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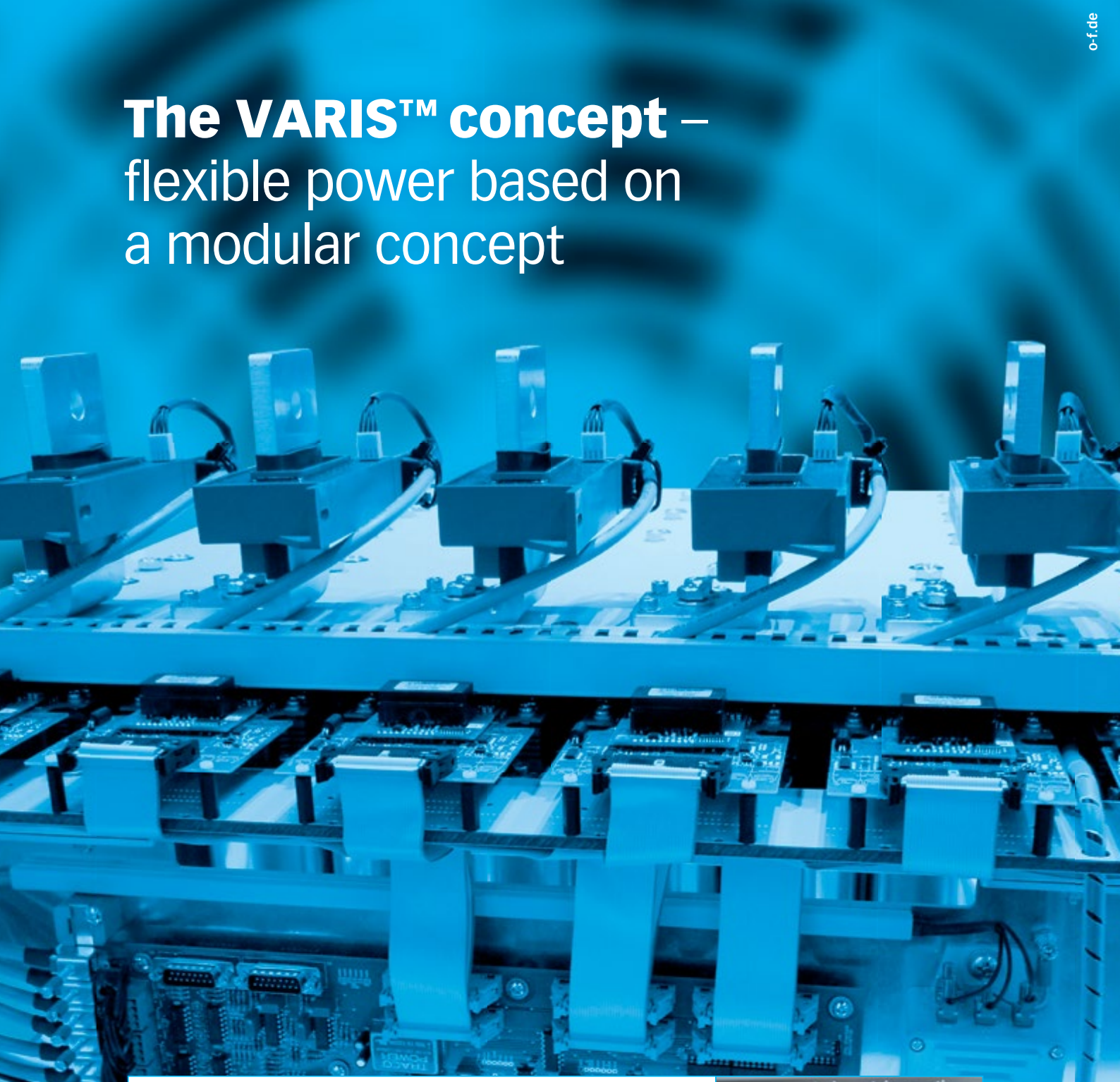
Bodo's Power Systems®

Electronics in Motion and Conversion

July 2015

The VARIS™ concept – flexible power based on a modular concept



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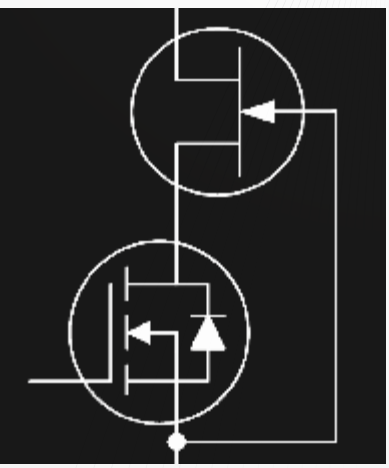
Read online and search for key subjects from all articles in Bodo's Power Systems by going to Powerguru: www.powerguru.org

powerguru.org

The Gallery

Silicon Carbide:
our sole focus, your superior solution.

USCi
United Silicon Carbide, inc.



Our name says it all. At United Silicon Carbide, Inc, we are solely devoted to bringing you the best and most efficient Silicon Carbide (SiC) power devices available in the marketplace. This month USCi is releasing an advanced silicon carbide cascode product line. These devices deliver the performance of silicon carbide with the ease of use of low voltage silicon.

United Silicon Carbide's cascode products co-package xJ series high-performance SiC JFETs with a cascode optimized MOSFET to produce the only standard gate drive SiC device in the market today. These normally off devices exhibit ultra-low on resistance and gate charge, but also the best reverse recovery characteristics of any device of a similar current rating. These devices are excellent for switching inductive loads in bridge configurations with boot strap or floating high side drive.

By leveraging the SiC JFETs proven superior performance with low voltage silicon, these innovative devices enable industry leading efficiency in applications such as EV Charging, PV inverters, Power Factor Correction and Motor Drives. Cascode products are available through our World Wide Sales Partners, or can be purchased directly from the USCi website.

Visit United Silicon Carbide website at www.unitedsic.com | info@unitedsic.com

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Events

Biricha Analog PSU design workshop,
Dallas, TX July 14-16
www.biricha.com/aps

SEMICON West, San Francisco, USA,
July 14-16 http://www.semicomwest.org

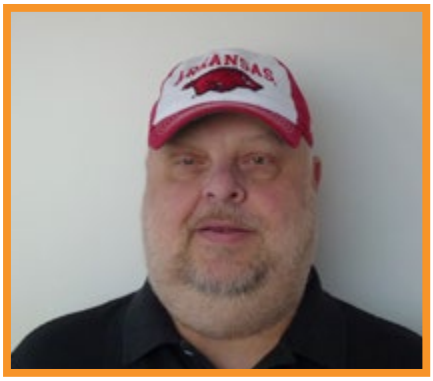
Thermal Management,
Denver CO, August 5-6
http://www.thermalnews.com/conferences

EPE ECCE 2015, Geneve, Switzerland,
September 8-10 http://www.epe2015.com/

Electrical Fuses 2015 Dresden,
Germany, September 14-16
http://www.icefa2015.com/

Enjoy the Summer!

As I live in a region with such different seasons, it is nice to enjoy the warmth and maybe to have a swim in the Baltic Sea. While the water is still a little chilly, it will warm up during the summer; all those people on our beaches can't be wrong.



PCIM Europe in Nuremberg was exciting as always, fueled primarily by the transition of power semiconductors to Silicon Carbide and Gallium Nitride. After decades of discussion, we are now finally in a transition phase with many vendors and practical applications by a myriad of customers. Silicon Carbide is establishing a strong position in the upper voltage range, from 600 volts up to kilovolts. SiC Diodes are now mature and widely used to reduce switching losses when used in conjunction with silicon devices. Module solutions incorporating SiC are commonly available, and some companies like ROHM and Mitsubishi, have modules fully built with Silicon Carbide. USCi now offers a discrete packaged cascode-switch device, with a depletion mode SiC high-voltage MOSFET and a low-voltage silicon MOSFET. This device functions like a common N-channel MOSFET, but with vastly improved performance. And Cree demonstrates continuing improvements in their line of n-type SiC FETs.

SiC devices use a vertical structure, their benefits resulting from the material characteristics, while GaN utilizes a dense lateral design and high electron mobility. Both reach new performance limits. GaN has a dominant position in the lower voltage range. It is nice to see all the variations of alliances that are building: Infineon, as we know, bought IR and also works with Panasonic, Texas Instruments works with Efficient Power Conversion (EPC) with a silicon driver IC and an EPC GaN chip together as a half bridge, Integrated Device Technology (IDT) announced its collaboration with Efficient Power Conversion EPC for more efficient solutions, and Transphorm and ON Semiconductor announced the production start of co-branded GaN power devices. Phew! What's next ?

WBG technology will become mainstream. The podium I moderated at the PCIM Europe had all the key players describing how they insure reliability, the basis of confidence for new equipment designs to take advantage of the technology. In the next few years we can expect continual transition, similar to when Bipolar Transistors converted to MOSFETs, and shortly thereafter in the late 80's, as IGBTs took over the motion control market. I expect that EPE ECCE in Geneva, and also ECCE in Montreal Canada will continue to focus on Wide Band Gap devices and applications of a wider range. I can't wait to see what APEC in Long Beach in March 2016 will have in store for us!

But before APEC we can enjoy the summer, look forward to Thanksgiving, and then wait for Santa. He will continue to bring many exciting gifts.

We have delivered seven issues this year. All technical articles are archived on my website and are also retrievable at PowerGuru. 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 July:
Consider installing a solar panel on the roof of your house to warm your water (and cool your roof). And a photovoltaic solar system could provide an independent electrical power supply. Capture some energy and reduce demand – it's worth it.

Regards

KEEP UP WITH THE TIMES

LF xx10

Current transducer range
Pushing Hall effect technology to new limits

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Available in 5 different sizes to work with nominal currents from 100 A to 2000 A, the LF xx10 range provides up to 4 times better global accuracy over their operating temperature range compared to the previous generation of Closed Loop Hall effect current transducers.
Quite simply, the LF xx10 range goes beyond what were previously thought of as the limits of Hall effect technology.

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MR Expands Skills and Expertise in Power Electronics

In April 2015, Maschinenfabrik Reinhausen (MR) acquired all industrial property rights, including patents and brands, of Amantys Ltd. (Cambridge, Great Britain), along with the bulk of the company's technical facilities and equipment. MR, a traditional family-run company headquartered in Regensburg, Germany, is the world market leader in the regulation of power transformers with on-load tap-changers. This acquisition marks the completion of another important stage in the implementation of its long-term technology strategy. Amantys Ltd. brought a great many new technologies to market featuring intelligent drivers for power electronic components (IGBTs, for example). The technologies acquired are an important element as the Reinhausen Group expands its skills and expertise for application in power electronics. The acquisition opens up a wide variety of new technological possibilities for expansion and optimization of the future product and application portfolio.

So that these technical possibilities can be brought back to market as quickly as possible, on May 19, 2015, Maschinenfabrik Reinhausen GmbH decided to found a wholly-owned subsidiary in Cambridge, Great Britain, with Amantys Power Electronics Ltd. The company's areas of activity will include research and development as well as the manufacture, marketing, and sales of products and services for power electronics and the regulation and control of electrical networks.

ww.reinhausen.com/de

Power Semiconductor Manufacturer Builds R&D Centre in Germany

StarPower Europe AG, the European subsidiary of the power semiconductor manufacturer StarPower Semiconductor Ltd, is building a European development centre in Nuremberg, Germany. In doing so, StarPower is investing close to a million euros in the laboratory. The goal is to test new technologies and materials, and provide the gained know-how to the headquarters and transfer it to the production. StarPower is thereby setting a new milestone for its growth in Europe with high-quality semiconductor modules—with European development know-how. Christian Kroneder, formerly employed at Semikron, is responsible for building the R&D Centre and is simultaneously heading the development team in the headquarters. 'We are testing prototypes and acquiring the respective production and testing equipment in Germany (from the bonder to the sintering press) in order to build and test modules', says Christian Kroneder, Head of R&D Center Europe. New technologies, packages and materials are being tested, such as the sintering of semiconductor chips to substrates. All these technologies lead to greater power cycling and reliability of the modules. This in turn plays a major role in specific applications, such as the automotive area and wind energy. The R&D Centre ensures that innovations and trends within Europe are integrated into the development of future products. 'We are primarily a Chinese company that is a player on the European level, and in the medium-term will go beyond the European level with the latest research trends', says Christian Kroneder.

The power semiconductor module production in Jiaxing China

www.starpowereurope.com

Global Distribution Agreement for Wide Bandgap Products

APEI of Fayetteville, Arkansas, a world leader in wide bandgap packaging and design, announced that it finalized a global distribution agreement with Richardson Electronics, Ltd.. Richardson Electronics is a global provider of engineered solutions and a leading distributor of electronic components. This agreement will support the expansion of APEI's products into new markets and applications as the demand for wide bandgap products continues to accelerate.

"The APEI and Richardson Electronics partnership helps expand the accessibility of our products and services to broader markets, as technology manufacturers seek to design systems with increased power-density, smaller size, and higher efficiency to meet their next-generation performance requirements," said APEI's CEO Alex Lostetter. "Richardson Electronics draws from its own engineering and manufacturing capabilities to provide technical expertise and value-added solutions to high performance markets. Richardson and APEI are forming a strong partnership, based on the shared philosophy that customers should receive high-quality technical support throughout the duration of the design-in process – from prototyping to full-scale production."

Chris Marshall, CTO of Richardson Electronics' Power and Microwave Technologies Group, responded, "APEI is a technology leader in GaN and SiC high power modules, offering dramatic size and weight reductions along with the ability to operate at extreme temperatures. We expect them to be a key strategic partner in our push into global power conversion markets, lining up with our new portfolio of GaN and SiC components, IGBTs, high power capacitors and ultracaps. APEI's strong portfolio of SiC and GaN optimized products affords system designers a previously unimaginable level of performance."

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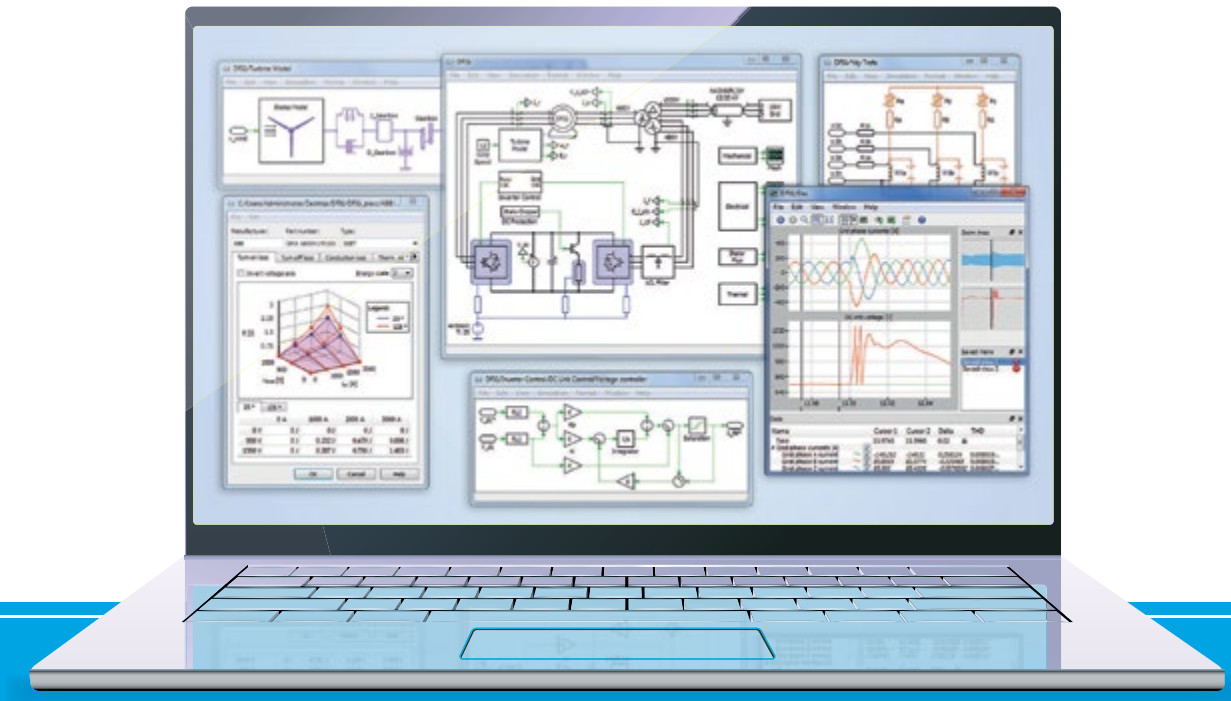

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BMZ Founder Sven Bauer as RSM Entrepreneur of the Year

Sven Bauer, founder and owner of BMZ GmbH – Europe's leading systems supplier of lithium-ion batteries, located in Karlstein, Germany – was named as winner in the prestigious 2014/15 European Business Awards in the category 'The RSM Entrepreneur of the Year Award'.

Photo 1: Daniel Fabbiano, BMZ Works Manager, receives the trophy for 'The RSM Entrepreneur of the Year Award' – on behalf of BMZ founder and owner Sven Bauer – from Jean Stephens, CEO of RSM.

The European Business Awards, sponsored by RSM, the world's 7th largest network of independent audit, tax and advisory firms, presented trophies in 11 categories. It is now in its 9th year and ranks among Europe's most prestigious business awards. In the 2014/15 competition, which this year attracted over 24,000 businesses, all EU member markets were represented plus Turkey, Norway, Switzerland, Serbia, Croatia and the Former Yugoslav Republic of Macedonia. BMZ GmbH was shortlisted as one of 709 National Champions and then named winner in its category. The winning businesses have achieved their success after 16 months in the largest, and one of the toughest, business competitions in Europe.

At an exclusive awards ceremony in London attended by leading business leaders, politicians, ambassadors and academics from across Europe, Jean Stephens, CEO of RSM, said: "The calibre of this year's competition finalists is outstanding. At RSM, we believe it is important to champion business excellence as successful and thriving companies are an integral force in driving growth and stimulating economies. All those involved are a credit to their country and we wish them every success for the future."

BMZ founder and owner Sven Bauer, is pleased about being named winner of 'The RSM Entrepreneur of the Year Award': "The award is a special honour for the entire team, showing once more how much dedication and know-how exists in small and medium sized European enterprises. The sustainable handling of finite fossil resources as well as a desire for the greatest possible degree of mobility and independence has led to a rapid increase in the demand for intelligent and professional rechargeable battery solutions for equipment, vehicles and energy storage systems in recent years. Our goal is to preserve the environment for coming generations. We are still in the very early stages of an exciting future."

www.bmz-gmbh.de

ECPE Calendar of Events

ECPE Tutorial 'Thermal Engineering of Power Electronic Systems - Part I (thermal design and verification)'
21 – 22 July 2015, Erlangen, Germany; Chairmen:
Prof. U. Scheuermann (Semikron), D. Malipaard (Fraunhofer IISB)

ECPE Tutorial 'Reliability of Power Electronic Systems'
1 - 2 September 2015, Helsinki, Finland
Chairman: Prof. E. Wolfgang (ECPE)

ECPE Tutorial 'Thermal Engineering of Power Electronic Systems - Part I (thermal management and reliability)'
21 – 22 October 2015, Nuremberg, Germany; Chairmen:
Prof. E. Wolfgang (ECPE), Prof. U. Scheuermann (Semikron)

The ECPE Calendar of Events 2015 with all ECPE Workshops and Tutorials is available on the ECPE website for download.

www.ecpe.org

Strategic Collaboration on Connected Car Technologies

Qualcomm Technologies, Inc., a subsidiary of Qualcomm Incorporated and Daimler AG announced a strategic collaboration focused on pioneering innovation in the connected car. In the first phase of the collaboration, the companies will focus on transforming future vehicles with mobile technologies that enhance in-car experiences and vehicle performance such as 3G/4G connectivity, wireless charging technology for in-vehicle use and implementation of the Qualcomm Halo™ Wireless Electric Vehicle Charging (WEVC) technology. In addition, the companies are jointly assessing the application of Qualcomm Technology's newly developed Automotive Solutions.

Qualcomm Technologies is collaborating with Daimler on its Wireless Power Transfer 2.0 high performance program for electric vehicles. The Qualcomm Halo™ WEVC technology provides high performance and high power in a small vehicle package that could allow Daimler customers to charge their electric vehicles (EV) and plug-in hybrid EVs without ever having to plug them in. In addition, Qualcomm® WiPower™ technology enables consumer electronics to charge wirelessly in-vehicle.

"It's important that we remain on the cutting edge of technology and continue to deliver unparalleled experiences to our customers," says Prof. Dr. Thomas Weber, Member of the Board of Management of Daimler AG responsible for Group Research and Mercedes-Benz Cars Development. "With this in mind, we are eager to jointly explore possible fields of future cooperation with an internationally leading tech firm like Qualcomm."

www.qualcomm.com/products/automotive

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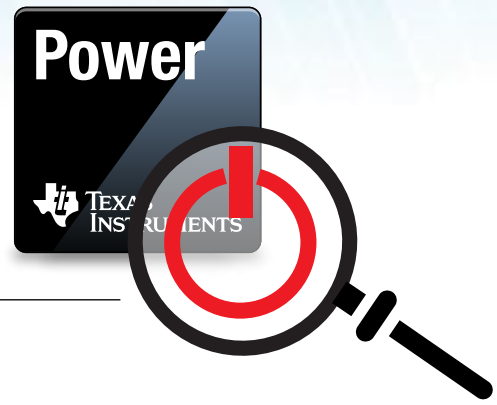

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Typhoon HIL Lauded for its Innovative Hardware-in-the-Loop Solutions

The company receives the 2015 Frost & Sullivan New Product Innovation Award for its pioneering ultra-high fidelity Hardware-in-the-Loop products for power electronics testing and test automation.

Based on its recent analysis of the Hardware-in-the-Loop (HIL) market for power electronics and smart grid, Frost & Sullivan recognizes Typhoon HIL with the 2015 Global Frost & Sullivan Award for New Product Innovation. Typhoon HIL is a pioneer in addressing key end-user challenges, notably the need for ultra-high fidelity Hardware-in-the-Loop test solutions. The product design team at Typhoon HIL has developed the fastest and easiest to use HIL real-time simulators that enable complete test automation and superior model fidelity compared to other available HIL solutions. In fact, Typhoon HIL's top competitors have no comparable simulating solution for power electronics and smart grid.

„Typhoon HIL provides tools for automated testing of control systems, software regression testing, pre-certification and continuous test and integration processes, which translate into a fully integrated HIL solution," said Frost & Sullivan Research Analyst Viswam Sathiyanarayanan. „In addition, the company uses its own highly optimized and fully integrated software and hardware platform, thus redefining the ease of use and greatly reducing deployment effort."

Previously, HIL systems could be run with millisecond-to-second simulation time steps, not nearly fast enough for power electronics. Typhoon HIL was the first to fulfill this unmet need by designing a 1 microsecond time step HIL. Typhoon HIL 4 series and Typhoon HIL 6 series solutions are now used in power electronics applications such as solar inverters, battery storage, wind turbines and motor drives. Another innovative product is the HIL Microgrid DSP Interface, a rapid prototyping tool for smart inverter controllers and microgrids that works seamlessly with the HIL4 and HIL6 series systems.

www.typhoon-hil.com/

SENSOR+TEST 2015 in Nuremberg

Developers and researchers from Germany and abroad, who made it to the fair, used the opportunity to delve extensively into the stands of the 548 exhibitors and to obtain in-depth information on the state of the art in sensor, measuring, and testing technology at numerous forums. The parallel scientific AMA Conferences, SENSOR and IRS², were also well attended. Technical presentations by the exhibitors in the open forums – for instance on this year's focal topic "Environmental Measuring Technology" – also captivated large audiences.

The 10,000-euro AMA Innovation Award 2015 was presented on the opening day to a team of young developers from Crystalline Mirror Solutions in Vienna for their innovative development on "Ultraprecise Frequency Measurement with Crystalline Semiconductor Mirrors." They had already won the Young Enterprises Special Award garnering a free fair stand at the SENSOR+TEST.

Long aspired by the exhibitors and organizers, the SENSOR+TEST will move to Halls 1, 2, and 5 of the Nuremberg Exhibition Center next year. The next SENSOR+TEST will be held from 10 to 12 May 2016 at the Nuremberg Exhibition Center as in the past.

www.sensor-test.com

PCIM Europe in Nuremberg

After three electrifying days, PCIM Europe has come to an end with a positive outcome. In total, 416 exhibitors and 88 represented companies presented themselves on an area of approximately 21,000 square meters. Thereby, they introduced the latest trends, developments and innovations from the fields of power electronics, intelligent motion, renewable energy and energy management to round about 9,000 visitors.

With more than 250 lectures about new technological trends in power electronics components and systems, the conference, which took place in parallel to the exhibition, provided a diverse, first-class program to 739 participants.

PCIM Europe 2016 will take place from 10 – 12 May 2016 at the exhibition centre in Nuremberg.

www.pcim-europe.com

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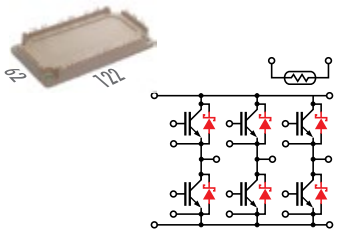
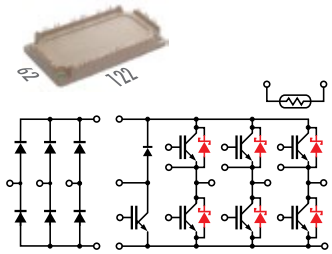


I_c	600 V	1200 V
100A		●

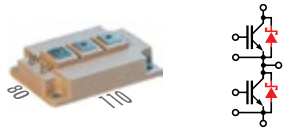
PIM



I_c	600 V	1200 V
35A		●
50A	●	●
75A	●	
100A	●	

2-Pack

I_c	1200 V	1700 V
200A	●	
300A	●	
400A	●	

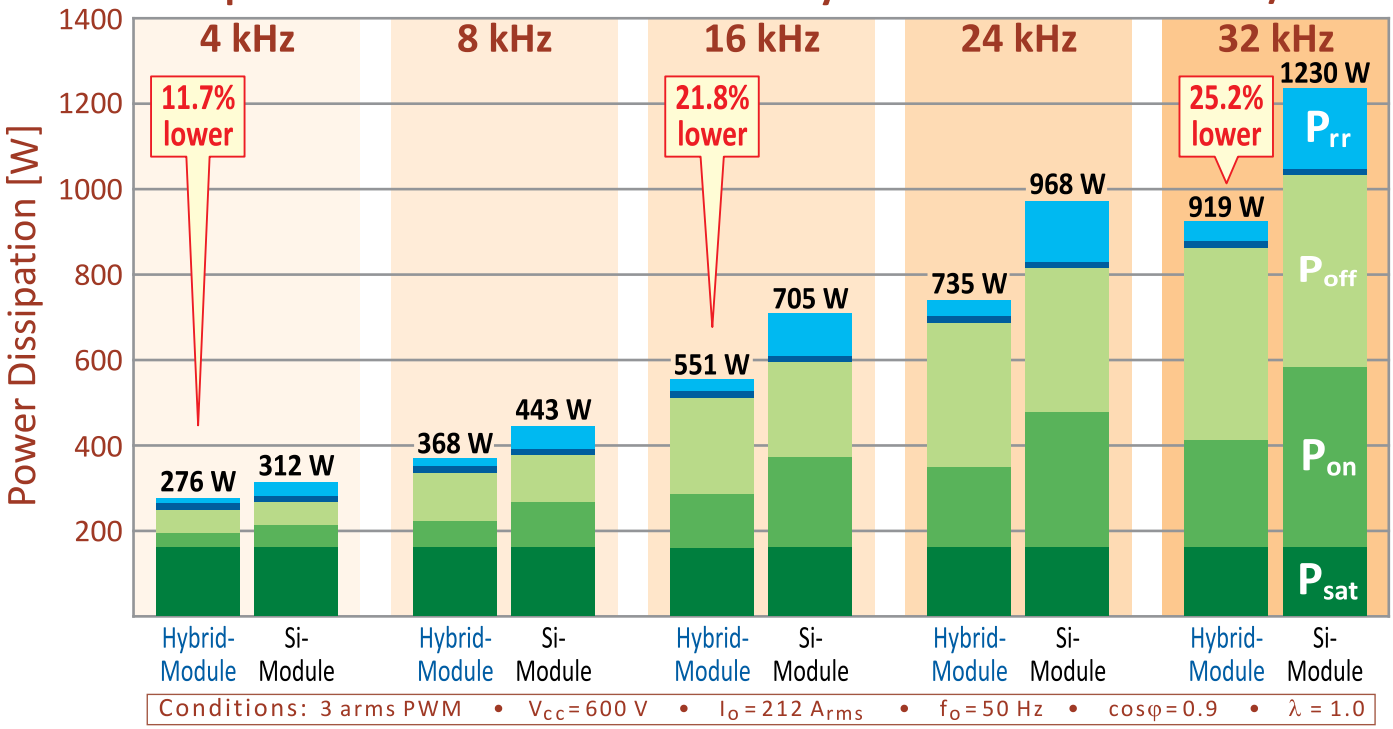


I_c	1200 V	1700 V
400A		●

I_c	1200 V	1700 V
1200A		●

I_c	1200 V	1700 V
1000A		●
1200A	●	●

Comparison between All Silicon and Hybrid IGBT Module 1200V/300A



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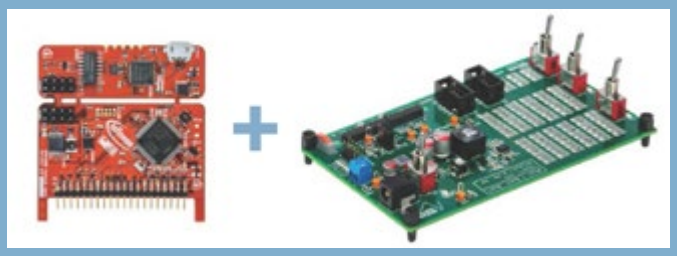
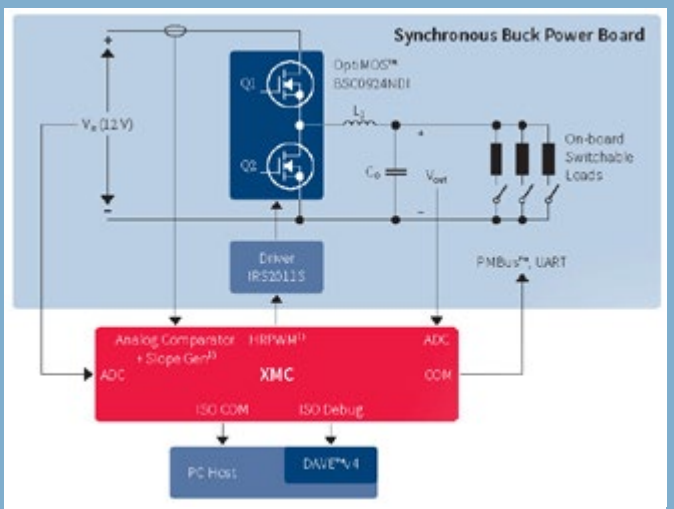
info.semi@fujielectric-europe.com

XMC Digital Power Explorer Helps Analog Power Supply Designers Start with Digital Power Control

The XMC Digital Power Explorer Kit utilizes Infineon's industry leading XMC range of ARM® Cortex™-M microcontrollers, OptiMOS™ BSC0924NDI MOSFETs and IRS2011S high and low side drivers. The kit's power board features synchronous buck converter with on-board resistive load banks. The load banks can be switched between 10%, 55% and 100% of the maximum load, so that the transient response and the quality of the control loop under different load conditions can be tested (for example continuous conduction mode vs. discontinuous conduction mode). The kit also includes 2 different control card options, XMC1300 control card (ARM® Cortex™-M0) and XMC4200 control card (ARM® Cortex™-M4F) with isolated on-board debugger, which allow designers to easy evaluate both XMC microcontroller families and make the right price/performance choice for their application. Multiple test points are provided on the power board for checking the quality of all the relevant signals. Communication option via PMBus™ is provided for easy integration in more complex power management systems.



The XMC Digital Power Explorer Kit has been aimed at analog power supply designers and embedded software programmers who need to accelerate their learning curve in digital power control. Infineon's free DAVE™v4 IDE, including digital power APPs and plenty of other examples, provide all the necessary tool and software support to quickly get started with using XMC microcontrollers in digital power control applications.



1) Only in XMC4200
Basically slope compensation feature (inside the microcontroller) is only available on XMC4200 control card (i.e. XMC1000 family doesn't have that feature implemented). For the use case when XMC1300 control card is used in peak current control mode, we implemented slope compensation function on the power board (bypassed in case of using XMC4200), which is not as accurate and flexible as integrated one, but that shows the tradeoffs which customers face when using low end/low cost micro vs. high end micro.

The kit has been developed in collaboration with Biricha Digital Ltd. and Würth Elektronik. Biricha Digital designed the power board employing years of training and consulting experience in digital power control. Würth Elektronik contributed by providing the best-in-class passive components and connectors, including their high-performance inductors and capacitors, perfectly fitting digital power control applications.

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60V Synchronous Buck Controller Takes Two Steps Down at Once

The easy-to-use ISL8117, launched by Intersil, is the first 60V synchronous buck PWM controller able to bypass the intermediate step-down conversion stage traditionally employed in industrial applications. Its low duty cycle (40ns minimum on time) enables the direct step-down conversion from 48V to a 1V point-of-load voltage. This technical achievement makes it possible for designers to reduce system complexity and solution cost in industrial, factory automation, medical and communications infrastructureapplications.

In high voltage applications where a lower output voltage is required, designers have traditionally relied on modules that increase system cost, or two stage DC/DC solutions that increase solution footprint and complexity. The ISL8117 controller offers a cost-effective and reliable alternative for applications where Vout to Vin ratio is low. It uses valley current mode modulation with adaptive slope compensation to enable stable operation for a wide range of Vin and Vout combinations, with no external compensation required. System designers can also use the adjustable frequency up to 2 MHz to optimize power supply cost, size and efficiency.

The innovative synchronous buck PWM controller reduces solution footprint and simplifies design without compromising performance. Default design values for commonly used functions and the wide Vin and Vout reduce the number of external components compared to competing solutions. With the new controller, engineers can design a complete DC/DC buck conversion solution with only 10 components, including MOSFETs and passives, and achieve up to 98% conversion efficiency with 1.5% output voltage accuracy. The low pin count and layout friendly pin architecture also minimizes the number of overlapping traces, further improving power supply performance.

“The ISL8117 buck controller addresses a growing need for direct POL conversion from very high input voltage such as 48V to 1V output,” said Mark Downing, senior vice president of Infrastructure and Industrial Power Products at Intersil. “The unique ability to support light load efficiency mode is critical in industrial applications and makes the ISL8117 a much better alternative than existing solutions based on older technology.”

The 60V synchronous buck PWM controller has the following key features and specifications:

- Wide input voltage range of 4.5V to 60V covers all standard input rails including 5V, 12V, 24V, 36V, 42V and 48V;
- Wide voltage output range is configurable from 0.6V to 54V;
- Smallest minimal on-time in the market, which enables a very low duty cycle power supply and eliminates the need for a two stage solution in many applications;
- Programmable100kHz to 2Mhz switching frequency can be synchronized to reduce radiated system noise and avoid beat frequency issues;
- Complete fault protection for long term reliability including over-voltage, under-voltage, over-current and over-temperature;
- High current FET drivers and DEM mode operation ensures efficiency at all load levels;
- Adjustable soft-start with pre-bias support enables the sequenced startup of multiple ISL8117 controllers.

The high voltage controller can be combined with Intersil´s low drop-out linear regulators such as the ISL80136, ISL80138, ISL80101A, and integrated FET switching regulators (ISL8023/24 or ISL8016) to support the bulk power rails in a typical process control industrial application.

The ISL8117 is available now in 4mm x 4mm QFN and 6.4mm x 5mm HTSSOP packages. Two evaluation boards allow designers to quickly evaluate device features and performance: ISL8117EVAL1Z low power (Vin 4.5V-60V and 3.3Vout/6A), and the ISL8117EVAL2Z high power (Vin 18V-60V and 12Vout/20A). Two demonstration reference design boards allow to produce low power (factory automation or robotic) and high power (telecom or pachinko) applications.

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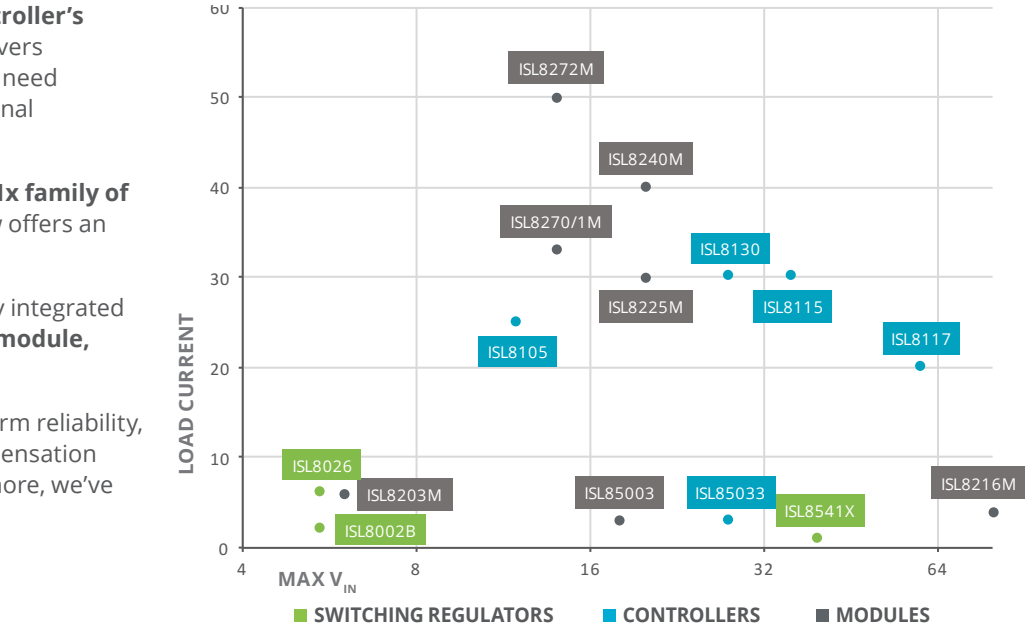

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The dsPIC (DSC) Signal Board supports both 3.3V and 5V operated devices for various applications and frequently used human interface features along with the communication ports. The Signal Board has two major connectors, a 120-pin connector and a 60-pin connector to enable connection to the plug-in boards.

The Motor Control 10V–24V Driver Board (Dual/Single) along with the compatible dsPIC DSC Signal Board provides a software development platform to build and evaluate embedded motor control application software using Microchip's high performance motor control Digital Signal Controllers (DSCs) and Microcontrollers (MCUs).

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The Expanding Footprint of Power Conversion

By Christopher Rexer, Senior Director, Power MOSFETs, ON Semiconductor

Power conversion solutions continue to expand throughout our personal lives. As a result, the professional challenges and opportunities for power engineering experts continue to grow. From the time we wake each day, we connect to the world, monitor our health, commute to our jobs, prepare meals, relax and entertain. To support the advances in these products, power device engineers continue the unending pursuit of power switch technology improvements.

Power systems experts continually work with a passion to break barriers which were inconceivable even a decade ago. They continually drive to develop new techniques to solve these problems such as increasing converter frequency to improve efficiency and reduce component and board size, while providing solutions in an environment for consistency of product delivery. The technical approaches are enabled by continuous advancements in the power switch and packaging technologies. Modern power MOSFET technologies from 25 Volts to nearly 1000 Volts use charge balance techniques to reduce conduction losses and provide improved switching characteristics. Advanced construction techniques propel IGBT performance improvements enabling both reduced Vce(sat) and improved switching performance. Packaging advancements such chip scale packaging, package miniaturization, elimination of wirebonds, use of high temperature capable materials, creative die placement and effective manufacturing techniques enable the full benefit of the advanced chip design to be achieved. Opening a new door to advance the industry for the highest power density solutions are Gallium Nitride (GaN) power switches.

Our lives have become tied to connectivity. Over the last decade, the reliance of communication in all aspects of our lives is largely defined by our portable devices. This is now expanding even further with recent offerings of wearable devices. The expansion of portable applications requires us to charge batteries efficiently, to control the battery safely, and to have the highest efficiency solution for extended battery life. Miniature MOSFETs for battery control and load control applications are fundamental to these devices. ON Semiconductor delivers these solutions including chip scale MOSFETs as well as the smallest packaged MOSFET available in the market: NTNS3193NZ at only 0.6x0.6x0.4mm.

To keep our connectivity portable, adaptors are used to charge the batteries. This conversion from an AC power to the DC battery voltage often requires us to carry this adaptor with us. The ability to shrink this adaptor to a smaller form factor and to decrease the weight can be achieved with new power switches built using GaN. The fundamental attributes of switches built using this new material enable low conduction losses and very high switching speeds. As a result, power system designers are able to increase the switching frequency of the converter, thereby reducing the size of the passive components enabling the small, lightweight adaptor. GaN switches also enable highly efficient power conversion in higher power applications such as photovoltaic microinverters and high power conversion solutions. ON Semiconductor has worked collaboratively with Transphorm to offer co-branded GaN products. The first of these are 600V switches in the TO-220 package such as the NTP8G206N, with a 150milliohm typical Rds(on).

The wide use of portable devices drives a huge amount of data transfer and storage. Server clusters, supporting the vast amount of data, provide several hundreds of exabytes of storage worldwide, with estimates of this amount doubling every two years. The efficiency of a server cluster is impacted by the computation performance as well as the power conversion systems. The telecommunication and networking industry requires highly efficient power conversion delivered reliably. Since power conversion efficiency is highly regarded, power MOSFETs with low losses are a building block for these systems. Products in the ON Semiconductor Trench 6 and Trench 8 technologies meet this challenge and are available in 25 Volt to 100 Volt offerings such as the NTMFS5C604NL.

In our lives, many of us use the automobile as the means of commuting. The electronic content of automobiles continues its expansion as new applications are being developed to reduce emissions, improve fuel economy, and advance active safety and convenience solutions. Electric vehicles and hybrid electric vehicles have changed the industry, providing additional options to the consumer for means of propulsion. Power devices such as IGBTs and wide bandgap switches are a fundamental enabler for these vehicles. Across all automobiles, the quantity of brushless DC (BLDC) motors is projected to double over the next 5 years. These motors are used in features such as electronic power steering, compressors and start-stop systems, and additional applications for motors are being developed. Advanced power MOSFETs in thermally advanced packages enable the widespread use of these motors. An example is the NVMFS5C404N, a 40V MOSFET in the 5x6mm package with a maximum Rds(on) of only 0.7milliohms.

The wide range of power conversion solutions are readily supported using ON Semiconductor advanced power MOSFETs, IGBTs and GaN switches for these applications. Our engineers will join those from around the world to continue to the pursuit of new products to enable highly efficient power solutions.

Chris.Rexer@ONSemi.com

www.onsemi.com

Electronics Industry Digest

By Aubrey Dunford, Europartners

The worldwide Internet of Things (IoT) market is expected to grow 19% in 2015, led by digital signage, so IDC. Digital signage use in retail outlets will grow from $ 6.0 billion in 2013 to $ 27.5 billion in 2018, a 35.7% five-year CAGR, as retailers continue to digitize the consumer experience. The IoT market in manufacturing operations will grow from $ 42.2 billion in 2013 to $ 98.8 billion in 2018, a five-year compound annual growth rate (CAGR) of 18.6%. Growth will be driven by ongoing efforts to increase efficiency and link islands of automation.

SEMICONDUCTORS

The top 20 semiconductor companies' sales increased by 9 percent in 1Q15/1Q14 (6 percent excluding the foundries), three points greater than the total worldwide semiconductor industry growth rate, so IC Insights. There were six companies that displayed >20 percent 1Q15/1Q14 growth: Sharp (+62 percent), TSMC (+44 percent), SK Hynix (+25 percent), Sony (+26 percent), Avago (+24 percent) and Globalfoundries (+21 percent). European suppliers NXP (+18 percent) and Infineon (+16 percent) also were doing well.

Samsung Electronics will invest 15.6 trillion won ($ 14.4 billion) in a new billion South Korean chip plant, the biggest amount it has ever committed to a single plant. The plant will be finished in 2017.

Maschinenfabrik Reinhausen (MR), a German family owned company, has purchased all of the assets and intellectual property (IP) of Amantys, a British innovator in the power electronics market. MR's priority is to reestablish the operating business of Amantys to continue to supply premium gate driver products to customers. The team will also progress the technology development in the field of IGBT drivers. MR has installed a transition manager in Cambridge, who is working together with former members of the Amantys team. MR intends to setup a new legal entity in the UK as a wholly foreign owned company. Maschinenfabrik Reinhausen (MR), based in Regensburg, Germany, founded in 1868, is mainly family owned and is now managed by the fifth generation of the family. In the 2014 fiscal year, 3,000 employees produced a turnover of € 650 M.

Infineon Technologies is the first company worldwide manufacturing automotive power MOSFETs on 300millimeter thin wafers, so the German company. The products are manufactured at Infineon's fab in Villach, Austria. Thin-wafer technology minimizes power losses and enables compact MOSFET designs for high system efficiency and power density. With wafer thinning down to 60µm OptiMOS 5 power semiconductors on 300millimeter thin-wafer technology are among the world's thinnest.

GaN Systems, a Canadian fabless semiconductor company involved in gallium nitride power switching semiconductors, announced a $ 20 M venture capital financing. Cycle Capital Management led the round and was joined by BDC Capital and Beijing-based Tsing Capital, as well as existing investors Chrysalix Energy Venture Capital and RockPort Capital.

Total silicon wafer area shipments were 2,637 million square inches in1Q15, a 3.4 percent increase from the previous quarter, so SEMI. New quarterly total area shipments are 11.6 percent higher than first quarter 2014 shipments.

PASSIVE COMPONENTS

Sales for German PCB manufacturers in March 2015 increased by 2.6 percent compared to March 2014 and ten percent over the long-term average, so the Zvei. Cumulative sales for the first quarter remained 1.75 percent lower than in Q12014. New orders in March increased by 11.5 percent YoY. This marks the highest order intake for a March since 2010. Cumulative orders for the first quarter 2015 were 8 percent lower than in Q12014.

OTHER COMPONENTS

Aavid has acquired Kunze-Folien. Based in Oberhaching near Munich, Germany, Kunze specializes in thermally conductive films, heat sinks, and transistor clips in power and other electronic environments. Additionally, Kunze provides lamination, thermal conductivity, IR analysis, and design simulation services associated with its products. Aavid, founded in 1964, provides a broad range of thermal management solutions for telecommunication, enterprise class computers, consumer electronics, transportation, and industrial applications.

DISTRIBUTION

The European semiconductor distribution industry started very strong into 2015 and continued the positive trend from the last quarters of 2014. Semiconductor distribution sales in 1Q15 grew by 13.3 percent to € 1.82 billion, the highest recorded quarterly sales since the introduction of the Euro in 2002, so the DMASS (Distributors' and Manufacturers' Association of Semiconductor Specialists).

The majority of the increase is due to a massive swing in the Euro/US-Dollar exchange rate, with the Euro losing 17 percent of its value, compared to 1Q14. As a significant part of billings to European customers are done in US Dollars, there is an artificial growth effect of ~50 percent of the total growth in Q1. From a regional perspective, the growth leaders in Q1 were to be found in the Eastern Regions – Israel, Turkey, Eastern European countries – and the Nordic countries. While Israel and Turkey grew over 30 percent, Eastern Europe in total grew by 29 percent (exception Russia with minus 15 percent), Nordic by 23 percent. Of the major regions, UK (16.3 percent) and France (17.2 percent) grew above average, while Germany (5.8 percent) and Italy (8.4 percent) trailed the trend. In absolute numbers, Germany reported € 544 M, Italy € 171 M, UK € 158 M and France € 146 M.

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

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ABB

Biricha Lecture Notes on Analog and Digital Power Supply Design

Part 2.B Voltage Mode PSU Compensator Design

In the previous article we discussed power supply compensators in detail; we can now design our first compensator to stabilise a voltage mode, Forward type power stage. The design method presented here can be applied to all hard-switched "non-isolated" Forward type converters with or without a transformer (i.e. Buck, Forward, Push-Pull, Half-Bridge, Full Bridge). We will discuss current mode control and opto-isolated power supply design in great detail in future articles.

By Dr Ali Shirsavar, Biricha Digital Power Ltd

But first let us have a quick word about voltage mode control. Voltage mode is one of the earliest forms of switch mode power supply control and its operation is very simple.

All we have to do is to look at the output voltage; if it goes up with respect to the desired value, we reduce the PWM duty and if it goes down we increase it. As such, all we are doing is regulating the output voltage with respect to our desired "reference" voltage.

Of course the manner with which we change this duty is dictated by the compensator that we design i.e. the position of its poles and zeros. The compensator should give us good transient performance, whilst at the same time make sure that we do not violate the stability criteria.

Voltage Mode Compensator Design

For voltage mode control we almost always need a Type III compensator. The circuit for our Type III compensators is given in figure 1.

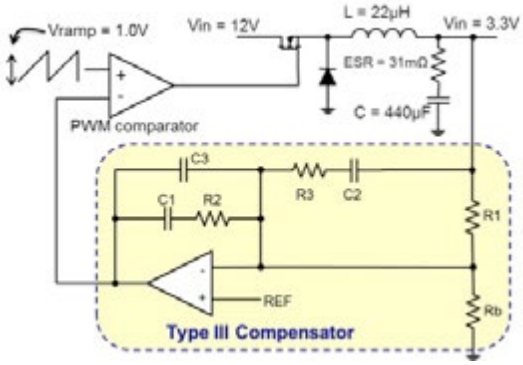

Figure 1: Type III compensator

From previous articles we know the transfer function Hc(s) and equations relating the poles and zeros to component values:

$$H_c(s) = \frac{\omega_{p0}}{s} \frac{\left(\frac{s}{\omega_{z1}}+1\right)\left(\frac{s}{\omega_{z2}}+1\right)}{\left(\frac{s}{\omega_{p2}}+1\right)\left(\frac{s}{\omega_{p3}}+1\right)}$$

Please note that these are in radians per second but we usually work in Hz so please don't forget that 2π scaling factor.

$$\omega_{p0} = \frac{1}{R_1\left(C_1+C_3\right)}; \omega_{p2} = \frac{\left(C_1+C_3\right)}{R_2\, C_1\, C_3}$$

$$\omega_{p3} = \frac{1}{R_3\, C_2}$$

$$\omega_{z1} = \frac{1}{R_2\, C_1}; \omega_{z2} = \frac{1}{C_2\left(R_1+R_3\right)}$$

Here wp0, wp2 and wp3 are the compensator's poles and wz1 and wz2 are its zeros. Of course Biricha Digital's automated power supply design software (Biricha WDS) automatically designs highly optimised compensators as discussed in the previous articles. However, if your transient response requirements are not very stringent, you can easily design a stable compensator by hand for most Buck/non-isolated Forward topologies.

Consider a Buck converter shown in figure 1. We can see all the necessary values from this figure. Below is step-by-step guidelines how to quickly design the compensator for this converter:

Step 1: Determine plant Bode plot

Setting the transformer turns ratio to 1:1 for now, for all Forward type topologies in voltage mode the plant bode plot is very simple; of course a Buck converter can be represented as a Forward converter with a transformer turns ratio of 1:1 .

Ignoring the PWM block for now, typically we have a resonant bump at 1/(2π √LC), and an ESR zero at 1/(2π ESR C). Using the values of L, C and ESR shown in figure 1, we can easily calculate the positions of the resonant bump and the ESR zero of the plant bode plot as shown on figure 2.

From this figure, you will notice that unlike a standard LC filter, our low frequency gain is not 0 dB. This is the impact of our PWM comparator and in many text books it is called the "PWM Gain". Again for voltage mode Buck converters this is very easy to calculate and is equal to our input voltage divided by the PWM ramp voltage of our controller

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IC, (i.e. Vramp in figure 1). We know our input voltage (12V in our case) and the PWM ramp voltage is always specified in the datasheet of our IC (for simplicity we have taken this to be 1V). In our case therefore, the low frequency gain will be 20.Log(12V/1V) = 21.58dB.

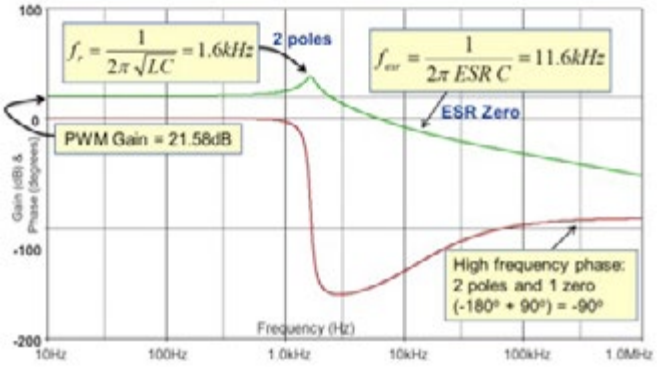

Figure 2: Plant Bode plot

Finally if we have a transformer in our circuit, all we need to do is to scale the gain plot by the transformer turns ratio. This completes the Bode plot of our plant and we can now design the compensator.

Step 2: Calculate Compensator pole/zero locations

The method presented here is an easy approximation to allow you to quickly calculate these for a compensator with relatively good performance with reasonable crossover frequencies. There are of course more accurate methods, and there are good books which have detailed analysis (please see the bibliography) but first and foremost, credit should be given to Dean Venable for his pioneering work in this field. Of course our WDS software uses exact equations to allows the user to specify exact phase margin and cross-over frequency; but for now all we need is a hand calculator and piece of paper

You can see from the compensator's transfer function that we have 2 pole, 2 zeros and 1 pole at origin. To get reasonable performance:

1 - Place 2 compensator zeros right on top of the plant's double poles (i.e. at 1.6kHz),
2 - Place 1 compensator pole at ESR zero to cancel the plant's zero (i.e. at 11.6kHz),
3 - Place the other compensator pole at half the switching frequency (i.e. if we have a switching frequency of 200kHz we place this pole at 100kHz). This will help in reducing high frequency noise,
4 - Finally we place the pole at origin at:

$$f_{p0} = \frac{V_{ramp} \times F_x}{V_{in}}.$$

Where Fx is the desired cross-over frequency. In our case let us design for Fx = 10kHz and therefore we will have to place our pole at origin at 833 Hz (i.e. 1V×10kHz/12V).

Step 3: Calculate compensator component values

Now that we know the positions of our compensator poles and zeros, we can use the equations above to calculate component values in a step-by-step manner:

1 - I usually start by calculating R1 and Rb based on the current that I am willing to let through them and the reference voltage needed on my controller IC. I will then check to make sure that the power dissipation per resistor does not exceed ~60mW so that I don't get a hotspot on my PCB. I also try not to let the current fall below 100µA for robustness in the EMC test chamber during the susceptibility test.

R1 and Rb form a potential divider (or sampling divider) and this sets the demand reference voltage (in our case let us assume that this is 2.55V). So we know the input voltage of the potential divider (in our case this is Vout = 3.3V) and we know the output voltage of the potential divider fed to the IC (in our case 2.55V). Starting by allowing 1mA of current through this pot and using the standard potential divider equations and Ohms law we have: R1 = 750Ω, Rb = 2.55kΩ, and power dissipation in each resistor < 60mW.

2 – Now that I know R1, I can use the equation for wp0 to calculate C1 (please don't forget that these equation are all in rad/sec so we need to scale by 2π. Furthermore, C1 is usually much larger than C3 and therefore the equation for wp0 simplifies to wp0 = 1/ (R1×C1). I know R1, I know wp0, so I can calculate C1 (in our case C1 = 1 / (2π×833 Hz×750Ω) = 250nF.

3 – Equation for wz1 is dependent on C1 and R2. We now know wz1 and C1 so we can calculate R2 = 390Ω.

4 – Again as C1>> C3 equation for wp2 simplifies to wp2 = 1/ (R2 C3). This pole is being placed on our ESR zero (i.e. @11.6kHz) and we know all the terms apart from C3 so we can calculate it. C3 = 34nF.

5 – Finally we are left with the equations for wp3 and wz2. These two are dependent on each other but we have 2 equations and 2 unknowns and therefore we can easily solve them. If we divide the equation for wp3 by the equation for wz2, then both C2 terms and the 2π terms cancel and we are left with all the known variables and we can solve for R3:

$$\frac{\omega_{p3}}{\omega_{z2}} = \frac{(R_1 + R_3)}{R_3} \Rightarrow \frac{100kHz}{1.6kHz} = \frac{(750\Omega + R_3)}{R_3}$$

With R3 calculated (in our case R3 = 12Ω) we can substitute back into equation for wp3 and hence calculate our very last component: C2 = 130nF.

We can easily use WDS in "manual pole/zero placement" mode to verify our calculations. WDS provides us with all the important stability parameters as well the Bode plot. WDS Bode plot for our design is shown in figure 3 and the stability information is shown in figure 4.

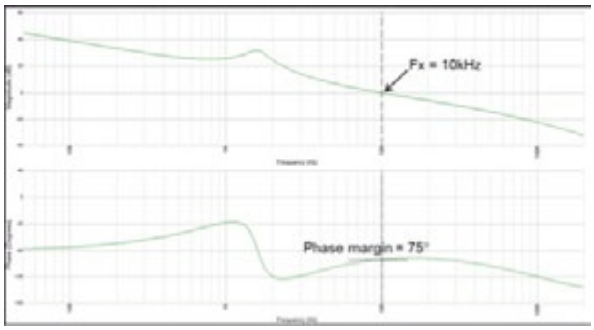

Figure 3 – Simulated loop bode from Biricha WDS

Stability	Fx	P.m.	G.m.	Slope at Fx
Nominal	10016Hz	75°	32dB	-20.0dB/dec

Figure 4 – Stability data from WDS for our design

From figures 3 and 4, we can see that we have achieved a crossover frequency of 10kHz as desired and a phase margin of 75 degree. Slope at crossover is -20db/decade and our gain margin is better than 32dB. Thus we have designed a very stable power supply with a respectable crossover frequency and even though we had no control over the phase margin, 75 degrees is more than ample.

Voltage Mode Compensator Design with Plants Containing a Transformer

If our Forward type topology has a transformer but no isolation (e.g. does not have an opto-coupler) then the design procedure is exactly the same as above with just one minor difference. All we have to do is to multiply our pole at origin by the turns ratio of our transformer.

For example if we had a Forward converter with exactly the same specification as the Buck converter in this article, but with a transformer turns ratio of 10:1 then all we would have to do is multiply our pole at origin by 10 (833 Hz × 10 = 8330Hz). The rest of the calculation and procedures will stay exactly the same.

Concluding Remarks

In this article, we discussed how to design a compensator for all hard switched Forward type non-isolated voltage mode converters. An approximate method has been presented that will give reasonable results in most cases. The advantage of the method presented here is that it is very easy and quick to calculate but we do not have any control over the phase margin. We also included a complete numerical example down to component value selection.

In the forthcoming articles we will discuss current mode control, isolation and why generally it is not a good idea to use a PID controller to stabilise a voltage mode power supply.

Things to Try

1 - Down a copy of Biricha WDS PSU Design software from www.biricha.com
2 - Attend one of our Analog power supply design workshops

Bibliography

[1] Biricha's "Analog Power Supply Design Workshop" Manual
[2] Switching Power Supplies A – Z by Sanjay Maniktala, ISBN: 978-0123865335
[3] Switch-Mode Power Supplies, Second Edition: SPICE Simulations and Practical Designs by Christophe Basso, ISBN 978-0071823463

For the PDF version and related videos please visit:

www.biricha.com/bodo2B

DC-DC Voltage Regulation: Complete Solution Targeting PoL Market

The requirement for ever increasing density and power efficiency is leading the DC to DC product application to new grounds. Infineon Technologies together with International Rectifier has focused on increasing density and efficiency in this regard with its latest Multiphase Digital Controller products the PXP1000 series for Point of Load (PoL) applications, SupIRBuck® regulators, DrMOS, and a full range of PowIR power stages.

By Matt Hunter, Infineon Technologies AG

The need for high performance in the CPU VR (voltage regulator) world has been with us for a few years now, but increasingly the PoL market is now under pressure to meet stricter requirements.

No longer is the mighty CPU the only power hungry silicon on the board. Today's ASICs are drawing in excess of 100 W and are requiring sophisticated features such as dynamic voltage changes/ AVS, margining, autonomous phase shedding, telemetry, PMBus compatibility, tight output voltage accuracy under demanding transient conditions, and high efficiency under light loads. Once only the realm of the CPU, the ASIC is moving center stage in demanding a high performance VR.

Integrating the IR product portfolio, Infineon now offers a variety of end to end solutions. For single phase fully integrated packages (controller/driver/MOSFETs) there are ten parts available ranging from the 3 A IR3823, to the 35 A IR3846. The SupIR product line continues with dual output 4 A + 4 A and 6 A + 6 A fully integrated solutions.

As a result of a new thermally enhanced package using copper clip and several proprietary innovations in the controller, the SupIRBuck® family can operate up to 35 A without a heatsink, and reduces PCB size by 20 percent compared to alternative integrated solutions and 70 percent compared to discrete solutions using a controller and power MOSFETs. A complete 25 A power supply solution can be implemented in as little as 168 mm^2 as shown in Figure 1.

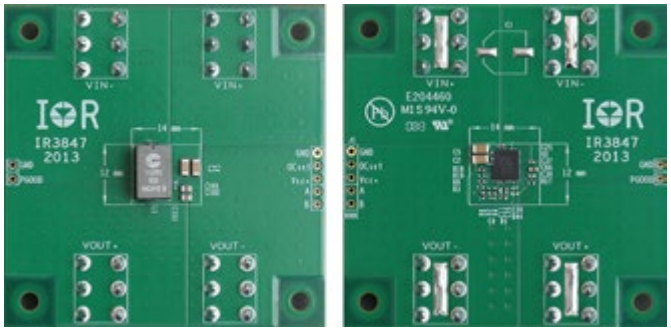

Figure 1: Reference Board SupIRBuck 25 A solution

The devices integrate a feature-rich, third generation SupIRBuck® controller that includes post-package precision dead-time trimming to optimize losses, and internal smart LDO to optimize efficiency across the entire load range along with the power MOSFETs. True differential remote sense essential for high current applications, 0.5 percent reference voltage accuracy in 25 °C to 105 °C temperature range, input feed-forward and ultra-low jitter combine to enable total output voltage accuracy less than 3 percent over line, load, and temperature, as required by high performance communications and computing systems.

The third generation SupIRBuck single input voltage (5 V – 21 V) family features a proprietary modulator scheme that reduces jitter by 90 percent compared to standard solutions. This has the dual benefit of reducing output voltage ripple by approximately 30 percent and allowing higher frequency (up to 1.5 MHz) and higher bandwidth operation for smaller size, better transient response and fewer output capacitors. To aid in ease of use, an online design toolkit provides a part selection matrix, simulator, and schematic/BOM generation. The free tool is available at http://ir.transim.com.

The lineup extends to the high performance fully digital multiphase controller family which is based on a highly reliable state machine core that delivers performance and flexibility from single phase single loop devices, three phase three loop devices, and even to an eight phase single loop device. All parameters of the controller are set via firmware that is stored in non-volatile memory. Accessible over I^2C and PMBus, the system engineer is able to adjust all parameters of operation in real time without the need to interrupt active regulation. System parameters such as number of phases, switching frequency, frequency response, dynamic voltage change, and numerous fault and protection features (OCP, OOVP, OUVP, etc.) can all be adjusted by firmware.

A unique feature of the PXP1000 series controllers is the embedded microcontroller. The intention of the microcontroller is to offer virtually unlimited flexibility in the control of the regulator, as well as the ability to add new functionality on the fly as requirements develop during the design process.

Using a dedicated GUI the designer has a simple interface to control all the parameters of the controller. A few clicks set up the turn on

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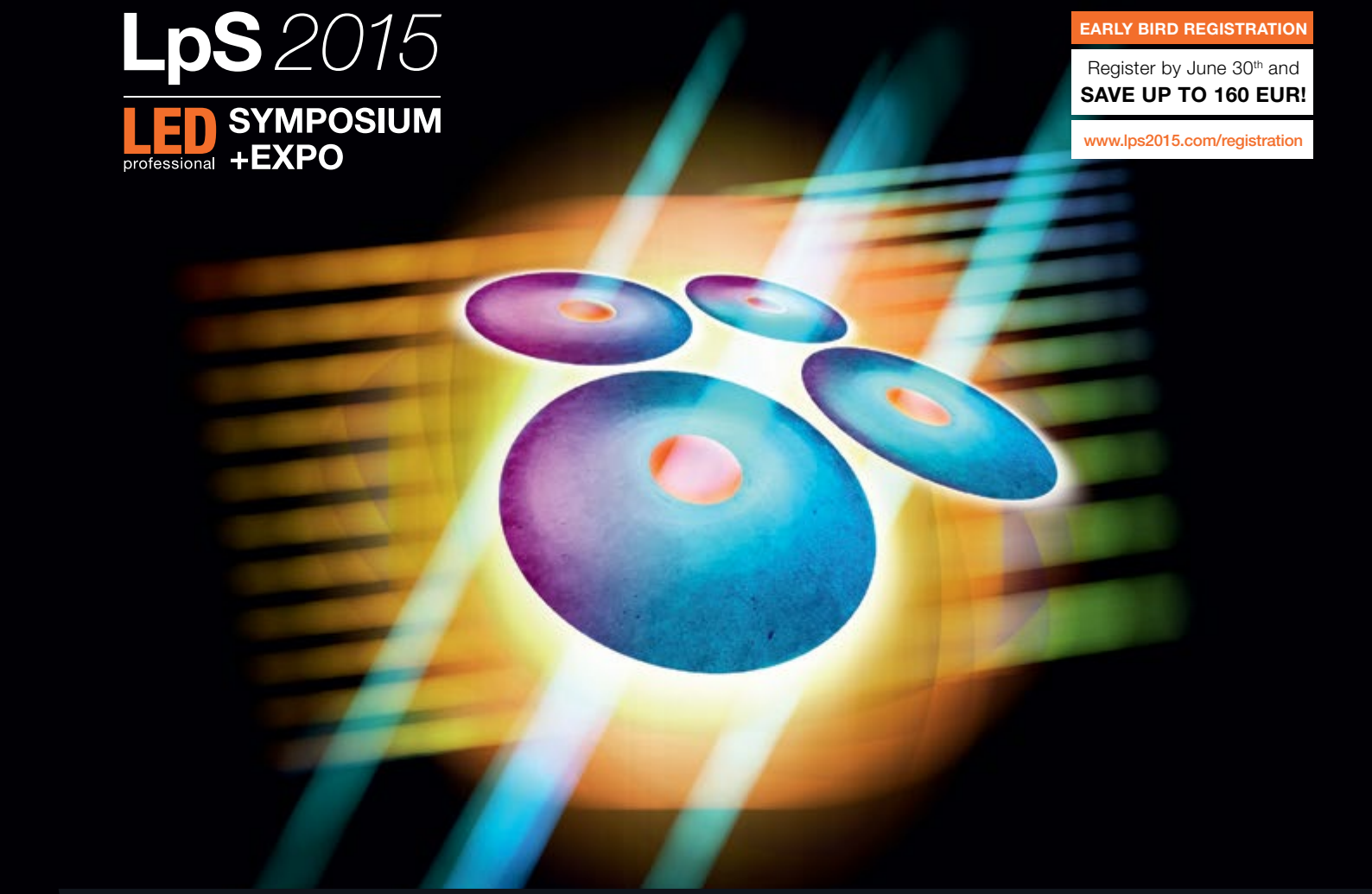

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conditions for features like Vin OVP, UVP, UVLO and even an input current monitor. Also software adjustable are the number of phases and switching frequencies, which are fully flexible for each loop (or independent output) as shown in Figure 2.

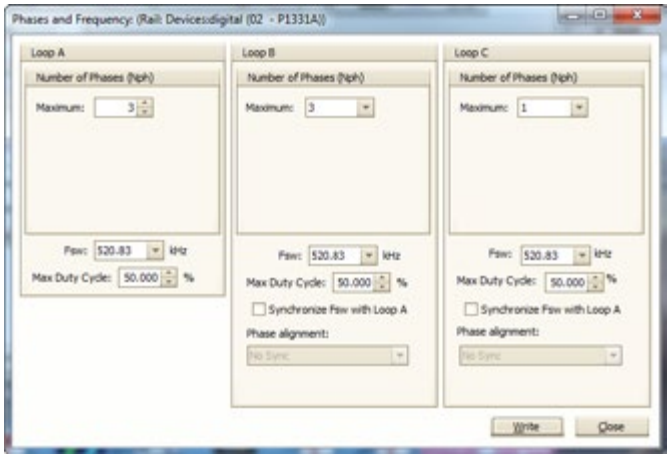

Figure 2: Software GUI phases control dialogue box

The controller features a PID compensation loop that is similar to an analog regulator's type III compensator. Independent PID loops for each output, and even each power state (i.e. dynamic phase count applications) allows the ability to keep transient performance optimized under all load conditions.

Figure 3 depicts the VR response to a high current step load. As is clearly evident, without controller adjustments the output is highly unstable (Fig. 3a). After making a few adjustments to the PID loop parameters (while in active regulation), the response has been optimized and no undershoot or ringing is observed (Fig. 3b). Of note, this particular application has droop (loadline) so the step response should be a square wave.

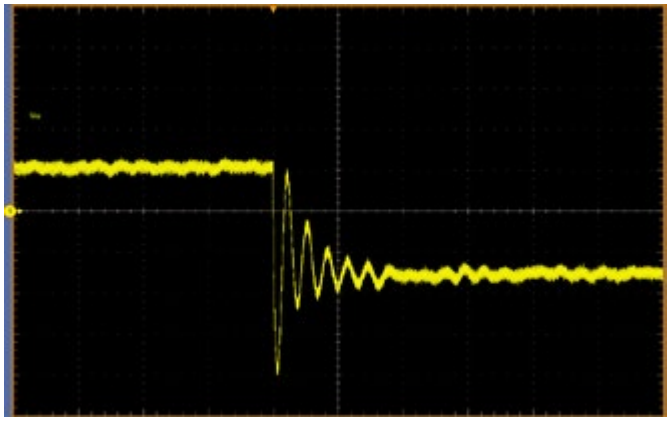

Figure 3a: Transient waveform before optimization

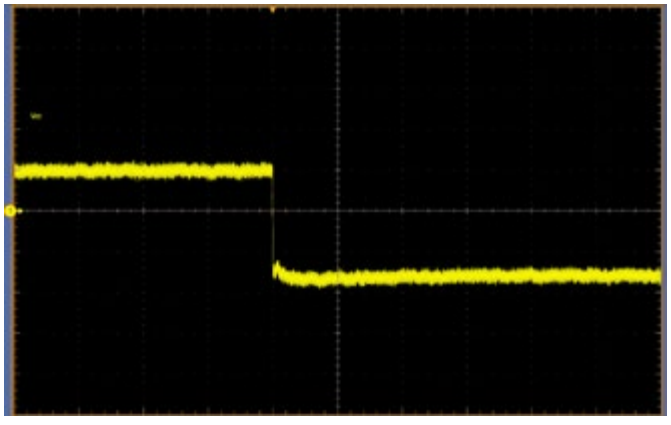

Figure 3b: Transient waveform after digital optimization

The built in Bode plot simulator allows the modeling of the board's output stage by entering inductor value, bulk capacitors as well as larger caps near the load, and even PCB parasitics. Once the board is simulated, the GUI can recommend stable PID parameters for all loops. The GUI also features a poles and zeros translator for conversion into PID parameters. The simulator and P&Z converter ease the transition of the designer from the analog world to the digital world of power.

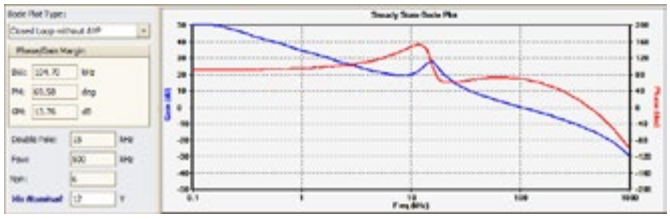

Figure 4: Software GUI Bode plot dialogue box

If the response of the loop is not adequate due to a board layout issue, or limited capacitor bank, the advanced features of the digital controller can be of great help. Many non-linear response parameters are available to overcome difficult operating conditions. During a load step increase, the Automatic Transient Response feature inserts extra PWM pulses to drive more current into the load. All while ensuring that inductor saturation limitations, on a phase by phase basis, are never exceeded, even under stressful thermal conditions. During a load step release, the PWM pulses are automatically blanked, if additional performance is required the controller can tri-state the power stage to dissipate energy in the low side body diode thereby reducing the output voltage. The controller features sophisticated limits to protect the power stage from over current during this and all operating conditions.

The output voltage is firmware programmable, as is the droop or loadline (AVP) setting. During active regulation the output voltage is adjustable by programmable VID settings. The controller features a flexible architecture that allows many different VID schemes that are dependent on the application. Output regulation is maintained within 0.5 percent of the desired setpoint, and a sophisticated fault handler watches for output voltage over threshold, under threshold, and VID tracking threshold errors. Even when the fault handler detects an error, the firmware has an adjustable response to the errors, which is extremely useful during bench debug or testing. The controller also supports PMBus so margining and other commands are readily accessible over the I^2C bus.

Extremely valuable is the vast amount of telemetry data that is available via I^2C or PMBus. Output voltage, high accuracy output current (both per phase and total), power stage temperature, controller temperature, input voltage, and input current offer a wealth of information that is useful during debug and during normal operation. Over I2C a system monitor can read the information and make decisions about the health of the controller and/or system.

This information can then be sent up the chain to chassis or rack system monitors for constant supervision of the health and status of the power delivery system. The ability to detect abnormal operating conditions before they become major problems is helpful in maintain-

ing system up time. Because the system communication is two-way, the ability to modify control parameters in deployed systems is also available. The telemetry data also available in the GUI is shown in Figure 5.

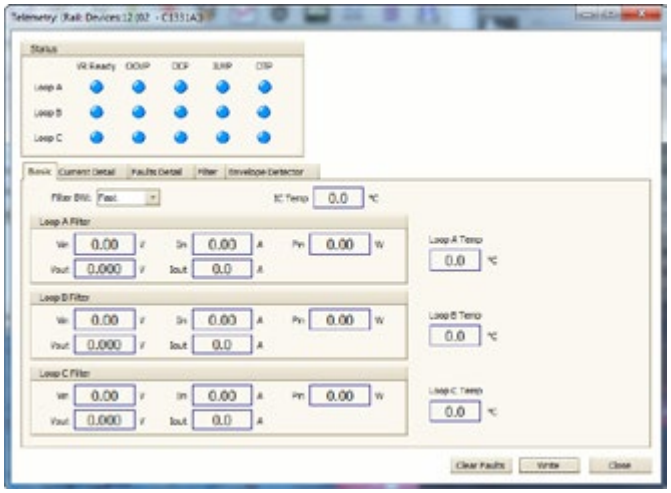

Figure 5: Software GUI telemetry dialogue box

Operating in tandem with the controller, Infineon now offers a broad variety of power stages from discrete to integrated, with internal current reading at industry leading efficiency levels.

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With ever increasing pressure on performance, cost, PCB real estate, and short design-in and validation times, the Infineon controllers and power stages deliver the requirements while being easy to use for the power and system designer.

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Keep Pace with Today´s Power Technology

As one of the leading electronics companies Texas Instruments fuels power designs with an innovative portfolio and speeds time to market with powerful, easy-to-use design tools. Now the company extends its power product range with some industry firsts.

By Wolfgang Patelay, Freelance Journalist, Bodo´s Power Systems

According to Dave Priscak, Director, Power Systems at Texas Instruments, is the company committed to help power designers realize the full potential of today's technologies with advancements in power innovation, including: Breakthrough Wide-Vin DC/DC converters, first zero-standby power PSR solution for AC supplies up to 75 W, first GaN half-bridge power stage in a QFN and accelerating digital power design to meet any power design requirement.

Industry's first 80-V half-bridge GaN FET module

The new LMG5200 is the industry's first 80V, 10A integrated gallium nitride (GaN) field-effect transistor (FET) power-stage prototype, which consists of a high-frequency driver and two GaN FETs in a half-bridge configuration – all in an easy-to-design quad flat no-leads (QFN) package. It will help accelerate market adoption of next-generation GaN power-conversion solutions that provide increased power density and efficiency in space-constrained, high-frequency industrial and telecom applications. One of the biggest barriers to GaN-based power design has been the uncertainties around driving GaN FETs and the resulting parasitics due to packaging and design layout. This GaN FET power stage will help power designers realize the full power potential of GaN technology by offering them a complete, reliable power-conversion ecosystem of optimized integrated modules, drivers and high-frequency controllers in advanced, easy-to-design packaging. Typically, designers who use GaN FETs that switch at high frequencies must be careful with board layout to avoid ringing and electromagnetic interference (EMI). LMG5200´s dual 80V power stage prototype significantly eases this issue while increasing power-stage efficiency by reducing packaging parasitic inductances in the critical gate-drive loop. It features advanced multi-chip packaging technology and is optimized to support power-conversion topologies with frequencies up to 5 MHz.

Figure 1: The LMG5200 integrated GaN FET power-stage prototype, consists of a high-frequency driver and two GaN FETs in a half-bridge configuration in an QFN package

The easy-to-use 6mm by 8mm QFN package requires no under fill, which significantly simplifies manufacturing. The reduced footprint solidifies the value of GaN technology and will help increase adoption of GaN power designs in many new applications, ranging from new high-frequency wireless charging applications to 48-V telecom and industrial designs. In addition to ordering the available LMG5200 evaluation module (EVM), designers can get started faster using PSpice and TINA-TI models for the LMG5200 to simulate the performance and switching frequency advantages of this technology.

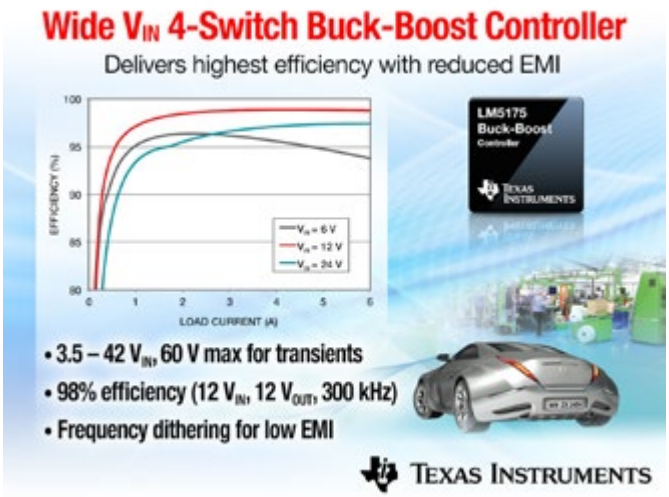

Figure 2: The LM5175 four-switch buck-boost controller achieves the highest power efficiency with reduced EMI

65-V synchronous step-down converter with Fly-Buck capability

The next industry's first TI launched is the 65V synchronous step-down converter LM5160A that provides isolated bias supplies up to 15 W – without the need for an opto-coupler. As part of the company´s innovative Fly-Buck power portfolio, the converter improves power density and addresses higher power needs more efficiently and reliably in industrial and automotive applications, such as three-phase AC motor drives, programmable logic controllers (PLCs), smart metering, renewable energy or grid infrastructure, factory automation, power over Ethernet (POE), IP cameras, and electric vehicles. The converter features a constant on-time control that requires no loop compensa-

tion and supports high step-down ratios with fast transient response. The innovative converter, which supports a wide-input voltage of 4.5 V to 65 V, can generate positive and negative bias-supply rails in non-isolated designs, or single and multiple isolated outputs, while minimizing solution size and simplifying the design compared to traditional flyback solutions. Used in conjunction with WEBENCH online design tools, the LM5160A speeds time to market of high-power DC/DC designs. The 4.5V to 65V input voltage range allows the converter to efficiently operate in harsh transient conditions without the need for input clamp circuits, resulting in higher reliability. Constant on-time control provides fast transient response and results in lower component count. Programmable soft start reduces in-rush currents when powering up into heavy loads or large capacitance. Internal ±1% voltage reference and VOUT error correction improve accuracy across line, load and temperature.

Buck-boost DC/DC controller achieves highest power efficiency with reduced EMI

The also introduced LM5175, a new wide VIN, four-switch buck-boost controller achieves - according to Priscak - the highest power efficiency with reduced EMI. The controller manages input voltages from 3.5 V to 42 V (60VIN absolute max) and regulates output voltages from 0.8 V to 55 V. This flexibility enables the controller to deliver high-performance designs for industrial and automotive applications such as industrial PCs, USB power delivery, in-vehicle wireless charging, LED lighting, electric vehicles, battery charging and telecom RF power amplifiers.

The flexible DC/DC controller addresses a wide variety of buck, boost, and buck-boost applications from output power of a few watts to greater than 100W using a single device. A proprietary switching scheme maximizes efficiency in the buck-boost transition region and uses a single inductor to further reduce board space. Its robust gate drive (2A at 7.5V) enables wide VIN MOSFETs to switch faster and more efficiently. Optional hiccup mode short-circuit protection prevents thermal runaway during extended load current faults, reducing thermal stress by up to 30 percent. Optional input or output average current limiting addresses applications requiring a regulated current from the input supply or to the load.

Zero standby power PSR solution for high-power AC/DC power supplies

Another industry's first introduction is the zero standby power controller chipset UCC28730 with the lowest standby power consumption for AC/DC flyback power supplies up to 75W. Taking power supply efficiency to the next level, the new primary-side regulation (PSR) flyback controller with 700V startup switch and UCC24650 wake-up monitor supports 5V to 24V output voltages and helps designers create smaller, more efficient power supplies for TVs, home appliances, AC adapters, heating, ventilation and air conditioning (HVAC), and building automation systems. A major design limitation with existing primary-side regulation power supplies today is poor transient response performance while trying to maintain low standby power.

The UCC28730 and UCC24650 chipset achieves zero standby power consumption while achieving the best transient response performance possible. Besides reducing cost by eliminating feedback components such as an opto-coupler and TL431, the voltage droop-detection feature in the UCC24650 wake-up controller enables the use of tiny output capacitors while maintaining a narrow-output voltage-regulation window with zero- to full-load transients.

This chipset solution is designed to work with TI's ultra-low-power DC/DC converters, sensors, radio frequency (RF) devices (including the SimpleLink CC26xx/CC13xx wireless microcontroller platform) and MSP430 MCUs to keep more system functions alive in standby mode while still maintaining zero standby

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consumption performance for the entire system. The UCC24650 is also compatible with UCC28633 PSR controller, which enables peak power delivery two times higher than rated name plates without a proportionate increase in magnetics size, making it optimal for applications such as printers, audio, gaming and industrial power supplies. Speed time to market by entering design parameters to create a custom design using WEBENCH Power Designer or by downloading a fully tested TI Designs reference design for a 12-W, 24-V offline power supply (PMP10927) based on the UCC28730 and UCC24650 chipset. Designers can quickly evaluate and test their power-supply designs with the UCC28730EVM-552 10-W, 5-V evaluation module (EVM), or download the TI Designs reference design based on the EVM.

Figure 3: The zero standby power controller chipset UCC28730 helps designers create smaller, more efficient power supplies for TVs, home appliances, AC adapters, heating etc.

Simple control of digital power designs

Texas Instruments announced also that it has simplified digital power control design with the new, low-cost Digital Power BoosterPack. The BoosterPack is a plug-in daughter card for the C2000 Piccolo TMS320F28069M LaunchPad development kit that makes it easy to understand digital power development using the real-time control architecture of TI's C2000 microcontrollers. The BoosterPack is suited for digital power applications such as power conditioners, uninterruptible power supplies, AC/DC power supplies, solar inverters and more. To further ease development, it is supported by the collection of graphical software tools in powerSUITE. Combined with F28069M LaunchPad, it simplifies to control a buck converter. Developers can leverage C2000 Piccolo F2806x MCU, which integrates the C28x real-time processing core as well as sophisticated control peripherals, including tightly coupled PWMs with 150ps of resolution and ADCs with speeds up to 3.46 MSPS to enable faster switching frequency power supplies. The BoosterPack also integrates CSD87588N NexFET power block, LM5109B and UCC27424 FET drivers, and OPA353 operational amplifier, all within a small form factor. The low-power Digital Power BoosterPack operates on 18 watts, which eliminates the risk associated with developing high-voltage systems.

The Digital Power BoosterPack includes out-of-the-box code examples to help developers quickly jumpstart development. It is supported by several software tools within powerSUITE, which is available within controlSUITE - the one-stop shop for C2000 MCU documentation and code examples. powerSUITE is a collection of graphical software tools, including the Solution Adapter, Compensation Designer and the Software Frequency Response Analyzer, that enables designers to easily develop and modify their digital power applications and accelerate time to market. These tools provide an intuitive interface to seamlessly integrate developed code into Code Composer Studio integrated development environment (IDE): The Solution Adapter allows designers to easily modify existing code examples for custom hardware using a simple GUI instead of writing development code. The Compensation Designer enables developers to create compensators of different styles, providing a method to effortlessly tune control loops. The Software Frequency Response Analyzer enables developers to quickly measure the frequency response of digital power converter control loops implemented on a C2000 MCU.

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How Proper Applications of Thermally Conductive Materials will Improve Motor Power Density

Motor designers have battled heat in motor designs for years. Thermal losses in electric machines rob motion systems of power and degrade efficiency. Excess heat can reduce reliability of motors and shorten their lifetimes. Meanwhile, electrification in all transportation sectors is driving requirements for motors with ever-higher power densities.

By Anita LaFond, Senior Editorial Manager, Constructive Communication, Inc.

Good thermal management in electric machines and their power electronic drives can minimize losses, particularly copper (I2R) losses, and yield improved performance, reliability and efficiency. Research shows a potting or encapsulation process using high thermal conductivity material from LORD Corporation can dramatically decrease the operating temperature of an electric machine at a given load. Proof-of-concept research explored the benefits of potting motor end windings and power electronics with thermally conductive materials. Results showed significant decreases in operating temperature that correlate to higher motor efficiency and double-digit increases in output power.

The ability of high thermal conductivity materials to improve performance in electric machines was demonstrated during research conducted by Shafigh Nategh while a graduate student at KTH School of Electrical Engineering, Stockholm, Sweden. Nategh's research, "Thermal Analysis and Management of High-Performance Electrical Machines," (http://kth.diva-portal.org/smash/get/diva2:623376/FULLTEXT01) dealt with thermal management aspects of electric machinery used in high-performance applications with particular focus on electric motors designed for hybrid electric vehicle applications.

LORD Thermoset SC-320 Thermally Conductive Potting Material, a relatively soft, high thermal conductivity material (3.2 W/m·K) with sufficiently low viscosity to be used in vacuum potting, was evaluated in Nategh's research. The electrically-insulating silicone encapsulant, designed for electrical/electronic applications, offers excellent thermal conductivity properties while retaining the desirable properties associated with silicones. Thermoset SC-320 is a two-component system that exhibits low shrinkage and stress on components as it cures, and maintains a low viscosity for ease of component encapsulation. Environmentally resistant and UL-rated to UL94V0 and 180C RTI, Thermoset SC-320 is composed of an addition-curing polydimethyl siloxane polymer that will not depolymerize when heated in confined spaces.

In the first part of Nategh's thesis, new thermal models of liquid-cooled (water and oil) electric machines (i.e., motors) were proposed based on a combination of lumped parameter (LP) and numerical methods. A permanent-magnet assisted synchronous reluctance machine (PMaSRM) equipped with a housing water jacket, as well as an oil-cooled induction motor where the oil was in direct contact with the stator laminations, were evaluated. In the second part of the thesis, the thermal impact of using different winding impregnation and steel lamination materials was evaluated.

Conventional varnish and epoxy, as well as a silicone-based thermally conductive impregnation material (LORD SC-320), were investigated and the resulting temperature distributions in three small permanent magnet motors were compared. The thermal impact of using different steel lamination materials was reviewed by simulations using the developed thermal model of the water-cooled PMaSRM. The differences in alloy contents and steel lamination thickness were studied and a comparison between the produced iron losses and the resulting hot-spot temperatures was outlined.

In comparing the effects of various impregnation materials, the hot spot temperatures of the windings were evaluated under various coolant flow rates and current levels for each of the potted motors. The hot spot temperatures of the motor impregnated with LORD SC-320 were generally 40-degrees-C to 45-degrees-C cooler than the varnish-only motor, and about 12-degrees-C to 15-degrees-C cooler than the epoxy-potted motor.

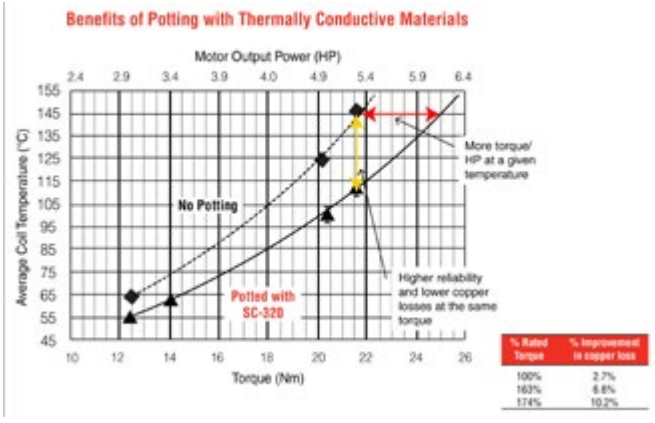
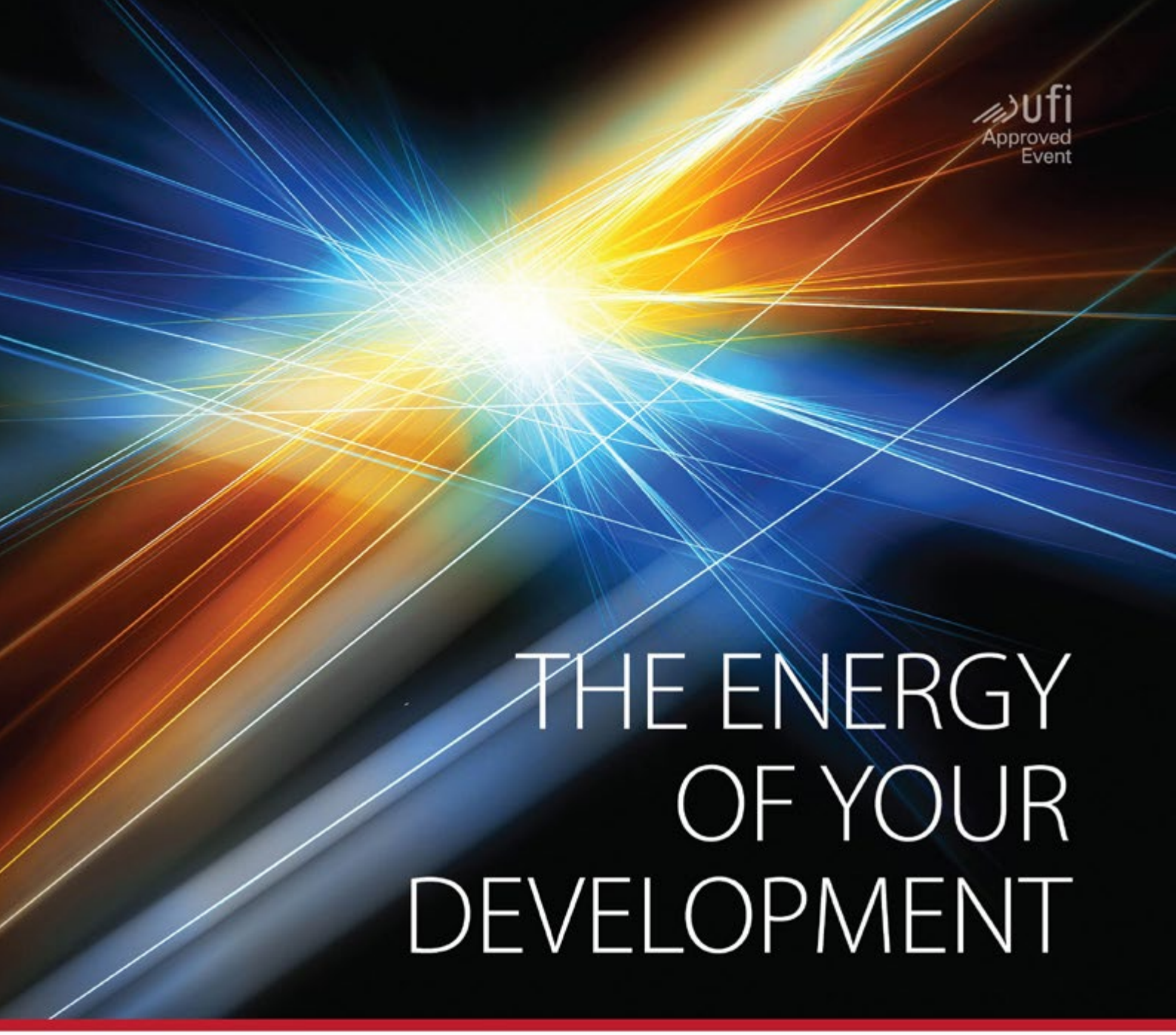


Figure 1: Motor Output Power Chart

No difficulties in vacuum filling were noted with LORD SC-320 despite its viscosity being somewhat higher than those of the epoxy and varnish. In addition, the potting compound was effective at decreasing the hot spot temperatures even when the potting was not 100-percent dense. For example, the hot-spot temperature of motors potted with LORD SC-320 increased by only 3-degrees-C as the potting density was decreased from 80-percent to 50-percent, whereas the hot spot



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temperatures of epoxy- and varnish-potted motors increased by 19-degrees-C and 25-degrees-C, respectively, as their potting densities were lowered from 80- percent to 50-percent.

Nategh's research showed that hot spot temperatures can be reduced by 35-percent to 50- percent using LORD SC-320 material as compared to an un-potted motor, compared to improvements of only 20-percent to 30-percent using typical epoxy potting materials. The potting compound may provide significant improvements in power density of electric motors.

A decrease in the hot-spot temperature of motors, depending on current, may provide an increase in achievable power/torque for a given motor size, decrease in motor size for a required power/torque, and longer motor operation before reaching temperature limits.

Analyzing the Test Data

Additional analysis of the data found in Nategh's dissertation was performed at LORD Corporation. Hot-spot temperatures from the dissertation were tabulated based on the potting materials thermal conductivity (varnish only, 0.25 W/m·K; Epoxylite, 0.9 W/m·K; and LORD SC-320, 3.2 W/m·K), coolant flow rate, and applied current. Data were analyzed as a three-variable general factorial experimental design using common statistical analysis software. The results showed that end winding temperatures depended strongly on the current and thermal conductivity of the impregnation material, but there was no statistically significant dependence on coolant flow rate.

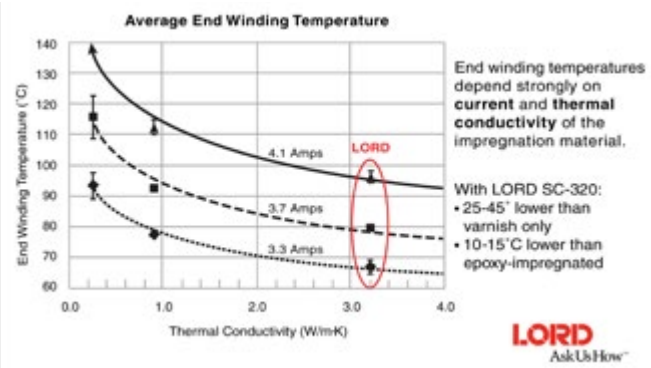

Figure 2: Average EndWinding Temperature Chart

Statistical analysis further showed that with the LORD SC-320 potting compound, the average end-winding temperature was 25-degrees-C to 45-degress-C lower than the varnish-only motor; and 10-degrees-C to 15-degrees-C lower than the epoxy-impregnated motor. Compared to varnish alone, the estimated achievable current required to reach the maximum temperature of 150-degrees-C is 14-percent higher with Epoxylite and 26-percent higher with LORD SC-320.

Since the current is directly related to the torque, improved thermal performance of the potted motors offers several benefits:

- Higher Power Density – more torque/horsepower from a similarly-sized motor; the same torque/horsepower from a smaller motor; and the ability to remove copper or steel from the motor
- Better Reliability – Low-temperature operation prevents insulation from degrading quickly, increasing the lifetime of motor insulation
- Lower Copper Losses – Lower operation temperatures translates to lower copper losses; less resistance to current flow = lower I2R losses

Independent Potting Study

To independently verify the efficacy of using high conductivity thermal materials to improve motor performance, LORD Corporation worked with Advanced MotorTech, an engineering consulting and services company. Advanced MotorTech is involved in the research, development, fabrication, testing, and re-design of industrial and high-performance machines.

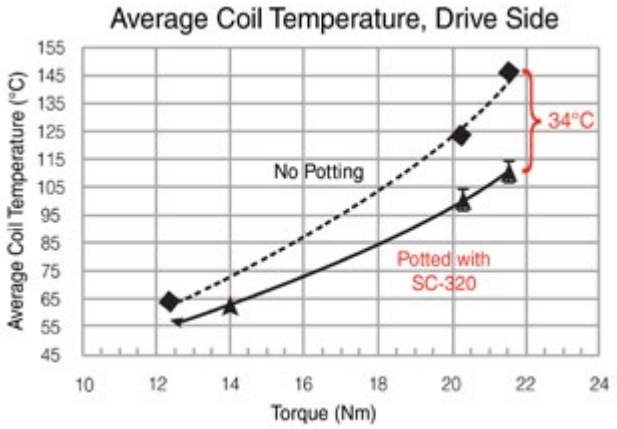

Figure 3: AverageCoilTemperature-Drive-Chart

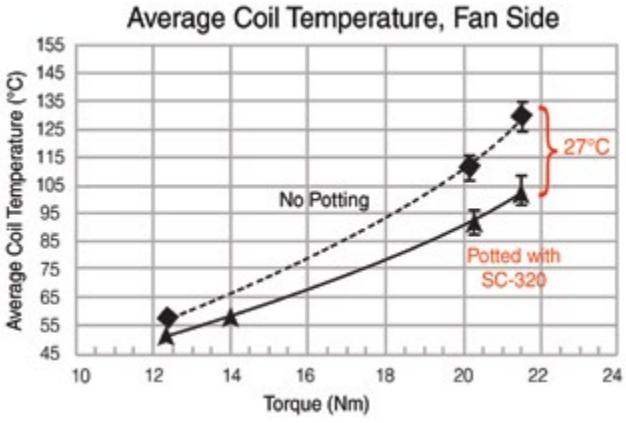

Figure 4: AverageCoilTemperature-fan-Chart

Advanced MotorTech tested the potting compound on a different type of motor from the ones used in the LORD Corporation research. They purchased Class F, 3 hp, 182T frame, totally enclosed, fan-cooled (TEFC) motors with a rated rpm of 1760; voltage: 208-230/460, three-phase, 60 Hz; full-load current: 8.4-7.8/3.0. For the test procedures, they knew that using a resin in a standard motor could improve a motor's performance by making the motor run cooler or making it run harder without exceeding its temperature rating. Advance MotorTech went into the testing with no preconceived notions of the outcome.

For testing purposes, the motors were coupled to a DC generator. A dynamometer accurately controlled the power output of the generator, and a digital meter provided readout of the torque transducer. The testing was done in a before-and-after manner; thermocouples were added to the motor before the epoxy was added to insure that the testing was done on an equal-match basis.

Six thermocouples were installed on each motor end (drive-end and fan-end), two per winding base, for a total of 12 thermocouples measuring winding temperature. Thermocouples were also added to the motor skin to monitor the outside temperature. Four "as-received" motors were tested using a "quick, full-load test." From that testing, two

motors with similar current, power and temperature rise were selected for subsequent tests.

A controlled test for equal comparison was done on the unpotted motors. To determine an accurate comparison between the motors, the testing was accomplished in the same room, with the same load, generator and meters; and the same ambient temperature (24.8-degrees-C). During the testing, the motors were run until they were thermally stable. Temperatures rose in the motors over time. The fan-end ran cooler and the shaft-end ran warmer, and both motors performed according to the manufacturer's instructions.

Of the two motors chosen for the testing, one was left unpotted and one was encapsulated with LORD SC-320 silicone. For the potted motor testing, Thermoset SC-320 resin was mixed with Thermoset SC-320 hardener. The silicone can be applied with handheld cartridges or automatic meter/mix/dispense equipment. A vacuum was used to minimize air bubbles. The encapsulant was allowed to cure for 24-hours at room temperature. It can also be cured faster at 125-degrees-C for 60-minutes. After curing, the insert was removed and the air gap cleaned. During the encapsulation process, workers at Advanced MotorTech found that Thermoset SC-320 exhibited none of the "strong" odor or "eye-irritating" fumes commonly noticed in other epoxy compounds.

The same load conditions were used for the potted vs. unpotted motors – a full-load test (100-percent torque). Testing results showed that the average overall temperature was 7-degrees-C cooler with the potted motor (54-degrees-C compared to 61-degrees-C for the unpotted control motor). The temperature difference between the fan and drive sides was only 3-degrees-C compared to 5-degrees-C to 6-degrees-C for the unpotted motor. Therefore, the potted motor, encapsulated with Thermoset SC-320, ran cooler than the unpotted motor.

Both motors were also tested at overload conditions (164-percent and 174-percent rated torque) to determine the thermal effects under extreme conditions. The potted motor averaged 30-degrees-C cooler than the unpotted motor at the highest torque. This is a significant difference, and could lead to a projected eight-time longer dielectric life. The temperature difference between the drive and fan sides was less in the potted motor (ΔT = 9-degrees-C compared to 16-degrees-C for potted compared to unpotted motors, respectively).

The potted compared to the unpotted motors also exhibited a dramatic difference in skin temperatures. Testing showed that, while the average skin temperatures were about the same, the potted motor had only an 8-degree-C difference between the hottest and coldest spots, whereas the unpotted motor had a 20-degrees-C difference. Thus, there was a more even distribution of skin temperature in the potted motor. This can be attributed to the air-gap-filling properties of the silicone resin. Thermoset SC-320 evenly and smoothly fills in all air gaps around the end windings. This results in even differential temperatures around the motor's frame, and helps to mitigate any stress and performance issues that might be created as the motor operates.

Conclusion

The results of testing both at LORD Corporation and at KTH clearly show the benefits of potting with thermally conductive materials. Motors potted with Thermoset SC-320 offer more torque and horsepower at a given temperature and should provide higher reliability and lower copper losses at the same torque. The tests demonstrated a 30-degrees-C difference at the highest applied torque and load, and an improvement in copper losses of about 10-percent. Alternatively, at the same highest temperature, there was a 16-percent improvement in torque with the potted motor.

Developed to provide exceptional thermal conductivity for electrical/electronic encapsulating, Thermoset SC-320 also retains the desirable properties associated with silicones. The low-viscosity encapsulant provides better flow-ability while reducing the risk of air entrapment. It is designed with lower durometer to reduce mechanical stress on electronic components and lower the probability of failure. Its low coefficient of thermal expansion results in lower stresses due to temperature change.

Possible applications for SC-320 include those in which higher power at lighter weight is needed, such as motors for electric vehicles; aerospace actuators and motors; and portable power generation equipment. Better thermal management in electric motors can reduce the current, and therefore, the energy required to provide the necessary power; and can also extend a motor's lifetime. Cost savings may also be possible due to the reduced amount of copper wire required for the motor windings. Thus, savings in weight, energy, and/or cost may all be possible depending on the application.

LORD Corporation is continuing to collaborate with development partners to verify the benefits of using high thermal conductivity materials in motor potting applications. These benefits include: higher power densities - reduced copper and steel weight via thermal potting material; improved reliability – substantially lower operating temperatures and elimination of hot spots; and improved efficiency.

http://www.lord.com/industries/electronics#ElectricHybridVehicle-4

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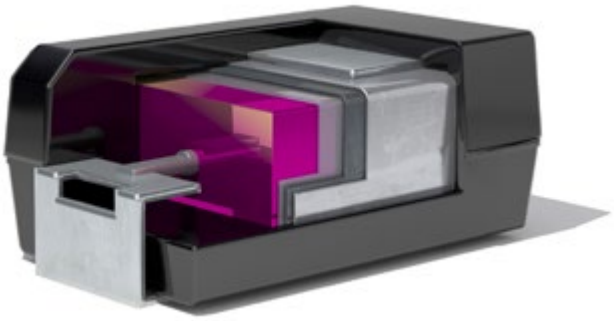
A New Dawn for Tantalum Capacitors



Tantalum capacitors hold significant technical advantages over other types, but sustainability issues slowed their adoption. A new generation of sustainable tantalum capacitors is now appealing to designers at the cutting edge of today's most demanding electronics applications in all kinds of products from smartphones and the cloud to satellites and implantable devices.

By Fernando Spada, Vice President Tantalum Product Marketing, KEMET Corporation

The rapid advances in automotive, telecom and industrial electronics from the late 1980s have been founded partly on the outstanding performance advantages of tantalum capacitors. The unbeatable high volumetric efficiency of these devices helped engineers achieve aggressive miniaturisation while significantly increasing functionality. In addition, low noise and stability over time have supported relentless progress towards ever-higher data rates and lower analogue and digital supply voltages. Moreover, high-temperature capability, unmatched longevity and proven reliability make tantalum the 'Number One' choice for applications likely to experience harsh operating conditions, including aerospace electronics as well as automotive and industrial equipment.

As tantalum technology matured and the supply base consolidated, a number of factors including materials shortages slowed the adoption of tantalum capacitors. At the same time, improvements in ceramic, electrolytic and polymer film capacitor technologies saw these types of devices offer a credible alternative in some applications. Subsequently, the arrival in the late 2000s of new legislation aimed at preventing conflict minerals entering the supply chain challenged component manufacturers to verify that tantalum in their capacitors is from conflict-free sources. This could potentially have closed off the advantages of tantalum technology to all but a few low-volume, highly demanding market sectors.

Addressing Sustainability

KEMET has addressed issues in the supply of raw materials and capacitor production, while at the same time developing advanced tantalum capacitor technologies to deliver even more capable and compelling products for customers. These initiatives have transformed the outlook for tantalum capacitors, introducing sustainability alongside the technical advantages of its unparalleled combination of superior energy density, high stability, outstanding electrical performance and self-healing capability.

KEMET's "Partnership for Social and Economic Sustainability" initiative is an extremely important aspect of the company's work aimed at ensuring a reliable source of audited conflict-free tantalum. This initiative is a benchmark for the industry. KEMET is working closely with a certified conflict-free mine in DRC (Democratic Republic of Congo); the company also supports projects in the local community to help establish a path to self sufficiency. The policies at the mine have been implemented in conjunction with experienced partners such as Mining and Mineral Resources (MMR) and the Kisengo Foundation, and follow known best practices. These ensure proper recording of mined coltan (tantalum ore), fair trading that rewards workers' productivity, and the safest possible working conditions for the miners. This has enabled KEMET to establish a reliable and sustainable source of conflict-free tantalum.

To complete the supply chain, KEMET has also acquired enterprises capable of performing all the post-mining processes such as smelting and refining to produce capacitor-grade tantalum powder and pure tantalum wire. These feed KEMET's capacitor assembly plants, creating the industry's only vertically integrated supply "closed-pipe" supply chain, giving unrivalled control over supply, quality and pricing of raw materials and finished capacitors. It has also been recognised as being compliant with the new conflict minerals legislation (The Dodd-Frank Act 2010) now in force in the USA. KEMET recorded the industry's first, and so far only, successful filing under the Dodd-Frank law in June 2014.

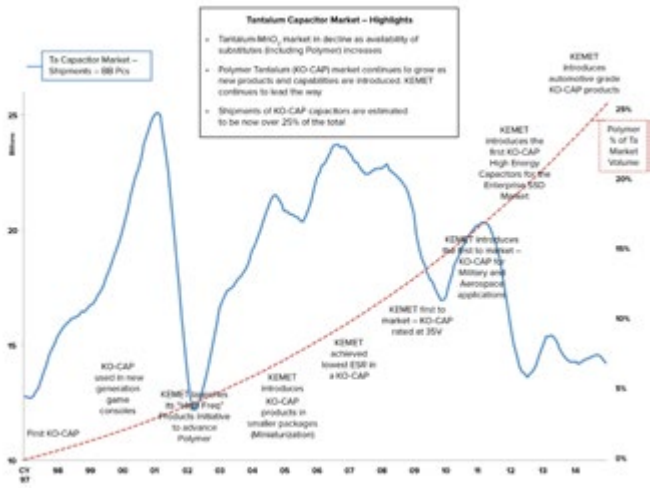


Figure 1: The Tantalum Market

Technical Advancement

Alongside these improvements in the supply chain, technological advances have enabled the emergence of the KEMET Organic Polymer Capacitors (KO-CAP) product line. Continued development has delivered successive generations offering market-leading low Equivalent Series Resistance (ESR) in a range of voltages in package configurations that no other capacitor technology can match. Low ESR minimises internal energy losses and self heating of the capacitor, thereby helping to enhance energy efficiency as well as reliability.

Dedication to technological progress has propelled KEMET to a position where it now holds a large number of material and chemistry patents and related intellectual property that serve to boost the reliability of KO tantalum capacitors. This simplifies design-in to applications where reliability is a key concern, such as military and medical equipment as well as automotive systems, telecom equipment and commercial avionics and radar.

Tantalum capacitors provide a competitively priced and superior-performing alternative to traditional capacitor types, and the KO-CAP product line is particularly popular. In fact, adoption and use of these devices has accelerated in fast-growing industry sectors such as mobile computing, telecom infrastructure and cloud services, as well as industrial automation and also in automotive, military and aerospace.

Type	MLCC	Aluminum (Electrolytic)	Tantalum (MnO_2)	KO-CAP (Polymer)	Aluminum (Polymer)
Rated Voltage	4V~3KV	4V~500V	4V~50V	2.5V~63V	2V~35V
Application Voltage	100%W	50~100%W	33~50%W	80~90%W	100%W
Working temperature	85~125~150~200℃	85~125℃	85~125~150~175~200℃	105~125℃	105~125℃
Capacitance	1p~100uF	0.1uF~8,200uF	0.1~1500uF	10~1000uF	10~680uF
Working Frequency	~GHz	~100KHz	~100KHz	~10MHz	~10MHz
Reflow (Peak Temp.)	260 ℃	240~260℃	260 ℃	260 ℃	260 ℃
Size (Min)	01005	Φ5mm	A(1206)	P(0805)	B(3528-20)
Size (Max)	2225	Φ35mm	E(7260-38)	H(7260-20)	X(7343-43)
MSL	1	1, 3	1	2a, 3, 4	3
ESR	Lowest (2~500mohm)	Middle 9mohm~5ohm	Middle 25mohm~7ohm	Low 3~150mohm	Low 3~45mohm
ESL	Lowest	Highest	1.0nH~2.7nH	130pH~2.7nH	1.1nH~2.3nH

Figure 2: Capacitor Type comparison

Type	MLCC	Aluminum (Electrolytic)	Tantalum (MnO_2)	KO-CAP (Polymer)	Aluminum (Polymer)
Ignition failure mode	•	•	•	--	--
Flex Crack	•	--	--	--	--
Piezo Noise	• Except C0G	--	--	--	--
Voltage Effect	• Except C0G	--	--	--	--
Polarity	--	•	•	•	•
Reverse Voltage	--		15%(25℃)	15%(25℃)	60%(25℃)
Surge Current	Best		Normal(10A~)	Good(20A~)	Good(20A~)
Surge Voltage	Best	Great (1.75X)	Good(1.3X)	Good(1.3X)	Good(1.3X)
ESD	Normal <300pF/50V has higherRisk	BEST	BEST	BEST	BEST

Figure 3: Comparison of Devices

The New Dawn

In April 2014, KEMET announced a breakthrough in polymer tantalum capacitor technology, having demonstrated stable electrical performance levels throughout high temperature and high humidity in testing based on AEC Q200 guidelines. Polymer tantalum capacitors are well-suited for use in automotive infotainment systems. KEMET's T591 series of high-performance automotive grade polymer tantalum devices features operating temperatures up to 125°C and is available in capacitances up to 220µF and rated up to 10V. The series is manufactured in an ISO TS 16949 certified plant. KEMET is currently developing further additions to its automotive-qualified tantalum family, to offer even greater choice for customers. In the second half of 2015 KEMET plans to release the T598 series with AEC-Q200 qualified and compliant components, with this, the automotive industry will be able bring the advantages of polymer tantalum capacitors to bear in more critical applications such as active safety systems and Advanced Driver Assistance Systems (ADAS).

In addition to this, KEMET will soon announce new smaller and thinner capacitors conceived especially to meet the demands of next-generation mobile devices and wearable electronics. The very high volumetric efficiency of these new devices will also make them ideal for space-constrained telecom equipment, as well as high-performance computer servers.

The advance of polymer tantalum technology will also bring benefits into the military domain, to help meet the demands of procurement agencies seeking to minimise the costs associated with new equipment. KEMET's technological development is enabling the emergence of new families of polymer tantalum capacitors offering higher reliability, not only for the military but also for civil aviation and space applications.

Leveraging the advantages of its vertically integrated tantalum supply chain, KEMET is also driving the development of new tantalum powders and capacitor internal components, optimised to deliver improvements such as higher energy density. The advances gained enable improved performance in applications such as the supply-voltage holdup circuitry of solid-state drives, which helps ensure data retention in the event of main power-supply failure.

Many polymer tantalum capacitor families are able to operate up to 125°C. On the other hand, MnO2 cathode technology produces capacitors that have very low leakage current and high maximum temperature capability, reaching as high as 175°C or over 200°C with KEMET's high-temperature families.

Conclusion: Three Critical Success Factors

KEMET has led the industry's response to the sustainability challenges associated with the tantalum supply chain, resulting in a stable and reliable supply of certified conflict free tantalum products and tantalum capacitors.

Continuing development of organic polymer capacitor technology, and expansion of the KO-CAP product ranges, is making highly cost-effective and high-performing devices more readily accessible to an increasing variety of designers targeting diverse applications.

Finally, KEMET's new Technology and Operations partnership with NEC TOKIN creates a new power that will continue to invest in market leading technologies and capabilities that match or exceed the requirements of engineers, maximising the advantages of tantalum's unrivalled energy density compared to all capacitor technologies.

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DC and AC Signals/Parameters and their Correct Representation by Measuring Instruments

Do you trust all displays and numbers your measuring instruments show? If the functional principles and/or the calibration of the 6 types of instruments are unknown, gross errors may go undetected. This article points out some common pitfalls.

By Dr. – Ing. Artur Seibt, Vienna

Definitions of AC parameters

Most of today's signals, power voltages and currents are AC and non-sinusoidal as well. It is vital to differentiate between their parameters:

* Average or mean value: this is the arithmetic mean of the signal as measured over a period or multiples thereof, it is identical to its DC content which is zero for pure AC signals.
* Root-mean-square value: this is the value of a voltage or current which is equivalent to a DC voltage or current when applied to a resistor, i.e. it causes the same amount of power dissipated: $I_{rms} = \sqrt{(1/T \int i^2 dt)}$.
* Peak value: this is the value of a signal from zero to its maximum.
* Peak-to-peak value: this is the value of a signal from its negative to its positive maxima.
* Crest factor: this is the ratio of the peak to the rms values. This is a vital parameter with all rms measuring instruments which, if disregarded, causes gross errors.

Types of measuring instruments

* Peak-to-peak displaying instruments: oscilloscopes.
* Peak responding instruments (True peak)
* Peak responding instruments, calibrated rms for sines.
* Average responding instruments (True average)
* Average responding instruments, calibrated rms for sines.
* Rms reading instruments: here the user has to watch out whether they measure "AC only" or "True rms" = "AC + DC". The majority are of the first type; in this case the user has to measure the "AC only" and the DC values separately and calculate the true rms value by using the familiar formula for uncorrelated signals: $I_{true\ rms} = \sqrt{(I_{DC}^2 + I_{rmsAC}^2)}$.

The measurement of the DC component may not be as trivial as it may seem: if a small DC component is buried in a large AC signal a DC instrument may show substantial errors.

Pitfall: Correction factors for non-sinusoidal waveforms required.

The most important parameter of a waveform is usually the rms value. While true rms instruments will deliver correct numbers for all waveforms within their specs, this can not be expected from all other types. Most of the average and peak responding types are calibrated rms for (pure) sines, they will indicate false numbers for non-sinusoidal waveforms! In practice, any of the 6 types can be used for non-sinuoidal waveforms if one knows the functional principle and its calibration and applies the proper correction factor. It is highly risky to grab an unfamiliar measuring instrument, because rarely does the front panel inform about how it measures and is calibrated! "Calibrated rms" is rather an indication that it is no true rms instrument, this would be described as "True rms".

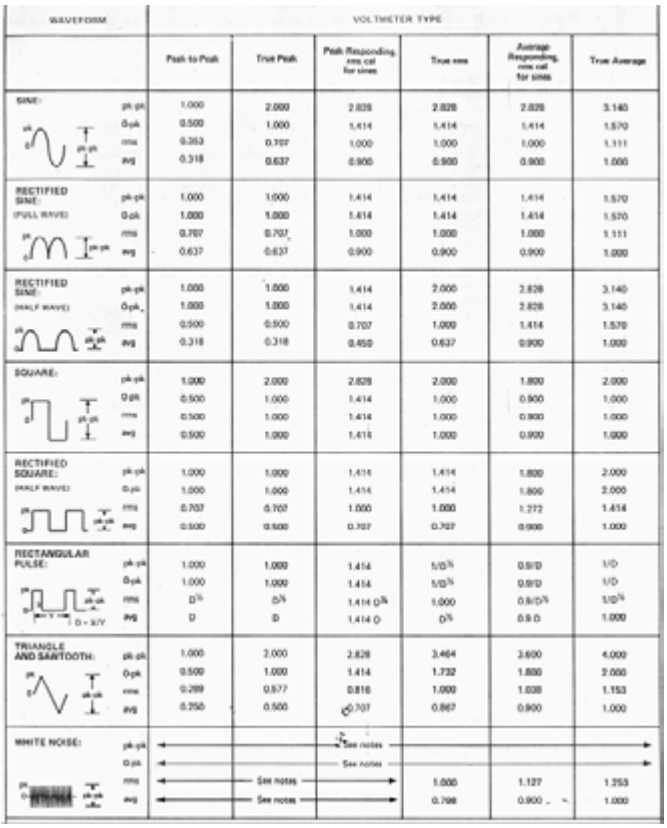

Table 1: Correction factors for 8 common voltage or current waveforms and their 4 main parameters as displayed on the 6 different types of measuring instruments

Table 1 lists the correction factors for the 4 main parameters of 8 common voltage or current waveforms as displayed by the 6 different measuring instruments, Table 2 contains the correction factors for the power.

How to use Table 1: Assumed the ac voltmeter available is of the average-responding type, calibrated rms for sines, and the rms value of a sawtooth is desired. The table shows the proper conversion factor

1.038 by which the reading has to be multiplied. But if the sawtooth was first measured on a scope and attributed the value 1.000, a true average-responding instrument would show only 0.25, so the correction factor is 4.000; in other words the reading was a whopping 400 % false. The values for white noise are only approximate because they are measured with a scope.

How to use Table 2: If voltage and current are both measured with any of the 5 types of instruments listed (with true rms instruments the factor is always 1), the power will be given by the product of the voltage and current readings times the dimensionless correction factor in the table. If, e.g., a sawtooth voltage across a resistor is measured with an average-responding instrument, calibrated rms for sines, then the power in the resistor is given by:
P = V2 /R x 32/3π2 ..(x 1.081.)

In case the voltage and the current are measured by differently responding instruments, the power will be given by: P = V x I x √ (FV x FI) where FV is the factor for the voltmeter and FI is the factor for the ammeter.

Both tables demonstrate convincingly, if not shockingly, that a measuring instrument can only be trusted if the user knows how it functions, how it is calibrated, also which limitations must be observed for correct results.

Waveform	Volt-(Am-) - Meter Response (see below)				
	I	II	III	IV	V
Sine	1	1	$\pi^2/8$	½	1/8
Rectified Sine Full-wave)	1	1	$\pi^2/8$	½	½
Rectified Sine (half-wave)	2	½	$\pi^2/4$	¼	¼
Square wave	$8/\pi^2$	2	1	1	¼
Rectified square (half-wave)	$16/\pi^2$	1	2	½	½
Rectangular pulse t/T= duty cycle D)	$8T/\pi^2$ t	2t/T	T/t	t/T	t/T
Triangle or sawtooth (symm. to 0 V)	$32/3\pi^2$	2/3	4/3	1/3	1/12
Triangle or sawtooth pulses (t/T = D)	$32T/3\ \pi^2$ t	2t/3T	4T/3t	t/3T	t/3T

I = Average-responding, calibrated for rms for sines
II = Peak-responding, calibrated rms for sines
III = True average
iV = True peak
V = Peak-to-peak reading

Table 2: Dimensionless correction factors for the power for 8 common waveforms and 5 of the 6 types of instruments; true rms responding ones are not listed as they require no correction factors

Specifications, Resolution, Accuracy
Since the advent of the first instruments with a digital display some decades ago, i.e. digital voltmeters and counters, many manufacturers can not resist the temptation to pretend a higher accuracy by a high number of digits. Customers indeed tend to prefer the higher digit instrument inferring it is the more accurate. A 0.01 % instrument needs only 4 digits, more contain no information. A professional instrument should not display more digits than is justified by its specs. It is the accuracy which determines cost and price because it requires expensive hardware which can not be substituted by software.

Calling an instrument e.g. a “0.1 % instrument” is already misleading, because every instrument is specified by an error budget, valid at one

specific temperature or within a narrow range and after a specified warming up period. This consists basically of “error of reading” plus “error of full scale” contributions, a temperature coefficient (TC), a time elapsed since the last calibration factor and, with AC instruments, a frequency dependent error. Pitfall: except for true rms instruments, the AC accuracy is only guaranteed for a pure sine wave, extremely rare in practice. As a rule, most errors also depend on the range used. If all error contributions are summed up, the accuracy to be reliably expected may be an order of magnitude lower than advertised! Specsmanship was invented by the measurement instrument and semiconductor industries.

Pitfall: Rms instruments display correct results only, if their crest factor = peak/rms spec is not exceeded. A typical measurement is the rms value of a pulse train, e.g. in a SMPS. A crest factor of 4 means that the instrument has a dynamic range 4 times as large as the full scale (fs) value of the range selected. In practice, this means that the rms value may be close to the fs value of a range, but that it is only correct as long as the peaks stay below 4 times the fs value. If the peaks are higher, they will be cut off, and the rms value will be inaccurate. This implies that the available crest factor increases towards the low end of a range. A quick test: downrange the instrument, if the value changes, the first measurement was false. Some instruments show the crest factor.

Analog/digital Instruments, Digitizing
The family of analog/digital instruments is large, only a few selected topics can be covered. Analog/digital instruments digitize voltages

or currents and show the results on multi-digit displays. They can be categorized into 3 classes:

- Integrating converters which measure the average of a signal, i.e. the DC component.
- Instantaneous converters, the object is only the measurement of parameters, then undersampling is possible, e.g. digital voltmeters or power analyzers.
- Instantaneous converters, the object is the reconstruction of the signal, this applies to DSOs.

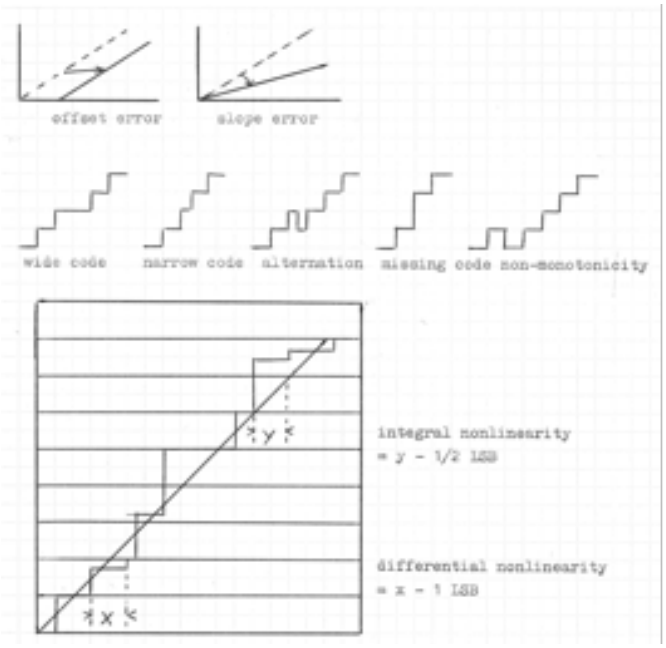

Figure 1: The various errors of a/d converters

In order to measure the peak, peak-to-peak, rms and derived parameters, in most instruments all inputs are digitized and the calculations performed in the digital domain, it is less expensive, and the data can be used for further processing. For AC fast instantaneous converters are required which are considerably more complicated than the averaging ones and suffer from a variety of errors depicted in Figure 1.

There are many misconceptions about digitizing of AC signals, it is often overlooked that it is not a 1-step, but a 3-step process: All analog/digital instruments with instantaneous converters are sampling instruments to start with. First the signal must be sampled and held until it is converted. Hence the rules of sampling have to be obeyed which has consequences, if they are violated, distortions or artefacts can be generated, this is independent of the following 2 steps!

The 2nd step is the a/d conversion; depending on the type of converter, the resolution and the percentage of use of the available dynamic range distortions originate also here.

In a 3rd step the digital signal is - mostly - d/a converted which also generates distortions because of imperfect reconstruction. The end result suffers hence from the combined errors of all 3 steps. With DSOs the amount and resolution of data gathered is generally too much for the usual LCD displays, so another slow sampling takes place internally, intransparent to the user.

The loss of fine detail is hence also threefold: Signal information between two samples is lost as well as between two a/d conversion levels and between two points of the reconstruction; this explains why digitized signals are always inferior to the analog originals

Pitfall: Another most detrimental effect of digitization is hardly ever mentioned, and even many engineers are highly surprised when it is pointed out to them: The distortions of the digitized and reconstructed signal increase the more the smaller the signal becomes! Eventually only the LSB will be switched on and off, i.e. the result will be a square wave, no matter how the signal looked like! This fact deflates the usual bragging about the enormous dynamic ranges of digitized signals, see Figures. 2 and 3. If an analog signal becomes smaller, it will keep its shape with all details until it disappears in the noise.

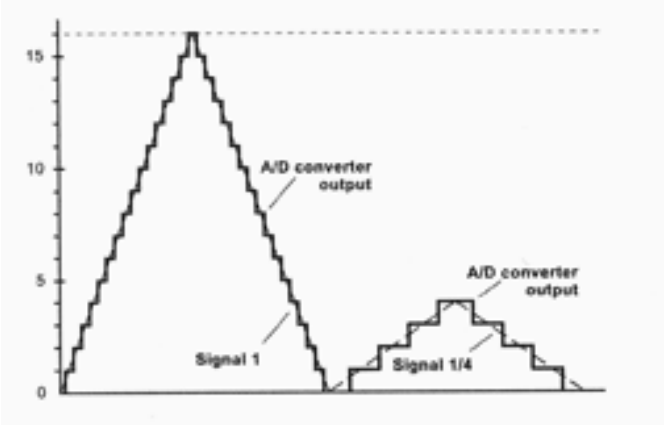

Figure 2: Digitized signals will be distorted the more the smaller they become resp. the less the available dynamic range is utilized. The example shows a triangle with 4 bits of resolution, left using the full range, right at ¼ amplitude with gross distortions. Eventually it becomes a LSB square wave.

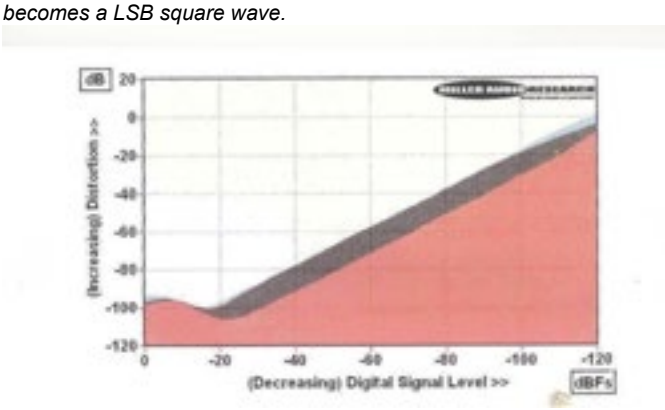

Figure 3: Practical example: Distortions of a digitized audio signal (vertical, 0 dB = 100 % distortion) vs. decreasing signal level from left to right (horizontal, 0 dB fs = maximum level, - 120 dB fs = lowest signal level, LSB) exemplifies the fact that the lowest bits of any digitized AC signal can not be used because they contain only distortions! From this diagram it is evident that if one desires to limit distortions to, say 0.1 % = - 60 dB, the theoretical dynamicn range of 120 dB can only be utilized down to - 60 dB!

The 16 bits of a CD = 65.000 : 1 = 96 dB, plotted in the same way, show that, depending on the level of distortions one is willing to accept, only a fraction of the 16 bit range is usable, the “higher dynamic range” is a fairy tale, if it were true there would be no need to compress the music into the upper bits, and no improvement could be perceived with 192 KHz/24 bits. (Apart from the absolutely insufficient 44.1 KHz which must be >= 100 KHz.)

This example from audio pertains directly to our regulation loops in SMPS which operate mostly in the audio range. Also, all SMPS are sampling systems which in turn limits the admissible frequency response of the regulation loops. The proponents of “Digital Power”

who deride analog designers as old fashioned, are bold enough, lacking power supply knowhow, to teach expert designers to replace 10 cent TL 431's by complicated, much more expensive, much less reliable and highly vulnerable DSP's, thus substituting a high quality analog loop by a digitized loop which e.g. shows up in poor transient behaviour.

Averaging of steps, noise

Often it is argued that the resolution steps of an instantaneous converter can be eliminated by "dither", i.e. one gets something for nothing. Dither means that noise is added intentionally (or inherent) to the signal to be converted. This works and can improve resolution by up to 3 bits, but requires that the converted signal is averaged. Averaging is identical to low pass filtering und knocks the bandwidth down; it is only possible if the signal does not alter its shape for the duration of the averaging period. In other words: Dithering is not applicable to changing signals, the improvement in resolution has to be paid for by a drastic reduction of bandwidth! Also it only works if there is noise; the noise is subdued by the averaging, because it is stochastic, the signal remains, hence the signal-to-noise is improved. As long as the output of a measuring instrument are just numbers, averaging works.

Analog scopes, Combi scopes

The oscilloscope remains the most important electronics measuring instrument, it is the only one which shows the waveform of an electrical signal, indispensable for the design of SMPS and similar electronics.

Analog scopes display the signal itself vs. a linear time base, for elementary physical reasons they cannot display distorted, false or phantom signals, they are the only ones which can be absolutely trusted. Their resolution is infinite, no fine detail is lost, trace intensity is a measure of the relative signal speed. There are more advantages, e.g. the ability to show signal details far above the bandwidth. The signal is always on-screen, it is only invisible for the short retrace period.

It is advisable to keep a high performance analog scope in every hardware design lab in order to check on the validity of DSO displays! Analog scopes like the unsurpassed Tektronix 7000 series (up to 1 GHz) are most precious instruments, the 600 MHz 7904A with a 24 KV crt highly recommended.

1993 Philips introduced the first "Combiscope", this was a 200 MHz 4-channel analog scope which also contained the electronics of a DSO; by pressing a front panel button the scope could be switched from analog to digital, so all displays in the DSO mode could be checked by just pressing this button. Also Hameg manufactured excellent Combiscopes for best buy prices until some years ago. No doubt: these were the ideal scopes, combining the best of both worlds. Understandably, the major scope manufacturers shunned Combi scopes: how can one convince customers of the alleged superiority of the higher profit DSOs if just pressing a button proved the opposite. One major DSO manufacturer was quoted: "Our worst competitors are our old (analog) instruments!".

DSOs (Digital Storage Oscilloscopes)

During the last 20 years analog scopes were displaced by DSOs, because their manufacturing costs are very considerably lower, profits much higher, and the technical knowhow required for the classic DSOs very much lower. A DSO easily fits onto one e.c. board, containing mainly cheap pc hardware. The displays are extremely low-cost while the crt of a hf analog scope is very costly. The marketing hype goes that DSO's are the "successors to analog scopes". This statement is false from the technical standpoint, correct from the marketing standpoint. Only the expensive high-performance DSO's (DPO's) approximate analog scopes in many respects, the vast majority of classic DSO's in the lower price ranges cannot replace analog scopes; those are inadequate!

There is no electronics measuring instrument with as many and as serious pitfalls for the user of which only a few can be mentioned here; a full description of functions and problems takes more than 100 pages. Whereas analog scopes are easy to understand, DSOs are extremely complicated, the manufacturers know only too well that the majority of customers lack the specific scope technology knowledge, advertising and manuals withhold salient facts, unfounded performance claims and misleading designations leave the customers in the dark. DSO's can never display a signal in real time like analog scopes, only a more or less distorted reproduction after the signal has disappeared. Users are blinded and attracted by the pc features, but less aware of the shortcomings as a measuring instrument. The only real advantages of DSOs are the ability to store waveforms and to replay them out of memory. Their other features are due to the built-in pc, if the reconstructed waveform is an artefact, the digitized data will also be false as well as all calculations derived; garbage in, garbage out applies. The built-in pc, however, allows, e.g., to calculate parameters like the rms value, power from two inputs, to generate a FFT, to decode buses etc., and this increases the usefulness enormously. Analog scopes are "only" measuring instruments, they lack the pc features. There are two classes of DSOs meanwhile:

The sequentially processing "classic" DSOs
Most low- and middle-priced models are classic DSOs which consist in principle of a pc with a multi-channel analog front end, a sampler and a 8 bit a/d converter for each input, a memory and a LCD or monitor display. They acquire a signal by sampling, a/d convert it, store it, reconvert it and display it. This long processing time allows only acquisition rates from some ten to some thousand per second, i.e. less than 1 % of the time, more than 99 % the scope is blind.

The parallel processing top models (DPOs and similar ones)
Realizing that the basic problems of DSOs cannot even be solved, if ever faster processing becomes available, Tektronix was the first to massively invest in parallel processing hardware in order to emulate analog scopes as much as possible. In 1994 the first "Instavu" scope appeared, later called "Real-Time" and then "DPO". In short: this class of scope contains additionally the equivalent of the electronics of an analog scope: the acquisition system runs at the speed of the signal trigger up to a maximum of 400 K which is the same as that of the best analog scopes, the information is rasterized in 3 dimensions, the third is the frequency of occurrence, which modulates the trace intensity as in analog scopes. Because of MB's of memory, the sampler running at full speed and the masses of acquisitions compiled in the raster memory, false displays are unlikely. Every 1/30th of a second a copy is transferred to the display. These scopes react as fast as analog scopes and emulate the phosphor properties, hence the name, they also catch rare events as fast. They are superior in that respect because the digital memory stores the event. "Real-Time" refers to the sampling mode called "Real Time", a display of the signal in real time is impossible, no matter how much hard- and software is invested; the signal reconstruction appears on the screen after the signal has long since disappeared. Customers are misled to believe that these DSOs show the signal in real time like analog scopes.

Sampling
All DSO's are by nature sampling scopes. As mentioned in section Analog/digital Instruments, Digitizing, the signal must be sampled and held before it can be a/d converted. The process of sampling is similar to mixing and correlation, it is a transformation method. Any information can be visualized as a brick-like volume in a three-axis coordinate system with the axes amplitude, bandwidth and time. While keeping the volume constant, the three parameters can be exchanged. With sampling the amplitude is held constant, the bandwidth is increased at the expense of time, in other words: the high frequencies are mixed down into the low frequency range (GHz to some hundred to some thousand Hz).

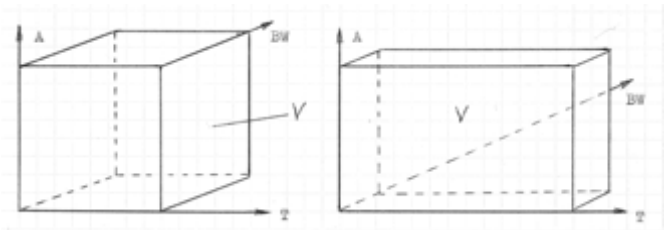

Figure 4: Sampling is a process similar to mixing, bandwidth BW is reduced at the expense of time T, the amplitude A and the information content (volume V) remaining constant

If signal reconstruction is not intended, undersampling is allowed and used, e.g. in all instruments which display only numbers. If signal reconstruction is the purpose, the rules of sampling must be obeyed, i.e. the Shannon/Nyquist theorem applies which is more often misunderstood than not: the highest frequency in a signal is not the same as the bandwidth. Hence the sampling frequency must be > 10 times the bandwidth, not > 2 times! Violation generates distortions, aliases and artefacts which have no resemblance to the original signal and, of course, the data obtained from such false signal reconstructions will be also false and can be off by orders of magnitude. This is still widely unrecognized because these facts are not advertised, however plainly admitted in other literature of the manufacturers.

The sampling time, also called sampling window, i.e. the time during which the input voltage is sampled, determines the bandwidth (independent of other limitations). The minimum time between successive samples, the sampling rate, is determined by the speed of the a/d converter.

Sampling Scopes and DSOs
Still today, there are two different families of scopes: Sampling Scopes (SOs) and DSOs and 3 different sampling modes. The highest bandwidth scopes are still SO's.

The first practical "Sampling Scopes" (SOs) came on the market in 1960 by HP and were the only scopes which offered GHz bandwidths with sensitivities of around 1 mV/cm, using ETS, hence for repetitive signals only. The analog samples are directly taken at the 50 ohm scope input, i.e. without any preamplifier, or at the tip of sampling probes, downconverted into the KHz range, amplified and directly fed to the crt, they retain thus the full amplitude resolution. A SO display with enough points looks almost identical to that of an analog scope of the same bandwidth. RS was invented in England in 1952, 1967 the first practical RS SO appeared from Tektronix. SOs are still the fastest scopes around.

DSOs differ substantially: Their front ends are identical to those of analog scopes, hence all accessories can be used. After preamplification the signals are sampled and fed into fast 8 bit a/d converters. The bandwidth is thus limited by the preamplifiers, the samplers and converters, the sampling rate by the converters. Because in DSOs the input signals need only amplification up to the input of an a/d converter, i.e. a few volts, they can achieve higher bandwidths than analog scopes just for that reason. The 8 bit signal reconstructions are only coarse approximations to an analog scope display, the display is noisy. While in SOs the samples appear immediately on the screen, DSOs must process the acquisitions. Thanks to their memory the display does not flicker at low rep rates..

Sampling modes
Equivalent Time Sampling (ETS): This is an ingenious stroboscopic method, invented 1880 in France; the signal must be repetitive, not necessarily periodic, and must not change its shape. The scope takes one sample along the waveform at each repetition, stepping in time along the waveform, so that it may take hundreds to millions of repetitions and some time until the whole waveform has been acquired and displayed once by the scope. This method does not require a fast sampling rate, in fact the sampling rate is independent of the bandwidth, it may be chosen such that the waveform can be slowly drawn on a plotter, even manual scanning is possible. These early instruments typically ran at max. appr. 100 KHz. In this mode SOs and DSOs achieve the highest bandwidths, and those are advertised without explaining that the signals must be repetitive with the same shape. Quite often, fictitious high sampling rates are quoted for ETS. ETS being a stroboscopic method, the time base can extend to infinity. In SOs a pretrigger or a delay line is required in order to show the triggering slope of the signal. Aliases and fancy pictures can be easily produced. All signals which change from period to period cannot be reproduced correctly, e.g. modulated signals, in SMPS e.g. signals

which are modulated by the line frequency, an oscillating regulation loop etc. Output ripple which typically consists of switching frequency, line frequency and hf components up to e.g. 300 MHz is impossible to measure in this mode. Realizing that, in practice, most signals are repetitive, one can get quite far with ETS. Pitfall: Especially in case of low-cost DSOs the bandwidth advertised is only valid in ETS/RS modes!

Random Sampling (RS): The difference to ETS: samples are not taken sequentially along the waveform but randomly. This yields two advantages: it is possible to display the triggering slope of the waveform without a delay line, a precondition for bandwidths beyond around 1 GHz, secondly the probability of stable displays of aliases and other phantoms is low.

Real Time Sampling (RTS): This is the "real" sampling method for which the Shannon/Nyquist theorem is valid and which is needed for single shot captures.

Assumed a 500 MHz signal, e.g. a sine, shall be captured once in the RTS mode: if the sampling rate would be a mere 1 GS/s, there would be just 2 points on the screen! The user is invited to draw any waveform through these 2 points, in other words: the display is absolutely worthless. The true meaning of the Nyquist theorem is that it implies knowledge about the waveform: it is a sine, and this the reason why it says that the highest harmonic in the signal must stay below half the sampling rate, the highest harmonic is a sine.

It is now apparent that a much higher sampling rate than Nyquist is necessary if one desires a usable signal reconstruction. Normally, a low pass filter must precede the sampler, this is impractical at high frequencies and for another reason: any scope must have a true Gaussian frequency response, which falls off very gradually, any attempt at a steeper roll-off causes pulse distortions. For this reason it is accepted meanwhile that the sampling frequency should be at least 10 times the bandwidth, at this point the response is so far down that aliasing is hardly likely. (In some modern DSOs the frequency response is "polished up" by software! Others have a "maximally flat" response in order to quote a higher bandwidth, accepting the pulse distortions.)

A 5 GS/s scope can acquire 10 points of a 500 MHz signal, e.g. a sine, at a sweep speed of 0.2 ns/cm which spreads the 2 ns period over the screen. Because the DSOs mostly use linear interpolation, the 10 points are connected by straight lines, the result does not look like a sine, it is severely distorted. Without the interpolation, there would be just 1 point per cm, this would alert the user that this is all the information the instrument could gather. A 50 MHz signal would produce 100 points and a relatively good replica. Depending on the waveform the number of points varies which are necessary for a usable display. Obviously, 10 times the bandwidth is not enough! Manufacturers have always claimed they could reconstruct waveforms by ingenious interpolation algorithms even with 2.5 points; such methods work only for certain waveshapes, i.e. the user is expected to already know the waveform and select a fitting interpolation. If he knows the waveform, he does not need the scope.

While the single shot results are only useful for > 25 points, the instruments use ETS resp. RS for repetitive waveforms to fill the screen with enough points. With DPO-class DSOs the sampler runs at its full speed, so ten signal repititions will yield 100 points.

Serious pitfall: Advertised and actual sampling rates and bandwidths
All advertising, catalog and manual specs say e.g. "Max. sampling rate 5 GS/s, bandwidth 500 MHz". Most people overlook the "max." preceding the sampling rate and, worse, do not realize that it must also read "max. bandwidth"! This is fatal: In contrast to analog scopes the bandwidth of DSOs is not constant, because the sampling rate is not constant, it can never be greater than about 1/10 (not ½!) the actual sampling rate!

Any capture memory is of limited size; if the instrument runs at its maximum sampling rate, the memory will be filled after a finite time; if this time is shorter than the time for a screen width expressed in time, the DSO must decrease its sampling rate. The lower cost DSOs even of renowned manufacturers usually contain only 1 to 10 K of memory, because these are low-cost high-noise analog (!) shift register memories (CCD's = charge-coupled devices) which also contribute signal distortions of their own. Now there is an

Iron rule for all DSOs:
Actual sampling rate = Memory/sweep speed (e.g. 5 ms/cm) x 10 cm (horiz. axis)

Note that the "maximum sampling rate" does not appear in this equation, In SMPS work it is often necessary to use lower sweep rates like 5 ms/cm in order to see line frequency related or motor waveforms. With a typical 2.5 KB the maximum sampling rate of e.g. 5

GS/s shrinks down to an actual sampling rate e.g. of 50 KS/s., hence the bandwidth is reduced from the advertised 500 MHz to a mere 5 KHz! What use is a 5 KHz scope? At 20 ms/cm only a sampling rate of 12.5 KHz is left over, the bandwidth is 1.25 KHz! Fig. 6 shows an example of everyday work on offline SMPS with a PFC; this is the current waveform in the PFC choke, consisting of a 100 Hz half sine and the superposed e.g. 125 KHz sawtooth current.

Any analog scope or a DPO-like type will display the correct waveform. Not so the low cost DSO: with 5 KHz bandwidth left it can only show the 100 Hz half sine, the 125 KHz would be totally lost, resp. only artefacts or phantoms will show up. This is the truth which will probably shock many readers who disposed of their analog scopes, bought the "successors" and thought that with a "500 MHz" DSO they could easily display signals in the hundred KHz range! Of course, this is neither advertised nor mentioned in manuals, but has been admitted ever since in other literature of the leading manufacturers. At such low sampling rates any number of grotesque artefacts can be easily produced. Even skilled engineers often fall prey to false displays.

Consequence: If any DSOs with less than appr. 1 MB should be in use in SMPS (or similar electronics) design or test labs, they should be scrapped and replaced! Engineers' time is too precious and costly to waste for chasing DSO phantom displays down. Competition by low-cost DSO's from East-Asian manufacturers featuring MB's of memory is coming up, but, e.g. a whole series of 2014 DSOs of a leading manufacturer between 5 and 10,000 E features only 10 KB for all models, another only 2.5 KB. Quite often, the vital memory depth is not even specified! For SMPS work a minimum of 200 MHz/2 GS/s and 10 MB is recommended.

All numbers derived from the false reconstructions will also be false. Figs. 5 and 6 and Table 3 show examples.

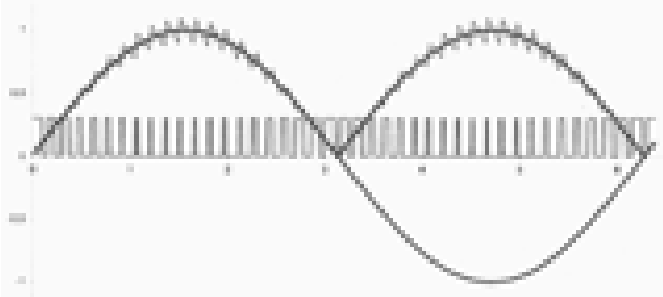

Figure 5: Choke current of a 50 Hz - PFC at 2 ms/cm

Sweep speed	Sampling rate	Rise time	Frequency
0.1 us/cm	500 MS	3 ns	none
1 us/cm	50 MS	16 ns	none
10 us/cm	5 MS	160 ns	100 KHz
50 us/cm	1 MS	800 ns	100 KHz
500 us/cm	0.1 MS	15 µs	1.6 KHz

Table 3: Rise time display of an expensive DSO of a 100 KHz square wave with a rise time of 0.7 ns. The 15 µs are off by a factor of 21,000 or 5 orders of magnitude!

Pitfall: Resolution, the truth about "11 bits".
Except for a few recent instruments all fast DSOs use 8 bit converters, the resolution is poor, especially because the 8 bit range is seldomly fully used. Users are led astray by telling them, the resolution could be increased to 11 bits; this is true as explained above, but at the expense of a dramatically reduced bandwidth - which is not mentioned! The higher resolution is gained by averaging over long time periods! E.g.: averaging over 99 values reduces a 100 MHz bandwidth to 1.3 MHz! Signal "smoothing" by averaging is standard since the first sampling scopes. Pitfall: Because the effects of digitizing and a noisy converter can be smoothed by averaging, this mode is often preselected to present more stable displays! If this is not detected, fast signals will be grossly distorted!

Averaging reduces noise. The bulk of the noise is contributed by the a/d converter, so, also here, there is a sharp distinction between low-cost and expensive DSOs: the best converter is the flash or parallel converter, which is the most expensive one, the worst converters are CCD plus slow a/d converter combinations which are by far the cheapest - in both meanings of the word! A CCD (charge-coupled device) is an analog MOS shift register, i.e. a cheap ic. The input signal is fed into the CCD at the sampling speed, after the acquisition the CCD is slowly read out into an a/d converter, often 12 bits, thus circumventing costly fast converters. Like all MOS CCDs are very noisy, also the charge packets which are shifted through the register interact, this causes signal distortions which depend on the signal shape.

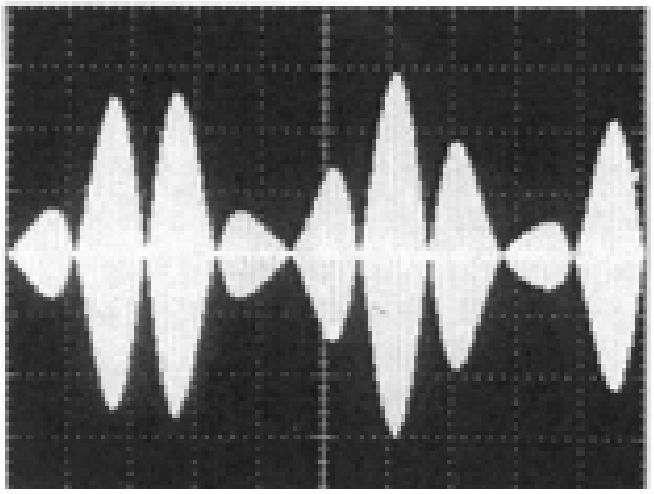

Figure 6: Alias of a 10 MHz sine, modulated with 1 KHz 80 % at a sweep speed of 100 µs/cm, the actual sampling rate is 100 KHz. No resemblance to the true waveform. The DSO is a 2 GS/s 500 MHz type. Display stopped

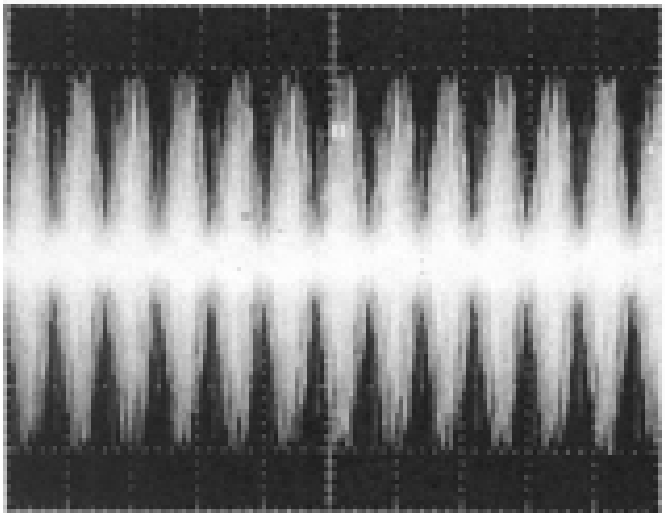

Figure 7: Same signal at 0.5 ms/cm, no stable display possible, because of the AM; each period is different from the preceding one. Actual sampling rate 100 KHz. Display running

Most low-cost DSOs, also from renowned manufacturers, use CCDs which is the main reason that their memories are limited to 1 to 10 K; as mentioned, he who may think that such small memories are not offered any more is invited to look into the 2014 catalogs, also of major manufacturers.

Some more hints about what to watch out for when using DSOs
Before you use a DSO, study the specs, look up the memory size, use the "Iron Rule" formula to find out from which sweep speed downward the sampling rate will be reduced. If the size is < 1 MB, take or buy another one! If you cannot find the memory size spec, hands off. The actual sampling rate must be >= 10 times the bandwidth at all sweep speeds you use. The frequency content in a switching transistor's drain voltage or current may well extend to > 100 MHz, the same is true for the ripple. Do not settle for less than 100 MHz/1 GS/s at your slowest sweep speed.

Example: A well known German semiconductor firm issued a data sheet for a SMPS ic, it claimed that the firm had invented a new gate drive circuit for switching mosfets which eliminated the start current spike in flyback circuits. For proof there was a screen shot from a DSO which indeed showed the switch current without that spike. But the actual sampling rate of 25 MS/s was displayed on-screen! Hence the bandwidth was a mere 2.5 MHz resp. the rise time 140 ns. No wonder that the spike which is only a few ten ns wide remained invisible! So this DSO ("successor to analog scopes") made the engineer believe he had invented something, probably his firm applied for a patent. Of course, measured with an analog scope, there was the spike, high as a tower!

If you suspect a false display or false numbers, change the sweep speed both ways, false screen or/and number displays will show up

If a picture shows steps in signal slopes, this is a clear sign of an insufficient sampling rate, this display is false! Actual sampling rates are not shown on-screen any more. It is mostly difficult for the user to find the actual sampling rate in the menus.

If the picture shows straight lines with sharp edges, there are too few points for a useful reconstruction, the display is false. Search for the "points display" in the menu, i.e. switch off the interpolation, then it will become apparent how many points there are.

If the picture is noisy, it's probably the DSO; do not trust a noise free trace without a signal, the software probably sets the display to zero. There is no other way to find out where the noise comes from but to check with an analog scope. Using the averaging modes of the DSO decreases the bandwidth as explained and may distort the signal.

If you are working with fast signals, make sure that all averaging functions are switched off, they may be preselected, otherwise the signals will be distorted.

DSO traces are evenly bright, they contain no signal information, hence fast signal slopes will also be evenly bright. (DPO-class DSOs emulate the intensity modulation of analog scopes.)

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8th Developer Forum Battery Technologies

E-Mobility and mobile Internet fuel future battery market

Batteryuniversity GmbH organized the 8th Entwicklerforum Akkutechnologien from 24th to 26th of March in the Stadthalle in Aschaffenburg. More than 600 attendees took the opportunity to get actual information about the battery market and newest developments in battery technology especially Li-Ion. 35 companies presented their solutions, innovations and visions about the future of batteries in the accompanying exhibition. This report highlights a short selection regarding innovations in battery power.

By Wolfgang Patelay, Freelance Journalist, Bodo´s Power Systems

After welcoming the attendees Sven Bauer, Geschäftsführer of batteryuniversity, gave an insight in the international battery market. According to his knowledge the international market for rechargeable batteries of all technologies including Li-Ion will grow with an average growth rate of 12% from 25,000 MWh in 2010 to 160,000 MWh in 2025, whereat Li-Ion in the 18650 format will be by far the most used technology. In Europe there are two main markets for rechargeable battery – stationary energy storage for renewable energy and e-mobility. For 2015 Bauer expects a demand for 100,000,000 battery cells per year with a potential 100% growth rate in this market. Electric vehicles are divided into e-bikes, e-scooters, and e-vehicles (EVs) like cars, forklifts, etc. Due to the pressure to reduce CO2 emissions Bauer sees a potential for 50,000,000 battery cells only for electric vehicles for the “last mile” in Germany. Deutsche Post has approx. 90,000 vehicles in use for long distance traffic, regional transport and service for the last mile. To electrify these vehicles results in a huge growths potential for rechargeable batteries. The private sector is to date hesitant yet to use EVs. In the period between January 2014 and May 2014 there were 4,432 EVs registered in Germany and 40,639 EVs in the USA (source: Kraftfahrtbundesamt). But the public authorities in both countries try to push the future use of EVs what in turn results in growth potential for rechargeable batteries. Due to the promotion of EVs it is expected, that the international market will grow in the main markets up to 6,000,000 EV units in 2020. At the same time it is expected that the price for large 3rd generation Li-Ion batteries (LIBs) will decrease from 1000 Euro/kWh to approx. 200 Euro/kWh and will also fuel the LIB market. Actual predictions assume a price decline of 80% until 2030. Bauer concluded his presentation with new research activities regarding Adaptive City Mobility (ACM), the smart grid, and emerging new Li-Ion chemistries which will also fuel further the market for rechargeable batteries.

Christian Gerspacher from batteryuniversity illustrates in his presentation “criteria for selecting battery cells” the advantages of Li-Ion technology e.g. high cell voltages, no memory und no lazy effect, high energy density, high efficiency up to 95%, wide operating temperature range from – 20 °C to + 70 °C, longevity up to 300 cycles, small self discharge, and environmental friendlyness. He discussed the various anode and cathode materials which creates in different combinations the wanted characteristics of the final battery cell. He also introduced a chart which simplifies the selection of the cell chemistry and cell features as well as a program developed by batteryuniversity to compare individual battery cells and simplify the selection of suited battery cells.

Figure 1: The Conference (image: Werner W. Wiesmeier)

Fuses protect Li-Ion batteries

In his presentation “Self Control Protector (SCP) - Surface mounted type fuse for Li-Ion rechargeable battery” Eelco Schottert from Dexerials described this fuse in detail which has been shipped over 1.3 billion units since its launch in 1993 the beginning of the Li-Ion battery commercialization. The small, thin and surface mountable device protects the batteries from overcurrent and overvoltage. After the explanation how this fuse works he gave same application examples starting with Smartphones, Tablet PCs, and Notebooks up to power tools, garden tools, E-bikes, E-scooters and energy storage systems (ESS). Then he gave an overview about the 21 types of fuses the company is offering today. The small SFH series (5.4x3.2x1.25mm) and the even smaller SFJ series (4.0x3.0x0.85mm) are rated for 12A and 15A respectively and suited for a multitude of mobile applications. The high rated (up to 30A) SFK series is available at the moment for power tools and ESS. The technology roadmap includes even smaller and thinner variants in the SFR series as well as up to 60A rated devices in the SFK series. Due to the trend to e-mobility the higher rated fuses will be extended with models up to 90A and more than 100A. Under development is also a specialized Protector only for overcur-

rent, the PSx series. Concluding his presentation he introduced a receiving coil for wireless charging which is capable for high receiving efficiency and flexibility, and maximizing the ability on design. The flexible 0.52mm to 0.75mm thick coil has over 70% receiving efficiency at 4W, shows consistent receiving capability for various Qi transmitters conforms to the RoHS directive and is Halogen free.

Wireless charging including data transmission

Wireless charging and data transmission was also the topic of Andreas Hagemeyers, Friwo, presentation "Inductive charge and data transmission" which was created in cooperation with Universität Duisburg Essen. He explained the reasons for the inductive power transmission because there is no aging but in plug-in connectors. In addition enables the encapsulated housing the use in harsh industrial environments and even ex-proof areas. The plain surface enables easy cleaning and disinfection. And there is no wired connection necessary between charger and receiver. But there are also challenges. The first are the poor efficiency, EMC problems, and the sensitivity for foreign particles. This leads to complex circuit designs. After that he explained a newly developed 2 stage concept for inductive power transmission which is suited for 300W to 150W and allows the simultaneous transmission of data. He concluded his lecture with the description of a demonstrator and an outlook to realize the transmission of larger amounts of power.

Robust batteries for industrial use

Dr. Carsten Jähne from Tadrian Batteries, an Israelite manufacturer of Lithium batteries for industrial applications, introduced the rechargeable TLI-1550A batteries. It features a nominal voltage of 4V, a maximum capacity of 330 mAh, a maximum continuous discharge current of 2A, pulse peak current of 5A, maximum current voltage of 4.1V, and maximum charge current of 100mA (-20°C to +50°C) or 20mA (-40°C to +85°C). If the TLI-1550A cells are used in larger batteries containing multiple cells it is recommended to use a separate PCM (protection circuit module) for balancing the individual battery cells. After describing major characteristics of the battery e.g. cycle stability and aging he explained the main applications like eCall and SVT (stolen vehicle tracking). In these applications the battery has to show an average capacity of 5W and a peak capacity of 20W for 15 minutes after 5 years – in SVT even multiple times. He concluded his presentation with an outlook of the future roadmap.

Scalable battery management solution

"Scalable battery management platforms for rapid cost-optimized design" was the topic of the lecture by Doug Williams from Texas Instruments Battery Management Group. After introducing his business group he explained the typical intelligent battery architecture as well as the "incredible diverse" industrial applications for batteries. Because the variety of battery powered products requires different batteries there is also a need for different pack sizes depending on various products. But the goal is to create a scalable BMS solution which fulfils most of the applications. Then he introduced the next-generation battery and monitor gauge bq76940 series, a scalable family which includes three different products for 10.8V to 18V, 24V to 36V packs, and 36V to 48V packs. This family is extended by the advanced CEDV fuel gauging companion battery manager bq78350 to enable complete battery management solutions. Another optional peripheral for the bq76940 family – the bq76200 - allows using high side power switches to realize even more flexible solutions. The description of typical applications concluded his presentation.

Gas sensors for battery monitoring

"Detection of failure modes and protection solutions for Li-Ion energy packs by means of gas sensors" was the topic of the lecture by Dr. Martin Herold from AMS. At the beginning he defined the motivation for using a gas sensor - added safety for small costs. Gas sensors are already used for monitoring battery charging station but are yet not used with Li-Ion-batteries. This new application offers new market opportunities by venting detection and leakage detection. The small sensor design can fit into existing battery packs and is easy to interface with BMS. After explaining the various principles of operation of gas sensors he introduced a portable battery management system with gas sensor. In this portable demonstrator pack the gas sensor is used for emergency shut-off. AMS performed all destructive and non-destructive tests for batteries like nail penetration, overcharging, short circuit, charging cycles, temperature cycling, and leakage and reported the results. The results demonstrated the suitability of the gas sensor to monitor battery packs:

- gas sensors are capable of increasing safety in large lithium-ion battery systems
- costs are comparably small
- gas venting from a cell under abuse is detected
- electrolyte leaks are detected
- user can be warned and an emergency shutdown performed to prevent further damage
- gas sensors might detect a rise in VOC concentration even before a bloated cell fully opens
- automated shut off may prevent cell venting
- the absolute value of the sensor signal is not always indicative and change in the resistance value should be taken into account.

Measurement technologies for energy consumption

Carlo Canziani, Business Development Manager of the Power and Energy Division of Keysight gave a lecture about a "real life battery use case & estimation of battery life". He started with the most common questions from battery users depending on the battery used in the individual device what results in the single question: "Can the energy consumption be optimized?" To illustrate how recent test and measurements innovations can help to measure and generate the corresponding measurement results he took the examples of drilling holes und tightening screws with a battery drill. He described the test challenge of measuring current accurately with oscilloscopes und DMMs and recommended a high performance power source / sink solution from ultra low power of some milliwatt to high power of several kW. After illustrating the innovations in this solution e.g. seamless current ranging, long term data logging and high integration of the source / sink solution, he explained an example measurement and introduced the entire test and measurement systems from his company to the audience.

www.batteryuniversity.eu

Effective Design Techniques for Signal and Power Supply Isolation

Today's electronics designers face a common set of goals: achieving higher throughput, higher resolution, more efficient systems and reduced time to market. In application areas such as industrial automation, medical electronics or telecommunication systems, it is often necessary to electrically isolate multiple signals to enable subsystems to share data or control signals without allowing noise or high voltages to interfere with system integrity and safety. Isolating signals is not sufficient to provide full isolation from noise and high voltages; the power supplies must be isolated too.

By Ashish Gokhale, Isolation Products Manager, Silicon Labs

Designing an isolated power supply often requires specialized skills and experience. Without the right expertise, components and tools, it costs precious time and multiple iterations to get the design right. Fortunately, plug-and-play isolation solutions that combine excellent signal isolation and power isolation capabilities into one IC are now available to simplify the process of high-voltage power supply design.

Signal Isolation Basics

Isolating signals is necessary to provide the following design-critical functions:

Protection from high voltages:

Isolation provides a dielectric barrier that acts as an insulator against high voltages in systems where higher power levels are required.

Level translation:

Enabling noise-free data transfer between circuits that operate at different voltage rails is a common challenge for electronics designers. Although there are many non-isolated level shifters available to circumvent this problem, using an isolator provides several solid advantages. Isolators are the most noise-free and robust solution, and they prevent parasitic paths that may inadvertently switch devices on or off.

Noise elimination:

Isolated products restrict the ground current (return path) of an electrical circuit to only one side of the barrier, enabling a noise-free environment for sensitive measurements on the other side.

System Considerations

To ensure that effective isolation has been achieved, the designer must eliminate all possible coupling paths from one circuit (Circuit A in Figure 1) to another circuit that needs to be isolated (Circuit B in Figure 1). Hence, when isolating signals, it is equally important to isolate the power supplies. For a circuit designer, the challenge of isolating signals is two-fold: to provide safe, reliable and accurate signal isolation as well as power isolation. Multiple solutions are available for signal isolation to suit the needs of designers based on data rate capabilities, jitter restrictions, noise immunity concerns, high voltage capability and compliance with various isolation component safety standards. However, for many applications where only a watt or so of isolated power is required, very few easy-to-implement power isolation solutions have been available.

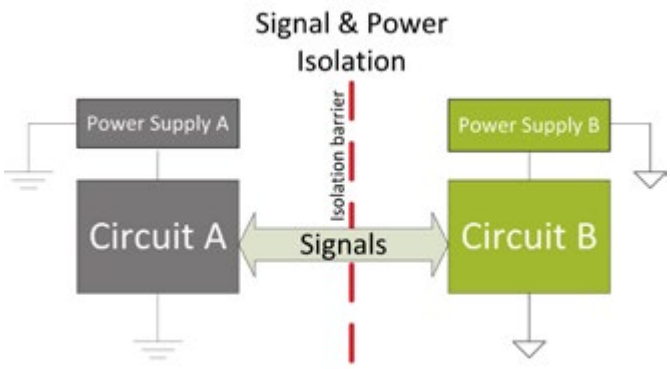

Figure 1: Isolating signals and power is necessary for many designs

Application Example

Factory automation systems depend on efficient and reliable real-time distributed networks to monitor and control complex manufacturing processes. Figure 2 shows a typical simplified hierarchical structure used in these systems. Human machine interface (HMI) in the factory control room is linked to an intermediary controller level and also down to the physical layer where the sensors and actuators are situated as part of motor drive units or machines controlled by programmable logic controllers (PLCs).

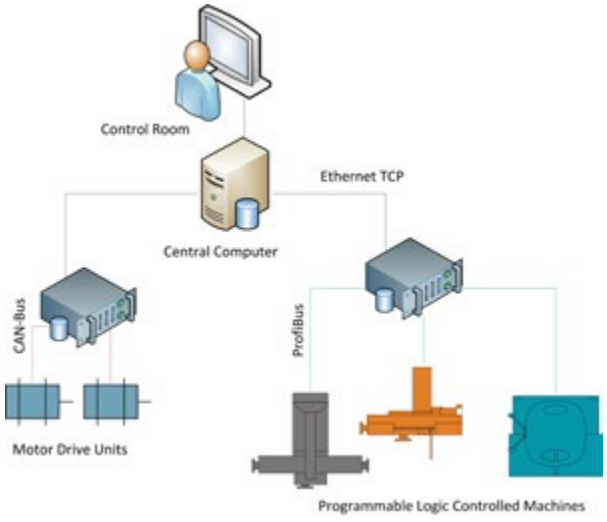

Figure 2: Example of factory automation system requiring isolation

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POWER FORTRONIC

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POWER FORTRONIC

The Italian point of reference in Power Electronics

Having just staged its' ninth event, and following the great success achieved in 2014, Power Fortronic is now acknowledged as the Italian point of reference in the power electronics market. Now in 2015, the event will represent an important opportunity for meeting manufacturers, suppliers and customers and to contact engineers, designers and buyers, all in a single day, with maximum efficiency in terms of time and investment

The aim of the day is to give an updated state on:

- Technological evolutions (SiC, GaN, MOSFET, IGBT, Modules);
- New solutions and topologies for inverters and converters;
- Motion control: technologies, methodologies, platforms and application proposals;
- Passive and power: magnetic supercapacitors and capacitors;
- Power management: analog & digital solutions;
- Power supplies;
- Energy efficiency;
- Systems for energy storage

TARGET

Manufacturers, suppliers, customers, engineers, designers and buyers

FORMAT

Fortronic is based on a day of meetings/conferences focused on contents and technological updates; corporate events (workshops and tutorials), business and relationships among companies. All this is in order to provide technology upgrades and product news and above all, to create business partnerships

The format is structured as follows:

Main session: Institutional conference with more speakers coordinated by the Technical Director to effectively present hot and current topics

Workshop & tutorial: Afternoon hi-tech seminars, dedicated both to the depth required by a single company as well as to transfer the pratical-didactic skills to participants

Community & solutions area: An area where people from both the supply and design communities can meet. An area dedicated to solutions and proposals made by the participating companies

The parteciparion is free. To subscrive: **http://fortronic.net/power**

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www.tecnoimprese.it

FORTRONIC — *Electronics Forum - Fortronic The **best cost-effectiveness** in terms of quality and contacts*

The physical layer connects the sensors and actuators in a process module and across the factory floor or plant. As shown in Figure 2, a CAN-based bus communicates with the various motor control units while an RS-485-based bus (PROFIBUS) communicates with the various machines on the factory floor. These physical layers are used commonly in industrial automation because they are very robust even in a noisy environment and support the long distance, multi-point communication needed on a factory floor that may cover hundreds of square meters. These buses have multiple nodes that connect to the bus through a CAN or an RS-485 transceiver. Isolating these interfaces is critical to protect against high voltages, high electromagnetic (EM) noise and large ground potential differences within the network.

Figure 3 shows a detailed diagram of an RS-485 transceiver node that has been isolated from the processor. Designers frequently have to design their own solutions from scratch using multiple discrete components to provide isolated power to the secondary side of the isolator and to the RS-485 transceiver on the isolated side.

The transceiver in Figure 3 is a half-duplex device with receive and transmit lines connected together. It communicates with the RS-485 bus through differential I/Os labelled A and B in Figure 3. The transceiver provides the interface to the processor through its single-ended digital I/Os labelled Rx (receiver) and Tx (transmitter) and an EN (enable pin) signal that controls the transmitter.

The transceiver typically has two to four digital signals that require fast, accurate digital isolation as well as 0.5 W to 1 W of power. This power must be supplied by a dedicated isolated source with the following characteristics:

Compact solution: Depending on the particular application, space may be at a premium. In general, a smaller bill of materials (BOM) is always better for manufacturability, reliability and cost.

High efficiency: It is important to have a compact solution with high efficiency to minimize heat and maintain green energy standards.

Low EMI: It is critical to keep the overall system noise to a minimum for sensitive measurements. To fine-tune the emissions spectrum to a specific use case, it is preferable to have a programmable frequency option that lets developers choose the switching frequency of the dc-dc converter.

Safety features: In industrial environments where safety is a top concern, it is recommended that the device have a soft start option to avoid inrush currents, current limiting capability, and thermal detection and auto shutdown in case of excessive heat conditions.

Multiple isolation channels: The isolated power solution must support multiple isolation channels with a minimum of 2.5 kV rms rated isolation capability for meeting safety standards. The isolator must have excellent signal integrity even in a noisy environment.

Solutions for Power and Signal Isolation

Only a few isolation products are currently available that strike the right balance between compactness and the ability to deliver power while minimizing emissions and maximizing efficiency.

Figure 3 shows a discrete solution that uses field-effect transistor (FET) power switches, a pulse-width modulation (PWM) controller, error amp and an optocoupler for feedback as well as other supporting BOM for power isolation. Such solutions are very common However, these solutions must be designed from scratch, require specialized experience and skill, and may take multiple iterations to get right.

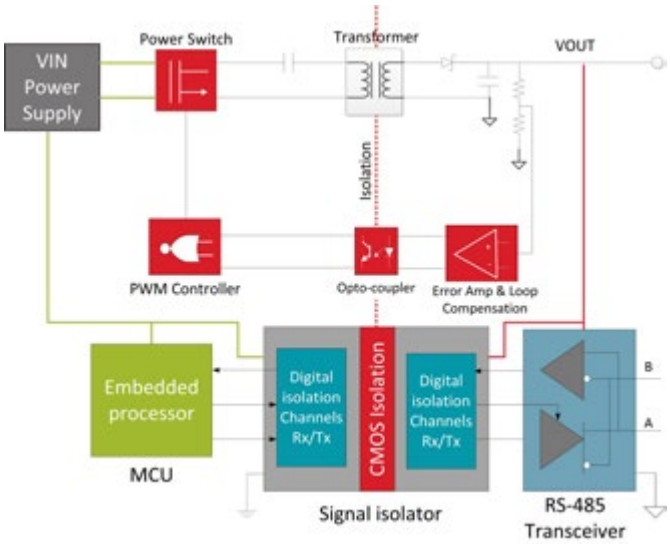


Figure 3: Isolating an RS-485 transceiver

Some solutions integrate digital isolation and the power transformer into a single IC package. These air core transformers have poor coupling coefficients and must be driven at much higher frequencies to deliver equivalent power. This approach results in a much higher emissions profile for electromagnetic interference (EMI), which poses an obstacle for many designers. In addition, the power converter efficiency of such solutions is usually low, from 10-35 percent. In applications where space is at a premium, efficiency is a “don’t-care” and high emissions are not a problem, these solutions might work. But more often than not, such solutions are not practical.

Other solutions are now available that integrate the signal isolators and dc-dc converter and are designed to work with a discrete transformer. Optimized for the highest efficiency and integration, these

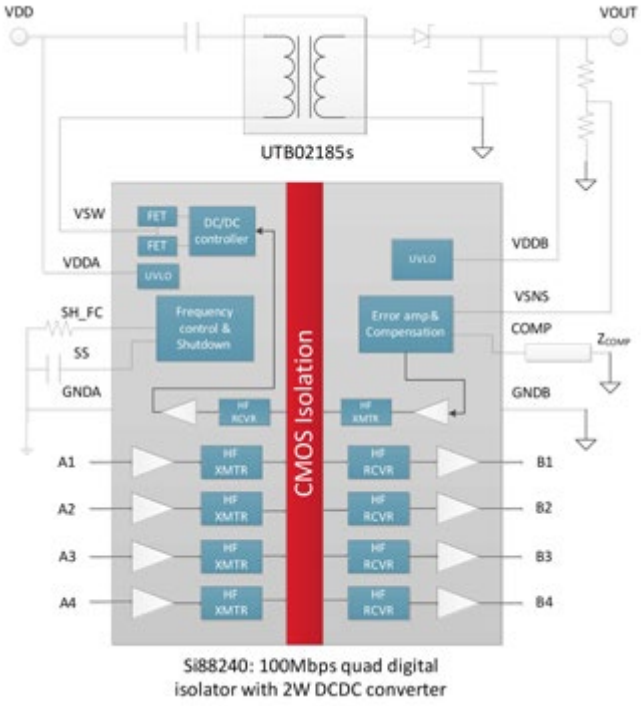


Figure 4: High-speed digital isolator with integrated dc-dc converter

compact, single-chip solutions can deliver up to 2 W of power with approximately 78 percent efficiency.

For example, Silicon Labs' Si88xx isolation products combine quad digital isolators with a modified fly-back topology dc-dc converter with built-in secondary sensing feedback control. The Si88xx devices have been designed for very low emissions by employing dithering techniques. Additional features include a soft start capability to avoid inrush currents on startup, cycle-by-cycle current limiting, thermal detection and shutdown for over-temperature events, and cycle skipping to reduce switching losses and thus boost efficiency at lighter loads.

Options for the Si88xx isolators are available for various voltage levels from 5 V to 24 V and for various combinations of digital isolation channels and their directionality. This solution leverages Silicon Labs' proprietary signal isolation technology, with its signature low EMI profile, to provide high integration, high efficiency and very low EMI.

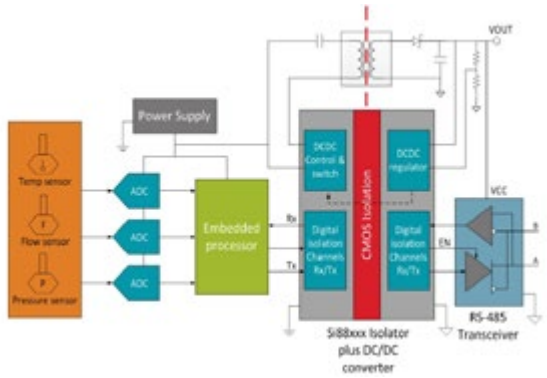


Figure 5: Si88xx solution used to isolate an RS-485 interface

Figure 4 provides a simplified block diagram of an Si88xx isolator. In addition to the four high-speed digital isolation channels, the Si88xx device integrates a dc-dc controller and internal FET switches that modulate power to the external transformer. The output side incorporates feedback through an external resistor divider to provide excellent line and load regulation. The dc-dc converter uses dithering techniques to minimize EMI peaks and a zero voltage switching (ZVS) scheme to minimize power loss when modulating power to the transformer. The device uses cycle skipping at light loads to minimize switching losses and boost efficiency. Multiple safety features include cycle-by-cycle current limiting, soft start to avoid inrush currents and thermal shutdown. The device also incorporates several user-programmable features such as soft start time control, a shutdown option for the dc-dc converter and switching frequency control to fine-tune the EMI profile.

The Si88xx isolator is an ideal fit for the application example shown in Figure 5. Rated to 2.5 kV rms, the isolated transformer is designed to work seamlessly with the Si88xx IC. By adding a few other inexpensive components such as resistors, diodes and capacitors, the developer has a complete power and signal isolation solution.

Summary

Elegant IC solutions that combine excellent digital isolation characteristics with high power conversion efficiency and extremely low EMI emissions are now available to simplify the development of isolated power suppliers. These plug-and-play isolation solutions eliminate costly design time and iterations and take the guesswork out of power supply design, ensuring first time success and faster time to market.

www.silabs.com

Tiny, Fast and Powerful DSCs for Digital Power Applications

Especially for digitally controlling a variety of applications like AC/DC power supplies, DC/DC power supplies, LED & HID lighting, solar inverters, battery chargers, welders, UPS etc. Microchip launched a family of new DSCs featuring higher performance, lower power, higher switching frequencies and new functions in very small packages.

By Wolfgang Patelay, Freelance Journalist, Bodo´s Power Systems

Microchip introduced the 14 new members of its Digital Signal Controller family (DSC) dsPIC33EP "GS" at a press conference to the power market. According to Tom Spohrer, Marketing Manager of Microchips MCU16 Divison, delivers this family the high performance needed to implement more sophisticated non-linear, predictive and adaptive control algorithms at higher switching frequencies. These advanced algorithms enable power-supply designs that are more energy efficient over widely varying load conditions and have improved dynamic response to transient conditions as well as better power-supply specifications. Higher switching frequencies enable the development of physically smaller power supplies by smaller inductors and capacitors that offer higher densities and lower costs. Compared with the previous generation of DSCs, the new dsPIC33EP "GS" devices provide less than half the latency, when used in a three-pole three-zero compensator, and consume up to 80% less power in nearly any application.

This new DSC family includes advanced features such as Live Update Flash capability, which is especially helpful for high-availability or "always-on" systems. Live Update can be used to change the firmware of an operating power supply, including the active compensator calculation code, while maintaining continuous regulation. It is realized by dual Flash partitions with a switchover of < 300ns and fits transparently between compensator updates to PWM. Variants from this new digital-power-optimised DSC family are available in the industry's smallest, 4x4mm UQFN package for space-constrained designs.

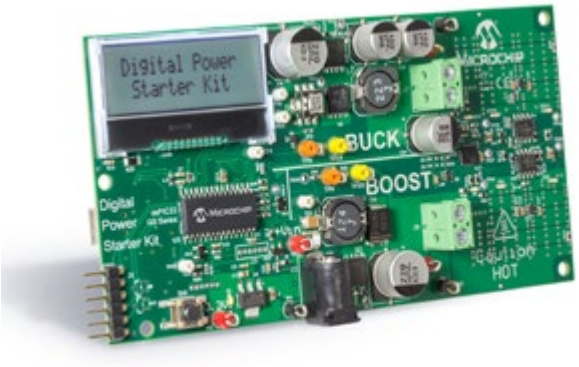
Other key features of this family include up to five 12-bit ADCs with as many as 22 ADC inputs, providing total throughput of 16 Mega samples per second (Msps) total with five ADCs and 300ns ADC latency. An early interrupt minimizes ISR overhead. Autonomous digital comparators offload the CPU for higher performance and compare results

against thresholds and interrupt if over, under, out-of-range etc. The hardware oversampling increases ADC precision by using more time. The devices include 12-bit DACs for each of the four analogue comparators, for higher-precision designs. The two on-chip programmable gain amplifiers can be used for current sensing and other precision measurements. Including these advanced analogue amplifiers on the device reduces the number of external components required, thereby saving cost and board space.

Figure 1: The new DSC family feature higher performance, more integration, lower power and smaller footprints

These features, combined with the overall high performance of the new DSC family, make it well suited to a wide range of applications including: computing & telecoms AC/DC and DC/DC power supplies; industrial solar inverters, LED lighting, HID lighting, battery chargers, projectors and welders; and automotive LED and HID headlights and DC/DC converters; among others.

The dsPIC33EP "GS" family is supported by Microchip's MPLAB Starter Kit for Digital Power which is priced at $129.99 and allows customers to explore using the new dsPIC33EP "GS" family in popular digital power-conversion topologies. Furthermore the new Digital Compensator Design Tool helps engineers to calculate the optimum compensator coefficients required to maximise the performance of their designs. It is a plug-in to MPLAB X IDE and accepts input plant details in poly nominal and pole/zero form as well as imported data tables from simulation or network analyzers. Response and stability



MPLAB® Starter Kit for Digital Power

Figure 2: MPLAB Starter Kit for Digital Power allows exploring the new dsPIC33EP "GS" family used in popular digital power-conversion topologies

calculations of the five compensator types digital 2P2Z, digital 3P3Z, PID, analogue type II & III can be performed and generates header files with compensator coefficients. This free tool, combined with Microchip's compensator software libraries and many royalty-free dsPIC33 reference designs, make it easier than ever to design digital power-conversion applications.

Microchip also partnered with Biricha Digital to offer in-depth digital-power design workshops that help analogue power-supply designers, as well as embedded system programmers, to leverage the capabilities of full digital control in their designs. The 14 dsPIC33EP "GS" family members are available in various packages, from 28 to 64 pins. All of these new DSCs are available today for sampling and volume production.

http://www.microchip.com/dsPIC33EP64GS506-051215a

Replacement of Electromechanical Relays

Supporting the trend from relay to more robust semiconductor solutions, Infineon Technologies AG rolls out its HITFET™+ family of protected low-side switches. The HITFET+ family (High Integrated Temperature protected MOSFET) offers a compelling feature-set with its diagnosis function, digital status feedback and short-circuit robustness, and – not available until today – controlled slew rate adjustment for easily balancing switching losses and EMC compliance. The HITFET+ family will comprise at least 16 members varying in R DS(on) (10 to 800mOhm), feature set (i.e. with and without status feedback), and package size (D-PAK with 5 or 3 pins, DSO with 8 pins). HITFET+ products of one package size are completely scalable: There is no need for system designers to change either software or PCB layout to drive various loads. The first family member, the BTF3050TE, is already available in high-volume.

HITFET+ is the right choice in a wide range of automotive and industrial applications whenever there is need for MOSFETs with protection functionality

In automotive applications, the HITFET+ products can drive solenoids for valve control with PWM (Pulse Width Modulation) up to 20kHz. Moreover, they suit automotive light dimming applications where they prevent flickering and support the current intensities of 10W to 60W which are typical here. In addition, the HITFET+ family is suitable for a vast range of other automotive applications such as mid-size and small-size electric motor drives for door lock or parking brake; for injection valves for alternative fuel (LPG, CNG); flaps driving in HVAC (Heating Ventilation and Air-Conditioning); rear wheel steering applications as well as safety relay replacement in active suspension systems.

Also, HITFET+ products are suitable as protected drivers in a wide area of industrial applications such as printers; vacuum cleaners; solar power modules; and vending machines.

www.infineon.com/hitfet

Dual Channel Brushless DC Motor Controller

Roboteq, Inc introduces the FBL2360, an intelligent controller capable of simultaneously driving two brushless DC motor up to 60Amps each at up to 60V.

Because they have no brushes, Brushless motors operate more quietly and have a longer life than equivalent Brushed motors. Roboteq's FBL2360 is ideally suited for use in Automatic Guided Vehicles (AGV's), Warehouse Automation Robots, Police/Military Robots, or any other high power brushless motor control application. Combined with Roboteq's MGS1600 Magnetic Guide Sensor, the FBL2360 can be used to design an Automatic Guided Vehicles (AGVs) with just two components.

The controller accepts commands from either analog pedal/joystick, standard R/C radio for simple remote controlled robot applications, USB or RS232 interface. Using the serial port, the FBL2360 can be used to design fully or semi-autonomous robots by connecting it to single board computers, wireless modems or WiFi adapters.

The FBL2360 incorporates a Basic Language Interpreter capable of executing over 50,000 Basic instructions per second. This feature can be used to write powerful scripts for adding custom functions, or for developing automated systems without the need for an external PLC or microcomputer.

The controller's two channels can be operated independently or combined to set the direction and rotation of a vehicle by coordinating the motors on each side (tank-like steering). The motors may be operated in open or closed loop speed or position modes with a 1 kHz update rate. The FBL2360 can use the motor's hall sensors or optical encoders to measure speed and travelled distance with high accuracy.

The FBL2360 features intelligent current sensing that will automatically limit each of the power outputs to 60A in all load conditions. The controller also includes protection against overheat, stall, and short circuits. The controller supports regenerative braking allowing the battery to get charged during robot decelerations.

The controller includes up to 8 analog, 10 digital and 6 pulse inputs. Four 1A digital outputs are provided for activating lights, valves, brakes or other accessories. The controller's operation can be optimized using nearly 80 configurable parameters, such as programmable acceleration or deceleration, amps limits, operating voltage range, use of I/O, and more.

A free PC utility is available for configuring, tuning and exercising the motor. The controller can be reprogrammed in the field with the latest features by downloading new operating firmware from Roboteq's web site.

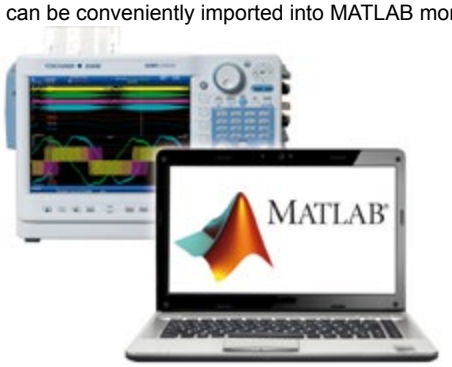
The FBL2360 is built into a compact 140mm x 140mm x 25mm enclosure with an aluminum bottom plate for efficient conduction cooling.

www.roboteq.com

ScopeCorder Firmware adds direct MATLAB File Saving

Yokogawa has released firmware Version 3.20 for the DL850 ScopeCorder series of instruments, which combine the features of a high-speed oscilloscope and those of a traditional data acquisition recorder in a single, portable instrument.

A key feature of the new firmware is direct file saving into the Mathworks MATLAB® data analysis and visualisation environment, offering users quicker and easier import of measurement data. By supporting MATLAB's .MAT file format on the ScopeCorder, the measurement results can be conveniently imported into MATLAB more speedily and with smaller file size. The .MAT file format on the ScopeCorder is compatible with Level 5 MAT-files, the latest file format from MATLAB. Other new features include support of an external USB printer for printing on long rolls of paper, and a "sure delete" function for erasing data from the ScopeCorder's hard disk drive where this is required for security reasons.



In order to support customers that require direct printout of measurement data, such as users of Yokogawa's earlier SL1400 and OR1400 recorders, the new firmware enables the DL850 ScopeCorder to reprint measurement results on A4 size roll paper using a Brother PJ623/PJ663 USB printer. Typical customers requiring this facility are found in nuclear power stations and marine applications.

The Version 3.20 firmware also enables the measurement data in the internal storage devices of the ScopeCorder to be deleted completely before leaving a test site. This scenario is sometimes required for security reasons in applications such as government research or in companies working on confidential projects.

http://tmi.yokogawa.com/DL850E

4500V 1200A IEGT Module Launched

Toshiba Electronics Europe has launched a high – current 4500V, 1200A power module for use in rail traction, industrial motor control, renewable energy systems and electricity transmission and distribution applications. The MG1200GXH1US61 PMI (plastic case module IEGT) integrates an N-channel IEGT (injection-enhanced gate transistor) and a fast recovery diode (FRD) into a standard package with a footprint of just 140mm x 190mm.

Designed to be used at much higher currents in the 4500V module class, the new module will also save energy, space and weight in high-power switching converter/inverter and motor control designs. The MG1200GXH1SU61 offers an isolation voltage rating of 6000 VAC (rms for one minute) and can handle a peak turn-off collector current of 2400A. Collector power dissipation (at 25°C) is 4000W. An operating temperature range of -40°C to +150°C ensures compatibility with the extended temperature environments that characterise high voltage applications.

www.toshiba.semicon-storage.com

Automotive Grade Coiltronics HCMA Series High Current Power Inductors

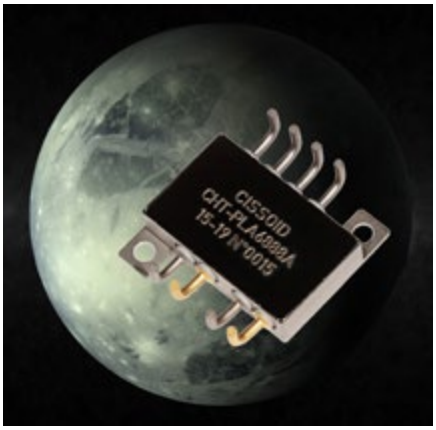
Power management company Eaton announced the launch of its automotive grade Coiltronics® HCMA Series of high current power inductors to meet and exceed the Automotive Electronics Council's (AEC) Q200 Grade 3 standard with a maximum total temperature operation range from minus 55 degrees to 125 degrees Celsius (C). The inductors are designed to withstand temperature and shock stresses found in automotive applications to support greater reliability in electronics for Advanced Drive Assistance Systems (ADAS), vehicle control, body control, lighting, infotainment, cluster controls, heating and air conditioning, chassis and safety systems.

Eaton designed, manufactured and tested the entire inductor series that includes HCMA0503, HCMA0703, HCMA1104, HCMA1305, and HCMA1707 to ensure compliance with AEC-Q200 Grade 3 standard. The AEC Component Technical Committee's definition of common electrical qualifications in automotive environments requires inductors to operatereliably in temperatures ranging from minus 40 degrees to 85 degrees (C). AEC-Q200 testing stresses devices beyond typical commercial reliability tests for temperature cycling duration and thermal shock. This reliability is required for DC-to-DC converters, voltage regulation modules, battery powered systems, multi-phase regulators and point-of-load modules used in vehicle electronic systems.

www.eaton.com/elx

PLUTO A High Temperature 60A /1200V Power Module

CISSOID, the leader in high temperature semiconductor solutions, releases CHT-PLUTO, a high temperature power module that can operate reliably between -55°C and +225°C, delivering up to 60A. CHT-PLUTO is a dual Silicon Carbide MOSFET module primarily meant for half-bridges with 30A continuous capability for both low-side and high-side. The two independent switches can be used in parallel to deliver a total of 60A with a breakdown voltage in excess of 1200V and a low on-resistance of 23mΩ at 25°C and 50mΩ at 225°C at VGS=20V.

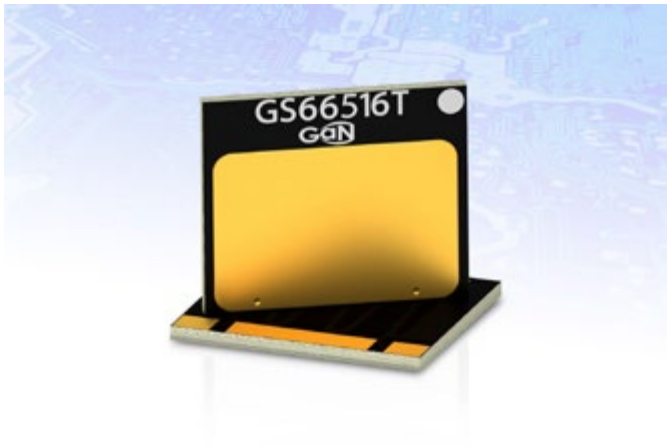


High operating frequencies can be used thanks to the low switching losses of the SiC transistors. CHT-PLUTO also embeds free-wheeling Schottky diodes with a low forward voltage Vf that reduces the power dissipation during dead times. Each switch can be controlled with a standard -5/+20V gate voltage. CHT-PLUTO is available in a hermetically sealed 8 pins proprietary "HM8A" metal package with dimensions of 18mm x 29mm excluding mounting tabs. The devices are electrically isolated from the case of the package. The module features a low junction-to-case thermal resistance of 0.7°C/W for each 30A channel. Two additional sources connectors allow for an easy and robust connection to the gate driver.

http://www.cissoid.com

Highest Current Gallium Nitride Power Transistor

GaN Systems Inc. launches the latest addition to its successful range of E-mode GaN-on-Silicon high power transistors based on its three core proprietary technologies. The new GaN high-power enhancement-mode device, designated the GS65516T, boasts the highest current capability on the market at 60A and further expands GaN Systems' range of power switching semiconductors.



The GS65516T 650V E-mode power switch features GaN Systems' new proprietary topside cooling configuration announced in March this year, which allows the device to be cooled using familiar and conventional heat sink or fan cooling techniques. It is based on the company's ultra-low FOM
Island Technology® die design, packaged in low inductance and thermally efficient GaNPX™ packaging and measures 9.0mm x 7.6mm x 0.45mm. Additional features of the GS65516T 650V E-HEMT include reverse current capability, integral source sense and zero reverse recovery loss. Dual gate pads help design engineers achieve optimal board layout. The GS65516T suits high frequency, high efficiency power conversion applications such as on-board battery chargers, 400V DC-DC conversion, inverters, uninterruptable power supplies (UPS) and VFD motor drives, AC-DC power supplies (PFC and primary) and VHF small form factor power adapters. The GS65516T is available to customers packaged on tape and reel or mini-reel, through GaN Systems' worldwide distribution partners. Pricing is available on request.

www.gansystems.com

Enhanced 5MBd Versatile Link Fiber Optic Receivers in Multiple Package Options

Avago Technologies unveiled a wide array of new industrial fiber optic products targeting renewable energy, industrial motor drive and transportation applications. The products have been showcased in the Avago booth at the PCIM Europe 2015 exhibition in Nuremberg.

AFBR-3905xxRZ/3950xxRZ – High Voltage Galvanic Insulation Links
Suppresses transient peak voltages up to 50 kV per IEC 60664-1 specification
Available in 1, 2, 3 and 4-inch length
Supports data rates from DC to 5 MBd (AFBR-3905xxRZ)
Supports data rates from DC to 50 MBd (AFBR-3950xxRZ)
Suitable for high voltage on-board insulation in applications such as power distribution, smart grid, and industrial inverters and motor drives
AFBR-59FxZ – Compact 650nm POF Transceivers with Bare Fiber Locking System
Supports serial data communications from 100 Mbps to 1 Gbps
Innovative bare fiber locking mechanism eliminating the need for connectors
Footprint comparable to RJ-45 connector
AFBR-25x1CZ – Enhanced 650nm Versatile Link Fiber Optic Receivers
Supports data rates from DC to 5 MBd with superior EMI performance
Link distances up to 50 meters using 1mm 0.5NA POF and 500 meters using 200um 0.37NA PCS
Operates in 3.3V or 5V supply with TTL data output
Available in horizontal, vertical and 30°-tilted packages

http://www.avagotech.com/

Integrate Gallium Nitride and Silicon for Faster, Higher Efficiency Devices

Integrated Device Technology, Inc. announced its collaboration with Efficient Power Conversion (EPC) to develop technology based on Gallium nitride (GaN), a semiconductor material widely recognized for its speed and efficiency. Under their collaboration, the companies will explore integrating EPC's eGaN® technology with leading IDT solutions.

The three areas in which the companies are collaborating:
Communications and computing infrastructure—GaN's low capacitance and zero QRR coupled with the low inductance of its chip-scale package result in high efficiency at high frequency. This increase in efficiency will combine with IDT's precise commutation and system expertise to drive up power density and deliver significant competitive advantage to communications and computing infrastructures.
Wireless power – The highly resonant wireless power transfer standard of the Alliance for Wireless Power (A4WP) consortium protocol operates at 6.78 MHz, where the high speed, low-loss switching ability of GaN drives efficiency to the levels of wired solutions. Combining the GaN expertise of EPC and precision solutions of IDT will deliver a highly efficient, cost competitive solution that will drive widespread adoption of wireless power.
Radio frequency (RF) – The two companies will explore collaboration to create a portfolio of RF products for the communications infrastructure market.

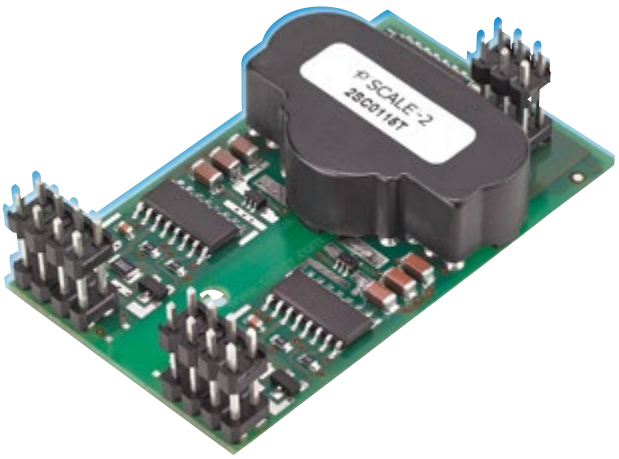
www.IDT.com

www.epc-co.com

1200 V Dual-Channel Gate-Driver Core Eliminates Opto-Couplers

Smallest IGBT Gate-Driver for 90 kW-500 kW Inverters

Power Integrations launched its 2SC0115T2A0-12 dual-channel gate-driver core for 90 kW to 500 kW inverters and converters. Leveraging SCALE™-2+ integrated circuit and isolated transformer technology for DC/DC power and switching signal transmission, the new driver core improves system reliability and performance by eliminating the need for an opto-coupler. The driver core's reinforced electrical isolation targets systems with a working voltage of 900 V, which is typical for 1200 V IGBT modules and complies with the PD2 and OV II requirements of IEC 60664-1 and IEC 61800-5-1. The 2SC0115TA0-12 gate-driver core supports modules up to 2400 A and switching frequencies of up to 50 kHz.



With a footprint of 53.2 x 31 mm and a profile [height?] of just 13 mm the 2SC0115TA0-12 gate-driver core is the most compact industrial unit of its type available. The highly integrated SCALE-2+ chipset uses about 85% fewer components than competing products and includes short-circuit protection by Vce-sat monitoring and independent supply-voltage monitoring from both the primary and secondary side. The new gate-driver core includes Soft Shut Down (SSD) protection for applications with low stray-inductance. For more demanding environments the 2SC0115TA0-12 supports full Advanced Active Clamping (AAC) to control the IGBT voltage overshoot during turn-off.

Each of the two output channels is electrically isolated from the primary side and the other secondary channel. An output current of ±15 A and 1.2 W drive power is available per channel with a gate voltage swing of +15 V to -6 V. The turn-on voltage is regulated to maintain a stable 15 V regardless of the output power level.

http://www.power.com/products/2SC0115T

Integrated Intelligent Power Modules for High-Performance Switching

ROHM Semiconductor presented its IPM (Intelligent Power Module) family optimized for high speed and power-efficient operation in motor driving and inverter applications. The 600V modules integrate a range of components such as gate drivers, bootstrap diodes, IGBTs or ROHM's proprietary Low Ron SuperJunction Power MOSFETs (PrestoMOS™) as well as a fly wheel diode (FWD) within a single compact package. The small footprint also houses comprehensive protection functions. This set-up offers especially to developers of white goods and industry motors multiple cost-efficient design options.

The full line-up includes different currents of 1.5A, 2.5A, 10A, 15A, 20A and 30A versions.

Applications with built-in motor drives require high integration, compactness and reliability and have to tolerate rugged environments for a long time. In order to meet this demand, ROHM has developed this highly functional IPM series which includes several components like high and low side gate drivers, bootstrap diodes for fast recovery, low saturation 600V IGBT or Power MOSFETs (PrestoMOS™), low Vf and high speed trr fly wheel diodes (IGBT version) as well as various protection functions within one compact HSDIP25 package.

The family leverages a number of proprietary technologies and material enhancements to facilitate current monitoring, heat dissipation and reliable operation. It significantly reduces power losses at light and heavy loads while increasing power capability. Featuring an innovative aluminium-based Silicon-on-insulator (SOI) technology, the module provides enhanced high-voltage capacity, high heat conductivity, low leak current and, at the same time, prevents latch-up. For excellent reliability, the IC additionally features a comprehensive set of protection attributes such as a current limit for the bootstrap diode, under voltage lock-out for floating supply, fault output, thermal shutdown and short circuit protection as well as a FWD (IGBT version) to eliminate flyback. Designers can choose from different set-ups – with integrated IGBT or MOSFET - in order to identify the ideal solution for their application and save time and costs.

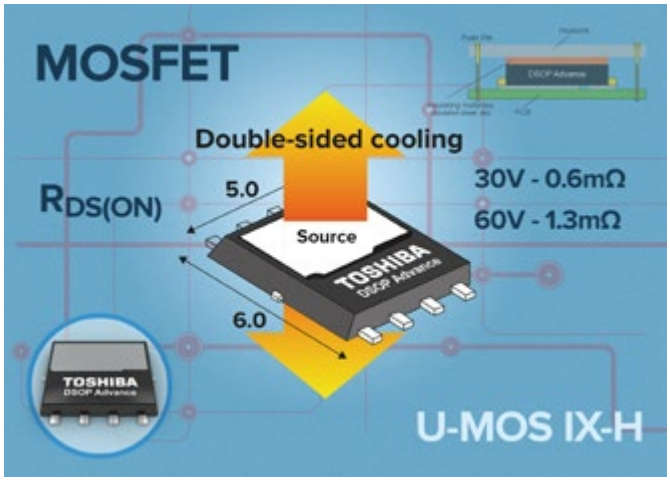
www.rohm.com/eu

Ultra-High-Efficiency MOSFET Family by Adding 30V and 60V Devices

Toshiba Electronics Europe (TEE) has expanded its family of ultra-high-efficiency, low-voltage MOSFETs by adding new 30V and 60V devices to the company's existing 40V offering. All of the devices will be available in ultra-compact, thermally efficient DSOP Advance package options that significantly improve heat dissipation through dual-sided cooling.

Comprising one 30V device and one 60V device, the new N-channel MOSFETs are based on Toshiba's next-generation U-MOS IX-H trench semiconductor process. This process has been designed to deliver 'best-in-class' efficiency across a wide range of load conditions by driving down on resistance (RDS(ON)) and improving switching efficiency by reducing output charge (QOSS).

The MOSFETs will help designers to reduce losses and board space in a variety of power management circuits including high-side and low-side switching in DC-DC conversion and secondary side synchronous rectification in AC-DC designs. The technologies are also ideal for motor control and for protection circuit modules in electronic equipment based on Lithium ion (Li-ion) batteries.



At a voltage (VGS) of 10V, the maximum RDS(ON) rating for the 30V MOSFET is just 0.6mΩ, while typical COSS is 2160pF. The 60V item offers RDS(ON) and typical COSS ratings: 1.3mΩ and 960pF. This ensures enhanced flexibility for optimising performance in a given application.

www.toshiba.co.jp/index.htm

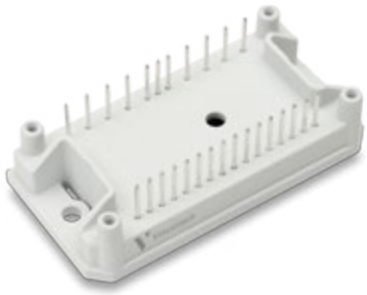
IPM Solution for Embedded Drive Applications

Vincotech announced the release of a new intelligent-power module (IPM) for low-power operation in embedded drive applications.

This three-phase input power module comes in a flow 1B housing with press-fit pins for easy assembly.

Vincotech's flowIPM product family is the best solution for mechanical environments where space is tight, for instance, in embedded motor drives for fans, pumps, washing machines and small industrial motor drives with up to 2 kW output power.

This intelligent power module (20-1B12I-PA008SC-L239C09) is a 1200 V / 8 A IPM that integrates an inverter, a rectifier, shunt resistors and the entire gate driver circuit for three-phase input operation in such a way that very few additional external components are needed. Even the bootstrap diode and capacitor are included. A high level of integration is achieved by adopting the screen printing technology on a ceramic-based substrate.



Sample modules may be sourced on demand from our usual channels. The product is being ramped up for mass production and will ship in September of 2015.

To learn more about Vincotech's IPMs, please visit:
http://www.vincotech.com/flowIPM-1B

To see Vincotech's entire range of power modules, please visit: http://www.vincotech.com/products/by-topologies.html

www.vincotech.com

Easy as Child's Play – Measuring Power with the LMG640

Applications for power analysis are as varied as the uses of electricity itself, and the utilized instruments need to take this variety into account. The resulting multitude of features challenges the user to quickly single out the desired settings and results among an abundance of available information.

Clarity, simplicity and flat menu hierarchies were top priorities when conceiving the user interface of the new LMG640 from ZES Zimmer– without compromises regarding the feature set and the precision of the results. The goal was to drastically shorten the time to familiarize oneself with the unit, to reduce training effort and minimize the risk of operating errors. To make navigating easier, a touchscreen has been introduced in order to evoke the corresponding configuration menu for any displayed item simply by touching it. Leafing through different views is equally simple, slightly tapping the tabs at the upper edge of the screen will do. In case the touchscreen is not used, a mouse can be connected via USB port, in addition the built-in display of the LMG640 can be complemented or even replaced by an external screen.

In order to better focus on selected values or even highlight them, individual views ("custom menus") can easily be defined. The desired values are displayed in the preferred form, and all irrelevant data gets suppressed. The layout can be adapted exactly in accordance with the requirements of the application at hand and individual preferences. To this end, tables, graphs and bar charts can

be freely combined and enhanced e.g. with depictions of the unit under test and wiring diagrams. Custom views can quickly and easily be put together via drag-and-drop, in line with most familiar PC software tools.

www.zes.com

Redefining the Power MOSFET Landscape with the Industry's First 900V SiC Device

Cree, Inc. has introduced its latest breakthrough in SiC power device technology: the industry's first 900V MOSFET platform. Optimized for high frequency power electronics applications, including renewable energy inverters, electric vehicle charging systems, and three-phase industrial power supplies, the new 900V platform enables smaller and higher efficiency next-generation power conversion systems at cost parity with silicon-based solutions.

"As a technology leader in SiC power, we're committed to breaking the performance barriers that really matter to the power conversion design community," said Dr. Cengiz Balkas, vice president and general manager, Cree Power and RF, "When compared to equivalent silicon MOSFETs, this breakthrough 900V platform enables a new market for our products by broadening the power range we can address in end systems. Following our 1200V MOSFETs, which exhibit superior performance to high voltage IGBTs, we are

now able to outperform lower voltage superjunction silicon MOSFET technology at 900V. This platform delivers vastly superior characteristics, thereby providing power designers with the potential to innovate smaller, faster, cooler, and more efficient power solutions.

Without question, it is beyond the reach of anything currently achievable with silicon." Built on Cree's industry–leading SiC planar technology, the new 900V MOSFET platform expands the product portfolio to address design challenges common to new and evolving application segments in which a higher DC link voltage is desirable. The lead product (C3M0065090J) features the lowest on-resistance rating (65mΩ) of any 900V MOSFET device currently available on the market. Moreover, in addition to the industry standard TO247-3 and TO220-3 packages, the new device is also offered in a low-impedance D2Pak-7L surface mount package with a Kelvin connection to help minimize gate ringing.

The C3M0065090J is rated at 900V/32A, with an RDS(ON) of 65mΩ at 25°C. At higher temperature operation (TJ = 150°C), the RDS(ON) is just 90mΩ.

www.cree.com/power

Expanded Cool-Power ZVS Regulator Portfolio with 48 V Buck Regulators

Vicor Corporation announced the expansion of its Picor Cool-Power™ ZVS Point-of-Load Regulator portfolio with the introduction of high efficiency PI3542, PI3543, PI3545, and PI3546 buck regulators. The entire Cool-Power portfolio is characterized by products with benchmark efficiency and density performance that are simple to use, accelerating time to market.

Enables 48 V direct to PoL high performance step-down regulation

Zero-Voltage Switching (ZVS) topology provides unparalleled efficiency over 96%

High density 10 x 10 x 2.5 mm LGA System in Package (SiP) module for power delivery over 100 W

Advanced features including constant current control for lighting and battery applications

PI354x Cool-Power ZVS Buck Regulators utilise the integration of a high performance ZVS topology that enables 48 V direct to PoL without sacrificing performance. With step-down regulation from a higher voltage source, engineers can deploy more efficient power distribution architectures, reduce I2R losses, and eliminate costly and inefficient intermediate conversion stages.

PI354x series operates from 36 Vin to 60 Vin

Regulates an output voltage ranging from 2.2 V to 14 V, with output current delivery up to 10 A

Power delivery can be further increased by using single wire current sharing without any additional components

The PI354x Cool-Power ZVS Buck Regulators are designed for a wide range of applications leveraging higher voltage distribution, including: telecom, network infrastructure, datacenters, industrial, battery, and lighting applications.

The PI354x series expands and enhances the Vicor Power Component Design Methodology. When used in conjunction with Vicor's front-end products and Factorized Power products, the PI354x series can enable a complete power chain from AC or HVDC (200 V+) source to PoL.

www.vicorpower.com

Integrated Power Module

The Powerex Integrated Power Module (PIPM) is a configurable IGBT-based power platform.

The module has rated power outputs from 75-229 KW and operates on DC bus voltages from 400 to 800 VDC and switching frequencies of up to 20 kHz. The power module can be mounted on various heatsinks, including both forced air and liquid cooled options, dependent upon application requirements.

Applications include three-phase inverters; DC/DC Convertors; choppers; half or full bridge; and power supply applications. The PIPM is compatible with the NX-Series of

Mitsubishi IGBT devices and is ideally suited for energy storage, uninterruptable power supplies (UPS), motor drives, solar, wind, photovoltaics, EV and hybrid electric vehicle applications.

For pricing and availability, contact global-sales@pwrx.com (subject line: PIPM RFQ)

http://www.pwrx.com/pwrx/app/PIPM%20-%20Lit%20Code%20251.pdf

www.pwrx.com

1200V/1350V E-Series IGBTs Optimized for Soft-Switching Applications

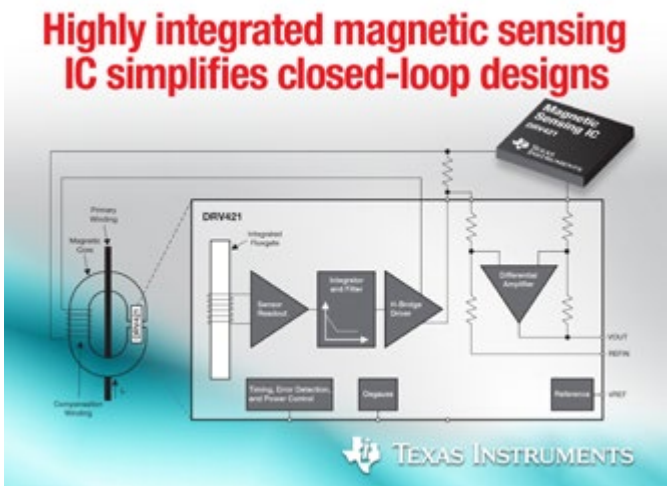
Alpha and Omega Semiconductor Limited (AOS) (Nasdaq: AOSL), a designer, developer and global supplier of a broad range of power semiconductors and power ICs, today introduced the new E-series IGBT platform with the 1200V AOK20B120E1 and 1350V AOK-20B135E1. This new platform has been honed to deliver exceptional performance by lower switching loss in soft-switching home appliance applications such as induction cooking, rice cookers and inverter-based microwave ovens.

The devices for the E-Series are built upon AOS's patent pending AlphaIGBT™ technology platform, and feature best-in-class VCE(SAT) and fast turn-off characteristics that reduce the power losses incurred during conduction and switching. The high BVCES rating and rugged BV performance allow for a larger resonant voltage safety margin to prevent avalanche destruction from voltage transients. Moreover, EMI is minimized as a result of very smooth turn-off current waveforms.

www.aosmd.com

Integrated Fluxgate Sensor, Signal Conditioning and Compensation Coil Driver IC

Texas Instruments introduced the industry's first magnetic sensing integrated circuit (IC) with a fully integrated fluxgate sensor and compensation coil driver, along with all the required signal conditioning circuitry. Complete integration enables the DRV421 to provide best-in-class sensor accuracy and linearity, high dynamic range, and simpler system design compared to traditional closed-loop sensors. With the DRV421, system designers will be able to more easily develop magnetic closed-loop current sensors for applications such as motor control, renewable energy, battery chargers and power monitoring.



The DRV421 evaluation module (DRV421EVM) enables designers to quickly and easily evaluate the new current sensing IC's features and performance. It is available for purchase for US$49 via the TI store and authorized distributors.

In addition, SUMIDA CORPORATION has introduced the SC2912, a magnetic module that system designers can place on top of the DRV421 as a printed circuit board (PCB) component. This allows engineers to design universal platform solutions targeting a wide range of current levels while choosing the appropriate magnetic module for their specific use case.

www.ti.com

Omnipolar 3D Magnetic Sensor IC using vertical Hall-Effect Technology

The A1266 from Allegro MicroSystems Europe is a unique 3-dimensional sensor IC incorporating a combination of vertical and traditional planar Hall-effect sensor ICs that can detect a magnetic field of either polarity in any direction.

The omnipolar, omnidirectional sensitivity of the new device makes it ideal for detecting magnetic tampering in smart meters, ATMs, gambling/gaming machines, ticket machines and electronic locks. The A1266 can also serve as a general-purpose magnetic switch that is virtually insensitive to magnet orientation or polarity in applications such as games, consumer electronics and white goods.

This compact surface-mount SOT23 IC is functionally equivalent to an array of three standard Hall-effect sensors mounted in three different orientations: something that is not possible using a single circuit board and all surface-mount components. With a typical BOP operating point of 25 G, the A1266 has higher sensitivity than most conventional Hall-effect switches, leading to high-sensitivity 3D tamper or proximity sensing in less space with lower assembly cost.

www.allegromicro.com

Optical Test System with Attenuation and Switch Modules Compatible with GI50 Multimode Fibres

Yokogawa has expanded its AQ2200 Series Multi-Application Test System (MATS) with a range of optical attenuation and switch modules for applications involving GI50 multimode optical fibre.

Multi-mode optical fibre has a much larger core diameter than single-mode fibre, which simplifies connections and allows the use of lower-cost electronics such as light-emitting diodes (LEDs) and vertical-cavity surface-emitting lasers (VCSELs) which operate at the 850 nm and 1300 nm wavelength. It is ideally suited for communication over short distances, such as within a building or on a campus.

Because of its superior bandwidth compared with copper cables, GI50 multimode fibre is rapidly becoming the preferred worldwide communications medium for short-reach, large-capacity, high-speed transmission systems in applications such as data centres. As a result, there has been an increased demand for instruments to test associated equipment such as SP4/SR10 optical transceivers and IP routers and hubs, and the new additions to the AQ2200 Series have been developed specifically to address this market.

The AQ2200 Series is a modular optical test platform with a wide selection of modules to allow the optimal configuration of test solutions in the design and manufacture of optical components and network systems. The system is available with two different frame controller platforms with three or nine slots for connecting modules, allowing users to select the optimum configuration for the intended measurement application.

A single MATS frame, which is programmable and remote-controllable, can handle multiple applications simultaneously, allowing different users to control the modules with savings in cost. The fast response of the instrument makes it an ideal tool in a manufacturing environment.

Yokogawa offers a wide range of hot-swappable modules for the AQ2200 Series, including variable optical attenuators (with or without built-in power meters), high power and multi-channel power meters, high-stability laser sources and switches in a variety of channel counts.

For further information about the AQ2200 Series visit:

www.tmi.yokogawa.com

Advertising Index

Medium power modules. Industry icons go quality.

Coming from high-power semiconductors, ABB is regarded as one of the world's leading supplier setting world standards in quality and performance. ABB's unique knowledge in high-power semiconductors now expands to industry standard medium-power IGBT and bipolar (thyristor/diode) modules. ABB is launching the

- **62Pak**: a 1,700 volt, 300 ampere, dual IGBT in a 62 mm package
- **20Pak**, **34Pak**, **50Pak** and **60Pak**: 1,600 - 6,000 volt, 120 - 830 ampere dual thyristor and dual diode modules in 20 - 60 mm packages

Demanding medium-power applications such as low-voltage drives, soft starters, UPS and renewables benefit from ABB's well-known experience and quality.

For more information please contact us or visit our website:
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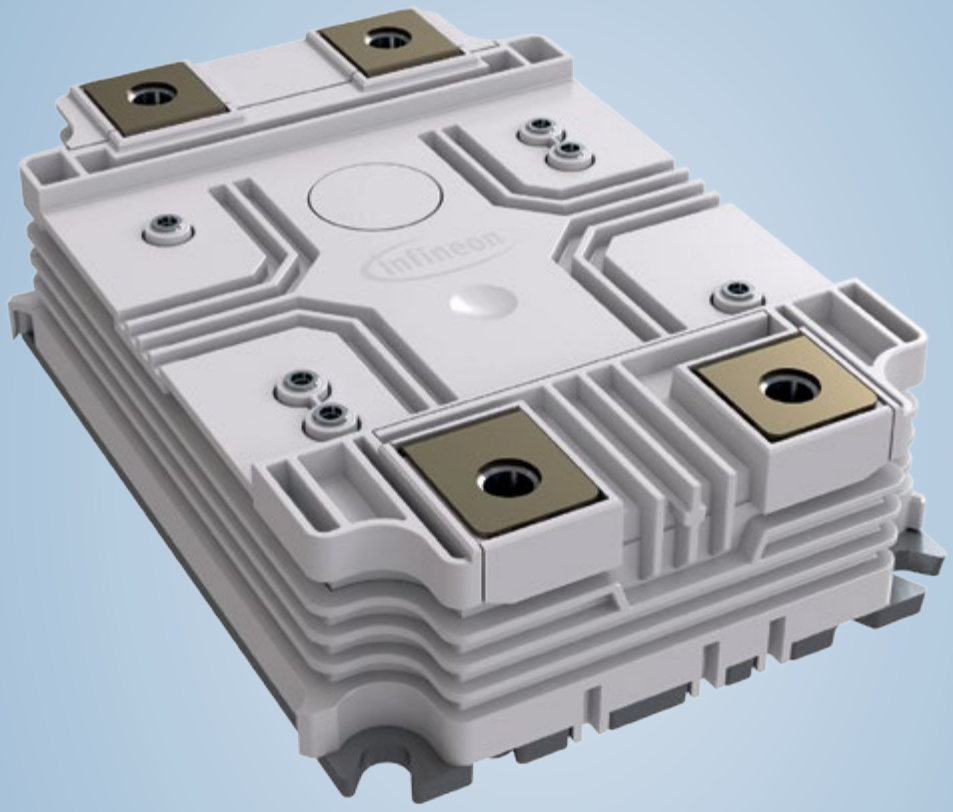
for a better world™



Flexible & Reliable

XHP™

New flexible high-power platform

The demands on modern power electronics applications continue to rise.
We understand these needs and found the answer.

- XHP™ is the flexible platform by Infineon for reliable high power modules
- A new housing ranging up to 6.5 kV for high power inverters

Main Benefits

- One high power platform offering flexibility and scalability
- High power density and optimized frame sizes
- High reliability and long service life
- Reduced system cost
- Low inductance

www.infineon.com/xhp