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Bodo´s Power Systems®

Electronics in Motion and Conversion

February 2016

PLECS Goes Real-Time

A New HIL-System for Power Electronics

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GvA Power Electronics

Read online and search for key subjects from all articles
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www.powerguru.org

powerguru.org

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Events

Embedded World 2016,
Nuremberg, Germany, February 23-25
http://www.embedded-world.de

EMC 2016,
Düsseldorf, Germany, February 23-25
http://www.mesago.de/en/EMV/home.htm

CIPS 2016, Nuremberg, March 8-10
https://conference.vde.com/cips/2016/Pages/welcome.aspx

Smartsystemsintegration,
Munich Germany, March 9-10
http://www.smartsystemsintegration.com

APEC 2016,
Long Beach, CA, March 20-24
http://www.apec-conf.org/

New Energy Husum 2016,
Husum Germany, March 17-20
http://www.new-energy.de/new_energy/de/

Progress in Industry

There have been a good number of mergers and acquisitions in the power electronics world. Infineon bought International Rectifier and it appears they have made good moves in matching their product and technology portfolios. ON Semiconductor has offered to purchase Fairchild, even though Fairchild is facing a law suit from Power Integration. Is Fairchild still a good candidate? Well, ON Semiconductor is persisting. Microchip bought Micrel, with a successful matching of products, one of the positive moves in the market. New news for me is that Gazelle Semiconductor, a semiconductor manufacturer based in the Cayman Islands, has been acquired by Silergy Corp., a Chinese chipmaker originally based in Hangzhou.. Gazelle Semiconductor developed DCDC converting at high operating frequencies. Patent US9086708 B2 was issued on July 21st 2015 and describes high slew rate switching regulator circuits and methods developed by Gazelle.

Some top level people benefit greatly from mergers, while others at a lower level suffer a loss of employment – some of whom, unfortunately, who made significant contributions to the success of their companies. This represents an opportunity for more benevolent management.

We can observe, as I have been saying for some time, the world is one market place – and I strive to have my magazine serve you all - all over the globe. Our magazine is the only power electronics print publication available any place in the world.

Conferences and shows are actively beginning this year, starting in March: embedded world in Nuremberg, and APEC again in Long Beach, California, both traditional assemblies of engineers and academia discussing future progress in electronics. The main subjects are more efficiency and a minimum of losses in any electronic design. A large portion of the discussions will be on wide band gap semiconductors. Rohm Semiconductor, at their December user workshop in Nuremberg, demonstrated significantly improvements in SiC wafer manufacturing. As a result, there will be more and more applications in general areas, replacing silicon devices. We are facing a cross-over in new system costs, with SIC devices replacing old solutions. The CIPS conference in Nuremberg in early March will also have a focus on wide band gap semiconductors.

I am looking forward meeting my friends at these events and to chatting about future designs.

This is the second issue for 2016. All technical articles are archived on my website.

Bodo's Power Systems reaches readers across the globe. If you speak the language, or just want to have a look, don't miss our Chinese version: www.bodoschina.com

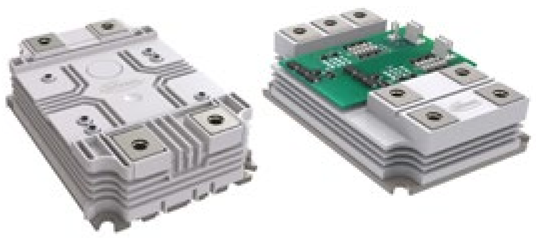
My Green Power Tip for February:
Close the rooms of your house that are not needed to avoid having to heat them in the winter. Heat only the sections that you are living in. That will reduce energy consumption.

See you at embedded in Nuremberg

Best Regards

Paving the Way for a Homogenous High Power Platform

Last year Infineon Technologies AG introduced the flexible high power platform XHP™. The first module available will be the high insulating package named XHP 3, designed for applications ranging from 3.3 kV to 6.5 kV like Medium Voltage Drives and Traction. The product ramp up of this 3.3 kV XHP 3 module will start this year.



XHP™ 3 and the new XHP™ 2 module with an adapter board which will be showcased at PCIM 2016

Now, the development continues: the new XHP 2 package for low voltage applications will increase the family's field of applications. This module is being designed for applications of up to 3.3 kV like Drives, Renewables and Traction.
The XHP 2 and the high insulting package XHP 3 will have the same dimensions of 140 mm in lengths and 100 mm in width. The height measures 40 mm. Implementing the same dimensions will give product designers the opportunity to build homogenous solutions across different current and voltage ratings.
The upcoming XHP 2 package will feature three AC terminals and four DC terminals. This will ensure a balanced load on all terminals maximizing the current carrying capabilities of the overall package.

The XHP family consisting of XHP 2 and XHP 3 will be exhibited during PCIM Europe 2016.

http://www.infineon.com/xhp

PMBus™ 1.3 Seminar Hosted by Bob White at APEC 2016

Since being introduced in 2005 the PMBus™ power management protocol has been widely adopted and is the accepted standard for digital power management. Bob White's three hour seminar on Sunday, March 20, 2016 from 2:30 – 6:30PM in Long Beach, CA will provide a detailed look at two major features introduced in the recent Revision 1.3, Zone Protocols and the AVSBus, as well as a review on the basics of the PMBus protocol.
The seminar is divided into two parts with a half hour break in between. The first half of the seminar reviews the basics of the 2-wire SMBus including the electrical interface and how data is transferred from one device to another. PMBus specific features such as the CONTROL signal and the use of SMBALERT# interrupt signal will be reviewed.
The second half of the seminar takes a deeper look at the two major PMBus additions introduced in Revision 1.3. The AVSBus is an all new protocol with an SPI-like interface that can operate at speeds up to 50 MHz. With a compact set of commands and fixed 32 bit frame, the AVSBus allows devices such as microprocessors, ASICs and FPGAs to quickly command changes to their operating voltage, improving performance and saving energy.

http://pmbus.org

Thermal Management at SPIE Photonics West

Rogers Corporation's Power Electronics Solutions (PES) group plans a strong presence at the upcoming SPIE Photonics West Conference and Exhibition, set for February 13-18, 2016 in San Francisco's famed Moscone Center.
Photonics West (www.spie.org) is the world's largest event for lasers, photonics, and biomedical optics products and technologies, with two exhibitions and a comprehensive technical conference. The show is expected to draw more than 50,000 attendees and will feature more than 4000 technical papers.
Representatives from Rogers Power Electronics Solutions (PES) group will be on hand at Photonics West Booth 309 to share insights on the company's latest thermal management solutions, including its innovative curamik® liquid and passive cooling products. curamik coolers include CoolPerformance and Cool Performance Plus, CoolPower, and CoolEasy product lines. At the show, Rogers PES will also present its new CoolPerformance Plus cooler, which includes a ceramic isolation layer for CTE matching and separating the electrical contact from water.
As part of Photonics West, Rogers PES, in partnership with Advanced Cooling Technologies (www.1-act.com), will present a report on ACT's (unique vapor-deposited Applied Nanoscale Corrosion Resistant (ANCER™) coatings that help extend the operating life of micro-channel copper coolers for cooling laser diodes.

https://www.rogerscorp.com

Yokogawa Acquires Cloud Data Service Provider Industrial Evolution Inc.

Yokogawa Electric Corporation announces the acquisition of Industrial Evolution Inc. to strengthen its provision of advanced solutions to the process industries. The acquisition of Industrial Evolution, a provider of cloud-based plant data sharing services, was carried out through Yokogawa Venture Group Inc., a wholly owned Yokogawa subsidiary that was recently established for the purpose of executing strategic mergers and acquisitions for the industrial automation and control business.
Expansion of the advanced solutions business in the industrial automation and control field is one of the main strategies set out in Yokogawa's Transformation 2017 mid-term business plan. Based on Industrial Evolution's cloud business environment, Yokogawa will provide Data-as-a-Service (DaaS - a cloud-based service for the provision of data that facilitates its use as a management asset), an advanced solution that will generate new value for its global customer base.

www.yokogawa.com

Cips 2016 March 8 - 10, 2016, Nuremberg, Germany

In the next decades, power electronic system development will be driven by energy saving systems, intelligent energy management, power quality, system miniaturization and higher reliability. Monolithic and hybrid system integration will include advanced device concepts including wide bandgap devices, dedicated ideas for system integration, new ideas on packaging technologies and the overall integration of actuators/drives (mechatronic integration).

The technical program consists of 4 Keynotes, 9 Invited Overviews, 54 Oral presentations and 33 Posters. A part of the Poster Session deals with Googles “Little Box Challenge” where the smallest PV converter will be awarded with 1 Million US$.

The topics of the four Keynotes are.

Little Box Challenge
J. Kolar, ETH Zurich and E. Hoene, Fraunhofer IZM

100 MHz GaN Power Conversion
D. Maksimovic, University of Boulder

Prospects of Advances in Power Magnetics
C.R.Sullivan, Dartmouth College

Review of Integration Trends in PE Systems and Devices
Tomohide Terashima, Takeshi Oi, Akihiko Iwata, Koichi Tsurusako and Gourab Majumdar, Mitsubishi

The topics of the nine Invited Overviews are:

- New Gate Driver Solutions for Modern Power Devices and Topologies (R. Herzer, Semikron, Germany)
- Investigation of a Power Module with Double Sided Cooling using a New Concept for Chip Embedding (H. Stahr, AT&S, Austria)
- SiC Power Devices Complementing the Silicon World - Status and Outlook (P. Friedrichs, Infineon, Germany)
- Design and Materials of Antiferroelectric Capacitors for High Density Power Electronic Applicationsn(G. Engel, CeraCap Technology & Innovation Consulting, Austria)
- Parasitic Inductance Hindering Utilization of Power Devicesn (R. Bayerer, Infineon, Germany)
- Challenges in Low-Voltage High-Current Applications - Fathom the Limits in System Design (U. Schwalbe, Technische Universität Ilmenau, Germany)
- Micro PV Inverter (R. Mallwitz, Technische Universität Braunschweig, Germany)
- 1-MW PV Inverter Employing Boost Converters with All SiC Power Module (Y. Furusho, Fuji Electric, Japan)
- GaN for Industrial Applications (R. Mitova, Schneider-Electric, France)

The conference is organized by VDE/ETG and ECPE and supported by IEEE PELS and ZVEI.
We kindly invite you to attend the 9th CIPS Conference in Nuremberg.
Andreas Lindemann, Dieter Silber and Eckhard Wolfgang;
Technical Program Chairs
Leo Lorenz and Thomas Harder; General Conference Chairs

https://conference.vde.com/cips/2016/Pages/welcome.aspx

ECPE Calendar of Events 2016

Date	Location	Event	Topic
3 – 4 Feb. 2016	La Rochelle, France	Workshop IMAPS France	**11th European Advanced Technology Workshop on Thermal Management**
4 – 5 Feb. 2016	Zurich, Switzerland	ECPE Workshop	**Smart Transformers for Traction and Future Grid Applications** Chairmen: Prof. J.W. Kolar (ETH Zurich), Prof. M. Liserre (CAU Kiel)
16 Feb. 2016	Dusseldorf, Germany	ECPE Tutorial	**Power Circuits for Clean Switching and Low Losses** Chairman: Dr. R. Bayerer (Infineon)
8 – 10 March 2016	Nuremberg, Germany	Conference & ECPE Annual Event	**CIPS 2016 - Int. Conf. on Integrated Power Electronics Systems in conjunction with the ECPE Annual Event 2016**
6 – 7 April 2016	Delft, Netherlands	ECPE Tutorial	**Power Semiconductor Devices & Technologies** Chairman: Prof. D. Silber (Univ. of Bremen)
25 – 26 April 2016	Berlin, Germany	ECPE Lab Course	**EMC Optimised Design (Parasitics in Power Electronics)** Course Instructor: Prof. E. Hoene (Fraunhofer IZM)
10 – 12 May 2016	Nuremberg, Germany	Conference & Exhibition	**PCIM Europe 2016 Conference and Exhibition with ECPE Students Day**
23 – 27 May 2016	Gaeta, Italy	Recruitment Event	**17th European PhD School on ´Power Electronics, Electrical Machines, Energy Control and Power Systems´** Chairman: Prof. G. Tomasso (University of Cassino)
June 2016	TBD	ECPE Workshop	**Power Electronics for e-Mobility** (System Architectures and Voltage Levels, High Power Density System Integration, Battery Charging and Grid Integration)
6 - 7 June 2016	Nuremberg, Germany	ECPE Tutorial	**EMC in Power Electronics** Chairmen: Prof. E. Hoene (Fraunhofer IZM), Prof. J.-L. Schanen (G2ELab)
12 – 16 June 2016	Prague, Czech Republic	Conference	**ISPSD 2016 - 28th International Symposium on Power Semiconductor Devices and ICs**
20 – 21 June 2016	Barcelona, Spain	ECPE Tutorial	**Power Electronics Packaging** Chairmen: Prof. U. Scheuermann (Semikron), Dr. J. Popovic-Gerber (TU Delft)
19 - 20 July 2016	Erlangen, Germany	ECPE Tutorial	**Thermal Engineering of Power Electronic Systems - Part I (thermal design and verification)** Chairmen: Prof. U. Scheuermann (Semikron), D. Malipaard (Fraunhofer IISB)
6 – 8 Sept. 2016	Karlsruhe, Germany	Conference	**EPE'16 ECCE Europe - 18th European Conference on Power Electronics and Applications**
19 – 23 Sept. 2016	Halle, Germany	Conference	**ESREF 2016 – European Symposium on Reliability of Electron Devices, Failure Physics and Analysis**
18 - 19 Oct. 2016	Nuremberg, Germany	ECPE Tutorial	**Thermal Engineering of Power Electronic Systems - Part II (thermal management and reliability)** Chairmen: Prof. E. Wolfgang (ECPE), Prof. U. Scheuermann (Semikron)
Autumn 2016	TBD, UK	ECPE Tutorial	**Drivers and Control Circuitry for IGBTs and MOSFETs**
Autumn 2016	TBD	ECPE Workshop	**Power Electronics and Smart Industrial Manufacturing (Industry 4.0)**
Oct./Nov. 2016	TBD	ECPE Tutorial	**Passive Components in Power Electronics: Inductors**
Nov./Dec. 2016	TBD	ECPE Workshop	**Power Supplies in Low Power Applications** (Digital Control, LED Lighting, Standby Power)

APEC 2016 – Plenary Session Speakers Announced

APEC 2016 will feature an exciting lineup of speakers for the Monday plenary session in Long Beach, California on Monday, March 21, 2016 at 1:30 P.M. The 2016 plenary session covers a range of interesting topics featuring the following speakers:

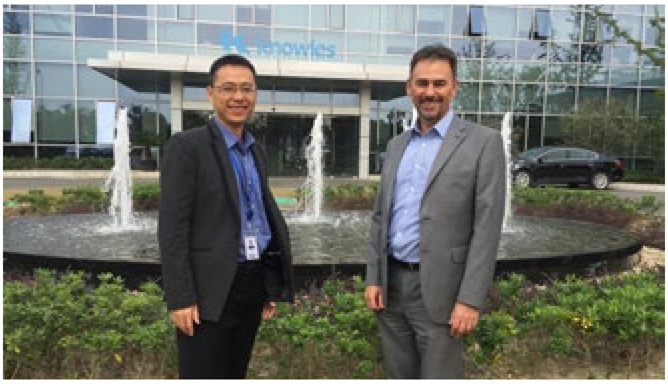
- Tony Sagneri, Finsix corp, "The Challenges of VHF Power Conversion"
- Michael Harrison, Enphase Energy, "The Future of Power Electronic Design"
- Dan Kinzer, Navitas Semiconductor, "Breaking Speed Limits with GaN Power ICs"
- Antonio Ginart, University of Georgia, "Residential Nanogrids With Battery Storage – Is This Our Future?"
- Ray Ridley, Ridley Engineering, "The Future of Magnetic Design for Power Electronics"
- David Hill, Power Clinic, "Why Do Power Supplies Fail? – A Real-World Analysis"

To view speaker biographies visit the APEC 2016 website.

http://www.apec-conf.org/

Key Staff Members with New Roles

Knowles Capacitors have made a number of changes within their sales and product management teams. Changes were brought into effect in October 2015 to continue a program of internal restructuring designed to fully leverage skill sets and put Knowles in the best position to service customers and grow revenue in 2016.



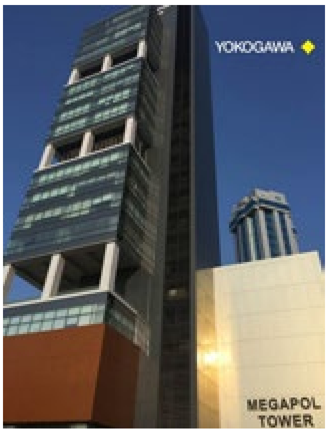
Pictured outside the Knowles facility, Simon Mao (left) and Chris Noade

Simon Mao, previously Asia Marketing Manager, is now in the position of Product Manager of MLC's. By staffing the position in China, Simon will be best positioned to work closely alongside the Suzhou factory operations team where Knowles commercial MLC products are made. Simon brings an in-depth understanding of products, applications and markets to the position, and his past experience in sales, marketing, research and analysis will allow him to bring a fresh perspective to this key role.

Chris Noade, previously Product Manager of MLC's, has accepted the position of European Sales Manager with responsibility for the full product portfolio. In this role Chris will focus on key account development and relationship management.

www.knowlescapacitors.com

Acquiring a Distributor in Turkey as Major Step forward



Yokogawa Electric Corporation announces that its subsidiary, Yokogawa Europe B.V. has acquired 100% of the shares of its distributor in Turkey, Birleşik Endüstriyel Sistemler Ve Tesisler A.Ş.(BEST), which is based in Izmir. The acquisition of shares was carried out on November 25. With this acquisition, Yokogawa strengthens its focus on Turkey as a market with substantial growth potential. It will allow Yokogawa to extend its position in promising segments such as the power industry. Through the acquisition, Yokogawa will ao enhance its relationships with customers in Turkey.

www.yokogawa.com

IDT and CERN openlab Engineer Low-Latency RapidIO Platform to Improve Analytics

Integrated Device Technology, Inc. ® announced that it has developed with the European Organization for Nuclear Research (CERN) a low-latency platform to speed and improve the management of analytics at the organization's Large Hadron Collider (LHC) and data center. Developed at IDT's Open HPAC Lab and built upon the company's RapidIO® technology, the platform marks the first major milestone in the three-year collaboration IDT and CERN openlab announced in March.

CERN openlab is a unique public-private partnership that accelerates the development of cutting-edge solutions for the worldwide LHC community and wider scientific research. Through CERN openlab, CERN collaborates with leading ICT companies and research institutes.

The collaboration was driven by the need to improve overall data acquisition and analysis for the massive volumes of data collected by the experiments on the LHC, the world's largest and most powerful particle accelerator. The LHC produces millions of collisions every second in each detector, generating approximately one petabyte of data per second. This data is vital to CERN's quest to answer fundamental questions about the universe.

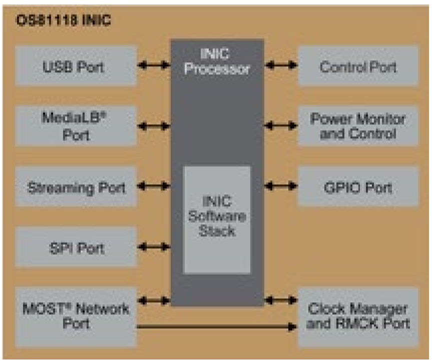
http://www.idt.com/landing/open-hpac-lab

MOST150 Technology in Audi A4 Virtual Cockpit Infotainment System

Microchip Technology Inc. announced that AUDI AG is using MOST® technology to network the high-end Audi virtual cockpit system in the latest model year of its best-selling A4 Sedans. This follows a similar deployment in its Q7 SUV and TT Coupe models. Specifically, Audi is utilizing Microchip's OS81110 and OS81118 MOST150 Intelligent Network Interface Controllers (INICs), which provide 150 Mbps performance and support all MOST network data types. The OS81118 also includes a High Speed USB 2.0 interface (PHY/HSIC), to seamlessly connect with the virtual cockpit's System-on-Chip processor.

To learn more about Microchip's MOST networking products, visit http://www.microchip.com/MOST-121515a.

To date, approximately 200 million MOST interface controllers have been installed in 194 car models since 2001. Audi and all major carmakers have for many years successfully implemented MOST technology in their multi-node infotainment networking systems, as it provides a field-proven, low-risk, whole-system solution.

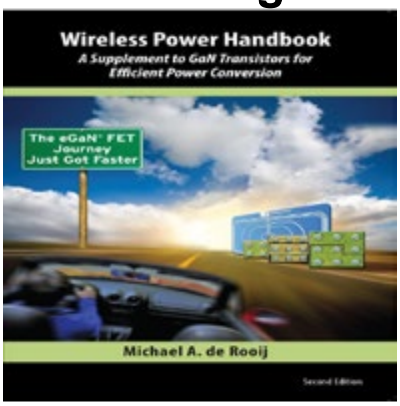


The MOST150 standard also provides Ethernet or Internet-protocol networking capabilities. This latest version of MOST technology continues to predictably and efficiently transport video, audio, packet and control data throughout the vehicle without time-synchronization protocols, using dedicated channels for minimal processor overhead in the main infotainment control unit processors.

"We are thrilled that Audi is continuing to roll out the latest MOST150 standard, this time in its mid-class A4 car model," said Dan Termer, Microchip's Automotive vice president. "Their ongoing deployments demonstrate that MOST technology continues to be the de-facto standard for automotive infotainment networks."

http://www.microchip.com/Homepage--121515a

Announcing Wireless Power Handbook, 2nd Edition



EPC announces the publication of a second edition of the Wireless Power Handbook. This second edition comes less than a year following the release of the first edition - this is the pace at which the understanding and application of wireless power transfer is moving. "Cut the cord" is the battle cry - and now that we know it can be done, what's holding us back, let's pick up speed and get on with it!

The scope of this second edition has expanded to include the latest work on A4WP class 2 and class 3 transmitters, adaptive tuning, radiated EMI, multi-mode wireless power systems, and control strategies. There are also systems demonstrated using the latest in eGaN FETs and integrated circuits that set new efficiency benchmarks as well as reduce system costs. There is still much more to accomplish as this fast moving technology evolves; the purpose of this second edition is to share the latest information on the subject.

http://epc-co.com/

Power Supply to Become more Efficient, more Stable and more Secure

The European research project headed by Infineon has been successfully completed.

Highly developed societies require a stable power supply that also protects the environment. The goal then is to generate electricity in as targeted and sustainable a way as possible, and to transmit it and use it as efficiently as possible. The research project “E2SG” (Energy to Smart Grid) supports these goals. It lays the foundations for greater stability, energy efficiency and data security in the smart grid. Infineon Technologies AG coordinated the project, which has now been successfully completed. A total of 29 project partners from nine European countries participated. At the European Nanoelectronics Forum 2015 E2SG was presented with the 2015 ENIAC Innovation Award.

The research results of the E2SG project will allow for a more sustainable energy production and more efficient energy conversion. For example, a bi-directional voltage converter – with an efficiency of over 96 percent – will facilitate the efficient power supply of electricity from different energy sources. This supports the use of renewable energies and makes the power supply more flexible and, by extension, more stable. By using optimized MOSFET power switches with over ten percent lower on-resistance in voltage transformers such as power supplies and converters, together with advanced high voltage technology, power and conversion losses can be reduced. This saves power and reduces CO2 emissions.

The results of E2SG represent a major economic potential and are also of value to society, winning the project the ENIAC Innovation Award. Dr. Yves Gigase, Acting Executive Director of ECSEL, presented the award at the European Nanoelectronics Forum 2015 on December 2 in Berlin. Project coordinator Holger Schmidt, R&D Funding Projects at Infineon, accepted the award on behalf of the consortium.

http://www.infineon.com/cms/en/

Level VI Compliant Ac-Dc Power Supplies Feature Interchangeable Input Blades for Global Use

CUI Inc announced a family of Level VI compliant external ac-dc power supplies ranging from 5 W to 36 W that feature interchangeable ac input blades. Designed for global use, the wall plug-in SMI5-USB, SMI6, SMI18, SMI24 and SMI36 include ac blade options for North America, Europe, the United Kingdom, Australia and China. The series are all designed to meet the stringent Level VI standards which aim to significantly lower the amount of power consumed when the end application is not in use or is no longer connected to the system. Any domestic or global manufacturer seeking to market their endproduct with an external adapter in the United States must meet these new performance standards mandated by the US Department of Energy (DOE) by February 10th, 2016.

The 5 W, 6 W, 18 W, 24 W and 36 W multi-blade adapters feature a wide universal input voltage range of 90~264 Vac and are available in single output voltages from 5~48 Vdc depending on the series. All models meet the Level VI standard's no load power consumption requirement of < 0.1 W. Protections for over voltage, over current and short circuit are also included and vary by series.The SMI5-USB comes with an integrated USB connector and offers UL/cUL, GS and RCM safety approvals, while the SMI6 series also includes CCC and PSE safety approvals. The SMI18 and SMI24 series both offer UL/cUL, GS and PSE safety approvals, while the SMI36 series also holds the CCC safety approval. All models meet FCC Part 15 Class B standards for EMI/EMC and bear the CE mark.

The new SMI5-USB, SMI6, SMI18, SMI24 and SMI36 series are available immediately through distribution with prices starting at $7.93 per unit at 100 pieces.

Please contact for OEM pricing: http://www.cui.com/contact

For more information on the US Department of Energy's upcoming Level VI regulations: http://www.cui.com/efficiency-standards

Summary

Product name: SMI5-USB, SMI6, SMI18, SMI24, SMI36
Availability: Stock to 12 weeks
Possible users: Consumer, industrial and mobile device designers
Primary features: Level VI efficiency, interchangeable ac input blades
Cost: $7.93 per unit at 100 pieces through distribution

About CUI Inc

CUI Inc is a technology company focused on the development and distribution of electronic components. At the leading edge of power supply design, the organization supports customers as they strive to improve the energy efficiency and environmental credentials of their application. The company's power group is complemented by a portfolio of world-class board level components, consisting of interconnect, sound, motion control and thermal products. An unwavering commitment to create collaborative partnerships with customers and a drive to see that their design project is a success has been a hallmark of CUI's sustained growth since its founding in 1989. As a leader in the industry, CUI will continue to invest in the future through new technologies, talented employees, expanded manufacturing capabilities, and a growing global reach. http://www.cui.com/
CUI Inc is a subsidiary of CUI Global, Inc., a publicly traded company whose common stock trades on the NASDAQ Exchange under the symbol CUI.

http://www.cuiglobal.com/

Capacitors for Power Electronics

IGBT Snubbers
RF Mica Capacitors
DC Link Capacitors
- **High Current, High Voltage Film**
- **High Capacitance Aluminum Electrolytic**

AC Output Harmonic Filter Capacitors

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International Electron Devices Meeting—IEDM 2015

The IEEE's premier forum for the discussion of advances in micro/nano electronics featured a special focus on advanced wide bandgap materials for power devices.

By Gary M. Dolny, Bodo's Power Systems, gary.dolny.us@ieee.org

The 2015 International Electron Devices Meeting, IEDM, took place at the Washington D.C. Hilton Hotel from December 7-9, 2015. The conference was preceded by day-long short courses on Sunday, December 6 and a program of 90-minute tutorials on Saturday, December 5. IEDM is sponsored by the Electron Devices Society of the Institute of Electrical and Electronics Engineers (IEEE) and is considered the premier forum for reporting breakthroughs in the technology, design, manufacturing, physics and the modeling of semiconductors and other electronic devices. This year's conference was attended by nearly 1400 scientists and engineers from around the world representing all areas of micro and nanoelectronics.

The conference technical program consisted of 226 papers chosen from 588 submissions, as well as a rich offering of other events, including evening panel discussions, special focus sessions, IEEE awards and an entrepreneurial luncheon sponsored by IEDM and IEEE Women in Engineering. The low percentage of acceptances guarantees a program of high quality presentations.

"From its inaugural meeting until today, the IEDM conference has been the place where breakthroughs that drive the electronics industry forward are unveiled," said Mariko Takayanagi, IEDM 2015 Publicity Chair and Senior Manager at Toshiba. "For example, at the IEDM in 1975 Intel's Gordon Moore gave a talk that refined his earlier prediction of transistor scaling into what has since become known as Moore's Law. That tradition of attracting the best speakers and a large, diverse audience from around the world continues, with a focus this year on devices intended to support the Internet of Things and other emerging areas of importance that depend upon advances in semiconductor technology."

The power semiconductor industry was well represented at this year's IEDM with several conference sessions devoted to topics of interest to the field. Power devices were also the subject of one of the conference's Special Focus sessions entitled "Advances in Wide Bandgap Power Devices". These Special Focus sessions consist of a series of invited talks by top experts in the field and are intended to highlight areas of increasing technical and commercial importance.

The technical presentations showed a clear consensus that wide-bandgap materials, especially gallium nitride, are the future of the power semiconductor industry. High electron-mobility transistors (HEMTs) made from GaN were shown to have great potential for reducing conduction and switching losses in power applications although some technical hurdles still remain. These include issues with material quality, reliability, cost, and the difficulties associated with producing true enhancement mode devices.

Several presentations discussed the phenomena of current collapse and dynamic on-resistance.

These are manifest as a decreased output current and increased on state resistance after reverse bias due to the presence of electron traps. A research group from Fujitsu, Japan, showed that a novel double-layer silicon nitride passivation technique was effective in alleviating these problems resulting in basic reliability for commercial products [1]. A team led by the Massachusetts Institute of Technology, USA, drew a similar conclusion, and indicated that with proper device passivation stable devices can be achieved [2]. Additional work by On Semiconductor, Belgium, University of Bristol, UK, and University of Padova, Italy, studied the impact of buffer layer leakage on the intrinsic reliability of 650V GaN HEMTs[3]. They showed dynamic Ron to be highly voltage dependent and could be completely suppressed under certain bias conditions.

HRL Laboratories, USA, presented a study on increasing the switching frequency of GaN HFET DC-DC converters. They showed that in hard switched applications the performance benefits of GaN may be outweighed by the cost and reliability risks of the new technology [4]. They further concluded that at 600V, GaN offers more value in soft-switched applications compared to Si, and could open new markets that cannot be addressed by conventional Si devices. Using a figure of merit analysis they predicted that GaN ICs in 400V soft-switched converters could achieve frequencies beyond 100MHz.

A group from Taiwan Semiconductor Manufacturing Corporation, Taiwan presented next generation CMOS compatible GaN-on-Si transistors [5]. They demonstrated enhancement-mode HEMTs from 100V to 650V fabricated on GaN-on-Si wafers. Their devices showed good performance in converter applications and have passed industrial reliability qualification, including 1000 hours of high-temperature reverse bias stress.

Although most of the presentations focused on GaN, silicon carbide also received attention. A group from ST Microelectronics, Italy, noted that SiC devices have been in the market for several years and have demonstrated excellent performance and reliability [6]. The SiC devices are expected to dominate the high-power applications.

Looking even further into the future, a group from Tottori University, Japan, presented a study of avalanche breakdown in diamond for power device applications [7]. They concluded that the material could potentially have advantages in future high-power, high-temperature applications.

2015 was the final year that IEDM will be held in Washington DC. After rotating between Washington D.C. and San Francisco, CA for more than twenty years, starting in 2016 the conference will be permanently held in San Francisco. Next year's IEDM will be held from December 5-7 at the Hilton San Francisco Union Square, San Francisco CA, USA. Additional information is available on the conference website http://ieee-iedm.org.

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PLECS Goes Real-Time

Plexim is expanding its PLECS product line with real-time hardware to provide a complete and one-stop solution for modern power electronics development teams.

By Beat Arnet and Felix Prausse, Plexim GmbH

Introduction

Designing power converters is a complex task requiring advanced tools and processes. Power converters are sophisticated systems composed of multiple subsystems, including hardware and software components. Consequently, development and testing of power converters means optimizing multiple aspects that need to be explored, developed and tested in parallel, until the complete system is available for final validation.

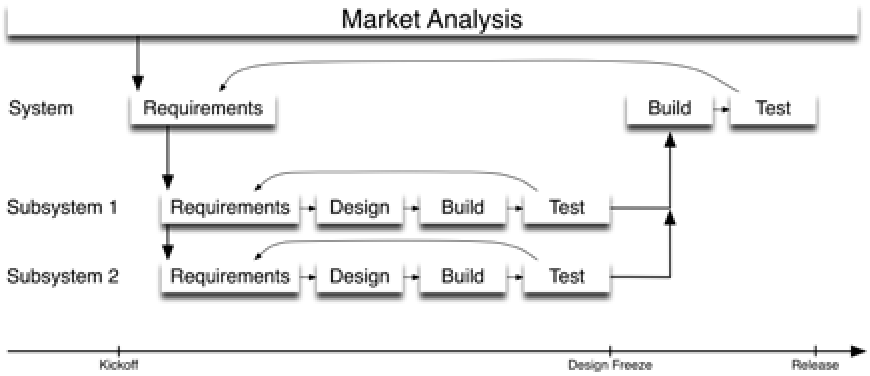

Figure 1: Conventional design flow

The conventional "waterfall" or "V" development process heavily emphasizes the solid upfront definition of system requirements, cascading into definition of a set of subsystem requirements. Subsystems can then be developed concurrently and independently according to well-defined specifications, until they are ready for integration and validation. The challenge with this approach is its strong dependence on the relevance and accuracy of initial requirements driving the entire development process. If requirements are improperly defined, subsystems may be incompatible. Furthermore, the waterfall method cannot account for shifting market conditions or changing customer requirements. In the worst case, the outcome of a long development process could be a nonsaleable product.

Recognizing the drawbacks of the waterfall process, many industries have moved to more agile development [1], based on multiple short design iterations rather than one linear development period. This approach offers the advantage of multiple opportunities to learn lessons and adjust system and subsystem requirements. Contrary to the waterfall method, where value is only generated at the end of the development process, a more agile and incremental process may yield new results and knowledge with each design iteration.

Independent of the methodology used, a modeling and simulation tool such as PLECS can be tremendously beneficial to power electronics engineers. In a waterfall process, efficiently modeling the complete power converter system is particularly useful when deriving system and subsystem requirements.

However, a circuit simulator is even more valuable (and critical) to agile developers. Since individual subsystems evolve at different rates and after different iteration counts, it is more difficult to perform early system testing without a virtual environment such as a PLECS simulation model. In other words, a circuit simulator can be a critical tool to keep the different subsystems in sync during their respective design iterations.

Plexim is continuously adding new functionalities to its PLECS product line to better assist modern power electronics develop-

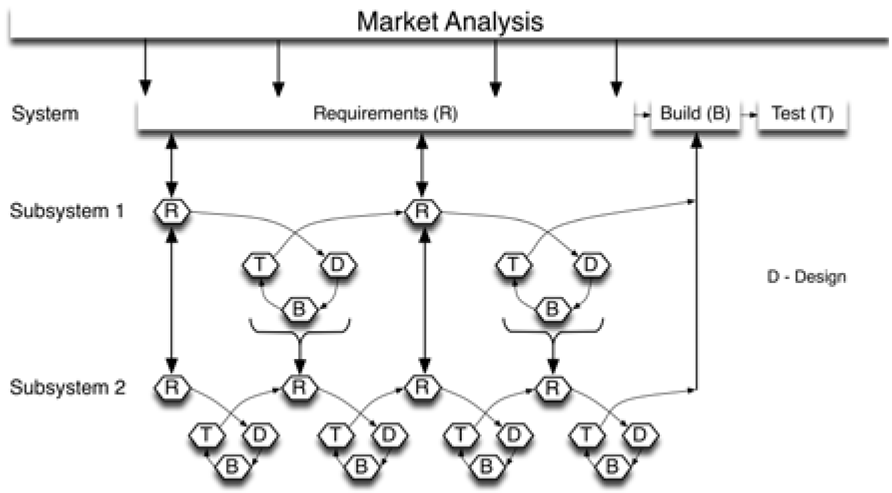

Figure 2: Agile design flow

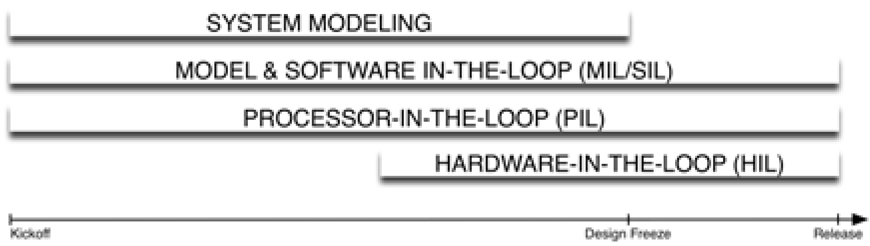

Figure 3: Applicability of PLECS to agile design flow

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ment teams. “In-the-Loop” methodologies are extremely valuable for parallel and iterative development projects. Starting with the introduction of PLECS’ control domain and C-Script block in 2009, followed by the Processor-in-the-Loop (PIL) tool in 2014, Plexim now provides solutions for real-time Hardware-in-the-Loop (HIL) testing.

This article introduces Plexim’s new real-time platform and illustrates the applicability of real-time simulations in the general context of modern product development.

PLECS Tools

At the core of PLECS is the PLECS circuit simulator. It was specifically designed to model power converters, including the system in which they operate. Features of PLECS include:

- Ease of use
- Ultrafast simulation speed
- Numerical robustness
- Extensive and open component library
- Support for multiple physical domains

With PLECS, the engineer can quickly sketch out the complete power conversion system at the beginning of the development process, and improve the model in a top-down fashion as the design evolves. Initially, the model is of relatively low fidelity, but useful to derive system and subsystem requirements and make early top-level design decisions. Over time, the model’s fidelity and quality increases as specific components are selected and measurements are available to fine-tune the models.

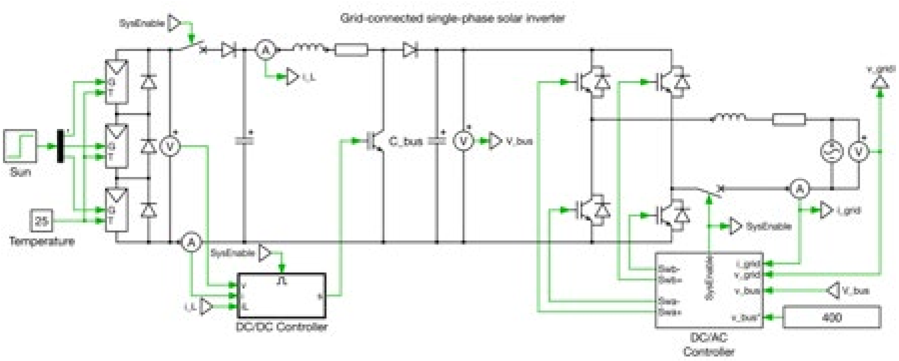

Figure 4: PLECS system model

Once a PLECS system model is created, it can be used as a virtual system test bed. For example, the model can be utilized to test and develop the “control software” subsystem if it adequately represents the most recent “control hardware” and “power hardware” subsystem iterations. Therefore, as long as a PLECS system model is maintained during an agile development process, it can serve as the virtual environment for system testing, long before actual system integration takes place.

As subsystem development becomes more mature, prototype software is written, and prototype hardware built, the engineer can tie such prototypes “into the loop”. For example, with the software-in-the-loop (SIL) approach, embedded code can be executed within the PLECS system model (using PLECS C-Script or DLL blocks).

For higher fidelity system testing, embedded code can be executed on the actual embedded processor and co-simulated with a PLECS model. This method is referred to as PIL and is discussed in detail in [2]. With PIL, platform-specific software defects, such as overflow conditions and casting errors, can be detected. A PIL co-simulation can also expose and analyze potential problems related to the multi-threaded execution of control algorithms, including jitter and resource corruption. The PLECS PIL package includes a PIL Framework library with support for the most relevant processor families used in power conversion and motor drive applications today. A set of high-fidelity peripheral models is also included. These accurately model the behavior of target-specific MCU peripherals such as ADC, PWM, and Capture modules. See [3] for more detailed information on MCU peripheral modeling with PLECS.

Once the control hardware has sufficiently evolved, developers can proceed to HIL testing, where the entire control hardware is tested in conjunction with a PLECS system model. This approach is fundamentally different from the system testing mentioned so far, because the PLECS model now must execute in real-time. Contrary to SIL and PIL, where control code execution is synchronized with an offline simulation, interfacing with physical control hardware requires generation and measurement of real-time analog and digital signals. Consequently, the PLECS model can no longer be executed on a conventional desktop PC, but must run on specialized real-time hardware, such as the new PLECS “RT Box”.

Plexim also offers the PLECS Coder. It is capable of generating C code from a PLECS model for execution on real-time hardware. This requires the simulation model to be discretized to run at a fixed sampling frequency. Due to the fast time constants inherent in power conversion systems, the step size typically is on the order of microseconds. The ideal step size is a compromise between system model fidelity and the accuracy of the simulation results. If the step size is too small, the real-time hardware may not be able to execute the system model fast enough. If the step size is too large, unacceptable fidelity of the digital and analog signals generated by the real-time hardware may occur.

To assist the developer with this tradeoff, the PLECS Coder supports simulating generated discretized code within PLECS before it is deployed onto the real-time hardware. This permits inspecting the signal waveforms for different use cases and ensuring they are accurate enough for system testing purposes.

Specifically for real-time code generation, the PLECS library now includes a new component category called “Power Modules”. Power Modules implement the most frequently used powerstage topologies, such as choppers, half-bridges, 3-level half-bridges and cascaded topologies, in a fashion ideal for real-time simulation. With these specialized components, it is possible to run real-time models containing a large number of switches.

The real-time code generated by PLECS is suitable for execution on many real-time platforms such as Opal-RT and dSpace systems. Additionally, to provide a completely optimized solution with a unified user experience, Plexim is now offering its own real-time platform, “RT Box”.

PLECS RT Box

The PLECS RT Box is a state of the art real-time simulator based on a 1 GHz Xilinx Zynq SOC. With its 64 digital and 32 analog I/O signals, the RT Box is well equipped for the HIL testing of complex power converter systems.

The PLECS RT Box is designed as a compact desktop unit (31 x 25 x 10 cm) and is competitively priced. For more details on pricing please contact: info@plexim.com

The unit also provides access to a 4-lane high-speed serial interface so it may be scaled up for more demanding HIL applications, such as modular multi-level HVDC converters.

Figure 5: RT Box front

Figure 6: RT Box back

Processor	Xilinx Zynq Z-7030, 1 GHz CPU clock
Analog In	16 channels, 2 Msps, 16 bit, -10...10 V or -5...5 V
Analog Out	16 channels, 2 Msps, 16 bit, -10...10 V or -5...5 V
Digital In	32 channels, 3.3 V (5 V tolerant)
Digital Out	32 channels, 3.3 V or 5 V
Connectivity	Ethernet, High Speed Interconnect (4 x SFP+), USB
Power Supply	100...240 Vac, 50...60 Hz

Table 1: RT Box specifications

When evaluating real-time simulators, it is useful to consider the following key characteristics:

- Calculation speed
- Sample rate and I/O latency
- Signal resolution
- Model implementation flexibility

As mentioned earlier, power electronic systems contain small time constants due to their inherently switched nature. Though it is not necessary to simulate the transient turn-on and turn-off waveforms of each switching event, the switching frequency harmonics and PWM resolution result in high-frequency components. These must be accurately measured and reproduced. Consequently, real-time simulators for power conversion systems execute models at a much higher rate than typically encountered in other HIL applications. With fast-switching wide-bandgap semiconductor devices pushing practical switching frequencies to ever higher levels, speed requirements for real-time simulation will increase even further.

Figure 7: Roundtrip latency

The most meaningful metric when comparing the “speed” of real-time simulators is overall roundtrip latency, i.e. total time elapsed from measuring inputs to updating outputs. This is the sum of delays associated with the ADC, model update (calculation), DAC, plus the latencies associated with transferring data.

Individual delays depend on the underlying hardware topology. Several approaches exist, each with advantages and disadvantages.

The first approach uses, at its core, a digital signal processor (DSP). DSPs are very effective number crunchers with complex instruction sets, resulting in short model update times. Unfortunately, the advantage of calculation speed is normally offset by poor I/O latency, caused by the commonly used PCIe bus protocol.

The second type of HIL system is FPGA-based. In this case, the model is fully calculated by the programmable logic cells. Direct access to I/O components is possible with minimal latency. Using an FPGA permits parallelization of certain calculation tasks, further improving speed. However, the challenge with FPGAs is limited numerical accuracy and reduced flexibility. Consequently, real-time models must be custom-designed and highly optimized by FPGA experts. FPGA-based HIL systems commonly come with a set of predefined topologies for the user to select. This is especially problematic if a HIL system is being used to develop and analyze new converter topologies. Such solutions are substantially less transparent and make it difficult for users to assess if the real-time model truly reflects the simulated system as intended.

With the goal of combining the advantages of both approaches described so far, the third solution uses a system-on-a-chip (SOC) device, comprising both processor cores and FPGA fabric. Though the I/O latency is slightly larger than with a pure FPGA solution, the calculation power of the associated processor cores offsets the difference and permits comparable roundtrip latencies, with the advantage of increased flexibility. The SOC approach therefore allows a more accurate real-time representation of the original offline system model and does not limit converter topology.

Table 2 summarizes the comparison:

	DSP	FPGA	SOC
Performance	++	++	+
Flexibility	++	-	++
Latency	--	++	+

Table 2: Comparison of approaches

The PLECS RT Box is based on a SOC, optimizing the tradeoff of I/O latency, numerical performance and modeling flexibility. Excellent signal resolution is achieved by using the latest generation of 16-bit ADC and DAC chips with sample rates of 2 MSPS. The digital capture module can resolve PWM signals at 7 ns.

When used with the PLECS circuit simulator and PLECS Coder, the PLECS RT Box provides a complete and consistent solution for system-level verification and validation of control software and hardware subsystems.

Outlook

The PLECS RT Box is designed with the future in mind. With its high-speed communication interface, the RT Box is prepared for operating multiple units in parallel or in a master/slave arrangement. Such configurations can leverage new PLECS solver and coder technologies currently under development, making the platform even more powerful and suitable for large scale and complex real-time simulations.

Summary

System modeling is an indispensable part of agile power electronics product development. It facilitates early design decisions and formulation of system and subsystem requirements. A system model maintained throughout the product development also serves as a virtual system test bed for subsystem iterations. “In-the Loop” testing (SIL and PIL) can be applied very early in development, minimizing risk of subsystem incompatibility. As control hardware becomes available, HIL testing can be used to increase test coverage.

With the introduction of the PLECS RT Box real-time platform, Plexim’s product portfolio now covers all aspects of virtual system testing, offering a one-stop solution with a unified user experience and the trusted power of PLECS “under the hood”.

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IGCT - A Highly Efficient Device with Continuing Great Success in High Power Applications

For reliable and efficient operation in high power applications, the Integrated Gate Turn-off Thyristor (IGCT) is the ideal device. The main advantage besides high reliability is the low device losses resulting in low system losses. In this article we compare IGCT and IGBT based 3-level converters with respect to device and system losses.

By Vasileios Kappatos, Sven Klaka, Christian Winter, ABB Switzerland Ltd. - Semiconductors
Madhan Mohan, ABB Global Industries and Services Ltd.

Since the end of the 1990s, the IGCT became the device of choice in applications where high power handling capability, low losses and high reliability are required. Typical applications are motor drives, interties, breakers and renewables. Reasons for this are the very low on-state losses provided by the thyristor structure, the negligible turn-on losses in the semiconductor and the high reliability of the device. The proven field experience in the aforementioned applications points out the IGCT as the ideal switch for the latest circuit topologies like modular multilevel converters (MMC) especially for highest power handling capabilities like in high-voltage DC current systems (HVDC).

Efficiency analysis of high-power semiconductors for converter ratings >5 MVA

Besides the high device reliability, the low device losses are the main advantage of the IGCT especially for applications in the range above 5 MVA. To demonstrate this, a loss comparison through simulation is presented between a converter equipped with IGCTs and a converter with IGBTs. The comparison was done using the ABB simulation tool SEMIS which is based on the PLECS software. All the semiconductor losses are calculated referencing data sheet conditions through lookup tables prepared by ABB to reflect the latest product specifications.
A typical 3-level Voltage Source Converter (VSC) with diode Neutral Point Clamping (NPC) circuit is accounted in inverter mode as shown in figure 1, typically used in motor drives or wind generator converters.

In each circuit are applied the same DC voltage, switching frequency F_{sw}, power factor P_F, device heat sink to ambient thermal resistance R_{th} and ambient temperature parameters for the IGCT and IGBT case, respectively. The comparison was done with ABB's well-established 4.5 kV IGCT (5SHY 35L4520) and IGBT (5SNA 1200G450350) devices. Since the simulation accounts for one semiconductor per converter position as shown in figure 2 and having in mind the highest current capability of the IGCT compared with that of insulated IGBT modules, a scaled comparison of the losses was evaluated.
By simulating the clamp circuit operation, the losses on the clamp resistor dissipated for both upper and lower clamp of the 3-level IGCT topology were accounted for 2 options of the selected clamp inductor Li. Moreover, in the IGCT circuit the ABB press-pack diode 5SDF 20L4520 optimised for IGCT application was chosen for the free-wheeling diode (FWD), NPC and clamp positions. For the NPC position in the IGBT based converter the standard ABB product 5SLD 1200J450350 was used. To distinguish the thermal configuration of the IGCT and IGBT based converter concepts, the following factors were accounted: The IGCT packaging concept is that of a press-pack device with double side cooling while with the IGBT we have an insulated module with only the

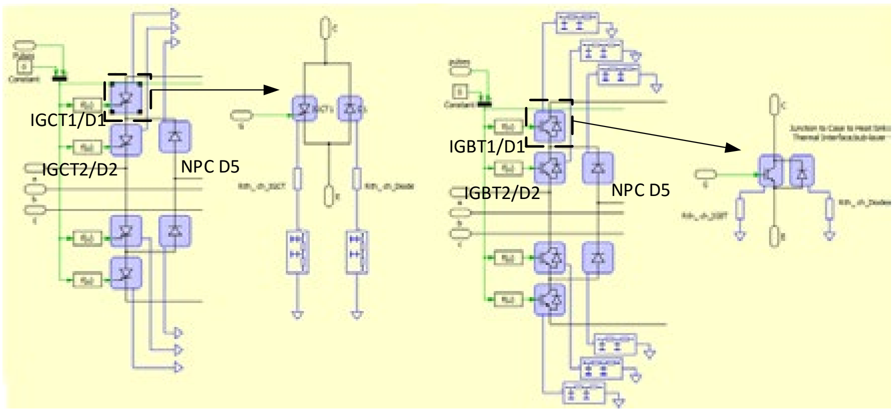

Figure 2: Thermal configuration of IGCT and IGBT based topologies

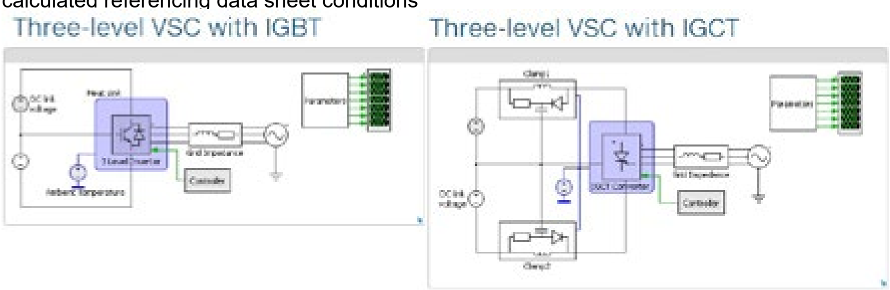

Figure 1: SEMIS simulation circuits

baseplate contacting the heat sink area. The FWD part is integrated in the IGBT module in the same package whereas for the asymmetric IGCT selected for this simulation, a separate press-pack FWD was used with its own double side cooling concept (figure 2).

The operating conditions of the Power Electronic Building Block (PEBB) and the IGCT / IGBT simulation results are presented in tables 1 to 3. They are calculated based on a three phase 3-level topology with 12 controlled semiconductors (IGCT and IGBT, respectively) and 12 diodes in free-wheeling position and 6 diodes in NPC position. It is clear that the power density achieved with single devices per converter position is double in the case of the IGCT design. A high power factor P_F was selected close to 1 to minimise the losses of the free-wheeling diodes. In any case for power factors in the range of 0.85 to 0.95 the contribution of these diodes to the overall losses for inverter mode is minimal, i.e. in the range of few hundreds of watts in total at maximum. Similar considerations apply for the switching losses of the controlled element in position 2, be it an IGBT or an IGCT. The switch in that position experiences virtually no switching losses accounting for its duty cycle which is continuously conducting and commutates to 0 current under zero voltage. This is also due to the NPC diode operation applying 0 voltage across position 2 of an active switch. The current of devices in position 2 exhibits a smooth continuous shape. The effect of a highly inductive power factor and increased switching frequency results in appearance of very few and negligible switching losses. Figure 3 shows scope waveforms of IGCT2 taken during the simulation which indicate this behaviour.

Proportionally the losses in the semiconductors are much lower in the case of the IGCT converter and even with the estimation of the additional losses in the clamp circuit with the higher clamp inductor Li option they are still lower compared to the IGBT based converter. It is also interesting to observe the pure losses in the controlled semiconductors

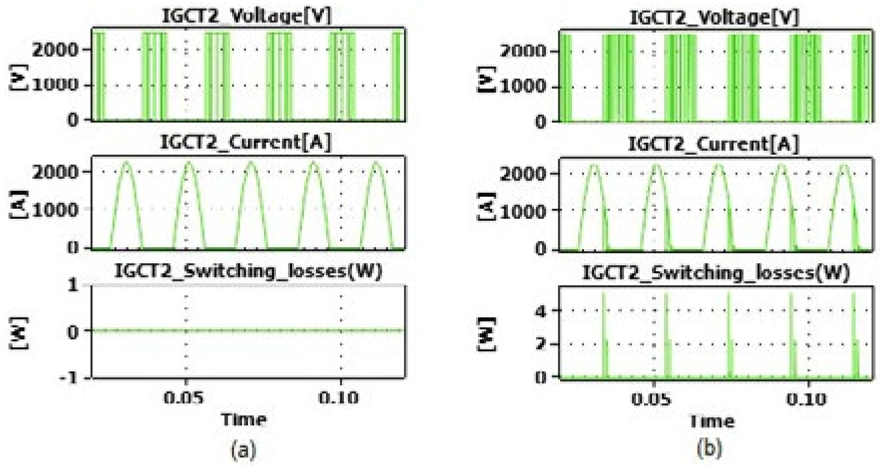

Figure 3: IGCT2 switching losses (a) P_F=0.95, F_{sw}=450 Hz, (b) P_F=0.8, F_{sw}=750 Hz

as a ratio to the input power drawn from the DC side. This figure shows clearly the performance advantage of the IGCT.

DC side Input Power (MW)	AC Phase Voltage (RMS)	AC Phase Current (RMS)	Power Factor	DC Voltage (kV)	Modulation Index	Switching Frequency (Hz)	Rth (Heatsink-Ambient) (K/kW)	Tamb (OC)
9.5	1.881	1.771	0.95	2.8	0.95	450	8	45
4.75	1.881	88	0.95	2.8	0.95	450	8	45

Table 1: IGCT and IGBT PEBB operating conditions

	Total losses in all phase legs – IGCT / IGBT PEBB			
Element Position	Switching (kW) IGCT / IGBT	Conduction(kW) IGCT / IGBT	Combined (Sw+Con) (kW) IGCT / IGBT	Tj_avg °C IGCT / IGBT
1-4 (Outer)	11.64 / 9.16	6.18 / 5.4	17.82 / 14.56	105 / 108
2-3 (Inner)	0 / 0	8.4 / 6.6	8.4 / 6.6	71 / 75
FWD1	0 / 0	0 / 0	0 / 0	45 / 65
FWD2	0 / 0	0 / 0	0 / 0	45 / 54
NPCD5	7.32 / 1.92	4.51 / 2	11.83 / 3.92	79 / 76

IGCT PEBB: Clamp losses (kW)	8.5
IGCT PEBB: Snubber losses (kW)	5.0

Table 2: IGCT and IGBT PEBB semiconductor losses

PEBB	Power Handling Capability(kW)	Pure IGBT-IGCT Losses (kW)	Total Losses IGCT with 5uH clamp (kW)	Total Losses/Input Power	Pure IGBT-IGCT losses / Input Power
IGBT	4750	22.16	25	0.52%	0.46%
IGCT	9500	26.22	46.5	0.48%	0.27%

Table 3: Performance comparison

Conclusion

The IGCT is proven over the years as the preferred device for high power applications especially above 5 MVA. Using the ABB SEMIS simulation tool a comparison was made between IGCT and IGBT based concepts for a common 3 level NPC VSC circuit. It is evident from the results that the IGCT allows for higher power density without the need of paralleling devices. At the same time it is resulting in proportionally lower device and converter losses than IGBT based configurations at comparable operating conditions. From these facts the system designer benefits in many ways. The higher power density allows for smaller converter footprint and simplicity on the semiconductor control circuit. The lower losses provide better performance and operational cost saving. ABB has a long history of evolution for this semiconductor element and is currently developing next generation technologies which will allow even higher capabilities.

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SiC MOSFETs Enable High Frequency in High Power Conversion Systems

Enhancing the performance of traditional IGBT-module-based power assemblies with SiC modules

In recent years, 1.2kV and 1.7kV silicon carbide (SiC) MOSFETs have become a real alternative for power converter designers who currently use IGBTs. To date, the majority of the SiC MOSFET design wins have occurred in power converters in the low watts to 20kW range, which are typically clean-sheet designs and this momentum is primarily driven by the need to improve efficiency in PV inverters and other industrial power supply applications.

By John Mookken, Cree Inc.

Designers are now using commercially available, high power, all-SiC power modules and drivers (see Figure 1) for both upgrading existing Si-IGBT systems and new designs especially tailored to take maximum advantage of these new SiC products to enable smaller, cooler, and all-around better performing power conversion systems.

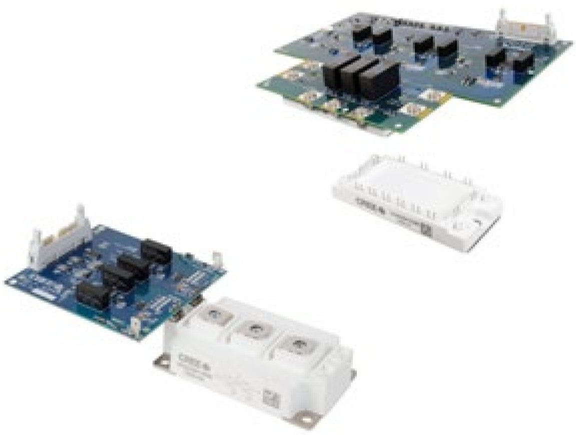
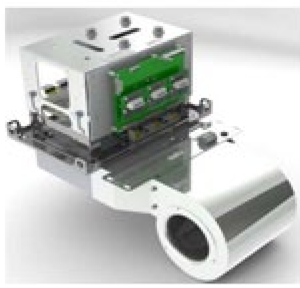


Figure 1: High power all-SiC power modules available in 1.2 and 1.7kV versions with their associated gate drivers are a real alternative to IGBT modules.

Si IGBT Assembly and Conversion to SiC

The material advantages of SiC over Si in power devices is well documented and requires no further review [1][2]. As such, our focus will be on the application of all-SiC modules in large power conversion systems. A commercial, off the shelf, Si-IGBT assembly based on 62mm, 400A, 1.2kV modules and including DC link capacitors, a forced air-cooled heatsink and blower, and gate drivers with protection logic and sensors was selected for SiC conversion and tested to determine performance improvements. Figure 2 depicts the IGBT assembly, which we will refer to as either an IGBT stack (before conversion) or a SiC stack (after conversion), and its critical performance specifications are shown in Figure 2, with additional details available in the manufacturer's data sheet [3]. With a datasheet rating of 140kW (200A rms) of output power at a switching frequency (Fsw) of 3kHz, the selected 200A IGBT stack is the smallest from a family of products, and is a good representation of a generic commercial-module-based power subsystem that we are likely to find in commercial central solar inverters or motor drives.



Key Max. Parameters		Units
I_{out}	200	Arms
V_{out}	400	Vac
V_{bus}	900	VDC
F_{out}	500	Hz
F_{sw}	25	KHz
P_{out} max @ F_{sw} = 3kHz, 750VDC, PF=1 , 400Vac & 900 m3/hr @ 40C cooling	140	kW

Figure 2: A commercial IGBT stack assembly and its key specifications

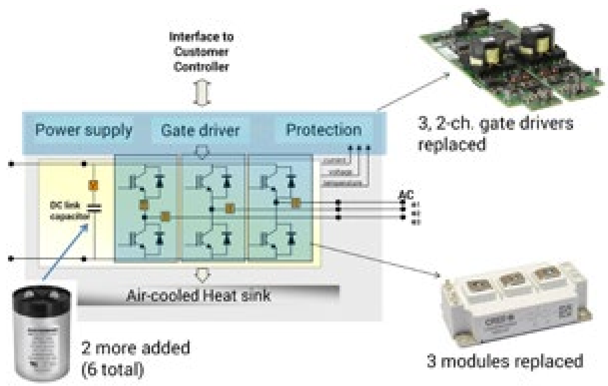


Figure 3: A block diagram of the IGBT stack with parts highlighted in blue is replaced or modified for the SiC stack conversion

The process involved in converting the IGBT stack to use SiC devices proved to be extremely simple due to the availability of all-SiC power modules in the same form factor with compatible gate drivers that have all of the features we see in typical IGBT module gate drivers. Figure 3 summarizes the changes. The additional DC link capacitors were only added to facilitate testing at higher output currents. The three 1200V, 400A IGBT modules were each replaced with 1200V, 300A all-SiC modules and the 6-ch gate driver board was replaced with three 2-ch gate driver boards designed for the SiC modules. One of the few mechanical changes to the SiC stack included repositioning the gate drivers from their original position, located approximately 8 inches away from the power modules, to direct mounting on the SiC modules. This modification was driven by SiC's higher switching speeds, which necessitate that we do everything possible to minimize the effects of parasitic inductance and capacitance due to layout.

The 1200V, 300A, SiC MOSFET modules, with the built in SiC Schottky diodes for free-wheeling, have five distinct performance advantages over the 400A IGBT modules it replaced: 1) lower switching losses, 2) lower conduction losses, 3) negligible diode switching losses, 4) higher breakdown voltage margins, and 5) immunity against cosmic radiation induced failures or single event burnout (SEB).

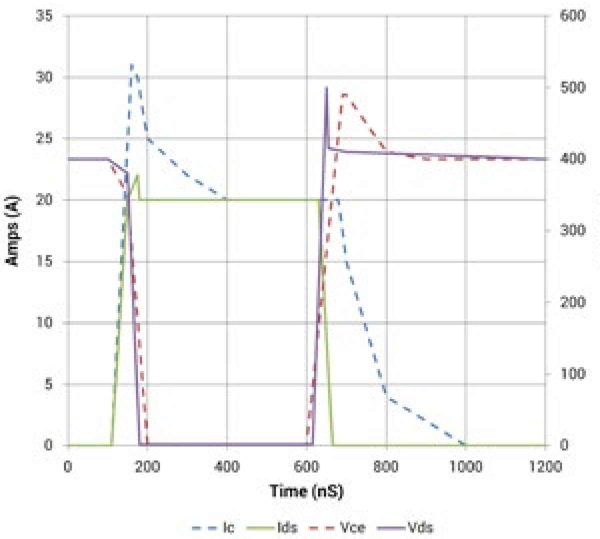


Figure 4a: MOSFET switching loss comparison

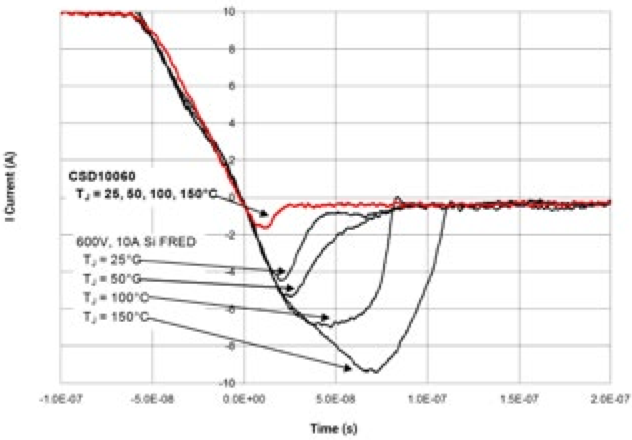


Figure 4b: MOSFET diode recovery loss comparison

It is generally a well-known fact that SiC MOSFETs have lower switching losses, as evidenced in Figure 4a, in which we compare a Si-IGBT with a fast recovery diode (FRD) in the anti-parallel position to a similarly rated SiC MOSFET with a SiC Schottky diode in the anti-parallel position of a half bridge circuit. Note, as shown in Figure 4b, that the SiC Schottky diodes have virtually no reverse recovery charge and is constant over a temperature from 25°C to 150°C, which contributes to lower Eon in the commutating MOSFET and significantly lower diode switching losses. A lesser known fact, however, is that the total switching losses (ET), which are the sum of turn-on and turn-off losses, in SiC MOSFETs actually remain constant or decrease with higher junction temperature (in some cases 10–25% lower), but the opposite is true for Si-IGBTs. So, at useable operating temperatures, the difference between Si-IGBT ET and SiC MOSFET ET is greater than they are at room temperature values.

In order to better understand the conduction losses, let us consider the forward characteristics of an IGBT rated for 50A to SiC MOSFETs with different current ratings. As shown in Figure 5, it is evident that an equivalent 50A SiC MOSFET will have about half the conduction losses. Plus, it is not necessary to replace a 50A IGBT with a 50A SiC device to get the same performance. The 40A SiC MOSFET and the 50A Si-IGBT both have the same conduction losses at the IGBT's rated current. So, one may assume that both devices have the same conduction losses. However, it is important to note that the rated current of the IGBT is the DC current rating of the device for a given case temperature and does not include device switching losses. If the 50A IGBT is switching, then it will have to be de-rated to a lower current to avoid exceeding the maximum power dissipation value (PDmax) value of the part. We can see from the shape of the lines in Figure 5 that, at any value below 50A, the 40A SiC MOSFET has an advantage with regard to conduction losses due to a MOSFET's pure Ohmic loss characteristic. Given the significant disparity if switching losses between the two devices, the SiC device will have a significantly lower current de-rating with higher switching frequencies when compared to a Si-IGBT equivalent.

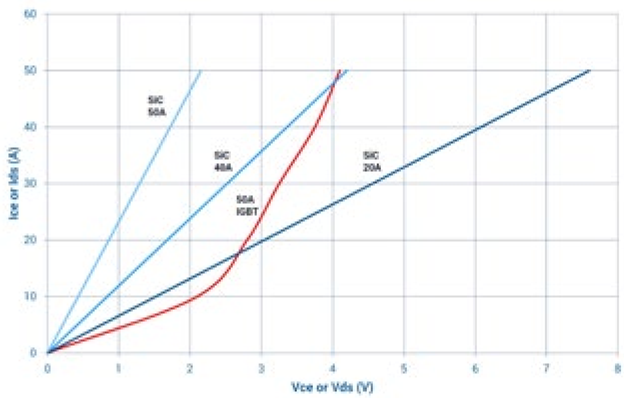


Figure 5: Forward voltage vs. current comparison between IGBTs and SiC MOSFETs

Having addressed the lower switching, conduction, and diode switching losses for SiC modules, we can now discuss their immunity against high energy particle induced failures or SEB, as SiC MOSFETs are expected to be significantly less susceptible to this mode of failure. Three factors have a significant contribution towards this mode of failure: device material type, device area, and voltage stress [4].

With approximately 3x the band gap of Si, only 33% the surface area of similarly rated Si devices, and a breakdown voltage margin

1.33 times over the maximum device voltage rating, it is easy to understand how a SiC MOSFET can minimize the effect of the three primary factors that contribute to SEB when compared to Si-IGBTs.

Enhanced Performance

After converting the IGBT stack to a SiC stack, we expected to have significantly lower power dissipation, which can result in the same output power and efficiency at much higher switching frequencies. This can reduce the size and weight of the overall system or produce more power at the same switching frequency, which can improve power density and Watts/$ or simply enable the system to operate at a lower junction temperature and higher efficiencies at the same operating conditions, effectively boosting reliability. Figure 6 shows the simulated improvement in performance, which is later verified with measured data, for output current versus switching frequency of the IGBT stack.

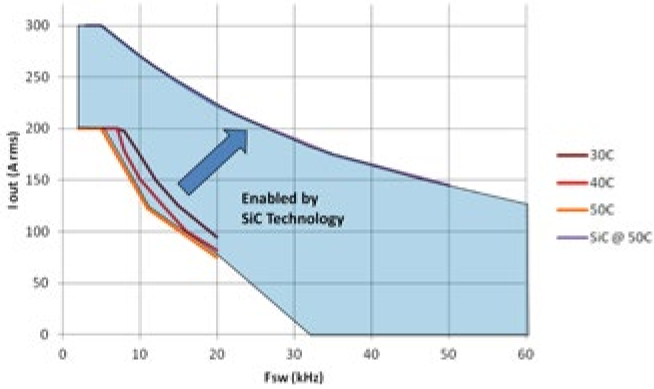


Figure 6: SiC enhanced capability, highlighted in blue, compared to the data sheet plot of the IGBT stack

To confirm the expected performance improvement, the SiC stack was tested as a 3-phase inverter, and the measured results were compared to the published datasheet values for the IGBT stack. The test was conducted using a 700VDC source with forced cooling from a 400m^3/Hr blower at an ambient temperature (TAMB) of 25°C. The output voltage was set to 480Vac rms l-l at 50Hz and connected to a balanced 3-phase resistive load bank that could be varied from 2.8 to 263kW. Initial testing was conducted at Fsw=10kHz, and then the test was repeated at Fsw=50kHz while keeping all other operating parameters constant. The results are summarized in Figure 7 and illustrate the distinct performance advantages achieved with the SiC stack.

If we consider the complete IGBT stack family, where would the converted SiC version of the stack fit in the product lineup? The answer depends on the operational switching frequency of the application. In Figure 8, we show the rated output current of the products versus Fsw. As expected, there is an inverse relationship between the output current and Fsw. However, due to the sharp de-rating of the output current for IGBT stacks, we can see that at Fsw=10kHz, the 750A rated IGBT stack, which is 3x the size of the SiC stack, has the same output current capability. Furthermore, the area highlighted in blue in Figure 8 illustrates new capabilities that are simply not economically attainable with Si-IGBTs.

Summary

High power converter designers have always had to strike a balance between performance, size, cost, and operating switching frequency (Fsw). Higher Fsw results in smaller and lighter converters, but they pay a penalty in efficiency. Typically, for high power systems (>500kW), the balancing act results in an optimal Fsw of about 3kHz. All-SiC power modules now allow design engineers to design to higher Fsw without a significant penalty on performance, tipping the scale in favor of higher frequency power conversion systems, which can result in smaller size and weight, faster response times, simplified, and more reliable power conversion systems.

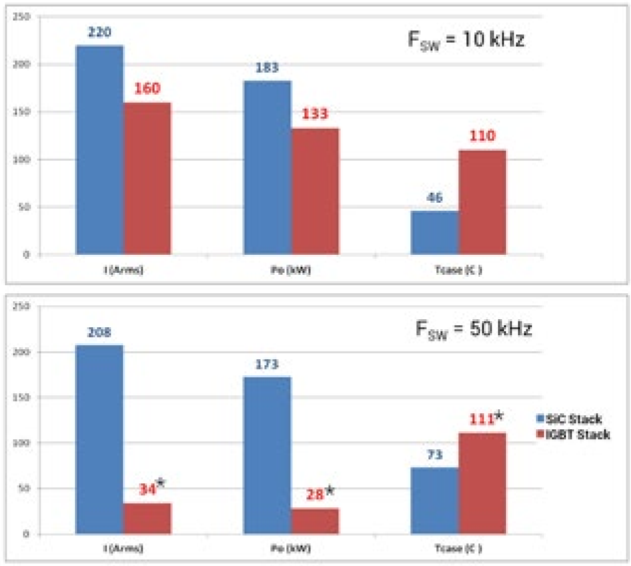


Figure 7: Output current, output power, and case temperature of the module compared before conversion (IGBT stack) and after (SiC stack) for Fsw=10kHz and Fsw=50kHz.
**Denotes simulated data due to IGBT operational limitations.*

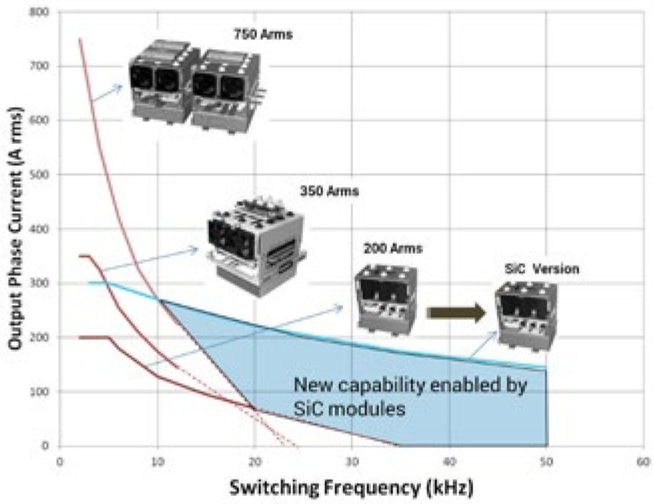


Figure 8: IGBT Stack product family compared with the SiC stack

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[2] A Elasser, et al, “A Comparative evaluation of new silicon carbide diodes and state-of-the-art silicon diodes for power electronic applications,” IEEE IAS Annual Meeting Conference Proceedings, pp. 341-345, 1999.

[3] http://www.semikron.com/dl/service-support/downloads/download/semikron-datasheet-igd-1-424-p1n4-dl-fa-08800445

[4] J. Dodge, “Reduce circuit zapping from cosmic radiation,” Power Electronics Technology, pp. 20-26, September 2007.

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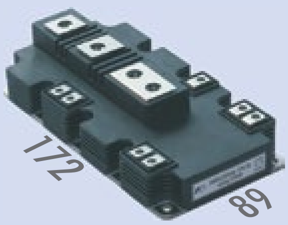
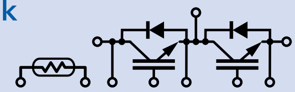
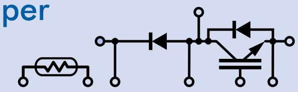
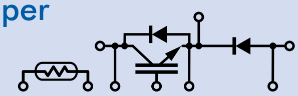
• Trench-FS IGBT • High thermal cycling capability • Low spike voltage & oscillation free • Excellent turn-on $^{dI_C}/_{dt}$ control by R_G

◆ Standard IGBT Modules

Package	Configuration		I_C	1200 V E-Type	1200 V P-Type	1700 V E-Type	1700 V P-Type
	2-Pack		600A	E			
			650A			E E+	
			900A	E	P		
	Chopper		650A			E	
			900A		P		
	Chopper		650A			E	
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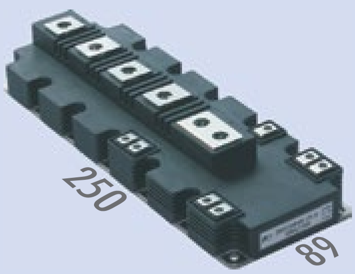
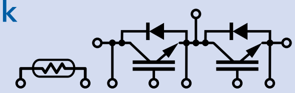
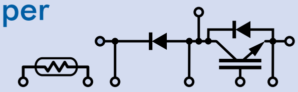
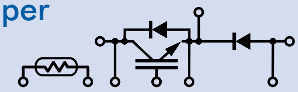
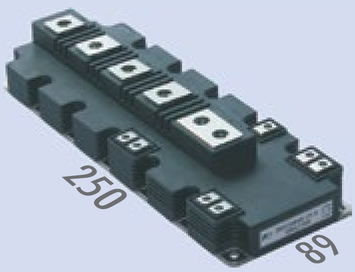
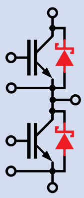
	2-Pack		1000A			E E+	P
			1400A	E	P	E	P
	Chopper		1000A			E	
			1400A		P	E	
	Chopper		1000A			E	
			1400A		P	E	

E : E-type (low switching losses) E+ : E-type with large Free Wheeling Diode P : P-type (low $V_{CE,sat}$ & soft turn-off)

◆ Hybrid IGBT Modules *(Si-IGBT with SiC-Schottky diode)*

Package	Configuration		I_C	1200 V	1700 V
	2-Pack		1000A		●
			1400A	●	●

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6500 V X-Series High Voltage IGBT Modules

The 6500 V X-Series high current IGBT power module breaches the technological barrier for operating at 150 °C junction temperature by employing the 7th Generation IGBT and Diode chip-sets. This could potentially unlock the possibility of discovering new horizons in inverter design.

By Eugen Wiesner and Eugen Stumpf MITSUBISHI ELECTRIC EUROPE B. V. and Y. Kitajima MITSUBISHI ELECTRIC CORPORATION

Introduction

On 29th Sep. 2015 MITSUBISHI ELECTRIC CORPORATION launched the first product of the new high voltage IGBT X-Series product family [1] - the IGBT module with a blocking voltage of 6500 V and a rated current of 1000 A. CM1000HG-130XA is the highest rated device in the industry for this voltage class (operating temperature of 150 °C). A key design aspect of the X-Series is the combination of the already well know and proven R-Series package technology with the newly developed 7th generation IGBT and Diode chip-set. The CM1000HG-130XA package outline is shown in Figure 1. It is the standard package type with a high isolation voltage of V_{ISO}=10,2 kV and a foot print size of 190 mm x 140 mm and this same package is used in the previous generation R-Series. For many years R-Series has been demonstrating excellent reliability for different applications (such as traction, industrial drives and power transmission) requiring a high demand on quality as well as reliability.

Durability at a high operating temperature of 150 °C was already demonstrated and proved with the R-Series package technology for power modules in the voltage classes: 3300 V and 4500 V. The new developed 7th generation chip-set allow for an increase in the operating temperature of up to 150 °C for the IGBT modules in the 6500 V class.

Figure 1: CM1000HG-130XA X-Series IGBT module package outline.

7th generation IGBT and Diode chip-sets contributes to the enhancement of power module current density

The 7th generation chip was developed and optimized especially for low power loss and high temperature operation. For both IGBT and Diode chips the new guard ring structure (edge termination) was developed allowing an increase in the active chip area [2]. It was possible to increase the IGBT active chip area by about 28%. A comparison of the 6500 V X-Series IGBT chip with an IGBT chip of a previous generation is shown in Figure 2. As a result of the reduced current density, a lower forward voltage drop could be achieved. This contributes to lower steady-state power losses. On the other hand thermal resistance between the junction and the case could be decreased to $R_{th(j-c)Q}$=11 K/kW for the IGBT and to $R_{th(j-c)D}$=17 K/kW for the diode respectively.

Additionally, the CSTBT (III)TM trench gate structure contributes to the reduction of the IGBT forward voltage drop. The Diode has an RFC structure that results in a soft reverse recovery switching even at higher values of stray inductance [4]. Both chips - IGBT and Diode possess a positive temperature coefficient that makes paralleling of the X-Series quite easy. At the junction temperature of 150°C the device has a typical leakage current of I_{CES}=30 mA and it is comparable to leakage current values of previous generation modules at 125 °C junction temperature. A low leakage current value at a high junction temperature in combination with a robust chip design enables safe switching at high temperatures and thereby permits increasing the operation temperature of the 6500V X-Series up to 150°C.

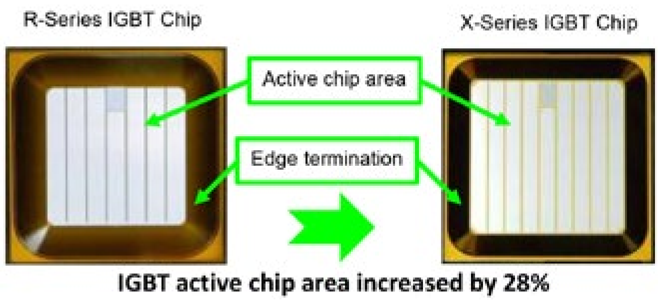

Figure 2: IGBT Chip comparison between 6500 V R- and X-Series.

Electrical characteristics

A brief overview of the key electrical parameters for the CM1000HG-130XA module at the rated current of 1000 A and junction temperature of 150 °C is shown in Table 1.

Parameter	Value	Conditions
$V_{CE(sat)}$	3,60 V	I_C=1000 A, T_J=150 °C
V_{EC}	3,05 V	I_C=1000 A, T_J=150 °C
E_{OFF}	6,8 J/Pulse	I_C=1000 A, T_J=150 °C, V_{CC}=3600 V
E_{ON}	7,5 J/Pulse	I_C=1000 A, T_J=150 °C, V_{CC}=3600 V
E_{RR}	4,6 J/Pulse	I_C=1000 A, T_J=150 °C, V_{CC}=3600 V

Table 1: Overview of electrical parameters

The new 7th gen chip-set has the same chip arrangement as the highly optimized tried and tested R Series chip-set. Furthermore, the internal layout of the main and the auxiliary terminals were maintained unchanged. As a result, the switching performance of the new X-Series can rely on the long and proven record of the R-Series. The below figures show the typical switching wave forms of the CM1000HG-130XA device. Figure 3 shows the IGBT turn on wave forms at nominal conditions. Figure 4 shows the typical IGBT turn off wave forms at nominal conditions. The module voltage and current have soft characteristics without any oscillations. The collector emitter peak voltage at turning off the collector current I_C=1000 A at a DC-link voltage of V_{CC}=3600 V. with a stray inductance of L_S=150 nH is about 4200 V only.

The typical CM1000HG-130XA reverse recovery waveforms are shown in Figure 5. Here too, the diode voltage and current have soft switching characteristics.

Application benefits of using the newly developed CM1000HG-130XA device.

The achievable inverter output current is the most important performance parameter for an IGBT module used for an inverter application. Figure 6 is the simulation result showing the inverter output current versus switching frequency for a three phase inverter using a sine-triangle PWM control algorithm. The new developed CM1000HG-130XA device is compared with the previous generation module CM750HG-130R. Simulation was performed at the same junction-case temperature swing of $\Delta T_{(j\text{-}c)}$=20 K and maximum junction temperature of T_J=125 °C. The curves are normalized with respect to the previous generation CM750HG-130R device and a switching frequency of f_{sw}=300 Hz. The new device CM1000HG-130XA has more than 20% better performance at f_{sw}=300 Hz. At a switching frequency of f_{sw}=150 Hz, the performance of the CM1000HG-130XA device is 30% greater compared to the previous generation. This advantage at low switching frequencies is especially beneficial for multi-level grid applications like HVDC (High Voltage Direct Current) power transmission and SVC (Static Var Compensation).

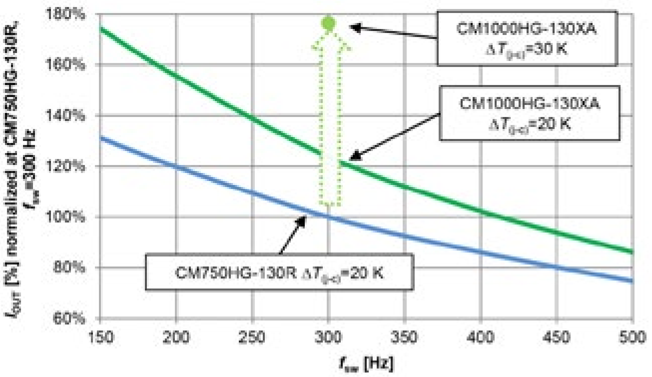

Figure 6: Inverter output current versus switching frequency at V_{CC}=3600 V, cos(φ)=0,9, m=1, T_J=125 °C.

In case the junction-case temperature is increased from 20 K to 30 K for CM1000HG-130XA module, the output power can be increased by 80% as shown in Figure 6. As a result, applications with high short time overload conditions would not need derating for nominal operation (attributable to the maximum junction temperature limitation of 125 °C).

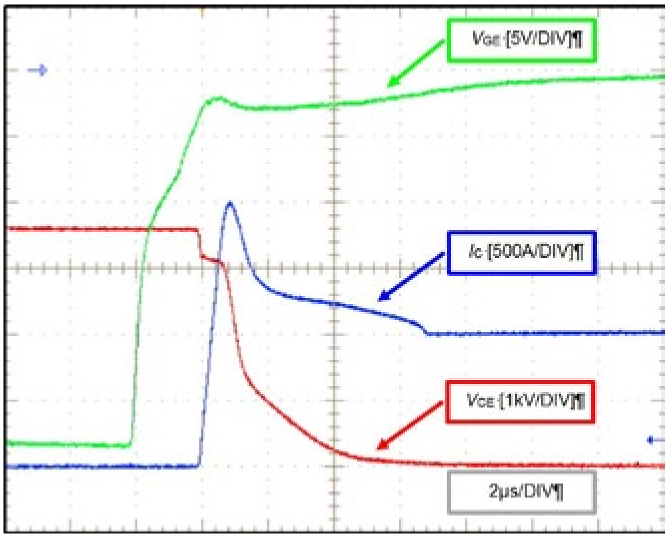

Figure 3: CM1000HG-130XA IGBT turn on wave forms at T_J=150 °C, V_{CC}=3600 V, I_C=1000 A, $R_{G(on)}$=1,8 Ohm.

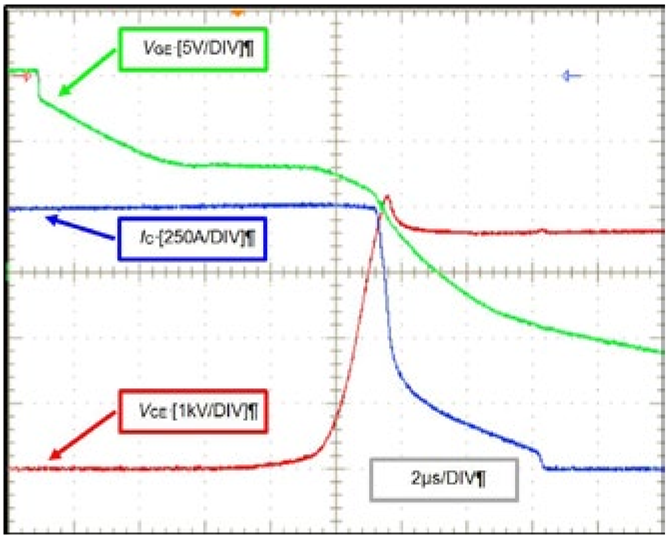

Figure 4: CM1000HG-130XA IGBT turn off wave forms at T_J=150 °C, V_{CC}=3600 V, I_C=1000 A, $R_{G(off)}$=30 Ohm.

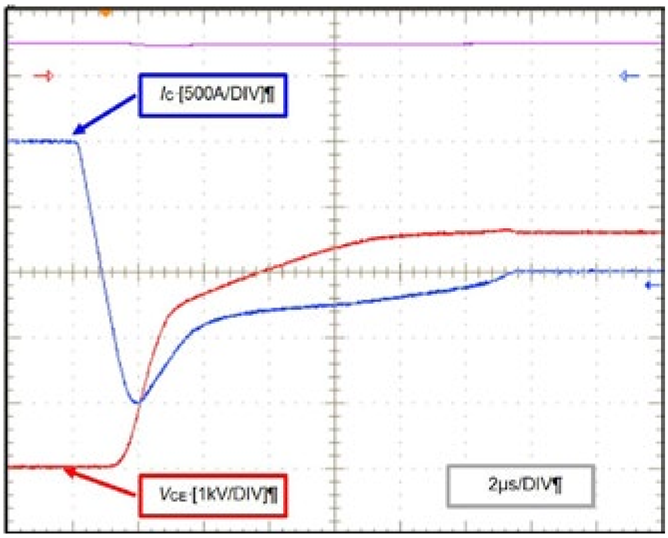

Figure 5: CM1000HG-130XA FWDi reverse recovery wave forms at T_J=150 °C, V_{CC}=3600 V, I_C=1000 A, $R_{G(on)}$=1,8 Ohm.

The capacity of the new module to operate at an increased junction temperature of 150 °C would greatly benefit applications such as traction and industrial applications with air cooled heat sink (compared to the modules operating at 125°C). This can be demonstrated by a simple calculation - for example – a heat sink (in a typical air cooled application) with an $R_{th(f-a)}$=70 K/kW would result in a 70 K temperature difference between the fin and the ambient for a power dissipation of 1000 W. Additionally, it must be noted that for air cooled applications the temperature increase internally within the module is not significant. Thus, (considering a linear dependency between power loss increase and output power increase), we can realize an output power increase of 20%. By increasing the power dissipation by 20% (1200 W), the heat sink temperature will increase additional by 14 K (to 84 K) and that can be easily buffered by the CM1000HG130XA device.

Increasing the operating temperature of the 6500 V power module allows further optimization in the cooling system such as:

- Reduction in the water flow rate in liquid cooled applications
- Using less expensive liquid heat sinks
- Reducing the cost for heat exchanger in liquitd cooled systems
- Using forced air cooling instead of water cooling
- In some cases, the paralleling of traditional type modules can be avoided by using of ingeniouse CM1000HG-130XA device.

The X-Series uses a well-known standard package and this allows for quick optimizations and improvements requiring no significant re-design/development to existing inverter designs. The cooling system can be optimized and higher inverter power density can be realized by using CM1000HG-130XA device with increased operating junction temperature.

The advantage of increase operating temperature can be easily translated into either a simplification of the existing cooling system (maintaining a modest output power) or increase of the output power (maintaining an existing cooling system).

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The Influence of IGBT5 and .XT Technology on the System Power Density illustrated through a Hardware Demonstrator

At present increase in power density and enhancement of lifetime of the power modules are limited by the chip and inter-connection technologies. 'IGBT5 and .XT' technology is based on the idea to develop a solution which will lead to an increase in the module power density along with lifetime improvement.

By Dr. Raghavan Nagarajan and Hubert Kerstin, Infineon Technologies AG

This new technology improves the power cycling (PC) capability of the power modules. The improved PC capability can be used in two different ways: firstly, to enhance the lifetime of the module. Secondly, to use PC enhancement for an increased power density by means of an increased maximum operational junction temperature. In this article, the influence of 'IGBT5 and .XT' technology on the system power density is illustrated through a hardware demonstrator.

IGBT5 and .XT – Module Power Density vs Lifetime Trade-off

Figure 1 depicts the power density vs lifetime trade-off triangle. The enhancement of the lifetime of the new 5th generation module corresponds to the movement in the horizontal direction in Figure 1 (along the x-axis). An increased module power density is enabled through an increased maximum operational junction temperature. In Figure 1, this corresponds to the movement in the vertical direction (along the y-axis) with respect to existing solution.

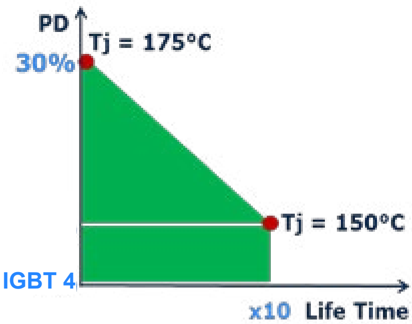


Figure 1: Power density and lifetime trade-off curve for 'IGBT5 and .XT' at the same chip size

IGBT5 and .XT in PrimePACK™ package

The PrimePACK™ 3 power module housing introduced in 2006 has become a standard for power module housing in the megawatt power range. Owing to its success it is self-evident that the launch of the new 5th generation 1700 V IGBT will take place in the PrimePACK 3+ housing [1-4].

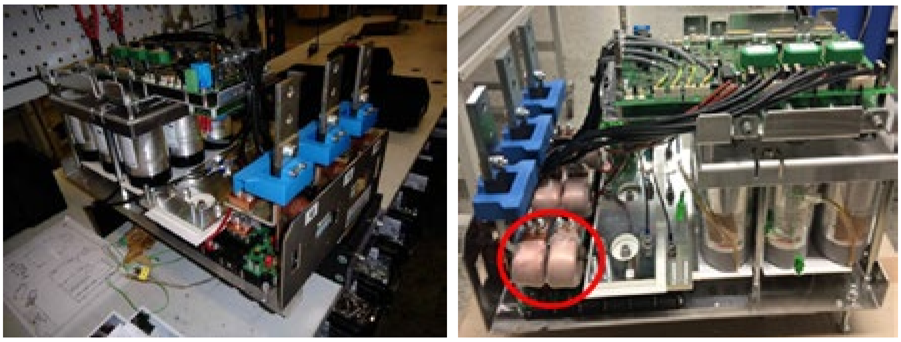


Figure 2: Photo of the two demonstrator stacks built: (left) Stack with FF1400R17IP4, (right) Stack with FF1800R17IP5

At present, the maximum available current rating in the PrimePACK 3 housing in a half-bridge configuration is 1400 A.

With the introduction of this new 5th generation IGBT half-bridge module together with new .XT interconnection technology, the nominal current rating of the module increases to 1800 A. To enable this increase in module current, the present PrimePACK 3 package is modified. It now contains two AC bus bar and terminals instead of one AC. The general outer dimensions of PrimePACK 3 package are retained with only a small modification.

Module Power Density vs System power density

The percentage increase in module's power density may not translate directly into system power density. The best way to determine the influence of module power density on the system power density is to build two demonstrators, one with existing IGBT4 power module (FF1400R17IP4) and another with new 5th generation module (FF1800R17IP5) and compare the system power density of both. The two demonstrators were built on an Infineon STACK platform as shown in Figure 2.

The main difference between the two demonstrators is that the FF1800R17IP5 features two output AC terminals instead of a single one. In the newly built demonstrator, the additional AC terminal has been taken into consideration and the mechanical construction of the system is adapted accordingly. This arrangement is explicitly marked with a circle as depicted in Fig. 2(right). This mechanical adaptation leads to a change in the length of IGBT5 based STACK thereby leading to a change in the system volume. It should be noted, however, that the PrimePACK 3 and the new PrimePACK 3+ have the same module footprint (HxWxL = 38x89x250 mm).

Each hardware demonstrator consists of a 3-phase inverter having one module in each phase. The DC link consists of a 3.6 mF DC bus capacitor and the output AC terminals of the demonstrator have three Hall-effect current sensors.

Table 1 lists the important parameters of the demonstrator developed.

Topology	B6I
Application	Inverter for Drives & Wind energy converters
Load type	Resistive, Inductive
DC link capacitor	3.6 mF
Heat sink	Water cooled
Thermal resistance heat sink to ambient per switch – $R_{th,HA}$	30.2 K/kW
Sensors	Current, Voltage, Temperature
Driver signals to the IGBT	Electrical
Rg_on	1.0 Ω
Rg_off	0.68 Ω

Table 1: Important parameters of the demonstrator

A summary of the change in system volume is pictorially depicted in Figure 3 and listed in Table 2.

	Length [cm]	Width [cm]	Height [cm]	System Volume [dm^3]
FF1400R17IP4 based stack	59	33.8	36.4	72.59
FF1800R17IP5 based stack	61	33.8	36.4	75.05

Table 2: Dimensions and system volume for FF1400R17IP4 and FF1800R17IP5 based Stacks

To obtain the system power density at conditions which are relevant and typical for the application, the two stacks were tested according to the parameters as listed in Table 3.

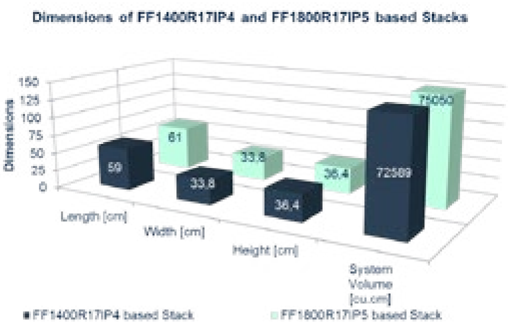


Figure 3: Dimensions of FF1400R17IP4 and FF1800R17IP5 Stacks

Both stacks were tested under identical output voltage and power factor conditions. Therefore, in such cases, the system power density is simply related to the output current and system volume. For example, if the output voltage and power factor is 690 V and 1.0 respectively, then the system power density is as listed in Table 4.

Increase in system power density of an IGBT5 based stack compared to an IGBT4 based stack is 26.5% as shown in Figure 4. For a detailed temperature profile of the stacks under above mentioned operating condition refer to [1].

	Output Current [A] @ 2000 Hz	Output Frequency [Hz]	DC bus Voltage [V]	Output to Module Current Ratio
FF1400R17IP4 based Stack	780	50	1100	55.71%
FF1800R17IP5 based Stack	1020	50	1100	56.67%

Table 3: Test conditions for the two stacks

	System Power [kW]	System Volume [dm^3]	System Power density [W/cm^3]
FF1400R17IP4 based Stack	932.16	72.59	12.84
FF1800R17IP5 based Stack	1218.98	75.05	16.24

Table 4: Comparison of system power density

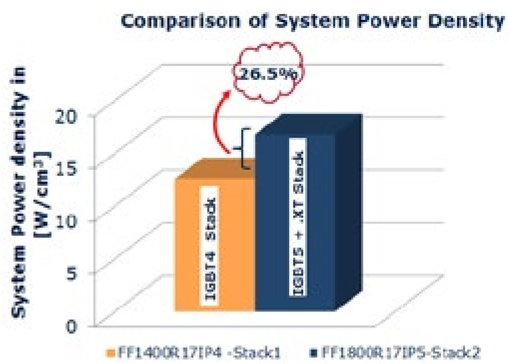


Figure 4: Comparison of system power density of IGBT4 and IGBT5 Stack

Conclusion

An increase in power density and lifetime of the power modules are enabled by IGBT5 and .XT technology. For nearly the same output current to module current ratio of both the demonstrators, the IGBT5 and .XT technology based power stack leads to an increase in system power density of 26.5% compared to IGBT4 based stack with no change in module footprint (HxWxL = 38x89x250 mm) between PrimePACK™ 3 and the new PrimePACK 3+ package.

[1] Raghavan Nagarajan and Dirk Brieke: Aspects of increased power density with the new 5th generation IGBT demonstrated by application relevant measurements, PCIM, Nuremberg, Germany, 2015.

[2] K. Guth et al.: New assembly and interconnects beyond sintering methods, PCIM, Nuremberg, Germany, 2010.

[3] M. Schulz: Power Semiconductor Development, Bodo's Power Systems, February 2015.

[4] Andre R. Stegner et al: Next generation 1700V IGBT and emitter controlled diode with .XT technology, PCIM, Nuremberg, Germany, 2014.

www.infineon.com/PrimePACK

First 18V Monolithic Synchronous DC/DC Buck Regulator

Alpha and Omega Semiconductor Limited announced the release of the AOZ3101, a high efficiency, simple-to-use synchronous buck regulator, with an operating input voltage range from 4.5V to 18V, supplying 2A of continuous current. The device offers a low on-resistant power stage in a thermally enhanced 3mm x 3mm DFN package, allowing cooler power conversion for a variety of consumer electronics application such as LCD TVs, set-top boxes, as well as DVD players and recorders.

The low on-resistance of the internal power MOSFETs in this device allows higher efficiency and less heat generation. It has over 90 percent efficiency at full load operation and maintains it at 85 percent efficiency while in 10mA light load operation. When operating in low output current conditions, the device will operate in a proprietary pulse energy mode (PEM) to obtain high efficiency. Under heavy load steady-state conditions, the device will operate in fixed frequency and Continuous-Conduction Mode (CCM).

The full load efficiency of the AOZ3101 is 1 percent higher and the IC surface temperature is almost 30 percent lower than that of the closest competitor.

"We continue to expand our fifth generation EZBuck product portfolio to provide our customers with higher efficiency and more reliable DC/DC solutions." said Kenny Hu, Power IC Product Marketing Manager at AOS.

www.aosmd.com

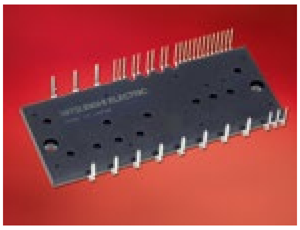
1608-Sized High Brightness Single Rank Chip LEDs

ROHM has recently announced the availability of high accuracy single-rank 1608-size high-brightness chip LEDs optimized for a wide variety of applications, from industrial equipment and consumer devices to automotive systems.
The need to reduce brightness variations is increasing as a greater number of applications and devices, particularly in the automotive and industrial sectors, are demanding improved consistency when configuring multiple LEDs side-by-side. However, up to now it has been difficult to minimize brightness variations during the manufacturing process. Conventionally, users were able to only narrow down the number of ranks from around 4 to 2-3, which still required sorting and the use of different resistors to match each rank, increasing the number of man-hours required along with inventory management. In response, the SML-D15 series was developed using a comprehensive, highly integrated manufacturing system (from device fabrication), allowing ROHM to surpass the limits of conventional LED production. As a result, high-accuracy brightness is achieved and brightness variations reduced by 75%. This makes it possible to provide a single rank of brightness (a rarity in the industry), significantly lightening design load.

www.rohm.com/eu

DIPIPM Transfer-Mold Intelligent Power Modules

Mitsubishi Electric Corporation announced the launch of DIPIPM+, new models in its DIPIPMTM series of inverter applications, featuring loading converter and brake circuits for reduced design load and size. Mitsubishi Electric commercialized its first DIPIPM transfer-mold intelligent power module in 1997, the beginning of its ongoing contributions to miniaturi-zation and energy savings in inverter systems. To achieve a more compact and simpler design, Mitsubishi Electric has developed DIPIPM+ incorporating inverter, converter and brake circuits into one package.

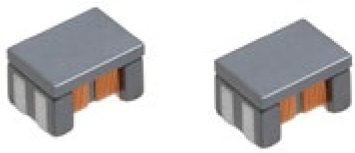


The dual in-line package intelligent power module (DIPIPMTM) incorporates a built-in inverter and a driving circuit as well as a newly added converter, and brake circuits into one package. The small package size could be realized thanks to Mitsubishi Electric's own direct wire bonding technology. The module's overall dimensions are 34mm x 85mm x 5.7mm. These novel power modules include a three-phase inverter bridge with built-in IGBTs, FWDs, HVICs, LVICs, bootstrap diode (BSD) with current limit resistor and analog temperature voltage output as well as a three-phase converter circuit, and a brake circuit. Functions include short-circuit protection (by shunt resistance), control power supply under-voltage protection (with FO output on N-side protection), and analog temperature voltage output (VOT).

http://www.mitsubishichips.eu/

Common-Mode Chokes for Automotive Ethernet Offer Best Noise Suppression

A series of common-mode chokes from TDK that offers best-in-class noise suppression for automotive Ethernet is now available in Europe at TTI, Inc.. The TDK ACT45L series also boasts the smallest footprint of any common-mode choke currently available for automotive Ethernet applications, yet incorporates advanced technologies to deliver high reliability and consistent quality.

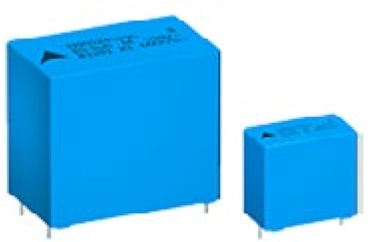


Ethernet is quickly becoming the preferred networking protocol for today's multimedia infotainment in cars, but reliable high speed data transmission requires high noise suppression and low attenuation of data signals. Common-mode chokes protect vehicle ECUs from incoming EMI and suppress noise emissions radiated over the unshielded twisted-pair (UTP) cabling. The noise suppression of the TDK ACT45L Series is the best available on the market - between 15dB and 25dB better than existing products, over a broad frequency range up to 100MHz. Its footprint is a mere 4.5mm x 3.2 mm and insertion height just 2.8mm, the smallest common-mode choke for automotive Ethernet available in the world. The Series offers a rated inductance of 200µH and, importantly for all automotive components, operates over a wide temperature range of minus 40degC to +105degC. Parts are fully-qualified to AEC-Q200.

www.ttieurope.com

Film Capacitors for EMI Suppression in X1 Circuits

Now available in Europe through TTI, Inc, is TDK's series of EPCOS X1 capacitors which have been designed for an extended operating voltage of up to 530V AC. The new parts are ideally suited for EMI suppression in X1 circuits (L-N). The types in the B32911 through to B32918 series cover a broad capacitance range from 1nF to 5.6µF. Featuring a very compact design, the dimensions of the X1 series film capacitors range from 4.0mm x 9.0mm x 13.0mm up to 35mm x 50mm x 57.5mm, depending on the capacitance. Lead spacings vary between 10mm and 52.5mm. The types with capacitance values of 4.7µF and 5.6µF are equipped with 4 pins for improved mechanical stability on the PCB.



The components have been designed for an operating temperature range from -40°C up to +110°C. Like all EPCOS MKP capacitors, the new types also feature high rated voltages and excellent self-healing properties. The series is certified according to ENEC, UL and CSA. Typical applications include power supplies of all kinds as well as frequency converters.

www.ttieurope.com

High Density AC-to-DC Front-End Modules with Isolation and PFC

Vicor® Corporation announced an addition to its family of high density PFM™ AC-DC front-end modules in the rugged VIA package that offers superior cooling performance and versatility in converter mounting. Featuring a universal AC input range (85 – 264 VAC), power factor correction, and a fully isolated 24 VDC or 48 VDC output, and

delivering 400 W of isolated, regulated, DC output power at efficiencies up to 93%, these new modules provide unprecedented power density of 127 W/in3 (8 W/cm3) and best-in-class performance in a diminutive, 9 mm thin VIA package. The new units are ideally suited for use in a broad range of industrial, process control, telecommunications, office equipment, test and measurement, LED lighting and other "off-line" applications.

www.vicorpower.com

1 W DC/DC converter with 6.4kVDC isolation

RECOM introduces its latest converter series RK/H6 and RH/H6, a reliable choice for a wide range of low-power applications in industrial electronics, measuring technology and sensor systems where high isolation voltage is particularly important.

Both converter series are rated for 1 W and offer up to 6.4kVDC isolation between the input and output for 1 second. In contrast to the RK/H6 series, the RH/H6 series comes with dual outputs. Both models are available for input voltages of 5VDC, 12VDC, 15VDC and 24 VDC and supply 3.3VDC, 5VDC, 12VDC and 15VDC (RK series) or ±3.3VDC, ± 5VDC, ± 12VDC and ± 15VDC (RH series) at the outputs. They have an efficiency of up to 80%, are permanently short-circuit proof and can be operated without a minimum load.

Both converter series come in the compact SIP7 housing (19.6 x 7 x 10.2 mm) and can be operated at full load over a temperature range of -40 °C to + 90 °C. They are IEC / UL60950-1 certified and come with a 3-year manufacturer warranty.

www.recom-power.com

www.recom-electronic.com

Half-Bridge Evaluation Board Simplifies GaN Transistor Testing

GaN Systems announces its Half-Bridge Evaluation Board which demonstrates the performance of its GaN enhancement mode power semiconductors in real power circuits. The fully functional GS66508T-EVBHB Evaluation Board is easily configured into any half-bridge-based topology, including synchronous boost and buck conversion modes, as well as pulsed switching to evaluate transistor waveforms.

Accompanied by a Quick Start Instruction Guide and YouTube video links, the Evaluation Board can be installed and used in minutes. Each development kit comes with full documentation, including Bill-of-Materials component part numbers, PCB layout and thermal management, and a gate drive circuit reference design to help system engineers develop their products. Designed to provide electrical engineers with a complete working power stage, the evaluation board consists of two 650 V, 30 A GS66508T GaN FETs, half-bridge gate drivers, a gate drive power supply, and heatsink. The GS66508T high power transistors are based on GaN Systems' proprietary Island Technology® and belong to its 650 V family of high density devices which achieve extremely efficient power conversion with fast switching speeds of >100 V/nS and ultra-low thermal losses.

http://gansystems.com/

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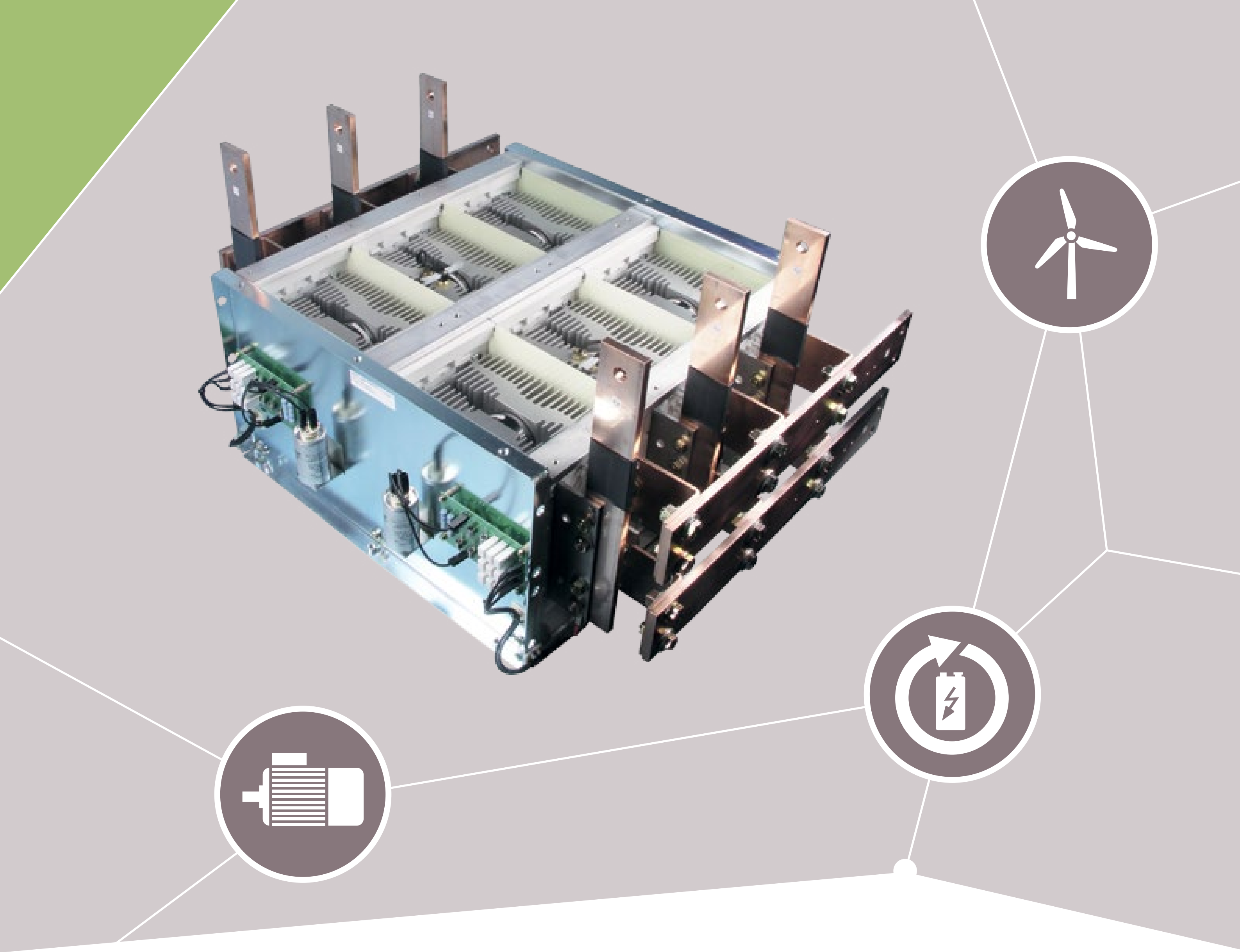

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www.infineon-bipolarshop.com/en/Stacks-Assemblies

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