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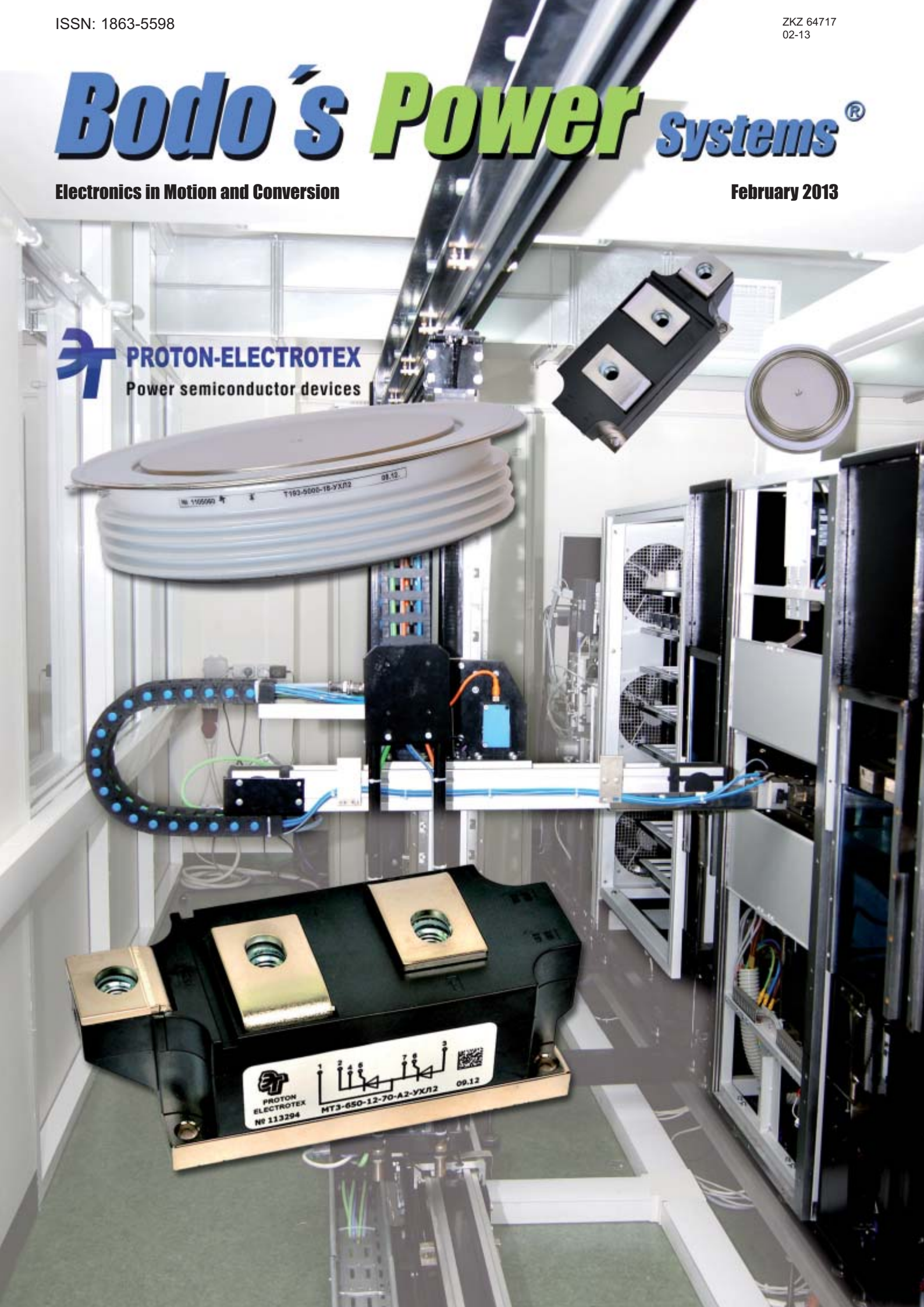
Bodo´s Power Systems®

Electronics in Motion and Conversion

February 2013



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EPCOS


Aluminum electrolytic capacitors for high ripple currents


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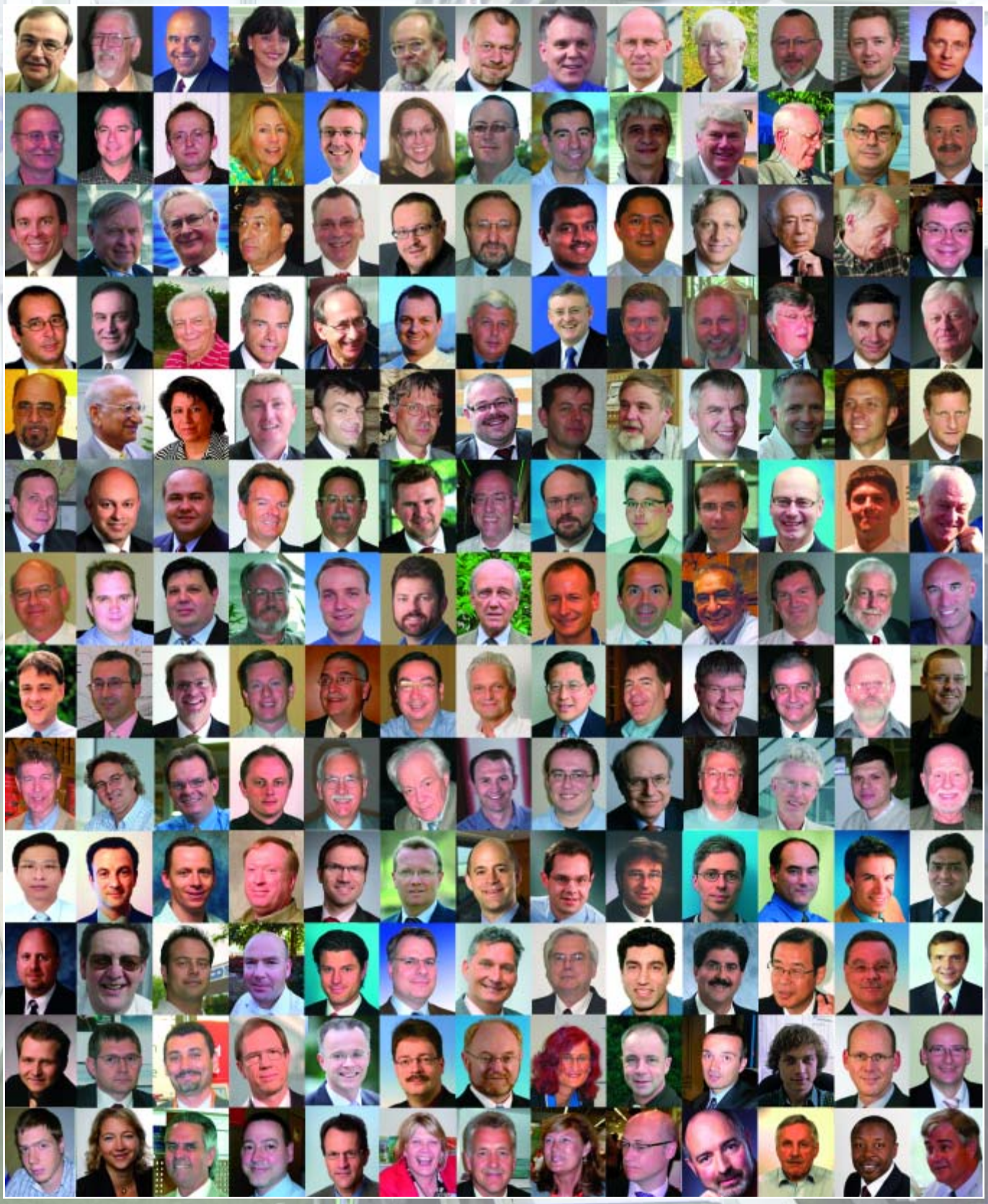

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A Media
Katzbek 17a
D-24235 Laboe, Germany
Phone: +49 4343 42 17 90
Fax: +49 4343 42 17 89
editor@bodospower.com
www.bodospower.com

Publishing Editor
Bodo Arlt, *Dipl.-Ing.*
editor@bodospower.com

Senior Editor
Donald E. Burke, *BSEE, Dr. Sc(hc)*
don@bodospower.com

Corresponding Editor
Marisa Robles Consée,
Marisa@bodospower.com

Creative Direction & Production
Repro Studio Peschke
Repro.Peschke@t-online.de

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Strong Expectations for 2013!

I would like to thank all my readers, all my supporters, and all of my team, who together have made the success of my magazine possible. A great start in China will pass along important articles in Mandarin, to serve one of the world's largest markets. Please have a look at Gavin's Guest Editorial – we must understand the world as one market. China's long history of innovations in technology is alive and vibrant once more. China is changing from the world's work bench, towards innovation in design and research. South Korea has already moved in that direction, and we see strong moves in India. Talented individuals from all over the world drive innovations across borders.

Technology is a driving factor in progress. We communicate in real-time between facilities that are spread out across the world – speeding up the innovation process and reducing time to market with fast volume-production starts. The race amongst competitors provides us the best technology. We expect the most advanced design to win the race. A strong market demand for alternative power generation from renewable sources encourages the development of advanced semiconductors. Wind power and solar are the driving elements.

It is sad to see Japan, after the Fukushima disaster, turning back to nuclear plants. Worst-case risks are most often underestimated - limited by our imagination and an inadequate understanding of what can be changed by nature's power. Nuclear waste will need centuries to cool down. Safe storage and adequate understanding has not resulted from our administrative political processing. World leaders have yet to act on the understanding of nuclear cool-down times – unfortunately far longer than a politician's time in office. What would Otto Hahn be telling us about this use of his discovery of nuclear fission? He was pretty clear about such weapons!

Communication is the way to progress. We delivered twelve issues last year and will continue this year, each month, on time, every time. Last year approached 900 pages and 132 technical articles, a continuous improvement since I started my publication. This year, with my February issue, we have 16 technical articles amongst 104 pages, to-date. As a media partner, Bodo's Power Systems is internationally positioned. If you speak the language, or just want to take to look, don't miss our Chinese version: www.bodospowerchina.com.

My Green Power Tip for February:
Replace your old light bulbs with LEDs. You will achieve a significant reduction in power consumption with the same illumination. Changing to LEDs will make a number of nuclear plants redundant, in your neighborhood and across the world!
See you at APEC in Long Beach
Best Regards,

Events

Embedded World 2013,
Nuremberg, Germany, February 26th - 28th
www.embedded-world.eu

New Energy 2013,
Husum, Germany, March 21st-24th
www.new-energy.de

EMC 2013,
Stuttgart, Germany March.5th – 7th
www.mesago.de/de/EMV

APEC 2013 Long Beach CA,
USA, March 17th - 21st www.apec-conf.org/

SMT/Hybrid 2013,
Nuremberg, Germany, April 16th-18th
www.mesago.de/de/SMT/

PCIM Europe 2013,
Nuremberg, Germany, May 14th -16th
www.mesago.de/de/PCIM/home.htm

Sensor + Test 2013,
Nuremberg, Germany, May 14th -16th
http://www.sensor-test.de

Thermal Management 2013,
Denver, CO, June 6-7,
www.thermalnews.com/conferences/

PCIM Asia 2013,
Shanghai, China, June 18th -20th
www.mesago.de/de/AsiaPCIM/home.htm

COWEC Wind Energy,
Berlin, Germany, June 18th -19th
www.vdi-wissensforum.de/en/cowec-landing-page/event/02KO181013/

Intersolar 2013,
Munich, Germany, June 19th – 21st
www.intersolar.de/de/intersolar-europe.html

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Conference on Solderability and Reliability for Electronics

IPC — Association Connecting Electronics Industries® announces registration is now open for the IPC Conference on Solderability and Reliability for Electronics Assemblies. The event in Budapest, Hungary, February 6–7, 2013, will deliver a robust technical conference and workshops presented by leading experts.

The workshops and agenda were developed with input from electronics industry professionals in Hungary, Romania, Poland, Czech Republic, Germany and Turkey to ensure the event meets the specific needs of the growing European electronics industry.

The two-day event will open with a day of educational workshops. Bob Willis, BobWillisOnline.com, will present two workshops: one on PCB inspection and quality control for bottom-mount components (BMC), land grid array (LGA) and quad flat no-lead (QFN) designs; and another on failure analysis. Wallin will also present two workshops: one on troubleshooting solder joints and another on producing IPC Class 3 boards. In addition, Dr. Thomas Ahrens, Trainalytics GmbH, will address repair and rework of lead-free solder joints, and Fern Abrams, IPC, will discuss conflict minerals regulations compliance.

www.ipc.org/europe-conference

COWEC 2013: Keynote Speakers Have Confirmed

Wolverine's MicroCool® Division has launched its redesigned MicroWell-known speakers and keynote presenters round out the program at COWEC "Conference of the Wind Power Engineering Community" on 18 and 19 June 2013, COWEC, an international meeting point of the wind energy industry organized by the VDI Wissensforum, will be held in Berlin, Germany. After a very successful call for papers, the board have now completed their evaluation of the papers received and the list of speakers has been finalized.

The welcoming address at COWEC is to be given by the conference co-president Dr. Andrew Garrad of GL Garrad Hassan, United Kingdom. Both Tuomo J. Hatakka, chairman of the board of directors of Vattenfall, and Dr. Hans Bünting, CEO of RWE Innogy, Germany, have agreed to be keynote speakers. "COWEC's technically challenging program is what is primarily the attraction," says Prof. Dr.-Ing. Andreas Reuter, President of COWEC and Director of the Fraunhofer Institute IWES in Bremerhaven. Bünting and Ignacio Láinez Aracama, Director Evaluación Energética at EDP Renováveis, will be contributing to the panel discussion.

Participants who decide early to attend the conference will profit from an early bird booking rebate. The final program for COWEC will be available online up from mid-February. Current information about the international wind energy industry and COWEC is on Twitter under @COWEC_News. For registration please go to

www.cowec.de

www.vdi-wissensforum.de

GoingGreen Silicon Valley Global 200 Winnner

Akros Silicon Inc., announced that it has been chosen by AlwaysOn as one of the GoingGreen Silicon Valley Global 200 winners. Inclusion in the GoingGreen Silicon Valley Global 200 signifies leadership among its peers and game-changing approaches and technologies that are likely to disrupt existing and entrenched players in green technology. Akros was specially selected by the AlwaysOn editorial team and global industry experts based on a set of five criteria: innovation, market potential, commercialization, stakeholder value and media buzz. Akros has established itself as a leading solution in network power applications adopted by major OEMs worldwide. Akros' flagship digital isolation technology, GreenEdge™, allows digital communication, power control and health monitoring across the isolation barrier. The newest member of their family of GreenEdge energy management SoCs, the AS1860, offers features that accommodate flexibility within systems to create robust power management, while providing enhanced energy saving features.

www.akrossilicon.com

Session on Energy Harvesting at APEC 2013

The Power Sources Manufacturers Association (PSMA) Energy Harvesting Committee is sponsoring an Industry Session at APEC 2013 titled "Forging Ahead: Global Commercialization of Energy Harvesting Technology." The PSMA session will take place on Tuesday, March 19, 2013, from 8:30 AM to noon at the Long Beach CA Convention Center, and will feature seven experts from the commercial and research institute sectors. Hailing from Cymbet, EnOcean, Fraunhofer Institute, Infinite Power Solutions, Linear Technology, NXP, and Texas Instruments, the speakers will discuss key technologies integrated into innovative energy harvesting-powered systems. Harvesting ambient energy to power systems is here today. The main commercial challenge for both macro and micro energy harvesting systems is to be cost effective compared to legacy power solutions such as fossil fuels and batteries. With the advent of the "Internet of Things" driving the need for billions of small autonomously powered wireless devices, new cost-effective micro energy harvesting solutions are now commercially available.

This PSMA Industry Session will provide an overview of the commercial progress of energy harvesting-based power for devices such as wireless sensors, data loggers, asset tracking, security and patient monitors. It will present technical details of key technologies that are driving successful commercialization in the following areas: energy harvesting transducers, energy conversion, energy storage, power management, ultra-low-power processors, sensors and wireless radio solutions. Commercial deployments of energy harvesting-powered systems from around the world in many industry segments will also be discussed. At the end of the session, several commercially available energy harvesting-powered systems will be demonstrated in the room for audience inspection.

Arnold Alderman of Anagenesis Inc., chair of the PSMA Energy Harvesting Committee, stated: "This Industry Session will present valuable information on the unique challenges of commercializing energy harvesting-based systems and will provide a timely and unique opportunity for attendees to interact with other professionals who have an active interest in this product space. We encourage people to register for APEC 2013 and make plans to attend the session, and also to consider participating in the other PSMA-sponsored meetings during the week."

www.psma.com

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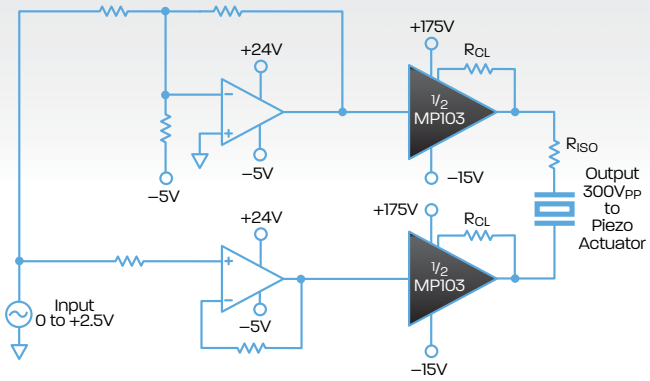
- Print head electronic drives for industrial ink jet printers



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Wind Power Status in Russia and the CIS Countries

The World Wind Energy Association has published a new report about the status of wind power in Russia and all CIS countries. The CIS countries are representing a world region with huge wind potentials, but where so far wind energy plays only a marginal role: The total wind installations have only reached 178 MW, a very small share of the global wind capacity of 254'000 MW (as of June 2012).

The CIS Report highlights the huge economic and social potentials and provides a comprehensive overview of the situation in the CIS countries. It aims at contributing to kick-start the deployment of wind technology in the region by providing information and by raising awareness amongst decision-makers from within and outside the region, amongst governments, industry as well as academia.

www.WWindEA.org

Free IPC APEX EXPO Educational Sessions Have BUZZ Factor

Tackling the hot topics that have the electronics industry buzzing, seven free BUZZ sessions will be offered at IPC APEX EXPO®, February 19-21, 2013, at the San Diego Convention Center. The industry's top technical experts on subjects ranging from automotive and new technologies to conflict minerals, export controls and technology roadmaps will provide insights into timely issues surrounding each of these BUZZ-worthy topics.

Addressing "New Technologies," Jasbir Bath, IPC principal engineer for assembly technology, will lead off the BUZZ sessions on February 19. Bath will chair a discussion on new and emerging component technologies. Advancements in state-of-the-art electronic component interconnections will be one of the central themes. Then, C. Don Dupriest, Lockheed Martin Missiles & Fire Control, will moderate a panel featuring a "who's who in electronics," during which IPC Hall of Fame Award recipients will take audience questions on technology and trends and share the wisdom earned from a collective 300-plus years of experience.

www.IPC.org

Andy Mackie Named Chair of Editorial Review Board

Indium Corporation announces that Andy C. Mackie, PhD, MSc, has been named the Chair of the Editorial Advisory Board of Chip Scale Review magazine. Dr. Mackie's responsibilities include management, coordination, and communications for the Editorial Advisory Board. He will review recommendations and participate in the selection of leading experts from companies and research institutions around the world to bring world-class expertise to the Chip Scale Review (CSR) advisory board. On behalf of the board he will provide recommendations to the CSR editorial staff and collaborate on editorial content, relevancy, and scope for the subscriber base, markets, and technology segments that CSR services. Dr. Mackie has been an active member of the Editorial Review Board for CSR magazine since 2008.

www.indium.com

Intersolar China Conference, Beijing, December 11–13, 2012

For the second time the Intercontinental Hotel Beichen in Beijing played host to the Intersolar China Conference, a valuable platform for the Asian solar markets of the future, from December 11-13, 2012. 69 speakers from around the world discussed current developments in the solar industry in front of 549 Chinese and international conference attendees. Developments within the Chinese market formed the central theme of the event and the conference focused on innovative technologies and trends in photovoltaics and solar thermal technologies. Around 70 expert presentations shed light on the most recent developments in the areas of energy storage, solar cities, large-scale photovoltaic plants, PV production and recycling, and a networking event on the first day of the conference allowed attendees to engage in intensive expert discussions.

Both the organizers and attendees were extremely satisfied with the success of the Intersolar China Conference 2012, which saw an increase in attendees of 17% in comparison to the previous year. 549 industry representatives from 24 countries used the conference and its 16 sessions, which covered the topics of photovoltaics and solar thermal technologies, to find out about current industry trends.

www.intersolarchina.com

MicroCool® Website Unveils New Standard Cold Plate products

Wolverine's MicroCool® Division has launched its redesigned MicroCooling.com website and unveiled its new Online Store featuring commercially available MicroCool® Standard Cold Plates for the IGBT Power Electronic and CPU markets.

"The launch of the new Online Store is an important milestone for MicroCool® and expands our footprint in the liquid cooling of computer systems and high-performance power electronics." said Peter Beucher, director of MicroCool®. "Now we can quickly respond to our customers' specific requirements by offering a complete line of readily available standard cold plates as well as custom cold plate designs with unsurpassed thermal and pressure drop performance."

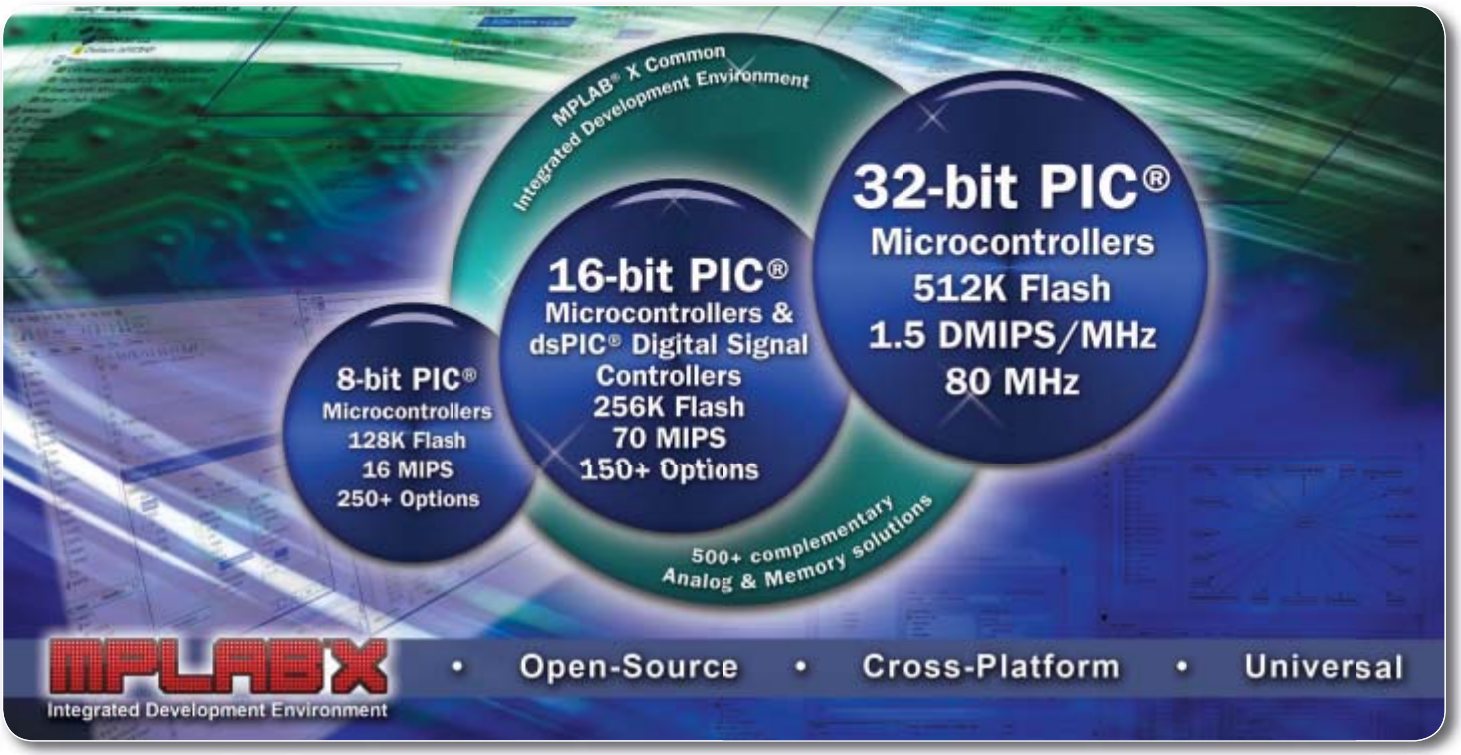
The site's MicroCool® Online Store offers standard, semi-custom, and custom cold plate design
options designed to fit most of the common IGBT and CPU configurations used today. The Online Store platform is designed to give customers fast and easy access to a commercial stockpile of MicroCool® aluminum standard cold plates. Semi-custom and custom cold plates are build-to-order, and are available for customers in need of a unique liquid cooling solution.

MicroCool® will add new features to the site over time and plans to release its MicroCool® Tool in the first quarter of 2013. This online tool is a cold plate simulator with a user-friendly interface designed to quickly provide thermal resistance, cold plate and fluid temperatures, as well as pressure drop performance with just a few easy inputs.

www.wlv.com

www.microcooling.com

One platform for 8-, 16- and 32-bit development - with Microchip's MPLAB® X IDE



MPLAB® X IDE is the free, integrated toolset for all of Microchip's 900+ 8-, 16- and 32-bit PIC® Microcontrollers, dsPIC® Digital Signal Controllers, and memory devices. Based on the open-source NetBeans platform, MPLAB X runs on Windows® OS,MAC® OS and Linux, supports many third-party tools, and is compatible with many NetBeans plug-ins.

MPLAB XC compilers help increase code speed of any PIC® Microcontroller or dsPIC® digital signal controller by 30%, whilst also cutting code size by 35%. These new compilers give designers the choice of Free, Standard or Pro code optimisation levels for 8-bit, 16- or 32-bit development, or a single C compiler suite to support all Microchip Microcontrollers and digital signal controllers.

Microchip's tool chain of compatible compilers and debugger/programmers operate seamlessly within the universal, cross platform and open-source MPLAB® X integrated development environment, reducing both learning curves and tool investments.

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High-Voltage Analogue Buck PWM Controller with Integrated MOSFET Drivers, and High-Speed, Low-Figure of Merit MOSFET Family

Microchip announces a new family of power-conversion controllers and its first-ever family of power MOSFET devices. This new Pulse Width Modulation (PWM) controller and complementary family of low-Figure of Merit (FOM) MOSFET products combine to support high-efficiency DC/DC power-conversion designs, covering a broad array of consumer and industrial applications. Together, these two families demonstrate a significant expansion of Microchip's commitment to enabling higher-voltages and higher efficiencies, as well as the industry trend toward smaller, power-conversion systems.

Key Facts:

- Expands microchip's power solutions portfolio
- Enables higher-voltage, higher-power DC/DC applications at increasing levels of integration
- Analogue-based PWM controller family integrates synchronous MOSFET drivers and operates over a wide 4.5 - 30Vdc range
- High-speed MOSFETs offer very low FOMs

The MCP19035 is a small, analogue-based PWM controller family with integrated synchronous MOSFET drivers offering outstanding transient performance. The MCP19035 devices operate over a wide 4.5 - 30Vdc range, have a 300 kHz switching-frequency, and offer a factory-adjustable dead-time setting, allowing designers to optimise performance across a wide selection of MOSFET devices. The MCP19035 family, when combined with Microchip's MCP87xxx MOSFETs, produces high-efficiency (>96%) DC/DC power-conversion solutions.

The MCP87xxx family of high-speed MOSFETs offers very low FOMs and is packaged in industry-standard 5x6 mm and 3.3x3.3 mm PDFN packages. The MCP87022, MCP87050, and MCP87055 devices offer on-state resistance of 2.2mΩ, 5.0mΩ, and 5.5mΩ, respectively and enable high-efficiency power-conversion designs.

The MCP87xxx MOSFET family also complements Microchip's existing portfolio of SMPS-focused PIC® microcontroller and dsPIC33 "GS" digital signal controllers. Microchip's MCP14700 synchronous MOSFET driver is ideally suited for driving high-speed, low-FOM MOSFETs. When driven by a microcontroller, the two form a flexible, high-performance power-conversion solution.

The MCP19035 300 kHz Evaluation Board (ADM00434) is priced at $45.99, is available now. Complementing the MCP87xxx MOSFET family release is an Excel-based Loss Calculator and user guide, which are also available now, via a free download from http://www.microchip.com/get/VC8M.

The MCP19035 and MCP87xxx families are available now for sampling and volume production. The MCP19035 family is offered in a 3x3 mm 10-pin DFN package; whilst the MCP87022 and the MCP87050 are offered in a 5x6 mm 8-pin PDFN packages; and the MCP87055 is available in a 3.3x3.3 mm 8-pin PDFN package.

For more information, visit Microchip's Web site at http://www.microchip.com/get/SET4

www.microchip.com

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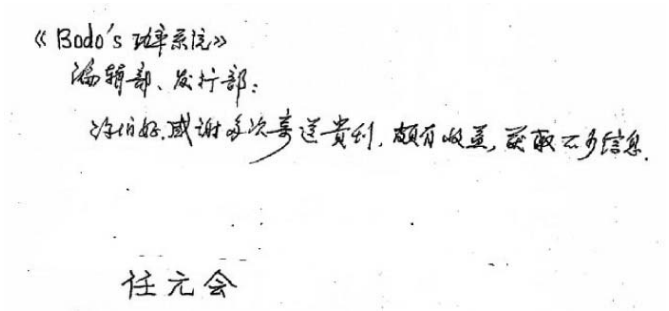
No Pain - No Gain

By Gavin Hsu, i2i Group

In Chinese, there is a saying: Yi Fen Geng Yun, Yi Fen Shou Huo, which loosely translated, means no pain, no gain. Each effort requires a bit of pain in order to achieve the gain, and this is especially so in growing new markets such as here in China.

We launched the first Bodo's Power China in March 2012, successfully bringing world-class news, information and feature stories to the world's fastest-growing power electronics marketplace. In the first year, we produced six issues, over 300 pages of content to highly qualified readers, engineers, researchers and power electronics professionals throughout China. With each passing issue of the magazine, more industry engineers subscribe to Bodo's Power China. Daily subscription forms arrive in our office. Below is a thank you note received from one of our readers, which inspires our editors and production staff to continue the challenge.

It is highly gratifying to see these notes of thanks from our readers because this shows how valuable the publication has become to the industry as well as the importance of the content being provided on a monthly basis.



《Bodo's 功率系统》
编辑部、发行部：
冷冰冰，感谢多次寄送贵刊，颇有收益，获取工业信息。

任元会

In 2013, Bodo's Power China will expand to eight issues a year, in order to accommodate the demand for global information and marketing in China. Each issue of the magazine is always available for download in digital version from: www.bodospowerchina.com

China is a growing marketplace for power electronics. For years, businesses and industries did not pay significant attention to the importance of power electronic devices, and the industry scale has been relatively small and disorganized. Texas Instruments and Infineon have already produced semiconductors based on 12 inch wafer technology, while in China; few businesses are even using 8 inch wafer technology. Most of China's power semiconductor IDM companies produce silicon based diodes, triodes and thyristors. MOS devices and IGBT's are just being produced in recent years. Wide band-gap semiconductor devices, primamrily SiCMESFET and GaN-HEMT, are just now being accepted for use. Recent reports list the top manufacturers without a single Chinese company. China has more pain before more gain.

But, the future is bright. The automotive industry in China is the largest application sector for power semiconductors, especially e-mobility and electric motors which are in especially high demand and production in China. The Chinese government is investing heavily in supporting these industries. But Chinese manufacturing and assembly still mostly use imported power semiconductors.

Since the invention of IGBT's, the technology adoption has been swift in China. The future will continue to see the growth of fine-pattern, slot grid structure, carrier injection enhancement and thin wafer processing technology. Although national policy promotes IGBT development, in fact China has only been producing IGBT samples with limited modules, without localization of IGBT chips. China's recent push has been in the development on large-size FEZ single crystal materials, IGBT chip technology and IGBT module packaging technology, all presenting a good future.

New developments from China include the 6 inch FZ single crystal material developed by Tianjin Zhonghuan Semiconductor, used used in batch production; and the 8-inch FZ single crystal material. The 1200VNPT IGBT used for induction cookers has been adopted by many companies for mass production, breaking the former monopoly by foreign companies.

Based on 6-inch and the 8-inch planar and trench-type chips, CSMC and Hua Hong NEC Electronics have successfully developed IGBT chip 600V, 1200V, 1700V, 2500V and 3300V; most with high reliability verifications and now mass production.

4500V and 6500V IGBT chips have been developed and are now in the early stages of mass production, as well as independent chip-based (IGBT, FRD, high voltage Driver IC) IPM modules created by Hangzhou Silan Microelectronics, which has received preliminary approval for production.

Recently, IGBT power modules produced by Zhuzhou CSR Times Electric Co., Ltd have been used in domestic subway/rail locomotives, with world class reliability.

CSR is building a high power IGBT industrial base in Hunan; with an IGBT module package production line, as well as an 8-inch IGBT chip line. Foreign producers continue to invest and build both

research and production in China, such as Infineon and Semikron, not because the the market costs are low, but rather because the demand in growth and the future will be strong.

CNR has recently become the world's 4th largest and number 1 in China assambling of 6500V IGBT power modules and even higher Voltages. Macmic's IGBT was also recently introduced to the electric welding machine market and Starpower's IGBT product is now actively being marketed and sold globally.

China is growing faster than many believe and increased investment, technology development and product demand will continue to spur growth in China. This is also why most major foreign manufactures now have significant operations and investments in China. They know what the future looks like. In 2012 it was rumored the world would come to an end, but it did not. Maybe we were lucky or maybe we knew it all along, but none the less, a New Year with new hope is now dawning and so is China. We continue to try, like everyone in China – no pain, no gain….. so maybe your next product will come with Chinese instructions and don't be surprised to see more Bodo's Power China.

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Electronics Industry Digest

By Aubrey Dunford, Europartners

Moody's Analytics forecasts that the Eurozone will only grow by 0.2 percent in 2013, with unemployment peaking above 12 percent in the middle of the year. The main driver of this growth will be Germany, which is expected to grow by 1.2 percent and have an average unemployment rate of 7.1 percent. Modest growth in the Eurozone is likely to start by the end of 2013.

SEMICONDUCTORS

European semiconductor sales were € 2.191 billion in October 2012, down 1.5 percent compared to September 2012 and down 1.0 percent versus October 2011, so the WSTS. Year-to-date sales in 2012 were down 3.8 percent compared to the same time last year. On a worldwide basis, semiconductor sales in October 2012 were $ 25.217 billion, up 1.7 percent versus the previous month and down 2.3 percent versus the same month in 2011. Worldwide year-to-date sales in 2012 were down 3.7 percent compared to the same time last year, but the deficit was smaller than it has been all year. Regionally, sales increased in the Americas by 8.1 percent, marking the region's largest sequential monthly upsurge in the last decade. STMicroelectronics has taken the decision to exit ST-Ericsson after a transition period and is currently in negotiations on exit options.

Out of 157 leading semiconductor suppliers tracked by IHS on a quarterly basis, more than 59 percent are expected to suffer revenue declines in 2012. Furthermore, out the four major global regions, only companies headquartered in Asia-Pacific will achieve growth as a group in 2012, with an expected 2.5 percent rise. Companies headquartered in the other three regions are expected to see their collective revenues fall between 2.7 and 5.8 percent in 2012. In particular, companies headquartered in Europe are expected to see their collective revenues fall by 4.3 percent at $ 26.7 billion.

Worldwide semiconductor revenue is projected to total $ 311 billion in 2013, a 4.5 percent increase from 2012 revenue, so Gartner which has reduced growth predictions for 2012 with semiconductor revenue expected to total $ 298 billion, down 3 percent from 2011.

Hitachi announced the decision to discontinue the manufacture of semiconductors for its information and telecommunication hardware on March 31, 2014.

Worldwide sales of new semiconductor manufacturing equipment will reach $ 38.2 billion in 2012, so SEMI. After a 151 percent market increase in 2010 and a 9.0 percent increase in 2011, the equipment market is expected to contract by 12.2 percent in 2012. Growth is expected in just two regions in 2012 — Taiwan (12.7 percent increase over 2011) and South Korea (10.7 percent increase).

OPTOELECTRONICS

Sharp is planning to accept up to 9.9 billion yen ($ 119 M) from Qualcomm. As a result of the equity investment, Qualcomm will become a minority shareholder in Sharp. Qualcomm also announced the expansion of its display technology agreement between its subsidiary Pixtronix and Sharp.

PASSIVE COMPONENTS

After a 7 percent increase of the European passives market in 2011, the experts of EPCIA (European Passive Components Industry Association) forecast a decrease of 6 percent in 2012.

OTHER COMPONENTS

Lagercrantz Group, a Swedish technology group in the areas of electronics, electricity and communication, has acquired Elkapsling. This Swedish company produces enclosures which are used to protect electrical and telecom installations. Elkapsling has aggregate annual sales of € 9.8 M with good profitability. Lagercrantz has about 900 employees and revenue of approximately € 266 M.

National Instruments announced its acquisition of Dresden-based Signalion. Founded in 2003, Signalion offers test and measurement products and services for wireless communications. The company has approximately 50 employees. The acquisition delivers wireless communications talent and technologies to the NI platform. Signalion will continue to operate as a wholly owned NI subsidiary and to sell and support its products through its direct, distributor and OEM channels.

Audax Group, an investor with over $ 5 billion in assets under management, has acquired Aavid Thermalloy, a designer and manufacturer of thermal management solutions operating with more than 1,900 employees. Aavid's global infrastructure includes manufacturing facilities and design centres located in North America, Europe and Asia.

EMS PROVIDERS

Flextronics has acquired Saturn Electronics & Engineering, a US-based supplier of electronics manufacturing services, solenoids and wiring for the automotive, appliance, consumer, energy and industrial markets.

DISTRIBUTION

Avnet has agreed to acquire substantially all of the operating assets of USI Electronics, a distributor of discrete semiconductor, passive and electromechanical components to the military and aerospace customers.

Intersil, a supplier of analog, mixed signal and power management semiconductors, has selected Future Electronics as a strategic global distribution partner.

Silica, an Avnet company, has been named as the Renesas Distributor of the Year for 2012. Silica received this honour from Renesas in recognition of Best Revenue Performance in FY'12.

This is the comprehensive power related extract from the «Electronics Industry Digest», the successor of The Lennox Report. For a full subscription of the report contact:

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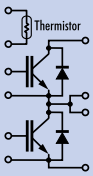

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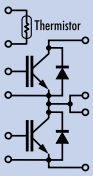

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225A	●	
300A	●	
450A	●	
550A		●
600A	●	
225A	●	
300A	●	●
450A	●	●
550A		●
600A	●	

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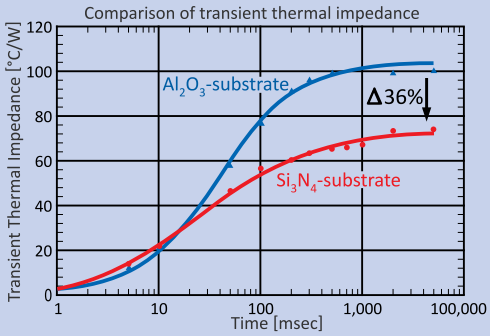

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Energy-Harvesting-Powered Systems Set for Accelerated Growth

By Jeff Shepard, President, Darnell Group

The announcement at the end of 2012 by the ZigBee Alliance of "Green Power" as an optional feature for ZigBee PRO is one of the most-striking indications that battery-less, wireless systems are poised for a surge in growth. Until the ZigBee announcement, the options for deploying energy harvesting (EH) powered controls and sensors were limited, and so was the market potential of those devices. Prior to the ZigBee announcement, there were fewer than 50 companies seriously involved in the market for EH-powered devices. As a result of the news from ZigBee, today there are hundreds of companies involved in this area.

In October of last year, ZigBee celebrated its first decade of successes, most notably in enabling the growing machine-to- machine (M2M) and Internet of Things (IoT) trends and providing utilities and energy service providers with new consumer energy management and efficiency capabilities. Hundreds of manufacturers have shipped hundreds of millions of ZigBee products for a variety of energy management, commercial and consumer applications, hence the importance of the ZigBee Green Power announcement in enabling the rapid-growth of EH-powered systems.

While the ZigBee announcement was a major step, it was only one of several important developments in the area of EH-power that have occurred recently. Another important standard announced in 2012 was ISO/IEC 14543-3-10 — for wireless applications with ultra-low power consumption. This standard was ratified by the International Electrotechnical Commission (IEC) and was claimed to be the first and only wireless standard that is also optimized for energy harvesting solutions. It lays the foundation for fully-interoperable, open wireless technology comparable to standards such as Bluetooth and WiFi. The new standard is geared to wireless sensors and wireless sensor networks with ultra-low power consumption.

The changing and expanding standards landscape is only one of the significant developments that will drive EH products into the mainstream in 2013. A convergence of technologies will also be a major driver in the growth of this market. The power consumption needs of control and sensor systems is falling with each successive generation of semiconductor devices and the energy-delivery capabilities of energy harvesting systems is rising with successive generations. At the same time, the cost of wired systems continues to rise as basic materials such as copper wiring and installation costs (labor) continue to rise. Copper is being replaced with silicon. As a result, the energy harvesting market is well positioned for accelerated growth starting in 2013 and continuing over the next several years.

In addition, while energy harvesting is often described as a "battery-less" technology, in reality, in many applications energy harvesting will be used to run devices when they can, but then need to store excess energy for later use. Both primary and especially rechargeable batteries are seen as a concurrent and critical market with energy harvesting solutions.

At the end of last October, Cymbet Corporation announced that it is now shipping EnerChip™ Smart Solid State Batteries from their second high-volume fabrication facility built in partnership with X-FAB Texas Inc. Shipping EnerChips from this production facility significantly increases Cymbet's manufacturing capacity to supply the growing global demand for Cymbet's solid-state batteries. In anticipation of identified high-volume customer requirements, additional floor space has been set aside for future expansion of the EnerChip production lines.

As if to highlight these trends, just last week Texas Instruments Incorporated (TI) introduced the industry's lowest-power dc-dc step-down converter, which increases the amount of harvested energy an end application can use as much as 70 percent over alternative devices. This is the latest in a string of energy-harvesting-related product announcements from TI. The ultra-low power circuit enables battery-free power to applications, such as wireless sensor networks, monitoring systems, smoke detectors, wearable medical devices and mobile accessories.

TI's TPS62736 dc-dc converter mobile accessories and wireless sensors to manage microwatts generated from solar, thermoelectric, magnetic and vibration energy. It delivers high power conversion efficiency from 10 uA to 50 mA output currents, and consumes only 350 nA of active current and 20 nA during standby. The converter achieves greater than 90-percent efficiency across output currents higher than 15 uA. The TPS62736 regulator steps down the voltage from a power source, such as a thin-film or regular battery or a super capacitor and features a programmable output voltage.

Last month, in direct support of the ZigBee Green Power announcement, GreenPeak Technologies announced its new GP410 chip offering the new PRO Green Power feature for low-cost energy harvesting and ultra-long battery life ZigBee applications for the Smart Home. The GP410 IEEE 802.15.4 ZigBee PRO Green Power controller is a fully integrated system-on-chip solution for power harvesting end nodes for light switches, smart home devices, or for applications designed to run on a single battery for many years. The Green Power feature gives battery-free, energy-harvesting devices the ability to join any Green Power enabled ZigBee PRO 2012 network.

In addition to GreenPeak, several other European companies and organizations made significant anouncements related to energy harvesting in 2012. For example, the Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) in Bremen presented a printed thermogenerator, which can be tailored exactly to technical specifications. The IFAM researchers have developed new production processes to custom manufacture the thermoelectric generators.

"Generative manufacturing processes produce both sensors and sensor networks as well as the required elements for energy harvesting such as thermogenerators: By directly depositing functional structures, which have an ink or paste base, using ink-jet, aerosol-jet, screen-printing or dispensing processes, not only can electrical circuit boards and sensor elements be attached to different interfaces but it is also possible to produce structures which harvest energy," explained Dr. Volker Zöllmer, Head of Functional Structures, whose work focuses on the topic of Energy Harvesting at the Fraunhofer IFAM.

Micropelt, German vendor of chip thermogenerators and thermal energy harvesting micro power sources, and IMST, German specialist in low power wireless solutions, announced the TE-CORE/RF – a new, modular, self-sustaining wireless sensor kit.

An embedded Micropelt thermogenerator which converts heat from a warm surface into electricity, provides the system power. A difference of 10°C (18°F) or more between surface and air temperatures drives the ZigBee module iM222A, member of the family of WiMOD radio modules of IMST, to transmit data every 2 seconds. The pre-certified iM222A uses Texas Instrument's Z-Stack protocol.

Depending on actual temperature difference and heatsink efficiencies 150 microwatts to over 10 milliwatts of harvesting power are available. A constant delta T of 25°C (45°F) generates an energy quantity comparable to 3 to 4 AA batteries. "Battery powered sensors usually have to operate several years with that energy budget," explained Heinz Syrzisko, IMST's product manager Wireless Solutions. "With Micropelt's energy harvesting solution providing a 3 years budget every year, we can reduce latency, do more measurements, increase wireless range or increase data payload." As a result the lifecycle cost of a wireless sensor is reduced, although its functionality is improved.

Perpetuum Ltd. in a collaborative effort with Emerson Rosemount announced the availability of an Intelligent Energy Harvester power module option for Emerson Rosemount 3051S Smart Wireless transmitters. The Intelligent Power Module offers a compact and technologically advanced power option which has the same form factor as the Emerson battery pack. It will enable the Emerson Rosemount 3051S to be powered by Vibration Energy Harvesters (also known as Vibration Energy Scavengers) thus eliminating the cost and logistics challenges associated with changing batteries.

By utilizing Perpetuum's Vibration Energy Harvesting power option end users can eliminate the need to change batteries for over 10 years. Savings are even greater for "prioritized" assets (those requiring the fastest data capture rates), remote locations and hazardous or safety restricted areas. And Perpetuum's Intelligent Power Module has been designed so that it is compatible with other forms of energy harvesting (e.g. thermal) when they become available and qualified for use.

G24 Innovations announced that it has achieved ground-breaking efficiency rates for the indoor performance of its Dye-Sensitised Cells. At an average of 26% conversion efficiency, a new cell composition has broken the company's previous record of 15%, which the company says is already recognized by Texas Instruments' Solar Lab as the most efficient indoor light energy harvesting technology on the market.

The company's PV cells are already being used instead of batteries to power a number of products on the market – from shade and blind systems for one of the largest hotels in Las Vegas to computer peripherals products such as wireless keyboards. The breakthrough is expected to substantially increase G24i's global market opportunity and, ultimately, the replacement of batteries with renewable power in everyday consumer electronics.

These are only a few examples of the growing number of companies announcing devices intended to support EH-powered controls and sensors. The demand is there. Recent standards announcements from ZigBee and the IEC provide the enabling framework. This year will be a "break-out" year for battery-less, wireless systems.

Energy harvesting and related M2M and IoT technologies will be major topics at the first-annual Darnell's Energy Summit to be hosted in Dallas, Texas, September 9-13, 2013.

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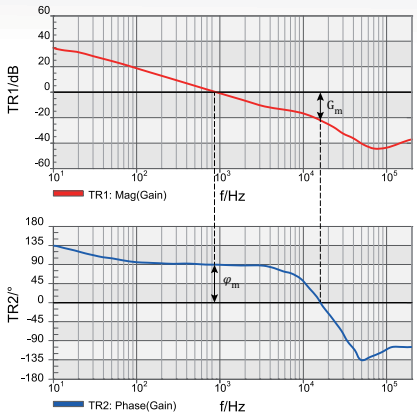

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Technology of Precise Adjusting of Static and Dynamic Characteristics of High Voltage Thyristors

Due to capacity growth of inverter units in power semiconductor electronics high voltage and high current thyristors adapted for usage in series and parallel connection are in great demand nowadays.

Thyristors designed for parallel assemblies must have high adequacy of volt-amps diagramm in on-state, thyristor designed for usage in series connection assemblies must have high adequacy of reverce recovery characteristics. General requirement for all applications is presence of identical and preferably minimized temperature dependencies of the above mentioned characteristics.

By A.M. Surma and V.S. Kislyakov, R&D Center, Proton-Electrotex JSC

To achieve identity of the above mentioned thyristor characteristics it is necessary, at first, to provide high precision of donor and acceptant dopants distribution in the layers of semiconductor element of thyristor. Modern technologies and equipment for implantation and diffusion process and usage as blank substrate of high quality "power" neutron-transmutation-doped silicon as a rule allow to solve this issue.

Secondly, it is necessary to ensure identity of carrier lifetime in the layers of thyristor. Solution for this issue for modern high voltage thyristors with voltage over 4000 V has the following difficulties: required for achieving satisfactory low voltage drop in on-state values of carriers lifetime (τ) in n-base of such thyristor equal 100-300 µs, at values and typical distribution of tin dispathed groups of initial single-crystalline silicon – 500-1000 µs.

In such a way to achieve drop of τin n-base of complete element with required precision (distribution lower than few percent, and sometimes lower than percent portions) will not be possible without initial value of this electrophysical characteristic for this certain semiconductor element.

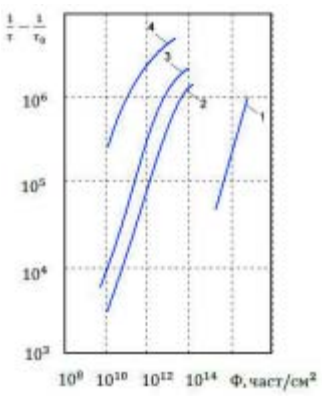

Figure 1: Typical dependencies of carrier lifetime on irradiation flow: 1 – γ-rays, 2 – electrons 2,5 MeV, 3 – electrons 30 MeV , 4 – fast neutrons.

One of effective technologies of precise regulation of τ and as a result precise adjustment of thyristor characteristics depending on it is irradiation with accelerated electrons. Decrease of minority-carrier lifetime in device base is in progress due to implantation of radiation-induced defects [1]. Typical dependencies of $1/\tau$ - $1/\tau_0$ (τ_0 – value before irradiation) in silicon on integral flow (dose) of irradiation D for different particles are shown in figure 1 [2]. Suchwise in the certain area of irradiation doses the following dependency takes place (1):

$$\Delta\frac{1}{\tau}=\frac{1}{\tau}-\frac{1}{\tau_0}=K_\tau D \qquad (1)$$

Experience has shown that during electron irradiation of high resistance "power" "float zone"-grown and neutron-doped silicon value of index K_τ is quite stable and is almost unchanged in the lots of dispathed material, which ensures possibility of precise adjustment of τin n-base of semiconductor element. It is necessary, however, to ensure precision and repeatability of irradiation integral flow density (dose) D.

The most prevailing method to control irradiation doses with help of Faraday cylinder has fractional error 15-20 % during measuring the required for irradiatoin of high voltage thyristors doses in range 1E11-1E12 cm^{-2}. This doesn't fully correspond to precision requirements in production of these semiconductor devices and makes search of alternative methods quite important.

One of the most prospective methods is method of direct measurement of τ on accompanying irradiated objects silicon crystal-satellites. From dependency (1) it is clear that if precision of carrier lifetime measurement is provided and index of radiation degradation K_τ is known, then using Δ $1/\tau$ it is possible to receive D. $K\tau$ and τ_0 values for irradiated thyristor elements and satellite diodes can be different, however, knowing values of τ_0 in each case, and also on condition of high stability of constants K_τ, it is always possible to receive τ value in satellite diode base when in n-base of thyristor element required value of carrier lifetime is achieved. Thus principle of dose control method lies in measurement of degradation of carrier lifetime in test structure during irradiation process and precision of the method will be defined by:

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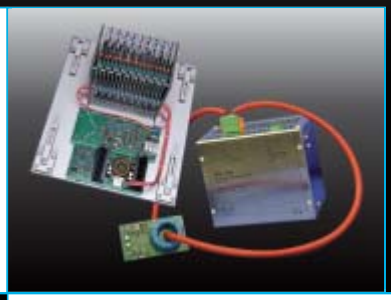

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1) Precision of τ measurement or connected with it characteristics of thyristor element before irradiation;
2) Precision of τ measurement or in satellite diode base during irradiation;
3) Constancy of K_τ.

Measurement of τ in base of diode satellite crystals is realized by Lax method [3]. Despite that in connection with real physical value ô this method can be inaccurate, it has high precision capability with invariable parameters of semiconductor layers and measurement conditions. In our case according to the physical and topological simulation data [4] with impulse characteristics I_1=200 mA, I_2=100 mA and $t_{imp}{}^{+} = t_{imp}{}^{-}$ = 200 µs we have the following :

$\tau=2t_s$, (3)
where t_s is delay time of reverse voltage.

Satellite diodes are produced on the basis of high resistance neutron-doped silicon, which is close in its characteristics to silicon on the basis of which thyristor elements are produced that ensure stability of K?. Satellite diodes' elements are crystals 4×4 mm cut from the wafers, which went through diffusion process of the power diode. During irradiation satellite diode is buttoned up in the center of the irradiating target in contact snap, from which a coaxial cable is stretched to the accelerator control panel (figure 2).

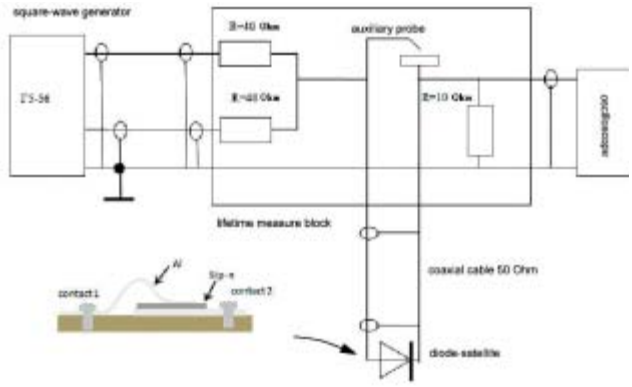

Figure 2: Scheme of measurement of carrier lifetime on crystals of satellite diodes during irradiation process

Typical results of precise adjustment of thyristor characteristics with irradiation by accelerated electrons with energy 6 MeV using the above described control method is the following:

For lots of thyristors T353-800-35 with average current 800 A and voltage 3500 V, which are used in series parallel assemblies as part of high voltage pulse converters, customers require ensurance of distribution of voltage in on-state V_{tm} not bigger than ±0,1V for even distribution of load in parallel connection of thyristors, and also simultaneous limitation of reverse recovery surge current I_{rrM} down to 130 A must be guaranteed. Thyristors are preliminarily groupped according to initial V_{tm} values with 0,05 V interval between groups, and then are being irradiated according the method described above. At that it is possible to lower technological distribution down to
1.8 V $\leq$ V_{tm} $\leq$ 1.9 V, which is twice as big of the required (figure 3), and also corresponds to requirements according to I_{rrM} (figure 4), herewith general percentage of produced with such characteristics devices exceeds 95%.

For thyristors T643-320-65 with average current 320 A and voltage 6500 V adapted for series connection, precise technology of reverse recovery charge adjustment allows lowering Q_{rr} variation in lot down to ± 70-80 µC (figure 5). V_{tm} variatoin is also minimized in this case (figure 6).

In figure 7 change of reverse recovery charge distribution in lots of high voltage thyristors T273-1250-44 with current 1250 A and volatge 44 V after precise irradiation process is shown. In figure 8 corresponding statistical distribution of voltage drop in on-state is shown. It is clear that variation of reverse recovery charge in massive lots of thyristors decreases down to value lower than 5%. Variation of voltage drop values in on-state after precise irradiation process is lower than ±0,05 V, which makes it easier, if necessary, to coordinate thyristors' operation in parallel connection.

In such a way radiating and technological methods of precise adjustment of high volatge thyristors characteristics adapted for usage in parallel-series connection allow decreasing in massive lots of V_{tm} down to values under ±0,05 V with Q_{rr} variation under 5%.

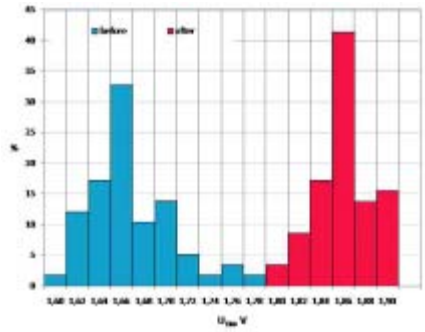

Figure 3. Typical statistical distribution of V_{tm} (I_{tm}=2500A) in lots of thyristor elements T353-800-35 before and after precise precise irradiation with accelerated electrons..

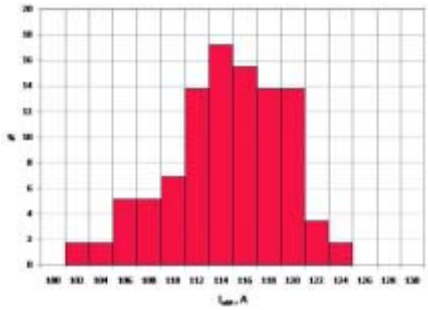

Figure 4. Typical statistical distribution of surge reverse recovery current I_{rrM} (T_j=125C, I_{TM}=800A, di/dt=-5A/µs) in lots of thyristor elements T353-800-35 after precise irradiation with accelerated electrons.

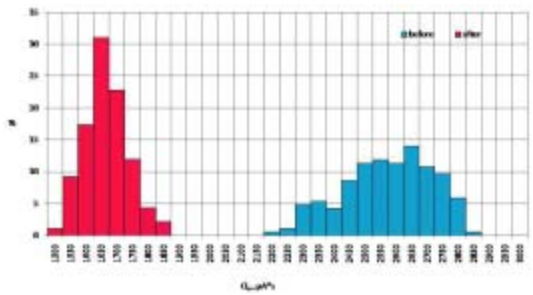

Figure 5. Typical statistical distribution of reverse recovery charge Q_{rr} (T_j=125C, I_{TM}=320A, di/dt=-5A/µs) in lot of thyristor elements T643-320-65 before and after precise irradiation with accelerated electrons.

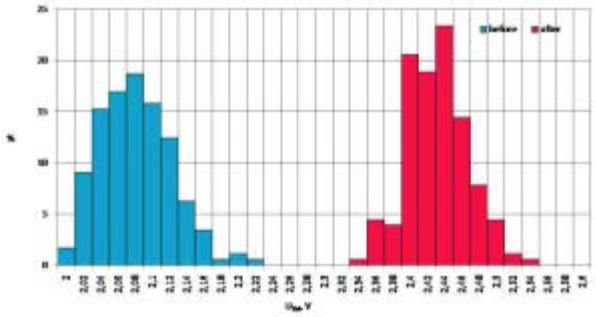

Figure 6. Typical statistical distribution of V_{tm} (I_{tm}=2500 A) in lot of thyristor elements T643-320-65 before and after precise irradiation with accelerated electrons.

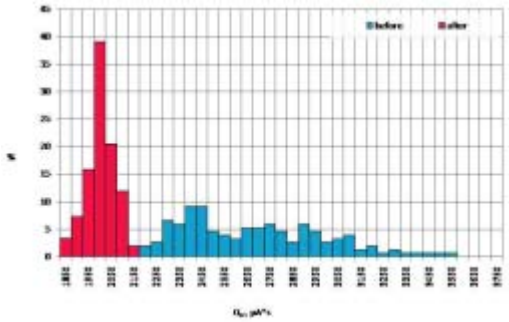

Figure 7. Typical statistical distribution of reverse recovery charge Q_{rr} (T_j=125C, I_{TM}=1250A, di/dt=-5A/μs) in lot of thyristor elements T273-1250-44 before and after precise irradiation with accelerated electrons.

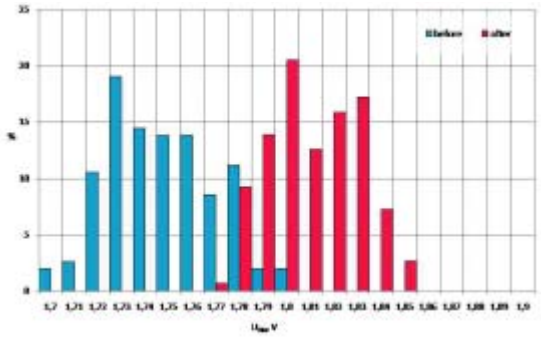

Figure 8. Typical statistical distribution of V_{tm} (I_{tm}=4000 A) in lot of thyristor elements T273-1250-44 before and after precise irradiation with accelerated electrons.

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SiC MOSFET Module Replaces up to 3x Higher Current Si IGBT Modules in Voltage Source Inverter Application

The low switching losses of the silicon carbide (SiC) MOSFET enable the reduction of end-system cost, even at low frequency. Commercially available 1200V SiC and Si modules are evaluated in a commonly-used voltage source inverter (VSI) design operating at conventional frequencies. At low 5kHz operation, the 100A SiC module is capable of replacing at least a 150A Si module while providing significant performance and reliability advantages. At modest 16 kHz operation, the 100A SiC module replaces up to a 300A Si module needed for overload and thermal margin requirements.

By Dr. Mrinal K. Das, Product Marketing Manager, Cree, Inc.

INTRODUCTION

SiC is currently the only wide bandgap material to address the power electronics market needs for high performance 1200V and 1700V devices. SiC diode technology has thrived in the market for more than a decade, and many switches have recently become available to enable "all-SiC" circuit solutions. For example, in November 2012, Cree announced the industry's first fully qualified, fully documented all-SiC module (CAS100H12AM1 1200V, 100A SiC MOSFET module) ready for immediate evaluation/design activity and high volume manufacturing as seen in Figure 1. The 50mm x 90mm x 25mm half-bridge module contains a commercially released chipset including: five 1200V, 80mΩ 1st Generation SiC MOSFETs (CPMF-1200-S080B) and five 1200V, 10A 2nd Generation SiC Schottky diodes (CPW2-1200-S010B) per switch. The all-SiC module is assembled with an AlSiC baseplate for better matching of thermal expansion and lighter weight as compared to conventional copper baseplates. The power semiconductors are isolated from the baseplate with a Si_3N_4 insulator featuring active metal brazed copper joints capable of extended thermal and power cycling. These module properties provide a maximum reliability package for the high performance SiC chips.

Figure 1: Commercially available SiC power module CAS100H12AM1 rated for 1200V and 100A.

VSI DESIGN

Because of significantly reduced switching loss of SiC devices, a SiC MOSFET of 100 rated Amperes is expected to replace a Si IGBT of much higher rated current. To illustrate and quantify this point, a basic three-phase Voltage Source Inverter (VSI) found in many DC/AC applications such as motor drives, uninterruptable power supplies and solar inverters is defined with the key characteristics as shown in Table 1.

Parameter	Value
Output Voltage	Up to $415V_{rms}$
Rated Output Current	$75A_{rms}$
Overload Capability	20% for 5 min ($90A_{rms}$)
DC Link Voltage	~ $690V_{DC}$
Fundamental Frequency	60Hz
Switching Frequency	Min: 5kHz, Target: 16kHz
Typical Load Power Factor	0.9
Cooling Method	Forced Air
Max. Ambient Temp.	50°C

Table 1: VSI specifications

In this analysis, 150A and 200A 6th Generation Trench-Field Stop Si IGBT half-bridge modules are compared against the 100A SiC MOSFET half-bridge module (Table 2). At the rated current of the application ($75A_{rms}$), the forward voltage drop of the 100A SiC MOSFET and the 150A Si IGBT are approximately equal for Tj = 150°C (Figure 1). For the overload condition ($90A_{rms}$), the 100A SiC MOSFET has a 0.3 V higher forward voltage drop than the 150A Si IGBT for a Tj = 150°C. However, the superior SiC MOSFET switching capability is evident in the total switching loss ($E_{on} + E_{off} + E_{rr}$) being 4× to 7× smaller than the 150A Si IGBT. This enables significant reduction in the overall semiconductor loss when using SiC compo-

nents, even in applications with low switching frequency (5 kHz). The reduced overall semiconductor loss allows for higher thermal margin (reliability enhancement) or higher system power.

Characteristic	100A SiC MOSFET	150A Si IGBT	200A Si IGBT
Rated Current @ T_{Case} = 100°C [A]	100	150	200
Rated Voltage [V]	1200	1200	1200
Max Junction Temperature [°C]	150	150	150
V_{CE}, V_{DS} @ 100A, 150°C [V]	2.0	1.6	1.5
Diode V_F @ 100A, 150°C [V]	2.5	1.5	1.4
Switch Loss (E_{on} + E_{off}) @ 100A, 600V, 150°C [mJ]	3.9	18.5	19.3
Diode Loss (E_{rr}) @ 100A, 600V, 150°C [mJ]	~ 0.0	8	9.5
Switch Junction-to-Case Thermal Resistance [°C/W]	0.240	0.140	0.100
Case-to-Heatsink Thermal Resistance [°C/W]	0.026	0.025	0.025
Dimensions [cm]	9x5x2.5	9.2x4.5x3	9.2x4.5x3
Weight [grams]	150	240	250

Table 2: Key parameters for 150A and 200A Si IGBT modules and 100A SiC MOSFET module.

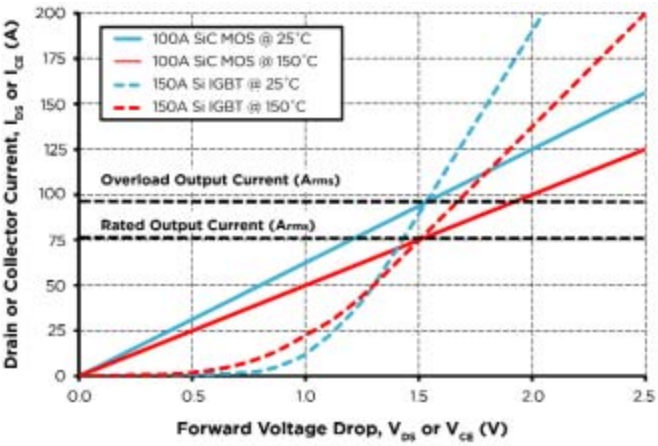

Figure 2a: Conduction loss for 150A Si IGBT and 100A SiC MOSFET at 25°C and 150°C

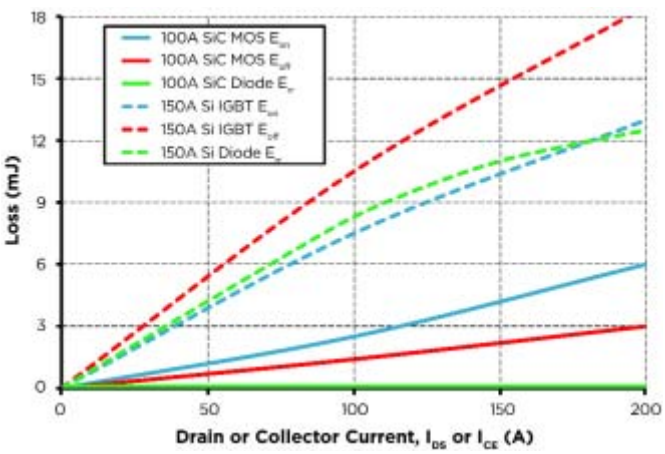

Figure 2b: switching loss (switch and diode) for 150A Si IGBT and 100A SiC MOSFET at 150 °C

VSI SIMULATION RESULTS

The VSI described in Table 1 is simulated using the Si IGBT manufacturer-provided software with the module parameters from Table 2 as inputs. The simulation is run for two operating currents (nominal 75A_{rms} and overload 90A_{rms}) and two switching frequencies (low 5kHz and modest 16kHz), while keeping the same heatsink size for the 150A Si IGBT and 100A SiC MOSFET modules.

Table 3 shows that the 5kHz operation of the 150A Si IGBT module at nominal and overload conditions maintains the average junction temperatures well below the 150°C maximum rating. Increasing to 16kHz switching frequency, however, results in a maximum current capability of 75A_{rms} with no overload capability or thermal margin. To achieve the 20% overload capability (90A_{rms}), the 150A Si IGBT module must be replaced by a 200A Si IGBT module. If thermal margin is needed at overload condition, a 250 or 300A Si IGBT module is required. On the other hand, the 100 A SiC MOSFET module is capable of delivering all the operating conditions targeted for this VSI at both frequencies.

Parameter	Si IGBT Modules					SiC MOSFET Modules			
Module Rated Current (A)	150	150	150	200	200	100	100	100	100
Operational Current (A_{rms})	75	90	75	75	90	75	90	75	90
Switching Frequency (kHz)	5	5	16	16	16	5	5	16	16
Switch Switching Loss (W)	37.0	43.2	118.5	124.2	146.6	7.6	9.1	24.2	29.1
Diode Switching Loss (W)	15.2	17.7	48.7	58.0	66.9	0.0	0.0	0.0	0.0
Switch Conduction Loss (W)	44.9	58.4	44.9	40.0	51.9	63.1	88.3	64.2	90.9
Diode Conduction Loss (W)	7.1	9.1	7.1	6.5	8.2	9.3	15.4	9.7	16.3
Avg. Heatsink Temp (°C)	86.1	94.4	125.8	109.9	121.5	78.7	90.4	85.2	98.8
Avg. Case Temp (°C)	88.7	97.6	131.3	115.6	128.3	80.7	93.4	87.7	102.4
Switch Avg. Junc. Temp. (°C)	100.1	111.8	154.1	132.1	148.2	98.0	116.7	109.0	131.1
Diode Avg. Junc. Temp. (°C)	93.1	102.9	142.7	126.0	140.3	83.9	98.1	90.8	107.3
Total Semiconductor Loss (W)	625.2	770.4	1315.3	1372.0	1641.6	479.9	676.9	588.9	817.7

Table 3: Simulation results for VSI with 150A and 200A Si IGBT modules and 100A SiC MOSFET module.

The efficient switching of the SiC MOSFET module also enables a thermal benefit. At 75A_{rms} and 5kHz operation, the switch losses are reduced by 13.7%, resulting in a 2.1°C decrease in junction tempera-

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ture. The diode losses are reduced by 58.3%, resulting in a 9.2°C decrease in junction temperature. The overall semiconductor loss is reduced by 23.2% (or 145.3 Watts). Moreover, the heatsink and case temperature is reduced by 7.4 and 8.0°C, respectively, thereby increasing the life of the thermal interface material. As such, the SiC MOSFET module delivers substantial loss reduction and potential for higher reliability, even in applications with low switching frequency.

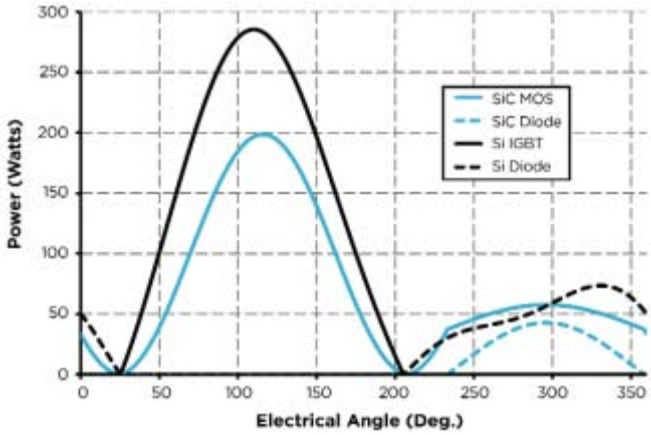

Figure 3: Total loss (switch and diode) of the 100A SiC MOSFET and the 150A Si IGBT modules for the 75A$_{rms}$ and 5kHz condition.

Figure 2 shows that the peak-to-average ratio of the total power loss waveform for the SiC MOSFET is only 2.81 while the Si IGBT is 3.48 (~24% higher). At similar thermal impedance, the SiC MOSFET will experience lower temperature ripple during normal operation than the Si IGBT, which further increases the module reliability.

As the switching frequency increases from 5kHz to 16kHz, the benefits brought forth by SiC MOSFET technology are even more pronounced. To satisfy overload conditions, the Si IGBT module requires 200A but with no thermal margin. During the nominal condition (75A$_{rms}$), the 100A SiC MOSFET module has overall semiconductor loss that is 57.1% (or 783.1 Watts!) lower than the 200A Si IGBT module. This results in significantly lower junction, case, and heatsink temperatures that provide reliability benefits. To achieve thermal margin requirements, a 250 or 300A Si IGBT module is required.

SUMMARY

VSI simulations demonstrate that the 100A SiC MOSFET module is capable of replacing 150, 200 and even 300A Si IGBT modules while delivering higher performance, lower losses, and the potential for higher reliability. Because rated SiC Amperes do not equal rated Si Amperes at the system level, SiC-based designs require evaluation of price per system power ($/kW) as the key cost metric rather than price per rated Ampere. As SiC power devices rapidly move down the cost curve with increased volumes, manufacturing experience, and material/device innovation, all-SiC modules like the CAS100H12AM1 are designed to gain market adoption by reducing end-system cost while providing additional performance and reliability benefits.

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New High Density Modules Deliver Maximum Thermal, Electrical Performance

Increasing complexity and performance of the latest FPGA's, processors and ASICS and associated memory demands are resulting in ever increasing system power needs while real estate available to place power solutions continues to shrink. This increasing power density also elevates the importance of system thermal management.

By Michael Althar, Jian Wang Yin and Steve Rivet, Intersil Corporation

In response to these trends, new flexible high density power modules are being developed that provide advanced electrical and thermal performance in an easy to use integrated package to meet these challenges.

As system performance increases drive increased power requirements, and time to revenue pressures push designers to cut development schedules, the need for full functioned, quick to implement power solutions has exploded. Power modules are providing those solutions and with the flexibility and performance system designers need to get maximum power out of minimum space. Power module options range from simple co-packs of controllers, FETs and a capacitor or inductor to full power solutions which include all of the IC components as well as virtually all of the discrete and magnetic components required to implement a full power supply in a single package; these devices are available both in open frame or fully encapsulated module form factors. Modules are also available with either analog or digital control loop; analog modules provide extreme ease of use while digital modules such as the Intersil ZL9117 can provide added benefits of telemetry, auto-compensation, and in-situ programmability. This article will focus on the latest in high power, simple to use analog power modules such as the 30 amp ISL8225 newly introduced by Intersil Corporation.

One of the greatest challenges inherent in high power (greater than 100W) module design is thermal management. Footprint and ultimate power rating, especially at high ambient temperature, are dictated by the module's electrical and mechanical design. This challenge is addressed by the design of the controller, inductor, and switching FETs, which contribute to high efficiency and low power loss, and the use of thermally efficient packages that can move the heat out of the module. In a highly integrated device such as a power module, the electrical and mechanical design is highly interdependent.

Inductor design is a key piece of the electrical/mechanical design task. Commercially available inductors need to be large to achieve high overall efficiency and maintain reasonable operating temperature. However, many applications have limited space with high ambient temperature and need a very small, low loss inductor; if forced to use an undersized inductor due to space limitations, the designer has to live with limited output current, heat crowding/hot spots and/or poor efficiency.

ISL8225M addresses these issues by utilizing a 3-D stackable inductor structure. In this structure, a large inductor, almost the as large as the entire module footprint can be used; this inductor is installed over the other components. This technique doubles the available area for placing other components on the substrate vs. a side by side mounting method, at the expense of a growth in package height. The larger inductor can have a very small Direct Current Resistance (DCR), which reduces the circuit conduction loss. Additionally, a large inductance can be used to reduce the current ripple, thus reducing the inductor core loss. The MOSFET switching loss can be decreased as well since the switching frequency can be lowered with the large inductance. The 3-D structure can reduce the overall power loss in the power supply and achieve a solution with high efficiency, higher power density and better thermal performance.

ISL8225M is a flexible device, which can be used in dual output mode, or a high-current single output. In the dual output mode, the ISL8225 provides independent outputs to supply two separate voltages with no cross-talk. The ISL8225M 2-phase inductor is a propri-

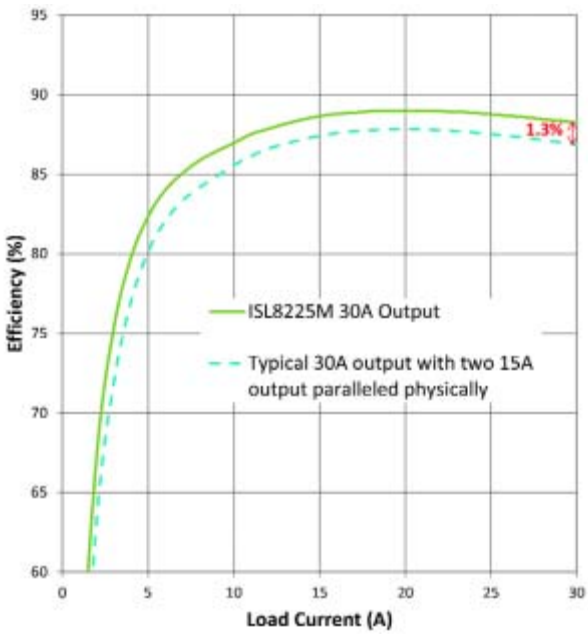

Figure 1: ISL8225M efficiency improvement due to the novel inductor design

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etary design utilizing non coupled windings on a single core. In the single output mode, the novel 2-phase inductor can partially cancel the magnetic flux of the two windings, thus reducing the inductor core loss and improving efficiency. Figure 1 shows the efficiency advantage of this structure vs. windings on separate cores with the same DCR. The design of the ISL8225 inductor reduces both the footprint and power loss vs. traditional design.

Many power modules on the market today use materials such as FR4 insulating laminates for mounting the module components. While these insulating laminates / LGA form factors provide ease of routing of signal traces of the components within the module, their ability to dissipate heat is limited due to the high thermal resistivity of the FR4 laminate and the limited conduction area of the copper vias that run from the components to the external pads of the package. Conversely the leading high power modules such as those offered by Intersil utilize a QFN style leadframe where the power devices are mounted directly to a copper leadframe, offering both a low thermal resistivity and very large conduction surface area to allow for efficient heat transfer. The difference in these packaging technologies is obvious when comparing high ambient temperature derating characteristics of the devices manufactured with each construction method. The improved thermal efficiency inherent to packages utilizing the copper leadframe package enables these devices to operate at rated output power levels to a much higher ambient temperature without derating versus similar laminate-based modules.

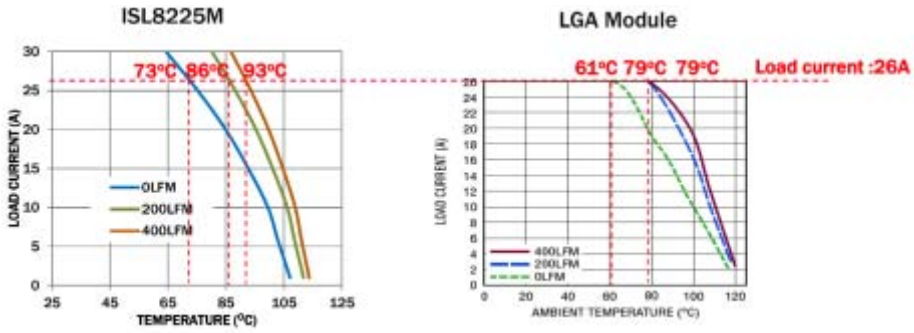

Figure 2: The ISL8225M can easily provide 30A of current in a dense 17mm x 17mm footprint.

Lack of heat sink/airflow requirements allow flexibility in placing solutions where needed or where space is available instead of where the air flow is available. Conversely, having airflow available allows these modules to operate in either a higher ambient temperature environment or at a higher maximum operating power.

An added benefit of the QFN style packaging over the LGA form factor and footprint is that all of the signal leads come out to the edge of the package vs the "hidden" land patterns under the device with an LGA. The benefit of lead access at the edge of the package is it enables both visual inspection of all solder joints, removing the need for x-ray inspection of the joints while also providing test probe access for initial system analysis & board debug.

Encapsulated modules are significantly more mechanically rugged than open frame modules and can be handled with auto pick and place equipment; in many cases this can eliminate a manual placement step needed with through hole open frame modules.

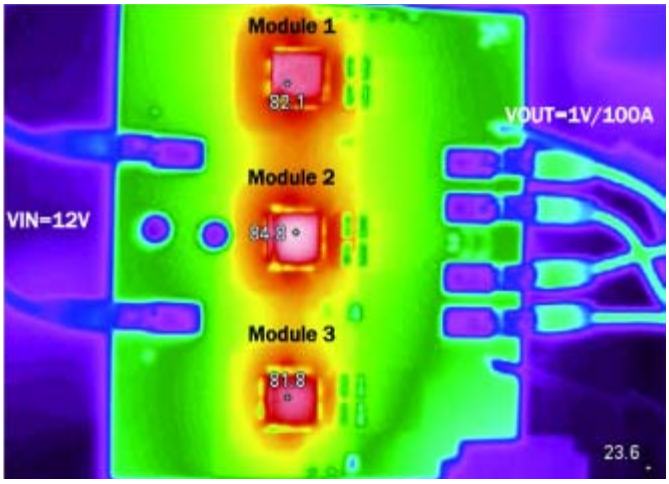

Figure 3: The ISL8225M utilizes a voltage-mode loop to regulate the output voltage. An additional current loop ensures current and thermal balance between phases and among modules, as shown in the thermal image.

Flexibility to utilize similar power solutions without having to implement a major design overhaul can significantly reduce a system designer's development time. Cascading multiple modules can provide higher power but does it come at significant design complexity? The latest generation controllers that are utilized in the ISL8225M allow for cascading of up to 6 modules for a total of 180A output with minimal system design changes. Clock synchronization between devices is automatically handled by tying the clockout (CLKOUT) of the master device to the sync pins of the slave devices; the integrated controller handles clock synchronization and automatically adjusts the phase relationship between outputs to produce fully interleaved multi-phase operation. With two phases per module the auto phase shift can handle up to 12 phases (6 modules) with all being offset by 30 degrees; this significantly reduces output ripple and instantaneous power loads on the input supply. Connecting the current share (ishare) pins of each of the modules also accomplishes automatic current sharing via a proprietary algorithm resulting in all of the cascaded modules output current being within +/-10% of each other, minimizing transient spikes during load transitions and maximizing thermal uniformity across the board. The result of this balance can be shown in fig 3 on a three module evaluation board running at 100A total load with the modules all operating within 3 degrees of each other. The uniform heat dissi-

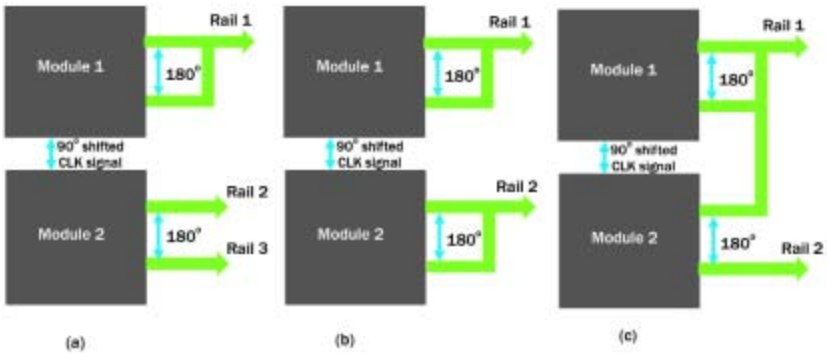

Figure 4: The flexibility and high level of integration contribute to ease of use.

pation and minimal external components allows for modules to be placed in relatively close proximity to each other. This is accomplished with no additional circuitry to manage current sharing, clock synchronization or phase shifting!

ISL8225M utilizes a voltage-mode loop to regulate the output voltage, with a special current loop to balance the current between phases and achieve accurate current sharing. Unlike most voltage-mode controlled power supplies, the current loop of ISL8225M provides the flexibility to parallel the outputs in different combinations by connecting the ISHARE pins of each module together. The ISL8225M can be easily programmed to realize phase interleaving, reducing input/output ripple and filter requirements. In figure 2, a 2-module design is shown to highlight the flexibility available to system designers. The CLK signal of the 2nd module can synchronize to the 90° shifted CLK signal from the 1st module; the internal 2 phases of each ISL8225M module operate with 180° phases shift. In this configuration, all four phases are evenly interleaved. ISL8225M also provides the flexibility to combine the outputs to supply more current for certain rails, to meet a wide variety of design requirements. Two ISL8225M can provide 4 rails with each at 15A or 1 rail at 60A; two ISL8225M modules can also be programmed to provide 3 rails (30A, 15A, 15A), 2 rails (30A, 30A), or 2 rails (45A, 15A). The ISL8225M makes the design the complicated system power supplies very straightforward.

The flexibility, electrical and thermal performance, and high level of integration all contribute to ease of use, enabling board designer who are not power experts to design dense, high performance power supplies. Intersil also provides several design tools to support board designers using our power modules. iSim is Intersil's design simulation tool that is available to be run from the www.intersil.com web site, or that can be downloaded and run on customers' PCs. The iSim tool also includes an extremely simple auto design interface that enable board designers to generate a schematic, BOM, and simulations by specifying only Vin, Vout, and Iout. Evaluation board that demonstrate typical single output, dual output, and three cascaded module operation are also available; schematic, BOM, and layout files for each of these boards can be download and can be used as reference designs.

In summary, power modules can provide a dense, easy to use solution for high performance power conversion needs. High levels of integration, and a suite of easy to use design tools dramatically increase the rates of first pass power design success, and enable quick board designs and fast time to revenue.

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Elegant Power Solutions Cut Energy Consumption of Low-Power Wireless Applications

Low-power wireless applications have become very popular in the industrial sector (e. g. wireless metering) and consumer applications, including multi-functional remote controls and gaming devices. For cost and reliability reasons, these applications will continue to be powered by primary batteries, or increasingly by rechargeable batteries.

By Markus Matzberger, Texas Instruments Deutschland GmbH

Traditionally, the system components were directly powered by the battery. However, the system's power consumption and battery lifetime can be improved using a new generation of switching converters which do not degrade the performance of the RF ICs.

This article introduces two power-supply concepts which are based on RF-compatible switching converters and can be powered by primary cells or rechargeable batteries.

The typical current profile of a low-power RF IC is depicted in Figure 1. Among other functional elements, the CC2540 Bluetooth Low-Energy System on Chip (SoC) integrates a 2.4GHz RF transceiver and a MCU. The device spends most of its time in the sleep mode with current drain of only 0.4µA. In the active state, however, current peaks of up to 17mA occur in the transmit and receive modes. Although the basic current profile may be typical for a low-power RF application, the timing of the sleep, Tx and Rx modes will vary depending on the RF protocol and RF standard. The selected transmission level will also influence the peak current drain in the Tx mode.

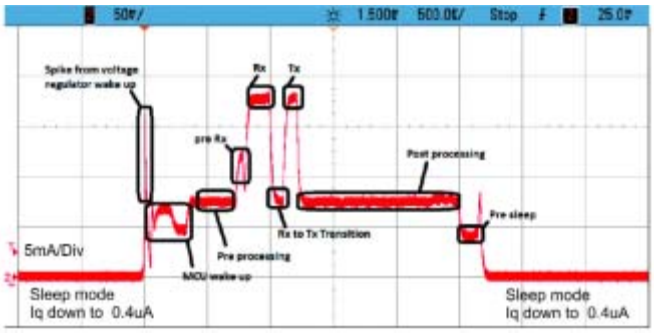


Figure 1: Current Profile of the CC2540 Bluetooth Low-Energy System on Chip (SoC)

Low-power RF ICs including the CC2540/41 usually operate at voltages ranging from 2V to 3.6V. For this reason, they were directly connected to a 3V or 3.6V battery in the past. In the active state (i. e. in the Tx, Rx or data-processing mode), the power consumption of an RF IC can be optimized by minimizing its operating voltage (e. g. 2.1V).

Figure 2 illustrates a novel power-supply concept. It is based on a buck converter maintaining a constant supply voltage of 2.1V for the RF system in the active state. This is accompanied by a parallel bypass switch which directly connects the system to the battery in the sleep mode. As the power consumption of the bypass switch is almost zero in the sleep mode, it has only a negligible impact on the power consumption of the system as a whole. This power-supply concept has been integrated into the TPS62730.

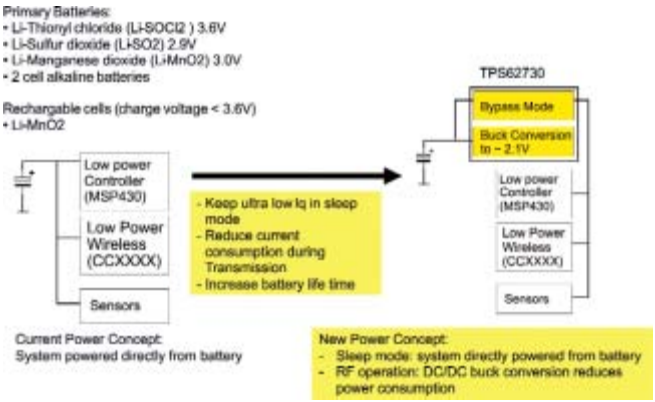


Figure 2: Power-Supply Concept Based on a Buck Converter and a Bypass Switch

In low-power RF applications, the buck converter must meet specific requirements including:

- High efficiency
- No degradation of the system's RF performance
- Small size (resulting from the use of small inductors and capacitors)
- Minimum power consumption in the bypass mode

The device meets these requirements by providing the following features:

- Bypass-mode current drain of 30nA (typical)
- Bypass switch with a typical ON resistance of 2.1Ω
- Efficiency up to 95%
- RF compatibility achieved by
  a) High switching frequency (up to 3MHz)
  b) Low output ripple voltage (<15mVpp)
- Pre-selected, fixed output voltage using an integrated feedback voltage divider (which can be disabled)
- Small-sized external components (L=2.2µH; COUT=2.2µF)

According to Figure 3, the current drain from the battery can be reduced by up to 33% (depending on the battery voltage) regardless of the Tx level if the TPS62730 switching converter is used. A comparable power reduction is achieved in the Rx mode.

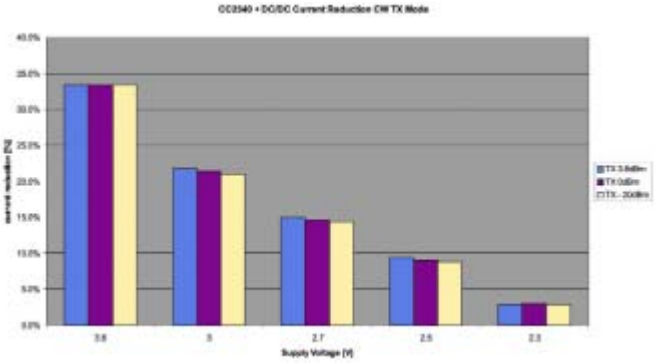
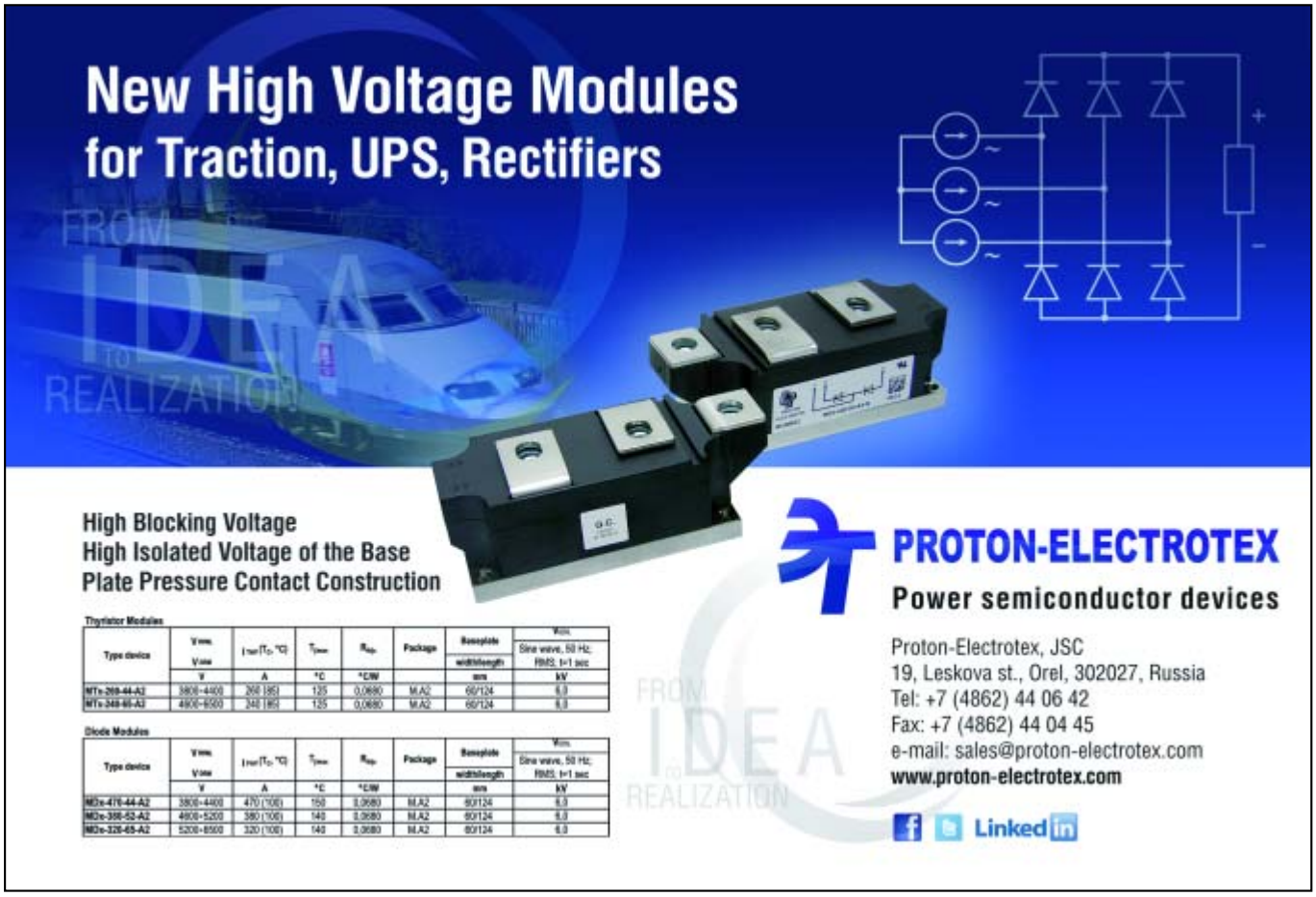


Figure 3: Reducing the Current Drain from the Battery Using a Switching Converter

The implementation of the switching converter accompanied by the CC2540 RF SOIC is illustrated in Figure 4. A power-down signal provided by the CC2540 controls the operating mode of the TPS62730 (bypass or switching-converter mode).

Low-power wireless applications often use lithium-based primary batteries including lithium thionyl chloride (Li-SOCl2 – 3.6V) or lithium manganese dioxide (Li-MnO2 – 3.0V). Even though the peak current consumption of these applications is only several tens of mA, the increasing internal resistance of the batteries during the discharge



process must be considered in order to achieve the desired battery lifetime. Fig 5. compares the pulse load behaviour of a new and a 90% discharged 3.6V lithium thionyl chloride (Li-SOCl2) battery. The internal resistance can increase so much that the battery is unable to provide the energy required for the Tx and Rx mode of the RF IC. Pulsed loads thus result in severe voltage dips making the system inoperable. Thus, the energy remaining in the battery cannot be used. To prevent this, a buffer capacitor (CBUF, see Fig. 4) must be connected in parallel with the battery. This capacitor should be able to provide the energy required during a pulse load event with an acceptable voltage dip (approx. 100mV).

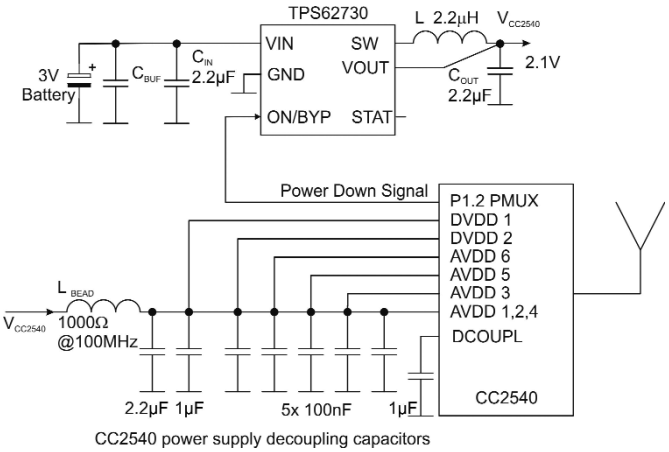


Figure 4: System-Level Implementation of the Switching Converter

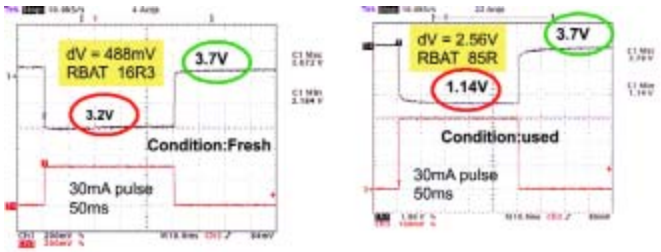


Figure 5: Pulse Load Behaviour of a Lithium Thionyl Chloride (Li-SOCl2) Battery (1.2Ah; ½AA Form Factor)

Complex low-power wireless systems consisting of MCUs, RF transceivers, accelerometers, GPS receivers, displays etc. are characterized by an increasing peak and sleep-mode current drain. In these applications, there is a growing trend towards replacing primary cells (e.g. coin cells) with rechargeable Li-ion or Li-polymer batteries supporting higher pulse currents. However, the typical charge-termination voltage of these batteries of approximately 4.1V to 4.2V exceeds the maximum supply voltage of most low-power RF ICs. In addition, it is a frequent requirement that the system be powered from an external source (e. g. 5V USB) during the charging process.

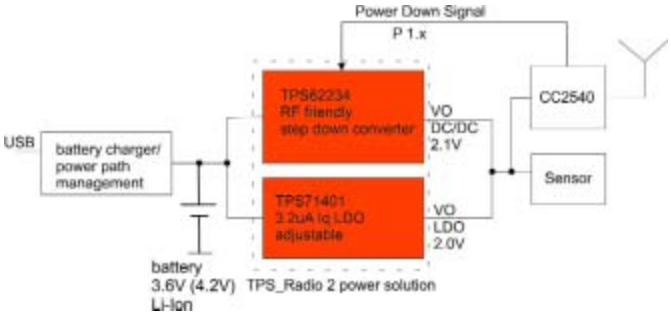


Figure 6: Power-Supply Concept Based on an RF-Compatible Switching Converter and an LDO

In this case, a power-supply concept based on a low-Iq LDO and an RF-compatible switching converter can be used (see Fig. 6). The LDO with a quiescent current of 3.2µA is always on, supplying the system with a voltage of 2.0V in the sleep mode. The RF-compatible switching converter, on the other hand, would draw a quiescent current of 22 µA. Controlled by the system, the switching converter is enabled whenever the system requires more current after a wake-up. Delivering a regulated voltage of 2.1V, the switching converter supplies the increased load current to the system. Fig. 7 illustrates the efficiency of the LDO and the switching converter depending on the load current. While the efficiency of the LDO is better below 100µA, the switching converter is more efficient at higher load currents.

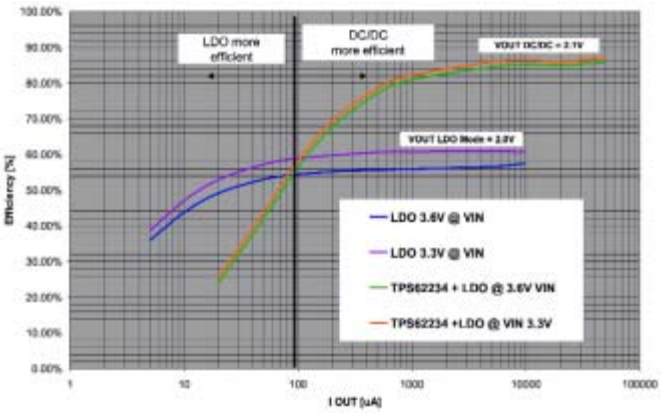


Figure 7: Efficiency of the Power Supply Based on an LDO and a Switching Converter

Summary

The power consumption of low-power RF ICs can be reduced by optimizing their supply voltage. The current drain from the battery is reduced using a suitable RF-compatible switching converter, thereby increasing the battery's lifetime. The article proposes a solution for operating RF ICs on batteries whose source voltage exceeds the RF IC's supply voltage range.

Since 2004, Markus Matzberger is working as a System Engineer in Texas Instruments' Product Definition Sector. He is also developing low-power DC/DC switching converters.

Contact him at m-matzberger@ti.com

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TPS62730 Product Folder: http://www.ti.com/product/tps62730
AN097 - Current Savings in CC254x Using the TPS62730 (Rev. B)
Using a DC-DC Converter to Reduce Power (Current) Consumption In CC430 Systems
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Vendor Positions in the High Voltage GaN Commercialization Race

High voltage GaN-on-Si HEMTs, ICs, and modules for power conversion applications

The race to commercialize GaN-on-Si technology for power conversion applications continues at an intensified pace. As of December 2012 more than twenty semiconductor vendors have participated in this race led by a group of about seven vendors. Vendor positions on the commercialization timeline are determined by a number of technology and business aspects.

By Steve Levin, Managing Director – Power, Petrov Group

Technology aspects

On the path to commercialization each competitor faces a range of obstacles, which it has to mitigate. This requires technological know-how, financial resources, and time. The type and magnitude of these obstacles vary widely among the competing vendors.

Technology-related obstacles typically dominate the commercialization of new advanced technologies such as GaN-on-Si for use in power conversion applications. Technology barriers to commercialization vary among vendors depending on their core technology expertise.

The figure 1 illustrates technology barriers to device design and manufacturing of high voltage (more than 600V) GaN-on-Si HEMTs for power conversion applications.

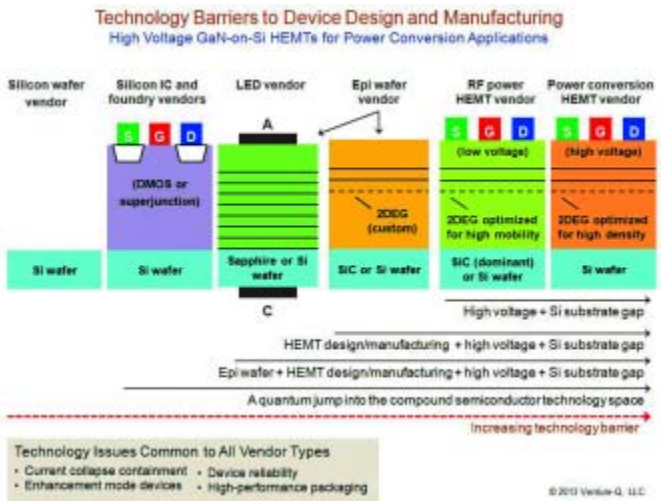

Figure1: Source: Technology Barriers, Venture-Q® LLC (www.venture-Q.com)

RF power HEMT vendors are the closest to commercialization of high voltage GaN-on-Si HEMTs for power conversion applications because they have to bridge only two technology barriers: (1) voltage (from less than 400V to 600V to 1,200V range), and (2) substrate type (from typically SiC to silicon).

The first commercially available RF power GaN-on-SiC devices emerged in 2004 (the formation of Eudyna, a Fujitsu spin-off). Eight years later there are no commercially available high voltage GaN power devices, either on silicon or on SiC wafers, for power conversion applications. This illustrates that even vendors closest to commercialization face a significant time to bridge only two technology barriers. All follow-up vendor types (e.g., epi wafer and LED vendors) face an even longer time to commercializing GaN-on-Si HEMTs for power conversion application.

Technology and manufacturing issues common to all vendor types could make a significant impact on the time-to-commercialization. They include:

- Current collapse containment, which since the late 1990s has remained a major obstacle to commercialization on high voltage GaN-on-Si HEMT power devices
- Development of enhancement mode (E-mode) devices versus the silicon MOSFET cascoded depletion mode (D-mode) devices
- Device reliability validation, which requires a significant amount of time
- Development of advanced high-performance device and module packaging required to fully exploit the benefits of the GaN HEMT power technology.

Business aspects

A competitor's business aspects also strongly influence the time-to-commercialization. These include the business model and strategy, commercialization motive (i.e., driver), allocated financial resources, R&D and manufacturing capabilities, and reliability validation.

Business model and strategy

Time-to-commercialization could differ significantly among vendors pursuing a foundry vs. merchant device vendor business. Similarly, a business acquisition and/or partnering vs. an organic growth strategy could also impact the time-to-commercialization, for example, acquisition of an epi wafer vendor.

Commercialization motive (the driver)

The primary near-term market for GaN-on-Si power HEMTs is replacement of superjunction (SJ) silicon power MOSFETs.

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The commercialization motive of a well-entrenched and dominant SJ MOSFET vendor (e.g., Infineon and STM) could be defensive while that of a newcomer (e.g., IRF) could be offensive. This could result in a different time-to-commercialization.

R&D and manufacturing capabilities
A resolution of the above described technology issues requires substantial R&D expertise and effort as well as manufacturing capability, which could affect time-to-commercialization.

Vendor positions on the High Voltage GaN commercialization timeline (as of Dec. 2012)
A vendor position on the commercialization timeline indicates how close a vendor is to selling high voltage GaN-on-Si devices for use in power conversion applications in the merchant market. This means offering products that could be purchased either directly from the vendor or from its distributor. As of December 2012, only Efficient Power Conversion (EPC) offers such products (sub-200V eGaN® devices sold by Digi-Key distributor).

Ten factors used for determining a vendor's position on the commercialization timeline as of December 2012 are:

1 Dynamic Rdson, <1.2 static Rdson representing a degree of containment of the current collapse phenomenon
2 650V or more operating BVds capability
3 Enhancement mode (E-mode) HEMTs (diodes don't count!)
4 Reliability validation
5 Commercial grade product availability (purchasable direct or via a distributor without NDAs, published datasheets)
6 Silicon wafer based devices (i.e., not SiC wafer based)
7 Business model (offensive vs. defensive)
8 Commercialization motive (i.e., driver)
9 R&D capability relevant to GaN-on-Si power devices for power conversion applications
10 Manufacturing capability relevant to GaN-on-Si power devices (e.g., in-house epi wafer manufacturing)

Vendors in the GaN commercialization race differ in degree of how they mitigate each of the ten commercialization factors. An aggregate rating of each of the ten factors provides a strong indication of a vendor's position on the commercialization timeline (shown in the figure below approximately scaled by the total rating values).

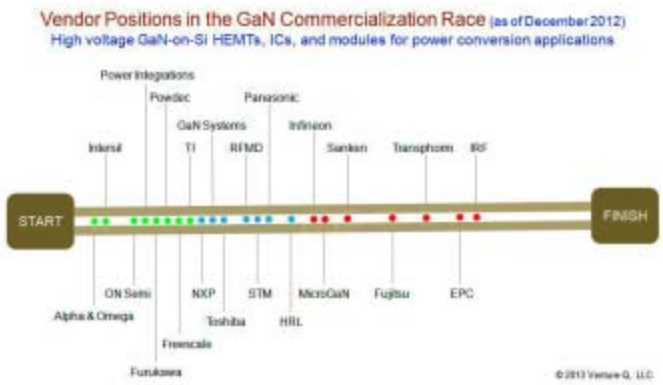

Figure 2: Vendor Positions, Source: Venture-Q® LLC (www.venture-Q.com)

The shown 22 vendors are, as of December 2012, engaged in commercialization of high voltage GaN-on-Si HEMTs, ICs, and modules for power conversion applications. Their engagements range from patent filing activity to device manufacturing. Device types include discretes, ICs, and modules. IC types include monolithic integration of GaN HEMTs only and hybrid monolithic integration of GaN HEMT and silicon devices.

The figure reveals three major vendor groups:
Group 1 The leading seven vendors, International Rectifier (IRF), Efficient Power Conversion (EPC), Transphorm, Fujitsu Semiconductor, Sanken Electric, MicroGaN, and Infineon, focus on discrete power devices and modules for power conversion applications.

Group 2 A group mainly consisting of the current RF power GaN vendors, including: HRL Laboratories, Panasonic, STMicroelectronics (STM), RF Micro Devices (RFMD), Toshiba, GaN Systems, and NXP. GaN Systems is the only pure-play GaN device vendor addressing power conversion applications.

Group 3 A group mainly consisting of silicon IC vendors, including, Texas Instruments (TI), Freescale, Powdec, Furukawa, Power Integrations, ON Semiconductor, Intersil, and Alpha & Omega Semiconductor (AOS). Powdec and Furukawa are the only non-IC vendors. Silicon IC vendors explore and/or develop monolithically integrated GaN HEMTs with silicon devices for power conversion applications.

Time-to revenue and profit implications
The high voltage GaN commercialization race, unlike its low voltage counterpart, has significant time-to-revenue and profit implications for the participating vendors. An early entry into a market rich in power conversion applications would result in a highly differentiated competitive advantage with significant financial rewards. These applications range widely from general lighting to automotive, solar energy, and industrial power systems. Therefore, we expect the pace of the race to intensify in 2013 and beyond among the current participants and new vendors joining the race.

This article is based on the first two reports of a six-report set, titled "Competitive Landscape" and "Vendor Analyses," published by Venture-Q® LLC (www.venture-Q.com). The six-report set is the industry's first to exclusively focus on the commercialization of high-voltage GaN-on-Si technology for power conversion applications.

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Simplifying Safety Certification for New Appliance Designs

IEC safety standards for electrical appliances permit system self testing, which can help save the cost of implementing sensors to detect abnormal operation. Software and firmware-based safety functions provided by microcontroller or system-on-chip vendors can further simplify the designer's task

By Alberto Guerra, VP Strategic Marketing Development and Ali Husain, System Design Manager, International Rectifier

Introduction: Appliance Safety Standards

Domestic appliances such as dishwashers and washing machines, as well as some types of non-household appliances such as dryers and commercial cleaning equipment, are required to meet basic and functional safety requirements as set out by the international standards IEC 60335-1 and IEC 60730-1.

The applicable standards create a distinction between basic safety and functional safety. Basic safety generally refers to risk of fire, electric shock or bodily injury, and is generally related to overheating of the motor and thermal stress on the winding insulation. In most cases these effects result from conditions such as jamming of the rotor leading to abnormally high current, or phase loss where one of the motor windings is disconnected or shorted out due to damage or degradation of insulation.

The traditional technique for preventing motor windings and insulation from overheating is to use a temperature sensor in the motor. This adds cost and increases system complexity. In addition, the chosen temperature sensor should be a component recognised by the certifying body. To avoid such costs and complications, phase loss detection, locked rotor detection and general overload detection are often implemented in software.

Functional safety refers to the risk associated with the normal operation of the product by the end user. In a dishwasher application, for example, the user may open the main door during the washing cycle to add or remove dishes. The inverter circuit controlling the main circulator pump needs to have a reliable motor speed signal to ensure that, by the time the door is open, the pump speed is reduced to avoid extremely hot water getting out of the washer. Similarly for a washing machine, if the door lock is released while the drum is still rotating, to allow access to clothes, this can create a hazard to the user's arm. Hence motor speed control is considered within the scope of functional safety.

Modern practice, when implementing speed control, is to avoid the use of Hall sensors in order to save cost and complexity. Hall sensors also tend to be relatively unreliable, particularly at high temperatures. Sensorless speed control executed in software – and typically applied via a sinusoidal inverter drive to a Permanent Magnet (PM) motor so as to ensure high energy efficiency and low audible noise - is therefore becoming pervasive in modern appliances.

The precise safety standards that apply, in cases where any part of the basic safety functions is performed by software, are IEC 60335-1 Annex R and IEC 60730-1 Annex H Class B. To comply with these standards, the automatic control system for the appliance must include in its code all necessary elements to prevent unsafe operation without relying on any external redundant sensors or independent circuits. This can be achieved through the use of low-level self-test routines that periodically verify correct operation of the system.

Speeding-up Software Safety Certification

Vendors of microcontrollers optimised for use in appliances have begun providing ready-made self-test routines as software utilities, which may be added to the application code thereby saving significant software development effort. This approach can help speed up product testing and reduce the cost of achieving certification according to the IEC safety standards.

Microcontrollers positioned for use in domestic appliances often provide peripheral features such as timers, PWM blocks and ADCs needed to control the inverter driving the appliance motor. The Vector Control, or Field-Oriented Control (FOC), algorithm responsible for generating the motor-driving signals, however, is often implemented in software. A suitable algorithm may be provided by the microcontroller vendor, or the appliance designer may need to develop or source the algorithm independently. The appliance designer must also take care of other aspects of the motor controller, such as building and integrating the gate driver and power stage. These can be time consuming aspects of a project that also demand specialised design skills.

Alternatively, an appliance system-on-chip solution implementing a significant proportion of motor-control functions in configurable hardware can help designers overcome challenges such as developing FOC code and integrating the power stage.

An example of such a solution is IR's IRMCK171, a One-Time Programmable (OTP) mixed-signal IC optimised for sensorless sinusoidal motor control in domestic and commercial appliances. This digital control IC is connected to an Intelligent Power Module (IPM) comprising an inverter power stage and gate driver built using HVIC technology, effectively creating a hardware chipset for appliance control. The ICs are part of IR's iMotion™ integrated design platform, which provides everything needed to produce complete variable-speed motor-control subsystems for applications up to 2.2kW. Figure 1 shows how the functions of the digital control IC and integrated power module combine to control a permanent magnet motor.

The IRMCK171 features a 60MIPS, 8-bit 8051 microcontroller for hosting application-level functions, co-integrated with IR's patented Motion-Control Engine (MCE™). The MCE implements an FOC algorithm in hardware. In addition to simplifying motor-control design, the hardware-based FOC also ensures faster execution resulting in improved motor torque and speed control. The 8051 microcontroller operates almost independently of the MCE and does not compete for system resources such as interrupts or internal registers.

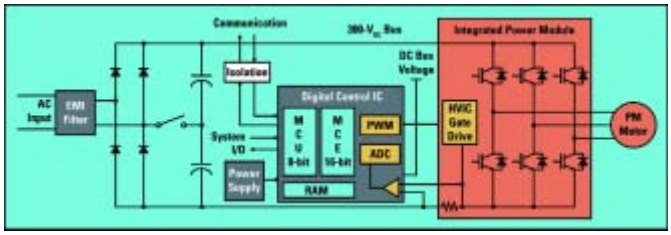


Figure 1: The digital control IC relieves software coding and power-electronic design challenges.

Working in conjunction with the MCE is an Analog Signal Engine (ASE) that integrates all the signal conditioning and conversion circuits required for single current shunt, sensorless control of a PM motor.

Built-in IC Tests

To help designers accelerate safety certification in accordance with IEC 60335-1 Annex R and IEC 60730-1 Annex H Class B, the IRMCK171 is supplied with source-code level self-test routines.

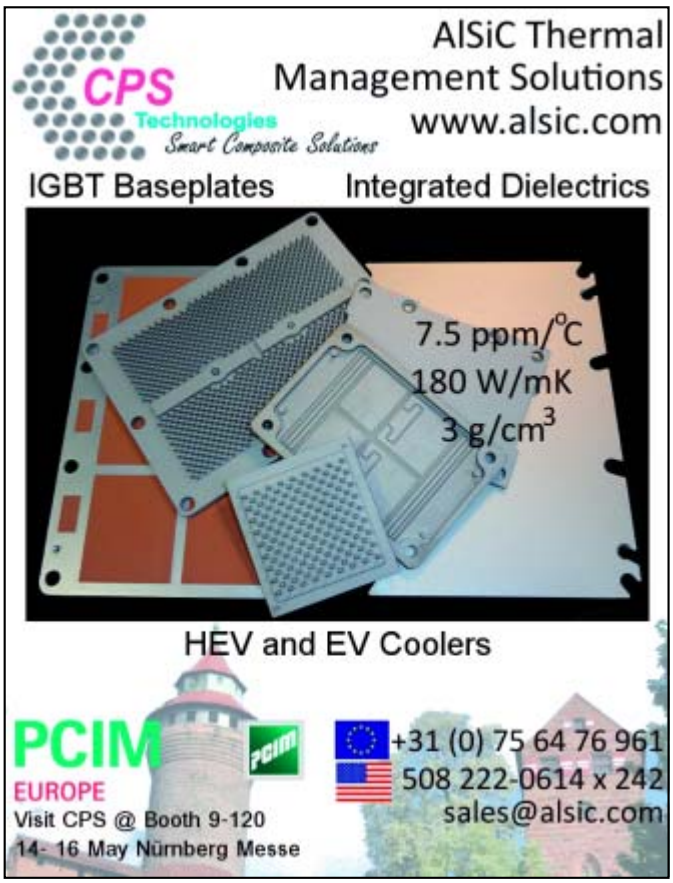
For the 8051 part of the IC, the self-test routines are provided in the form of libraries, effectively presenting a set of function calls that implement the required 8051 power-up and periodic self-tests (safety checks). This permits designers to implement an IEC-compliant 8051 application with minimal effort. Figure 2 shows the power-up and periodic self tests implemented by software running on the 8051.

Power-up Safety Check	Library Function(s)	Application Requirements
Initial Hardware Stack Check	Low-level assembly code in startupa51	Do not remove or modify safety checks in startupa51.
8051 Internal Registers Test		
8051 Internal Data RAM Test		
8051 Program Counter Test	doI8051PowerupTests	Call doI8051PowerupTests during system initialization.
External data RAM Test		
8051 Program Memory Test		
Clocks and Timers Test		
Periodic Safety Check	**Library Function(s)**	**Application Requirements**
Watchdog Timer	doI8051PeriodicTests	Call doI8051PeriodicTests on a regular periodic basis along with designated safety-critical functions.
8051 Internal Data RAM Test		
8051 Program Memory Test		
Hardware and Software Stack Checks		
Software Watchdog Test for logical monitoring of the program sequence	doI8051PeriodicTests, updateSoftWatch	Designated safety-critical functions must call updateSoftWatch.
Periodic Timers Test	doI8051PeriodicTests, registerStartTimer, registerStopTimer, doTimerService, doSysTimerService	Timer 0 interrupt service routine must call doSysTimerService; Timer 1 and 2 interrupt service routines must call doTimerService; if timer 1 and timer 3 are used, registerStartTimer and registerStopTimer must be called.

8051 Safety Check Summary

Figure 2: Microcontroller safety checks.

Power-up and periodic self tests are also required for the MCE. IR provides tests for the MCE that are built into firmware, rather than being supplied in library form. Since the MCE firmware is not user-modifiable, this approach provides additional safety assurance by eliminating any risk of programming errors. The MCE tests run in conjunction with the functions of the 8051 library, since the 8051 self-test library functions control and manage the MCE self-test functions automatically.



Of the two types of tests provided, the power-up tests execute once at system startup, immediately after power up or reset. Their purpose is to validate the basic functionality of the 8051 and MCE processors and memories. The periodic tests execute on a regular basis during normal runtime operation to monitor proper operation of system components, firmware and application software. Figure 3 lists the safety checks built into the MCE firmware.

Power-up Safety Check	Library Function(s)	Application Requirements
MCE Internal Registers Test	doMcePowerupTests	Call doMcePowerupTests during system initialization.
MCE Program Counter Test		
MCE Extended ALU Test		
MCE Program Memory Test		
External Registers Test		
Periodic Safety Check	**Library Function(s)**	**Application Requirements**
Data RAM Test	doMceIntService	MCE interrupt service routine must call doMceIntService to check MCE test results.
Software Watchdog Test (logical monitoring of the program sequence)		
External Registers Test		
MCE Program Memory Test		
ADC Test		
MCE Internal Registers Test		
MCE Extended ALU Test		

MCE Safety Check Summary

Figure 3: Motion Control Engine safety checks.

Conclusion: Savings in Cost and Time

By taking advantage of pre-developed self-test routines, designers can simplify and shorten the processes that must be followed to obtain the required safety certifications from a recognised test house. When included as part of a dedicated appliance control platform based on a programmable mixed-signal IC that provides solutions to key motor control and power integration challenges, this approach can yield dramatic savings in development costs, project duration, and time to market.

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Advanced Power Quality Analysis Tools

Test sourcing specialist Livingston has further expanded the portfolio of power quality test equipment offered to its customers. The company has announced availability of the Fluke 437 Series II handheld energy analyser to rent through its Europe-wide supply chain. Supporting 400Hz operation, this model is optimised for aerospace, defence and other space-constrained mission critical applications, which often need to utilise higher power frequencies so that the transformers and motors specified can be smaller and lighter.

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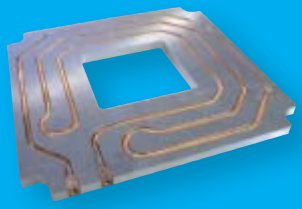

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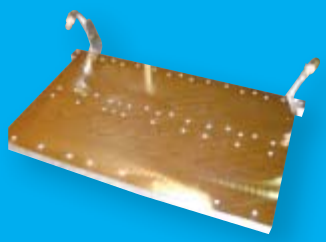

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Three-Phase IR3230SPbF Gate Drive IC Simplifies eBike Design

International Rectifier has introduced the IR3230SPbF three-phase gate drive IC for eBike inverters providing efficient electric mobility. The IR3230SPbF is a highly integrated three-phase gate drive IC designed specifically to meet the needs of eBike inverters. The new device offers input range up to 60V, enabling operation from 48V battery systems, regeneration mode to recharge the battery, and the integration of many protection features to reduce component count and improve system reliability.

The IR3230SPbF integrates the sensor interface and 120°/60° selection capability which eliminates the need for a programmable logic array, and simplifies the control scheme while an integrated charge pump enables the removal of three electrolytic capacitors required in a typical system.

The IR3230SPbF is available in an SOIC28 package featuring an environmentally friendly, lead-free and RoHS compliant bill of materials. A datasheet, qualification standards, Spice Model and design tool are available on the International Rectifier website at www.irf.com. Production orders are available immediately.

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Industry's Smallest Bipolar, Beyond-the-Rails ADCs

Maxim Integrated Products, Inc. announced that it is now shipping the MAX11166 and MAX11167, the industry's smallest bipolar ±5V, 16-bit analog-to-digital converters (ADCs). Available in a tiny 9mm2 package, the MAX11166 and MAX11167 are the only 12-pin 16-bit bipolar ADCs to integrate an internal reference with buffer, saving cost and at least 88% board space over competing solutions. These highly integrated ADCs feature Beyond-the-Rails™ technology, which supports ±5V input signal from a single positive 5V rail. This technology eliminates the need for negative power supplies and simplifies designs. At 19.5mW, 500ksps, and 1µA in shutdown mode, the ADCs are applicable for precision measurement data acquisition systems (DASs), industrial/process control, medical instrumentation, and automatic test equipment (ATE).

The MAX11166 and MAX11167 communicate using an SPI-compatible serial interface at 2.5V, 3V, 3.3V, or 5V logic levels and have sample rates of 500ksps and 250ksps, respectively. The serial interface can be used to daisy-chain multiple ADCs for multichannel simultaneous-sampling applications; it also provides a "busy" indicator option for simplified system synchronization and timing. Maxim's proprietary input-charge-pump architecture allows direct sampling of high-impedance sources, eliminating the need for external analog buffers to drive the ADC inputs in some applications.

www.maximintegrated.com

Compact Chassis Mount Ac-Dc Power Supplies Ease Installation in Challenging Environments

CUI Inc announced the release of five new series of encapsulated ac-dc power supplies ranging from 5 W to 25 W. The VSK-T family

is housed in a potted and encapsulated chassis mount package, providing a convenient mounting solution when a dedicated circuit board for the power system is either not feasible or is cost prohibitive. The units are compact, measuring as small as 76 x 31.5 x 24 mm (2.99 x 1.24 x 0.94 in) in the 5 W series. The package design also protects against environmental factors such as dust, moisture, and shock and vibration, making these ac-dc modules ideally suited for use in a range of low power ITE, industrial, security and transport applications.

The VSK-T family provides a universal input of 85 to 264 Vac and fully regulated dc outputs of 3.3, 5, 9, 12, 15, 24, and 48 Vdc depending on the series. The modules reach efficiencies of up to 87% and carry UL/cUL and CE 60950-1 certifications. Protections for over voltage, over current, over temperature and short circuit are included as well as isolation voltages of 4K Vac in the 5 and 10 W versions and 3 K Vac in the 15, 20, and 25 W versions. The VSK-T family is available immediately with prices starting at $8.90 USD for 1000 pcs.

www.cui.com

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- Clip-soldered die technology
- Less weight
- Optimized heatsink & DCB construction
- 93 mm x 65 mm x 50 mm (L x W x D)
- M10 screw connections

Applications

- Input rectification
- AC-Control
- Motor control, softstarter

TYPE	I_{TAVM}	V_{RRM}
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MCMA 600 PD 1600CA	600	1600
MDMA 600 P 1600CA	600	1600

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ECPE Calendar of Events 2013: Topics & Dates

Date	Location	Event	Topic
6 – 7 Feb. 2013	La Rochelle, France	**Conference**	**8th European Advanced Technology Workshop on Micropackaging and Thermal Management**
Feb. 2013 (week 9)	Switzerland	**ECPE Tutorial**	**Power Semiconductor Devices & Technologies** Chairman: Prof. D. Silber (Univ. of Bremen)
March 2013 (week 10)	Reutlingen, Germany	**ECPE Tutorial**	**Power Electronics Packaging** Chairman: Dr. U. Scheuermann (Semikron)
March 2013 (week 11)	Kassel, Germany	**ECPE Workshop**	**Power Electronics in the Electricity Network (Renewables, Energy Storage, Grid Stability)** Chairman: Prof. P. Zacharias (Univ. of Kassel)
3 – 4 April 2013	Paris, France	**Conference**	**APE - Automotive Power Electronics**
17/18 April 2013	Nuremberg, Germany	**ECPE Annual Event**	**ECPE Annual Event 2013 – 10th Anniversary**
22 – 23 April 2013	Berlin, Germany	**ECPE Lab Course**	**EMC Optimised Design (Parasitics in Power Electronics)** Course Instructor: Dr. E. Hoene (Fraunhofer IZM)
2 – 3 May 2013	Munich, Germany	**ECPE Workshop**	**ECPE SiC and GaN User Forum** Chairmen: Prof. A. Lindemann (Univ. of Magdeburg), Prof. L. Lorenz (ECPE)
14 – 16 May 2013	Nuremberg, Germany	**Conference & Exhibition**	**PCIM Europe 2013** **Conference and Exhibition with ECPE Students Day**
27 - 31 May 2013	Gaeta, Italy	**Recruitment Event**	**14th European PhD School on ´Power Electronics for Electrical Machine and Energy Control´**
June 2013 (week 26)	Erlangen, Germany	**ECPE Tutorial**	**Thermal Engineering of Power Electronic Systems - Part I (thermal design and verification)** Chairmen: Dr. M. Maerz (Fraunhofer IISB), Dr. U. Scheuermann (Semikron)
June/July 2013	TBD	**ECPE Workshop**	**Lifetime Modeling and Simulation** Chairman: Prof. E. Wolfgang (ECPE)
3 – 5 Sep. 2013	Lille, France	**Conference**	**EPE'13 - ECCE Europe** **15th Conference on Power Electronics and Applications**
Sep. 2013 (week 38/39)	Hamburg Germany	**ECPE Tutorial**	**Reliability of Power Electronic Systems** Chairman: Prof. E. Wolfgang (ECPE)
October 2013	Nuremberg, Germany	**ECPE Tutorial**	**Thermal Engineering of Power Electronic Systems - Part II** (thermal management and reliability) Chairmen: Prof. E. Wolfgang (ECPE), Dr. U. Scheuermann (Semikron)
October 2013	Grenoble, France	**ECPE Tutorial**	**EMC in Power Electronics** Chairmen: Dr. E. Hoene (Fraunhofer IZM), Prof. J.-L. Schanen (G2ELab)

ECPE European Center for Power Electronics e.V., Landgrabenstr. 94, 90443 Nuremberg, Germany
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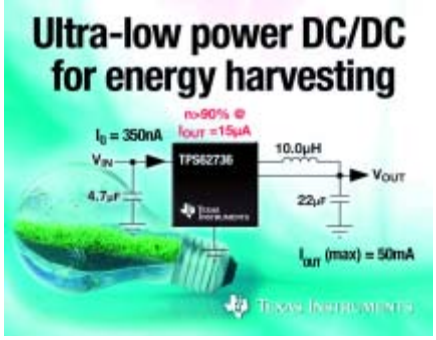
TI Ultra-Low Power Converter to Accelerate Energy Harvesting Designs

Answering the question, "How low can you go with power?" Texas Instruments Incorporated (TI) (NASDAQ: TXN) today introduced the industry's lowest power DC/DC step-down converter, which increases the amount of harvested energy an end application can use as much as 70 percent over alternative devices. The ultra-low power circuit enables battery-free power to applications, such as wireless sensor networks, monitoring systems, smoke detectors, wearable medical devices and mobile accessories.

TI's TPS62736 DC/DC converter delivers high power conversion efficiency from 10 uA to 50 mA output currents, and consumes only 350 nA of active current and 20 nA during standby. The converter achieves greater than 90-percent efficiency across output currents higher than 15 uA. The TPS62736 regulator steps down the voltage from a power source, such as a thin-film or regular battery or a super capacitor and features a programmable output voltage.



Innovative power management, sensors and microcontrollers from TI are taking low-power design to the next level by optimizing extracted energy from ambient sources using the highest possible efficiency and lowest power consumption. In 2011, TI introduced its bq25504 boost charger circuit with a low quiescent current of 330nA, to allow start-up from single-cell solar cells under low light or thermoelectric generators with low temperature differences.

www.ti.com/innovation

Embedded Motor Control Devices and Tools Alongside Micros for Smart Metering

At Embedded World 2013 Toshiba Electronics Europe (TEE) will launch new devices and development tools designed to simplify and speed embedded motor control implementations in industrial control and home appliance applications. Visitors will also be able to see microcontrollers dedicated to reducing the component count of domestic, commercial and industrial smart metering applications. Among the devices on show will be the latest family of ultra-miniature ARM Cortex-M3 microcontrollers that combine on-board FOC (Field Oriented Control) capabilities with dedicated peripherals and functions that reduce system development time. Smart meter microcontrollers will include devices built around the ARM Cortex™-M0 32-bit core that replace traditional two-chip analogue front end (AFE) and processor implementation with a single chip. embedded World 2013: Hall 4, Booth 534

www.toshiba-components.com

Compact DIP4 Photorelays with 5000V Isolation

Toshiba Electronics Europe (TEE) has announced a new series of photorelays that provides a minimum input-to-output isolation voltage of 5000Vrms (AC, 1 min) for reinforced insulation. Devices in the TLP220 series are supplied in a compact DIP4 package that measures just 7.6mm x 4.6mm x 3.7mm. Clearance and creepage distances are 7mm as standard with the option of 8mm in the case of the TLP220AF.

The photorelays suit designs where engineers want to replace a mechanical relay with an optically isolated part to meet reinforced insulation safety requirements. Target applications will include smart meters, factory automation systems, test and measurement equipment, security systems and gaming and entertainment products.

Featuring minimum blocking voltages of 60V, 200V, 350V, 400V and 600V respectively, the TLP220A, TLP220D, TLP220G, TLP220GA and TLP220J each consist of a photo MOSFET that is optically coupled to an infrared LED. Respective maximum on-state currents are 500mA, 250mA, 100mA, 120mA and 90mA.

The photorelays have a low maximum LED trigger current of just 2mA, contributing to energy-efficient designs. All TLP220 devices feature a normally open (1-Form-A) configuration.

www.toshiba-components.com

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Automotive Constant-Current LED Driver IC with 3 A Output Current

The A6213 from Allegro MicroSystems Europe is a 3 A constant-current LED driver IC that has full AEC-Q100 automotive qualification and operates over a wide input voltage range from 6 to 48 V.
The new device is a DC-DC buck switching regulator that provides a constant-current output of up to 3 A for driving high-power LEDs. It integrates a high-side, N-channel, MOSFET switch, and includes a range of innovative fault protection features.
The design of the A6213 is optimised for automotive use, and is targeted at a variety of applications in this sector including map lights, daytime running lights, rear fog lamps, fog lights, cargo and under-hood lamps as well as "puddle" and emergency lights.
A true average LED drive current is output

using a cycle-by-cycle controlled "on" time method. The LED drive current is user-configurable using an external current sense resistor. The output voltage automatically adjusts to optimise constant-current supply to a wide variety of LED array configurations including multiple LEDs in series. Series LEDs can be configured in a single string or parallel strings using a balancing resistor.
LED dimming is accomplished via a direct logic input pulse-width-modulation (PWM) signal such as an automotive courtesy signal. PWM dimming and enable signals can range from logic level (1.8 V) to the input voltage level.
The A6213 provides load supply and gate drive undervoltage lockout protection, thermal shutdown protection, and load overvoltage protection (OVP).
The device is provided in a compact 8-pin narrow SOIC package (suffix LJ) with exposed pad for enhanced thermal dissipation. It is lead (Pb) free, with 100% matt tin leadframe plating.

www.allegromicro.com

5th Generation of the World's Best-Selling Power Meter

The WT300 series of digital power meters are the fifth generation of Yokogawa's best-selling compact digital power meters: instruments that play a key part in ensuring optimum standards of energy efficiency and conservation by measuring the power consumption of electrical equipment.

Combining accurate and reliable power measurement over a wide power range with flexibility, ease of use and a choice of communication interfaces, the new instruments will help developers and manufacturers of electrical equipment – ranging from domestic "white goods" to lighting systems and air-conditioning equipment – to ensure that their products comply with emerging IEC and EN standards and increasingly complex and stringent specifications on energy efficiency.
In addition to standard power measurements, the new meters offer a wide range of harmonic measurement capabilities, including the ability to carry out simultaneous measurement of normal power parameters such as RMS, mean or DC power along with measurement of harmonics up to the 50th order. As a result, overall measurement times are reduced, allowing users to allocate their effort and time to other tasks.

www.tmi.yokogawa.com

ADVERTISING INDEX

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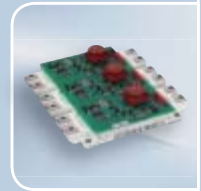

The new FS500R17OE4DP completes the state-of-the-art, compact package EconoPACK™ + D-Series in 1700 V with IGBT4.
The FS500R17OE4DP combines with the rugged package design, the high power cycle capability of IGBT4, the reinforced diode and the excellent thermal behavior of the pre-applied Infineon Thermal Interface Material (TIM) the features to fulfill the wind application lifetime requirements.

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- Rugged package design of EconoPACK™ + D-series
- State-of-the-art IGBT4
- Reinforced diode for generator operation
- Pre-applied Infineon TIM

The EconoPACK™ + key benefits:

- Improved lifetime
- High reliability and rugged design
- Reliable and solderless PressFIT contacts
- Long-term and stable thermal performance
- Compact inverter design
- Fit for the future and ready for next chip generations

www.infineon.com/econopack-d-series

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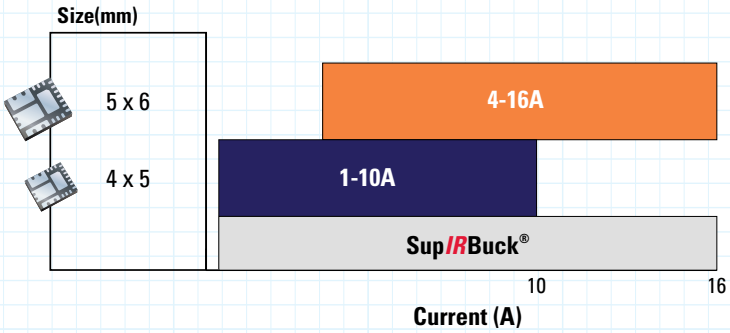
1-3A	IR3843W				
4-6A	IR3842	IR3853		IR3839*	IR3897*
	IR3842W	IR3863			IR3898*
	IR3832W*	IR3856	IR3473		
7-10A	IR3831W*	IR3859		IR3838*	IR3899*
	IR3841	IR3865	IR3475	IR3865	
	IR3841W				
11-16A	IR3840		IR3476	IR3837*	IR3894*
	IR3840W		IR3477		IR3895*

*DDR Tracking



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