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Electronics in Motion and Conversion

November 2011

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The Gallery

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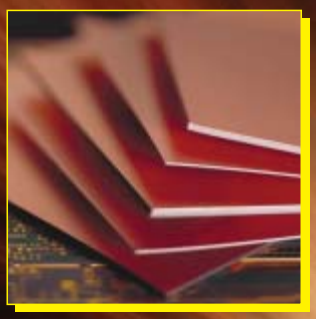
Mission-critical applications have relied on Rogers' microwave materials for years. The superior electrical and mechanical characteristics of Rogers' military-grade laminates provide the stable, consistent performance over time and temperature that's so critical for aerospace and defense applications.



The rock solid performance of Rogers' microwave materials deliver the high performance and high-reliability demanded by the most mission-critical applications. Can you afford to use anything less?

To learn more about Rogers' aerospace and defense microwave material solutions, visit us at:
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www.rogerscorp.com/acm

	Features	Benefits
RT/duroid® 6202PR	Reduced planar resistor variation	Lower manufacturing costs due to decreased tuning
	Low thermal coefficient of dielectric constant	Stable electrical performance versus temperature
	Low coefficient of thermal expansion	High reliability in complex multilayer designs
RT/duroid® 5880LZ	Dielectric constant of 1.96	Lowest dielectric constant microwave PCB material
	Low z-axis coefficient of thermal expansion	Plated through hole capable
	Light weight	Advantage for airborne applications
RT/duroid® 6035HTC	Highest thermal conductivity (1.44 W/mk) for 3.5Dk printed circuit board laminates	Excellent power handling capability
	Low loss 0.0013	Excellent high frequency performance
	Low profile, thermally stable copper options	Lower insertion loss, and performance reliability in high temperature applications

productronica 2011

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Approaching Thanksgiving

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Events

Productronica,
Munich, Nov. 15th -18th
www.productronica.com

SPS/IPC/Drives,
Nuremberg, Nov. 22nd -24th
wwwmesago.de

Smart Grids Forum,
London UK, 29th http://marketforce.eu.com/Conferences/europeansmartgrids11

Power electronics Moscow,
Nov. 29th –Dec. 1st
www.powerelectronics.ru

Smart Grids Summit Stockholm,
Jan. 24th -25th
www.thesmartgridsummit.com

APEC,
Orlando, Florida, Feb. 5th -9th
http://apec-conf.org

EMC,
Düsseldorf, Germany,
Feb. 7th -9th www.mesago.de/en/EMV/main.htm

Embedded world,
Nuremberg, Germany,
Feb 28th- March 1st
www.embedded-world.de

The days are becoming shorter and the last warm ones are showing their colors to let us know that winter is coming.

This has been a year that significantly changed our understanding of nuclear power. The world is getting ready to discard a high risk technology with disaster costs that are paid for by our governments, the majority of which is funded by individual taxes and not utility corporations, as repeated worst case scenarios have shown. As such the projected cost for nuclear power has been miscalculated and furthermore, nuclear waste still has no final storage space in any part of the world. I feel very sorry for the people in Japan who were affected directly and cannot understand the slow response of the utility company and a government in charge of protecting the population of the region.

The only positive outcome of Fukushima is a new focus on alternative energies, wind, water and solar in particular. Smart grids and smart metering will help reduce power consumption and help alternative power generation to become a first choice. Storing energy in different ways is a must in smart grid systems. A battery could be an important feature for the household of the future to bridge the down times of wind and sun.

As we approach Thanksgiving, we should slow down for a moment and reflect on the important things in life. Some of today's lifestyle accessories have had a big impact on our lives. The world learned on October 5th that Steve Jobs passed away, after losing his battle with cancer. He gave us all a number of very attractive personal communication products using leading edge technology that is perfectly adapted to, and possibly even created, a new lifestyle of personal connectivity. As I have often said – communication is everything. We have lost a great visionary leader who built his success from scratch. Too many leaders just administer companies, without enough vision to make a unique contribution and ensure a stable future in the industry.

The world remains financially driven and banks still have a gambling mentality, offering products that are often toxic for the real world. The last one buying has lost the game. Can we expect banks to administer billions, through honest business practices as opposed to gambling? Must so many losers support bank profits? If the bank fails we have the same scenario as with nuclear

waste. The taxpayer fixes it and governments around the world effectively support healthy retirement packages for the failed bank's management.

But let us focus on the real world of engineers doing their job. The LED symposium in Bregenz, Austria, provided information about the coming revolution in lighting applications. Heat was yesterday, light is today. Bregenz and its location on the shore of the Bodensee provided a beautiful backdrop for important developments in lighting. Leading companies described their progress at the conference and showcased their products at the exhibition. The Bregenz Seebühne is a spectacular theater built directly on the lake's edge - a very special place. The nice warm weather of October was perfect for enjoying the trip to the LED symposium.

Every other November we look forward to the Productronica in Munich, where semiconductor manufacturing experts will communicate their progress. The SPS/IPC/DRIVES conference in Nuremberg will provide an excellent platform for presenting developments in industrial electronics and drives.

Communication is the only way to progress. We have now delivered eleven issues this year, with 726 pages of information - on time, every time. As a media partner, Bodo's Power Systems is internationally positioned and represented at more than two dozen shows and conferences worldwide.

My Green Power Tip for November:
Rain water from your roof drains can also be used for your laundry; you need less soap as the water is soft and not chlorinated.

Looking forward to seeing you again at an upcoming show!
Best Regards

SPS/IPC/
Drives
Hall 3.252

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- Analog Voltage output

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At the heart of power electronics.

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Texas Instruments Completes Acquisition of National Semiconductor

National becomes part of TI's Analog business and expands company's ability to deliver more products, expertise and support for customers. Texas Instruments announced the acquisition of National Semiconductor is complete.

"National is now a strategic part of TI's Analog growth engine. Together, we're focused on accelerating semiconductor innovation to improve performance and power efficiency for our customers' electronic systems," said Rich Templeton, TI's chairman, president and chief executive officer.

More than 5,000 National employees will immediately become part of TI. The two companies will begin the work to integrate National as a unit of TI's Analog business, which will have a combined portfolio of nearly 45,000 analog products, strong customer design tools, and a sales force that is 10 times larger than National's previous footprint.

"The closing of this transaction allows TI to expand its market presence with more leading-edge analog products, greater manufacturing capacity, and the largest sales and applications team in the industry. Together, we will serve more customers in more markets," Templeton said.

The transaction, announced on April 4, 2011, cleared all required regulatory reviews and was approved by National's shareholders. TI will include National's contribution to financial performance in the company's third-quarter earnings announcement on October 24.

With today's close, TI's Analog semiconductor business now represents more than 50 percent of the company's revenue. TI will continue to operate National's manufacturing sites, located in Maine, Scotland and Malaysia, as well as business headquarters in Santa Clara and sales/design support around the world.

www.ti.com/deliveringmoretogether

Analysis Confirms EMV as the Most Important Industry Event in Europe

The analysis of the EMV in 2011 confirms its position as Europe's most important event in the sector of Electromagnetic Compatibility. All parties involved look back on a successful show. The visitor analysis shows that the event attracts especially engineers (41%) and executives (16%) from electronics / electrical engineering (46%), measuring and testing (15%) and machinery and equipment (12%). With 94% the decision-authority (decisively and assistingly / advisory) of the visitors is very high. Motives for visiting the trade fair were mainly 'looking for new products' (60%), 'preparation of investments' (52%) and 'search for concrete solutions to problems' (53%). The EMV 2011 was again the place where visitors found answers to their EMC problems.

Recent information about EMV 2012 in Duesseldorf from 7 – 9 February 2012 is now available at

www.e-emc.com

Record Attendance Expected at SPS/IPC/DRIVES

This year's SPS/IPC/DRIVES, the trade fair for electric automation held in Nuremberg, will be bigger and more international than ever before. For the first time it will cover 12 exhibition halls and more than 100,000 sqm of exhibition space. Almost 1,400 exhibitors from home and abroad are expected to attend the event. With all the key players in the sector represented again this year, SPS/IPC/DRIVES 2011 promises to provide the most comprehensive overview of electric automation related products and solutions ever.

Companies from almost 40 countries will be exhibiting at SPS/IPC/DRIVES 2011, representing an increase of 20%. With 76 companies registered so far, Italy is the foreign country providing the most exhibitors, followed by Switzerland (36), China (35) and Austria (27). Following 2010's record total visitor number, more than 50,000 visitors are likely to attend again this year. About 20% of the visitors are expected to come from abroad and the proportion of international trade visitors continues to increase.

The complete SPS/IPC/DRIVES 2011 conference program comprises 69 seminars on topics of electric automation technology, one trend session and three tutorials.

www.mesago.com/sps

Strategic Partnership for Locomotives, High-Speed and Metro Trains

Infineon Technologies and Bombardier Transportation have entered into a strategic partnership in the field of drive electronics for advanced rail vehicles. The agreement envisages the supply of semiconductor components by Infineon to Bombardier in the course of the coming five years. These power semiconductors enable energy-efficient control of electric motors in locomotives, high-speed trains, underground and urban railways. Infineon will ensure supplies by reserving manufacturing capacity for Bombardier. Bombardier will contribute towards the investment costs required. Furthermore, the two companies will join forces in developing the drive electronics for trains with a view to optimizing the energy efficiency and reliability.

IGBT modules (Insulated Gate Bipolar Transistors) are so-called power semiconductors used in high voltage operation between several hundreds to thousands of volts. These Power semiconductors are noted for high efficiency and fast switching with high-current handling capability and can hence control multi-megawatt electric motors (1 megawatt equals 1,360 horsepower) with minimum power losses. IGBTs permit variable speed and torque control of the electric motor. Drive electronics for railway applications represents a significant growth market, particularly considering the railway network expansion in and between the megacities of emerging countries with large populations, such as China and India.

www.infineon.com/highpower

www.bombardier.com

Efficient Power Conversion Corporation Achieves ISO 9001:2008 Certification

EPC has received ISO certification for the design, development, marketing and sales of gallium nitride power transistors and power management devices

Efficient Power Conversion Corporation the leader in energy-efficient enhancement mode gallium nitride (eGaN®) power transistors used in power conversion applications, has received the International Organization for Standardization ISO 9001:2008 certification for its quality management system.

The ISO standards are published by the International Organization for Standardization and available through national standards bodies. To achieve certification, EPC passed an assessment conducted by Det Norske Veritas, an ANSI-ASQ National Accreditation Board (ANAB) certified auditor.

Upon receiving ISO certification, Alex Lidow, co-founder and CEO, noted, "Achieving ISO 9001:2008 certification is recognition that for EPC quality has been a way of life from the beginning. Our quality management system is dedicated to continuous improvement, our processes are well documented and controlled, changes are made in a considered way and we listen systematically to our customers."

www.epc-co.com

Design Software to Optimize Wind Power Generator Design

Cobham Technical Services has been awarded a contract for its powerful Opera electromagnetic design tool by Siemens Wind Power, a leading supplier of wind turbines for onshore, offshore and coastal sites.

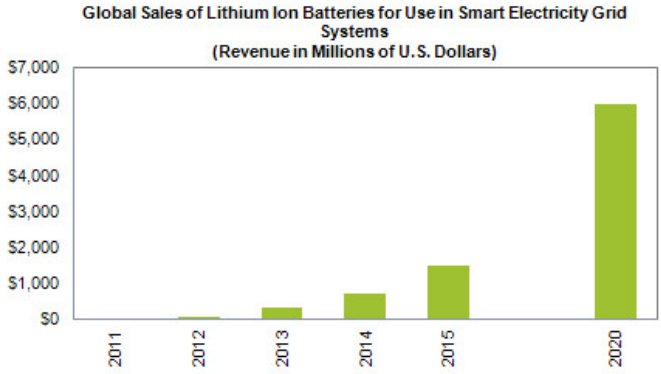
Fast and accurate electromagnetic simulation helps wind turbine suppliers to make breakthroughs in wind turbine design. The Siemens design team employs the Opera electromagnetic simulator from the Vector Fields Software product line of Cobham Technical Services to help it develop new generator concepts, and often runs thousands of simulations within a few hours to discover the best design solution for applications.

Opera was selected as a core design automation aid following an in-depth review of tools on the market, because of the package's speed and efficiency, and its ability to cross-couple with other software used in the overall equipment design.

www.cobham.com/technicalservices

Smart Grids Spur Massive Demand for Lithium Ion Batteries

The expected proliferation of electrical smart grids during the next decade will generate nearly $6 billion worth of demand by 2020 for lithium ion batteries used mainly in energy storage systems, according to the IHS iSuppli Rechargeable Batteries Special Report from information and analysis provider HIS. From its starting point in 2012, the market for lithium ion batteries in smart grids is set for rapid growth, as presented in the figure. Worldwide revenue from sales of lithium ion batteries for smart grids will surge to $5.98 billion in 2020, up by a factor of more than 80 from $72 million in 2012.



Smart grid energy storage comes in multiple form factors, ranging from single-home systems to a cluster of homes or a building, to uninterruptible power systems for corporate information technology (IT) operations, to large-scale systems used by grid operators.
An advantage to lithium ion batteries is that they maintain full capacity even after a partial recharge. Furthermore, they are considered to be more environmentally safe than other battery technologies.
A smart grid is a utility electricity delivery system that employs computer and communications technology to improve the flexibility and efficiency of power distribution.
In conventional power grids, power flows just one way, going from large-scale power generators to users. Smart grids, in contrast, can accommodate and control electricity that is generated both by big utilities and by individual consumers and businesses. This makes smart grids a key element in utilizing and redistributing the energy generated by solar systems installed by electricity users.
Development of smart grids is being spurred by various government initiatives throughout the world. To learn more about this topic, see the new IHS iSuppli report, entitled: “Strong Growth to Drive Lithium-ion Battery Market to $54 Billion by 2020”.

www.ihs.com

Smart Grid Leaders Form a Global Alliance to Drive G3-PLC Implementation

Maxim Integrated Products has joined 11 other companies in the smart grid industry to form a new global partnership, the G3-PLC Alliance. Announced at the Metering Europe Conference in Amsterdam (October 4 - 6, 2011), the G3-PLC Alliance was created to support the deployment of the G3-PLC™ powerline communications protocol, originally developed by Maxim. Maxim is a founding member of the Alliance.
G3-PLC has been adopted by multiple international standards (ITU, IEEE®, and CENELEC), independently tested by dozens of organizations worldwide, and implemented by several major international OEMs.
“Now, electricity utilities and distributers around the world will be able to come off the sidelines and begin rolling out their smart grid networks with confidence,” said Mr. Navid. “Being one of the original founders of the G3-PLC Alliance, we are fully committed to supporting its objectives for the benefit of the industry.”

www.maxim-ic.com/smartergrid

Existing TI Distributors to sell combined TI and National product portfolio

Texas Instruments announced that effective immediately the existing distributors in its global network will integrate National Semiconductor products onto their line cards. This will expose National products to a number of new distributors, and will ensure that customers all over the world have an extensive authorized channel from which to obtain TI’s and National’s newly combined portfolio of almost 45,000 analog products. The move follows TI’s acquisition of National, which was finalized in late September.
TI also said that all of National’s current distribution contracts with Future Electronics will conclude by December 1, 2011.
To find an authorized distributor in your region, see

www.ti.com/distribution

For more information on how TI and National are delivering more together, see

www.ti.com/deliveringmoretogether

Cooperation for Smart Digital Point-of-Load Solutions

ZMDI and Murata Power Solutions offer smart PoL solutions with high power density enabling fast and flexible designs for servers, storage units, and FPGA boards. ZMD and Murata Power Solutions, the world's leading supplier of board mount power, today announced a cooperation on smart digital point-of-load solutions for power management.

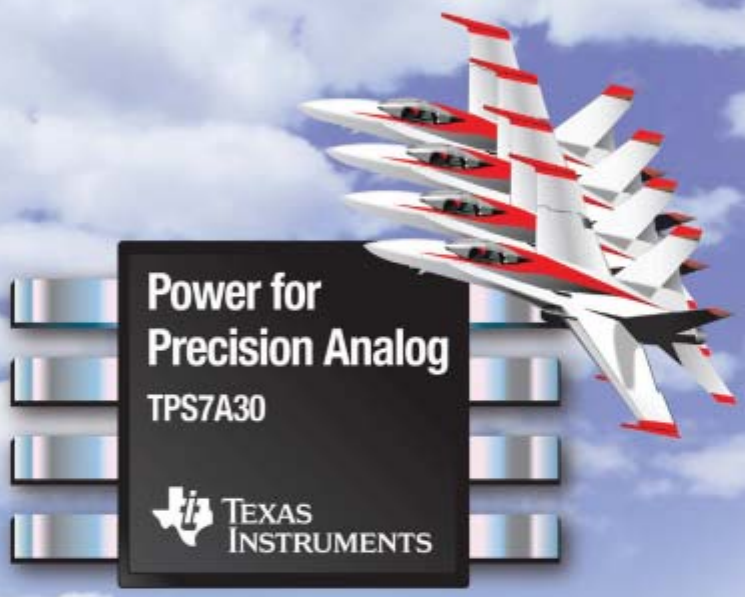
Murata Power Solution's single-phase surface-mount power blocks, combined with ZMDI's ZSMP1000 single-phase digital PWM controller for non-isolated DC/DC supplies, enable fast and flexible design of smart digital POL systems. The resulting systems have the high power density required for space-sensitive applications such as servers, storage units and FPGA boards.
.

www.zmdi.com

Industry's First –36V LDO for Noise-Sensitive Applications

High-Performance Analog>>Your Way™

The **TPS7A30**, paired with the positive-voltage **TPS7A49**, provides designers with a total solution for powering precision analog applications. The devices feature ultra-high power supply rejection ratio (PSRR) performance and as low as 16µVrms of output noise. The TPS7A30 generates –200mA, while the TPS7A49 supplies 150mA.



Device	TPS7A30	TPS7A49
V_{IN} (V)	–3 to –36	+3 to +36
I_{OUT} (mA)	–200	150
V_{DO} (mA)	216	241
I_Q (µA)	55	55

Key Features	Benefits
1% nominal accuracy	Better precision for VCOs, PLLs and ADCs
Stable with >2.2-µF ceramic output capacitor	Smaller size and low cost versus tantalums
Low noise/high PSRR • Output noise as low as 16µVRMS • PSRR: ◦ 72dB at 1kHz ◦ 55dB at 10kHz to 700kHz	Improved dynamic range in RF applications, filters and handling of DC/DC spikes

Learn More

www.ti.com/tps7a30

Get samples, datasheets, evaluation modules

Texas Instruments

Z-Rec™ Silicon Carbide Schottky Diodes Improve Energy Efficiency in Solar Micro Inverter Designs

Cree, Inc. a market leader in silicon carbide (SiC) power devices, continues its mission of advancing the adoption of SiC into mainstream power applications. Cree's advances in SiC technology are setting new standards in energy efficiency while reducing system costs and improving reliability when compared to silicon-based power devices. Cree's latest addition to its 1200V SiC Schottky diode product offering includes four new surface mount devices in 2A, 5A, 8A, and 10A current ratings and packaged in the industry-standard surface mount TO-252 D-Pak. Cree is the first manufacturer to offer this comprehensive range of current ratings for commercially available 1200V SiC Schottky diodes in the surface mount D-Pak package. Designers of systems, such as solar micro inverters, now have more options to develop smaller, lighter and less costly power conversion circuits. The new surface mount devices deliver the same proven performance as Cree's TO-220 Schottky diodes, but with a smaller PCB footprint and lower profile.

"These new surface mount devices provide all the proven benefits of SiC Schottky diodes - zero reverse recovery losses, temperature-independent switching, higher frequency operation with low EMI, and significantly higher surge and avalanche capability - with a smaller footprint and a lower board-mounted profile," explained Cengiz Balkas, Cree VP and GM, Power and RF. "The new 2A device is ideally suited for lower power applications allowing them to benefit from the advantages of SiC while providing the best performance and cost option. With the addition of the 8A and 10A devices, the same space and cost savings can be extended to higher power applications"

"There are significant design advantages to implementing SiC power devices in high efficiency power electronics systems, including the ability to achieve higher current and voltage ratings with fewer components. By reducing the component count, designers can achieve lower overall system costs with increased reliability and maximum efficiency," continued Balkas. "When used in conjunction with Cree's new series of 1200V SiC Power MOSFETs in an all-SiC design, these Schottky diodes make it possible to achieve high-efficiency power electronics systems with switching frequencies that are 5x to 8x higher when compared to conventional silicon solutions. The higher switching frequencies enable smaller magnetic and capacitive elements, thereby shrinking system size, weight and cost."

Cree's C4D02120E Series Schottky diodes are rated for 2A/1200V; the C4D05120E Series diodes are rated for 5A/1200V; the C4D08120E Series diodes are rated for 8A/1200V; and the C4D10120E Series diodes are rated for 10A/1200V. Operating junction temperature for all C4DXX120E devices is rated for -55°C to +175°C.

The C4DXX120E surface mount Schottky diodes are fully qualified and released for production use. Check with Cree for availability of devices in die form. For samples and more information about Cree's SiC power devices, please visit http://www.cree.com/power.

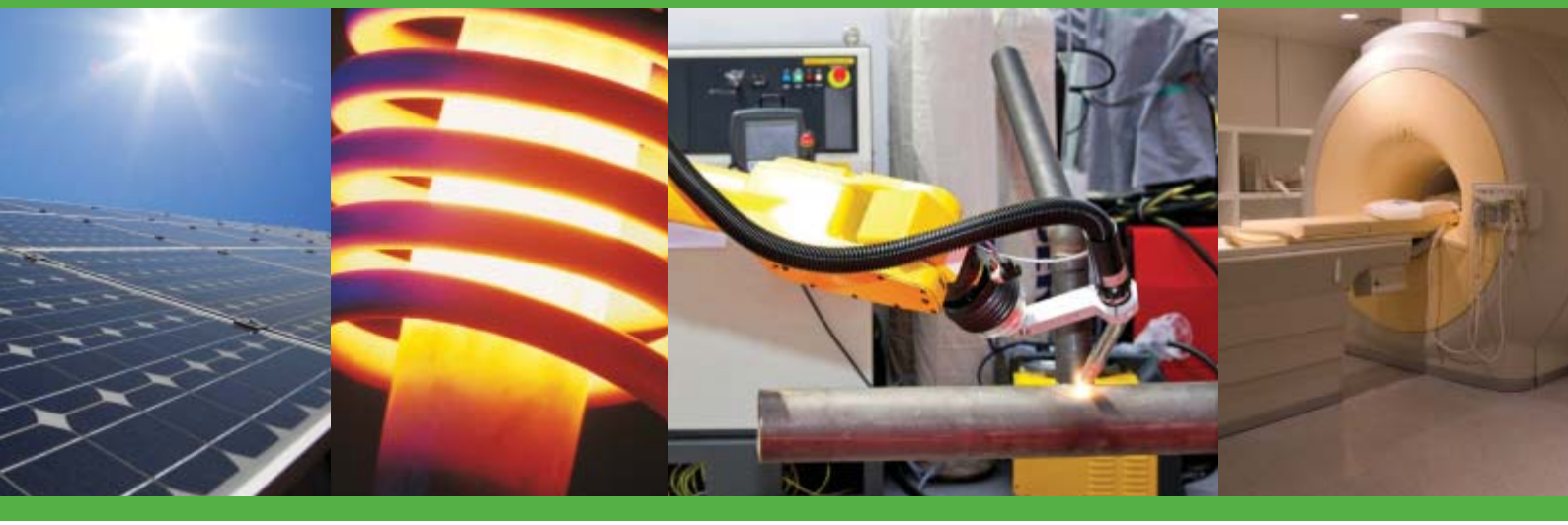
Cree is a market-leading innovator of semiconductor solutions for wireless and power applications, lighting-class LEDs, and LED lighting solutions.

Cree's product families include power-switching devices, radio-frequency/wireless devices, blue and green LED chips, high-brightness LEDs, lighting-class power LEDs, and LED fixtures and bulbs. Cree solutions are driving improvements in applications such as variable-speed motors, wireless communications, general illumination, backlighting and electronic signs and signals.

For additional product and company information, please refer to:

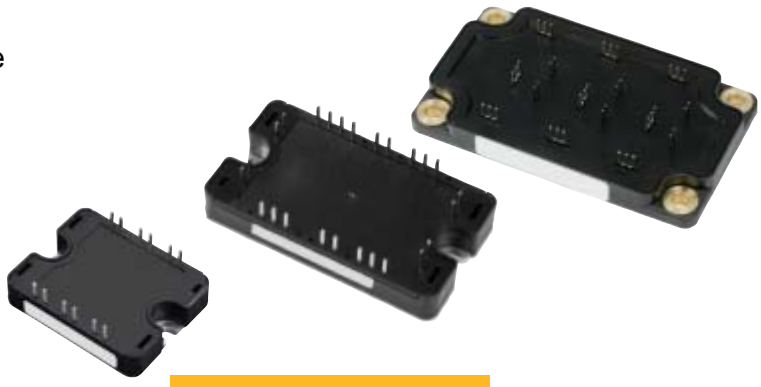
www.cree.com

Achieve Superior Efficiency In Your Power Inverter Designs



With more than two decades experience, Microsemi's unique mixed semiconductor power module products feature a combination of configurations and technologies to ensure maximum performance and reliability.

Microsemi
POWER PRODUCTS GROUP

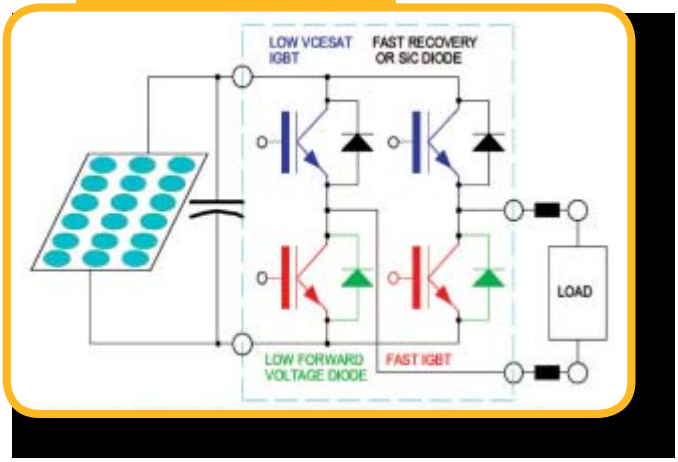


Low-Profile Power Modules

- **MOSFET - IGBT - FRED - SiC**
- **75 - 1700 volts, 10 - 750 amps, 5 - 500 kW**
- **High-efficiency**

As Microsemi's global channel partner, Richardson RFPD provides the engineering support to identify the best solution for your application.

Full Bridge Topology



Others include: 3-Level Inverter, PFC, Phase Leg, Single Switch, 3-Phase Bridge, Rectifier Bridge, AC Switch

Download Application Brochure

View Microsemi's latest low-profile power modules brochure at: www.rell.com/microsemi

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www.richardsonrfpd.com

Highly Integrated IEEE 1588v2 Over Ethernet Solution For Industrial Ethernet

Groundbreaking New Technology Offers Compact Energy Efficient IEEE 1588v2 Switch

Micrel Inc. introduced the KSZ84xx family of IEEE 1588v2-enabled Ethernet devices for Industrial Ethernet and Power Substation Automation applications. The groundbreaking solution employs Micrel's EtherSynch™ technology, which integrates IEEE 1588v2 distributed synchronization, Ethernet switching, and Precision GPIO in an energy efficient, compact package. The ICs are currently sampling with volume production expected in the first quarter of 2012. For specific pricing, please contact your local Micrel sales office.

The KSZ84xx platform is the most compact, highly integrated, and energy efficient IEEE 1588v2 10/100 switch available, supporting both centralized and distributed network topologies. A full complement of Precise Timing Protocol timing modes are provided, including the Transparent Clock (TC) introduced in IEEE 1588v2, along with a range of host interfaces capable of interfacing to a wide range of CPUs.

The KSZ84xx switches are particularly well-suited for distributed network topologies which are preferred for Industrial Ethernet networks. The ICs feature a hardware-oriented architecture that reduces the synchronization and communications processing demands on the Host CPU. Such features as Source Addressing, One-Step TC corrections, and Bypass mode facilitate both Ring and Linear topologies. By integrating the IEEE 1588 PTPv2 time stamping as close to the physical layer as possible, sub-100ns synchronization performance has been demonstrated.

The KSZ84xx product family consists of:

- KSZ8463: IEEE 1588v2, 3-port switch with MII/RMII interface
- KSX8462: IEEE 1588v2, 3-port switch with generic host interface
- KSX8441: IEEE 1588v2, Controller with generic host interface

Micrel also intends to offer a pre-qualified Precise Timing Protocol software stack, which has been integrated with the driver and optimized to exploit the KSZ84xx architecture. Source code is available under license. Please contact your local sales representative for more information.

"The KSZ84xx is a cost-effective solution for implementing Industrial Ethernet networks, reducing size and power consumption vs. FPGA-based designs," noted Dr. J.C. Lin, vice president Micrel Ethernet. "Such a high level of integration reduces costs, making IEEE 1588v2/Ethernet a viable contender for FieldBus applications by replacing point-to-point serial interconnects."

Like all of Micrel's LAN Solution products, the KSZ84xx significantly reduces operational power consumption, which is less than 300 mW. Advanced power management features complement the inherently low-power Physical Layer design, including Energy Efficient Ethernet (EEE- IEEE 802.3az), Wake on LAN (WoL), Energy Detect Power Down (EDPD), and software power down. Standby power savings of over 95 percent are achievable, rending the new platform the lowest power, most energy-efficient IEEE 1588v2/Ethernet solution available.

Micrel Inc. is a leading global manufacturer of IC solutions for the worldwide analog, Ethernet and high bandwidth markets. The Company's products include advanced mixed-signal, analog and power semiconductors; high performance communication, clock management, Ethernet switch and physical layer transceiver ICs. Company customers include leading manufacturers of enterprise, consumer, industrial, mobile, telecommunications, automotive, and computer products. Corporation headquarters and state-of-the-art wafer fabrication facilities are located in San Jose, CA, with regional sales and support offices and advanced technology design centers situated throughout the Americas, Europe and Asia. In addition, the Company maintains an extensive network of distributors and reps worldwide. Web:

www.micrel.com

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Power Semiconductor Devices

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The Electrification of the Power Train - a Paradigm Shift of the Typical Automotive Semiconductor Portfolio Offers Challenges and Chances for Innovation

Henning Hauenstein, Vice President and General Manager,
Automotive Products Business Unit at International Rectifier Corp

For many years, the conservative automotive market and its tendency towards slow adoption of new technologies has been both a curse and a comfortable cushion for automotive semiconductor suppliers. On the one hand , it was tremendously difficult to promote and sell any major "revolutionary technology" or product concept into the automotive market even with reliable and proven high quality technology, and more so, to instigate a rapid change to a promising leading edge technology or product solution that intrinsically bore a certain higher risk of unforeseen failures. On the other hand, this reluctance to change was also a very beneficial feature of this market, since once a technology or product was designed-in and consistently good quality and performance delivered, the entry barrier for any competitor was also tremendously high.

Therefore, the community of automotive semiconductor suppliers with significant business was relatively small and less diversified than in many other markets. With regards to the typical automotive product portfolio, the well defined and standardized 14V/12V automotive power net driven by a lead acid battery pretty much determined the requirement for the Silicon process platforms used for automotive devices. Power switches and ICs could rely on well managed and maintained voltage levels and the required breakdown voltage limits could be set to typically 40V, and sometimes up to 55V or 75V to take some higher voltage application such as the 24V truck market into account. So over many years, the automotive semiconductor industry could operate on a 14V/12V car architecture and the product portfolios for automotive electronics, especially power management, was well defined.

However, now we see a major shake-up in the requirements for a modern automotive product portfolio. The so called electrification of the car, spearheaded and successfully demonstrated and introduced by Toyota brought completely new requirements to automotive semiconductors. On top of the traditional 14V/12V lead acid battery, an electric or hybrid electric vehicle requires much higher voltages in order to provide tens or hundreds of kilowatts of electric motor power to replace or at least support the combustion engine. Today, we are talking of several hundred volt NiMH- or LiIon-batteries that requires driver ICs and power switches that can withstand breakdown voltages typically between 600V and 1200V.

From a purely semiconductor perspective, this is a major shift for the typical automotive semiconductor world which was previously sitting comfortably on a portfolio supporting a 12V architecture. In order to meet the more than 10-40 times higher voltage capabilities, innovative new IC and power switch technologies, platforms and products needed to be developed and introduced.

This new power semiconductor portfolio supporting the electric power train and high voltage car architecture is a huge paradigm shift for a typical automotive focused semiconductor supplier. Normally, it takes many years to develop new Silicon processes and technology platforms with such a revolutionary change in requirements. We are not talking of incremental modifications; the high voltage arena is a completely new world for automotive with new devices needed to be added to the proliferation of 14V/12V products.

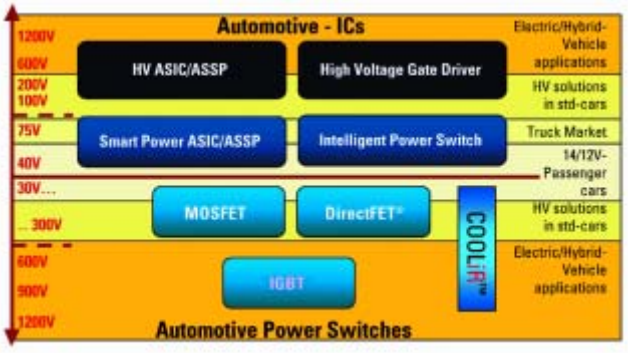

Figure 1: IR's Automotive Product portfolio of AEC-Q100 qualified Power switches and AEC-Q101 qualified ICs and their typical applications fields in cars trucks and (hybrid) electric vehicles

Usually, this could offer innovative newcomers a good chance to enter the automotive space with the right high voltage portfolio. Luckily for the existing players, up until that point, the high voltage space was mainly reserved for higher power industrial applications and

appliance and consumer space where electronics were powered directly by the 110V or 220V AC current from the home power outlet. Therefore, the advantage of gaining access to rugged and robust automotive high voltage technology and products was very much on the side of existing players who already served those high voltage non automotive markets. Though it is not straight forward to make industrial or consumer Silicon and packages automotive capable with a quality target of zero field failures, it was a very good starting point to leverage the technology platforms and products available.

In the case of International Rectifier, our automotive group could leverage quickly and efficiently our wide range of high voltage products, adding automotive grade and AEC-Q100 or AEC-Q101 qualified high voltage driver ICs and power switches to our standard 14V/12V-portfolio. Obviously the product mix of a portfolio addressing the energy efficient cars of today and tomorrow is very different from the standard combustion engine car of the past. Consequently, the electrification of the power train and the mandatory fuel efficiency and low emission regulations have a major impact on roadmaps and product strategies. As shown in figure 1, IR's portfolio extends widely beyond the traditional 14V/12V application range of passenger cars and trucks (24V) Besides the need for robust automotive high voltage Silicon, the packaging challenge of those devices must also be addressed. This also leaves a lot of room for innovation and some faster introduction of evolutionary technology than in the past.

In the case of IR's automotive portfolio this paradigm shift driven by the power train electrification has triggered enormous potential for innovative new solutions, driving the efficiency and power density of our products. Within the last few years IR has introduced more innovative new automotive products than ever before. Our new automotive product pipeline is filled with exciting products such as our new COOLiR2 bond-wireless and dual side cooled power package platform and our leading edge COOliR-Silicon platform. Overall, the revolution of the car architecture has had a very positive impact on automotive semiconductor development. Ultimately we, the end-user who will buy energy efficient cars, will soon benefit from today's innovation in the high voltage – high efficiency power management segment

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Electronics Industry Digest

By Aubrey Dunford, Europartners

GENERAL

IPC — Association Connecting Electronics Industries has released the summer 2011 edition of its quarterly business report, showing slower growth in most national economies, as well as in the worldwide electronics industry.

SEMICONDUCTORS

Worldwide semiconductor revenue has slowed in 2011, and the market is on pace to have revenue total $ 299 billion, a decline of 0.1 percent from 2010, so Gartner. This outlook is down from Gartner's previous projection in the second quarter for 5.1 percent growth this year. Three key factors are shaping the short-term outlook: excess inventory, manufacturing overcapacity and slowing demand due to economic weakness.

Measured in Euro, European semiconductor sales were € 2.138 billion in July 2011, down 2.2 percent on the previous month and down 12.2 percent compared to the same month a year ago, so the WSTS.

IDT and Qualcomm announced the signing of a definitive agreement to transfer the design team of IDT's Hollywood Quality Video (HQV) and Frame Rate Conversion (FRC) Video Processing product lines and certain related assets to Qualcomm in an all-cash transaction. In addition, both companies will explore opportunities to include IDT's broad portfolio of mixed-signal products into Qualcomm reference designs. This transaction enables IDT to intensify their focus on core timing, interface and analog-intensive mixed-signal solutions for applications in cloud computing, wireless infrastructure and consumer mobility.

The Swedish research institute Acreo announced the foundation of a new company, Ascatron. Based on the silicon carbide (SiC) technology developed at Acreo, Ascatron will specialise on the manufacturing of energy efficient SiC semiconductors. Target customers are suppliers of power devices and modules to the power electronic industry. Ascatron will the first independent "pure play" SiC foundry offering the complete fabrication service from device epitaxy to diced wafers. In the beginning Ascatron will use the established 4" wafer SiC process line at the Electrum Laboratory in Kista, Sweden. Then Ascatron plans to build up a dedicated large volume SiC device production fab, capable of handling more than 50 000 6" wafers per year.

Worldwide semiconductor manufacturing equipment billings reached $ 11.92 billion in the second quarter of 2011, so SEMI. The billings figure is 1 percent lower than the first quarter of 2011 and 31 percent higher than the same quarter a year ago. Worldwide semiconductor equipment bookings were $ 10.76 billion in the second quarter of 2011. The figure is 8 percent less than the same quarter a year ago and 3 percent lower than the bookings figure for the first quarter of 2011.

OPTOELECTRONICS

Falling prices and weak demand expectations for large-area TFT LCD panels have caused panel makers to adjust their H2'11 production strategies, so Displaysearch. As panel prices approach cash cost, panel makers are reducing capacity utilization. Global TFT LCD glass input peaked in Q2'11 at a record 14.2 million square meters per month.

PASSIVE COMPONENTS

Omron will acquire Shanghai Best Electrical Appliance Manufacturing (BST), a. manufacturer of power latching relays in China. BST commands the leading position in the Chinese market for power latching relays, with a share of approximately 30 percent. Power latching relay sales in China are expected to account for about 65 percent (quantity basis) of worldwide sales by fiscal 2015, growing into a 15-20 billion yen business.

OTHER COMPONENTS

Teradyne, a supplier of automatic test equipment, has signed a definitive agreement to purchase LitePoint, a provider of production line test equipment for wireless products including smart phones, tablets and WiFi-enabled PCs, for $ 510 M net of LitePoint cash and tax benefits. LitePoint had sales of $ 86 M in 2010.

Powervation, a supplier of adaptive digital power management IC solutions, has opened a new headquarters in Cork, Ireland.

DISTRIBUTION

Avnet Abacus has recently been named 'Design Distributor of the Year 2010' by Amphenol Infocom. The award recognizes the outstanding success Avnet Abacus has achieved designing in the company's electrical, electronic and fibre optic connectors, interconnect systems and coaxial/flat ribbon cable products.

Avnet Memec, a specialised semiconductor distributor, announced the expansion of its pan-European distribution agreement with Renesas Electronics Europe to include industrial automation products. Avnet Memec already distributes Renesas Electronics' mainstream technologies including MCUs, Opto-Couplers, Power MOSFETs and ASICs across Europe.

EBV Elektronik, an Avnet company, and Aptina, a split off from Micron and one of the leading suppliers of image sensors globally, announced a distribution agreement to promote and deliver Aptina products to customers within the total EMEA region.

Anglia Components has been awarded the Mitsubishi Electric Europe Distributor Award 2011 for sales of High Frequency Semiconductor Components.

Power supply manufacturer TDK-Lambda extends its reach in the Irish market with the signing of a franchised distribution agreement with Futura Electronics, a distributor headquartered in Dublin.

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

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Does your digital power-supply design require high performance flexible on-chip peripherals?...

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Microchip's new dsPIC33F 'GS' Series DSCs provide on-chip peripherals including high-speed Pulse-Width-Modulators (PWMs), ADCs and analogue comparators, specifically designed for high performance, digital power supplies.

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Typical applications of the new 'GS' series DSC include: Lighting (HID, LED, fluorescent), uninterruptable power supplies, intelligent battery chargers, AC-DC and DC-DC power converters, solar and pure sine-wave inverters, induction cooking, and power factor correction.

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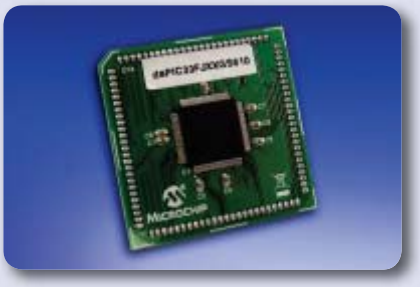

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4th ECPE SiC & GaN User Forum

Potential of Wide Bandgap Semiconductors in Power Electronic Applications

By Andreas Lindemann, Otto-von-Guericke-Universität Magdeburg, Chair for Power Electronics

After the Silicon Carbide (SiC) User Forums organised by ECPE in 2006, 2007 and 2009, technology has advanced significantly and time had come to continue the exchange between experts involved in converter and device development: The fourth User Forum focused on recent developments, in particular of SiC transistors and of first Gallium Nitride (GaN) power devices. Typical power electronic systems the use of wide bandgap devices is highly promising for have been presented in conjunction with SiC and GaN devices themselves which are the base for future system development. Renowned experts from all over the world have been invited to give an overview in a keynote, to foster physical understanding, to in depth explain their research and development work in technical presentations and to share their knowledge in discussion forums as an indispensable part of the event. The User Forum this way established a platform to share experience and ideas, to discuss and find out which power electronic systems are predestinated for usage of SiC or GaN and how to appropriately design-in those novel, almost ideal but also challenging components. It aimed at finding and pointing out approaches to exploit the high potential of those devices and to support their beneficial introduction in power electronic systems. User Forum 2011 took place right after EPE-ECCE Europe conference in Birmingham. Prof. Andreas Lindemann (Otto-von-Guericke-Universität Magdeburg, Germany) took the chair together with Prof. Phil Mawby (University of Warwick, UK) and Mr. Thomas Harder (ECPE). The major findings of the event are summarised in the following:

State of the Art and Trends

Starting in the beginning of the supply chain, SiC material situation has relaxed with respect to defect density and also some cost reduction, which is a remarkable, but nevertheless comparable development as Silicon (Si) has undergone earlier. Consequently GaN on Si for power devices is still in an earlier stage, promising an attractive cost structure but still requiring considerable research and development effort for further commercialisation.

On the device side, SiC Schottky diodes up to 1700V blocking voltage and some tens of Amps nominal current are a well-introduced commercial product for use in switched mode power supplies, power factor correction stages etc. Based on this and as already demonstrated in laboratory, the diode current and voltage ratings might be further increased in future for industrial applications to exploit their advantageous switching behaviour in high power electronics, where they can complement Si IGBTs as free wheeling diodes, leading to significantly lower switching losses compared to Si diodes.

The development of SiC transistors was in the focus of this year's ECPE User Forum: Compared to Si, a surprising variety of SiC transistor types has established which constitutes an attractive playground for circuit designers: There are SiC MOSFETs, bipolar transistors and junction FETs (JFETs). The SiC MOSFETs behave in a similar way as Si MOSFETs although still concerned by some stability and mobility issues; the former fact is attractive because control circuitry known from Si MOSFETs can basically be re-used for these normally-off devices. In contrast, normally-off JFETs should be turned on with a gate voltage that leads to some current flow. The performance of normally-on JFETs can be exploited optimally with a modified cascode circuit, where the low voltage, normally-off Si MOSFET is only used as a back-up to block, when no driver supply is available, while otherwise the JFET is controlled itself. A major step to commercialise this will be modules ioncorporating the cascodes and in particular driver ICs for these modules, this way providing a fast switch with the same logic interface as used for conventional solutions. Care needs to be taken in package and circuit design especially regarding parasitics which should be reduced because of the steep switching slopes; some new approaches have been elaborated to achieve this. SiC bipolar transistors finally are driven with a base current; their switching times are comparable to unipolar MOSFETs' or JFETs'. Transistor devices have recently been released as commercial products with ratings comparable to aforementioned SiC diodes'. Photovoltaic inverters can be expected to be a key application for commercial introduction of SiC transistors: Here the prerequisite can be expected to be met reasonably quickly that reduced system cost will compensate higher device cost. Reliability of course is a further key issue for industrial application: There is plenty of experience with SiC Schottky diodes; SiC transistors have been qualified and released, field experience will now need to prove that the tests have been appropriately chosen.

GaN high electron mobility transistors (HEMTs) in this respect have been presented to fill a particular niche --- their exceptional irradiation hardness is a prerequisite for use in collider physics detectors. In addition, the potential of circuit integration can be expected to also make them attractive for variuos volume applications.

Outlook and Conclusion

Device and system related research and development has led to remarkable results: Power electronics with wide bandgap SiC and GaN semiconductors is established on an industrial level. Nevertheless, this process will go on with future R\&D covering the areas from material level via device structures, technology and packaging, circuit and control issues up to system design as outlined above. This way, wide bandgap power electronics can contribute to solve actual challenges, aiming e. g. at energy efficiency, increasing usage of electric energy from renewable sources or electromobility. The European Center for Power Electronics ECPE fosters this; an update about further progress can be obtained on the occasion of the next ECPE SiC \& GaN User Forum.

www.uni-magdeburg.de/llge

www.ECPE.org

The Future Is Now at Darnell's Power Forum

By Linnea Brush, Senior Research Analyst, Darnell

Most power electronics companies have a good handle on their products and markets. Keeping up with an existing market is not the same as looking ahead to emerging markets, however. The continuing success of any company is knowing where future sales will come from. Being on the "leading edge" has become critical in a competitive global economy.

In power supply terms, this translates into three mandates: (1) knowing where power electronics is headed; (2) what is going to enable these forward-looking technologies; and (3) the current commercial opportunities. These are the result of good timing on the part of applications, emerging power designs and good business models.

Darnell's Power Forum (DPF '11) has evolved into a showcase of the latest power electronics developments, presented by leading-edge companies at the component, power supply and system levels. This focus has gotten refined over the years, and DPF '11, held in San Jose, California, featured most of the major trends going on in the power electronics world. This not only included "top level" drivers, such as digital power, energy harvesting, Silicon-carbide (SiC) and Gallium-nitride (GaN), solid-state batteries and power-supply-on-chip; but also new topologies for performance optimization and power measurement. The Smart Grid, vehicle electrification, photovoltaics, and high-performance consumer devices were backdrops for these developments.

GaN, along with solid-state and thin-film batteries, are good examples. These are just coming onto the commercial scene, with new products being announced. The companies making these products, like Efficient Power Conversion (EPC), Transphorm, Cymbet, and Infinite Power Solutions (IPS), all provided updates on both their products and how they see the markets for their products evolving.

For example, Transphorm, which recently came out of "stealth mode," claims to be "redefining energy efficiency with the most efficient and compact power conversion technology." The company uses GaN materials to produce ultra-efficient and cost-competitive power modules that are said to "eliminate up to 90% of all electric conversion losses." Transphorm delivers custom-designed power modules for consumer electronics products, industrial motor drives and inverters for solar panels and electric vehicles, and sells these modules to power equipment manufacturers. The company uses vertical integration in its designs, and this reflects a general theme at DPF '11.

According to EPC, "changing topologies are still driving the industry." GaN FETs have the opportunity to improve dc-dc converter efficiency and performance, but "layout design is critical." Paralleling the company's eGaN FETs, for instance provides a configuration that is fast and stable, according to the company. EPC expects to see 600V products by the end of 2011, with 900V to 1,200V products for electric vehicles and motor drives "within the next couple of years."

These products are examples of the trend toward higher levels of integration in packaging. And the trend is emerging in some unexpected areas, such as Cymbet's embedded solid-state battery for SoC power. The company's EnerChip™ rechargeable solid-state energy storage devices are created using semiconductor processing techniques on silicon wafers. EnerChip devices are compatible with other semiconductor integrated circuits and passive devices and can be co-packaged together. EnerChip devices as small as 1mm x 1mm can be coupled with other ICs to create unique innovative products.

EnerChip rechargeable solid-state energy storage devices became available in 2008 and are designed for direct integration at the chip level, or as an SMT component replacing current coin cell battery or supercapacitor products. Embedded Energy is useful in industries such as consumer electronics, industrial controls, medical devices, environmental sensors, hand-held devices, networking and communications systems, security and tamper protection, and military/aerospace.Another solid-state storage solution comes from Infinite Power Solutions. The company offers a solid-state micro-energy cell (MEC) for ambient energy harvesting techniques for recharging – such as solar, thermal, RF, magnetic and vibration energy. The company's THINERGY MECs are fabricated using a vacuum deposition process to sputter deposit thin layers of inorganic battery materials onto a thin metal foil substrate. According to the company, external terminals in the form of positive and negative nickel-plated tabs are located along the top edge of the cell for "easy soldering to printed circuit boards (PCBs)." IPS says that, "Component selection and system design must be appropriate for the long-term life of the system, especially when it comes to energy storage."

The Roundtable Panel discussion raised the same question as last year's Roundtable: "What will be the most important driver for the power electronics industry in the future: Architectures, Topologies, Materials or Applications?" Chief Executive Officers, Presidents, Vice-Presidents and other top-level people in the industry addressed this question from a very different perspective than in 2010 – showing how much has changed in just 12 months.

Even though most of the panelists last year agreed that all four drivers were important, this year, topologies gained a distinct edge, even if these ultimately lead to an emphasis on materials or cost. Along with EPC's assertion that changing topologies are driving the industry, CUI has also chosen to focus on topologies. All the panelists agreed that both value and cost are important, but that "even cost cannot make up for performance problems."

This focus on topologies continued through the technical presentations related to performance optimization and power measurement. National Semiconductor presented "the industry's first" half-bridge gate driver optimized for eGaN FETs. The FET structure is a lateral

device. Eight eGaN FETs have been used in an isolated dc-dc converter, and the device has also been used in a non-isolated dc-dc converter. Product release was planned for October, 2011.

Fairchild Semiconductor spoke about a high-efficiency, three-phase, soft-switched dc-dc converter for arc welding applications. And Sensitec discussed their "integrated" AMR current sensor (i.e. SO16 packaged sensor plus ASIC), packaged with an external 10A to 1,000A external conductor. The advances being made at these levels are in direct response to demands being made at the system level.

The Energy Harvesting session included numerous developments, from wireless charging, micro-inverters for PV applications, electro-dynamic generators, building automation systems, and solid-state batteries. A single application can encompass multiple power supply technologies and solutions, all of which are coming closer and closer together.

The trend toward integrating all the power conversion components on a single chip has its parallel at the system level, where power converters, ICs, batteries, and capacitors may all be used and must work together. As a result, equipment standards were also discussed in these sessions, and their importance is likely to grow as Smart Grid technologies start appearing in greater numbers. In fact, Tyndall Institute said that "smart cards" are expected to drive energy harvesting technologies, along with microbatteries, capacitors, sensors, radio frequency and antennas.

Another sign that energy harvesting is moving into the mainstream was Digi-Key Corp.'s announcement that it had added an Energy Harvesting TechZone to its expansive listing of online resources. Digi-Key was a Diamond Sponsor at DPF '11, and the company said that energy harvesting is "one of the fastest-growing technologies in the industry." The new TechZone features application notes, product highlights of the latest innovations, product guides, Product Training Modules, videos, white papers, and an in-depth solutions library containing articles penned by experienced engineers discussing the industry's leading solutions and state-of-the-art technologies. Digi-Key also created an Energy Harvesting Community on their TechXchange to promote discussion and to aid engineers in need of project assistance in the Energy Harvesting area.

One of the most interesting things to come out of DPF '11 is that, although many of the technologies presented are "emerging," there are more commercial products available than one might think. The Forum included several sessions devoted to digital power management and control, which has moved solidly into the commercial sphere – even though it is still considered a "newer" development. By definition, these technologies are not the lion's share of the market, and they are not intended to be that – at least not now. The rapid development of advanced systems, however, will drive the need for power that these products address.

Darnell's Power Forum

http://dpf.darnell.com/index.php

Power Electronic Modules in Critical Auxiliary Drives in Windmill Applications

The main task of a windmill clearly is harvesting energy and feed it to the grid. It often remains unnoticed, that controlling the mechanical parameters of the power plant also involves power electronic. To properly control the mechanical components of the plant, adapt its aerodynamic properties to the wind speed, allow for safe shut down during grid failure and enable the demanded low-voltage–ride-through capability, highly reliable power electronic components are mandatory.

By Dr.-Ing. Martin Schulz, Infineon Technologies

Basic Aerodynamics and Windmill Characteristics

The operating range of a wind turbine can be separated into four

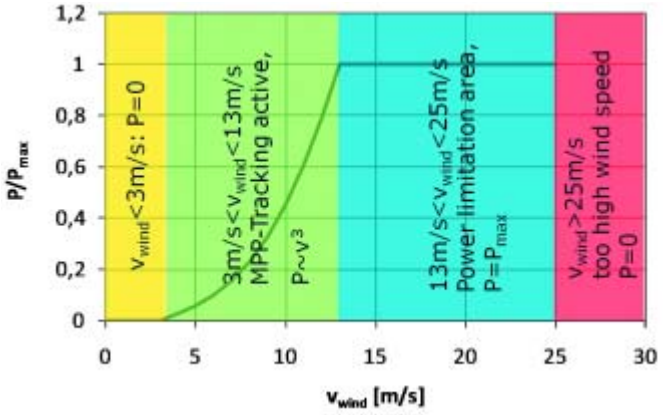

Figure 1: Operating range of a windmill

regions as it is hinted out in Figure 1.

Below a certain wind speed, 3m/s in the example, energy generation remains impossible. Afterwards, up to 13m/s chosen here, the power output becomes a cubical function of the wind speed. Maximum power point tracking can be done in this region by choosing a proper output current rather than adapting the mechanical characteristic of the rotor. At wind speeds exceeding a specified value, the mill is operated in power limiting mode varying the aerodynamic properties of the rotor by properly aligning the blade's angle – also known as its pitch.

A windmill is an aerodynamic machine with a torque-to-speed characteristic that, to certain extend, is defined by the blade's geometry. For a notional device, a normalized characteristic is depicted in Fig. 2. The diagram is based on the assumption that the blades are kept at constant angle to the wind.

Normalizing is done to eliminate the wind speed in the considerations regarding the mill's characteristic; normalizing factor is the ratio between rotor tip-speed and wind-speed

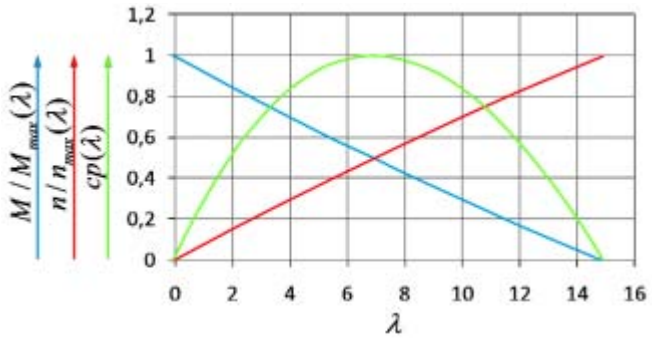

Figure 2: A notional windmills characteristic showing normalized torque, speed and power

$$\lambda = \frac{v_{rot}}{v_{wind}}$$

From mechanical aspects it is mandatory to keep the tip speed at subsonic levels, thus a limitation of the rotor's speed is mandatory at high wind speeds. To allow energy generation at a maximum wind speed of 25m/s, l has to be limited not to exceed 13 at this point.

To adapt the rotor's characteristic to continuously suit the changing conditions, the blades have to be turned along their longitudinal axes. This function, known as Pitch Control, is achieved by geared motors at the base of each blade; each motor is equipped with a converter that is referred to as Pitch Controller. A closer look to this particular application of power electronics reveals the high demands that need to be fulfilled.

Pitch Control – a most demanding application

The Pitch-Controller suffers from several influences coming from the location it is mounted in. Rotating with the hub of the mill, the inverter is subject to low frequency centrifugal forces and has to withstand the vibrations inside the hub. From thermal aspects, the geographic location matters as the ambient temperature may reach from -40°C and less in cold regions to more than 50°C in equatorial regions.

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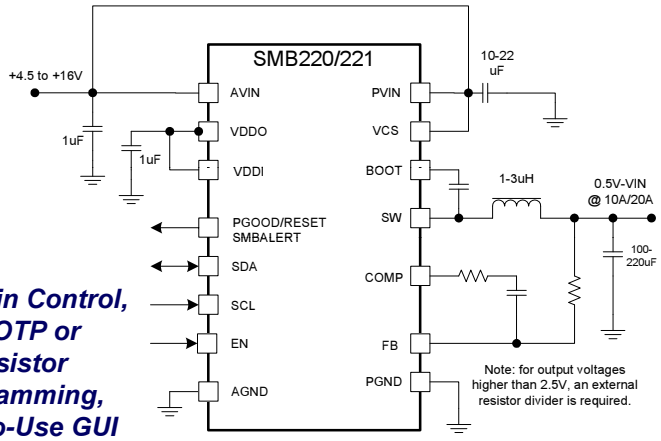

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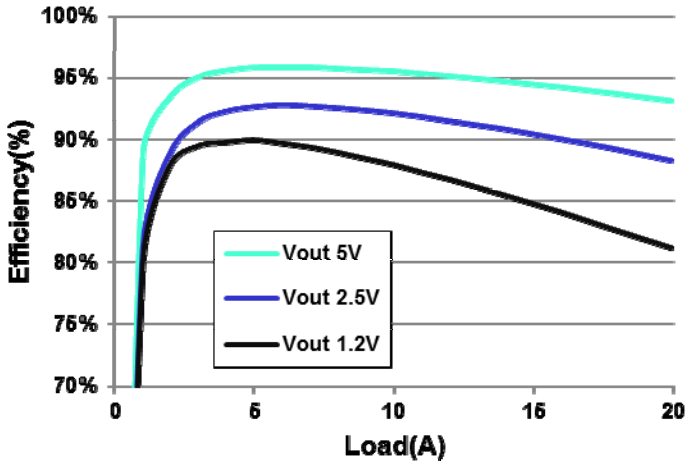

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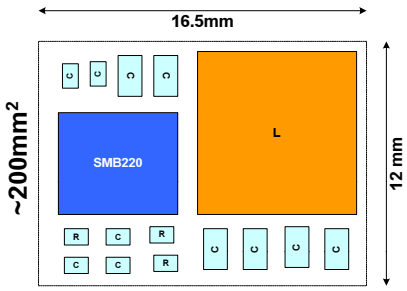

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Switching Frequency (kHz)	300-1200	500/1000	500/1000	250-1000	250-1000
Output Voltage Range (V)	0.5-VIN (Prog)	0.8-VIN (Prog)	0.8-VIN (Prog)	0.5-VIN (Prog)	0.5-VIN (Prog)
Internal/External FETs	External	Internal	Internal	External	Internal
Output Voltage, Seq., Softstart, OCP	Prog	Prog	Prog	Prog	Prog
Output UV/OV Monitor	Prog	√	√	Prog	Prog
RESET/POWER GOOD Output	√	√	√	√	√
I2C/SMBus Interface	√	√	√	√	√
Packages	7x7 QFN-56 5x5 QFN-32	3x3 QFN-20 TSSOP-24	3x3 QFN-20 TSSOP-24	3x3 QFN-20	5x6 QFN-28

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Atmospheric conditions can include dry heat and dust in deserts as well as high humidity and salty mists in offshore plants.

Electrically, pitch controllers resemble the structure of an uninterruptable power supply (UPS) as they have to operate safely in case of grid failure. Therefore, batteries are part of the design, and in case of grid failure the DC-link voltage given by the battery in use differs from

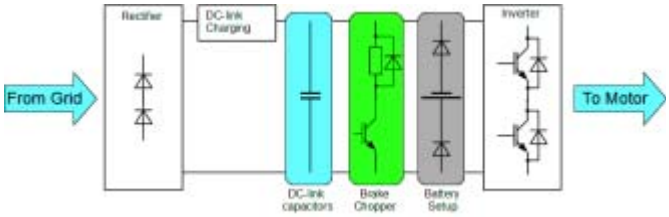


Figure 3: Block diagram of a converter for Pitch-Control including rectifier, DC-link with brake chopper, battery with decoupling diodes and inverter

the one in case the grid is available. To maintain the batteries, auxiliary chargers need to be added. Being connected to a DC-link with voltage levels higher than the battery voltage, decoupling diodes are installed to protect the battery from DC-link voltages exceeding its specification. A block diagram of the setup is given in Figure 3.

From the diagram and the mode of operation, several special demands not usually seen in a drive application can be derived.

As the pitch controller has to operate in case of short-term grid failures in the range of several hundred milliseconds, there is a high probability that the motor is active the moment the grid voltage returns. In this instant, a difference between input voltage and DC-link voltage will lead to an inrush current that could damage the input rectifier. To prevent diode failure, the inrush current has to be limited. Using a resistor and a relay contact is the most widely used method in low-power drives applications. The resistor limits the current; the relay contact is activated to bridge the resistor as soon as the DC-link voltage reaches a certain limit. The procedure is well established and works properly in industrial drives as during the time needed to charge the DC-link capacitors no current is delivered to the application.

In pitch controllers, this is a reoccurring scenario whenever the grid voltage is restored while the motor is driven from the battery. Charging the DC-link using a resistor may take too long as some of the input current will go to the motor. Thus, extensive heat would be generated inside the charging resistor leading to accelerated ageing or even destruction. Keeping the resistor bridged using the relay contact

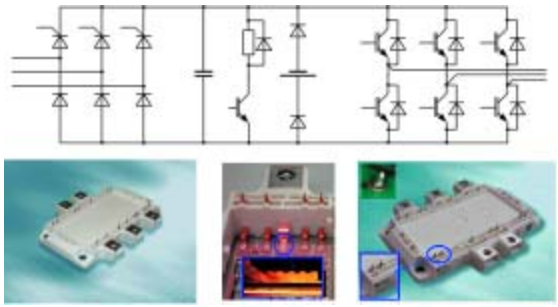


Figure 4: Schematic to substitute the charging resistor in pitch-control applications using a half controlled thyristor-rectifier as an input stage. Modules displayed are the TDB6HK360N16P and FS200R12PT4 showing details about PressFIT and ultrasonic welding in the center

will lead to high inrush currents threatening the rectifier diodes.

To prevent both from happening, a half controlled thyristor-bridge as an input rectifier poses a viable solution. In combination with a six-pack to drive the motor, the resulting schematic is depicted in Figure 4 also including power modules suitable for this application.

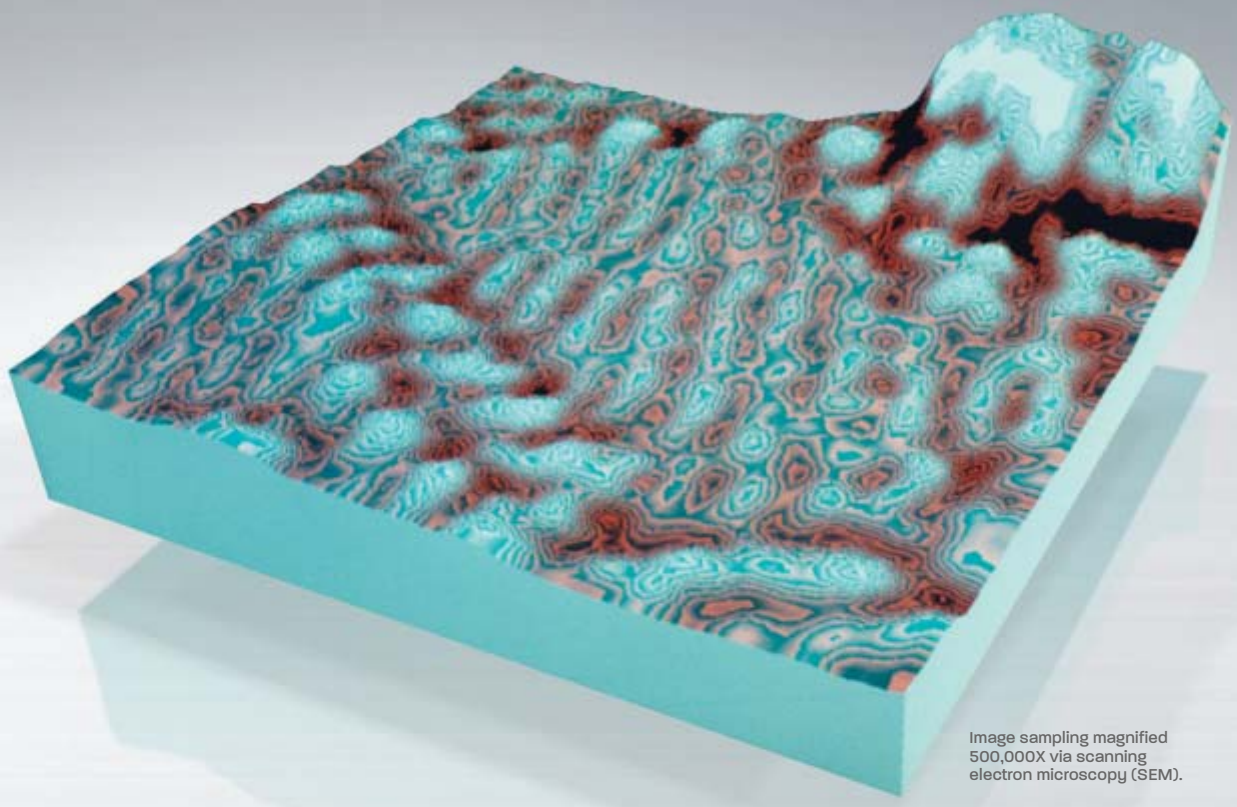
The power modules are based on the EconoPACK™ 4 which is especially designed to support applications with demands resulting from extended mechanical stress. To do so, special features of the module family include:

* Injection molded copper bars for power connections·
* Ultrasonic welding to replace wire bonding to the module frame
* PressFIT-Connectors to improve the interconnection to the control terminals ·
* Screwable power terminals ·
* Qualification regarding vibrations according to harsh military standards.

In this setup, charging the DC-link can be controlled using the thyristors. These can be chosen to provide current levels high enough to ensure fast charging of the DC-link even if the motor is operated at full power.

Besides the mechanical robustness, pitch control is a highly demanding application regarding thermally induced stress. To control the blades it is demanded by the grid code to rotate a blade at a speed of 3° per second in continuous operation and with up to 12° per second in emergencies. Given that a single blade of a 6MW windmill has a mass of up to 20 tons it becomes obvious that moving these masses comes with large inertias and high breakaway torques that need to be overcome in addition to the aerodynamic forces applied to the blade.

At the speed demanded by the grid codes, changing the blade's alignment only takes a few seconds which makes pitch control an application delivering short burst of high torque.
So-called power cycling, a rapid heating and cooling of the power electronic component's internal construction, is the consequence. Power cycling leads to mechanical stress at the bond wires. Their thermo-mechanically induced movements lead to deterioration and bond lift-off in the final state.
To compensate this effect, proper dimensioning of the semiconductor and appropriate thermal management has to be done; characteristically, oversizing of the power electronic components is a consequence of this mode of operation. Larger semiconductors inherently feature larger thermal capacitances, thus the thermal swing to the internal construction is reduced.
Special care in dimensioning has to be taken, also taking the battery-powered operation into account. In case the drive is operated from the batteries, the DC-link voltage is reduced. If constant output power is driven to the application, the currents to the motor have to be increased to compensate for the lower voltage. This also adds to the burden of overload already described.
The task of rotating the blades includes a further mechanical challenge. Due to the construction of the blade it acts as a torsion spring element, excited by starting the rotation. In a worst case scenario, a wave-like movement can occur. The wave is reflected at the tip of the blade and returns to the motor. Oscillations like this have to be kept at tolerable limits and damage to the mechanical components has to be prevented. To do so, regulation strategies include the regenerative operation of the pitch controller to smoothly dampen these oscillations. This in turn leads to the necessity of integrating a brake chop-



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per to control the DC-link voltage in case it reaches critical limits.

Finally, proper torque-to-speed characteristics have to be maintained during the start of the rotation to minimize the excitation of the spring-system in the beginning.

Low-Voltage-Ride-Through

Windmills as power plants are connected to the grid and are required to cope with the according transient changes without shutting down. One phenomenon that has to be handled is a voltage drop for a period of several hundred milliseconds. During this low-voltage period, the countertorque to the generator is reduced leading to a sudden increase in the rotor speed, possibly leading to overspeed conditions. As in the instance the voltage sag takes place the duration of the effect is not predictable, the mill's control can protect the rotor from overspeeding by realigning the blades to produce a braking torque. Emergency shut-down can bring the rotor to a full stop in less than one turn. Though this protects the mill from mechanical point of view, the plant goes off-line and its contribution to power generation is lost in case the voltage levels are restored within a certain time. Lately, this effect has lead to a shut-down of complete wind parks in Asia with turbines not able to handle this situation. It resulted in the loss of several MW that were no longer available to the mains.

Grid-codes in Europe like the E.On-Directive therefore demand that a wind turbine can handle voltage sags of at least 1.5 seconds before the mill shuts down. To achieve this so-called Low-Voltage-Ride-

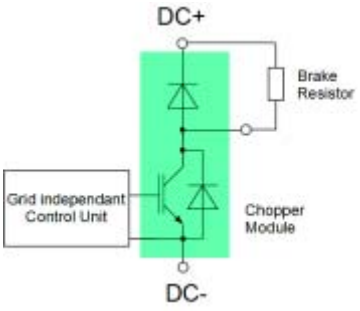

Figure 5: Brake-Chopper to add Low-Voltage-Ride-Through capability to the power electronics of a wind turbine

Through capability, it is mandatory to control the energy generated during this time. As the grid is not available, converting the energy to heat is the most widely spread option. A brake chopper is added to the power electronics of the grid inverter, consisting of a chopper-type module and a brake resistor. A typical schematic is depicted in Figure 5.

The approach is valid for synchronous generators; asynchronous machines like the double fed induction generator (DFIG) would require an additional crow bar to operate properly.

This particular brake chopper is designed to operate without the grid being available and therefore needs a power source that is independent from the grid. Several design possibilities can be covered using Infineon building blocks or power modules.

In case the brake chopper is designed as a part of the grid-side inverter, it depends on the power level demanded, what kind of power module could be used.

Starting from several hundred amps, a PrimePACK™ in either high-side or low-side chopper configuration is an excellent option to create a customized design. Modules of up to 1700V/1400A are available. Due to their enlarged creepage and clearance distances along with outstanding mechanical robustness, these modules are predestined to be used in wind-mill applications. Higher power levels can easily be achieved by paralleling modules.

A dedicated solution offered by Infineon is based on the fact that the low-voltage-ride-through chopper only needs to be operational for less than two seconds and most likely only a few times a day. From these conditions it is obvious, that a cost-efficient thermal capaci-

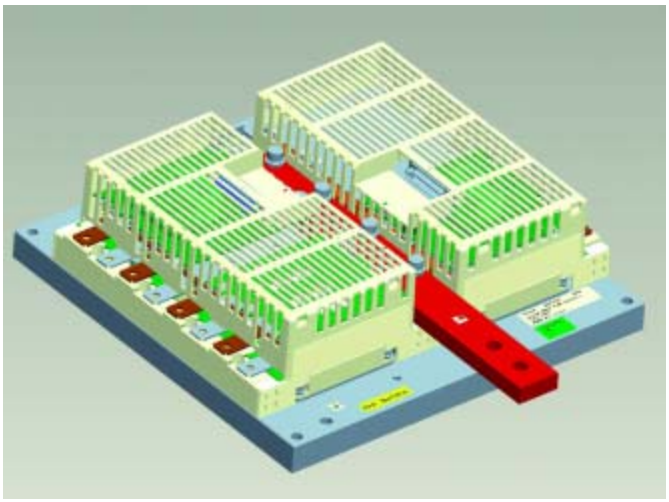

Figure 6: PrimeSTACK™ based brake chopper 2PS24017E3CE31401 with a thermal capacitance replacing the more expensive heat sink

tance can be installed to replace the more expensive heat sink or even cold plates. Infineon therefore has designed a chopper based on the well-established PrimeSTACKÔ components, making use of eight paralleled 62mm modules in half-bridge configuration. As can be seen in Figure 6, an aluminum plate is used to mount the electronic units, serving as a carrier and as a thermal capacitance at the same time.

The internal half bridge can be configured to either be a high-side or a low-side chopper depending on customer's preferences. The thermal capacitance is dimensioned to allow an operation of the device for 10 seconds at full power and therefore is well suitable for the task. Current ratings of the half-bridge displayed reach up to 2400A in 1700V designs. Making use of the thermal capacity only, fans or even more advanced cooling systems are omitted, making this a cost-efficient and reliable solution as no external, especially mechanical, components can fail.

Conclusions

A wind turbine is often seen as a megawatt application only. As a power plant, it can only operate properly if all interacting subsystems are considered. Special care has to be taken regarding the design of auxiliary drives that are mandatory for the safe operation of the whole system. Infineon, with extensive knowledge in both, the application and the semiconductors needed, can contribute to this application providing highly reliable solutions for a power range spanning from kilowatt to megawatt.

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The Grey Area

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Data sheet specifications for power semiconductors are values which are assured by the manufacturers. But they can only be used to a limited extent for dimensioning and calculation.

By Thomas Schneider (Dipl.Ing.FH), GvA Leistungselektronik GmbH, Mannheim

Even semiconductor parameters which at first glance appear mundane and often negligible, such as the reverse current, can become crucial for the operational reliability of the entire system when they are examined in more detail and there is an appropriate operational mode. Another “static” parameter alongside the blocking characteristic is the forward voltage of semiconductors. Contrary to the blocking behaviour where the residual current through the semiconductor is specified in the turned-off state, the forward voltage VF, VT or VCE(sat) describes the voltage which remains across the element when it is in the turned-on state. Depending on the technology and the type of semiconductor, the forward voltage is in the range of approx. 1V (for thyristors and diodes) up to approx. 5V (for high-blocking transistors). For power semiconductors which are typically used in switching operations, the forward voltage is portrayed in trends as a function of the current, the temperature and the activation conditions. What these diagrams do not reflect is the fact that, in the transition from the blocking to the conducting state, it takes a certain amount of time until the forward voltage reaches its static value which is stated on the data sheet. The "forward-recovery" voltage arises when the junction areas are not yet fully inundated with charge carriers and only partial conductivity arises. The voltage swell, which is also again dependent on other parameters such as temperature or the di/dt of the current, takes a few microseconds even with fast components such as IGBTs or epi-diodes and, if the elements only conduct for very short periods of time, this can easily increase the forward power losses considerably compared with the value on the data sheet.

The following example shows the turn-on of a 400A/3300V free-wheeling diode in an IGBT module. In spite of the really low di/dt of the current, an anode-cathode voltage of almost 20V is produced, which reaches its static passage value only after approx. 10 µs. It is only after this time that the junction of the diode is completely inundated with charge carriers – the diode is in the saturated conducting state.

When the semiconductors are operated with very short current pulses, there is another critical operating point whose effects are not specified on any data sheet. By means of suitable diffusion profiles and strengths, the charge carrier life spans are set in such a way that the flooding and evacuation of the junction regions takes place continuously, i.e. adapted to the load current. However, this requires that the junction is also completely inundated with charge carriers. Power semiconductors which are fabricated with such doping profiles are noted for having a so-called "soft" switching behaviour. The current transitions are constant, without any steps. But even elements with "soft" switching behaviour also change their characteristics if, as a result of very short turn-on or turn-off times, the static states of "blocking" or "conducting" are not achieved.

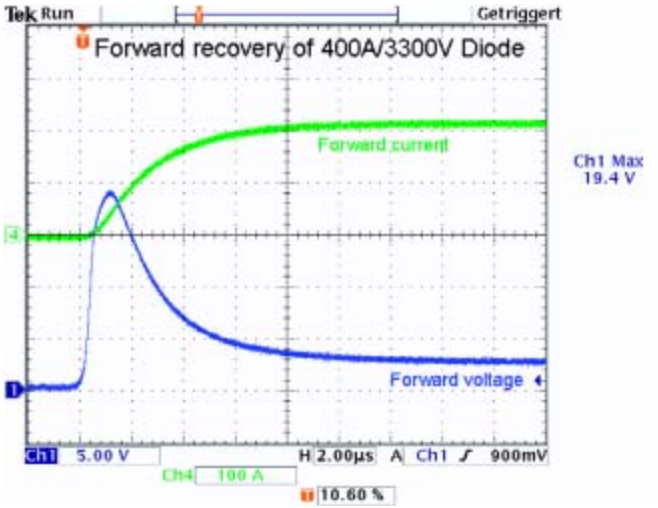

Figure 1: Forward recovery behaviour of a 400A/3300V IGBT free-wheeling diode

Example:
The active input rectifier of a 3-level NPC converter works perfectly at full load and partial load. However, in low partial-load operation and when in idle mode, the electromagnetic interferences increase so much that the signal transmission and communication within the converter repeatedly grinds to a halt and failures of IGBT modules were also seen.

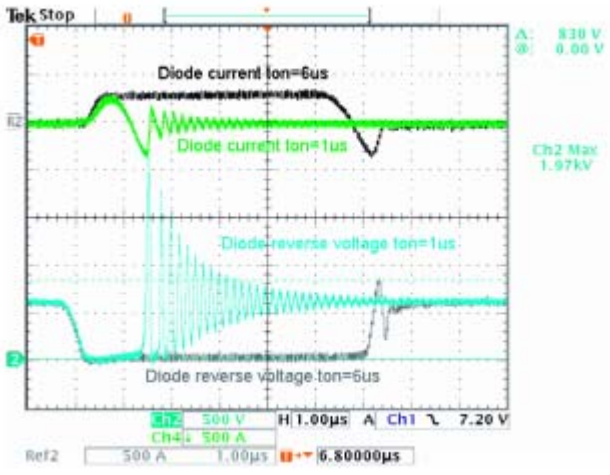

Figure 2: Turn-off behaviour of a 1200A/3300V IGBT free-wheeling diode with a long turn-on time (6µs) and a short turn-on time (1µS)

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The cause of this were, owing to the control behaviour, short pulses in the range of 2-3µs relating to the neutral point diodes. As can be seen from the "forward recovery" in figure 1, the diodes are not yet fully turned on after this time. If the junction is now removed from the charge carriers again by the application of the reverse voltage, this will happen very quickly on account of the non-existent saturation of the diode. The forward current through the diode breaks off with a very high di/dt and this produces high overvoltages coupled with severe oscillations.

The two measurements were each performed with 300A diode current and 600V DC-link circuit voltage. With a turn-on time of 6µs, the diode is almost completely saturated. The subsequent commutation process is gentle, the clearance of the charge carriers is continuous and the resulting overvoltage is low. The non-saturated diode interrupts its reverse recovery current very quickly, and the high di/dt produces a switching overvoltage which can become so high that the limit voltage of the semiconductors is exceeded.

Conclusion: Alongside the obligatory low-inductance execution of the commutation pathways, the control process of the semiconductors can also bring about problematic operating states. Particularly in the case of IGBT modules with reverse voltages of >= 2500V, it is therefore absolutely essential to comply with minimal turn-on and turn-off times.

	Test voltage	Test current	Temperatur e	Gate voltage	E_{On}	E_{Off}	Ls
	Volts	Amps	°C	V	mJ	mJ	nH
Manufacturer A	1800	1200	125	+/-15	1890	1950	100
Manufacturer B	1650	1200	125	+/-15	1700	1900	100
Manufacturer C	1650	1200	125	+/-15	1650	1750	100
Manufacturer D	1800	1200	125	+/-15	1730	1900	125
Manufacturer E	1800	1200	125	+/-15	2200	1550	40

Table 1: Switching energy specifications for various 1200A/3300 IGBT modules

Another aspect which is very important for the dimensioning and functional reliability is the dynamic losses of the power semiconductors which, depending on the application, can account for more than 75% of the total power loss of a system. Reliable data sheet specifications are vital here, but the interpretation of the specified values is just as difficult as the interpretation of the reverse currents. Most manufacturers of power semiconductors, especially IGBT power modules, only provide typical specifications both in the characteristic values and in the diagrams relating to the switching energies. Even if the power and voltage specifications under which the values were determined are handled almost uniformly, they still differ on one important point, the leakage inductance of the test benches. The following table shows the EON/EOFF specifications for 1200A/3300V IGBT modules from different manufacturers:

If you take account of the slightly lower test voltage with two of the manufacturers, the switching energies for manufacturers A to D are of the same order of magnitude. Only manufacturer E deviates from this, but with lower values for the leakage inductance. This has a substantial influence on the relation between EON and EOFF. A simple test makes the influence of the leakage inductance clearly visible. In an existing converter output stage, the electrolytic capacitors which were originally provided were replaced with polypropylene capacitors. The mechanical structure, that is to say the inductance of the feed lines and the DC link bus bar configuration, remained the same. The internal inductance of the electrolytic capacitor bank was approx. 250nH, and that of the film capacitor bank was approx. 40nH.

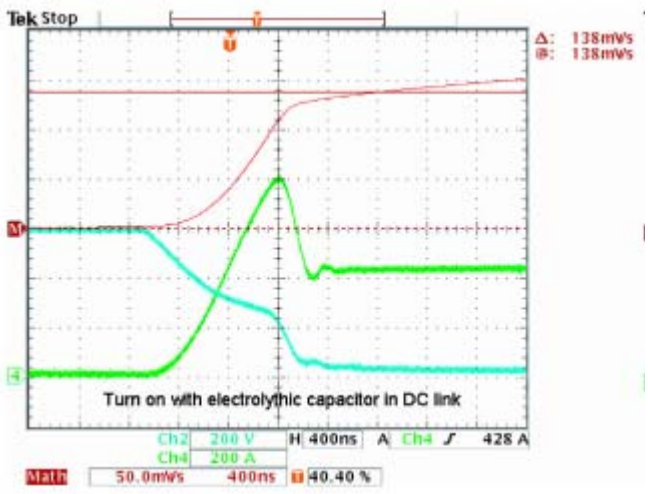


Figure 3: Turn-on behaviour with electrolytic capacitors

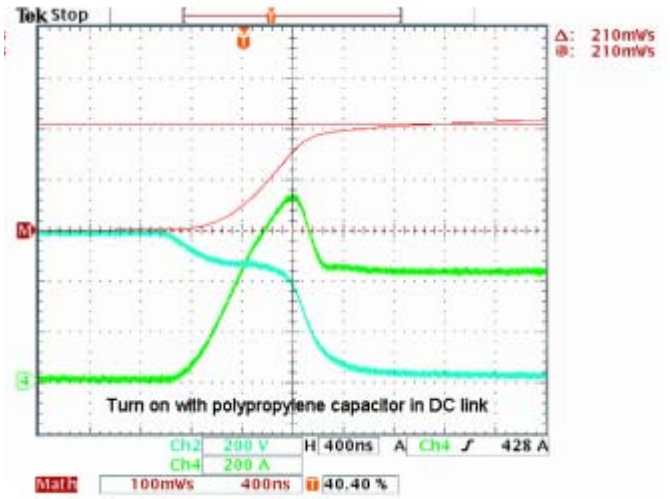


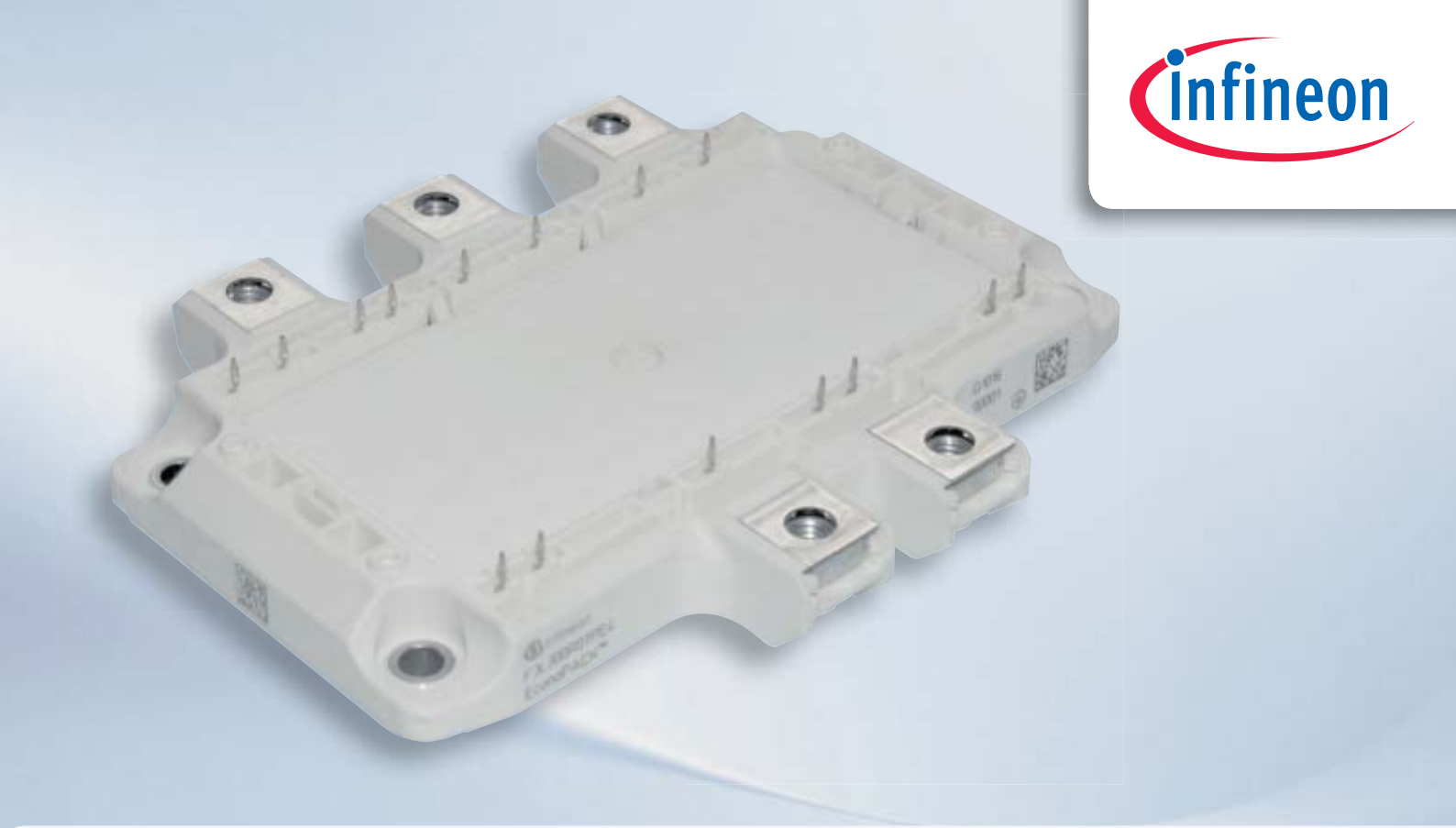
Figure 4: Turn-on behaviour with film capacitors

The inductive voltage drop which is caused by the leakage inductance when the IGBT is turned on reduces the turn-on energy.

However, when the power is turned off, exactly the opposite is achieved and the increased leakage inductance generates higher turn-off voltages and thus also higher turn-off losses:

In this example alone, the total switching losses EON+EOFF increase from 281mJ to 337mJ, and this is primarily as a result of the changed turn-on behaviour.

This means that the varying data sheet specification of manufacturer E in Tab. 1 can also be explained. The much lower leakage inductance leads, as a result of the lower inductive voltage drop on the collector of the test specimen, to higher turn-on losses, but also to lower turn-off losses. This correlation puts the high EON and lower EOFF values of manufacturer E into context. In a test environment which displays the same leakage inductances of the other competitors of approx. 100nH, the dynamic losses will also approximate one another. The first impression does not always have to be the right one.



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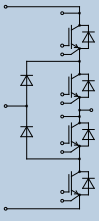
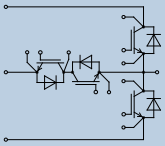
NPC1 topology

- 650V IGBT4
- Optimized for $f_{sw} \geq 12kHz$
- Portfolio
  - F3L200R07PE4
  - F3L300R07PE4



NPC2 topology

- 650V/1200V IGBT4
- Optimized for $f_{sw} < 12kHz$
- Portfolio:
  - F3L300R12PT4_B26
  - F3L400R12PT4_B26



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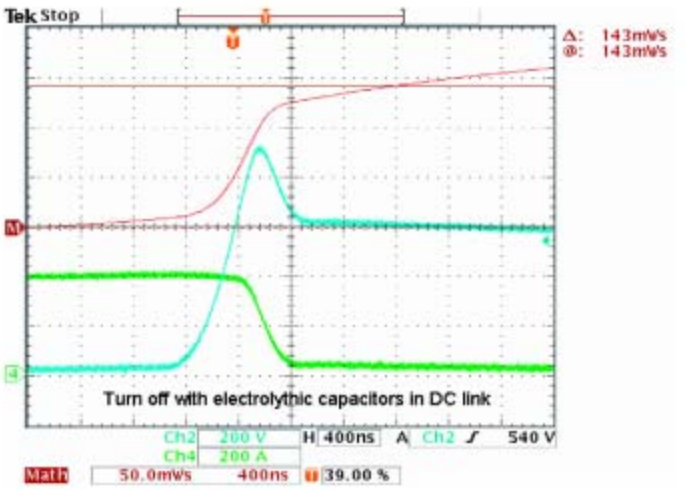

Figure 5: Turn-off behaviour with electrolytic capacitors

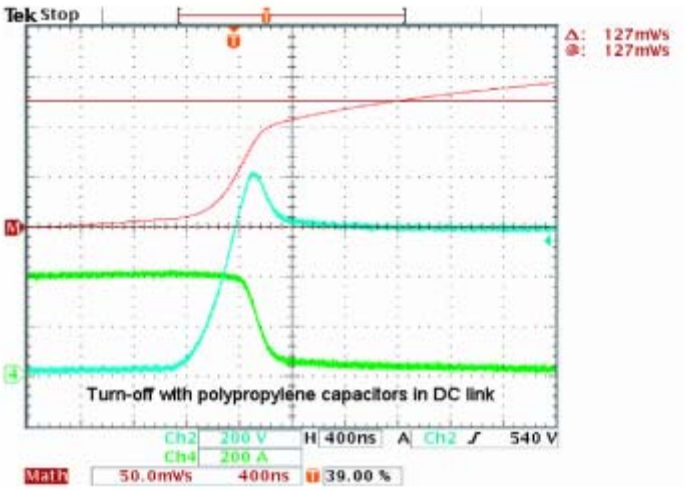

Figure 6: Turn-off behaviour with film capacitors

The leakage inductance is of course not the only thing that determines the switching losses. The activation of the IGBTs largely governs the dynamic behaviour, and a powerful driver output stage which also quickly provides the required gate voltage of +15V offers the best prerequisite for an optimum design.

In addition to the actual semiconductor parameters, specifications such as the external thermal transfer resistance RTHCH are also of key significance for the thermal design and operating reliability. Although this value is governed by purely mechanical conditions and material properties, very high deviations often occur here between the real structure and the data sheet values. The optimum heat transfer would result if there were a firmly bonded connection between the semiconductor base plate and the heat sink, so without any air pockets and with contact over the full area. However, as this cannot be achieved in reality, an attempt is made to avoid the air pockets which occur between the semiconductor and the heat sink during assembly by using elastic, thermally conductive materials such as films or viscous pastes. But these auxiliary thermal materials generally display much poorer thermal conductivity than metals and therefore the application thickness of the pastes or the thickness of the films has to be chosen to be sufficiently high on the one hand to avoid any "gaps" in the thermal conductivity path but on the other hand it must be as low as possible in order to keep the thermal resistance at its minimum.

In modern, thermally optimised designs, attempts are increasingly being made to calculate the chip temperature which is produced during operation by means of a thermal simulation running in parallel with the gate pulse pattern and thus improve the performance capacity of the output stage. However, the simulation requires exact knowledge of the thermal conditions and thus the reproducibility of the transfer resistances which occur when the semiconductors are assembled. The best option for this is to adopt a screen printing method as the quantity of paste and the distribution on the cooling surface are then defined.

But even if these requirements are met, the data sheet value for the RTHCH must be examined very critically in a new design. The power loss in an IGBT module does not arise evenly distributed across the entire cooling surface, but only in the active areas which are covered by the semiconductor chip. If the thermal transfer is now to be verified by way of measurement, the measurement points must be located exactly at these "hot spots".

Specifically, they must be located in the module base plate and on the side lying directly opposite in the heat sink. If the measurement is only carried out on the edge of the module, the values will be distorted on account of the lateral thermal conductivity of the base plate material and the cooler material.

As has been shown, especially when the power components have a thermally tight design, the data sheet specifications for power semiconductors must always be critically examined and scrutinised. What may appear at first glance to be advantages or disadvantages often appear in a different light in the real device.

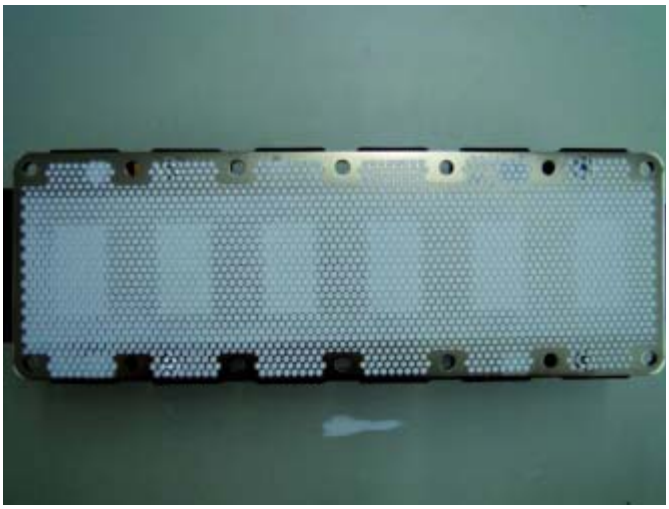

Figure 7: Application of the thermally conductive paste using the screen printing method

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New Power Semiconductor Devices

A practically all range of power semiconductors

Proton-Electrotex JSC is one of the leading Russian companies in terms of development and production of high-power semiconductor devices: diodes, thyristors, and modules on their base, heat-sinks.

By Loktaev Yu. M., Stavtsev A.V., Surma A.M., Chernikov A.A., Proton-Electrotex

The released production covers practically all range of power semiconductor thyristors and diodes with voltage from 100 to 6500 V and with current from 100 to 3000 A. Thyristors and diodes are produced of disk and stud constructional type. Along with thyristors and diodes which are supposed to operate under industrial frequency Proton also produces fast and pulse-frequency thyristors, fast-recovery diodes as well as diodes with soft reverse recovery characteristic.
A wide nomenclature of modules is also produced on the base of thyristor and diode elements in different circuit configurations in full press-pack construction with isolated basement. Modules are produced from 100 to 1250 A.

The main tendencies of new equipment development can be characterized as following:

1. **Development and exploitation of production of high voltage thyristors and high power diodes including the devices on the base of silicon crystals of 100 and more millimeters in diameter.**
   Today the thyristors and diodes with voltage to 6500 V are developed on the base of silicon crystal of 23-80 mm in diameter with average current from 200 to 1250 A and as well thyristors on the base of silicon crystal of 100 mm in diameter with voltage to 6000 V and average current to 2000 A.
   The development of thyristors with voltage to 8500 including thyristors on the base of crystals of 1000 mm in diameter with average current of 1850 A is close to completion.
   It is planned that such devices will be applied to the native power-efficient electro converter equipment of a new generation in electro energy and transport. Our foreign partners are interested in new high-voltage and high-current thyristors and diodes.

2. **Development and exploitation in production of high-voltage thyristors and diodes with precise controlled characteristics of reverse recovery not only with increased operation speed but also for the operation with industrial frequency.**
   TFI 473-1600 on the base of a crystal of 80 mm in diameter was developed and exploited. This device possesses unique characteristics even in comparison with the best foreign analogues: voltage to 4300 V, average current to 1600 A, turn-off time less then 80 µs, recovered charge (125Ñ, di/dt = - 50 À/µs) not more than µC with the opportunity of precise selection in a delivered part with variation not less than 2%.
   The company also offers high voltage thyristors and diodes (with voltage to 6500 V) with precisely selected characteristics of reverse recovery for operating in simultaneous applications of these devices. Grouping of devices by characteristics of reverse recovery is made on a special booth which reproduces the operating conditions in series type connection in the regimes close to operational conditions. Usage of these testing application and special methods allows making the selection of the devices groups reliably operating in consequential columns even without matching RC-circuits.
   Proton is also supposed to produce power stacks KT.5.11-800 on the base of thyristors grouped according to the described technology for being used in high-voltage soft starters of asynchronous motors (to 6 kV) with power from 630 kW.

3. **Development and exploitation of high-voltage modules with isolated basement on the base of thyristor and diode crystals of 24-56 mm in diameter.**
   New devices of such type with voltage from 4000 to 6500 V have been developed and in the nearest time the voltage diapason is planned to be extended to 8500 V.

4. **Development and exploitation of a series of thyristors of increased reliability.**
   The new more reliable cover peripheral areas are being used, a new technology of connection of crystals with thermal compensator is being developed.
   Proton has developed a series of high-voltage thyristors with elements of self-protection integrated in silicon structure which allows switching the device safety in peak overvoltage and also in voltage supplying on the thyristor with incomplete recovery of blocking capability.

5. **Development of high-power semiconductor devices using new constructional technological decisions and physical operating principals.**
   The interesting results of the investigations leading in these directions in our opinion are:

5.1.) Symmetrical voltage suppressors with improved power capacity containing hidden n-layers.
   Symmetrical avalanche voltage suppressors of “traditional” construction and a new device containing hidden n-layers with reduced specific resistance, they are schematically shown in Figure1.
   For the devices of traditional type the problematic area which limits the maximal impulse values of dissipated power and avalanche current as well as the maximum allowable loss energy is

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the edge area bordering with the bevel. In this area under any polarity of applied voltage there is concentration of current density and besides the conditions of heat rejection were made worse because the size of the upper case contact is smaller than the size of semiconductor structure.
In Figure 2 dependence of current and voltage for an experimental avalanche symmetrical suppressor of new construction is shown. The diameter of this semiconductor structure was 32 mm, the voltage of the beginning of avalanche discharge – 1650 V. The peak stroke power was about 300 kW, the loss energy to 150 J under single impulses.

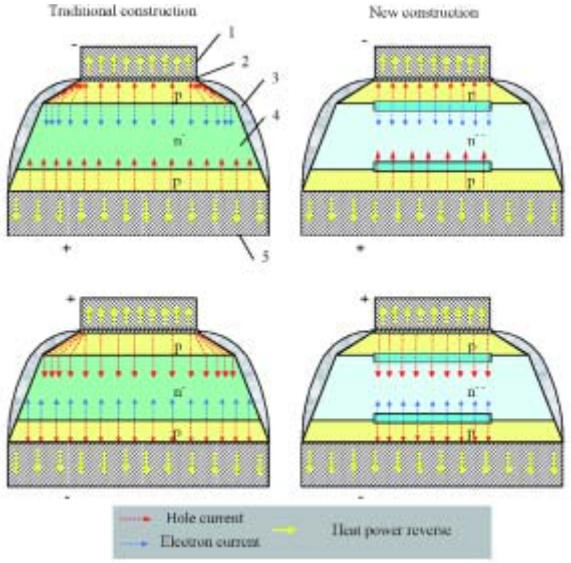

Figure 1: Numbers: 1 – copper case contact, 2 – contact metallization of semiconductor structure, 3 – compound, 4 – semiconductor structure, 5 – molybdenum thermal compensator.

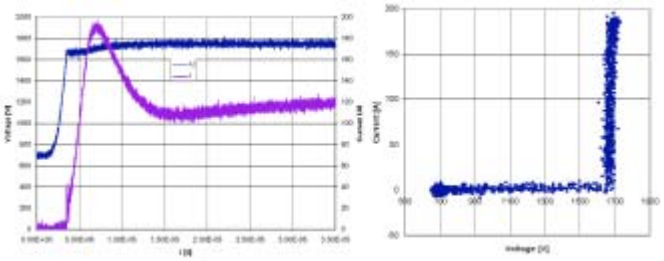

Figure 2a: – current and voltage dependence on time
Figure 2b: isothermal dynamic volt-ampere characteristic

5.2.) Power high-voltage impulse dinistors

Power high-voltage impulse dinistors are produced on the base of four layers thyristor structures with integrate transistor element – overvoltage suppressor. (Figure 3)
The basic structure of the devise is a thyristor, a thyristor at that plays a role of a gate commutator of currents of high amplitude. Instead of a fast voltage suppressor there is a three layers suppressor integrated in the device structure the avalanche current of which includes a thyristor structure. If a thyristor structure has multistage regerative gate this element on the whole can be placed in the limits of any gate areas or in each of them.
Such a device may be used as a very powerful and very fast protective element or commutator of current and voltage impulses with exclusively fast rise times. In Figure 4 there are oscillograms of voltage and current while commutation of experimental dinistor the semiconductor element of which is shown in Figure 5.

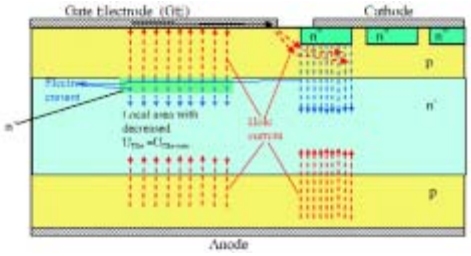

Figure 3: High-voltage impulse dinistors are produced on the base of four layers thyristor structures with integrate transistor element – overvoltage suppressor

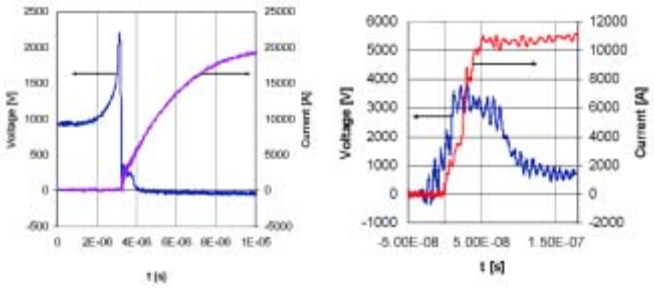

Figure 4: Commutation of current impulses with rise times about 5 kA/ µs (a.) and about 200 kA/ µs(b.)

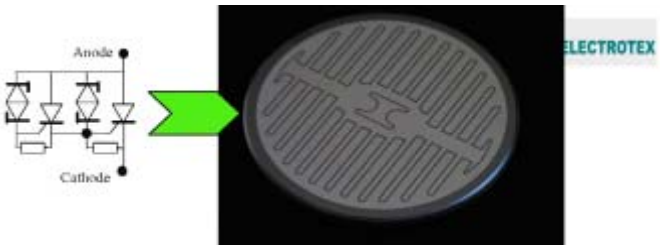

Figure 5: Experimental dinistor semiconductor element

5.3.) High-voltage high current diodes with ultrasoft reverse recovery characteristic

In Figure 6 there is oscillogram of reverse recovery current of experimental high voltage diode (UR=4800 V) produced on the base of silicon crystal of 56 mm in diameter. The examinations were held with primary inductive load which determined the anode current loss speed under reverse voltage of voltage source U R (DC) about 1000 V. The original DC was about 1000 A, loss speed was about 1600 A/µs. Typical values of S-factor has been 1.6-2.

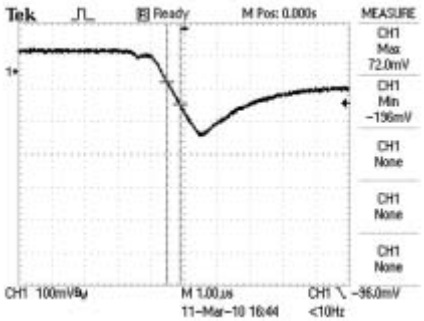

Figure 6: Oscillogram of reverse recovery current of experimental high voltage diode (UR=4800 V)

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The Effective Use of High-Speed Isolated Data Acquisition Systems

for Safe, Accurate Rapid Transient Electrical Measurements

Typical rapid transient electrical applications are often characterized as "mission critical." In many cases, an engineer or test technician may have just one viable opportunity to capture invaluable diagnostic data for the prevention of damage to machinery and equipment.

By Michael Hoyer, Applications Engineer, HBM, Inc, Marlboro, Massachusetts, USA
Molly Bakewell Chamberlin, President, Embassy Global, LLC, Buffalo, New York, USA

In many cases, improper data collection could add millions of dollars to project costs and cause significant personal injury. As such, this very short-duration event requires a high-speed, high-accuracy, isolated data acquisition system to ensure measurement accuracy and reliability.

Within such applications, it is essential for an engineer to fully understand measurement demands and risks; ultimate testing goals; and the true compatibility of specified hardware and software for these objectives. The team at HBM, Inc. has nearly 40 years of experience in the successful design and manufacture of ultra-high speed data acquisition devices for extremely rapid single-shot electrical event measurements.

At the time of measurement, rapid transient electrical applications commonly include the presence of high-voltage conditions, such as those created by a cloud-to-ground lightning strike and high-current conditions with extreme electromagnetic (EMI) fields created during a switchgear test. These conditions create a definitive need for a system that is electrically isolated to be safe for the user and from equipment damage and data corruption while at the same time incorporate the ability to record signals with high-accuracy at extreme high speeds to meet customer application challenges and industry standards. This article shall present a series of considerations and application examples for the successful implementation of such ultra high-speed data acquisition devices.

High-Voltage Impulse Testing

The risk of lightning strike damage to machinery and equipment poses significant risks for utilities and municipal power grids, for which damages to power masts, generators –or the grid itself– can result in unforeseen power outages, costly and unpredictable downtime and blackout conditions. This increases overall power consumption requirements and decreases customer satisfaction.

In most cases, electricity is not produced at the location of consumption. The power grid serves as the primary infrastructure by which power plants connect to end users. It is also the mechanism by which electrical energy is transported to utility consumers. Most power grids exist as power lines installed onto towers, which are further organized into levels by their required amount of power transport capacity: low voltages (LV) to several 10 kV; medium voltages (MV) to several 100 kV; and high voltages (HV) of over 100 kV. Levels are interconnected by a series of substations which rely upon transformers, circuit breakers, surge arrestors, isolators, switchgear and other equipment to ensure safe and reliable electricity transport. The nature of the power grid setup itself leaves supporting substation components highly vulnerable to lightning strike damages. As hundreds of thousands of utility customers may all be linked within a single grid, the use of effective lightning testing is essential for sustained, continuous, efficient power grid operation.

This requirement poses an associated challenge for component manufacturers to develop a rigorously tested, rugged product that can withstand power grid conditions. Proper quality assurance testing and certification of transformers, surge arrestors, isolators and switchgear for their high-voltage survivability is vital. To stay globally competitive, each manufacturer must prove compliance with all relevant high-voltage testing standards, while adding minimal testing costs per component. In addition, the manufacturer must still be able to offer utility companies a favorable cost of ownership for installed product throughout its useful service life.

Globally recognized testing standards describe the proper steps for high-voltage test setups and procedures, as well as specific hardware and software requirements. Key criteria include high-resolution and accuracy, amplifier linearity, immunity against existing electromagnetic fields and grounding capabilities for safety.

High-voltage component testing requires specialized equipment, capable of producing lightning waveforms with known wave shapes and peak voltage levels of up to several MV. On the other side of the test object, equipment must be able to both measure wave shape and evaluate all relevant parameters according to appropriate standards. The more accurate an initial measurement, the greater likelihood of avoiding component under-testing or over-testing.

Another important aspect of optimal component testing is efficiency. For example, a three-phase transformer tested on all six phases/bushings (three inputs and three outputs) on a number of voltage levels and a number of different waveforms can easily result in 50 to 100 shots per test object. All waveforms are analyzed and documented within a report. By allowing for test

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sequences with automated analysis and limit testing, as well as automated report generation, overall test time is dramatically reduced and results in more cost-effective measurements, including type testing and final testing, with significantly minimized risk of operator error.

For automated high-voltage component test setups, HBM offers the ISOBE5600t/m, a high-voltage fiber-optic isolated data acquisition system with Lightning Impulse Analysis software. The system is designed to meet the highest possible grade reference digitizer standards. Impulse attenuators interface between the customer's voltage dividers and the ISOBE5600t transmitter input. The Lightning Impulse Analysis software evaluates captured data; tests for overshoot, oscillations and chopping; limit checks; and allows for test sequences with automated storage. The software also allows for test waveform and results storage for further analysis and automated reporting. A user-selectable limit checking feature also increases testing efficiencies. The ISOBE5600t/m can test several phases or bushings at positive and negative polarity, as well as different voltage levels, for support of up to >100 measurements per test object. Test collections allow for individualized per test object measurements and brings them into the same report for process optimizations. A manual accept/reject verification is available after each measurement for real-time accuracy checks. Each test, whether a single measurement or a full data collection, is automatically available in the report generator. The user defines the report layout one time and gets test results, including Pass/Fail indication, at the click of a button. These systems allow for successful integration of new high-voltage grid systems and components, as well as upgrading of legacy systems, with safeguards for continuous, uninterrupted power service.

Current Zero Detection

Traditional circuit breaker systems operate on the premise of electrical contacts moving away from one another, thereby creating an electrical arc. Another high-voltage testing area is the measurement of interruption phenomena affecting breaker performance and operation, a term known as circuit zero (CZ). CZ measurements are commonly used as a research tool to help better understand and improve the descriptive mathematical model of the electric arc, while identifying dominant parameters for successful current interruption, such as pressure, temperature, ion density, plasma flow and other parameters, leading to circuit breaker design improvements and greater interruption capability.

Circuit-breaker manufacturers often rely upon third-party test laboratories for acceptance testing. The external test house acts as a credible, independent authority between buyer and seller, verifying product performance according to published specifications, with a buyer identifying individual specifications of interest for verification. While international testing standards for circuit-breaker final products are well-established, CZ testing standards can vary. As a result, the Netherlands-based KEMA High-Power Laboratory, one of the leading global experts in high-power acceptance testing, established its own fully dedicated CZ test program.

To conduct CZ testing, use of a fiber-optic isolated digitizer with particular performance attributes, such as the HBM GEN 6600 HV, is recommended. The digitizer should ideally be placed as close as possible to the test article, in order to minimize required analog cable lengths and ensure best results. A suitable fiber-optic digitizer must also be able to deliver signal quality conditions for safe performance, as can be found within the existing KEMA system. Among necessary system attributes, high dynamic input range is important, as currents in the order of 100 mA should be measured immediately following interruption of many tens of kA of short circuit currents. While the main application frequency range is typically 50 or 60 Hz, other relevant processes occur on a sub-microsecond scale, making required bandwidth another key specification, as well as vertical resolution.

As the system must also be able to reliably operate, uninterrupted, in the presence of naturally occurring transients, electromagnetic field immunity is important. Further immunity against fast or transient electrical events that can arise within both current and voltage during the switching progress is also critical. High-voltage circuit breaker test laboratory environments tend to see greatest electromagnetic interference, as the highest voltages and currents occur simultaneously. A typical acceptance test can verify proper system operation under severe product operating conditions within a high-power test laboratory. A system's ability to pass under the worst possible conditions implies that its operation under less severe conditions, such as medium- and low-voltages, would not cause significant problems, as components are exposed to less stress, and less energy is used to perform testing. The HBM GEN 6600 HV fiber optic digitizer was fully tested by KEMA and passed at all levels of acceptance testing, including extreme conditions, making it a viable option for high-voltage or CZ-related testing requirements.

Switchgear Testing

Another rapid transient electrical application exists in the area of switchgear testing. This application calls for equipment to effectively measure low-, medium- and high-level energy values on an as-needed basis, with each requiring different isolation capabilities. The system must also be able to offer accurate sequencing and timing control, so that in case of a single segment failure, such as short circuit due to component breakdown, the rest of the grid may be protected by disconnecting the failed segment and interconnecting remaining, active segments. Because of its complexity and wide energy measurement ranges, specific hardware and software must be used to produce accurate, safe and reliable test results. High currents of up to hundreds of kA must be interrupted, while voltages of up to several hundred kV are still present. Thus, hardware must have isolation, excellent electromagnetic field immunity and battery-powered operation, with supporting software that features strong data integrity, repeatability and optimal user test efficiencies. A typical high-power switchgear test is ideally conducted using a battery-powered and fiber-optic isolated digitizer to obtain optimal signal quality, with appropriate voltage protection for personnel and equipment. Successful switchgear testing requires use of a data acquisition system, fiber-optic isolated digitizer, test sequencer and supporting analysis software. Due to the complexity and dangers of this testing type, it is recommended for a customer to source all components from a single manufacturer, to ensure seamless system compatibility, experienced technical support and calibrations.

The HBM Genesis HighSpeed data acquisition system has been successfully used to support high-voltage switchgear testing. For high-speed test sequencing, the fully fiber-optically isolated HBM BE3200 is ideal for switchgear applications, due to its fully user-synchronized timing pattern to the main generator, either via the external mains or derived from an internal timer, and application specific extensions. Both hardware and software associated with HBM switchgear monitoring system components are fully compliant with international high-voltage testing community regulatory and safety standards, with proven software designs and algorithms developed according to globally accepted practices.

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New Hardware-in-the-Loop Platform for Rapid Development of High-Reliability EV and HEV Propulsion Drives

Main propulsion drives are one of EVs (electric vehicles) and HEVs (hybrid electric vehicles) safety-critical systems. A configuration with only a DC-link current transducer instead of two phase-current transducers promises improved sensor reliability when matched with equally reliable software implementation of the phase-current reconstruction algorithm. With a new ultra-low-latency (ULL) hardware-in-the loop (HIL) emulator, it is now possible to develop, debug, optimize and type-test such safety-critical real-time software functionality within one integrated environment.

An affordable HIL environment promises to revolutionize the power electronics design tool-chain

By Evgenije Adzic and Nikola Celanovic, Typhoon HIL GmbH

Typhoon HIL development environment

State of the art HIL systems with their often massive computational power, excel at modelling large, relatively slow systems but typically have too long a latency to provide sufficient time-resolution needed to model the fast-switching dynamics of power electronics (PE) systems. A high-fidelity ULL HIL400 system dedicated to HIL emulation of power electronics circuits offers a “time microscope” that expands the time resolution of the existing (digital) HIL solutions. It comprises a programmable, application-specific processing architecture, fast IO subsystem and a custom tool-chain which, all together, make a 1µs simulation time-step and latency possible.

Typhoon HIL also offers a range of interface boards that simplify the hardware interface between HIL400 and some of the standard DSP evaluation boards and rapid control prototyping platforms such as the ezDSP TMS320F2812 used in this application example.

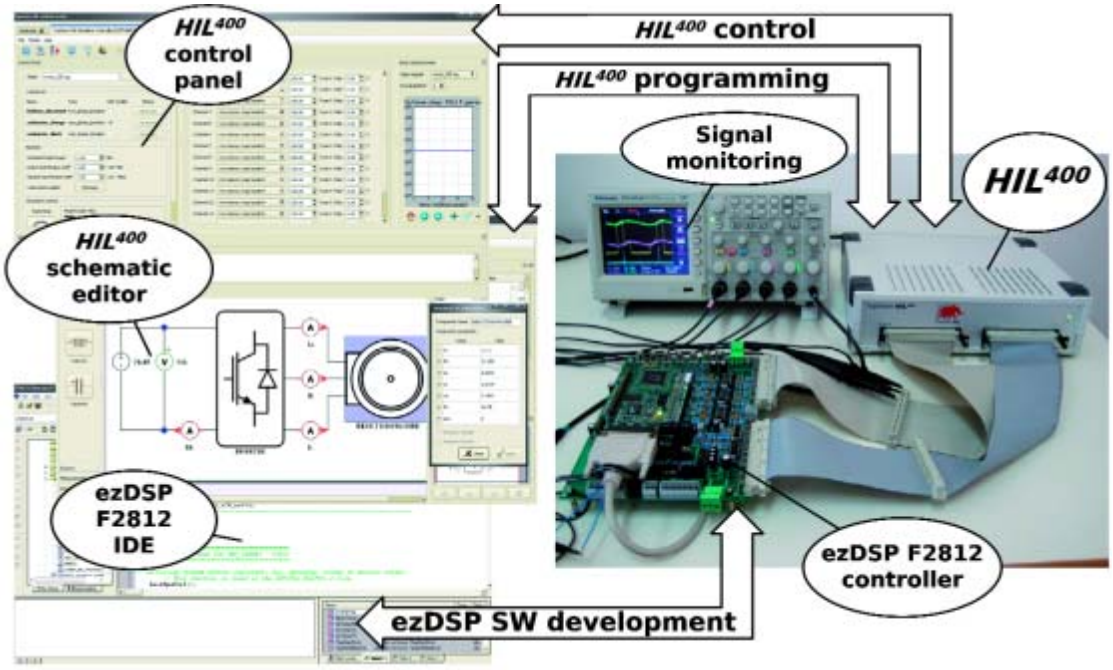

Figure 1: Typhoon HIL400 development environment.

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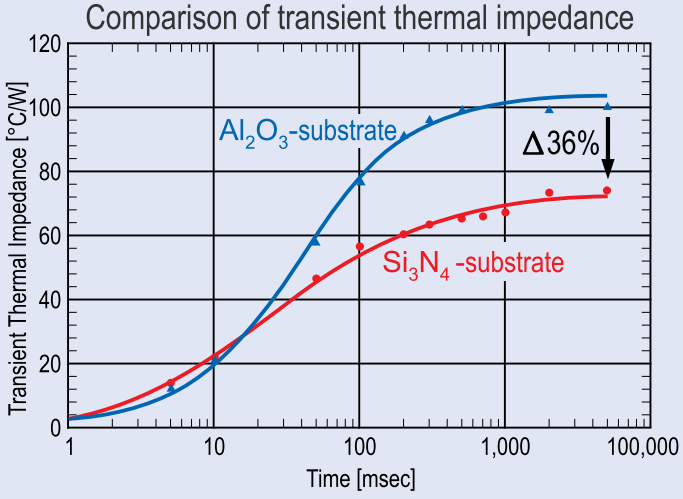

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Figure 1 illustrates the HIL development environment comprising the HIL400 and an ezDSP TMS320F2812 evaluation board with the hardware shown to the right. The ezDSP TMS320F2812 controller is set on a HIL400 interface board from Typhoon HIL. On the left-hand side of Figure 1 can be seen the PC-based tool-chain comprising HIL400 and DSP tools. HIL400 tools include an intuitive schematic editor with a circuit compiler and the HIL400 control panel which provides a convenient way to assign signals to IO interface pins, program their gains and offsets, operate contactors, change grid voltage (where applicable), start/stop the HIL400, etc. The DSP tool-chain in this example, is TI's Code Composer Studio.
The HIL400 signals are viewed on the oscilloscope, as would be done in a high power laboratory, only in this case, there is no need to worry about safety requirements or deal with current and voltage probes etc. Moreover, because all the internal signals of the modelled circuit are available at the HIL400 analog outputs, it is now possible to also view the signals that are otherwise difficult (or impossible) to measure in the lab, such as machine flux.
The most reliable way to measure inverter phase-currents is by means of a single DC-link current-transducer and a reliable phase-current reconstruction algorithm implemented in software. Figure 2b shows that within every sampling cycle, there are two time-intervals where the DC-link current equals one of the phase currents (or the negative value of the phase currents), which is enough to reconstruct all three phase currents if we assume a negligible common-mode current, i.e. ia+ib+ic=0.
It is important to emphasize that the illustrations of Figures 2 - 4 are actual real-time oscilloscope measurements of the TMS320F2812 gate-drive signals controlling the motor drive within the HIL400. In other words the configuration of Figure 1 is a real-time simulator and a laboratory test-bench all-in-one: a true "power electronics laboratory in a box".

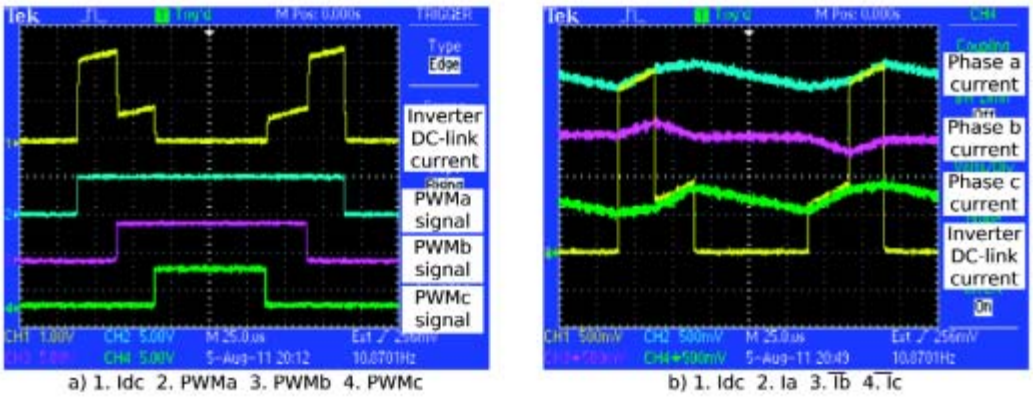


Figure 2: Inverter DC-link current relationship to: a) PWM signals (i.e. voltage vectors) and b) motor line-currents

The current reconstruction technique requires that the DC-link current-sampling instants be synchronized with the PWM pulses. High fidelity requires that dead-times, gate drive delays and signal processing delays (which depend on the actual control platform and algorithm implementation) be taken into account. Only by means of a ULL emulator it is possible to take into account those delays that are of the order of a microsecond and may also be time-varying. As one can see from Figures 2 – 4, the switching frequency in this example, is set to 4kHz.
Figure 3a illustrates that sampling the DC-link current twice per PWM period is not enough because it results in a current measurement error. Instead, in order to accurately reconstruct the average value of the phase current located at the middle of PWM period, it is necessary to sample the DC-link current four times per PWM period (twice for each phase) as shown in Figures 3b and 4b and to calculate their average values.

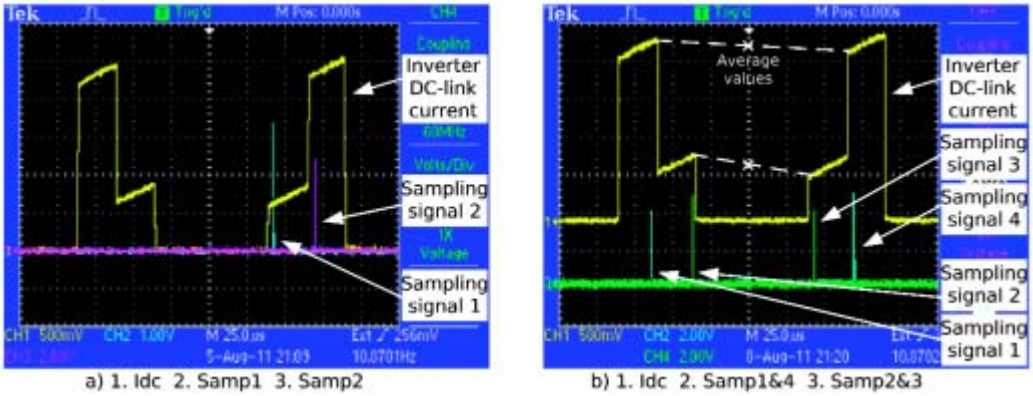
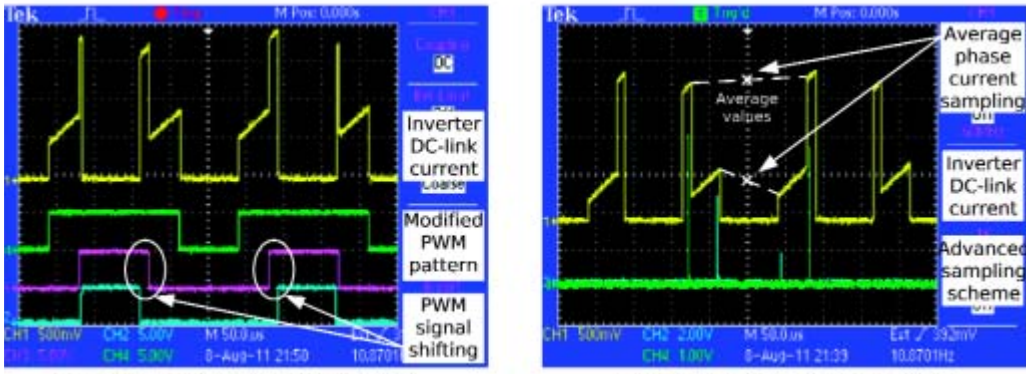


Figure 3: DC-link current sampling scheme:
a) two samples in the lagging side of the PWM period aligned with the beginning of the current sampling windows;
b) four samples in the same PWM period in order to cancel the PWM ripple influence and phase-shift between reconstructed phase currents

However, as the results from Figure 5 show, this is still not enough to correctly reconstruct the phase currents. The cause of this, as the setup from Figure 1 clearly reveals, is the short vectors that are always present at the 60 degree sector-crossing and for low modulation indices.
One way to solve this problem is illustrated in Figure 4a where the PWM signals are modified (shifted) in order to provide long enough DC-link current sampling windows.



a) 1. Idc 2. PWMa 3. PWMb 4. PWMc

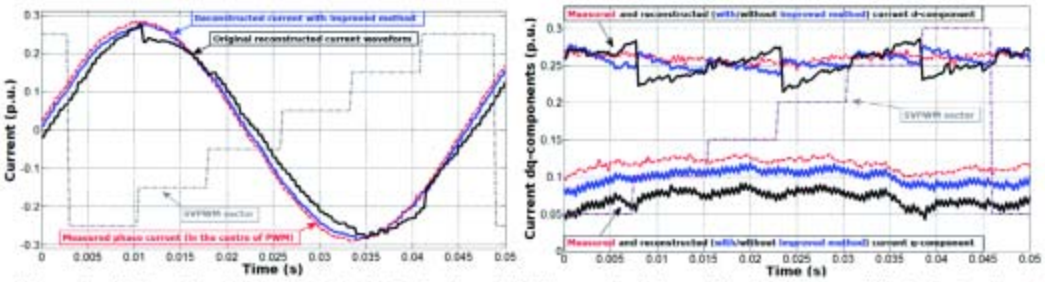
b) 1. Idc 2. Samp1&4 3. Samp2&3

Figure 4

a) Modified PWM pattern in order to provide optimal sampling windows and to have reliable line-current reconstruction;

b) Advanced DC-link current sampling scheme in order to eliminate current PWM ripple influence (also during PWM signals altering/shifting, i.e. during critical cases for the current reconstruction method)

The complete control system for the virtual drive was assembled. Rotor speed was estimated using a Model Reference Adaptive System (MRAS) and phase currents estimated by means of the current-estimation algorithm from Figure 3a and Figure 4a. By using the arrangement of Figure 1, it is easy to observe the influence of microsecond-order changes in the PWM and sampling pattern on the drive-current waveforms in the millisecond range.



a) I_{a_meas} (red), I_{a_rec} (black), $I_{a\_rec\_new}$ (blue), Sector (grey) b) I_{dq_meas} (red), I_{dq_rec} (black), $I_{dq\_rec\_new}$ (blue), Sector (grey)

Figure 5:

a) Reconstructed line-current waveform with (blue) and without (black) improved method compare to measured line current (red);

b) Reconstructed current dq-components when PWM and sampling signals are modified (blue) have limited harmonic oscillations (d-currents) and less average offset error values (q-currents) compared to the original reconstruction method (black).

Summary and outlook

This article showed some of the ways in which the rather unique, 1µs time-resolution of the HIL400 is helpful when developing high reliability EV and HEV propulsion-drive control algorithms. Clearly, there is much more to the HIL400 which is, in fact, a universal PE development platform, enabling PE specialists to study with great ease and confidence, all the fine details of the interaction between the controller and the PE hardware in any and all operating conditions, as they occur in real-time. It can be said that this is the beginning of a new approach to PE system development and a paradigm shift in fast prototyping and type testing.

www.typhoon-hil.ch

Applying High Frequency GaN Transistors to Motor Drives

No Diodes? Really?

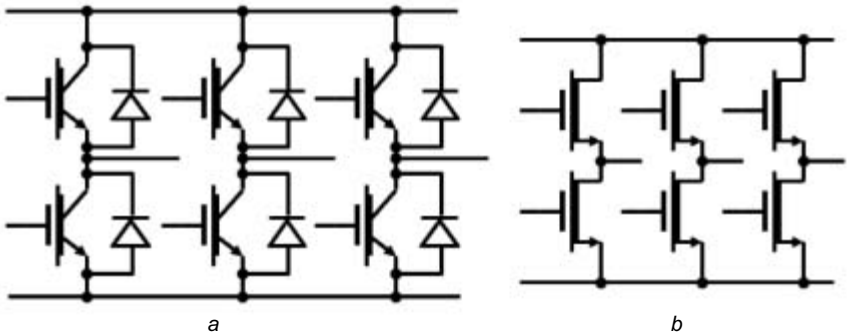
The low charge associated with gallium nitride high-electron-mobility transistors (GaN HEMTs), and the consequent low switching loss and fast switching speed, make these devices attractive for any switch-mode power application. A lesser known characteristic, the lack of a parasitic junction, is also particularly advantageous for motor drives, in that it relieves the need for freewheeling diodes.

By Jim Honea, Transphorm Inc., Goleta, CA

This article will explain how the diode-free operation is possible, and then present a methodology for using GaN to advantage in motor drives, including a presentation of efficiency data achieved in motor testing with a GaN three-phase bridge.

Diode-Free Bridges

The typical three-phase bridge used in AC motor drives is shown in Figure 1 (a). Each switch (shown here as an IGBT) is clearly paired with a freewheeling diode, which, for voltages beyond about 200V, will be either a silicon junction diode, or a GaN or SiC Schottky diode. Some transistor technologies include junctions which could, if permitted, serve the function of the freewheeling diode, the body diode of a MOSFET being one example. Figure 1 (b) shows a three-phase bridge constructed with six GaN HEMTs, and no diodes [1].



a b

Figure 1: Three phase bridges made with (a) IGBTs and discrete diodes, and (b) GaN HEMTs.

When presented with a schematic of this sort, circuit designers will typically ask if this doesn't merely indicate that the body diode of the GaN transistor is acting as the freewheeling diode. The answer is no, because there is no body diode. This is true, almost by definition. High electron mobility is achieved in a HEMT precisely because the sheet of mobile electrons forms in a region of pure, undoped crystal. If there is no doping, there can be no junction between p and n doped regions. The GaN material is truly insulating everywhere except in the channel, but the electrons in the channel are free to flow in either direction. Therefore, while the device will block appreciable voltage in only one direction (Vds>0), it can conduct current in either direction through the channel. The difference between this and conduction through the body diode of a MOSFET is profound. Even though the freewheeling current will flow through the same source and drain pins in a MOSFET, the path it takes in the die is completely different for the two directions: the forward current is a flow of majority carriers only, down the channel and across the drift region, while the reverse current is a flow of minority carriers, injected across a barrier. This injected charge has to be recovered when the voltage reverses, constituting the troublesome reverse recovery charge (Qrr). To emphasize the difference, Figure 2 contrasts Qrr for a 600 volt GaN HEMT and a Si MOSFET of similar ratings.

The device tested in Figure 2 was actually a hybrid device, in which a low-voltage, normally-off silicon MOSFET is coupled with a high-voltage, normally-on GaN HEMT. The configuration of the composite hybrid device, shown in Figure 3 (a), along with the symbol

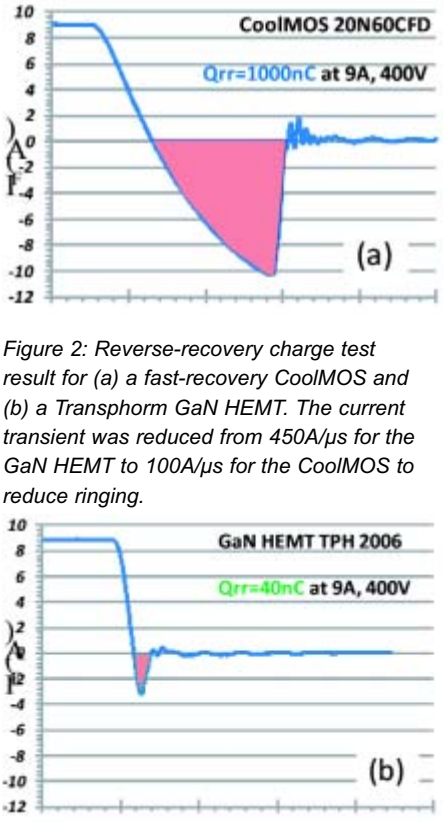


Figure 2: Reverse-recovery charge test result for (a) a fast-recovery CoolMOS and (b) a Transphorm GaN HEMT. The current transient was reduced from 450A/µs for the GaN HEMT to 100A/µs for the CoolMOS to reduce ringing.

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3 (b), is such that the low-voltage silicon device provides the desired normally-off functionality, while the GaN device provides the advantages of low on-resistance, low charge, and high-voltage blocking. This raises the question concerning whether this device can be used in a bridge application and still have the diode-free characteristic, since, evidently, the free-wheeling current will flow in the body diode of the silicon device. In fact, the benefit is nearly the same. This is because the silicon device is a low-voltage device (20-30V). The low blocking voltage permits a short drift region, and therefore a small volume in which injected charge will be stored.

The voltage drop across the GaN switch, whether single die or hybrid, can be reduced during the reverse conduction period by driving the gate to enhance the channel. Figure 4 shows gate-drive waveforms to accomplish this, assuming Vgs1 is the gate-source voltage of the actively switched transistor, and Vgs2 is the gate-source voltage of the transistor carrying the freewheel current. The freewheel current flows in times A and B, but the freewheel device is only enhanced during time B. During time B, the voltage drop is just Id *rds-on. A significant point is that, because Qrr is low, there is no great penalty in providing plenty of safety margin in the the dead times (designated as time A in the figure). During these dead times, the voltage drop is increased by the forward voltage of the silicon MOSFET's body diode, in the case of the hybrid, or the threshhold voltage (plus overvoltage, depending on the current) in the case of the enhancement-mode HEMT.

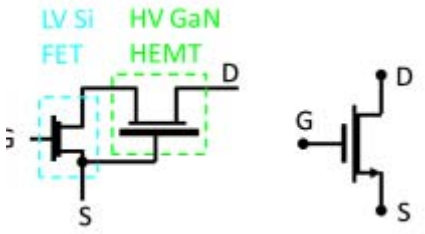

Figure 3: Schematic (a) and symbol (b) for a hybrid transistor comprising a low-voltage, normally-on silicon MOSFET and high-voltage, normally-off GaN HEMT.

High Frequency Motor Drive

Having explained the operation of a diode-free, three-phase GaN bridge, we will consider how to take advantage of the simple design and potential for low loss in a motor-drive application, beginning with some background on the problem.

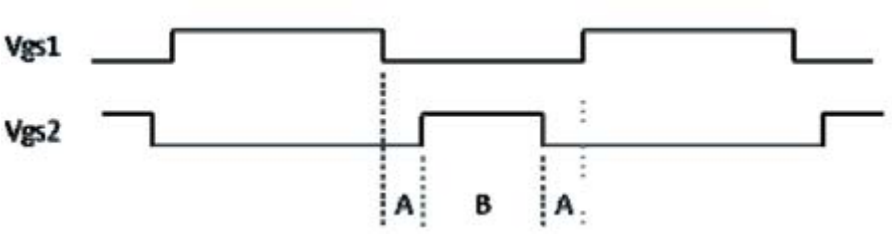

Figure 4: gate-drive waveforms to lower conduction loss during the reverse conduction period.

A logical first step towards improving overall system efficiency in any motor system is to use an inverter to power the motor, with the subsequent benefit of variable speed operation. However, application of inverter drives to motor systems introduces additional stresses which has necessitated improvements in motor design [2,3]. A key point is that these improvements – measures such as improving the magnet wire insulation and providing static discharge paths – enable realization of the benefits of variable speed operation, but do not actually improve the intrinsic power efficiency of the motor itself. On the contrary, some loss of motor power efficiency is the unavoidable consequence of PWM operation associated with using an inverter. This loss of efficiency may be attributed to two basic mechanisms: additional real power converted to heat in the motor itself due to nonproductive harmonics in the current waveforms, and loss which occurs in the inverter due to reactive elements in the motor and wiring.

Any real power delivered to a motor at a frequency other than the fundamental (that of the back EMF) only serves to heat the motor. The higher the switching frequency, the lower the distortion which may be achieved, including ripple current at the switching frequency. This principle is applied in other applications, such as power-factor correction circuits, where 100kHz (and higher) switching is common in order to reduce harmonics on the 50/60Hz power lines. The obvious conclusion, therefore, seems to be that motors should also be driven at switching frequencies above 100 kHz; but this provides additional complications. Regarding efficiency, the most immediate problem with increasing switching frequency is increased switching loss.

For a motor drive built with high-speed switching devices, such as the GaN HEMT's discussed here, the dominant part of the switching loss is most likely contributed by external capacitance. The energy of a linear capacitor, charged to voltage V, is ½CV². This energy is lost when the capacitance discharges in a hard-switching transient. In fact, if the node is truly hard switched in both directions, the same energy is lost in the charging process, and the energy loss per cycle is now CV². For now, we will assume that either the charge or discharge transient is soft, meaning the energy is transferred from the total inductance where it has been temporarily stored during the previous cycle. In this case, the loss per switching cycle, per node, is ½ CV², and the total switching loss due to external capacitance in a three-phase drive is 3(½CV²)fs. Note that this is independent of the rise and fall times: the energy is placed on the capacitors, and then dumped to the heat sink. The presence of an EMI output filter, which simply slows the rise and fall, does not lower the loss.

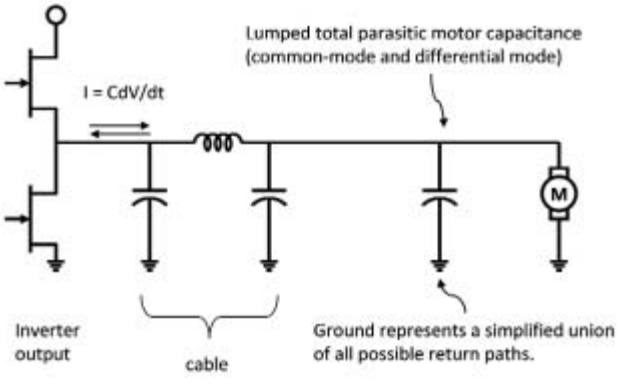

Figure 5: conceptual schematic showing external capacitance connected to a switching node.

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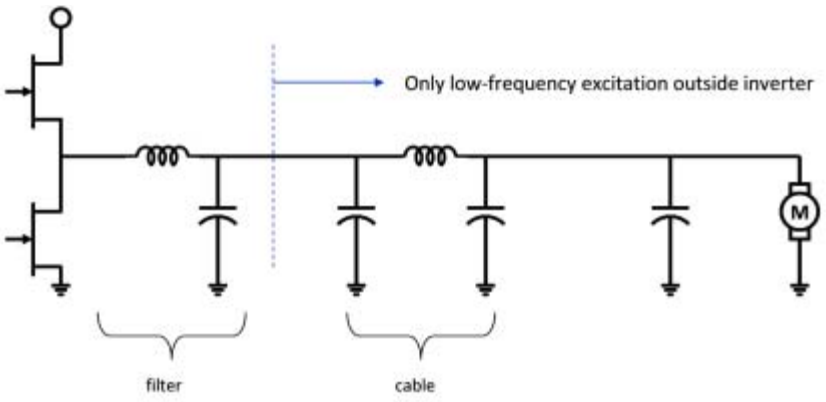

Figure 6: Using a filter to isolate the inverter from external capacitances.

The motor also has a number of capacitances between its windings and the motor frame, and between the individual phase windings themselves. For the 1Hp AC induction motor used in the following tests, capacitance values on the order of nanofarads per phase are probably correct [4].

A solution to the problem of capacitive switching loss is to isolate the external capacitances from the switching signals. An output filter designed to eliminate the switching frequency will accomplish this, as illustrated in Figure 6.

Of course, the inductors used in a filter also have winding capacitance, and will also contribute core loss. But these losses can be minimized through design trade offs which are not necessarily available in the motor and cabling. The motor's winding has a primary purpose of transferring energy to the rotating load, and minimizing the associated capacitance and core loss can only be done within constraints imposed by that primary purpose. Working against this factor is the low switching frequency of existing inverters. A typical filter that is effective at 8kHz must use large, relatively lossy inductors. With a higher PWM frequency, the filter can be better optimized for both efficiency and cost or size. This consideration leads to what may be the ideal solution – a high frequency inverter, with low inherent switching loss, that is isolated from the motor and cable by an output filter.

A concern that arises when fast rise and fall times are discussed is electromagnetic interference (EMI). As pointed out by Carsten and Mammano [5], three elements must be present for EMI to take place - a source, a coupling means, and a receptor (or victim, as they put it). To the extent the coupling means can be minimized, the severity of the source can increase. The charge on the switching node produces an electric field that terminates on some other conductor in the system, which is to say, a parasitic capacitance exists between the nodes. If the switching signal is considered the EMI source, then this capacitance is the coupling means. The presence of the electric field itself is not typically a problem. What is a problem is the current produced when the switching node slews, I = CdV/dt. This current often finds its way to the chassis, or ground return, constituting a common-mode current. However, if the capacitance between the switching node – the source, where the high dV/dt exists – and any other nodes in the circuit approaches zero, then the slew rate may approach infinity. This ideal cannot be appreciably realized if the motor is driven directly with the switch-mode signal, but may be if the only connections are two transistors and one lead of a small inductor, internal to the inverter, as indicated in Figure 7. One final observation is that the use of a properly shielded cable can limit emissions, but most likely increases total capacitance.

GaN Motor Drive Test Results

Figure 8 shows the basic design of a simple inverter built with a 6-transistor module, and associated test circuit. The filters used are simple LC filters, with 200µH inductors and 0.3µF capacitors. A simple V/F, open-loop algorithm was used in all cases.

The efficiency of this system driving a variable resistive load up to 2Hp is shown in figure 9. Figure 10 shows the result when driving a 1Hp AC induction motor (Marathon Electric, Micro Max series) with variable torque load.

A comparison was made between the GaN inverter and a 230VAC/2Hp commercial inverter drive to demonstrate the impact on the efficiency of the motor itself. Figure 11 shows the result, confirming that the motor itself operates less efficiently when driven directly with PWM signals. Here, the ratio of mechanical power to three-phase electrical power is the plotted quantity. The commercial inverter was operated at 16 kHz, directly connected to the motor (without filter). Note that the additional switching loss due to the cable and motor capacitance is not included here, since that energy is dissipated in the inverter, and only appears in the motor as reactive power.

A point to be acknowledged is that the open-loop drive algorithm used here lends itself quite easily to a drive with filtered outputs. More sophisticated algorithms which require sensing of phase currents and voltages could need some adaptation for use with filtered outputs.

Conclusion

GaN power transistors can simplify bridge circuits for motor drives through elimination of freewheeling diodes. They can also enable increased efficiency through high-frequency switching, although the method for realizing that benefit is complicated by the nature of the load. We have presented a

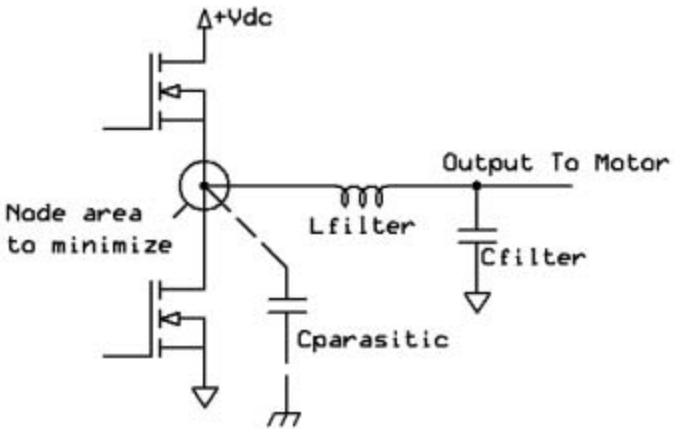

Figure 7: Minimizing the area indicated minimizes the parasitic capacitance, which is a coupling means for EMI signals.

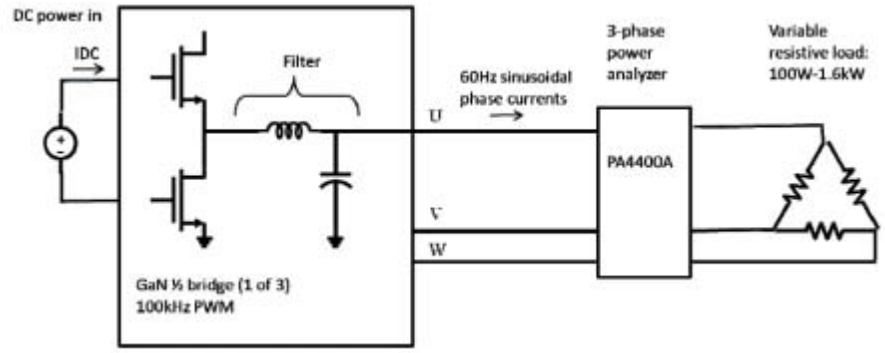

Figure 8: Block diagram of test circuit for testing inverter-drive efficiency. For the motor-test data, the three-phase ACIM motor replaced the resistive load.

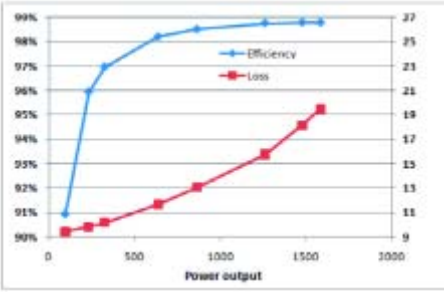

Figure 9: Electrical efficiency - Pac(out)/Pdc(in) -of the GaN inverter driving a 3-phase resistive load, switching at 100kHz. Loss due to the output filter is included in the efficiency calculation.

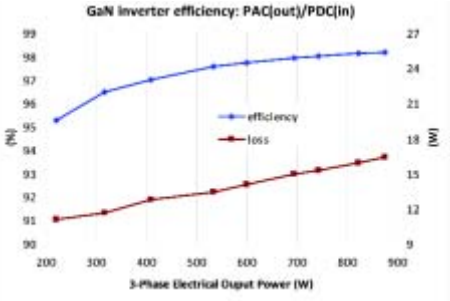

Figure 10: Electrical efficiency of the GaN inverter - Pac(out)/Pdc(in) - driving a 1Hp AC induction motor with variable torque load, switching at 100kHz, with a 60Hz fundamental frequency. Loss due to the output filter is included in the efficiency calculation.

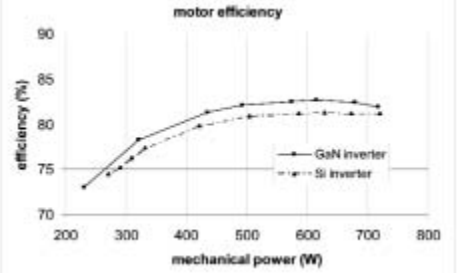

Figure 11: Electromechanical efficiency of the 1Hp ACIM motor when driven by a GaN inverter, and by a commercial, silicon-based drive. The GaN inverter includes output filters; the silicon inverter drives the motor directly using 16 kHz PWM frequency.

methodology for achieving both benefits through addition of small output filters, keeping the high switching frequency isolated from the motor and wiring. Test data confirms that high efficiency can be achieved in the inverter itself, even with the filter, while the system-level efficiency is improved by reduction of core loss, copper loss, and capacitive switching loss.

www.transphormusa.com

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High Speed Measurement Option for Precision Power Analyser

A new high-speed data-capture option has been introduced for the Yokogawa WT1800 precision power analyser. The new /HS option provides fast, accurate measurements of power parameters such as voltage, current, power, torque, speed and mechanical power with millisecond response. This allows it to capture numeric data on the change of status during one rotation of a motor when the motor is started, when the rotation speed changes, or when the load condition varies.

This new function takes advantage of the WT1800's sampling frequency (up to 2 MS/s) and its unique ability to carry out calculations on measured parameters in real-time.

The new high-speed data-capturing function can measure 3-phase voltage/current/power and torque/rotation speed/mechanical power

every 5 ms (when external synchronisation is off) or every 1-100 ms (depending on the clock signal frequency) if external synchronisation is on.

It transmits a block of data every second to an internal or external memory or to a PC using a communications interface. Every second, the WT1800 updates its displays with the previous one second of data.

The average characteristic is set using the cutoff frequency of the high-speed filter for measured data during the 5 ms or 1-100 ms period. The cutoff frequency can be varied from 1 Hz to 1 kHz in 1 Hz steps. Wiring configurations include single phase for DC input, 3-phase 4-wire and 3-phase 3-wire (3V/3A).

The new firmware will also support German and Chinese menus and messages.

Major target markets for the WT1800 with the high-speed option include motor and inverter evaluation in the automotive and aerospace sectors as well as alternative energy and power conditioning applications.

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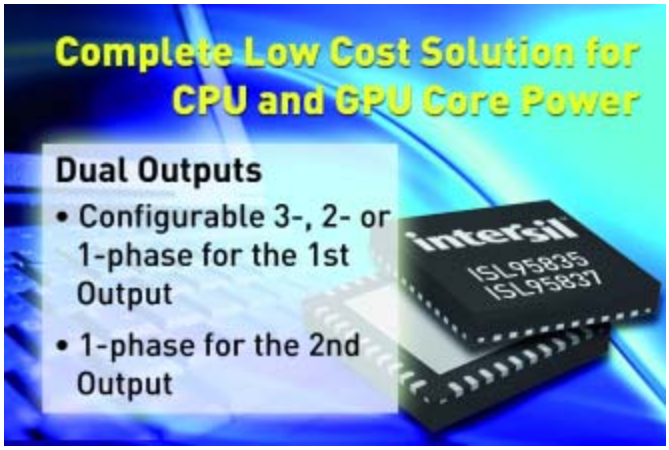
DC/DC Controller Portfolio with Complete Solutions for Embedded

Intersil Corporation today expanded its portfolio of industry leading multi-phase DC/DC controllers by introducing the ISL95835 and ISL95837. Both controllers provide a complete low cost solution for CPU and GPU core power while delivering best-in-class transient response and efficiency. Each complies with Intel's IMVP-7/VR12™ specification for smart voltage regulation to reduce power dissipation in the second-generation Intel® Core-i5/i7 processors.



Both the ISL95835 and ISL95837 are the industry's smallest solutions available and offer combined functionality and reduced pin count, saving valuable board space and reducing the total bill of materials. The ISL95837 has been optimized for lower power, thin and light applications.

The controllers are based on Intersil's Robust Ripple Regulator (R3)™ technology, a hybrid of fixed-frequency PWM control and variable-frequency hysteretic control that delivers the industry's fastest transient response. The R3 modulator delivers faster transient settling time than typical modulators and automatically adapts switching frequency to optimize light load efficiency.

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1200V/5A SiC Diodes Offered in True Surface Mount DPAK

SemiSouth Laboratories, Inc. has launched new 1200V/5A diodes in the true, compact DPAK (TO-252) surface mount packaging which provides the necessary creepage distance and does not require a center pin.

Like many SiC diodes from SemiSouth, the new SDB05S120 parts feature a positive temperature coefficient for ease of paralleling. Switching behavior is independent of temperature and the devices have a maximum operating temperature of 175degC. The new diodes also have a zero reverse recovery current and voltage. They have a footprint of 0.385 x 0.260in and a profile of 0.090in.

The major application for these new SiC diodes lies in photo-voltaic micro-inverters, but the devices are also highly suitable for use in SMPS, Power Factor Correction circuits, induction heaters, UPS and motor drives.

www.semisouth.com

Efficient, Reliable Ultra-Fast 1200V IGBTs for Induction Heating

International Rectifier has launched a pair of efficient, reliable ultra-fast Trench Insulated Gate Bipolar Transistors (IGBTs) optimized for induction heating and resonant switching applications such as welding and high power rectification.

The new 1200V IGBTs utilise IR's proven thin-wafer trench technology to offer critical performance benefits including low VCE(on) and ultra-fast switching to reduce power dissipation and achieve higher power density.

In addition, the devices feature a 1300V repetitive peak rating for added system reliability. The IGBTs are co-packaged with a low forward-voltage high peak current soft forward-recovery diode optimized for resonant zero current turn-on operation.

These new IGBTs complement IR's family of IGBTs for motor drive and hard switching applications. IR's focus on power applications allows for optimization of devices to meet the technical requirements of various power systems.

www.irf.com

50V LDMOS RF Power Transistors

Richardson RFPD, Inc announced the availability of two breakthrough 50V LDMOS RF power transistors which set new standards for ruggedness in the UHF broadcast industry. The MRFE6VP8600H and MRFE6VP8600HS are push-pull power transistors that provide enhanced efficiency and operate over the 470 – 860 MHz frequency band. These devices are capable of transmitting highly-linear, 125W average DVB-T output power, with a peak envelope power output capability of over 600W. Moreover, these devices are fully capable of withstanding a nearly 100% mismatched load, specified as greater than 65:1 VSWR at all phase angles, with no damage to the transistor. Ultimately, the MRFE6VP8600H and MRFE6VP8600HS provide a unique combination of linear power amplification, high efficiency and enhanced ruggedness never before seen in the UHF broadcast industry.

www.richardsonrfpd.com/ruggedldmos

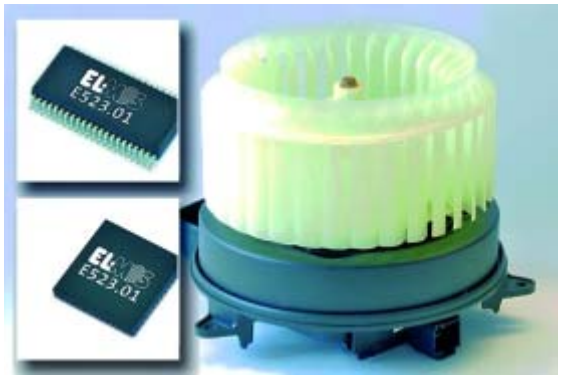
High-Power LED Driver ICs Provide Flexibility and Performance

Infineon Technologies extended the family of switch-mode LED drivers for high power LEDs for general lighting applications. Combining thermal protection feature that contributes to the lifetime of LEDs with flexibility in output current range from 350mA up to multiple amperes, the new drivers are cost-effective solutions for the design of highly-efficient indoor and outdoor lighting.

The new ILD series include LED driver ICs with integrated power stage as well as with external MOSFET achieving up to 98% driver efficiency across a wide range of general lighting applications, including MR16 halogen retrofits, residential and commercial luminaires, architectural lighting and street lamps. In addition to high output current range Infineon's ILD family provides high flexibility to customers by two different dimming methods, analog and PWM (Pulse Width Modulation) dimming. Besides the wide spread over-current protection the ILD drivers offer an over-temperature protection that is tailored to protect the LEDs and the LED driver IC from thermal overstress delivering the maximum possible operating life of the LED lamps and LED fixtures.

www.infineon.com/lowcostleddrivers

B6 Bridge Driver with Integrated LIN2.1 or PWM Interface



Gleichmann Electronics now offers the E523.01 motor driver from Elmos Semiconductor. This new IC controls up to three external NMOS half bridges for driving BLDC motors or DC motors. The E523.01 features a LIN2.1 compatible interface as well as a PWM interface with data preprocessing.

For operation with an external microprocessor, the E523.01 provides a 3.3 V or 5.0 V power supply, a reset function and a configurable window watchdog. Other features of the E523.01 include a low standby current drain of <50 µA, an integrated motor current measuring amplifier and an optionally available external boost transistor for the integrated voltage regulator. With the help of this external transistor, the microprocessor can be supplied with higher current or the internal power loss of the E523.01 can be minimized even further.

The dead time between the high-side and low-side FETs can be very precisely adjusted via SPI interface for an optimized control. A short-circuit detection at all external FETs as well as voltage, current and temperature monitoring provide the greatest possible safety.

The E523.01 is suited for use in automotive and industrial drives in a voltage range up to 28 V. In addition to the E523.01, the E523.11 with only a PWM interface is also available. Both versions are available in QFN44L7 and QSOP44 packages.

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Clock Generator Reduces Component Count up to 80 Percent

Texas Instruments introduced a highly integrated clock generator featuring the industry's best jitter performance. The National LMK03806 offers designers the ability to synthesize their required clock frequencies from a single low-cost crystal, enabling a dramatic reduction in component count of up to 80 percent, board size, and bill of materials (BOM) cost by up to 50 percent, while improving performance over legacy solutions. For more information and to order samples, visit www.ti.com/lmk03806-pr.

The LMK03806 simplifies timing architectures in wired and optical communications line cards by simultaneously synthesizing seven independent frequencies on 14 outputs. With an output frequency that spans 2.37 MHz to 2.6 GHz, the LMK03806 provides clocking support for all of the components on a typical line card.

Key features and benefits of the LMK03806

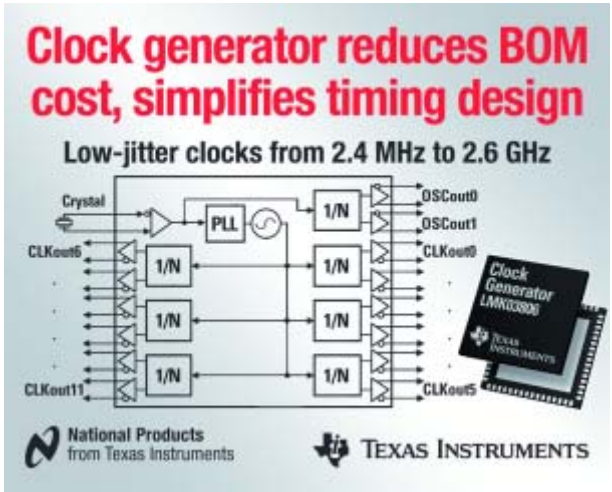
High-frequency voltage-controlled oscillator (VCO) and programmable output dividers: Simplifies timing design by simultaneously generating a wide array of common frequencies.

Ultra-low jitter: Sub-50 femtosecond (fs) rms jitter at 312.5-MHz output frequency improves bit error rate and carrier-to-noise ratio performance.

Programmable LVDS, LVPECL and LVCMOS: Each output clock is independently configurable, eliminating the need for level translators and fanout buffers.

Crystal interface: Allows designer to use a low-cost crystal for simultaneously generating multiple clocks.

The companion LMK00301 differential fanout buffer/level translator accepts a single-ended, differential or crystal input, and produces 10 additional buffered copies of the input clocks of up to 3 GHz in LVDS, LVPECL or HCSL format. The LMK00301 features best-in-class jitter performance, generating 51 fs rms jitter at 156.25 MHz, and less than 30 fs rms at 312.5 MHz output frequency when paired with the LMK03806 clock generator. Its extreme flexibility allows clock designers to address several additional markets, including wireless infrastructure and industrial applications.



www.ti.com

Hall Effect Sensors with Primary Integrated Winding

Premo introduces a new series of Hall Effect sensors called the SY series. The new product has been designed for a double supply voltage of ±12 to ±18Vdc.

SY family is a closed loop technology component in a very small package for THT mounting. Primary winding is already integrated, which allows to measure DC, AC and pulse currents on printed circuit boards.

Key characteristic of this series is the fully impregnated with a high isolation voltage: 3kV.

This series has been designed for nominal currents of 5, 10, 15, 20, 25 and 50Amps.

The output signal is centered at 0V with an output voltage of ±4 V allowing the detection of currents up to 3 times nominal value.

It also provides a linearity <0.1% with a ±0.7% accuracy levels. Bandwidth is up to 150 kHz with a response time below 1us.

Offset drift versus temperature is as low as 0.5mV/ºC.

The current sensor is specially designed to meet the highest safety requirements and is UL marking (USA and Canada).

It is fully compliant to below industrial standards:

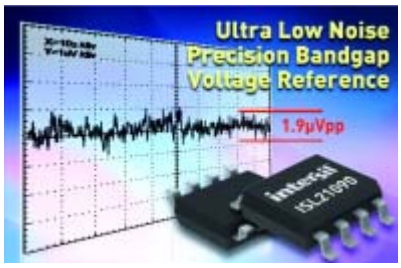
Isolated plastic case recognized according to UL94-V0; EN 60947-1:2004; EN 60950-1:2001

EN 50178:1998; UL 508 and CSA C22.2 No. 14-10

We encourage you to study the use of this new Hall Effect family in new or existing designs.

www.grupopremo.com

Voltage Reference Provides Exceptional Initial Accuracy at



The newest precision voltage reference from Intersil Corporation features low noise, low temperature drift and meets the low power requirements of high end and portable instrumentation systems. The ISL21090 is a wide input range, low noise precision bandgap voltage reference that provides half the noise of alternative solution with only half the power consumption. The device features exceptionally high initial, or 'start-up,' accuracy of +/-0.02%. The combination of low current consumption of 930microAmps, typical, and low noise of only 1.9microVpp (0.1Hz to 10Hz), makes the ISL21090 an excellent choice for high-end instrumentation systems up to 24 bits, and for process control, communications and data acquisition systems. It can accept input voltages up to 36V, compared with typical 18V ratings of alternative products.

www.intersil.com

Microcontroller Families Optimized for Smart Metering Applications

Renesas Electronics Europe has announced the availability of the RX210 and RX630 microcontrollers (MCUs), two compatible families designed to provide flexible and scalable solutions for the next generation of smart meters. Both RX210 and RX630 MCUs are based on Renesas' powerful 32-bit RX CPU core.

The new RX210 and RX630 families of MCUs have been developed using two advanced MONOS flash processors to provide compatible devices with a range of different features optimised for smart metering applications. The development of two compatible families allows the system designers to choose the optimum MCUs with particular characteristics required for a new design, while allowing the reuse of much of the same software for each application.

www.renesas.eu

Single-Phase Digital Point-Of-Load Chipset for Smart Power

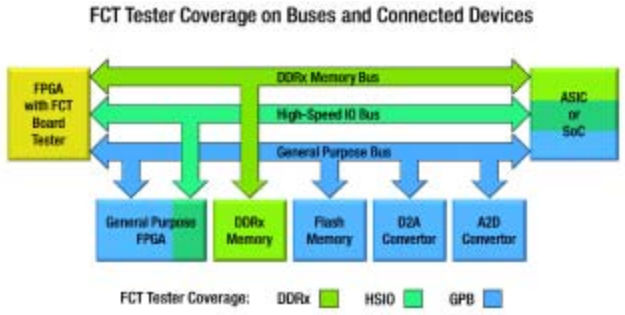
ZMD AG enters the smart power management market with the launch of a configurable true-digital, high-performance PWM controller for non-isolated DC/DC POL supplies. The ZSPM1000 operates as synchronous step-down converter in a single-rail and single-phase configuration. In combination with the ZSPM9000, ZMDI's ultra-compact MOSFET with integrated power-stage driver, the ZSPM1000 enables smart digital POL solutions for area constraint and high-performance applications such as servers, storage units, processor & FPGA boards, and others.

The ZSPM1000 provide best-in-class transient performance, enabled by ZMDI's Tru-Sample™ technology. At the same time, ZMDI's State-Law™ technique ensures a good steady-state behavior.

The ZSPM9000 DrMOS is the ideal companion for ZMDI's ZSPM1000 for non-isolated Point-of-Load (POL) supplies. An internal linear regulator enables the ZSPM9000 to operate from a single supply.

www.zmdi.com

FPGA-Controlled Test Inserts and Operates a Board-Tester-in-a-Chip



With new tools for the ASSET® ScanWorks® platform for embedded instruments engineers can simply select instruments they need, set their parameters and insert them into a field programmable gate array (FPGA) to function as a circuit board tester. Once inserted, ScanWorks FCT operates the board-tester-in-a-chip from a drag-and-drop user interface to perform validation, test and debug.

Because of significantly escalating gate densities, FPGAs are an effective platform for embedded test and measurement functionality at a time when legacy external probe-based equipment like oscilloscope and in-circuit test (ICT) systems are providing less and less test coverage. Faster speeds and greater complexities have increased the electrical sensitivities of chips and boards to the point where a physical probe will not provide adequate test coverage or reliable results.

www.asset-intertech.com

AC-DC Power Supply Compact, Efficient and Reliable

TDK-Lambda UK, a group company of the TDK Corporation, introduces the 65 watt MWS65 series of open-frame, medical AC-DC power supplies. With 4kVac reinforced input to output isolation and output to ground isolation of 1500Vac, all models in the MWS65 series comply with UL/EN60601-1 Editions 2 & 3 safety approvals for medical equipment and with the convenience of onboard dual fusing are ideal for use in B (Body) and BF (Body Floating) type medical applications.

Using innovative design techniques to combine high efficiency and high power density, the MWS65 also has less than 0.3W no load input power. With an industry standard footprint of 2 x 4 inches and very low 25.4 mm (1 inch) profile, the MWS65 is a compact, convection cooled unit also suitable for use in light industrial equipment, Point-of-Sale terminals and displays, Test & Measurement and Broadcast applications.

Operating from a universal 90 to 264Vac input, the MWS65 power supply is offered in 5 models with nominal outputs of 5V (11A), 12V (5A), 15V (4.4A), 24V (2.8A) and 48V (1.4A), which are user adjustable by ±10%. With a flat efficiency curve of up to 89%, from 20 to 100% load, the MWS65 can be operated at full load from -20 to 50°C ambient temperature and up to +70°C with suitable derating. Overvoltage and overcurrent protection is standard.

CE marked in accordance with the LV Directive and delivered with a 3-year warranty, the MWS65 carries a host of safety agency approvals, including UL/CSA/EN60950-1, EN50178 (OV II) and UL/EN60601-1, as well as compliance to EN5011/EN5022-B, FCC Class B and VCCI-B for both conducted and radiated EMI.

www.uk.tdk-lambda.com/mws

Phase-Change Thermal Materials Range with High Temperature, High Conductivity Variant

The Bergquist Company has extended its range of phase-change thermal management materials by introducing Hi-Flow® 650P, specified for continuous use up to 150°C and featuring high thermal conductivity, electrical isolation, polyimide reinforcement, and natural tack to aid assembly. Hi-Flow 650P is a new member of Bergquist's versatile Hi-Flow family, which presents a selection of isolating and non-isolating materials as a clean and easier handling alternative to thermal grease at the interfaces between components and heatsinks. Hi-Flow materials are solid at room temperature but change phase at higher temperatures to wet-out the interface fully without overflowing. Hi-Flow 650P changes phase at 52°C.

With its 150°C temperature rating, Hi-Flow 650P is suited to use in automotive assemblies such as electronic control units (ECUs) in under-the-hood locations, as well as other types of equipment operating in harsh conditions. With high thermal conductivity of 1.5W/m-K, this new formula assures efficient removal of heat energy from the sensitive semiconductor device into the attached heatsink. The polyimide reinforcing film provides high resistance to cut through and has high dielectric strength.

Hi-Flow 650P is available as sheets, rolls or in custom sizes, in thicknesses from 0.114mm to 0.140mm. Bergquist recommends the use of spring clips to maintain constant pressure for optimum thermal performance at the interfaces between the component and heatsink.

www.bergquistcompany.com

ADVERTISING INDEX

HiPak™. Superior reliability in high power IGBT packaging.

Perfect soldering is one of the major requirements in producing reliable modules with high life expectancy. All ABB modules undergo intensive scrutiny including X-ray analysis and acoustic microscopy to ensure highest quality. This is only one of many process control steps towards operational excellence. For more information please visit our webpage: www.abb.com/semiconductors

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Extend Battery Life With IR's Benchmark MOSFETs

Small Power MOSFETs Designed for Handheld Devices

Gate Drive - 4.5V Optimized, 2.5V Capable, 12V Maximum

BV_{DSS}	Package	Max. $R_{DS(on)}$ @		Part Numbers
		4.5V (mΩ)	2.5V (mΩ)	
-20V	PQFN 2x2	31	53	IRLHS2242
	SOT-23	54	95	IRLML2244
20V	PQFN 2x2	11.7	15.5	IRLHS6242
	SOT-23	21	27	IRLML6244
	Dual PQFN 2x2	45	62	IRLHS6276
30V	PQFN 2x2	16	20	IRLHS6342
	TSOP-6	17.5	22	IRLTS6342
	SOT-23	29	37	IRLML6344
	Dual PQFN 2x2	63	82	IRLHS6376

Gate Drive - 10V Optimized, 4.5V Capable, 20V maximum

BV_{DSS}	Package	Max. $R_{DS(on)}$ @		Part Numbers
		10V (mΩ)	4.5V (mΩ)	
-30V	PQFN 2x2	37	60	IRFHS9301
	SOT-23	64	103	IRLML9301
	Dual PQFN 2x2	170	290	IRFHS9351
25V	PQFN 2x2	13	21	IRFHS8242
	SOT-23	24	41	IRFML8244
30V	PQFN 2x2	16	25	IRFHS8342
	TSOP-6	19	29	IRFTS8342
	SOT-23	27	40	IRLML0030

Features

- Available in both N & P Channel for simple design
- Latest silicon technology offering low $R_{DS(on)}$ for increased battery life
- 2.5V drive capable available for 1-cell Li-Ion Battery Applications
- PQFN package offers high power density reducing system size

Applications

- DC Load Switch
- Battery Protection
- DC-DC Converter
- Screen Backlight Boost Converter

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