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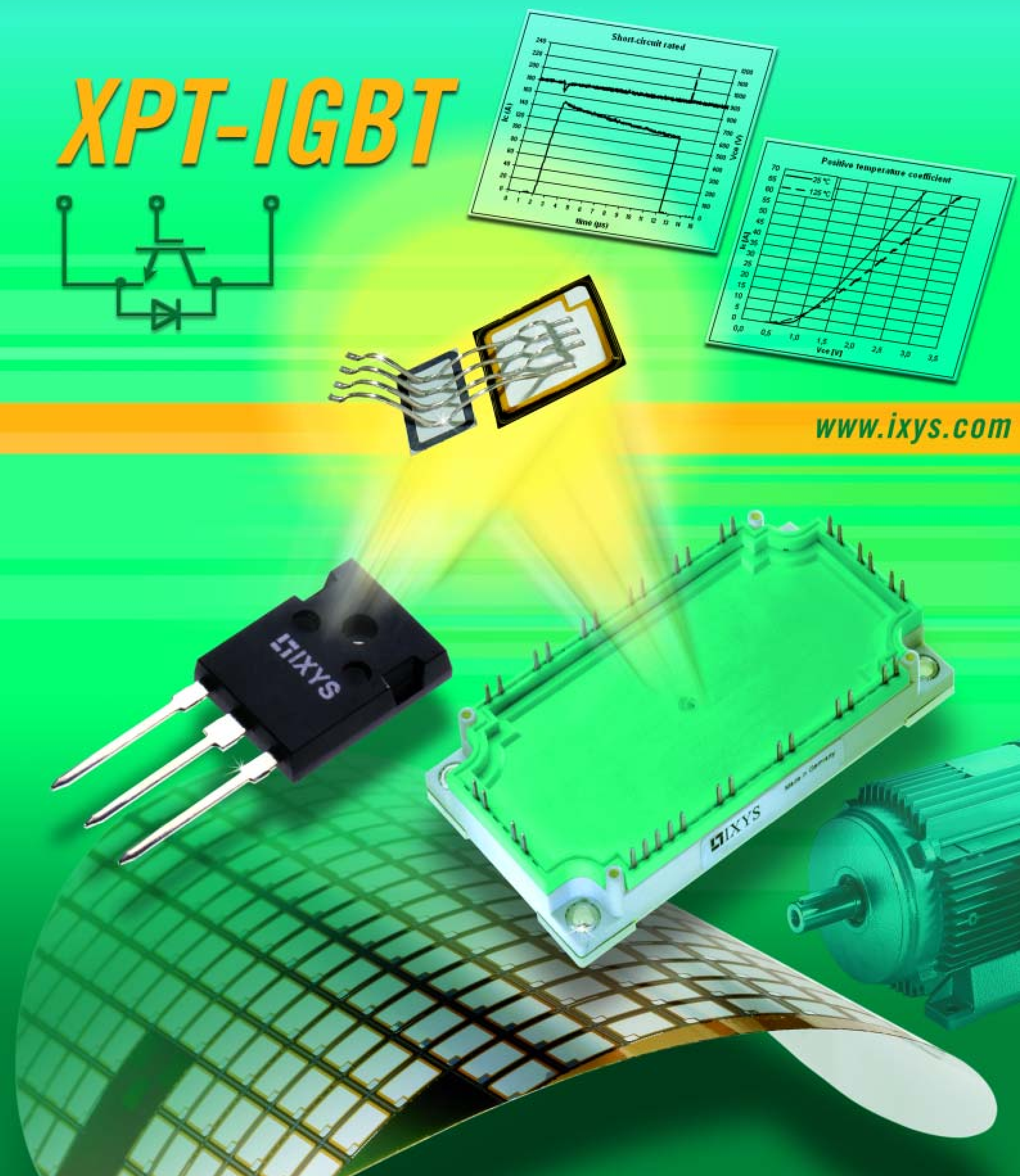
Bodo´s Power

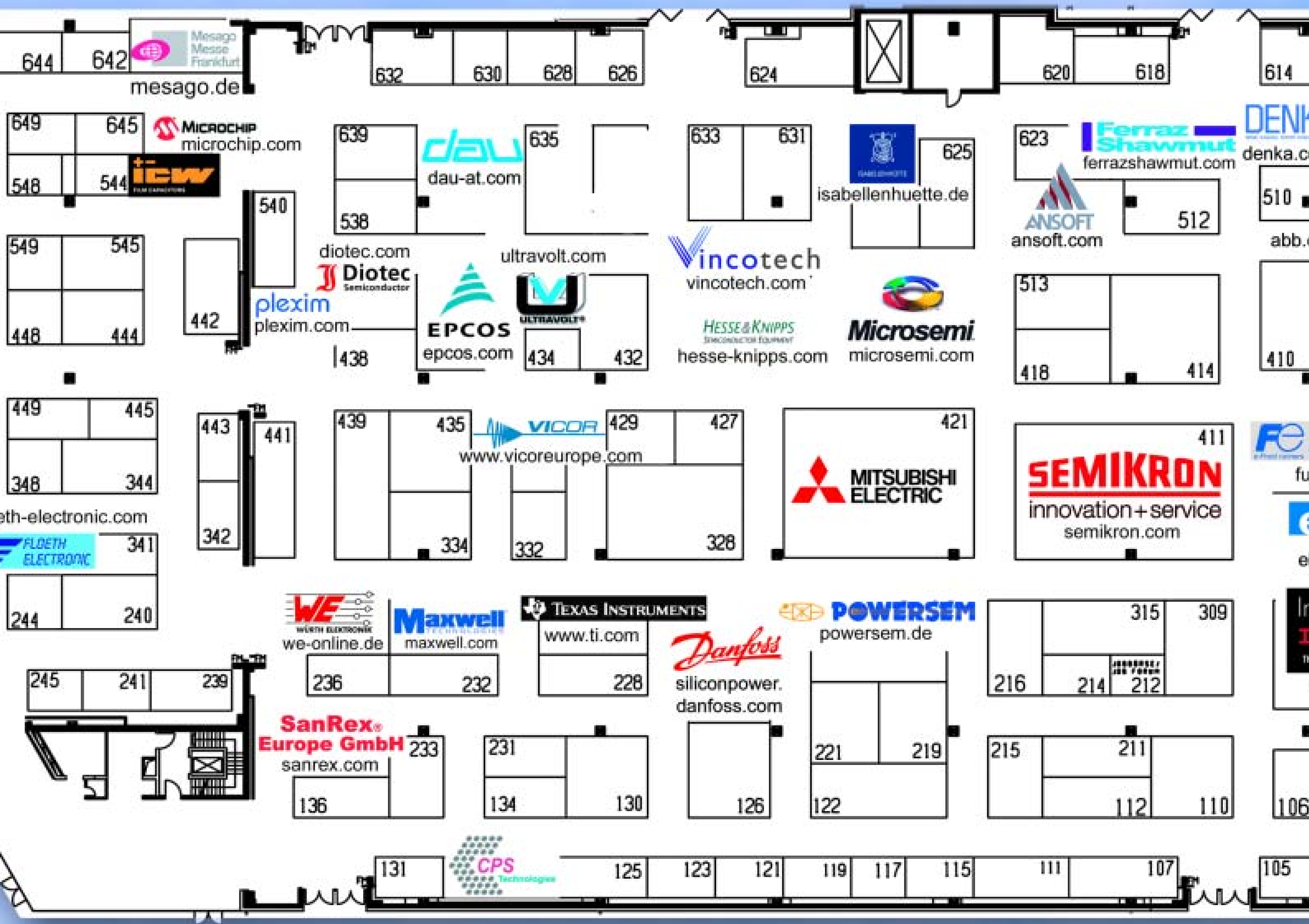
Electronics in Motion and Conversion

May 2008



PCIM Europe 2008

Bodo´s Power



Bodo´s Power

Become a Winner at the Podium on Wendsday, May 28th Booth 12 / 366

Only the seated people at the podium at 12:00 will benefit.

Are you are dying to know now? Come and get your surprise!

This year’s podium discussion at PCIM will focus on Blue Efficiency.

I am looking forward to seeing you at the podium on Wednesday, May 28th between 12:20 and 13:20.

Something special will surprise the audience at the end of the open discussion.

Hot Show Events

Stop at the Podium at its Best

Wednesday, May 28th
Booth 12 / 366
12:20 and 13:20

Blue Efficiency at the Next Level
Bodo Arlt, Editor, Bodo's Power

ECPE Students Day,

29 May 2008:

11.20 – 11:30h Welcome and Introduction.
11.30 – 12.20h Presentations at the PCIM Forum
12.30 - 13.00h Light lunch (sponsored by ECPE)
13.00 – 16.00h Exhibition Rallye.
16.00h Awards ceremony.

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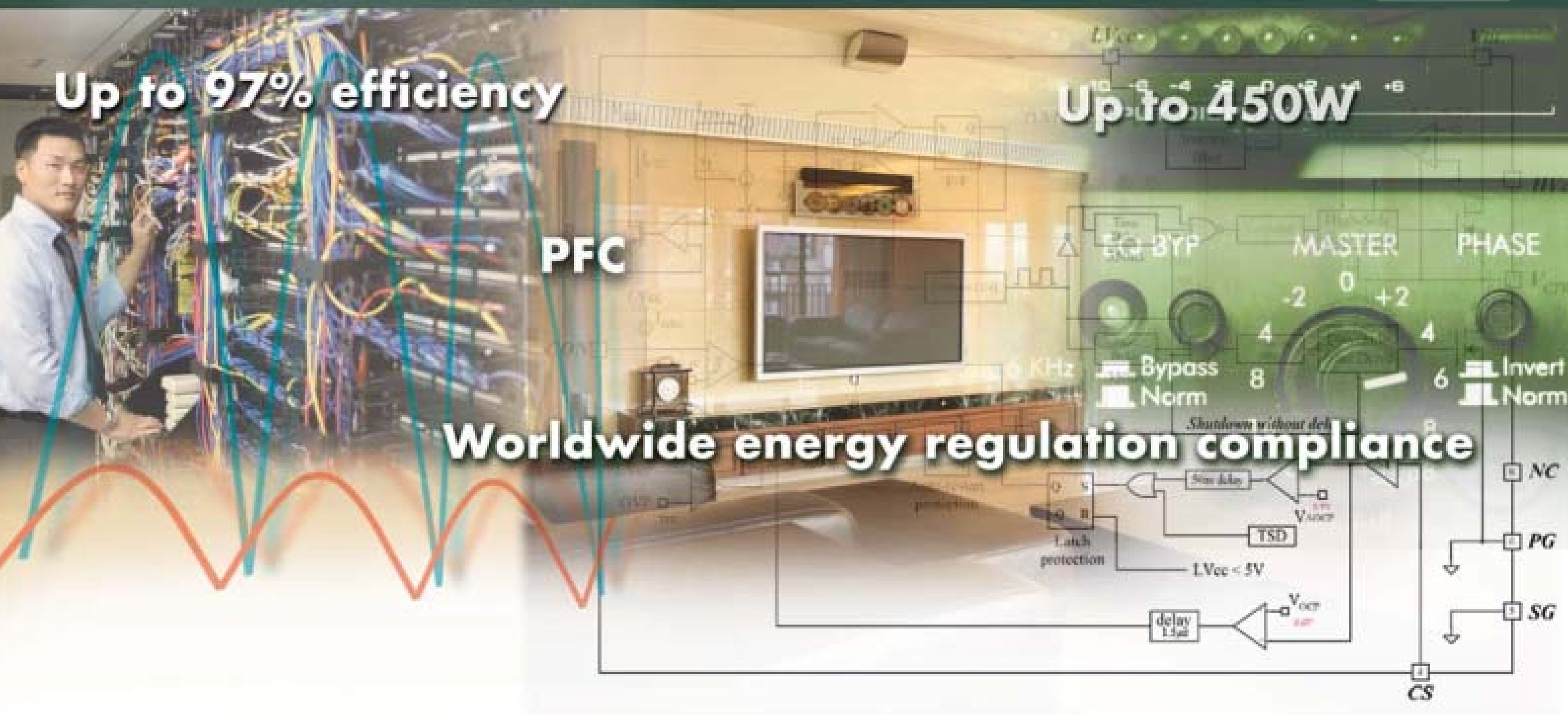
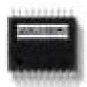
AC-DC conversion and your design time can't get more efficient.



SMPS solutions with efficiency designed in and extra work designed out

Application notes and evaluation boards help you simplify and optimize SMPS designs. Access the solutions you need at www.fairchildsemi.com/acdc

Fairchild Power Switches: Our Green FPS™ family includes more than 20 PWM controller + FETs with protection features for meeting worldwide energy efficiency requirements. All are optimized for specific topologies, like our new **FSFR2100** for LLC resonant half-bridge converters.



PFC Controllers: Our PFC controllers with built-in protection increase efficiency and reliability while minimizing external components. Choose from stand-alone or combination of PWM and PFC controllers, such as our new green mode **SG6905** boost PFC/flyback PWM combo controller.

Gate Drivers: Our new **FAN3xxx** series of high-speed, low-side gate drivers offers the industry's best combination of performance, size and design flexibility in primary-side gate drive or secondary-side synchronous rectifier solutions. Reduced switching times, many input options and tiny MLP packages allow you to optimize your design.

Only Fairchild offers complete SMPS solutions – including high voltage MOSFETs, isolated error amplifiers, bridge rectifiers and the industry's leading design support. To make your AC-DC designs fast, easy and up to 97% efficient, all you need to know is Fairchild.

Saving our world, 1mW at a time™

www.fairchildsemi.com

the power franchise®

The Gallery

Bodo´s Power

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Events

SENSOR+TEST 2008
Nuremberg May 6-8
http://www.sensor-test.de

PCIM Europe 2008
Nuremberg May 27-29
http://www.mesago.de

SMT/Hybrid 2008
Nuremberg June 3-5
http://www.mesago.de

PESC 2008
Rhodes Greece June 15–19
http://www.pesc08.org

EPE – PEMC 2008
Poznan – Poland September 1-3
http://epe-pemc2008.put.poznan.pl

3X Show Time for Nuremberg

May and June are full of important events for Power Electronics, on both the design and development fronts.

First is the Sensor + Test Conference from May 6th to 8th in Nuremberg. Power electronics depend on sensed inputs to function properly and test and measurement is no less mandatory for electronics, especially on the power side.

The 8th International Conference for Optical Technology in Sensor and Measuring Technology, OPTO 2008, is chaired by Prof. Dr. E. Wagner of the Fraunhofer Institute for Physical Measurement Techniques in Freiberg. It will feature four presentation tracks and a poster session covering the following areas: sources and modules, fiber optic sensing, measurement technologies and applications.

The 10th International Conference on Infrared Sensors and Systems, IRS² 2008, chaired by Prof. Dr. G. Gerlach of the Technical University in Dresden concentrates on sensors and arrays as well as applications. The IRS² conference features a poster session in addition to technical presentations.
The main event for power electronics without question, however, is the PCIM Europe conference and show at the end of May, from the 27th to 29th. The show will kick-off on the previous weekend with tutorials. Prof. Rufer will provide welcoming remarks targeted especially at visitors and young engineers who are attending the PCIM Europe for the very first time. The conference includes two sessions: one dedicated to power electronics and one to automotive systems and technologies. The increasing interest in automotive applications is arising, without a doubt, from the emergence of alternative propulsion systems and this major development is clearly stimulating new research. Each conference day starts with a keynote speaker and a special round table session will feature the European Center for Power Electronics (ECPE).

The PCIM Europe Conference begins in just a few days. Are you ready to go?

This year's podium discussion by Bodo's Power at PCIM will focus on Blue Efficiency. I am looking forward to seeing you at the podium on Wednesday, May 28th between 12:20 and 13:20. As some of you might expect, I plan to surprise the audience with something special at the end of the open discussion. Only those still seated at the podium will benefit. Are you are dying to know now? Come and get your surprise!

Finally, the SMT/HYBRID/PACKAGING show takes place from June 3rd to 5th.
Power electronics solutions are highly influenced by efficient packaging and module design – important aspects for power products. Extracting heat from power chips through optimized design is a key subject in today's electronics. SMT/HYBRID/PACKAGING offers a comprehensive and compact presentation of products that fit well with power design.

My Green Power Tip for this month is:
Do you check your trunk regularly for unnecessary heavy baggage? Is your tire pressure correct? Did that engine tune-up get done?

All these factors help reduce fuel consumption - prior to converting to a new hybrid automobile.

See you at PCIM at my Booth, 12-457

Best Regards

Bodo Arlt

PCIM Conference China 2008 Results

By Prof. Leo Lorenz, Infineon Technologies, China

From March 18th to 20th the PCIM 08 took place for the first time at it's new location in the German Center for Industry and Trade in Pudong /Shanghai. Due to the excellent technical program many attendances from Universities, Research centers and Industry were attracted to this nice location. This year more than 50 experts from Industry and academia additionally to 3 distinguished key note speakers gave their presentation and answered the questions from the audiences. The mainstream of the conference was guided by the needs of Chinese industry and research directions such as:

- Advanced Power Semiconductor Devices and Signal Processing Control IC's
- DC/DC and AC/DC power converters for Power Supplies
- New concepts for motor drive systems and automotive power electronics
- Renewable Energy and Power Quality

Special high lights at this year's conference come from key note speakers.

Top experts from Industry and academia covered actual topics and demonstrated very impressive future technology trends in

- Power Devices for Sustainable Growth of Power Conversion Application
- Medium Voltage Drivers from kW to MW
- Solar Inverter-Market and Technology
- Based on these contents the Mission of these years PCIM conference was: " **Power Electronics- A Key Technology for Power Conversion, Conditioning and Management"**

Gourab Majumdar from Mitsubishi stressed in his key note speech the state-of-the –Art leading technologies related to the advancement of power devices and their contributions in power conversion applications, focusing mainly on IGBT and Intelligent Power Module (IPM) technologies. It also highlighted on new areas of power module advancement including prospects of SiC power devices for future application possibilities.

In the second key note speech Oscar Apeldoorn from ABB shows potential for low and medium Voltage drive. Medium voltage drives have become a key tool in the chain on economic value added. The market demands planned on these products have continuously increased. Power density, efficiency, footprint, power quality and reliability; plays an ever more important role. To meet these demands, ABB has introduced new converter topologies and high power semiconductors. Standardization now plays an important role and it is reached by implementing modular power electronics building blocks PEBBS. ABB has successfully introduced this concept into its drives. They prove themselves in markets for traction, industrial drives and renewable energies. The excellent quality of ABB drives makes sure that wind turbines generate, traction recuperates and drives save energy in an efficient and reliable way.

A further highlight at the PCIM 08 conference was the key note paper from Bruno Burger FhG Freiburg about Solar Inverter Technology and market data. In his presentation he pointed out:

Market trends:

- The photovoltaic market has growth rates between 30% and 50%
- The global annual installation in 2007 was in the range of 3GW to 4 GW.
- The golbal cumulative installed capacity in 2007 was approx. 10GW.

Technology:

- For PV inverters about 40 different basic power electronics circuits are used.
- There are three general topologies:
  - Inverters with low frequency (50/60Hz) transformer,
  - Inverters with high frequency transformer (16kHz to 100kHz) and
  - Transformerless inverters.

The advantages and disadvantages of the different circuits were discussed in the presentation.

- Inverters with low frequency or high frequency transformer achieve maximum efficiencies up to 95%.
- Transformerless inverters with bipolar switching achieve up to 97% efficiency and transformerless inverters with unipolar switching achieve up to 98% efficiency. There is a trend to transformerless inverters with high efficiency and unipolar switching. In case of single phase inverters, the HERIC topology and the H5 topology achieve highest efficiencies. In case of three phase inverters, the three level inverter and Neutral Point Clamped (NPC) inverters have highest efficiencies.

Future trends in Solar Cells:

- Concerning solar cells, there is a trend to higher efficiency. This can be reached with crystalline back suface contact cells like Emitter Wrap Through (EWT) cells or Metal Wrap Through (MWT) cells. Efficiencies of 22% are reached in series products. Higher efficiencies can be reached with multi-junction cells like the triple junction cell with three stacked cells of Gallium-Indium-Phosphite (GaInP), Gallium-Indium-Arsenide (GaInAs) and Germanim (Ge). In this case the efficiency is in the range of 40%.

Cells with five junctions will reach even 50% efficiency in the future.

Future Trends in PV Inverters:

- There will be a trend to high inverter efficiency. Some companies even reached 98% efficiency and the others will have to follow.
- Since power semiconductors of Silicon (Si) are today near the theoretical limit of on-resistance in case of MOSFETs or forward voltage drop in case of IGBTs, there must be a change to Silicon Carbide (SiC) or perhaps Gallium Nitride (GaN).

This change will be a milestone in power electronics. In first tests, efficiency improvements of up to 2.4% could be reached by using SiC MOSFETs.

Also a efficiency record of 98.5% was reached for a complete solar inverter by the use of SiC MOSFETs.

Future trends in PV systems:

- There is a trend from rooftop installations with several Kilowatts to solar parks with hundrets of Megawatts.
- We need to extend the grids for the transportation of wind and solar power. One big step will be the Mediterranean Electrical Ring, a grid around the Mediterranean Sea. So solar power could be produced in the deserts of north Africa and consumed in Europe. With a high voltage dc HVDC grid from Norway to Marocco, we could produce nearly 100% of the electrical power of Europe by renewables.

The main stream of the oral presentations during the technical session for silicon devices showed new results in the IGBT development including advanced packaging and chip interfacing technologies as well as improved reliability data. New technologies for low voltage power MOSFET's in DC/DC converters and high voltage devices in super junction technologies (up to 900V) as well as SiC schottky diodes were presented by various companies.

Future power conversion in DC/DC and AC/DC topologies are driven by passive components and fully digital controlled systems. Multiphase digital controlled interleaved PFC concepts and new light sources with smart control techniques will dominate future energy saving power electronics systems. Fully digital controlled lower power motor drives for Home Application with advanced motor concepts are improving the energy efficiency by more than 40%. Multilevel inverter dominates high power motor control applications. Automotive power electronics for motor control and ultra high power density bidirectional DC/DC converters will direct future development. New standards in Power Quality and converters for renewable energy sources are going to become an attractive industry in China.

It has been demonstrated that the PCIM conference with more than 25 years experience serving the world market for power electronics industry play a key role in discussing and introducing new technologies also benefits in China. The new set up of Board of Directors and technical committee members with worldwide reputation and crucial influence in Chinese industry and academia in pushing PCIM in China.

www.mesago.de

Michael Barrow Executive VP and COO

International Rectifier Corporation has announced the appointment of Michael Barrow as Executive Vice President and Chief Operations Officer, effective April 14, 2008. Barrow, 53, will report directly to Oleg Khaykin, President and Chief Executive Officer, and will be responsible for implementing strategies to build a world-class manufacturing organization.

Mr. Barrow brings 30 years of semiconductor and operational leadership experience to International Rectifier, having served at both Amkor Technology and Intel.

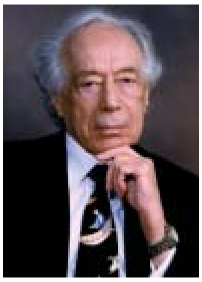
“We are very pleased to have Michael Barrow join the management team here at International Rectifier,” said Oleg Khaykin, International Rectifier's President and Chief Executive Officer.

“I am excited about the opportunity to join International Rectifier and help build upon the strong foundation that is already in place,” said Michael Barrow.

Mr. Barrow holds a BSEE/BSME degree from Natal Technikon (Institute of Technology) in Durban, South Africa.

www.irf.com

Retirement of Founder and Chairman Eric Lidow



International Rectifier Corporation announced that the Company's Founder and Chairman, Eric Lidow, will retire from his position as Chairman and as a member of the Board of Directors effective on May 1, 2008. Mr. Lidow had served as the Company's Chief Executive Officer until 1995, after which time he assumed the position of Chairman.
Mr. Lidow founded International Rectifier in 1947. Over the course of more than six decades, Mr. Lidow transformed a start-up company that developed selenium photo-electric cells and selenium rectifiers into a world leader in power management technology that today produces thousands of innovative analog, digital, and mixed signal integrated circuits and other advanced power management technologies and products. Speaking on behalf of the Board of Directors, President and Chief Executive Officer Oleg Khaykin said, "Eric is one of the most respected pioneers in the power semiconductor industry. His long-standing commitment to the employees and customers of International Rectifier has been crucial to our progress over the decades. As we continue to grow as a Company, the legacy of Eric's leadership during his 60 years at IR will remain."

Appointment of Richard J. Dahl as Chairman

International Rectifier Corporation announced that the Board of Directors has appointed Richard J. Dahl Chairman of the Board, effective on May 1, 2008.
Mr. Dahl, 56, was elected to the Company's Board of Directors in February 2008. Since 2004, Mr. Dahl has served as a Director of the NYSE-listed IHOP Corporation, where he presides as Chairman of the Audit Committee and was Chairman of the Special Committee of the Board formed to oversee IHOP's successful bid to acquire Applebee's International. His executive experience includes serving as President and Chief Operating Officer of the Dole Food Company and of the NYSE-listed Bank of Hawaii Corporation. Mr. Dahl, a former CPA with Ernst & Young, has extensive business experience in Asia, the Pacific Basin and Europe.
"I welcome Mr. Dahl to the Chairmanship of International Rectifier," stated retiring Chairman and Director Eric Lidow, Founder of International Rectifier. "The Company will benefit from his extensive business experience and knowledge of international trade issues."

www.irf.com

PLECS Simulation Endorsed in Academia

Piece-wise Linear Electrical Circuit Simulation from Plexim, widely used in the Power Electronics (PE) industry, is now being adopted as a teaching tool.
CPES joins other leading research and teaching facilities in selecting PLECS for power electronics simulation.
(Center for Power Electronics Systems is a consortium of five US universities, consisting of Virginia Tech (VT), University of Wisconsin-Madison (UW), Rensselaer Polytechnic Institute (RPI), North Carolina A&T State University (NCAT) and University of Puerto Rico-Mayagüez (UPRM).)
Plexim welcomes CPES as the most recent member of the PLECS-users community.
CPES joins a distinguished group of academic users consisting of ISEA (Aachen), Manchester University, Nottingham University, Imperial College, QUT and many others.
Dushan Boroyevich (Professor and Co-director of Virginia Tech & CPES) says, "CPES sees Plexim's PLECS as a valuable tool for education and research in power electronics. The Center is glad to have the opportunity to evaluate this innovative software over the coming years."
The PE fraternity is interested in results and needs simulation tools that are fast, stable and intuitive. "We are very focused on Power Electronics both in teaching and research at ISEA", says Director and Professor Rick De Doncker, "and PLECS allows us to do just that rather than obliging us to invest time in learning and implementing software applications".
Dr Mike Barnes of Manchester University adds, "We have selected PLECS because it is very convenient to use in both development and teaching. We need to keep our students competitive by using standardised tools that are optimised for today's power electronics industry."
PLECS is the preferred tool for research and teaching, not only in conventional "face-to-face" teaching but also in "e-learning" using modern communication technologies such as those of the web-based Power Electronics Education Electronic Book (www.peeeb.com). "PEEEB is a PE teaching website which offers comprehensive teaching and simulation material", says Dr Firuz Zare, responsible for PEEEB at QUT Australia, "We use PLECS for its speed and stability and because it operates in the Matlab/Simulink environment which is standard in most universities and institutes".

www.plexim.com

Ansys to Acquire Ansoft

ANSYS, Inc. and Ansoft Corporation announced today that they signed a definitive agreement whereby ANSYS will acquire Ansoft for a purchase price of approximately $832 million in a mix of cash and ANSYS common stock. The strategic, complementary business combination of ANSYS and Ansoft will create the leading provider of 'best-in-class' simulation capabilities, with combined trailing 12-month revenues of $485 million. When completed, ANSYS currently anticipates that the transaction will be modestly accretive to non-GAAP earnings per share in its first full year of combined operations.

Under the terms of the definitive agreement, which was unanimously approved by the Boards of Directors of both companies, Ansoft stockholders will receive $16.25 in cash and 0.431882 shares of ANSYS common stock for each outstanding Ansoft share. Based on the 10-day trailing average closing price of ANSYS common stock, the implied value is $32.50 per Ansoft share.

www.ansys.com

www.ansoft.com

Denis Regimbal Named CEO of Enpirion

Enpirion announced the appointment of Denis Regimbal as Enpirion's new CEO. Mr. Regimbal brings extensive semiconductor executive management experience to Enpirion as the company intensifies its targeting of growth markets including storage, networking, wireless, and audio/video. Mr. Regimbal will oversee the company's worldwide operations from its New Jersey headquarters location.

Mr. Regimbal comes to Enpirion from LSI Corporation, where he was the executive vice president and general manager of the Mobility Group, overseeing the mobile phone and mobile entertainment semiconductor device businesses. Mr. Regimbal said, "I am thrilled to be joining this highly talented and energetic team. The challenge of delivering optimized power efficiency in space-constrained applications is uniquely solved through Enpirion's technology innovation. No other company is better positioned to benefit from this critical and growing industry need."

Prior to his management position at LSI, Mr. Regimbal held numerous executive-level positions at Agere Systems, including executive vice president and general manager of the Telecommunications division, as well as vice president and general manager of the Media Connectivity division. In addition, Regimbal led cross-divisional strategy and marketing initiatives for Agere's wireless data, computer communications and storage businesses. Regimbal also was vice president of sales and applications for Europe, Middle East and Africa (EMEA), responsible for growing the business across the EMEA region. In addition, he was general manager of the Wireless Infrastructure division

www.enpirion.com

Record 2007 UPS Market From Three-Phase Growth

According to the latest analysis by IMS Research, the global UPS market at year end is estimated to have grown by almost 20% from 2006 to 2007. Global growth continues to be driven primarily by large three-phase installations into new and refurbished data centers; as well as into developing segments for UPS systems, such as transport and security.

The single-phase segment of UPS showed signs of slowing towards the tail end of 2007 with increased economic concern in the US. According to analyst Michael Markides, "Although the three-phase sector continues to push the market to record levels, the concern over the US economy can be seen in the lower power segments, which are governed by small to medium sized businesses and their related IT investment. The three-phase market will continue to surge. It is too early to say whether the recent slowdown in the single-phase market will persist"

2007 as a whole was a banner year for UPS suppliers worldwide, with IMS Research estimating the global market to be worth $7.4 billion, with APC-MGE the largest supplier with a market share of more than 30%. Adds Markides, "As we see the financial sector globally suffering from uncertainty, it will be interesting to see if this affects large UPS installations in data centers, the main driver of double-digit growth for the market over the past few years."

www.imsresearch.com

Specialist Distributor of the Year 2007 in the UK & Ireland

Tyco Electronics has selected IS-Rayfast as its UK & Ireland Specialist Distributor of the Year 2007. The award honours the distributor's class-leading increase in the value of sales of Tyco Electronics products over the last year. Tyco Electronics Account Manager Paul Godden commented: "We are very glad to be able to reward IS-Rayfast for their continued excellence in promoting Tyco Electronics." He added: "IS-Rayfast offers outstanding technical solutions, quick turn-around times thanks to good inventory holding and provide very good design-in work to support the Tyco Electronics Raychem brand."
James Leonard, Sales Director of IS-Rayfast, commented: "We are very happy to have won this award for the second year running. The award recognises our continued commitment to providing superior technical support to our customers and our excellent stock of products. I want to congratulate my superb team of people without whom this success wouldn't have been possible." "I also want to thank our good contacts at Tyco Electronics for supporting us throughout the year", Leonard added.
IS-Rayfast acts as a value-added distributor for Tyco Electronics' wire, harnessing, protection, identification and labelling products, in sectors such as aerospace, defence, marine, motorsport and industrial. Paul Godden attributed much of the distributor's recent success in these markets to IS-Rayfast's technical solutions, with sales specialists spending the time required to provide customers with a unique solution to their particular problem or design.
Picture (from left to right): Michael Finch, Tyco Electronics Distribution Manager UK & Ireland; Karen French, IS Rayfast Managing Director; Paul Godden, Tyco Electronics Account Manager

www.tycoelectronics.com

Ultravolt Purchases Stake in Distribution Company

UltraVolt, Inc. announced it purchased a major stake in a high-voltage products distribution company during a period of intensive growth financing, ensuring a pathway for future growth and success.
To further its goal of "Making High Voltage Easier", UltraVolt, Inc. has acquired a 50% stake in HVP Global, LLC the world's first electronic products distributor dedicated to high-voltage components and subsystems. Founded in 2005, HVP Global focuses on a unique distribution strategy, offering only complementary high-voltage products. In addition, each HVP office has a technical sales force that offers engineering support from project definition through development and design to production, ensuring the customer's project stays on track, and the principal gets key customer knowledge along the way. HVP Global has partially owned or franchised sales offices covering 17 countries in Europe and Asia.
HVP Global's sales offices work with a wide variety of applications, including pulsed-power systems, semiconductor equipment, medical devices, industrial machinery, analytical instruments, and many more.

www.ultravolt.com

NEC Signs up Future for Distribution in Europe

Future Electronics Ltd announced that it has agreed a franchise agreement to sell the products of NEC Electronics Europe (hereafter referred to as NEC Electronics) in the UK and elsewhere in Europe. The agreement is effective from 1 April.

Future, the world's third largest global electronic components distributor, is already franchised to sell NEC Electronics products in Israel and the Americas. The new agreement, which covers NEC Electronics' complete range of semiconductor and LCD products, extends the franchise to the UK, France, Spain, Ireland and Eastern Europe.

www.futureelectronics.com

APEC 2009 Call For Papers

Twenty-fourth Annual IEEE Applied Power Electronics Conference and Exposition February 15th – 19th, 2009, Marriott Wardman Park Hotel, Washington, DC.
APEC 2009 continues the long-standing tradition of addressing issues of immediate and long-term interest to the practicing power electronics engineer. Outstanding technical content is provided at one of the lowest registration costs of any IEEE conference.
APEC 2009 will provide a) the best power electronics exposition, b) professional development courses taught by world-class experts, c) presentations of peer-reviewed technical papers covering a wide range of topics, and d) time to network and enjoy the company of fellow power electronics professionals in a beautiful setting. Activities for guests, spouses, and families are abundant in the Washington area.

www.psma.com

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for POWERSEM
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INTELLIGENT MOTION
POWER QUALITY
27-29 May 2008, Nuremberg, Germany

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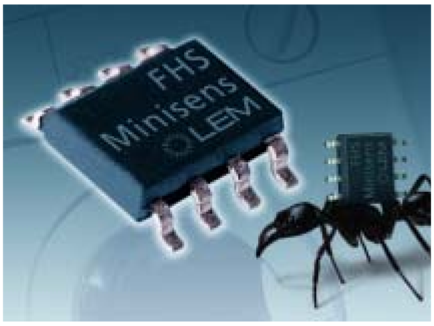
LEM

LEM is a global market leader, designing and manufacturing transducers for measuring electrical parameters such as current and voltage. Today, LEM's current and voltage transducers are used to improve control and save energy in motor control applications, automotive systems (particularly hybrid vehicles), rail transport, AC/DC converters, uninterruptible power supply systems for computers as well as in renewable energy applications such as micro-turbines and wind and solar power generation. LEM's technology development drives key trends in the industry:

Miniaturisation:
transducers have become smaller and more cost effective opening up new markets and opportunities to leading players as the range of potential applications is increased. LEM's new miniature IC transducer Minisens, in an SO-8 package, provides isolated current measurement enabling improved electronic motor control and lower energy consumption.



Greater degree of application integration and complexity: increasing demand for extended functionality requires a higher level of integration of LEM's products and opens up new markets. LEM has added functionality in many ways, including the addition of intelligent microelectronics. Its wireless electrical sub-metering component Wi-LEM gives a precise image of local power consumption helping customers achieve real energy efficiency. For UPS systems LEM's Sentinel measures the state of health of standby batteries.

Enhanced performance:
smaller and more integrated current and voltage transducers can provide improved performance in an increasing number of applications. The power electronics in the motor drive need the current transducer to measure and feedback the required power. LEM's transducers are able to provide substantial energy savings of 30% or more and improved speed and torque control.

Process control and automation place particular demands on the need for increased intelligence and LEM has formed a division dedicated to developing these macro components. LEM's unique manufacturing systems and in-house development of custom mixed-signal silicon chips also give the company an unmatched capability to meet the challenging requirements of customers across the wide range of power electronics applications.

LEM's long track record in the industry allows it to better understand customers' needs and requirements. Furthermore, its transducer technology delivers clear and recognisable added value to customers by:
- offering a comprehensive range of standard products as well as customised products;
- providing unique quality and reliability – guaranteed;
- isolating low power applications from high voltage; and
- strategically by linking power electronics to 5V microelectronics.

The company invests a considerable amount of its financial resources in research and development. It also improves and optimises its manufacturing processes, e.g. accelerating the time to volume production. LEM's leading market position is assured through a

number of key patents in technical design as well as trade secrets.

LEM offers a wide variety of transducers based on different technologies:
- Hall effect transducers, which include closed-loop, open loop and Eta™ transducers;
- Fluxgate transducers;
- Air-core transducers, including Rogowski and PRIME™ technologies;
- Other voltage transducers, including the AV product family as well as devices based on Hall effect and fluxgate technologies.

The most suitable product and technology for an application depends on many factors, predominantly the electrical and mechanical requirements, thermal conditions and environment in which the transducer is to be used. More complex applications may add criteria – e.g: electromagnetic interference, mechanical disturbance (vibration, shock etc), special isolation or compliance with industry-specific standards. Although the requirements of most applications are met with standard devices, LEM also develops customised products.

LEM employs approximately 950 people worldwide. It has production plants in Geneva (Switzerland), Machida (Japan) and Beijing (China), and adaptation centres in Milwaukee (USA) and Tver (Russia). It also has 14 regional sales offices, offering a seamless service to customers across the globe. For high-volume products, LEM's automated production lines include custom-developed equipment that optimises quality, with failure rates as low as 1ppm. In-house six-sigma training and support for employees to study for the Swiss Association for Quality (SAQ) diploma create a culture of quality and all production follows the OHSAS 18001 model. Every LEM plant is certified to recognised standards with certifications including ISO 9001, TS 16949 and ISO 14001. LEM's commitment to quality is demonstrated by the five-year warranty offered on all its industrial products.

www.Lem.com

Power Architectures by V•I Chip

V•I Chip Inc., a Vicor company, specifies, designs, manufactures and markets V•I Chip power components to enable next-generation power architecture in high end computing, ATE, telecom, solid-state lighting, and defense electronics markets worldwide.

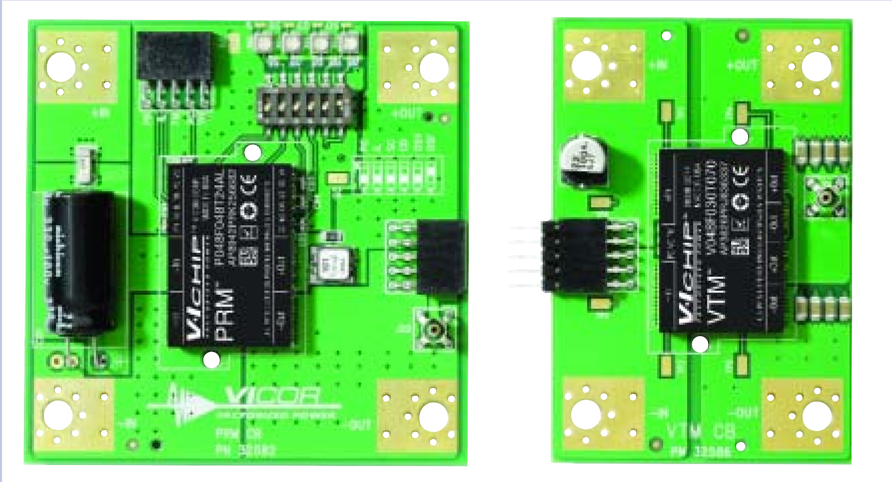


Figure 2: Evaluation board for the PRM and VTM

In the early 1980s, Vicor used its patented Zero-Current and Zero-Voltage switching technologies to design and manufacture power converters that were much smaller and more efficient than the conventional power supplies. These high-density "bricks" could be used as building blocks to create power systems—an innovative approach that became a standard in the power electronics industry. In twenty-five years, Vicor's product line of modular brick power components and power systems has grown to include thousands of combinations of input voltage, output voltage and power levels, complete with accessory components that integrate other power system functions. With this approach, Vicor has expanded its reach to more than 8,000 customers in the industrial, communications, data processing, defense and medical electronics markets worldwide.

V•I Chip Inc. is focused on new power electronics challenges. With each new generation of processor, memory, DSP and ASIC, the trend is toward lower voltages, higher currents and faster speeds. System designers must contend with a proliferation of lower voltages, provide ever-faster transient response, improve overall power system efficiency, and use a smaller power system footprint. V•I Chip Inc. has developed innovative power conversion topologies that enable more efficient power processing, distribution, and management.

Factorized Power Architecture (FPA) and V•I Chip power components offer the power architect new ways to meet power system requirements. The name V•I Chips comes from their ability to multiply currents and divide voltages while preserving the V•I power product (the •). Factorized power breaks down power conversion into high-performance, flexible and scalable power building blocks. A VTM current multiplier offers speed, density and efficiency levels to meet the demands of DSP, FPGA, ASIC, processor cores and microprocessor applications. A "factorized bus", controlled by a PRM regulator, supports efficient power distribution and provides 97% efficient regulation. This means that, for isolated conversion, including regulations from 48 V down to 1 V, a PRM and VTM system offers 7% higher efficiency and 60% smaller size than competitive solutions.

With these advanced power components, the future of power is available to power architects right now. Visit www.vicorpower.com/vichip for more information on products and applications, data sheets, mechanical drawings, and white papers.

Figure 1: PRM™ regulator and VTM™ voltage transformer

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The 2SD315AI is a 2-channel driver for IGBTs up to 1700V (optionally up to 3300V). Its gate current capability of ±15A is optimized for IGBTs from 200A to 1200A.

The 2SD315AI has been established on the market as an industrial standard for the last four years. The driver has been tried and tested within hundreds of thousands of industrial and traction applications. The calculated MTBF to MIL Hdbk 217F is 10 million hours at 40°C. According to field data, the actual reliability is even higher. The operating temperature is -40°C...+85°C.

The driver is equipped with the award-winning CONCEPT SCALE driver chipset, consisting of the gate driver ASIC IGD001 and the logic-to-driver interface ASIC LDI001.

Chipset Features

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- Dead-time generation
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- Transformer interface
- Isolated status feedback
- 5V...15V logic signals
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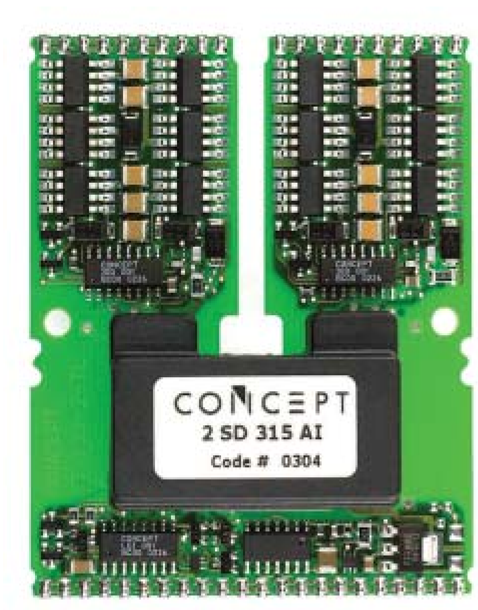
- Switching frequency DC to >100kHz
- Duty cycle 0...100%
- Delay time typ. 325ns



Driver stage for a gate current up to ±15A per channel, stabilized by large ceramic capacitors

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CT-Concept Technology Ltd. is the technology leader in the domain of intelligent driver components for MOS-gated power semiconductor devices and can look back on more than 15 years of experience.

Key product families include plug-and-play drivers and universal driver cores for medium- and high-voltage IGBTs, application-specific driver boards and integrated driver circuits (ASICs).

By providing leading-edge solutions and expert professional services. CONCEPT is an essential partner to companies that design systems for power conversion and motion. From custom-specific integrated circuit expertise to the design of megawatt-converters, CONCEPT provides solutions to the toughest challenges confronting engineers who are pushing power to the limits.

As an ideas factory, we set new standards with respect to gate driving powers up to 15W per channel, short transit times of less than 100ns, plug-and-play functionality and unmatched field-proven reliability.
In recent years we have developed a series of customized products which are unbeatable in terms of today´s technological feasibility.

Our success is based on years of experience, our outstanding know-how as well as the will and motivation of our employees to attain optimum levels of performance and quality. For genuine innovations, CONCEPT has won numerous technology competitions and awards, e.g. the "Swiss Technology Award" for exceptional achievements in the sector of research and technology, and the special prize from ABB Switzerland for the best project in power electronics. This underscores the company´s leadership in the sector of power electronics.

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Let experts drive your power devices

Power Electronics Engineers:
Providing Energy Efficient Solutions

Christopher L. Rexer; Fairchild Semiconductor Corporation

These are both challenging and exciting times for power electronics engineers. Power engineers should take time to step back and recognize their achievements and contributions to world energy solutions. The choices made by engineers in the power electronics field impact electronic energy system efficiency and ultimately the global carbon footprint.

The world energy consumption is expected to increase 57% through the years 2002-2025. Regulatory bodies worldwide have imposed efficiency standards to our field that raise the bar and challenge power designers. In our daily lives we see, participate in, and often lead initiatives for energy conservation. We are able to see the fruits of our labor in the vast array of products that are available to reduce energy consumption or include power saving features. These range from one watt mobile solutions, which increase battery lifetime, to improved power supply efficiency and lighting solutions, as well as efficient motor and motor control solutions. Renewable energy sources such as solar and wind power generation provide new application challenges to be solved. We also see new applications in transportation systems which are shifting from mechanical to electrical solutions. Examples include the drive train in hybrid electric vehicles, electrical power steering, and more efficient electronic controls – all of which provide performance advantages or reduce fuel consumption.

Power electronics systems designers are empowered to make the appropriate choice of topology, switches, passive components, and thermal design for each application. These choices impact the system performance, cost, size and more importantly the electrical energy consumption, whether in operation or standby mode. Technical choices made are based upon training, expertise and experience as well as continued knowledge of new trends in the power industry.

The power semiconductor switch continues to be the foundation of the power system. Continuous and dramatic improvements in power switches have been a strong trend in

the power electronics industry. The shifting trend of the design solution is the increasingly popular 'functional power product' which includes the power die along with an appropriately configured set of integrated circuits as well as passive components. The power systems that employ these products are carefully designed by power systems engineers and can enable the most efficient and cost effective solution for their end product.

The power switch product selection for each of these applications is a key choice for the power designer. Power semiconductor device designers continue to develop new products by using new process integration techniques and design concepts. The power MOSFET has been a key component in the low and medium power applications. New PowerTrench® MOSFET technology generations continue to provide the power designer with a leading edge switch solution for improved efficiency. These are achieved through advancements in transistor cell design optimized for conduction and switching losses. The on-resistance (Rds(on)) conduction losses for these low voltage products has been reduced by about half in the past few years. The power switch of choice for high power applications is the IGBT. With the trend to move from low (40%) energy efficient gas cooking to highly efficient (90%) induction heating cooking, the IGBT becomes a key product for energy conservation.

The integration of single chip solutions with performance or functional solutions such as SyncFET™ and IntelliMAX™ switches provide power system designers with alternative solutions to improve energy use through increased operating efficiency or decreased losses in standby mode. The Fairchild Smart Power Module (SPM®) product family continues to expand. Each of the new products provides energy efficiency improvements in targeted applications, from motion control to power supply designs as well as in lighting/visual solutions. Further examples of functional products are gate driver and MOSFET (DrMOS) solutions for computing and automotive applications.

One new advanced class of products available to provide efficiency improvements is Fairchild Semiconductor's Field Stop IGBT products. These are available in 600V and 1200V versions. Advanced planar and trench cell designs are used to optimize the performance of these products. For example, the 1200V Field Stop Trench IGBTs provide 25% lower conduction losses and 8% lower switching losses, compared to the previous generation, to increase efficiency in induction heating and solar inverter applications. These results further provide a reduced system operating temperature and reliability. The Field Stop IGBT, PowerTrench and new SPM products are but a few examples of the trends in power components aimed to support systems targeted for improved energy efficiency.

As power electronics engineers, we should consider the positive feedback of what has been already achieved by our efforts to reduce energy consumption. It is an exciting time to realize that there continue to be many challenges yet to be solved while providing a positive influence on the environment. Leveraging the knowledge and trends of the latest power electronic products enables our solutions to be the most efficient.

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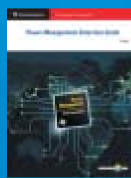

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TEXAS INSTRUMENTS

ELECTRONICS INDUSTRY DIGEST

By Aubrey Dunford, Europartners

GENERAL

The Commission decided to add the Digital Video Broadcasting Handheld standard (DVB-H) to the EU List of Standards, which serves as a basis for encouraging the harmonised provision of telecommunications across the EU.

SEMICONDUCTORS

Discrete semiconductors even managed growth of 4.2 percent. Microprocessor revenue grew by 2.1 percent in 2007. Global revenue growth for analog ICs amounted to 2.9 percent in 2007. Among applications for semiconductors, automotive electronics drove the highest growth opportunities in 2007 with 11.2 percent growth.

The Intel Atom processor will be the name for a new family of low-power processors designed specifically for mobile Internet devices. The Intel Atom processor is based on a new microarchitecture designed for small devices and low power, while maintaining the Intel Core 2 Duo instruction set compatibility.

TSMC unveiled the foundry's first 40 nanometer (nm) manufacturing process technology. The 45nm node introduced in 2007 provided double the gate density of 65nm, while the new 40nm node features manufacturing innovations that deliver a 2.35 raw gate density improvement of the 65nm offering.

Atmel has completed its acquisition of Quantum Research. The acquisition of the British company provides Atmel with an immediate presence in touch sensing, one of the fastest growing markets for microcontrollers. Quantum develops capacitive sensing IP and solutions for user interfaces.

Tronics Microsystems, a French manufacturer of custom MEMS components, and IMEC, representing Europractice IC Service, will collaborate to enable Europractice IC Service to add MEMS to its Multi-Project Wafer (MPW) programs. Since 1995, Europractice IC Service has brought ASIC design and manufacturing capability within the technical and financial reach of any university, research institute and company. Coordinated by IMEC, it offers low-cost ASIC prototyping and ASIC small-volume production through MPW and dedicated wafer runs at leading foundries and IC manufacturers. Today more than 650 European universities and research institutes and several hundreds of companies and non-European universities use the Europractice IC service for prototyping and small volume fabrication.

IBM and Hitachi have signed a two-year joint semiconductor metrology research agreement in order to speed the pace of semiconductor innovation.

Based in Taiwan, Lite-On Technology has purchased the IrDA infrared business unit of Avago Technologies.

Lam Research has completed the tender offer for the SEZ Group, a Swiss supplier of single-wafer clean technology and products to the global semiconductor manufacturing industry.

OPTOELECTRONICS

LG Display has signed a cross licensing agreement on OLED and related TFT technologies with Eastman Kodak Company. Under the agreement, the OLED technology which Kodak holds patents of, enables LG Display to purchase Kodak's proprietary OLED materials and utilize Kodak's process technology, which should strengthen its OLED research, product development and manufacturing.

Liquavista, a fabless display manufacturing company based in Eindhoven, with offices in the UK and Hong Kong, has announced the completion of an €8 million Series B fund raising, comprising equity and debt. Existing investors Amadeus Capital Partners, GIMV and New Venture Partners LLC all participated in the round. Liquavista, which was founded in 2006 by a team which originates from Philip Research Labs, uses advances in materials and technology to create Electrowetting displays.

Supertex and Varioptic, a French pioneer in the development of auto-focus liquid lenses, have announced their partnership in the production of a driver and liquid lens.

PASSIVE COMPONENTS

AT&S, the first European PCB manufacturer, builds a new plant in Nanjangud, India. The decision is based on the fact that the capacity of the existing factory, also located in Nanjangud, is currently fully utilized.

Tyco Electronics announces intend to divest its Radio Frequency components and subsystem business.

Methode Electronics, a manufacturer of electronic components and subsystem devices, has acquired the business assets of Tribotek. The US-based company manufactures high current power connectors and power distribution systems.

Germany's printed circuit board (PCB) revenues for 2007 were down 1.4 percent compared with the previous year, so the ZVEI. Germany's PCB revenues increased slightly only 0.4 percent sequentially in December 2007.

Hi-rel connector company, ITT Interconnect Solutions has created a centre of excellence for military and aerospace customers at its Basingstoke facility in the UK. The company has significantly increased its engineering and sales capabilities dedicated to this European sector.

OTHER COMPONENTS

Global Industry Analysts estimates that the world market for MEMS will maintain a CAGR of over 12.3 percent over 2001-2010 and reach in excess of US$8.65 billion by the end of the decade.

Siemens plans to spin off its electronics assembly systems business unit. The unit which produces SMT equipments is no longer considered part of the core business. With a staff of about 2100 persons, the unit presently is part of Siemens' Drive Technologies division.

DISTRIBUTION

German distributor MSC Vertriebs has acquired the majority stake in Able Design. In addition to sales of standard assemblies with TFT, electroluminescent and plasma displays, ABLE Design, which was founded in 1994 and is located in Munich, focuses mainly on the design of customer-specific display solutions.

This is the comprehensive power related extract from the « Electronics IndustryDigest », the successor of The Lennox Report. For a full subscription of the report contact: eid@europartners.eu.com or by fax 44/1494 563503.

www.europartners.eu.com

Technology Convergence Powering Wireless Networks

By Linnea Brush, Senior Analyst, Darnell Group

A "technology convergence" is occurring that is enabling the use of thermoelectric, piezoelectric and photovoltaic energy sources to power wireless networks. The continuing decline in the power consumption of electronic circuits and systems is one aspect of this convergence. The second factor is that energy harvesting transducers are becoming more efficient and delivering more power.

As a result of these converging trends, today's more-efficient energy harvesting transducers produce enough power for current low-power wireless networking devices.

Several European companies and organizations are among the leaders in the commercial development of advanced energy harvesting technologies and devices.

Efficiency always plays an important role in power management circuits, but it becomes a critical design consideration when only microwatts are processed in the converters. Special care must be taken in the design of the control circuits for energy harvesting transducers due to the low amount of available energy and small voltages.

Fraunhofer Institute is one of the organizations with a focus on the development of devices with the small quiescent and leakage currents that are necessary in power management units for energy harvesting transducers. Minimum start-up and supply voltage values are critical in applications with thermo-generators, inductive generators or solar cells in single cell systems. Low-voltage ICs based on classical dc-dc converters are not sufficient to cope with the minimum amount of energy and low current and voltage levels obtained from energy harvesting transducers. Special circuit techniques like charge pumps or coupled inductors promise better results.

The operation with energy harvesting transducers requires additional functionality of the power management to meet the goal of minimum power consumption of the whole system. Dedicated start-up circuits are mandatory to deal with the inherently low input voltages. A rectifier circuit to invert input voltages of thermo-generators is necessary when the temperature gradient becomes negative.

Further on, a shut-down operation mode for discontinuous operation with minimum standby current is required. For extracting the maximum output power generated by the transducer, a maximum power point tracker (MPPT) has to be implemented. To support an energy or event-driven operation, voltage detectors are required. Moreover, a delay circuit is necessary to connect the load after the settling of a certain start-up phase, avoiding interference.

The challenge in wireless sensor application development is not just reliable communication. The energy supply is an even bigger problem, and essential: in order to maximize the benefit of avoiding cabling cost through wireless communication, the power cable must also be eliminated.

Greenpeak is a Dutch/Belgian company specialized in ultra low power communication chips and software. In order to come to the lowest possible power consumption, Greenpeak has taken the application as a starting point, and has developed a number of techniques to provide the characteristics of efficient communciation devices, and incorporated these into a new fully integrated IC. Greenpeak has addressed these features in its ultra-low-power communication chips, bridging the gap between communication technology based on standards such as Zigbee and IEEE802.15.4, and maintenance-free lifelong power supply through energy harvesting sources such as solar panels or electromagnetic generators.

A group of key companies across Europe and North America have united to form the EnOcean Alliance with the mission to enable intelligent green buildings based on EnOcean energy harvesting wireless technology. Founding promoters of the Alliance include Distech, MK Electric (a Honeywell Business), EnOcean, Masco, Omnio and Thermokon. Additional member companies are joining from over 70 product partners currently deploying EnOcean-enabled products.

The foundation of the EnOcean Alliance addresses the demand in today's environment for a wireless eco-system that combines a broad range of interoperable, flexible and uncomplicated monitoring and control products for use in and around residential, commercial and industrial buildings. In wireless building automation EnOcean claims the largest self-powered wireless product base.

IMEC, part of Belgium's Holst Centre, has developed a battery-free wireless 2-channel EEG system powered by a hybrid power supply using body heat and ambient light. The hybrid power supply combines a thermoelectric generator that uses the heat dissipated from a person's temples and silicon photovoltaic cells. The entire system is wearable and integrated into a device resembling headphones. The system can provide more than 1mW, on average, indoors, which is more than enough for the targeted application.

Thermoelectric generators using body heat typically show a drop in generated power when the ambient temperature is in range of the body temperature. Especially outside, the photovoltaic cells in the hybrid system counter this energy drop and ensure a continuous power generation. Moreover, they serve as part of the radiators for the thermoelectric generator, which are required to obtain high efficiency.

Compared to a previous EEG demonstrator developed within Holst Centre, which was solely powered by thermoelectric generators positioned on the forehead, the hybrid system has a reduced size and weight. Combined with full autonomous operation, no maintenance and an acceptable low heat flow from the head, it further increases the patient's autonomy and quality of life.

Potential applications are detection of imbalance between the two halves of the brain, detection of certain kinds of brain trauma and monitoring of brain activity. The whole system consumes only 0.8mW, well below the power produced to provide full autonomy.

The thermoelectric generator is composed of six thermoelectric units made up from miniature commercial thermopiles. Each of the two radiators, on left and right sides of the head, has an external area of 4×8cm2 that is made of high-efficiency Si photovoltaic cells. Further, thermally conductive comb-type structures (so-called thermal shunts) have been used to eliminate the thermal barrier between the skin and the thermopiles that is caused by the person's hair on the thermoelectric generator.

Energy harvesting and power management for low-power wireless systems will be discussed in detail at the 2008 nanoPower Forum. http://nanopower.darnell.com/

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The Optimal IGBT for Motor Drives Applications

Drive with the XPT IGBT

IXYS introduces the XPT IGBT, the newest generation of short-circuit rated IGBTs with paralleling capabilities and competitive performance. Implementation of innovative cell designs and new process technologies resulted in improved IGBT characteristics. Combination of the XPT IGBT with the recently introduced SONIC diode delivers fast and soft switching behavior. The XPT IGBT has been optimized for motor drives, UPS, solar and inverter applications. The first IGBT products are in the 1200V range from 10A to 60A. These IGBTs will also be integrated in the IXYS line of modules, in bridge configuration for higher power applications.

By Iain Imrie, Jeroen van Zeeland, Ulrich Kelberlau, Vladimir Tsukanov and Elmar Wisotzki; IXYS Corporation

XPT Technology – Going Thin!
Moving from punch through technology to XPT (extreme light punch through) IXYS follows the well established trend in IGBT manufacturing towards decreasing wafer thickness using bulk float zone Si wafers. The challenge of processing wafers with thicknesses down to 70µm (e.g. 600V XPT IGBT in Figure 1) is merited by a reduction in thermal resistance as well as on-state voltage of the IGBT thus enabling higher current densities. This in turn leads to a reduced chip size for a given current rating, improving packaging capabilities.

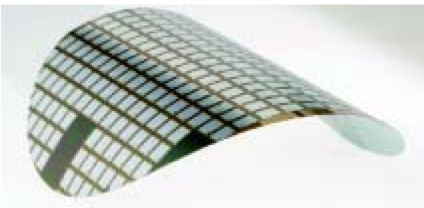

Figure 1: 70µm thick XPT IGBT-Wafer showing flexibility due to low Si-thickness

The XPT technology uses adjustable emitter efficiency via controlled p-emitter/n-buffer concentration on the anode side of the IGBT, which leads to easy IGBT paralleling due to positive temperature coefficient of the on state voltage. The benefits of merging the IXYS cell design with XPT thin wafer technology can be clearly seen in the following IGBT characteristics, detailing the competitive static and dynamic behaviour as well as the rugged and reliable response during power turn-off testing.

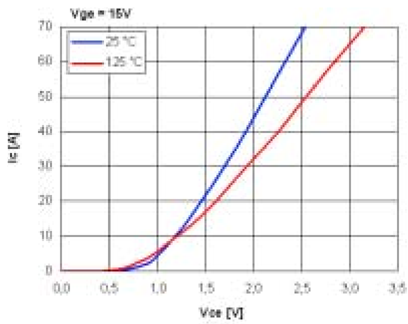

Figure 2: XPT IGBT output characteristic

XPT Characteristics
The XPT IGBT was designed to provide low switching losses while retaining low on-state voltage. This was achieved with improved SOA and short circuit ruggedness ratings. The output characteristics at different temperatures are shown in Figure 2.

The XPT IGBT has a low VCE(sat) (1.8V @Inom,25°C & 2.1V @Inom,125°C). The positive temperature coefficient of the XPT IGBT provides a negative feedback, making the XPT suitable for paralleling in modules or circuits. In addition to the low VCE(sat) the XPT IGBT also has a low off-state leakage current at 150°C (<75µA @1200V). The switching characteristics of the 35A, 1200V XPT IGBT are shown in figures 3 & 4.

As can be seen in figure 3 the current waveform has smooth switching behaviour reducing EMI and resulting in small over voltage transients. The linear voltage rise and short

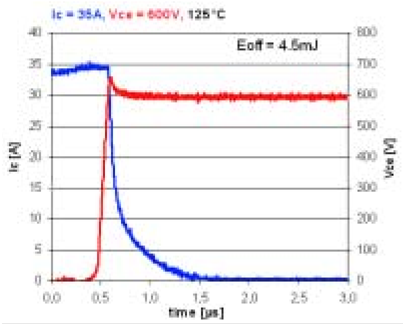

Figure 3: XPT IGBT turn-off characteristic

tail current during turn-off, leads to reduced losses (Eoff = 4.5mJ). The XPT IGBT has a low gate charge (Qg = 110nC @15V), requiring lower gate drive power, when compared to trench IGBTs

XPT and SONIC – the perfect match
The optimal match for reduced turn-on losses is achieved when the XPT IGBT is paired with the IXYS Sonic diode, which also has a

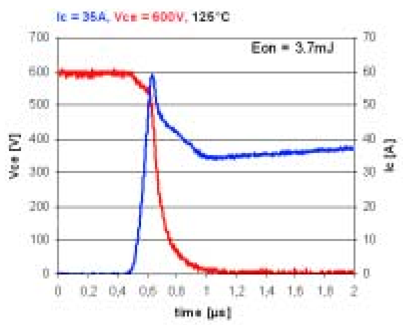

Figure 4: XPT IGBT turn-on characteristic

low on-state voltage with excellent temperature behaviour.
The Sonic diode has soft recovery characteristics, which allows the XPT IGBT to be turned on at very high di/dt's even at low current and temperature conditions where usually diode snappiness can occur.
The Sonic diode retains soft switching behaviour during turn-off of freewheeling currents nullifying EMI problems.

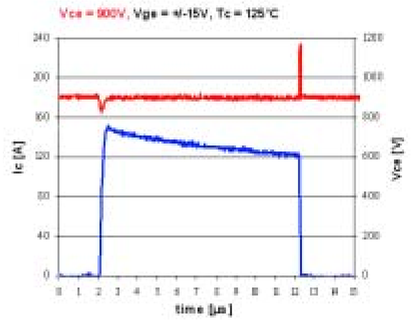

Figure 5:
XPT IGBT short circuit characteristic

Sonic diodes combine a low reverse recovery current along with a short reverse recovery time, as shown in figure 4 to minimise the turn-on energy of the XPT IGBT (Eon = 3.7mJ). The Sonic diode Vf is less sensitive to temperature resulting in better suitability for parallel operation of diodes and minimising switching losses.

Rugged XPT Characteristics
The IGBT behaviour under short circuit conditions is a very important issue relating to motor drives applications and the IXYS XPT IGBT has shown extremely rugged performance during short circuit testing. The chip design was optimised with a low forward transconductance, therefore providing an approximate short circuit current of 4x nominal current, to ensure robust short circuit performance.

Figure 5 shows the 35A, 1200V XPT IGBT during short circuit with a gate voltage of +/-15V at 125°C for 10µs. Characterisation of the XPT IGBT technology showed extreme ruggedness during short circuit of the device at elevated voltages and temperatures for 10µs without any detriment to the IGBT characteristics. The IXYS XPT IGBT has a square RBSOA at 1200V up to two times nominal current at very high temperatures.

XPT modules – losses calculation
The XPT IGBT modules' losses and junction temperature during operation in a three phase drive application can be calculated by the user, at their operating conditions, using the IXYS IMC-Tool (IGBT Module Calculation

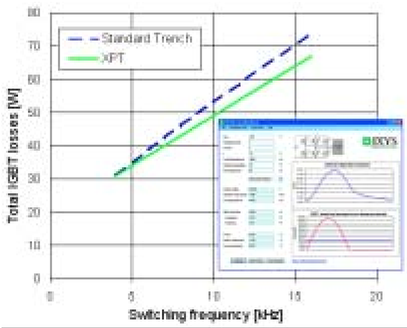

Figure 6:
Switching frequency dependence of the total losses calculated with the IMC Tool

Tool). Calculation models for all the copper baseplate XPT modules are available in the latest version of the IMC-Tool. The IGBT losses and consequently its junction temperature are calculated with respect to the heating effect of the conduction and switching losses during the phase frequency. The IMC-Tool calculates, within seconds, the impact on the thermal response (Tj) over a range of different phase frequencies (e.g. 2 to 50Hz). The IGBT losses and junction temperature over a period, once thermal stabilization has been achieved, are also graphically displayed.

A comparison of XPT and trench technologies over a range of phase frequencies can be easily calculated using the IMC tool, as shown in Figure 6. The application conditions are shown in the IMC-Tool snapshot also in Figure 6 (Udc=700V, fphase=50Hz, I=25A, Ths=60°C). In this example a 35A XPT IGBT in a CBI module (MIXA40WB1200TED) was used as the basis for the calculation. Figure 6 clearly illustrates that for applications up to 4 kHz the difference in total losses between the two technologies is neglectable, whereas above 4 kHz the XPT excellent switching behavior reduces the total losses significantly resulting in lower junction temperatures, therefore making the XPT IGBT module clearly the device of choice.

Comparison of the XPT modules regarding

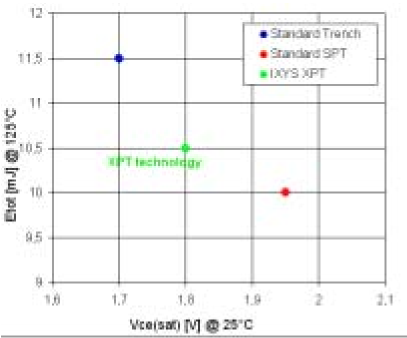

Figure 7: Comparison XPT IGBT

on-state voltage versus total switching losses with IXYS modules (IXYS E2-Pack), using Trench and SPT technologies, can be seen in figure 7.

The XPT IGBT module has a significantly lower voltage drop compared with the standard SPT (MWI50-12E7) and lower switching losses than the standard Trench (MWI50-12T7T). This shows that merging XPT IGBT technology with Sonic diodes results in a competitive IGBT module compared to the currently available modules.

XPT Products
The introduced 1200V XPT IGBT are rated at 10A, 15A, 35A and 50A. These IGBTs will be available in standard discrete and modules as well as customer specific designs. The XPT IGBT / Sonic combination range is available in CBI and six-pack topologies in 3 different package sizes. Diode bridge input rectifier with break chopper supplement the 3-phase inverter six-pack stage in the CBI configuration. On the ceramic substrate an NTC temperature sensor is also integrated, to signal the heatsink temperature near the chips. The IXA37IF1200HJ is an example of a discrete co-pack, containing the XPT IGBT and the Sonic diode, integrated in the ISOPLUS 247 package.

Figure 8: Selected product overview

In figure 8 the first targeted products are listed. In the near future the range will be extended with four new IGBTs, the 25A, 75A and 100A in 1200V and the 100A in 1700V. The complete XPT IGBT range will cover 3A to 150A in 600V, 1200V and 1700V.

Conclusion
With the introduction of the XPT IGBT IXYS expands its IGBT product range to meet market demands for highly rugged, low loss devices with easy paralleling possibility. Electrical as well as thermal characteristics of first available products prove that matching the new XPT IGBT with IXYS Sonic diodes delivers competitive solutions with respect to existing IGBT technologies.

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Driver Core goes Fully Digital

Power electronic systems in the voltage range of 1200V and higher call for fully insulated signal transmission for both PWM and IGBT status signals. In order to achieve sophisticated and repetitive signal transmission for all signals, including sensing signals, a fully digital driver core solution was developed to drive and control IGBT power semiconductors.

By Markus Hermwille, Senior Product Manager Electronics, Semikron

This article describes the characteristics and advantages of insulated digital signal transmission in comparison to analog signal transmission and explains the direct link between controller and gate driver interfaces. On the basis of an eye diagram, a qualitative analysis of digital transmission is shown. Furthermore, the performance of a digital-based driver core solution is evaluated.

The primary purpose of an electronic driver circuit is to drive power transistors. Under static operating conditions, the IGBT needs no gate drive current because it is voltage-controlled. Due to the large gate input capacitance, however, a gate drive current with short pulses at turn-on and turn-off has to be generated. The pulse sequence is generated according to the signals from the supervisory control unit. Besides this function, the driver must also provide galvanic insulation (e.g. optical, magnetic) for data transfer between the control system and the power semiconductor. By adjusting the switching time, the driver influences the switching losses of the power semiconductor and improves overall efficiency.

Signal Insulation

At all times, the control system elements (µC, DSP, etc.) operate at a low voltage level of between 3.3V and 5V. For this reason, the potential signal insulation must have a low level of noise sensitivity. Noise signals can reach the control system via the internal capacitive coupling of the device used for electrical insulation to the high-voltage circuits and may interfere with the control system.

For medium and high-voltage applications, the most important requirements for potential insulation are a high insulation voltage and sufficient dv/dt-ruggedness. A high degree of dv/dt-ruggedness can be achieved by reducing the coupling capacitances between the primary and the secondary side to within the range of a few pF. This will minimize signal transmission interference caused by displacement currents during switching. In the case of inverters, the fast switching of the IGBTs causes steep voltage steps (high dv/dt values). Signal transformers are best suited to fulfil these requirements. [3]

Edge Triggered Signal Transmission

State-of-the-art signal transformers feature edge triggered signal transmission for switching and status signals. In this type of transmission, the primary side of the driver circuit generates a pulse by the strongly damped series-resonant circuit. This pulse is detected by an edge memory. High pulse voltage and slow pulse detection ensure transmission reliability.
This technology can be used to transmit alternating on and off pulses only, but not two series signals sequentially, i.e. repetitive pulses. Once a pulse has been transmitted, a given time – the recovery time - must pass before a pulse can be transmitted in the opposite direction.

Digital-Based Signal Transmission

The most important part of this development was to develop sophisticated signal processing technology which is very robust, does not cause problems related to temperature dependency or aging effects, and which is not dependent on device parameters.
The technology used is digital-based signal transmission. The essential principle behind this technology is that the pulses are generated by an internal digital logic (FPGA), have a defined length and shape, and are almost independent of the component parameters. Additionally, the pulses are evaluated differentially.

Interference normally affects both outputs of the pulse transformer in the same way. If the voltages are drawn off one another at both outputs, the interference is eliminated as a result of the subtraction, and the signal information remains clear, even if the amplitude of the interference exceeds that of the actual signal. Transmission reliability is achieved with high transformer currents and the far lower terminating impedance of the receiver. As a result, a high supply voltage for pulse generation is no longer necessary. Due to the relative independence from component parameters, a low regulated supply voltage of 3.3V can be used.
A simplified circuit diagram of digital-based signal transmission is shown in Figure 1.
The powerful bridge on the primary side generates time-varying voltages that are insulated and transferred through the transformer to the secondary side. On the secondary side, the transferred signal is received by a differential window comparator and transmitted to the digital logic (FPGA) for secondary-side encoding and signal processing.

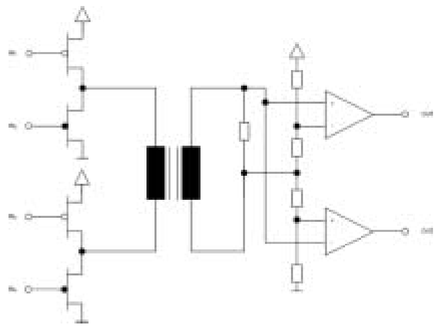

Figure 1: Schematic of digital-based signal transmission

Figure 2 shows the generation of pulses from the primary side to form one impulse signal on the secondary side. The transmission half bridges are shown in a simplified form by logic gates and the differential win-

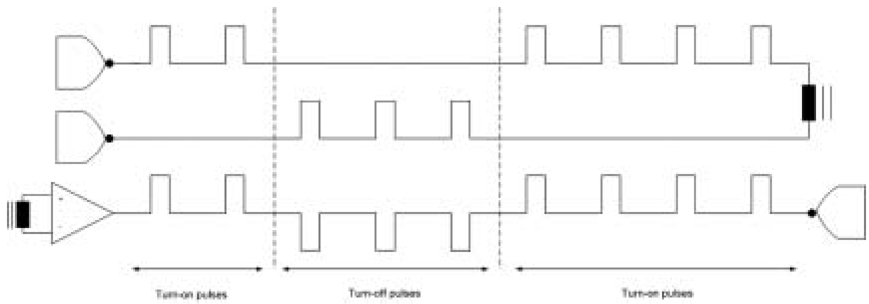

Figure 2: Pulse pattern

dow amplifier is replaced by a differential receiver.

Since the transformer used for digital-based signal transmission was designed using a high-permeability core material, it is magnetized with a relatively low current of around 10mA. The current flowing on the secondary side is much higher. By keeping the magnetizing current this low, it is rather easy for the primary side to reduce the current to zero until only the residual magnetism is left. The time that has to pass between repetitive pulses is therefore rather low. Owing to the relatively small magnetizing current and, consequently, the low energy stored in the core, a high pulse repetition frequency of 1 MHz can be achieved. The repetitive pulse can be interrupted by counter pulse at any time. A typical turn-off pulse sequence is shown in Fig. 3. This sequence was measured at one leg of the differential transmission. The transmitted turn-on and turn-off pulse have a defined pulse shape.

By modulating the repetitively transmitted pulses, i.e. changing the pulse width and distance between the repetitive pulses, communication back and forth between the primary and secondary side can be now achieved. Differentiated status and error signals can be transmitted. Furthermore, the transmission of a certain sensor signal is possible. This means that insulated signal transmission can be used to transmit, for example, the IGBT modules' internal temperature sensor information from the secondary to primary side. A continuous evaluation of the temperatures is then possible. With a transmission frequency of around 500 Hz, this communication between primary and secondary side is designated for slowly changing sensor signals.

Analysing Digital Signal Integrity using an Eye Diagram

The eye diagram is a measurement method used to deduce important parameters of the data signals in digital signal transmission. This method takes its name from the fact that the display representation corresponds to the human eye. The rising and falling edges of the signal are not sharp due to the transmission process. The rectangular pulses are therefore changed into rounded signals. When these pulses are superimposed, a

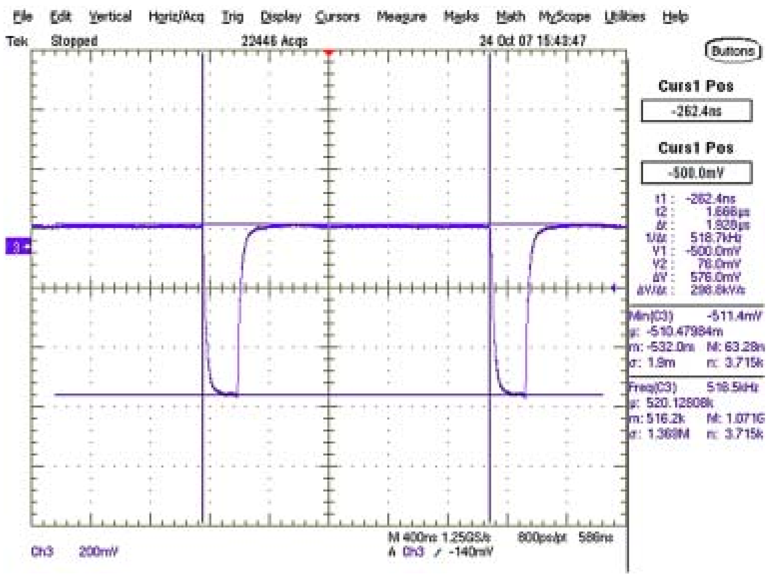

Figure 3: Repetitive turn-off pulse

shape appears that looks similar to an eye.
The eye diagram is created by superimposing the signals of the differential lines on a broadband digital oscilloscope. The representation itself can vary in terms of the eye opening and signal rounding. On the basis of the eye height and width, signal amplitudes and distortion in the form of delays, bit error rate, noise and jitter can be evaluated.

An open eye demonstrates good signal quality. If, however, the eye is closed, a distinction between the signals is no longer possible. Strong distortion can close the eye completely. This means that no reliable signal detection is possible.

The eye diagram measurement method was used for the evaluation and qualitative analysis of the insulated digital signal transmission system developed. Figure 4 shows the transmitted data stream, frozen in a single image. The eye opening is wide and high. Furthermore, the distortion is very low. This means the noise level is low and the signal amplitude high, which is a sign of good digital signal integrity. With this transmission method extremely fast transmission can be achieved and jitter is negligible.

Using Digital-Based Signal Transmission
Digital-based signal transmission is used in the digital driver core SKYPER® 52. This driver circuit comprises two independent output channels. Figure 5 shows the layout of the digital driver core. Characteristic are the FPGAs on the primary and secondary side that are used for signal processing.

The insulation barrier with two pulse transformers for signal transmission and one DC/DC-converter for energy transmission is designed to drive power semiconductors with a collector-emitter voltage of between 1200V and 1700V. By reducing the small coupling capacitance to within the low pf-range between the primary and the secondary side, a high degree of dv/dt-ruggedness of about 100kV/µs is achieved. Owing to the insulated DC/DC-converter used to supply the driver secondary circuits, the driver can be supplied with +24V non-insulated supply voltage. For the user, this means that no additional insulated power supply is needed. The driver circuit features the following functions:

- o 50A peak drive current
- o Negative off-state voltage
- o Individual adjustable interlock / dead time mode
- o Critical frequency monitoring
- o Undervoltage control to ensure working in saturation region
- o Individualised dynamic short-circuit detection with adjustable intelligent soft turn-off characteristic
- o Insulated transmission of slowly changing sensor signals (e.g. temperature)
- o Individual error processing
- o CAN compatible diagnostic I/O

Owing to the use of digital signal processing, several different parameters, as well the operating performance of the digital driver core in normal and error conditions can be individually configured. The driver core itself can be soldered onto a printed circuit board or assembled using connectors.

Differential Digital Signalling for High Noise Immunity
The gate driver circuit amplifies the pulse pattern forced by a microcontroller or DSP (fsw(max) = 100 kHz with no duty cycle limitation) and provides on and off switching gate signals. The signal inputs and

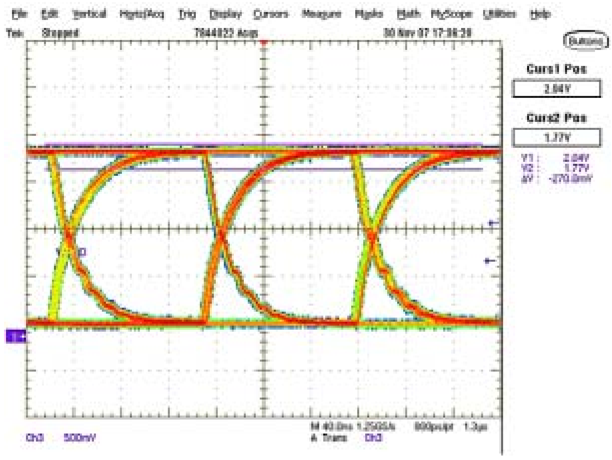

Figure 4: Eye diagram showing data stream transmission on the secondary side

outputs of the digital-based driver core primary side are compatible with 3.3V and 5V I/O standards. This means that the driver circuit can be directly connected to the microcontroller or DSP without additional level shifting. To obtain high performance and reliable signal transmission in a power electronic environment, differential digital signalling is used.

Characteristic of this differential interface technology is the use of two separate wires for signal transmission. By using low impedance termination and differential analysis for the two transmitted voltages, a high noise rejection and hence an extremely low electromagnetic influence (EMI) is achieved.

The insulated transmitted sensor signals and the differential status signals are available at the diagnostic interface with a CAN characteristic, which also uses differential signal transmission with dominant recessive levels.

Adaptation of Error Processing
Failure in power transistors may be detected at various points and the reaction to detected errors can vary. In many applications it is the case that in the event of failure detection within the switched device itself or within the driver circuit, all power transistors are turned-off directly by the gate driver circuit. A failure signal is transmitted to a central error processing unit in the gate driver circuit, as well to the connected microcontroller or DSP. To prevent turn-on during a short-circuit, the signal path for subsequent turn-on signals remains blocked until reset is carried out via a reset pulse.

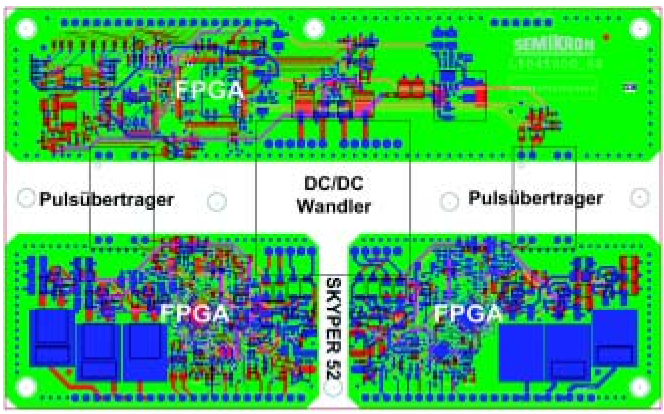

Figure 5: Layout of digital driver core SKYPER® 52

In multi-level inverter applications, by contrast, all of the power transistors are not immediately switched off in the event of failure. Instead, each power semiconductor is turned off sequentially in a process controlled by the supervisory control unit; this is necessary in order to protect all of the power transistors in the circuit. With the digital driver core, however, the driver circuit behaviour, i.e. the power electronic systems behaviour in the event of failure, can be defined by the user individually.

High-Current Driver Output Stage

The driver output stage, with 50A peak drive current, is designed with two MOSFETs in totem pole configuration. Both gates of the MOSFETs are driven by separated signals, generated by the internal digital logic. When one of these signals is high, the N-channel MOSFET is on and when the signal is low, the P-channel MOSFET is on. This has the advantage that the interlock or overlap between the two transistors of the output stage can be accurately adjusted. In this way, the most inevitable cross current from VG+ to VG-, generated when the driver MOSFETs are switched, can be avoided. The result is a push-pull output configuration with two transistors.

This output stage has two outputs for easy asymmetric gate control. This allows for the gate resistor to be split into two resistors RG(on) and RG(off) for turn-on and turn-off, respectively. The main advantage, however, is that this solution allows for the separate optimisation of turn-on and turn-off with regard to turn-on overcurrent, turn-off overvoltage spikes and short-circuit behaviour [4]. Since the gate resistor is not used to limit the cross current in the totem pole configuration, a gate resistor can, if necessary for switching reasons, be totally eliminated by using the digital method.

Additionally, the digital logic core can be used to drive and control two output stages with paralleled gate resistors. This allows for time dependency to be defined for the effective gate resistor switching the IGBT and, thus, for the IGBT switching time sequences to be modulated. This in turn means reduced switching losses and still allows for the overvoltage peak to be limited.

Conclusion

In order to achieve even more robust and sophisticated signal transmission, a digital-based signal transmission technology has been developed that allows the transmission of insulated sensor and status signals. The quality of the digital signal integrity was represented by an eye diagram.

Digital-based signal transmission is used in the digital driver core SKYPER® 52, which is highly suitable for any IGBT power semiconductor and any application that requires high driving power and high-voltage galvanic insulation. The use of digital signal processing allows for the individual configuration of driver circuit performance and direct interface link to the microcontroller or DSP using a differential interface in order to obtain high noise immunity.

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www.semikron.com

Accurate Dynamic Power Measurement

Achieving Efficiency, Reliability and Cost Advantages

By Richard Kroeger, Applications Engineer, International Rectifier, Durham, NC

Designers of modern systems are using active power management techniques to limit energy consumption and maintain equipment within a tight thermal envelope for cost and size savings. However, established techniques for dynamic power monitoring can be subject to errors as high as 30%. A new technique now greatly reduces dynamic errors and enables power to be measured to within 2.5% accuracy to bring benefits including reduced power, lower demands on the cooling system, and increased reliability.

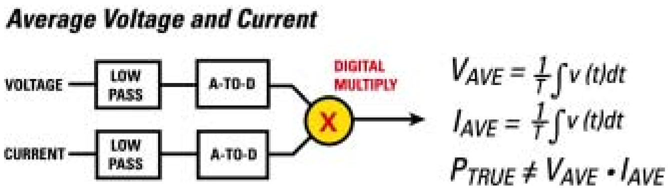

Figure 1. Conventional power measurement using independent voltage and current monitoring.

Figure 1 illustrates the logical approach of a typical circuit for measuring the output power of a buck converter for a high-performance device such as a PC. The current and voltage are sampled, filtered and converted independently before being multiplied to calculate an expression for the average power.

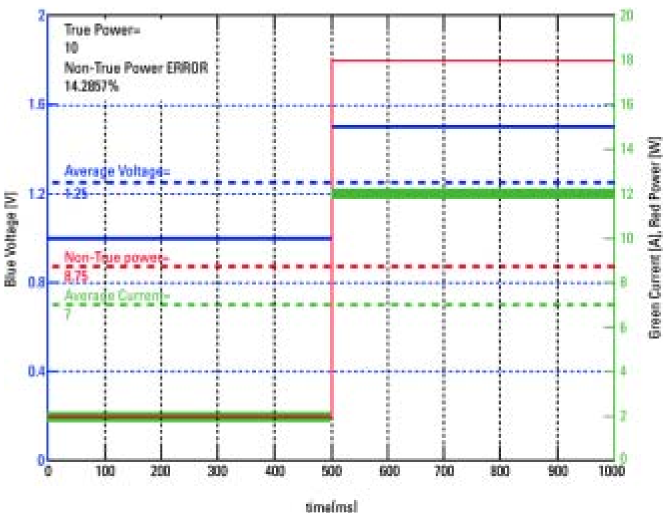

Figure 2. Dynamic power monitoring errors.

Figure 2 shows how results gained this way can be subject to large errors. The example waveform repeats every second. The solid blue voltage waveform steps from 1V to 1.5V and back at 500ms intervals and has an average potential of 1.25V, shown as a dashed blue line. The solid green current waveform steps from 2A to 12A and back with an average current of 7A, and is shown as a dashed green line.

It is tempting to simply multiply these two averages together for (1.25V * 7A) = 8.75W, shown in dashed red. However, the true power is as shown by the average of the solid red power waveform. In this case, the true power is 14% higher than the average volt amp product. In systems that experience larger or faster dynamic load variations, errors can be significantly greater.

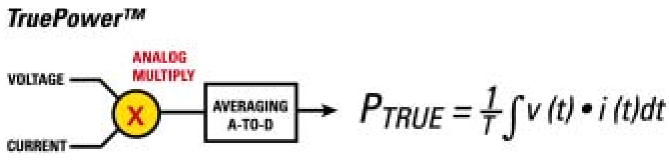

Figure 3. Dynamic power measurement based on instantaneous current and voltage.

Figure 3 illustrates an alternative approach to dynamic power measurement. By multiplying instantaneous current and voltage at the output of the converter and then performing an averaging A-to-D conversion, most dynamic errors are eliminated.

By monitoring instantaneous power, this technique provides the power system with accurate information that can be used to restrict the CPU to a closed-loop maximum power to optimise system performance and peak temperature. In this way the system can ensure that the load does not exceed its optimum thermal envelope.

This assurance allows system designers to predict performance and throughput accurately under all operating conditions, and also to optimise cooling system performance without incurring cost and size penalties by over-specifying.

The International Rectifier IR3721 TruePower™ monitoring utilises this technique to capture highly dynamic power information at high accuracy. The device allows designers to implement an additional resistor at the output of the converter, for sensing purposes, or to detect current in the equivalent DC resistance (DCR) of the converter's output filter inductor. This technique eliminates the need for a discrete sense resistor and enables loss-less power measurement.

Inductor Current Sensing

Figure 4 shows a typical application circuit for the IR3721, sensing current in the inductor equivalent DC resistance.

Referring to figure 4, power flow from the buck converter inductor is the product of output voltage times the current IL flowing through the inductor. The IR3721's internal TruePower™ circuit converts the current to a duty ratio that appears at the DI pin. The duty ratio of the DI pin is:

$$DI_{DUTYRATIO} = \frac{I_L \cdot DCR}{(R_{CS1} + R_{CS2})} \cdot \frac{R_T}{V_{RT}}$$

The amplitude of the DI pin is the voltage appearing at pin VK. If a fixed voltage is applied to VK then the output of the RC filter driven by DI will be proportional to inductor current IL.

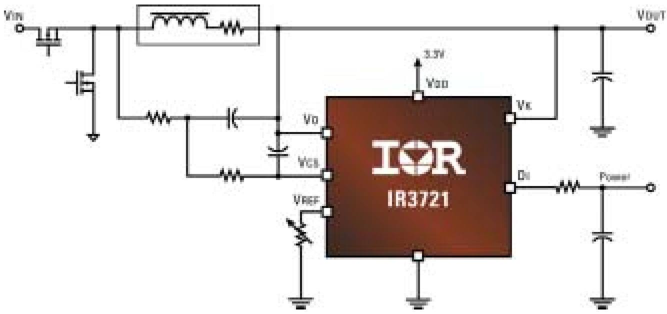

Figure 4: Buck converter with IR3721.

If VO is applied to VK as shown in the figure then the output of the DI driven RC network will be proportional to power. Since this pin measures DCR voltage drop it must be Kelvin connected to the buck inductor output. The full-scale voltage that can be measured is established on the chip to be 1.8V. The full-scale power PFS that can be measured is the product of full-scale voltage and full-scale current.

Because the DCR of the copper winding changes with temperature, so, too, does the value for IL. A compensation network including a NTC thermistor is connected to the IR3721's VRT pin to compensate this effect.

Resistor Sensing Application

The circuit shown in figure 5 illustrates current sensing using a dedicated sense resistor. Because the voltage on the shunt resistor is directly proportional to the current IL through the inductor, RCS2 and CCS2 do not need to match the L / DCR time constant.
Because the value of the shunt resistance does not change with temperature as the inductor DCR does, RT is a fixed resistor. A precision resistor should be used, such as 25.5kÙ and 1% tolerance.

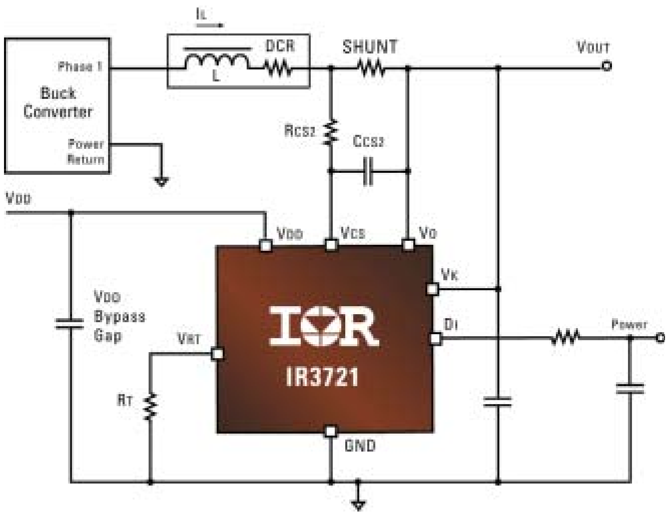

Figure 5. Resistor sensing circuit.

Output Signal Conditioning

An internal bilateral switch uses the voltage of the VK pin to modulate the amplitude of the DI pin. If VK is connected to a fixed voltage then the output of the multiplier is proportional to current. If VK is connected to the buck converter output voltage then the output of the DI driven RC filter is proportional to power.

The DI pin is intended to drive an external low pass filter to restrict fundamental frequency ripple. An RC filter passes power information at the highest frequency of interest. Multiple pole filters are also an option if more ripple attenuation is desired at frequencies just above the maximum frequency of interest.

Conclusion

Techniques to accurately monitor the output power of low-voltage DC-DC converters are critical to improving efficiency and reliability, and lowering costs, in space-constrained applications such as PCs and telecom network equipment.

A new approach, implemented in emerging power-monitoring ICs such as the IR3721, overcomes the established challenges surrounding measuring dynamic power and enables an integrated solution for optimum system performance and throughput.

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Current Limiting for Redundant Power Systems

A New Approach using Multiswap

The new TPS2359 hot-plug controller integrates all of the power management functions for two AdvancedMC™ (AMC) modules. Its current limiting circuitry enables designers to meet tight AMC requirements. This is relevant because many applications use redundant supplies. A unique feature called multiswap maintains a fixed current limit, regardless of the number of supplies connected to the load.

By Roger Chan and Alan Hastings, Texas Instruments

The Advanced Telecom Computing Architecture (ATCA) standard provides a modular approach to designing telecom equipment. Adoption of this industry standard speeds product design and simplifies field upgrades.

In the ATCA architecture, each carrier blade is required to contain up to eight AMC modules. These modules require hot-plug protection. The carrier board distributes two main power supplies to each AMC module: a 3.3V management power supply, and a 12V payload power supply.

In order to help designers meet these requirements, the TPS2359, a full featured dual-slot AdvancedMC™ controller was designed to provide all of the protection and monitoring circuitry required to support two AMC modules. The controller fully integrates management power inrush control, over-current protection, and FET ORing. Adding two external power transistors provides each payload power channel all of these same features. Figure 1 shows a simplified block diagram of a two-channel AMC application where both channels draw from common supplies. They can also draw from independent supplies.

This unique controller integrates accurate current limiting for payload and management power channels. The payload power current limit uses three external resistors per channel to implement the 8.25A +/– 10% ATCA specification. The management power current limit uses one external resistor per channel to set the 195mA +/– 15% specification.

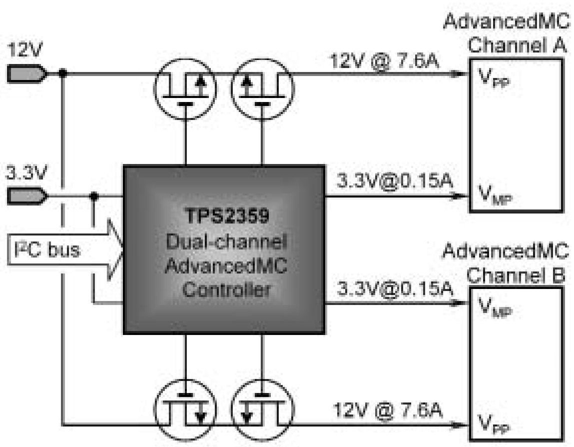

Figure 1. Simplified block diagram of an application supplying two AdvancedMC modules using the TPS2359 dual-channel controller

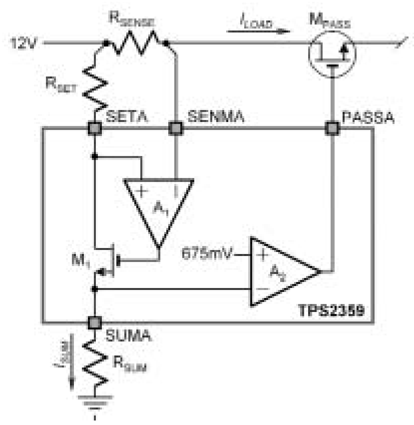

Figure 2. Payload power current limiting circuitry schematic

Precision Current Limit

Figure 2 shows a simplified block diagram of this controller's payload power current limit circuitry. Amplifier A1 monitors load current I_{LOAD} by sensing the voltage across sense resistor R_{SENSE}. The management power channels use similar circuits, but integrate resistors R_{SENSE} and R_{SET}.

The current limit circuitry includes two amplifiers: A1 and A2. Amplifier A1 forces the voltage across external resistor R_{SET} to equal the voltage across external resistor R_{SENSE}. The current that flows through R_{SET} also flows through external resistor RSUM, generating a voltage on the SUMA pin equal to:

$$V_{SUMA} = \left(\frac{R_{SENSE} R_{SUM}}{R_{SET}}\right) I_{LOAD}$$

Amplifier A2 senses the voltage on the SUMA pin. As long as this voltage remains less then 675mV, the amplifier sources 30µA to PASSA. When the voltage on the SUMA pin exceeds 675mV, Amplifier A_2 begins to sink current from PASSA. The gate-to-source voltage of pass FET M_{PASS} drops until the voltages on the two inputs of Amplifier A_2 balance. Current flowing through the channel then equals:

$$I_{LIMIT} = \left(\frac{R_{SET}}{R_{SUM} R_{SENSE}}\right) \cdot 0.675V$$

Using typical values of R_{SENSE} = 5mΩ and R_{SUM} = 6810Ω gives:

$$I_{LIMIT} = (0.0198 A/\Omega) \cdot R_{SET}$$

To set a current limit of 8.25A as required by the MicroTCA™ specification, choose RSET = 417Ω. The nearest EIA standard one-percent resistor equals 422Ω. This resistor allows the system to power an 80W AMC module.

Both payload and management channels have their own programmable fault timers. These timers start whenever the respective channels enter current limit. If a channel remains in current limit too long and the fault timer runs out, the channel turns the pass FET off and reports a fault condition. The management channel incorporates an over-temperature shutdown (OTSD) feature. The OTSD trips if the management channel remains in current limit long enough for die temperature in the vicinity of the internal pass transistor to exceed approximately 140°C. When this occurs, the management channel operating in current limit turns off. This feature prevents a prolonged fault from damaging the internal pass transistor.

The current limit feedback loop has a finite response time. Serious faults such as shorted loads require a faster response to prevent damage to the pass FETs or voltage sags on the supply rails. Although not discussed in this article, the TPS2359 includes a fast trip comparator that shuts off the channel in these situations. Moreover, this controller also supports an ORing function using an extra blocking FET. This feature blocks reverse conduction when the output-to-input differential voltage exceeds about 3mV.

Multiswap Redundancy

ATCA systems frequently require redundant parallel power sources. The MicroTCA specification advocates a redundancy technique that requires a microcontroller to independently limit the current delivered by each power source. The current drawn by the load cannot exceed the sum of the individual power sources' current limits.

An alternative mode of operation available is multiswap redundancy. This limits the load current to a fixed value, regardless of the number of operational power sources. Removing or inserting power sources within a multiswap system does not affect the current limit seen by the load. This technique does not require a microcontroller, making it simpler and faster than the redundancy scheme described in the MicroTCA standard. This is an attractive alternative for AMC applications that need not fully comply with the MicroTCA power module standard.

In order to implement multiswap redundancy, connect the SUM pins of the redundant channels together and tie a single R_{SUM} resistor from this node to ground. R_{SUM} needs to reside on the backplan for the multiswap configuration, unlike the MicroTCA redundancy configuration in which each power source has its own resistor R_{SUM}. Figure 3 shows an application employing multiswap for payload power. The current limit thresholds now apply to the sum of the currents delivered by the redundant supplies. When implementing multiswap redundancy on payload power channels, all channels must use the same values of R_{SENSE} and R_{SET}.

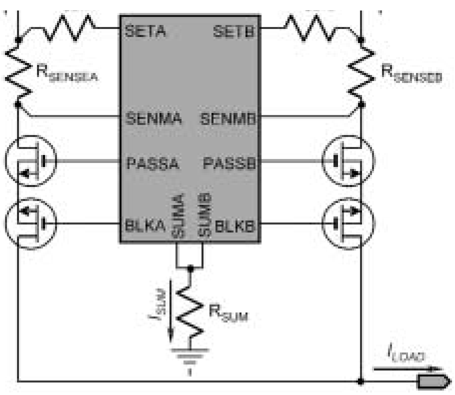

Figure 3. Application employing multiswap for payload power current limiting

Conclusion

ATCA is the first open standard to address telecommunications equipment power requirements. The power management challenges that system designers face for ATCA include narrow current limit, redundant sources for high availability, hot-plug requirements, fault protection, and complex status monitoring. These issues are addressed when the TPS2359 combines precise current limiting circuitry, a unique multiswap feature, and all the necessary protection and monitoring circuitry in a compact 36-pin QFN package. The TPS2358 has all the same functionality, but occupies a 48-pin QFN package that supports designs using external controls and indicators instead of an I2C™ interface.

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www.ti.com

IGBT Behavior under Short Circuit and Fault Protection

Using Two-Step-Soft-Turn-Off Gate Driver

In inverter driven UPS or motor applications, the IGBT can be destroyed when it is turned-on into a faulted motor or an output short circuit or an input bus voltage shoot through. Under these conditions current through the IGBT increases rapidly until it saturates. After fault detection, depending on the point at which the fast turn-off pulse is applied, very different levels of hole current can flow under the n+ source region, making this an important factor in the successful containment of the fault current. We present experimental observations showing that IGBT failure under short-circuit conditions is dependent on where and how the turn-off pulse is applied. A two-step (two-level) turn-off gate driver circuit is introduced which safely turns-off even a high transconductance IGBT during short-circuit and abnormal over current faults. This turn-off process starts during faulted condition only.

By Sampat Shekhawat and Bob Brockway, Fairchild Semiconductor

It is very common that an IGBT used for motor drive, UPS and some other industrial applications, be selected for 10 micro-second short-circuit withstand time (SCWT) if regular de-sat protection driver is used. But this driver generates high turn-off stress to the IGBT during inverter short circuit or the output becomes faulty. Under these abnormal conditions when the IGBT is turned-off abruptly, failures can occur if the IGBT is not selected properly. If the smart fault protection is not used, high turn-off loss will be generated and even short circuit current can ramp-up to a dangerous level destroying the IGBT. There are several ways to turn-off the IGBT once fault condition is detected. Some of these are as follows:

Gate is discharged through high gate resistance. This discharge path is activated only during the above said abnormal conditions. This is not the best solution.

Gate voltage is abruptly reduced to zero.

Adding some source inductance which is common for both gate discharge path and load current.Gate de-bias occurs. But during normal condition switching loss is increased.

Sense IGBT can also be used where fault current is sensed by pilot cell but the current sense accuracy of these pilot cells is not good which is further is affected by temperature.

Gate voltage pattern analyzer for short-circuit protection in IGBT inverters [1]. These circuits are very sensitive to load changes and type of loads.

Current sense resistor or Hall-effect devices are also used to detect fault through IGBT. But again these methods either generate power loss or are costly.

But de-sat protection is the most commonly used for short-circuit and over current fault protection. De-sat detection truly provides the state of electrical over stress of IGBT under current fault condition when gate voltage is high. Reducing gate voltage in a controlled manner to just above gate threshold voltage is preferred and described in this article. This will reduce fault current and after some finite time gate voltage is brought down to zero safely, turning-off the IGBT without stress.

Gate Drive Circuit

The main function of any gate driver circuit is to convert a control signal to a power signal that can efficiently controls the IGBT or MOSFET turn-on and turn-off. If the IGBT or MOSFET requires short circuit protection, the gate drive circuit must safely turn-off the switch during a shorted or abnormal overload condition. A more detailed list of the gate drive circuit requirements for an IGBT or MOSFET are as follows:

A controlled turn-on and turn-off of the IGBT so as to optimize the conduction and switching losses.

In some applications, electrical isolation between control circuit and power circuit is very important.

In the case of a short circuit condition, the IGBT should be protected and turned-off safely with minimum power dissipation and stress. The gate drive circuit should be able to minimize short circuit current and short-circuit withstand time without device failure. If both of these parameters are minimized, the power dissipation under short circuit will reduce and the system reliability will increase.

During a short circuit condition, the IGBT collector to emitter voltage can rise fast. The voltage across the gate to emitter should not be allowed to rise due to gate to collector displacement current flowing into the gate to emitter capacitance, Cge. Current flowing into Cge will cause Vge to rise and further increase the short circuit current. One should make sure that this condition is avoided.

Preferably a totem pole output stage with separate turn-on and turn-off resistance option. The gate discharging switch of the totem pole should be as close as possible to IGBT and minimize the loop inductance between this switch and IGBT gate & emitter terminals.

Minimize the propagation delay time between input and output pulses of the gate driver.

De-Saturation

The de-saturation detection technique for identifying a short circuit and fault condition in an IGBT is well known. Generally, a de-saturation condition is said to exist if the voltage across the IGBT collector to emitter terminals rises above 5-8 volts while the gate to emitter voltage is high. This condition indicates that the current through the IGBT has exceeded the normal operating level. The gate drive circuit should be designed so that it reacts promptly to the short circuit and safely turns-off the IGBT within SCWT rating of the IGBT. However, in recent years, IGBTs have been designed with lower conduction and switching losses but this generally reduces SCWT. IGBT technology utilizes shallow junctions to decrease switching and conduction losses. However these new technologies have increased the transconductance (gm) of the IGBT. Since the magnitude of the IGBT short circuit current is directly proportional to gm, during a short-circuit condition, a higher collector current results. The large collector current and high bus voltage place the IGBT in a state of high instantaneous power dissipation that can only be sustained for a few microseconds. The gate drive circuit must respond very quickly and efficiently to the fault current to protect the IGBT. Due to the two-step turn-off, the IGBT with even 4 microseconds short circuit withstand time can safely be turned-off and protected. The IGBT, used in conjunction with the two-step turn-off gate drive, safely turns off low impedance over-current faults and shorted bus conditions where single-step gate drivers fail. The Industry standard (10 µs) SCWT is no longer required when the IGBT is used with this gate driver.

IGBT Behavior during short circuit and over current

The peak current during a short circuit is limited by the gm of the IGBT. Moreover, the rate of rise of the current is limited by the turn-on characteristics of the IGBT in combination with common emitter inductance. If IGBT collector current does not saturate and reach a state of equilibrium and bus voltage has not raised high enough attempting to turn off the IGBT during can lead to IGBT latch-up [2]. In case of fault conditions very different hole current flow under n+ source regions. These different hole current conditions and patterns of hole current under n+ source generate different electrical stress. In case if the gate voltage is brought down abruptly to zero before device voltage reaches clamp, the IGBT can latch-up and fail. Flow of electron through the channel is cutoff once the gate is turned off. Holes continue to inject from emitter of p-n-p structure which is known as IGBT collector. This process stops when electrons in IGBT N-base are depleted. At this point IGBT current is almost all hole current. The amount of holes is very high here and if IGBT does not reach clamp voltage IGBT can latch-up and fail. However if enough time is allowed to complete this process and plasma of electrons in IGBT N-base is reduced or depleted so that base current reaches zero. At this point the carriers from emitter of IGBT p-n-p transistor are no longer injected and IGBT current is almost all hole current. IGBT voltage rises at a rate so that edge of the depletion spread can sweep out enough carriers to maintain inductive current. If enough time is allowed to stabilize the bus voltage while the channel current is flowing, the IGBT N-base is depleted and because of this current flow is more uniformly distributed. The displacement current becomes very small since dv/dt reduces and latch-up is avoided. If enough time is not allowed for the IGBT to reach clamp voltage and gate voltage is removed abruptly, IGBT voltage will rise with high dv/dt and current in IGBT is non-uniformly distributed, high displacement current generated by high dv/dt can latch-up IGBT. Non-uniform gate ESR combined with Miller capacitance result in non-uniform turn-off of IGBT active area. This results into high localized hole current density flowing laterally in P-base of parasitic n-p-n bipolar resulting in latch-up of parasitic thyristor. Because of these reasons one has to wait untill IGBT reaches clamp voltage collector current saturates. So it is safer to choose IGBT with 10 microseconds SCWT for motor drive and UPS inverter applications if a regular gate driver is used.

Two step soft turn-off gate drive

It is clear that if the collector to emitter voltage rises to the DC Bus slowly and high transconductance increases short circuit current, regular driver does not protect an IGBT with a low short circuit withstand time (<5us). However the longer SCWT comes at the cost of higher switching and conduction losses. The rate of rise of the collector to emitter voltage is dependent upon the operating conditions and can take several microseconds to rise to bus voltage. However, the gate drive must respond quickly to initiate turn off to protect a low SCWT IGBT. The only solution is to lower the gate voltage to just above threshold voltage of the IGBT. The IGBT reaches clamp voltage faster and reduces IGBT current during fault.

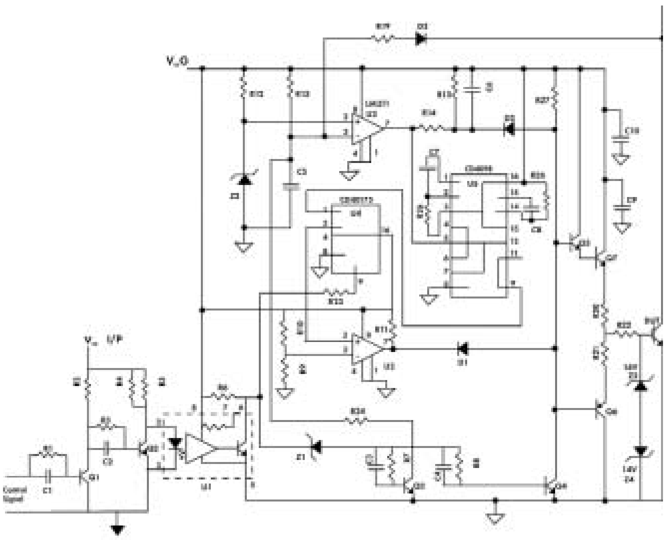

Figure 1: Two-step gate drive circuit

The schematic of two step gate driver is shown in Figure 1. The gate driver output will produce a positive signal with respect to the IGBT emitter terminal when the control signal goes high. As the control signal goes high, transistor Q1 turns on, Q2 turns off, and the LED of optocoupler U1 turns on. This forces the output voltage of the optocoupler to the low state. When the optocoupler output goes low, both transistors Q3 and Q4 turn off, turning on the Darlington combination of transistors Q5 and Q7. This will connect the Von supply to the gate of the IGBT through the gate turn-on resistor initiating the IGBT turn-on process.

During the time that transistor Q4 is off, the output stage PNP transistor Q6 remains off. Once the IGBT is turned on, the inverting input of comparator U3 will be clamped to one diode drop (forward voltage drop of de-saturation diode DC) plus the IGBT Vcesat voltage. For the gate driver to operate properly, the inverting voltage node must be at a lower voltage level than the non-inverting voltage node. The non-inverting input voltage is set by zener diode Z2. When the control signal goes low, the LED of U1 turns off, and the optocoupler output voltage Von goes high with respect to negative terminal of VccG. This turns on transistors Q3 and Q4. When Q3 turns on, capacitor C5 discharges through R24 allowing the output of the comparator U3 to remain high. Once transistor Q4 is on, the output stage Darlington combination turns off, and the PNP transistor Q6 turns on. Now, the gate of the IGBT will discharge through R21, R22 and transistor Q6, initiating the IGBT turn-off. During normal operation (no short-circuit or overload condition) comparator U3 remains off without effecting the gate driver circuit.

However, the de-saturation circuit activates when a fault occurs at the inverter output, or the complimentary IGBT turns on due to noise. When the IGBT is turned-on into the low impedance load, it draws a large current, which causes the collector to emitter voltage of the IGBT to rise towards the bus voltage. As the IGBT collector to emitter voltage rises, the voltage across capacitor C5 will begin to charge towards VccG.

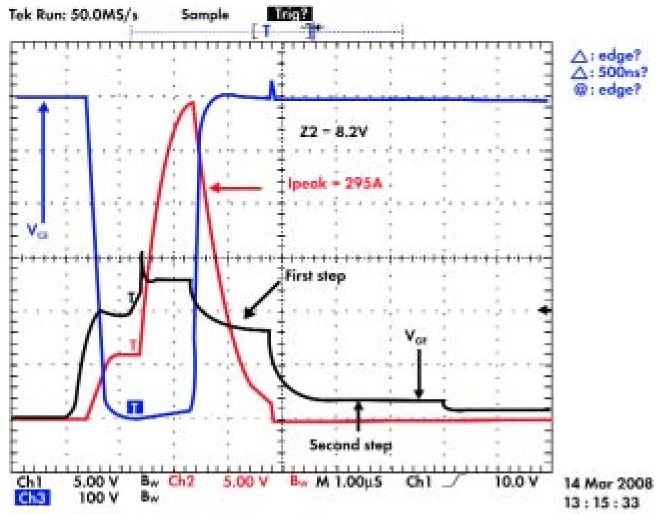

Figure 2: Trench IGBT (FGA25N120ANTD) into short circuit 'case 1'

When the voltage across C5 rises above Z2 zener voltage, the comparator U3 turns-on. When U3 turns on, the base voltage of Darlington transistor Q5 lowers to approximately 8 volts with some quick slope. R14, R15, R27, C6 and D2 set this voltage and slope. The applied gate voltage of the IGBT is reduced from approximately 13 volts to about 8 volts, significantly decreasing the saturation current of the IGBT. As soon as the gate bias reduces, electron current (MOSFET current) reduces. As electron current reduces, base current of the IGBT structure PNP transistor reduces. Hence, the saturation current of the IGBT reduces.

When IGBT is turned-on into an inductive short-circuit or it is under shoot through condition current ramps quickly. The voltage across the device increases and current through the IGBT saturates if the gate voltage is kept on. Now if the gate voltage is brought to zero after IGBT current saturates and drain voltage rises to clamp voltage the IGBT will turn-off safely.

The Ic U4 & U5 decide the time duration of first step level voltage and after this time the comparator U2 turns on and transistor Q5 & Q7 turn-off and Q6 turns-on turning-off IGBT safely. During first step time, the collector to emitter voltage across the IGBT rises faster than it would by holding the gate at 15 volts. As previously mentioned, the faster collector to emitter voltage rise is beneficial for the IGBT to safely turn-off the IGBT under a shorted load.

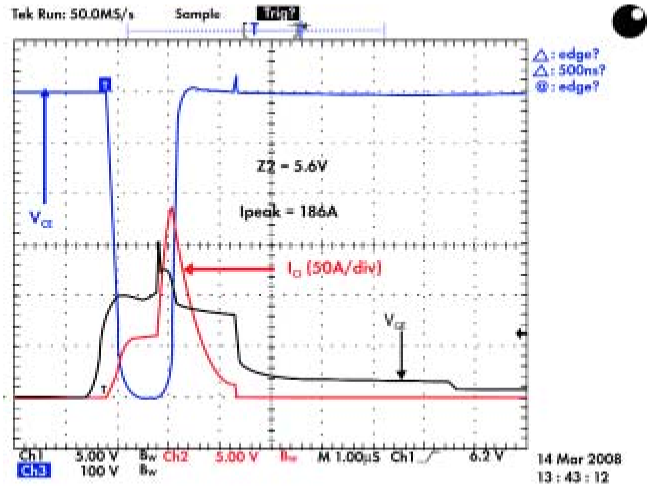

Figure 3: Trench IGBT (FGA25N120ANTD) into short circuit 'case 2'

Figure 2 and Figure 3 depicts the Fairchild 1200V Trench IGBT turning on into a resistive load and after 1 micro-second the resistor is shorted. In 'case 1' IGBT is protected within 2.6 micro-seconds. The zener Z2 decides when to start first step. The second step voltage level is decided by D1 and Vbe of gate turn-on transistor as shown in figure 2. When the zener Z2 value is 8.2V, that allows IGBT peak current to rise up to about 300A but still it turns-off IGBT safely as shown figure 2 'case 1'. But in figure 3 'case 2' when this zener value is reduced to 5.6 volts the short circuit current only rises up to about 190A. By selecting this zener properly depending on type of IGBT technology one can reduce this short circuit peak current and increase system reliability.

Summary

A new two-step gate drive circuit has been proposed which protects the IGBT during short circuit and over load fault. The gate-drive safely turns-off the IGBT in two steps. The IGBT stress during short circuit or fault current conditions is minimized. The new gate drive circuit can safely shut-off IGBTs with SCWT as low as 3?sec. The Fairchild trench IGBT can be turned-off safely in less than 3 microseconds.

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Advantages of SiC Schottky Diodes

Fast switching are the targeted power electronics solutions

SiC is discussed as a future high performance replacement of the silicon power components. The new technology enables products with almost ideal behaviour. Currently, SiC Schottky rectifiers are already available as qualified standard products

By Ernö Temesi, Development Engineer, Vincotech Hungary Ltd.

This article will investigate how to utilize the advantages of the new technology in commercial module applications. The investigation is done based on the example of a standard boost circuit used in active power factor correction or DC-DC step up converters.

Theory

The theoretical advantages of SiC technology are obvious. The new technology promises new semiconductor products with a behavior very close to that of ideal components:

⇒ Forward voltage drop is reduced:
The static losses are significantly lower than in Si semiconductors with the same chip size. This leads to higher efficiency regarding static losses.

⇒ High operating temperature:
The operating temperature of SiC devices already extends to temperatures > 225°C. But in theory, much higher temperatures are also possible.

⇒ Ultra low Qrr:
There is nearly no reverse recovery charge (QRR) stored in a SiC diode. The QRR of a hard switched freewheeling diode causes additional losses in the switch and is a root cause for EMC/EMI.

⇒ Low leakage current:
The leakage current of a SiC semiconductor is very low and doesn't rise siginificantly at higher temperatures.

The Real World

It is currently not possible to utilize all the potential of the SiC technology into real advantages of new power electronic circuits. The reasons are the following.

⇒ Within a cost-saving environment, a high purchase price is always the 1st barrier for any new technology. The volume cost of SiC components is a 2 digit factor higher than that of Si components with the same chip area.

⇒ Usually, the high temperature capabilities of SiC technology would also lead to higher heat sink temperatures. However, other components that are mounted on the same heatsink are only available in Si technology with standad temperature rating. Therfore, this cannot be utilized.

⇒ Also the high Tj-max does not offer big advantages in real applications. A higher junction temperature should theoretically allow a higher power rating, which in turn increases the temperature swing of the component. The lifetime for soldered and wire bonded components is dependent on the temperature rise of the chip.In most packages it is either the chip soldering or the wire bonding that limits the lifetime and not the chip itself.

⇒ Limited power rating:.
Presently, the number of failures per mm2 on a SiC wafer is much higher than for Si technology. This results in a limited chip size to achieve an acceptable yield.

⇒ The highest rating for diode chips is approx. 20A / 600V. For applications exceeding this value, a paralleling of the diodes is necessary.

The remaining advantage for SiC technology is its ideal dynamic behavior. In hard switching applications, the switch-on losses of the transistor are mainly infuenced by the corresponding diode. And this is where the SiC diode is able to reduce the switching losses in the transistor, since the reverse recovery current of the diode needs to be added to the nominal switched current.

This reverse recovery current not only increases the losses, it is also the main source of EMC/EMI emission in the application. In the following section a boost stage with a SiC diode is compared to alternative solutions based on standard silicon technology.

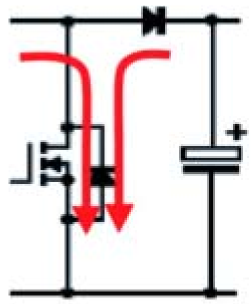

Figure 1: Reverse recovery current added to nominal current

Efficiency Benchmark

In the comparison the active components of the PFC boost stage are benchmarked at 230VAC input and 400VDC output at 2kW input power. The input rectifier and choke are not included in the comparison.

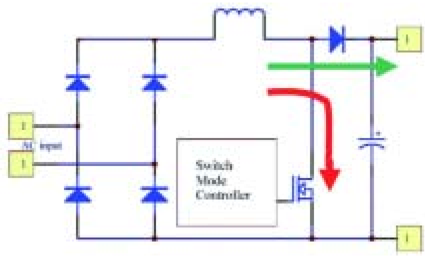

Figure 2: PFC boost stage

The following components are compared:

In all following tests cases, a CoolMOS™ mosfet is used as the switching transistor together with different boost diodes:

- fast 600V FRED in Si technology
- 2 fast 300V FRED in Si technology connected in series
- SiC diode

The components for the efficiency benchmark are assembled as bare dies into a Vincotechs flowPFC0 power module.

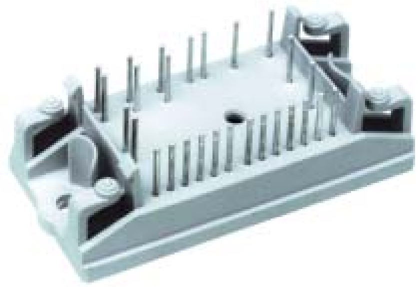

Figure 3: Tyco Electronics module: V23990-P800-D30

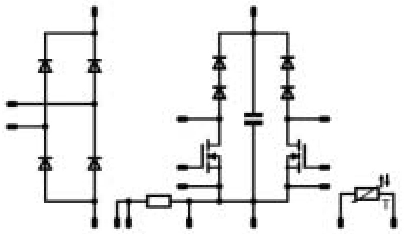

Figure 4: Schematics of the flowPFC0. In the benchmark only 1 boost phase is used.

Single Hyperfast FRED

The following comparison is carried out between:

- Vincotechs test module:
  MOS-FET: SIPC44N50C3
  Rectifier: single Si-FRED FD120N60 (solid line)
- Vincotechs standard module:
  V23990-P800-D30 (only 1 boost phase used)
  MOS-FET: SIPC44N50C3
  Rectifier: 2 paralleled SiC rectifiers SIDC02D06SiC02 (dashed line)

The following figure 5 shows the comparison of the efficiency in a PFC-boost application depending on the diode technology.

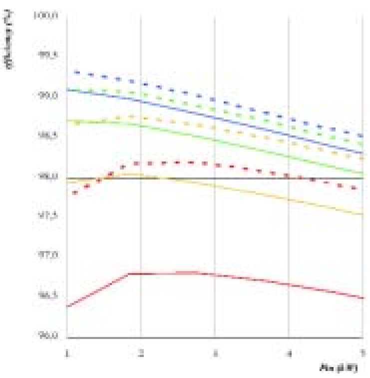

Figure 5: Efficiency comparison: single hyperfast FRED vs. SiC-diode:
The frequency steps are given from 25kHz to 200kHz in x2 steps.

At 50kHz, the losses of the standard circuit are already 32% higher. At 100kHz, the efficiency of the circuit with the SiC diode is 98,7% as compared to only 98% of the circuit with the Si diodes. This means that the losses in the circuit with standard technology are approx. 59% higher. At 200kHz the losses of the standard technology are 76% higher. This practically disqualifies the standard Si technology for frequencies higher than 100kHz.

2 fast 300V FRED's

The following comparison is made between:

- Vincotechs standard module:
  V23990-P803-D30 (only 1 boost phase used)
  MOS-FET: SIPC44N50C3 (CoolMOS)
  Rectifier: 2 x fast Si-FRED (solid line)
- Vincotechs module:
  V23990-P800-D30 (only 1 boost phase used) MOS-FET: SIPC44N50C3 (CoolMOS)
  Rectifier: 2 paralleled SiC rectifiers SIDC02D06SiC02 (dashed line)

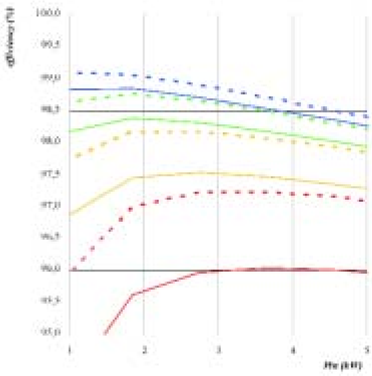

Figure 6: Efficiency comparison: 2x fast 300V FRED vs. SiC-diode:
The frequency steps are given from 50kHz to 400kHz in x2 steps.

The connection of 2 fast 300V diodes in series is the 1st alternative. This solution shows much lower losses than the circuit with a single Si diode (Figure 6). However, at 100kHz, the losses are again already 31% higher than with a SiC diode. At 200kHz, the losses using a SiC diode are 39% lower and at 400kHz 46% lower.

EMC/EMI

The electric noise and its compensation is highly dependent on the application in question. The effort for EMC filtering in applications connected to the public power grid is estimated at approx. 20% to 30% of the total cost. The reverse recovery current in hard switched applications is one of the main sources of EMC/EMI. Using SiC Schottky diodes, it is possible to reduce the filtering effort significantly. EMC/EMI debugging is often implemented as a separate development step after the selection of the semiconductors. This makes it difficult to compare the cost benefit ratio. However, in many fast switched applications, the SiC diode compensates for its higher price if the EMI filtering is taken into account.

Conclusion

For PFC-boost applications with switching frequencies above approx. 150kHz, SiC diodes are a good and also cost efficient solution. For frequencies between 20kHz and 150kHz, two Si diodes in series is the best trade-off between efficiency and cost. The standard Si diode is clearly outperformed already at frequencies of >25kHz. In special applications, such as efficiency driven solar inverters, SiC diodes bring considerable value already at much lower frequencies.

Many features of SiC technology cannot be utilized in today's power applications. However, considerable advantages can be realized in fast switching power applications:

⇒ SiC technology will improve the efficiency and reduce EMC/EMI.
⇒ Higher efficiency will reduce the size of the heat sink
⇒ Reduced EMC/EMI will reduce the filter components and the PCB area.
⇒ The combination both above mentioned features will reduce the cost of the mechanic and passive components and the size of the electronic device.
⇒ Reduced size and the increased efficiency will add value on the application.

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⇒ New Power Module Structure for Efficiency Improvement in Fast Switching - Power Applications (>50kHz, >1kW) Temesi, Zsadany, Frisch Mar. 2005, Vincotechs

Optimizing Thermal Solutions

Software cuts design costs

CFD (computational fluid dynamics) thermal analysis software is freeing engineers to create smaller, more reliable boards and systems, while simultaneously reducing development time and costs. The software solves the differential equations that model airflow and heat transfer and presents the results as 3-D color-coded simulations that accurately show thermal conditions inside an enclosure or across a board. Airflow and temperatures can be overlaid so that the engineer can detect the impact of one on the other.

By Peggy M. Chalmers, Daat Research Corporation

Development time and costs are dramatically reduced because the need for prototyping is eliminated. Want a different heat sink, thermal pad, additional vents, or a more powerful fan? A few keystrokes will modify the design or alter component placement. Because optimum configurations can be developed in a fraction of the time previously required, time-to-market is dramatically reduced, even on small projects.

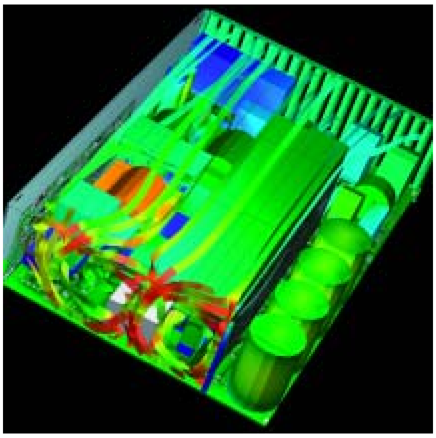
Designing a smaller rectifier

A leading international provider of comprehensive power quality and backup power management solutions uses Coolit CFD thermal analysis software from Daat Research Corp to design its rectifier modules. In one application, a 3 kW unit dissipating 300 W, had to be mounted in multiples of three on shelves in order to achieve balanced three-phase currents. This meant the new design had to be at least 50% smaller than the company's existing rectifier designs. In addition, the components had to be positioned in a predefined sequence which limited the possible locations for heat sinks, vents and fans.

Using Coolit, the design engineers quickly determined where hot spots would develop and explored numerous "what if" scenarios without expensive and time-consuming physical prototypes. They designed a tiny, but highly effective heat sink with optimized fin size and spacing and pinpointed preferred fan and vent locations. The resulting design exceeded the power density of competitor units and was small enough to fit six units on a 19-inch (48 cm) wide shelf.

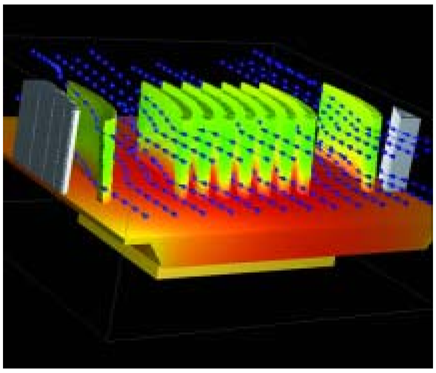
A better power supply

When electronics designers wanted to make quick circuit improvements in very small power supply modules that provided highly precise power conversion for a military helicopter's night vision and target acquisition system, they turned to Coolit. Each module consisted primarily of two high-density printed circuit boards mounted on opposing sides of a finned heat sink, and the engineers had to address the overall heat of each board, as well as the heat generated by hot spot components. Though they were new to CFD, it took them less than 4 hours to load the software, run the tutorials, perform test sample simulations and then begin building and running actual design scenarios. They were able to quickly characterize a fin design that would remove heat from the boards and into the customer's specified airflow.



CFD simulation of rectifier color-codes surfaces to indicate temperature and color-codes streamlines to indicate air velocity.

The highest risk components for hot spots were the FET drivers, small, SO packages with moderate thermal dissipation, but with a high, 40C/W, junction to case resistance. While the engineers had pre-conceived notions as to which chips would present thermal problems, the Coolit simulations revealed other hidden risks. Once the problem chips were identified, the engineers were able to fix most problems by splitting a thermal load so that part went to a remotely located resistor instead of having the driver chip handle it all.



Airbus power supply simulation indicates maximum cooling occurs when chips are mounted directly over stator blades.

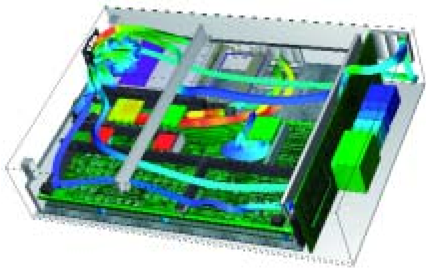
Air-conditioning controls

AMS Technologies, AG of Munich, Germany used Coolit to design cooling for the power supply in Airbus' air-conditioning controls. The IGBT module's is built without conventional base plate, so that IBGT chips and power diodes are mounted directly to the die cast housing of the turbine that circulates conditioned air throughout the cabin. Heat is conducted through the housing to stator blades that are immersed in the air drawn through the turbine.

To adequately cool the power module, the turbine's die casting had to be thick enough to spread the heat to the blades, and the number and pitch of the blades sized to dissipate the heat at 70 deg. C ambient and inlet temperatures.

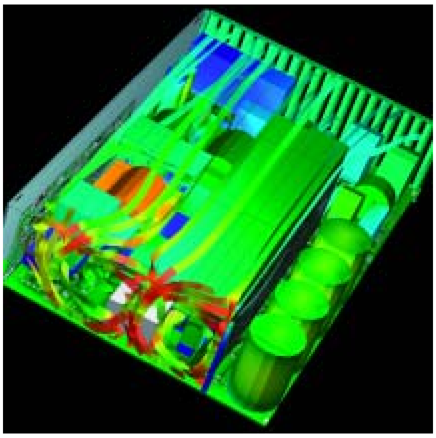
The approach velocities in the turbine are above 50 m/s and the velocity between blades approaches the speed of sound. The heat transfer coefficient to air is close to maximum and cannot be improved. Therefore, the junction-air thermal resistance is governed by the heat conductance from the module to the blade surface and by the effective cooling surface area.

The analysis showed that optimum heat transfer occurs when the components are positioned precisely above the blades and that even a small offset is detrimental over the entire design temperature range. Varying other design parameters, such as number of blades, blade pitch, etc. produced a critical variation of temperature drop of 10-17 K between junction for the hottest chip and the sensor of the IGBT module.



Honeywell used Coolit analysis to balance conflicts between cooling requirements and need to minimize chassis openings for improved EMI protection.

AMS also investigated the heat dissipated by the electrical windings in the core of the annulus. Initially, there was concern that this heat might raise the IGBT temperature significantly. However, the Coolit analysis showed that even maximum temperature conditions only slightly increased the junction temperature of the IGBT.



Using Coolit's flow visualization capabilities, VT Miltope discovered that much of the air was bypassing the cooling fins on this digital mass storage system. The problem was fixed by adding an air duct to force the air through the fins.

Saving time and money developing thermal solutions

As electronic designers are pushed to deliver smaller and more powerful packages, they are finding thermal issues more and more difficult to solve. To solve these tough problems in a timely fashion, engineers are finding powerful and accurate thermal design software to be essential, particularly in today's competitive market. CFD thermal analysis software will deliver an optimum thermal solution in the least time and for the lowest cost. Predictions are typically accurate to within 5-10 percent, and there is no waiting for prototypes to be built and tested----they aren't needed.

www.daat.com

The Tailor Made Thermal Solution Kit

GraviTherm is a kit designed to transport heat away

Electronic controls and computers become more and more important to all sectors of our life. Today there are almost no industrial applications which work without electronic components to control and to monitor the processes. The use of these components makes production processes, administration and all our every day life more effective and convenient.

By Jörg Hamann, Bio Cooling Systems GmbH

The price for this convenience is that only a fraction of the therefore consumed electrical power is used to make calculations, but a large part of the electrical power is wasted heat, as we know this from Edison's light bulb. This waste heat becomes more and more a problem and the GraviTherm system get a chance to handle with this.

Figure 1: GraviTherm in a cabinet application

What is the GraviTherm system? GraviTherm is a kit designed to transport heat away from the heat source to a place where the heat can be treated more effective. Therefore the engineers of the German BCS Bio Cooling Systems GmbH have developed the GraviTherm Rails. These rails are available in different sizes and can transfer heat capacities from 50 W up to 500 W per rail. The smallest size of a rail actually is 16 x 2,9 mm. This rail can transfer a heat of 50 W over a distance of at least 1 meter. With special designed clutches, GraviTherm Click, two or more rails can be connected to a long heat transfer rail. It is also possible to use the rails parallel to increase the transferred heat quantity. The GraviTherm Click is also used to connect the GraviTherm Rails with the heat source and the heat sink.

The GraviTherm Rails are made from special aluminum profiles, which are very light and pressure stable. Unlike heat pipes it is possible to bend them without loss of heat transfer performance.

On customers request the BCS can design and manufacture customized heat transfer systems for any application.

To complete the GraviTherm product portfolio a light weight, high efficiency heat exchanger, GraviTherm Helix, will be available soon. The aim of the development of this heat exchanger is to transfer the same heat as an aluminum extrusion with only 1/3rd of its weight.

How does all this work? The secret behind the efficiency is the thermo siphon system. In simple terms the system works like a refrigerator without compressor. A small quantity of an environment friendly refrigerant circulates inside the rails. At the heat source the refrigerant evaporates. This process needs thermal energy, which is provided from the heat source. The vapor soars

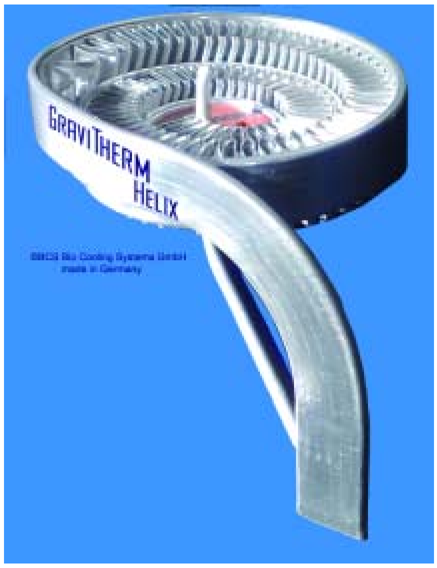


Figure 2: GraviTherm Helix

up in the rail. When the vapor reaches the condensing zone, the place where the rail is connected with a heat sink or another rail, the vapor condenses. This process gives away the thermal energy, which was collected in the evaporation zone and the liquid refrigerant runs back to the evaporator zone, driven by the force of gravity.

The force of gravity makes the system fast and efficient, at the price that the system can not work against this force. A minimum rise between heat source and heat sink of 3° is needed. This is enough for the most applications.

What is it good for? As explained in the beginning, electronic components produce more and more waste heat. The packing density rises with miniaturization in every new generation of electronic applications.

The only problem is: How to handle with the waste heat? This is the point where the GraviTherm kit can prove its superiority.

Actually the smallest available GraviTherm Rail is 16 x 2,9 mm. This rail can transfer more than 50 W of thermal energy. The biggest rail is sized 60 x 4 mm and can transfer more than 500 W. Every rail can be connected to flat surfaces with or without a heat spreader. There is no complicated heat spreader structure needed, which converts round heat pipe surfaces to flat heat sink or heat source surfaces. The GraviTherm Rails transfer the heat directly from the CPU or any other component with critical thermal dissipation loss to the heat sink, which could be the housing of the application for instance. At the embedded world fair 2008 in Nuremberg the BCS was showing a customized cooling solution based on GraviTherm Rail using an untreated door of a switch cabinet for convection cooling of the whole system with 35 W TDP at the Fujitsu Siemens both. This sample demonstrates impressively the potential of the GraviTherm solution. With a small investment in engineering know how it is possible to use the existing environment to bring away heat without additional energy for fans or climatisation.

The BCS GmbH offers a wide range of concepts for energy saving heat transfer and cooling solutions based on the GraviTherm kit. So it is possible to design fully encapsulated systems which use their housing as heat sink for fan less cooling. In best case there are only flat surfaces for the thermal dissipation needed. This is interesting for all applications where high requirements to cleaning and hygiene are needed to meet.

It is also possible to collect the heat from many heat sources, as for instance in a computer center, and to deliver the heat to a cooling circuit without polluting the ambient air. This helps to save a lot of money which otherwise would have to be spent for room climatisation and fans.

The energy discussion became more and more important within the last years due to increasing energy prices and decreasing resources. Nowadays even the power consumption of a CPU fan is a cost factor. This is the reason why solutions like the GraviTherm kit become important for the energy saving treatment of waste heat, because saving energy is the key to cost efficient applications in the future.

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Taking Transducer Technology to the Limits of Current Measurement Accuracy

HPCT transducer for the future of MRI scanning

The development of magnetic resonance imaging (MRI) has led to an increased ability to diagnose and, subsequently, treat a growing number of physical conditions at the cellular level, perhaps most notably cancer. As a diagnostic methodology, MRI continues to evolve but for some time that evolution has been geared to developments in the underlying technology, not least of all the techniques used to acquire the images.

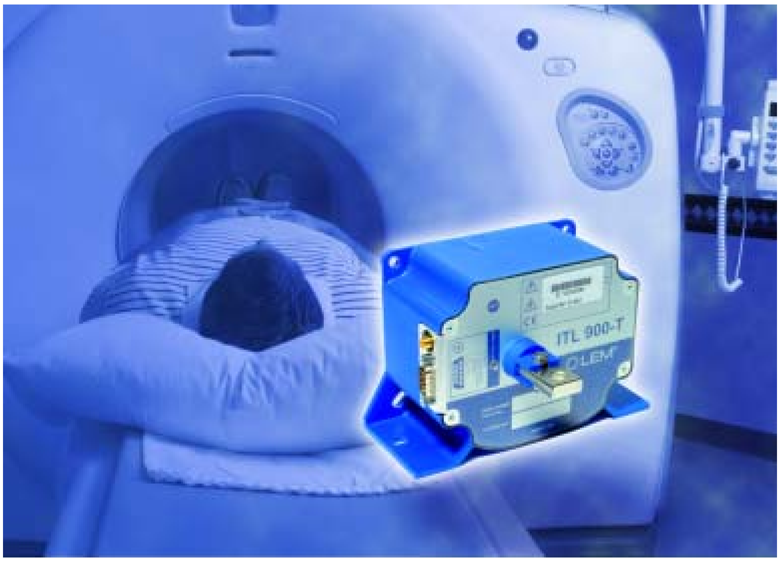
By Claude Gudel, LEM SA, Switzerland

Although the profile of MRI scanning has been increasing since the early 1970s, the phenomenon that enables it was first observed in the mid-40s. It was around this time that two independent research groups, at Harvard and Stanford universities, both discovered what was to become known as Nuclear Magnetic Resonance. Shortly after, Dr Bernard Rollin, operating out of Oxford University in the UK, built what must be the earliest example of an NMR spectrometer. Further discoveries made in the early 50s led to the development of high resolution NMR spectroscopy, when it was recognised as a potentially useful tool in the field of chemistry and biochemistry. Efforts to increase the resolution of images eventually saw its application in diagnostic medicine, and MRI scanning began its own development on a parallel path to NMR.

Beyond the iconic image of a horizontal platform large enough to carry a patient, sliding into a larger, circular machine resembling a huge inductor, it isn't immediately obvious just how MRI scans are carried out.

A key element of NMR/MRI spectrometry is the detection of small magnetic fields generated by the movement of cells in a soft tissue. This movement is effectively cell realignment, which happens following their displacement. That in turn is caused by the cells' exposure to a stronger magnetic field. The speed at which the cells realign themselves depends on their structure and condition, and the resolution with which the much smaller magnetic fields they generate can be detected determines the overall resolution of the instrument.

Crucial to any MRI scanner's efficacy is the level of cell excitation generated by the magnetic field, so controlling this field is as critical as detecting the resulting cell realignment. There are now many companies that develop MRI scanners, many of whom are household names, but interestingly they rely heavily on other, less well known specialists to develop and supply the sensors used to enable these machines.



One such company is LEM, a leading provider of innovative and high quality solutions for measuring electrical parameters. As MRI scanners have become more widely used, a need to improve their resolution has also developed. This can only be achieved through careful and precise regulation of the magnetic fields, which in turn depends greatly on the ability to measure and control the currents used to generate them.

For some time, the technology used in this application was based on Hall Effect current transducers, but this technology has significant limitations in this application area, particularly in their precision. LEM was approached by a customer in this field, who needed a new kind of current transducer; one that, in order to improve on what was already available, needed to offer much greater precision. It took LEM around 7 months to adapt an existing technology to meet the customer's demand and the current transducer it developed now offers the highest performance available on the open market.

The solution developed by LEM can be described as a double fluxgate closed loop transducer, known as HPCT, but it may be more useful to compare its operation against the more commonly found Hall Effect technologies.

The Hall Effect was discovered in 1879 by an American physicist called Edwin Herbert Hall, at John Hopkins University in Baltimore. The Hall Effect is created by Lorentz force, F=q.(VXB), which acts on charges moving through a magnetic flux density. A control current flows through a very thin plate of semi-conductor passing through the field. The mobile charge carriers of the control current are deflected as the external magnetic flux density, B, generates a Lorentz force, perpendicular to the direction of current flow. This deflection causes more charge carriers to gather on one side of the conductor, creating a potential difference across it, referred to as the Hall voltage.

Certain elements of the Hall Effect; specifically the Hall constant and the offset voltage of the Hall element, are temperature dependent. Therefore it is necessary in any current transducer using the Hall Effect to provide temperature compensation.
The simplest practical implementation of the Hall Effect is an open loop transducer, providing the smallest, lightest and most cost sensitive current measurement solution, while also having very low power consumption.

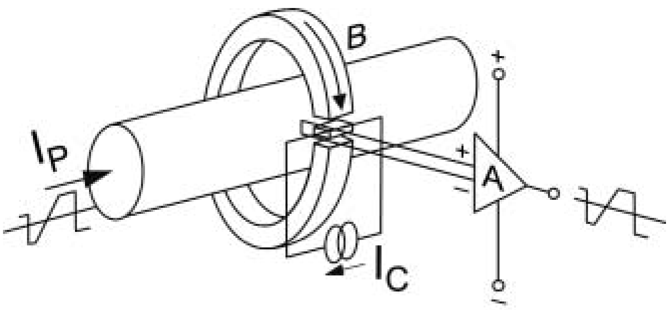


Figure1:
Principle of operation of open loop Hall effect current transducers

As Figure 1 shows, the transducer is formed of a current carrying conductor creating a magnetic field. The field is concentrated by a magnetic core, which is cut to create an air gap. Within the air gap, a Hall element is used to sense the magnetic flux density. The control current and differential amplification are applied electronically, with the components normally integrated within the transducer. Within the linear region of the B-H loop of the material used to create the magnetic circuit, the magnetic flux density, B, remains proportional to the primary current, I_p, and the Hall voltage, V_H, is proportional to the flux density. Therefore, the output of the Hall element is proportional to the primary current plus the offset Hall voltage, V_o.

Open loop transducers measure DC, AC and complex current waveforms, while providing galvanic insulation. As mentioned earlier, the advantages include low cost, small size and low power consumption. They are also especially advantageous in applications where high currents (>300A) are being measured. The limitations of open loop transducers include poor bandwidth and response time – due to the magnetic losses in the magnetic circuit – and a relatively large gain drift with respect to temperature.

In comparison, closed loop transducers, also called Hall Effect compensated, or 'zero flux' transducers, use the Hall element voltage to generate a compensation current in a secondary coil, in order to create a total magnetic flux equal to zero.

In other words, the secondary current, I_s, creates a magnetic flux equal in amplitude – but opposite in direction – to the flux created by the primary current.

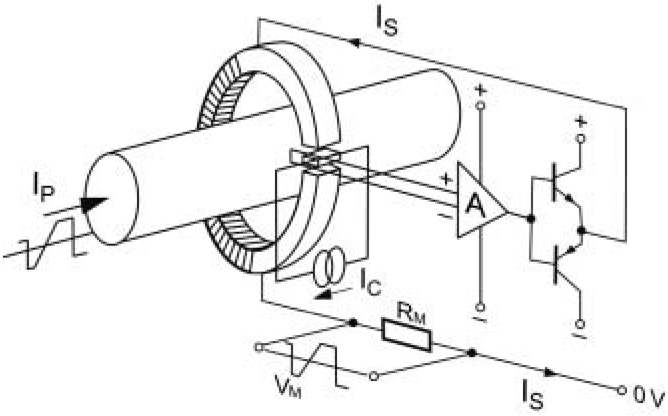


Figure 2: Principle of operation of closed loop Hall effect current transducer

Operating the Hall element in a zero flux condition eliminates the drift of gain with respect to temperature, an additional advantage to this configuration is that the secondary winding will act as a current transformer at higher frequencies, significantly extending the bandwidth and reducing the response time of the transducer.

When the magnetic flux is equal to zero, the magnetic potentials (ampere-turns) are equal, consequently the secondary current, I_s, is the exact image of the primary current, I_P. While the advantages of a closed loop transducer include very good accuracy and linearity, as well as a fast response time, the main limitation is the high current consumption from the secondary supply, which must provide the compensation current as well as the bias current.

In particular applications, where specifications such as extremely low non-linearity error, very low noise floor, or low offset drift with respect to temperature are becoming more demanding, Hall Effect current transducers are no longer suitable. To meet these requirements, LEM designed the double fluxgate closed loop transducer (HPCT), which provides AC and DC current measurement with very high accuracy and stability, while eliminating the injection of noise into the primary side.

The principle of operation can be explained using Figure 3. The transducer consists of a current measuring head made of three magnetic cores, C_1, C_2 and C_3, with primary winding (W_{p1}) and secondary windings (W_{s1} to W_{s4}) as shown. Closed loop compensation is

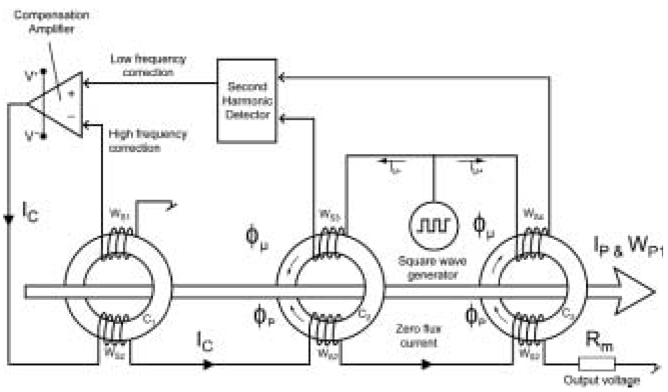


Figure 3: Principle of operation of HPCT transducer

achieved by a secondary current, I_c, injected in to one of the secondary windings, W_{s2}. This latter coil, magnetically coupled to the three magnetic cores, is connected in series with a measuring resistor, R_m, in order create an output voltage.

For the upper frequency range, the secondary current results from a transformer effect generated within two secondary coils (Ws1 and Ws2). For lower frequencies, including DC, the transducer works as a closed loop fluxgate transducer, with the windings Ws3 and Ws4 being the fluxgate sensing coils.

Although fluxgate technology has been around for a while, LEM was able to take this technology and adapt and improve it. The result is a transducer that offers very high accuracy, with very low offset drift with temperature, and very high stability over time. Excellent linearity with very low output noise add to the HPCT's accuracy and resolution, while a wide measuring bandwidth (DC to 200kHz, -3dB) ensure its application across a wide number of applications.
Indeed, as well as precise current control in gradient amplifiers for medical imaging, the HPCT is equally applicable to measuring feedback in precision current regulated power supplies, current measurement for power analysis, calibration equipment for test benches, and laboratory and metrology equipment which also require high accuracy.

Presently, the technology is limited to a relatively narrow operating temperature (typically +10°c to +50°c). However, LEM is confident that the technology used to develop the HPCT transducer could prove to be as significant for the future of MRI scanning as the Hall Effect transducers were for its introduction, while finding further uses in a host of as yet unforeseen applications.

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Hysteretic Control Performance with no Output Ripple? Smooth!

First implemented in buck regulators of the PowerWise product family

Whenever you start a new switch mode power design, you might ask yourself: What switch mode control scheme should I use? What are the advantages and disadvantages? Which one is the best for my needs?

By Werner Berns, Technical Support Manager and Michele Sclocchi, Principal Application Engineer, National Semiconductor Europe

Well, there is not just a simple answer like: Use control scheme 'A' and you are fine. The decision depends on your needs and your experience. The following article will give an overview about some of the most common control schemes such as PWM (Pulse Width Modulation) and Hysteretic Control as well as some of their different 'flavours'. At the end the article describes a new addition to the family of hysteretic controls that allows easier designs by maintaining excellent performance characteristics. But let's have first a look at the PWM control.

PWM control

The most common control mode is the classic PWM control scheme. An internal clock leads the beginning of each duty cycle, which corresponds to the ON transition of the main MOSFET. The on-time is timed by the control voltage (Vc) compared with a saw-tooth ramp (Vp).

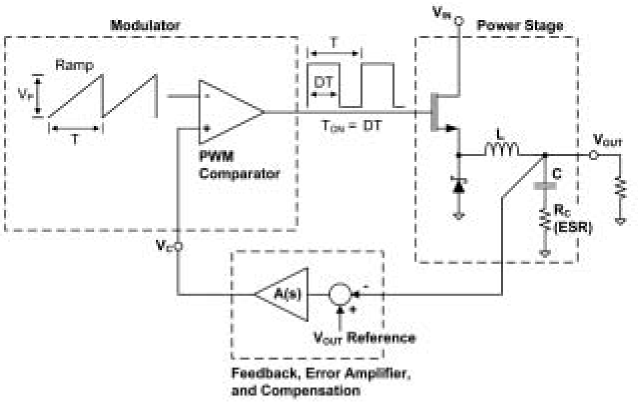

Figure 1: PWM buck regulator, basic architecture, e.g. LM3743

The saw-tooth ramp can be generated in three different methods, leading to voltage mode, voltage mode feed-forward, and current mode control scheme.

Voltage Mode Control

A constant saw-tooth ramp is internally generated with a fixed amplitude Vp. The loop gain and the loop bandwidth increases with the increase of the input voltage. A type 3 compensation is usually used to compensate a double pole given by the inductor and output capacitor, and its zero resulting from the output capacitor and its ESR. This makes the loop compensation a bit more complicated. Voltage Mode (VM) is widely used for applications where the input voltage is relatively stable.

Voltage Mode with Feed-Forward Control

With this methodology the slope of the sawtooth ramp changes with the input voltage removing the variability of the loop gain and bandwidth caused by a changed input voltage. Line transient respond is improved because the regulator changes the duty cycle before an error occurs at the output voltage. The other advantage associated with voltage mode feed forward scheme is that it allows the loop gain to be optimized over the entire input voltage range. An example for this implementation can be found in National's LM5115.

Current Mode Control

Rather than using a constant sawtooth ramp to control the duty cycle, the current mode control uses the sawtooth ramp generated by the output inductor current (Figure 2).

A current sense amplifier detects the inductor current by measuring the current of the main MOSFET. A corrective ramp is added to avoid the problem of sub-harmonic oscillation for duty cycles larger than 50%.

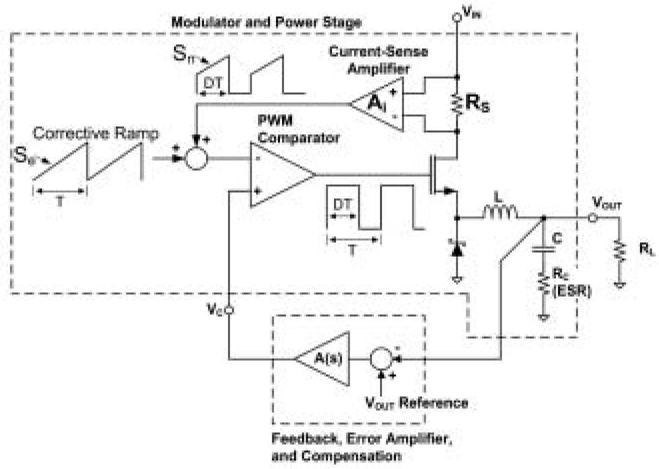

Figure 2: current mode buck regulator, basic architecture, e.g. LM201xx

In the current mode control scheme, the modulator, output switch and inductor operate like a transconductance amplifier, supplying a regulated current to the output. As a result, the gain in this stage is not affected by varying Vin, instead, the gain changes with the load resistance.

Current mode control offers several advantages, such as easy current sharing between power converters connected in parallel, better compensation due to the single pole of the system, precise cycle by cycle current limit, and immunity to input disturbance.

One of the main disadvantages of current mode control is the difficulty to measure the current at small duty cycles. This measurement can be quite susceptible to noise and the modulation can be erratic.

Emulated Current Mode (ECM) Control:
The emulated current mode control technique, patented by National Semiconductor, overcomes noise issues at low duty cycles and therefore makes it especially ideal for high Vin to Vout conversion ratios and/or at high switching frequencies. The current ramp is not directly measured as in the classical CM control, but built from two different portions. The first part is created by measuring the current in the low side MOSFET (or Schottky diode) and 'frozen' with a sample-and-hold element just before starting the next cycle. It basically represents the starting current of the main switch. The second part is an artificially created ramp where the slope varies with the difference of Vin and Vout. The resulting signal represents the inductor current during the ON phase but without the noise issues and blanking time issues. The ECM technology has been implemented for example in National's latest Simple Switcher regulators (LM557x, LM2557x) and in the 100V buck controller LM5116. All are members of the company's energy-efficient PowerWise® family.

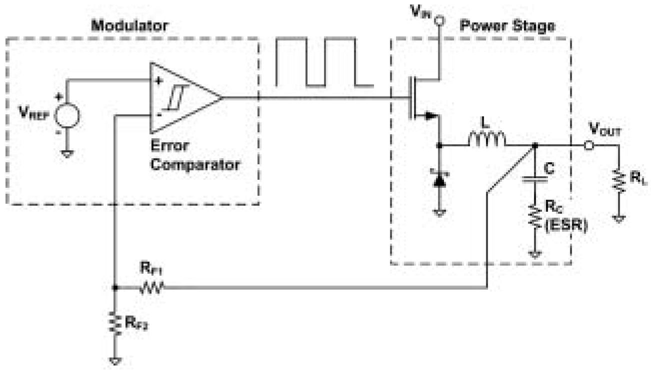

Figure 3: Hysteretic buck regulator, basic architecture, e.g. LM3489

Hysteretic control
Another possible solution is the hysteretic control scheme (figure 3). The modulator is simply a comparator with a few mV of input hysteresis that compares the feedback voltage with a reference voltage. If the feedback voltage exceeds the upper threshold, the comparator turns the switch off. The switch turns on again, once the feedback voltage falls below the lower threshold of the comparator.

This topology reacts extremely fast to load and line transient, it is very simple and it does not require loop compensation.

The main issue associated with this control scheme is that the switching frequency is not set by an oscillator; it is not constant and dependent on many variables. The frequency varies very much on the variation of components' parameters and operational conditions. Input voltage, load current, inductor value, output capacitor and especially its equivalent series resistor (ESR) can all have a huge impact on the switching frequency.

	PWM control				Hysteretic control		
	VM	VM FF	CM	ECM	2 level	COT	COT ERM
Typical Compensation	type 3	type 3	type 2	type 2	non	non	non
Line Transient Performance	+	++	++	++	+++	+++	+++
Load Transient Performance	++	++	++	++	+++	+++	+++
Cout ESR Variation Immunity	+	+	++	++	-	+	+++
Noise Immunity	++	++	+	+++	+	++	+++
Switching Frequency Constant	yes	yes	yes	yes	no 2)	nearly	nearly
Ext. Freq. Synchronisation Possible	yes 1)	yes 1)	yes 1)	yes 1)	no	no	no
Ease of design 3)	+	++	++	++	+	++	+++
Product examples	LM3743 LM274x LM2853	LM5115	LM201xx LM202xx LM3481	LM557x LM3495 LM5116	LM3489 LM3485	LM5010 LM1771	LM310x

Ratings:	
+++	excellent
++	good
+	ok
-	poor

1) feature may not be provided in all products
2) very much depending on ESR, L, Vin, Load, ...
3) can be positively influenced with good design tools, such as National's Webench® or an integrated compensation, as realized in the Simple Switcher family

Overall this has some advantages and disadvantages. Positive arguments are the easy control loop. It is very easy to get such a controller stable.

The control loop is extremely fast with a delay response of less than 100ns. This results in extremely fast transient response. It is superior to any competing PWM regulator architecture.

The disadvantage of such a control scheme is mainly the very large range of operating switching frequency. The selection of the right components and corrective actions with respect to EMI might make it more difficult too.

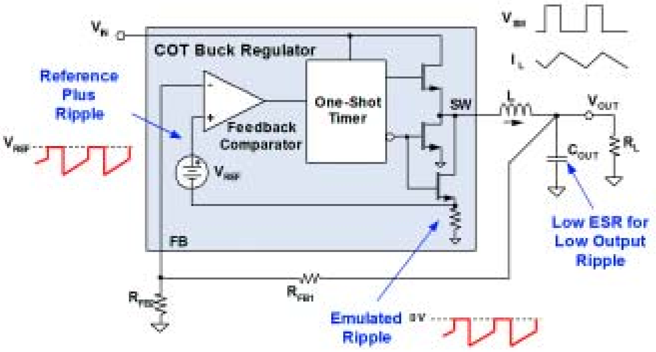

Figure 4: Internal creation of the ripple

Hysteretic Constant On Time (COT)

As mentioned above, the hysteretic scheme has some interesting advantages, with the only major problem of a 'more or less' unpredictive switching frequency. The introduction of a one-shot generator triggered by a comparator and the on-time being inversely proportional to the input voltage, the switching frequency remains now nearly constant.

In practice, load variations will vary the switching frequency around the centre point. This actually has a positive side effect with regard to EMI results, because the switching frequency will not create a single peak, so it becomes easier to fulfill EMI limits. Actually it behaves similar to a spread spectrum system.

There is one remaining thing that requires the designer's attention: The comparator input (FB) does require a minimum ripple for stable operation. Thus, a minimum ESR is usually required at the output capacitor to generate a sufficient ripple voltage. Because of this, ceramic capacitors cannot be used without other measures such as integrating the switch-node voltage and then adding the resulting triangle waveform to the feedback input voltage (see National's LM5010A datasheet, figure 11, page 15 for more details).

Besides this ripple issue, such a concept is easy to use and the transient response remains very fast. It actually combines many of the advantages of a PWM fixed frequency concept and a hysteretic mode concept into one solution. In discontinuous operation, the switching frequency decreases together with the load current. This keeps the conversion efficiency high at light load.

COT with Emulated Ripple Mode (ERM)

The emulated ripple mode is a new methodology, patented by National Semiconductor, which overcomes the need for an appropriate ripple at the feedback input. This allows the use of any capacitor type, including those with a low ESR, e.g. ceramics. Figure 4 shows the internal creation of the ripple (emulated ripple) which is of course still required for proper operation of the comparator, but because that creation is internally, you don't need to worry about it anymore.

This new technique combines ease-of-use, fast transient response and nearly constant switching frequency in one. It has been first implemented in the new LM310x synchronous buck regulators that are also members of National's PowerWise product family. More products of this kind are planned to be announced within this year.

Conclusion

The importance to understand functionality inside any controller is essential to benefit from its advantages associated with a particular application. Table 1 shows a summary of the discussed topics and control techniques and compares them without claiming for completeness. There are many other derivatives and combinations of techniques possible. ERM adds another 'flavour' to the picture and has its specific advantages as discussed above. National Semiconductor offers a wide range of solutions utilizing those mentioned and others for any application and power size, together with software simulation, technical support and training material that facilitate the selection and the design of your power supply.


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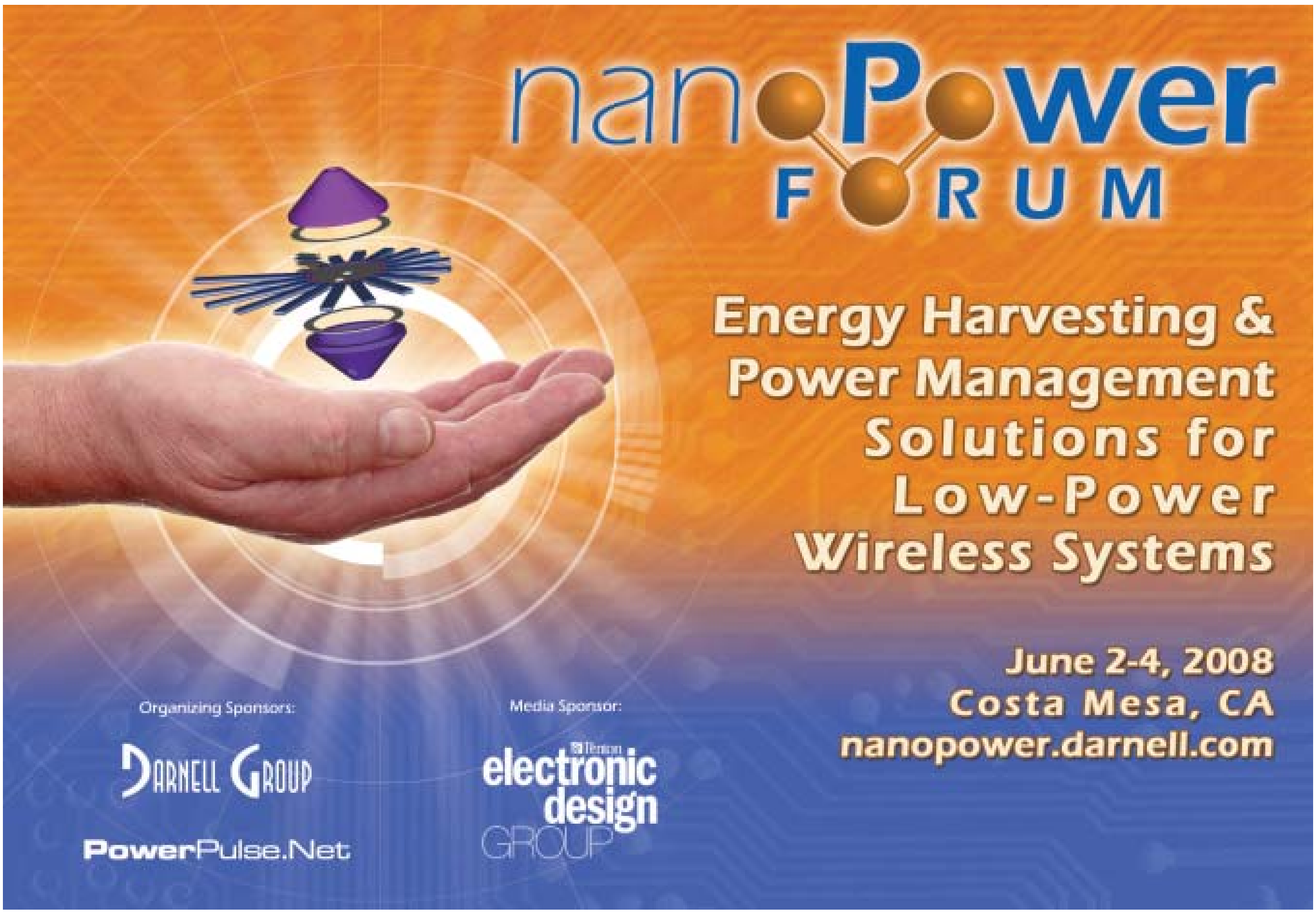
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Powering The Next Generation of Digital Television

The power density of a switch plays a big role

Television's evolution from analog to digital alters the very concept of what a television is. While the main function of a television remains as a method for watching broadcast channels, it has also evolved, becoming a multimedia center in itself.

By Mike Voong, Applications Engineer,
Alex Baskin, Senior Product Marketing Manager, Mixed-Signal Products and
John Lee, Non-Portable Power, RF and Mixed-Signal Products, Micrel Inc.

The new generation of digital televisions includes smart cards, USB ports, Bluetooth, Internet access, cameras, and more. Combining the power requirements for these new functions with those of powering up a digital television will require more than a dozen separate power rails. And in the spirit of evolution and moving towards the future, television manufacturers will now have to juggle the dilemma of powering these new functions with ever more efficient "green" power. The objective of this article is to discuss using new technologies that help alleviate an increased demand of power in digital television.

Power Switches

The most prevalent method of minimizing power losses due to increased functionality is to disable these functions when they are not in use. With the use of a power switch, the control circuitry can prevent power to these unused functions, minimizing the overall system's power. However, with the many manufacturers of power switches out there, it is hard to know what to look for in a good power switch. Efficiency, size, and functionality of the power switch are all tradeoffs designers have to prioritize. In most cases, choosing either functionality or efficiency would translate to a bigger switch. Fortunately, with new process, geometry, and packaging, designers can face all three tradeoffs in one solution.

Since all power going to the circuitry has to go through these power switches, it makes sense that efficiency is a priority. The ON resistance (R_{DSon}) of a switch plays a big role in how efficient the power switch is, the lower the R_{DSon}, the higher the efficiency. Figure 1 compares the R_{DSon} of industry-leading power switches with those in the Micrel power switch family. Micrel's MIC94060 and the MIC2009 families have one of the industry's lowest R_{DSon}, helping provide the highest efficiency in power switches.

In order to achieve low RDSon, the effective surface area of the switch needs to become larger. Since television board space is limited, the size of the switch can not be increased without bound. Fortunately, a new packaging improvement in Micrel's power switch family has helped to maintain a low RDSon while still keeping the package size small. To accomplish this, the package does not the use traditional bond wire connections from the die to the pads. Instead, Micrel uses a thicker and shorter copper connection, helping provide lower R_{DSon} in a small package size.

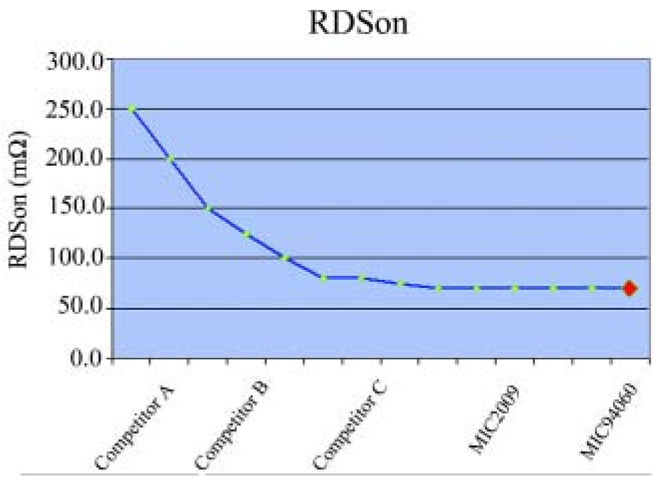


Figure 1: RDSon of industry-leading power switches

Size and RDSon are important qualities, but the power switch itself must still be able to provide the power necessary to power these new functions. Similar to achieving low RDSon, a higher current capacity is usually accompanied with an increase to the switch size. The comparison of output power to the package size gives the power density. Again, because board space on a television is expensive, power switch size cannot be enlarged without bound. This will lead the designer to choose the part with a higher power density to ensure the circuitry receives adequate power while not taking up any unnecessary space. Figure 2 compares the power density of industry leading power switches to those in Micrel's power switch family. With the recent introduction of the Propeller FET to Micrel's process, coupled with the packaging improvements, Micrel is able to achieve more than five times the power density of the closest industry leaders.

The importance of features in power switches should not be overlooked. Certain added features can help protect the digital circuitry from shorts or in-rush currents and provide fault reporting. Supplies in digital televisions will drive up to three or four different functions and therefore, become capable of sourcing high currents. Without some protection, the camera or Bluetooth circuitry would cease to operate. The most common method of protection is current limit. Types of current limit protection can differ from fixed, adjustable, to other unique methods of limiting.

Micrel's new Kickstart™ current limiting feature allows momentary high current surges to pass without sacrificing overall system safety. This unique feature is useful with dynamic loads such as small disk drives or portable printers connected through the USB ports of the television. The extra current is needed to help overcome inertial loads. Without the Kickstart™ feature, the motors could be starved and cause load to stall or stutter. Kickstart™ comes with in internal delay, typically 128mS, where a secondary current limit is used within the duration of the delay. After the delay, the current limit reverts to the original current limit of the part.

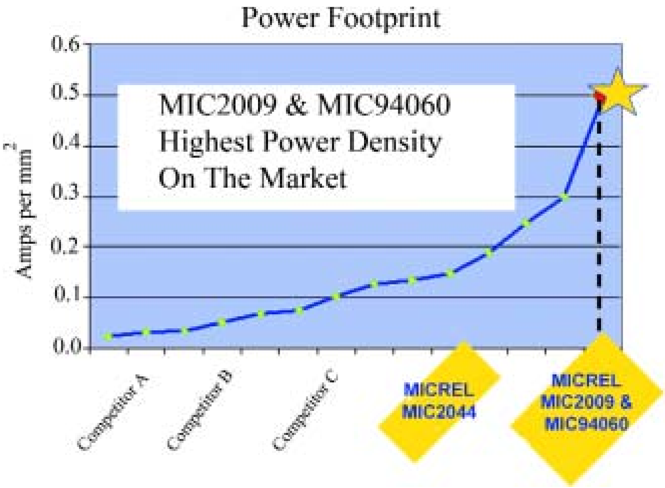


Figure 2: Power density of industry leading power switches

Protecting the digital circuitry goes beyond current limit. When the processing unit of the television decides to turn on a function, the in-rush of current could cause an overshoot in the startup voltage. Using switch output protection functions such as soft-start, the circuitry after the power switch can slowly ramp up even with an overshoot in the input voltage. An equally hazardous effect could also happen when the output of the switch is disabled and the output voltage is waiting to be discharged. This output voltage could potentially back bias other supplies. Fortunately, a load discharge feature can be used to help discharge the output voltage quickly and safely. These protection features as well as thermal protections and under voltage lock out will make sure the power is controlled and only available when desired.

MIC2009 and MIC94060

The newest additions to Micrel's power switch family are the MIC2009 and MIC94060, capable of driving up to 2A. The MIC2009 includes features to provide the ultimate protection for a power switch. Integrated in the chip are two forms of current limit protection, one embedded in the Kickstart™ feature and the other adjustable from 0.2A up to 2A. Also included are the thermal protection and under voltage lock-out for thorough control of the output. With the downstream circuitry well protected, the MIC2009 also includes a Fault status flag that indicates if the part has been shutdown due to current limit or thermal shutdown. A Fault masking feature is included to eliminate any noise-induced false alarms.

The MIC94060 is a high-side load switch driven by a built-in level-shift and slew-rate control circuitry. The built-in level shift circuitry allows for a logic signal that may be different from the supply voltage to switch the high-side P-channel MOSFET on or off. A 1µs turn-on slew rate control prevents in-rush current from causing glitches on the supply rail. The MIC94060 also features an active pull-down circuit that discharges capacitive loads through a 200-Ohm switch when the IC is set to the OFF state. Pull down circuitry keeps the MIC94060 in a default OFF state until the EN pin is pulled to a high level. This power switch is capable of further minimizing the power dissipation with its low 2ìA operating current.

The MIC2009 and MIC94060 have industry-leading size packages of 2mm x 2mm MLF® and 1.2mm x 1.6mm Thin MLF® packages, respectively, giving them one of the highest power densities in the industry. Both of these parts are have less than 1ìA of shutdown current, helping keep power dissipation low and maximizing efficiency. Their power densities, coupled with their efficiently low RDSon of 70mohm, make them the ideal choice for power switches used in digital television.

www.micrel.com

Introduction to IEC 60269

gS Type Fuses

In circuits where there are no overloads requiring the gG fuse curve it is possible to use a gS fuse and optimise the protection by reducing the peak current and then improving the coordination with all associated switches and components.

By Charles Müllert, Ferraz Shawmut

The gS type fuses are new fuses defined by the IEC 60269-4 standard . They are fuses designed for the protection of semi conductors and cables.

the IEC 60269-4 4 main sections
- IEC 60269-1: general section
- IEC 60269-2: protection systems with fuses for authorized persons (industrial applications)
- IEC 60269-3: protection systems with fuses for unskilled persons (household applications)
- IEC 60269-4: protection systems with fuses for the protection of semi conductors (special applications)

IEC 60269 fuse types (or classes) are defined with two letters.

The IEC 60269 defines two large families of fuses with the first letter:
- The « g » fuse: general purpose fuse; it will interrupt all faults between the lowest fusing current and the breaking capacity. Such a fuse is able to protect against overloads and short circuits.
- The « a » fuse: this fuse can not interrupt faults below a specified level. Such a fuse is generally used to provide short circuit protection only. The « a » fuse must be associated to another protective device designed to interrupt overloads.

The second letter indicates the utilization category (or application type):
G = cable and conductor protection
M = motor circuit protection
R = semi conductor protection
S = semi conductor protection
Tr = transformer protection
N = North American conductor protection
D = North American "Time Delay" for Motor circuit protection

Most wellknown fuses are : gG, aM, gM, aR, gR etc…

Note: FERRAZ SHAWMUT fuses type URB,URC, URD, URE etc are all IEC aR type fuse. The UR- designation is necessary because FERRAZ SHAWMUT offers a lot of fuses having the same rated voltage and rated current but with different I^2t . They can not be in a same group with the same designation. However the marking of the fuse shows the URD designation as well as the aR designation as per IEC 60269.

The gS fuse is then a fuse for semi conductor protection able to interrupt low overloads and short circuits. The gR fuse is able as well to interrupt low overloads and short circuits. The difference between the two fuse types is only in the non melting current value:

The gS fuse will not melt when the overload is below 1.25 In (In is the rated current of the fuse)
The gR fuse will not melt when the overload is below 1.10 In (In is the rated current of the fuse)

The top of the prearc curve (Time / current curve) of the gS fuse and the gG fuse are defined in the same manner.
For both fuses the conventionnal non melting current is 1.25 In and the conventionnal melting current is 1.60 In.

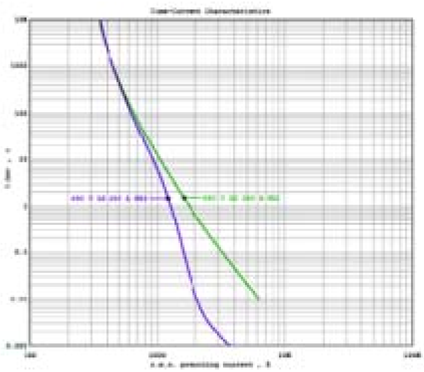


Figure 1: Difference between the prearc curves of the gS 250 A fuse and the gG 250 A fuse as well as the large difference of the i²

The curves are different for times between 1 hour and 1 miliisecond:
- the gG fuse must comply with non melting gates and melting gates between 10 s and 100 ms.
- the gS fuse does not need to comply with any gates and then can melt for currents lower than the non melting gates of the gG fuse. This is why the gS fuse can be fast enough to protect semi conductors.

As an example figure 1 shows the difference between the prearc curves of the gS 250 A fuse and the gG 250 A fuse as well as the large difference of the i².

Introduction to the 690 V gS fuses in the FERRAZ SHAWMUT NH technology
This fuse range is using the NH technology (figure 2) so that all corresponding fuse holders and fusegears can be used. For such fuses it is not necessary to derate their operating current as their power consumption comply with the maximum wat losses of the standard accessories.
In an existing circuit protected by a gG fuse it is not recommended to propose its replacement by a gS fuse. As a matter of fact the gS fuse, due to its speed, can be subjected to undesired interruption of normal transient currents (inrush currents or currents resulting from acceptable overvoltages).
It is then possible to replace a gG fuse by a gS fuse with the same current rating in circuits where there are not overloads requiring the non melting gates of the gG fuses.
Therefore circuits feeding a current converter controlling all overloads can be protected by a gS fuse. This fuse will be able to protect the conductors as well as the semiconductors of the converter.

These fuses have temperature rises much lower than very fast acting URD type (table 1).

Figure 2: This fuse range is using the NH technology

TABLE 1			
SIZE	RATED CURRENT (A)	DISSIPATED POWER (W)	
		PSC 690 V URD	NH 690 V gS
1	250	52	29
2	400	75	41
3	500	105	52
3	630	120	63

Table 1: temperature rises

Consequently the calculation of the rated current of a gS fuse is using easier corrective coefficients (table 2).

TABLE 2		
	CORRECTIVE COEFFICIENTS	
	PSC 690 V URD	NH 690 V gS
A	130	130
C1	0.85	1
A_2	0.60	0.75
B'_2 for 5s < t < 100 s	0.60	0.75

Table 2: Using easier corrective coefficients

It can be seen the ratio between the rated current of an URD fuse and a gS fuse is often 1.5 and sometimes more. The rated current of the gS fuse will always be smaller than the rated current of an URD type fuse.

TABLE 3			
SIZE	RATED CURRENT (A)	I^2t (A^2S)	
		PSC 690 V URD	NH 690 V gS
1	250	27 000	77 000
2	400	86 000	271 000
3	500	107 000	435 000
3	630	225 000	750 000

Table 3: The rated current of the gS fuse will always be smaller than the rated current of an URD type fuse

For this reason the i^2t of the URD fuse must not be compared to the I^2t of a gS fuse having the same rated current. For example (table 3) the gS 250 A fuse must be compared to a PSC URD 400 A or the gS 400 A must A gS fuse may replace 2 fuses:

In an installation there are often circuits where two different types of fuses are fitted in two different cubicles at each end of a cable (figure 3). They are in series.
A new calculation of the fuse protecting the speed variator shows the NH 690 V URD fuse rated 450 A can be replaced by a 690 V gS 315 A fuse.
But the same 690 V gS 315 A fuse can replace as well the gG 300 A fuse upstream. As a matter of fact the gS fuse is able to protect the 185 mm² cable connecting the two cubicles to each other.

Finally it is not necessary to use a fuse inside the cubicle containing the speed variator since it is enough to replace the gG 300 A fuse by the gS 315 A fuse in the upstream cubicle (figure 4).
This brings also the advantage to reduce the temperature rise inside the cubicle containing the speed variator. be compared to a PSC URD 630 A or even to a 700 A according to the type of equipment to be protected.

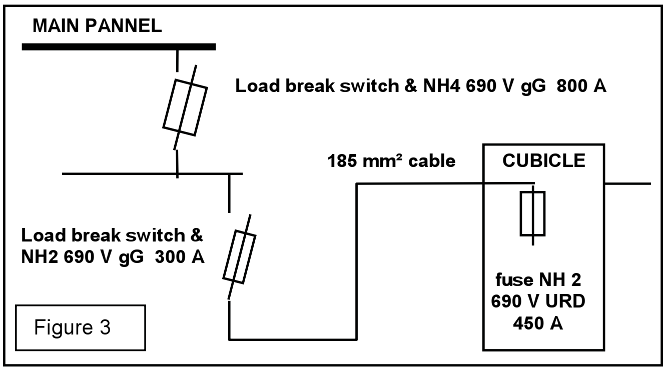


Figure 3: There are often circuits where two different types of fuses are fitted in series.

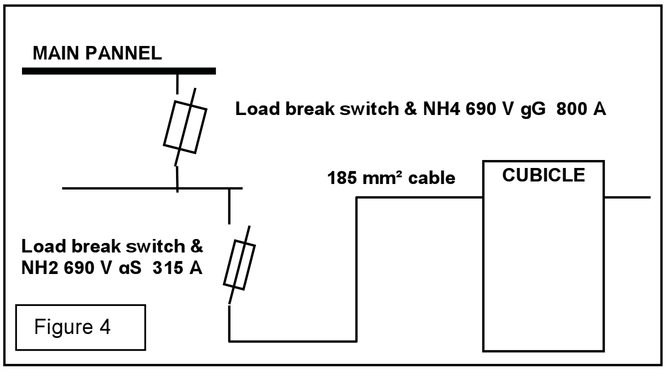


Figure 4: It is enough to replace the gG 300 A fuse by the gS 315 A fuse in the upstream cubicle.

Conclusion

The gS 690 V fuses are well adapted to the protection of cables and static converters. Moreover in circuits where there are no overloads requiring the gG fuse curve it is possible to use a gS fuse and optimise the protection by reducing the peak current and then improving the coordination with all associated switches and components.

www.ferrazshawmut.com

Battery Authentication ICs for Cell Phones

Intersil Corporation introduced the most advanced and flexible battery authentication ICs for cell phones, featuring the company's unique FlexiHash technology.

The new ISL9206 and ISL9206A are cost-competitive battery authentication ICs that incorporate Intersil's FlexiHash+ engine. It provides very high levels of security using a basic challenge/response scheme based on 32-bit challenge code and 8-bit response code.

FlexiHash+ employs two sets of 32-bit secrets for generating authentication code to offer tens of billions of potential configurations for users. And with 16x8 one-time programmable (OTP) ROM, the devices can store a total of three sets of these 32-bit secrets.

Programmable memory adds the ability to store up to 48 bits of ID code and/or pack information. The result is fast, highly secure and flexible battery/device authentication that makes hacking prohibitively difficult due to the exhaustive key search that would be needed to break a code.

www.intersil.com/power

Highly Flexible Processor-Based Power Solutions

International Rectifier's IR3502 XPhase control IC provides overall system control and interfaces with any number of IR's XPhase®

phase ICs, each driving and monitoring a single phase. The IR3502's key features include 0.5 percent overall system set point accuracy and daisy-chain digital phase timing for accurate phase interleaving without the need for external components. Combined with the IR3507 phase IC, the IR3502 and IR3507 chipset provides the power state indicator (PSI) capability to improve voltage regulator module (VRM) light load efficiency.

Designed for IR3502 for Intel VR11.0 and VR11.1 processors, the IR3502 is 50 percent smaller than a traditional six-phase control IC in a 7mm by 7mm MLP package. Co-designed with the IR3507 phase IC and DirectFET MOSFETs, the Xphase chipset provides higher power density compared to traditional multiphase architectures and results in a power supply that is smaller, less expensive, and easier to design introduced.

See You@PCIM Stand12/202

http://www.irf.com

Filters for Wind Turbine Generator

Premo EMC presents the EMI FVDT filters series to be installed in frequency investors destined to wind turbine generator.

These filters present high extenuations in 150 kHz up to 30 MHz frequencies according to EMC 2004/108/CE Directive and specific norm product EN61800-3:2004.

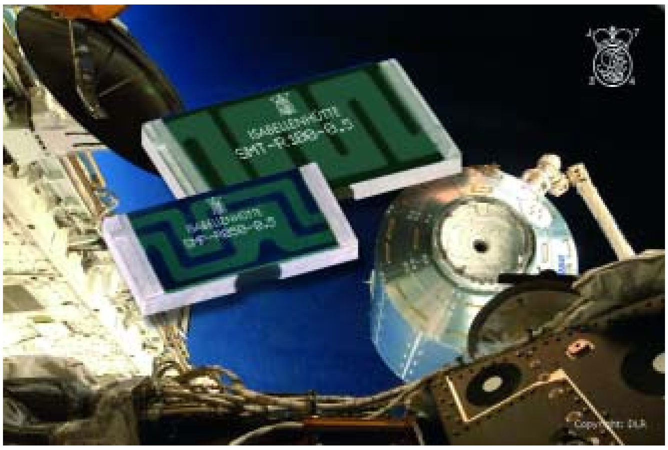
The product range destined to wind turbine generator include three-phase filters which current range from 180 amperes up to 900A. Nominal tensions can be 520 Vac or 720 Vac according to investor requirement.

The filters format is stand-alone and they are connected by copper platens. Filters have been designed to work at nominal current with atmosphere temperatures up to 50ºC and their climatic classification (HMF) guarantees the correct components functioning up to 100ºC in these conditions.

www.grupopremo.com

SMx Resistors in the Columbus Space Laboratory

The European Columbus laboratory is now in space, and precision resistors from the Isabellenhütte SMx series are on board. It is by no means easy to fulfil the stringent requirements set by aerospace and space organisations. Components must function reliably even when subjected to extreme influences. For example, the SMx series resistors for use in space can endure the vibrations which occur when the shuttle lifts off, remain undamaged in conditions of ultra high vacuum and at high levels of radiation and still perform consistently at a temperature of -50 °C.
To ensure this degree of reliability in such extreme surroundings a large number of tests is performed on individual components taken from normal production lots. The rigorous testing includes ageing tests, detailed visual inspections and vibration tests.
Most of the resistors deployed in space are manufactured using ISA-PLAN technology. This process ensures a high continuous load capacity (3 watts) as well as a high pulse power rating.



See You@PCIM Stand12/629

www.isabellenhuette.de
www.isa-asic.de

L1-Series Intelligent Power Modules

Mitsubishi Electric is introducing its Intelligent Power Module (IPM) of the L1-Series featuring high-speed, low-loss IGBT chips with full gate CSTBT™ (Carrier-Stored Trench Gate Bipolar Transistor). In addition to the mechanical compatibility with existing L-Series IPMs, L1-Series family covers an additional small package with improved performance.

The active plugging cell in Full-Gate-CSTBT-Structure of L1-Series IPM offers significant improvement in VCE(sat) (L-Series IPM: VCE(sat) of 1.9V, L1-Series IPM: 1.75V (@ Tj = 125°C) by keeping the Eoff almost at the same level. Furthermore, the total switching losses in L1-Series IPMs are reduced by 15% as compared to L-Series IPMs at comparable conditions.
The L1-Series, which is designed for optimized switching and conduction losses with good EMI performance, is suited for switching frequencies up to 20kHz.

See You@PCIM Stand12/301

www.mitsubishichips.com

Digital IGBT - Drivers

InPower Systems Germany offers a broad portfolio of digital IGBT- drivers for medium- and high-power-IGBT – modules in the voltage range from 1200V to 6500V. The drivers may be used in single- and multilevel–topologies. Key advantage of the digital drivers compared to analog solutions is the wide function range: In addition to variable hardware (gate- and emitter - resistors and –capacitors) the software may be adapted (e.g. timing constants and delay times).
Despite the excellent performance compared to an analog solution this trailblazing technology offers an excellent price-performance ratio.
Using these new drivers allows reducing the switch-ON-losses; in addition the drivers include excellent protection features for the IGBT-modules. The drivers may easily be adapted to the application by changing the software; changes are possible on the fly without demounting. Programming skills are no precondition for users, as the drivers are delivered plug-and-play and optimized for the used IGBT-module.
Besides the standard portfolio InPower Systems is your partner for customized solutions.
Applications are industrial drives, power-supplies, transportation and in the field of renewable energies, the internal switching frequency of 20MHz allows the use in applications with higher frequencies (e.g. induction heating).

InPower Systems has a long lasting experience in drive technology, the drivers prove themselves in the field since many years.

See You@PCIM Stand12/602

www.inpower-sys.com

Spring Lever Technology

Worldwide expert in connection technologies for over 60 years, ABB is launching a new PCB terminal block using an innovating spring lever connection technology.
Ergonomics, rapidity and security are the main ideas which have driven the design of the SLT range.

It becomes easy to safely connect equipments with the user friendly bistable lever. The finger replaces the screwdriver. It offers a great wiring solution that reduces operator fatigue and strain on the PCB.
The SLT terminal block can be used with the reflow soldering process to optimize manufacturing costs.
This patented system offers one of the most reliable solutions on the market in terms of vibration and shock resistance.
The cable clamping pressure is not dependent on the operator.
This is a single block product that is particularly robust and compact.

www.abb.com

Field Stop Trench IGBTs Increase Efficiency

Fairchild Semiconductor's new series of 1200V Field Stop Trench IGBTs, the FGA20N120FTD and FGA15N120FTD, provide system designers of induction heating applications with a highly efficient solution. Using both Field Stop structure and avalanche-rugged Trench gate technology, these IGBTs offer optimal tradeoffs between conduction losses and switching losses, which maximize efficiency. Compared to conventional NPT-Trench IGBTs, the FGA20N120FTD offers 25 percent lower conduction losses and eight percent lower switching losses, significantly reducing the system's operating temperature. By lowering the cooling needs, system reliability is increased and overall system cost is reduced. Reliability is further ensured by a built-in fast-recovery diode (FRD) that is optimized for Zero Voltage Switching (ZVS) technology.

Fairchild's FGA20N120FTD and FGA15N120FTD minimize performance variability and device failures in avalanche-mode operation due to a tight parameter distribution and increased avalanche energy. This is achieved with Fairchild's innovative Field Stop structure and proprietary advanced Trench gate cell design.

See You@PCIM Stand12/601

www.fairchildsemi.com

LCD with LED backlight

With the introduction of the new 10.4-inch display LQ104V1DG62, Sharp presents a fully industry-compatible TFT LCD with LED backlight for the first time. Like all displays in the Strong2 series from Sharp, the new industry display from Sharp is also characterised by

extreme resilience. The special housing design means that the new industry TFT LCD withstands accelerations of up to 14.7 m/s² in the range of

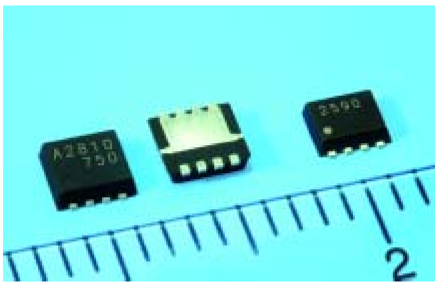
57 – 500 kHz during the vibration test. In the standard impact test, the display can withstand impacts with acceleration values of up to 490 m/s² without damage when switched off.

Furthermore, Sharp has designed the housing specifically for the LED backlight and equipped it with dedicated heat management: Heat conductors transport the dissipation heat of the LEDs to the rear outer side of the panel where it can be easily given off into the environment. Like all the other displays in the series, the new LED backlight variant of the proven Strong2 LCDs therefore fulfils the full industry specification with an operating temperature of -30°C to 80°C and a lifecycle of 50,000 hours.

www.sharpsme.com

PowerMOSFETs Targeting Mobile Devices

NEC Electronics Europe announced the availability of two new package types, 8p-VSOF and Mini-HVSON, for notebook computer and other mobile device applications. Besides realizing very low on-state resistance values and high speed switching characteristics, the 7 devices in the new packages have the additional advantage to reduce the mounting areas significantly. The introduction of the new package types is part



of the company's product portfolio expansion for PowerMOSFET devices.

Two N-channel and one P-channel MOSFET have a 3.3mm x 3.3mm x 0.9mm Mini-HVSON package.

www.eu.necel.com/mosfet

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8. Electromagnetic Compatibility
9. Power Electronics in Transportation
10. Mechatronic Systems
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Notification of provisional acceptance:	23 March, 2008
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http://www.epe-pemc2008.put.poznan.pl

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Advanced Modular Power Platform

The Brick Business Unit of Vicor Corporation announces the introduction of an advanced modular power platform: the VI BRICK. The VI BRICK family incorporates the superior technical attributes of V?I Chip™ technology and a robust packaging that facilitates thermal

management and through-hole assembly. Models include high-current density low-voltage DC-DC converters, a wide range of highly efficient bus converters (BCM), and individual modules – PRM and VTM - for both regulation and transformation.
Incorporation of V•I Chip technology into the traditional brick environment gives power designers significantly increased power capabilities and greater design flexibility.
VI BRICK BCMs provide a highly efficient solution for Intermediate Bus Architecture or point-of-load (POL) designs that require multiple output voltages. They are available with nominal input voltages including 48 Vdc (11 models) and high voltage up to 380 Vdc (three models) and a wide array of output voltages from 1.5 to 48 Vdc. The efficiency and compact size of these modules yields power density up to 390 W/in³ and their fast transient response means that less capacitance is required for energy storage near the load which equates to space and cost savings.
See You@PCIM Stand12/431

www.vicoreurope.com

Heatsinks for 19" EMC Subracks

The reliable functioning of electronic subassemblies in EMC applications is sometimes compromised thermally, as closed casings cannot easily ensure heat dissipation from the electronics. Fischer Elektronik is able to offer suitable heat dissipation methods using heatsinks adapted to suit 19“ subracks. The heatsinks with a width of 84U and a height that matches the subrack height are suitable for installation on the rear or on the front of subracks. The heatsink design,

which complies with EMC requirements, features an electrically conductive surface coating and contact strips for connection to the subrack chassis. This ensures efficient heat dissipation and effective EMC protection.

See You@PCIM Stand12/458

www.fischerelektronik.de

PFC 100-kvar Capacitor Contactor

The range of capacitor contactors of the Epcos B44066S*J230/N230 series has been extended by a 100-kvar version for PFC equipment with and without reactors. This means that a total of seven power stages are now available: 12.5, 20, 25, 33, 50, 75 and 100 kvar.

For the first time, a 100-kvar circuit can be implemented with only one contactor, obviating the need to connect two 50-kvar components as before. This allows better utilization of the space in the switching cabinet. In addition, the new contactor offers all the benefits of the previously available series: avoidance of transients, longer operating life of the capacitor and the whole PFC system thanks to optimized switching behavior, reduced resistive losses and good attenuation of high inrush currents.

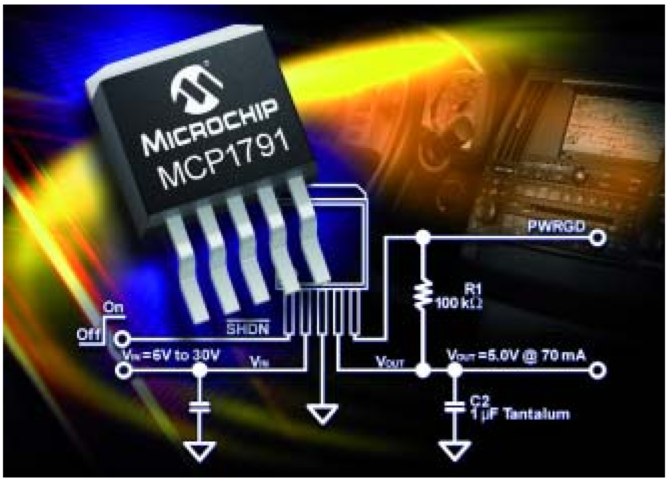
The precharging resistors for attenuating the transients are integrated into the package in the new type, unlike in the lower-power versions. Two variants are available: B44066S9910J230 and B44066S9910N230. The latter is designed exclusively for applications with reactors.

See You@PCIM Stand12/535

www.epcos.com/pfc

High-Voltage Linear Regulators

Microchip announces MCP1790 and MCP1791 high-voltage linear regulators (LDOs). With a continuous 70 mA output, the ability to operate at a continuous input voltage of up to 30V and load-dump protection up to 43.5V, the new LDOs are ideal for automotive and industrial applications. They also feature low quiescent current, low shutdown current and ceramic capacitor stability, which enable smaller, ultra-efficient designs at lower costs.



The MCP179X LDOs were designed for use in applications requiring continuous operation at high input voltages, such as 12V automotive and 24V industrial applications. The built-in load-dump protection feature isolates the voltage transients often found in these types of applications, particularly those in the automotive market. All of this, combined with ceramic output capacitor stability and a low quiescent current of just 70 uA, enables more compact, power-efficient and reliable designs.
See You@PCIM Stand12/466

www.microchip.com/MCP179X

Ansoft Releases Maxwell v12 and RMxprt v12

Ansoft Corporation has announced Maxwell v12 and RMxprt v12. Maxwell is the company's electromagnetic field simulation software used for the design and analysis of 3D/2D structures, such as motors, actuators, transformers and other electric and electromechanical devices common to automotive, military/aerospace and industrial systems. RMxprt is a specialized software program dedicated to the design of electric machines.
Maxwell v12 includes a new 3D electric transient solver that solves time-varying electric fields due to a transient disturbance, such as lightning strikes on electrical equipment. The new version also is equipped with advanced model healing capabilities. This productivity feature will automatically identify and resolve potential problems with geometry imported from popular CAD systems and streamline the solution process.

See You@PCIM Stand12/516

www.ansoft.com

Industry's Lowest Power, High-Speed, Voltage Feedback Amplifier

Texas Instruments introduced a high-speed, unity gain stable, voltage feedback amplifier that features more than 90 percent less power than devices with comparable slew rates in the market today. The new device's unique architecture provides designers with high bandwidth and slew rate, coupled with a very low quiescent current, making it well-suited for portable instrumentation, active filters and analog-to-digital converter (ADC) buffers. The OPA2889 represents a significant evolution in unity gain stable, voltage feedback amplifiers, offering an excellent combination of bandwidth and slew rate capabilities while consuming only 460 µA of quiescent current per channel. Coupled with the ultra low power, the high bandwidth of 115 MHz and slew rate of 250 V/µs, allows customers to process data faster and more efficiently. The device also includes a power down feature, enabling even further power savings by reducing the quiescent current to 18 µA/channel when not in use. See You@PCIM Stand12/329

www.ti.com/amplifier

High-Current Flash LED Driver

National Semiconductor introduced the industry's first high-current light-emitting diode (LED) driver that enables dual LED operation for the camera flash function in portable multimedia devices.
The LM3553, a member of National's PowerWise® energy-efficient product family, drives one or two high-current LEDs in series in hand-held devices such as mobile phones, personal digital assistants (PDAs), smartphones, portable scanners and medical strobe lights. National's LM3553 flash LED driver is a fixed-frequency, step-up DC-DC converter with two regulated current sinks, driving loads up to 1.2A from a single-cell Li-Ion battery. Using the driver's adjustable over-voltage protection circuitry allows designers to drive two high-current LEDs in a series configuration, which maximizes the illumination-to-power ratio. The LM3553 can drive the camera in a high-power flash mode for still photography or a low-power torch mode for video recording.

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