paneling to increase the annual yield of energy. As already mentioned above, here the 3-L NPC topology is the best solution. For these type of inverters Semikron introduced the SEMITRANS® 10 MLI modules where the NPC topology is split to two halves. With current rating of 1200A and the use of 1200V medium power (E4) IGBT chips in combination with Semikron CAL4F diodes SEMITRANS® 10 MLI enables air cooled power blocks up to 750kW without paralleling of modules. Similar to SEemikron's standard SEMITRANS® 10 modules, MLI version modules utilize an advanced baseplate soldering process to create a very robust package for passive temperature cycling to increase the lifetime of the modules also in harsh environment.

Figure 5a shows SEMITRANS® 10 MLI implementation and Figure 5b highlights split NPC topology concept.

Benefits of SEMITRANS®10 MLI:
- Industry standard module
- High power three level NPC building block without paralleling modules
- Compact, scalable and efficient design
- Advanced baseplate soldering

To demonstrate the benefits of this split topology Semikron has developed two different application samples for power stacks, using SEMTRANS® 10 MLI:

3-phase 750kW building block without paralleling of modules, Figure 6.

Figure 6: Application Sample three phase 750kW SEMITRANS® 10 MLI stack

Single phase 1.500kW building block with two parallel modules, Figure 7.

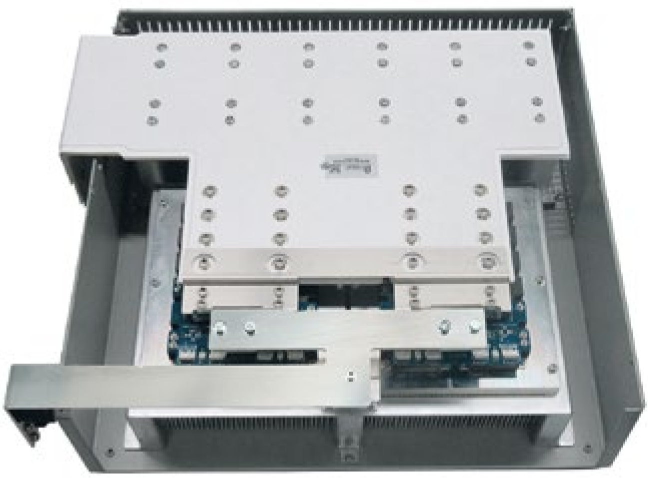

Figure 7: Applications Sample Single Phase 1500kW SEMITRANS® 10 MLI

This compact solution based on two SEMITRANS® 10 MLI modules allows an easy DC-link connection and low stray inductances. About 24nH for the outer switches and 64nH for the inner switches are responsible in lowering overvoltages in the inverter.

Compared to competitor solutions using three modules with same packaging technology like SEMITRANS® 10 MLI this brings significant benefits which are: lower losses, less space and simpler design. The efficiency can reach 98,8% @ fsw=5kHz and up to 99,0% with fsw=3kHz, and modules exhibit up to 15% lower junction temperatures when compared to competitor modules or available industry solutions.

Also the driver effort is clearly reduced by using only two modules for the NPC topology instead of three.

For fast time to market, in addition to power modules Semikron can provide dual adapter boards for a pair of SEMITRANS® 10 MLI modules (top + bottom) including two SKYPER 42 LJ drivers. These adapter boards also include gate resistors, VCEsat monitoring circuitry for all IGBTs, active clamping and error management. SEMITRANS® 10 modules are also available with pre-applied phase change thermal interface material for optimal thermal conduction and a clean manufacturing process.

Conclusion and Summary

Solar energy growth is fueled by cost reduction. Increasing the voltage levels from 1000V to 1500V overcomes the high cost of energy generation. On the other hand, this voltage change has implications and challenges on the inverter modules and topologies that are required to build solar plants.

Semikron, a leader in power modules, offers various solutions to the PV market. Its portfolio covers the demands and the challenges of the 1500V solar inverters with innovative packaging technologies and module solutions. Semikron's complete portfolio provides coverage from string inverters up to central inverters for installations in the MW range. Further, efficiency, power density, reliability and scalability demands are addressed with various platforms. Hence, customer cost performance ratios and specific needs are met effectively.

In particular, recently introduced SEMITRANS® 10 MLI based solution shows significant benefits for new 1500V central inverter systems.

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The Importance of the Ignition System in Reaching Greener Mobility

Next Challenges for the Electronic Ignition System

By José Padilla, Dr. Hugo Guzman, Stefan Edenharter, Littelfuse

The long road for electric vehicles

Although the number of newly-registered electric cars hit a record in 2016 with around 750,000 units worldwide, electric vehicles (EVs) still represent roughly only 1% of new light vehicles sales [1], far below the forecasts done in the past [2]-[6]. Over the next five years, we expect to see an increase in the share of EVs but by 2022, approximately 88% of the cars would still be powered exclusively by an internal combustion engine, and another 10% would be hybrid, containing both electric and combustion drive train [7].

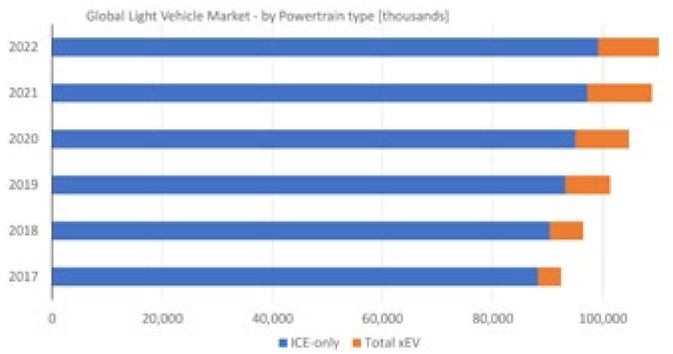

Figure 1: We observe a moderate growth rate of EVs in the growing world's car fleet. Source: LMC Automotive – Global Engine and Transmission Forecast, including LF estimations.

Due to environmental concerns, there's a need to pursue a more sustainable mobility model. Electromobility news fill the mass media. Examples include entire automobile companies converting completely to EV production, and countries vowing to eventually ban the sales of automobiles with internal combustion engines [8]. So, the interest in electromobility is obvious. Then, if this is the case, what makes the vast majority of current customers purchase a vehicle that is powered solely by an internal combustion engine (ICE) instead?

First, the economic impact of higher acquisition and ownership costs (including maintenance and replacements) for EVs' powertrain for comparable power and size [10]. Without incentive policies enacted by local and national administrations, the electric car would hardly penetrate the market in a considerable way. Second, drastic improvements are needed in the capability of, and accessibility to, the energy infrastructure. Also, the increased load on the grid and need to retain stability while reliably supplying energy to unpredictable, highly variable loads have to be considered.

ICE vehicles make up the vast majority of the new cars sold, and the market trend does not indicate a significant change in the future. Subsequently, in order to reduce the environmental impact of cars we must focus on making the gas-fueled vehicles "greener".

Emission regulations and impact on the ignition systems

In this effort, governments and international institutions are requiring car manufacturers to reduce vehicle emissions through the adoption of more restrictive legislations: European Euro 6, Japanese PNLT, America's Tier 1-3, for example. Other industrialized countries are catching up: China with China 6 and Beijing 6 and India with Bharat 5 and 6 are following rules equivalent to Euro 5 and beyond [11]. All of these activities aim to dramatically reduce the number and amount of pollutants released to the environment, and at the same time, provide an improvement in vehicular mileage. There are various mechanisms at the vehicle and subsystem levels to achieve this goal. While improvements in aerodynamics, reductions in mechanical friction and adding advanced drive assistance will help move the market to this goal, clearly the drive train plays a crucial role.

In the engine, focusing on combustion can lead to improvement through advanced pollution control and combustion monitoring [9], to ensure that combustion has been done properly. More advanced and precise spark generation helps to improve the power that the engine delivers as well as reducing the emissions. By varying the spark timing, more power is generated at higher RPMs and tailpipe emissions at cold-start are reduced, for example. Of course, improving the vehicle fuel economy and reducing the CO_2 emissions further can diminish the power output. However, incorporating new mechanisms like friction reduction, turbocharging, etc. can offset the power losses. Also, higher compression ratios (ratio between the maximum volume introduced into the engine and the minimum volume compressed inside the chamber) seem to benefit the energy efficiency: from 8:1 to 10:1 or even more, like in compression combustion engines [12].

Now the question is, how do these new regulations affect the ignition system and consequently, the ignition IGBT?

Combustion in ignition systems is triggered by the spark across the gap in the spark plug. Spark characteristics are determined by parameters such as the spark gap width, the secondary side pulsed voltage level, the spark duration and the spark energy [13]; parameters that depend on the operating conditions and characteristics of the combustion engine. For instance, leaner fuels require the use of wider gaps to allow more air-gas molecules between the spark gap to ensure proper heat transfer when the combustion process is initiated. The use of wider gaps requires higher voltage ratings in order

to initiate the arc in the spark gap and consequently, higher voltage ratings are required for the Ignition IGBT and the elements used in the ignition system. This is also the case when higher compression ratios are required, where it is found that the increase in pressure needs higher voltage levels to ensure the arc-over in the spark gap. Furthermore, smaller engines (with smaller cylinders, while maintaining the same power) and increased acceleration capabilities (for high performance vehicles), require that a higher number of combustions, and consequently, higher Ignition IGBT switching cycles take place within a given timeframe. In both cases, that results in higher operating temperatures [Figure 2].

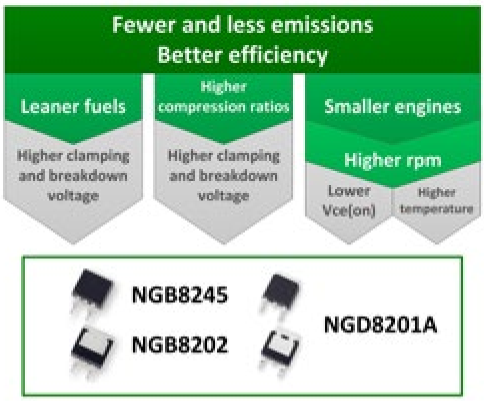

Figure 2: New requirements for the Ignition IGBTs based on new emission regulations and some Littelfuse featured devices.

Littelfuse Ignition IGBTs have very low Collector to Emitter ON state voltage, Vce(ON), compared to other devices with similar current and power ratings, which makes them ideal for use in newer ignition systems with higher RPM ratings, where the rising temperature is a concern. Lower Vce(ON) values result in lower power losses and consequently, lower junction temperatures, smaller system footprint, and less losses. As an example, the test bench setup shown in Figure 3 was used to study the thermal behavior of different Ignition IGBTs under different switching frequencies.

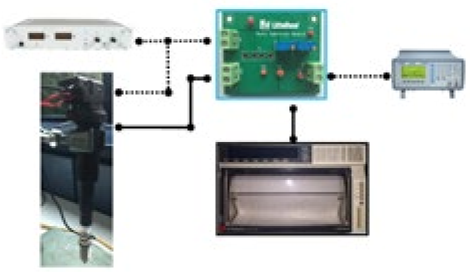

Figure 3: Ignition system experimental setup. The DC supply is set to 12 volts, the square wave generator is set to 5 volts and the frequency is adjusted depending on the test performed. The temperatures of the Ignition IGBTs are taken at room temperature and using a Yokogawa hybrid recorder. The Ignition IGBTs and associated circuitry are mounted in Littelfuse Ignition Evaluation Board. Bosch spark plug and ignition coil 0221504470 were used.

The Ignition IGBTs used in the comparison are Littelfuse NGD18N45 (Vce(ON)typ<1.5V), NGD8201A (Vce(ON)typ<1.35V) and one very popular device from competition (Vce(ON)typ<1.85V), all of them in the same DPAK package. The selected semiconductors are comparable, as they possess similar electric and physical die characteristics and equivalent current and energy ratings. As shown in Fig. 4a, an increase in the switching frequency of the Ignition IGBT, from 33 Hz up to 200 Hz, results in higher losses and consequently, higher temperatures. It is foreseeable that this rise in temperature will affect the performance of the Ignition IGBT and the expected lifetime of the device. Regardless of the switching frequency, Littelfuse devices ensure lower operating temperatures than the competitor device, as shown in [Figure 4b, 4c and 4d]. Notice that the benefit of a lower Vce(ON) gains importance as the switching frequency rises. Results show that Littelfuse devices work at approximately 10°C and 20°C degrees less than the competitor device at 200 Hz [Figure 4d]. Furthermore, the obtained temperature of the NGD8201A at 200 Hz is approximately the same as the obtained by the competitor device at 150 Hz [Figure 4a]. Consequently, Littelfuse devices enable the development of ignition systems capable of achieving higher RPMs. A significant advantage that allows our customers to meet the ever-increasing regulations of the automotive industry, while maintaining a small footprint since they do not require the use of bulky heat sinks or thermal management systems.

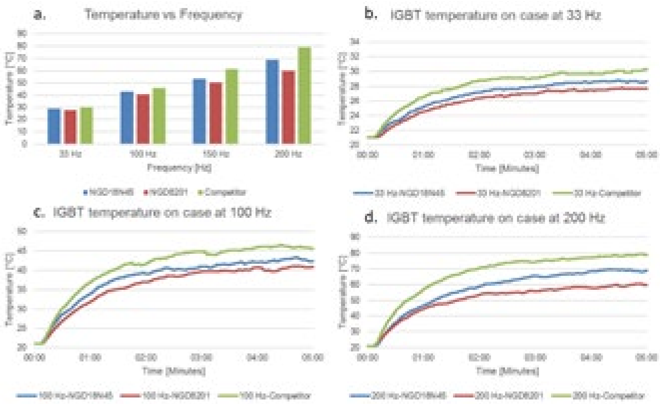

Figure 4: Correlation of temperature against switching frequency.

Stricter legislations will challenge the ignition system designers to continue improving the combustion efficiency as a bridge technology until much broader success of e-Mobility occurs; in some cases, even leading to new combustion concepts - like Mazda's SKYACTIV-X, released to the market recently. Other potential developments include new igniters which require newer semiconductor technologies, for example corona and plasma igniters. In the meantime, increasingly more stringent requirements and harsher operating conditions are applied to the Ignition IGBTs, and Littelfuse devices can cover these current and near-future architectures, bringing sound experience in circuit protection to its rich Ignition IGBT portfolio. Surely, challenging and exciting times are to come for the car makers towards a greener mobility.

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Stefan Edenharter

Senior Marketing Manager, Automotive Electronics

Stefan Edenharter joined Littelfuse in November 2016 in his currently role as Senior Manager Marketing for Automotive Electronics. He received his M.Eng. in Industrial Engineering from the University of Applied Sciences Amberg-Weiden, Germany. Prior to joining Littelfuse, he worked 8 years for Infineon Technologies in engineering, product management and marketing for combustion and electric-engined drives within the automotive division. Stefan is based in Munich, Germany, and can be reached at: sedenharter@littelfuse.com

A New Approach to Superjunction MOSFETs

D3 Semiconductor has entered the market with the intention of changing the DNA of superjunction MOFETs. The company used a novel technique of adding configurability – at the wafer level – when developing its new +FET™ product line. This approach is already yielding design flexibility options never seen before.

By Tom Harrington, CTO, and Scott Carson, VP-Sales & Marketing, D3 Semiconductor

Introduction
A new approach of adding wafer-level configurability to high-voltage superjunction MOSFETs is now available to help solve power supply circuit issues. Offering a new level of configurability in slew rate, threshold voltage, on-resistance and ampacity of the MOSFET offers more control of system dynamics. It also gives the designer freedom to tune the MOSFET to the system – and to reduce time modifying printed circuit board layouts or prototyping magnetic options.

Typical Approaches
Noise and Efficiency Issues
Given the multitude of issues facing designers, the traditional approach is to consider the MOSFET a simple switch with given behaviors, performance and consequences. The remainder of the circuit is then designed to keep the switch operating comfortably in its safe operating area. Additionally, the external circuitry is tuned to reduce noise generated by the MOSFET during its normal operation. From the outside looking in, it seems like rational approach, but the additional circuitry contributes complexity, cost and weight to the system.

The MOSFET can often times be its own enemy in the circuit. Its normal operation generates high-frequency noise during its transition from off-on and on-off. During the on-off transition, this noise can be amplified by parasitic physical properties in the circuit components and board layout. If the amplified noise is coupled back to the gate/gate drive circuitry, the amplified noise can then act to raise the gate voltage to a level high enough to turn-on the device and cause losses.

Adding an additional dimension to the challenge of noise mitigation is ensuring efficiency remains high. Product requirements dictate EMC compliance with the highest efficiency attainable. This leaves the designer pursuing every last 0.1% efficiency from a circuit.

Timing Constraints
Variations in threshold voltage and gate resistance determine system timing constraints that propagate into overall power supply efficiency ratings for the circuit utilizing the device. Tighter and more accurate control of threshold voltage and gate resistance distributions provides many advantages. There are several device parameters of this nature where the absolute value of the parameter is not as important as the width of the variation observed for the parameter. Tighter controls of these distributions would allow the designer the flexibility to make tradeoffs in the system design, improving a particular performance characteristic as needed for a particular application while mitigating electrical noise.

Various techniques have been employed over the years to tighten parametric distributions in a cost effective manufacturing process, but none have been completely satisfactory.

One prior solution has been to concentrate on low cost processing, test the resulting components, and sort the manufactured devices into various parametric distribution categories and to choose only those which are in an acceptable range. This is generally known as “binning.”

Another approach has been to modify the design of the components slightly to allow trimming with a laser or other post-fabrication techniques to shift large numbers of the parts into a desired parametric range. This has been successfully applied to mixed-signal circuitry in mass production. This method has not been successfully applied to vertical semiconductor devices.

The reason that trimming techniques are difficult to apply to vertical semiconductor devices is because the internal units making up the vertical device all have a common connection on the bottom side of the wafer. In order to implement trimming on devices with common terminals, novel techniques, such as those being implemented by D3 Semiconductor, are being employed.

New Approach
When developing its new +FET™ product line, D3 Semiconductor chose a non-traditional technology approach by applying integration to high-voltage superjunction power MOSFETs.

In a traditional transistor configuration, no elements are present to provide trimming capability, as shown in Figure 1.

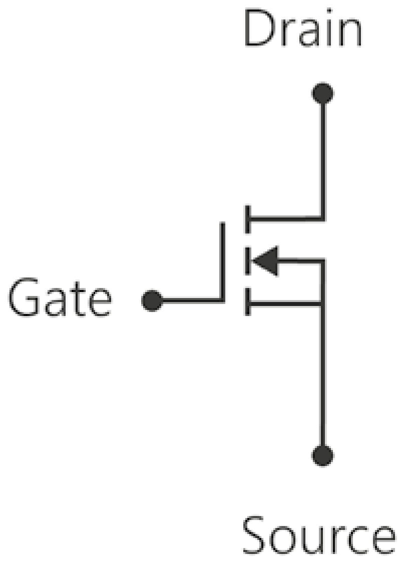
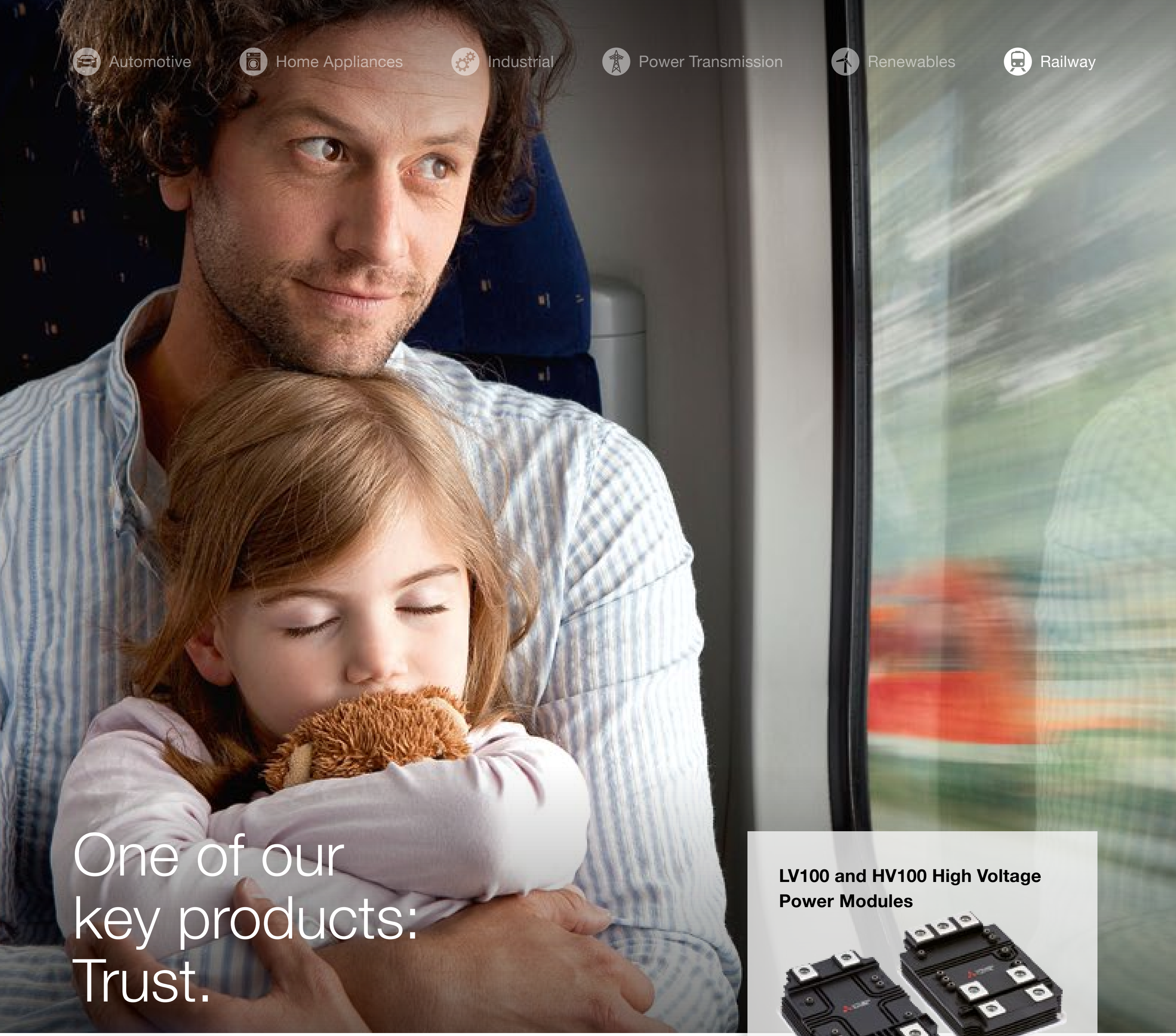


Figure 1: Traditional transistor without trimming capability

By choosing to add control mechanisms in the circuit, choosing a transistor enabled with laser trimming provides an entirely new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host of variables that can be defined by the designer. In particular, behaviors such as switching time, on-resistance, threshold voltage and ampacity can be defined, or configured, to the designer's specifications within a range of choices.

This configurability is implemented by laser trimming the transistor device using multiple parallel device segments, as shown in Figure 2. The same method may be used to match the desired parameter from device-to-device and wafer-to-wafer. This translates into the capability of providing identically matched devices consistently over large-scale production runs.

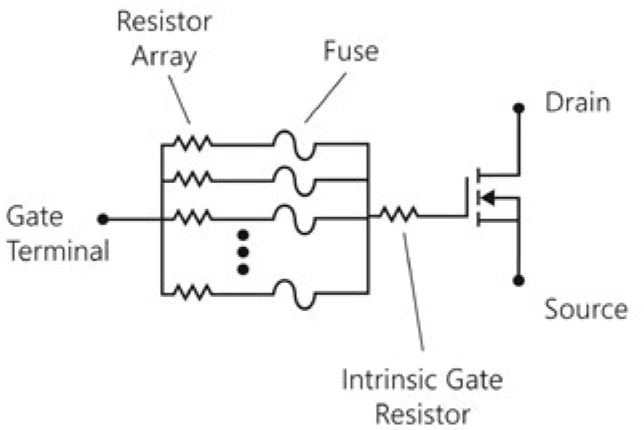


Figure 2: Transistor with configurable gate resistor

The benefit to the designer is that one can have identically matched FETs in an H-bridge configuration (Figure 3) or parallel operation (Figure 4). Knowing the MOSFETs are identically matched allows system overhead to be reduced since the current flow in a given circuit will be predictable.

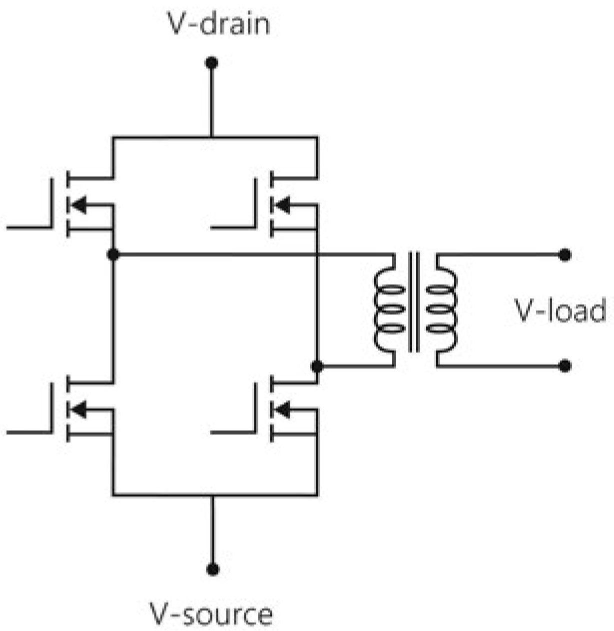


Figure 3: H-bridge circuit configuration.

In addition to trimming for dynamic behaviors, static parameters can be configured in a similar manner. Configuring threshold voltage, on-resistance and ampacity by targeting specific gate resistors and fusible links enables the designer to choose the optimum voltage for the targeted circuit, as shown in Figure 5. By utilizing a laser to create an open circuit in the gate region of the transistor during a standard manufacturing flow, the static parameters may be configured to a desired level.

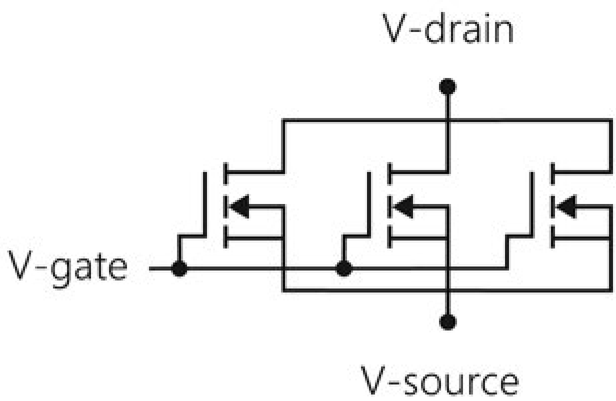


Figure 4: Parallel circuit configuration.

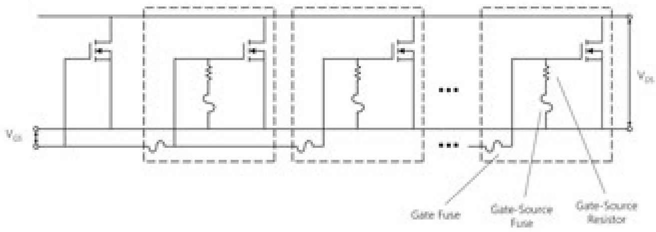


Figure 5: Multiple device trimming to set static parameters.

The benefit to the designer is that one can configure the threshold voltage at a level high enough to ignore circuit noise or low enough to capture lost efficiency in the gate drive circuit. When performing rapid prototyping and a specific on-resistance or ampacity is needed, trimming is implemented to remove transistor active area. The result is the ability to quickly deliver a wafer's quantity of parts in a short period of time while meeting the designer's requirements. When prototyping is complete and the project moves to mass production, a mask set is generated to target the specific threshold voltage, on-resistance and ampacity, so unit costs are optimized.

When developing the architecture of the D3 Semi +FET, considerations for laser trimming were made to keep the injection of laser heat from affecting overall transistor operation. Mixed-signal manufacturing techniques were applied without affecting cost of manufacturability.

Summary

Utilizing laser trimming in volume manufacturing has been performed for years. In the case of high-voltage superjunction power MOSFETs, employing this manufacturing technique is unique and groundbreaking. Not only does it open many new ways for the designer to pursue circuit optimization, this trimming option can be utilized for high-volume production.

www.d3semi.com

New Gen 3 650V IGBT: A Soft and Efficient Switch for Industrial Applications

Recent developments of trench stop IGBTs has led to very high performance devices. However, high performance comes together with some challenges related to the occasional snappy behavior of the device. The new Gen 3 IGBTs from Rohm Semiconductor offer an optimal compromise between performance and ease of use. High system efficiency is combined with minimum effort in the PCB design and electromagnetic interference (EMI) filtering.

By Masaharu Nakanishi, Product Marketing Manager / Power Devices; and Vladimir Scarpa, Field Application Engineer, Rohm Semiconductor GmbH

Rohm IGBT Introduction

Rohm Semiconductor started to manufacture IGBT devices in 2009. In its second generation, the light punch through (LPT) structure was introduced and is shown in Figure 1. LPT structures bring several benefits to IGBTs, like lower saturation voltage $V_{CE(sat)}$ and faster switching. This is obtained since the carrier concentration gradient in the drift layer is smaller than in conventional punch through type, where epitaxial layer is used. This way, the electron current density – majority carriers – is increased, whilst holes density – minority carriers - is decreased. [1]

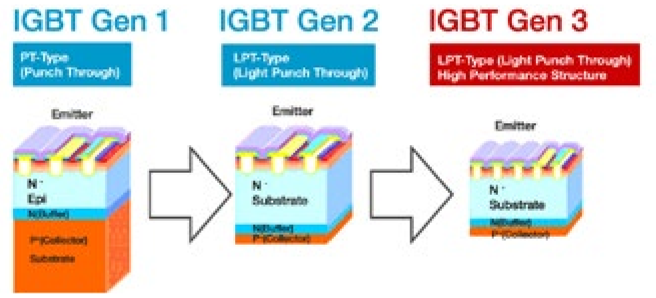


Figure 1 – Technology improvement of punch though IGBTs in Rohm-Semiconductor.

In the Gen 3 IGBTs, in addition to LPT structure, a significant shrink of the cell structure has been realized. This reduces the parasitic capacitances of the device, optimizing the dynamic behavior and reducing the driver efforts. Finally, a wafer thinning of 15 % with respect to the former generation is achieved. This not only reduces the device losses in the conduction state, but also the dynamic losses, as less carriers have to be extracted during the turn-off process.

Product portfolio

The complete portfolio of Gen 3 is presented in Table 1. Device names follow the code depicted in Figure 2. As an important difference from other IGBT vendors, the current portion of the device name contains twice the rated current at T_C=100°C. For each current class, there are two available devices: a single IGBT, or co-packed with fast recovery diode (FRD). In RGTV series, the co-packed FRD has the same rated current as the IGBT. In RGW series, the FRD is rated to a lower current than the IGBT. The rated current of FRDs is shown in brackets in Table 1.

In addition, Gen 3 portfolio is divided in two different series, namely:

- RGTV, for fast switching and with shot circuit withstand time (SCWT) of 2 μs;
- RGW, for even faster switching, in applications where SCWT is not required.

These series contain devices with different rated currents, from 30 A to 80 A at case temperature T_C=100°C. They are packaged in both TO-247N (non-isolated) and TO-3PFM (isolated).

RGTV Series

650V	TO-247N		TO-3PFM	
	Single IGBT	Co-packed w/ FRD (diode rated current)	Single IGBT	Co-packed w/ FRD (diode rated current)
30A	RGTV60TS65	RGTV60TS65D (30A)	RGTV60TK65	RGTV60TK65D (30A)
50A	RGTV00TS65	RGTV00TS65D (50A)	RGTV00TK65	RGTV00TK65D (50A)
80A	RGTVX6TS65	RGTVX6TS65D (80A)	-	-

RGW Series

650V	TO-247N		TO-3PFM	
	Single IGBT	Co-packed w/ FRD (diode rated current)	Single IGBT	Co-packed w/ FRD (diode rated current)
30A	RGW60TS65	RGW60TS65D (20A)	RGW60TK65	RGW60TK65D (20A)
40A	RGW80TS65	RGW80TS65D (20A)	RGW80TK65	RGW80TK65D (20A)
50A	RGW00TS65	RGW00TS65D (30A)	RGW00TK65	RGW00TK65D (30A)

Table 1 – Portfolio of Gen 3 IGBT

Fuji Electric

series 7G

7th Generation Modules

Dual XT & Premium Dual XT

Dual XT – More power, lower losses

FEATURES

- 7G IGBT & FWD
- New internal layout
- Higher reliability
- Improved silicone gel
- Solder or Mini press-fit pins

Premium Dual XT – High power density

FEATURES

- 7G IGBT & FWD
- Advanced bond wire design
- High thermal conductive ceramic substrate
- Package material with CTI > 600
- V_{iso} = 4 kV
- Improved silicone gel
- Solder or mini press-fit pins

www.fujielectric-europe.com

Rohm Semiconductor offers several IGBT series, each of them tailored to match certain application requirements, like short-circuit withstand time SCWT, saturation voltage $V_{CE(sat)}$ and dynamic losses. Figure 3 plots the different IGBT series from Rohm, according to the rated SCWT (x-axis), and operation switching frequency (y-axis).

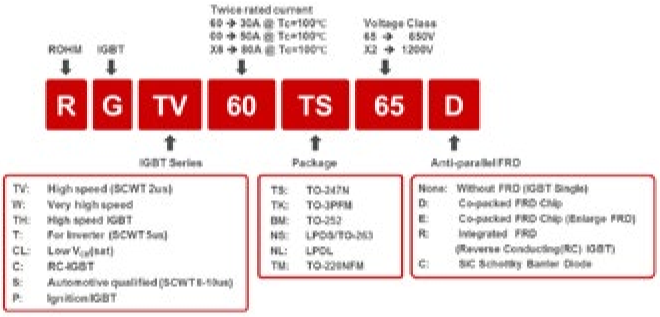


Figure 2 – Naming code for Rohm IGBTs.

Product positioning

As shown in Figure 3, the newest Gen 3 is targeting high efficiency industrial applications such as single-phase power supplies, photovoltaic inverters, uninterruptable power supplies (UPS), battery chargers and welding machines. In these applications, very short or no short circuit withstand time is required. Instead, maximum IGBT performance is requested. This is what devices from Gen 3 are able to offer, with low static and dynamical losses, as is going to be presented in the next section.

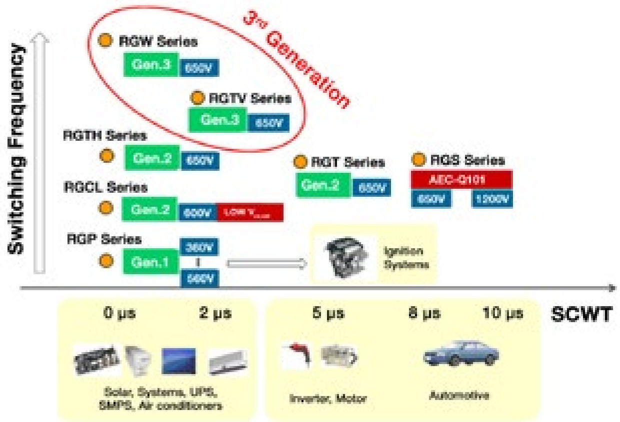


Figure 3 – Applications spectrum and available IGBT series from Rohm Semiconductor.

Device performance

The structure of Gen 3 IGBTs has features that enable a better trade-off between $V_{CE(sat)}$ and turn-off losses. It is possible to optimize these parameters and to obtain thus devices with both lower static and lower dynamic losses.

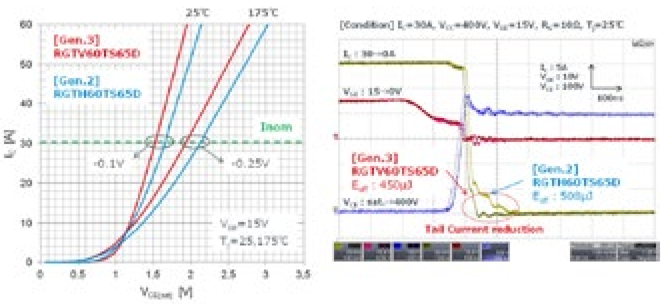


Figure 4 – Static and dynamic comparison between IGBT devices from Gen 2 and Gen 3 from Rohm.

Figure 4 contains the comparison between same current rated devices from RGTH series – Gen 2 – and from RGTV series – Gen 3. On the left side graph, the $V_{CE(sat)}$ of both devices is plotted as function of collector current, for room temperature as well as for maximum junction temperature. The $V_{CE(sat)}$ of the new device is 0.1 V (6%) lower at T_j = 25°C, and 0.25 V (12%) at T_j = 175°C.

In the same way, the right graph of Figure 4 shows the waveforms of both devices during turn-off, at the same environmental conditions. It is possible to observe the effects of the optimized structure of Gen 3. In the RGTV60TS65D, the collector current rapidly goes to zero, with minimum tail current. As a result, 10% less turn-off losses E_{off} are achieved.

The devices from RGW series are very fast IGBTs. This is proved by the waveforms from Figure 5, which compares the turn-off of a 50A rated IGBT from RGW series, compared to an equivalent device from RGTV series. Under same conditions, the RGW device has an additional 30% reduction in the E_{off}.

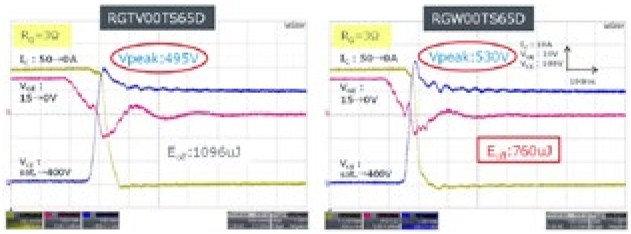


Figure 5 – Comparison between 50A rated IGBTs from RGTV and RGW series.

The fast recovery diode (FRD) technology that is co-packed with Gen 3 IGBT has also been improved. The new Gen 6 FRD technology presents thinner wafer and field stop structure. This results in both lower forward voltage V_F and lower reverse recovery charge Q_{RR}. These are important parameters in inverter applications, in order to reduce losses not only in the diode itself but also in the counterpart IGBT. At the same time, Gen 6 FRD has a very smooth response during its turn-off. This guarantees a fast but soft commutation, avoiding oscillations in the FRD as well as in the IGBT. This is presented in the waveforms of Figure 6, where the turn-off of the former Rohm Gen 3 FRD, the new Gen 6 and a competitor part are compared. Gen 6 presents almost no oscillations in the current and voltage. In addition, it is also the tested device whose QRR increases the least with temperature.

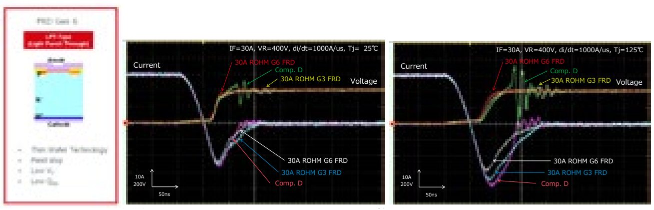


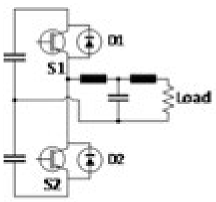
Figure 6 – Simplified Gen 6 FRD technology (left), and turn-off of 30A rated FRDs at T_j=25°C and T_j =125°C.

Benefits in DC-AC Inverters

Systems like photovoltaic (PV) inverters and uninterruptable power supplies (UPS) contain at least one inverter stage, which converts DC into AC voltage. The resulting sinusoidal energy will be injected into the grid in the case of PV inverters, or used to feed an AC load in case of the UPS. Typically used topologies are half-bridge (HB) and full-bridge (FB) in case of single-phase systems, and 3-level, neutral point clamped (NPC) topologies in case of 3-phase systems. IGBT discretes and modules are widely used in all these topologies. They commutate in hard-switching both for turn-on and turn-off. Therefore,

the performance of the co-packed anti-parallel diode plays an important role. As mentioned before, the co-packed Gen 6 FRDs have low forward voltage and reduced reverse recovery charge.

In order to evaluate the performance of Gen 3 IGBTs in hard switched operation, a single-phase HB inverter has been used. Figure 7 presents on its left side its simplified schematic, while the right side contains a table with main electrical parameters.



Parameter	Value
Input Voltage	400 V_{DC}
Output Voltage	130 V_{AC}
Nominal Power	2 kW
Frequency	24 kHz
Gate Voltage On/Off	15 V / -3 V

Figure 7– Simplified schematic of the inverter used for tests (left) and its main electrical parameters (right).

For comparison in the inverter circuit, devices from Gen 2 (RGTH80TS65D) and Gen 3 (RGW80TS65D) have been used. Additionally, devices from „Comp C", today's benchmark device available on the market, have been tested for comparison. The gate resistor $R_{g,off}$ has been selected in order to avoid an excessive VDS voltage spike during turn-off. The inverter loop inductance is quite low, around 50 nH, therefore small gate resistors can be used. For both Gen 2 and Gen 3 IGBTs, a $R_{g,off}$ = 5 Ω resulted in a maximum voltage spike during turn-off of 520 V, i.e. 20% below breakdown voltage. For Comp. C, $R_{g,off}$ was increased to 10 Ω in order to reach 20% margin. The ON gate resistor was $R_{g,on}$= 5 Ω for all three devices.
With the above defined gate resistors, the efficiency of the inverter has been measured for different load conditions. The values are plotted in Figure 8. They include the losses in the IGBTs, as well as in the output filters, cables and connectors.

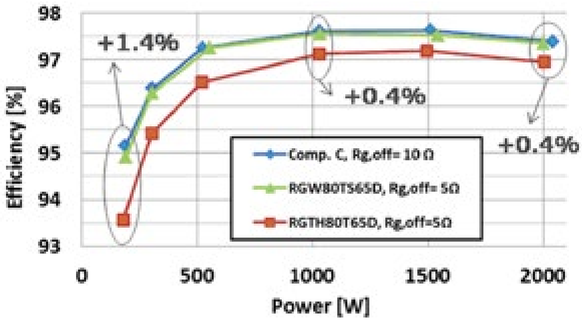


Figure 8– Efficiency comparison between 40A rated IGBTs from Gen 2, Gen 3 and Comp. C.

It is possible to observe in Figure 8 the improvement of Gen 3 with respect to Gen 2. For low power conditions, up to 1.4% improvement in efficiency is achieved. For middle and high power conditions the improvement is 0.4%. The difference between Comp. C and RGW80TS65D (Gen 3) is inside the accuracy of the measurements, and can be therefore neglected.

Behavior during Turn-Off
Besides performance, an important characteristic of the IGBT is its V_{CE} characteristics during turn-off. This characteristic is related to the oscillations which can be generated in V_{CE}, and eventually be reflected to gate voltage.

Figure 9 shows a comparison between of RGW80TS65D (left side) and a competitor device (right side). This is a fast version of Comp. C, and has been labeled as Comp. B. The waveforms have been obtained during the tests in a portable welding machine, with relatively high loop stray inductance, above 100 nH.

In the right upper corner of Figure 9, Comp. B was tested with $R_{g,off}$ =10 Ω. Compared with the waveforms from RGW80TS65D (left), one can see that not only the overshoot of V_{CE} of Comp. B is twice as high – 244 V against 120 V, - but also that a series of further oscillations occur after the first peak. In the RGW80TS65D, there is a single overshoot, after which the V_{CE} is reaching the DC link voltage smoothly. It is thus expected that a much lower level of electromagnetic emission (EMI) comes from RGW80TS65D. Additionally, the feedback capacitance between collector and gate causes oscillations in VCE to be reflected in VGE. This generates positive peaks much higher than the threshold voltage of the IGBT. This leads to the risk of parasitic turn-on and leg shoot through, with consequent destruction of the entire machine.

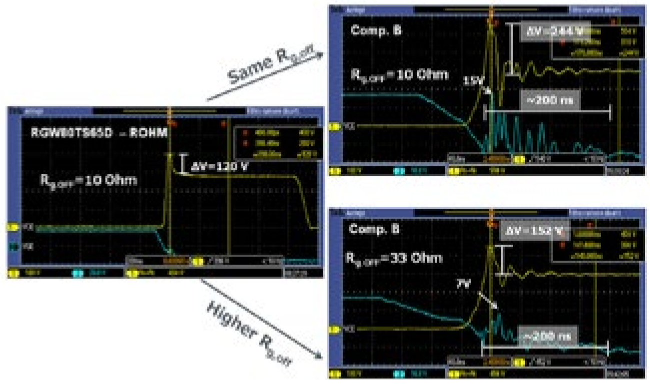


Figure 9– IGBT waveforms of VCE (yellow) and VGE (light blue) during turn-off in tested in a portable welding machine.

In order to reduce the oscillations in the IGBT, the turn-off gate resistor can be increased. This is proved by the waveforms in the lower right corner of Figure 9, for $R_{g,off}$ =33 Ω. However, even if the peaks are now reduced, the oscillation in VCE in Comp. B will occur during a much longer time than in RGW80TS65D with $R_{g,off}$ =10 Ω. In addition, the peak in VGE is still higher than the IGBT threshold voltage.

Summary
Gen 3 IGBTs from Rohm Semiconductor represent a remarkable technology improvement. The two available versions RGTV and RGW offer IGBT devices rated up to 50A (RGW) and 80A (RGTV), in a standard TO-247N package.
The performance of Gen 3 matches the needs of many industrial applications, such as: single phase power supply, welding machines, photovoltaic inverters, UPSs and battery chargers.
Experimental tests of Gen 3 devices in DC/AC inverter proved that their performance is comparable to the market benchmark. Differently to other high speed IGBTs in the market, though, Gen 3 has a soft and oscillation free turn-off. This guarantees safe operation even if small values of external gate resistance are used. In combination with the new Gen 6 co-packed fast recovery diode technology, Gen 3 IGBTs offer an optimal compromise between performance, design simplicity and filtering effort.

Reference:
[1] S.Hondo, Y.Enomoto, Y.Kawamoto, A.Hikasa, K.Ino, "High efficient and soft IGBT technology", PCIM 2017

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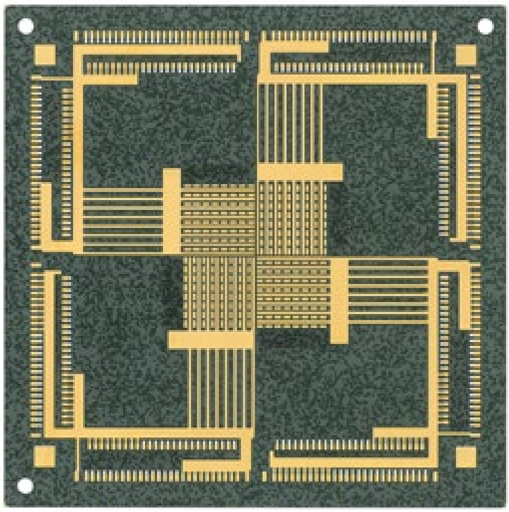
Substrate with Integrated ESD Protection



The printed circuit board has long since become more than just a carrier material and redistribution layer for components. A growing number of functions are now being embedded directly into the circuit board. With CeraPad™, TDK has now succeeded in developing an ultra-thin ceramic substrate with integral ESD protection, specifically for LEDs.

By Dr. Dieter Vogel, Product Marketing Multilayer Piezo and Protection Devices, TDK

LEDs are the state-of-the-art in lighting systems both inside and outside buildings. In addition, LEDs are now commonplace in smartphones for flashlight and camera flash functions. Car headlights and other lighting systems for all kinds of vehicles are likewise based on this lighting technology. Despite their great advantage such as high energy efficiency and longevity, LEDs have one serious drawback: like all semiconductors, they are very sensitive to electrostatic discharges (ESD). For this reason, corresponding discrete protective components are necessary for existing solutions, depending on the series and parallel connection of the individual LEDs. Suitable devices for this purpose are TVS diodes or – significantly better – compact and attractively priced multilayer varistors from the EPCOS CeraDiode® series. These SMD components exhibit no temperature-dependent derating and enable the use of soldering process for mounting rather than complex wire bonding on a PCB. Figure 1 shows a conventional solution for protecting LEDs against ESD.

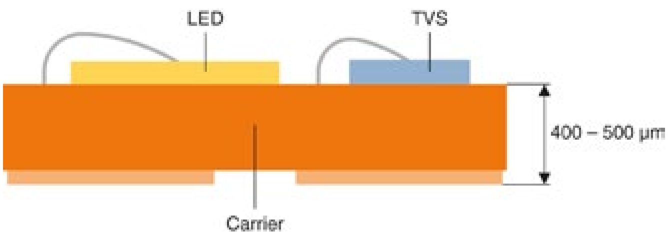


Figure 1: In conventional LED lights, the ESD protective component – in this case a TVS diode – is positioned next to the LED on the substrate.

The discrete approach however has the crucial disadvantage of less efficient use of the printed circuit board surface by the actual light source. In addition, the protection component impedes the optimum radiation of the light generated by the LED, thus diminishing the efficiency of the LED.

In order to solve this problem, TDK has taken a completely new approach with CeraPad, in which the company's long-term experience in the development of miniaturized multilayer ESD protection components and LTCC substrates have been very elegantly combined. CeraPad is an ultra-thin ceramic substrate with integrated ESD protection. This satisfies the demand for maximum miniaturization combined with the best possible ESD protection and thus enables highest degree of ESD integration in sensitive applications. As such, it completely eliminates the need for additional discrete ESD components, enabling the mounting density of the LEDs to be massively increased, which also results in financial savings due to the more efficient use of the substrate surface. Finally, reliability is improved by the elimination of TVS diodes and bond wires, as well as the associated cost-intensive component placement and process steps. Figure 2 shows a cross-section through the new carrier material.

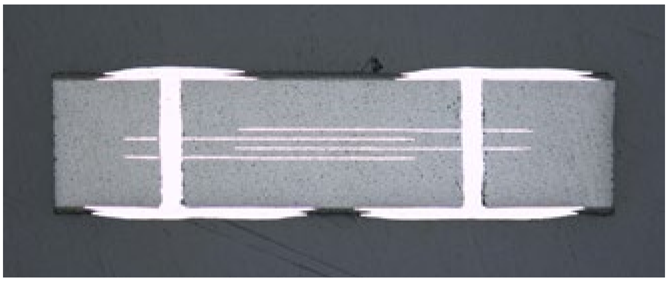


Figure 2: The multilayered structure of the embedded overvoltage protection component can be seen between the two vias.

CeraPad is far superior to silicon-based Zener diodes

This functional ceramic wafer is an ideal LED substrate with an ESD strength of up to 30 kV. This is more than three times higher than that of Zener diodes which only offer 8 kV. CeraPad also enables customized chip-scale packages (CSP) to be implemented for standard LED elements from CSP0707 to CSP1515 with a considerably higher packing density.

Furthermore, CeraPad offers a low coefficient of thermal expansion of 6 ppm/K, which is nearly identical to that of silicon-based LEDs. As a result, there is no critical mechanical stress between substrate and LED when the temperature changes. Moreover, the ceramic substrate features a high thermal conductivity of at least 22 W/mK that can be further increased by means of silver thermal vias. Another advantage is the high bending strength of 250 MPa for a substrate thickness of just 300 µm to 400 µm.

Depending on customer requirements, the CeraPad contact pads can be designed for both standard SAC (Sn/Ag/Cu, 260 °C) reflow processes and eutectic bonding (AuSn, 320 °C). Figure 3 shows the design of an LED unit implemented with CeraPad.

CeraPad is an extension to TDK's CeraDiode portfolio, which includes powerful ceramic ESD protection components with innovative wafer technology, as well as modular solutions. With CeraPad, TDK now offers attractive customized packaging solutions that

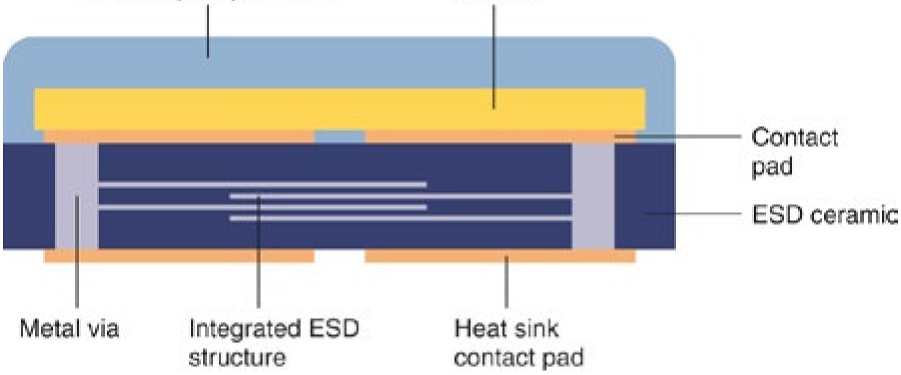


Figure 3(a+b): With CeraPad, the ESD protection is embedded directly into the substrate below the LED. Thanks to chip-scale packaging this permits a considerably higher packing density compared to existing solutions.

Adaptive headlights using LED matrix arrays

CeraPad is not only suitable as a substrate for LED dies with integrated ESD protection, but – like a conventional printed circuit board – can also be used as a redistribution layer at the same time. As many as ten such redistribution layers can be implemented in this way without compromising the thermal performance. For comparison: Using conventional isolated metal substrate (IMS), only five redistribution layers can reasonably be implemented, and here the thermal conductivity decreases with each additional layer. On the CeraPad substrate, however, it is possible to place as many as 1000 tightly packed LEDs which are individually controllable according to customer requirements (Figure 4).

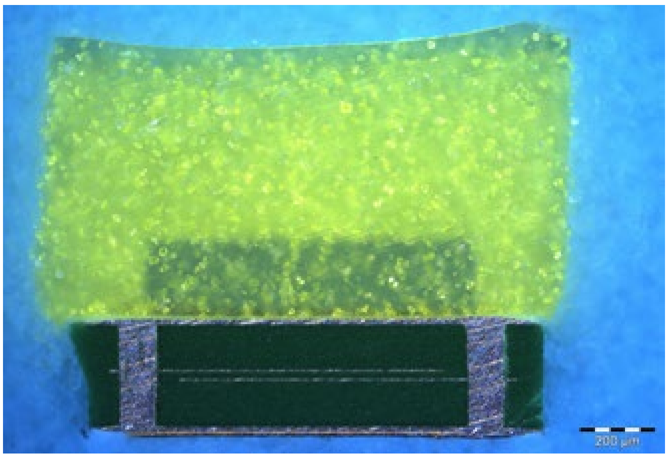


Figure 4: With this CeraPad design it was possible to realize a 16 x 16 LED array consisting of CSP0707 LEDs, in which every LED is individually controllable. On this basis, for example, adaptive car headlights can be designed with a customer-specific layout using as many as 1000 LEDs.

Using this technology, designers can create innovative, high resolution lighting effects in the smallest of spaces, for example in multiple LED flashes in smartphones, automotive interior lighting systems, or in the adaptive headlights of cars.

both meet the technological challenges of increasing sensitivity of ICs and continue to drive the miniaturization of LED modules. For customers, this opens up attractive possibilities for optimizing light design and further increasing the light yield of LEDs.

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System-Simulation for Virtual Power Modules

Designing, dimensioning and optimization of power modules and its management is a complex task. Electronic designers of power modules are focused today on targets like: cost reduction, increase of power density, increase of product reliability and reduction of parasitic elements. These targets will result on a negative impact on the overall performance of switching behavior and switching loss of power semiconductors.

By Roberto Gandía, FlowCAD EDA-Software Vertriebs GmbH

Different fields of application (automotive, IoT, medical) are driving the need to design and optimize the complete power system with respect to performance of the power module and at the same time keeping the cost low and design a system with a high degree of interchangeability. This increase of the requirements and a mixed signal architecture of power modules make the design process a difficult task.

Optimization often results in an increasing number of interacting sensors which adds another level of complexity to such feedback control system. At the same time all industries want to miniaturize their devices and the dimensions of power modules have to shrink with less safety space between the sensitive parts of the circuit. Flexibility and reliability often drives the demand to build platforms of power system, which can be reused for multiple applications very quickly. Platforms are designed for a much wider specification and they need to operate in all corner cases.

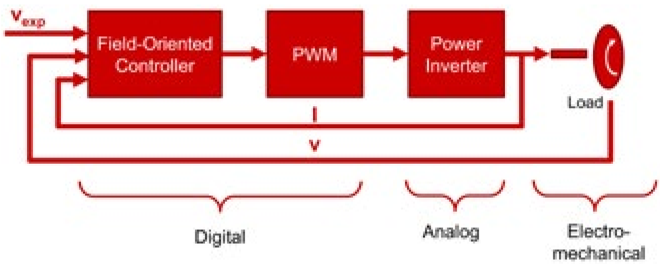

Figure 1: Example of system which includes a power module, a controller and a load

The conventional way to evaluate and verify all requirements of a power system was to design the analog and the digital part of the circuit in its respective departments and working in separate teams. Each of these teams achieved the proposed specification and finally integrated all the parts in a hardware prototype to test it. Many errors were only found when the first set of hardware prototypes was build and required modifications had to be done in the different (analog and digital) departments. These iterations would lead to redesigns and building of multiple prototypes.

This process of physical prototypes is time consuming and requires an increasing number of measurements for different corner cases.

To overcome the cost and time spend on multiple prototypes and measurements a mixed signal simulation of the complete system is required to simulate the interaction of the analog and digital part of the system. In such a simulation the goals of performance, reliability, yield and flexibility should be covered and evaluated before the first physical prototype is build.

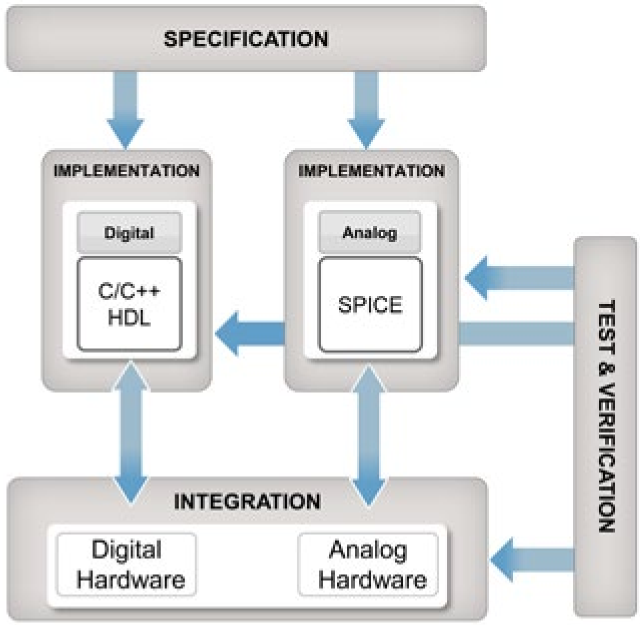

Figure 2: Traditional analog/mixed signal design flow

Cadence Design Systems introduced a new comprehensive simulation to analyze further partial aspects of the power module and its management in different kind of simulations. First you could simulate different analog designs to prove not only that it works as it is expected, but also to prove that they are reliable for production. The simulation covers manufacturing tolerance variations, different ambient temperatures during operation, the full operating range as specified, and aging of electrical components. After stabilizing the analog or digital implementation of the design, it has to be integrated in a system-wide simulation with all integration parts of the power design together.

Power systems are complex and often developed by teams with several people or in different departments. This means that different parts of the power module are developed independent of each other, without the interaction between the analog part, digital part, embedded regulator software, and consideration of different ambient conditions.

Only when individual parts are assembled in a hardware prototype and a physical verification is carried out differences or gaps occur regarding the specification. Some errors found while validating the prototype will require massive changes to the design block. Necessary changes discovered late in the design process are very expensive, because the design has to be performed again and all time spent so far is lost. It is very cost intense to introduce changes to the specification after start of development and communicate the impact to all members of the development team.

In general the cost of changes to the specification will be higher, when they occurred in advanced stages of the design process. In order to minimize the cost of changes and not delay the planned start of production, an early merge of the partial developments in a single simulation environment makes sense.

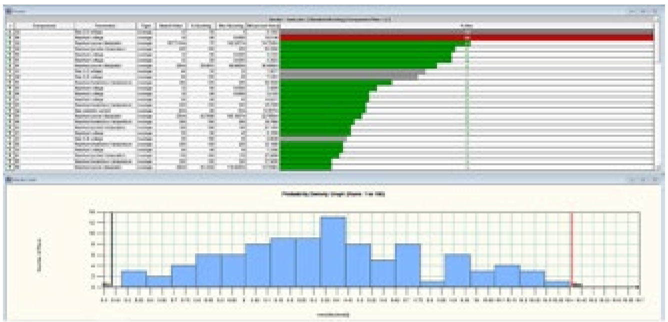

Figure 3: Example showing stress and component tolerances (Monte Carlo Analysis) to improve overall reliability

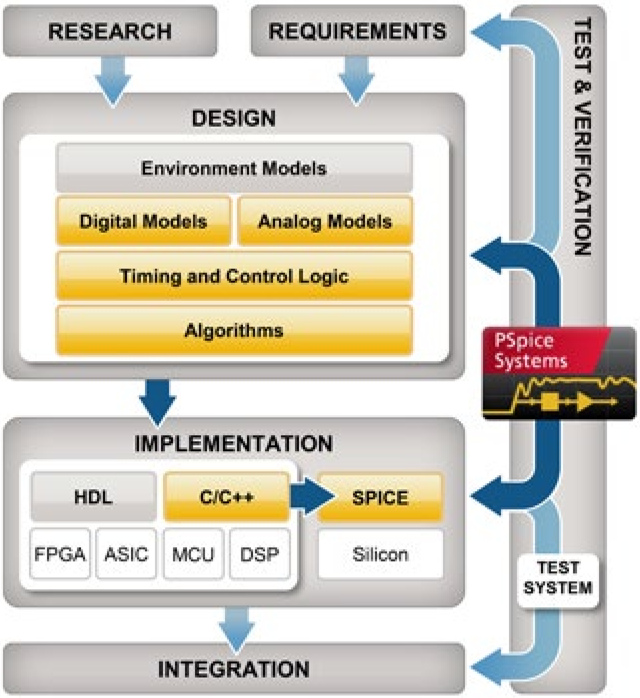

Figure 4: Use of PSpice Systems Simulator to match simulation environment for electrical and physical system

Iterations in the development process can be reduced if a parallel methodology is used in which information between departments is exchanged at any time and is available to all members at the same time. Individual development results can be exchanged and their influence on the overall system is recognized at the earliest stage possible. The results can be used immediately for improvements or changes.

Such exchange of information across teams requires compatible tools and appropriate interfaces. Only when blocks of the other departments can be used quickly, easily and safely in other departments the methodology is accepted by the users. For the electronic developers, it is advantageous if they can integrate other modules of the drive circuit as a function block in his simulated environment familiar to him. In this virtual world, the software control, the management and the power module can now be optimized.

In the case of complete new developments, an early simulation also provides results which enable the specification to be checked.

Specifications have frequently gaps or undefined states because some things were not thought of in the preview or not all requirements were known at the beginning. If these questions arise during the simulation, the points can be clarified and the specification is supplemented or clarified.

A system simulation flow consists of a combination of MATLAB/Simulink and PSpice in a bi-directional co-simulation. On the first hand, MATLAB/Simulink is a platform for multi-domain simulation and model-based design of dynamic system, which offers a massive simulation library for different application fields like automotive, medical, IoT, etc. On the other hand, PSpice is a full-featured ISO 26262 certified analog simulator with support for digital elements to help solve virtually any electrical design challenge, where it is possible to use a big set of very new models, as most IC vendors provide compatible models. Using both together in a co-simulation allows to exhibit the non-linearities, delay and other real-world effects for the electrical components in the system simulation. You can even visualize the PSpice results in MATLAB as well as use all MATLAB mathematical functions in PSpice to debug the system level error much more easily avoiding processing this manually, which usually prone to error. This bi-directional co-simulation between the behavioral/mathematical MATLAB/Simulink blocks and the circuit level analog/mixed signal PSpice blocks in one integrated environment allows increasing quality, flexibility and reliability of the whole system. Furthermore it lets verify that the integrated system works as the requirements and decrease the developing difficulties and the time to market of the product.

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Effectiveness of Phase Correction When Evaluating High-Efficiency Motor Drives

Against the backdrop of international efforts to prevent global warming, the increasingly efficient motor drive systems used in electric vehicles and industrial applications have been attracting attention in recent years. Essential in evaluating the efficiency and loss of motor drive systems, the ability to measure power accurately demands a range of expertise.

By Hideharu Kondo, Chiaki Yamaura, Yukiya Saito and Hiroki Kobayashi; Hioki E.E. Corporation

Introduction

This article focuses on the characteristics of inverter output waveforms in order to outline requirements for the power measuring instruments that are needed to accurately measure inverter output power. It also introduces phase correction by a power analyzer with a focus on current sensor phase error in order to satisfy those requirements. Finally, it reports on the authors' verification of the effectiveness of current sensor phase correction.

Characteristics of inverter output waveforms

Principal components of inverter output power include a fundamental frequency component (up to 2 kHz), its harmonic components, the switching frequency (5 kHz to 100 kHz), and its harmonic components. Of those, the fundamental frequency component is dominant. Figure 1 illustrates an inverter output's line voltage waveform, line current waveform, and associated FFT results for a typical motor drive system. Table 1 provides detailed information about the measurement target.

Looking at the voltage FFT results, it is possible to observe the fundamental wave that is the principal component of the line voltage PWM waveform and its harmonics, along with the switching frequency and its harmonic components. A spectrum of at least 0.1% f.s. exists up to approximately 2 MHz.

The fundamental wave, its harmonics, the switching frequency, and its harmonic components can also be observed for the current waveform. However, the observed spectrum at frequencies of 100 kHz and above falls below 0.1% f.s., and the current level falls abruptly as the frequency increases. This phenomenon can be explained by considering the equivalent circuit of a motor that is connected to an inverter as a load (Figure 2). The motor's winding can be thought of as an R-L load consisting of a resistance and inductance connected in series. Consequently, impedance grows at high frequencies, making it harder for current to flow.

Similarly, if we look at the power factor (cos θ) for the power of an R-L load, the power factor approaches a value of 1 when the frequency is low, for example for the fundamental wave and its harmonics. However, because inductive reactance becomes dominant at high frequencies such as the switching frequency and its harmonics, current exhibits lagging phase, resulting in a low power factor.

The bottom half of Figure 3 provides an enlarged view of the time axis for the inverter output voltage and current waveforms up to the switching frequency region. The voltage waveform is rectangular, while the current waveform is triangular. It is apparent that their phase relationship is characterized by the current's lagging phase, as described above, resulting in a low power factor.

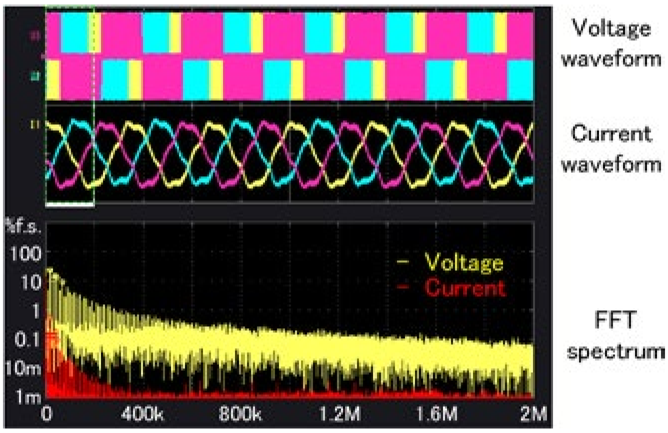

Figure 1: Waveform and FFT results for an inverter-driven motor (measured using the Hioki Power Analyzer PW6001)

Inverter		Motor		
Switching element	Switching frequency	Inductance	Resistance	Rated power output
SiC-MOSFET SCH2080KE (ROHM)	20 kHz	3.6 mH	0.9 Ω	120 W

Table 1: Measurement target specifications

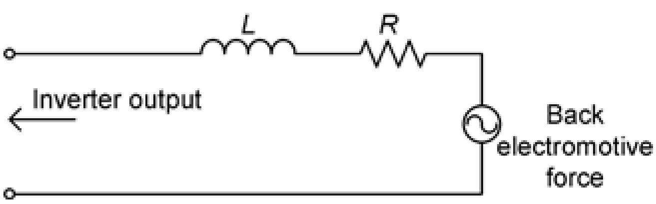

Figure 2: Motor equivalent circuit (for 1 phase)

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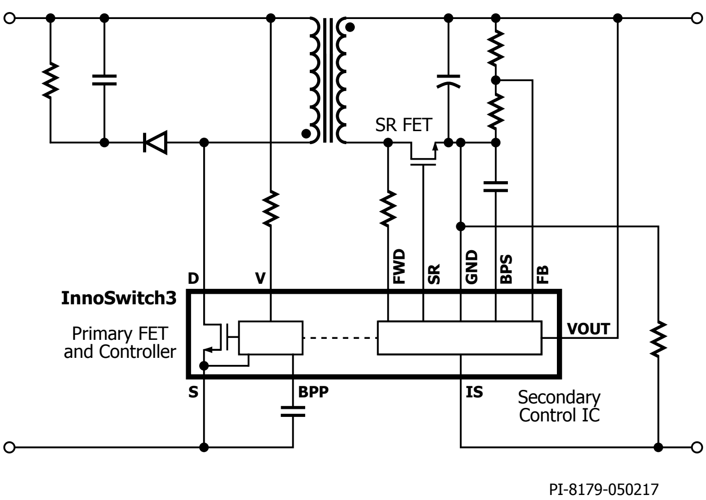

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Performance required for high-precision measurement of inverter output

This section describes the requirements that a power measuring instrument must satisfy in order to accurately measure inverter output power. Based on the characteristics described above, it is important that such an instrument be capable of measuring active power not only for a high-power-factor fundamental wave and its harmonics, but also for a low-power-factor switching frequency and its harmonic components.

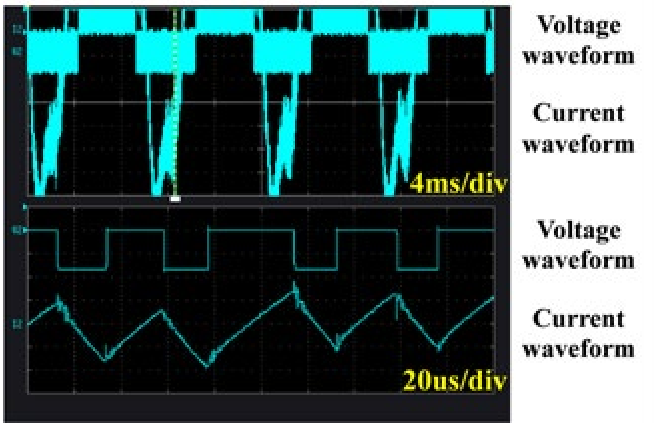

Figure 3: Enlarged view of inverter output waveforms

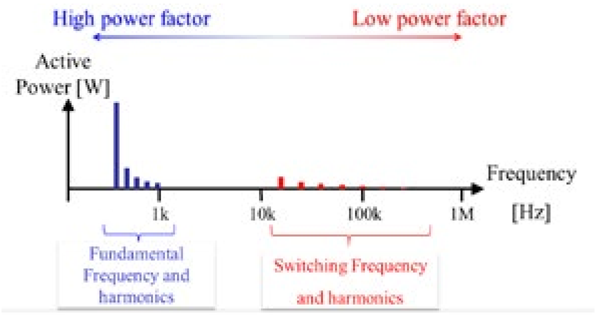

Figure 4: Principal components of inverter output active power and their characteristics

Figure 5 illustrates the relationship between phase error and active power error at different power factors. Voltage and current phase error in the measurement circuit has a greater effect on active power at low power factors than at high power factors. Consequently, accurate measurement of active power at the switching frequency and its harmonic components requires both flat amplitude characteristics and flat phase characteristics across a broad frequency band (the latter being particularly important). For power components that consist of a rectangular-wave voltage and triangular-wave current as shown in Figure 3, the frequency band across which the instrument must exhibit flat amplitude and phase characteristics in order to measure efficiency at a precision of 0.1% is likely 5 to 7 times the switching frequency[1]).

Active power frequency characteristics at a power factor of zero provide a yardstick for measuring flat amplitude and phase performance. Figure 6 provides example active power frequency characteristics at a power factor of zero for several Hioki Power Analyzer models. Please note that these example characteristics describe the instruments' standalone performance.

The PW6001 delivers flat characteristics up to 1 MHz, reflecting its envisioned use case of measuring inverters that use SiC switching elements.

The PW3390, which is designed to measure inverters that use IGBT switching elements, provides flat characteristics up to 150 kHz. The instrument is designed to surpass the performance of the 3390, the previous-generation model, in order to facilitate high-precision measurement of inverter output.

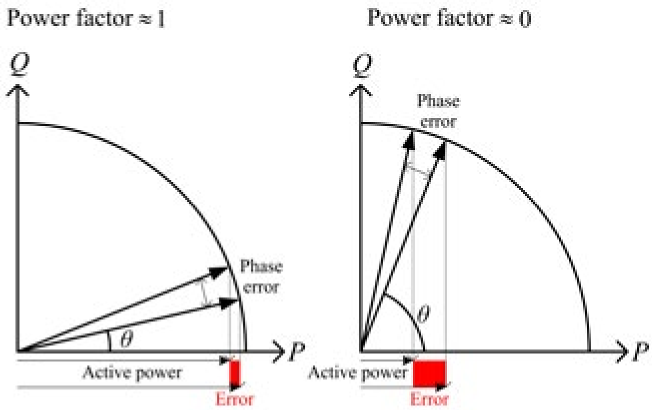

Figure 5: Relationship between phase error and active power error at different power factors

Current sensor phase correction

When a power analyzer is used in a high-precision power measurement application, it is typical to utilize a current sensor to measure currents that exceed 5 A[2]). Consequently, in order to implement a power measurement system whose flat amplitude and phase characteristics extend to high frequencies, it is necessary to satisfy the above performance requirements not for the power analyzer on a standalone basis, but rather when the power analyzer and current sensor are used in combination.

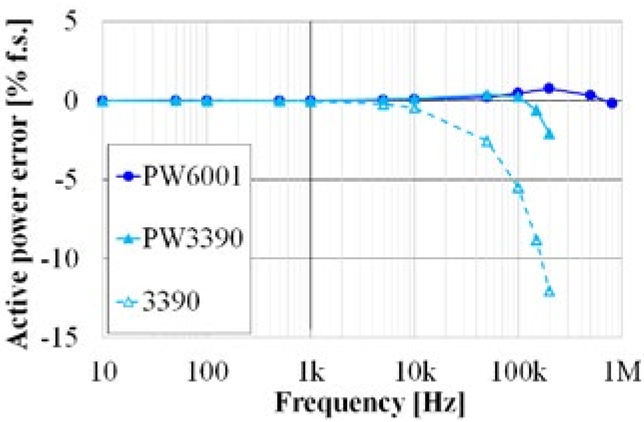

Figure 6: Example active power frequency characteristics at a power factor of zero for Hioki Power Analyzers

However, current sensors typically exhibit gradually increasing phase error in the high-frequency region due to the characteristics of the sensor's magnetic core and circuitry. Furthermore, differences in the design of various sensor models cause the magnitude of this error to vary. Figure 7 illustrates example phase characteristics for several Hioki high-precision current sensors.

The current sensor phase correction functionality provided by the Hioki Power Analyzer PW6001 and PW3390 can be used to resolve this issue. Phase correction uses current sensor-specific phase error information to correct the error, thereby improving phase characteristics in the high-frequency region and reducing power measurement error.


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The phase correction function utilizes virtual oversampling technology to perform real-time de-skew processing for sampled waveforms at a high time resolution equivalent to a frequency that is 400 times higher than the actual sampling frequency. By performing delay compensation for waveforms using the concept of time, phase correction benefits can be extended across the full frequency band.

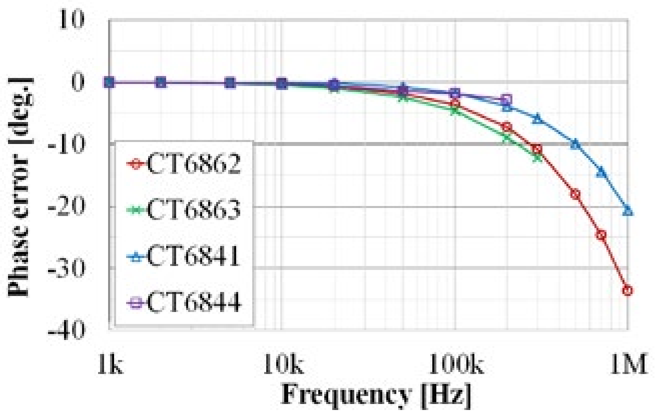

Figure 7: Current sensor phase-frequency characteristics

Hioki develops high-precision current sensors in-house, and it has ascertained the phase characteristics of each sensor model by optimizing design and manufacturing processes and by implementing strict production control. The current sensor-specific phase characteristics information used in phase correction can be found in the user manual of each Hioki power analyzer. Figure 8 illustrates the result of performing phase correction for the current sensors shown in Figure 7 using that phase characteristics information. Performed properly, phase correction yields significantly better phase characteristics in the high-frequency region.

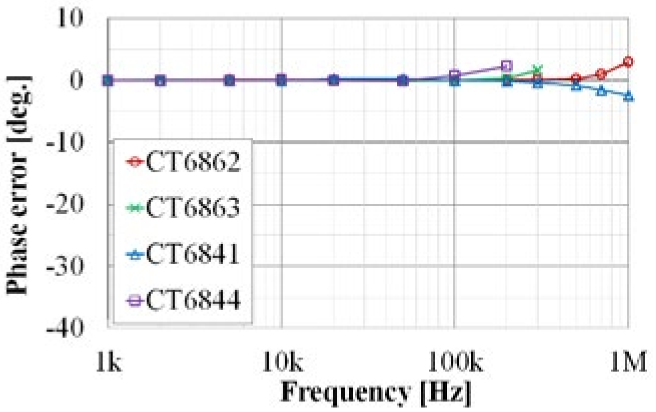

Figure 8: Phase-frequency characteristics following phase correction

Item		Model PW6001	PW3390	3390
Input (DC)	Wiring	1P2W		
	Current Sensor	CT6862		
	Phase Correction	OFF / ON (-10.96deg@300kHz)		N/A
Output (PWM)	Wiring	3P3W3M		
	Current Sensor	CT6862×3		
	Phase Correction	OFF / ON (-10.96deg@300kHz)		N/A
	Fundamental Frequency	100Hz		
Power Analyzer Frequency Band		~2MHz	~200kHz	~150kHz

Table 2: Measurement conditions

Comparison of actual inverter efficiency measurements

The authors measured the efficiency of the SiC inverter described in Table 2 above using three Hioki Power Analyzer models and compared the results. Table 2 summarizes the measurement conditions. Separate measurements using the PW6001 and PW3390 were performed with phase correction enabled and disabled.

Figure 9 summarizes the measurement results for efficiency and loss. Both the PW6001 and PW3390 yielded efficiency values that were 0.1% to 0.15% greater than the 3390 with phase correction disabled. The difference in values was likely due to the instruments' superior active power frequency characteristics at a power factor of zero (Figure 6).

Efficiency values with phase correction enabled were another 0.1% to 0.15% greater than those obtained with the function disabled. Figure 10 illustrates the DC input power P4 and the PWM output power P123 for the measurements shown in Figure 9. Whereas the P4 values from the PW6001 and PW3390 remained unchanged regardless of whether phase correction was enabled or disabled, P123 values were 0.1% to 0.15% greater when phase correction was enabled compared to when it was disabled. Based on these results, the reduction in the CT6862 current sensor's lagging phase error (Figure 7 and Figure 8) is readily apparent in the P123 measured values.

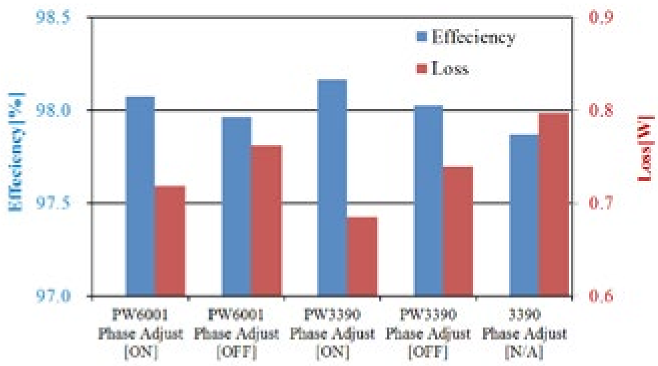

Figure 9: Comparison of inverter efficiency and loss by model

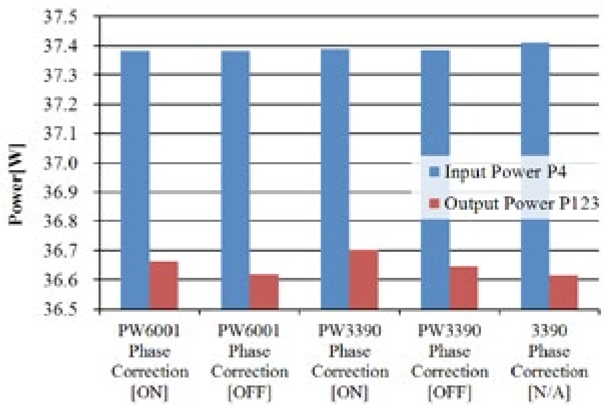

Figure 10: Comparison of inverter input and output power by model

Finally, a comparison of the loss values shown in Figure 9 reveals that loss values obtained from the PW6001 and PW3390 with phase correction enabled were 0.1 W (equivalent to 12%) lower than values from the 3390. This test measured a small motor as its load, but a 12% difference in loss for a 10 kW, 95% efficient inverter would be equivalent to 60 W of power, a difference large enough to have an impact on thermal design.

To accurately evaluate efficiency down to the 0.1% level and loss to the 1 W level in a high-efficiency motor drive system, it is important to ensure that the entire power measurement system has appropriate amplitude and phase characteristics. The authors' measurement results illustrate the effectiveness of current sensor phase correction.

Because the measured inverter used a switching frequency of 20 kHz, both the PW6001 and PW3390 had an adequate frequency band, and there were no significant differences in the measurement results from the two instruments. However, differences between the two models are expected if the switching frequency increased further.

Conclusion

This paper focused on inverter output power, outlining the requirements for power measuring instruments in order to facilitate accurate measurement. It identified the importance of current sensor phase correction expertise in fulfilling those requirements and verified the effectiveness of that technique by comparing actual measurements. In the field of power electronics, there are numerous opportunities for measuring power at high frequencies and low power factors[3]) apart from motor drive systems, and phase correction expertise can be effectively utilized in those applications. We look forward to providing more useful information about this topic to readers in the future.

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Modeling Thermal Behavior of IGBT Modules in Conversion Equipment

The article describes research of Proton-Electrotex, JSC in modeling thermal behavior of IGBT modules in conversion equipment.

In recent years designers of power electronics turned to increasingly wider usage of integrated system solutions (power assemblies) from manufacturers of power semiconductors. In some industries such stand-alone units optimized for specific applications are preferable to discrete power modules.

By Timofei Fedorov, New Products Engineer, Candidate of Technical Sciences, Assistant Professor, Proton Electrotex

Of course, the process from receiving technical specifications to production of a test sample of power assembly is no easy task. It is complicated by the need to select a semiconductor-heatsink combination that would ensure maximal usage of semiconductor capabilities, at the same time meeting the price cap set by similar solutions on the market.

Designers use temperature of the transistor chip in the heaviest operation mode as an efficiency measurement of a given solution. The procedure of losses calculation is described in many manuals on operation of semiconductors and amounts to finding the sum of losses related to end time of switch-on/switch-off of semiconductor components (dynamic losses) and losses related to non-ideal conductivity of semiconductor module components in on-state and leakage current in off-state (static losses). The type of more prominent losses depends on switching frequency, modulation rate and used circuitry.

The development process is iterated. The amount of iterations depends on experience and tooling of the designer. We recommend the following algorithm to select a suitable IGBT module:

1. Select a module of suitable class and nominal current no lower than the maximal output current of the converter.
2. Determine currents and voltage at its separate elements.
3. Calculate static and dynamic losses at each semiconductor element of the module in maximal operation modes of the converter. Calculations should be based on chip temperatures close to maximal permissible.
4. Use values of thermal resistance for each module component relative to the module baseplate and the value of thermal resistance between the module baseplate and the heat sink to calculate maximal permissible temperature of the heat sink in the module installation area.
5. Calculate total losses in the module. Calculate temperature of the heatsink in the modules installation area on the basis of intended heatsink structure and maximal permissible temperature of environment.
6. If this temperature does not exceed the calculated value received in Item 4 with sufficient margin, selection of the module is considered complete.
7. If the margin of the heatsink temperature in module installation is too high, consider switching to a module with lower nominal current. If the module is replaced, repeat the thermal calculations.
8. If the margin of heatsink temperature is not sufficient, consider switching to a module with higher nominal current or change the system of module cooling. If the module is replaced, repeat the thermal calculations.

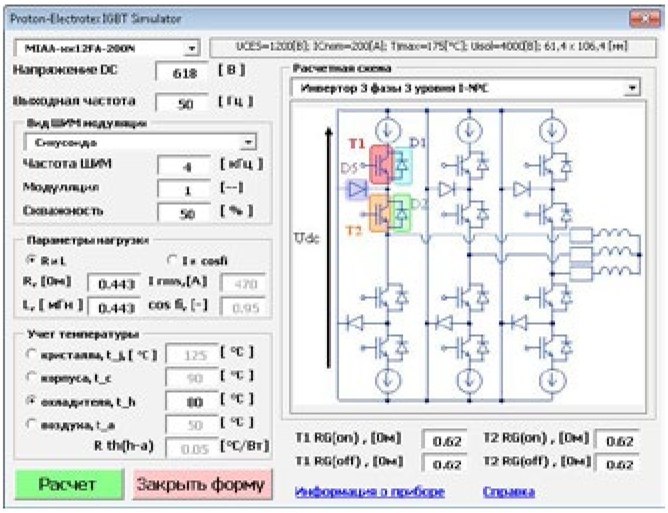


Figure 1: Interface of the program.

To assist with selection of a suitable solution, leading manufacturers of semiconductors offer software for heat analysis of semiconductors operation modes in typical applications. Such software is mainly aimed at calculation of thermal losses in the chips and temperature of chips in specific operation modes. Such programs have identical main features, however each of them is only suitable for thermal analysis of modules produced by its own manufacturer, being their common and unavoidable shortcoming.

Proton-Electrotex has also started development of its software for simulation of thermal modes of IGBT operation in conversion equipment. Testing capabilities of the company make it possible to establish all dependencies needed for development of the software.

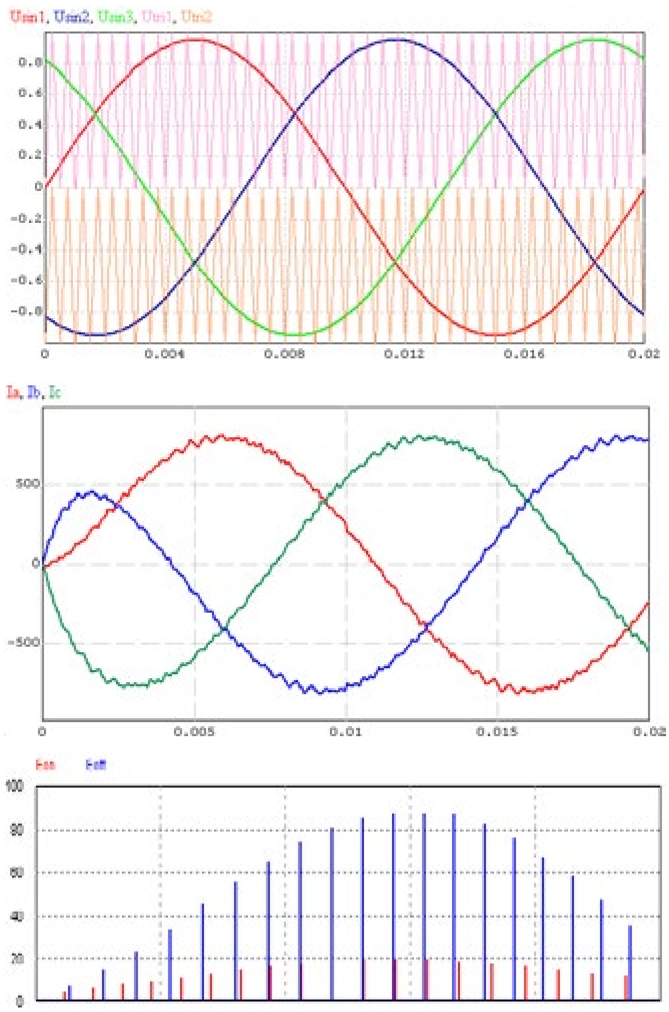
However, besides existing knowledge of semiconductors development of software also requires modeling and programming skills. For this reason the first stage of development included refining algorithms and mathematical models using universal programs for solving differential equation systems in Cauchy normal form.

In order to use such approach a mathematical model of the inverter is required. Its important advantage is ability to model the entire circuit, to calculate currents and voltages in all elements, to use real models of the components and to use such tools as spectral decomposition, calculation of power factor and harmonic distortion ratio.

The program consists of several blocks: the first block calculates functions of IGBT switching, instantaneous values of electromotive force branches and instantaneous values of voltage in RL load. The second block calculates instantaneous values of current in the load, transistors and diodes. The third block calculates instantaneous values of energy and power at conductivity and switching of transistor and diodes. The fourth calculates temperatures.
Interface of the program is shown on Figure 1.

The program allows the user to select any of the modules produced by the company, choose circuitry and enter input values of DC bus voltage, output frequency, phase load, setup pulse-time modulation and account for chip or baseplate temperature.
Simulation results for 3-L I-NPC invertor are shown on Figure 2.

Development of proprietary modeling software will allow the company to use advanced tools, provide its customers with templates for typical processes and input signals, optimize balance between parameters of a designed device, research properties of typical converter circuits taking into account nonlinearities, and create electronic design manual on the basis of previously completed projects. Currently calculations in the program are carried out only at the customer's request. Later the software will be available in free access or as a MS Excel macros, or a WEB application at the company's server.Future plans include adding a block for modeling distribution of temperatures across the heatsink surface.



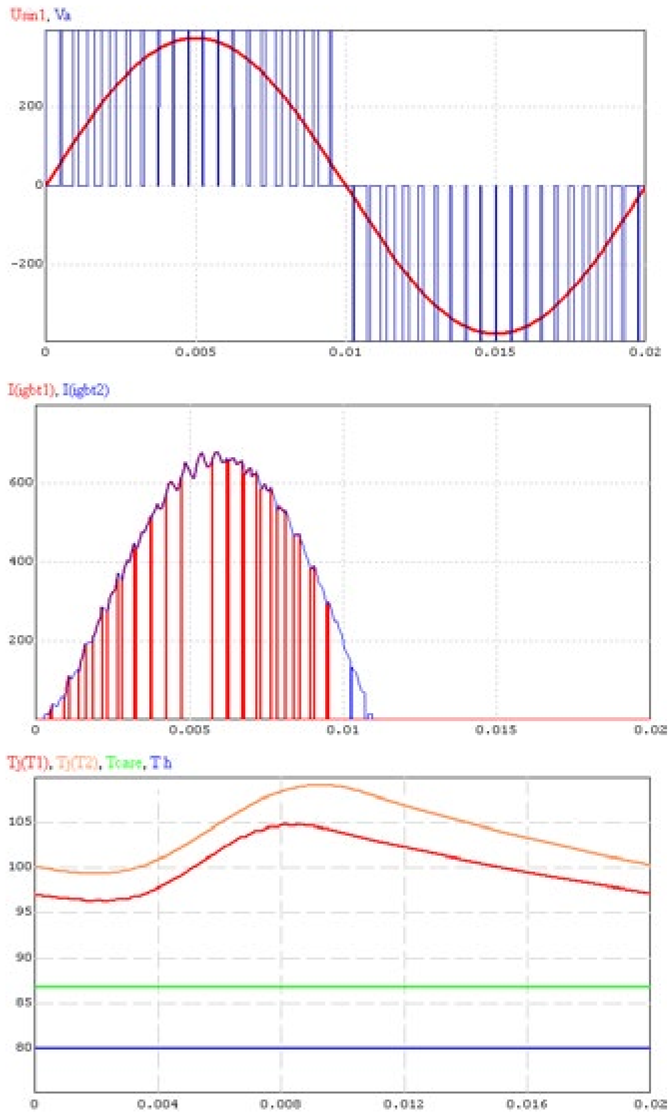


Figure 2. Simulation results: a) driving voltages and triangular signal for pulse-time modulation shaping; b) pulse-time modulation and its sine wave; c) currents at loads; d) current of upper and lower transistors; e) switch-on and switch-off energy at T1 transistor;
f) graphs of T1 and T2 transistor temperatures, Tcase case temperature and heatsink temperature Th=const.

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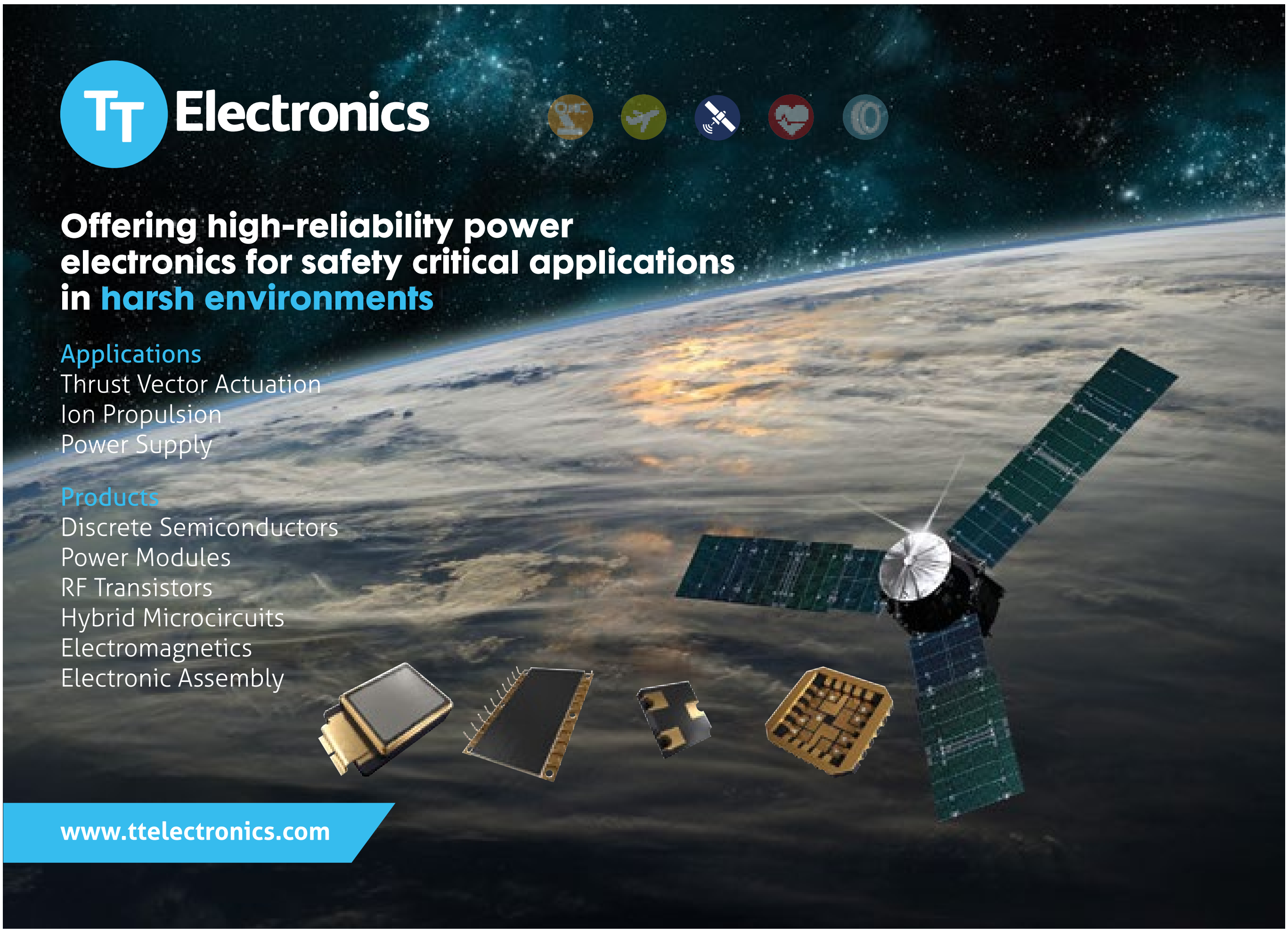
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New Circuit Topologies for Highly Efficient Power Converters

Energy efficiency plays a crucial role when developing cost-effective, high-power electronic systems. It stands to reason that reducing power loss also lowers costs because cooling expenditures can be reduced and more compact passive components can be integrated – as long as the switching frequency can be increased. The following article introduces technologies enabling developers to significantly reduce the switching losses in power converters, thus reducing costs.

By Dr Ralf Hauschild, Principal Engineer, European LSI Design and Engineering Centre, Toshiba Electronics Europe

An inverter is the key component of any photovoltaic system converting DC into AC voltage. Its efficiency is strongly influenced by the switching losses of the power transistors.

Highest efficiency can be achieved by the correct circuit topology as well as the best choice of components. In order to increase efficiency, GaN or SiC transistors made of semiconductor materials with a wider band gap are increasingly used in inverters. However, the cost of such technologies is significantly higher than that of silicon-based components.

Therefore, cost-effective systems require an innovative circuit design, which should achieve the highest possible efficiency, while simultaneously using silicon-based components.

Using a half-bridge, we will explain how the efficiency of an inverter is optimised by significantly reducing the switching losses. As an example, the commutation of the current flow from the free-wheeling diode of the blocking upper switching transistor to the lower switching transistor is considered (Figure 1).

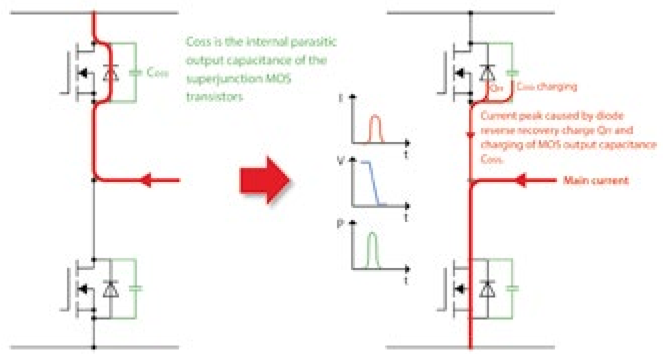


Figure 1: Current commutation and power loss mechanisms when switching a half-bridge

Switching losses occurring alongside the resistive losses are determined by two power loss mechanisms. One is the reverse recovery charge (Q_{rr}) stored in the free-wheeling diode. This causes a current peak in the activated lower switching transistor which transitions into the conducting state. The other one is the charging current peak occurring during the reversal of the output capacitance (C_{OSS}) of the upper switching transistor.

The two switching topologies shown in Figure 2 – Synchronous Reverse Blocking (SRB) and Advanced SRB[1] (A-SRB) – greatly reduce the sources responsible for the switching losses.

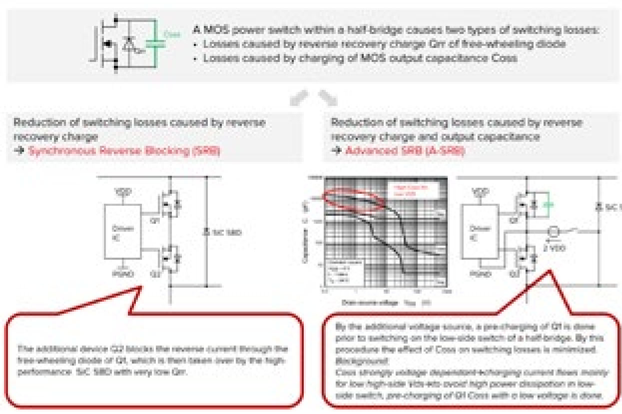


Figure 2: Technologies for reducing the switching losses of a half-bridge

With synchronous reverse blocking (SRB), the reverse current in the free-wheeling diode of switching transistor Q1 is blocked by a second switching transistor Q2 connected in series. Q2 is controlled synchronously with Q1. The reverse current is passed through a parallel silicon carbide (SiC) Schottky diode with high breakdown voltage and extremely low reverse recovery charge. This significantly reduces the impact of Qrr. The free-wheeling diode of Q2 is polarized so that no high voltage can build up over this transistor. A low-voltage type (60V) is sufficient.

[1]Toshiba Corporation Energy Systems & Solutions Company, 2016. Semiconductor switch and power conversion apparatus. European patent EP2 600 527 B1. 03.02.2016

With Advanced SRB (A-SRB) the power losses caused when reloading the output capacitance of Q1 are significantly reduced by pre-charging Q1 to a low voltage. The characteristic of the output capacitance C_{OSS} across the drain-source voltage V_{DS} shows a very high voltage dependence. An increase of V_{DS} from 0 to roughly 40V reduces capacitance by a factor of 100. This means that during the switching process the loss-causing charging current occurs predominantly when V_{DS} of Q1 is low. A low voltage across Q1 is, however, equally significant with a high voltage across the lower transistor of the half-bridge transitioning into the conducting state. Therefore, a high power loss is generated by the charging current peak.

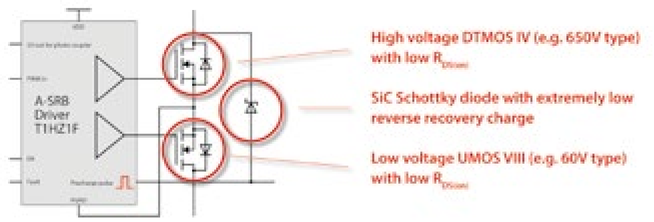


Figure 3: Components of the A-SRB circuit topology

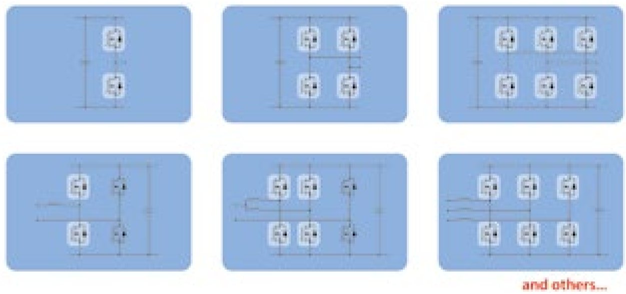


Figure 4: Circuit topologies suitable for A-SRB

C_{OSS} being pre-charged by Q1 to 40V before the lower switching transistor of the half-bridge is turned on means, the predominant part of the charging current does not flow through this transistor and thus can hardly cause power losses. Pre-charging is carried out by an additional voltage source, which is realised by a charge pump implemented in the gate driver IC.

Figure 3 shows the key components of the A-SRB circuit topology. The actual switching transistor (Q1) is a high-voltage superjunction DTMOS IV type MOSFET with a maximum blocking voltage of, for example, 650V. The auxiliary transistor Q2 connected in series to Q1 is a low-voltage superjunction UMOS VIII type MOSFET with a blocking voltage of 60V. A SiC Schottky diode with very low reverse recovery charge is used as a free-wheeling diode. This special circuit topology is controlled by a dedicated T1HZ1F driver IC. From a PWM input signal, this IC generates all necessary control signals for the transistor gates as well as the charge pulse for pre-charging the output capacitance of Q1.

Toshiba's A-SRB technology results in greatly reduced switching losses. It is suitable for a wide range of applications such as solar inverters, DC/DC converters, power factor correction (PFC) and motor drive control. Figure 4 shows a selection of power converter topologies suitable for A-SRB. The highlighted transistors are simply replaced by the A-SRB circuit topology shown in figure 3.

To demonstrate how effective A-SRB is, SPICE simulations of an inverter bridge (H4 topology) were carried out with and without A-SRB. For bipolar modulation, figure 5 shows the enhanced efficiency achieved with A-SRB for different output powers and switching frequencies when using a Toshiba DTMOS IV type switching transistor with low $R_{DS(on)}$ (100A, 600V). Since A-SRB reduces switching losses, the highest efficiency gain will be realised at high switching frequencies. The maximum efficiency gain realised in this example is about 4%.

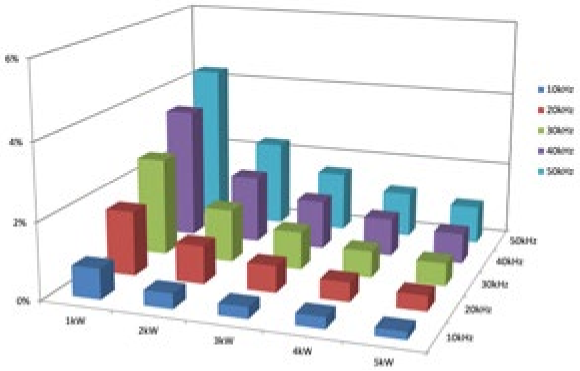


Figure 5: Improvement of efficiency with use of A-SRB

The main part of the system, the inverter bridge with A-SRB functionality, can be implemented differently depending on the rated power. For module inverters with a maximum input power of about 300W, Toshiba offers the T1JM4 module. This integrates a complete half-bridge, including the gate drivers with A-SRB functionality, the switching transistors and the SiC Schottky diodes. For solar inverters with a higher input power of up to 5kW, discrete gate drivers are available as a kit in combination with the switching elements.

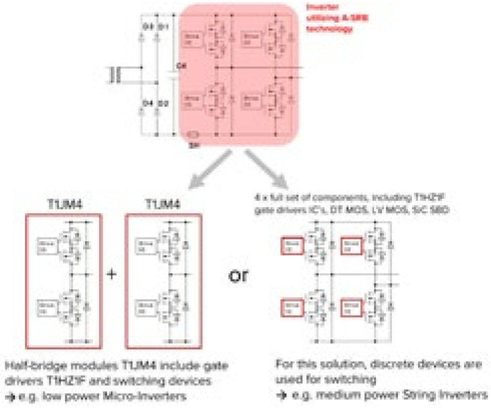


Figure 6: Different options for implementing an inverter bridge with A-SRB

Conclusion

Optimising the costs of power electronics systems means that power losses must be addressed effectively. Intelligent power loss management, based on proven semiconductor technology, enables cost-effective systems with increased power density and energy efficiency. Toshiba's A-SRB technology provides significant efficiency gains. It is suitable not only for solar inverters, but also for many other applications in the area of power electronics, e.g. for DC/DC converters, reactive power compensation and for motor drives.

www.toshiba.com

Radiation-Tolerant Plastic ICs to Power Small Satellite Mega-Constellations

Intersil, a subsidiary of Renesas Electronics Corporation announced the first three members of its family of radiation-tolerant plastic-package ICs designed to support the emerging field of small satellites that will provide solutions such as high-speed Internet connections to hundreds of millions of users in communities, governments, and businesses worldwide. Fleets of hundreds of small satellites will create mega-constellation networks to deliver broadband Internet links from low Earth orbit (LEO) to every corner of the globe, including rural areas without wireless connectivity access.

Intersil's rad-tolerant plastic parts include the ISL71026M 3.3V controller area network (CAN) transceiver, ISL71444M 40V quad precision rail-to-rail input and output (RRIO) op amp, and the ISL71001M 6A point-of-load (POL) voltage regulator. These ICs deliver rad-tolerance performance at a much lower cost point versus radiation assurance tested Class V (space level) products. All three ISL71xxxM devices go through characterization testing, which includes total ionizing doze (TID) up to 30krads (Si) for single event effects (SEE). SEE take into account single event burnout (SEB), single event latch-up (SEL), single event transients (SETs) and single event functional interrupts (SEFIs) at a linear energy transfer (LET) of 43MeV•cm2/mg.

Intersil's rad-tolerant plastic packaging flow leverages the company's more than 50 years of spaceflight experience developing rad hard (>75krad) and rad-tolerant (<75krad) products for extremely harsh environments. The upfront radiation effects characterization and AEC-Q100 automotive-like qualification gives customers the utmost confidence to design Intersil radiation-tolerant plastic parts into cost-sensitive small satellites for LEO mission profiles up to five-years. The ISL71xxxM are also well suited for high altitude (>40km) avionic systems, launch vehicles that are prone to heavy ions, and medical equipment where radiation is a concern.

www.intersil.com

Extending 48V Cool-Power ZVS Buck Regulators Family

Vicor has extended the Cool-Power 48V ZVS 20A Buck Regulator portfolio by releasing the PI3523-00-LGIZ (PI3523). The PI352x family offers 20A solutions complementing the previously released 10A 48VIN PI354x family, enabling scalable power options for 48V direct to point-of-load (PoL) applications. The PI3523 is a 48VIN, 3.3VOUT nominal Buck Regulator capable of supplying up to 22A. This family of regulators enables 48VIN to 20A point-of-load voltages spanning 2.2VOUT – 14VOUT.

Compact Size Delivering Twice the Power

Offering all the same industry leading features of Vicor's existing 48V Cool-Power ZVS Buck Regulators, the PI352x portfolio extends performance by delivering twice the power of the PI354x regulators using only a 40% larger package. The PI3523 requires only an output inductor and minimal passives for a complete cost effective design that consumes less than 740 mm2 of PCB space. Designed to be easily paralleled in combinations of up to three regulators, the PI352x regulators can be scaled to support higher current loads.

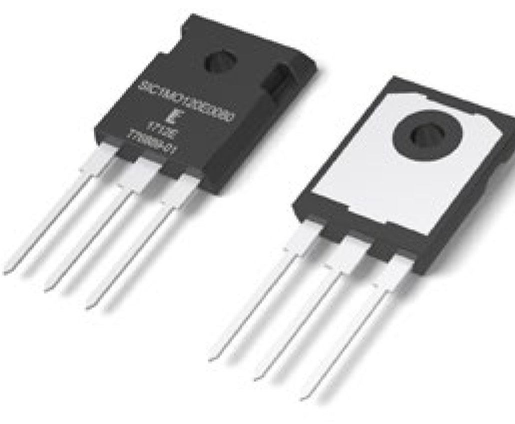
The PI352x family addresses the growing need for 48V direct-to-PoL solutions in many applications including lighting, communications, automotive equipment, and datacenter applications. The Cool-Power ZVS Regulators are focused on high power density and high efficiency while delivering ease of use. The end result is first pass design success with best-in-class performance.

Learn more about these products at:

www.vicorpower.com

SiC MOSFET Provides Ultra-Fast Switching in Power Electronics

Littelfuse, Inc. introduced its first series of silicon carbide (SiC) MOSFETs, the latest



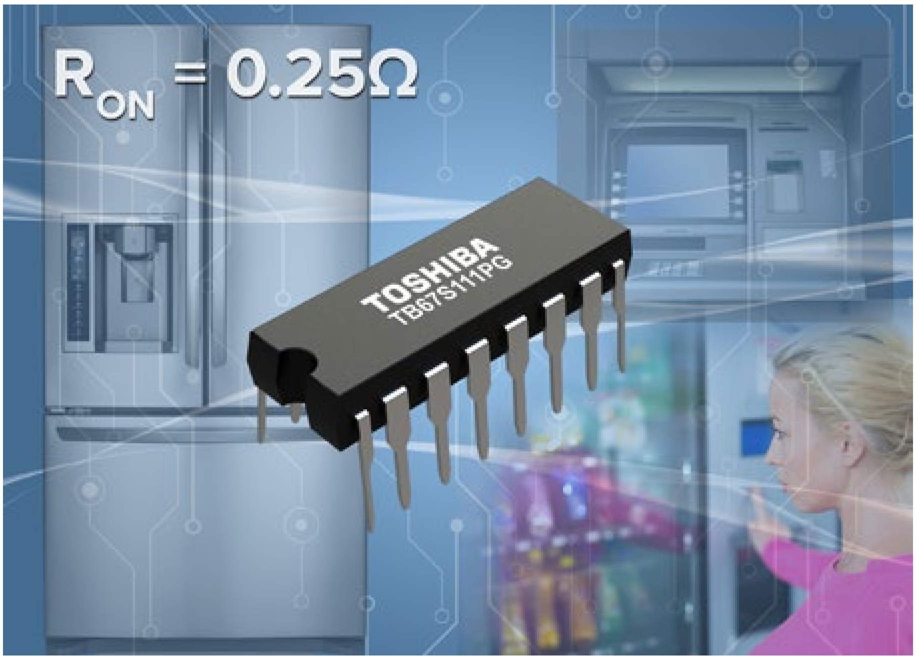
addition to the company's growing power semiconductor line. In March, Littelfuse took another incremental step towards establishing industry leadership in the power semiconductor industry through a majority investment in the well-respected SiC technology development company, Monolith Semiconductor Inc. The LSIC1MO120E0080 Series, with a voltage rating of 1200V and ultra-low (80mΩ) on-resistance, is the first organically designed, developed, and manufactured SiC MOSFETs to be released by this partnership. This device is optimized for high-frequency switching applications, providing a combination of ultra-low switching losses and ultra-fast switching speeds that's unavailable with traditional power transistor solutions.

When compared with silicon devices that have the same rating, the SiC MOSFET Series enables substantially greater energy efficiency, reduced system size/weight, and increased power density in power electronics systems. It also offers superior robustness and exceptional performance, even at high operating temperatures (150°C).

www.littelfuse.com

High-Voltage Multi-Channel Solenoid and Unipolar Motor Driver IC

Toshiba Electronics Europe (TEE) announced the launch of a multi-channel solenoid and unipolar motor driver IC (TB67S111PG) that delivers high-voltage and low ON resistance drive. TB67S111PG incorporates four channels each consisting of one low-side MOSFET and a free-wheeling diode connected to drain. This enables it to control each channel independently and realises a design that is suited to driving the solenoids and unipolar motors that are widely used in applications such as slot machines and home appliances (refrigerators), industrial equipment (vending machines, banking terminals, ATMs) and office and factory automation equipment. Fabricated with the latest high-voltage analog power process (BiCD 130nm), the motor driver IC offers an output rating of 80V at 1.5A per channel. Power dissipation is minimised by an output ON resistance of 0.25Ω.

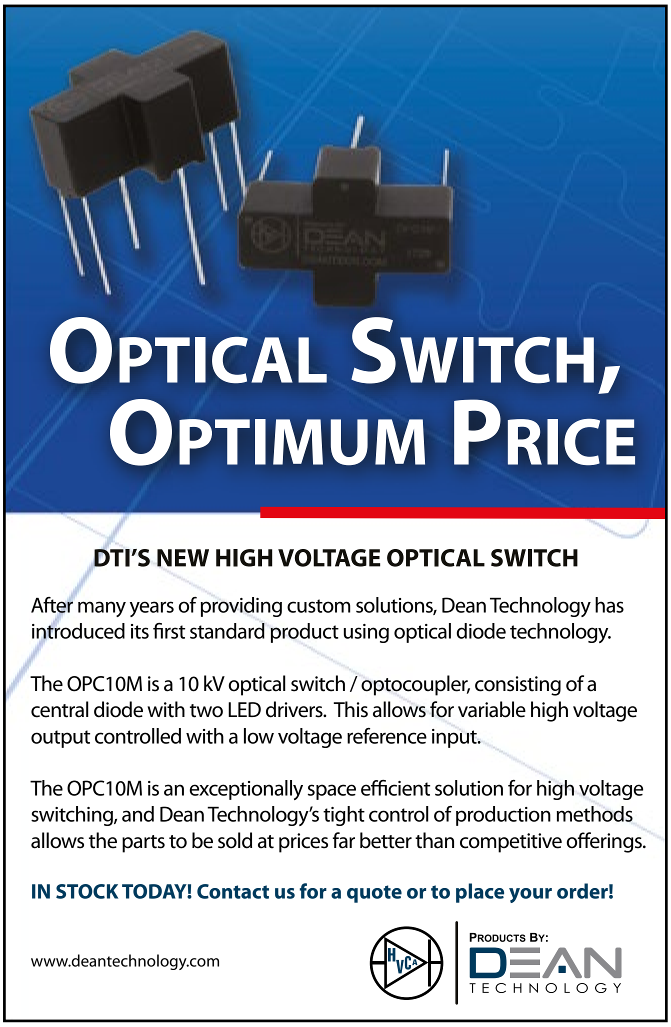


Thermal and overcurrent shutdown circuits protect and automatically reset IC operation after a specified time. There is also a built-in thermal shutdown flag output. The device supports power-on sequencing for a single power drive.
The IC is packaged in a thermally dissipative H-frame DIP16-P-300-2.54A package that can be mounted on low-cost paper phenol board and on a general glass-epoxy board.

www.toshiba.semicon-storage.com

Revision Notice on behalf of Mitsubishi:

The content of article “SiC Power Modules for a Wide Range of Applications” published in BPS 09-2017 has been revised. At page 24 one sentence has been modified as follows: “In June 2015 Mitsubishi Electric announced the installation of first Railcar propulsion system using 1500A/3300V All-SiC Power Modules in a Shinkansen Bullet Train [5] (Figure13)”.



First Silicon Carbide Power Devices

Ascatron provides next generation Silicon Carbide (SiC) power semiconductors using its proprietary 3DSiC® technology with a quality and performance unattainable through current methods. SiC radically reduce losses in electrical power converters and lowers system costs, making it key for electric vehicles and renewable energy. The global impact will thus be large.

Ascatron, with background in producing advanced SiC epi material for global customers, has recently transformed from a service provider to a device product company. The first products available for customer testing are diodes rated to 1200V, 1700V and 10kV. MOSFET switches are under development and will be introduced 2018.

"We have developed a unique material technology that makes it possible to fully use the potential of SiC to handle very high power with minimal losses, while maintaining the reliability of silicon", says Adolf Schöner, CTO of Ascatron. "We call it 3DSiC® and is based on our expertise in producing advanced SiC epitaxy material. The technology has the potential to lower the losses up to 30% compared to conventional solutions".

The 3DSiC® technology enables a modular design of Ascatron product line. Each device is divided in a high voltage module related to the desired voltage class, and a low voltage part for each type of component. Combination of different modules gives a wide range of products.

"Our business target is to be highly trusted and innovative supplier of SiC semiconductors for power electronics in industry, automotive and energy", says Christian Vieider, CEO of Ascatron. "We foresee a period of technology change when shifting from silicon to SiC and target to take part in such industry consolidation".

www.ascatron.com

Compare Cleaning Machines – Manufacturer Neutral

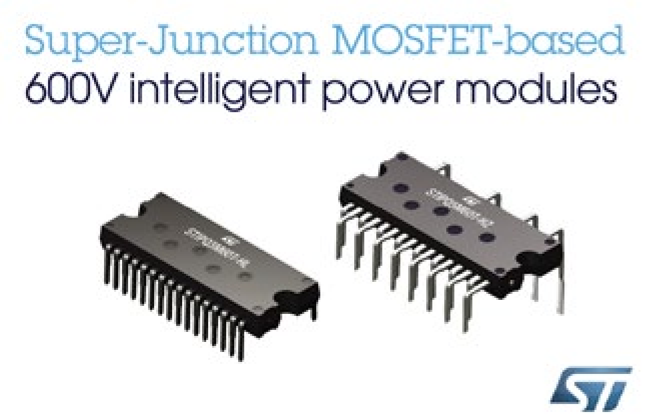
For companies looking into a new cleaning process, ZESTRON offers a unique service in the industry. Interested customers can answer five questions at www.compare-machines.com, and ZESTRON quickly reduces the wide market selection of over 60 cleaning machines down to just a few relevant cleaning systems based on the individual requirements of the customers.

On site at the Technical Center in Ingolstadt, customers can compare and evaluate their selection under real operating conditions. Within one day, customers can assess the performance of their cleaning machine choice in combination with their electronics boards, DCBs or SMT stencils and appropriate cleaning chemicals. The customer is supported by a ZESTRON process engineer. Immediately following the cleaning process, a cleanliness analysis is performed by using high-resolution analytical methods in the adjacent Analytical Center. Based on the evaluation, a written process guarantee including the recommended machine- and cleaner combination ensures the customer's investment decision

www.zestron.com

600 V Super-Junction MOSFET-based IPMs

ST has extended its portfolio of intelligent power modules with the introduction of the second series of SLLIMM-nano devices based on super-junction MOSFETs (5 A and 3 A current rating at 25 °C, with 600 V breakdown voltage).



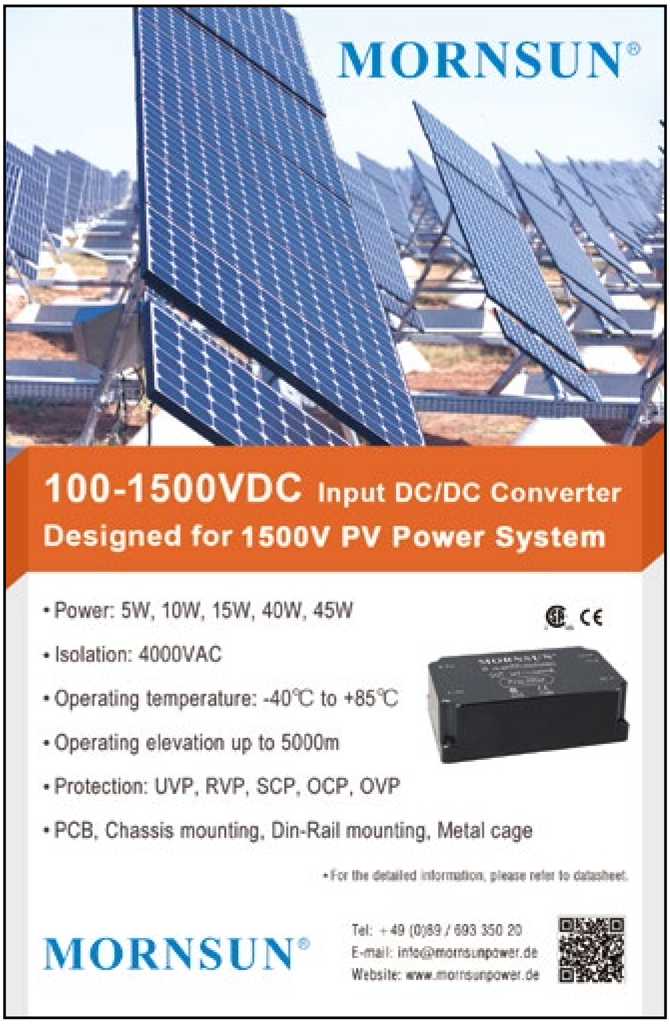
ST's SLLIMM™ family of small low-loss intelligent molded modules enhances the efficiency of home appliance motor drives working up to 20 kHz in hard-switching circuitries and of applications with a power range up to 3 kW.

ST's intelligent power modules (IPMs) provide a direct connection between a low-voltage microcontroller and a mains-powered electric motor. They greatly reduce costs by simplifying design and significantly reducing component count while saving space, improving reliability and lowering EMI.

Available in different package options (fully molded and DBC) , lead options (through-hole and SMD), discrete technologies (IGBT and MOSFET), current ratings and driving options, they feature the best compromise between conduction and switching losses for high efficiency, along with outstanding robustness and EMI behavior.

The low MOSFET on-resistance (1.0 Ω or 1.6 Ω max, in 5 A and 3 A variants, respectively), combined with low capacitances and gate charge minimize both conduction and switching losses, enhancing the efficiency of compressors, pumps, fans and any low-power motor working up to 20 kHz in hard-switching circuitries for an application range up to 300 W. The devices are available in both zig-zag lead and line-lead form giving designers extra design flexibility.

www.st.com/ipm



Wire-in-Air Fuse Performance under Extreme Electric Vehicle Conditions

EETech Labs, in cooperation with AEM Components, has produced a video that demonstrates the effect on circuit protection devices when subjected to worst case electric vehicle (EV) battery short circuit conditions. This comparison study highlights the advantages of using AEM (AirMatrix®) wire-in-air fuse versus similarly rated competitive surface mount fuses.

The video clearly displays the adverse effects that short circuits from EV batteries can exert on a fuse. Automotive specifications require circuit protection to break the circuit without causing damage to PC boards or other components in the system. The AEM wire-in-air fuse technology is able to comply with this prerequisite by remaining intact. Competitive fuses that were also tested under the same conditions not only caught on fire, they also caused damage to the PCB on which they were mounted.

https://www.allaboutcircuits.com/industry-articles/how-to-protect-against-catastrophic-shorts-in-evs/

AEM AirMatrix® fuses are designed to meet stringent automotive standards, so testing for worst case conditions is critical. When testing in electric and plug-in hybrid vehicles battery systems, a short circuit condition is created for all batteries in the array, causing the full amount of current to be present at the fuse. Assuring that the fuse opens properly and protects the battery system is of primary concern.

http://aemcomponents.com

2MOPP 1-Watt DC/DC Converter in Compact SIP7 Module

Ready to save space in medical-device designs, the Recom REM1 series, now available from Dengrove Electronic Components, is a 1-Watt DC/DC converter family certified to medical IEC/EN/ANSI/AAMI 60601-1 and general IEC 62368-1 equipment safety standards.

The series is also covered by a CB Test Report, which simplifies access to international markets.

Packaged as compact SIP7 modules, the converters provide two means of patient protection (2MOPP), with 250V working voltage, 5.2kV/1-minute isolation, and 8mm creepage and clearance, within the 19.6mm x 6.0mm x 10.2mm outline.

In addition to meeting high safety standards and helping new OEM products pass approval tests quickly and economically, the REM1 series also delivers flexibility and high performance. Input-voltage options are 3.3V, 5V, 12V, 15V, or 24V, and the output can be 3.3V, 5V or 12V. Maximum efficiency of 85% keeps power dissipation low, and enables the converters to operate in ambient temperatures from -40°C to 90°C without derating.

The 1W REM1 series complements the existing Recom 3W, 6W and 10W REM families of medical DC/DC converters. The new devices comply with IEC 60601-1-2 medical EMC specifications, and meet Class B EMC with a simple L-C filter placed at the output.

The full line is in stock now, and comes with a five-year manufacturer's warranty.

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www.dengrove.com

Silicon Carbide Power Device

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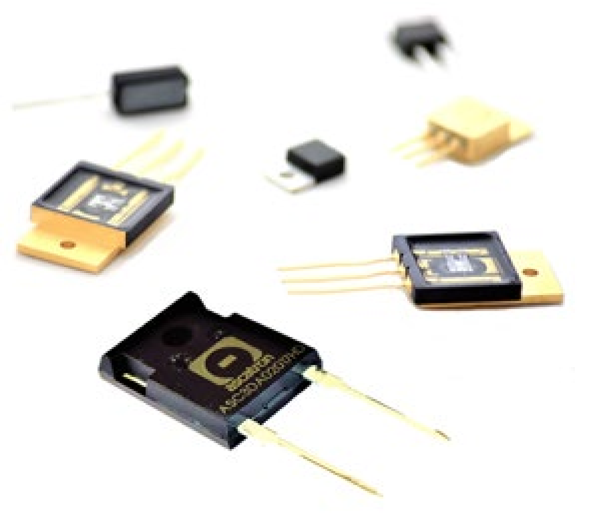

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www.ascatron.com

Conductive Polymer Aluminium Solid Capacitors

Panasonic Automotive & Industrial Systems Europe recently announced a series of eight new conductive polymer aluminium solid capacitors with super high voltage capabilities of up to 100VDC max for industrial, digitalisation, control system, noise filtering, and power supply applications. The products benefit from low ESR values and high ripple current and offer very stable characteristics.

Both radial lead type SXE series components and surface mount type SXV series products are fully REACH and RoHS compliant as well as halogen-free. The components have been designed for an operating temperature range from -55°C up to +125°C, benefit from a voltage range from 63VDC up to 100VDC, a rated capacitance range of 6.8μF up to 68μF, and a capacitance tolerance of ±20% (120Hz / +20°C). The endurance is up to 1000h at +125°C.
https://na.industrial.panasonic.com/whats-new/sxe-series-and-sxv-series-os-con%E2%84%A2-conductive-aluminum-polymer-solid-capacitors

www.panasonic.com

Trench 9 MOSFETs in Robust Packages Save Space

Nexperia, the former Standard Products division of NXP, announces a series of Trench 9 power MOSFETs, targeted primarily at the automotive industry, which combine the company's low voltage superjunction technology with its advanced packaging capability to deliver high performance and ruggedness. Five years ago, the company introduced the world's largest range of automotive-qualified Power-SO8 MOSFETs. Now Nexperia is expanding this portfolio to include ultra-low RDS(on) parts that address the ever-increasing demand for higher power density in many typical automotive applications. The Trench 9 devices are all qualified to AEC-Q101, and exceed the requirements of this international automotive standard by as much as two times on key reliability tests including temperature cycling, high temperature gate bias, high temperature reverse bias and intermittent operating life.

LFPAK56E is the latest innovation in the family of automotive LFPAK packages from Nexperia. LFPAK56E is an enhanced version of the popular LFPAK56 package, with an optimised lead frame and package design that results in an improvement in RDS(on) and power density of up to 30%. This improvement in power density enables the Trench 9 LFPAK56 MOSFETs to be used in applications previously only possible with D2PAK and D2PAK-7, delivering significant PCB space-savings.

www.nexperia.com/automotivetrench9

Alpha to Showcase Latest Products for SMT Assembly at productronica

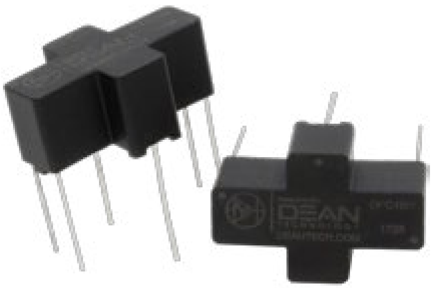
Alpha Assembly Solutions will be exhibiting its latest range of product solutions, alongside its sister company MacDermid Enthone Electronics Solutions, at the productronica exhibition in Munich, Germany from Tuesday 14th – Friday 17th November.

Alpha will present its latest stencils innovation, Alpha® tensoRED® Master Tensioning Frame at the show. Apha® tensoRED® enables a higher and more even tension compared to Alpha® Tetra Frame. “Due to the innovative design of Alpha® tensoRED®, no air pressure on the frame is needed resulting in reduced maintenance costs and improved reliability,” explained Donald Corlett, Stencils Manager for Alpha Assembly Solutions, a MacDermid Performance Solutions Business. “Alpha® tensoRED® also delivers several printing process benefits associated with higher tension such as less paste smearing*, reduced variation in and improved positional alignment on volume deposits*”.
Alpha® tensoRED® is now available in all common printer sizes, as well as configuration options for full 29” printer openings.

www.alphaassembly.com

OPC10M – Optocoupler / Optical Switch

Dean Technology, Inc., announced the introduction of a high voltage optocoupler, the OPC10M. This 10 kV optical switch is able to variably control a high voltage output up to 10,000 volts by adjusting a reference low voltage input, and is the first product in a set of optical devices that DTI will be introducing in its HVCA line of products over the coming months.



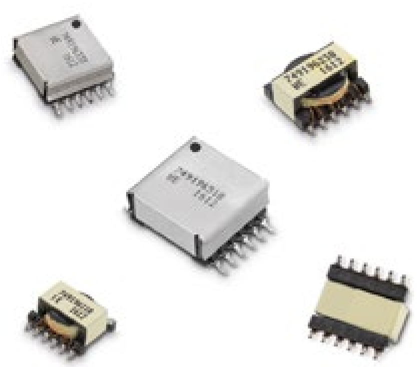
Dean Technology's optical switch products consist of a central diode and two or more LED drivers in a fully encapsulated and light-tight package. It is exceptionally space efficient, and the tight control of production methods will allow DTI to offer these parts at prices far better than competitive solutions. "We're starting off our optical switch line with a 10 kV part that should provide a perfect solution for many of the applications where this kind of device can be used," said Lynn Roszel, Engineering Manager for Dean Technology. "For a long time, we've built custom solutions for customers using this technology and we've put all of that learning into the OPC10M. It is a very useful and stable optical switch that we're very excited to have gotten into production."

Dean Technology intends to release a wide range of new optical devices, starting with the OPC10M. A range of optical switches with higher voltages and power levels is planned, and a full line of optical diodes with clear encapsulation is already in the works. Custom parts for both of these types of products are being produced now and DTI has engineering resources ready to help with custom development for any customer's needs. Full product details for the OPC10M, with example test circuits, are on the company's website and the part is in stock and ready for purchase directly from Dean Technology or through any approved sales channel.

www.deantechnology.com

Flexible Transformer for Switched-Mode Power Supplies

Würth Elektronik eiSos, one of the leading manufacturers of electronic and electromechanical components, presents a new line of transformers for SMT assembly - WE-FLEX HV (Flexible Transformer High Voltage). Like the WE-FLEX series of transformers, these excel because of their flexible capabilities in various applications making them ideally suited for fast prototyping. Different circuit configurations enable over 375 transformer solutions and around 125 choke solutions with WE-FLEX HV. Applications include flyback converters, forward converters, push-pull converters, step-up and step-down converters or single-ended primary-inductor converters (SEPIC). With their isolation voltage of 1.5 kVAC, these transformers are currently unrivaled on the market. The newly developed MnZn core material reduces core losses by up to 30 percent as compared with classical products and makes the new SMD transformer an attractive solution for all types of isolated DC-DC converters in industrial and telecommunications applications.



WE-FLEX HV is available in four sizes, each with five different air gap lengths.

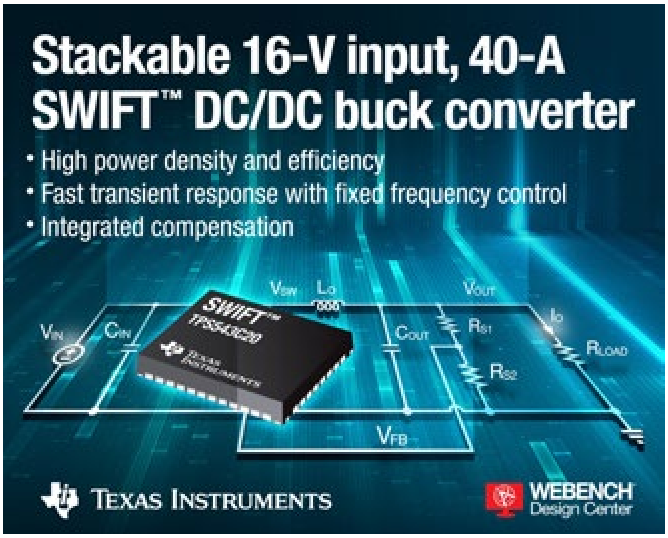
The working temperature is specified as -40°C to +125°C. Given suitable circuitry, the large package types of the series have a basic isolation for working voltages up to 250VRMS.

Free samples from the new SMD transformer series are now available. WE-FLEX HV is now available from stock.

www.we-online.com

DC/DC Converter Combines True Fixed Frequency and Ultra-Fast Transient Response

Texas Instruments introduced the industry's first 16-V input, 40-A synchronous DC/DC buck converter with an internally compensated advanced-current-mode (ACM) control topology supporting frequency synchronization. TI's TPS543C20 SWIFT™ converter provides enhanced efficiency by integrating its latest generation of low resistance high- and low-side MOSFETs into a thermally efficient small-footprint package. Designers can stack two converters side by side to drive loads up to 80 A for processors in space-constrained and power-dense applications in various markets, including wired and wireless communications, enterprise and cloud computing, and data storage systems. For more information, samples and an evaluation module, see www.ti.com/tps543c20-pr-eu.



The unique internally compensated ACM control topology with fast transient response maintains stability over a wide range of input and output voltages. What makes ACM different is that it is an emulated peak-current-mode control topology that internally generates a ramp with the ability to dynamically adjust for stability over a wide range of operating switching frequencies. This provides the best of both traditional fixed frequency for low noise operation and constant on-time (COT) control for fast transient without external compensation. Read the blog post, "Lightning-fast internally compensated ACM topology – what can it do for you?" and the "Control-Mode Quick Reference Guide" to understand the difference between TI's various control modes.

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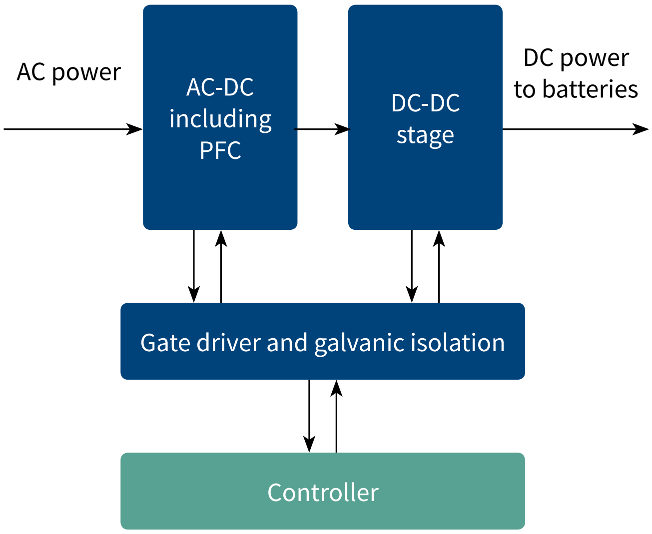

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