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Bodo's Power Systems®

Electronics in Motion and Conversion

July 2017

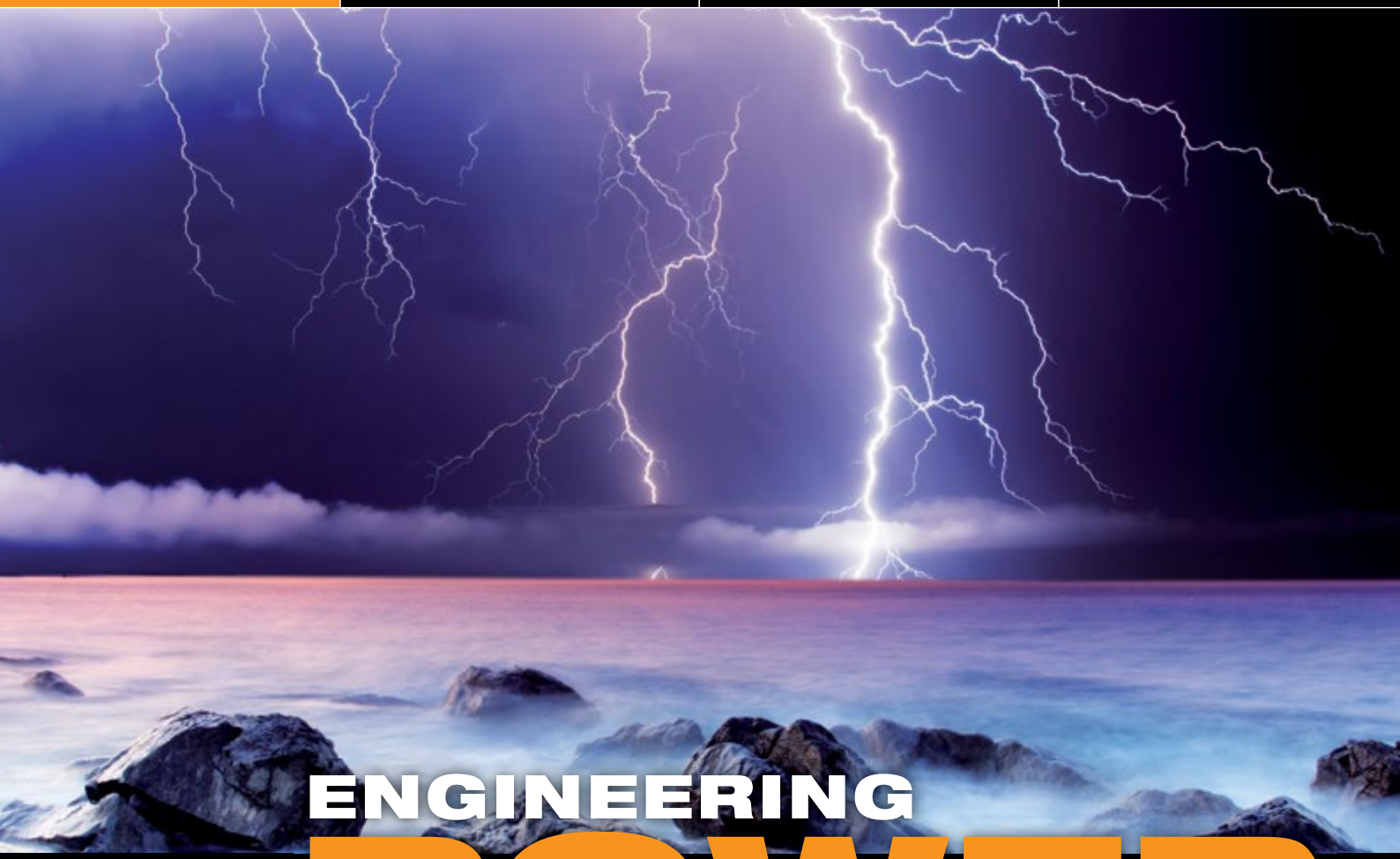
power integrations™

From petrol to wireless charging:

Mobility evolves with advanced power systems - Page 28

WELCOME TO THE HOUSE OF COMPETENCE

ENGINEERING | PRODUCTION | GvA SOLUTIONS | DISTRIBUTION



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Whether small or large development tasks: speed is no witchcraft but the result of perfectly fine-tuned processes in interplay with highest competence - our engineering power for your success.

- Quick design-to-product
- Time and cost savings through synergy effects
- Extensive experience gives you an edge
- State-of-the-art technology
- Simulation and in-house tests ensure reliability

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info@gva-leistungselektronik.de
www.gva-leistungselektronik.de

GvA Power Electronics

The Gallery

REDEXPERT

WÜRTH ELEKTRONIK

REDEXPERT. Würth Elektronik's online platform for simple component selection and performance simulation.

- The world's most accurate AC loss model
- Filter settings for over 20 electrical and mechanical parameters
- Inductor simulation and selection for DC/DC converters
- Ability to compare inductance/current and temperature rise/DC current using interactive measurement curves
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- No login required
- Order free samples directly
- Direct access to product datasheets

#REDEXPERT

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www.we-online.com/redexpert

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Events

SEMICON West 2017
San Francisco CA, USA July 11-13
www.semiconwest.org

Intersolar North America 2017
San Francisco CA, USA, July 11-13
www.intersolar.us

Thermal Management 2017
Denver CO, USA, August 8-9
www.thermalnews.com/conferences

EPE ECCE 2017
Warsaw, Poland, September 11-14
www.epe2017.com

EV Tech Expo 2017
Novi MI, USA, September 12-14
www.evtechexpo.com

We only have this one World

We are over 7 billion people all sharing this one single planet, and in light of our differences respect for one another is of ultimate importance. Leaders who don't respect freedom do not support a society that cares for its people and should not be tolerated.

Education is one of the most important things we can offer children, especially in regions which depend on the help of richer societies. When people have the prospect of a promising future in their home country, they'll not have to risk a dangerous journey to try and find a better place to live in freedom and prosperity.

The span of our time on Earth is brief, but over the last two hundred years industrialization has had a proven, and very negative, impact on the environment and climate. This must be understood by leaders who are in a position to inspire plans to limit the destructive effects of global warming.

The second half of the year is already here and we're looking forward to a number of exciting conferences such as the EPE ECCE in Warsaw, Poland and the ECCE in Cincinnati, USA. These conferences focus on power semiconductors and their applications. Wide-band-gap devices are at the leading edge of new designs for reduced losses and improved efficiency. It was clear in May, after my podium discussion at the PCIM, that there is great interest amongst engineers for more detailed information. As a result we're planning a comprehensive event in December to teach engineers how to best use SiC and GaN in new developments. Stay tuned for details. Experts from leading players in industry will present their know-how.

Great news: Dr. Ray Ridley will work with my publication on a regular basis. For many in our industry, magnetics are viewed as the last roadblock to improving power supply performance. Dr. Ridley, renowned magnetics expert and teacher, presented numerous papers and seminars on the design of high-frequency power supplies at the last two APEC conferences. Over the coming year, Dr. Ridley will contribute a special series of articles on magnetics design for Bodo's Power focusing on the basics of design, practical manufacturing aspects, and advanced topics of proximity loss and modelling. To learn more, check out Dr. Ridley's video on magnetics at: http://www.bit.ly/2rUZc4C

A wide range of additional information can be found in the papers and articles on Dr. Ridley's Power Supply Design Center at: http://www.bit.ly/2rlcfha

We very much look forward to our collaboration.

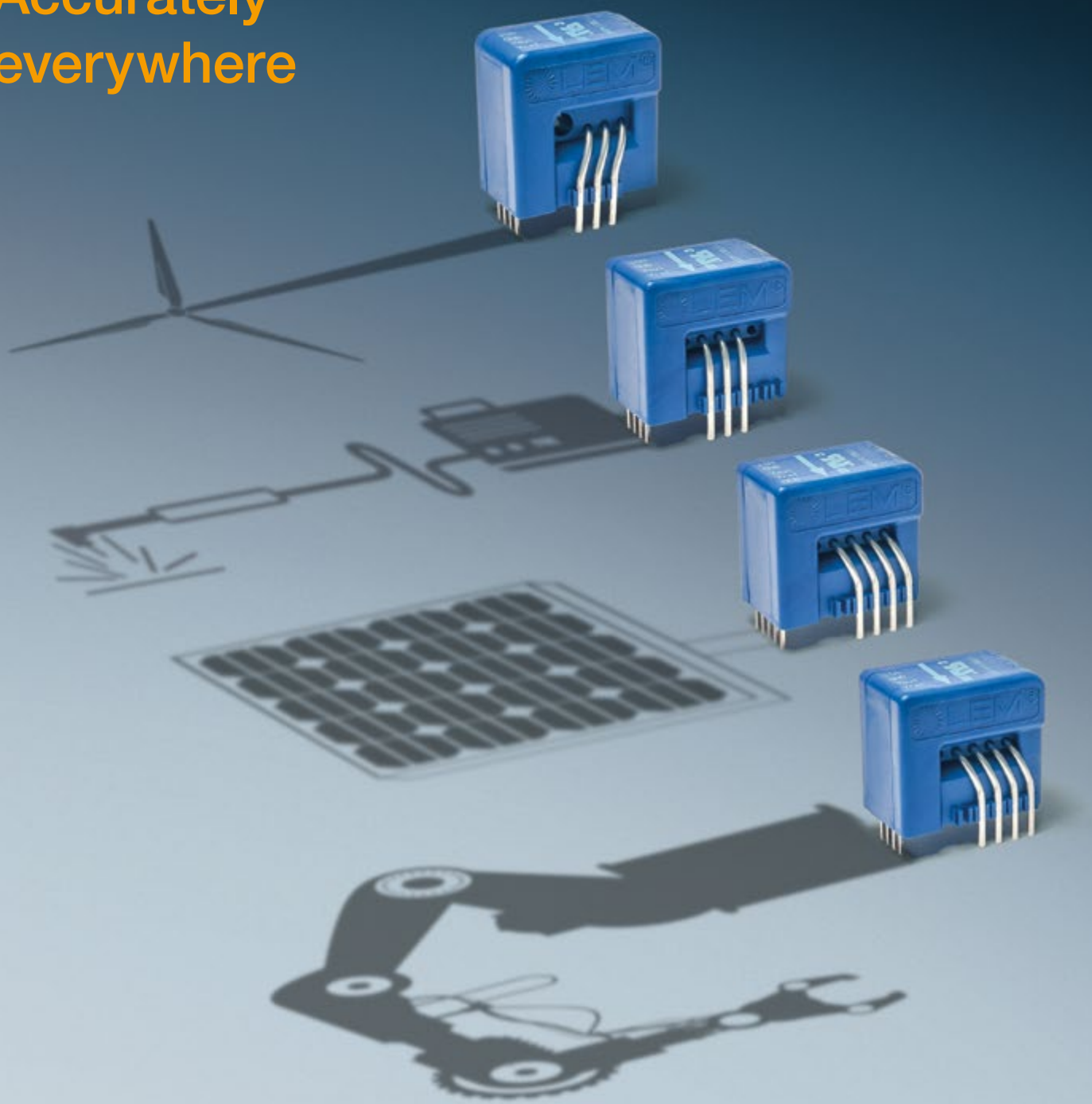
Bodo's Power Systems reaches readers across the globe. If you are using any kind of tablet or smart phone, you will find all of our content on the new website www.eepower.com. If you speak the language, or just want to have a look, don't miss our Chinese version: www.bodospowerchina.com

My Green Power Tip for July:
By using simulators instead of building prototypes, especially HIL (Hardware in the Loop) simulators, you can save a lot of resources.

There is still time for a nice vacation during the summer, we wish you well.

Best Regards

Accurately everywhere



LXS, LXSR, LES, LESR, LKSR, LPSR series

New closed-loop current transducers, based on a custom Hall Effect LEM ASIC, perform at the level of fluxgate transducers, achieving the highest levels of quality and traceability using advanced manufacturing techniques. Offset drift is over four times lower than the previous generation of closed-loop transducers based on Hall cells and very similar to those using fluxgate.
There are 6 families and 22 models available with various options, such as an integrated reference (V_{REF}), footprint (3 or 4 primary pins with different layouts), with an aperture and/or with integrated primary conductors and overcurrent detection.

- 1.5 to 50 A nominal current
- PCB mounting
- Low offset drift (4 – 14 ppm/°C)
- Overcurrent detection output (LPSR models)
- -40 to +105°C operation
- 100 % compatible with previous LEM generation
- Multi-range configuration

Energy Storage Systems and Multigrid Inverter Form the Perfect Team

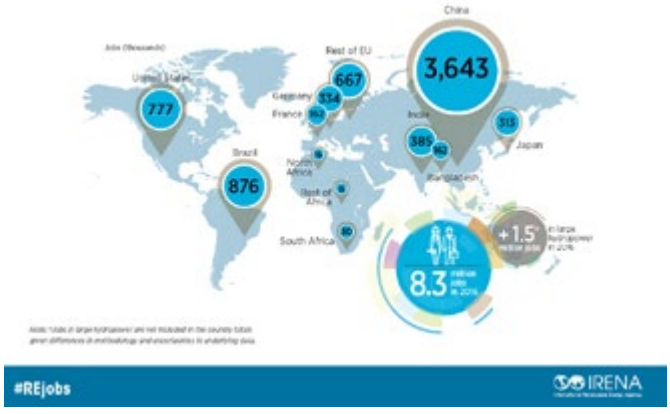
BMZ GmbH cooperates with Dutch company Victron Energy B.V. in the energy storage system area. The BMZ Energy Storage System (ESS), including the products ESS 7.0 and ESS 9.0 work perfectly with an inverter from Victron – the Victron Multigrid Inverter. This combination of energy storage system and inverter is a flexible solution for storing energy and optimizing energy consumption for home use. Energy storage solutions from BMZ and Victron make users independent from power companies and reduce electricity costs through personalized energy use.

www.bmz-group.com

Renewable Energy Employs 9.8 Million People Worldwide

Global energy system creating more jobs in renewables than in fossil-fuel technologies

More than 9.8 million people were employed in the renewable energy sector in 2016, according to a new report from the International Renewable Energy Agency (IRENA). Renewable Energy and Jobs – Annual Review 2017, released at IRENA's 13th Council meeting, provides the latest employment figures of the renewable energy sector and insight into the factors affecting the renewable labour market. The Annual review shows that global renewable-energy employment, excluding large hydropower, reached 8.3 million in 2016. When accounting for direct employment in large hydropower, the total number of renewable-energy jobs globally climbs to 9.8 million. China, Brazil, the United States, India, Japan and Germany accounted for most of the renewable-energy jobs. In China for example, 3.64 million people worked in renewables in 2016, a rise of 3.4 per cent.



IRENA's report shows that solar photovoltaic (PV) was the largest employer in 2016, with 3.1 million jobs — up 12 per cent from 2015 — mainly in China, the United States and India. In the United States, jobs in the solar industry increased 17 times faster than the overall economy, growing 24.5 per cent from the previous year to over 260,000. New wind installations contributed to a 7 per cent increase in global wind employment, raising it up to 1.2 million jobs. Brazil, China, the United States and India also proved to be key bioenergy job markets, with biofuels accounting for 1.7 million jobs, biomass 0.7 million, and biogas 0.3 million.

www.irena.org

'Innovator of the Year' awarded to Tim Brauner and David Bates

The Manufacturers Association of Central New York (MACNY) have crowned Tim Brauner and David Bates of Knowles Capacitors as the joint winners of the 2017 'Innovator of the Year' award. They were honored at MACNY's 104th Annual Dinner, held on the 18th May, after being nominated for the award by President of Knowles Precision Devices Chris Dugan, on behalf of the entire Knowles team.

From L to R: President & CEO of MACNY Randy Wolken, Tim Brauner, Chris Dugan and David Bates of Knowles Capacitors

Tim Brauner and David Bates were nominated on account of their teamwork, innovative thinking and commitment to the success and growth of Knowles in the RF industry. Founders of the Thin Film product line, the pair have created double digit growth every year and tripled the line's revenue in just 5 years, contributing towards the future success of the Knowles facility in Cazenovia.

During his 10 year career at Knowles, Tim's finger is always on the pulse of what customers want and uses this insight to ensure Knowles's processes, technologies and products support the ever-growing and changing customer needs. Tim's teammate David has over 20 years of experience in the RF industry and as Chief Scientist at Knowles has developed processes to align Knowles's roadmap with that of their customers. Together they've helped to maintain Knowles's status as an industry leader in RF products, particularly in the microwave field.

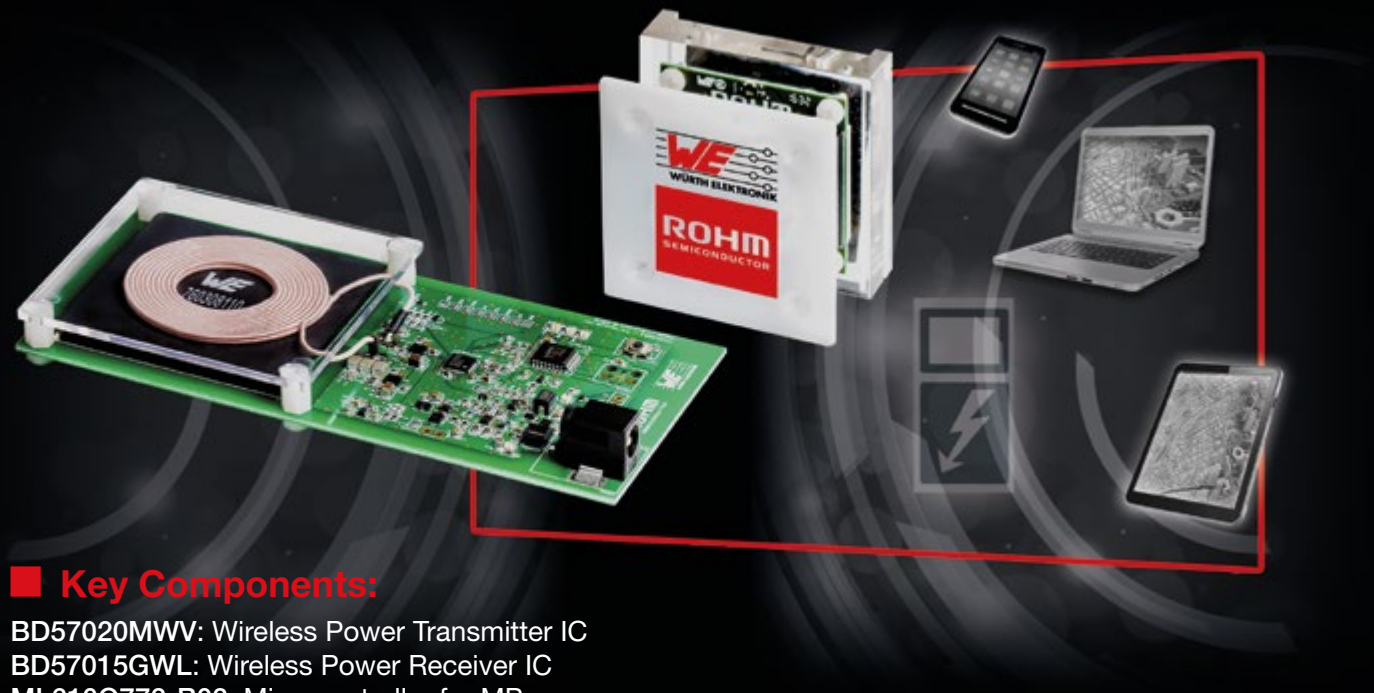
www.knowlescapacitors.com

SMALLER
STRONGER
FASTER

Wireless Power Design Kit

Qi Medium Power compliant

ROHM Semiconductor and Würth Elektronik developed a plug & play wireless power solution to demonstrate the advantages of wireless power. This gives you the opportunity to test and integrate a wireless power solution into your product design.



Key Components:

BD57020MWV: Wireless Power Transmitter IC
BD57015GWL: Wireless Power Receiver IC
ML610Q772-B03: Microcontroller for MP

Main Features:

- Plug & Play Medium Power (15 W) Wireless Power Design Kit
- Compliant with Qi Standard of the Wireless Power Consortium (WPC)
- Complete solution consisting of Tx, Rx and LED Load module
- Flexible and modular approach for fast integration of wireless power in your product design

Applications:

- Portable devices used in a clean area, where connectors pose a risk of polluting e.g. medical facilities and (industrial) clean rooms
- Devices with a large number of mating cycles to avoid connector damage
- Headsets
- Battery operating portable devices
- Smartphones, Tablets

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www.rohm.com/eu

LpS 2017 Returns for its 7th Year this September

The symbiosis of LED/OLED lighting and modern technology has led to new technical system architectures that will alter the light market, forever. For the next generations of lighting concepts to succeed a holistic approach between technology and the system is required, but how? The associated interdisciplinary developments require comprehensive knowledge of applications, designs and technologies in order to meet their potential.

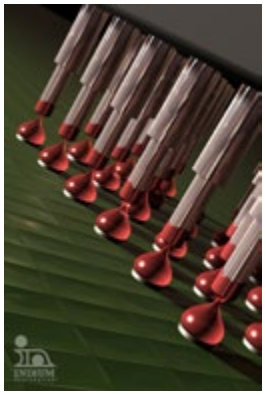
The 7th international LED professional Symposium +Expo (LpS 2017) is dedicated to these questions. This leading lighting technology conference will take place from 26 to 28 September in Bregenz.

Over 100 specialist lectures, workshops, forums, and in the exhibition, more than 1,600 visitors will be discussing the topics surrounding "Smart Technologies for Lighting Innovations".

The stellar conference program encompasses strategies and markets, engineering and design, testing and applications, and covers the central building blocks of lighting systems from the component or materials right the way through to the application. The design questions concern topics such as reliability, costs and issues around the production of modern lighting systems.

The LpS 2017 is primarily aimed at technology experts from industry and research, as well as those who are curious about the latest developments in lighting technology.

www.LpS2017.com



WS-575-C Ball-Attach Flux at Microelectronics Tech Asia Singapore

Indium Corporation will feature its WS-575-C Ball-Attach Flux at Microelectronics Tech Asia Singapore, July 4-5, 2017 in Singapore.

Indium Corporation's WS-575-C Ball-Attach Flux is halogen-compliant ("no-intentionally-added" halogens) and designed as a true one-step ball-attach process for Cu OSP substrates.

WS-575-C eliminates many assembly issues, such as missing ball, weak joints, and voiding.

WS-575-C can be completely cleaned using room temperature deionized (DI) water, significantly reducing the costs of heating water.

For more information on WS-575-C Ball-Attach Flux , visit Indium Corporation at booth 14.

www.indium.com/ballattachflux

MiniSKiiP – Anticipating the Future for 20 years

20 years ago the MiniSKiiP was born. A unique design, setting a new standard in the power electronics world: solder-free PCB assembly using spring contacts, leading to the shortest of assembly times, easy PCB design and a high degree of connection reliability, resulting in an immediate system cost benefit.

With more than 35 million modules in the field, MiniSKiiP has changed the world of power electronics. It is the first module available with pre-applied Thermal Interface Material, one of the first industrial standard modules with Silicon Carbide and is the only module to cover a power range from 1 to 90kW as a full motor drives solution.

Today, we are still innovating the future. Utilizing the SEMIKRON technology portfolio, MiniSKiiP boosts reliability and power density and is now finding its way into new markets such as medium-voltage inverters. In the area of motor drives, MiniSKiiP has become the Power Density Master.

One way to achieve this is to optimize the thermal resistance layer between the chip and heatsink. Using the unique SEMIKRON packaging technologies, the output current capability and, consequently, power density is increased by more than 30% while using the same physical chipset and power module size.

www.semikron.com

90 Percent Efficient High Power Converter

Bourns, Inc., has showcased the company's extensive capabilities in high power, high frequency magnetics design, high power current sensing and circuit protection for consumer, automotive, industrial and communications applications at the PCIM Europe 2017 conference.

Bourns engineered its broad line of high current shunt resistors, high power converters and custom transformer solutions to incorporate the extremely efficient technologies developers need to meet next-generation battery management system (BMS), smart switch and battery storage application requirements.

Booth highlights include: Demonstration of a 5 V, 12 W high frequency magnetics converter that achieves 90 % efficiency using a low-profile planar transformer. Demonstration of an ultra-fast high voltage over-current protector for cell tap lines in battery stack applications.

www.bourns.com

One Hitachi.
Endless Possibilities.

HITACHI
Inspire the Next

High Voltage IGBT Robust. Reliable. Reputable.

Hitachi Europe Limited, Power Device Division email pdd@hitachi-eu.com

TerraE Plans Gigafactory for Lithium-Ion Cells in Germany

Start-up company TerraE Holding GmbH based in Frankfurt am Main is planning a large-scale production for lithium-ion cells in Germany. The founding partners are BMZ Holding GmbH, Europe's leading manufacturer of industrial battery modules, Dr Ulrich Ehmes, former CEO of Swiss battery manufacturer Leclanché SA, and Holger Gritzka, so far a manager at engineering and system provider Thyssenkrupp System Engineering who will also take over the management. The aim is to gradually build up production capacity of up to 34 GWh/year by 2028. The business model will be that of a foundry, similar to the practice in the semiconductor industry. The focus is on industrial and electromobility markets. It will be addressed with different cell formats. The financing is to be secured through industrial partners as through well as financial investors. Discussions are ongoing with partners in other European countries.

Important aspects of the production concept are results, which have been developed in the course of the "Giga-LIB" project supported by the BMBF, the German federal ministry of education and research. The initiative emerged as part of the German "KLiB" competence network for lithium ion batteries, to which 45 companies and institutions belong.

www.terrae.com

Würth Elektronik eiSos Enthusiastic about Formula E and eMobility

Having been staged in Asia, Africa, South and Central America, the FIA all-electric racing series arrived in Europe with events in Monaco,Paris and Berlin. Würth Elektronik eiSos, technology partner and sponsor of the ABT Schaeffler Audi Sport team, sees the race also as a chance to awaken more enthusiasm for eMobility in Europe. The German team has been very successful in this Formula E season. "We are all captivated and look forward to the race in Berlin", said Alexander Gerfer, CTO Würth Elektronik eiSos. "The allegiance with our team is strong. Our technology is now on-board and is knocking out laps at a tremendous pace. We wish our team, and also Formula E as a whole, every success. "

As a manufacturer of high quality components, like REDCUBE PRESS-FIT terminals for high current applications, not only has Würth Elektronik recently entered into partnership with ABT Schaeffler Audi Sport, but is also actively involved in new developments. For instance, Würth Elektronik eiSos worked with ABT Sportsline in developing a backup battery to supply power in the cockpit. ABT Schaeffler Audi Sport also developed the charging infrastructure and several subsystems with Würth Elektronik eiSos.

www.wespeedupthefuture.com

"Best Key Account" Award from Siemens DF MC for Jianghai Europe

„Best Key Account" Award from Siemens DF MC for Jianghai Europe Every year, Siemens Digital Factory Motion Control honors its best suppliers under the motto „Our Stars for MC". From hundreds of suppliers, Siemens DF MC selected the 29 best and nominated them for being awarded a prize in five categories (Best Overall, Best Key Account, Best Logistics and Best R & D / Innovation), and a special prize.

With the award „Best Key Account", Siemens DF MC honored the long-lasting, outstanding cooperation and intensive support for design-in projects for customer-specific aluminum electrolytic capacitors. Joachim Düsterhaus, Global Commodity Management, Siemens DF MC, handed over the engraved star to Dr. Arne Albertsen, Sales and Marketing Manager of Jianghai Europe Electronic Components GmbH, during the festive award ceremony in Neunkirchen am Brand. „It is a special honor and a great incentive to receive this year's „Best Key Account" award", said Dr. Arne Albertsen, Sales and Marketing Manager of Jianghai Europe, during the award ceremony. „We are very pleased with the great appreciation of our work by Siemens, and thank the entire team at Jianghai Europe in Krefeld and Nantong Jianghai Co., Ltd. for outstanding and continuous support in China", added Ole Bjørn, Managing Director of Jianghai Europe.
Jianghai Europe Electronic Components GmbH, headquartered in Krefeld, Germany, is the European sales organization for the capacitors of Nantong Jianghai Capacitor Co., Ltd., headquartered in Nantong, China. Jianghai Europe offers capacitor solutions for professional industrial users who produce power supplies and inverters with a defined lifetime and reliability.

www.jianghai-europe.com

THREE-LEVEL TOPOLOGY FOR SINGLE-PHASE SOLAR

Vincotech

SOLAR

OUT NOW: *flow*SOL 0 BI (TL) based on H6.5 topology

650 V / 20 A

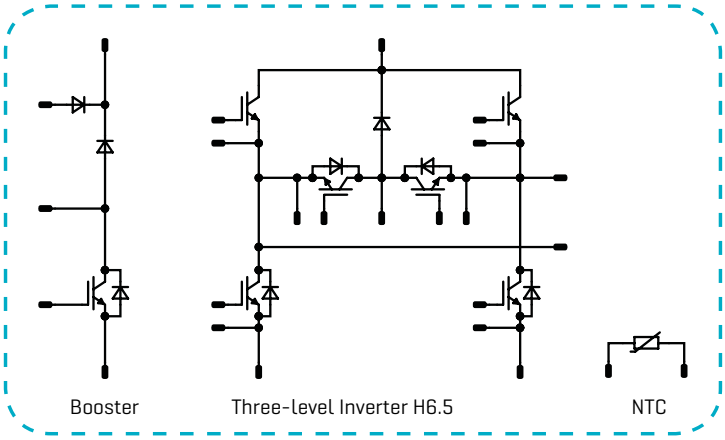
How can you improve your time to market, reduce your development costs and increase your system efficiency in your next design?

Vincotech's next generation power modules will take your single-phase solar designs to the next level. Our new *flow*SOL 0 BI (TL) combines the well-known advantages of three-level H6.5 architecture with an integrated booster and NTC. Designed for applications up to 3 kW and featuring next generation IGBTs.

The new *flow*SOL 0 BI (TL) module is housed in a 12 mm, 2-clip *flow* 0 low-inductive package.

Main benefits

- Increased system efficiency thanks to next generation IGBTs and leading three-level H6.5 architecture
- Accelerated time to market due to proven power module technology
- System cost optimization through reduced filtering requirements
- Compact integrated solution for increased reliability and power density



www.vincotech.com/*flow*SOL-0-BI-TL

EMPOWERING **YOUR IDEAS**

Wolfram Krueger Vice President of European Sales

To support its accelerating growth, Efficient Power Conversion Corporation (EPC) is proud to announce that Wolfram Krueger has joined the EPC leadership team as Vice President of European sales. Mr. Krueger has over 30 years of sales operation experience within the semiconductor industry. His primary responsibilities at EPC are creating and implementing sales and marketing strategies to achieve the company's sales objectives throughout Europe. He is based in Cologne, Germany. "Wolfram Krueger is an electronics engineer by background and has extensive experience in leading edge power semiconductors with extensive experience in the industrial, automotive, and Telecommunications markets," said Nick Cataldo, senior vice president of global Sales and Marketing and co-founder of EPC.

Mr. Krueger joins EPC from Ioxus, where he was vice president of sales for Europe, Middle East, and Africa. Previously Krueger held senior sales and marketing leadership positions with several companies including Maxwell Technologies, Mitsumi Electronics, and Rohm Electronics.

www.epc-co.com

Greater Reliability with New Material Set Combinations

Alpha Assembly Solutions, the largest soldering materials provider in North America, will feature its new material set combinations at the upcoming SMTA Ohio Expo and Tech Forum to be held July 13th at the Embassy Suites Cleveland-Rockside in Independence, Ohio.

The material set combinations represent various pastes, tacky fluxes, cored wire, and wave soldering fluxes that are tested with one another to achieve greater reliability. "Reliability is a critical issue for our customers", said Kurt Graulich, District Sales Manager for Alpha's Eastern Region. "Alpha has done the testing necessary to demonstrate which material pairings will produce the greatest reliability, relieving our customers from much of the trial and error that can occur when selecting products for specific electronics assembly processes."

Alpha, a part of the MacDermid Performance Solutions group of businesses, will also showcase its portfolio of innovative materials and solutions for the electronics assembly industry, and its ALPHA® Recycling Services capabilities.

www.AlphaAssembly.com

GaN Power ICs Enable Smallest Power Adapters for Ultra-Thin TVs and Laptops

Navitas Semiconductor announced the availability of a 150W AC-DC reference design utilizing the company's industry-leading GaN power ICs. At over 21 W/in3 and at over 95% efficiency, the NVE021A is more than 2x smaller than typical commercial designs and 40% smaller than previous best-in-class today.

The design can be adapted over a power range of 85-500W to enable a new class of converters to address ultra-thin LED TVs, fast-charging laptop adapters, high-density gaming systems, all-in-one PCs and any other systems seeking high-density or high efficiency power solutions. Navitas GaN Power ICs enable high-frequency switching to shrink passive components. Soft-switching critical-conduction mode (CrCM) PFC and LLC DC-DC stages operate at working frequencies up to 300 kHz (600 kHz during start-up, burst mode) – the fastest-possible speed provided by off-the-shelf controller ICs available today.

The NVE021A reference design (150W, AC to 12V DC) is immediately available direct from Navitas at a price of $465 each, which includes a comprehensive user guide / test report with all schematic and layout design files, plus bill of material.

www.navitassemi.com

Joining World Business Council for Sustainable Development

Yokogawa Electric Corporation announces that it has joined the World Business Council for Sustainable Development (WBCSD). By joining this organization, Yokogawa will be able to accelerate its efforts to foster sustainability and thereby help to achieve the United Nation's Sustainable Development Goals (SDGs).

WBCSD is a CEO-led organization of almost 200 global companies that aims to have a positive impact on business, the environment, and society by encouraging the pursuit of sustainable practices. In so doing, it aims to accelerate the transition to a sustainable world and ensure the long-term success of its member companies.

The decision to join this organization is driven by an awareness of the need for a response to the pressing environmental issues that we all face. By working to achieve the transition from fossil fuels to renewable energy sources and introducing practices such as recycling, we can play a role in ensuring a more sustainable future for all. We believe that our membership in this organization will allow us to develop a better grasp of global market trends and develop tools and other solutions that businesses can use to enhance their sustainability.

www.wbcsd.org

SEMIKRON
innovation + service

Expect More from Standard Modules.

Industry standard power module packages are commodities today. Supply chain safety for these modules is one of the most important requirements. Being compatible on the one hand, SEMIKRON standard modules even exceed these standards on the other hand.

Our portfolio of sintering and bonding technologies takes output power capability and reliability to new levels. Module-integrated current measurement shunts, plug & play drivers and pre-applied Thermal Interface Materials reduce the number of system parts, cutting development time as well as system costs and time-to-market.

SEMiX® 6

Latest commodity product

Power Modules
Systems
Power Electronic Stacks

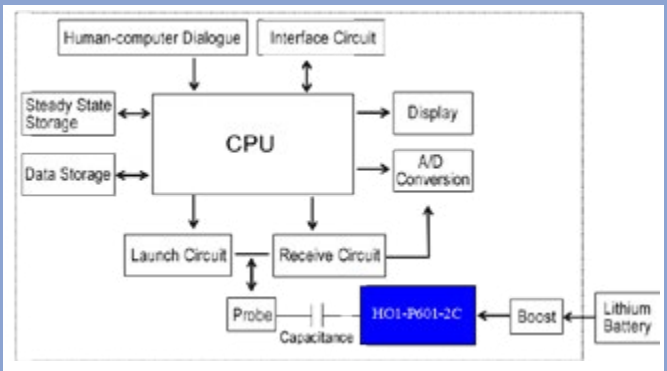
AC|DC

www.semikron.com

Fixed Input, Non-Isolated Adjustable Output Power Supply

HO1 series of high-voltage output

MORNSUN announced high-voltage output power supply HO1 series recently. The series addresses applications of portable devices with ultrasonic technology including ultrasonoscope, pile test instrument, ultrasonic thickness gauge, non-metallic ultrasonic testing detector for concrete, and electrostatic printing, high voltage bias, industrial control, medical chemical industry, scientific experiment and so on. Distinguished advantages of HO1 series are as follows.



12V fixed input voltage, 0-600V continuous output with linear adjustable function
Adjustable output voltages of 200-1200V (0-200V, 0-600V, 0-800V, 0-1000V, 0-1200V optional) are available depending on different requirements. HO1 series offers 600V high voltage to power ultrasonic detector, forms high voltage pulse at probe chip by drive circuit and results in pulsed ultrasound for high-frequency mechanical oscillation after electro-acoustic conversion.

Operating temperature ranging from -40°C to +85°C without any derating
Internal devices of high-voltage output power supply are subject to pressure of high voltage. On the other hand, high temperature means high pressure. Both of them demand higher product reliability. MORNSUN HO1 series has an wide operating temperature range without any derating, high reliable.

Temperature coefficient ≤ ±0.01%/°C, time coefficient ≤ ±0.05%/hour, output ripple as low as 15mVp-p (typ.);
Stable output of HO1 series has no deviation for environmental changes, making portable devices' testing results more accurate.

CE meet CISPR22/EN55022 CLASS A, without external components

RE meet CISPR22/EN55022 CLASS B, without external components
HO1 series offers excellent EMC performance, better compatible system design, less electromagnetic interference to sensitive acquisition circuit, and more sensitive and accurate measurements.

In addition, HO1 series also has output short circuit and over-current protections to meet specific environment applications. These applications include but are not limited to ultrasonoscope, photomultiplier tubes (PMTs), avalanche photodiodes, solid-state detectors, EO lens, piezo devices, capacitor charging fields. These converters offer a cost effective solution with high-quality performance in the industry.

Features:

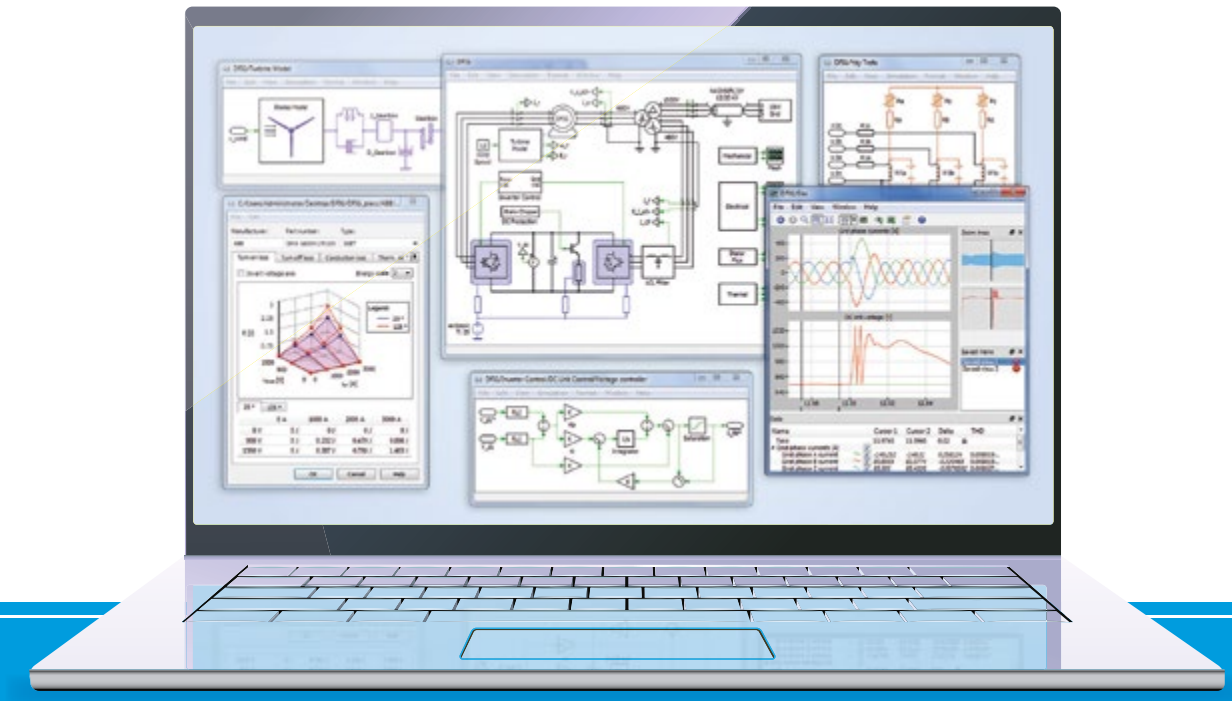
- Low ripple & noise
- Ultra-low temperature coefficient and time coefficient
- 0-600V continuous output with linear adjustable function
- Output short circuit and over-current protections
- Operating temperature:-40°C to +85°C (without any derating)
- CE meet CISPR22/EN55022 CLASS A, without external components
- RE meet CISPR22/EN55022 CLASS B, without external components

www.mornsun-power.com

plexim
electrical engineering software

plecs

THE SIMULATION SOFTWARE PREFERRED
BY POWER ELECTRONICS ENGINEERS



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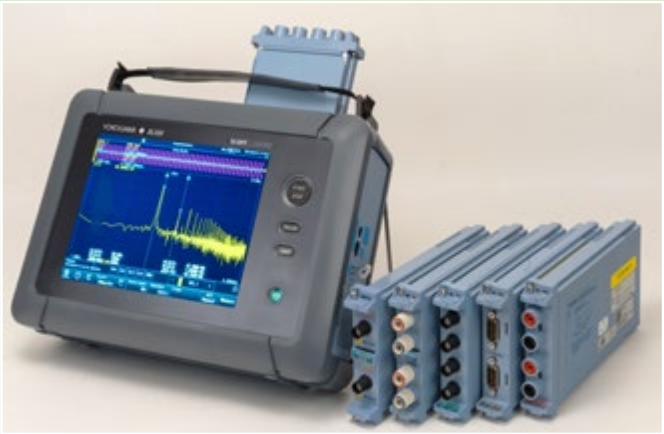
Portable ScopeCorder - More Than a Test Tool

Yokogawa launched its DL350 ScopeCorder – a compact, portable combination measuring instrument. It is the most comprehensive fully portable measuring instrument available for capturing, displaying, recording and analyzing a wide variety of electrical and physical parameters in industry sectors including automotive, electronics, energy, transport and mechatronics.

By Roland R. Ackermann, correspondent editor Bodo's Power Systems

Like other models in Yokogawa's ScopeCorder family, the DL350 combines features of a general-purpose oscilloscope and those of a high-performance data acquisition recorder in a single, portable instrument.



Picture: DL350+modules

Another key feature of the DL350 ScopeCorder is its plug-in modularity, which allows it to be configured to suit a variety of user applications. Whether carrying out straightforward high-precision voltage measurements or handling a blend of signals coming from current probes, temperature sensors, strain gauges, accelerometers and serial buses, the DL350 can deliver, without extra boxes or cables.

User-swappable Modules

This flexible input capability is achieved by incorporating two slots which are populated with any of 18 different types of user-swappable input modules. This means, for example, that four isolated 16-bit voltage inputs can be measured at speeds of one megasample per second (MS/s) alongside 16 temperatures or two separate CAN or LIN buses each containing 60 signals. Changing a single module enables measurement at 100 MS/s with 12 bits and 1 kV of isolation. Meanwhile there are 16 logic inputs always available, with even more available by swapping a further module. Among other modules are AC measurements using an RMS module in real time and a mathematics channel for signal processing and analysis after the recording is finished.

The DL350 offers compatibility with many existing ScopeCorder input modules and thereby provides a potential cost saving to existing users. For users who are more familiar with chart recorders than with long-memory oscilloscopes, the DL350 offers a choice of operating modes:

Recorder mode is suitable for long-term, continuous recording for a specific duration and where the sampling interval is specified. A set-up wizard can be used in this mode to guide the operator quickly through the entire set-up process.

Scope mode allows the DL350 to be used just like an oscilloscope with all the associated benefits, including comprehensive triggering and flexible memory use. Using the history memory enables up to 1000 separate triggered acquisitions to be captured to the internal memory so that the causes and effects of abnormalities can be carefully analyzed.

Continuous Recording Up to 50 Days

Up to 5 Gpoints of data per module can be recorded directly to an SD card. This means that the DL350 can be used for continuous recording up to 50 days. For high-speed signals, up to 100 Mpoints per module of internal memory is available to capture fast transients. This is up to 10,000 times more than other portable oscilloscopes or oscilloscope/multimeters offer and allows signals to be captured with higher sample rates or over longer periods.

A high-resolution, high-speed sampling module, unique amongst portable measuring instruments, provides individually isolated 12-bit, 100 MS/s inputs, which can precisely measure and record transient waveforms (superimposed on inverter outputs, for example) and the edges of control signals which cannot be measured by traditional handheld recorders or oscilloscopes.

An 8.4-inch resistive touch screen has been adopted to deliver superior noise-free performance. In environments with the highest levels of electrical noise such as motors and inverters, measurement precision is maintained whilst enabling the unit to be operated using gloved hands or a stylus.

The user has a choice of a simple level trigger or enhanced triggers on such things as pulse width, waveform period and across multiple channels. For example, the wave window trigger is ideal for AC power-line monitoring, and enables voltage sags, surges, spikes, phase shifts or drop-outs to be easily captured (available for 40 to 1000 Hz waveforms).

A DL350 can be left unattended with the captured waveform automatically saved to a file, or a notification email sent if and when it triggers.

The DL350 is first and foremost a field tool. However, it still provides the functionality users expect in a bench instrument. The sampling clock, trigger and start/stop controls are all available as external signals, so that a rotary angle encoder or degree wheel, for example, can be used as the sample clock to analyze engine rotation and performance.

The power in single and 3-phase systems can be evaluated. In addition, for fundamental waveforms of 50 or 60 Hz, up to 40 harmonic orders can be analyzed. Alternatively, it is possible to use the suite of FFT functions to perform full frequency analysis.

Advanced Features Support In-Vehicle Testing

The DL350 with /VE option and bus monitor module can decode CAN bus, LIN bus or SENT signals and display information such as engine temperature, vehicle speed and brake pedal position as trend waveforms and compare this with the analogue data coming from the actual sensors. This enables automotive engineers to gain an insight into the dynamic behaviour of the complete electromechanical system. An optional GPS unit (release pending in the EU) enables latitude, longitude, altitude, speed and motion direction data to be synchronized with the waveform data, perfect for drive testing, mobile testing or distributed field recordings. Moreover, the DL350 is vibration resistant due to an aluminum inner frame and an external rubber bumper, conforming to Japanese JIA DS1601 standard for resisting in-vehicle shock and vibration.

www.tmi.yokogawa.com

Positive Balance of Intersolar Europe and of ees Europe 2017

Innovations and Falling Prices Stimulate the New Energy World

With great success ended the Intersolar Europe2017, the leading trade fair for the solar economy and its partners of the world, and – taking place at the same time – the ees Europe 2017, the largest trade fair for batteries and energy storage systems. More than 1,100 exhibitors from 51 countries presented innovative solutions and products in Munich from 31 May through 2 June. Both fairs attracted about 40,000 visitors in seven halls.

By Roland R. Ackermann, correspondent editor Bodo's Power Systems

Intersolar Europe 2017

This year's exhibition focused on the new energy world. One of the highlights was the special exhibit Smart Renewable Energy. Other topics included new financing and business models for photovoltaics (PV), large-scale PV power plants and the operation and maintenance of PV installations. Manufacturers, suppliers, distributors, service providers and partners of the solar industry attended the show and the conference in Munich.

Figure 1: Intersolar Europe 2017 Conference

The global photovoltaics market is booming: According to the latest Global Solar Demand Monitor by GTM Research, analysts expect the demand for PV to reach 85.4 GW this year, which would mean a doubling of the global PV market since 2014. As a result, Intersolar Europe is becoming even more attractive for the industry's manufacturers, suppliers, wholesalers, and service providers. In 2017, the leading exhibition occupied one hall more than in the previous year.

Special Focus: Smart Renewable Energy

The energy industry's shift towards a digital energy world and the interconnectedness of electricity, heat and mobility (sector coupling) are the main factors in the success of the energy transition, which has put them at the top of the agenda at Intersolar Europe. Visitors to the exhibition could find out all there is to know – from the challenges of efficient, safe and cost-effective integration of renewable energies to new business models that result from the energy industry of the future.

Manufacturers and experts from industry, business and research presented their latest solutions on the three exhibition days, where Friday was all about local energy supply and self-consumption. The Karlsruhe Institute of Technology (KIT) and its project partners from the Helmholtz Association demonstrated the Energy Lab 2.0, a real-life laboratory showcasing new approaches to integrating different technologies into the energy system.

Smart Renewable Energy Forum: Digitalization is Key

The digital transformation in the energy industry has fundamentally changed the electricity landscape. In the future, the energy supply will be ensured by a range of renewable energy plants, storage systems and consumers acting as prosumers. Therefore the Smart Renewable Energy Forum concentrated on new concepts and technologies for digital networking along the energy value-added chain. It threw a spotlight on diverse aspects of a digitalized energy industry on all three exhibition days. Industry experts from science, industry and associations discussed the wide-ranging topic of digitalization.

The future of renewable energies in the power supply depends strongly on digitalization along the whole value-added chain – as this is the only way to ensure that power from decentralized and disparate volatile energy sources is optimally integrated into the grid. Numerous new digital services, products and solutions are currently under development. These will control the decentralized energy market flexibly and safely, and in doing so, optimally coordinate generation and consumption. In addition to this, smart communication between energy producers, smart grids, storage systems and consumers is also necessary. "The large number of players in the communication chain naturally involves risks to grid security and data protection. Cyber security always has to be taken into account in this context. "For this reason, we are continuously working on solutions for improving system security," said Prof. Dr. Michael Waidner, Director of the Fraunhofer Institute for Secure Information Technology SIT.

Intersolar/ees AWARD

The Intersolar AWARD was given for the tenth year in a row. For years, the award ceremony has been a highlight of the exhibitions and a source of excellent publicity for the finalists and winners. The top-class panel of judges honoured cutting-edge, sustainable solar products and projects in the categories of Photovoltaics and Outstanding

Solar Projects. For the first time, submissions were accepted for the topic of Smart Renewable Energy. The ees AWARD is among the most important prizes for the energy storage industry and honours pioneering developments and innovations. This year's many international submissions included projects for the integration of renewable energies into the grid, increased efficiency and durability of lithium-ion batteries, and the step towards megawatt output. The award ceremony was attended by high-calibre dignitaries and brought together Intersolar and ees exhibitors, representatives and decision-makers from the international solar industry.

Intersolar Europe Conference

The Intersolar Europe Conference saw experts delving into the exhibition topics, discussing the latest trends and the developments of international markets. Large-scale PV power plants were a hot topic this year, as they are driving the expansion of PV at an international level. Financing and the profitability of large-scale systems were of particular interest at this year's conference, with digitalization often playing a prominent role.

ees-Europe 2017 – "Charging the Future"

This year, the event dealt with the topics of self-consumption in residential and commercial buildings, large-scale storage systems and grid integration, battery safety and global storage markets as well as e-mobility. ees Europe, the continent's largest and most visited exhibition for batteries and energy storage systems, presented the latest trends and technologies in the industry in cooperation with the International Battery and Energy Storage Alliance (IBESA). The exhibition took place in parallel with Intersolar Europe, whereas the ees Forum was dedicated entirely to the most important markets and practical experiences in the production, sales, installation and application of batteries and energy storage systems. It featured presentations and discussions from specialists and experts from all over the world.

Figure 2: ees Europe Forum

ees Europe offered an overview of the versatile applications for large-scale storage systems. Suppliers, manufacturers, and users of stationary and mobile electricity storage systems had the opportunity to share information and gain insights into the future of modern energy supply. Major trends were an enormous market upturn, driven by considerably decreasing costs. The prices for e.g. small lithium-ion storage units up to 10 kWh in Germany have dropped by around 4o per cent since 2013, and in the same time frame prices of the bulk storage systems up to 30 kWh even dropped by more than 50 per cent. That is one of the reasons why more than 20,000 new solar power storage units have been installed in the last year.

Storage Helps Reduce Costs

Energy storage systems are set to play a central role in the energy supply of the future: As the use of renewable energy sources becomes more widespread, it will be increasingly important to guarantee a reliable power supply and smart energy management. Storage systems allow electricity to be retrieved even at times when cloud formations or windless conditions prevent the generation of clean power. Furthermore, they can help to connect different generating units to create virtual power plants, and thus ensure a reliable energy supply across entire regions. With their capacity to uncouple the generation of clean power from consumption and ease the burden on grids, large-scale storage systems will play a central role in the energy supply of the future, because they allow flexible coordination of energy supply and demand.

The potential for use of such storage systems in Germany is far from being exhausted, however: The German Energy Storage Association (BVES) put the total market for large-scale storage systems at some 35 MW in August 2016. By January 2017, the cumulative capacity had already reached around 120 MW, and the association expects approximately 200 MW to be available by December 2017. The BVES estimates that somewhere in the region of 600 projects have been completed in Germany in agricultural settings, apartment buildings, trade, commerce, and industry to date. Demand for large-scale storage facilities is rapidly increasing.

Thus the success story of ees Europe is unbroken: from 48 exhibitors at its start in 2014, the exhibition has grown to include 251 companies from all over the world this year. Around 440 of the roughly 1,100 exhibitors at ees Europe and Intersolar Europe are presenting energy storage technology.

ees Forum: Growth and Change of Energy Storage
At the ees Forum, experts, exhibitors and start-ups were offering insights into the latest developments in the energy storage industry on all three exhibition days. Right at the start, the market research institute EuPD Research reported on the status quo and the future of the energy storage market in the keynote speech titled “Current Trends and Market Forecasts in the German and Global Energy Storage Market”. Subsequent presentations addressed the legal conditions for the profitability of energy storage systems, installation and operation safety, and quality assurance.

The storage market for renewable energies is booming and bringing long-term change to the energy landscape. This goes hand in hand with new business models and competitive opportunities which benefit consumers as well as manufacturers and suppliers. For this reason, the ees Forum, held in cooperation with IBESA for the fourth time, shone a spotlight on promising market strategies for suppliers of small-scale and commercial storage devices. The afternoon sessions was entirely devoted to the innovative industry environment with the keynote speech “How Start-ups and Innovations Enrich the Storage Industry”.

Further presentations saw researchers, manufacturers and solution providers addressing e-mobility as part of a sustainable energy supply. Networking and new connectivity solutions play an important role in this, as was shown in the presentation “E-Mobility and HVAC Technology: Integrating What Belongs Together – Market Overview and Product Diversity in Charging Systems”.

Large-Scale Storage Systems
Finally, the ees Forum turned to large-scale storage systems. Energy storage systems used in industrial installations or neighbourhood-scale distributed energy storage systems are facing significant challenges, but also opportunities. Furthermore, experts were concentrating their attention on practical topics: The presentation series “PV Domestic Storage Systems – A Booming Market with Pitfalls”, held in cooperation with the German Solar Association (BSW-Solar), was addressing the most important questions on the usage of energy storage systems, such as an overview of the current standards, or the PV storage passport from ZVEH (German Central Association of Electrical and Information Technology Contractors) and BSW-Solar.

One important application of large-scale storage systems is in industry, where they are used for peak shaving. Surplus energy, produced for example at midday, can be captured by the storage devices and then released on demand, for instance at times when large amounts of electricity are required. Power supplied by the electric grid is reduced dramatically as a result, and costs fall. Businesses are then able to benefit from so-called “atypical grid usage”. If they predominantly consume energy at times when the general grid load is light, they pay significantly lower tariffs. “Large-scale storage is essential to distributed, green, reliable energy supply systems. We are delighted to be presenting our innovations at ees Europe, and to have the opportunity for discussions with a wide range of trade visitors here,” stated Daniel Hannemann, Managing Director of TESVOLT GmbH.

Lucrative business models
Other business models are also suited to the use of large-scale storage systems, one example being neighbourhood-scale distributed energy storage: Here, operators of cogeneration plants and PV installations utilize the same energy store. Since investment is only required in one storage facility, purchase costs are far cheaper than the installation of several small domestic storage systems. When used to capture surplus power from the German grid, large-scale storage systems also allow plant operators to optimize their electricity marketing.

Hot Topic: E-Mobility
The energy storage industry is becoming increasingly attractive for other industry sectors. Alongside traditional battery and storage system manufacturers, large automotive companies are now setting up production facilities for batteries. Electric vehicles fuelled by electricity from renewable sources represent the climate-friendly mobility solution of the future, and increasingly powerful batteries are becoming more and more important storage resources. The topics of e-mobility and mobile storage systems were among the most important trends at this year’s ees Europe. The new mobile applications are also serving to expand the market, which until recently was dominated by stationary storage systems.

The ees Forum and the ees Europe Conference
The ees Forum also took up the hot topic of e-mobility. Many keynote speeches and case studies illustrated the development of high-performance batteries, e-mobility as well as storage components and infrastructure. Presentations and discussions from international specialists were shedding light on the most important markets and practical experiences in the production, sales, installation and application of batteries and energy storage systems.

For even deeper insights into the trends, the ees Europe Conference kicked off with a number of sessions dedicated to the most pressing questions for all sectors of the energy storage industry. The two-day conference focused on storage systems for household, commercial and industrial applications, energy management, and the political framework conditions for the future of Germany’s energy supply. The conference agenda also included e-mobility. Large-scale storage systems were a key topic at ees Europe Conference, too: Drawing on best practice case studies, the session “Real Life Projects: Commercial & Utility-Scale” provided insight into the technical and economic potential of PV battery systems. In the conference session “European and Global Market Developments for Stationary and Automotive Storage Systems”, attendees had the opportunity to learn how the market for stationary and mobile storage systems is poised to develop, chiefly in Europe but also worldwide,

The Smarter E
More Fairs and an Umbrella Brand
In the future, the new umbrella brand “The smarter E Europe” will combine several fairs around renewable and intelligent energy solutions – among them Intersolar Europe and ees Europe in Munich. From 2018 The smarter E will be a new bracket for diverse events covering topics like regenerative production, distribution, storage and intelligent use of energy. For the first time in Munich, new trade fairs under this umbrella will be “Power2Drive” and “EM-Power”. The Power2Drive Europe addresses traction batteries and the charging infrastructure for e-mobility plus networking of electric vehicles. At the same time the EM-Power will be the trade fair for intelligent energy usage in the industry and in buildings. Later in the future the fair organizers intend to start events, workshops and forums around intelligent energy under the roof of The smarter E.

The next Smarter E event, including Intersolar and ees, will take place 20 to 22 June 2018 in Munich.

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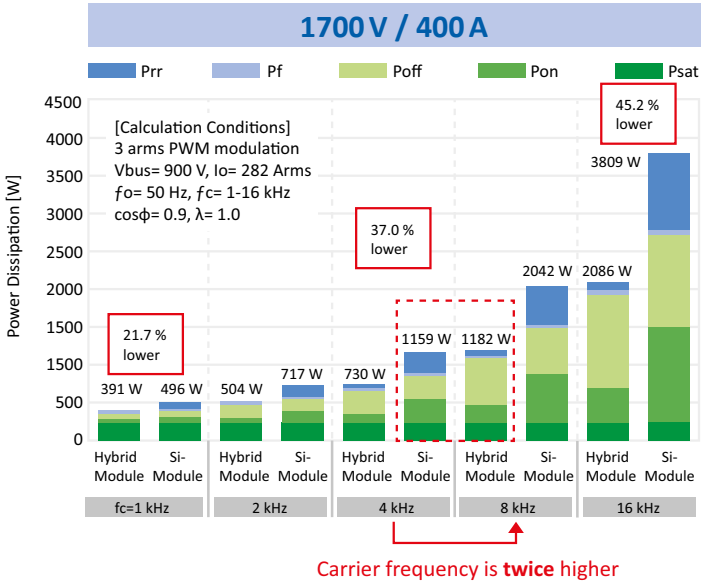
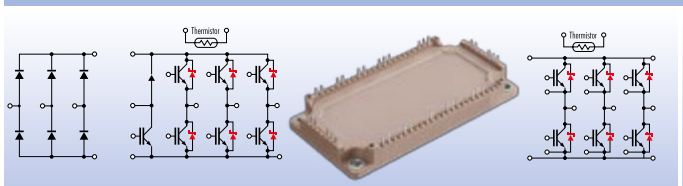


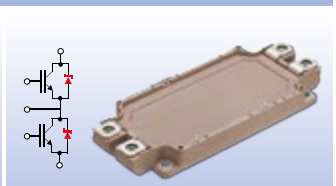
Line-up Plan

1200 V



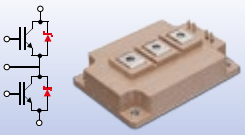
35 A & 50 A | 100 A

200 A & 300 A



200 A – 600 A

1700 V



400 A

450 A & 550 A

1200 A

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Understanding Battery Life for Bluetooth BLE Devices

By Markus Levy, President, Embedded Microprocessor Benchmark Consortium, (EEMBC)

Recently, the industry association named EEMBC produced a new standard for IoT edge node benchmarking. IoTMark™-BLE, as it is called, allows microcontroller and module vendors to demonstrate the real energy usage of their BLE-enabled devices (Bluetooth Low Energy) in IoT edge nodes. The emphasis is on the phrase 'real energy usage'. While all vendors spec out their devices' transmit and receive power in datasheets, these numbers cannot be translated into energy values. BLE is a complex protocol with a variety of operational modes where the power changes over time (e.g. connection interval, advertising interval). Additionally, if the exact runtime details for transmit and receive are not specified in a datasheet (which they are not), it makes it nearly impossible to compare the power or the energy of one microcontroller and/or module to another.

Making the device comparison even more difficult is the fact that vendors can use any settings for transmit power, which will also have a significant effect on a device's energy usage. For example, LSR's SaBLE-x Bluetooth BLE module is spec'd at 8.4mA transmit mode (+5 dBm), whereas the Silicon Labs EFR32 Blue Gecko BLE SoCs are spec'd at 8.5mA transmit mode (0 dBm). The methodology for the EEMBC IoTMark-BLE will help clarify these spec games.

Fundamentally, this benchmark suite, which includes a combined hardware + software framework, measures the energy used by the system while it performs relevant real-world tasks (as defined by the benchmark methodology). The framework is comprised of several hardware components: an EnergyMonitor to measure energy, a Radio Manager to coordinate the communication with the device under test (DUT), and an IO Manager to synchronize activities. The IO Manager is also used to simulate a sensor input (e.g. accelerator, temperature, pressure) on the DUT's I2C and/or SPI ports.

In the paragraph above, the operative phrase is 'used by the system'. We're talking here about a system benchmark. As opposed to CPU benchmarks such as CoreMark, the IoTMark-BLE works on the system which is represented by the MCU, the BLE radio (often integrated into the MCU), the protocol stack, and relevant peripherals. This system benchmark requires hardware interaction to physically perform the radio transmit and receive functions, as well as the IO functions. In EEMBC's case, a Raspberry Pi board with a BLE shield was used as the Radio Manager and an Arduino was used for the IO Manager (both inexpensive platforms). The challenge is coordinating the separate pieces of hardware used for the radio function, IO functions, and for synching the timing window for the energy measurement – this is handled by the host's scripting program).

To establish a real-world environment for BLE usage, you must examine a cross section of applications, such as health monitors, thermostats, toasters, and wearable devices, and see how they operate. Parameters such as payload size and payload transmission frequency, for example, can vary considerably. So since it's impossible to represent every type of IoT edge node, the benchmark standard focuses on the lowest common denominator, sending and receiving a small packet once per second. The most important thing with IoTMark-BLE, and any other benchmark for that matter, is consistency to ensure repeatability and accuracy.

There has been an extremely high level of interest in this new benchmark, partly because there's no other similar testing methodology and partly because of the popularity of IoT and BLE. At this point, we are waiting to see which vendor will be first to publish results and start including them in their datasheets as some have already done with benchmarks such as CoreMark and ULPMark. Whenever EEMBC releases a new benchmark, there's always a period of time where members are determining how to optimize or ensure they are getting the best results possible. This is especially important for an ultra-low energy test where you're checking for any unnecessary power draws from unused pins and proper sleep mode transitions. Without going into explicit detail, the benchmark repeats a specific amount of work once per second (in addition to the BLE transmit and receive). During each second, the DUT must wake up and go back to sleep during periods of inactivity. Therefore, there might be tradeoffs to make based on how long it takes to come out of sleep as well as the ramp-up energy.

There's no question that BLE is one of the most popular communication protocols for low power IoT devices. Beyond BLE energy measuring, EEMBC is evaluating how to next pursue a similar testing strategy for 802.11ah or Wi-Fi HaLow, Thread, or LoRA. The current hardware/software framework is flexible enough to support most of these other protocols with limited effort. Having support for these additional protocols will also help to answer the top-level question, what is the most efficient IoT communication protocol?

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Design Simplicity: GaN Power ICs with iDrive

Navitas Semiconductor was formed in 2013 to enable a high-speed revolution in power electronics with the invention of the industry's first GaN power ICs which deliver up to a 100x increase in switching speeds while increasing energy savings by 40% or more.

VIP-Interview with Navitas Co-Founder and CEO Gene Sheridan about his company's achievements and plans for the future in power electronics.

By Henning Wriedt, US-Correspondent Bodo's Power Systems

Henning Wriedt: Mr. Sheridan, Navitas Semiconductor was founded in 2013. What were the most important facts for the founders to go ahead?
Gene Sheridan: Major disruptions in a given technology domain only present themselves maybe once every two or three decades; GaN power ICs is one of those disruptive opportunities to change the landscape of a $30B power electronics market.

Henning Wriedt: Navitas seems to only bet on the GaN technology. What makes you so sure?
Gene Sheridan: GaN offers a 10 - 100x improvement for a large percentage of the power semiconductor market; only recently has the industry solved fundamental manufacturing and reliability challenges for this technology. Navitas, with its industry-first power IC, has solved the remaining system level issues so there are no remaining barriers to a large scale adoption.

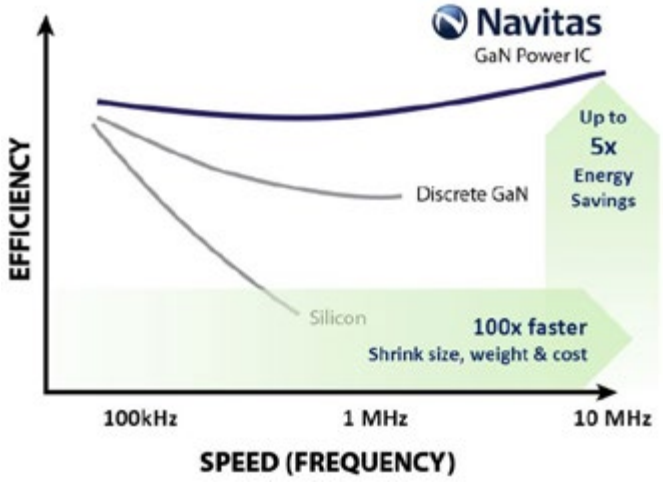

Figure 1: In power conversion, fast switching combined with high efficiency enables small size, low weight and lower system cost.

Henning Wriedt: Do you think of other basic materials as well? Maybe later?
Gene Sheridan: It's a question of applying the right materials and device structures to various power and voltage levels. In lower voltages below 100V, silicon continues to be very compelling with significant performance and integration developments. In medium voltages between 100V to 1,000V, GaN lateral device (on a low-cost silicon substrate) is a clear choice to enable higher performance, higher density and lower cost systems. Above 1,000V, SiC vertical devices are the likely choice for these high powered systems for the best cost/performance advantage.

Henning Wriedt: Regarding GaN Power ICs: How do you manage this triangle of high frequency, high efficiency and reduced costs?
Gene Sheridan: GaN power ICs enable all three simultaneously through the high level of integration that is achieved. By integrating power with analog and digital circuits, we are (1) eliminating parasitics between these circuits thereby increasing frequency and efficiency, (2) leveraging GaN for these circuits which is fundamentally faster and more efficient than their silicon counterparts and (3) reducing cost by eliminating the multiple packages and die area as compared with silicon discrete components and by reducing the cost of passive components that is reduced through the higher frequency operation of GaN power ICs. The perfect trifecta!

Henning Wriedt: In February you introduced the "world's first half-bridge GaN Power ICs". Why did you choose this type of IC?
Gene Sheridan: The half-bridge circuit is the most popular circuit used in power electronics, applied in over 70% of all power systems in one form or another. To enable a half-bridge circuit to operate at high frequency and high efficiency, the integration of hi-speed circuits including driver, level shifter, boot strap, UVLO and shoot-through protection are all very critical. In addition, eliminating the circuit parasitics, such as source loop inductance, is essential for high speed operation. All of these goals are accomplished simultaneously with our half-bridge GaN power IC.

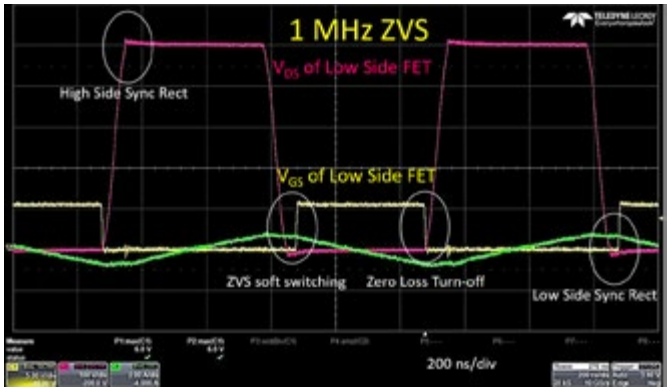

Figure 2: Switching waveforms exhibit a true "text book" feeling with very clean rising and falling edges and no ringing.

KNOWLEDGE IS POWER

Massive power density in the smallest packages

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

Highlights

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

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Henning Wriedt: Your website says: GaN Power ICs with iDrive are the ultimate in circuit design simplicity. Please give us some more details.
Gene Sheridan: To drive silicon or GaN discrete devices at high-speed with high efficiency requires a very careful component selection and layout optimization. All circuits such as driver, level-shifter, boot-strap, UVLO, gate protection and shoot-through protection are critical and if not designed or laid out perfectly can lead to poor circuit efficiency, excessive heat dissipation or even reliability risks. With AllGaN power ICs, all of these circuits are pre-designed and perfectly matched to each other. Only a simple, layout-insensitive digital input is needed and high-speed and high-efficiency power is enabled effortlessly.

Figure 3: The industry's first integrated half-bridge Gallium Nitride (GaN) Power IC

Henning Wriedt: Please explain your AllGaN process design kit. Do customers have access to this kit regarding custom designs?
Gene Sheridan: This PDK includes an extensive and growing library of GaN devices, circuits and models. It is proprietary to Navitas developed over the past three years. While not open to customers, it is the key enabler that allows Navitas to innovate new power, analog and mixed-signal circuits with unprecedented efficiency and frequencies for our customers addressing a broad range of applications.

Henning Wriedt: Getting into worldwide markets - will you use established distribution companies?
Gene Sheridan: Yes, we plan to offer our GaN power ICs broadly available through many traditional and new sales channels later in 2017.

Henning Wriedt: What can the electronics industry expect from Navitas in the upcoming two years?
Gene Sheridan: We are initially targeting mobile and consumer adapter applications – in these segments, we are enabling a 3x increase in faster charging and higher density power adapters with lower bill-of-material costs. This will have a major impact on these industries. Within the next two years, we will expand in to data centers, LED lighting and solar inverters in which we will enable a 5-10x increase in power density and 3-5x improvement in energy savings. Fun times ahead!!

Biography of Gene Sheridan, Co-Founder and CEO of Navitas Semiconductor

Gene Sheridan brings over 25 years of experience in power management and semiconductors with an impressive track record in creating, leading and scaling businesses that have enjoyed excellent value creation, growth and profitability.

Most recently, Gene served as CEO of the VC-backed semiconductor start-up BridgeCo that captured 80% market share in the wireless audio market before a successful sale to Standard Microsystems Corporation (SMSC).

Prior to BridgeCo, Gene served as VP & GM at International Rectifier where he managed a business unit with a team of over 100 employees and $600M annual revenues.

At IRF, Gene held several positions that spanned engineering, manufacturing, sales & marketing including the creation of a $70M/yr start-up. Gene holds a BSEE from Clarkson University.

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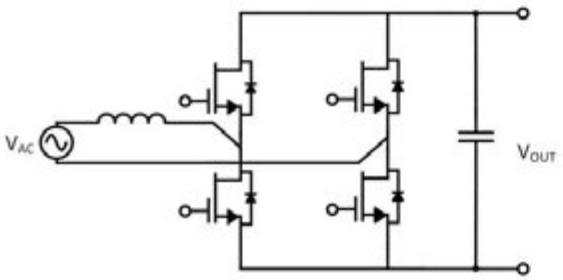

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From Petrol to Wireless Charging

Mobility evolves with advanced power systems

This article explains the development of electric mobility, with a focus on e-bikes which are proliferating around the world, especially in developing regions. These new means of personal travel have necessitated a rethink in charging technology – primarily to reduce charging time while adhering to stringent safety standards. Integrated high-voltage ICs are now available to address the needs of such advanced power systems.

By Chris Lee, Product Marketing Manager, Power Integrations and Alix Paultre, Industry Commentator

Easing the ability for a person (and their belongings if possible) to travel from point A to B has always been a challenging and competitive enterprise. From human-powered systems to steam to internal combustion to super-capacitors, the desire to safely compress energy into a form useful to a vehicle has driven (no pun intended) designers to try just about every technology that can store energy, from coiled steel springs to flywheels.

Mainstream mobility has been driven by internal combustion engines connected to the drive wheels of a vehicle with a mechanical drivetrain. From scooters to semitrailers, burning engines have dominated the power scene. However, the emergence of truly viable alternative drivetrain and energy storage systems has made the coming proliferation of electric vehicles in the marketplace inevitable. In every single case, solid-state solutions have displaced analog in every application space one has been created for.

EVs everywhere

Electric mobility is getting a big boost with the advent of next-generation power electronics. New topologies and technologies have shrunken circuits, increased power density, reduced thermal loading, and enhanced efficiency. The next generation of passenger vehicles will break the anxiety over range limits, and; commercial applications like electric buses and autonomous trucks are already beginning to germinate.

One area often overlooked in developed countries is in two-wheeled and three-wheeled e-mobility. The impact of e-bikes, trikes, and carts in the developing world cannot be understated. In addition to providing highly reliable and quiet transportation to the masses, EVs in this category push dirty and noisy two-stroke engines out of the market, quieting and cleaning up the street environment. This provides cascading benefits throughout an economy.

Certain countries have even passed laws to encourage the adoption of e-bikes. In China the authorities will stop issuing new licenses for gas-powered bicycles in favor of e-bikes. In every mobility industry size, weight, and energy density are paramount, fomenting development in improved power management systems. With the expansion in EV ownership there is an increasing need for more and better charging stations, with the demand to support faster charging at higher voltages and currents than previously available.

Overcoming challenges

This pressure for smaller, faster, and more powerful presents the design engineer with a great many challenges to address. Nobody wants charger to be slower, yet nobody wants to fumble with ungainly cables and connectors just to be able to drive their EV. Everyone wants higher power densities, but nobody wants a thermal runaway in their basement (go figure).

Each requirement has a school of related issues following it like remoras on a shark. Increased power density and current handling impacts thermal management as well as vias, pins, cables, and connectors. Increased durability and ruggedness affects bulk and cost in a near-direct ratio. Chasing only cost and time-to-market can lead to incomplete engineering that leads to eventual system failure.

Powering mobility

To meet this need, companies like Power Integrations offer solutions using integrated high-voltage ICs. Devices able to address the needs of advanced power systems must have features like current limiting and thermal shutdown, frequency jittering to reduce EMI, and high switching frequencies to significantly reduce the size of the magnetics.

For example, their TOPSwitch™-JX cost-effectively incorporates a 725 V power MOSFET, a high-voltage switched current source, multi-mode PWM control, and additional protection features into a single device. Energy-efficient over its entire load range, the device has a no-load consumption of less than 70 mW at 230 VAC.

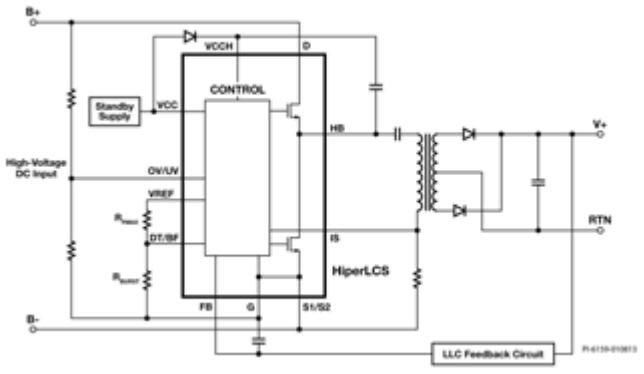

Figure 1: HiperLCS showing very low component count

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Cu-AlN AMB Substrates with superior bending strength > 600MPa and lowest thermal resistance with thin AlN (0.38mm thick; 170 W/mK). DAB Substrates with excellent reliability > 3.000 cycles for -40/+125°C.

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Another highly-integrated example is the HiperLCS™ IC, an integrated LLC power stage with a multi-function controller, high-side and low-side gate drivers, and two power MOSFETs in a half-bridge configuration. Devices like these can eliminate dozens of external components in a circuit, reduce assembly cost, and dramatically shrink magnetics size while using SMD ceramic output capacitors.

Reducing the BOM

This reduction in external power components is a significant force multiplier in a system. As another example, Power Integration's HiperTFS™-2 devices bring a high-power two-switch-forward converter and a mid-power flyback (standby) converter into a single, low-profile eSIP™ power package. This single-chip solution provides the controllers for both of the two-switch-forward and flyback converters, high- and low-side drivers, all three of the high-voltage power MOSFETs while eliminating the converter's need for costly external pulse transformers.

The device is ideal for high power applications that require both a main power converter (two-switch forward) up to 586 W peak, and a standby converter (flyback) up to 20 W. The devices operate over a wide input voltage range, and can be used following a power-factor correction stage such as HiperPFS™-4, and has a self-biased high-side driver eliminating the bias winding and drive circuitry normally required. It is important to note that the solution addresses the system needs for high efficiency and high reliability, -but does not compromise performance for the sake of reduced parts count.

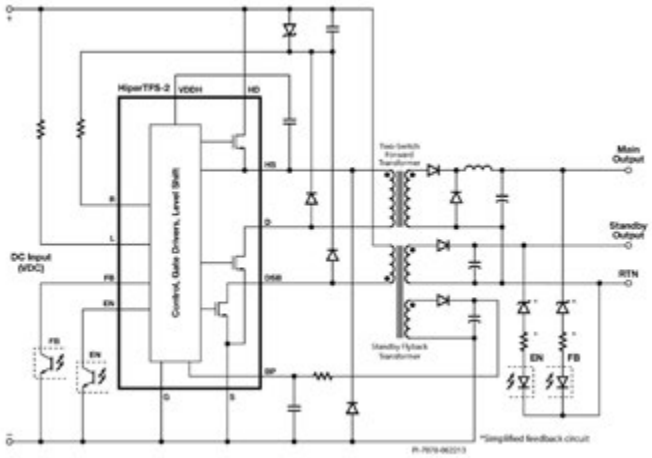

Figure 2: Highly integrated two-switch-forward plus flyback power conversion

High device integration allows for a smaller form factor, with delivering benefits throughout the system beyond higher power density and reduced component count by incorporating control, gate drivers, and power MOSFETs.

Enhancing performance

The HiperPFS-3 family of devices take that integration even further by incorporating a continuous conduction mode (CCM) boost PFC controller, gate driver, ultra-low reverse recovery diode, and high-voltage power MOSFET into a compact, heat-sinkable package. In addition, the HiperPFS-3 family features a light-load digital enhancer that increases the power factor to more than 0.92 at 20% load (highline) plus an efficient "light load" mode which consumes less than 60 mW in no-load.

The HiperPFS-3 families' variable-frequency continuous-conduction mode operation minimizes loss by maintaining a low average switching frequency and by modulating that frequency across each input half cycle, also suppressing peak EMI. Systems using HiperPFS-3 typically minimize the total X and Y capacitance requirements of the converter and the inductance of both the boost choke and EMI noise suppression chokes, thereby reducing overall system size and cost.

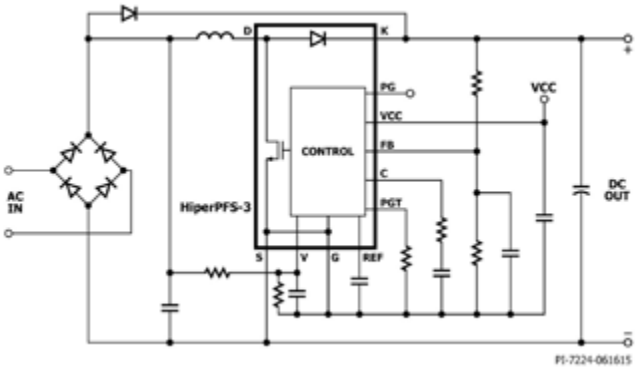

Figure 3: HiperPFS-3 – Note the integrated CCM-boost diode and simplified feedback network feeding the integrated non-linear amplifier via the FB pin

HiperPFS-4 devices use the same innovative control technique that eliminates the need for external current-sense resistors and their associated power loss, and also adjusts the switching frequency over output load, input line voltage, and across the input line cycle. This maximizes efficiency, particularly at light loads, and minimizes the EMI filtering requirements due to its wide-bandwidth spread-spectrum effect. The devices use digital line monitoring, line feed-forward scaling, and power factor plus THD enhancement at light load, while using analog techniques for the core controller in order to maintain extremely low no-load power consumption.

HiperPFS devices also feature an integrated non-linear error amplifier for enhanced load transient response, a user programmable Power Good (PG) signal as well as user selectable power limit functionality. Protection features include UV, OV, brown-in/out, and hysteretic thermal shutdown, as well as cycle-by-cycle current limit and Safe Operating Area (SOA) protection of the power MOSFET, output power limiting for overload protection, and pin-to-pin short-circuit protection.

Efficiency without PFC

The DER-447 reference design creates a high-efficiency system without PFC. The 184 W constant voltage and current power supply uses the HiperLCS LCS705HG and the LinkSwitch™-TN LNK302D. The solution can accept from 90 VAC to 132 VAC and deliver 184 W (23 V at 0.5 to 8 A). To highly integrated LLC stage further reduces parts count. The LNK302D is used in a flyback mode as a bias supply to provides power for both primary and secondary control circuitry. The secondary control circuitry provides a CV/CC output characteristic for use in battery charging applications.

The DER-580 is a 118 W flyback design taking from 180 VAC to 264 VAC and delivering 59 V at 2.0 A for battery charging applications. The high-power flyback design also has a low component count, and offers features like 66 kHz operation for high efficiency (>90% at 230 VAC). At charging currents below ~0.5 A, the output voltage switches form the 59 V charging voltage to a float voltage of 56 V to maintain battery charge without overcharging.

Based on TOPSwitch TOP267EG with no PFC input stage, it is designed to operate without a fan, and includes a thermal switch that reduces the current limit at elevated temperature (thermal foldback) to enable continued charging at reduced output current without thermal shutdown. Solutions like these maximize function without reducing safety or reliability of the system while still providing the service desired.

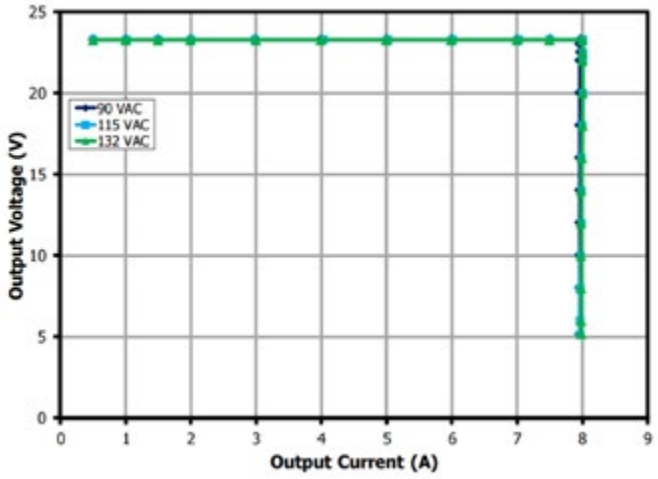

Figure 4: CV CC output characteristic of DER-447 showing excellent stability across line

Driving ahead

Creating power systems for the next generation of advanced vehicles using battery systems must address the increased demands for size, power density, reliability, and performance. Using highly-integrated building blocks and designs intended to maximize the benefits of each component in the system will go a long way to addressing those concerns.

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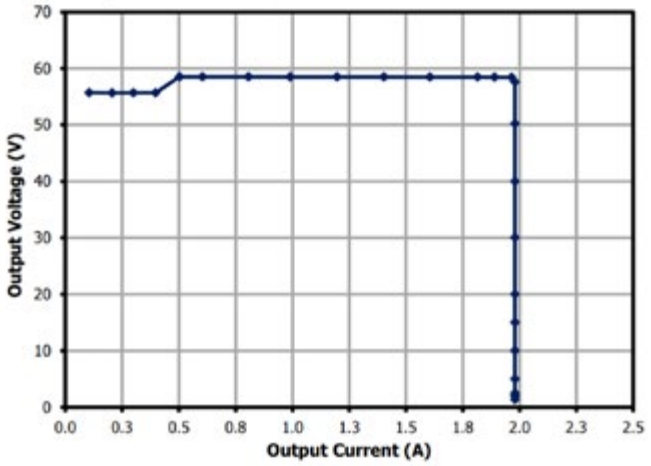


Figure 5: CV CC output characteristic of DER-580 showing the light load voltage step to ensure support of both charging and float-voltage modes depending on charge-state

"PFC + Inverter" IPM (Intelligent Power Module) in 21mm x 36mm for Low Power Drives

A PFC+Inverter IPM (Intelligent Power Module) optimized for low power Drives is introduced. A three phase inverter and a single boost PFC stage are integrated in one single miniaturized DIL (Dual-In-Line) transfer molded type package with a SOI (Silicon On Insulator) gate driver.
With this IPM, the size and cost of system can be dramatically reduced.

By Byoungho Choo, Hyosang Jang, Junbae Lee, Minsub Lee and Daewoong Chung, Infineon Technologies Power Semitech, Korea

Overview

The internal circuit of the new IPM is composed of inverter stage and PFC stage. The three phase inverter stage has six 600V rated TRENCHSTOP™ IGBTs and six Emitter Controlled Diodes together with one SOI gate driver IC which provides integrated bootstrap circuit, and thermistor for temperature monitoring. The PFC stage consists of a 650V rated TRENCHSTOP™ IGBT and a Rapid Switching Emitter Controlled Diode which has fast and soft switching characteristics (figure 1).

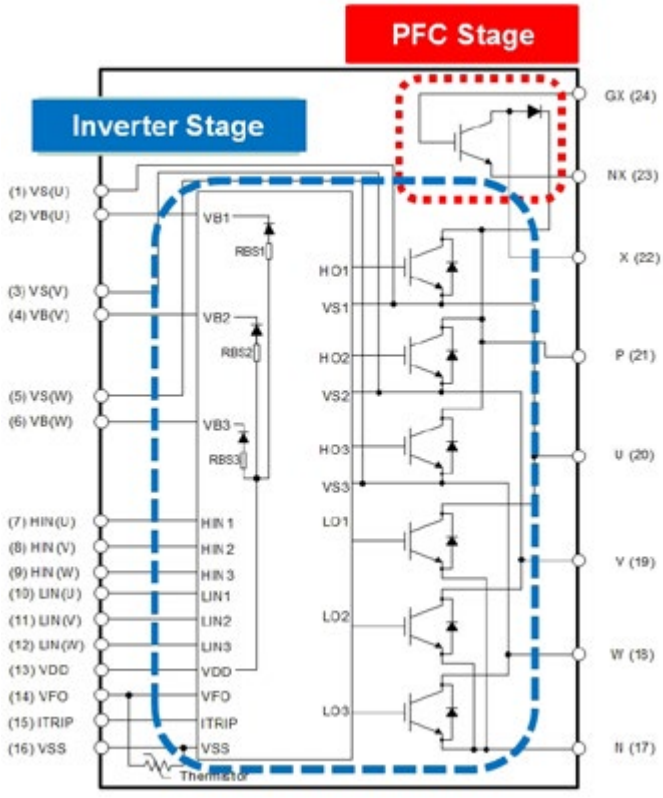


Figure 1: Internal circuit

Cost reduction

Minimizing total cost is the most important consideration for system engineers when developing new motor drives. Not only material cost like IPM itself, heatsink and PCB but also development time to market is main factors of the total cost.

Miniaturized transfer molded package (package size and structure)

Package outlines of the IPM with high level integration are shown in figure 2. The IPM builds in a compact size of Infineon Technologies CIPOS™ (Control Integrated POwer System) Mini package of 21mm x 36mm x 3.1mm. The new IPM is UL approved (UL 1557 File E314539) and RoHS compliant.

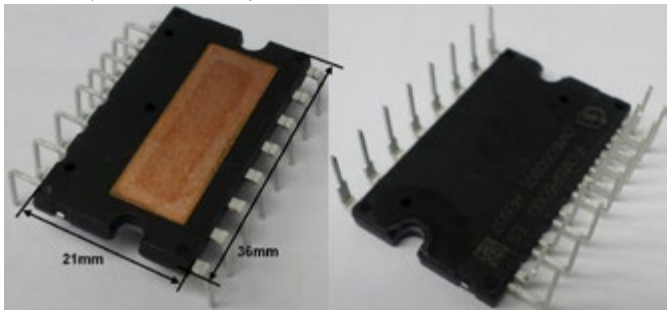


Figure 2: External view

DCB (Direct Copper Bond) which is a substrate with good thermal conductivity is adopted as a substrate for high thermal performance. Figure 3 shows the cross section view of the new IPM. All of the major heat sources like IGBTs and Diodes are mounted on DCB, in order to fully utilize the heat transfer capability of this package. Therefore the new IPM can be an excellent solution for up to 3kW motor drives even though the package size is extremely compact [1].

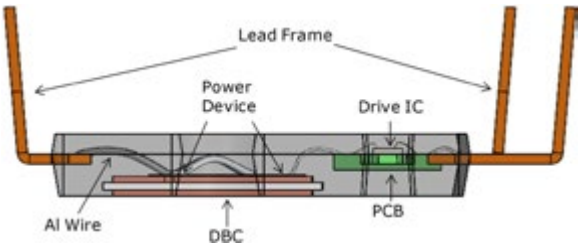


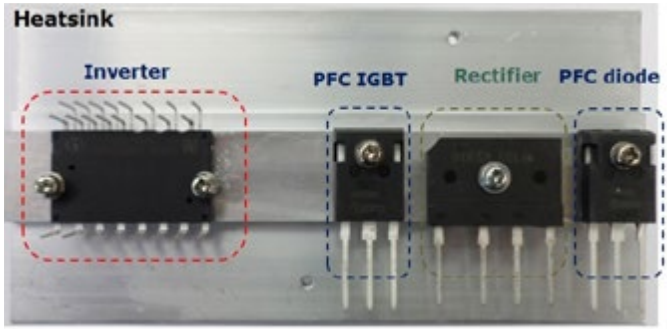
Figure 3: Cross section view

Heatsink and PCB size

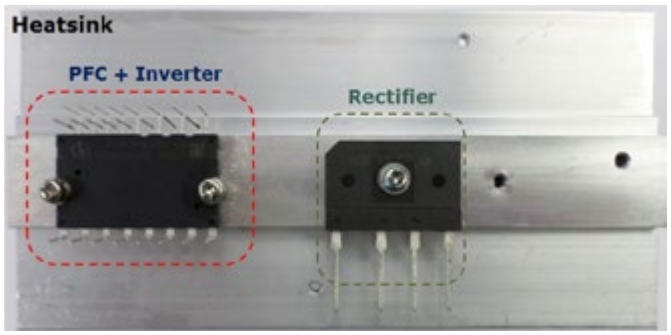
All of the power semiconductor components (i.e. a bridge rectifier, a discrete IGBT for PFC, a discrete boost diode, and an IPM for motor drive) are normally mounted on one heatsink for their heat dispassion. Figure 4 shows how much the size of PCB and heatsink can be reduced and the assembly process can be simplified by integrating discrete power semiconductor and drivers into one package [2].

Discrete PFC and inverter IPM solution

The new IPM solution



4a: Discrete PFC and inverter IPM solution



4b: The new IPM solution

Figure 4: Mounting configuration on a heatsink

Development speed up (reference board, Figure 5 and 6)

Circuit design, artwork and PCB assembly take much time in system development process. To reduce the time spent in the process, and quickly determine whether the new IPM can run a motor, a reference board has been developed. The minimum set of peripherals to operate a motor are mounted on the board and the others like PWM signals, +5/+15V dc power source, PFC inductor, DC-link electrolytic capacitor can be utilized from outside of the board via wire connection to the reference board.

650V rated PFC stage

Infineon Technologies has developed two kinds of products according to their PFC IGBT characteristics. They are High Speed 3 (HS3) for 20kHz switching frequency and TRENCHSTOP™ 5 (TS5) for 40kHz switching frequency, as listed in Table 1. The Rapid Emitter controlled Diode of Infineon is optimized to operate with TRENCHSTOP™ IGBT as a boost diode in PFC topology. It combines low VF for lower conduction losses and low Irr to reduce E_{on} of the IGBT [3]. All of the power devices have 650V of voltage rating and it provides higher reliability and ruggedness against unstable AC grid [4].

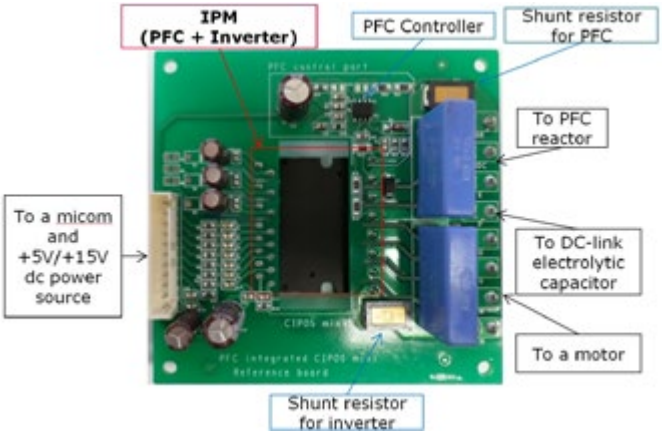


Figure 5 a: Reference board structure Front side

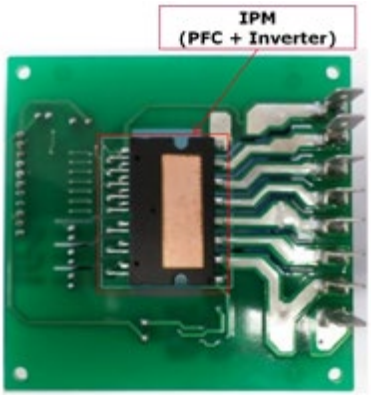


Figure 5 b: Reference board structure Back side

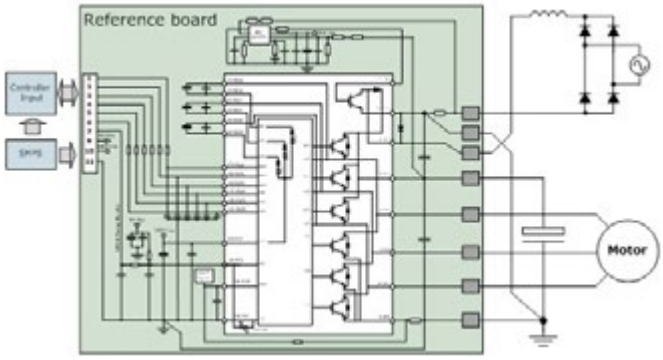


Figure 6: Application example of the reference board

Part number	PFC Stage			Inverter Stage			Maximum motor power
	Voltage rating	Current rating	Target Fsw	Voltage rating	Current rating	Target Fsw	
IFCM15P60GD	650V	30A	40kHz	600V	15A	5 kHz	3kW
IFCM15S60GD	650V	30A	20kHz	600V	15A	5 kHz	3kW
IFCM10P60GD	650V	30A	40kHz	600V	10A	5 kHz	2kW
IFCM10S60GD	650V	30A	20kHz	600V	10A	5 kHz	2kW

Table 1: Product line up, ratings and target switching frequency

Features of inverter stage

Inverter stage has many functions for safe operating of Inverter. These functions can be achieved by a rugged SOI gate driver and a thermistor.

- Allowable negative VS potential up to -11V for signal transmission at VBS=15V
- Integrated bootstrap functionality
- Under-voltage lockout at all channels
- Cross-conduction prevention

- All of 6 switches turn off during protection
- Over current shutdown
- Temperature monitor

Over current protection

The new IPM monitors the voltage of ITRIP pin and when the voltage exceeds the $V_{IT,TH+}$ (positive going threshold voltage), a fault signal is activated and all the 6 IGBTs are turned off. The maximum over current trip level is generally set to below 2 times of the nominal rated collector current [5].

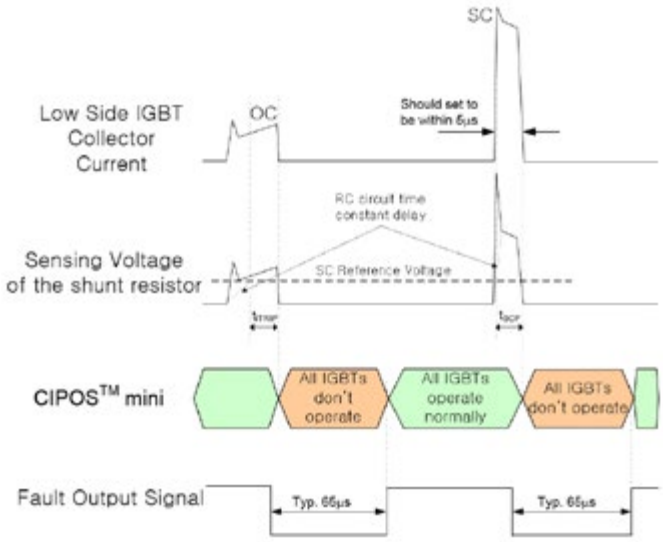


Figure 7: Time chart of over current protection

Over temperature protection

For over temperature protection, a thermistor is integrated in this IPM. The resistance is typically 85kΩ at 25°C and 5.4kΩ at 100°C (Figure 8).

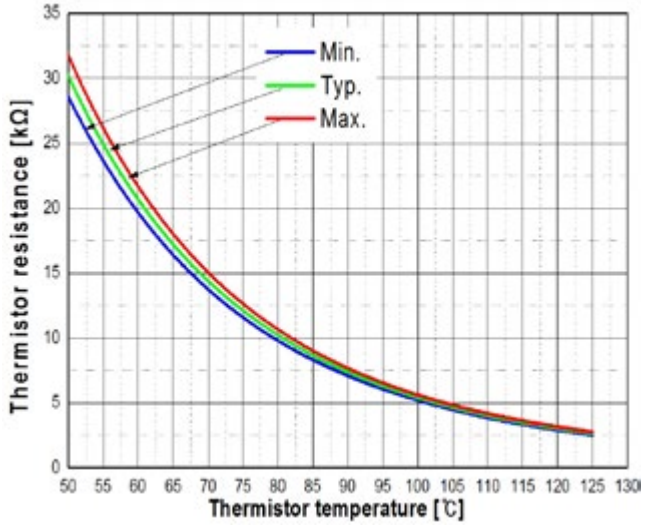


Figure 8: Thermistor resistance vs. temperature

As shown in Figure 9, VFO pin is connected directly to ADC and fault detection terminals of micro controller because the thermistor is connected in parallel with fault out terminal which has open drain configuration. For example, when pull-up resistor R1 is 3.6kΩ VFO voltage at about 100°C is 2.95V_{typ}. at V_{crt}=5V and 1.95V at V_{crt}=3.3V as shown in Figure 10.

Thermal evaluation

Figure 11 is the test circuit and measured waveforms which show the test system's operating status for evaluating thermal performance at input power of 2kW. The operating conditions are PFC controller=ICE2PCS05G, input power P_{IN}=2kW, AC input voltage V_{IN}=220V/60Hz, DC-link voltage V_{DC}=400V, switching frequency of inverter=5kHz, switching frequency of PFC=20kHz, R-L load (R = 13.75Ω, L = 2.96mH, Power factor=0.99), MI=0.69, Gate resistor Rg=5.1Ω, ambient temperature Ta=25°C. The device under test is IFCM15S60GD. Input power factor is about 0.995 and THD is about 9.78%.

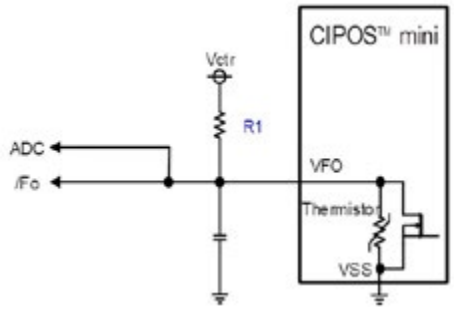


Figure 9: Circuit for over temperature protection

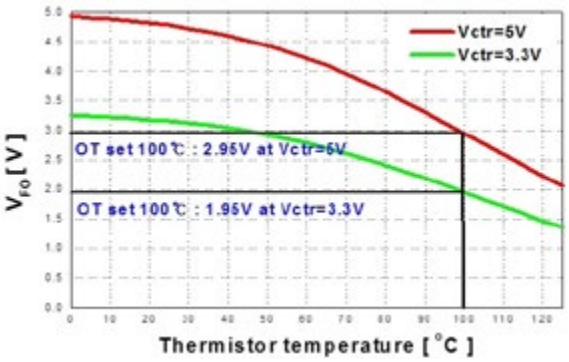


Figure 10: V_{FO} voltage vs. temperature

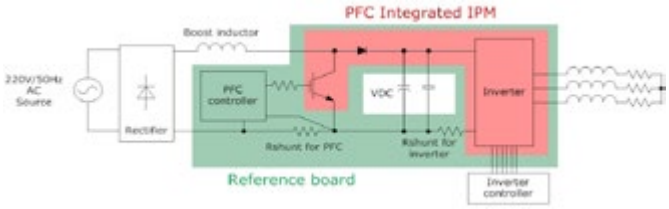


Figure 11a: Test circuit and waveform of the new IPM, Test circuit

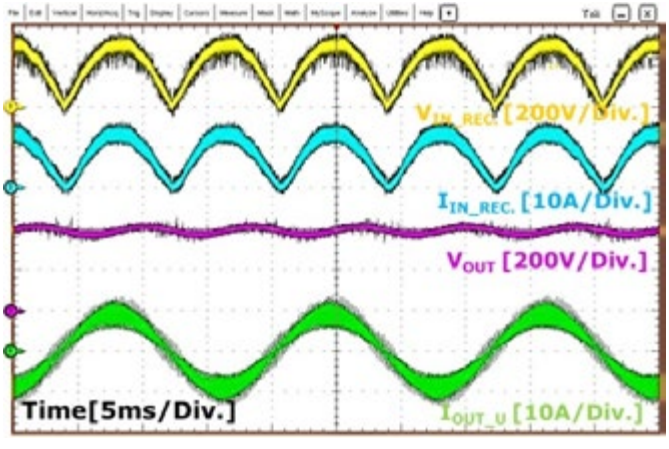


Figure 11b: Test circuit and waveform of the new IPM, waveform

The case temperature under PFC IGBT's position is about 67.5°C as the highest point and it is higher than that of inverter part. IFCM15S-60GD is enough to deal with over 2kW power.

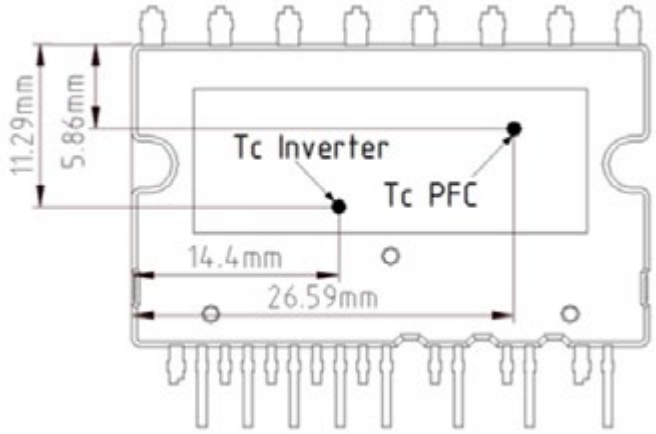


Figure 12a: Temperature measurement point and test results of the new IPM (IFCM15S60GD), Temperature measurement point

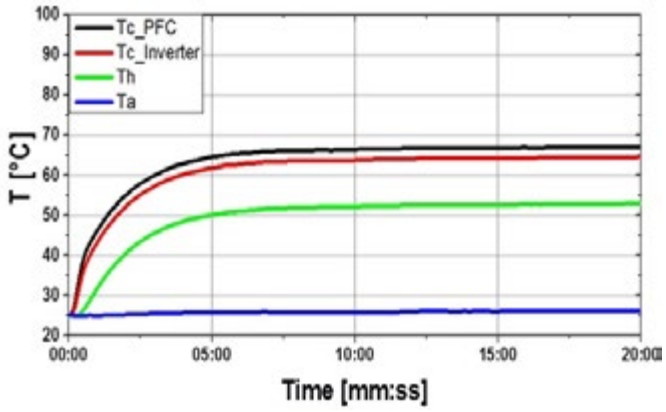


Figure 12b: Temperature measurement point and test results of the new IPM (IFCM15S60GD), temperature graph

Summary

New Intelligent Power Module is the best solution with inverter and PFC topologies for variable speed motor drive such as room air conditioner. Infineon Technologies owns all necessary technologies and is committed to support its customers to realize compact and more efficient solutions with minimized system size, total cost and time to market.

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A New Thyristor Platform Optimized for 10 GW UHVDC Transmission

To satisfy the permanently growing demands on the transmission capacity and efficiency of UHVDC systems, ABB has developed the 3rd generation Phase Control Thyristor Platform targeting the current rating of 6250 A. It offers 100 mV lower ON-state voltage drop V_T (a better technology curve V_T - Q_{rr}), shorter commutation turn-off time t_q, higher surge current capability with I_{TSM}, and much more, while providing the same blocking stability and system fault tolerance as the previous generations. Likewise the 2nd generation, the new platform is based on more than one voltage class. As shown in this paper, 7.2 kV and 8.5 kV voltage classes keep the design and application versatility from the previous generation.

By Jan Vobecký, Urban Meier, Kenan Tugan, Christian Winter and Makan Chen, ABB Switzerland Ltd. – Semiconductors, Lenzburg

Introduction

As the possible length of the high-voltage direct current (HVDC) transmission line is not limited by any fundamental stability criteria, the lines with lengths at 2000 km are in operation today. Under construction in China are 10 GW and 12 GW HVDC projects, among which the Changji–Guquan ultra high-voltage direct current (UHVDC) link will transmit 12 GW of electricity over 3400 km using ±1100 kV/5.5 kA dc voltage line. This record-breaking rating represents 50 % higher capacity than the current state [1]. The line-commutated converters for AC-DC and DC-AC conversion in both ends of this transmission line are using PCTs produced from 150 mm silicon wafers with a rating current of ≈6 kA (see Fig.1). The line should be in operation by State Grid Corporation of China from 2018. To make these projects even more energy and cost efficient, further development of low-loss thyristors is going on. A possible way to contribute to this development on the thyristor side is shown below.

Figure 1: PCT wafer processed on 150 mm silicon wafer to be closed into a hermetic package

Device Design for Lower Losses

To further improve the technology curve and increase the current ratings requires either:

- to reduce the silicon wafer thickness or
- to increase the cathode area (wafer diameter) or
- to apply both above.

The silicon thinning (1.) is more demanding from the silicon design point of view. On the other hand, it does not require any changes in package design and does not increase the assembly cost. To increase the active area (2.) is relatively simple from the silicon design and process viewpoint as long as we did not reach the 150 mm or other commercially available diameter of silicon wafer bearing in mind that larger diameter possesses new design challenges, e.g. mechanical clamping. As this area limit has been already reached at the 2nd generation for 150 mm, the wafer thinning approach has been utilized for the 3rd generation described below.

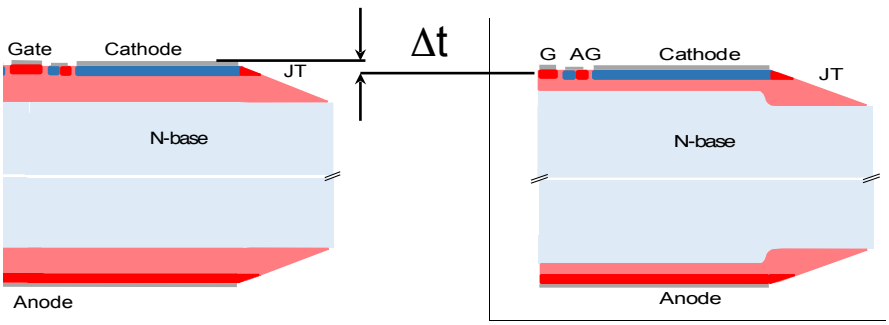
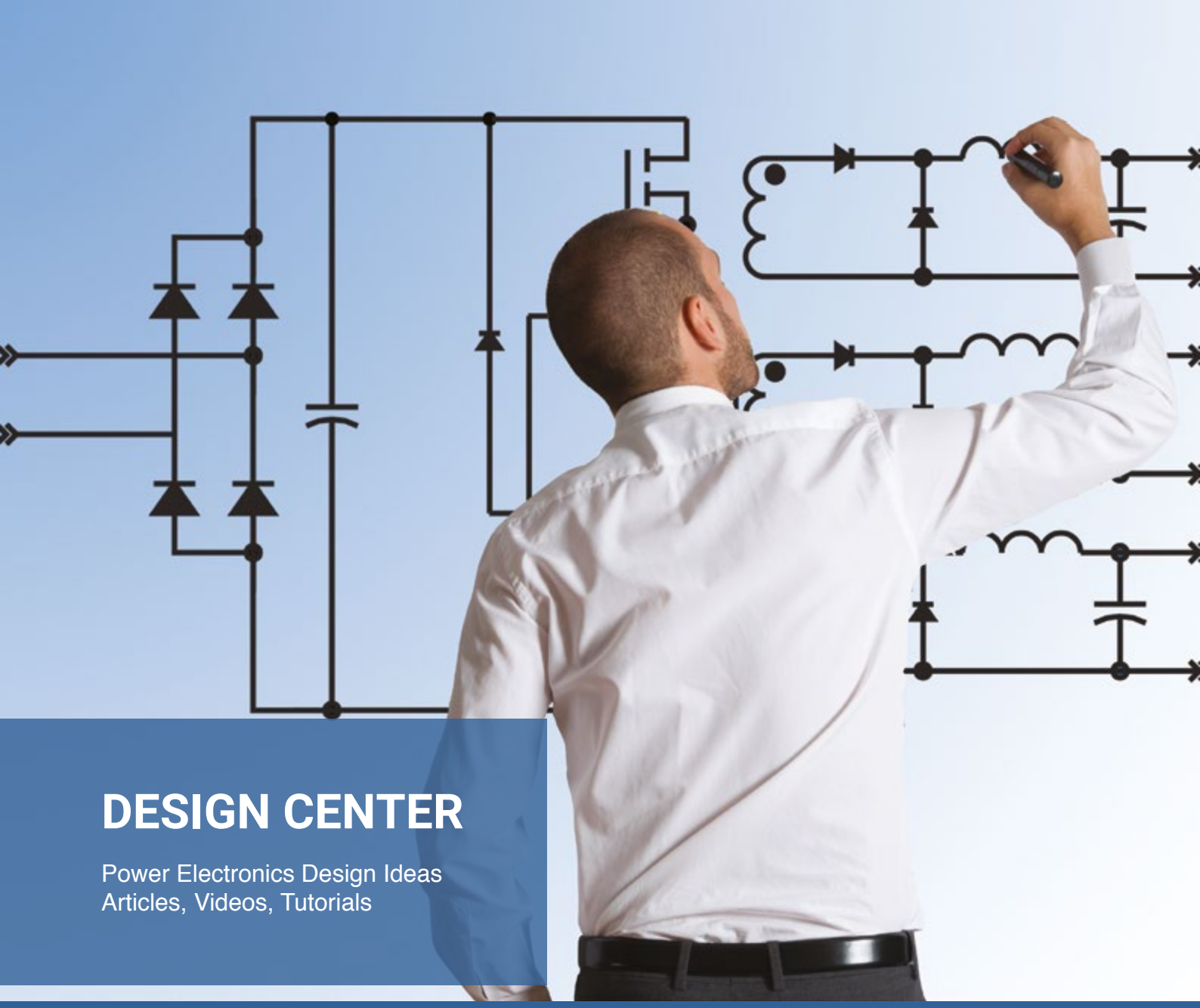


Figure 2: Thin wafer concept of the low loss 3rd generation PCT



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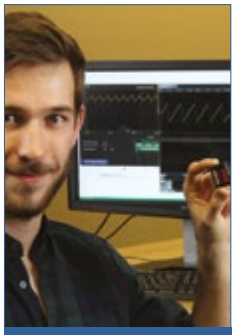

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Following the successful development at four inch wafer [2], which manifests itself in the Raigarh-Pugalur 800 kV HVDC system with a capacity of 6 GW and a length of 1830 km contracted by the Power Grid Corporation of India Ltd for energization in 2019 [3], we introduce the same wafer thinning design concept to our six inch platform. In spite of the thinner wafer, the leakage current does not increase and the original blocking capability stays unchanged. This is because we reduce the thickness of the Ptype anode and P-base layers only in the active area while keeping their original thicknesses at the junction termination (see Figure 2). In the bulk, where the N-base is much thicker than at the junction termination, the leakage current caused by the punch-through effect is eliminated. At the periphery, the punch-through effect remains in its original magnitude. Since the bulk represents about 90 % of the total area, the total leakage current is reduced, which is invested into the wafer thinning to lower the ON-state voltage drop V_T.

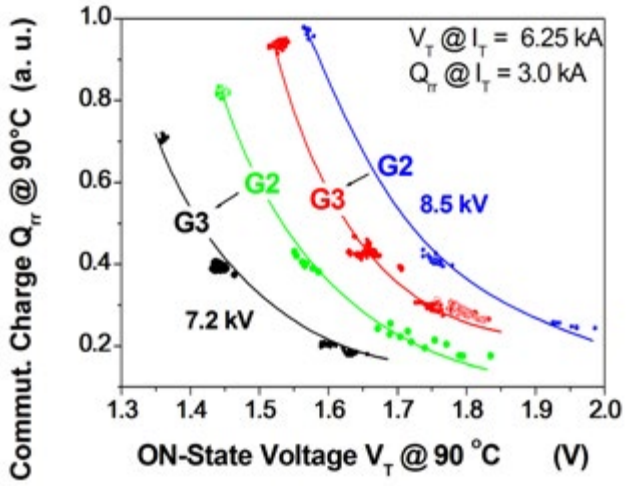

Figure 3: Technology curve Q_{rr} – V_T for the 2nd and 3rd generations of 7.2 kV (Gen. 2 green and Gen.3 black) and 8.5 kV PCTs (Gen.2 blue and Gen.3 red) at 150 mm silicon wafer.

Device Performance

Figure 3 shows the improvement of the technology curve Q_{rr} – V_T measured at T = 90 °C between the 2nd and 3rd PCT generations. The technology curves start from the high commutation charge Q_{rr} of as processed wafers. At this stage, they have high excess carrier lifetime as a result of the gettering treatments by phosphorus- and boron-doped glasses applied after the long diffusion processes in order to move the metal contaminants outside the bulk [4]. In the UHVDC applications with typically one hundred PCTs connected in series, all PCTs must show the Q_{rr} in a narrow band to minimize the dynamic voltage imbalance $\Delta V = \Delta Q_{rr} / C_{snub}$ during commutation recovery. This is performed by high energy electron irradiation, which brings the Q_{rr} into a narrow band and reduces also the turn-off losses at the expenses of increased V_T. The magnitude of the resulting Q_{rr} corresponds to about 20 to 30 % of its initial value with its exact selection depending on the preferences of valve designers. In the whole range of Q_{rr}, the V_T of the new PCTs is reduced by about 100 mV. Valve designer has the freedom to choose between a V_T of about 1.75 V for 8.5 kV class and V_T of about 1.60 V for 7.2 kV nominal blocking capability, both with narrow Q_{rr} band after the Q_{rr} reduction to about 25 % of its initial value. For the owner of our HVDC system, the reduction of the V_T by 100 mV operated at 6 kA leads to saving of »200 W per device, which turns to approximately 1.000 USD saving per device over lifetime, if we account for well accepted conversion of 5 USD/W.

Figure 4 illustrates the further advantage of having available two thyristor voltage classes for the HVDC system design. As shown, the 7.2 kV class gives about 40 % lower t_q, when compared to the 8.5 kV class for both low dv/dt test conditions and medium forward blocking voltage V_D and high dv/dt test conditions and high forward V_D. This

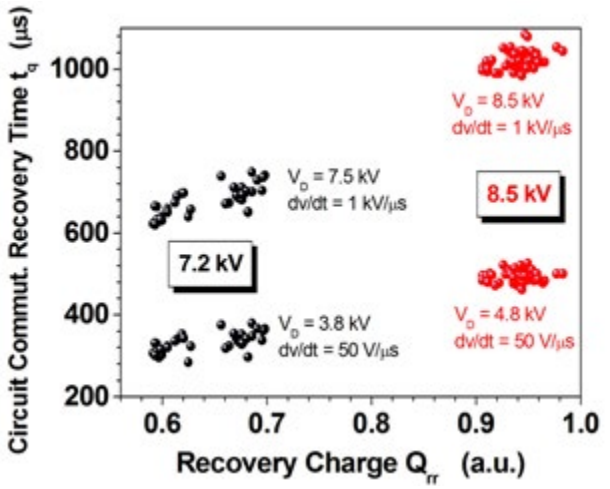

Figure 4: Circuit commutation recovery time t_q of the 7.2 kV and 8.5 kV PCT voltage classes under two different test circuit conditions relevant for application

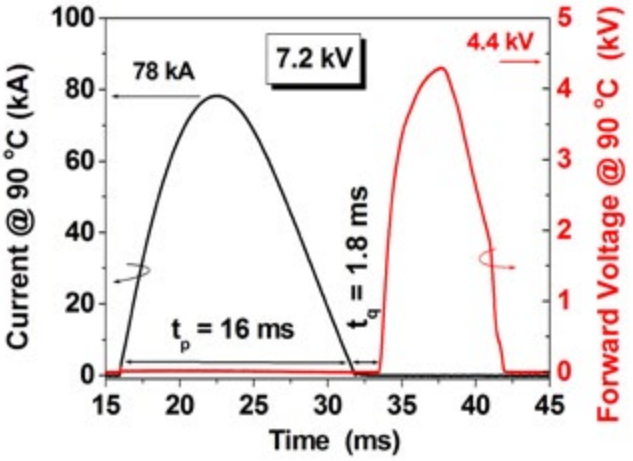

Figure 5: Surge current test with re-applied forward voltage at 7.2 kV class

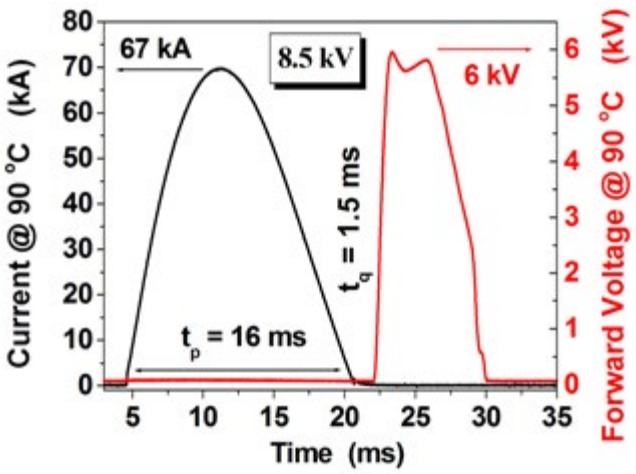

Figure 6: Surge current test with re-applied forward voltage at 8.5 kV class

enables system designer to choose between the lower and higher t_q according to the required controllability of the HVDC system as soon as possible after the commutation recovery. Another option would be to decrease the t_q by further reduction of the Q_{rr}. However, it leads to a significant increase in V_T, therefore we prefer to minimize the t_q by other design means.

The reduced V_T typically reflects in an increased surge current capability (a higher maximal surge current I_{TSM}), if no voltage is applied after the surge current pulse. In this respect, the capability of our 3rd generation has been found beyond the limits of our fab tester, which is 93 kA for the 7.2 kV class and 84 kA for the 8.5 kV class. Similar magnitudes can be obtained for the testing with reverse voltages applied after the surge current pulse and the PCTs have to remain in reverse blocking regime without a failure. These values are about 10 kA higher compared to the 2nd generation.

Figures 5 and 6 illustrate the most demanding I_{TSM} test, when the forward voltage pulse is applied after the surge current pulse of 78 kA for the 7.2 kV class and 67 kA for the 8.5 kV and the devices have to remain blocking the forward voltage pulse of 4.4 kV, respectively 6.0 kV. The example is given for t_p = 16 ms surge current half sine. Again, the possibility to choose the magnitude of the I_{TSM} value with the difference of »10 kA is obvious.

Conclusions

The 3rd generation thyristor platform for UHVDC transmission has been developed with repetitive peak blocking voltages of 7.2 to 8.5 kV in order to facilitate the design of converter valves capable of 6250 A with power rating of 10 GW and above. The presented thin wafer technology provides improved technology curve V_T - Q_{rr}, increased surge current, reduced commutation time and other relevant electrical parameters improved. Altogether, the new generation six inch PCT technology offers valve designers sufficient design flexibility for future UHVDC systems.

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Myth and Truth: Applications & Standards for a 1 W Isolated DC/DC Converter Power Module

By Timur Uludag, Graduate Engineer FH; Product Manager MagI³C Power Modules

Summary:
If you look into the low power range of DC/DC converter modules that which provide galvanic input to output isolation, several questions come to mind. Here are the four most common questions:
Why do you even need an isolated power module?
What does the specification IEC/EN60950-1 in the datasheet actually mean?
How is the 4000 VDC for 1s specification to be understood?
Which solutions does Würth Elektronik offer in it's portfolio?

Why do you even need an isolated power module?
The following schematic (Figure 1) shows a typical application for an isolated power module. It shows the set-up for isolated RS485 communication with the essential functional units.

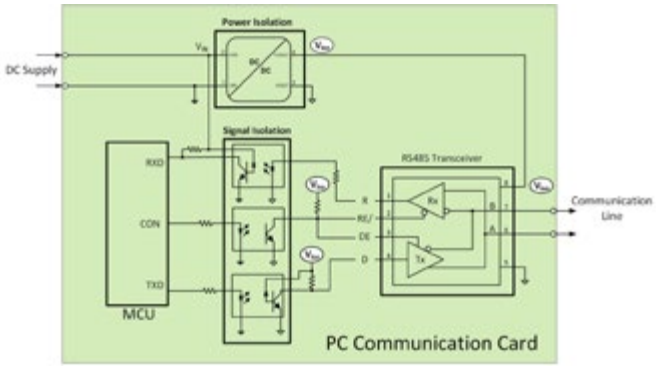

Figure 1: Typical application for an isolated power module

The following functional units are necessary to set up isolated communication:
The Micro Controller Unit (MCU) provides the data for the RS485 transceiver and receives data from it. The signal isolation unit implements galvanic isolation of the signals using optocouplers. Galvanic isolation of the grounds between the signal isolation unit and the transceiver unit is achieved with a power isolation unit - a DC/DC converter power module.

But why should you galvanically isolate a supply from a bus? Galvanic isolation prevents faults that can propagate from the supply voltage onto the bus and disturb it. We pursue this question in more detail in the following subsection.

Ground loops and how to eliminate them:
A ground connection principally fulfills two tasks. On one hand, it serves as a reference for all parts of a circuit and for ground level equalization and hence as a return conductor for currents, on the other.
If a voltage in a circuit is referenced to ground, i.e. an asymmetrical circuit structure, ground loops can take place. They always arise if two ground points of a spatially separated circuit are electrically connected at several points.

The illustration shows a simplified schematic consisting of two functional units (block 1 - source, block 2 - sink). As a result of the spatial separation of the grounds between block 1 and block 2, a non-negligible line impedance Zsource arises. When the current flows in the "return line from block 2 to block 1", i.e. on the ground line, a voltage drop UM1/M2 across the line impedance Zsource is generated. This results in a shift of the respective ground levels M1 and M2.

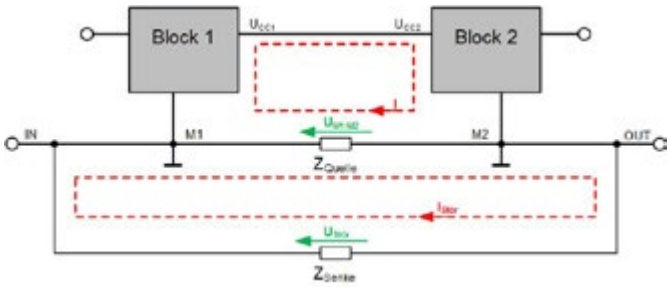

Figure 2: Analog circuit with ground loop

Taking a voltage measurement from the input relative to the output ground point and the output relative to the input ground point, this voltage appears as a DC interference voltage. As long as ground M1 and ground M2 are not yet connected together via a further electrical connection, this is of no consequence.

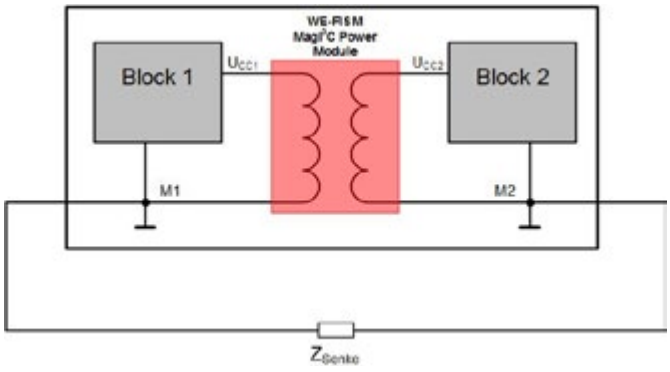

Figure 3: Galvanic isolation of the grounds

Only when the two ground nodes M1 and M2 are connected together via an additional line an interference current can flow. This in turn generates a voltage drop across the line impedance Zsink – which consequently leads to DC interference. An additional connection arises, e.g. through inserting another part of the circuit with its ground structure into the existing ground structure, as depicted in Figure 2.

The attenuation of the interference described can be attained by selecting suitable decoupling methods. In principle, there are several options, whereby the following are essential:

- Selection of a suitable ground structure
- Systematic design of a star ground structure (star tree, bypass)

- Galvanic isolation

The decoupling design through galvanic isolation is shown in Figure 3. Galvanic isolation of block 1 and block 2 inserts a very high isolation resistance with a decoupling effect into the ground structure. Therefore, an interference current cannot flow or can only circulate through the coupling capacitance of the transformer. In general it is said that the ground loop is "broken".

The following types of interference can be eliminated through the use of a DC/DC power module:
EMC – As a result of the spatial extent of the ground loop, e.g. on a circuit board, to a first approximation it can also be viewed as a kind of loop antenna (see Figure 2). This antenna can now both transmit/output interference, as well as "receive" interference from the surroundings and thus input into the circuit. This loop antenna is eliminated by using an isolated DC/DC power module, as there is no longer any closed circuit path.

Over voltage / voltage imbalance – If, due to a fault or external influence, the voltage UCC2 increases in block 2 of the circuit, a galvanic connection also increases the voltage UCC1. This may mean the output is irreparably damaged by exceeding the absolute maximum values. By isolating with a DC/DC power module, both voltages, UCC1 and UCC2, are decoupled.

Source overloading – If a short-circuit at the output of block 2, due to an uncontrolled rise in current, causes thermal overload, given galvanic coupling of the two blocks, block 1 (source) is also adversely affected. This can manifest as a short-circuit, such that the output current of block 1 also rises uncontrollably, which in turn could result in thermal overload of block 1.

What does the specification IEC/EN60950-1 in the datasheet mean?
The International Electrotechnical Commission (IEC) defines standards for electrical technologies. The specifications defined this way in a document for a product have to be fulfilled for a certain context. The application of a standard is only mandatory if it is referenced in contracts, guidelines or laws.

IEC/EN means this is a harmonized standard. It is applied both internationally and nationally. Depending on the application or deployment

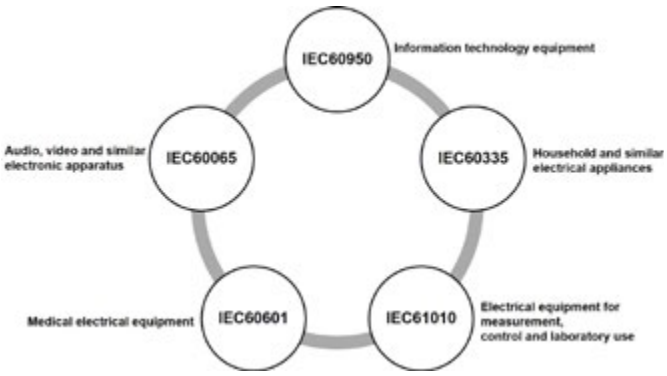

Figure 4: Overview of existing IEC standards

area, different requirements arise for electrical safety, which can be reflected by specific safety standards. The illustration shows the most common standards for the DC/DC low voltage range (see Figure 4).

IEC 60950 is a standard that addresses the general requirements for the safety of devices such as computers, adapters, switch mode power supplies, electrical office equipment and IT devices like printers, copiers and fax machines. The specification in datasheet – IEC/EN60950-1 certified - says that according to the specifications for the product regarding electrical safety, for instance, the product has been assessed and the tests passed. However, such a specification in datasheet says nothing about the quality/type of galvanic isolation. IEC 60950-1 specifies the type of this isolation in function, basic, supplementary and reinforced isolation. Functional isolation ensures the electrical functionality by isolating various supply lines, for example. It does not serve to protect against electric shock when touching the voltages. Basic isolation isolates one of the two terminals, such that protection against electric shock is ensured. Protection only exists as long as the isolation remains intact. If both lines are isolated from each other, such that both terminals have protection against electrical shock, then one speaks of supplementary isolation. Reinforced isolation is provided if e.g. both terminal are in a solid plastic body and there is therefore just “one” isolation.

How is the 4000 VDC for 1s specification to be understood?
Würth Elektronik MagI³C power modules are subject to 100% testing in production to ensure a consistently high level of quality. As one of the final tests, each isolated power module is subjected to a DC voltage of 4000 V for one second. The test is intended to reveal production faults in the area of galvanic isolation. The level of test voltage says nothing about the type of isolation, however - functional, basic, supplementary or reinforced. So the level of isolation voltage cannot be taken to deduce the suitability of the DC/DC power module for certain applications. An example of a frequent misconception is that a DC/DC power module with 4 kV isolation voltage can be deployed in medical technology in the one or two MOOP – Means Of Operator Protection - field. Voltages of 1500VDC and 3000VDC are indeed used here, but only for testing other isolation types.

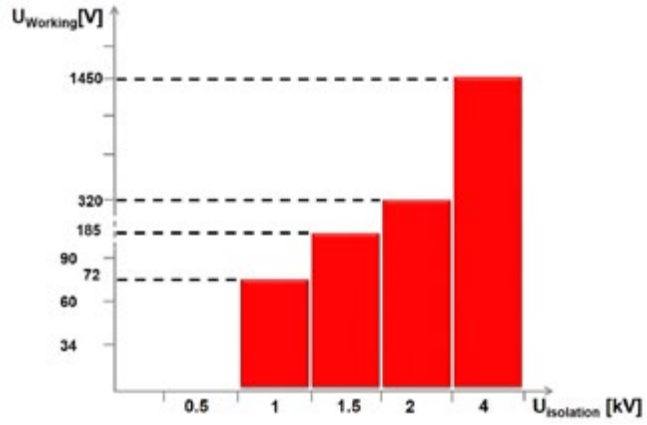

Figure 5: Uisolation is a function of Uworking for DC/DC converters

But wher does the value for isolation voltage come from? It depends on the type of isolation and the prevailing working voltage. Here the term “working voltage” is the max. voltage that can occur in the system. Depending on the converter topology, this does not necessarily have to be the input voltage, but for a flyback topology, for instance, can be the peak voltage across the primary MOSFET. As shown in Figure 5, the required isolation voltage of a converter is proportional to its working voltage.

The specification “4000VDC isolation voltage” can now be read in a more differentiated fashion”. According to the graph, an isolation voltage of 4 kVDC would mean that a converter with a working voltage of up to1450 VDC could be used. Converters in the low voltage range that have such a specification for isolation voltage are only specified up to 24 VDC or max. up to 72 VDC input voltage. How does that fit together?

As converters have progressed from their original application as auxiliary voltage supplies to gain a foothold in evermore applications with very diverse requirements, the specified isolation voltages are also higher than the normative specifications. Field bus applications, such as CAN, Interbus, etc., demand even higher robustness of the supplying DC/DC converter with regard to interference, which in turn is reflected in increasing isolation voltages. The MagI³C power modules have to meet an isolation voltage of 700 VDC in their power range, and with a value of 4000 VDC ensure safe functionality for many applications.

Which solutions does Würth Elektronik offer in its portfolio?
The WE-FISM (Fixed Isolated SIP Module) MagI³C power modules integrate transistors, rectifier diodes, the isolated transformer, as well as input and output capacitors. This makes the WE-FISM MagI³C power module very easy to implement in an existing circuit. No further components are needed for the power module function. Values for the filters tested and their component values are listed in the APPLICA-

Figure 6: WE-FISM portfolio

TION CONSIDERATIONS chapter of the datasheet. Würth Elektronik offers a wide product spectrum of isolated converters with functional isolation:

The current portfolio of isolated MagI3C power modules is shown in Figure 6. WE-FISM are currently available with the following data:

- Input voltage: Uin = 3.3 – 24 VDC
- Output voltage: Uout = 5 VDC
- Output current: Iout = 200 mA
- Isolation voltage: UISO= 1000 VDC / 4000 VDC
- Package: Industrial SIP-4 / SIP-7
- Pinning: Industrial Standard

This 1 Watt converter is suitable for the following application options:

- Interfaces / bus isolation – RS232, RS485, CAN, Interbus, Profibus
- Isolation of digital circuits
- Supply of isolated amplifiers, analog to digital converters
- Measurement recording and data acquisition

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Investigating Losses of GaN-HFETs in a Synchronous Buck Converter

This article illustrates a thermal measuring method as well as an electrical method with air-core inductors in order to investigate the losses in eGaN™ FETs and in passive components caused by switching. The goal of this research is to show the potential of GaN-based devices for power energy conversion.

By Marita Wendt (HAW Hamburg), Thiemo Kleeb, Peter Zacharias, (Kassel University)

When a new semiconductor material is introduced into an important area of electrical engineering this raises expectations of business and industry but at the same time can be a significant challenge for manufacturers. After gallium nitride was used for the first time 20 years ago as a transistor and has been used in radio frequency technology for more than a decade, it now conquers power electronics.

The unique material properties of gallium nitride, such as the high electron mobility and saturation velocity as well as the high layer carrier concentration and the high breakdown voltage, propose a superior device performance. This enables operation at high switching frequencies and junction temperatures in power electronics applications. Thus, GaN technology has a superior potential to overcome the performance limitations of silicon semiconductors.

Electrical circuit with EPC2010 eGaN® HFETs

EPC2010 eGaN® HFETs were chosen for these investigations. The transistors have a lateral structure with a hetero-junction between an AlGaN-layer and a GaN-layer in which a two-dimensional electron gas forms, which is responsible for the high electron mobility [1]. The unique characteristic of this structure is the capability to conduct in both directions. Therefore, GaN HFETs do not need a commutation diode, because this function is integrated due to the special structure and characteristics of the materials GaN and AlGaN. Originally, GaN-based HFETs are normally-on switches as the two-dimensional electron gas (2DEG) conducts without a voltage applied between the gate and the source. Due to an additional p-GaN layer under the gate, which interrupts the 2DEG, it is possible to create enhancement mode power transistors. EPC2010 eGaN® FETs have a breakdown voltage of 200 V and enable rapid switching, due to their low input capacitance and internal gate resistance [2]. Due to the absence of a pn-junction in lateral AlGaN/GaN structures, there is no reverse recovery charge and therefore no delay in these transistors. They can therefore, be implemented in topologies such as a synchronous buck converter without a freewheeling diode.

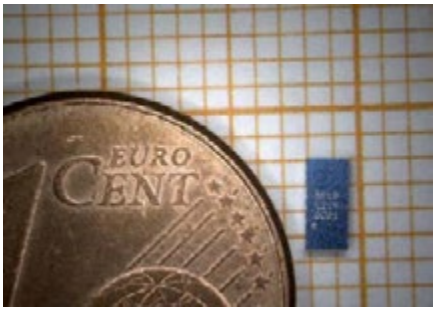

Figure 1: GaN-HFET EPC2010 compared with 1 Cent coin

Since the investigated low-voltage GaN HFETs have no common package as it is the case for conventional semiconductors (Figure 1), it is difficult to realise conventional current measurement. In a practical example of a synchronous buck converter, two experimental methods to determine the power losses in EPC 2010 eGaN HFETs are evaluated.

A synchronous converter topology with a half-bride was chosen for the investigations (Figure 2). The behaviour of the transistors was investigated for hard switching operation with different switching frequencies, input voltages, and output currents.

The evaluation board EPC9003 with two 200 V EPC2010 eGaN HFETs was used in this electrical circuit. The DC-link consists of a film capacitor of 3.3 µF and three ceramic RF-capacitors of 330 nF each. The driver provides a bootstrap circuit with a low gate on-resistor and no gate off-resistor. Several inductors, built with magnetic cores from different materials, were used as output chokes with inductance values between 100 µH and 500 µH. These values were calculated from the initial parameters and test conditions which were:

- 100 V input voltage
- output current from 0.5 A to 2 A with 0.5 A ripple current
- 0.5 duty cycle
- switching frequencies from 100 kHz to 500 kHz in 100 kHz steps

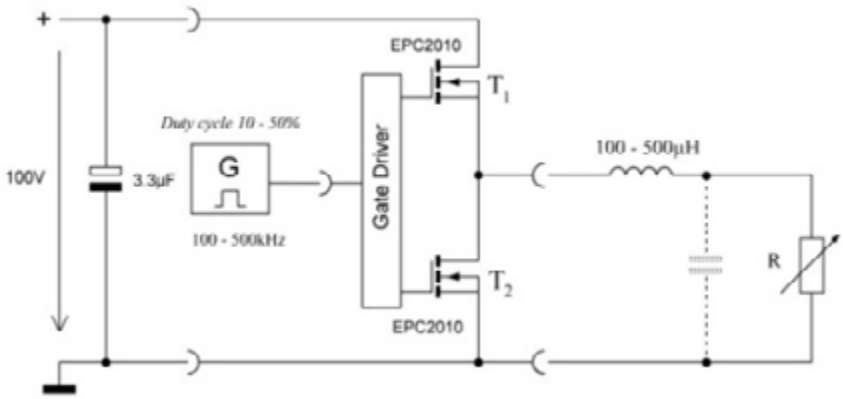

Figure 2: Synchronous converter topology with a half-bridge using two AlGaN/GaN-HFETs (T1 and T2)

Experimental methods of investigating the power losses

To estimate, where the limits of the switching frequency of the semiconductors are in terms of the switching power losses, conventional methods use current and voltage measurements during the commutation period. The conventional current measurement is based on the induction of a magnetic field, caused by the flowing current (current sensor) or on measuring the voltage drop across a resistance built in the drain-source path (shunt). However, an accurate measurement of the drain current of the EPC GaN HFETs with the conventional current measurement is not suitable. Any such measurements (sensors, shunts) cause additional leakage inductance. Due to the small size, the EPC GaN HFETs have extremely low internal leakage inductance, which is significantly less than the leakage inductance of an external component for current measurement. For this reason, the measurements of the drain-source current in EPC GaN HFETs, using conventional current sensors or shunts, would not provide meaningful results.

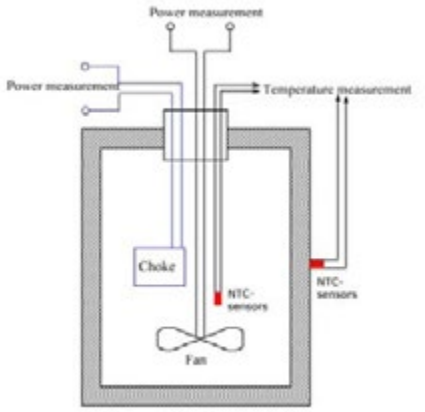

Figure 3: Schematics of the calorimeter to determine the power losses in the output choke

Nevertheless, the losses in these unusually tiny power transistors can be determined indirectly without actually measuring the drain current. The suggested method is based on the measurement and determination of the remaining losses in an electrical circuit and, after that, a calculation of the semiconductor's losses, which are the only losses that cannot be determined directly by experimental tests.

Measurements with a calorimetric method

The total power losses of the entire circuit were measured with a power meter (analyser) ZES ZIMMER as well as with multimeter and oscilloscope. The losses in the output choke were determined by means of the inertia calorimeter principle (Figure 3 and Figure 4).

In order to calculate the power losses in the chokes eight NTC-sensors were used: four inside and four outside the thermally insulated container, to monitor the temperatures. It was investigated which core material was most suitable for each of the applied frequencies and currents. Conclusions were drawn regarding the usability of the magnetic components operating at high frequencies (in terms of power electronics). Three magnetic core materials were chosen for the investigation: ferrite MnZn (3C20) as well as powder (AmoFlux and 3W7538). Fourteen chokes were built up, using the selected materials, for different switching frequencies.

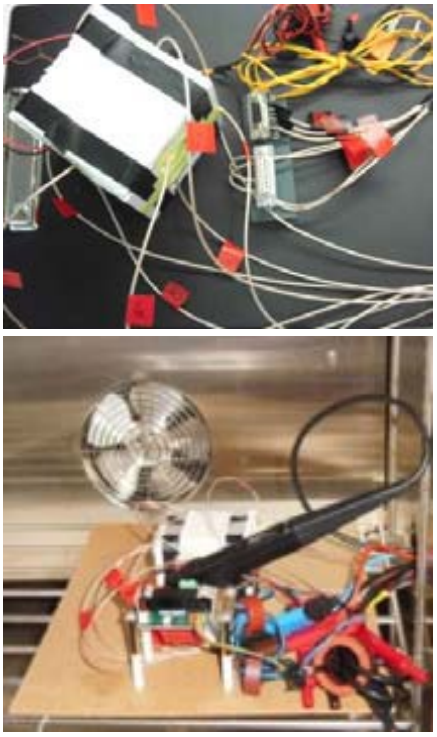

Figure 4: Calorimeter set-up for analysis of the power losses in the output choke with sensors and terminals

The efficiency of the circuit was investigated with various output chokes which were designed as toroids from different magnetic core materials.

The losses of the chokes were calculated by using the formula [3]:

$$P_{loss\ choke} = \frac{\Delta T}{R_{th}} + \left(\sum_i m_i \cdot c_{p,i} \right) \frac{dT}{dt} \qquad (1)$$

The time derivative of the temperature was assumed to be negligible, as the time for each measurement was long beyond the thermal equilibrium. The thermal resistance was determined by means of reference measurements with several load resistors.

Measurements by means of air coils

The disadvantage of the calorimetric method is the considerable period of time for any single measurement and inaccuracies caused by temperature measurements of different chokes. The disadvantage of using chokes with ferromagnetic cores is the non-linearity of magnetic materials. Therefore, the determination of the losses in a choke with ferromagnetic core is more complicated and less accurate than in an air-core coil.

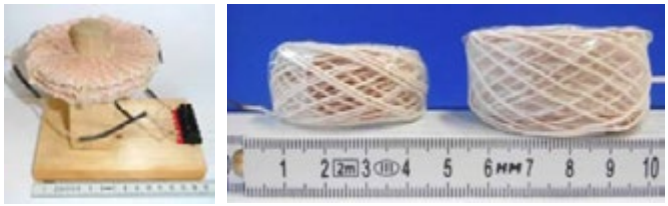

Figure 5: Low capacitive air-core coils

Several air-core chokes with low capacitance, such as basket coils (Figure 5; left) or cross-wound coils (Figure 5; right), were assembled for different switching frequencies. Using these chokes, the power losses may be determined easier.

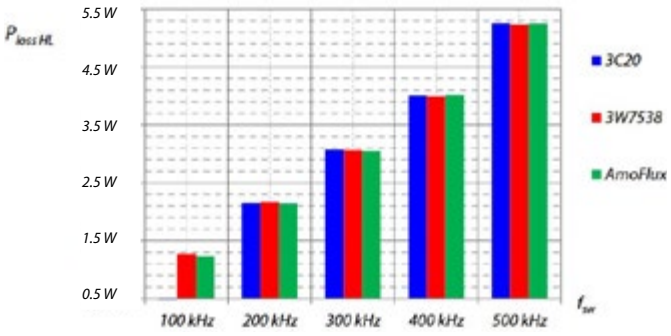

Figure 6: Power losses in GaN semiconductors at different switching frequencies; circuit operated at different frequencies with three chokes (3C20, 3W7538 and AmoFlux) at 100 W output power [5]

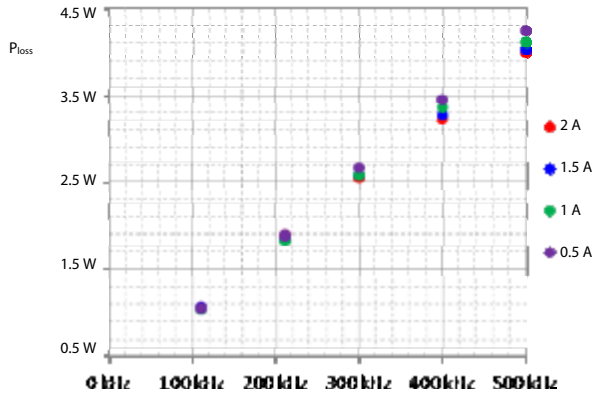

Figure 7: Power losses in the eGaN-HFETs and their approximation as a function of the switching frequency at 100 V input voltage and four different output currents [5]

Results

The chokes with 3C20 and AmoFlux magnetic cores feature a higher efficiency over the entire tested frequency range and can be used in a circuit with eGaN® FETs. However, it must be considered that not only semiconductors, but also the magnetics exhibit limits regarding power density [4]. The power losses in the GaN semiconductors are determined from the losses of the whole circuit and the ascertained power losses in the chokes. The driver losses are also considered. The losses in other components and conductors were found to be negligible at output powers of 100 W or less. As Figure 6 shows, the power losses in the GaN semiconductors are similar regardless of the choke used.

In the measurements with the air-core coils, the power losses in the eGaN-HFETs were calculated, after the total losses of the circuit were determined and other losses such as winding losses had been subtracted (Figure 7).

One interesting fact from these measurements is that – at relatively low current levels (e.g. 0.5 A) – the total losses rise steeper with increasing switching frequency than at a current level significantly higher (e.g. 2 A). This tendency was also observed during tests with infra-red thermal imaging (Figure 8). Losses of the two transistors increase at different rates. It can be observed that the temperature in the top transistor (T1) rises, as expected, with increasing current and increasing frequency. In the bottom transistor (T2) the conditions are different. This transistor is soft-switching. Not only increases the temperature along with the frequency at a steeper rate when the current is low, but the absolute figure of dissipation in the bottom transistor is higher at 0.5 A than at 2.0 A for frequencies above 100 kHz (see Figure 8).

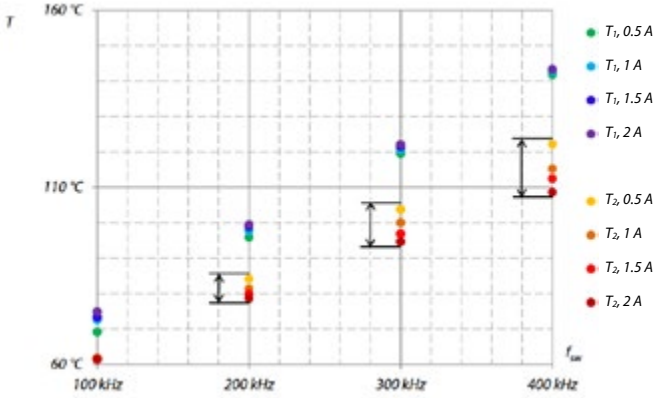

Figure 8: Temperature gradients for different currents at different frequencies split for top (T1) and bottom (T2) transistors [5]

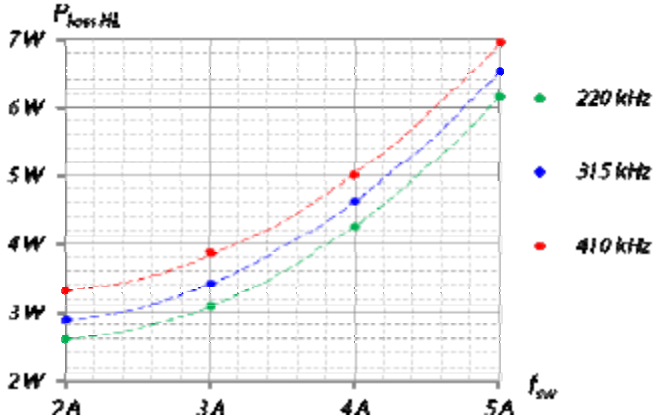

Figure 9: Power loss dependency of the eGaN-HFETs with 100V input voltage and currents up to 5A for different frequencies [5]

Initially, this seems paradoxical. However, it is due to the fact that the frequency dependent losses, attributable to changing the charge status of the transistors, are a) dominant for smaller output currents and b) distributed very asymmetrically. More specifically: One important factor for the current charging and discharging the output capacitance of the upper transistor is the load impedance. A high impedance (i.e.

low load current) will let a greater proportion of the charge/discharge current be taken up by the bottom transistor. This is a major contributor to the dissipation and thus heating of T2. As the load is increased (i.e. the load impedance decreases) a greater proportion of the top transistor's charge/discharge current flows through the load path and thus mitigates the dissipation of the bottom transistor. Once the current reaches approximately 2 A, the increasing conduction losses become dominant. This apparent inconsistency is a less important fact when designing a synchronous buck converter with these specific devices used, as it occurs only when operating at very low load. The settings of the interlock delay times (dead times) play a decisive role in this.

Finally, the EPC 2010 eGaN® HFETs were tested at currents up to approx. 5 A and at frequencies of 220 kHz, 315 kHz and 410 kHz (Figure 9).

For this, air-core inductors were wound with RF-litz wire appropriately sized for the current. The frequencies were chosen accordingly so that the ripple current was 0.5 A, as with all other measurements. The dotted lines in the diagram (Figure 9) indicate the trend lines between the measured points. At all frequencies there is a current dependence, which can be described with a polynomial of the second degree. This, in turn, means that the change in the power losses at any frequency is determined primarily by the conduction losses, which are entered into the equation as a square function.

The semiconductor losses at 5 A are approximately between 2.5% at 220 kHz and 2.8% at 410 kHz accordingly. With a calculated design of the magnetic components, adequate cooling and an appropriate circuit board design, an efficient and compact synchronous buck converter with EPC eGaN-FETs is thus possible.

Conclusion

Undoubtedly the eGaN-HFETs are suitable for operation in high frequency switching applications. However, several points can be discussed in more detail. Hard switching will cause limitations regarding the combination of the magnetic core material and losses occurring due to the switching action itself. Depending on the application there will be an optimum frequency, where the losses drop to a minimum depending on the combination of the semiconductors and magnetic components. A further frequency increase may allow downsizing of the filter components in the circuit even more, whilst higher semiconductor losses must be suffered. If, therefore, an excessive frequency increase is required, the application of soft switching circuits and resonant methods should be considered. One further issue is the optimization of specific operating values. Namely the interlock delay times, the leakage inductances of the various circuit parts, balancing of inductive and capacitive components (both real and leakage), setting up of a suitable control function for the duty cycle, to mention just some.

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Comparing Power Transistors Operating at High-Temperature (Tj~200°C)

Get to Know the Transistors in Your Designs

While weighing potential benefits of SiC transistors to meet challenging design requirements to reduce size, weight, improve reliability, thermal management, you need to assess all constraints of high-temperature operation, some less obvious than others.

By Alberto O. Adan, Ph. D., LTEC Corporation

Introduction

The relentless demand for increased efficiency and power density in industrial and automotive electrification applications have pushed semiconductor manufacturers to develop devices able to operate at Tj=175°C junction temperatures and recently at Tj=200°C [1-2]. Although Wide Bandgap (WBG) GaN and SiC semiconductors are capable of operation at Tj>500°C [3], constraints in the chip metallization, wire-bonds, die-attach and package encapsulation materials remain preventive factors [4].

Component manufacturers and power electronic system designers must decide on the appropriate technology from the view point of performance, cost, manufacturability, availability, and perhaps most importantly, reliability. Designers must be aware of all intrinsic limitations of a power semiconductor device to identify potential weak links. Some of these may be structural, constructional, or material limitations not readily available from the manufacturers' datasheet [5].

In this article, we review and benchmark-analyze state-of-the-art power transistors to identify some of the technologies deemed essential to achieve reliable operation at high junction temperatures. This analysis reveals techniques used in reliability-proven high power transistors already in mass production.

High Temperature Constraints

In switching transistors used in power electronic systems, the maximum junction/channel temperature Tjmax is generally constrained by

- the rise of leakage current,
- thermal runaway when the semiconductor intrinsic temperature (Ti) is exceeded [6],
- thermomechanically induced strain and residual stress due to CTE (Coefficient of Thermal Expansion) mismatch of materials, especially in wirebond/die metal interface and back-side die attach solder, and
- the package Epoxy Mold Compound (EMC) [7].

	Vdd [V]	Tjmax [°C]
Si MOSFETs	~ 100	175
Si MOSFETs	~ 600	150
Si IGBT	~ 600	175
SiC MOSFETs	1200	175→200

Table 1: Relation between rated Vdd and Tjmax

Table-1 shows the relation between the rated maximum drain operating voltage Vdd and the maximum junction temperature for commercial power transistors. It is well known that owing to their low intrinsic temperature, Si transistors cannot operate reliably at Vdd~800V and Tj>125-150°C due to insufficient operating margin during high temperature transients induced by short-circuit events, thus GaN and SiC are the only viable options available above Vdd=1200V and Tj>175°C.

To assess the robustness of commercially available power transistors, we evaluated SiC MOSFET devices encapsulated in TO-247 type package, focusing on STMicro's SCT30N120 having the highest stated Tjmax=200°C. We benchmarked and compared this device with the ROHM SCH2080KE having Tjmax=175°C. Since in these devices the package, die-attach, and solder materials limit high temperature operation, we performed a complete set of advanced physical and material analyses. Figure 1 shows the relevant datasheet specs and physical structure (SEM cross-sections) of the evaluated SiC MOSFETs. Both the devices feature a conventional planar gate structure. The main differences are in the metallization, wire-bond, and the package EMC.

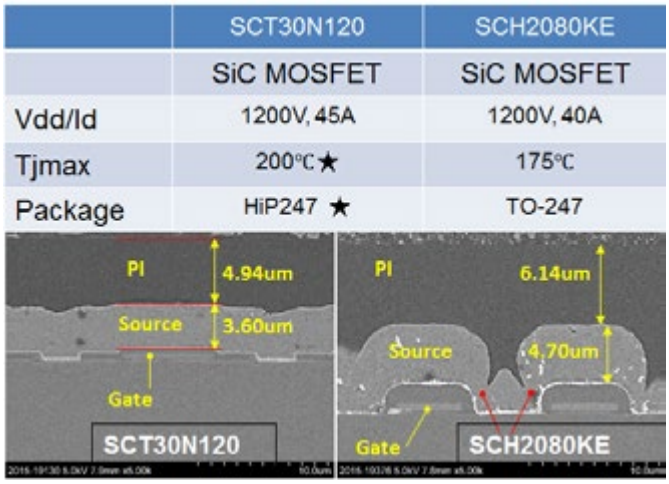


Figure 1: Key datasheet specs and physical structure of the evaluated SiC MOSFET devices

Temperature rise within the die-attach material

The choice of the correct solder die attach material is essential to prevent delamination and void formation during thermal cycles [4]. The expected die-attach temperature, Tb, is estimated from the rated Tjmax; power dissipation, P_T; and semiconductor die area, Adie; thickness, ddie; and thermal conductivity, κdie as

$$T_b = T_{j\max} - \frac{d_{die}}{\kappa_{die} \cdot A_{die}} \times P_T$$

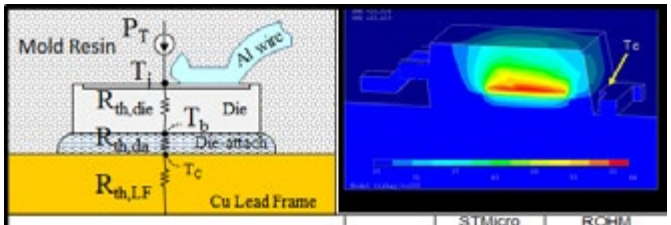
The general criterion for the die attach material melting temperature is TDAmax<0.8xTmelt (in Kelvin degrees); this can be written as

$$T_{melt}[oC] > \frac{T_{DAmax}[oC]}{0.8} + 70$$

For example, Ag-based die attach melting temperature is Tmelt ~300°C=573K, hence the maximum operating Ag-die attach temperature would be limited to Tb,Ag ~185°C. Typical die attach materials are given in Table 2.

	Solder Material	Tmelt
Pb free	·PbSn-base Pb-Ag-Sn	Tmelt ~ 276-310°C
	·SnAg-base	Low T_{melt} ~220-300°C
	·Conductive adhesives Ag sintering µ-powder & nano-powder	T_{melt}~400°C
	SnSb alloys Zn-based Zn-Al-Cu Bi-based Bi-Ag	T_{melt}~380-400°C T_{melt}~360°C
	·Transient liquid-phase sintered (TLPS)	·SnCu TLPS T_{melt}~400°C
	·Eutectic Soldering	T_{melt}>400°C

Table 2: Die-attach materials for high Tj



	Units	STMicro SCT30N120	ROHM SCH2080KE
Die Area size	mm2	14.4	12.9
Spec Tjmax	°C	200	175
Power Pt (@ Tc= 25 °C)	W	270	262
Semiconductor		SiC	SiC
Thermal Conductivity	W/m·°C	350	350
Thermal Res. Rth,jc (Datasheet)	°C/W	0.65	0.57
Die Thermal Resistance Rth,die	°C/W	0.074	0.052
Die Attach Thermal Res. Rt,DA	°C/W	0.576	0.518
Die Attach Temp. Tb (@Tjmax)	°C	180	161

Figure 2: Estimated steady state die-attach temperature Tb based on parameters extracted by physical analysis

We estimated the die attach temperature Tb, for the evaluated transistors based on our physical analysis data. Figure 2 summarizes the results. In the SCT30N120 transistor, rated at Tj=200°C, the solder temperature rises to Tb ~180°C, implying that its melting point must be Tmelt >295°C. Figure 3 shows the EDX analysis results of the back-side metal and the die-attach material. Still, for high Tj devices, PbAgSn-based soft-solder is being used. The Pb-free SnAgCu solder having TDA (Thermodilatometry) melt temperature of 217-228°C, implies not enough margin for 200°C operation. On the other hand, the PbAgSn-based soft-solder used by STMicro's SCT30N120 discrete SiC MOSFET is reported to have TDA melt temperature in the range of 276-310°C (Sumikin). Pb-free die-attach solder and/or more advanced materials such as Cu-Sn, Ag-Sn Transient Liquid Phase bonding (TLP) and Ag-nano-particles are not utilized, perhaps indicating a need for further development to comply with stringent reliability and manufacturability/environmental requirements.

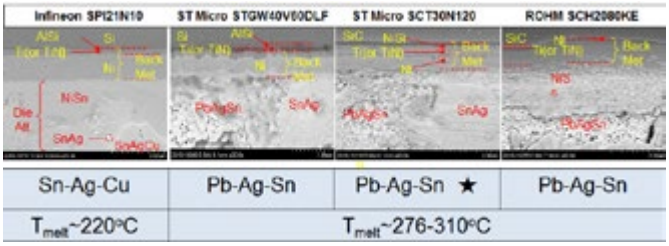


Figure 3: EDX analysis results of the back-side metal and the die-attach materials used in several power transistors. For high Tj devices, the PbAgSn-based soft-solder is still being used

Package mold resin

Being in direct contact with the semiconductor, the package EMC must be able to withstand higher junction/channel temperatures without degradation. Use of higher glass transition temperature Tg epoxy resins is necessary.

Figure 4 shows the EDX material analysis results of the package EMC. The low thermal resistance package resin of the Tj=200°C ST-Micro SiC device uses ZnO, MgO fillers to enhance thermal conductivity. The FeS2 (iron disulfide) content serves as flame retardant.

Fourier Transform Infrared (FTIR) spectroscopy analysis was used to clarify the differences between the EMCs of the evaluated power transistors. The FTIR spectrums of the EMCs are similar. The FTIR footprint shown in Figure 5 identifies a key enhanced molding material composition technology in the STMicro device, one that is not present in other package mold materials. Strong peaks around 980 cm^{-1} and the 1200 cm^{-1} wavenumbers in the FTIR spectrum of the SCT30N120 package are observed at the red lines. Comparison to the reference IR spectrum indicates the presence of P=O bond at the 1200cm^{-1} wavenumber. Further GC-MS (Gas Chromatography–Mass Spectrometry) analysis of the cresol novolac-type resin detected tri-methyl benzimidazole and triphenylphosphine (TTP) oxide compounds, the latter corresponding to the 1200cm-1 FTIR peak.

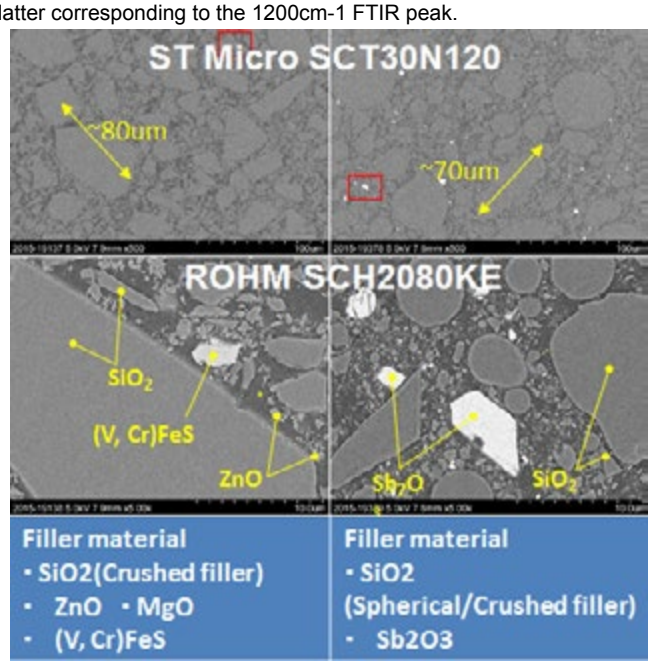


Figure 4: EDX analysis results of the package mold compound. The STM device uses ZnO, MgO to enhance thermal conductivity

Bond wires

Use of thick bond wire (f = 365 um) is necessary for high current applications: (I) The large diameter wire also helps achieve high pull/shear strength, as illustrated in Figure 6, and it serves as a thermal cycle enhancement. (II) The larger peripheral length of the bonding pads helps reduce current density in the top metallization. This is a countermeasure against electromigration. The SCT30N120 device exploits the large area bond pad complemented with a smooth top metallization, as shown in Figure 1.

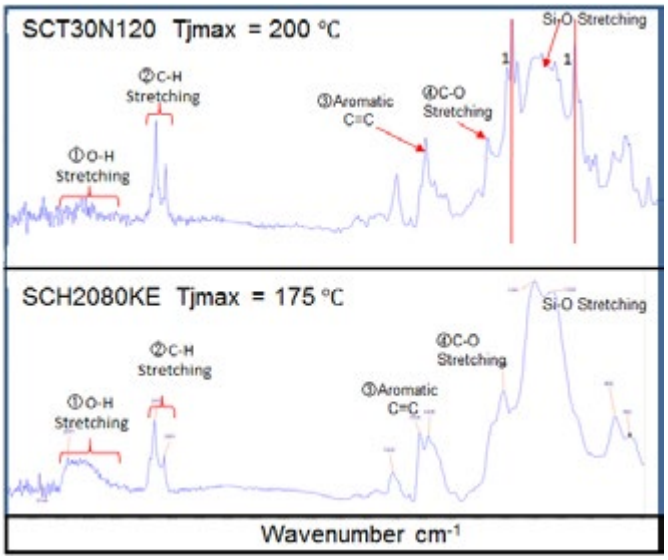


Figure 5: FTIR spectra of the mold compound revealing the high Tj enhanced resin composition in the SCT30N120 package

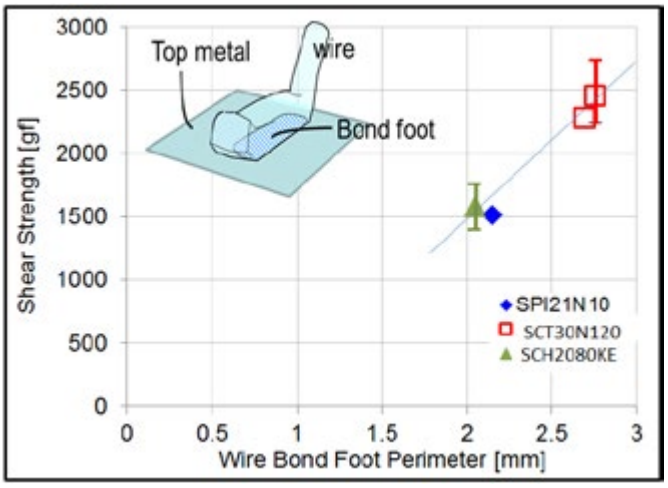


Figure 6: Plot of the evaluated bonding shear strength as a function of bond-foot perimeter length. High bond wire pull strength is essential to withstand high number of thermal/power cycles. A trend line is drawn to indicate the strength improvement as bond-foot size increases.

Conclusion

Physical (structural/material) analysis of high power SiC MOSFETs rated for high temperature operation revealed technologies deemed essential to achieve Tj>175°C. Table 4 summarizes the main structural and material properties of the high temperature-capable SiC MOSFETs.

The EMC of the SCT30N120 200°C-capable TO-247-type SiC MOSFET package was evaluated by EDX, FTIR, and GC-MS analyses. Comparing the cresol novolac-type resin with that of a Tj≤175°C conventional transistor, use of ZnO, MgO fillers and Triphenyl Phosphine performance enhancers were detected. When considering manufacturing variations (e.g., material/chemical composition, processing temperature uniformity), the Pb-based die-attach solder may be subjected to ~180°C, thus leaving little margin relative to the melting temperature.

	Evaluated Properties	Evaluated Devices	
Device	Part No.	SCT30N120	SCH2080KE
	Rated Tjmax, Operating Tj	200°C, 200°C	175°C, 150°C
Package Mold Resin	Structure / material	Mold resin / PIQ / Die	Mold resin / PIQ / Die
	Filler material EDX analysis	SiO2 /ZnO MgO / (V, Cr) FeS	SiO2 / Sb2O3
	FT-IR spectrum analysis	Epoxy resin ★peaks at 980,1200cm-1	Epory resin
Wire Bonding	Wire material /Diameter	Al, ϕ =365 um (N=1)	Al, ϕ =255 um (N=2)
	Wire Bond Foot Area/Permeter	0.405 mm² / 2.7mm ★	0.23 mm² / 2.05mm
	Shear Strength [gf]	~2273	1400~1758
Die Attach	Die attach material	Pb-Ag-Sn ★	Pb-Ag-Sn
	Die attach temperature, Tb	180°C	161°C

Table 4: Results of benchmarking of power SiCMOSFETs

The presented analysis results provide information for the system designer on package technology, the intrinsic limitations of the power devices that are complementary to the published datasheets; and it can serve as a basis for reliability/quality assurance evaluation. Moreover, it can be used to further enhance electro-thermal device models or to set the direction for further analysis not yet undertaken.

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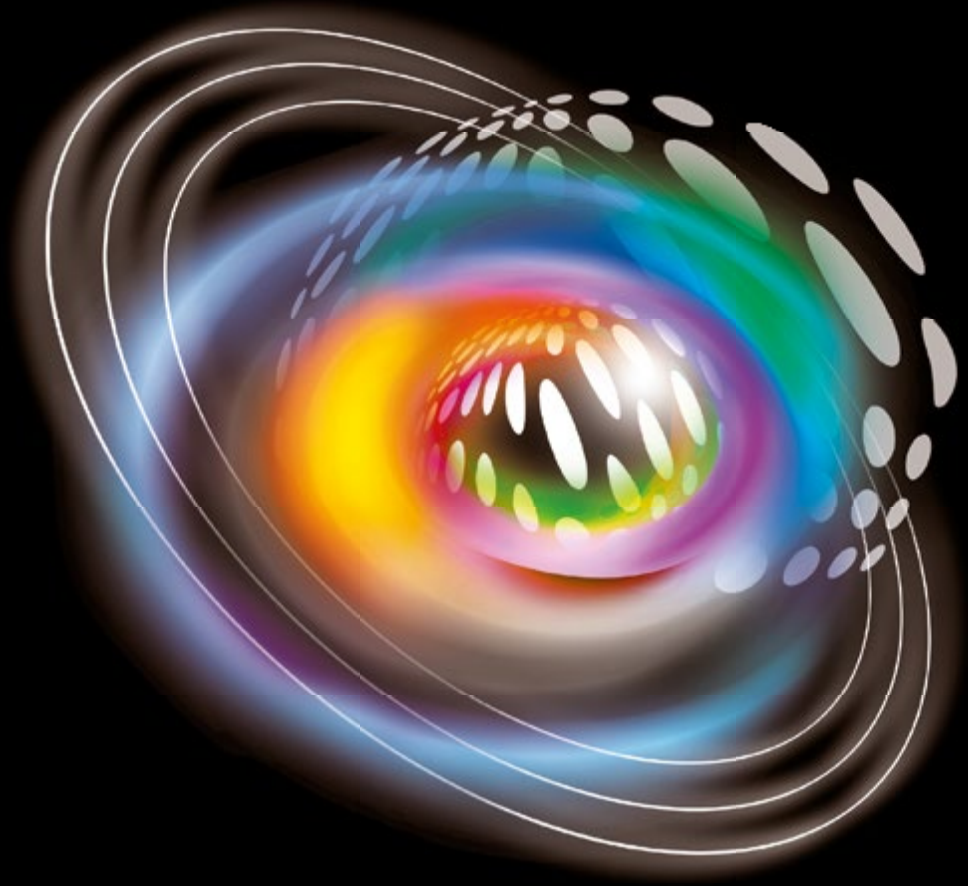

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Don’t let your Digital Storage Oscilloscope betray you

Caveat emptor = Let the buyer beware: The majority of low and medium-priced DSO’s in use and still on the market lack sufficient memory and are unfit for use in design and test of switching circuitry. Refrain from buying or using any DSO with less than 1 MB.

By Dr.-Ing. Artur Seibt, Vienna

1. The requirements on oscilloscopes for switching circuit design and test.

By far, the oscilloscope is the most important measuring instrument of design and test engineers and their “eye”, without it they would remain blind, because the indications of other instruments depend on the waveform of signals and their measuring principles. This is especially true if a signal is not pure but corrupted by noise, hum, hf interference, or distortions. Other instruments include such disturbances and may show erroneous results, see the article “DC and AC Parameters ...” in Bodo’s Power July 2015.

SMPS and related circuitry like motor drives require high performance oscilloscopes because they operate at clock frequencies of > 100 KHz, rise and fall times of even < 10 ns and signal amplitudes of several hundred volts to kilovolts. This requires >= 200 MHz bandwidth and a sensitivity of <= 10 mV/cm; DSO’ s must have a memory of >= 1 MB ; the vast majority of DSO’s in use and still on the market offers only 1 ... 10 KB, few up to 50 KB. The author checked the homepage of a leading manufacturer and still found a wide variety of DSO’s with memories from 2.5 to 10 K, even up into the 5-digit price range, and, to boot, this manufacturer is bold enough to explicitly recommend those “for power supply design” - with memories which are 100 to 400 times too small!

While analog scopes are easy to understand and use, DSO’s are extremely complicated, this explains why even electronics engineers miss the stern warning which is implied in the advertisements “max. sampling rate 5 GS/s, bandwidth 500 MHz” ; the “max.” preceding the sampling rate warns directly that it can be lower. By the way this is the only hint manufacturers give to the many serious problems of DSO’s. The most important memory length spec is hidden in the table of specs or altogether missing! The fact that the bandwidth is tied to the sampling rate should be common knowledge, hence it should alert potential buyers why “max.” is missing preceding the bandwidth. Undersampling and insufficient bandwidth will give rise to gross distortions, ghosts, artefacts as well as worthless digital data. The bandwidth of DSO’s is not constant because the sampling rate depends on the memory length and the time scale used and shrinks to fractions of the maximum at slow time scales - without any warning to the user! This is known since the first DSO’s, the manufacturers prefer not to mention this in their advertisements, data sheets and manuals. Most potential buyers and users are hence totally unaware of this and other serious DSO problems.

The author took the trouble to download the 200 page manual of a 500 MHz, 5 GS/s model with 10 K memory and searched for a warning. There was only one short paragraph somewhere around p. 100, not prominent, headlined “Nyquist”, bluntly stating that the sampling rate depended on the time scale and could, e.g. shrink to 25 MS/s, so the Nyquist frequency was 12.5 MHz. The Nyquist frequency is of no practical value, only the bandwidth, which is - as will be shown - 1/10 of the sampling rate, so at 25 MS/s it will be down to 2.5 MHz! This is belittling the problem: at time scales like 10 ms/cm, typical in power supply work, the bandwidth will be down from 500 MHz to a ridiculous, useless 10 KHz! Would an engineer scrap his analog scope and buy such a scope if he had been fully informed? The fact is that some decades ago when DSO’s came up their functions and problems were described, but not any more. Only if a manufacturer advertises his newest product he will describe in detail the shortcomings and problems of his former product.

“Digital is better than analog” has caused most buyers of scopes to reach for DSO’s, often intrigued more by the software features than the measuring qualities, forgetting that all those are for the birds if the digital data gathered are false to start with. Many have regretted that they replaced their reliable analog scopes.

DSO’s were massively forced into the market, not because of any better performance, but because the profits exceed those on analog scopes by orders of magnitude! The hardware of analog scopes is necessarily fairly expensive, this pertains especially to the wideband cathode ray tubes; the manufacturing cost of such a crt surpasses that of a whole DSO! In contrast DSO’s consist of the same lowest-cost mass-produced components as any pc or similar product, in fact a DSO is a pc with just an analog front end and an a/d converter added. The cost of a DSO display is zilch and independent of the bandwidth, because sampling converts GHz to KHz. A whole DSO fits easily on one e.c. board, production is in China anyway. The manufacturing cost of the higher-priced models is by far not proportionally higher so the profits on those are exorbitant.

Memory being cheap these days, it seems odd, why should DSO’s with too small memories still be on the market. This is special, extremely fast expensive memory. Therefore even leading manufacturers use mainly so called CCD’s (charge-coupled devices). These are cheap MOS ic’s, analog shift registers; the input signal is captured by writing it into such a shift register, each sample is converted into a charge packet. Thereafter a slow clock shifts the samples out to a serial a/d converter which may offer 12 bits. These MOS circuits contribute noise, the analog charge packets tend to dissolve and also influence each other; this is the reason why the memory length is limited to some KB. The best solution is the so called flash or instantaneous converter, which is also the lowest-noise type, but this is much more expensive.

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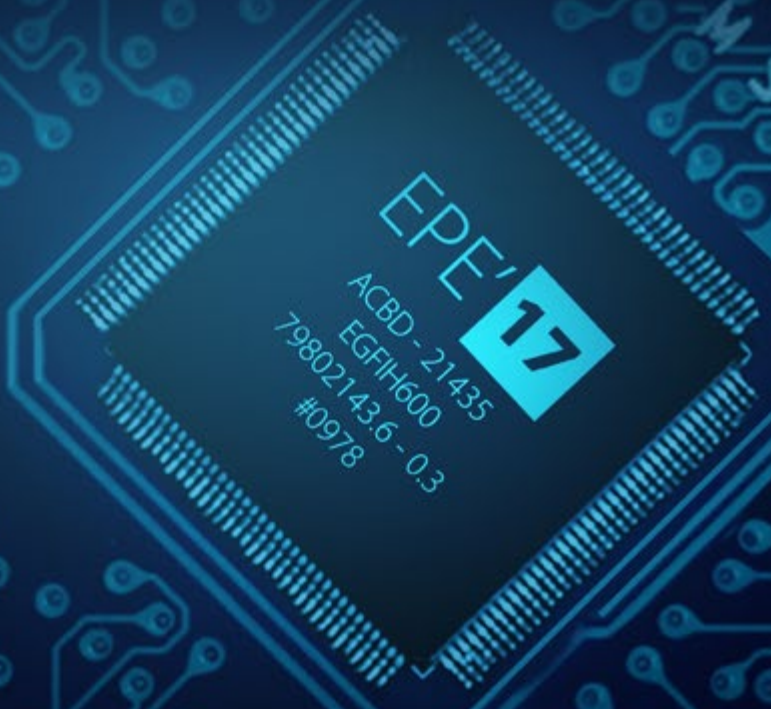

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In the history of oscilloscopes even the very first Tektronix scope in the 1950's was specified for 10 MHz, the standard scope of the 50's was the 30 MHz 545A. Even special If scopes featured a minimum of 1 MHz.

Caveat emptor the Romans already knew, and Let the Buyer beware is the American translation, funny enough there is no equivalent in the German language. Today, it is more necessary than ever to be continuously aware of this principle and to meet all claims with a sound portion of distrust when buying electronic measuring equipment. Neither can neutral advice nor full information be expected.

Buyers were told that DSO's were the "successors of analog scopes", so users assumed that they would perform at least as well and provide advantages, because "digital is better and more modern than analog".

Analog scopes can be described comprehensively by:

► Only analog scopes show the signal itself and in real time, they are absolutely reliable. False displays are impossible, due to elemenary physical laws. Their use does not require knowledge of oscilloscope technology.
In contrast, more than 100 pages are necessary for a description of the functions and problems of DSO's. The purpose of this article is limited to pointing out the worst problems of the majority of low and medium-priced models.

► DSO's only show a more or less distorted rough and jittery reconstruction of the signal or artifacts which bear no resemblance to it. There are no "Real Time DSO's", this term is misleading as it infers that a DSO were able to show a signal in real time. All DSO's are sampling scopes, one operating mode is called "Real Time Sampling". When the reconstruction becomes visible on the screen, the signal has long disappeared.

► DSO's are not the successors of analog scopes although they pushed them out of the market. The fact that DSO's achieve higher bandwidths than analog scopes has nothing to do with "digital", but is due to the fact that they are sampling scopes! Sampling scopes achieved 14 GHz already in 1967. Also, further design of analog scopes stopped after the 1 GHz Tektronix 7104.

While design and manufacturing of analog scopes requires an enormous special knowhow so only a few firms were ever able to make them, DSO's can be assembled by anybody wholly from standard components, so a multitude of new manufacturers flood the market, and DSO's are available for three-digit prices, probes for two-digit-prices. Warning: Cheap probes can ruin the best scope; such a probe may contain a 1206 SMD 9 M resistor while being specified for 600 V and a capacitor with poor ceramic which distorts larger signals grossly and constitutes a safety hazard.

► In contrast to analog scopes the use of DSO's requires vast knowledge of sampling, a/d converter, d/a converter and data compression technologies. Each display has to be checked whether it may be true or not.

Because this is the First Law of DSO's:
► He who uses a DSO must already know the signal.
A leading manufacturer wrote "Know your waveform" in an earlier catalog: "Before you evaluate digitizers, evaluate your signals".
With analog scopes this is unnecessary.

He who does not yet know the signal needs an analog scope to verify the DSO display. Lucky who still owns an analog scope, preferably a Tektronix 7000 series model.

2. Some of the main problems resp. disadvantages of DSO's.
For the user, the advantage of DSO's - their ability to capture and store single events for a long time - is rarely needed in practice. This advantage has to be weighed against a host of serious problems hitherto unknown and therefore not expected by the innocent user who tends to extrapolate the performance from analog scopes to DSO's. The acceptance of DSO's was promoted by the fact that many users were blinded by the software features of DSO's. In this chapter only the main problems are discussed, the explanations are deferred to the later chapters.

2.1 Actual sampling rate, bandwidth and rise time.
The vast majority of DSO's offered and in use are low and medium-priced models with memories of 1 to 10 KB, few to 25 ... 50 K, which creates serious problems. The overwhelming importance of the memory length is veiled by not mentioning it in the prominent specs but only in the fine print if at all! Sometimes the "maximum sampling rate window" is given instead, e.g. if it is 2 ms, this means that slower sweep speeds than 0.2 ms/cm will cause lower sampling rates and bandwidths!

Short memories will overflow quickly at high sampling rates. It depends on the time scale selected how long one acquisition takes, e.g. at 0.1 us/cm this is 1 us. At a sampling rate of 1 GS/s this will fill 1 KB of memory in just that time. Already at 0.2 us/cm the sampling rate must thus be reduced by half and so on. At 0.1 ms/cm it will be only 1/1,000 of the maximum, i.e. 1 MS/s, at 1 ms/cm 100 KS/s. The Shannon - Nyquist theorem is common knowledge although it is misunderstood more often than not. It will be shown later that the bandwidth is 1/10 of the sampling rate. Therefore not only does the actual sampling rate decrease to fractions of the maximum one, but also the bandwidth! The bandwidth of analog scopes is constant.

► The sampling rate and the bandwidth of DSO's are NOT constant, they depend on the memory depth and the time scale used. They can shrink to fractions of the maximum values! Hundreds of MHz can decrease to KHz! This is independent of the maximum values.

► It is common practice to advertise: "max. sampling rate 2 GS/s, bandwidth 200 MHz". This is factually wrong, the bandwidth is never constant, the correct specification is: "max. bandwidth 200 MHz",

► The bandwidth depends on the sampling rate and is always limited to 1/10 of the actual sampling rate. So it decreases with the sampling rate the slower the time scale becomes. For each time/cm position the sampling rate and the bandwidth are different.
► Formula: Actual sampling rate = Memory depth/Time/cm x 10 cm

Note that neither the maximum sampling rate nor the maximum bandwidth appear in this formula, they are irrelevant! Hence an assumption that a 500 MHz DSO would easily handle any low frequency work is only valid if that DSO is a very expensive one with a large memory.

► DSO's with smaller memories than 1 MB, better 10 MB, are entirely unfit for any work on switching circuitry and should be scrapped.

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Consequently, some DSO's, especially handhelds, are not even capable of showing 50 Hz decently. Increasing the memory of existing models is hardly possible, a CCD can not simply be replaced by a better sampler/converter, this would be a new instrument.

The overwhelming importance of a large memory in switching circuitry work will be immediately apparent by these examples from daily practice:

Example 1: The current flowing in the choke of a pfc shall be measured which operates at 125 KHz. In order to see the 100 Hz half-sine, the time scale is switched to 10 ms/cm. The 125 KHz sawtooth rides ontop of the 100 Hz half-sine and is typically 20 %.

What happens? Assumed there is a 1 KB memory; the DSO must reduce the sampling rate below 0.1 us/cm - without any warning to the user - and also the bandwidth:

► At 10 ms/cm the sampling rate will be reduced from 2 GS/s to 10 KS/s and the bandwidth from e.g. 200 MHz to 1 KHz! For a 10 KB memory to 100 KS/s and 10 KHz.

Of course, the 125 KHz sawtooth ontop the 100 Hz half-sine will not be visible at 1 or 10 KHz bandwidth, maybe some artefacts of it.

With a 1 MB memory 1 MHz bandwidth will be left, so the 125 KHz sawtooth will be visible. But even with 10 MB only 10 MHz bandwidth will be left of the 200 MHz. The oldest museum analog scope of the 1950's, a Tektronix 545A with its 30 MHz constant bandwidth will still outperform such a DSO 60 years later by far! The DSO would require at least 30 MB of memory in order to come to a par with the oldtimer. So much memory is only available in extremely expensive top DSO's. But the needle-sharp infinite resolution analog display with its Z - axis infomation in the trace would still remain far superior.

A DSO knows very well when it decreases sampling rate and bandwidth; it would be easy to display a warning on the screen: "Warning! Low sampling rate, low bandwidth!" But few DSO's show even the actual sampling rate, never prominently, none shows the actual bandwidth! If manufacturers had been forced to display prominent warnings on the screen, DSO's would never have displaced analog scopes. Considering the fact that many users of scopes, e.g. in medicine, have no knowledge of electronics, the absence of a clear warning cannot be condoned.

Example 2: A well-known German semiconductor manufacturer brought a so called combo ic to market which contains the control circuitry for a SMPS with a PFC and a Flyback. The data sheet proudly said that the firm had invented a "new method of power MOSFET gate drive which eliminates the high current step at the start of a flyback completely". For proof, a DSO printout was shown in which indeed no such step was visible. But the actual sampling rate was on the screen shot: 25 MS/s. This is equivalent to a bandwidth of only 2.5MHz resp. a rise time of 140 ns. Of course, a scope with 140 ns rise time can not display a current spike of 10 to 20 ns! On an analog scope the current spike stood high as a tower. So the engineers of this firm fell prey to a false DSO display, because nobody ever told them that this was highly probable! For sure, the firm also applied for a patent, all based on a false DSO display!

All these low and medium-priced scopes with the short memories can only be used at the fast sweep speeds. There is only one solution: scrapping, or, to return them to their manufacturers, but the answer would probably be that it was the buyer's own fault if he did not know enough about DSO's...

► The time of an engineer is much too precious and expensive to waste it questioning the validity of a DSO display and searching for the reason of false displays, not to speak of today's time pressure. And the consequences of false measurements can be serious - like in the example above.

Why DSO manufacturers do now mention this? Oh yes, they do, but neither in their advertising, nor in data sheets or manuals, only in their other and older publications:

Quotations Tektronix:
"Sample rate varies with time base settings, the slower the time base setting, the slower the sample rate. Some DSOs provide peak detect mode to capture fast transients at slow sweep speeds." Note that it was "forgotten" to state that the bandwidth is also reduced!

"The usable rise time and the usable memory bandwidth elucidate a remarkable difference between analog and digital scopes: While bandwidth and rise time of analog scopes do not not change with the time scale this is in fact the case with DSO's because of the changing sampling resp. digitizing rate."

Quotations LeCroy:
„As the time base is reduced (more time per division), the digitizer must reduce its sample rate to record enough signal to fill the display. By reducing the sample rate, it also degrades the usable bandwidth. Long memory digitizers maintain their usable bandwidth at more time base settings than shorter memory digitizers."

"In contrast to analog scopes DSO's show significant variations of parameters like bandwidth, sampling rate, resolution."

"Oscilloscopes with nominally equivalent specifications may differ substantially in their actual performance so they may be totally unfit for certain applications!"

Quotation HP:
"The sampling rate specification of DSO's refers to the fastest time scale setting. If you select a slower time scale, the sampling rate will be automatically so far reduced that the signal portion captured fits into the memory. Assumed your DSO has a 1,000 point memory, it must capture 1,000 samples to fill it. If you select a time scale of 1 ms/cm, it can store 10 ms/10 cm. In this case the signal must be sampled every 10 ms/1,000 = 10 us; the sampling rate is thus 100 KS/s... The memory length influences the single-shot bandwidth."

The quotation "forgets" to say that the bandwidth at 100 KS/s is a mere 10 KHz, but it shows a diagram in which 100 MHz bandwidth = 8 mm, so that 10 KHz = 0.0008 mm! In earlier publications the company called users of analog scopes "analog hold-outs".

The Shannon-Nyquist theorem is mostly misinterpreted: highest frequency in the signal is mixed up with bandwidth!

► In discussions about digitizing it is usually assumed that a sampling frequency of twice the desired bandwidth is sufficient. This is absolutely false! Each system which should transmit a signal without distortions must obey a Gaussian frequency response which rolls off very gradually. At half the sampling frequency all frequency components must be sufficiently small in order to prevent aliasing. In

practice this requires that the sampling frequency must be at least ten times the bandwidth.

Quotations of leading firms advocate 10 : 1, and almost all DSO's today follow this rule, e.g. a sampling rate of 2 GS/s allows for not more than 200 MHz bandwidth. Consequently, the 44.1 KHz of the DC as well as the 48 KHz used by radio stations are ridiculously inferior; audio requires at least 100 to 200 KHz.

Oscilloscopes must be designed for a Gaussian frequency response because this is the only one which provides an undistorted pulse response with the shortest rise time. The amplifier's group delay must be constant. The pulse response of a square wave will be symmetrical to half the amplitude.

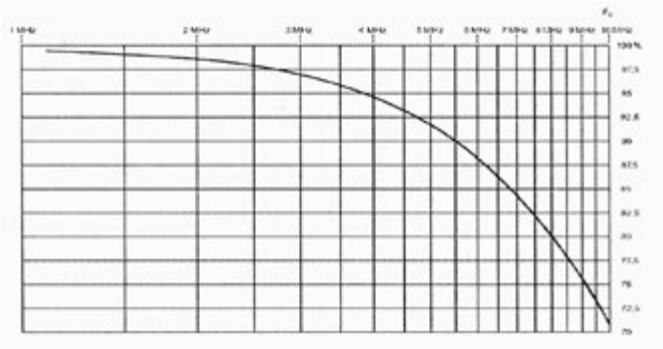

Figure 2.1: The Gaussian response starts to decay very early, any steeper fall-off would cause overshoots. Therefore oscilloscopes are not suited for measuring the amplitude of sine wave signals, at least not for frequencies beyond 1/10 the bandwidth.

Bandwidth and rise time are related by Rise time x bandwidth = 0.35

This relationship still holds even if the pulse response differs substantially from the Gaussian one, e.g. in case of a RC amplifier. The rise times of amplifiers or other units in a signal path add up geometrically if each has a Gaussian response:

$$t_{rtotal} = \sqrt{(t_{r1}^2 + t_{r2}^2)}$$

From this the rule of thumb follows that a scope should be at least three times faster than the signal to be measured.

The article will continue in August.

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Micropower LED Driver with Integrated Hall-Effect Switch

Allegro MicroSystems Europe has announced the release of a new micropower LED driver IC that features an integrated Hall-effect switch. The APS13568 enables compact, elegant, reliable, and fault-tolerant LED lighting with minimal electrical engineering and low component-count and cost. A single silicon chip integrates: a micropower regulator, a Hall plate, a small-signal amplifier, chopper stabilisation, a Schmitt trigger, open drain Hall-effect switch, output polarity selection, and an LED driver with soft on/off and short circuit and thermal protection with automatic recovery.

The integrated solid-state Hall-effect switch supports silent, sealed, contactless activation and offers a significant upgrade from failure-prone mechanical switches and provides very low standby current (25 µA). The LED driver features low-noise, adjustable, linear drive of up to 150mA into one or more LEDs. An optional external capacitor programs the turn-on/turn-off rate, adding an elegant "theater" effect. It is controlled by the Hall-effect switch and turns on and off in response to a magnet. The Hall-effect switch is omnipolar (responsive to both North and South magnetic poles) and highly sensitive (BOP = 40G) to support a wide range of mechanical configurations and enclosures with various air-gaps and degrees of mechanical misalignment. The AP13568 features selectable output polarity as well as an open drain output for connecting to additional external circuitry.

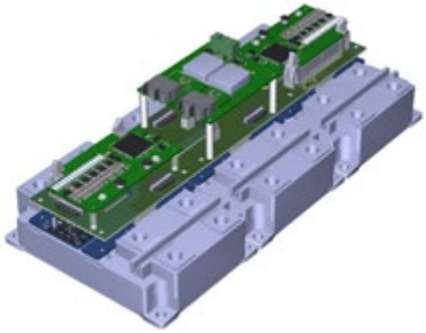
www.allegromicro.com

Gate Drive Provides a Scalable Solution for Power Stack Designers

Amantys Power Electronics Limited has launched support for the Next Generation IGBT Module, a new IGBT module that was a requirement from the European Roll2Rail Project.

The Next Generation IGBT Module Gate Drive (NG Gate Drive) is compatible with IGBT modules known as LinPak, XHP, nHPD2 and SemiTrans20 that are available from several power semiconductor manufacturers. The NG Gate Drive drives up to six of these IGBT modules in parallel. The modular design allows for a scalable solution in line with the requirements for traction applications.

The NG Gate Drive offers Amantys Power Insight, a two way communication protocol between the gate drive and a central controller, allowing configuration of the gate drive in the target power stack to optimise the switching performance. Configurable parameters, include the gate resistors (Rgon, Rgoff and Rgsoftoff), gate-emitter capacitor (Cge), operating mode (two level or three level) and timeouts such as the fault lock out time and dead time. The NG Gate Drive also features multi level desaturation detection for improved protection of the IGBT module.



The NG Gate Drive records faults that the gate drive has seen during operation. Using the Power Insight Adapter and the Power Insight Configurator these can be downloaded at a later date for analysis.

The NG Gate Drive is suitable for a wide variety of applications such as traction, wind energy and medium voltage motor drives. The NG Gate Drive is capable of driving IGBT modules from all manufacturers without any changes to the gate drive core functionality. IGBT module variation, such as the position of gate drive connections, is accommodated through use of a module interface card which means the NG Gate Drive can target modules from 1700V to 3300V, and up to 6500V in the future.

www.amantys.com

GaN-on-Silicon Devices on 200-mm Wafers

Silicon Foundry and GaN Start-Up Achieve Major Milestone in Establishing a 200-mm, Fully CMOS-Compatible Process While GaN Power Products Gain Market Traction

X-FAB Silicon Foundries and Exagan, a start-up innovator of gallium-nitride (GaN) semiconductor technology enabling smaller and more efficient electrical converters, have demonstrated mass-production capability to manufacture highly efficient high-voltage power devices on 200-mm GaN-on-silicon wafers using X-FAB's standard CMOS production facility in Dresden, Germany. This accomplishment is the result of a joint development agreement launched in 2015, enabling cost/performance advantages that could not be achieved with smaller wafers.

Exagan and X-FAB have successfully resolved many of the challenges related to material stress, defectivity and process integration while using standard fabrication equipment and process recipes. Combined with the use of 200-mm wafers, this will significantly lower the cost of mass producing GaN-on-silicon devices. By enabling greater power integration than silicon ICs, GaN devices can improve the efficiency and reduce the cost of electrical converters, which will accelerate their adoption in applications including electrical vehicle charging stations, servers, automobiles and industrial systems.

The new GaN-on-silicon devices have been built using substrates fabricated at Exagan's 200-mm epi-manufacturing facility in Grenoble, France. These epi wafers meet the physical and electrical specifications to produce Exagan's 650-volt G-FET™ devices as well as the tight requirements for compatibility with CMOS manufacturing lines.

www.xfab.com

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200 V Gallium Nitride Power Transistor

Efficient Power Conversion (EPC) Introduces 200 V Gallium Nitride Power Transistor 12 Times Smaller Than Equivalently Rated MOSFETS EPC2046 GaN power transistor offers power systems designers a 200 V, 25 mΩ power transistor about 12 times smaller than equivalently rated silicon MOSFETs for wireless power, multi-level AC-DC power supplies, robotics, and solar micro inverters.

EPC announces the EPC2046 power transistor for use in applications including wireless power, multi-level AC-DC power supplies, robotics, solar micro inverters, and low inductance motor drives.

The EPC2046 has a voltage rating of 200 V and maximum RDS(on) of 25 mΩ with a 55 A pulsed output current. The chip-scale packaging of The EPC2046 handles thermal conditions far better than the plastic packaged MOSFETs since the heat is dissipated directly to the environment with chip-scale devices, whereas the heat from the MOSFET die is held within a plastic package. It measures a mere 0.95 mm x 2.76 mm (2.62 mm2). Designers no longer have to choose between size and performance – they can have both! “Manufactured using our latest fifth-generation process, the EPC2046 demonstrates how EPC and gallium nitride transistor technology is increasing the performance and reducing the cost of eGaN® devices. This opens up entirely new applications beyond the reach of the aging silicon MOSFET and offers a big incentive for users of MOSFETs in existing applications to switch. This latest product is further evidence that the performance and cost gap of eGaN technology with MOSFET technology continues to widen.” said Alex Lidow, EPC’s co-founder and CEO. Development Board The EPC9079 development board is a 200 V maximum device voltage, half bridge with onboard gate driver, featuring the EPC2046, onboard gate drive supply and bypass capacitors. This 2” x 1.5” board has been laid out for optimal switching performance and contains all critical components for easy evaluation of the 200 V EPC2046 eGaN FET.

Price and Availability The EPC2046 eGaN FETs are priced for 1K units at $3.51 each. The EPC9079 development boards are priced at $118.75 each.

www.epc-co.com

More Efficient Energy Storage with 2kW Bidirectional Reference Design for UPS

Texas Instruments introduced the industry’s first 2-kilowatt (kW) isolated bidirectional DC/DC converter reference design for 48V to 400V uninterruptable power supplies (UPS) and energy storage systems. Designers can leverage this reference design, which features innovative TI analog and embedded technologies, to achieve greater than 93 percent efficiency in next-generation UPS, energy storage, power banks and battery charger applications. Download the new reference design today.

Key benefits of TI’s new isolated bi-directional DC/DC converter reference design:

48-V to 400-V range: The industry’s first design to provide support for energy storage supplies with a wide range of input voltages.

A fully tested design with TI products to help designers quickly meet ENERGY STAR guidelines and quicken time to market is available.

For applications with wide-range voltage needs such as electric vehicles (EVs) or industrial servers, the integration of a backup converter and charger into a single power stage, coupled with the compact board space of this reference design, allows developers to more easily implement the transfer of energy to designs. The reference design includes TI’s industry-leading analog technology, including the 100V NexFET™ CSD19536KCS power MOSFET and half-bridge UCC27211A gate driver, for achieving high efficiency. The INA240 current sense amplifier provides accurate current measurements, while the AMC1301 reinforced isolated amplifier and the UCC21520 isolated half-bridge gate driver provide an effective option for sensing the isolated high-voltage rail and driving the high-voltage full-bridge respectively. The Piccolo™ TMS320F28033 microcontroller implements system control digitally.

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All- SiC 1.2kV Power Module Reliability Benchmark for Harsh Environment Operation

Wolfspeed, a Cree Company and a leader in silicon carbide (SiC) power products, extends its leadership in SiC power device technology with the release of the industry's first power module that passes the harsh environment qualification test for simultaneous high-humidity, high-temperature and high-voltage conditions.

This reliability benchmark enables system designers to use this device in outdoor applications such as transportation, wind, solar and other renewables where extreme environmental conditions have historically challenged safe device operation. The all-SiC module, rated for 300 A and 1.2 kV blocking, was stressed in an 85 percent relative humidity, 85°C ambient while biased at 80 percent of rated voltage (960V). Success in harsh environment testing under bias provides further confidence in the overall ruggedness of SiC device technology for all applications.

"SiC components enable the design of compact, lightweight, low–loss converters required for railway transport applications," said Michel Piton, semiconductor master expert at Alstom, a leading global supplier of systems, equipments and services for the railway market. "Achieving March 2017 the benchmark for temperature and humidity under high bias voltage is a key milestone for SiC devices in its adoption into our demanding market."

Powered by Wolfspeed™ MOSFETs (CPM2-1200-0025A) and Gen5 Schottky diodes that also pass the harsh environment test at the die level, the module retains the low 4.2 mΩ on-resistance and more than five times lower switching losses than similarly rated, latest generation IGBT modules. Module construction utilizes high thermal conductivity aluminum nitride substrates and optimized assembly methods to meet industry thermal and power cycling requirements.

"This device is yet another industry-first driven by Wolfspeed," said John Palmour, Wolfspeed's chief technology officer. "The latest 1200V module demonstrates our commitment to enabling markets and applications by meeting the anticipated system requirements for 2020 and beyond."

Available under part number WAS300M12BM2, the module can be driven using existing Wolfspeed™ gate drivers for 62mm modules.

www.wolfspeed.com/power/products

www.cree.com

Sensors and Power ICs

At the PCIM Europe 2017, Allegro MicroSystems Europe has shown its extensive range of sensor ICs for position, angle and speed sensing, current sensors, motor drive ICs and power devices for lighting applications, including a number of new products.

Being previewed at the exhibition is the A5931 motor driver IC; a 3-phase sensorless BLDC fan driver IC that incorporates sinusoidal drive to minimise audible noise and vibration. Also scheduled for release in the near future is the A5932; a 3- phase, sensorless brushless DC fan controller that is designed to drive external N-channel power MOSFETS. It incorporates 180° sinusoidal drive with sensorless commutation to minimise vibration and eliminate the requirement for Hall sensors for server fan applications.

Current sensor products include the ACS780xLR; a fully integrated linear current sensor IC in a new coreless package designed to sense AC and DC currents up to 100 A. The automotive-grade, low-profile (1.5 mm thick) sensor IC package has a very small footprint. The Hall sensor technology also incorporates common-mode field rejection to optimise performance in the presence of interfering magnetic fields generated by nearby current-carrying conductors.

www.allegromicro.com

Ruggedized Axial Aluminum Electrolytic Capacitor Performs to +175 °C without Derating

Cornell Dubilier Electronics, Inc. (CDE) has announced a line of axial-lead aluminum electrolytic capacitors, for applications demanding very high-performance under all operating conditions. The HHT is the only axial-lead electrolytic featuring a glass-to-metal seal to prevent dry-out of the capacitor electrolyte. Shelf life is an extraordinary10 years and operational rated life is 2,000 hours at rated voltage and +175 °C. At 150 °C and full-rated voltage, HHT capacitors outperform competitive technologies in a 5,000 hr test with ripple currents of up to 10 Arms. This level of performance makes the HHT an excellent match for high-stress applications in military, aerospace, down-hole and off-road transportation applications. Nine values are offered, from 470 µF to 4,700 µF, with ratings from 16 Vdc to 40 Vdc.

The CDE HHT Series is the only aluminum electrolytic capacitor available in the market with +175 °C performance. This is usually the domain of the considerably more expensive wet tantalum technology.

The HHT's glass-to-metal seal is the reason. Without the seal, high temperatures will cause conventional electrolytics to lose electrolyte over time. This causes a drop in capacitance and an increase in ESR. With capacitance stability at high temperature, low leakage current and very competitive ESR and ripple current specifications, these devices provide new options for mission-critical applications.

www.cde.com/HHT

Cool-Power ZVS Buck Regulator Extends 48V Direct to Point of Load Product Family

The PI3526-00-LGIZ is the latest addition to the Cool-Power ZVS Buck Regulator Portfolio with a 48V (30-60Vin) input. The PI352x is a higher current offering to the existing PI354x portfolio enabling scalable power options for 48V Direct to point of Load (PoL) applications.

The PI3526-00-LGIZ is a 12V output regulator, supplying up to 18A, packaged in a 10x14mm LGA SiP package. Offering all the same industry leading features of Vicor's existing 48V Cool-Power ZVS Buck Regulators, the PI352x portfolio extends performance by delivering twice the power of the PI354x regulators using only a 40% larger package. The PI3526-00-LGIZ requires only an output inductor and minimal passives for a complete cost effective design that consumes less than 740mm2 of PCB real estate. Designed to be easily paralleled in combinations of up to three regulators, the PI352x regulators can be scaled to support applications with even higher load currents.

New part targets Datacenters and LED Industries

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

www.vicorpower.com

Advertising Index

HiPak

The solution for your demanding applications.

ABB Semiconductors' HiPak modules are a family of high-power IGBTs in industry standard housings using the popular 190 x 140 mm, 130 x 140 mm and 140 x 70 mm footprints. HiPak modules are the perfect match for demanding high-power applications such as traction, transmission & distribution, renewable energy (wind, solar) and industrial drives.

abb.com/semiconductors

Maximize your design flexibility for high-power discrete IGBTs

Upgrade to increase power, reliability and lifetime with less paralleling

Features

- 1200 V discrete IGBT with highest current density at 40 A, 50 A, 75 A
- IGBT co-packed with fully rated free-wheeling diode in TO-247 footprint
- 2 package variants – high-power TO-247PLUS 3-pin and TO-247PLUS 4-pin in Kelvin emitter configuration offering lowest switching losses
- Extended creepage extender (C-E) distance – 5.4 mm for TO-247PLUS 4-pin and 4.25 mm for TO-247PLUS 3-pin

Benefits

- 20% lower thermal resistance with the new TO-247PLUS package
- 20% drop in total switching losses with TO-247PLUS 4-pin
- 20% increase in TO-247-3 power output with TO-247PLUS 4-pin

www.infineon.com/to-247plus
www.infineon.com/to-247-4