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January 2019

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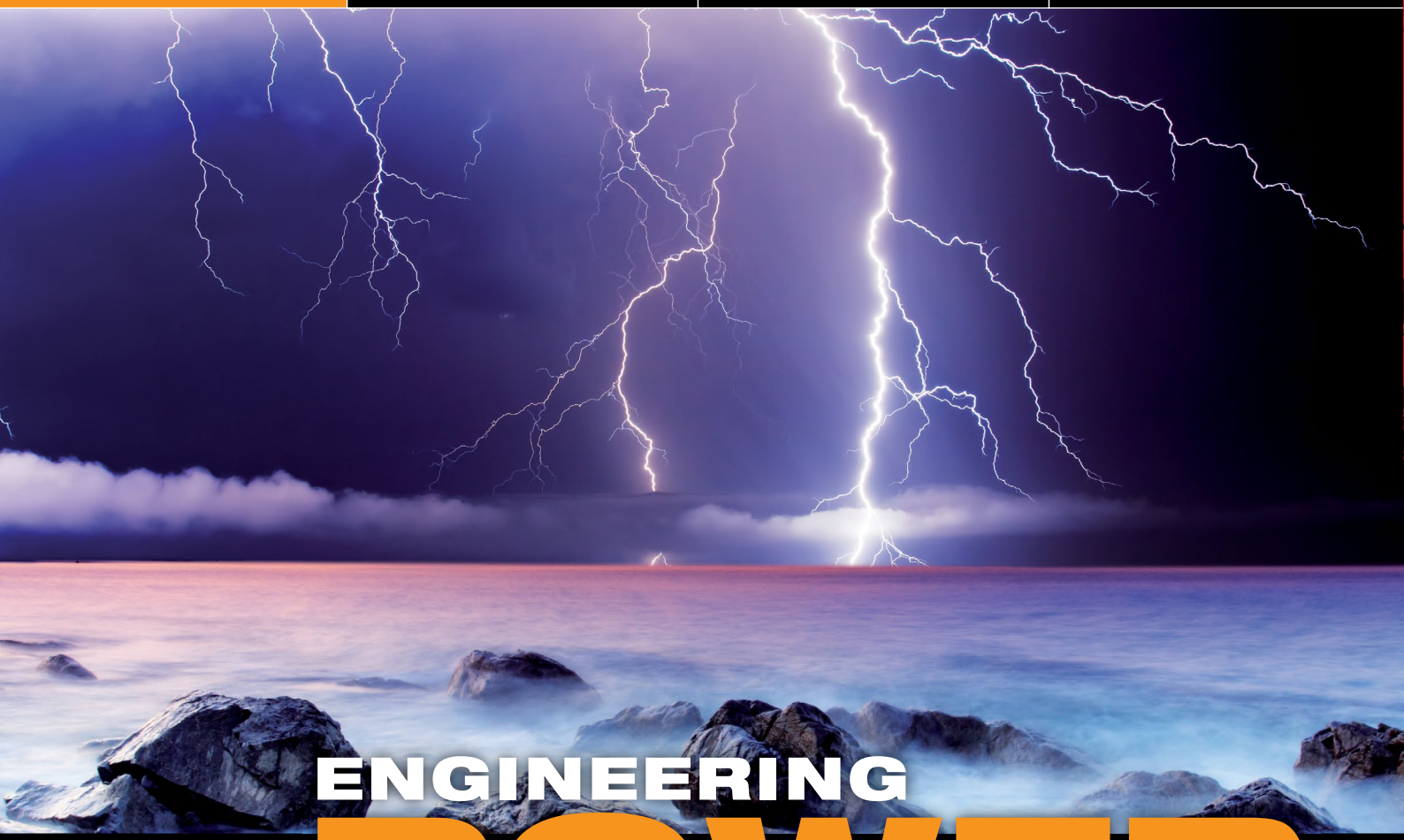

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GvA Power Electronics

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The Gallery

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A Thankful Review

When a new year starts, it is a nice tradition to look back and draw some conclusions! Overall, 2018 has been another very successful year for our small family business. The first business highlight was in March - the APEC show in Texas. We made it a brief stay as we wanted to get home in time to welcome Bodo's latest grandchild (my nephew). Now with four of them, we are nearly as busy as publishing a monthly magazine!
The next big event was PCIM Europe – Nuremberg, once again the gathering place for the experts of our industry. Our traditional podium discussion was the hot topic "Wide Band Gap". Speakers from GaN and SiC teams presented their latest news and outlook for the future. I still remember the audience overflow standing during the talks. I consider this a good sign of success!
As PCIM was held in June, attendees had a taste of one of the hottest and driest summers seen in Europe for many years! Nature is reminding us that climate change and global warming are not fake news, but an insight into some of the serious problems that we are facing!

In November the bi-annual electronica called us to Munich. What can I say: they even managed to make it bigger! I think that visiting all the stands would take two weeks. Our partners from EETech had their own booth, so besides a very demanding week of working and meetings, it was great fun to see them and to deepen our co-operation. One of the big topics in Munich was of course 'Electric Vehicles'. While writing these words, one of the countless notifications on my mobile seems significant : Germany's biggest auto-manufacturer published his roadmap for the future showing a complete change to electric drives. Planning a goal as far ahead as 2040 leads to some incredulous shaking of my head. On the other hand, considering how long it takes to build an airport in Germany, maybe we will be happy reaching this date. But I do believe that there will be a lot of EVs on our streets before then, made in Europe or not.

In December, our Wide Band Gap event in Munich, held in co-operation with ICC Media/ Aspencore, was a great success. The list of presenters was long and impressive and it was a day of amazing presentations and good networking. I'm quite sure that this meeting will be continued. We will keep you notified of future events.

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

My Green Power Tip for the Month:
Consider local destinations when planning your summer vacation. Aircraft do have the worst ecological footprint you can imagine!

Happy New Year

Events

NEPCON 2019
Tokyo, Japan, January 16-18
www.nepconjapan.jp/en

APEX 2019
San Diego, CA, USA, January 26-31
www.ipcapexexpo.org

DesignCon 2019
Santa Clara, CA, USA, January 29-31
www.designcon.com

India Electronics Week 2019
Bangalore, India, February 7-9
www.indiaelectronicsweek.com

Embedded World 2019
Nuremberg, Germany, February 26-28
www.embedded-world.de/en

APEC 2019
Anaheim, CA, USA, March 17-21
www.apec-conf.org

EMV 2019
Stuttgart, Germany, March 19-21
www.mesago.de/en/EMV/home

AMPER 2019
Brno, Czech Republic, March 19-22
www.amper.cz/en.html

Power Electronics Expo 2019
Telford, UK, March 28
www.powerelectronicsexpo.co.uk

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9th China International New Energy & Intelligent Vehicle Forum 2019

Based on the past 8 successful New Energy Vehicles Forum, Polaris will host the 9th China International New Energy & Intelligent Vehicle Forum 2019 on 2nd April to 3rd April in Shanghai. The series of New Energy Vehicle Forum successfully invited government units and research institutions included the National Development and Reform Commission, World Electric Vehicle Association & Academician, IAHE and WADE, Chinese Academy of Engineering, SAE International, and industry experts from OEM's and Integrated Components. Enterprises like BMW group, Mercedes-Benz, Chery Jaguar Land Rover, Volkswagen, AUDI, BYD, SAIC Group, BAIC Moto, Continental, Denson, LG to discuss about New Energy Vehicle Industry Policy trends, technology roadmap and challenges, business models and infrastructure, and won the praise of people in and outside the industry.
In the upcoming 2019, in order to thank you for the support and attention to series of forums, organizing committee will hold NEV9 Forum which is the largest involving 8 forums, CEO TALK, award ceremony, cocktail party and one-on-one meeting. We will invite vehicle manufacturers, powertrain companies, battery and fuel cell companies, charging and energy storage companies, core technology providers, and government officials, nearly 900 people come together, in 2 days, to make more constructive and strategic discussion in New Energy Vehicle industry.

www.ourpolaris.com/2019/nev9/index_en.html

Expansion Continues in Support of Worldwide Growth

Mouser Electronics, Inc. is preparing to break ground on another large expansion of its global headquarters and distribution center. The expansion will support the company's business, which is growing at an incredible double-digit rate. Construction will soon begin on a new 127,500 sq. ft. (11,845 sq. m) distribution center extension, which follows a previous large expansion that included more warehouse space and the addition of an employee fitness center and medical clinic, all completed within the last two years. Mouser also plans to add a new building on the company's 78-acre campus to house customer service teams. The distributor has approximately 1,800 employees at its corporate headquarters and more than 2,300 employees globally.

Explains Mark Burr-Lonnon, Senior Vice President, Global Service & EMEA and APAC Business, "We are starting to view the building expansion as a continual process to support the growth that we have been experiencing for a long time. Every year is a new record for us, and yet we must have freely available stock; that's our business model. We are committed to holding over one million parts in stock by the end of 2018 and continue ramping in 2019 and beyond. Inventory requires space, so we'll just keep adding — luckily there's plenty of room in Texas."

www.mouser.com

Production Technologies Benefit from Solar Power and Storage Boom

The solar market is thriving, and demand for batteries is also rising steadily. Market researchers have predicted photovoltaics (PV) deployment of roughly 100 gigawatts (GW) for 2018. At the same time, the global market for batteries and fuel cells is already worth 5.5 billion euros and is forecast to exceed 81 billion euros by 2025. The industry's impressive growth is fueling a boom in production. Everything points to a continuing upward trend in the coming years – prompting Intersolar and ees Europe to focus more closely on production technologies. In 2019, the two energy exhibitions will dedicate a whole hall to this topic for the first time. Exhibitors and trade visitors can learn all about PV and battery production technologies in hall C1 from May 15–17, 2019 in Munich. And at the Production Technologies forum, they will gain

essential first-hand knowledge of the latest developments and innovations. Solar energy is playing an increasingly dominant role in the energy industry. Forecasts for 2018 anticipated that new solar power systems with a capacity of around 100 GW would be installed worldwide. The trade association SolarPower Europe even predicts that, within the next five years, more than 1,000 GW of PV power will be installed. This upward trend is being driven by innovative and cost-effective production technologies, a rapid rate of progress, and guaranteed quality and reliability. The outlook for the storage market is equally promising. Bloomberg New Energy Finance predicts that the annual installation rate of stationary storage devices will increase significantly by 2030. Another factor driving growth on the battery market is the rapid expansion of e-mobility.

www.intersolar.de/en

www.ees-europe.com/en

Expanding Asian Team

To support its accelerating sales growth in Asia, Efficient Power Conversion Corporation (EPC) is proud to announce the expansion of the sales and FAE team in Asia Pacific to support its expanding customer base, maximize new business acquisition and capture new market opportunities. As part of its expansion to support a widening customer base for DC-DC, LiDAR, wireless power applications and beyond, Efficient Power Conversion Corporation has expanded its Asia-based team with new members who are in close proximity to customers in 21 regions throughout Asia Pacific.

www.epc-co.com

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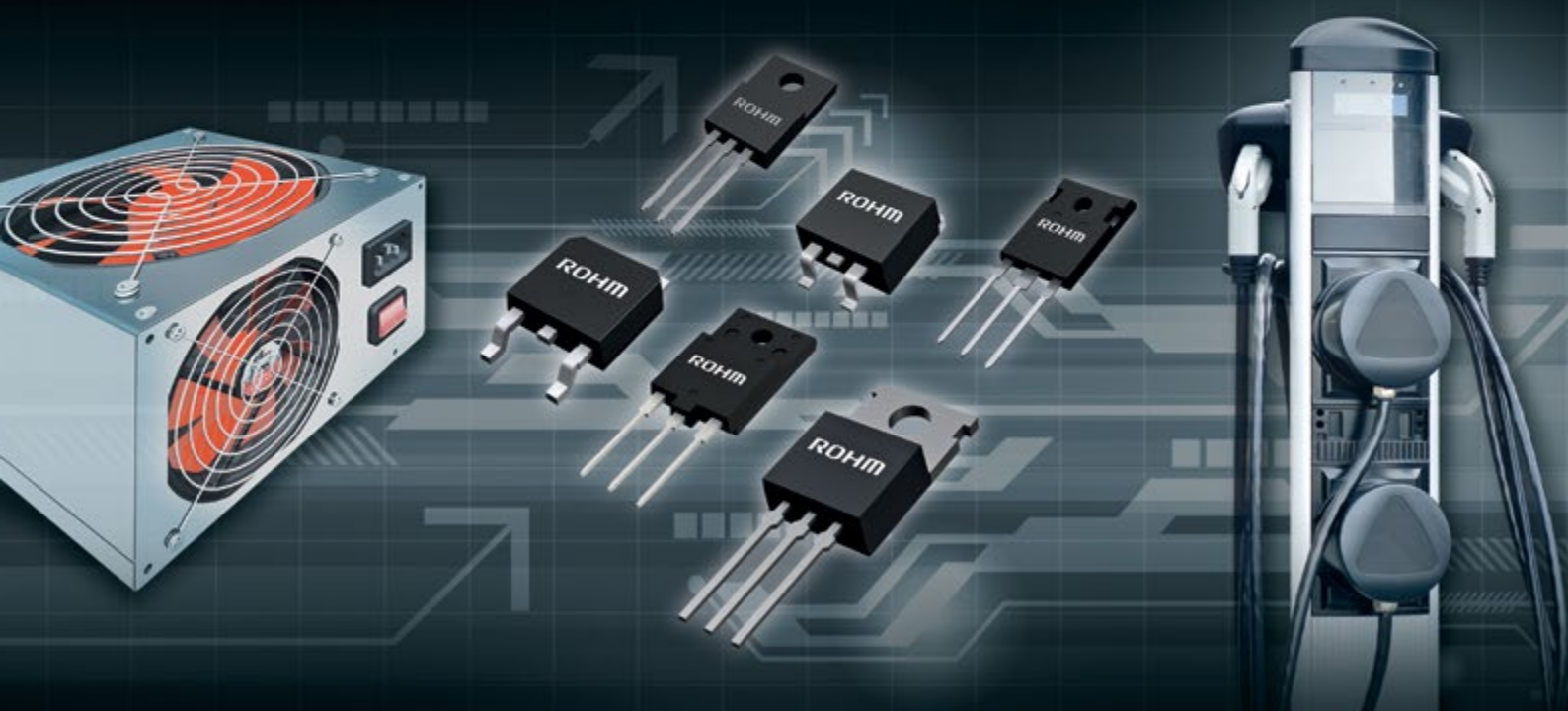

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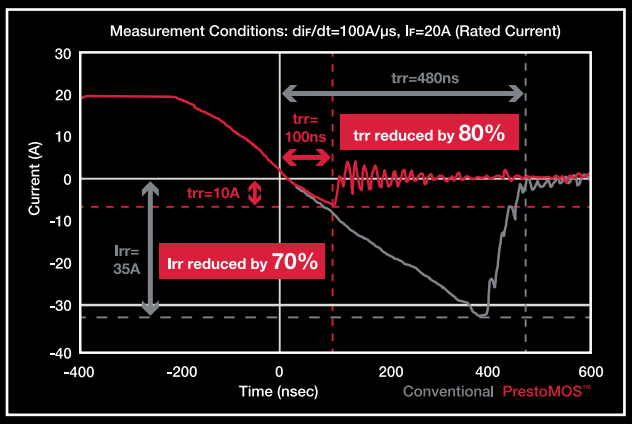
Super Junction-MOS KN series 600V / 650V / 800V

- Part number R60xxKNx (600V), R65xxKNx (650V) & R80xxKNx (800V)
- Fast switching and low switching loss
- Usable for high efficiency SMPS
- Max. current up to 76A (600V, 650V) and 52A (800V)
- Packages: TO-220FM/AB, TO-247, TO-3PF, D2PAK, DPAK

Body diode recovery wave form of PrestoMOS™



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Expanding GaN Epiwafer Production

EpiGaN has selected Aixtron's G5+C MOCVD system to boost its manufacturing capability of large-diameter GaN-on-Si and GaN-on-SiC epiwafers. The AIXTRON AIX G5+C reactor will be installed at EpiGaN's manufacturing site in Hasselt/Belgium and operational in Q1/2019. The fully automated Planetary© MOCVD system features in-situ chamber cleaning and enables configurations of 8x6 inch, or 5x8 inch epitaxial wafers to be automatically loaded and removed from the system in an enclosed cassette environment. "The demand from our global customer base for GaN product solutions is booming. Our key customers are getting ready to launch and scale-up products based on our GaN RF-power technology, which is optimized for 5G broadband network applications. With Aixtron's AIX G5+C planetary system EpiGaN will increase its capacity for 150mm and 200mm product solutions to cope with these increasing market demands," says EpiGaN co-founder and CEO Dr Marianne Germain. "Aixtron's planetary system combines excellent on-wafer uniformity and run-to-run performance at the lowest cost of ownership – these attributes are critical to serve our customer base with products of exceptional performance and at the right price point." Dr. Felix Grawert, President of AIXTRON, commented: "We are confident the AIX G5+C will support EpiGaN's demanding requirements for high-quality, cost-effective production of GaN epitaxial wafers as our tool meets the highest standards in terms of uniformity and particle density."

www.epigan.com

www.aixtron.com

Acquisition of XiTRON Technologies Brand and Product Lines

Vitrek announces the acquisition of XiTRON Technologies. XiTRON is a recognized source of precision power test and measurement solutions for industrial and consumer product development and manufacturing. The XiTRON product line includes a range of single, dual and 3 channel Power Analyzers, portable calibration equipment, programmable DC electronic loads, power quality analyzers, digital milliohmmeters and phase angle voltmeters. The XiTRON line also contains products targeting the lighting industry, including ballast analyzing equipment and portable micro spectrometers for LED lighting measurement. In addition to the extensive product range, the acquisition of the XiTRON personnel adds a wealth of industry knowledge and consistency in supporting and maintaining relationships with XiTRON customers. Vitrek will be able to provide significant engineering support for new product development as well as substantial marketing resources to sustain the expansion and growth of the Vitrek-XiTRON product portfolio. "Acquisition of the XiTRON Technologies brand and its products is a vital component of our expansion strategy," said Don Millstein, Vitrek's President. "These two companies, each founded in 1990 here in San Diego County, share a heritage of excellence in power measurement and analysis. The addition of XiTRON's products and brand recognition, market access and distribution channel all create exceptional synergies for Vitrek's continued growth."

www.vitrek.com

Fully Sustainable, Global Headquarters and R&D Center

The $10 million, 3,600 m2 facility, due for completion in June 2019, emphasizes ABB's commitment to advancing developments in the field of sustainable mobility. ABB recently gained global recognition by Fortune Magazine, which ranked ABB as #8 in its list of companies who are 'changing the world' for the advances it has made in e-mobility and EV charging. Frank Muehlon, Managing Director for ABB's EV Charging business comments: "The investment in this new head office and R&D center demonstrates ABB's commitment to technological leadership and setting the standard when it comes to sustainable mobility. The facility will allow us to increase the pace of product testing and development, ensuring we can deliver innovate products to market faster than ever." Located on the southern part of the TU Delft Campus, the complex, which will be able to house up to 120 people, will mark the return of ABB's EV charging business to the home of its conception. Indeed, the students who founded Epyon (the EV charging start-up acquired by ABB in 2011), were former students of Delft University of Technology. With interoperability the key focus for ABB chargers, the building will be fitted with the latest technology to ensure that ABB chargers are compatible with all types of vehicle. Simulators have been built exactly for this purpose, with 95 percent of all tests to be conducted with a digital copy of vehicles loaded into the simulator.

www.abb.com

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Hitachi Power Semiconductor Devices Ltd. email pdd@hitachi-eu.com

200 mm GaN-on-Silicon microLED Applications

Veeco Instruments Inc. and ALLOS Semiconductors GmbH announced the completion of another phase of their mutual effort to provide the industry with leading GaN-on-Silicon epiwafer technology for microLED production. The purpose of the companies' most recent collaboration was to demonstrate the reproducibility of ALLOS' 200 mm GaN-on-Si epiwafer technology on Veeco's Propel® MOCVD reactor when producing epiwafers for many prominent global consumer electronics companies.

"To bring microLED technology into production, simply presenting champion values for a single metric is insufficient. It is essential to achieve the whole set of specifications for each wafer with excellent repeatability and yield," said Peo Hansson, Ph.D., senior vice president and general manager of Veeco's Compound Semiconductor business unit. "This successful joint effort reaffirms the power of combining Veeco's superior MOCVD expertise with ALLOS' GaN-on-Silicon epiwafer technology to provide customers a novel, proven and reliable approach to accelerate microLED adoption."

Sorting and binning are standard methods to achieve wavelength consistency for conventional LEDs. But microLEDs are too small and numerous to be sorted and binned; therefore, the uniformity of the epitaxial deposition is even more critical. The most important success factor for turning the promise of microLED displays into mass production reality is to achieve extremely good emission wavelength uniformity, which eliminates the need to test and sort individual microLED chips.

www.veeco.com

www.allos-semiconductors.com

Thomas Krebs new Head of Application

Aaron Hutzler as Head of Application has left PINK GmbH Thermosysteme for personal reasons end of November 2018. Since mid of 2016 he took over the responsibility of setting up a strong and successful application team. He started alone and today the team consists out of 10 employees and offers a variety of applications services to customers worldwide. Thomas Krebs will take over the responsibility for this application team in January 2019. He is a 45-year-old graduated Engineering Manager and has many years of experience in integrated circuit packaging. For 11 years he worked for the Heraeus technology group in Hanau, where he built up the application centre and ran the power electronics and sintering groups until 2016. In 2016 he became responsible for the global management of Applications for SLM Solutions, a manufacturer of 3D metal printing systems.

The experience and knowledge Mr. Krebs is having, is ideal for his new position. We look forward to working with him in the future. A warm welcome to the team!

www.pink.de

Innovation Award 2019: Submit Projects Now

The Association for Sensors and Measurement (AMA) invites researchers and developers to compete for the renowned AMA Innovation Award for 2019. The AMA is looking for research and development results in sensor and measuring technology. The submission deadline is 31 January 2019. Individuals or developer teams may submit innovative research and development projects that have a clear market relevance. The renowned AMA Innovation Award is endowed with 10,000 euros. Young enterprises that have been on the market no longer than five years, have no more than 50 employees, and an annual turnover of less than 10 million euros, may compete for the special Young Enterprise Award. The winner in this category will receive a trade-fair stand at the SENSOR+TEST 2019 free of charge. The AMA Innovation Award has been presented for 19 years to innovative individuals in sensors and measurement. It goes to the developers themselves, not their institutes or enterprises. The jury comprises representatives from universities, institutes, and enterprises. The jury members especially consider novel approaches, the general scientific achievement, as well as the project's chances on the market.

www.ama-sensorik.de/en/science/ama-innovation-award

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Simply More Efficient

Silicon Carbide FETs – Simply More Efficient

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Recognized as “Outstanding EMEA Semiconductor Company”

Infineon Technologies AG was awarded “2018 Outstanding EMEA Semiconductor Company” by the Global Semiconductor Alliance (GSA). The prize is granted to the leading semiconductor company from Europe, the Middle East and Africa that demonstrates the highest excellence in regard to vision, strategy, execution and future opportunity. “Infineon is very much honored by the award,” said Dr. Helmut Gassel, Member of the Board and Chief Marketing Officer at Infineon. “It represents a vote of confidence by the semiconductor ecosystem in Infineon’s growth, innovation and business strength. This certainly spurs our ambition to further advance innovation through semiconductor solutions that link the real and the digital world for the benefit of people and society”. Infineon was presented with the prestigious award at the Annual GSA Award Dinner in Santa Clara, California. The celebration honors the achievements of semiconductor companies in several categories ranging from outstanding leadership to financial accomplishments, as well as overall respect within the industry.

Examples of Infineon’s innovative prowess include the companies’ strength in electric vehicle and assisted driving system solutions, a complete portfolio of automotive-grade silicon carbide components or a first automotive design-win of its 3D Time-of-Flight sensor technology.

Semiconductors are the most fundamental building block of our modern age and serve as foundation of modern technology and key driver for innovation.

www.infineon.com

High Power-Conversion Solutions for Server and Automotive Applications

Exagan is extending its market reach by introducing new G-FET™ power transistors and G-DRIVE™ intelligent, fast-switching devices with enhanced power capabilities for automotive and server applications. With the products’ drain-source on resistance (RDSon) capabilities ranging from 30 milliohms to 65 milliohms, these new releases provide enhanced performance and power efficiency for diverse applications including electric vehicles (EV), industrial equipment and data servers.

Power supplies for the fast-growing server market are one of the first power applications to benefit from Exagan’s GaN solutions. Global server shipments increased 20.7 percent year over year to 2.7 million units in the first quarter of 2018, according to the research firm International Data Corporation.

Another sector to benefit from these enhanced products is automotive power electronics, where Exagan’s solutions provide robust performance and simplify design-in at the system level. During the Automotive Conference at Electronica, Exagan’s President and CEO Frédéric Dupont gave a presentation entitled “From Evolution to Revolution: Disrupting Automotive Power Conversion with GaN” that explained how small, lightweight and highly cost-effective power solutions made with GaN can be applied in EVs. “Our G-FET and G-DRIVE product lines offer the most comprehensive portfolio of easily integrated GaN solutions for an extensive range of applications spanning consumer, server and automotive markets,” said Exagan’s chief executive Dupont.

www.exagan.com

Investing More Than $ 2,800,000 USD in Virginia Beach

BMZ Group will retain 21 full-time jobs in Virginia Beach and create at least 30 new jobs within the next 2 years. The Virginia Beach Economic Development Authority approved an Economic Development Investment Program grant in the amount of $170,000 based on the capital investment and the number of new jobs created with the expansion. BMZ will invest $2,800,000 in Virginia Beach with real estate, construction, machinery and tools. “BMZ has grown significantly in the past two years,” said Virginia Beach Economic Development Business Coordinator Michelle Chapleau. Under the new management and by hiring experts from the industry, sales volume has increased from less than $4 million in 2016 to approximately $10 million in 2018. “This is the second EDIP grant we’ve awarded, and it’s clear this investment has paid off in keeping a major international manufacturing headquarters here in addition to creating more jobs.” BMZ’s U.S. facility handles North American sales, assembly, distribution, research and development of lithium ion battery units for a variety of industry sectors. The batteries are used in power tools, outdoor power equipment, material handling, medical devices, wind and solar energy, household items and e-bikes. BMZ also imports lithium ion batteries and chargers from its manufacturing facilities in Asia and Europe and partners with local companies to manufacture plastic housings and wiring components.

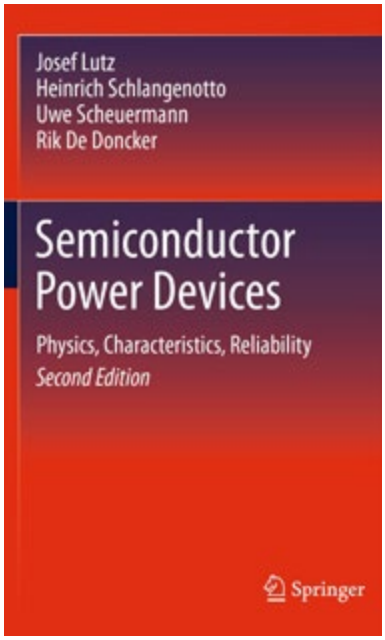
www.bmz-group.com

Global Microelectronics Experts Develop SEMI’s Technology Leadership

In the face of the microelectronics industry’s unprecedented challenges and opportunities with artificial intelligence (AI) and new markets outside the historic semiconductor audiences, SEMI announces the Technology Leadership Series of the Americas. The seven-part sequence of related strategy and technical conferences comprises the world’s largest and most comprehensive approach for examining and fabricating future innovations that can fuel a higher quality of life for the planet. As the era begins with the volume of the world’s data doubling every 12-18 months, a global brain trust of hundreds of industry experts has provided inputs for a coherent, step-by-step process that will position the microelectronics industry to navigate the future. With an objective to reduce learning curves and shorten product times to market, key interest groups have rallied with SEMI in the past 24 months to multiply interactions with the supply chain. In turn, these exchanges are calculated to increase the members’ respective technical ROIs. Technology communities include the Fab Owners Alliance (FOA), FlexTech, MEMS & Sensors Industry Group (MSIG), Electronic System Design Alliance, as well as global partner associations such as IEEE and SAE International, which leads technical learning for the mobility industry. As a result, more than 2,100 global market-related businesses have teamed with SEMI to help structure content for the Technology Leadership Series of the Americas.

www.semi.org

Semiconductor Power Devices: Physics, Characteristics, Reliability:



The book on Power Semiconductor Devices has the authors: Josef Lutz, Heinrich Schlangenotto, Uwe Scheuermann and Rik De Donker.
The following comments had been stated by Dr. Leo Lorenz:
It´s a great achievement for students and experts in the semiconductor and power electronics industry that a high experienced team of power device designer, packaging and chip interfacing technologies, reliability and power electronics system experts have written this excellent book. The authors are well known in the power electronics society and have a long history in the relevant industries as well as distinguished professors and researchers at German universities.
The book, covering the major power devices today, is segmented in 15 chapters and 5 appendices comprising 706 pages.
Power conversion technologies today is driven by power density, efficiency and reliability while the semiconductor devices and their operation in the circuit are playing a key role.
To operate the devices up to their limits in the SOA diagram it´s important to get deeper understanding about the intrinsic semiconductor structures along with parasitic components added on due to the packaging and chip interfacing technologies and finally the destruction mechanism during the operation in particular dynamic intervals. This is even more the case when we are moving from fast switching to ultrafast switching power devices. On top of this developing trend for the same power rating the chip volume is scaled down along with an increase in junction and operating temperature. This is having a major impact on the thermal and mechanical stress, dynamic overloading and finally new destruction mechanism.
The second Edition had been published by Springer- Verlag, Berlin Heidelberg 2018

www.springer.com/de/book/9783642111242

Teaming Up in Piezo Haptics

TDK Corporation announces that its subsidiary TDK Electronics is joining forces with Aito, a leading company in controller solutions for piezo haptics. Both companies will cooperate in the development and promotion of cutting-edge touch response solutions that are based on TDK's portfolio of piezo actuators with haptic feedback and Aito's HapticTouch control solution. Based on this partnership the product range of touch response solutions will be continually expanded.
"Together with Aito we are able to provide much more comprehensive support to customers, who are facing the challenging process of integrating haptic actuators into their applications," explains Dr. Georg Kuegerl, CTO of the TDK Piezo & Protection Devices Business Group. "They will benefit from a fully-integrated solution that combines our piezo actuators and Aito's smart control ICs, enabling much faster development, far better haptic performance and lower costs."
Peter Kurstjens, CEO of Aito, stated: "TDK is well known for their reliable high-volume piezo component manufacturing and development. Their experience will help us to further strengthen our leading position in touch response solutions." Aito's HapticTouch control solution transforms piezo actuators with haptic feedback into precise touch sensors that provide haptic feedback to users' fingertips and make smooth surfaces feel like physical buttons, shapes, edges or textures.

www.tdk-electronics.tdk.com

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EMV 2019: Workshop Program Published

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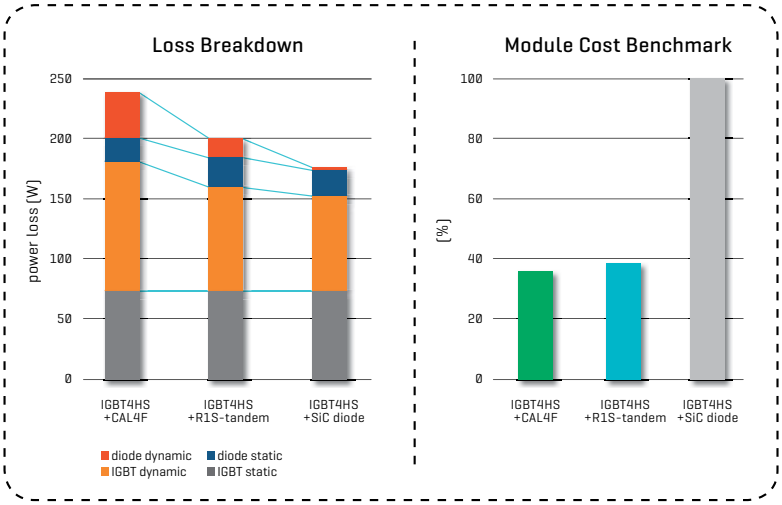

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EMPOWERING **YOUR IDEAS**

The Efficiency Revolution: Migrating to Advanced Low-Standby Power Architectures

The power electronics industry has come a long way in the last 30 years and the pace of development shows no signs of stopping. In the area of technology advances, the numbers for operational efficiency keep going up, to the point where some Point-of-Load (PoL) and other board-level devices are exhibiting efficiency numbers approaching the theoretical maximum.

By Silvestro Fimiani, Product Marketing Manager, Power Integrations

How do you save energy in a power supply that's already 95%+ efficient? One answer is to reduce the amount of energy a device consumes when it is in standby mode. This 'vampire' power usage has been an issue for years, first manifesting itself in the first generation of remote-controlled, 'instant-on', power-hungry television sets. Some consumers would unplug the sets when not in use to reduce their household energy bills (arguably, this is the first example of zero quiescent power, albeit under direct human control).

Once standby power was recognized as a serious area for energy conservation (think of the millions of unused phone chargers plugged into walls at this very moment), governments began to issue regulations on the matter. From ENERGY STAR to the Federal Energy Management Program to the EU's ErP (Energy Related Products) Directive, there has been a tremendous pressure to both increase efficiency while reducing standby power, a trend that has all-but-eliminated the use of linear power supplies in some markets.

Such regulatory requirements for standby, 'off', and networked standby performance in power consumption in electrical and electronic household and office equipment are forcing the power electronics industry to migrate systems to the next level. In the case of the ErP, the commission is looking to further improve low-load efficiency significantly (see Figure 1). The most recent study was completed in April 2017, with likely implementation in 2021. Since January 2017 networked standby devices must not consume more than 3 to 8 watts depending on the product, compared to 20 to 80 watts previously.

Policy scenarios	Potential energy savings	2020	2025	2030
0.2 W scenario	Annual savings (TWh/year)	2.0	2.9	3.1
	Cumulative savings (TWh)	3.9	17.4	32.3
0.3 W scenario	Annual savings (TWh/year)	1.2	1.7	1.8
	Cumulative savings (TWh)	2.4	10.4	19.4
0.4 W scenario	Annual savings (TWh/year)	0.4	0.6	0.6
	Cumulative savings (TWh)	0.8	3.5	6.5

Figure 1: The ErP commission is looking to further improve low-load efficiency

Standing by

Any intelligent device that needs to immediately respond to input must draw power to operate, even if momentarily on a long duty cycle. Generally, the touch-screen and/or user interface and/or wireless connections may remain on in rest states, requiring enough power to keep them alive, while still achieving the stand-by requirement. This demands high-efficiency operation at light loads, among other things.

One way to address this need is with Power Integrations' InnoSwitch™ technology, with ON/OFF control to maximize efficiency at light load. In addition to having the most efficient algorithm in low power, this functionality enables the device to only deliver power when output is needed. InnoSwitch-based devices always switch at the minimum frequency possible, reducing switch losses that kill efficiency at light load. In addition, InnoSwitch also provides excellent cross-regulation in multi-output designs, eliminating the linear regulator for secondary outputs that hurts efficiency at light load. Synchronous rectification also allows an efficiency increase by several points in stand-by. The InnoSwitch-EP architecture is revolutionary in that the devices incorporate both primary and secondary controllers, with sense elements and a safety-rated feedback mechanism into a single IC (Figure 2). PSR (primary side regulators) can only measure output voltage when they are switching. But when they are switching they are sending energy. If too much energy gets sent just for checking' the output voltage, then it needs to be burned or the output voltage will ratchet up. This forces PSR based units to trade off speed-of-response with no-load energy use. However, because the InnoSwitch architecture does not require a pre-load, it is naturally 'low-load' and also very fast.

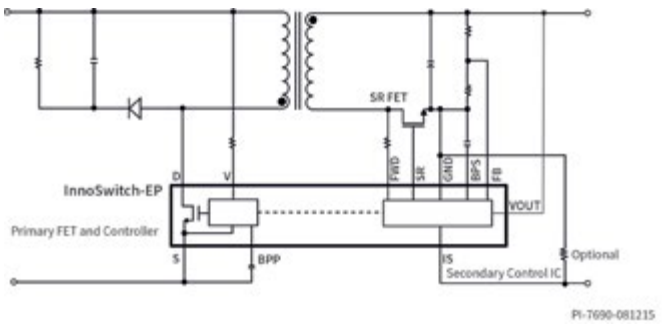

Figure 2: The InnoSwitch-EP flyback switcher IC in a typical application

Close component proximity and innovative use of the integrated communication link permit accurate control of a secondary-side synchronous rectification MOSFET and optimization of primary-side switching

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to maintain high efficiency across the entire load range. Additionally, the minimal DC bias requirements of the link enable the system to achieve less than 10 mW no-load to maximize efficiency in standby.

Optimize your design

Design optimization is fundamental to reach the highest level of efficiency available to a system. A power circuit in one sense is a chain that is only as efficient as the weakest link in it. An improvement in one portion of a design may result in some improvement, but if every point in the circuit is optimized, much more significant results will be realized.

Figure 3 shows the levels of efficiency achieved by using the best solution at each point in the chain. In this case, a non-isolated flyback converter was created that provides a dual output of 5 V at 650 mA and 12mV at 400 mA from an input from 85 VAC to 350 VAC. This power supply utilizes the LNK3696P from the LinkSwitch™-XT2 900 V family of devices, which is optimized for industrial and metering applications operating off voltages up to 480 VAC.

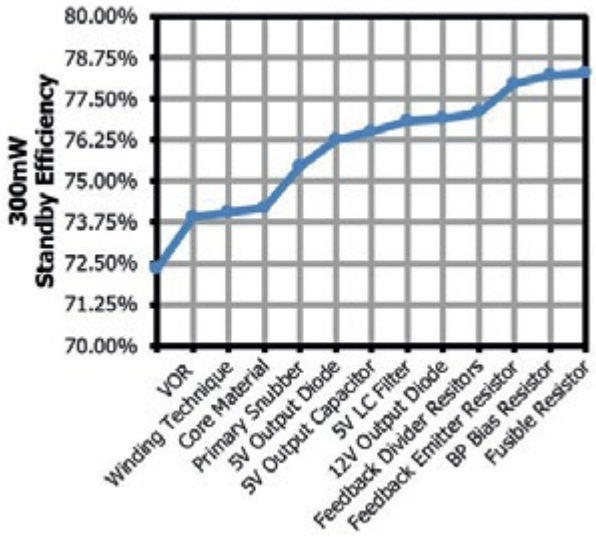

Figure 3: The levels of efficiency achieved by using the best solution at each point in the chain

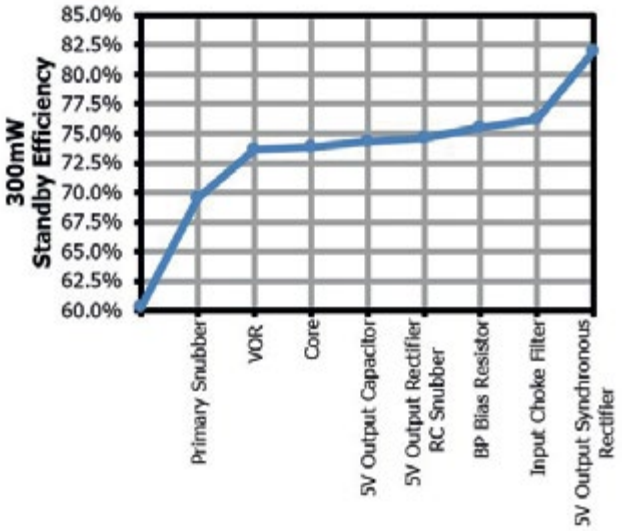

Figure 4: Design optimization in a 15 W dual-output converter based on the InnoSwitch3-EP

The accurate design-in of each component adds another six points of efficiency at 300 mW, underscoring the importance of total system optimization. A clampless design can be used in low-power applications to further improve efficiency. Note how each step in the optimization chain adds its own contribution to overall system efficiency.

Another example can be found in Figure 4, showing the improvement that design optimization can provide in a 15 W dual-output (5 V/1.2 A and 12 V/0.75 A) converter based on the InnoSwitch3-EP. The design achieves greater than 83% standby mode efficiency, and is ErP compliant. Just like the previous example, design optimization of Vor and primary snubber are important.

This design improves standby efficiency by maximizing the available output power for any given input power, with an optimized transformer design along with best selection of active devices, primary clamp, filter components, and bias resistors. For 15 W the design can use a clampless approach, but transformer design is more complicated. In addition, synchronous rectification (SR) can give a big boost in efficiency versus a conventional output.

Looking forward

These advances in power electronics provide many benefits beyond the obvious ones. The biggest advantage is in the reduced bill of materials that results in using an optimized integrated design. If you compare the costs of a linear power supply from 10 years ago to the cost of a modern switcher based on technologies like InnoSwitch, the new supply is significantly less expensive in quantity. Even more significant differences can be found in the reduced size, weight, and thermal requirements of the modern power solution. These advances provide cascading benefits across the board, from smaller form factors and higher thermal efficiency to lower BoM costs due to reduced component counts.

To address requirements like the new EuP, the latest core technologies must be employed, as well as an optimal system design for the best possible efficiency and performance. Using innovative technologies like InnoSwitch, with ON/OFF functionality, integrated SR, and its highly-efficient algorithm, designers can enjoy real benefits and deliver the best power solution for their application.

Dynamic configuration enables precise control

Capable of delivering up to 65 W and achieving up to 94% efficiency across line and load conditions, the InnoSwitch3-Pro family of off-line CV/CC and CP flyback switcher ICs enable precise, dynamically adjustable, control of voltage (10 mV step) and current (50 mA step), via a simple two-wire I2C interface. Devices may be paired with a microcontroller or take inputs from the system CPU to control and monitor the off-line power supply. Applications include virtually any rapid-charging protocol, including USB Power Delivery (PD) 3.0 + PPS, Quick Charge™ 4/4+, AFC, VOOC, SCP, FCP and other industrial and consumer battery chargers, dimmable LED ballast drivers and field-configurable industrial power supplies.

A microprocessor VCC supply is included, eliminating the need for an external LDO to power the microcontroller; also included is an n-channel FET driver which may be used to enable or disable the main power output. Together with integrated bus voltage, current and fault-reporting telemetry and dynamically configurable protection functions such as OTP, line OV/UV, output OV/UV, and short-circuit, the BOM count for a sophisticated offline power supply is significantly reduced and design complexity is considerably simplified.

This combination of features addresses current market challenges as the AC-DC power conversion market rapidly-transitions with system designers needing a programmable solution that can adapt to various fast-charging protocols including the recently completed USB PD 3.0 + PPS specification. The ability to precisely control the output voltage and current of a power supply over a wide range is also useful for designers of specialized applications with smaller production runs, as they can easily configure a single board design for multiple product SKUs using software either at manufacture or during installation.

InnoSwitch3-Pro ICs employ Power Integrations' high-speed digital communications technology, FluxLink™, plus synchronous rectification, quasi-resonant switching and a precise secondary-side feedback sensing and feedback control circuit. Devices are CQC certified, UL recognized and TUV (EN60950) approved to bridge the isolation barrier; the products' InSOP™-24D package also provides a low-profile, thermally efficient solution with extended creepage (>11.5 mm) and clearance between primary and secondary sides for high reliability, surge protection and ESD robustness.

www.power.com/products/innoswitch/innoswitch3-pro

Making GaN Power Electronics Universal

As GaN power electronics is gaining momentum, an interesting question to ask is whether GaN will remain a niche player like GaAs or whether it will truly displace silicon power MOSFETs. Based on experience of how bipolar power transistors were displaced by power MOSFET in the 1980's, several aspects are important.

By Simon Li, Ph.D.; CEO; GaNPower Intl Inc.

The first is that using GaN must be much more beneficial and it must enable many new applications to make it worthwhile. The second is that it must be easy to use and universally available in a wide range of current and voltage ratings. Finally, it must be very cost effective and highly reliable.

This article will focus on how GaNPower International Inc., a Canada based company offering advanced GaN power devices and system solutions, is able to make GaN easier to use and more universal.

Pushing the breakdown voltage higher

It was commonly believed that high voltage applications (> 1000V) were exclusive domains of silicon IGBT and SiC (both vertical devices) until recently GaNPower proved otherwise. In August 2018, GaNPower International Inc. announced [1] a major breakthrough. By innovative design GaNPower had succeeded in the tapeout of its first commercial lateral single-die E-mode GaN transistor suitable for rating at 1200V breakdown voltage. The breakthrough was supported by on-wafer testing as indicated in Figure 1 and the typical threshold voltage was found to be around 1.4 volt (E-mode).

Understandably device packaging for high voltage lateral devices were challenging. So far GPI has just released GaN E-mode devices rated at 1000V and 1100V on TO252 (15A/95mOhm) [1].

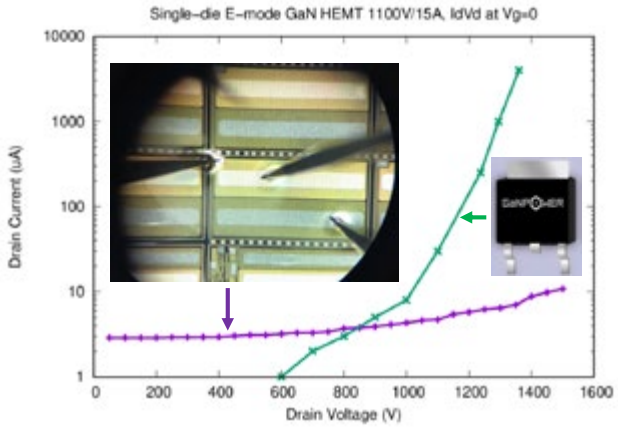

Figure 1: On-wafer and after packaging results for high voltage Emode GaN.

With continued improvement in packaging, it is certain that single-die E-mode devices will soon be commercially available at ratings of 1200V and higher. It is worth noting that increasing the breakdown voltage of GaN does not mean significant sacrifice of switching performance. The Qg*Rdson product of 650V/15A GaN from GaN-Power is around 300 (mOhm*nC) which is to be compared with that of 1100V/15A GaN at 320 (mOhm*nC). It is a pleasant surprise that high voltage lateral GaN works so well.

Making the gate easier to drive

Behaviors of E-mode GaN transistors are very similar to those of conventional power MOSFETs (except they are much faster). Therefore power engineers can use their system experience with minimal additional training. However, special attention should be paid to how the gate is driven. Taking the popular p-GaN GaN/silicon as example, the Schottky barrier associated with the gate would be driven into exponential current increase when gate voltage reaches 13-14 volts (see simulation and experimental data in Figure 2).

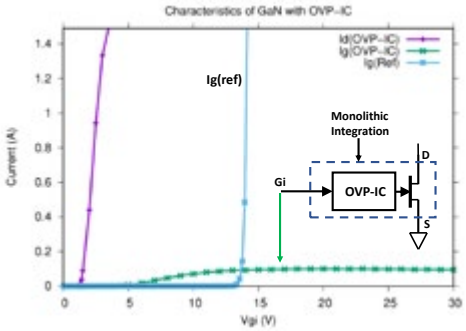

Figure 2: On-wafer results of GaN integrated with over-voltage-protection IC. Simulated gate current for a reference device is also down.

Due to the above possible catastrophic gate damage, extreme care must be exercised in designing and implementing the circuits such that no instantaneous over-voltage would happen to the gate.

Even picohenries (pH) of parasitic inductance can cause several volts of overshoot in gate drive and power loops and this can cause irreversible damages to the device. The above requirement in design and implementation is easier said than done and this continues to be a major hold back in the adoption of GaN.

To make the GaN device easier to drive, GaNPower invented a GaN specific over-voltage protection (OVP) circuitry monolithically integrated with GaN power device. The OVP circuit uses the gate voltage as its auxiliary power supply and the whole new IC appears to be just another GaN discrete power device except the gate would not easily be damaged. Preliminary on-wafer testing results (Figure 2) are very promising while the packaging effort is on-going. The gate current is clamped at a controlled value when the input voltage is above the desired driving voltage (6V).

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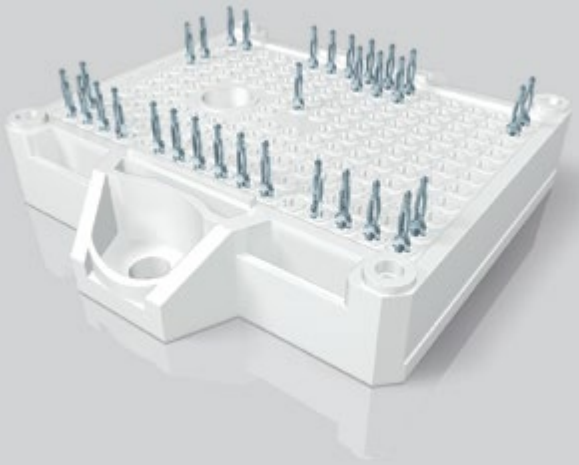

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The over-voltage protection can in theory go up to 100V without damaging the device thus providing effective protection. The benefit is that with little or no degradation in switching performance and slight increase in semiconductor wafer area, the GaN works just like a silicon MOSFET without runningthe risk of the catastrophic gate damage. System engineers would be more willing to use such power device/IC since they behave like MOSFET except it has much better performance.

Next generation GaN specific system solutions

The rationale for using GaN has been that since it is still a relatively expensive device, it should be used where high switching frequency and high power density are required. With patented circuit topology and control method [2], GaNPower is creating a series of next generation system solutions specific to GaN technology.

It is generally agreed in the power industry that GaN is especially suitable for resonant topologies at high switching frequency. The reason is a smaller Qg*Rdson enabling faster charging/discharging of the internal capacitors of GaN transistor and therefore a much smaller dead time is required in switching control.

Conventional LLC resonant circuits have a major shortcoming: they are difficult to parallelize (multi-phasing or multi-staging). The reason is that the voltage gain of LLC converter is sensitive to the resonant frequency, or resonant inductor and resonant capacitor values. When connected in parallel with same switching frequency operation, any slight difference in L and C value due to tolerance will cause current imbalance and therefore, current sharing cannot be achieved. In other words, one phase will deliver majority of the current and the other phase deliver small current. So all the current application of LLC and other resonant converters uses single converter to deliver all the power. This limits the output power carrying capability of the resonant converters. This problem is especially true for low voltage (such as 12V, 14V), high output current (such as 100A, 200A) application where the conduction loss will be very high and therefore, reduces the efficiency and increases the cooling requirement. The transformer size is also increased, which defeats the purpose of using GaN for high density. This problem is more severe for the EV on board DC – DC converter with 14V output voltage and 140 – 280A load current.

Combined with the fact that the GaN device is a lateral power device which is very difficult to be designed to carry a high current, due to packaging limitation. With larger area lateral device, it would be difficult to wire bond (or other connection means) the center area of a large device without causing significant increase in on-resistance and issues in wire crossing.

GaNPower proposed a Switch-Controlled-Capacitor (SCC) technology to solve the current sharing problem of the LLC resonant converters with two or more LLC converters connected in parallel [2]. By controlling the equivalent resonant capacitor value, the resonant frequency of each LLC phase can be made equal even with L and C tolerance. Therefore, perfect current sharing can be achieved among all the phases. The extra cost for SCC could be as low as one MOSFET with source connected to primary ground, which significantly simplify the gate drive. The MOSFET operates at zero-voltage-switching (ZVS) condition.

When phase-shedding (with some phases shutting down) operation is used, peak efficiency operation can be maintained over a very wide output current range. As a proof of concept, a 600W (2x300W) two-phase LLC DC-DC converter were constructed (Figure 3).

Good efficiency and phase shedding were achieved. With the SCC technology for multi-phasing, high frequency switching, high power density and high efficiency would be achieved to maximize the benefit of using GaN for any high power conversion systems.

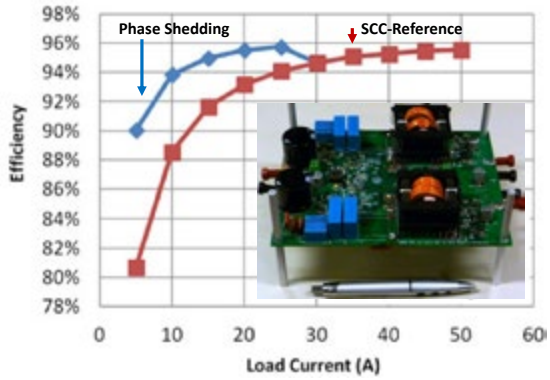

Figure 3: Proof of concept demo of a 600W(2x300W) switch-controlled capacitor LLC DC to DC converter.

The team at GaNPower also demonstrated that LLC topology is not only suitable for GaN in medium to high power applications, it is also a good choice for GaN in lower power application such as 65W power adapter. Table I list a comparison between ACF and LLC and it is clear that LLC is fundamentally more suitable for commercialization of GaN in 65W power rating. A recent prototype of GaN-LLC design of 65W power adapter is shown in Figure 4 and GaNPower is expected to make it available commercially soon.

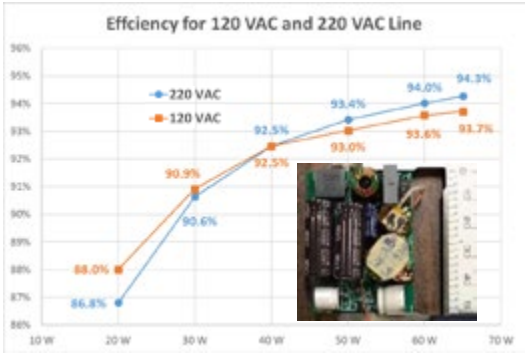

Figure 4: Demo systems of 65WPD using LLC topology and GaN at 1MHz switching.

	ACF	LLC	Comment
Voltage stress	550V	370V	More reliable
ZVS	Not guaranteed	Guaranteed	More reliable
EMI	Two stage	One stage	Lower cost
Digital control	No	Yes	More intelligent

Table 1: Comparison of ACF and LLC for 65WPD.

With innovative GaN device designs and next generation LLC solutions, GaN technology appears to be increasing likely to displace silicon power MOSFET and SiC in the near future. The author acknowleges helpful comments from Drs. Gary Dolny, Yanfei Liu and Yue Fu.

[1] www.iganpower.com
[2] US Pat. 9729070B2

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Inverter Cost Reduction Owing to Current-Measurement Integration in Power Modules

Cost reduction and increased power density combined with long lifetimes are the main challenges for the development of new generations of inverters. For instance, the electrical performance of IGBTs and diodes, and interconnection technologies has been consistently improving over time. A further potential for cost reduction is the introduction of shunts for current measurement internal to the power modules, replacing Hall-effect sensors measuring the AC current in inverters at power levels above 75 kW.

By Klaus Vogel, Michael Gadermann, Andreas Schmal and Christoph Urban; Infineon

This article describes the impact of introducing internal shunts to the power module in inverters in the power range above 75 kW, specifically: cost reduction, performance improvement and simplified inverter design. Current sensing is required for speed/torque control, and protection functions like overcurrent and short-circuit detection. The type of current measurement is dependent on different factors, for example, power level, cost targets, accuracy requirements, and available physical space.

In reference [1], the different possible current-measurement technologies are described and discussed in detail. They can be summarized in Table 1:

Innovation

The implementation of shunts inside the IGBT modules opens the door for the use of shunts and delta-sigma modulators with 250 mV input voltage in the inverter power range above 75 kW. The development of new delta-sigma modulators that can operate with an input voltage of 50 mV [2] will help to reduce the power losses in the shunts for future systems. Infineon has developed a portfolio of modules with integrated shunt resistors in the AC output. Table 2 gives an overview about the available products at present.

An important property of the shunt is its temperature stability that enables a current measurement with excellent linearity over a wide temperature range. It can be shown that the shunts used by Infineon feature a temperature drift of less than ±0.3 percent. Details about the shunts deployed are described in Reference [3].

Inverter design – reduction of parts quantity

The simplification of an inverter design is one crucial requirement during development of new inverter generations with the target of reducing the bill of materials and the production costs, as well as to increase system reliability and power density. The fact that current measurement can be integrated in the power electronic module helps significantly to address these topics.

Figure 1 shows a drawing of a typical 240 kW three-phase system with Hall-effect sensors as well as the improved system utilizing internal shunt resistors.

Using internal shunts, the overall parts' count can be reduced. Often the output busbar design can be simplified, as it does not have to meet the constraint of fitting through the Hall-effect sensor aperture. The screws, which were needed for the connection of the Hall-effect sensor, are saved as well as the cable that connects the Hall-effect sensor to the PCB. In combination, these changes lead to a reduced bill of material and a production-time saving. This will reduce the inverter costs and improve the system reliability.

I_C [A]	1200V	1700V
75	IFS75B12N3E4_B31	
100	IFS100B12N3E4_B31 IFS100B12N3E4P_B11	IFS100B17N3E4P_B11
150	IFS150B12N3E4_B31 IFS150B12N3E4P_B11	IFS150B17N3E4P_B11
200	IFS200B12N3E4_B31	
300	IFF300B12N2E4P_B11	IFF300B17N2E4P_B11
300	IFF300B12ME4P_B11	
450	IFF450B12ME4P_B11	
600	IFF600B12ME4P_B11	
	IFS - 6-pack, IFF - 2-pack	

Table 2: Overview with the product line-up of available Infineon IGBT modules with integrated shunts

	Shunt module + ΔΣ modulator	Hall-effect sensor closed loop	Hall-effect sensor open loop
Accuracy	high	high	medium
Cost	low	high	medium
Physical space required	low	very high	high
Assembly/ Mounting effort	Very low Some parts on PCB	high mounting, cable & plug connection	high mounting, cable & plug connection
Isolation	reinforced via ΔΣ modulator	reinforced w/o additional measures	reinforced w/o additional measures
Step response time	Configurable tradeoff between resolution and response time	typ. <1µs	typ. ~2...4µs
Power supply	typ. unipolar 5V, <20mA	typ. bipolar ±15V, >100mA	typ. unipolar 5V, 20mA

Table 1: Summary of the main difference between three different approaches for current measurement

Inverter design – thermal aspects

The maximum temperature of the busbar has to be taken into account if using a Hall-effect sensor. Typical sensors are specified to operate below 85 or 105 °C housing temperature, depending of the device used; see References [1], [4]. For a solution using shunts, the thermal aspects are different. The working principle of the shunt current measurement is that the load current flows through a resistor, and the resulting voltage drop is measured. This leads to the generation of power losses in the shunt resistor. The inverter designer has to take care not to exceed the maximum shunt temperature of 200°C. The module datasheet specifies the important parameters.

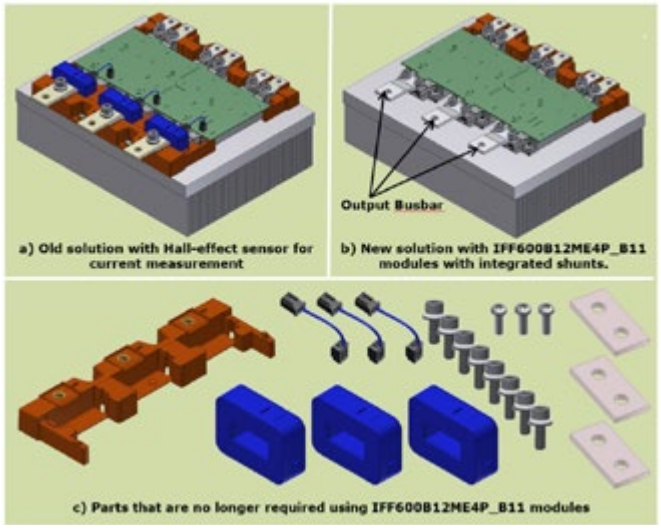

Figure 1: Example of a 240 kW three-phase system: (a) using Hall-effect sensors, (b) using internal shunts and (c) the difference in parts between the two. The parts illustrated in figure (c) can be saved.

It is essential to know the heatsink temperature below the shunt at the maximum operation point of the inverter to have an accurate shunt temperature estimate. Knowing the maximum heatsink temperature, the temperature of the shunt resistors can be easily calculated. In the section “Application test”, more details are presented.

Mounting process and system reliability

The new concept that substitutes the Hall-effect sensors by shunts inside of the module simplifies the mounting process, and improves the system reliability. A direct comparison of the conventional Hall-effect sensors with shunt modules shows that many additional advantages of the shunts are to be found in the process and design of an inverter. The assembly of a Hall-effect sensor to the busbar by screws as well as the connection of the cable from the PCB to the sensor adds manual working steps that can be prone to failure.

These steps consume production time and thus increase costs. Furthermore, the use of a cable-plug connection always comes with some obvious manufacturing risks. The plug might not be connected properly or can even be left out altogether by the operator, which leads to a failure during final tests, and additional rework in production.

During the lifetime of an inverter, it is possible for the plug or connections to become intermittent due to vibration that can lead to a unit failure. The shunt module on the other hand needs no additional mounting steps during production.

Economic benefits

Hall-effect sensors, especially the closed-loop type, are very expensive compared to shunt resistors. This is not only from the cost advantage, coming from the simple replacement of “standard module and Hall-effect sensor“ by “module with shunt resistor inside” being taken into account. Also, the cable to connect the sensor to the PCB and the AC busbar design, designed to fit through the Hall-effect sensor aperture generate higher costs in the bill of material.

In addition to that, the assembly time of the inverter is reduced with the use of the new solution. No sensor has to be placed around the busbar, no screw has to be screwed to fix it, and no cable has to be placed to connect it to the PCB. For the calculation of the economic benefits, a reduction of the inverter mounting time due to use of the IGBT module with integrated shunts by 1.5 minutes and production costs of 30 € per hour was assumed. Figure 2 shows how much the cost of the inverter can be reduced.

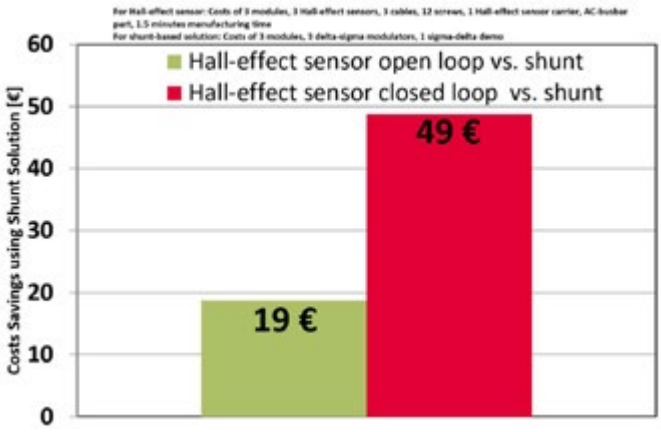

Figure 2: Cost savings due to usage of IGBT module with integrated shunts (IFF600B12ME4P_B11) compared to Hall-effect sensor solution.

It becomes visible that the cost advantage can be attractive. For a reference solution using open-loop Hall-effect sensors, the cost reductions are in the range of 20 €. If a closed-loop Hall-effect sensor is the basis of comparison, the module with integrated shunts can save a value in the range of 50 €.

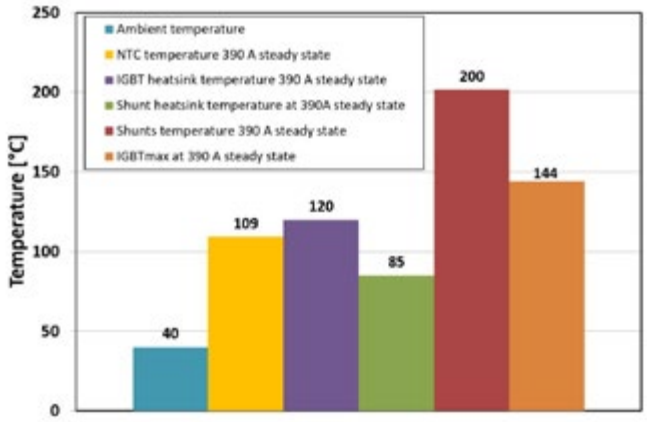

Figure 3: Operation conditions and temperature of shunt, IGBT, heatsink and ambient at maximum operation point for the shunt

Application test with new shunt-based module

To evaluate the performance of the new shunt-based module, a thermal test under application conditions was performed. The devices under test are the IFF600B12ME4P_B11 modules. Both are without gel, and painted black for the evaluation of the internal temperatures using an infrared camera. Additionally, thermocouples are placed in the heatsink below the middle IGBT of the upper system and below the middle shunt. The operation conditions and the temperature of the shunt, IGBT, heatsink and ambient are depicted in figure 3.

At an output current of 390 A, the shunt achieved the maximum allowed temperature of 200°C. At this operation point, the IGBT junction temperature is at 144°C, very close to its own maximum allowed temperature. It can be concluded that the dimensioning of IGBT and shunt is well-balanced. The difference between NTC and heatsink temperature below the shunt can be more than 20 K and is dependent on the heatsink and operating conditions. It is recommended to perform such a type of test during the inverter design phase to find out the correct temperature conditions for calculation of the shunt temperature. Using the example of figure 3, the shunt temperature can be calculated as follows:

$$T_{SHUNT} = T_{HEATSINK} + P_{LOSSES} \times R_{TH\_SHUNT\_HEATSINK} = 85\ °C + 390^2\ A^2 \times 0{,}25 m\Omega \times 3 \frac{K}{W} = 199°C$$

The calculation of the shunt temperature is very close to the measured value.

Summary

The advantages of using shunt resistors integrated in the power module instead of Hall-effect sensors for inverters, at power ranges higher than 75 kW, is presented. The economic and technical benefits are described in detail. The inverter costs can be reduced by 20 € compared to a system with open-loop Hall-effect sensors, and by 50 € compared with closed-loop Hall-effect sensors. The system reliability with the new solution will be increased due to lower quantity of components, cables and connectors, and improved EMI robustness. The electrical and thermal performance in a real application is explained.

References

[1] K. Vogel et al., System Cost Reduction with Integration of Shunts in Power Modules in the Power Range above 75 kW, PCIM 2018

[2] Mouser Electronics, “Texas Instruments AMC1303x High-Precision Delta-Sigma Modulators” https://www.mouser.it/new/Texas-Instruments/ti-amc1303-modulators/

[3] U. Schwarzer et al., „IGBT Module with integrated Current Measurement Unit using Sigma-Delta Conversion for direct Digital Motor Control“, PCIM 2010

[4] LEM Holding SA, Datasheet of Current Transducer HTFS 200…800-P, www.lem.com

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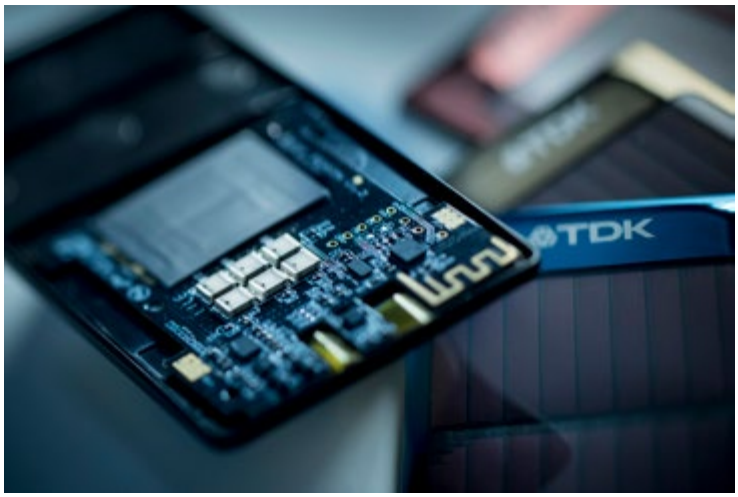
Rechargeable Solid-State SMD Battery for IoT Applications

From simple gadgets to complex devices for the industrial IoT – they all require compact, reliable and extremely safe power supplies. CeraCharge™, the world's first rechargeable solid-state SMD battery, is a new technology that meets all these demands.

By Masahiro Oishi, Director Material Development, Piezo and Protection Devices Business Group TDK



Life today would be unimaginable without batteries and accumulators using a wide variety of technologies and with widely differing capacities. The Internet of Things in all its facets will in future require billions of special power supplies tailored to the requirements of new ultra-low-power semiconductors and sensors. These devices must function for years, independently of external power supplies, by using energy-harvesting technologies. The demands made on energy storage media are as follows: small dimensions, rechargeability, intrinsically safe, easy to assemble, low cost and long service life. Not all of these requirements can be met simultaneously using currently available technologies. For many applications, the TDK CeraCharge now offers a way out of this dilemma. Unlike most common technologies, this involves a solid-state rechargeable battery with no liquid electrolyte through which the lithium ions move during charging or discharging. CeraCharge is based on a multilayer technology, similar to MLCCs, as shown in Figure 1.

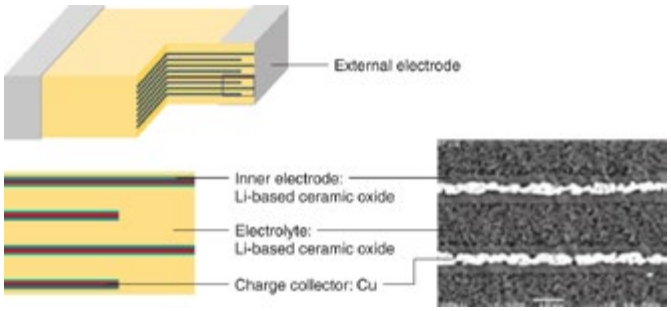
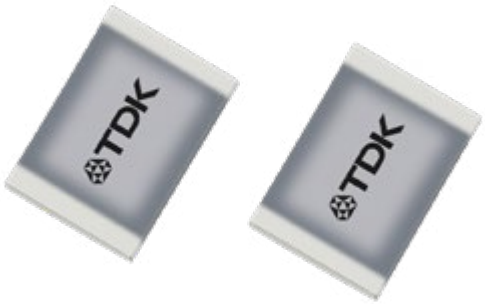


Figure 1: Cross-section of the CeraCharge. A solid ceramic electrolyte is used in place of a liquid electrolyte.

Thanks to this technology, a relatively high energy density and smallest volume are combined with the safety and high volume manufacturing benefits of ceramic multilayer components. In addition, the use of a solid ceramic electrolyte rules out the risks of fire, explosion, or the leakage of liquid electrolyte.

Simple process thanks to SMT-compatible design

CeraCharge is the world's first rechargeable battery to be designed as an SMT-compatible component. Accordingly, this results in further advantages such as easy placement of components and the use of conventional reflow soldering processes, which in turn reduces the production costs of the devices using CeraCharge. Initially, the CeraCharge is available in an EIA 1812 package (4.5 mm x 3.2 mm x 1.1 mm). This component offers a capacity of 100 µAh at a rated voltage of 1.4 V and an initial internal resistance of <200 Ω. The key technical data of CeraCharge is shown in Table 1.



Rated voltage	[V]	1.4
Operating voltage	[V]	0 to 1.6
Nominal capacity	[µAh]	100
Nominal discharge current	[µA]	20
Operating temperature	[°C]	-20 to +80
Initial inner resistance *	[Ω]	<200
Weight	[g]	~ 0.04

Table 1: Key technical data of CeraCharge rechargeable solid-state SMD battery in a EIA 1812 package

The typical discharge characteristics are shown in Figure 2. The nominal discharge current for CeraCharge is 20 µA, but one CeraCharge is also able to support a continuous discharge 1 mA (10 C).

Compared to conventional batteries, rechargeable or otherwise, CeraCharge offers a very wide temperature range of between -20 °C and +80 °C, making it suitable for outdoor use, for example in weather stations. The typical temperature characteristics for a constant current discharge of 20 mA are shown in Figure 3.

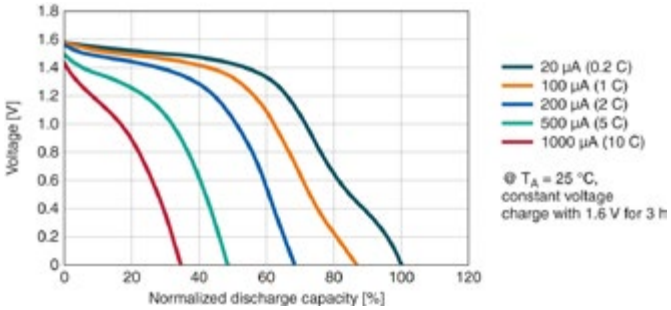


Figure 2: Typical discharge characteristics of CeraCharge

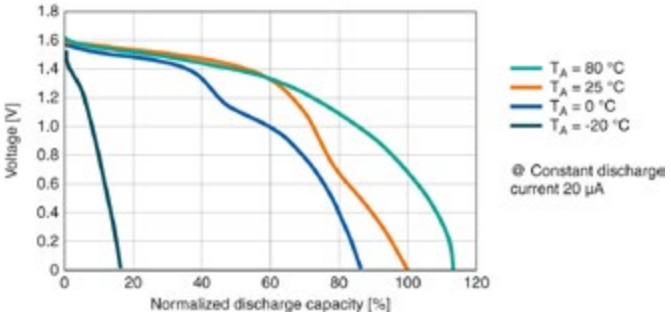


Figure 3: Typical temperature characteristics of CeraCharge

Depending on the requirements, the number of charge/discharge cycles that CeraCharge is able to perform ranges from several dozens of to up to 1000 without any significant losses in terms of electrical parameters (up to 80 percent of the initial values). Figure 4 shows the typical cycle characteristics for CeraCharge for charging at a constant voltage of 1.6 V for 3 h and discharging with a constant current of 20 µA.

For short periods or in pulsed operation – when supplying a Bluetooth beacon module during transmission, for example – one CeraCharge can cupply currents with magnitude of about 3 mA/s (Figure 5).

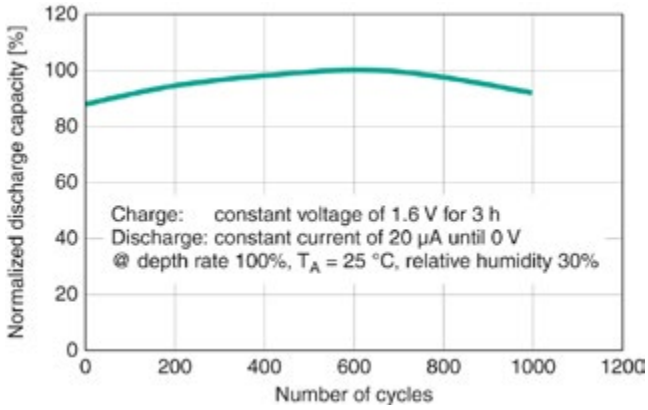
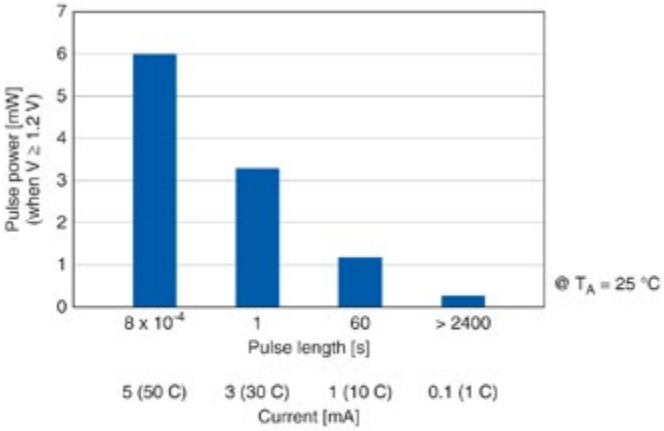


Figure 4: Typical cycle characteristics of CeraCharge



Current square pulse length	0.8 ms	1 s	60 s	> 2400 s
Interval	1 s	30 s	none (continuous)	none (continuous)

Figure 5: Typical pulse power of CeraCharge

Extremely wide range of possible applications
To increase the capacity and the voltage, any number of individual CeraCharge components can by connected in series and parallel. This opens up a wide range of possible applications, for example, as the backup battery for real-time clocks (RTC) or energy storage for Bluetooth beacon transmission.

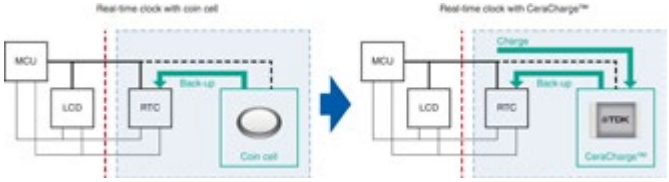


Figure 6: CeraCharge can replace the primary coin cell that is typically used as a backup battery for real-time clocks (RTCs).

In most cases primary cells (coin cells) are used as the battery for RTCs. The major disadvantage of this conventional solution is that users must eventually change the battery. Because a VSB (supply voltage to battery) exists in an RTC, replacing the primary cell the RTC module with a rechargeable battery such as CeraCharge overcomes this problem (Figure 6). The RTC generally needs power from the backup battery for less than one hour at a time, and one CeraCharge can back up the RTC function for 1 to 2 weeks without recharging.

Solar powered beacon with CeraCharge
The prerequisite for the IoT (Internet of Things) is the ability to connect all kinds of appliances and devices with the Internet. Solar powered Bluetooth Low Energy (BLE) beacon technology is emerging as the connectivity solution of choice because of its miniature space requirements and low power consumption. Figure 7 shows a driving model for a solar powered BLE beacon. In this circuit, the solar cell first charges a capacitor (either an MLCC or EDLC), which provides the primary power for the BLE module. CeraCharge serves to store energy in order to charge the capacitor, when the solar cell is not active. It is charged with a surplus energy after the capacitor is fully charged, and discharges to the capacitor when it's empty. This enables the solar powered beacon to operate continuously. The number of parallel CeraCharge units needed in the circuit depends on the maximum the BLE module must be powered without the solar cell.

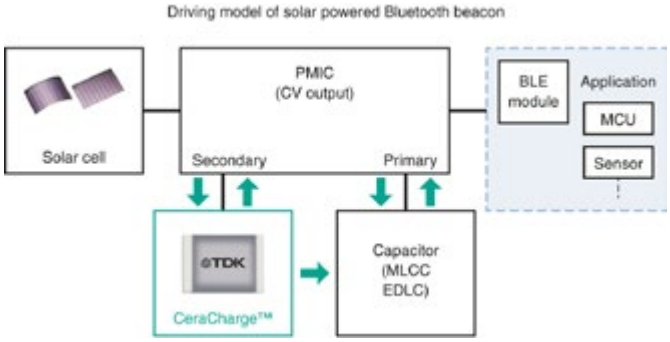


Figure 7: CeraCharge can be used secondary power source and store energy to charge the capacitor as primary power source for the BLE module.

Apart from the SMD type currently available in EIA size 1812, TDK will in future also develop CeraCharge types in other sizes such as EIA 0603 and with other capacities, in order to cover an even wider range of applications. Some examples include energy storage for energy harvesting, often in combination with a capacitor, or as a sub-battery in wearables to smooth current and voltage levels during momentary periods of high demand.

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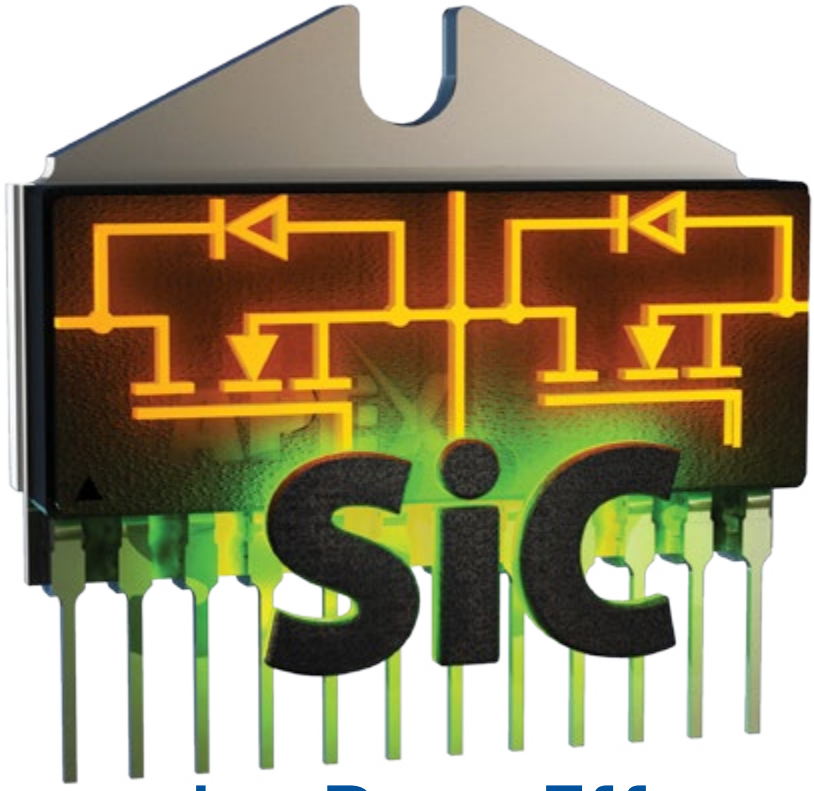


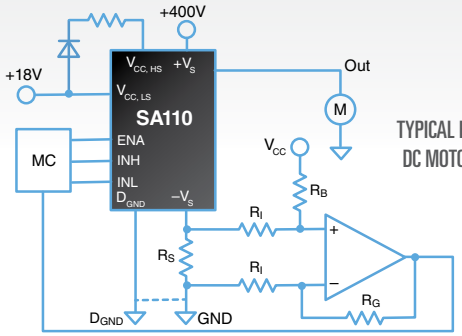
Driving the Best Efficiency

The SA110 is the first half H-Bridge with silicon carbide MOSFETs and integrated digital gate drive to provided reduced switching losses, reduced conduction losses and a low temperature dependency of $R_{DS(on)}$

With the use of silicon carbide (SiC) MOSFETs, the SA110 drives a significant increase in performance and reliability compared with silicon or IGBT alternatives while providing 40 A of peak output current on supply voltages up to 400 V. The integration of a gate drive with full digital control makes it easier to control and reduce the impact of parasitics on switching frequency. As a result, the SA110 can switch at a very high 400 kHz MAX frequency. Protection features include under voltage lockout and active Miller clamping. The SA110 is available in a very compact 12-pin Power SIP to save on valuable board space.

Target Applications:

- Sonar
- AC/DC Inverters
- Brushless DC Motors



TYPICAL BRUSHLESS DC MOTOR CIRCUIT

12-PIN, POWER SIP, STYLE DP WITH HEAT TAB

Footprint 31mm x 29.5mm

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APEX MICROTECHNOLOGY

1700V X-Series HVIGBT Power Modules with Excellent Performance and Reliability

High performance 1700V HVIGBT power modules providing reliable solutions for railway applications.

The railway applications require components with high quality and high efficiency, especially the converter drives should have reliable and robust switching devices. It is an established practice to utilize 1700V IGBT modules to operate directly on the catenary with the DC voltages below 1000V or in 3-level configuration with catenary DC voltages above 1000V.

By Eugen Wiesner, Dr. Nils Soltau MITSUBISHI ELECTRIC EUROPE B. V.
Nobuhiko Tanaka MITSUBISHI ELECTRIC CORPORATION

Mitsubishi Electric continuously improves the quality of the IGBT power modules concerning three key concepts:

- Robust power module design considering high margin of safe operating area,
- Low power losses using latest chip generation,
- Quality control with dedicated production lines and traceability.

Mitsubishi Electric has several years of experience and a long development history of 1700V modules for railway application from the start of this century. This year MITSUBISHI ELECTRIC has released the latest generation of 1700V IGBT power modules called X-Series that satisfies requirements of railway applications. Fig. 1 shows the historical evolution of the 1700V HVIGBT modules indicating the continuous reduction of the IGBT forward voltage. The IGBT forward voltage contributes to the converter power loss reduction. IGBT forward voltage reduction has continuously been achieved during the development of each series. The remarkable step in the reduction of the forward voltage was the implementation of the trench gate structure in the beginning of 2000s [1]. For further reducing the forward voltage the IGBT chip structure was optimized and thinner chips were used. In the latest 1700V X-Series the state of the art 7th Generation chip technology is applied in conjunction with a further reduction of IGBT thickness. Additionally, several optimizations on the chip back side (collector side) were carried out.

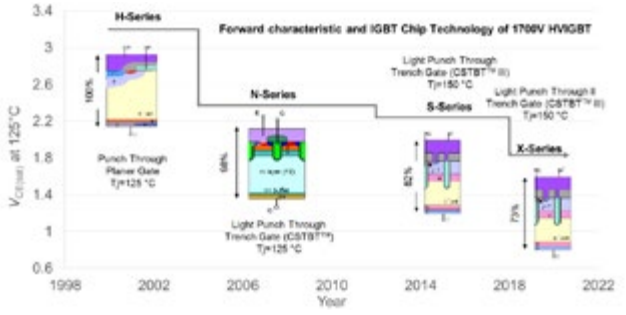


Figure 1: Chronology of 1700V IGBT chip forward voltage reduction.

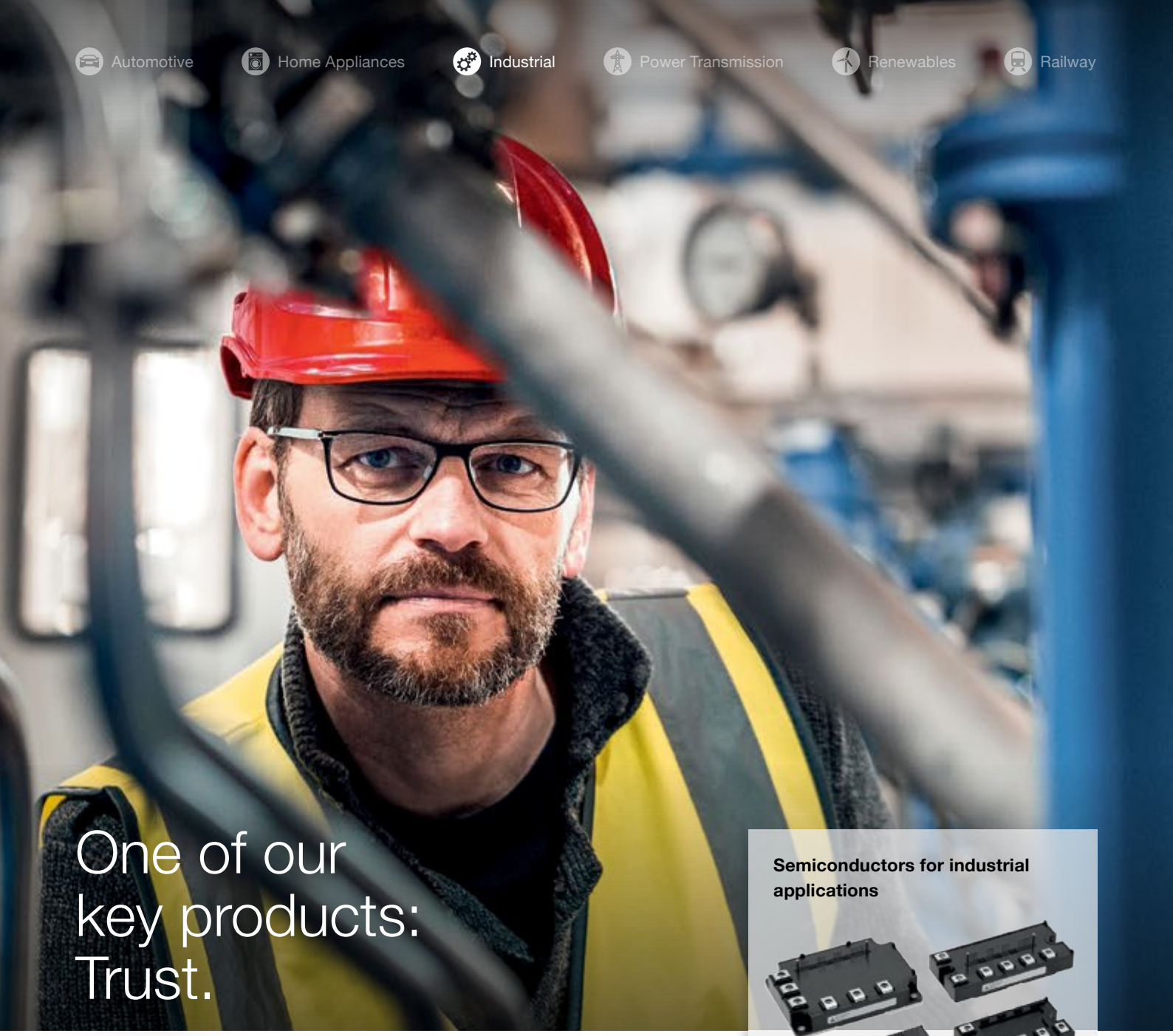
The 1700V X-Series contains three module packages. The first is the conventional package with the footprint dimensions of 190mm x 140mm. The second type is also conventional having the footprint size of 130mm x 140mm. The third package is the new standard dual package called LV100 with the footprint of 140mm x 100mm. The complete line-up of the X-Series 1700V IGBT modules is shown in table 1.

Circuit	Foot print	Current rating	Type name
Single 1 in 1	190mm x 140mm 	2400A 3600A	CM2400HCB-34X CM3600HC-34X
Single 1 in 1	130mm x 140mm 	1600A 2400A	CM1600HC-34X CM2400HC-34X
Chopper	130mm x 140mm 	1200A	CM1200E4C-34X
Dual 2 in 1	100mm x 140mm 	1000A 1200A 1200A	CM1000DC-34X (Si) CM1200DC-34X (Si) CMH1200DC-34X (SiC hybrid)

Table 1: 1700V X-Series Line-up

High current 1700V HVIGBT X-Series single modules.
The conventional 1in1 packages were completely reworked compared to the previous N-Series. The chip layout inside the module was optimized for better thermal conductivity and better power cycling life time. Inside the module a newly developed high performance silicone gel is used. The operation temperature now is covering the range from -50°C to 150°C. The new X-series modules will receive the UL certification. Furthermore, these modules were proven during the qualification against the humidity influence. That is an important factor for the operation in the harsh railway environment.

Automotive | Home Appliances | Industrial | Power Transmission | Renewables | Railway



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Changes for the Better

The standard package type is available since many years on the market. Then converter manufacturers have proven reliability records of the converters having this package type in the field. Now it is possible to boost the converter performance using the cutting edge technology of X-Series modules. The small size package (130mm x140mm) is favorite choice for compact water cooled application. The large package (190mm x 140mm) with its low case to heatsink thermal resistance Rth(c-f) is especially attractive for air cooled applications. In the Figure 3 is shown the potential of the power loss reduction for single X-Series device CM2400HCB-34X compared to the previous N-Series.

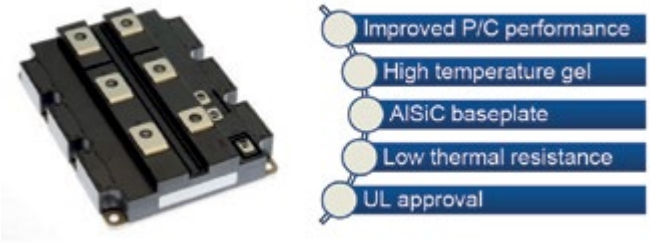

Figure 2: 1700V X-Series single modules features

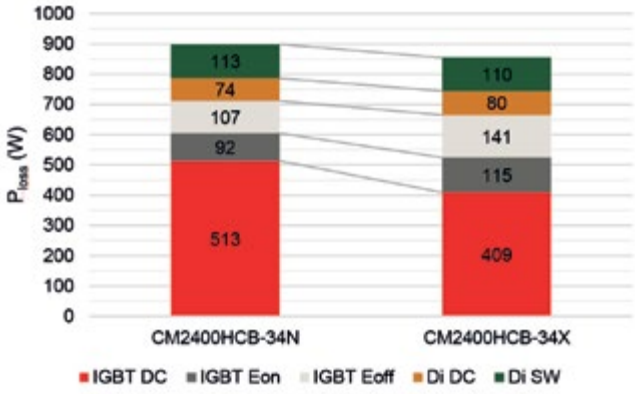

Figure 3: X-Series power loss simulation under the conditions: V_{CC}=850V, I_{peak}=1200A, PF=0.85, M=1, f_{sw}=1kHz, f_o=60Hz, T_j=125°C.

Dual LV100 X-Series 1700V modules

The standard LV100 package was developed with the target to cope with high switching speed devices like 1700V X-series modules and modules having Silicon Carbide technology. The low inductive package structure is one of the key advantages of this device.

Thanks to low package inductance and comfortable construction of the DC-Link connection, it is possible to switch off the device at high current without increasing the turn off gate resistance. The IGBT turn off measurement result at maximum turn off conditions V_{CC}=1200V, I_C=2400A, $R_{g(off)}$=$R_{g(nominal)}$, L_s=40nH and T_J=150°C is shown in Figure 4. Even at such conditions the overvoltage spike is below the maximum blocking voltage of 1700V.

Furthermore the diode performance was enhanced in the LV100 module. Compared to the previous S-Series the diode forward voltage was reduced by more than 15%. At the same time the reverse recovery energy was reduced by more than 25%.

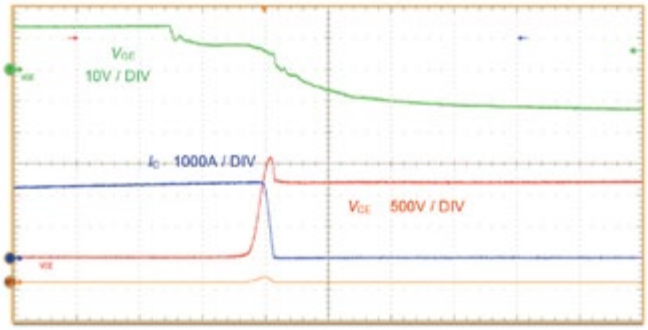

Figure 4: CM1200DC-34X turn off event at high current and maximum DC-Link voltage.

The current density in the LV100 package was increased by about 30% from 13.2A/cm^2 to 17.1A/cm^2 for CM1200DC-34X compared to CM2400HC-34N device. To carry the high output current the device has three screws at AC output terminal.

The forward characteristics of IGBT and FWDi has positive temperature coefficients that is essential for good module parallel operation.

Additionally this package provide the flexibility of converter power scaling by module paralleling. This point is also an additional challenge for converter designer. To overcome this challenge the proposed reference test setup [2] can be used in combination with these modules.

Conclusion

The introduced 1700V X-Series utilize the cutting edge chip and package technologies. The modules offers the highest reliability combined with low power losses and flexibility.

References

[1] S. Iura, E. Suekawa, K. Morishita, M. Koga, E. Thal. “New 1700V IGBT Modules with CSTBT.” PCIM Europe 2004.

[2] Dr. J. Weigel. “Paralleling of High Power Dual Modules: Standard Building Block Design for Evaluation of Module Related Current Mismatch.” EPE’18 ECCE Europe.

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Switch Mode Power Supply Current Sensing

Current-mode control is widely used for switching mode power supplies due to its high reliability, simple loop compensation design, and simple and reliable load sharing capability. The current sense signal is an essential part of a current-mode switch mode power supply design; it is used to regulate the output and also provides overcurrent protection.

By Henry Zhang, Mike Shriver, and Kevin B. Scott; Analog Devices, Inc.

Figure 1 shows the current sensing circuit for an LTC3855 synchronous switching mode step-down power supply. The LTC3855 is a current-mode control device with cycle-by-cycle current limiting. The sense resistor RS monitors the current.

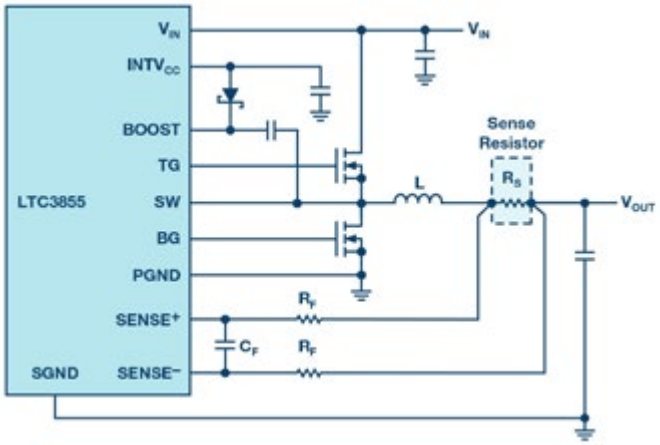

Figure 1: The switch mode power supply current sense resistor (R_S).

Figure 2 shows a scope image of the inductor current for two cases: in one case, with a load that the inductor current is capable of driving (red line), and in the second case, where the output short circuited (purple line).

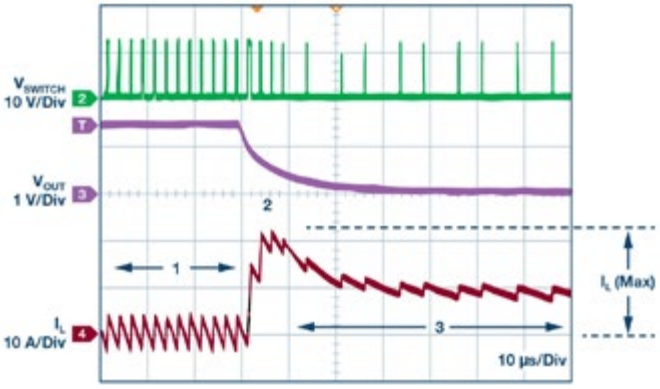

Figure 2: LTC3855 current limit with foldback example, as seen on a 1.5 V/15 A rail.

Initially, the peak inductor current is set by the inductor value selected, the power switch ON time, the input and output voltages of the circuit, and the load current (signified by "1" on the plot). When the short circuit is applied, the inductor current quickly ramps upward until it hits the current limit at the point where $R_S \times I_{INDUCTOR}$ (IL) equals the maximum current sense voltage—protecting both the device and downstream circuitry (signified by "2" on the plot). After that, the built-in current foldback limit (number "3" on the plot) further reduces the inductor current to minimize thermal stress.

Current sensing also serves other purposes. It allows accurate current sharing in a multiphase power supply design. With lightly loaded power designs, it can be used to increase efficiency by preventing reverse current flow (reverse currents are currents that flow the opposite way through the inductor, from output to input, which may be undesirable or even destructive in some applications). In addition, when a multiphase application is lightly loaded, current sensing can be used to reduce the number of phases needed, which increases circuit efficiency. For loads that require a current source, current sensing can turn the power supply into a constant current source for applications such as LED driving, battery charging, and driving lasers.

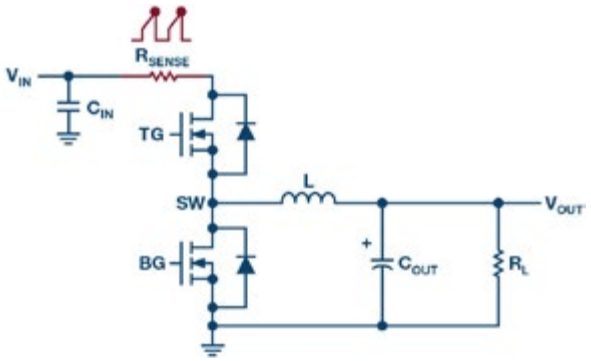

Figure 3: Buck converter with high-side R_{SENSE}.

The placement of the current sense resistor, in conjunction with the switching regulator architecture, determines what current is being sensed. Currents that are sensed include the peak inductor current, the valley inductor current (the minimum value of the inductor current when in continuous conduction mode), and the average output current. The location of the sense resistor affects power loss, noise calculations, and the common-mode voltage seen by the sense resistor monitoring circuitry.

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Buck Regulator High-Side Placement

For a step-down (buck) regulator, the current sense resistor can be placed in several locations. When placed on the high side of the top MOSFET (as shown in Figure 3), it detects the peak inductor current when the top MOSFET is on and, thus, can be used for peak current mode controlled supplies. However, it does not measure inductor current when the top MOSFET is off and the bottom MOSFET is on.

In this configuration, current sensing can be noisy because the turn-on edge of the top MOSFET has strong switching voltage ringing. To minimize this effect, a long current comparator blanking time (the time during which the comparator ignores the input) is needed. This limits the minimum switch ON time and can limit the minimum duty cycle (duty cycle = V_{OUT}/V_{IN}) and maximum converter step-down ratio. Note in the high-side configuration, the current signal can be riding on top of a very large common-mode voltage (V_{IN}).

Buck Regulator Low-Side Placement

In Figure 4, the sense resistor is placed below the bottom MOSFET. In this configuration it detects the valley mode current. To further reduce power loss and save component cost, the bottom FET RDS(ON) can be used to sense current without using an external current sensing resistor R_{SENSE}.

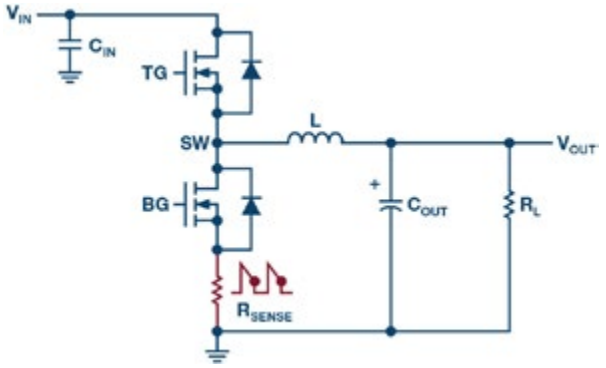

Figure 4: Buck converter with low-side R_{SENSE}.

This configuration is usually used for a valley mode controlled power supply. It can also be sensitive to noise, but in this case it is sensitive when the duty cycle is large. A valley mode controlled buck converter allows high step-down ratios; however, its maximum duty cycle is limited due to its fixed/controlled switch ON time.

Buck Regulator Placement in Series with the Inductor

In Figure 5, the current sensing resistor R_{SENSE} is placed in series with the inductor so it can detect the continuous inductor current, which can be used for average current monitoring and peak or valley current monitoring. Accordingly, this configuration allows peak, valley, or average current-mode controls.

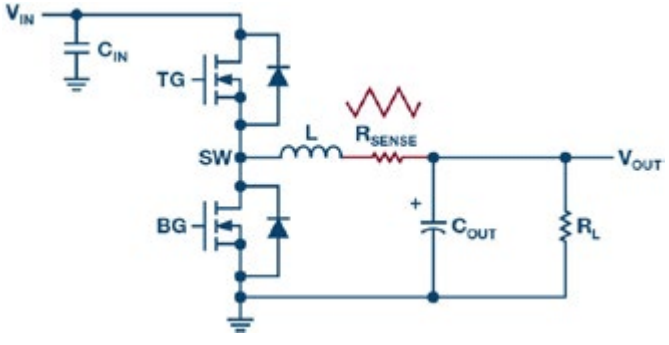

Figure 5: R_{SENSE} in series with the inductor.

This sensing method provides the best signal-to-noise ratio performance. An external R_{SENSE} usually can provide a very accurate current sensing signal for accurate current limit and sharing. However, the R_{SENSE} also causes additional power loss and component cost. To reduce the power loss and cost, the inductor winding dc resistance (DCR) can be used to sense current without an external R_{SENSE}.

Boost and Inverting Regulators' High-Side Placement

For a step-up (boost) regulator, the sense resistor can be placed in series with the inductor providing high-side sensing (Figure 6).

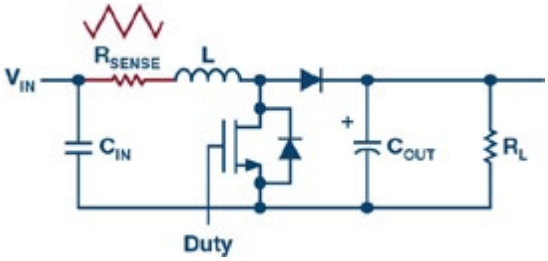

Figure 6: Boost converter with high-side R_{SENSE}.

Since the boost has continuous input current, a triangular waveform results and current is continuously monitored.

Buck-Boost Low-Side SENSE Resistor Placement or in Series with the Inductor

A 4-switch buck-boost converter is shown below in Figure 8 with the sense resistor on the low side. The converter operates in buck mode when the input voltage is much higher than the output voltage, and in boost mode when the input voltage is much lower than the output voltage. In this circuit, the sense resistor is located at the bottom of the 4-switch H-bridge configuration. The mode of the device (buck mode or boost mode) determines what current is being monitored.

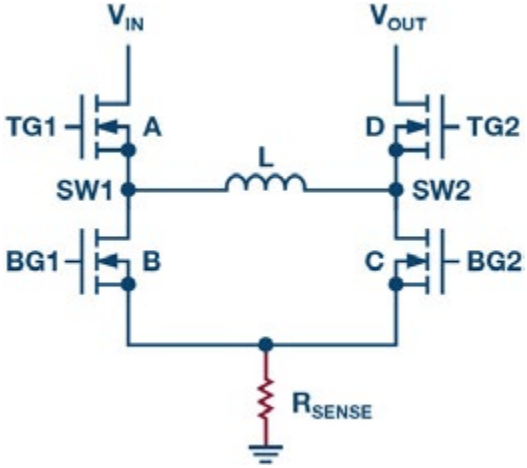

Figure 8: Buck-boost with R_{SENSE} on the low side.

In buck mode (Switch D always on, Switch C always off) the sense resistor monitors the bottom side Switch B current and the supply operates as a valley current mode buck converter.

In boost mode (Switch A always on, Switch B always off) the sense resistor is in series with the bottom MOSFET (C) and measures peak current as the inductor current rises. In this mode, since the valley inductor current is not monitored, it is difficult to detect the negative inductor current when the supply is in light load condition. Negative inductor current means energy is simply being transferred from the output back to the input—but due to losses associated with the

transfer, efficiency suffers. For applications such as battery-powered systems for which light load efficiency is important, this current sensing method is undesirable.

The circuit of Figure 9 resolves this issue by placing the sense resistor in series with the inductor so that the inductor current signal is continually measured in both buck and boost modes. Since current sensing R_{SENSE} is connected to the SW1 node that has high switching noises, the controller IC needs to be carefully designed to allow sufficient blanking time for the internal current comparator.

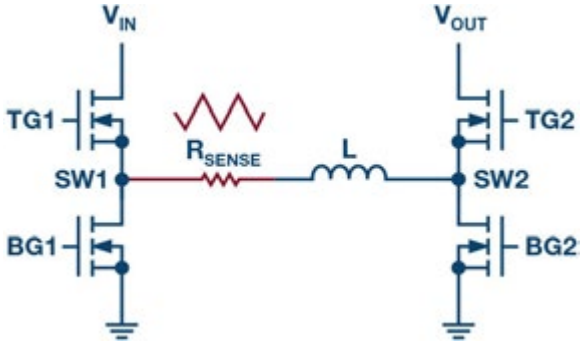

Figure 9: LT8390 buck-boost with R_{SENSE} in series with the inductor.

An additional sense resistor can also be added at the input for input current limiting or at the output (as shown below) for constant output current applications such as battery charging or driving LEDs. In this case, since the average input or output current signal is needed, a strong RC filter can be added to the current sensing path to reduce current sensing noise.

In most of the above examples the current sensing element is assumed to be a sense resistor. However, this does not have to be and often is not the case. Other sensing techniques include using the voltage drop across a MOSFET or the dc resistance (DCR) of the inductor. These current sensing methods are addressed in Part 3 “Current Sensing Methods.”

The three commonly employed current sensing methods for switch mode power supplies are: using a sense resistor, using the MOSFET RDS(ON), and using the dc resistance (DCR) of the inductor. Each method offers advantages and disadvantages that should be considered when selecting one method over another.

Sense Resistor Current Sensing

A sense resistor as the current sensing element results in the lowest sensing error (typically between 1% and 5%) and a very low temperature coefficient, on the order of 100 ppm/°C (0.01%). It provides the most accurate power supply in terms of performance, aids in providing a very accurate power supply current limit, and also facilitates accurate current sharing when multiple power supplies are paralleled.

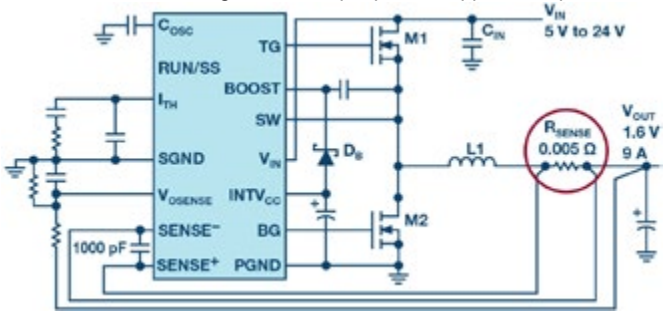

Figure 10: R_{SENSE} current sensing.

On the other hand, because a current sensing resistor is added to the power supply design, the resistor also generates additional power dissipation. Thus, the sense resistor current monitoring technique may have higher power dissipation compared with other sensing techniques, resulting in a slight reduction in the solution’s overall efficiency. The dedicated current sensing resistor may also increase solution cost, as a sense resistor typically costs between $0.05 and $0.20.

Another parameter that should not be ignored when selecting a sense resistor is its parasitic inductance (also referred to as effective series inductance or ESL). The sense resistor is correctly modeled as a resistor in series with a finite inductance.

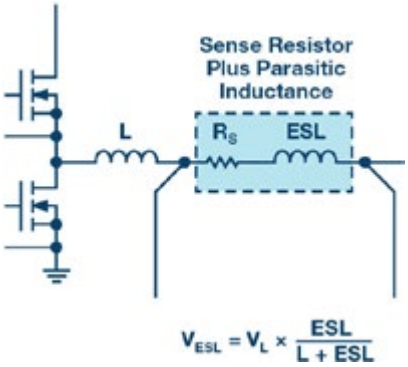

Figure 11: R_{SENSE} ESL model.

This inductance depends on the specific sense resistor chosen. Some types of current sensing resistors, such as metal plate resistors, have low ESL and are preferred. In comparison, wire wound sense resistors have higher ESL due to their package structure and should be avoided. In general, the ESL effect becomes more pronounced with increasing current levels, reduced sensing signal magnitudes, and improper layout. The circuit’s total inductance also includes the parasitics inductance due to component leads and other circuit components. The circuit’s total inductance is also affected by layout, so component placement must be given proper consideration; improper placement can affect stability and exacerbate existing circuit design issues.

The effects of sense resistor ESL can be mild or severe. The ESL can result in significant ringing on the switch gate driver, adversely affecting switch turn on. It also adds ripple to the current sense signal, resulting in a voltage step in the waveform, instead of the expected saw tooth waveform as shown in Figure 12. This degrades the current sensing accuracy.

To minimize resistor ESL, avoid using sense resistors that have long loops (such as wire wound resistors) or long leads (such as high profile resistors). Low profile surface-mount devices are preferred; examples include the plate structure SMD sizes 0805, 1206, 2010, and 2512; even better choices include reverse geometry SMD sizes 0612 and 1225.

Power MOSFET-Based Current Sensing

Simple and cost-effective current sensing is accomplished by using the MOSFET RDS(ON) for current sensing. The LTC3878 is a device that uses this approach. It uses a constant on-time, valley mode current sensing architecture. Here, the top switch is on for a fixed amount of time, after which the bottom switch turns on and its RDS voltage drop is used to detect the current valley or the lower current limit.

Though inexpensive, there are some drawbacks to this approach. First, it is not very accurate; there can be a wide variation (on the order of 33% or more) in the range of RDS(ON) values. It also can have a very large temperature coefficient; values greater than 80% over 100°C are not out of the question. In addition, if an external MOSFET is used, the MOSFET parasitic packaging inductance must be considered. This type of sensing is not recommended for very high current levels, and especially not for polyphase circuits, which require good phase current sharing.

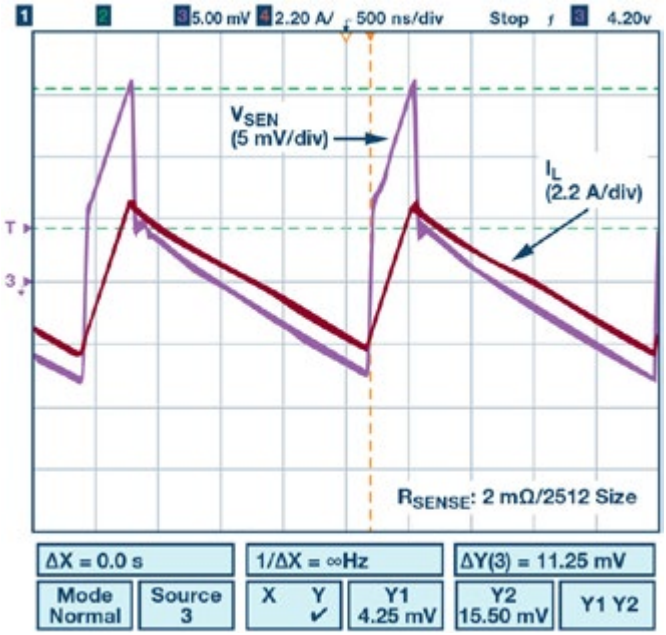

Figure 12: R_{SENSE} ESL can adversely affect current sensing.

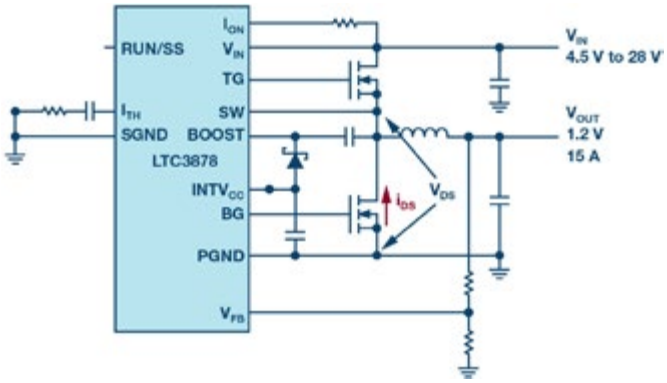

Figure 13: MOSFET RDS(ON) current sensing.

Inductor DCR Current Sensing

Inductor dc resistance current sensing uses the parasitic resistance of the inductor winding to measure current, thereby eliminating the sense resistor. This reduces component costs and increases power supply efficiency. Compared to the MOSFET RDS(ON), inductor DCR of the copper wire winding usually has less part-to-part variation, though it still varies with temperature. It is favored in low output voltage applications because any drop across a sense resistor represents a significant portion of the output voltage. An RC network is placed in parallel with the series inductor and parasitic resistance combination, and the sense voltage is measured across the capacitor C1 (Figure 14).

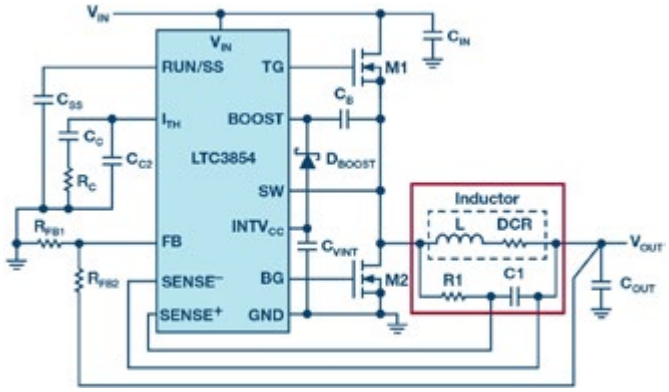

Figure 14: Inductor DCR current sensing.

With proper component selection (R1 × C1 = L/DCR), the voltage across the capacitor C1 will be proportional to the inductor current. To minimize measurement error and noise, a low R1 value is preferred.

Because the circuit does not directly measure inductor current, it cannot detect inductor saturation. Therefore inductors that have a soft saturation, like iron power core inductors, are recommended. These inductors typically have higher core loss than a comparable ferrite core inductor. Compared to the R_{SENSE} method, inductor DCR sensing eliminates the sensing resistor power loss but may increase the inductor core losses.

With both R_{SENSE} and DCR sensing methods, Kelvin sensing is required due to the small sense signal. It is important to keep the Kelvin sense traces (SENSE+ and SENSE– in Figure 5) away from noisy copper areas and other signal traces to minimize noise pick-up. Some devices (such as the LTC3855) have temperature compensated DCR sensing, which improves accuracy over temperature.

Table 1 summarizes the different types of current sensing methods and the advantages and disadvantages of each.

Each of the methods mentioned in Table 1 provides added protection for switch mode power supplies. Trade-offs in accuracy, efficiency, thermal stress, protection, and transient performance all can factor into the selection process, depending on the design requirements.

Sensig Method	Sense Error @ 25°C (%)	Temperature Variation (%/°C)	Detects Inductor Saturation	Reliability/ Protection	Current and Thermal Balance	Component Cost	Supply Efficiency
R_{SENSE}	1 or 5	~0.01	Yes	Highest	Best	R_{SENSE} ($0.05 to $0.20)	Baseline value
Inductor DCR	≥10	~0.39		Medium	Medium	n/a	Higher
MOSFET R_{DS} (ON)	≥30	~0.8		Lower	Worst	n/a	Higher

Table 1: The Advantages and Disadvantages of Current Sensing Methods

A power supply designer needs to carefully select the current sensing method and power inductor, and design the current sensing network properly. Computer software programs such as Analog Devices' LTpowerCAD design tool and LTspice® circuit simulation tool can be very helpful in simplifying the design effort with optimum results.

Other Current Sensing Methods

There are other current sensing methods available. For example, a current sensing transformer is often used with isolated power supplies to provide current signal information across the isolation barrier. This approach is usually more expensive than the three techniques discussed above. In addition, new power MOSFETs with integrated gate drivers (DrMOS) that also integrate current sensing have become available in recent years, but to date not enough data exists to conclude how well DrMOS sensing works in terms of accuracy and quality of the sensed signal.

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D.C. Output for the 27 MHz Resonant Converter

This is the 3rd of a 3 part series describing a 27 MHz off-line converter. In Part One, a quasi-class E topology having ZIS turn-on and ZVS turn-off over a wide range of load impedances was described. In Part Two, we described power output control by tuning a load network toward or away from resonance by means of variable capacitance diodes. In this installment, we added a rectifier/filter network to convert the AC (RF) output to DC, which should have been straightforward. Instead, we encountered higher-than-expected loss in the silicon carbide Schottky diode rectifiers we tested.

By David Pacholok, Paul Reich and Jim Spangler

A previous design[1] was modified to obtain a DC output from the quasi-class E circuit. "AC efficiency" was first measured with a 50 volt supply and a 50 ohm load at AC_OUT. The drain waveform of Q1 was recorded.

A rectifier/filter network was then connected to the class E output. A substitution power measurement was made by loading the rectifier at DC_OUT with a variable resistor. The load was adjusted to provide the same DC input power and drain wave forms as the 50 ohm load. Equivalent power occurred with a load of 510 ohms. Measurements were made after 1 hour of continuous operation with a load current of 0.215A at 110 VDC output. AC and DC efficiency were compared.

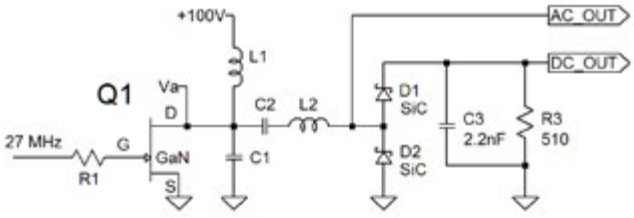

Figure 1: Class E with DC Output

Type (AC/DC)	Device	Po/Pin, %	Comment
AC_OUT	50 ohm resistor	87.8 %	Baseline efficiency
DC_OUT	GB01SLT12-220	77.9 %	GeneSiC 1A 1200V SiC diodes
DC_OUT	CSD01060E	83.5 %	Cree 1A 600V SiC diodes

Table 1: AC and DC Conversion Efficiency Compared

Temperature rise for both pairs of diodes was measured. For this measurement, a DC current source was substituted and adjusted to produce the same diode temperature rise as the rectification condition. A temperature rise of 79C occurred with GeneSiC (TO-220) devices. The apparent power dissipation was 1.8 watts per diode or 3.6 watts total. For the Cree (D-Pak) diodes the temperature rise was 44C, indicating a power dissipation of 0.39 watts per diode or 0.78 watts total.

At 125C with 1A forward current, the GeneSiC diode data sheet[2] specifies a 2.1V typical forward voltage drop. Diode current was measured with a Tektronix P-6022 current probe. Peak forward current was 1.1 amperes.

To support a 0.215A load current the average current in each diode must be the same, i.e. 0.215 amps. Using a 2.1 volt drop and and average current of 0.215 amperes and 1.1 amperes peak, the forward dissipation of each GeneSic part should have been 0.45 Watts. The measured dissipation was 4 times greater.

The peak forward current of the Cree 1A 600V devices was 0.8 amperes. Cree specifies (at 100C) a forward voltage drop of 1.4V at 0.8 amperes. Again, the average current is 0.215 Amps. The expected dissipation of a "zero recovery" diode using the average current was expected to be 0.30 watts. The measured dissipation was 0.39 watts.

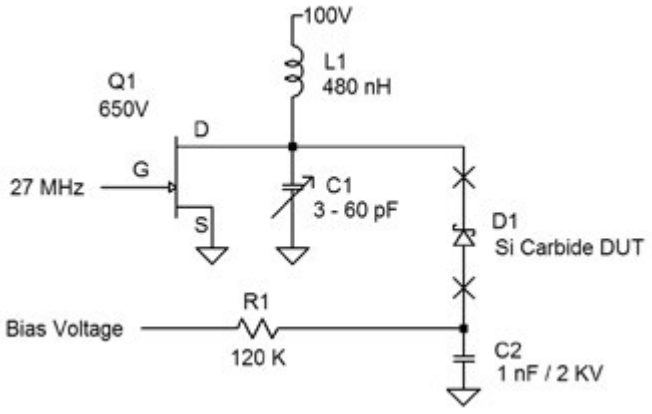

Figure 2: Varactor Effect Test Circuit

Bias Voltage, VDC	Diode Capacitance, pf	Diode RF Current, Amperes	Dissipation, Watts (Nominal Rd)	Dissipation, Watts (Rd=5.5Ω)
-200	15.1	0.68	1.28	2.35
- 500	9.7	0.32	0.54	0.565
- 800	7.6	0.25	0.37	0.345

Table 2: Measured Silicon Carbide Diode Properties

In an attempt to gain insight into the unexpected loss, a resonant flyback circuit was modified. A 2A, 1200V SiC diode, C4D02120, was added as shown in shown in Figure 2. As bias was made more negative, diode junction capacitance decreased. C1 was increased to maintain the same peak-peak voltage across the diode. Diode dissipation decreased with increasing reverse bias (less junction capacitance, lower high frequency current). The reverse bias diode voltage was variable over a 700 volt range.

During previous tests of the varactor effect [5], we used back to back 8A 1200V SiC diodes as varactors. In those tests, we measured 4 watts dissipation (2 watts per diode).

We tried to predict loss that might result from a 5.5 ohm internal diode resistance scenario. The rightmost column in Table 2 shows this prediction. While reasonable agreement with actual dissipation was had at higher reverse voltages, the measured dissipation departed from our hypothesis of constant ESR at lower bias voltages. We note that our equivalent "diode resistance" was lower at -200V bias than expected, about 3 ohms.

Discussion

Our quasi class E converter requires a high voltage power device. The ratio of peak drain voltage to DC voltage is about 3.5:1. Operation at high line (132 VAC) causes peak drain voltage in excess of of 650 Volts, exceeding the maximum rating of currently available gallium nitride parts. Low-loss variable capacitance diodes in the kilovolt range are also an issue.

With present technology, the designs presented may not be suitable for off-line application in the general power supply market. A good fit for our concept might be in the fields of dielectric heating, medical diathermy, cautery applications and near-field wireless power transfer.

A major semiconductor house is rumored to be releasing a family of low gate resistance 1700V silicon carbide MOSFETS during Q1 2019. This may be an enabling technology for world-wide off-line capability at high power, assuming device losses are reasonable.

Efficiency improvement and size reduction of any power conversion topology in the 3-30 MHz range are hampered by currently available magnetic materials. To achieve low loss at 27 MHz, both ferrite (such as 4F1) and powdered iron (such as Carbonyl E) magnetics require very low flux densities, making for bulky inductors. Solenoid or toroidally-wound air-core inductors may be the only option.

Our converter and control topology provide reasonable efficiency at higher power, although efficiency at lighter loads is less. A possible work-around might be pulse width modulation of the 27 MHz drive signal with a lower frequency, to maintain efficiency at low output power levels.

We noted previously[1] that regulatory problems may result from variable frequency control of a power supply/RF generator. FCC Part 15 requirements[4] include frequency ranges ("restricted bands") where spurious emission limits are strict.

For wide range frequency control of converters such as the L-L-C or series resonant topologies, a frequency range of at least 2:1 is required. However, there is no 2:1 frequency range from 3 to 30 MHz that would allow variable frequency control of a converter without incursion into one or more of the FCC Part 15 restricted bands. In the (narrow) ISM frequency bands, allowable spurious emissions are greater relative to non-ISM frequencies.

We stated that it should be possible to design an L-L-C converter operating at a fixed frequency, employing electronically variable resonant power control as described in Part 2 of this series[5]. The reduction in the cost and complexity of additional shielding and filtering could be substantial.

Conclusion

In this series, we presented designs and data for a quasi-class E converter capable of operating into a wide range of inductive and resistive loads while maintaining ZIS turn on and ZVS turn off wave forms. We described two variable-reactance control methods to vary output power over a wide range.

We eliminated the need for a pre-converter, such as a buck or boost regulator, to control output power. This offers significant cost and size reductions for certain applications.

Conversion of RF output to DC was described. We observed higher-than-expected dissipation in silicon carbide diode rectifiers. Similarly, higher than expected losses were found when reverse-biased SiC devices were used as varactor diodes.

References

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3. N.O. Sokal, "Class E RF Power Amplifiers", QEX Magazine, Jan/Feb. 2001.
4. US CFR Title 47, Part 15, ppg 809 et seq.
5. D. Pacholok, P. Reich, J. Spangler, "Controlling Power at 27 MHz With Variable Reactance", Bodos Power systems, December 2018

About the Authors

David Pacholok has operated Creative Electronic Consultants LLC since 1981. His interests include switch mode power conversion, electronic ballasts, RF power, pulse power, and induction heating. He can be reached at 847-809-2786 (cell), 847-428-5676, or by email at cecinduction@gmail.com.

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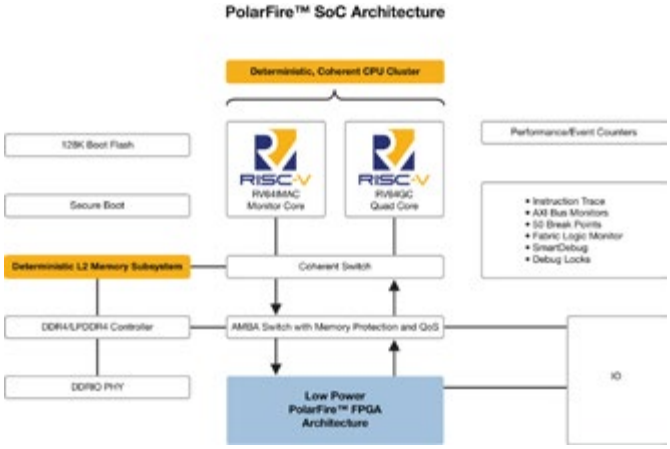
RISC-V SoC FPGA Architecture Brings Real-Time to Linux

Microchip, via its Microsemi Corporation subsidiary, announces an extension to its Mi-V ecosystem by unveiling the architecture for a new class of SoC FPGAs. The family combines the industry's lowest power mid-range PolarFire™ FPGA family with a complete microprocessor subsystem based on the open, royalty-free RISC-V Instruction Set Architecture (ISA). Microchip's PolarFire SoC architecture brings real-time deterministic Asymmetric Multiprocessing (AMP) capability to Linux platforms in a multi-core coherent Central Processing Unit (CPU) cluster. The PolarFire SoC architecture, developed in collaboration with SiFive, features a flexible 2 MB L2 memory subsystem that can be configured as a cache, scratchpad or a direct access memory. This allows designers to implement deterministic real-time embedded applications simultaneously with a rich operating system for a variety of thermal- and space-constrained applications in collaborative, networked IoT systems. In a new era of computing driven by the convergence of 5G, machine learning and the Internet of Things (IoT), embedded developers need the richness of Linux-based operating systems. These must meet deterministic system requirements in ever lower power, thermally-constrained design environments, while addressing critical security and reliability requirements. Traditional System-On-Chip (SoC) Field Programmable Gate Arrays (FPGAs) blend reconfigurable hardware with Linux-capable processing on a single chip to provide developers with ideal devices for customisation, yet consume too much power, lack proven levels of security and reliability, or use inflexible and expensive processing architectures.



www.microsemi.com/polarfiresoc

Kelvin Connection Parts into UF3C "FAST" FET Series

UnitedSiC expands its UF3C FAST Series product offering by introducing an additional range of 650 V and 1200 V high-performance silicon carbide FETs in a TO-247-4L 4-pin Kelvin Sense package option. Based on an efficient cascode configuration, this new series provides designers with very fast switching, high-power devices in a package capable of high-power dissipation. The Kelvin package avoids gate ringing and false triggering which would otherwise require slowing of switching speeds to manage the large common source inductance of 3-leaded packages. The 4-leaded Kelvin connection packages offer maximum operating temperatures of 175°C, excellent reverse recovery, low gate charge along with up to 2X lower switching losses. Designers of Totem Pole PFC stages, LLC and Phase Shifted Full Bridge converters, used in EV chargers, telecom and server power applications can achieve new levels of switching speed, efficiency, ease of use, and power density with the new UF3C series. Compared with other wide band-gap technologies, the SiC cascode devices offer standard 12V gate drive, and have assured avalanche ratings (100 percent production-tested). The 4-terminal packages, which form part of the UF3C FAST series, offer easy screw or clamp mounting with very low junction-to case-thermal resistance allowing lower temperature rise for a given power dissipation or higher power operation, taking advantage of the high junction temperature capabilities of SiC.

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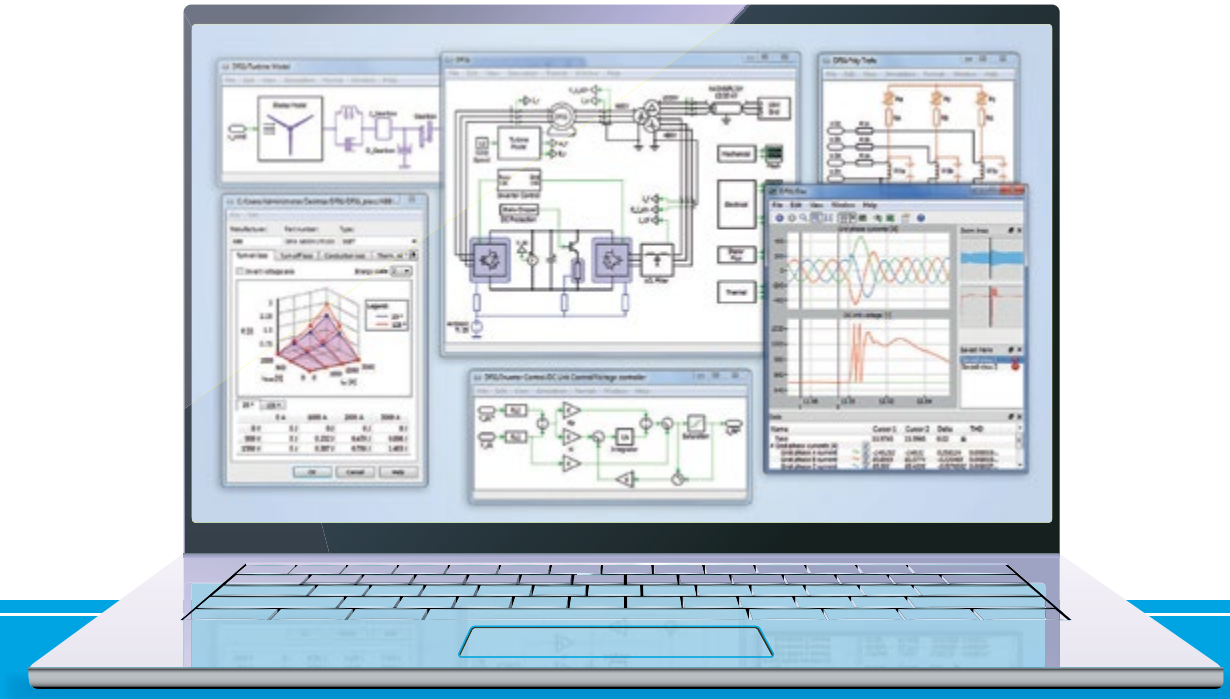

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SIMO PMICs Shrink Power Regulator Size in Half

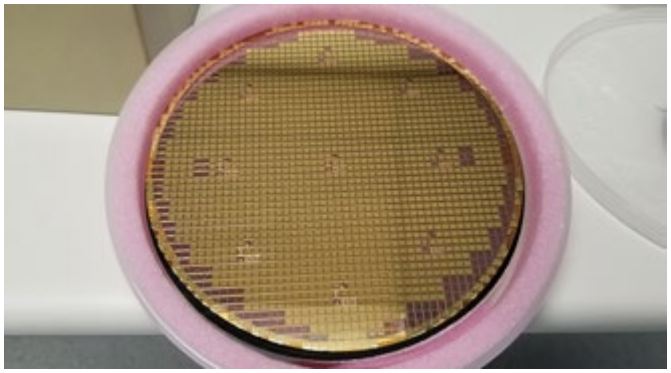
Designers of small, battery-powered electronics can enhance the user experience by extending battery life and further shrinking device size with six new low-power power-management integrated circuits (PMICs) from Maxim Integrated Products. They help to reduce the power-management footprint by up to 50 percent for space-constrained products such as wearables, hearables, sensors, smart-home automation hubs and internet of things (IoT) devices.

They increase the overall system efficiency by nine percent compared to the closest competitive solution, while also reducing heat dissipation, an important consideration for wearable products that make skin contact. Designers are striving to make electronic gadgets more integral in consumers' lives by scaling down their form factor, reducing heat, improving efficiency and extending battery life. Meeting each of these criteria is a formidable challenge given the rich feature sets, lower thermal thresholds and smaller capacity batteries required to achieve increasingly compact solution sizes. Maxim is expanding its portfolio of SIMO PMICs to enable designers to overcome these challenges, continuing the compact size and efficiency precedents set by MAX77650/MAX77651. The unique control architecture in the MAX17270, MAX77278, MAX77640/MAX77641 and MAX77680/MAX77681 PMICs allows a single inductor to serve as the critical energy-storage element for multiple, independent DC-rail outputs. This allows engineers to reduce the number of bulky inductors in their designs, thereby improving efficiency, shrinking form factor and reducing heat dissipation.

www.maximintegrated.com

Digital-Micro-Switch Technology now Commercially Available

Menlo Micro announced that its Digital-Micro-Switch (DMS) technology platform has been successfully ported from an R&D facility to a commercial 8" wafer manufacturing line. In partnership with Corning Incorporated and Silex Microsystems Menlo is now sampling products from this new manufacturing line and will begin scaling up the production of its unique micro-mechanical switches before year's end. Innovations in advanced alloys, processing and packaging have allowed Menlo to shrink the size of its products by more than 60 percent when compared to previous generations. Menlo's material science breakthroughs have also enabled a simplified manufacturing flow, representing a 30-40 percent reduction in manufacturing steps when compared to typical CMOS processes. This simplification helps to reduce manufacturing costs. Together, these advancements play a key role in Menlo's vision of reducing the size, weight and power consumption of critical electronic systems.



Menlo's unique approach allows it to offer unprecedented power handling in a micromechanical device with superior electrical performance, size, cost, and reliability as compared to both traditional mechanical relays and solid-state devices. Menlo's switches are built in a structure smaller than a human hair, yet they have been proven to be capable of handling kilowatts of power – while operating 1000x faster and lasting 1000x longer than typical mechanical relays.

www.menlomicro.com

DC Link Capacitor Modules for Large Inverter Systems

Cornell Dubilier has announced a series of DC link polypropylene film capacitor modules aimed at high-power inverters. The MDL series offers capacitance values ranging from 600 µF to 4,200 µF, with applied voltages of 900 Vdc to 1,300 Vdc. Designed as an alternative to banks of cylindrical bus-mounted capacitors, these modules have higher energy density and simplify bus connections by reducing the number of terminations. By using a single DC Link capacitor in a compact rectangular package, smaller inverter topologies are possible. The use of one capacitor versus several parallel-banked capacitors typically results in enhanced system reliability with lower assembly costs. The

MDL series also features long life, meeting a 5,000-hour life test at rated voltage, with a core temperature of 85 °C. This translates to a life of 200,000 hours when operated at a 60 °C ambient at full rated voltage and ripple current. The MDL series is based on CDE's well proven DC Link film technology utilizing low-loss, high-grade polypropylene dielectric. Featuring current ratings up to 400 Arms these modules are well suited for high-power inverters used in commercial and utility-scale wind, solar and fuel cell systems. Other applications include UPS, switching power supplies and large motor drives.

The series consists of 12 values in 4 case sizes, is RoHS compliant, and meets IEC 61071 and UL94V-0. Each unit passes through CDE's industry-leading 100% burn-in testing.

www.cde.com/mdl

5V, 10A Synchronous Silent Switcher 2 Buck

Analog Devices announces the Power by Linear™ LTC3310S, a 5V, 10A low EMI monolithic synchronous buck converter. The device's fixed frequency peak current mode architecture is ideal for high step-down ratio applications that demand fast transient response. The LTC3310S uses the Silent Switcher®2 architecture with integrated hot loop bypass capacitors to deliver a highly efficient, small footprint solution at frequencies up to 5MHz with excellent EMI performance. Multiphase operation enables direct paralleling of multiple devices for higher current. The LTC3310S' 2.25V to 5.5V input range supports a wide variety of applications, including most intermediate bus voltages. Integrated low on-resistance MOSFETs deliver continuous load currents as high as 10A with minimal thermal derating. Output voltages ranging from 0.5V to VIN are ideal for point-of-load applications such as high current/low voltage DSP/FPGA/GPU/ASIC reference designs. Other key applications include optical networking, telecom/datacom and automotive systems, distributed power architectures and general medium to high power density systems. The LTC3310S' low 35ns minimum on-time enables a high step-down ratio power supply at high frequency. 100% duty cycle operation delivers low dropout performance. The operating frequency can be synchronized to an external clock.

www.analog.com/LTC3310S

Dual-Channel 4A Gate Driver Integrates Galvanic Isolation and Protection Features

The STGAP2DM gate driver, the second in the STGAP2 series of galvanically isolated drivers from STMicroelectronics, integrates low-voltage control and interface circuitry with two isolated output channels that allow either unipolar or bipolar gate driving. Rated up to 1700V, the STGAP2DM's built-in isolation enhances safety as well as simplifying design and saving bill of materials and board space. The two 26V rail-to-rail outputs with 4A gate-drive capability ensure strong performance in industrial motor drives and high-power inverters. The STGAP2DM is also ideal for battery chargers, welders, induction heaters, and general-purpose power supplies and converters.

Galvanically isolated 4A gate driver enhances safety, simplifies design

Comprehensive built-in safety features simplify system design and enhance reliability, including dedicated Shutdown and Brake pins, Under-Voltage Lockout (UVLO), interlocking to prevent both outputs being high at the same time, and thermal shutdown. A standby mode, controlled by managing voltages on the input pins, lets users save power when the driver is idle.

The 3.3V/5V TTL/CMOS logic-compatible inputs allow easy connection to a host controller, and input-to-output propagation delay of 80ns ensures fast operation with high PWM-control accuracy.

The STAGP2DM is in production now, packaged as a compact SO-16 device with pinout optimized to simplify board design.

www.st.com/stgap2d-pr

Expanding Portfolio with the Stencil Cleaner VIGON® TC 150

In addition to the typical stencil cleaning agents for removing solder pastes and adhesives, a water-based MPC® cleaner, which was developed especially for the removal of thermally conductive compounds from stencils and screens, is now included in the product range. It removes the most varied forms of thermally conductive compounds, e.g. silicone-based, silicone-free or even silver- and aluminum-containing residue-free. In addition to thermally conductive compounds, the cleaning medium also removes silver sinter pastes and can also be used to remove uncured hydrophobic coatings from electronic boards. Since this is a water-based cleaning agent it is an ideal replacement for other common solvents.

www.zestron.com

8.9HF Solder Paste

Electrical reliability is a must-have for electronic components and products to work properly, especially when issues like ionic contamination under low stand-off components can cause dendritic growth which can lead to intermittent operation or short-circuiting and ultimately field failures. Indium8.9HF is an air reflow, no-clean solder paste specially formulated to enhance electrical reliability and eliminate dendritic growth in high power products, such as automotive electronics manufacturing. Indium8.9HF delivers peace-of-mind, knowing that assemblies will maintain integrity with:

- Increased electrical reliability via enhanced surface insulation resistance (SIR) that inhibits current leakage and dendritic growth
- Improved thermal reliability due to its low-voiding performance on bottom terminating components (BTCs), reducing the risk of application or product failure

Indium8.9HF can accommodate the higher processing temperatures required by the SnAgCu, SnAg, and other alloy systems favored by the electronics industry to replace conventional Pb-bearing solders.

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Rugged Micropower Magnetic Sensor ICs

Allegro MicroSystems Europe has announced the release of a family of Micropower Hall-effect switch ICs- the APS11700 and APS11760, designed specifically for battery powered applications in harsh industrial and automotive environments. Automatic power management enables average supply current as low as 6µA while operating directly from a vehicle battery or other unregulated supply. The power management happens in the background and is transparent to the host system, making them a drop-in upgrade for existing Hall-effect switches or a solid-state replacement for mechanical microswitches or reed switches. “Thanks to the APS11700/760’s unique combination of ruggedness and ultra-low power, there is finally a reliable, solid-state upgrade for reed and microswitches, even in the most power-sensitive applications where the sensor will be connected directly to the battery,” explains Jim Judkins, Product Line Director for Allegro’s Position Sensor ICs. These monolithic devices include either a standard Hall plate or a vertical Hall plate, a small-signal amplifier, chopper stabilisation, a Schmitt trigger, automatic power management controller, and an NMOS output transistor. The APS11700 uses a standard planar Hall-effect sensing element, while the APS11760 implements AVHT technology in the form of a silicon-based vertical Hall-effect sensing element. The APS11760 devices are therefore sensitive to magnetic flux parallel to the face of the IC package, mimicking the in-plane sensitivity of common reed switches.

www.allegromicro.com

12:1 Input Quarter-Brick DC/DC Converters for Railway

The latest addition to RECOM’s railway portfolio are two 40W and 60W DC/DC converter series in quarter-brick packages with an ultra-wide input voltage range from 14-160VDC making them a universal solution for railway rolling stock applications and high voltage battery systems.

The 12:1 input voltage range of RECOM’s RP40Q-RUW and RP60Q-RUW series covers all input voltages from nominal 24VDC up to 110VDC in a single product (including EN50155 transients). These quarter-brick DC/DC converters are designed for railway rolling stock and high voltage battery applications and offer basic isolation with regulated 5V, 12V, 15V, 24V or 48VDC outputs, including sense and trim pins. They have a consistently high efficiency over the entire input voltage range and an operating temperature range from -40°C up to +85°C (+68°C for the RP60Q-RUW) at full load without forced air cooling. An optional heat sink allows these converters to provide full load up to +90°C and +77°C respectively. The case is fitted with threaded inserts for secure mounting in high shock and vibration environments. The converters are CE marked, EN50155 and EN45545-2 certified and come with a three-year warranty. Samples and OEM pricing are available from all authorized distributors or directly from RECOM.

www.recom-power.com

High Power Motor Driver Qualified for Industrial and Consumer Applications

Infineon Technologies is launching the IFX007T NovalithIC™ motor driver for industrial applications. The IFX007T smart half-bridge provides an easy and efficient way to drive brushed and brushless motors, integrating a p-channel high-side MOSFET, an n-channel low-side MOSFET and a driver IC into one package. Along with a microcontroller and power supply, no other devices are necessary to drive a motor. For many years, Infineon has followed this unique NovalithIC integrated approach for automotive applications. The IFX007T now allows industrial customers to benefit from this experience. It is qualified according to JESD47I and can be used to drive motors with supplies up to 40 V and peak currents up to 55 A. The broad application range includes pumps, healthcare, home and garden appliances as well as industrial automation, fans, and many more. Ease-of-use is a key benefit of the integrated solution. It becomes apparent during the customer’s manufacturing process. Customers save layout and manufacturing effort while reducing stray inductances and external components. Additionally, only three general purpose microcontroller pins are needed to control a full H-bridge.

The IFX007T has integrated self-protection, including over-temperature and cross-current protection. Within an H-bridge configuration, the half-bridge approach provides logic redundancy – if one device fails, the other can still stop the motor.

www.infineon.com/novalithic

High Voltage Diodes - XOE™, eXtreme Optimized Efficiency

Dean Technology, Inc. announced the introduction of its technology for high voltage diode production – XOE™, eXtreme Optimized Efficiency. Using the same production line, raw materials, and achieving the same overall yield, diodes made with this technology offer dramatic upgrades in performance in devices of the same size. Diode performance is a delicate balance between many variables, each having a direct impact on the performance of the other. The high voltage diode engineers at Dean Technology (DTI), through a multiple year research and development effort, discovered that by tightly controlling all of these variables and individually designing all elements of each diode it is possible to increase the overall performance beyond that of similarly sized products using the same raw materials.

The benefits of XOE include higher current capabilities, lower voltage drop, reduced heat dissipation, better breakdown immunity from transitions into the avalanche region, and enhanced reliability for end user products and a cost effective and easy migration path for existing circuit board platforms. DTI's new XGF15 axial lead 15 kV high voltage diode shows the significant improvements over the standard G15FS version. "XOE shows our overall commitment to taking legacy products into the future. We wanted to meet customers continued demands for better performance and smaller sizes, but we didn't want to have to move into more exotic and expensive materials to accomplish it," said Pedro H. Gonzalez, technical product manager for the HVCA line at Dean Technology. "

www.deantechnology.com

Integrated Motor Controller and Driver for 2-Phase Stepper Motors

After the successful launch of the TMC5160 early 2018, TRINAMIC Motion Control announces the TMC5161. This cDriver™ solution is an easy to use building block with a powerful integrated MOSFET driver stage and complete motion control features, including innovative current regulation.
Designed with ease of use in mind, the powerful chip can be set up and evaluated easily using Trinamic's free, easy to use TMCL-IDE software and the modular evaluation kit. This not only minimizes development time, it also allows engineers to quickly try out different parameters for the optimal result, including Trinamic technologies that are in high demand such as SixPoint™ ramping, StealthChop2™, StallGuard2™, and more. The cDriver™ covers a wide spectrum of applications from battery powered, high efficiency systems up to embedded applications, ideal for robotics and industrial drives, textile, lab and office automation, medical drives, and next-generation desktop manufacturing applications. The complete solution reduces the learning curve to a minimum while giving the best performance in class.

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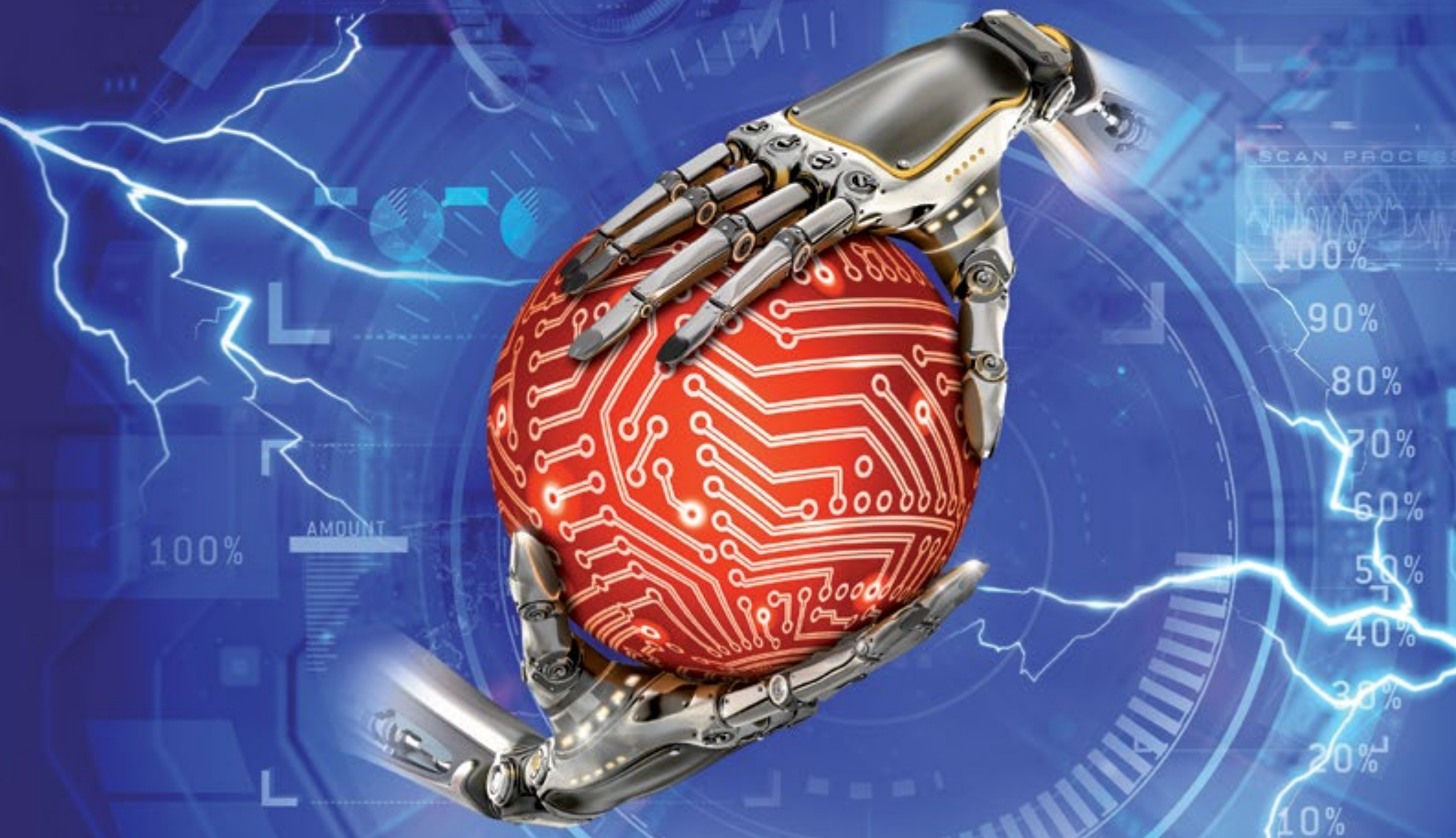

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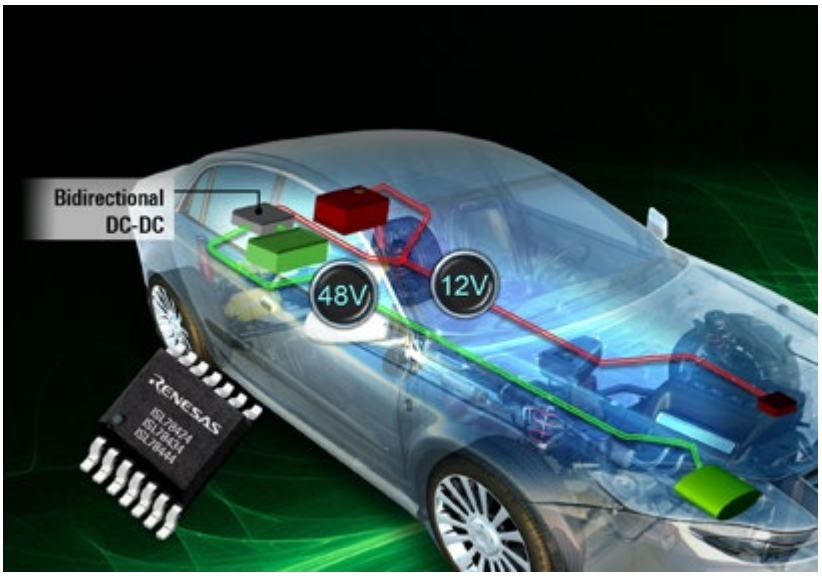
100V Half-Bridge Drivers Safely Drive MOSFETs for Bidirectional Controller

Renesas Electronics Corporation announced a family of automotive-grade 100V, 4A half-bridge N-channel MOSFET drivers. The ISL784x4 family features three devices: the ISL78424 and ISL78444 with single tri-level PWM input for controlling both gate drivers, and the ISL78434, which has dual independent inputs that separately control the high-side and low-side drivers. The ISL784x4 half-bridge N-MOSFET drivers complement the ISL78224 4-phase bidirectional controller, enabling it to provide up to 3kW of power and greater than 95 percent efficiency in 12V-48V converters used in mild hybrid vehicles. The ISL784x4 drivers are also well suited for 12V-24V bidirectional DC/DC converters, as well as other high current buck or boost applications. The ISL784x4 drivers simplify driving high-current MOSFETs by offering independent sourcing and sinking MOSFET gate drive pins. This makes it easy for designers to use external gate resistors to tune the slew rate of the rising and falling DC/DC switch node transitions, thereby reducing electromagnetic interference (EMI). The ISL784x4 also provide adaptive dead-time control to ensure accurate break-before-make switching operations that prevent shoot-through current that would occur if both DC/DC converter switches were allowed to close simultaneously. Additionally, the ISL78424 and ISL78434's adaptive dead time function is able to sense at the gate of the MOSFETs, eliminating potential errors introduced by voltage drops across the external gate resistors controlling the switching node slew rate.



www.renesas.com

Single Phase 6A to 30A EMC Filters

TDK Corporation announces the introduction of the RSKN series of 6A, 10A, 20A and 30A, 250Vac/250Vdc rated EMC filters. A two stage design delivers high attenuation across a wide 100kHz to 100MHz frequency range and provides protection against high voltage input pulses. The general purpose RSKN series is suitable for use in a wide range of industrial and communications applications. The filters are packaged in metal cases with sizes ranging from 47mm x 107mm x 26mm (W x L x H) for the 6A, to 67mm x 151mm x 35mm for the 30A. The terminal blocks have integral covers to avoid lost hardware. The RSKN filters will operate in ambient temperatures of -25 to +85°C, derating above 50°C for the 6A and 10A and above 45°C for the 20A and 30A models. All models are certified to UL1283, CSA C22.2 No.8, EN60939 safety standards and are RoHS2 compliant. The products have a five year warranty.

www.uk.tdk-lambda.com/rskn

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