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Bodo´s Power Systems®

Electronics in Motion and Conversion

October 2010

Setting the Benchmark for Accurate Current Measurement

Bodo´s Power Systems®

Bodo´s Power Systems®

The Gallery

for Accurate Current Measurement

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

Control complex Digital Power applications and save power

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

The powerful dsPIC33F 'GS' series is specifically aimed at power control applications and can be configured for a variety of topologies, giving power-supply designers the complete freedom to optimise for specific product applications. Multiple independent power control channels enable an unprecedented number of completely independent digital control loops. The dsPIC33F 'GS' series offers the optimal digital power solution supported by royalty free reference designs and advanced power design tools.

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

- Digital control loops with 12 to 18 high-speed, 1 ns resolution PWMs
- Up to 24 channels 10-bit on-chip ADCs
- 2 to 4 Million samples per second (MSPS) ADC for low latency and high-resolution control
- Pin range – 64 to 100
- Memory – 32 to 64KB Flash memory

dsPIC33F 'GS' Series Plug-In Module – MA330024

GET STARTED IN 3 EASY STEPS

1. Purchase a new 'GS' Series Plug-In Module
2. Download Digital Power Reference Design
3. Order samples and start designing!
   www.microchip.com/SMPS

Intelligent Electronics start with Microchip

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MICROCHIP

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Events

Digital Power Workshops
Munich Ger. Oct. 5
http://www.biricha.com

NDT Level 4
Dubai Oct. 11
http://www.ndtlevel4.com

Elektro Mobil Ausstellung
Aschaffenburg Ger. Oct. 8-9
http://www.ema-ab.de

Smart Grid Forum
San Jose, CA Oct. 18-20
http://SmartGrid.Darnell.com

Semicon Europa
Dresden Ger. Oct. 19-21
http://www.semiconeuropa.org

Substation Technology Europe
Berlin Ger. Oct. 25-27
http://www.theiet.org/substation

Electronica Munich Ger. Nov 9-12
http://www.electronica.de/en

SPS/IPC/DRIVES
Nürnberg Ger. Nov 23-25
http://www.mesago.de/en/SPS/main.htm

Power electronics
Moscow Nov.30-Dec.2
http://www.powerelectronics.ru

Power Smart Grid

The renewable energies derived from wind, water and sun and have to be distributed and stored in a way that ensures they will be available when demand arises. The grid is consists of several levels which are dictated by the level of high voltage distribution. Anything over that is in the kilo volt range including the DCDC transmission as explained by ABB in my July issue cover story. A reduction in loss of just a few percent versus an AC transmission over long distances can make a significant difference. End users are in the 100 volt regions. As a result we need a highly sophisticated system to forecast demand and distribution power lines that can handle current demand peaks by location.

Most of today's distribution networks were built by the established power generation and are optimized for centralized, old-fashioned power generation and distribution. We need investment to upgrade to very high power lines that can handle the current based on demand. Energy harvested offshore and in the desert require efficient long-distance transmission. The wind might blow over the ocean but the demand for the resulting energy is usually somewhere inland, thousands of kilometers away.

In our homes we have 110 and 240 volts on the line and while we talk a lot about smart metering, metering cannot foresee future consumption requirements – it simply follows existing demand levels and sets the kilowatt price. We need smarter systems that can forecast overall usage and communicate with power generators to either ramp up or down appropriately, providing constant power levels and eliminating peaks.
It's the peak demands that make additional power plants necessary. A case in point is peak morning time in California which have oil burning power stations distributed across the whole country desperately trying to keep up with demand. There are many exciting projects around the globe. Wind power can be stored locally by using the electricity to generate hydrogen and then storing the hydrogen for later usage. Electric vehicles and the charging station can be used bi-directionally. The battery can help feed the grid, but what if you want to drive your electric car and the battery is empty? Communication can avoid such situations.

One smart technology is small-sized power stations who practice "co-generation" in which heat and electrical power are generated together. The smart grid has a long way to go to before it can be considered practical. The semiconductor technology for supporting the smart grid is already available. What's lacking is the coordination and communication of what will be done by whom along with the financial investment in new transportation lines at the kilo volt stage. These are exciting prospects for the future. Presently the power meter is read manually every year in practically every household in Germany and since it's usually in the basement it requires a lot of time and effort. Electronic metering would be much more efficient and reduce costs significantly. The engineers have, for most part, done their jobs and now politicians have to do their part to make these systems work efficiently. I look forward to covering the progress for you in this area by highlighting upcoming solutions in science and industry.

Including this October issue - delivered, as always, on time – we will have produced a total of 598 pages this year: strong performance thanks to strong support.

My Green Power Tip for October:
Check your roof and consider solar panels. You can become an active part of the smart grid. Electrical solar power is a clean green generator of power.

Hope to see you at an upcoming event!

Best regards

Bodo

We're giving power a

digital upgrade.

Find out how our new Digital EXL Core™ technology is redefining Power Factor Correction ICs.

Cirrus Logic's CS1500 and CS1600 are the industry's first Digital Power Factor Correction (PFC) ICs to surpass ordinary analog solutions in performance and price. Enabled by Cirrus Logic's EXL Core technology, these digital solutions intelligently solve traditional power management challenges with newly patented and patent pending designs that dramatically reduce the need for bulky, high-priced components and complex circuitry, lowering overall system cost and simplifying designs. Cirrus Logic now makes it possible for more energy-efficient power supplies in digital televisions, notebook adapters, PC power supplies and lighting ballast applications through advanced digital technology that creates smarter, greener, and more energy-efficient products.

Experience Digital PFC. Register for free samples at www.cirrus.com/bppfc

CIRRUS LOGIC®

AEG Power Solutions Signs Frame Agreement with Bombardier

Bombardier is a world-leading manufacturer of innovative transportation solutions. Its equipment, systems and services will be used in eighty three electric multiple units of the brand new ET 430 train series.

"We truly appreciate the opportunity to continue and develop our close and long-term relationship with Bombardier Transportation GmbH, and we look forward to remaining a sustainable and viable business partner to Bombardier long into the future," says Sebastian Oertel AEG Power Solutions' Global Head of Business Development Transportation & Wind.

With decades of experience within the railway industry, AEG Power Solutions has utilized its world-class battery chargers to provide Bombardier with a tailored solution that satisfies all of the requirements of their new vehicles.

By leveraging its customization capabilities and high levels of product reliability, AEG Power Solutions customers can enjoy the full benefits of the end-to-end power solutions leader's railway portfolio.

In the field of railway power supplies, AEG Power Solutions stands out by offering component life expectancy which matches that of the trains themselves. Power supplies are manufactured with premium, industrial-grade components built to withstand extreme weather conditions, high-temperature and seismic environments. Engineers at AEG PS designed Bombardier's battery charger to meet its unique technical requirements and form factor.

www.aegps.com

SEMICON Europa 2010 to Focus on Latest Nano-Manufacturing Innovations

SEMI announced the lineup of keynote speakers and program highlights for SEMICON Europa 2010, which takes places in Dresden, Germany from October 19-21. All of the European fabs will present at the event, including GLOBALFOUNDRIES, Infineon, Intel, STMicroelectronics and X-Fab, as well as leading R&D organizations in SEMICON Science Park.

SEMICON Europa features the most advanced and innovative electronics platform in Europe. Key segments addressed include: semiconductor front-end and back-end, MEMS/MST, and Secondary Equipment and Advanced Packaging. This year, for the first time, the Plastics Electronics Conference will be co-located with SEMICON Europa, which will include topics like organic electronics, displays, organic photovoltaics, and lighting.

Driving advancements in semiconductor and related industries requires industry professionals to exchange technical and market information. Forty-one programs and events are scheduled in conjunction with SEMICON Europa this year, including: 12 technology conferences, 13 free technology and standardization sessions, 4 executive and networking events and 12 technical courses. Eight keynote speakers are scheduled for SEMICON Europa.

Program highlights at SEMICON Europa include the 14th Fab Managers Forum, with sessions on Fab Automation and Control, Advanced Technologies, Secondary Equipment Technology and Services, Fab/Equipment Life Cycle Planning and more.

www.semiconeurpa.org

Mersen Participated at Innotrans 2010 in Berlin

Carbone Lorraine is now Mersen. Ferraz Shawmut, a supplier of electrical protection solutions, is pleased to announce the name change to Mersen. This name change reflects his history - and more importantly his strategic direction. Ferraz Shawmut is now Mersen.

Ferraz Shawmut has long benefited from being part of Carbone Lorraine, a large international group which specializes in providing high-performance materials for extreme environments and solutions to enhance the reliability and safety of electrical systems. The company now consolidates its identity under one name: Mersen.

During Innotrans, Mersen had showcased his solutions, his expertise in providing power transfer solutions for safer and more reliable mass transportation means, the necessity of developing low-carbon transport systems and his diversity: through innovative product development and strategic acquisitions Mersen is positioned to serve a broad range of electrical applications with diverse solutions. Mersen is a recognized leader in various markets - energy, transportation, chemical/pharmaceutical, electronics, process industries with a focus on sustainability. Mersen represents every nationality around the globe, with production located to serve local markets across Asia, Europe and the Americas.

Moreover, in the Safety & Reliability for Electrical Power activity, Mersen is partner with major OEMs to design, bring to production and maintain complete electromechanical systems and integrates protection components and power transfer and connection solutions to meet targeted functions and performance.

Mersen had introduced a new DC Load break Switch for 750DC Railway Applications.

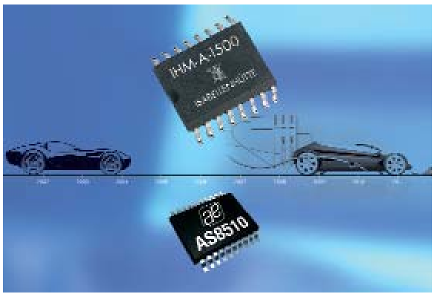
This switching device is capable of making and breaking currents. The available ratings are 2, 3, 4 and 6 kA. The key market is metro railway. These Mersen switches are used by transit authorities in substations and besides the track.

www.mersen.com

Flexible Battery Sensor ICs for Efficient Battery Management in all Vehicles

Isabellenhütte is one of the pioneers in current and voltage measurement of 12 V vehicle batteries. In 2002, the company introduced the ISA-ASIC, the world's first all-in-one measuring system for current, voltage and temperature for electronic battery management. Together with the Austrian company austriamicrosystems, which is an international leader in the field of design and production of high-performance analogue ICs, the company has produced numerous ICs for 12 V vehicle systems in recent years.

This longstanding successful working relationship has now led to a cooperation agreement being signed by both companies to focus their expertise. This will provide them with advantages for future development work and drive market penetration. Both austriamicrosystems and Isabellenhütte have already introduced sustainable solutions for measuring the current of 12 V and 24 V batteries and also high-voltage systems for hybrid and electric vehicles and will now jointly continue developing their products.



"We feel that by joining forces with austriamicrosystems in our development work, we are increasing our opportunities for developing and producing flexible and adaptable sensor systems", says Peter Müller, Managing director of Isabellenhütte Heusler GmbH & Co. KG.

"We have found a renowned partner in Isabellenhütte, whose precision sensor solutions are highly regarded in the automotive industry. We anticipate that demand for ICs will continue to rise, as battery management is a key technology for hybrid and electric vehicles", explains Bernhard Czar, Marketing Director of the Automotive division of austriamicrosystems AG.

Isabellenhütte is exhibitor at electronica 2010 hall B6, booth 436

www.isabellenhuette.de

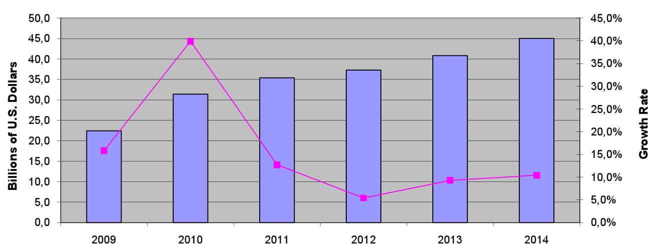
Power Management Semiconductors to Enjoy Unparalleled Growth

Fueled by gains in both the commercial and industrial sectors, the power management semiconductor industry will finish 2010 on a high note that will be unmatched over the next few years, according to the market research firm iSuppli Corp.

Comprising integrated circuits and discretes, power management semiconductors will generate $31.4 billion in 2010, up a sizable 39.9 percent from $22.4 billion in 2009. This year's expansion not only will reverse the losses of 2009—when revenue declined by 15.8 percent—it also will be unequaled during the next four years, none of which will enjoy growth higher than 13 percent.

The attached figure presents iSuppli's revenue projections for the power management semiconductor market from 2009 to the end of the forecast period in 2014.

iSuppli Figure: Revenue Forecast for Power Management Semiconductors, 2009-2014 (in Billions of U.S. Dollars)



Power management market to continue strong growth until 2014

Over the next five years, a good part of growth in power management semiconductors will derive from the vibrant alternative energy market, which will bring inverters to the attention of many suppliers. The need for inverters—devices that convert direct current to alternating current—will stem from applications in the automotive, solar and wind turbine markets. Revenue is expected to more than double by 2014, reaching $7.2 billion, compared to $2.9 billion in 2009.

Among the various types of power management semiconductors, the fastest growth will take place among power MOSFETs, a kind of discrete semiconductor device designed to handle large amounts of power.

From 2009 to 2014, power MOSFET revenue will increase at a Compound Annual Growth Rate of 20.8 percent—higher than any type of power management semiconductor in either the discrete or Integrated Circuit (IC) category.

Within the power MOSFET group, the best performer will be low-voltage discretes, exploding at a runaway CAGR of 25.6 percent during the same period of time with forecasted revenue by 2014 of $4.9 billion, iSuppli data show. Several markets will contribute to the growth of low-voltage power MOSFETs, including wired communications, consumer, automotive and industrial.

Overall, ICs will slightly outpace discretes in growth during the period. Total revenue for integrated circuits will climb from $12.4 billion in 2009 to $25.3 billion by 2014—a CAGR of 15.3 percent. In comparison, total revenue for discretes will rise from $10.0 billion to $19.7 billion—a CAGR of 14.5 percent.

Power management semiconductors as a whole are expected to grow about 15 percent, driven mainly by the notebook market, server infrastructure replacement and alternative energy requirements issuing from hybrid and electric vehicles, wind and solar energy and grid upgrades.

Furthermore, observable improvements in the efficiency of electronics products and processes that make use of the semiconductors—everything from power tools to forklifts, from trains to cars—can be considered an emerging trend for power management, iSuppli believes.

www.isuppli.com

SolarMagic Chipset Wins the Solar Industry Award

National Semiconductor announced that the company's SolarMagic™ SM3320 smart panel chipset has received the Solar Industry Award for the "Energy Usage Enabling" category, which recognizes technologies and processes that enable better energy usage. The industry, through Solar (A PV Management Magazine), honored National's in-panel SolarMagic chipset for optimizing efficiency through a new category of solar systems: "smart panels". National received the award on September 7 at the publication's Solar Industry Awards event in Valencia, Spain. Solar panels today are prone to underperform due to real-world conditions such as age, mismatch and shade. However, the SolarMagic SM3320 smart panel chipset uses advanced electronics to harvest the maximum energy from a solar system, providing junction box and module manufacturers with the ability to ensure the highest efficiency and return on investment. By coupling more energy production with a lower balance of systems cost, the SM3320, based on National's analog and mixed-signal technology, provides solar system owners a high-performance solution at the lowest cost per kilowatt-hour.

www.national.com

Successful Launch of the PV Production Forum 2010 in Valencia

The 'PV Production Forum 2010', jointly organized by the European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC) and the International Photovoltaic Equipment Association (IPVEA) attracted 250 participants in its three sessions about PV markets, silicon and thin film production. Industry experts from manufacturers and suppliers of PV fabrication equipment and related raw materials highlighted the newest trends and developments in PV production in 22 presentations.

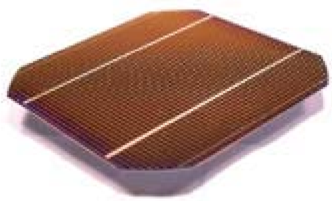
Both, presenters and participants of the PV Production Forum 2010 took the opportunity for networking across all segments of the industry and its changing dynamics, processes and production technology steps in the PV manufacturing supply chain.

Bryan Ekus, Managing Director of IPVEA is very pleased with the outcome of this first PV Production Forum: "The PV Production Forum 2010 has been a great opportunity to explore the connection between science and industry. Definitely, this will be repeated next year in Hamburg."

www.IPVEA.org

Large-Area Silicon Solar Cells with High Efficiency

At the 25th European Photovoltaic Solar Energy Conference (Valencia, Spain), imec presented several large-area silicon solar cells with a conversion efficiency above 19%. Two types of cells were realized namely with Ag-screenprinted contacts and plated Cu-contacts. Efficiencies of cells with screenprinted contacts were up to 19.1% whereas 19.4% was obtained with Cu-plated contacts. These high efficiencies were obtained thanks to several factors amongst which a combination of improved texturization and optimized firing conditions. The



results were achieved on large-area cells (148cm2) with 170µm thickness, proving the industrial viability of the process.

Imec's record efficiency silicon solar cells feature rear-side passivation, laser ablation and, local aluminum back-side field and screenprinted contacts or Cu-plated contacts on advanced emitter schemes.

The results were achieved within imec's silicon solar cell industrial affiliation program (IIAP), a multi-partner R&D program that explores and develops advanced process technologies aiming a sharp reduction in silicon use, whilst increasing cell efficiency and hence further lowering substantially the cost per Watt peak.

www.imec.be

Tommy Sokola appointed as National Sales Manager

Solitron Devices, Inc. of West Palm Beach, FL, a world class manufacturer of QPL Power Semiconductors located in South Florida has appointed J. Thomas (Tommy) Sokola as its' new National Sales Manager. Solitron manufactures MIL-PRF-38534 Hybrid Microcircuits and MIL-PRF-19500 Power Discretes.

Tommy is a 32 year veteran in the semiconductor industry with both military/aerospace and commercial experience from his time at Harris Semiconductor/Intersil in Palm Bay, FL., most recently being the Sr. Product Marketing Manager for several product families in the Power Management area. Mr. Sokola also served as a Program Manager on the Trident II missile program and other defense and space programs at Harris and as a Product Development Engineering Manager after several years in design and product engineering. Following his time in the semiconductor industry, Tommy served as Director of GSM Product Management for Vadium Technology in Tacoma, WA, a small company specializing in encryption technology.

Mr. Sokola reports directly to Solitron President/CEO Shevach Saraf and will be based out of Solitron's corporate headquarters in West Palm Beach, FL and can be reached at tsokola@solitrondevices.com or 561-848-4311 x102.

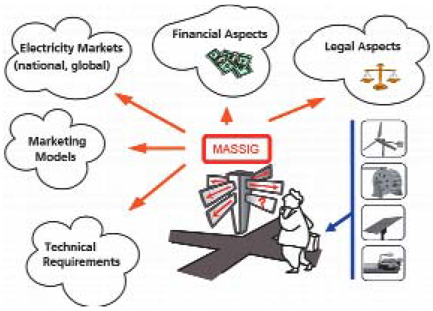
www.solitrondevices.com

Intelligent Marketing of Electricity from Distributed Generation

European Research Project Coordinated by Fraunhofer ISE Finalized.

Distributed energy generation (DG) from renewable and environmentally friendly energy sources will increasingly play a major role for electricity provision in Europe. Renewable energy systems (RES) and distributed power units with combined generation of heat and electricity (CHP) are going to take over a significant part of the electricity supply in Germany. Today their success still depends on subsidies and feed-in tariffs. But even now technical and economic concepts can be found allowing successful market participation of an intelligent mix of such generation technologies. An European team of researchers, utilities and service providers developed such concepts as part of "Market Access for Smaller Size Intelligent Electricity Generation (MASSIG)".

Within the research project "MASSIG" funded by the European Union researchers of Fraunhofer ISE together with project partners identified promising solutions for selling electricity from DG/RES on the liberalized electricity markets according to market needs. The key question was: How to enable small and medium size generators (up to some MW)



entering big markets? The project team investigated this for a number of exemplary ountries: Denmark, Germany, Poland and UK. The national market chances were analyzed by gain-loss evaluations considering the legal, regulatory and technical framework conditions in these countries. As key results measures and procedures for successful market participation were developed.

www.ise.fraunhofer.de

Partnership Capitalises on Strong Growth in Chinese Wind Energy Market

Goldwind Science & Technology Co., Ltd. recently signed a sales contract directly with Semikron China thereby ensuring the continued supply of SKiiP intelligent power modules and complete Semistack power electronic assemblies for the Goldwind wind power generators. This order further seals the business partnership of Goldwind and Semikron which provides solutions for the growing Chinese wind energy market.

"It is an honor to now be the direct supplier for Goldwind" says Lixin Ren, managing director of Semikron Greater China. "Semikron technology powers nearly half of the globally installed wind power capacity and Goldwind is one of the top five wind turbine manufacturers in the world. This is a perfect business combination. Our goal is to establish a long-term business relationship providing the most efficient technology and best service beneficial to both companies." The power electronics are optimized for wind power applications: SKiiP are the most powerful intelligent power modules on the market with a long service life. The SEMISTACK power assemblies boast a high power density of 12 kW/ litre and a flexible modular design.

Photo: "It is an honor to now be the direct supplier for Goldwind" says Lixin Ren, managing director of Semikron Greater China.

"A high quality supplier plays a vital role in the development of Goldwind and helps us grow and stay one of the leading wind turbine manufacturers in China," says Mr. Kai Wu, Supply Chain Management General Manager of Goldwind. "The state-of-the-art technology, reliable product quality and professional technical support of Semikron met our high standard of requirement. Semikron`s experience in stack design and production gave us confidence that we can work together and achieve long-term success."

In 2009, Semikron expanded its global network of Solution Centers to Zhuhai, China. The new solution center specializes in the design and manufacture of SEMISTACK power assemblies based on SKiiP for wind generators and solar power inverters. Customers can benefit from "made in China with German quality" power assemblies with flexible and customized designs, local technical support, fast deliveries and competitive pricing.

Goldwind is one of the first enterprises in China focusing on innovative research and manufacturing solutions for wind turbines. Since 2000, Goldwind has had an average annual growth of hundred percent for the last ten consecutive years. Goldwind was one of the top five global suppliers of wind power generators with a market share of 7.2 percent of the newly installed wind power capacity in 2009.

China has the world's second largest wind power capacity after the US and just ahead of Germany. In 2009, 13,7 GW wind power was installed thereby more than doubling the cumulative installed capacity in a single year, which has now reached 25.8GW (Source: BTM Consult APS, March 2010).

www.goldwind.cn

www.semikron.com

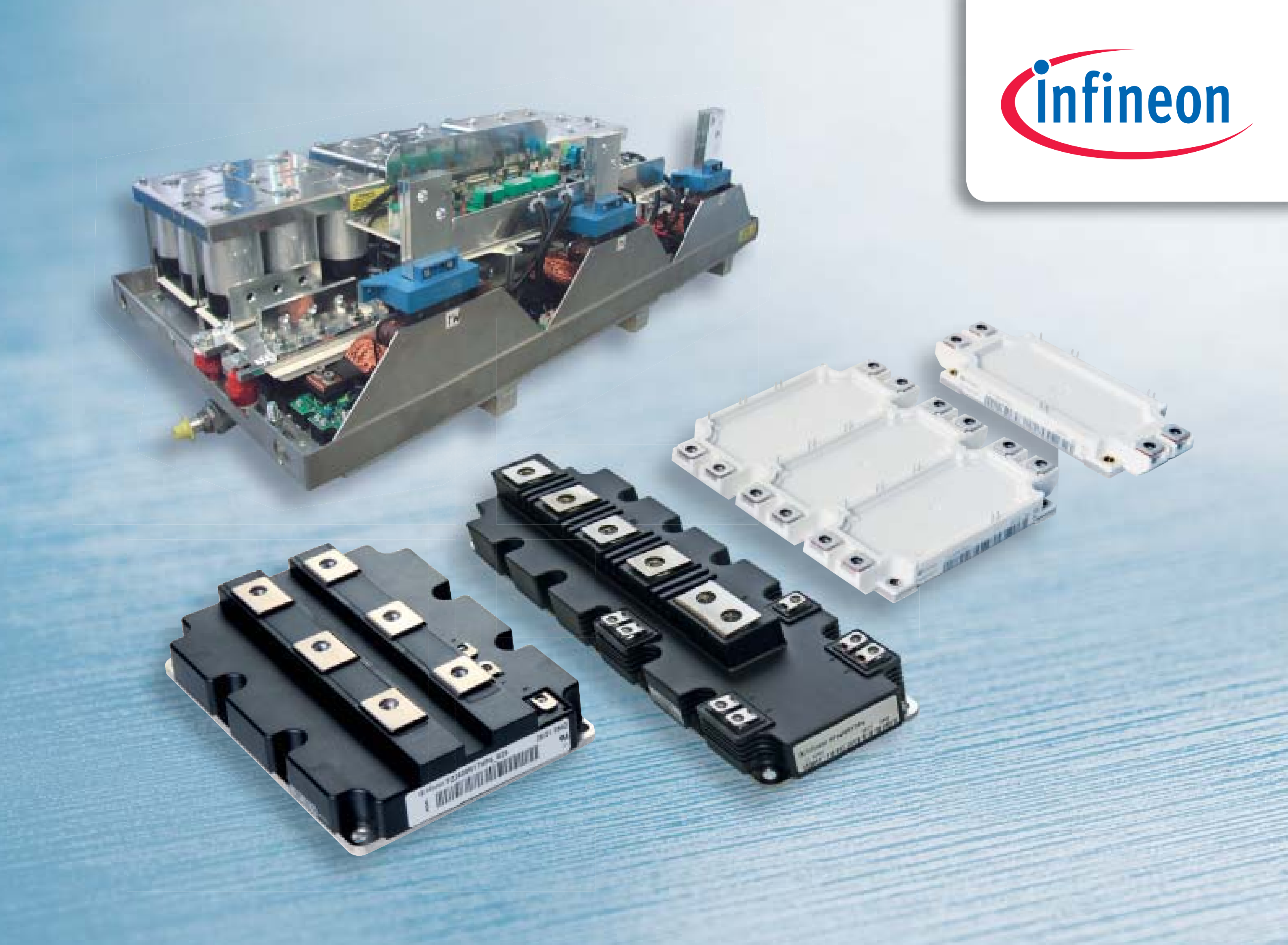
Unveil Latest Solutions at electronica 2010

Silicon Laboratories Inc. will demonstrate innovative semiconductor solutions for the wireless, embedded and consumer electronics markets at electronica 2010 from Nov. 9 - 12 in Munich, Germany. Visit Silicon Labs' booth A4.361 to see hands-on demonstrations of the latest proximity and touch sensing, sub-GHz wireless, timing, embedded control and connectivity, and consumer audio technologies, all designed from the ground up to reduce the cost, power and complexity of electronic designs.

Silicon Labs also will provide a free half-hour technical presentation for all electronica attendees, giving embedded designers an opportunity to learn more about adding touch-based and touchless human interface capabilities to their applications. The presentation will be part of the Embedded Forum and will be held in Hall A6 near the Main Entrance East at electronica 2010 on Nov. 11 at 1:00 p.m.

In addition, Silicon Labs' will demonstrate mixed-signal IC solutions in booth A4.361. Electronica 2010, Silicon Laboratories Inc., Hall A4, Booth # 361

www.silabs.com



Solutions for windpower systems

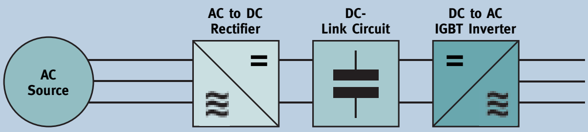
Energy-efficient components for high system reliability

The Infineon product portfolio provides components for the highest energy efficiency in windmill power converter and pitch control solutions.

Our Power Modules with newest 1200V/1700V trench fieldstop IGBT4 and Emitter Controlled diode chip technology offer best in class power density solutions in conjunction with extended lifetime. The modules feature low on state losses, optimized soft switching behavior and a wide operation temperature range up to 150°C maximum junction operation temperature. The newly introduced stack assembly ModSTACK™ HD leads to more than 50% higher power density at same footprint.

The following benefits are provided to our customers:

- Extended module utilization by 150°C maximum junction operation temperature
- Highest power density
- Supreme power cycling and thermal cycling capability



[www.infineon.com/highpower]

Reducing Transient Damage

By Franck Ageron, PM Surge Protection, Mersen, Saint Bonnet de Mure, France

FERRAZ SHAWMUT IS NOW MERSEN

The impact of power-related problems is far-reaching and affects just about every aspect of community, business and even private life. To protect sensitive equipment from harmful transients, we propose a reliable TPMOV technology delivering higher safety levels for all kind of electrical installations, especially for solar.

Three Distinct Types of Damage

Most transients originate from within a facility and nearly 80% of today's overvoltage problems are caused by equipment and power disturbances within the plant. These inter-facility transients are caused by light load panels switching on and off, motors starting and stopping, and close conductor proximity, just to name a few. Less than 20% of transient problems originate outside of the facility due to lightning strikes, utility grid switching, switching of capacitor banks or electrical accidents.

Transients cause three general types of damage to sensitive electrical equipment:

Disruptive damage occurs when a voltage transient enters an electronic component which interprets it as a valid logic command, resulting in system lock-up, malfunctions, faulty output or corrupted files. Dissipative damage is caused by a repetitive, short duration energy surge which results in long-term deterioration. And last but not least there is also destructive damage which is associated with high level energy surges, resulting in immediate equipment failure.

SPD Solution with Built In Thermal Protection Saves Space and Money

A Surge Protection Device (SPD) contains by definition at least one nonlinear component and is designed to limit overvoltage peak and divert surge current. The market offers a multitude of surge suppression options. However most SPDs are designed to function in tandem with fuses and so they take up quite a lot of space. An integrated, compact system will by comparison reduce costs and eliminate the need for additional overcurrent protection, saving space as well as money.

Surge Suppression by Thermally Protected MOV

The Thermally Protected MOV (TPMOV®) is a patented invention of Mersen developed to assist in eliminating the failure characteristics of Metal-Oxide-Varistors. The fail-safe solution is composed of a voltage clamping device and a disconnecting mechanism that monitors the status of the metal-oxide disk. In the event that the disk is approaching thermal runaway it is effectively disconnected from system power. The TPMOV is rated for 40kA of 8/20 µs surge current with ratings from 150V to 550V. The TPMOV has two built-in, isolated indicating features. The first is a visual indicator with two finger safe pins showing on the front of the enclosure when the unit has disconnected from system power. The second is a remote indicator composed of a micro-switch. When the TPMOV disconnects from system power the switch changes status. All these features reduce the costly engineering time required for traditional MOV products. Because TPMOV footprints are similar to those of equivalent voltage ratings of traditional 25 to 45mm MOVs they can be used on existing systems without costly board redesigns. The "no-fuse" surge suppressor does not require the use of additional fuses or overcurrent protection and can be installed upstream or downstream of the main disconnect.

Figures: Surge TrapTM SPDs manufactured by Mersen offer a patented no-fuse Type 2 solution combined with a patented thermal overload technology that delivers higher safety ratings and protection.

TPMOV® is a registered trademark of Mersen

www.mersen.com

Increasing the Power Density of Power Products

By Christopher L. Rexer, Fairchild Semiconductor

Increasing the power density of electronic systems is a continuing design challenge for our industry. This applies to a wide range of applications including DC-DC conversion, LED lighting, solar, portable, automotive and industrial designs. System performance within a reduced physical size is achieved through topology optimization and advancements, the reduced size of passives and the increased performance of power discrete components. An increasing area of recent focus has also been the reduction in size of the power discrete device.

The continuing advancements in technology development of power MOSFETS has resulted in a ten-fold reduction of on-resistance (Rds(on)) for 30V products, six-fold for 150V products, and seven-fold for 600V products over the past 15 years. The 30V and 150V improvements have been implemented at Fairchild through leadership technology development from planar power MOSFETs transitioning to PowerTrench™ power MOSFETs, and more recently with PowerTrenchTM products using advanced trench-based charge balance concepts. For Fairchild's 600V products, the improvements have been implemented in the transition from planar MOSFETs to SuperFET™ and SupreMOS® superjunction technologies.

Systems, applications and device designers at Fairchild, working together, have developed advanced design techniques for the design of new products. These improvements are achieved in the power chip, the package and the package interconnection. As the power density of the electronic systems increases, there is an increasing importance to improve each of these elements - individually and together. The advanced design techniques provide insight to the individual requirements for the power chip such as on-resistance, switching speed, gate charge and body diode dynamic perform-

ance. Package and package interconnect improvements are made for thermal, resistance and inductance optimization. The final result of the combined design is an overall product with increased power density capability (watts/mm2).

On one hand, the product improvement can be as simple as the improved performance of a new power chip technology in an existing package. For example, the Rds(on) performance of a 150V MOSFET in a 5x6mm Power56 package is reduced from 47 to 18mOhms when using the latest charge balanced PowerTrench technology. When this chip technology is also coupled with a package change from an SO8 to the Power56 package, an increase of power density from 8 to 347 mW/mm2 is achieved. Furthermore, the addition of advanced die to package interconnection techniques provides both a resistance and thermal advantage for the product. This technique is achieved by eliminating wire bonds and replacing them with a clip attachment to the surface of the die. In the most recent product configuration, DualCool™ package construction exposes an embedded heatsink on the topside of the package to provide enhanced thermal performance: both sides of the package provide cooling.

With both chip and package design at hand, Fairchild device designers have taken the product performance to the next level. By leveraging the Rds(on) reduction of the new PowerTrench technologies, the chip size has been reduced and then combined with packages designed with a reduced footprint. Application solutions previously supplied in Power56 packages are now available in Power33 (3x3mm) packages. A power density of 376mW/mm2 is realized in this package.

The reduced die size also enables dual die solutions. For DC-DC synchronous buck converters a 30 Volt MOSFET 25A solution, the footprint transition can be achieved from three (3) Power56 MOSFETs of 90mm^2 to a footprint of 30mm^2 of a Power56 dual die package. For a 5A solution the footprint size is reduced from 60mm^2 to 11mm^2 through transitioning from two (2) SO8 products to a single PowerStage™ dual die Power33 package.

These combined improvements of power chip technology and advanced packaging provide leadership products to support power systems designers. As a result, electronic systems have reduced losses, operate at lower temperatures, require a reduced quantity of components, have smaller dimensions and ultimately offer an increased power density capability.

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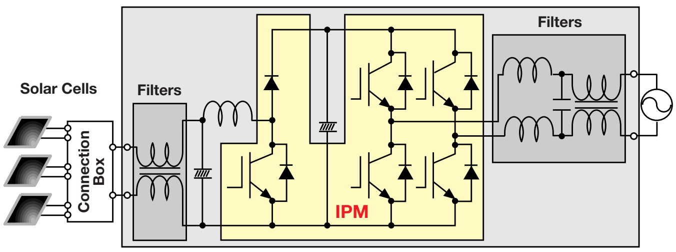

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Electronics Industry Digest

By Aubrey Dunford, Europartners

SEMICONDUCTORS

The Q22010 capacity utilization of semiconductor manufacturing plants worldwide grew to 95.6 percent from 93.5 percent in Q12010, so SICAS. Actual wafer-starts grew sequentially by 3.2 percent to 2.032 million per week in 8 inch equivalent wafers, and by 23.9 percent than those in Q22010. The utilization of advanced facilities that make chips with circuits of less than 60 nm came to 98.6 percent. In Q22010, the foundry industry was running at 98.8 percent of its capacity, and 300mm wafer production was running at 98.4 percent of capacity.
Worldwide sales of semiconductors were strong in July despite growing indications of slower growth in the overall economy, so the SIA: sales grew to $ 25.2 billion, an increase of 1.2 percent from June. Year to date sales total $ 169.2 billion, an increase of 46.7 percent from the first seven months of 2009. But second half growth is expected to be below seasonal norms as semiconductor sales align with electronic system sales. However the SIA continues to expect that industry growth for 2010 will be in line with their mid-year forecast of 28.4 percent.

Infineon and Intel have entered into a definitive agreement to transfer Infineon's Wireless Solutions (WLS) business to Intel in a cash transaction valued at approximately $ 1.4 billion.

On August 5, 2010, NXP announced the company's initial public offering of 34,000,000 shares of common stock priced at $ 14 per share.

ON Semiconductor has signed a definitive agreement for the acquisition of Sanyo Semiconductor, a subsidiary of Sanyo Electric.

Mitsubishi Electric plans to invest 6.5 billion yen to expand its wafer production capacity for power devices by approximately 2.5 times that of the previous fiscal year. The expansion will be completed by April 2011.

Marvell has acquired the intellectual property and assets of DS2, a supplier of high speed semiconductor solutions for powerline communications. DS2 was founded in 1998 and is headquartered in Valencia, Spain. At the close of the acquisition, approximately 75 employees joined Marvell's worldwide development team.

Applied Micro Circuits has entered into a definitive stock purchase agreement to acquire TPACK A/S of Copenhagen, Denmark. Applied Micro Circuits will pay $32 M in cash plus up to $ 5 M in cash earn-outs. Implemented in Altera FPGA devices, TPACK's solutions accelerate time-to-market for 10, 40 and 100 Gbps OTN switching and routing solutions. Founded in 2001, TPACK has 37 employees, including 28 design engineers.

OPTOELECTRONICS

Shipments of large area (9.1" and larger) TFT LCDs climbed to achieve a quarterly record high 170 million units, with 9 percent Q/Q and 31 percent Y/Y growth rate, so DisplaySearch. The revenues reached $ 22.9 billion. Panel makers are aiming to continue shipment growth in the second half of the year despite the recent drop in panel prices and supply chain inventory adjustments.

PASSIVE COMPONENTS

Overall sales of PCBs in Germany slid in May, but were still a 40 percent improvement from May last year, so the ZVEI. Cumulatively, sales for the first five months of this year were up 32 percent compared to the same period last year. Incoming orders also reached record high in May, which jumped 137 percent year-on-year. The book-to-bill ratio posted a record high at 1.66.
The Leoni group strengthens its market position in North America with the acquisition of RoMack, Virginia. RoMack specializes in fiber optic systems solutions in the aerospace, optical analysis, devices for medicine and for industrial laser solution. With the acquisition of RoMack, Leoni set its strategy for strength in technologically sophisticated niche markets.

Miba, strategic partner to the international engine and automotive industry, has acquired EBG and DAU, producers of power electronics components, as of September 1, 2010. The group, which generates annual sales of € 30 M, has production sites at two locations in Styria (Austria) and staff headcount of around 130. EBG and DAU are specialists in passive electronic components such as resistors and cooling systems for power electronics.

OTHER COMPONENTS

Emerson has agreed to sell its Motors and Appliance Controls businesses to Nidec. Combined, these businesses accounted for more than $ 800 M in sales in fiscal 2009. Manufacturing facilities and technology centres for both businesses are in the United States, Mexico, China, India, and the UK. The businesses employ about 6,000 employees around the world, including 1,700 in the US. Nidec, based in Kyoto, Japan, is about an $ 8 billion precision manufacturer of small and medium-size motors and fans for IT/consumer electronics, automobiles, home appliances, and industrial applications.

Süd-Chemie, a specialty chemical company based in Munich/Germany, is investing approximately € 60 M in the production of lithium iron phosphate (LFP), an energy storage material used in batteries for electric vehicle drives and other applications. Commercial production for series delivery will start in 2012 to reach a rate of 2,500 tons per year. Such volume, will allow the production of approximately 50,000 all-electric automobiles per year.

DISTRIBUTION

2010 looks like the all-time record year for European semiconductor distribution, so the DMASS (Distributors' and Manufacturers' Association of Semiconductor Specialists). The first half 2010 grew by over 50 percent as compared the same period last year. Q2/2010 even grew by a historic 70 percent over Q2/2009, at € 1.5 billion. The record growth in Q2/2010 is enjoyed by all regions, although the growth rates vary quite dramatically.

This is the comprehensive power related extract from the «Electronics Industry Digest», the successor of The Lennox Report. For a full subscription of the report contact:
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Key Trends Emerge from Darnell's Power Forum

By Linnea Brush,Senior Research Analyst, Darnell Group

The line between "emerging" and "established" technologies is getting increasingly blurred, with new power solutions getting to market more quickly. Nowhere was this more evident than at Darnell's Power Forum (DPF), which was recently held in Chicago. DPF '10 combined two previous conferences hosted by Darnell Group, the Digital Power Forum and the nanoPower Forum, and added additional sessions related to the smart grid and advanced packaging and components. As a result, the conference highlighted the key trends that are currently shaping the power electronics market.

DPF included sessions on digital power implementation; energy harvesting solutions; implications for power in the smart grid; gallium-nitride (GaN) developments; and the future of power-supply-on-a-chip (PwrSoC). IBM presented a new architecture model that could change how power is delivered in server systems; and major companies introduced products that will support manufacturing economies of scale. The Roundtable discussion asked, "What will be the most important driver for the power electronics industry in the future: Architectures, topologies, materials or applications? Overall, the mood of the conference was enthusiastic optimism, with the global recessionary constraints fading into the background.

The Plenary session identified some of the most critical developments in the power conversion industry, including the "major disruptions" that will define the industry going forward. Alex Lidow, CEO of Efficient Power Corporation (EPC), discussed how GaN can offer "superior performance" compared with both silicon and silicon-carbide. Pointing toward lower-cost and higher-performance switching transistors, Lidow predicted that EPC's enhancement-mode eGaN transistors will cost less than comparable silicon power MOSFETs by 2015. He discussed the effort to develop dedicated wafer processing equipment specifically for GaN transistors that will lead to lower device costs. Driver ICs designed to meet the specific needs of eGaN devices are expected to be available in 2011.

The Fraunhofer Institute has been on the forefront of energy harvesting research and development for many years. Henrik Zessin discussed new adaptive power management techniques being developed to enable widespread use of various energy harvesting technologies. One specific circuit was presented to maximize the energy captured from thermal electric generators (TEG). The TEG converter proposed by Zessin included an automatic polarity detector that reconfigures the input of the converter between positive and negative as demanded by the TEG operating conditions. Zessin also pointed out that, originally, energy harvesting was targeted at applications where battery maintenance and replacement was problematic. That is still the case, but energy harvesting is now being used to augment or extend battery usage, as well.

Chris Young, Senior Manager at Intersil/Zilker Labs, provided an update on the "future of digital power." This topic had a different slant than it would have five years ago, when the benefits of analog versus digital power were still being argued. Now that digital control has become more mainstream, its "future" depends more on economics and the business case of each application. Young sees three major trends: the commoditization of digital power ICs, development of differentiated application-specific digital power ICs and the continued integration of additional functions into digital power ICs. This integration will include the development of digitally-controlled power supply on chip devices where passives are integrated with the digital controller and power devices. He also expects to see digital power integrated directly into ASICs, FPGAs and microprocessors.

Major shifts in power architectures are rare, and when they do occur, they are usually accompanied by changes in power supply design or product development. Such a change could be on the horizon, based on the presentation made by Randy Malik, Senior Member Technical Staff with IBM. Malik presented a vision of the future of servers where each core in a multi-core processor is individually powered. He predicted over 100 individual dc-dc converters for each microprocessor, all turned on and off at the command of a complex and comprehensive power management system. In his analysis, this new power architecture could save up to 40% of the energy currently consumed by servers. IBM is no longer looking for incremental improvements in converter efficiencies; they are already over 90%, and the company is working to develop a "game changing" new power architecture.

The Roundtable discussion continued the theme of "what is most important now and what will be important in the future?" for the power supply industry. Panelists from Efficient Power Conversion, Intersil/Zilker Labs, Texas Instruments, Anagenesis, National Semiconductor, and Embedded Power Labs each contributed their perspectives on this question, based on many years of experience in the industry. New architectures, topologies, materials and applications were all considered, with each having its advocates. Two panelists voted for materials, since they are "both an enabler and a driver." Another panelist said applications were most important; "everything else are tools." A couple of speakers felt that none of the above really applied; that other industries will create the demands that power supplies will fulfill. Several panelists agreed that the "needs of the customer" drive everything, including power supply density, efficiency and cost.

Ultimately, the issue addressed by the Roundtable was whether customer needs drive product development, or does product development drive market needs? Similarly, does demand lead technology, or does technology lead demand? Each of these sides produces different business models and demand characteristics. This can be challenging, but a couple of points were made that can give power supply companies an edge: First, get ahead of your customers by talking to their customers; and encourage transfer of technology. For example, as power delivery expands in range from microwatts to megawatts, simulation tools will become increasingly important for testing.

DPF '10 had a very strong sense of optimism and change in the power supply industry, with progression and development in many emerging applications areas. These include photovoltaics and the smart grid. Dave Freeman from Texas Instruments presented multiple opportunities for applying digital power technologies in photovoltaic inverters, including micro-inverters, distributed dc-dc converters, battery management and (wireless and powerline) communications/control. He reviewed seven different maximum power point tracking (MPPT) algorithms and the applicability of digital power. The opportunity for digital power is expected to grow even larger as distributed dc-dc converters and micro-inverters incorporating distributed MPPT are used in next-generation photovoltaic installations.

The smart grid was addressed in a dedicated session that included papers from GE Energy, the Electric Power Research Institute and Embedded Power Labs. The opportunities for power supply companies are still being clarified, but this session gave some critical insights from the utility side, the research side, and the customer premises side. At the utility level, EPRI believes that two-way communication with the utility is the "current status," with two-way communication among home appliances being much further out – possibly 10 to 20 years. Automated meters installed today, for instance, may be obsolete in two years, since not all of them do two-way communications and not in real time. This is an area that is still evolving, with companies like Intel leading in the exploration of solutions that extend to the customer premises.

Delegates at DPF agreed that advancements in materials (like GaN) and topologies will very likely enable these emerging applications, along with others like dc powering in buildings. For example, Arnold Alderman presented a review of the current state-of-the-art for power-system-in-package (PSiP) and PwrSoC devices. At this time, PSiP devices offer cost and performance advantages compared with PwrSoCs. That advantage may continue for a significant time into the future if PSiPs employ more advanced interconnects, a combination of chip-on-board and flip-chip assemblies and R/L/C integration into the circuit board.

The questions and discussion at DPF was spirited, with delegates raising issues that extended the already leading-edge material given by the presenters. Many delegates said that they not only got useful information at the conference, but they were also able to keep up with the latest trends in power electronics. The exhibits supported this, and the networking with key decision-makers provided a forum that pretty much represents where the power supply industry is right now and where it is headed in the future.

Next year's DPF in the Silicon Valley will continue this tradition and likely expand the opportunities for delegates even more.

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

ITxx Current Transducers, setting the benchmark for accuracy!

Certain Power Electronics applications require such extraordinary performance in accuracy, drift or response time that it is necessary to switch to advanced technologies to achieve them. The validation of equipment is often made through recognized laboratories using highly accurate performance test benches supported by high-tech subassemblies, including extremely accurate current transducers. These transducers are still in need for these traditional applications, but are also becoming part of high performance industrial applications, namely: medical equipment (scanners, MRI…), precision industrial motor controls, metering or accessories for test & measuring equipment.

By Morten Bruun-Larsen, LEM , Stephane Rollier, LEM and Horst Bezold, Signaltech GmbH

High Precision Current Transducers for the Test & Measurement Market

The world has to become more efficient and power electronics have played a crucial role to reach this goal. Hybrid- and electric vehicles, wind turbines and solar systems, industrial inverters and motors of higher efficiency. All these components must be optimized according to their losses. Efficiency measurement for power electronics and drives components needs a power measurement system of highest accuracy. During the past 10 years the LEM IT and DANFYSIK ULTRASTAB high precision current transducers became the standard for current range extension in power analysis and efficiency calculation.

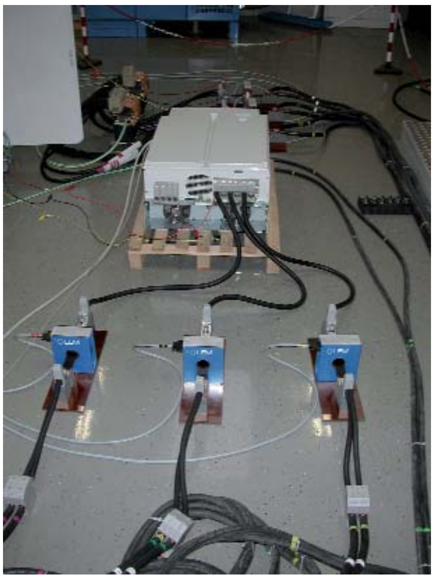


Figure 1: Six channel power measurement at KEB inverter

Demands of a Power Measurement System

Active electric power is defined in the following formula:

$$P = 1/T \cdot \int_0^T p(t)\,dt \quad \text{with} \quad p(t) = u(t) \cdot i(t)$$

The multiplication of voltage and current integrated over one signal period gives you active power. Besides a precise synchronization on the fundamental signal period the power accuracy depends on two items:

1) Amplitude error
   How precise is voltage u (t) and current i (t) measured
2) Phase error
   How long is the time (phase shift) between the sampling of voltage u (t) and current i (t)

Voltages up to 1000 V can be measured with a power meter directly. For current signals above some amps associated current transducers of highest precision are needed.

The influence of a phase error caused by an instrument or transducer increases with the decreasing of the power factor. Figure 3 shows this problem. At power factor 1, there is no phase shift between voltage and current and even an additional phase shift of 1° caused by a current transducer would result in a small power error of 0.2 %. At power factor 0.1, the phase shift between voltage and current is already 84°. An additional transducer phase error of 1° would lead to a huge power error of 17.4 %.

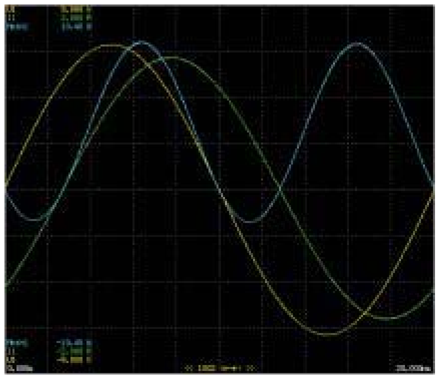


Figure 2: Power signal (blue) calculated from u (t) (yellow) and i (t) (green)

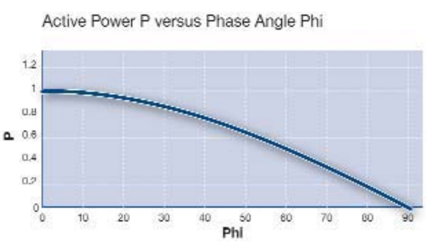


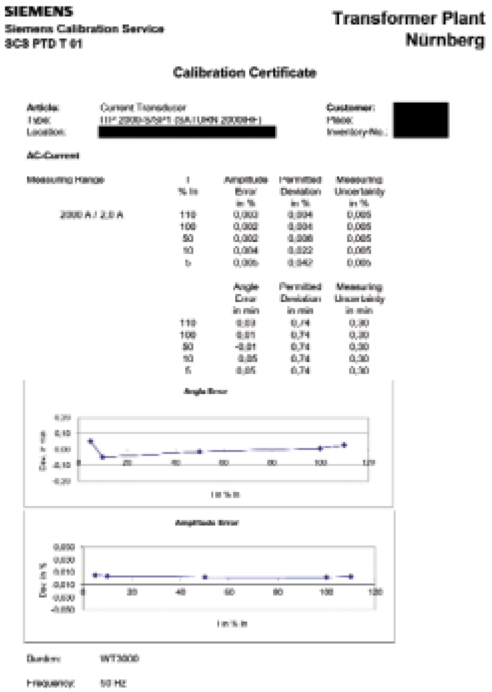
Figure 3: Influence of power factor

Problem of Differential Measurement and high Efficiencies
The biggest problem in efficiency calculation is that losses cannot be measured directly with a high enough accuracy. The most precise power meters offer a basic accuracy of 0.02 to 0.1 %. The problem is that the losses cannot be measured directly but only input- and output power. The losses must be calculated from both power values. In the worst case, the errors of both measurements are opposite. This problem increases with the efficiency of the load. Electric drives have an efficiency of around 95 %, inverters even up to 99 %. Only instruments and current transducers of highest precision are able to deliver reliable results.

Figure 4: Deviations of input- and output power measured with a power system of 0.1 % accuracy

Result: Total power error of 0.195 W (worst case) compared to actual losses of 5 W is equal to an error of 3.9 % for the losses

Optimal Current Sensors for Power Measurement
LEM Danfysik ULTRASTAB current transducers combine all the requirements for a power measurement current transducer. Offset and linearity are in the ppm range. 1 ppm is equal to 0.0001 %. Since the offset is so small one sensor can be used from a few A up to the kA-range. The transducers measure from DC up to several kHz large signals and some hundred kHz small signal bandwidths. The phase error of all transducer types is far below 1 minute, which is 1/60 degree. The sensor is galvanically isolated. The analysis of medium voltage inverters and drives is fully sustainable. Due to the galvanic isolation, there is no common mode signal, which influences the result.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Siemens Calibration Service
SCS PTD T 01

Transformer Plant
Nürnberg

Calibration Certificate

Article: Current Transducer
Location: [redacted]
Customer: [redacted]

AC-Current

Figure 5: Calibration protocol of a 2000 A transducer. Even at low range of 50 A the accuracy is better than 0.005 % and the phase error below 0.05 min

Special Solutions for Power Analyzers
Most power measurement applications are 3-, 4- or even six channel applications. For an easy installation, wiring and use of our transducers, we provide complete multi channel solutions (Figure 6) including power supply and transducer connection cables. Thus a power measurement setup consisting of power meter and transducers is done within minutes.

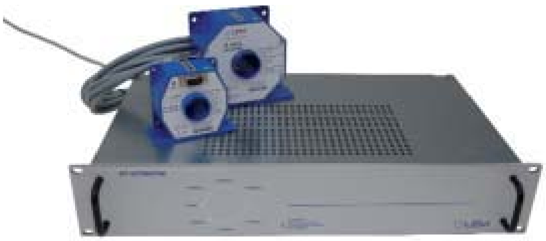

Figure 6: LEM multi channel system

Applications
You can find LEM current transducers everywhere inverters or drives need to be developed or tested.

The ITZ 2000 and ITZ 5000 range of products are normally used for final test of large low voltage and medium voltage motors and generators. Even if the machine is a pure 50 or 60 Hz drive, LEM transducers are a very economic way to measure. Other current transducer technologies demand to switch between different transducers to cover the entire current range. This increases the price of the test system remarkably. The large ITZ transducers for 2 kA and 5 kA are used for development of wind generators and solar inverters.

The IT and ITN transducers families can be used from 60 A to 1000 A for development and test of lower current applications such as small solar inverters, small and medium motors and industrial inverters and power electronics components for automotive applications. Most of the transducers are used for power and signal analysis but since this technology is so precise some of the transducers are used in calibration labs for DC and AC current calibration.

Precision Motion Control for Photolithographic Scanning Steppers

Semiconductor manufacturing relies on complex photolithographic processes, to image and create the nanoscale structures that form the integrated circuit components on the chip. The basics are to a large extent comparable to a standard photographic process, wherein an illuminated object is imaged onto a light-sensitive surface such as a film emulsion or a CCD array through the use of a lens. Speaking in terms of wafer illumination, the object is a mask containing a (large-scale) geometrical “model” of the structure to be formed and the film/CCD is a silicon wafer with a so-called photoresist spun onto its surface. Illumination is not made by visible light, but by use of deep UV (ultra-violet) light-sources like an excimer laser operating at 193nm. The use of a very short wavelength is crucial since the resolution of the process is directly proportional to the wavelength – so by using a shorter wavelength for the illumination, smaller geometries can be created – and in the end a higher integration level (“transistors/area”) can be achieved.

The kind of machinery that illuminates a wafer by shining UV light through a photomask is called a wafer stepper. The term “stepper” stems from the fact that the machine steps the wafer through a series of positions in order to produce a number of “dies” (identical circuits or “chips”) on each wafer. When illuminating one specific die, mask, wafer and light-source are kept stationary relative to each other.

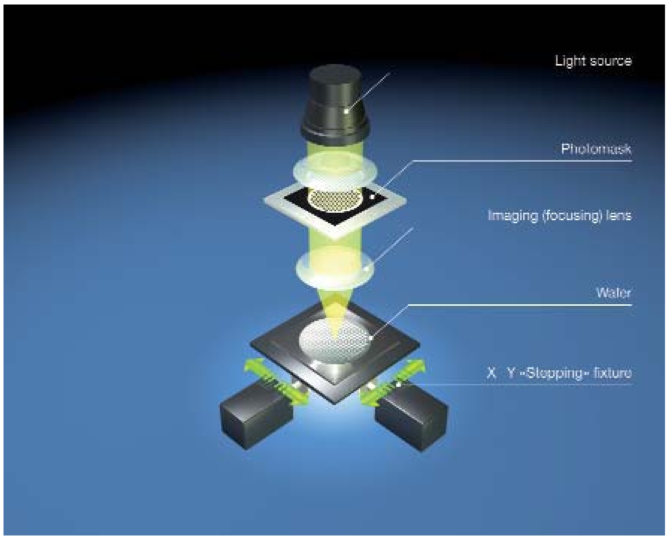

Figure 7: The basic principle of photolithography

Because the full die is exposed in one process during each step, aberrations (imaging flaws) in the optics sets an upper limit to the die area and to the achievable detail of geometry. To overcome this, the method of scan-stepping the photomask pattern onto the die has been developed. Using this method each die is exposed in a process where mask and wafer are moved opposite each other during the illumination. In this way, the photomask pattern effectively “sweeps” the wafer only by use of the center portion of the lens system and a relatively large area can be covered, yet keeping the beam at the center of the optics to keep resolution and detail at max.

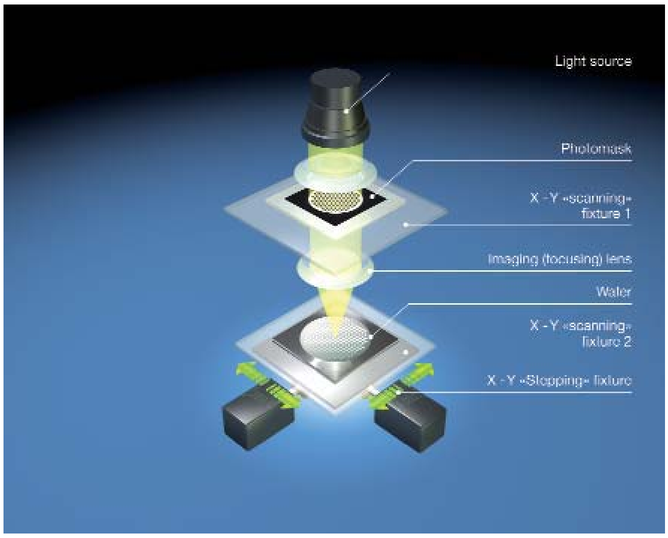

Figure 8: The photolithographic scanning stepper

Since the core technique in the scanning stepper is to move “object” and “film” while exposing, and still hoping to reproduce nanometer scale geometries, it seems evident that position and motion control is vital in this scheme. Positioning is split over two mechanisms: stepping positioning, wherein the wafer is positioned to a specific die position, and the challenging scanning positioning, where the scanning positioning mechanism controls movement of wafer and photomask in opposite directions.

The scanning positioning mechanism has limited travel (on the order of 10-20 mm) and is typically laid out using a linear (“voice coil“) actuator. Motion control of this kind of mechanism can be implemented by measuring the drive current in the actuating coil; however,

since it is of highest importance that near-perfect synchronization between the two movements is achieved, a high precision current measurement with extremely high differential linearity is crucial. Ultra-high precision DC Current Transducers like the PCB mounted LEM ITN 12-P offers the required precision and differential linearity for use in this type of application. The only valid alternative offering the same level of linearity is a simple shunt resistor, but since the drive currents typically are several amperes (5-15A) this method is on the edge in terms of power loss and consequential temperature induced drift. Furthermore, the output from a shunt resistor intrinsically carries a common-mode contribution – this is not present using a DCCT where primary and secondary are galvanically isolated.
In conclusion, despite the higher cost of an ultra-high precision DCCT, the advantages offered by this technology outperform the simpler alternative of a shunt resistor for applications in scanning steppers for semiconductor manufacturing.

LEM has been producing high performance transducers for years at costs that appeal to the target market The acquisition of the Danish company Danfysik ACP A/S in 2009, the world's leading company in the development and manufacturing of highest precision current transducers reinforced this position.
To achieve the required accuracy performance, LEM's ITxx current transducers do not use Hall generators but are based on Fluxgate technology, an established technology LEM has used for many years. This is a proven high technology at the heart of several LEM current and voltage transducer families. LEM uses various versions of Fluxgate technologies, each version providing different levels of performances and costs matching depending on the customer's requirements. For the ITxx range, the Fluxgate closed Loop technology applied is certainly the most efficient. That is why we can achieve an accuracy by using ppm (part per million) of the nominal value which is quite representative of the performances reached by this product.

ITxx - Fluxgate Technology Principle
For accurate measurement of DC currents, the methods used since the beginning of the 20th century consist in compensating the current linkage Θ_P created by the current I_P to be measured by an opposing current linkage Θ_S created by a current I_S flowing through a known number of turns N_S, to obtain (Figure 9):

$\Theta_P - \Theta_S = 0$
or $N_P \cdot I_P - N_S \cdot I_S = 0$
N_P: Number of primary turns
N_S: Number of secondary turns

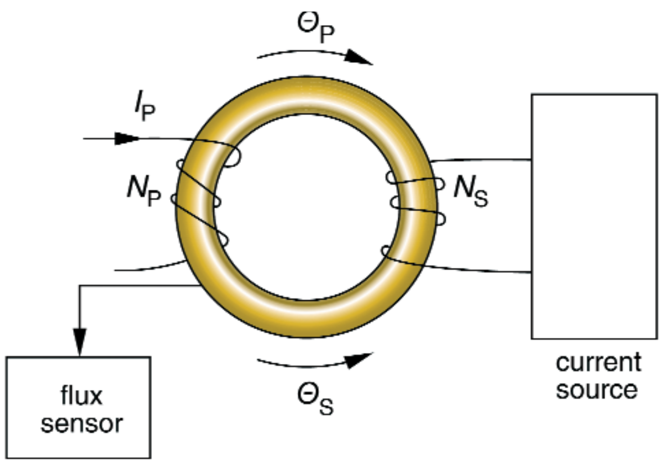

Figure 9: ITxx Fluxgate Technology Principle

To obtain an accurate measurement, it is necessary to have a highly accurate device to measure the condition $\Theta = 0$ precisely. The aim is to obtain a current transducer with the following characteristics:

- Excellent linearity
- Outstanding long-term stability
- Low residual noise
- High frequency response
- High reliability

Operation principle

To achieve really accurate compensation of the two opposing current linkages (Θ_P, Θ_S), a detector capable of accurately measuring $\Theta = 0$ must be available, which means that the detector must be very sensitive to small values of a residual magnetic flux ψ (created by the current linkage Θ) in order to achieve the greatest possible detector output signal.

Fluxgate detectors rely on the property of many magnetic materials to exhibit a non-linear relationship between the magnetic field strength *H* and the flux density *B*.

The hysteresis cycles of the magnetic cores have a form comparable to the one represented in figure 10 (more or less square according to the type of material used).

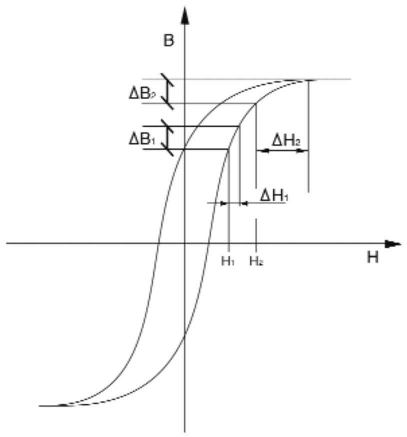

Figure 10: Hysteresis cycles of the magnetic cores

Observing $B = f(H)$ on the magnetization curve, notice that for a given field strength H_1 a flux density variation ΔB_1 corresponds to ΔH_1. But, also observe that further along the cycle, for another given field strength H_2, for the same variation $\Delta B_2 = \Delta B_1$, the ΔH_2 variation must be much greater.

The detection of the zero flux condition ($\psi = 0$) is based on this phenomenon.

When applying a square wave voltage (Figure 11a) to a saturable inductor until its magnetic core starts to saturate, a current (Figure 11b) is created. This current flowing through a measuring resistor will provide a symmetric voltage relative to zero with peak values $+\hat{V} = -\hat{V}$.

When a DC current flows through the aperture of the core, the curve of the hysteresis cycle is then shifted causing asymmetry of the current produced by the square wave voltage (Figure 11c) and leading to a measured voltage at the terminals of the resistor where $|+\hat{V}| > |-\hat{V}|$. By using peak detection to measure $+\hat{V}$ and $-\hat{V}$ and by comparing the two peak values, the deviation of the flux in the core is thus detected. As soon as the flux ψ is not zero, an error voltage $|+\hat{V}| - |-\hat{V}|$ is supplied to a power amplifier that drives a current into a compensation winding until $\psi = 0$, thus $|+\hat{V}| = |-\hat{V}|$.

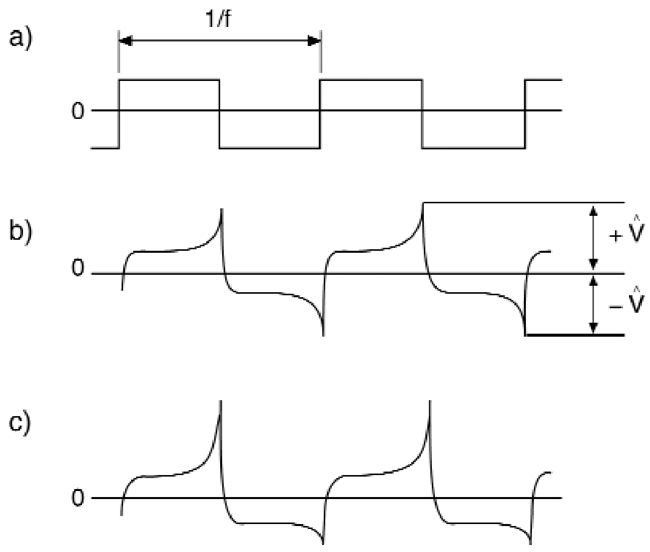

Figure 11: Square wave voltage (11a); Current created (11b); Asymmetry of the created current (11c)

Figure 12 shows a very simplified base circuit for the compensation of a DC current.

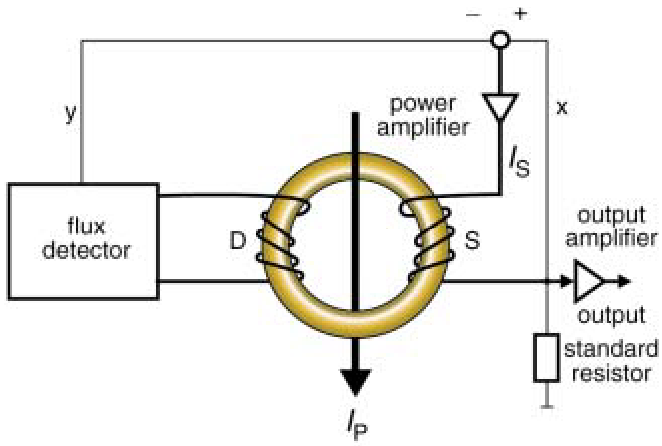

Figure 12: Simplified base circuit for DC current compensation

If the primary current $I_P = 0$, the compensation current I_S will be equal to 0. When I_P varies, the flux varies. Therefore, we detect an error $|+\hat{V}| - |-\hat{V}|$ which controls the power amplifier to supply a compensation current I_S until $\psi = 0$, thus:

$$N_S \cdot I_S = N_P \cdot I_P$$

The current I_S flows through a measuring resistor, transforming the current into a proportional voltage.

The accuracy of the measurement will not only depend on the accuracy of the measuring resistor but also strongly on the sensitivity of the flux detector. However, in spite of the DC measurement function accuracy, there are some drawbacks to this DC measurement system (Figure 13):

As the winding "D" of the flux detector is coupled with the compensation winding "S", the applied square wave voltage is re-injected into the compensation winding and creates a parasitic current in the measurement resistor.

However, the square wave voltage induced in the S winding by this flux may be practically cancelled out when a second D' winding is mounted on a second detector core (identical to D) inside the compensation winding S. The residual flux (the sum of the opposed fluxes in D and D') will create very small voltage peaks that cause the remaining signal correlated with the fluxgate excitation (Figures 13 and 14).

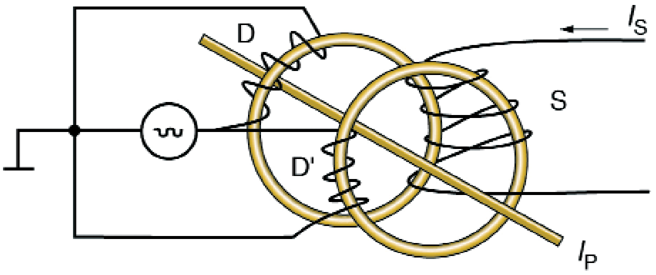

Figure 13: Solution against voltage peaks re-injection

If the application does not need a large bandwidth, the system's cut-off frequency can be designed to be lower than the excitation frequency of the fluxgates. LEM offers transducers that allow a synchronization of the fluxgate excitation with a user supplied clock to provide a workaround.

We recommend only applying primary current to the transducer after powering up the current transducer. Failing to do so will result in oscillation on the output, and a delayed lock-on to the primary current. It will further more result in an additional offset.

The magnetic part of the transducer is realized as schematically represented in figure 14:

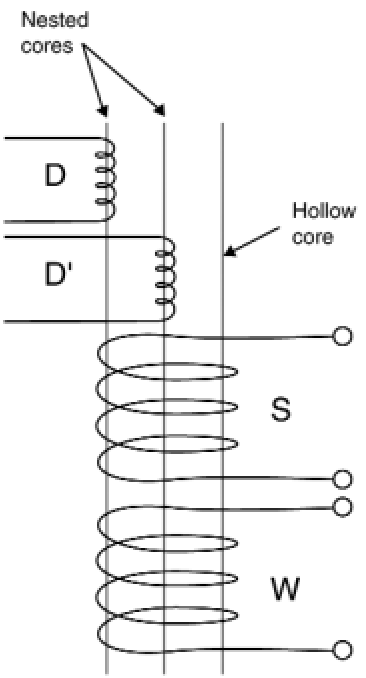

Figure 14: The various windings used and their arrangements

A fourth winding W is wound before the compensation winding S on the main core to extend the frequency range of the transformer effect to lower frequencies. It is connected to a circuit that adds some voltage via the power amplifier to compensate the too small induced voltage in a frequency range too high for the fluxgate detector.

The diagram of the compensation loop is shown in figure 15.

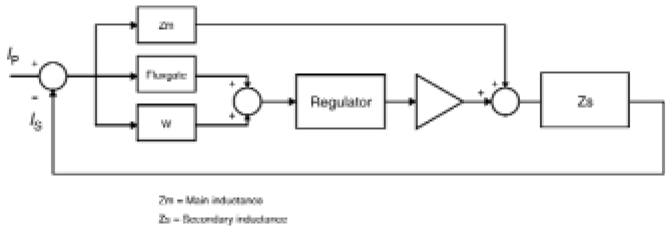

Figure 15: Compensation loop diagram

The simplified overall diagram is shown in figure 16 and can be directly deduced from the diagram, figure 15. The saturation detector is activated when the output voltage exceeds its specified range.

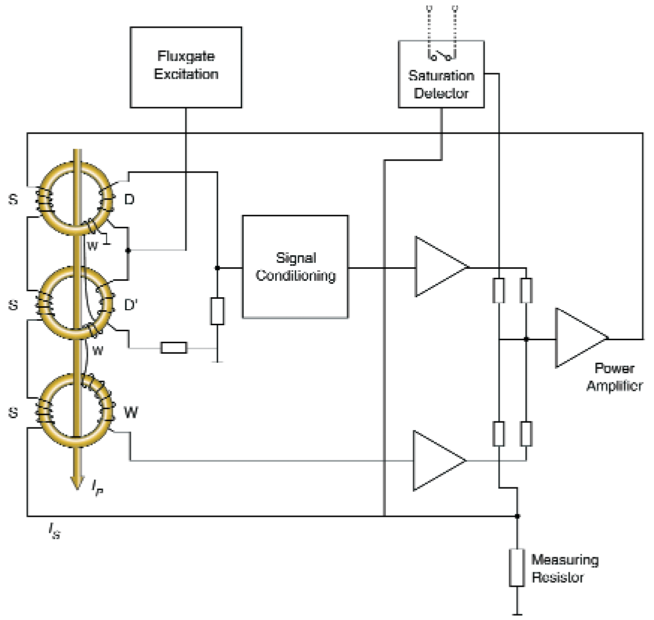

Figure 16: ITxx operation principle: simplified overall diagram

ITL 4000 model does not integrate W winding and uses a lower oscillation frequency for the fluxgate excitation.

The design of the measuring head is simplified in comparison with the other ITxx models.

Figure 17: LEM Danfysik current transducers range

Based on this technology, the LEM transducers range covers high accurate nominal current measurements from 12.5 A to 24 kA providing overall accuracy at +25°C from few ppm. Thermal offset drifts are extremely low, from only 0.1 to 6.7 ppm/K. Models from 12.5 A to 60 A nominal can be used for PCB mounting, models from 60 A to 24 kA are for panel or rack mounting.

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Original or Fake

Allocation the root of all evil

Recently, the number of incidents users submit complaints to the manufacturer about the power semiconductor failures is steadily increasing. Failure analyses show that these power semiconductors are counterfeits or rejects originally intended for scrapping. How can you protect yourself from such counterfeits and what is the background leading up to such criminal acts?

By Werner Bresch, GvA

It is certainly beyond question, that power semiconductors are key components. Only if they are readily available, power electronic modules and systems can be delivered in time and thus generate added value. If shortages cause these components to be unavailable, unfinished goods of high value idle in the production and cannot be delivered. The same is true for high-quality systems which can no longer be operated because the appropriate spare power semiconductor is not available. Both scenarios can threaten the existence of a company. In any case, extreme pressure will mount on the purchase department responsible.

Such shortages often occur during economic boom, or, as just recently, at the tail end of a downswing. Demand cannot be covered because power semiconductor manufacturers already produce at their capacity limit or are unable to quickly ramp up their production capacity.

Allocation is the logical consequence, and affected are mostly, sought-after high-quality power semiconductors, such as IGBT, IGCT, GTO, and high-performance thyristors. The large number of internet-based search action giving an impression of a procurement panic, ultimately paving the way for dubious business practices.

Conflict of interest

Purchasers have a legitimate interest to buy products, among them key components like power semiconductors, at the lowest possible price, and, preferably without any long-term contractual obligations. Formerly appreciated soft facts, like good customer-supplier-relations, supplier expertise, and direct contact to decision-makers at both partners and delivery reliability are no longer crucial for the placement of new orders. The procurement process has become completely impersonal, mutual understanding and appreciation is fading, the differing needs of business partners are no longer taken into consideration.

However, power semiconductor manufacturers and their distribution channels depend on these soft facts to reliably deliver their customers. This also applies for long-term contractual obligations of both parties.

Manufacture of power semiconductors – a tough business

Few customers are aware that, all delivery deadlines and process cycles taken into account, a time span of up to 18 months is required from silicone order to power semiconductor delivery. It requires that a power semiconductor manufacturer orders silicone of a certain specification to deliver a product his customer may need only 12 to 18 months later, even if no long-term orders are pending. Such long-term planning is tricky, after all, who knows what demand will be next year? The aforementioned alienation of purchaser and supplier makes matters even more difficult.

The fact that power semiconductor manufacturers are not volume customers for silicone producers aggravates this circumstance. They only need about 1-2% of the silicone used worldwide. Furthermore, power semiconductor manufacturers are rather a disturbance in the process flow of large-scale silicone producers because they only need moderate amounts with very special specifications. Therefore, only a limited number of suppliers produces and delivers silicone in a predetermined annual volume.

If the power semiconductor demand was correctly calculated, suitable power semiconductors are available to customers 12-18 months later. If planning turned out to be off-target for the aforementioned reasons, demand grows even more and market shortages can aggravate the situation for all the players involved.

Another minor theater of war is the limited number of molybdenum suppliers or housing suppliers for specific silicone irradation after-treatment which has become increasingly few and far apart due to changes in the legal regulations. However, this limitation can be responsible for drastic delivery time delays, even if the projected silicone planning was sound. Problems with diffusion process flow, bonding or encapsulations can pose additional risks for delays. Power semiconductor manufacture is a highly complex business which, due to the aforementioned number of circumstances, does no allow to rapidly respond to the ever changing demand.

Closing the stable door after the horse has bolted

It was inevitable: the monster contract was awarded and requires a production conversion with more power semiconductors that was implemented yesterday. Despite extensive procurement efforts suitable power semiconductors can not be delivered within due time. Manufacturing slots for large power semiconductor batches are booked well into the future because other users had ordered extra quantities to be on the safe side. Often, power semiconductor suppliers receive the same order inquiries for one component from different customers, and must turn them all down. The news will spread and shortages of one specific power semiconductor will soon be documented and dissemenated on the web.

And then, all of a sudden, and as if like a miracle, these exact component types (usually high-priced large IGBT, GTO, IGCT) are offered in moderate quantities of some 50 pieces and to horrendous prices, but deliverable ex works.

Well, everyone knows that power semiconductors do not grow on trees. So where do they come from?

Currently, this phenomenon will have the following reasons:

Components made of an identical or similar looking new material and manufactured by a competitor are neutralized by an unknown third party and labeled with all the relevant data that is actually needed on the market.

Power semiconductors contain precious resources which are recycled into the economic cycle. When power semiconductors have reached the end of their life cycle, they are preventively replaced to make sure high-tech systems using them can be operated for many more years. There are incidents where such components have not been disassembled and recycled but visually rehashed and offered as new, often simply relableled as previously described.

Nobody is perfect! Every once in while it happens that power semiconductors do not pass the manufacturer functional test. Usually, such components are recycled as scrap. But sometimes it happens that they find their way mysteriously back from the scrap yard to the warehouse of some mysterious distributors.

One can imagine what such rehashed power semiconductors will do to their intended application …

An ounce of prevention is worth a pound of cure

Every supplier will understand, if a customer in jeopardy searches for alternative sources of supply. But once such a source is found, the customer should demand an approved authentication that the offered product is really genuine merchandise.

Every manufacturer has a specific system to designate components. Such designations usually consist of data codes, bar codes and

Figure 1: Labeling of the fake

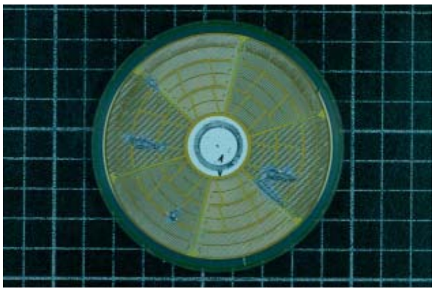

Figure 2: Wafer of the GTO fake

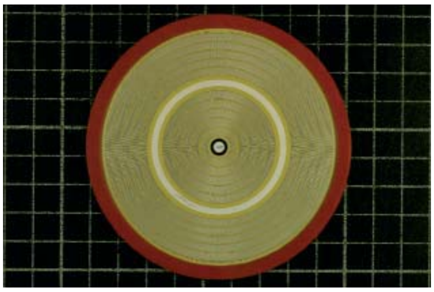

Figure 3: Original ABB wafer
Pictures from an analysis report for the investigation of fake ABB GTOs (Courtesy of ABB Switzerland Ltd.).

numbers embossed, labeled, printed or lasered on the power semiconductor casing. Prior to the purchase, the customer should request all numbers, codes and designations and check them for plausibility. Most likely, the manufacturer has records, which prove when each power semiconductor was manufactured and where it was delivered. Of course, this only helps, if the component has a designation that roots back to its manufacturer.

If power semiconductors cannot provide such information, they are at least suspect and potential purchasers should be most careful.

Eventually, users can take precautionary measures so that these situations never occur!

Avoid delivery bottlenecks

Today, reliable supply with key components power semiconductor provides an enormous competitive edge because the number of competent manufacturer of power semiconductors capable of delivering large quantities is relatively small.

It is a proven fact that a good customer-supplier relationship helps to detect and tackle supply shortages with power semiconductors early. Long-term contractual agreements offer both partners planning certainty and allow to satisfy the basic demand. Possible bottlenecks can be opened by a framework contract flexibly responding to changing demands. If the customer communicates with the supplier by allowing access to their ERP-system, increased demand can be recognized early and allows the supplier to flexibly respond. Ideally, the planning horizons of both partners are identical or at least meeting on one level.

At any rate, it is much more sensible to place an order, and, if need be, postpone it, rather than not process the order and not be allocated in a production slot.

Even project business can be smartly planned by devising a flexible agreement and creating a buffer warehouse to cover initial demand. This requires more understanding and active contribution of both partners than a regular customer-supplier relationship.

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IGBT Drivers Provide Reliable Protection

To ensure that power electronic components are reliably protected from the effects of non-permissible operating conditions, fast and reliable error detection and effective protective measures are needed. In power modules, error management can be provided either by the system controller or by IGBT drivers.

By Johannes Krapp, Product Manager Driver Electronics, Semikron

The system controller is suitable for reacting to slow failure modes such as overheating caused by excessive temperatures. Driver electronics, in contrast, are needed to detect and respond to sudden errors. Various driver concepts are available on the market today and differ as regards their applicability, efficiency and reliability.

Fast errors in power converter systems include short circuits and circuit-induced overvoltages. Short circuits are the fastest errors. When power electronic systems are commissioned, connection and isolation errors are often the cause of short circuits, while in field applications short circuits may be down to faulty components. If a short circuit occurs in the load path or bridge branch, the collector current in the IGBT increases starkly, causing transistor desaturation. The IGBT modules available on the market today are short-circuit-proof for a very brief time only. To prevent the IGBT from being destroyed by thermal loading, it is crucial that the short circuit be detected within this safe period and turned off reliably.

Driver electronics can detect short circuits by way of the di/dt measurement or V_{CE} monitoring.

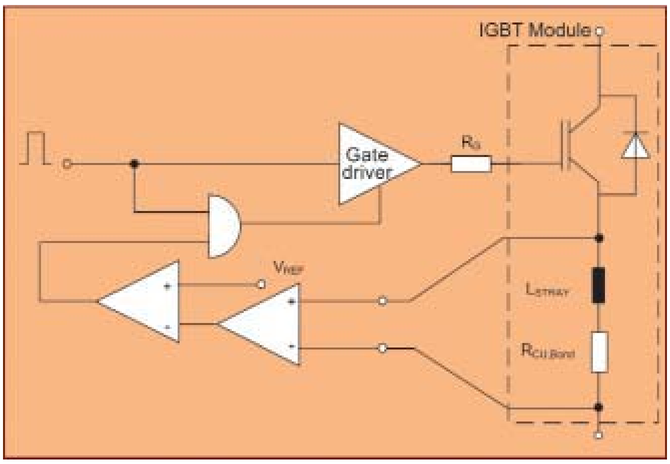

Figure 1a: Circuit diagram for di/dt detection

In di/dt detection (Figure 1a), the driver electronics measure the rate of change in current in the IGBT. The voltage drop at the stray inductance between auxiliary and power emitter is proportionate to the rate of change (di/dt) of the collector current. By comparing the voltages with a reference voltage, a fast short circuit can be detected. To monitor slow short circuits, this method uses the resistive components in the wire bonds and internal busbars between power and auxiliary emitters. This method also depends, however, on the screw connections used for the power connections. These display a certain distribution in the contact resistance characteristic, and are to be taken into consideration in series connection with the other ohmic components. This calls for precise adaptation to the given system. In general, di/dt detection can only be used for IGBT modules with an auxiliary emitter output.

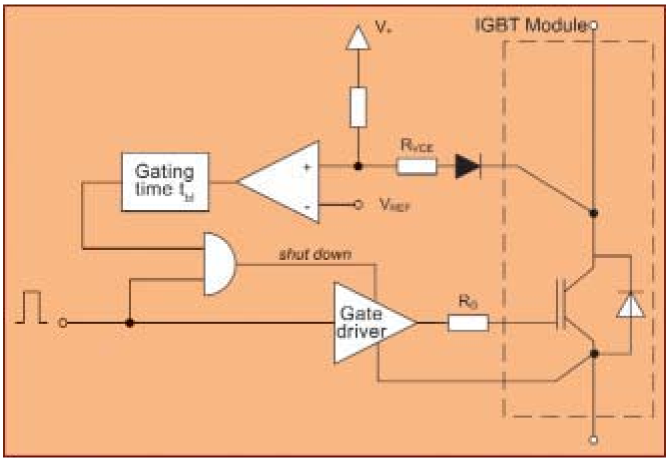

Figure 1b: Circuit diagram for V_{CE} monitoring

$V_{ce\,(sat)}$ monitoring (Figure 1b) uses the correlation between collector current and on-state voltage. To do so, the collector-emitter voltage is measured and compared with a dynamic reference voltage by a comparator. If the voltage reading exceeds the reference voltage, the driver electronics automatically turns the transistor off. Owing to the rapid increase in transistor voltage, Vce monitoring is a reliable short circuit detection method. The advantage of Vce monitoring is that short circuits are detected quickly and it is suitable for use with any standard IGBT.

Should the short circuit occur in combination with a high inductance, e.g. on the power side, the collector current rises more slowly. In this case, the Vce threshold has to be adapted accordingly. To be able to apply the Vce method to overcurrent detection, multi-stage Vce monitoring can be used. Here, several trip thresholds with given reference times are defined. The disadvantage of this method, however, is its temperature-dependence, as well as the complexity involved in adapting the individual stages to the given system. In general, a more effective and reliable way of detecting slow overcurrents is to use integrated current sensors.

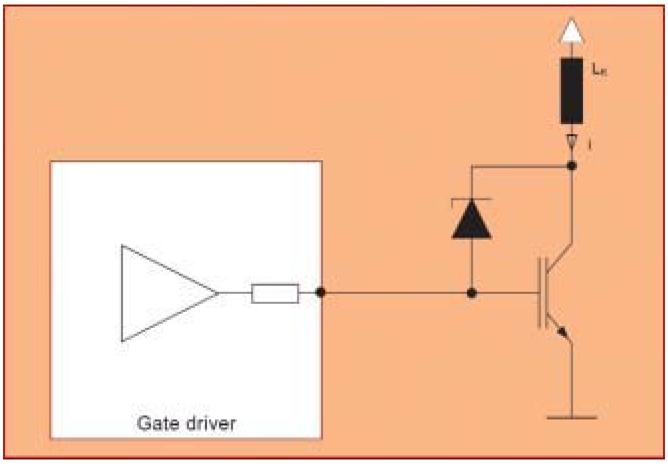

Figure 2: Active clamping circuit diagram

Besides fast error detection, an effective and reliable response to a short circuit is also crucial. If drivers are used in multilevel applications or in drives for synchronous motors, the master controller should be responsible for system turn-off. In this case, the driver sends only the isolated error signal to the controller and waits for instructions. In multilevel applications, for example, if the driver turns off the power semiconductor directly and then sends the signal to the controller, the entire DC link voltage may be present across one IGBT for the entire signal transmission and response time. This would lead to the destruction of the module. In the majority of applications, however, it is safer to allow the power modules to be turned off directly by the driver. The driver can respond more quickly, since it does not have to wait until the signal transmission process is complete, but can independently turn off the module from the secondary side. The avoidance of voltage spikes when turning off short circuit currents is ensured by the driver by way of a soft-off or two-level turn-off function. Here, the driver turns off the IGBTs that have higher gate resistances more slowly, in doing so protecting the module from exceeding the safe operating area (SOA).

Circuit-induced overvoltage

The second fast error mode results from circuit-induced overvoltages. Overvoltages that occur during turn-off have to be detected and reduced quickly in order to prevent the IGBT module from being damaged. The switching surges result from stray inductance in the power circuitry, e.g. as a result of busbars. Externally induced overvoltages are slow and can be controlled more effectively by way of DC link voltage monitoring.

Driver electronics can control overvoltage directly by way of active clamping, or can use IntelliOff, intelligent turn-off feature used to reduce critical voltage spikes.
Active clamping turns the IGBT back on as soon as an overvoltage occurs. The gate recharging process is essentially controlled by a central element between collector and gate in order to reduce the overvoltage.

Here, the overvoltage value corresponds at a maximum to the Zener voltage. The transistor operates once again in the safe operating area, but converts the energy stored in L_K to heat. During this process, substantial additional losses occur in the IGBT within a very short time. These losses accelerate the ageing process of the components and limit the reliability of the converter system.

One way of preventing the occurrence of overvoltages would be to use the IntelliOff turn-off feature. IntelliOff offers optimised turn-off, combining the advantages of virtually immediate switch response with soft turn-off. The turn-off process itself is optimised by IntelliOff thanks to different-speed gate discharging. To start with, the driver initiates the IGBT turn-off process as quickly as possible. As soon as the turn-off process enters the overvoltage phase, the driver slows down the turn-off process, in doing so working proactively against the overvoltages. Finally, the IGBT driver turns off the module safely and reliably.

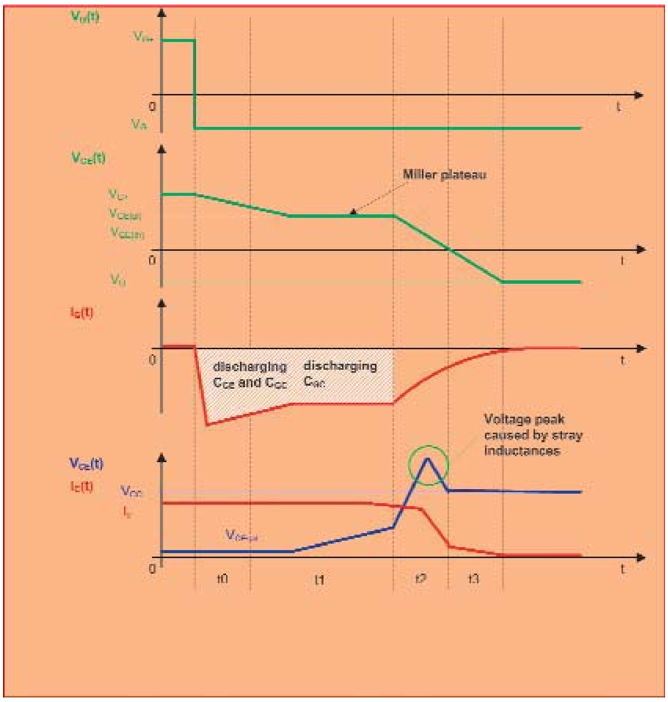

Figure 3: IntelliOff, pro-active overvoltage protection

As soon as the turn-off signal comes, the driver generates the negative gate charge. The discharging process of the gate collector and emitter capacitances begins and the gate current reaches its negative peak (period 0). Owing to the Miller Effect, which describes the process of capacitive feedback that opposes the turn-off process, the gate emitter voltage remains at a higher level for a certain time (period 1). IntelliOff reduces this discharging time thanks to a low-ohmic turn-off resistance and allows for the process to speed up. During period 2, a high-ohmic resistance slows down the turn-off process, in doing so avoiding circuit-induced voltage spikes (period 2). Without IntelliOff, an overvoltage may occur in this phase which, in the case of Active Clamping, will produce additional losses and, if suitable protective measures are not taken, might ultimately lead to the destruction of the module. Once the critical, voltage spike time frame has passed, the driver establishes – by way of the IntelliOff function – the parallel connection of the turn-off resistances, ensuring that the IGBTs are switched off safely and efficiently. The simple adjustment is possible thanks to an adjustable time constant between high and low turn-off resistances.

New IGBT generations, in particular, have very fast and hard switching characteristics. The IntelliOff function can ensure faster turn-off without the risk of critical voltage spikes and, consequently, help ensure optimum performance in new IGBT modules. Alternative protective concepts, in contrast, respond by limiting the performance of the IGBT module, in doing so producing additional losses.

Conclusion
The ideal protection concept for gate drivers depends on the given application. In general, however, it is advisable to investigate and analyse the error mechanisms during the system dimensioning stage already. Using the gate driver to permanently compensate for non-permissible conditions is not an efficient solution and reduces reliability into the bargain. A more effective way of providing overvoltage protection is to use the IntelliOff function, which prevents voltage spikes from occurring in the first place. VCE monitoring is a reliable short circuit detection method and has a number of advantages over di/dt detection owing to its easy adaptability and applicability with any standard module.

Many different driver protection solutions are on the market today, ranging from standard protection functions to highly complex driver solutions. With simple driver solutions, however, users have to integrate protective functions themselves and provide driver protection for the overall system themselves. This can be rather costly, and driver protection is often underestimated. Highly complex driver solutions, by way of contrast, often have the disadvantage that system implementation is rather complex and service life is often limited. An optimum driver solution has to meet system reliability requirements, but should also factor in the all-important price-considerations of mass-production applications.

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Opportunities & Threats from Emerging Countries' Automotive Solutions

Major component and system suppliers are setting up advanced design centers for next-generation vehicles

To understand the various different approaches taken by automotive manufacturers in various territories worldwide, it can be helpful to visualize a triangle in which each corner represents the three automotive values of "Quality", "Cost" and "Technology/Innovation" (see figure 1). The triangle can be applied to advanced or emerging markets, as these three values are common to all OEMs in the automotive business. The emphasis a manufacturer places on each of these values varies according to factors such as demands coming from customers (the car brands) and end-user markets.

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

Drawing on long experience working with"Tier-1" and "Tier-2" automotive system suppliers in America, Europe and Asia it is possible to position these OEMs inside this triangle, placing them in closest proximity to the values most important to them.

Such judgments are, of course, subjective. However, the generally perceived openness among European automotive manufacturers to adopt new technologies and innovation places these suppliers closer to the Technology/Innovation corner of the value triangle. Quality is a very strong second-placed value driver.

Figure 1: Automotive Value Triangle

Japan, however, is quite different. Here, Quality (focused on reliability) is the clear number-one value driver. The tendency with the Japanese automotive manufacturers and suppliers is to utilize proven technologies much longer in their cars for the sake of reliability so that the adoption of brand new technologies appears to take somewhat longer. Of course, there is no doubt that Japan is the technology leader in Hybrid-Electric Vehicles (HEVs) but the majority of the Japanese cars are petrol or diesel powered, with generally lower levels of leading-edge technology and innovation under-the-hood, and displaying a strong emphasis on quality and reliability. Many Japanese buyers see their cars as an important transportation mechanism that must be fully reliable; like the country's enviable rail system.

For quite some time, North American automotive OEMs have been mainly driven by cost-reduction programs as indigenous car brands have sought to cut prices and offer big rebates. Adoption of new technologies has been notably slow, which, arguably, has contributed to the current strength enjoyed by German and Japanese brands in the US. Accordingly, US OEMs tend to be positioned nearer the Cost apex of the value triangle.

This analysis can provide an interesting perspective on how emerging markets like China and India may develop. Currently, the design approach for OEMs and suppliers operating in these territories is completely different from the Japanese or Western automotive markets. While low cost is the biggest driving factor in emerging automotive countries - as companies focus on providing local markets with "affordable cars" - the design approach is also a world apart. For instance, in the established advanced automotive world, subsystem manufacturers – the tier 1s and tier 2s – will typically provide a supplier with very detailed specification for required products; such as power semiconductor s, for example. However, a local automotive system manufacturer in China or India expects a fully functional "plug and play" system solution rather than "just a product." This is a very different world which requires a very different approach to enter that market.

Nevertheless, in cooperation with major component and system suppliers, key automotive manufacturers in these emerging countries, especially China, are setting up advanced design centers for next-generation domestic vehicles. As a result, automotive OEMs in the developing world are expected to demonstrate notable technological advancement and significant increases in technology development capabilities in the coming years.

South Korean automotive OEMs have already successfully pursued a similar trend. Only a few years ago, they were known for producing “cheap” cars but more recently South Korean brands have begun delivering products of much higher quality. Likewise, Chinese automotive OEMs are also expected to move towards quality in the next couple of years. So while the brands of emerging countries will initially provide affordable cars for their local markets, they can be expected to follow the South Koreans’ example by expanding into the more lucrative export markets. India and China already present their car brands in all important automotive shows around the world.

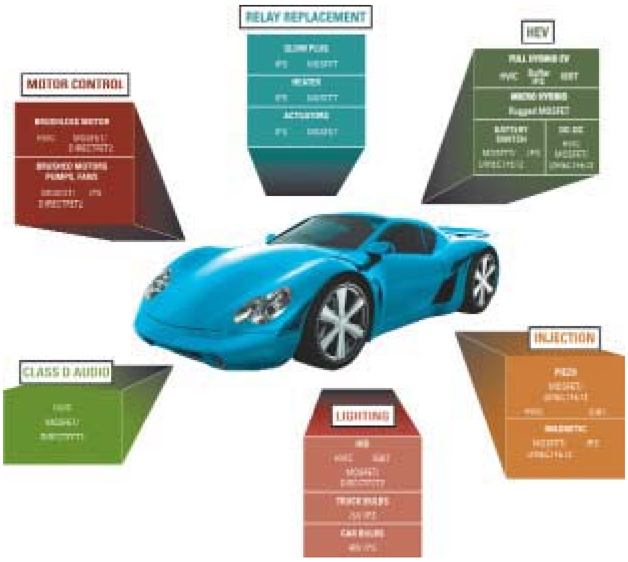

Figure 2: IR’s power management solutions for automotive applications

However, in order to be successful in established automotive markets, the cars must still meet certain minimum standards for quality, safety and performance. So as indicated in Figure 1, emerging automotive nations like China will move towards the center of the value triangle in order to address export markets with their cars. This could present a significant threat for the more established automotive OEMs in the rest of the world.

China is approaching from a low-cost approach and moving into the triangle’s center by upgrading their concepts to an optimized compromise of all three automotive values. The established European and Japanese OEMs are positioned on the other end of the triangle. If they want to move their products towards the balanced center of the value triangle they must downgrade their currently established value propositions for leading-edge technology or high quality; a step that will be less appreciated in the eyes and expectations of their established customer base who probably would like to get the same value just at lower cost.

This is the dilemma which established OEMs will face and they need to react quickly to defend their market shares against the emerging car brands from low cost countries. International Rectifier, as a major supplier of power semiconductors and solutions to the automotive electronics sector, has developed technologies that can support system cost reduction by higher integration to help OEMs positioned in the technology or quality corner looking for more affordable solutions. However, IR also offers an excellent automotive portfolio for emerging markets to upgrade their solutions towards higher standards.

Since its foundation 1947, IR has always emphasized its energy saving mission. Consequently, its two main focus areas in automotive include supporting environmentally friendly fuel-efficient or energy-efficient (a broader definition also covering the HEVs and full-electric vehicles now entering the market) solutions with application-specific products and chipsets. The second major focus is to further improve the energy efficiency of the established power-consuming subsystems in today's car architecture with a broad range of generic or application-specific standard products for the automotive mass market.

To succeed in these market segments, IR's automotive business unit manages five product lines that address basically all power-management applications that can be found in a car today or in the HEVs or full-electric vehicles of the future. The five product lines provide our customers with low-, medium- and high-voltage power switches (MOSFETs and IGBTs, covering the traditional 12V car and 24V truck power net up to the high-voltage HEV applications with bus voltages of 600V-1200V), Intelligent Power Switches (IPS) with integrated protection and intelligence for cars and trucks, high-current analog ICs up to 75V and high-voltage mixed-signal ICs capable of driving power switches up to 1200V (such as for (H)EV power-train motor drives). These products all emerge from proprietary silicon processes developed in-house, combined with very advanced proprietary packaging technologies such as the bondwire-free and 100% lead-free automotive DirectFET®2 product line (figure 3).

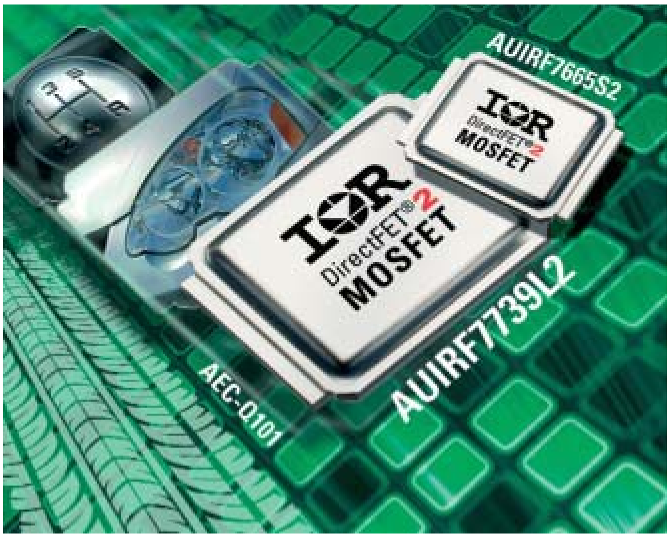

Figure 3: DirectFET®2 power MOSFETs

With this wide variety of products, IR provides chipset solutions that help drive down the cost on a system level, or can support customers with fully developed solutions that can easily be adapted to their application-specific control units within a very short time to market. Particularly for emerging markets that want to re-use proven solutions with short development times and good quality and innovative technology needs, IR is the partner of choice to help its customers move to their preferred position on the automotive value triangle (figure1).

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Electromagnetic Compatibility Considerations for Switched Mode Power Supplies

Characterization of the EMI problem requires understanding the interference source

Switched Mode Power Supplies (SMPS) generate Electromagnetic Interference (EMI) by virtue of their inherent design characteristics. Internal SMPS circuits that generate undesirable emissions that are rich in harmonics can cause electrical interference both internally to the circuit in which the power supply is installed and to other electronic equipment in the vicinity of the emission source.

By Don Li, Chief Technical Officer, CUI Inc and Jeff Schnabel, VP of Marketing, CUI Inc

Introduction

This article examines the rules and regulations governing control of EMI, discusses types of noise generated by SMPS, and provides basic guidance for EMI mitigation for SMPS, whether installed in other equipment as part of a larger system or a SMPS designed for stand-alone applications.

Laws, Regulation, and International Cooperation

The electro-magnetic spectrum has been widely used for broadcasting, telecom and data communications through intentional emissions of electro-magnetic fields. There have also been unintentional emissions from many electrical and electronic equipment, such as arc welding machines, household appliances and computer equipment. In order to protect the electromagnetic spectrum and to ensure compatibility of collocated electrical and electronic systems from trouble free operations, regulatory bodies both within the United States and throughout the world community have established standards to control conducted and radiated electromagnetic interference in electronic equipment. This discussion mainly focuses on unintentional electromagnetic compatibility in systems that utilize switch mode power supplies

United States Standards

In the United States the government agency responsible for regulating communications is the Federal Communications Commission (FCC). Control of electromagnetic interference is outlined in Part 15 of the FCC rules and regulations. FCC rules decree that any spurious signal greater than 10 KHz be subject to these regulations. The FCC further specifies the frequency bands in which these spurious emissions must be controlled according to the type of emission. Radiated emissions, i.e., those radiated and coupled through the air, must be controlled between 30 MHz and 1000 MHz. Conducted emissions, i.e., those RF signals contained within the AC power bus, must be controlled in the frequency band between 0.45 MHz and 30 MHz.

The FCC further categorizes digital electronic equipment into Class A (designated for use in a commercial, industrial, or business environment excluding residential use or use by the general public) and Class B (designated for use in a residential environment notwithstanding use in commercial, business and industrial environments). Examples of Class B devices are personal computers, calculators, and similar devices for use by the general public. Emission standards are more restrictive for Class B devices since they are more likely to be located close to other electronic devices used in the home.

International Standards

A standard widely used in the European Community is the Third Edition of the International Special Committee on Radio Interference (CISPR), Pub. 22, “Information Technology Equipment—Radio Disturbance Characteristics—Limits and Methods of Measurement,” issued in 1997. This standard is better known as simply CISPR 22. Unlike the FCC which regulates electromagnetic interference in the United States, CISPR is a standards organization without regulatory authority. However, CISPR standards have been adopted for use by most members of the European Community.

CISPR 22 also differentiates between Class A and Class B devices and establishes conducted and radiated emissions for each class. In addition, CISPR 22 requires certification over the frequency range of 0.15 MHz to 30 MHz for conducted emissions (Recall that the FCC range starts at 0.45 MHz).

Standards Harmonization

The FCC Part 15 rules and the requirements of CISPR 22 have been harmonized and either standard, with minor exceptions, can be used to certify digital electronic equipment. Harmonization requires that the same standard be used for both conducted and radiated emissions. Measurements made above 1000MHz must be made in accordance with FCC rules and limits since CISPR 22 has no speci-

fied limits for frequencies above 1000 MHz. Conducted and radiated emission limits specified in FCC Part 15 and CISPR 22 are within a few dB of each other over the prescribed frequencies, so using either set of limits does not compromise accuracy of the measurement and certification process. FCC limits are given in ìV and CISPR limits are given in dBìV, so conversion of the units for one set of limits is necessary for direct comparison.

SMPS and EMC Standards

Switched Mode Power Supply (SMPS) is a generic term that describes a power source that uses a circuit to convert a DC voltage to an AC voltage that can be further processed to become another DC voltage. SMPS can be further categorized as AC-DC converters (AC input) and DC-DC converters (DC input) since both incorporate DC to AC conversion for voltage change. By virtue of their inherent design characteristics, SMPS generate electromagnetic interference composed of signals of multiple frequencies. The DC-DC converter converts the input DC voltage to an AC voltage that can be stepped up or down via a transformer. AC-DC converters also utilize high frequency circuits for voltage conversion. However, the internal AC voltage in either case is not a pure sine wave but frequently a square wave which can be represented by a Fourier series that consists of the algebraic sum of many sine waves with harmonically-related frequencies. These multiple-frequency signals are the source of conducted and radiated emissions which can cause interference to both the equipment in which the SMPS is installed and to nearby equipment which may be susceptible to these frequencies.

Switched mode power supplies generate EMI which is subject to FCC and CISPR regulations. Since Class A electronic equipment is marketed for use in a commercial, industrial, or business environment, and Class B electronic equipment is marketed for use in a residential environment, emission limits for Class B equipment, which is likely to be located in close proximity to radio and television receivers, are therefore more restrictive than Class A. In general Class B limits are more restrictive than Class A by a factor of 3 (~10 dB). FCC conducted emission limits are specified for frequency ranges of 0.45-1.6 MHz and 1.6-30 MHz. FCC radiated emission

CISPR Class A Conducted EMI Limit		
Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	Quasi-peak	Average
0.15 - 0.50	79	66
0.50 - 30.0	73	60
CISPR Class B Conducted EMI Limit		
Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	Quasi-peak	Average
0.15 - 0.50	66 to 56*	56 to 46*
0.50 - 5.00	56	46
5.00 - 30.0	60	50

* Decreases with the logarithm of the frequency.

CISPR Class A 10-Meter Radiated EMI Limit	
Frequency of Emission (MHz)	Field Strength Limit (dBµV/m)
30 - 88	39
88 - 216	43.5
216 - 960	46.5
above 960	49.5
CISPR Class B 3-Meter Radiated EMI Limit	
Frequency of Emission (MHz)	Field Strength Limit (dBµV/m)
30 - 88	40.0
88 - 216	43.5
216 - 960	46.0
above 960	54.0

Table 1 CISPR Field Strength Limits for Conducted and Radiated Emissions

limits are specified for frequency ranges of 30-88 MHz, 88-216 MHz, and 216-1000 MHz at a fixed measuring distance of 3 meters. The specified limits are shown in Table 1 for CISPR and Table 2 for the FCC Part 15.

FCC Class A Conducted EMI Limit	
Frequency of Emission (MHz)	Conducted Limit (µV)
0.45–1.6	1000
1.6–30.0	3000
FCC Class B Conducted EMI Limit	
Frequency of Emission (MHz)	Conducted Limit (µV)
0.455–1.6	250
1.6–30.0	250
FCC Class A 30-Meter Radiated EMI Limit	
Frequency of Emission (MHz)	Field Strength Limit (µV/m)
30–88	30
88–216	50
216–1000	70
above 1000	70

FCC Class B 3-Meter Radiated EMI Limit	
Frequency of Emission (MHz)	Field Strength Limit (µV/m)
30 – 88	100
88 – 216	150
216 – 1000	200
above 1000	200

Table 2: FCC Field Strength Limits for Conducted and Radiated Emissions

These limits apply to both systems with SMPS installed and SMPS in stand-alone applications.

EMC Testing and Compliance

EMC testing and compliance is performed according to the test procedure defined in ANSI C63.4-2009 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". This ANSI Standard does not include either generic or specific product-related limits on conducted and radiated emissions. These limits are specified in the FCC and CISPR documents discussed above. It is worth noting that testing is done with the entire system, not just the power module, especially with embedded power modules. With external power supplies (as in standalone power adapters), the entire system needs to be tested, even if the power adapter is in compliance with the regulations.

EMI/EMC Fundamentals

Sources and Associated Frequencies

EMI cases generally include a source of interference, a path that couples the EMI to other circuits, and a target referred to as the "victim" whose performance is degraded by the source EMI. The damaging effects of EMI pose unacceptable risks in many different technologies, thus making it necessary to control EMI at its source or reduce the risk of exposure to EMI to acceptable levels at the victim.

EMI can first be categorized as continuous interference as opposed to transient interference. Continuous interference occurs when the source emits an uninterrupted signal composed of the source's fundamental frequency and associated harmonics.
Continuous interference can be further subdivided by frequency band. Frequencies from a few tens of Hz up to 20 KHz are classified as audio. Sources of audio interference include power supply hum and associated wiring, transmission lines and substations, audio processing equipment such as audio power amplifiers and loudspeak-

ers, and demodulation of high frequency carrier waves such as those seen in FM radio transmission.

Radio Frequency Interference (RFI) occurs in a frequency band from 20 kHz to a constantly increasing limit defined by advancing technology. Sources of RFI include wireless and radio frequency transmissions, television and radio receivers, industrial, scientific and medical equipment, and high frequency circuit signals such as those in microprocessors, microcontrollers, and other high speed digital equipment.

Broadband noise, consisting of signals of multiple frequencies, may be spread across parts of both frequency ranges. Sources of broadband noise include solar activity, continuously operating spark gaps such as arc welders, and CDMA mobile telephony.

Transient EMI arises when the source emits a short duration pulse of energy rather than a continuous signal. Sources include switching electrical circuitry, e.g., inductive loads such as relays, solenoids and electric motors. Other sources are electrostatic discharge (ESD), lightning, nuclear and non-nuclear electromagnetic pulse weapons, and power line surges. Repetitive transient EMI can be caused by electric motors, gasoline engine ignition systems and continuous digital circuit switching.

EMI Coupling

Coupling can occur through conduction via an unwanted path (a so-called "sneak circuit"), through induction (as in a transformer), and radiated or through-the-air coupling.

Conductive coupling occurs when the coupling path between the source and the receptor is formed by direct contact. Direct contact may be caused by a transmission line, wire, cable, PCB trace or metal enclosure. Conducted noise can appear in a common or differential mode on two conductors.

Differential mode noise results from a differential mode current in a two wire pair. The differential mode current is the expected current on the two wire pair, i.e., current leaves at the source end of the line and comes back on the return side of the line. The noise is measured on each line with respect to a designated reference point. The resultant measurement would be the difference in the noise on the two lines. Differential mode currents flow between the switching supply and its source or load via the power leads and these currents are independent of ground. Consequently no differential mode current flows through ground.

Common mode noise is caused by a common mode current. In this case noise current flows along both the outgoing lines in the same direction and returns by some parasitic path through system ground that is not part of the design, the so-called "sneak circuit" discussed earlier. In many cases, common mode noise is conducted through parasitic capacitance in the circuit. Common mode currents flow in the same direction in or out of the switching supply via the power leads and return to their source through ground. Common mode currents will also flow through the capacitance formed between the case and ground.

Conducted EMI emissions are measured up to 30 MHz. Currents at frequencies below 5 MHz are mostly differential mode, while those above 5 MHz are usually common mode.
These currents are defined in Figure 1.

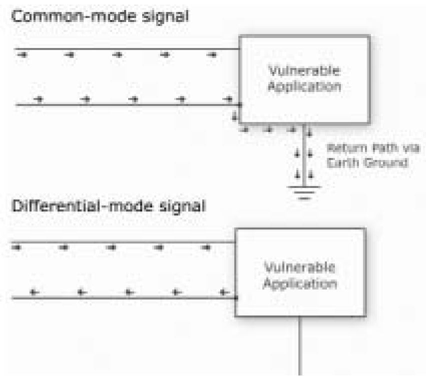

Figure 1: Definition of Differential and Common Mode Currents

Inductive coupling occurs where the source and receptor are separated by a short distance. Inductive coupling can be due to electrical induction or magnetic induction. Electrical induction results from capacitive coupling while magnetic induction is caused by inductive coupling. Capacitive coupling occurs when a varying electric field exists between two adjacent conductors, inducing a change in voltage across the gap. Magnetic coupling occurs when a varying magnetic field exists between two parallel conductors, inducing a change in voltage along the receiving conductor. Inductive coupling is rare relative to conductive or radiated coupling.
Radiated coupling occurs when source and receptor (victim) act as radio antennas. The source radiates an electromagnetic wave which propagates across the open space between the source and the victim and is received by the victim.

Characterization of the EMI problem requires understanding the interference source and signal, the coupling path to the victim and the nature of the victim, both electrically and in terms of the significance of the malfunction. The risk posed by the threat is usually statistical in nature; so much of the work in threat characterization and standards setting is based on reducing the probability of disruptive EMI to an acceptable level rather than its assured elimination.

EMI requirements, both radiated and conductive, apply to an overall electronic system. Power modules are one of many components within a system. Since the EMI requirements apply to the overall system, significant effort must be expended on system design to limit noise. Most electronic equipment has only one interface with the power source, which is through the power supply. If adequate EMI filters are inserted between the power supply and the power source, conducted emissions from the power module can be sufficiently suppressed to meet the FCC or CISPR limits without any of the power modules meeting the EMC standard as a standalone component. However, it should be noted that SMPS in stand-alone applications, typically in the form of external power adapters, are required to operate below the conducted EMI limits.

Practical Measures for EMI Mitigation in Power Systems

In systems and circuits that are powered by switched mode power supplies, good practices should be observed in order to minimize EMI problems and ensure agency compliance. Suppression of EMI to levels below that specified by regulatory bodies requires an understanding of the design of the switched mode power supply and the application in which the converter is incorporated. It is important to note that even an application with a properly filtered SMPS may not achieve compliance if the application is not designed to minimize EMI. Cautions must be taken to use the power supply/converter properly as intended, to prevent power supply generated noise from radiating or reaching the source, minimize noise pick up from the power supply, minimize system noise generation, and prevent system generated noise from reaching the power supply.

Mitigation Techniques Conducted EMI

To effectively mitigate conducted emissions, it is imperative to address the differential mode noise and common mode noise separately because the remediation solution is different for each type of noise. Solutions for differential mode noise will not eliminate common mode noise present in the circuit. The same is true for common mode noise solutions as applied differential mode noise.

Differential mode noise can usually be suppressed by connecting bypass capacitors directly between the power and return lines of the switching power supply. The power lines that require filtering may be those located at the input or the output of the switching power supply. The bypass capacitors on these lines need to be physically located adjacent to the terminals of the noise generating source to be most effective. The actual location of the bypass capacitor is critical for efficient attenuation of differential mode currents at high frequencies. Attenuation at lower frequencies of differential mode currents around the fundamental switching frequency of the noise generating source may dictate that a much higher value of bypass capacitance be required that cannot be attained with a ceramic style capacitor. Ceramic capacitors up to 22 ìF may be suitable for differential mode filtering across the lower voltage outputs of switching power supplies but not be suitable for the switching power supply inputs where 100 volt surges can be experienced. For these applications electrolytic capacitors are employed because of their high capacitance and voltage ratings.

Differential mode input filters usually consist of a combination of electrolytic and ceramic capacitors to suitably attenuate differential mode current both at the lower fundamental switching frequency as well as at the higher harmonic frequencies. Further suppression of differential mode currents can be achieved by adding an inductor in series with the main power feed to form a single stage L-C differential mode low pass filter with the bypass capacitor.

Common mode conducted currents are effectively suppressed by connecting bypass capacitors between each power line of the switching power supply and ground. These power lines may be at the input and/or at the output of the switching power supply. Further suppression of common mode currents can be achieved by adding a pair of coupled choke inductors in series with each main power feed. The high impedance of the coupled choke inductors to exiting common mode currents forces those currents through the bypass capacitors.

Mitigation Techniques for Radiated EMI

Radiated EMI can be suppressed by reducing RF impedance and reducing the antenna loop area which is done by minimizing the enclosed loop area formed by the power line and its return path. The inductance of a printed circuit board track can be minimized by making it as wide as possible and routing it parallel to its return path. Similarly, because the impedance of a wire loop is proportional to its area, reducing the area between the power line and its return path will further reduce its impedance. Within printed circuit boards this area can be best reduced by placing the power line and return path one above the other on adjacent printed circuit board layers. Recall that reducing the loop area between a power line and its return path not only reduces the RF impedance, but also reduces the effectiveness of the antenna because the smaller loop area produces a reduced electromagnetic field. A ground plane located on the outer surfaces of the printed circuit board, particularly if located directly below the noise generating source, suppresses radiated EMI significantly.

To further reduce radiated noise, metal shielding can be utilized to contain radiation. This is achieved by placing the noise generating source within a grounded conductive housing. Interface to the clean outside environment is via in-line filters. Common mode bypass capacitors would also need to be returned to ground on the conductive housing.

Additional Mitigation Considerations for Switched Mode Power Supplies

Reliable wiring connections should be implemented to and from the SMPS. Wiring must be of suitable size and be kept as short as possible, and wiring loops should be minimized. Avoid running input or output wirings near power devices to prevent noise pick up. Ensure all grounding connections are made and properly secured. Earth ground wires should be kept as short as possible. If the circuit or system operations induce current transients, it is very important to have local decoupling capacitors to supply the pulsed current locally, instead of letting the pulsed current propagate up stream to the supply.

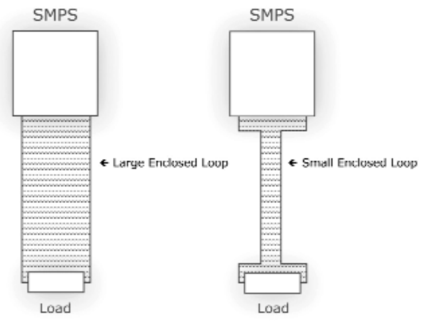

Figure 2: Reduced Antenna Loop Area to Reduce Radiated Emissions

These capacitors should include high frequency ceramic caps and bulk capacitors. If the operation allows, slow down the clock, or rising/falling edges. Circuits with higher clock rates/fast switching times should be located close to the power line input to reduce power transients. It is recommended that both analog and digital circuits should be individually physically isolated on both power supply and signal lines.

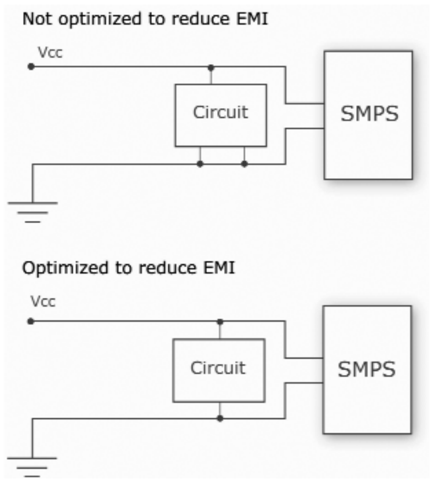

Figure 3: Eliminate Loops in Supply Lines

Care must be taken to prevent ground loops in the system, especially when the system becomes complex. This can be achieved by using a single point ground or a ground plane. An example is highlighted in figure 3.

If there are multiple circuits in a system, decouple the circuits from each other by running separate supply lines, and/or place inductance in the supply lines as highlighted in figure 4 below.

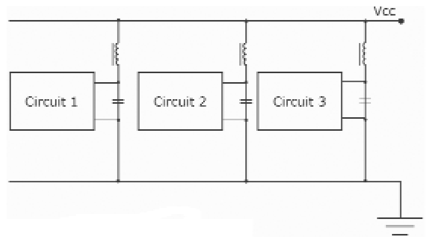

Figure 4: Decoupled Supply Lines at the Local Boundaries

If needed, ferrite beads can be placed on the DC supply lines to AC isolate the system and the supply. This can be effective to prevent power switching harmonics from disrupting the system's operation, or to prevent system generated noise from reaching the power supply. On the input side, if the built-in EMI filter is insufficient for a specific application, additional EMI filtering can be applied before the power supply. A bead can also be placed on the earth ground wire between the AC inlet and the supply.

Although many of the mitigation techniques highlighted above are applicable to the implementation of both AC-DC and DC-DC converters within a system, there are specific considerations that must be addressed for DC-DC converters. The switching action in most DC-DC converters demand a pulsed input current, which is best supplied by local capacitors close to the switching devices. As many switching DC-DC converters are compact in size, they generally do not contain sufficient capacitance. The system designer will need to place additional capacitance at the input to reduce differential mode noise. For even better filtering performance, a PI filter can be employed as in figure 5. The additional capacitors are used to reduce common mode noise.

Additional System-Level Mitigation Techniques

As mentioned above, although most switch mode power supplies are designed to meet applicable EMI standards as stand-alone modules, the system itself needs be designed to generate a minimum EMI profile to meet regulatory standards. Specific areas in the system design that are candidates for EMI mitigation practices include the signal lines, printed circuit boards (PCB), and solid state components.

Signal line considerations include the use of low pass filters on signal lines to reduce allowable bandwidth on the line to the minimum that will still allow the signal to pass un-attenuated. Feed and return loops should be kept close on wide bandwidth signal lines to minimize radiated emissions. Additionally, signal lines carrying RF or near-RF signals should be properly terminated to reduce reflection at the termination. Ringing and overshoot on these lines can also be minimized as a result of using the appropriate termination.

PCB high impedance runs that contribute to EMI can be mitigated by using wide PCB metal stripes to decrease the impedance of power lines. Where possible, signal tracks should be designed considering their propagation delay vs. signal rise/fall time and include a ground and a power plane. Slit apertures in PCB layout should be strictly avoided, particularly in ground planes or near current paths to reduce unwanted antenna effects. Board metal stripes should be kept as short as is practical, and metal stubs which can cause reflection and harmonics should be avoided. Also, avoid overlapping power planes to reduce system noise and power coupling. Reduce or eliminate sharp bends in metal stripes (also known as beveling or track mitering) to reduce field concentration and run conducting stripes orthogonally between adjacent layers to reduce crosstalk. Floating conductor areas can act as a source of radiated emissions, so their use should be avoided except for overriding thermal considerations. Additionally, solid State component on the PCB should be decoupled close to chip supply lines to reduce component noise and power line transients.

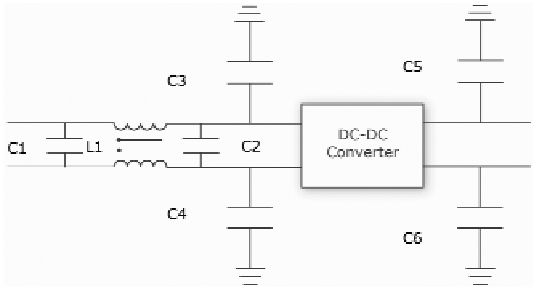

Figure 5: Typical Input-Output Filter Circuit

Summary

Switched mode power supplies can generate EMI because of their inherent design. Domestic and international regulatory bodies regulate these emissions through promulgation of rules and standards such as the FCC Part 15 rules and the CISPR 22 standard.

Noise has been discussed with respect to type, how the noise is transmitted, frequency of the noise, and noise modes in circuits. A basic design guideline for suppression of noise has been provided, including input/output filter circuits and reduction of antenna loop area. Best practices for EMI mitigation as regards power supply, signal line, printed circuit board (PCB) and components have also been discussed.

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Optical Isolation Amplifiers and Gate Driver Optocouplers

Both help improve efficiency and protect micro-inverters in PV solar applications

In 2009, the residential solar photovoltaic (PV) inverter market represented 90 percent of the total PV inverter worldwide market based on the number of units shipped. Growing at an annual average rate of 26 percent, the number of residential inverters sold should reach 4 million units by 2015 [1].

By Hong Lei Chen and Chun Keong Tee, Product Managers, Avago Technologies

Typically residential PV inverter systems provide 3 to 10 kilowatts of output power; a low amount when compared to the megawatt inverters in solar farms. Due to space constraints, the primary selection criteria for a residential inverter are compact size, ease of design, build quality, and monitoring capability. In response, the industry has introduced the micro-inverter topology for residential PV applications because it eliminates the need for a large centralized inverter, simplifies installation and energy management, increases reliability and optimizes efficiency.

Each micro-inverter in a solar PV application can use its maximum power point tracking (MPPT) algorithm to optimize the power conversion efficiency of each PV module. Current and voltage information is required to implement MPPT algorithms and isolation amplifiers (iso-amps), working with shunt resistors, to help provide accurate current measurements. When used with a resistive divider, iso-amps work as precision voltage sensors. Gate drive optocouplers with high current driving capability carry the pulse-width-modulation (PWM) signal across an isolation barrier to drive IGBTs. Since they provide tight dead time control and shoot-through prevention, gate drivers improve conversion efficiency and help protect the IGBTs.

This article discusses how current/voltage sensors and gate drivers can help ensure safe and stable micro-inverter operation in PV applications.

A residential solar PV power system using micro-inverters
Figure 1 illustrates a typical residential solar power system with a micro-inverter attached to each solar panel. This parallel configuration helps prevent energy loss from PV panel shading, since the entire system can be optimized for maximum energy harvesting on an individual-panel basis. Trees, fallen leaves, debris or clouds can partially shade or obscure solar panels from direct sunlight, leading to disproportionate power losses. For instance, in a typical series PV array, a 10 percent shading of the cell area will cause the source impedance to increase significantly and may cause power loss as high as 50 percent [2]. By using a parallel configuration, each PV string can operate at its optimum power point, independent of other strings, which helps eliminate problems from potential shading and other variances.

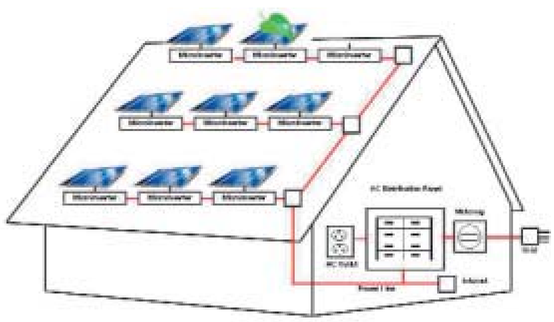

Figure 1: PV panel arranged in parallel with micro-inverters

The advantages of a parallel configuration can be further enhanced by attaching micro-inverters to each PV module rather than using one centralized inverter. This allows each micro-inverter to utilize a MPPT algorithm and optimize the performance of each PV module. Any atmospheric disturbances or mismatch on a module is then limited to that individual module. Although MPPT algorithms and other techniques can increase conversion efficiency of single-inverter systems, the measures performed on the entire array will only offer an average and will not reach the full energy potential of each panel in the solar array.

Another striking advantage of using a multiple micro-inverter topology instead of a centralized inverter is enhanced system reliability. If one or more inverters malfunction, the whole system will at least generate some power. Besides improved efficiency and reliability, micro-inverters also add flexibility since it is easy to expand capacity by simply adding PV panels.

Nevertheless, tradeoffs must be considered when employing a multiple micro-inverter topology when it comes to system design and cost. Besides the obvious increase in design complexity that results from using multiple inverters in the system, inter-panel communications becomes necessary for load balancing and proper planning of power allocation and distribution.

Maximizing conversion efficiency
One primary design goal in a PV micro-inverter application is to maxi-

mize power conversion efficiency, which often involves sophisticated, iterative processes to develop MPPT algorithms and real-time controllers with sufficient computing power to execute the algorithms.

The current-voltage (I-V) characteristic represents the basic performance of a PV module. A typical PV I-V curve (under constant irradiance and temperature) is shown in Figure 2. The point at which a PV device delivers its maximum power output and operates at its highest efficiency is referred to as its maximum power point (MPP or PMP). As the I-V curve changes, so does the MPP. Changing sunlight level and temperature also change the MPP [3, 4].

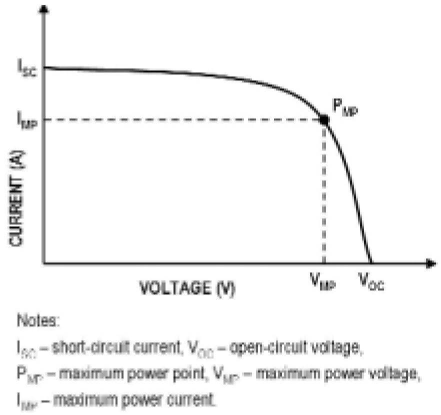

Figure 2: Typical current-voltage (I-V) curve of a PV module

The MPPT algorithm operates the PV module at the output voltage level where maximum power can be extracted from the module. It needs to find and track the MPP that is constantly changing with atmospheric conditions. An effective MPPT algorithm relies on accurate tracking of the PV module's current and voltage in addition to feeding that current and voltage data back to the microcontroller [4].

Another example that requires accurate current sensing is load balance control, which is required when the solar panels are connected in parallel. The controller must be able to detect the load current and adjust the converter output voltage by varying the PWM duty cycle.

When designing drive and sense circuits for inverters, galvanic isolation between the high-voltage circuits, low-voltage controller, and user interface must be maintained both for operator safety and to prevent hazardous high-voltage transients from damaging the controller.

Figure 3 shows a simplified block diagram of a PV inverter. In this example, the solar panel provides a DC source that is stepped up by a DC-to-DC boost converter to a high voltage of 300 V or more. The

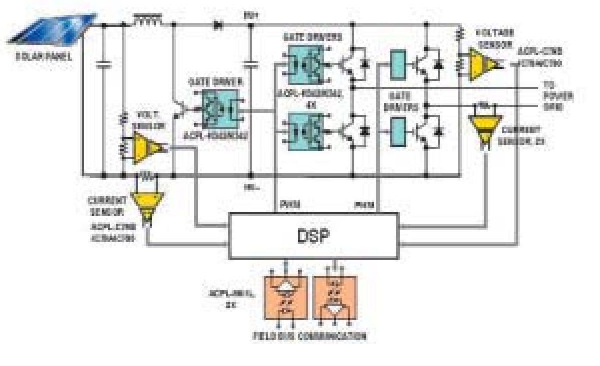

Figure 3: Block diagram of a micro-inverter with simplified DC-DC-AC topology

high-voltage DC is converted by a full-bridge inverter to AC power that must then be synchronized to the power grid in phase, frequency, and voltage and have low total harmonic distortion.

In order to achieve optimum system efficiency, the converter illustrated in Figure 3 shows that important current and voltage information must be fed back to the DSP for calculations and effective controls, such as MPPT and load balancing. This information includes panel output voltage, DC-link current and voltage, and inverter output currents. Therefore, current and voltage sensors with sufficient accuracy, response speed, high-switching noise rejection and safety insulation are needed.

Inter-panel and inter-system communications are part of a solar PV energy system since each panel must communicate with the central controller for control and monitoring. In such a fieldbus communication design, an ultra-low-power digital optocoupler, such as the ACPL-M61L, can be used for high-speed signal transmission with galvanic isolation. By providing an extremely low-current LED, working at 1.6mA, the device uses as little as 10 percent of the power of a standard digital optocoupler. When compared to an alternative technology isolator using magnetic coupling, power savings is 60 percent.

Current and voltage sensing using iso-amps

By providing enhanced linearity, low cost and design flexibility, shunt resistor current sensing is an optimum current measurement method, despite the drawback of power loss in the shunt. Today, better thermal performance and low-resistance shunt technology allows power loss to be minimized by reducing the shunt signal level. This is possible because of the availability of low cost, precision optically-isolated amplifiers.

One example is the family of ACPL-C79X miniature iso-amps that help meet the stringent requirements in power conversion systems. By accepting input signals of ±200mV, these devices optimize direct connection to shunt-based current-sensing applications. By choosing an appropriate shunt resistance, any range of current can be monitored, from less than 1A to more than 100A. Such a device can also be used to monitor voltage with the use of a resistive voltage divider at its input [5].

These iso-amps use advanced sigma-delta A/D converter technology and a fully differential implementation to realize 0.5 percent gain accuracy (ACPL-C79B) and 0.05 percent nonlinearity and DC to 200 kHz bandwidth, as shown in Figure 4. Available in a stretched small outline, 8-lead (SSO-8) package with 8 mm clearance and creepage (Figure 5), the device provides robust galvanic isolation with safety approvals of 1230 V working voltage, 5 kVrms/1min double protection, and 15kV/µs common-mode rejection [5].

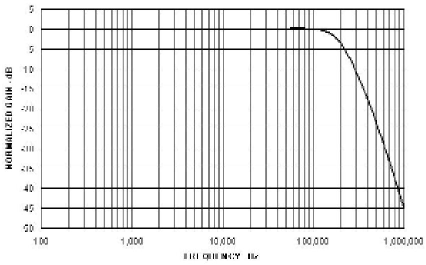

Figure 4: The gain-frequency response of an ACPL-C79X iso-amp

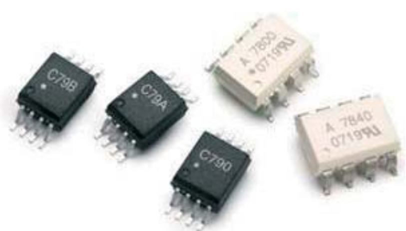

Figure 5: Available iso-amps in SSO-8 package (left) with 30% smaller footprint than DIP-8 package

Protection and efficient driving in power converter

A micro-inverter has the ability to adjust conversion parameters on each panel by using a high-resolution PWM. Based on the current/voltage, and probably temperature information (collected from the panel and inverter), the controller will vary the PWM signals according to its MPPT algorithms. The PWM signals need to be sent to the IGBT gates after passing through an optical isolator with high-output current drive capability.

A gate driver must have sufficient source/sink current to quickly charge/discharge the gate capacitance of an IGBT to turn it on/off. One example is the S0-8-packaged IGBT gate drive optocoupler called the ACPL-H342/K342.With a 2.5A peak output current and rail-to-rail output voltage, this device can directly drive IGBTs with ratings up to 1200 V/150 A. Its short, 260 ns propagation delay ensures the PWM signal quickly crosses the isolation barrier and turns on/off the IGBT. Built on robust optical isolation technology, the gate driver features a high common mode rejection rating of 40 kV/µs minimum for smooth control in the presence of high transient noise.

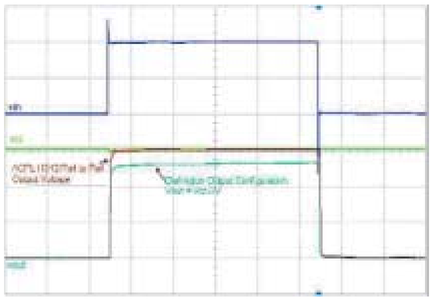

Figure 6: Comparison of an ACPL-H342 gate drive optocoupler's rail-to-rail output and the Darlington output

The gate drive optocoupler uses a MOSFET to pull the output to VCC for rail-to-rail output voltage swing. In the past, a gate drive optocoupler used bipolar Darlington transistors in the output stage to deliver high output current. As shown in Figure 6, a rail-to-rail output stage exhibits a higher output voltage swing than the Darlington approach. This helps ensure that the IGBT's gate voltage is driven to the optimum intended level with minimum power loss across the IGBT. The high swing also protects an IGBT from overheating.

Another advantage of using a driver with rail-to-rail output capability is improved gate driver switching efficiency. Figure 7 shows the energy per switching cycle of a gate driver under conditions that simulate driving a 1200 V/150 A IGBT in an inverter stage. The power dissipation of the gate drive optocoupler decreases by as much as 30 percent because of the lower saturation voltage and does not need to increase VCC to compensate for the 3VBE diode drop of the Darlington circuit. This translates to improved overall system efficiency.

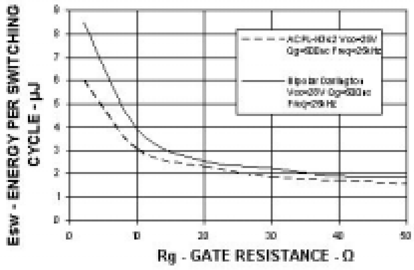

Figure 7: Gate drive optocoupler (ACPL-H342) vs. bipolar Darlington gate drive optocoupler power dissipation

Shoot-through is a serious short circuit condition in a power converter using the H-bridge configuration. It occurs when both the high side (Q1) and low side (Q2) IGBTs are on at the same time. Shoot-through wastes energy because a large current flows from the HV+ rail directly to the HV- rail without going through the load. More importantly, the resulting high-IGBT power dissipation can overheat and damage the expensive IGBTs.

An anti-cross conduction feature in the ACPL-H342/K342 gate drive optocoupler helps prevent shoot-through from occurring by factoring in a minimum dead time

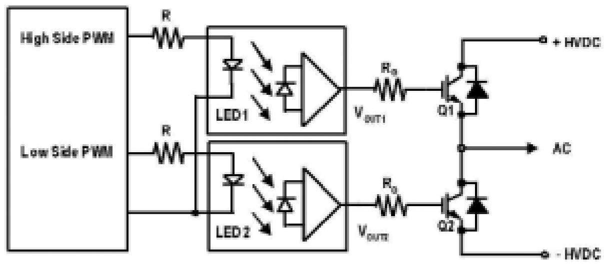

Figure 8: Simplified connection diagram using an ACPL-H342/K342 gate drive optocoupler

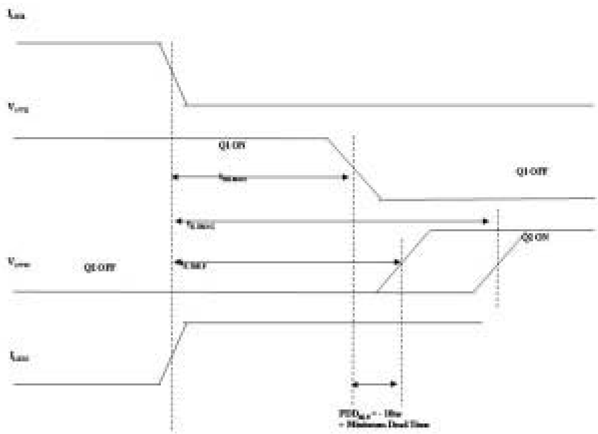

Figure 9: Minimum dead time prevents shoot-through

between the high- and low-side IGBTs (Figure 8). This is achieved by ensuring turn off is faster than turn on (Figure 9) [6]. This preventive feature simplifies the PWM design, because there is no need to consider delay time before toggling an IGBT on and off.

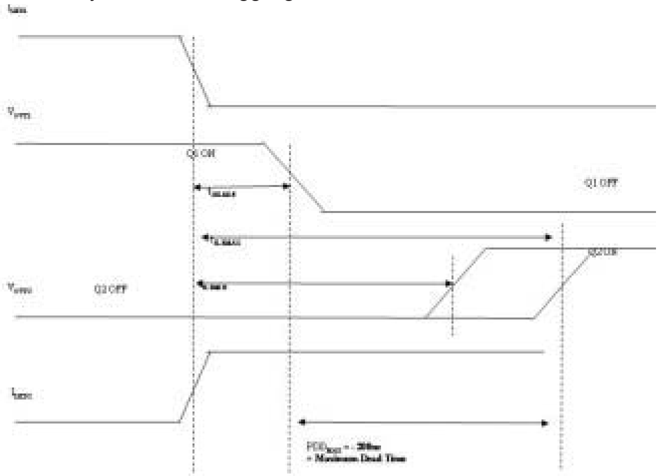

Figure 10: Smaller maximum dead time improves efficiency

Minimum dead time prevents shoot-through and yet, on the other hand, the maximum dead time is the longest period of time which both IGBTs Q1 and Q2 are off. During dead time, no work is done and too much dead time reduces the efficiency of the power converter. The gate drive optocoupler reduces the maximum dead time to 200 ns and this improves efficiency (Figure 10).

Conclusion

Micro-inverter-based PV solar installations are gaining market share. In small capacity PV systems, such as the residential and commercial rooftop solar inverters, the micro-inverter topology's parallel configuration offers easier installation, higher efficiency, better panel power harvesting, and no-single-point-of-failure reliability issues.

Current/voltage sensors and gate drivers are critical components in the control and drive loops that help ensure safe and stable micro-inverter operation. Advanced miniature isolation amplifiers can accurately measure the currents and voltages that are required in micro-inverter designs to achieve optimum efficiency. Gate drive optocouplers, featuring high current driving capability and compact packaging, can carry isolated PWM signals while driving the IGBT. And, they also provide rail-to-rail output and a shoot-through preventive circuit to help reduce power loss and protect the micro-inverter.

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www.avagotech.com

Keep it Cool – Ceramic simplifies Heat Dissipation

Thermal energy must be transferred to the surrounding area

LEDs suffer heat problems limiting their success as a light source. Much attention is given to the heatsink, less to the layers and barriers between LED and the heat dissipating surface. A change of concept and material allows significant gains in thermal management and reliability as well as a simplified system.

By Dr. Armin Veitl, Director of Design, Europe, Altair Engineering GmbH

Using ceramics as heatsink, circuit carrier and part of the product design needs some fresh thinking and the willingness to overcome traditional patterns. A simulation method based on Computational Fluid Dynamics supports thermal optimization and technical product design. The paper explains the theoretical approach, the proof of concept and what and how improvement with ceramic heatsinks can be achieved.

What's Hot?

LEDs are known to be efficient and are loved for being tiny. But they are only really tiny as long as heat management is not involved. Incandescent light sources work with temperatures up to 2.500°C. LEDs are much colder and many people stumble upon the fact that heat is such an issue. Being relatively cold LEDs still do produce heat which is not yet a problem. But they are based on semiconductors which, roughly speaking, simply allow temperatures below 100°C. According to the law of energy conservation the thermal energy must be transferred to the surrounding area. The LED can only use a small temperature gap between 100°C of the hot spot and 25°C ambience temperature; offering just 75 Kelvin. Consequently a larger surface and powerful thermal management are needed.

Two Optimization Blocks

Group 1 is the LED itself and mainly remains untouchable. Its centre is a die and a heat slug, a copper part, which connects the die with the bottom of the LED. Thermally, the ideal solution is direct bonding of the die to the heatsink itself. Due to mass production this concept is commercially unrealistic. We consider the LED as a standardized "catalogue" product which can not be modified. It is a black box.

Group 2 is the heatsink, transmitting energy from a heat source to a heat drain. This is usually the surrounding air either with free or forced convection. The less aesthetic the material, the higher is the need to hide it. The more you hide it the less efficient is the cooling. Alternatively, pleasing and worthy materials can be used, directly exposed to the air and being part of the visible product design.

In-between group one and two is Group 3 providing mechanical connection, electrical isolation and thermal transmittance. That seems contradictory since most materials with good thermal conductivity conduct as well electricity. Vice versa almost every electrical isolation material translates into a thermal barrier. The best compromise is soldering the LED to a PCB which is glued on the metal heatsink. The original function of a PCB as a circuit board can be kept. Although PCBs exist with various thermal conductivities they remain an obstacle to thermal transfer.

R_{tt} for Valid System Comparison

The thermal resistance of LEDs (die to heat slug pad) and heatsinks is available from the manufacturer. But there is little focus on group 3 and its significant influence on the total thermal performance.

Adding all thermal resistances but the LED (group 1), the total thermal resistance R_{tt} is born. The R_{tt} allows a real comparison of heat management concepts!

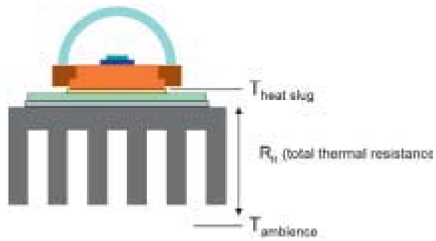


Figure 2: R_{tt} = (T_heatslug – T_ambience) / heat emission LED
R_{tt} indicates the total thermal resistance from the LEDs headslug to the surrounding. The comprehensive factor simplifies the comparisons of cooling systems and their efficiency.

Ceramic: Two Jobs in One Material

It is common to optimize only the heatsink. Hundreds of designs are available, essentially of aluminum. But for further improvement it is necessary to advance or even eliminate the third group! Electrical isolation

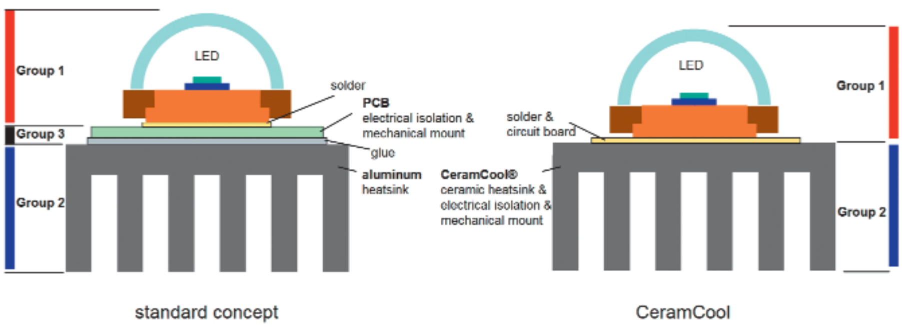


Figure 1: Three groups build a thermal management system and are examined for optimization potential. Why not eliminate block 3?

has to come from the heatsink itself by the use of other materials. Our conclusion is ceramic. Ceramics, e.g. Rubalit (Al_2O_3) or Alunit (AlN), combine two crucial characteristics: They are electrically isolating and thermally conductive.

Rubalit has a lower, Alunit a slightly higher conductivity than aluminum. On the other hand Rubalit is less expensive than Alunit. Their thermal expansion coefficient is adapted to semiconductors, they are rigid, corrosion-resistant and RoHs compliant. Completely inert, they are the last part of a system to die…The simplified construction (without glues, insulation layers, etc.) combined with a direct and permanent bond between the high-power LED and the ceramic heatsink create ideal operating conditions for the entire assembly. Put simply: What isn't there won't wear out and materials that expand in proportion to each other won't separate. The result is excellent long-term stability, secure thermal management and exceptional reliability. A patent has been filed and the concept has been baptized CeramCool.

The Theory

The ceramic heatsink CeramCool is an effective combination of circuit board and heatsink for the reliable cooling of thermally sensitive components and circuits. It enables the direct and permanent connection of components. Also, ceramic is electrically insulating per se and can provide bonding surfaces by using metallization pads. Customer-specific conductor track structures can be provided, if required even three-dimensional. For power electronic applications direct copper bonding is possible. The heatsink becomes a module substrate that can be densely populated with LEDs and other components. It quickly dissipates the generated heat without creating any barriers.

Validation and Proof of Concept

The idea to use ceramics was first cross-checked in several simulation models. To predict thermal behaviour of various designs a method based on Computational Fluid Dynamics (CFD) was developed. Equally an optimized ceramic heatsink for 4W cooling was developed. Manufacturing requirements where taken into account. The optimized geometry allows operation of a 4W LED at a maximum temperature below 60°C which was validated against physical tests. The design is square in shape (38mm x 38mm x 24mm) and comprises longer, thinner fins with a larger spacing. The identical geometry in aluminum with a PCB mounted LED showed significant higher temperatures. Depending on the thermal conductivity of the PCB (from λ = 4 W/mK to λ = 1,5 W/mK) the temperature raised between 6 to 28K.

Already a 6K reduction at the hot-spot implies significantly less stress for the LED. The total thermal resistance of the Rubalit assembly is at least 13% better than aluminum with identical shape. Using Alunit the minimum improvement of CeramCool reaches 31%. These good results are outperformed largely for both ceramics if the heat drop of 28K is taken into account.

Flexibility of Concept

The concept is flexible and can be used for different targets. It's your choice whether you run a LED on its optimum temperature assuring high life time and high lumen per Watt or you accept higher temperatures reducing life time and efficiency. A temperature spread from 50°C to 110°C is common. If more lumina are needed the 4W-heatsink can be equipped with 5W or 6W LEDs. Splitting the power into several 1W LEDs helps to get a better heat spreading. The results are 65°C with 5W and 70°C with 6W.

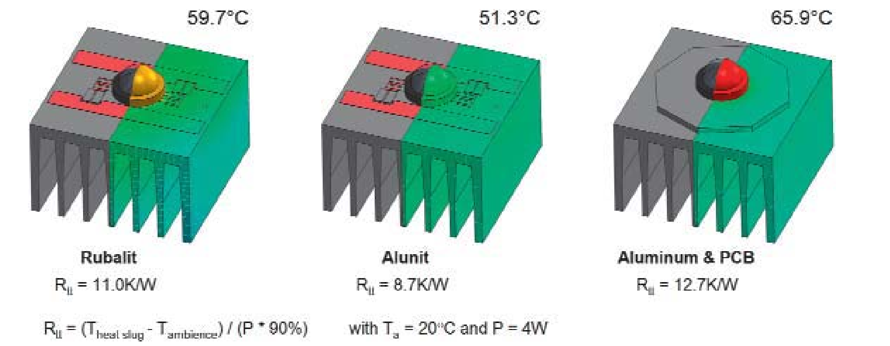


Figure 3: For validation purposes a simulation model has been developed. All results were verified by product samples.

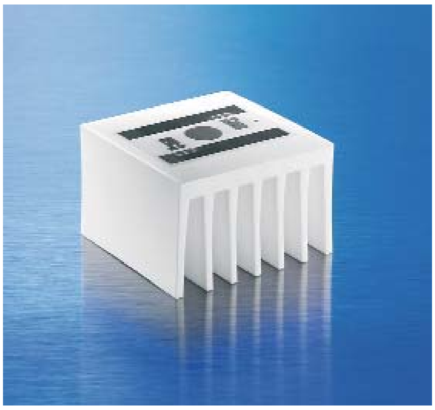


Figure 4: First serial production of optimized CeramCool geometry for 4W cooling. With Rubalit the total thermal resistance Rtt of the assembly is at least 13% better than aluminum. Using Alunit it is more than 31% better.

Smaller Sizes

With the chip permanently and reliably bonded to the electrically insulating CeramCool, the heatsink takes more heat and becomes hotter. It takes the burden off the LED and does exactly what it is made to do, namely, cool the critical components. The reduced die temperature allows a downsized surface, a smaller heatsink. Its higher temperature makes it possible.

Cooling Water at 1.5mm Distance

Air cooling reaches its limits at very high power densities. This is where liquid cooling is best suited. One example is CeramCool water cooling which benefits from the inertness of ceramics. No corrosion can cause trouble. The concept follows the same goal as for air cooled heatsinks: Shortest (thermal) distance between heat source and heat drain. With ceramic it is feasible that cooling

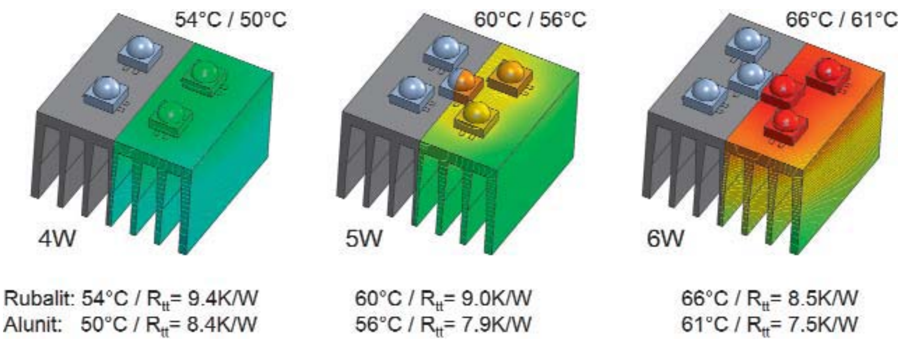


Figure 5: Splitting the power for better heat spreading offers new prospects

water is only 1.5mm away from the LED heat slug! No other concept can do this in combination with the durable nature of ceramics. Multilateral electrical circuits can be printed directly on the ceramic without creating thermal barriers. CeramCool Liquid Cooling made from the aluminum nitride ceramic Alunit cools packing densities of up to 75W / cm². Until now the elongated, rod-shaped heat-sink has only been manufactured using the alumina material Rubalit (≥22W/mK); extruding linear shapes was not possible with the more thermally conductive aluminum nitride ceramic material Alunit (≥170W/mK). Now CeramTec has developed an aluminum nitride that makes series extrusion possible, enabling the production of linear cavities, which double cooling capacity compared to Al_2O_3. For example, CeramCool Liquid Cooling using the alumina ceramic Rubalit cools 290W on 120mm; with Alunit, it is an impressive 640W on the same construction. No other design can achieve this and still assure such a long lifetime. The new geometry features three cooling channels to provide a homogeneous LED temperature.

Figure 6: CeramCool liquid cooling allows almost any needed cooling capacity. With Rubalit ceramics the power density of 290W is managed with only 120mm lengths. The cooling water is only 1.5mm away from the LED heat slug. The solution is now available from extruded Alunit – a breakthrough in production engineering. While Rubalit dissipates 290W on 120mm, Alunit can cool 640W!

Simulation Models for Customized Solutions

Since most of the applications where CeramCool is used are customer specific solutions, it is essential that the performance can be proved before first expensive prototypes are made. Intensive studies were made to build up simulation models. These simulation models have been verified against various tests and showed reliable correlations to test results. Based on this knowledge, new concepts or variations are easily evaluated. What is the thermal advantage of splitting a 5W LED into 5 LEDs of 1W? What is the benefit of a heat spreader included in the circuit layout?

Retrofit Lamps and Isolation

The problem of retrofit lamps is mainly one of isolation. Any retrofit lamp has to be class II construction because you cannot guarantee an electrical earth. This means that any exposed metal part has to be isolated from the mains wiring by double or reinforced insulation. Often retrofits with metal heatsinks do not comply as it requires larger distances (like 6mm in air) or double layers of insulation which stop the heatsink working well. The integrated electronic driver in a GU10 LED is so restricted for space that this is a very difficult product. With a ceramic heatsink even if the driver fails completely mains electricity is not conducted by the heatsink and the product is safe.

The new CeramCool GU10 LED spot works with any LED. Socket and reflector are made from a single material: a high-performance ceramic. Thus its simple class II construction with safe insulation. A high voltage 4W LED only reaches a maximum temperature below 60°C, so both lifetime and light output are increased. In all CeramCool ceramic heatsinks the substrate becomes the heatsink. Here it acts as the lamp, or even the luminaire. The simplified design delivers extremely high reliability. In addition, the mount and reflector of GU10 LED spots are usually made of different materials. With this solution far fewer materials are used and ceramics are exploited for their electrical insulation, good EMC and high mechanical and chemical stability. Last but not least: The indirect light and the continuous ceramic construction are beautiful.

Figure 7: The CeramCool GU10 LED spot has a fully ceramic construction. Takes any LED. Simple class II construction with safe insulation. Designs are developed in consultation with customers.

Figure 8: CeramCool GU10 LED spot: only lamp or even luminaire? Indirect light and continuous ceramic construction delight the eye.

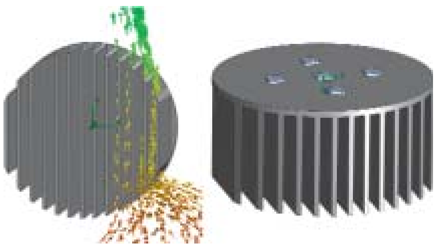


Figure 9: Scalable heatsink family of round geometry

Figure 10: This CeramCool is destined for linear applications. The extruded heatsink joins thermal management, mechanical structure and circuit board. Once again the difference between lamp and luminaire is melting away.

Concepts under Development

High power applications, especially for outdoor usage, gain as well from the features of CeramCool. A family of round heatsinks, which will meet the demands of different power levels, is under development. The concept combines cost efficient production with high flexibility of usage. It is going to be a “semi customized” product family.

www.altair.com

MOSFET with SiC Diode in an Isolated Integrated Package

IXYS announced the successful integration of Silicon Carbide (SiC) technology and the latest super junction MOSFET technology into a single user friendly package enabling increased power density and higher efficiency in fast switching power supplies and solar inverter applications.

“Currently the system designers in high frequency, high efficiency applications are forced to consider using separate discrete devices, often from different suppliers complicating mechanical layouts and time to market. The MKE range of products released by IXYS effectively integrates these technologies into one part thereby reducing parasitic inductance and its associated losses,” stated Bradley Green, VP of International Sales for IXYS. “Our patented ISOPLUS i4TM package, with its proven ruggedness based on the internal DCB construction, enables the co-location of the MOSFET and SiC diode thus also reducing real estate requirements in power switching topologies that are getting far more focused on not only reducing power losses but also challenging the traditional restraints on power supply size. It has better thermal impedance with lower weight than alternative solutions that use a heavier copper lead frame and bulky modules.”

The first product in the MKE range of devices is an ultrafast boost chopper which integrates a super junction COOLMOS® CP MOSFET and a SiC boost diode integrated in the IXYS ISOPLUS i4TM package.

The ISOPLUSTM technology gives the designer a discrete package with ceramic, Direct Copper Bonded (DCB) isolation. This isolation has low thermal impedance and a higher reliability in power cycling than standard copper based solutions and non-isolated products.

An example of this technology is the MKE11R600DCGFC which integrates a 600V, COOLMOS® MOSFET and a 12A 600V SiC diode in boost chopper circuit topology which is a common combination for Power Factor Correction (PFC) stages in high switching applications. COOLMOS® is an Infineon registered trademark.

www.ixys.com

DirectFET2 MOSFETs Optimized for Class D

International Rectifier has introduced a family of automotive DirectFET®2 power MOSFETs for high frequency switching applications including the output stage for Class D Audio systems.

The AUIRF7640S2, AUIRF7647S2 and AUIRF7675M2 devices expand IR’s portfolio of automotive DirectFET®2 power MOSFETs for Class D Audio systems, and are optimized with low gate charge (Qg) to improve Total Harmonic Distortion (THD) and efficiency, while low Diode Reverse Recovery Charge (Qrr) further improves THD and lowers EMI.

With a footprint smaller than an SO-8, the AUIRF7640S2 and AUIRF7647S2 Small Can devices are capable of delivering 100W per channel into an 8 Ohm load with no heat sink to offer an exceptionally compact class D solution ideal for saving PCB space where multiple channels are required. The Medium Can AUIRF7675M2 device, which features a footprint 54 percent smaller than a DPak is capable of delivering 250 W per channel into a 4 Ohm load with no heat sink making it well suited for the sub-woofer output stage of class D audio systems.

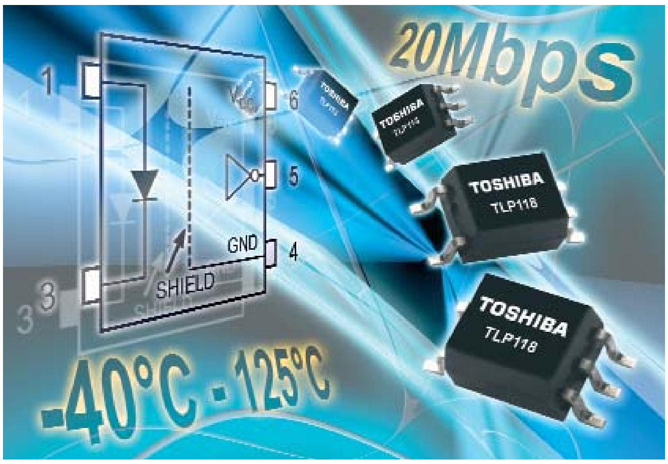
As with all DirectFET® products, the new devices offer minimal thermal impedance and parasitic package resistance and inductance to deliver excellent power density and efficiency facilitated by dual-sided cooling.

The devices are qualified according to AEC-Q101 standards, feature an environmentally friendly, lead-free and RoHS compliant bill of materials, and are part of IR’s automotive quality initiative targeting zero defects.

www.irf.com

Ultra-Compact IC-Coupler for High Speed, Extended Temperature Applications

Toshiba Electronics Europe (TEE) has announced an ultra-compact photocoupler that delivers data transmission at speeds up to 20Mbps, features a minimum isolation voltage of 3750Vrms, and offers guaranteed operation from -40°C to 125°C.



The TLP118 integrates a GaAlAs infrared LED, optically coupled to a high-gain, high-speed photodetector, into an SO6 package measuring just 4.5mm x 3.7mm x 2.1mm. Target applications for the device will include high-speed communication interfaces in factory automation systems, office products, measurement and control equipment and digital appliances such as plasma display panels (PDPs).

Designed to meet the reinforced insulation requirements of global safety standards, the SO6 package has guaranteed minimum creepage and clearance distances of 5 mm and a minimum internal insulation thickness of 0.4 mm. The photodetector features an internal Faraday shield to provide for a high common mode transient immunity of ±15kV/μs.

The TLP118 is configured with a general-purpose inverter logic (open collector) output stage and operates from a power supply voltage of 4.5V to 5.5V.

www.toshiba-components.com

CUI Adds Compact 2 A model to DC Switching Regulator Series

CUI Inc's power line, V-Infinity, announced the addition of a 2 A model to their V78XX switching regulator series. The compact V78XX-2000 series has been designed to be a high performance alternative to linear regulators. Unlike linear regulators, this series does not require a heat sink, making it ideal for applications where board space is at a premium and energy efficiency is a concern. The V78XX-2000 series has efficiencies up to 92% in a compact SIP package measuring 11.50 x 9.00 x 17.50 mm. Units are pin out compatible with industry standard LM78XX linear regulators and come in both straight and right angle pin configurations. This series has a wide input range available from 4.75 to 18 Vdc and regulated output voltages of 2.5, 3.3, 5, and 6.5 Vdc. Operating temperature range of -40 to +85°C at 100% load. The non-isolated converters offer short circuit protection, thermal shutdown, very low ripple and noise, and an MTBF of 2 million hours. The V78XX-2000 series switching regulators are available now through Digi-Key and start at $7.46 per unit at 1000 pieces. Contact CUI directly for OEM pricing.

www.cui.com

E Series of Precision, Enhanced Power Supplies is listed to UL and Demko

UltraVolt, Inc. announced its E Series line of precision, enhanced power supplies is now listed to applicable Danish Standards and requirements by UL International Demko A/S.

"We are thrilled the E Series is in compliance with UL International Demko safety standards," said James Morrison, UltraVolt co-founder and CEO. "This recognition is a testament to the lengths we go to create high-quality products for our customers."

The E Series of precision high-voltage power supplies has very low ripple, excellent linearity, and very stable temperature characteristics. Models in this series are offered with a 10ppm temperature coefficient and reference. The control and monitoring functions are available on a standard DB15 female connector. Typical applications for the E Series include mass spectrometry, electron beams, ion beams, and contraband detection.

www.ultravolt.com

SENZero™ HV ICs Eliminate Sense Resistor Power Losses in Standby Mode

Power Integrations introduced SENZero, a family of ICs that disconnect sense resistors from high-voltage rails during standby or remote-off conditions. SENZero devices eliminate sense resistor power losses in standby mode and reduce total system power consumption, helping to meet the stringent demands of energy-conscious equipment makers and efficiency standards regulators.

SENZero enables high-voltage sense resistors or resistor dividers connected to the DC high-voltage rail in Power Factor Correction (PFC) and/or power conversion stages of a power supply to be disconnected during no-load or standby conditions to reduce power consumption. This allows functional blocks within the power supply to be shut down or disabled so that they do not draw power unnecessarily when the PSU is not in its full operation mode. When used in this manner for PC or TV power supplies, SENZero is able to shut down the main power while keeping standby power on. The device is also suitable in other high-power applications such as laser printers, appliances, servers and networking equipment, and any other power supply where no-load performance or standby consumption is tightly regulated.

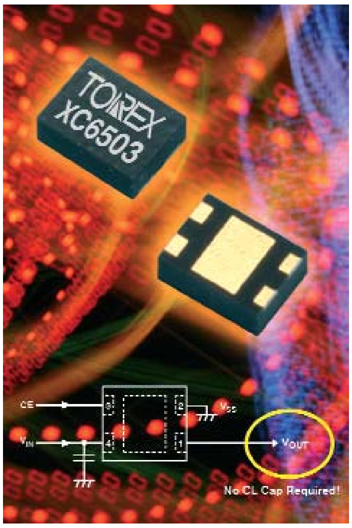
www.powerint.com/senzero

Shipment of the First Triple-Head 7600HD Automatic Wedge Bonder System

Siegbert Haumann, the Director of Product Marketing – Equipment at Orthodyne states that “The Triple-Head 7600HD Bonder” provides a complete, capacity balanced, in-line solution for bonding PDFN power packages. The bond heads were configured as two PowerRibbon® heads and one small wire head. PowerRibbon® is quickly becoming the preferred interconnect choice for small dense PDFN power packages. PowerRibbon®’s low profile can fit into thin packages. Its large cross-sectional area has a lower resistance and can carry more current than round wire. The advanced leadframe handling and clamping capabilities of the 7600HD leadframe transport system were ideal for the small geometries, high density and complexity of the customer’s PDFN leadframes.”

The 7600HD Automatic Wedge Bonder’s modular and flexible design can be configured in one to four head configurations depending on the line balancing requirements. The system can be easily reconfigured in the field, offering opportunities to rearrange production lines as product mix changes. For added flexibility, each bondhead can accommodate large wire, small wire or PowerRibbon®.

www.orthodyne.com



LDO offers High Speed Performance without

The XC6503 series from Torex, integrates internal phase compensation circuitry, removing the need for expensive output capacitors and dramatically reducing the necessary PCB layout area. Even with no capacitor, the XC6503 can deliver output currents up to 500mA and is readily available with fixed output Voltages from 1.2V to 5.0V in 0.05V increments.

Performance is always important for an LDO and the XC6503 offers fast transient response and high PSRR (55dB @ 1kHz) whilst consuming only 15uA in operation and less than 0.1uA in standby mode. The voltage-drop is also optimised to maximise battery life with only 300mV required at 500mA.

The XC6503 is also very safe, with integrated short circuit protection; thermal shutdown and built-in current limiter. This clever LDO can also work with an Output Capacitor if required and includes an optional CL discharge function to immediately discharge of the Output Capacitor, ensuring that the VOUT pin drops down to ground quickly, should the XC6503 be turned off via the CE pin.

www.torex-europe.com/products/range/320

Richardson Electronics Improves Ultra-Broadband Circuit Designs

Technologically Advanced RF, Microwave, and mmW Surface-Mount Capacitor

The 550L Series UBCTM (Ultra-Broadband) Capacitor from American Technical Ceramics (ATC) provides reliable and repeatable Ultra-Broadband performance from 16 kHz to over 40 GHz. Desired features include:

- Defense/Aerospace Extended Operating Temp. Range (-55ºC to +125ºC)
- One-piece, Orientation-Insensitive Package (Rugged Ceramic Construction)
- Ultra-low Insertion Loss (< 0.5 dB)
- Flat Frequency Response
- Excellent Return Loss (see datasheet)
- RoHS Compliant Terminations (Gold-plated or Tin-plated available)

This 100nF capacitor is ideal for DC Blocking, Coupling, and Feedback applications requiring Ultra-Broadband performance. The applications include Receive and Transmit Optical Subassembly (ROSA/TOSA) circuits, trans-impedance amplifier (TIA) designs, optoelectronic high-speed data circuits (such as SONET), and broadband test equipment.

www.rell.com/RFPD

True-RMS Clamp Meter Measures Down to 1mA

GMC-I PROSyS has introduced the CP41 AC/DC True RMS Clamp Meter, a hand-held unit that combines simplicity of operation and convenience with non-invasive measurement of current to an accuracy of ± 1% of reading and resolution of 1mA.

The CP41 meets the needs of a wide range of users in industrial and automotive markets. Its range and sensitivity allow measurement of operating currents, and leakage currents, with a single product, and without breaking connections in the circuits under test. Measurement capability in the mA range permits verification of 4-20mA current-loops in process-control systems, while the meter is equally applicable to testing light-

industrial and residential electrical installations.

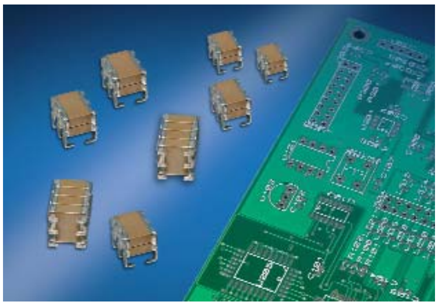
The CP41 measures, selectably, DC or AC currents with a resolution of 1mA and, on its AC ranges, with true-RMS current indication.

It maintains accuracy even in electrically noisy environments, featuring excellent rejection of external magnetic fields together with a very high level of immunity to interference from voltage transients. The meter is battery-powered, and has a 4-digit liquid-crystal display: full-scale readings are up to 4A or 40A, with auto-ranging and auto-zero functions. GMC-I PROSyS also offers a second variant of the CP41, the CP410, which measures higher currents: its auto-range full-scale limits are up to 40A or 400A.

www.i-prosys.com

Surface Mountable Stacked MLC Capacitor Line

HolyStone (Europe) Ltd. has announced the expansion of their SMC Series of Stacked Multilayer Ceramic Capacitors. In addition to 2225 and 1825 sizes, HolyStone now offers 1210, 1812 and 2220 sizes. All sizes can be



offered as taped and reeled and are pick and place compatible.

The SMC series offers up to 4X the CV value in the same footprint as comparable SMC products. With capacitance values of up to 34uF, the SMC Series' design offers the high capacitance levels similar to tantalum product but with the advantage of an extremely lower ESR.

This, along with the strain relief provided by the lead frame design, makes HolyStone's SMC Series stacked capacitors with its MLCC design particularly useful in power supply, surge protection, DC-DC converters, industrial control circuits and for a myriad of other consumer product applications where high CV values are required.

The HolyStone SMC Series capacitors have an operating voltage range of from 25 to 500VDC within a temperature of from –55 to +125ºC. The SMC Series is available in both NP0/C0G and X7R dielectrics with HIREL screening available on a special order basis. Both EIA 1825 and 2225 size codes and are offered in J, L, and N leaded configurations providing both thermal and mechanical stress relief. The entire SMC Series of stacked capacitors is available as RoHS compliant or as Lead(Pb) solder attachment.

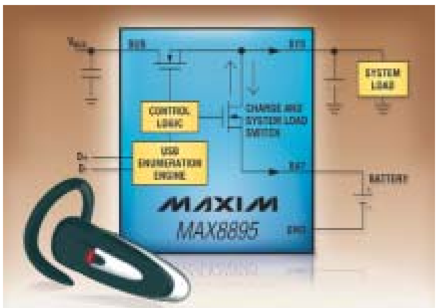
www.holystonecaps.com

Battery Charger with Automatic USB Enumeration

Maxim Integrated Products introduced the MAX8895, a linear battery charger for Bluetooth(R) headsets and portable devices that is compatible with the USB Battery Charging Specification, Revision 1.1. The MAX8895 is uniquely equipped with automatic adapter detection for distinguishing between USB devices, USB chargers, and dedicated chargers. It also integrates a USB enumeration function that automatically negotiates with the USB host to optimize charging current without processor intervention. This capability eliminates the need for a separate microcontroller and system software, thus providing the industry's only stand-alone charging solution.

Smart Power Selector(TM) functionality provides seamless distribution of power from the USB power input (Vbus) to the battery and system load. This allows simultaneous charging of the battery while powering the system, as well as operation of the portable device with a discharged battery or no battery. The battery also supplements Vbus when the system load exceeds the Vbus input current limit.

The MAX8895 integrates a battery-disconnect switch, current-sense circuit, thermal-regulation circuitry, MOSFET pass elements, and overvoltage protection (OVP) up to 16V, providing an easy-to-implement, extremely compact charger solution. Flexible programming options include fast-charge current, termination current, and charge timer duration.



The MAX8895 also supports adaptive battery charging, which reduces charge current when necessary to prevent the charge source from collapsing.

www.maxim-ic.com

Power Line Communications with Development Kit

Demonstrating its commitment to provide the most comprehensive products and tools for power line communications (PLC) development, Texas Instruments announced the PLC Development Kit (TMDSPLCKIT-V2) based on the industry's only PLC modem solution capable of supporting multiple modulation and protocol standards on a single hardware platform. The new kit provides everything developers need to network systems and implement monitoring capabilities and other new services that reduce device maintenance cost while increasing system reliability to create greener, more efficient products. Developers will now be able to quickly evaluate the suitability of using PLC-based communications and then jumpstart development for Smart Grid applications ranging from smart electrical meters to intelligently controlled industrial applications, including lighting, solar, home automation, building control, plug-in electrical vehicle and energy-managed appliances.

www.ti.com/plc-pr

Availability of Current and Voltage Characteristics for Automated Testing

Maren Ewert - UIandT.com has developed an inexpensive, external control unit, which in a simple way, heads for power supply via its analog interface with the trajectory for automated testing (sequencing). Arbitrary waveform generators provide higher flexibility than function generators (only applicable for standard curves such as sine, square, triangle and saw tooth) due to the ability to save and give out any (arbitrary) and curve trajectories.

One of the characteristics of the AWG S1 is a well considered and simple handling in a broad range of functions. Even complex curve trajectories are created in with minutes as a CSV file and transferred via USB interface to the internal microSD-card. Afterwards the arbitrary generator can be used without computer assistance.
The AWG S1 possesses two analog outputs, which cover any voltage range between 0 - 10 V. So the voltage waveform as well as the flow of the power supply, can be regulated at the same time. If only V or I need to be controlled, two power supplies can be controlled parallel.
Up to 500 different curve trajectories find space on the changeable microSD card, and each can contain up to 5,000 data points. This means 5000 changes in the signal height. The time interval between individual data points may vary from 1ms to 119h. Wave forms are possible over very long periods of time.

www.uiandt.com

FlatPower TVS Diodes in Industry's Smallest Package

NXP Semiconductors announced the extension of its Transient Voltage Suppressor (TVS) diodes portfolio by 35 new products housed in its 2-lead FlatPower package SOD128 (3.8 x 2.5 x 1 mm). NXP is the first supplier to offer a 600W peak pulse power rating (10/1000ìs) TVS diode in such a small plastic SMD package. Alternative 600W TVS products in the market are only available in much larger packages like SMA or SMB. The new SOD128 FlatPower package fits on a SMB footprint allowing a 1:1 replacement and enabling engineers to save space on the PCB while delivering optimum power performance.

The TVS diodes are designed to protect sensitive components against transient voltages in various electronic applications such as power management units and telecommunication circuits. Qualified with the rigorous AEC-Q101 standard, the FlatPower TVS devices can be used for all automotive and industrial applications. Due to the very low leakage current of only 1nA (typical), the new PTVS series reduces energy consumption and facilitates its use in battery powered mobile applications. The very low height and small outline dimensions save PCB space and allow further miniaturisation of circuit designs.

www.nxp.com

5 mm Buzzers Ideal for Mobile Equipment Applications

CUI Inc announces a addition to their buzzer product line with the CSS-05 series. Available in three configurations, the buzzers are extremely compact, housed in a 5 x 5 mm SMT package. Using magnetic technology, the series has a rated voltage of 3 V and a rated frequency of 4 K Hz. Sound pressure level options range from 75~78 dB with an operating temperature range of -30~70°C. The CSS-0575A, CSS-0575B, and CSS-0578 are ideal for mobile equipment applications where board space is a concern, including handheld scanners, glucose monitors, and GPS devices. The CSS-05 series is available through Digi-Key with prices starting at $1.44 per unit at 1,000 pieces. Please contact CUI for OEM pricing.

www.cui.com

Automotive DirectFET2 Power MOSFETs

International Rectifier has launched two automotive DirectFET®2 power MOSFETs optimized with low gate charge for switching applications including Switch Mode Power Supplies (SMPS), Class D Audio systems, High Intensity Discharge (HID) lighting, and other automotive power conversion applications.

The AUIRF7648M2 and AUIRF7669L2, IR's first automotive grade DirectFET® devices tailored to DC-DC applications, offer low gate charge and on-state resistance (RDS(on)) to help minimize switching and conduction losses in a variety of switching applications. Moreover, the low parasitic inductance offered by the DirectFET® power package results in excellent high frequency switching performance with reduced waveform ringing which in turn helps limit EMI and filter size.

The AUIRF7648M2 features a PCB footprint 54 percent smaller than a DPak while the AUIRF7669L2 features a PCB footprint 60 percent smaller than a D2Pak. With package current ratings of 179 A and 375 A respectively for each device, the DirectFET® package places no constraint on current capability of the silicon. Moreover, the maximum package current ratings far exceed the limits of traditional DPak and D2Pak packages. The devices are qualified according to AEC-Q101 standards, feature an environmentally friendly, lead-free and RoHS compliant bill of materials, and are part of IR's automotive quality initiative targeting zero defects.

www.irf.com

ADVERTISING INDEX