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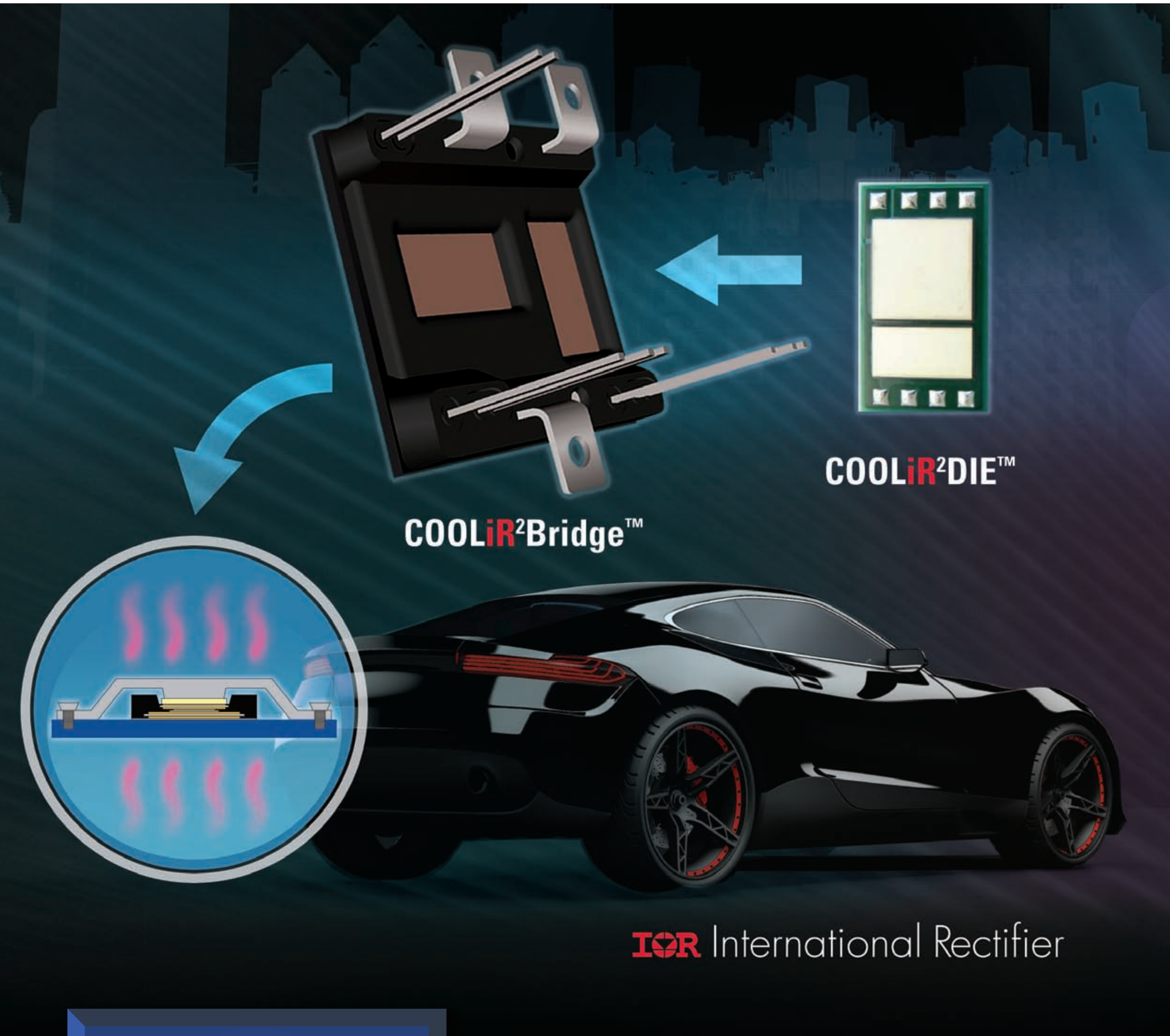
AUTOMOTIVE POWER

Bond Wireless Building Blocks Provide a New Approach to Power Modules



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Also inside this issue

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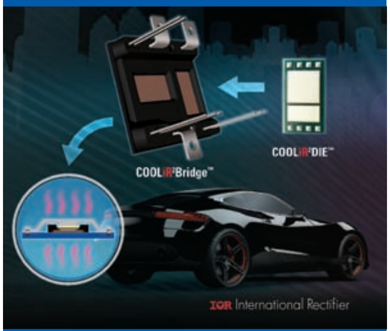
COVER STORY



Bond Wireless Building Blocks Provide a New Approach to Power Modules

Traditional industrial motor drive modules are generally based on 600 V or 1200 V IGBTs and diodes in a wire bonded package. However there are several limitations with wire bonding: multiple wires are needed to carry higher currents, therefore more complex and costly assembly processes are needed. When an issue occurs in the assembly it is very hard to rework the module resulting in a particularly expensive yield fall out. Reliability is also the week point of the wire bonds – after thousands of active power cycles the wire bond and its interface to the Silicon is all too often the cause of a failure. In our Jan/Feb edition the article 'COOLiR?DIE™ Bond Wireless Power Packaging for Hybrid and Electric Vehicles' took a look at how the advent of the Hybrid Electric Vehicle was bringing along new opportunities for power semiconductor packaging and in particular those without bond wires. We now move on to see how the discrete bond wireless building blocks of the CooliR?DIE can be used to develop a complete module. Full article on page 20.

Cover supplied by International Rectifier

More Power in 2013

In 2012, Power Electronics was in crisis. IGBT fell 20 – 25 percent in sales, according to market researcher Yole. Meanwhile, Super Junction (SJ) MOSFET grew more than 8 percent, a trend Yole Développement expects will continue until 2018, when it tops the $1 billion limit. This forecast demonstrates how much the technology is needed. In 2011, production capacity was too small to handle the high demand. This shortage situation helped the SJ MOSFET market weather the 2012 crisis. For manufacturers, this demand was used as a buffer, and analysts believes that in 2013 the market will return to its normal supply status. Another sign of SJ MOSFET being very attractive is the numbers of players that have entered/may enter the market. The last 36 months have seen eight new players throw their hats in the ring; among them, the Chinese foundries and their fabless counterparts appear to pose the biggest threat to the historical leaders' market share. Since the technology is widely used and widely produced, the market will see more players join, such as Magnachip and ON Semiconductor. The availability of the technology in Chinese foundries makes things even simpler. 2010 market share was split between the historical leaders, with Infineon having a clear advantage since they were first to commercialize the technology. However, recent announcements and partnerships will probably lead to a more level playing field. Additionally, the feedback from integrators is that they don't really worry about the manufacturer's name or brand; instead, they focus on the specifications they need and the devices that fit. With Chinese, Taiwanese and Japanese foundries and device makers entering the market, the analyst expects market share to shift. Several small players will eat a few percent and cause the leaders' share to shrink.

Consumer is Super Junction MOSFET's main application segment, representing 2/3 of its total market. And while some applications are stagnant, i.e. Desktop PC and game console power supplies, most applications are still growing. The biggest growth area will be power supplies for tablets, with an expected 32 percent increase annually from 2013 to 2018. However, the main products where SJ MOSFETs are used are PC (Desktop and laptop) power supplies and TV sets, which total half of the SJ MOSFET market. The driver for using SJ MOSFET in these applications is, first and foremost, size reduction. SJ MOSFET allows for a much smaller size than planar MOSFET, since they generate less heat.

Meanwhile Infineon has started to produce power semicoductors such as SJ MOSFETs and IGBTs on 300-mm wafers. The company has purchased 300-mm wafer processing equipment from its former subsidary Quimonda for a pilot line in Villach/Austria and a volume manufacturing site in Dresden/Germany. First silicon has been achieved on the pilot line by mid 2011. And first C3/C6 CoolMOS devices have been already supplied to power supply manufacturers such as Emerson and Delta. Infineon is confident that the power eletronics industry and thus the demand for power semiconductors will recover, and with the 300-mm wafers they are prepared to meet increased future demand.

Market researcher IHS is predicting that the power supply market will offer strong opportunities for some semiconductor manufacturers in 2013, because the total world market for semiconductors used in power supplies is forecasted to grow at a fairly healthy 6.5 percent in 2013.

Compound semiconductor remains a threat to SJ MOSFET. SiC will be positioned at higher voltage and will target high-end solutions as well. Silicon will still be present in 2015. IGBT is the best cost vs. switching efficiency trade-off, and industry is working on high-speed IGBTs that are competing directly with Super Junction MOSFET. In the end, SJ MOSFET is positioned in-between, and depending on the voltage, application and frequency of switching, it could compete with SiC, Fast IGBT, IGBT or GaN, Yole analyzed.

The upcoming events such as APEC and PCIM will more or less clarify the positioning of power semiconductor technologies in certain applications. These events have a focus on SiC and GaN technologies and applications within conference sessions and round table discussions.

Power Electronics Europe will be happy to inform our readers about these ongoing developments. Stay tuned.

Achim Scharf
PEE Editor

Power Supply Demand to Drive Growth for Semiconductors

Despite a largely flat market for power supplies in 2012, IHS is predicting that the market will offer strong opportunities for some semiconductor manufacturers in 2013.

Although the total world market for semiconductors used in power supplies is forecast to grow at a fairly healthy 6.5 percent in 2013, growth opportunities differ widely by semiconductor product and by application. Strongest growth is predicted for MPU/MCU/DSP/DSC products at 35 percent in 2013. Although this is currently one of the smallest markets for semiconductors used in power supplies, it is projected to grow by $45 million from 2012 to 2016 owing to adoption of digital power and advanced power factor correction (PFC) techniques. "Demands for greater efficiency and increased power density continue to drive opportunities for semiconductor vendors. The market for digital power alone is forecast to quadruple in the next five years, as a direct result of this. Many more opportunities exist, however, linked to legislation and design changes", analyst Ryan Sanderson commented.

Other growth drivers include the increase in demand for power supplies which use synchronous rectification at the output, a trend projected to account for a large part of the $80 million growth forecast for the power MOSFET market from 2012 to 2017. In addition, the combined market for AC-DC switching regulators (integrated FET) and switching controllers (external FET) is predicted to grow by $270 million in the next five years. This is driven in part by demand for more intelligent solutions in cell phone chargers to cope with requirements for "no-load power consumption" and strong demand from applications such as tablets and LED lighting. "2012 was a difficult year for many semiconductor vendors who sell into power supplies, with reduced demand from many sectors. Demand from end markets such as notebook PCs and industrial applications, which typically offer steady growth, was much weaker than average. Opportunities did exist, however, particularly in tablet PCs and the rapidly expanding market for LED lamps and luminaires. These opportunities are forecast to drive further growth in 2013 and beyond", Sanderson underlined.

www.ihs.com

Ten Percent SJ Market Growth

Super Junction MOSFET is jumping from consumer power supplies to the renewable energy and industry segments at growth rate of 10 percent to reach $10 billion by 2018, market researcher Yole forecasts.

Consumer is Super Junction (SJ) MOSFET's main application segment, representing 2/3 of its total market. And while some applications are stagnant, i.e. Desktop PC and game console power supplies, most applications are still growing. The biggest growth area will be power supplies for tablets, with an expected 32 percent increase annually from 2013 to 2018. However, the main products where SJ MOSFETs are used are PC (Desktop and laptop) power supplies and TV sets, which total half of the SJ MOSFET market. The driver for using SJ MOSFET in these applications is, first and foremost, size reduction. SJ MOSFET allows for a much smaller size than planar MOSFET, since they generate less heat.

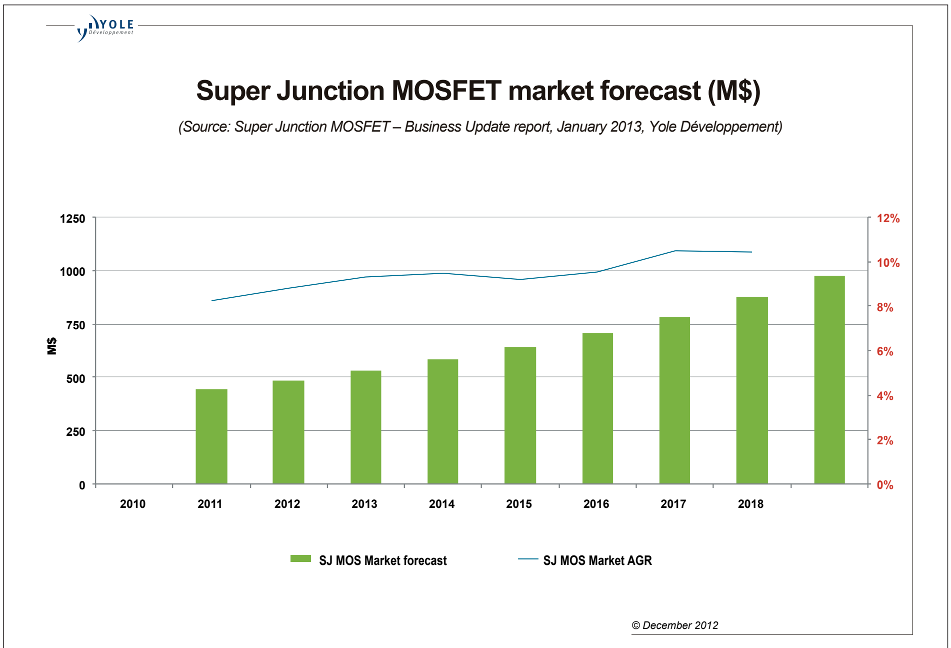
The hybrid and electric car markets should not be ignored. True, they are less than $5M today, but they will represent more than $100 million by 2018. Industrial applications are less interested in SJ MOSFET use, since these applications do not require high-frequency switching when operating in an H-bridge. SJ MOSFET is interesting only for specific topologies such as multi-level, or for cheap low-power solutions (small UPS, residential PV). But even in these applications, planar MOSFET or IGBTs remain better solutions since they are cheaper and meet all requirements. In summary, SJ MOSFET is currently employed mostly for high-end solutions.

The technology used for Super Junction MOSFET is of two types. The first one, developed by Infineon, uses a series of epitaxies and doping to create a locally doped "island" in the epi-layer. The doped region then diffuses and creates an N-doped pillar. The second technology uses deep reactive ion etching to dig a trench. This trench is then filled with an N-doped material to create the super junction structure. Players exploiting this particular technology are Toshiba, Fairchild Semiconductor and IceMOS Technology.

"Technology evolution is accelerating and the opposition between multiple epitaxy and deep trench is growing stronger", explains analyst Alexandre Avron. "Toshiba released its 4th generation of its DTMOS, a deep trench power MOSFET with a smaller pitch size. It means a smaller die size and an improved on-resistance. It's still more expensive to produce than a CoolMOS (Infineon's brand name), but it's becoming more and more competitive".

Compound semiconductor remains a threat to SJ MOSFET. SiC will be positioned at higher voltage and will target high-end solutions as well. Silicon will still be present in 2015. IGBT is the best cost vs. switching efficiency trade-off, and industry is working on high-speed IGBTs that are competing directly with Super Junction MOSFET. In the end, SJ MOSFET is positioned in-between, and depending on the voltage, application and frequency of switching, it could compete with SiC, Fast IGBT, IGBT or GaN.

www.yole.fr



Infineon Manfactures Power Chips on 300 Millimeter Wafers

Infineon's Power 300 project has been started two years ago aimed to produce power semicoductors such as MOSFETs and IGBTs on 300-mm wafers.

Infineon has purchased 300-mm wafer processing equipment from its former subsidary Quimonda for a pilot line in Villach/Austria and a volume manufacturing site in Dresden/Germany. Such huge wafers are supplied 1 mm thick and have to be processed down to a thickness of 40 micrometer. "First silicon has been achieved on the pilot line by mid 2011. And first C3/C6 CoolMOS devices out of Power 300 have been already supplied to customerrs", Infineons CEO Reinhard Ploss stated. "We are confident that the power eletronics industry and thus the demand for power semiconductors will recover, and with the 300-mm wafers we are prepared to meet increased future demand".

Qualification for mass production is scheduled for March 2013. According to Pantelas Haidas, Operation Manager Infineon Dresden, investment in this line was Euro 150 million so far. Another Euro 105 million have been spent for the 300-mm infrastructure in Villach. "In order to become profitable an amount of 1000 - 3000 wafers per week will be necessary", Ploss adds. Having around 4500 CoolMOS dies on su h a 300-mm wafer, compared to 2500 on a 200-mm wafer, one can imagine the productivity gains possible through this investment. "So far we neded to invest 1 Euro to achieve 1 Euro on additional sales, Ploss said. With the 300-mm line this investment will be significantly lower".

Infeons roadmap covers firstly C6 and upcoming C7 CoolMOS (600/650 V) devices, at a later stage 1200 V IGBTs. All new designs will be transfered to 300-mm technology. Additionally the company is working on GaN devices on Silicon (200 mm) and SiC (150 mm). "But with each new Silicon generation the empire strikes back", Ploss commented – meaning that Silicon also is catching up in performace (on-resistance, gate charge, switching frequency).

AS

www.infineon.com

Infineon CEO Reinhard Ploss proudly shows a 300-millimeter wafer with thousands of CoolMOS devices exhibiting a 20 percent increase in productivity to the existing 200-millimeter line

Photo: AS

Turbomiser Chiller for Power Semiconductor Manufacturing

In what is believed to be the first application of the technology in the semiconductor manufacturing industry, an ultra-efficient Turbomiser chiller is cooling IXYS UK Westcode's high-tech Chippenham facility. The Turbomiser runs on virtually frictionless magnetic bearings, and can cut cooling energy costs by up to 60 percent compared with conventional cooling systems.

IXYS UK Westcode is a leader in the manufacturer of high power semiconductors, and introduced the first commercial rectifier in the 1920s. Today its products are used across the world in applications such AC and DC drives, uninterruptible power supplies, motor soft starts, power conditioning and high energy physics. Cool-Therm installed the 280kW Turbomiser TMA280 chiller at the company's plant at Langley Park, Chippenham, to provide essential cooling for its clean room for the manufacture of high power semiconductors. The process requires tight control of temperature and humidity to maintain the stable environment required to ensure the quality of components under manufacture.

The chiller produces chilled water for an air handling unit, which in turn supplies conditioned air to the manufacturing hall. Due to space restrictions within the plant room, run and stand-by pumps were incorporated within the chiller itself rather than being located separately. These were designed into the system and factory-installed by chiller manufacturer Geoclima on behalf of Cool-Therm.

"The Turbomiser is vital for manufacturing quality to maintain strict environmental conditions. The Turbomiser has delivered a rock solid temperature of 21°C and relative humidity of 40 percent, which is the ideal condition for both production and the workforce", plant manager Steve Barnden commented. "The Turbomiser is a premium machine and capital costs are higher than for standard chillers. However, due to its exceptional energy efficiency and rising power costs, payback can be achieved relatively quickly, with savings continuing to accrue over the lifetime of the plant."

Look into IXYS/Westcode's Chippenham power semiconductor facility

Following the success of the project, the company is looking to replace three further existing chillers at the site, running on R22, with two new larger capacity Turbomisers.

www.cooltherm.co.uk, www.ixys.com

ECPE SiC & GaN User Forum

After the previous Silicon Carbide (SiC) or Wide Bandgap Semiconductor User Forums organized by ECPE in conjunction with EPE, new power electronic systems with wide bandgap components and new devices have been reported in research and also commercially on the rapidly moving international market. They use SiC which in the meantime has reached a high level of maturity or, more recently, also Gallium Nitride (GaN) material. Time has thus come to seize on this recent development and to continue the exchange between experts involved in converter and device development.

The 5th ECPE User Forum (2. - 3. May in Munich) will focus on typical power electronic systems, the use of wide bandgap semiconductors is highly promising for. Application examples will come from the areas of power supplies including inverters for renewable energy and electrical drives. Additionally, insights in recent SiC and GaN material and device technology - which is the base for future system development - will be given for a deeper understanding. International renowned experts have been invited to give an overview in keynotes, to in depth explain their research and development work in technical presentations and to share their knowledge in discussion forums as an indispensable part of the event.

The SiC & GaN User Forum is this way intended as a platform to share experience and ideas, to discuss and find out which power electronic systems are predestinated for usage of wide bandgap devices and how to appropriately design-in those novel, almost ideal but also challenging components. The ECPE SiC & GaN User Forum 2013 is chaired by Prof. Andreas Lindemann (Magdeburg University), Prof. Leo Lorenz (ECPE) and Thomas Harder (ECPE).

www.ecpe.org

More Applied Power in Long Beach

In our Jan/Feb issue (page 12) the Education Seminars and Plenary Session have been introduced. Below a summary of the Technical Sessions. These will be complemented by Industry and Rap (Round Table) Sessions on March 19. Rap Session 1is entitled Sustainable Energy versus Sustainable business: Is there a viable business case for power electronics in Solar? Rap Session 2 focuses on the question Wide band-gap semiconductors - Prime time or promises? And Rap Session 3 asks for is EV going to make it?

APEC's comprehensive conference program will start on March 19 (8.30 am – 12.00 pm) with the parallel running Technical Sessions 1 – 7 on the subjects ZVS DC-DC Converters, PV, Inverter Topologies, Device Failure Modes and Extreme Devices, Control of Switching Converters, Control of Grid Tied Inverters and Converters, AC-DC Converters - Control Methods.

Session 1 (ZVS) covers "A Zero Voltage and Zero Current Soft-Switching PWM DC-DC Converter with Synchronous Phase Shifting Hybrid Rectifier", Inherent Volt-Second Balancing of Magnetic Devices in Zero-Voltage Switched Power Converters", "Hybrid Transformer ZVS/ZCS DC-DC Converter for Photovoltaic Microinverters", A High Efficiency Hybrid Resonant PWM Zero-Voltage-Switching Full-Bridge DC-DC Converter for Electric Vehicle Battery Chargers", "A Dual-Channel Isolated Resonant Gate Driver for Low Gate Drive Loss in ZVS Full-Bridge Converters", "A Novel Three-Level DC-DC Converter with Load Adaptive ZVS Auxiliary Circuit", "Performance Analysis of a ZVS Bidirectional DC-DC Converter with Reduced Voltage Stress on High Voltage Side","A Novel Three-Phase ZVS PWM DC-DC Boost Converter","A Novel Nonlinear Switch Cell Topology".

Session 2 (PV) covers "Novel Scheme for Zero Voltage Switching of Single Stage Photovoltaic Micro-Inverter", "Design and Analysis of the Synchronization Control Method for BCM/DCM Current-Mode Flyback Micro-Inverter", "Novel Multi-Input Solar PV Topologies for 1-Phi and 3-Phi Stand Alone Applications to Mitigate the Effects of Partial Shading","Analysis and Design of Smart PV Modules","A Novel Solar Panel Optimizer with Self-Compensation for Partial Shadow Condition","Low Voltage Ride Through Control Strategy for High-Power Grid-Connected Photovoltaic Inverter","Sub-Module Differential Power Processing for Photovoltaic Applications","Photovoltaic AC Parameter Characterization for Dynamic Partial Shading and Hot Spot Detection","Individual MPPTs of Dual Photovoltaic Arrays Using Single-Phase Split-DC Bus Inverter".

Session 3 (Inverters) covers "Half-Bridge Resonant Inverter with SiC Cascode Applied to Domestic Induction Heating","A Step-Up/Down Three-Phase Resonant High-Frequency AC-Link Inverter","Bi-Directional Sparse Parallel Partial Resonant AC-Link Inverter","Dual-Output Four-Leg Inverter","PWM Control of a Dual Inverter Drive Using an Open-Ended Winding Induction Motor","Development of High Efficiency Current-Fed Quasi-Z-Source Inverter for HEV Motor Drive","Model Predictive Control Applied for Quasi-Z-Source Inverter","Operation Modes Analysis and Limitation for Diode-Assisted Buck-Boost Voltage Source Inverter with Small Voltage Vector","AC-Link, Single-Phase, Photovoltaic Module Integrated Inverter".

Session 4 (Device Failure Modes) covers "High Frequency Capacitive Behavior of Field Stop Trench Gate IGBTs Operating in Short Circuit","MOSFET Gate Open Failure Analysis in Power Electronics","Short-Circuit Capability of 1200V SiC MOSFET and JFET for Fault Protection","A Physics-Based, Dynamic Electro-Thermal Model of Silicon Carbide Power IGBT Devices","Cryogenic and High Temperature Performance of 4-HSiC Power MOSFETs","Paralleling High-Speed GaN Power HEMTs for Quadrupled Power Output","The gFET™ Switch: a New Low Voltage High Speed GaAs HEMT for Switching Applications","7.5 kV 4H-SiC GTO's for Power Conversion"," 1200 V SiC Schottky Rectifiers Optimized for >= 250°C Operation with Low Junction Capacitance".

Session 5 (Control of Switching Converters) covers "I? Average Current Mode Control for Switching Converters","Fully Decentralized Modular Approach for Parallel Converter Control","Dynamic Gate Resistance Control for Current Balancing in Parallel Connected IGBTs","A New Decoupled Control Scheme for a ZVS Dual Full-Bridge Phase-Shifted DC/DC Converter with Two Degrees of Freedom","A Multi-Variable Control Technique for ZVS Phase-Shift Full-Bridge DC/DC Converter","Multiphase Current Controlled Buck Converter with Energy Recycling Output Impedance Correction Circuit (OICC)","Tuning of a Digital Proportional-Integral Compensator for DC-DC Power Converter","External Ramp Autotuning for Current Mode Control of Switching Converters","Improved Transient Response Control Strategy and Design Considerations for Switched-Capacitor (SC) Energy Buffer Architectures".

Session 6 (Control of Grid Tied Inverters) covers "Control of Three-Phase Cascaded Voltage Source Inverter for Grid-Connected Photovoltaic Systems","A Novel Load Flow Analysis for Particle-Swarm Optimized Microgrid Power Sharing","A Modified Droop Control Strategy in Parallel Inverters System When Inductance Values of Transmission Lines Are Different","Phase Locked Loop Based on an Observer for Grid Synchronization","A Multi-Resonant PR Inner Current Controller Design for Reversible PWM Rectifier","DC Power Ripple Minimization of LCL Filter Based Distributed Generation Inverter Under Unbalanced Voltage Conditions","Analysis of Delay Effects in Single-Loop Controlled Grid-Connected Inverter with LCL Filter","Wide Bandwidth Three-Phase Impedance Identification Using Existing Power Electronics Inverter", "Power Controllability of Three-Phase Converter with Unbalanced AC Source".

Session 7 (AC-DC Converters) covers "Interleaved Continuous Conduction Mode Power Factor Correction Boost Converter with Improved Modulated Carrier Control Method","Sensorless Control of a Boost PFC AC/DC Converter with a Very Fast Transient Response","Common Mode and Differential Mode Circulating-Current Control in Paralleled Single-Phase Boost Rectifiers","A Line Cycle Skipping Method to Improve the Light Load Efficiency and THD of PFC Converters","Adaptive Master-Slave Interleaving Method for Boundary Conduction Mode (BCM) Buck PFC Converter","Increased Frequency Resolution of Active Rectifiers Using Fractional Digital PWM","Comparison of Modulation Strategies Driving a Three-Phase PWM Delta-Switch Rectifier in Wind Energy Conversion Systems Applications","A Reduced Common-Mode Voltage Space Vector Modulation Method for Current Source Converters","SiC Based Current Source Rectifier Paralleling and Circulating Current Suppression".

On March 20 (8.30 am – 10.15 am) the parallel running Technical Sessions 8 – 14 on the subjects DC-DC Converters for Powering VLSI Devices, Grid, Multi-Level Converters, High Performance Devices in Circuits, Component Level Modeling, System Integration, and Module Interconnect & Cooling are scheduled.

Session 8 (DC-DC Converters) covers "A High Efficiency High Density Voltage Regulator Design Providing VR 12.0 Compliant Power to a Microprocessor Directly from a 48V Input","A Fixed Frequency Dual-Mode DC-DC Buck Converter with Fast-Transient Response and High Efficiency over a Wide Load Range","Dynamic Physical Limits of Buck Converters: the T0/4 Transient Benchmark Rule","A Multi-Level Ladder Converter Supporting Vertically-Stacked Digital Voltage Domains","Accurate Design of High-Performance Synchronous Buck DC-DC Power Converters".

Session 9 (Grid) covers "Grid-Synchronization Modeling and its Stability Analysis for Multi-Paralleled Three-Phase Inverter Systems","Microgrid Reactive and Harmonic Power Sharing Using Enhanced Virtual Impedance","Low-Power Energy Harvester for Wiegand Transducers","Aalborg Inverter – a New Type of "Buck in Buck, Boost in Boost" Grid-Tied Inverter","Three-Phase Modular

Cascaded H-Bridge Multilevel Inverter with Individual MPPT for Grid-Connected Photovoltaic Systems".

Session 10 (Multi-Level Converters) covers "Direct Space Vector Modulated Three Level Matrix Converter","Decoupling Control of Input Voltage Balance for Diode-Clamped Dual Buck Three-Level Inverter","A New Switching Algorithm for Voltage Balancing of a Three-Level NPC in DTC Drive of a Three-Phase IM","A Method to Reduce Zero-Sequence Circulating Current in Three-Phase Multi-Module VSIs with Reduced Switch Count","A Novel Flying-Capacitor Dual Buck Three-Level Inverter".

Session 11 (High Performance Devices) covers "Enhanced Shielded-Gate Trench MOSFETs for High-Frequency, High-Efficiency Computing Power Supply Applications","SiC Vertical JFET Pure Diode-Less Inverter Leg","An Analytical Model for Evaluating the Influence of Device Parasitics on Cdv/dt Induced False Turn-on in SiC MOSFETs","Design Considerations for Secondary Side Synchronous Rectifier MOSFETs in Phase Shifted Full Bridge Converter", "Experience with 1 to 3 Megahertz Power Conversion Using eGaN FETs".

Session 12 (Component Level Modeling) covers "Modeling of SiC MOSFET with Temperature Dependent Parameters and its Applications", "Parameter Extraction Procedure for a Physics-Based Power SiC Schottky Diode Model","New µPEEC Formulation for Modeling 2D Core Transformer. Principles, Academic and Industrial Applications","Noninvasive Self-Tuning Output Capacitor Time Constant Estimator for Low Power Digitally Controlled DC-DC Converters","Real-Time State of Charge and Electrical Impedance Estimation for Lithium-Ion Batteries Based on a Hybrid Battery Model".

Session 13 (System Integration) covers "Multi-Parallel-Connected Static Synchronous Series Compensators","A Fast Overcurrent Protection Scheme for IGBT Modules Through Dynamic Fault Current Evaluation","Design of DC-Side Wiring Structure for High-Speed Switching Operation Using SiC Power Devices","Important Aspects on Effective Common Mode Noise Filtering by Means of Passive Cancellation","EMI Filter Design and Optimization for Both AC and DC Side in a DC-Fed Motor Drive System".

Session 14 (Module Interconnect & Cooling) covers "Full SiC Power Module with Advanced Structure and its Solar Inverter Application","A 1200 V, 60 A SiC MOSFET Multi-Chip Phase-Leg Module for High-Temperature, High-Frequency Applications","Double-Sided Cooling Design for Novel Planar Module","Novel Bonding and Joining Technology for Power Electronics","A Review of Thermal Management in Power Converters with Thermal Vias".

On March 20 afternoon Technical Sessions 15 – 21 on Wide Gap/Hi Freq/Hi Density DC-DC Converters, Converters/Control, Motor Drives I, LED Lighting, Analysis & Control of Grid Connected Converters, Grid-tied Power Converters, and AC-DC Converters – Topologies will run in parallel.

Session 15 (DC-DC) covers "13.56 MHz High Density DC-DC Converter with PCB Inductors","Optimizing the Efficiency of a DC-DC Boost Converter over 98% by Using Commercial SiC Transistors with Switching Frequencies from 100 kHz to 1MHz","Understanding the Effect of PCB Layout on Circuit Performance in a High Frequency Gallium Nitride Based Point of Load Converter","Improvement of GaN Transistors Working Conditions to Increase Efficiency of a 100W DC-DC Converter","Application of GaN FET in 1MHz Large Signal Bandwidth Power Supply for Radio Frequency Power Amplifier","100 MHz, 85% Efficient Integrated AlGaAs/GaAs Supply Modulator for RF Power Amplifier Modules","Overview of Three-Dimension Integration for Point-of-Load Converters","Advantages of Paralleling Inductors-on-Silicon in High Frequency Power Converters","A 4.6W/mm? Power Density 86% Efficiency on-Chip Switched Capacitor DC-DC Converter in 32 nm SOI CMOS".

Session 16 (Converters/Control) covers "Modulation Technique to Reduce

Leakage Current in Transformerless Photovoltaic Systems Using a Three-Level Inverter","Novel Soft-Switching Snubberless Current-Fed Half-Bridge Front-End Converter Based PV Inverter","A Modular Multilevel Space Vector Modulation for Photovoltaic Quasi-Z-Source Cascade Multilevel Inverter","Control Strategy for the Front-End DC-DC Converter to Reduce the Second-Order Harmonic Current in the Two-Stage Inverter","Current Distortion Correction in Dual Buck Photovoltaic Inverter with a Novel PWM Modulation and Control Method","A Coupled-Inductor Multi-Level Ladder Converter for Sub-Module PV Power Management","An Improved Constant On/Off Time Control Scheme for Photovoltaic DC/DC MIC","A ZVS Parallel-Series Dual-Bridge Phase-Shift DC/DC Converter with Two Degrees of Freedom Used in Hybrid Renewable Energy Power Conditioning Systems","A Hybrid Control Method for Photovoltaic Grid-Connected Interleaved Flyback Micro-Inverter to Achieve High Efficiency in Wide Load Range".

Session 17 (Motor Drives I) covers "An Immune-Algorithm-Based Dead-Time Elimination PWM Control Strategy in a Single-Phase Inverter","Analysis of IGBT Based Fundamental Front End Regenerative Motor-Drive Systems","Variable Switching Frequency PWM Strategy for Inverter Switching Loss and System Noise Reduction in Electric/Hybrid Vehicle Motor Drives","An Adaptive Quasi-Sliding-Mode Observer-Based Sensorless Drive for Heavy-Duty Interior Permanent Magnet Synchronous Machines","Sensorless Control of Synchronous Machine with an Inverter Integrated Rotor","A Synchronized Sinusoidal PWM Based Rotor Flux Oriented Controlled Induction Motor Drive for Traction Application","Real Time Operating System Based Online Rotor Position Error Minimization Technique (RPEM) for Permanent Magnet Synchronous Machines","Fast Optimal Efficiency Flux Control for Induction Motor Drives in Electric Vehicles Considering Core Losses, Main Flux Saturation and Rotor Deep Bar Effect","Post-Fault Control Technique for Multi-Phase PM Motor Drives Under Short-Circuit Faults".

Session 18 (LED Lighting) covers "A New High Power Factor, Soft-Switched LED Driver Without Electrolytic Capacitors","A Multi-Channel DC/DC LED Driver with Inductor-Less Series-Parallel Auto-Regulated Rectifier","Very High Frequency Resonant DC/DC Converters for LED Lighting","A TRIAC-Dimmable LED Lamp Driver with Wide Dimming Range","A Dual-Path, Current-Sensing Resistor-Free Boost LED Driver with Fast PWM Dimming","Two-Stage Power Conversion Architecture for an LED Driver Circuit","Self-Driven Synchronous-Rectification Technique for the Asymmetrical Half-Bridge Converter in LED Lighting Applications","Filter-Free AC Direct LED Driver with Unity Power Factor and Low Input Current THD Using Binary Segmented Switched LED Strings and Linear Current Regulator","Dual Purpose HB-LED Driver for Illumination and Visible Light Communication".

Session 19 (Grid Connected Converters) covers "Fast Voltage Sag Detection Method for Single-/Three-Phase Application","Harmonics Suppression for Single-Phase Grid-Connected PV Systems in Different Operation Modes","Influence of Phase-Locked Loop on Input Admittance of Three-Phase Voltage-Source Converters","An Optimal Sequence-Based-Controller (OSBC) for a Grid-Connected Three-Phase Photovoltaic HFL Inverter","On Control Strategy of Cascaded H-Bridge Multilevel Converter with Fluctuating Output Voltage","Stability Analysis of the Three-Phase Single-Stage Boost Inverter","A Novel DC Voltage Balancing Method for Cascaded STATCOM","Compensation of Input Current Distortion in Three-Phase Buck Rectifiers","Analysis of Phase Locked Loop (PLL) Influence on DQ Impedance Measurement in Three-Phase AC Systems".

Session 20 (Power Converters) covers "Design and Optimization of 99% CEC Efficiency Soft-Switching Photovoltaic Inverter","A Technique for Voltage-Source Inverter Seamless Transitions Between Grid-Connected and Standalone Modes","A Robust Multi-Resonant PR Regulator for Three-Phase Grid-Connected VSI Using Direct Pole Placement Design Strategy","A Fast Nonlinear Control Technique for a Grid-Connected Voltage Source Inverter with LCL Filter Used in Renewable Energy Power Conditioning Systems","A Dynamic Voltage Restorere with a Selective Harmonic Mitigation and Robust Peak Detection","Novel Low Harmonic Rectifier Using 12-Pulse Inductive Current Splitter/Merger","An Improved Current Control Scheme for Grid-Connected DG Unit Based Distribution System Harmonic Compensation","Modeling and Control of an LCL Filter Based Three-Phase Active Rectifier in Grid Emulator","Enhanced Power Quality Compensation in PV Single-Phase Grid-Tied Systems".

Session 21 (AC-DC Converters) covers "Analysis and Design of an Interleaved Three-Phase Single-Stage PFC AC-DC Converter","A High Efficiency Bridgeless Flyback PFC Converter for Adapter Application","Integrated Magnetics for Boost PFC and Flyback Converters with Phase-Shifted PWM","Single-Phase PWM Rectifier with Power Decoupling Ripple-Port for Double-Line-Frequency Ripple Cancellation","Low-Volume PFC Rectifier Based on Non-Symmetric Multi-Level Boost Converter","Interleaved Multi-Cell Isolated Three-Phase PWM Rectifier System for Aircraft Applications","The Single-Stage TAIPEI Rectifier","Experimental Verification of the Efficiency/Power-Density (Eta – Rho) Pareto Front of Single-Phase Double-Boost and TCM PFC Rectifier Systems","A Current Ripple Cancellation Circuit for Electrolytic Capacitor-Less AC-DC LED Driver".

On March 21 morning Technical Sessions 22 – 28 and in the afternoon 29 – 35 will be held. The morning subjects are Multi-port DC/DC Converters, Renewable Energy Applications, Fault-Tolerance and Condition Monitoring for Inverters, Inverters & Converters, Gate Drive and Cascode Applications, Multilevel and High Power Converters, and Digital Control of DC-DC Converters.

Session 22 (Multi-port DC/DC Converters) covers "A Family of Cost-Efficient Integrated Single-Switch Three-Port Converters","A New Isolated Multi-Port Converter Using Interleaving and Magnetic Coupling Inductor Technologies","Bidirectional Multiple Port DC/DC Transformer Based on a Series Resonant Converter","A Family of Cost-Efficient Non-Isaolated Single-Inductor Three-Port Converters for Low Power Stand-Alone Renewable Power Applications","Topology and Control of a Family of Non-Isolated Three-Port DC-DC Converters with a Bidirectional Cell","Investigation of Multiple-Input Converters Bi-Directional Power Flow Characteristics","Multivariable Control of Single-Inductor Dual-Output Buck Converters".

Session 23 (Renewable Energy Applications) covers "Sensitivity Analysis of Symmetrical Direct Control of Torque and Power Variables of Doubly-Fed Induction Generator","A Highly Reliable Converter for Wind Power Generation Application","A Multi-Terminal DC to DC Converter Topology with Power Accumulation from Renewable Energy Sources with Unregulated DC Voltages","An Active Damper for Stabilizing Power Electronics-Based AC Systems","Parallel VSIs Wireless Control by Emulation of Output Current State Using Optimal Linear Controller","Bidirectional LLC Resonant Converter for Energy Storage Applications","Low Cost Battery Equalizer Using Buck-Boost and Series LC Converter with Synchronous Phase-Shift Control".

Session 24 (Fault-Tolerance and Condition Monitoring) covers "Separation of Disturbing Influences on Induction Machine's High-Frequency Behavior to Ensure Accurate Insulation Condition Monitoring","Reliability Assessment of Energy Conversion Components in Geographically Distributed Power Grid Through a Modern Communication Network","Open Loop V/F Control of Multiphase Induction Machine Under Open-Circuit Phase Faults","Fault Tolerant Operation of a Five Phase Converter for PMSM Drives","An on-Line Fault Detection and a Post-Fault Strategy to Improve the Reliability of Matrix Converters","A New Diagnostic Technique for Real-Time Diagnosis of Power Converter Faults in Switched Reluctance Motor Drives","Real Time Monitoring of Aging Process in Power Converters Using the SSTDR Generated Impedance Matrix".

Session 25 (Inverters & Converters) covers "Efficiency Analysis on a Two-Level Three-Phase Quasi-Soft-Switching Inverter","Study on DC Busbar Structure Considering Stray Inductance for the Back-to-Back IGBT-Based Converter","Generalized DC-Link Voltage Balancing Control Method for Multilevel Inverters","Damping Control Combined to Output Stage for a Multi-Modular Matrix Converter","High-Efficiency High-Power Density Series Resonant Inverter Based on a Multi-MOSFET Cell Implementation","A Fast and Generalized Space Vector Modulation Scheme for Multilevel Inverters","Dynamic Ramp with the Invariant Inductor in Current-Mode Control for Buck Converter".

Session 26 (Gate Drive and Cascode) covers "Third Quadrant Behavior of SiC

MOSFETs","An Integrated Current Sense Technique for Multiphase Buck Converters to Improve Accuracy and Reduce Solution Footprint","A Novel Gate Assist Circuit for Cross Talk Mitigation of SiC Power Devices in a Phase-Leg Configuration","Switching Performance Improvement of IGBT Modules Using an Active Gate Driver","Dynamic Optical Turn-Off Control of a High-Voltage SiC MOSFET","Evaluation and Application of 600V GaN HEMT in Cascode Structure","SiC JFET Cascode Loss Dependency on the MOSFET Output Capacitance and Performance Comparison with Trench IGBTs".

Session 27 (Multilevel) covers "Nine IGBTs Based UPFC Topology and Control for Renewable Power Integration";"A Coordinated Active and Reactive Power Control Strategy for Grid-Connected Cascaded Photovoltaic (PV) System in High Voltage High Power Applications","Control of a Three-Stage Three-Phase Cascaded Modular Power Electronic Transformer","A Flexible Modular Multi-Level Converter for DC Microgrids with EV Charging Stations","Arm Inductance Selection Principle for Modular Multilevel Converters with Circulating Current Suppressing Control","A Hybrid Railway Power Conditioner for Traction Power Supply System","Grid Active Power Filters Using Cascaded Multilevel Inverters with Direct Asymmetric Switching Angle Control for Grid Support Functions".

Session 28 (Digital Control) covers "Comparison of Linear and Non-Linear Digital Power Solutions","Average Natural Trajectories (Ants) for Buck Converters: Centric-Based Control","Mixed-Signal CPM Controlled DC-DC Converter IC with Embedded Power Management for Digital Loads","Digital Control of a Bi-Directional DC-DC Converter for Automotive Applications","Ultra-Fast on-Chip Load-Current Adaptive Linear Regulator for Switch Mode Power Supply Load Transient Enhancement","Adaptive Driving of Synchronous Rectifier for LLC Converter Without Signal Sensing","Digital Constant on-Time Controlled Multiple-Input Buck and Buck-Boost Converters".

Session 29 (DC-DC Resonant Converters) in the afternoon covers "A New Generation of Buck-Boost Resonant AC-Link DC-DC Converters","Dynamical Modeling for Series-Parallel Resonant Converter Under Optimized Modulation","High Efficiency Resonant DC/DC Converter Utilizing a Resistance Compression Network","Active Clamp LLC Resonant Converter for Point-of-Load Applications","Eta-Rho Pareto Optimization of Bidirectional Half-Cycle Discontinuous-Conduction-Mode Series-Resonant DC/DC Converter with Fixed Voltage Transfer Ratio","An Interleaving and Load Sharing Method for Multiphase LLC Converters","Optimal Design Method for Series LCLC Resonant Converter Based on Analytical Solutions for Voltage Gain Resonant Peaks","Characterization of a 6.5kV IGBT for Medium-Voltage High-Power Resonant DC-DC Converter","Optimal Trajectory Control of LLC Resonant Converters for Soft Start-Up".

Session 30 (Power Systems and EMI) covers "A New Current Injection Method for Impedance Measurement Using Superposed Modulated Square Pulse","Novel Dynamic Control Strategy on Resisting Impulsive Load for Uninterruptible Power Supply System","A New Topology of Bridge-Type Non-Superconducting Fault Current Limiter","A Low-Volume Power Management Module for Portable Applications Based on a Multi-Output Switched-Capacitor Circuit","High-Voltage Isoltated Multiple Outputs DC/DC Power Supply for GCT Gate Drivers in Medium Voltage (MV) Applications","Film Bulk Acoustic Resonator (FBAR) Based Power Converters: a New Trend Featuring EMI Reduction and High Power Density","Suppression of Voltage Harmonics in Single-Phase Inverters Based on Multi-Voltage Control","Influence of High-Frequency Near-Field Coupling Between Magnetic Components on EMI Filter Design","A Novel Hybrid Low Cost Controller for Maintaining Low Input Current Harmonic over Wide Range of Load Conditions for Power Factor Corrected Boost AC to DC Converter".

Session 31 (Motor Drives II) covers "A Doubly-Fed Induction Machine and the Control in a Single-Phase Grid Connection","Control Architecture for a Doubly-Fed Induction Machine Propulsion Drive","An Efficient Universal Controller for

Switched-Reluctance Machines","Dq Control of Switched Reluctance Machines","Power Enhancement of Dual Inverter for Open-End Permanent Magnet Synchronous Motor","Feature Rich and Highly Efficient Intelligent Power Modules for Consumer Goods Applications","A Study of Motor-End EMI Filter on Output Common-Mode Noise Suppression in DC-Fed Motor Drive System","Common-Mode EMI Solutions for Modular Back-to-Back Converter Systems","Tuning of Phase Locked Loop for Industrial Regenerative Motor-Drive Systems".

Session 32 (Industrial and Utility Interface) covers "Design of Household Appliances for a DC-Based Nanogrid System: an Induction Heating Cooktop Study Case","Series Resonant Inverter with Active Snubber Circuit for Improved Efficiency Operation Applied to Domestic Induction Heating","Design and Analysis of an Energy Recycling Electronic Load System","Design and Implementation of a Highly Efficient DBD Ozonizer Using the Single Switch Resonant Converter with Piezoelectric Transformer","Power Density Design of SiC and GaN DC–DC Converters for 380 V DC Distribution System Based on Series-Parallel Circuit Topology","Experimental Validation of a Parallel Hybrid Modular Multilevel Voltage Source Converter for HVDC Transmission", "Influence of Network Voltage Level, Converter Topology and Integration of Energy Storage on the Power Losses of STATCOM Devices","Performance Analysis of Conventional STATCOMs and STATCOMs with Energy Storage in Electric Arc Furnace Applications","Droop Controller Design Methods for Isolated DC-DC Converter in DC Grid Battery Energy Storage Applications".

Session 33 (Magnetic Devices) covers "Nanogranular Nickel Iron Thin Films for High Frequency Power Applications","Inductor Geometries with Significantly Reduced Height","Embedded Magnetic Power Transformer","Development and Verification of Printed Circuit Board Toroidal Transformer Model","A Toroidal Power Inductor Using Radial-Anisotropy Thin-Film Magnetic Material Based on a Hybrid Fabrication Process","Impact of Planar Transformer Winding Capacitance on Si-Based and GaN-Based LLC Resonant Converter","Comparison of CCTT-Core Split-Winding Integrated Magnetic and Discrete Inductors for High-Power DC-DC Converters","Optimized Design of LLC Resonant Converters Incorporating Planar Magnetics","High Current and High Frequency Planar Inductor Loss Measurement and Analysis".

Session 34 (Modeling) covers "Stability Analysis and Design of Stable DC Distribution Systems Through Positive Feed-Forward Control Using a Novel Passivity-Based Stability Criterion","Simplified Small-Signal Stability Analysis for Optimized Power System Architecture","Small Signal Analysis of V? Control Using Current Mode Equivalent Circuit Model","Small-Signal Analysis and Design of Constant Frequency V2 Peak Control","FPGA Based Real Time Electro-Thermal Modeling of Power Electronic Converters","Small–Signal Analysis of the Asymmetrical Half-Bridge Converter with Two Transformers","A New Large Signal Average Model for Variable Frequency Pulse-Width Modulators","Small-Signal Analysis of DCM Flyback Converter in Frequency-Foldback Mode of Operation","State Space Modeling and Performance Analysis of a Multilevel Modular Switched-Capacitor Converter Using Pulse Dropping Switching Technique".

Session 35 (Vehicular Electronics) finally covers "An Isolated DC/DC Converter with Reduced Number of Switches and Voltage Stresses for Electric and Hybrid Electric Vehicles","High-Temperature SOI-Based Gate Driver IC for WBG Power Switches","High Gain Soft-Switching Bidirectional DC-DC Converters for Eco-Friendly Vehicles","Surface Spiral Coil Design Methodologies for High Efficiency, High Power, Low Flux Density, Large Air-Gap Wireless Power Transfer Systems","A Reduced-Part Single Stage Direct AC/DC on-Board Charger for Automotive Applications","An Efficient Soft Switched DC-DC Converter for Electric Vehicles","Control Strategies for a LLC Multi-Resonant DC-DC Converter in Battery Charging Applications","Optimized Magnetic Design for Inductive Power Transfer Coils","A Semi-Bridgeless Boost Power Factor Corrected Converter with an Auxiliary Zero Voltage Switching Circuit for Electric Vehicle Battery Chargers".

PCIM
EUROPE

International Exhibition and Conference
for Power Electronics, Intelligent Motion,
Renewable Energy and Energy Management
Nuremberg, 14 – 16 May 2013

PCIM Stronger Than Ever

The PCIM Europe 2013 conference (14.-16.May) program is more comprehensive than ever before. From a record 276 abstracts in total the conference directors have put together a comprehensive program on the latest technological trends in power electronics components and systems. 28 oral sessions as well as two poster sessions provide an excellent overview of the current trends and developments in the sector. On the two days before the conference well known experts will share their knowledge on topics such as “Power Electronics for Renewable Energy Systems”, “New Developments in Power-Factor Correction” and “High Frequency Magnetics Design” in six half-day seminars and 10 full day tutorials.

The PCIM Europe international conference and trade fair is the meeting point for experts from industry and industry related sciences. About 7,000 professionals from the power electronics, intelligent motion, and renewable energies sectors annually visit this leading exhibition for power electronics in Nuremberg.

The highlights include, amongst others, three keynote speeches on “HVDC – State of the Art and Future Trends”, “New generation of Traction Drives based on SiC Power Components” and “High-density Fast-transient Voltage Regulator Module”, as well as special sessions on: “Solar Power”, ”Wind Energy Technology”, “E-Mobility” and “Power GaN for Highly Efficient Converters“.

PEE Special Session

The latter is organized by Power Electronics Europe in order to give power electronic designers an impression of what is happen in power semiconductors in the near future. Market researcher Yole positions GaN Power for high-end and middle-end solutions in applications up to 200 V by the year 2015. Because power semiconductors are “just a piece” of the power electronics industry, the power semiconductor industry has to answer requirements from a bigger system- the converter.

At this point in time, according to Yole the GaN industry is mostly a US business. International Rectifier, EPC, Transphorm and GaN Systems now propose fully off-the-shelf or customized products.

First results for the use of GaN based power devices in highly efficient high frequency power circuits such as AC/DC power supplies, DC/AC inverters and DC/DC boost and buck converters are presented. The current status of the development and current performance of the required 600 V rated GaN on Si based devices at International Rectifier are presented. Results of long term reliability studies of more than 2500 hrs will be presented, as well as results for device robustness in application conditions. RF Envelope Tracking and high-frequency Wireless Power Transmissio are beyond the fundamental capability for the aging power MOSFET due to the requirements of high voltage, high power, and high frequency. As a result, these are early growth markets for GaN on Silicon devices. EPC’s egaN FETs have also made inroads in several other applications that will be discussed along with the latest developments in device technology and future direction for both discrete and integrated circuits made in GaN.

Transphorm’s presentation investigates how GaN is making such rapid performance progress and uses test results to illustrate what is now possible using GaN compared to recent SiC transistor performance. It then predicts future improvements that will continue to make GaN a more attractive alternative to either Si or SiC for high efficiency systems. The combinations of GaN switches and CMOS or SOS custom driver devices from GaN Systems serve to accelerate the adoption of the advantages of GaN switches into power conversion and control systems by providing the system designer with a single device that is easily driven fromlogic signals. The inclusion of feedback from on chip sensors and the ability to control switching slew rate open the prospect of tailoring the switch performance for given applications.

GaN Systems novel switch is formed from a sea of source and drain islands with a common gate region running between them. This results in up to four times reduction in the die area occupied by a transistor of given on-resistance and simplifies the semiconductor processing required, thereby minimizing manufacturing cost. In addition high breakdown voltages, in excess of 1,200 V, can be achieved with this topology. The current in each source island flows directly from the die through a copper post into the interconnect pattern on the surface to which the die is mounted. Initially produced using GaN on SiC processes, these devices are now migrating to GaN on Silicon.

AC Mains or DC Input Dimmable LED Driver

Intersil has introduced two new LED driver controllers that not only operate in critical conduction mode (CrCM) but also deliver high efficiency and dimming performance in industrial and commercial lighting systems.

The ISL1903 and ISL1904 are single-ended buck and flyback LED driver controllers that support single-stage conversion of the AC mains to a constant current source with power factor correction (PFC). Designed for isolated and non-isolated power applications, the ISL1903 supports buck converter topologies including isolated forward converters and non–isolated source return buck converters. The ISL1904 supports isolated flyback as well as non-isolated SEPIC and Boost topologies. They operate in CrCM to allow near zero-voltage switching, maximizing both efficiency and magnetic core utilization. Both the ISL1903 and ISL1904 may also be used with DC input sources. Both devices deliver near-universal dimmer compatibility, and are designed for industrial and commercial lighting installations and retrofits. Additionally, they can be used in DC or AC input LED ballasts and in universal AC mains input LED retrofit lamps.

Oscillator

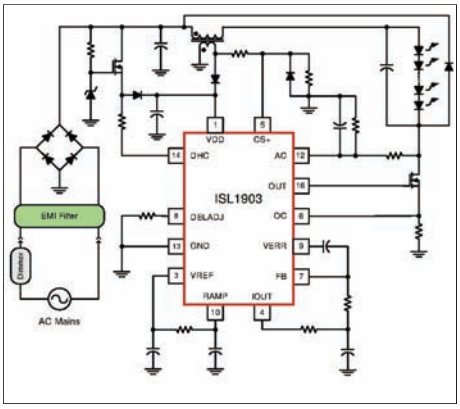
The ISL1903 uses a critical conduction mode (CrCM) algorithm to control the switching behavior of the converter. The ON-time of the primary power switch is held virtually constant by the low bandwidth control loop (in PFC applications). The OFF-time duration is determined by the time it takes the current or voltage to decay during the flyback period. When the mmf (magneto motive force) of the transformer decays to zero, the winding currents are zero and the winding voltages collapse. Either may be monitored and used to initiate the next switching cycle.

The ISL1903 monitors the CrCM condition using the CS+ signal. It may be used to monitor either current or voltage. Additionally, there is a user adjustable delay duration, DELADJ, to delay the initiation of the next switching cycle to allow the drain-source voltage of the primary switch to ring to a minimal. This allows quasi-ZVS operation to reduce capacitive switching losses and improve efficiency.

By its nature the converter operation is variable frequency. There are both minimum and maximum frequency clamps that limit the range of operation. The minimum frequency clamp prevents the converter from operating in the audible frequency range. The maximum frequency clamps prevents operating at very high frequencies that may result in excessive losses.

An individual switching period is the sum of the ON-time, the OFF-time, and the restart delay duration. The ON-time is determined by the control loop error voltage, VERR, and the RAMP signal. As its name implies, the RAMP signal is a linearly increasing signal that starts at zero volts and ramps to a maximum of ~VERR/5 – 235 mV. RAMP requires an external resistor and capacitor connected to VREF to form an RC charging network. If VERR is at its maximum level of VREF, the time required to charge RAMP to ~850 mV determines the maximum ON-time of the converter. RAMP is discharged every switching cycle when the ON-time terminates.

The OFF-time duration is determined by the



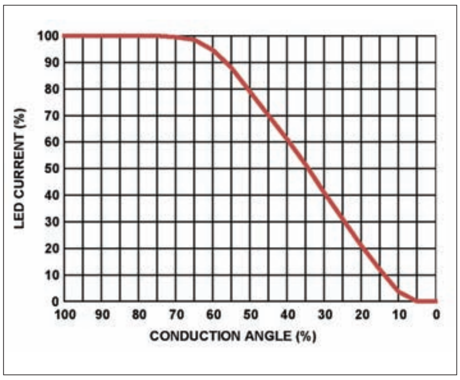
Boost-return (buck) topology

design of the magnetic element(s), which depends on the required energy storage/transfer and the inductance of the winding(s). The transformer/inductor design also determines the maximum ON-time that can be supported without saturation, so, in reality, the magnetics design is critical to every aspect of determining the switching frequency range.

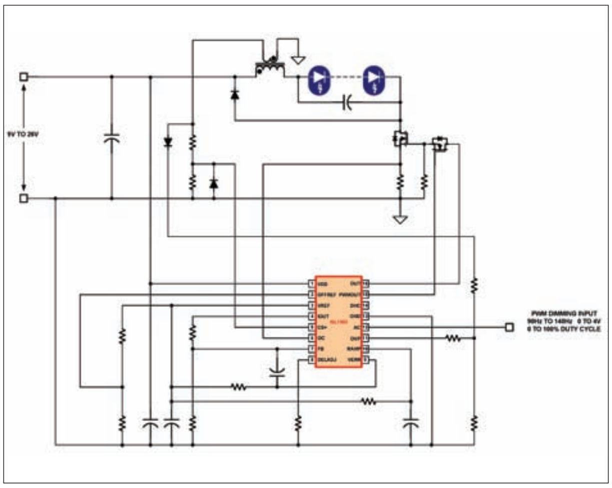
The design methodology is similar to designing a discontinuous mode (DCM) buck converter with the constraint that it must operate at the DCM/CCM boundary at maximum load and minimum input voltage. The difference is that the converter will always operate at the DCM/CCM boundary, whereas a DCM converter will be more discontinuous as the input voltage increases or the load decreases. In PFC applications, the design is further complicated by the input voltage waveform, a rectified sinewave.

Once the output power, the output current, the output voltage, and the minimum input AC voltage are known, the inductor design can be started. From the minimum AC input voltage, the minimum DC equivalent (RMS) input voltage must be determined. In PFC applications, the converter behaves as if the input voltage is an equivalent DC

Dimmable LED driver controllers



Current vs AC conduction angle



LEFT: Typical application diagram - DC Input Dimmable Buck LED Driver

value due to the low control loop bandwidth.

A typical minimum operating frequency must be selected. This is a somewhat arbitrary determination, but does ultimately determine the inductor size. The typical frequency is what occurs when the instantaneous rectified input AC voltage is exactly at the equivalent DC value. The frequency will be higher when the instantaneous input voltage is lower, and lower when the instantaneous input voltage is higher. However, the duty cycle at the equivalent DC input voltage determines the ON-time for the entire AC half-cycle. The ON-time is constant due to the low bandwidth control loop, but the OFF-time and duty cycle vary with the instantaneous input voltage since the peak switch current follows V = Ldi/dt.

The typical frequency may require adjustment once the initial calculations are complete to see if the operating frequency at the peak of the minimum AC input voltage is acceptable. The peak current will be 1.41 times higher at the AC peak than at the DC equivalent (RMS) input voltage. So, while the ON-time is nearly constant due to the low bandwidth control loop, the OFF-time will be 1.41 times longer.

The effective AC conduction angle must also be considered when calculating the inductance. Since no current flows to the load when the instantaneous input voltage is less than the output voltage, the equivalent DC input voltage (rms) is duty cycle modulated by the effective AC conduction angle. This results in higher currents during the portion of the AC half-cycle when the converter can deliver power to the load. The switching currents increase and the frequency of operation decreases. Obviously the higher the output voltage the greater the impact.

Dimming

The ISL1903 supports both PWM and DC current modulation dimming. In either case, the control loop determines the average current delivered to the load. PWM dimming is not recommended for non-isolated applications requiring PFC. The PWM dimming method will cause high harmonic content due to the low PWM dimming frequency.

The usual method of dimming an LED string is to modulate the DC current through the string. DC current dimming is the lower cost method, but results in a non-linear dimming characteristic due to the increasing efficacy of the LEDs as current is reduced.

PWM dimming results in linear dimming behavior. For PWM dimming, an external FET, controlled by PWMOUT, is required to gate the drive signal to the switching FET (see typical application diagram - DC Input Dimmable Buck LED Driver for an example. When PWMOUT is high, the main switching FET operates normally. When PWMOUT is low, the main switching

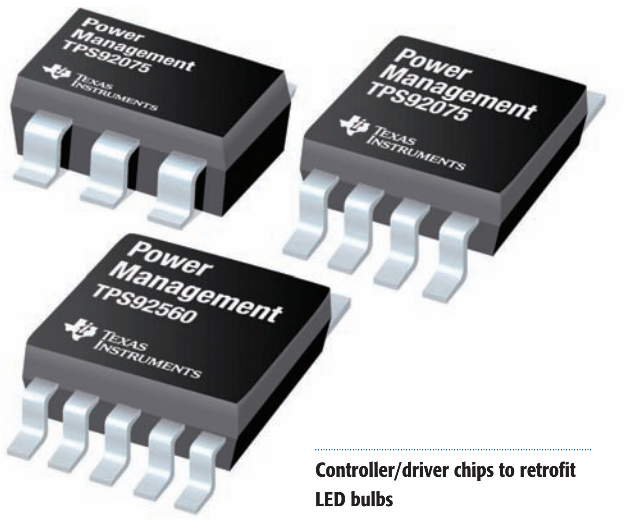
FET gate signal is blocked and the converter is effectively off.

Regardless of the dimming method used, the control loop determines the average current delivered to the load. It does not matter if the load current is DC or pulsed, the converter control loop and output capacitance operate to filter and average the converter output current independently of the actual load current waveform.

The dimming PWM and control loop are linked together such that the PWM duty cycle tracks the main control loop reference setpoint. If the control loop is set for 50 % load, for example, the dimming PWM duty cycle is set for 50 %. The LED current will be at 100 % load for 50 % of the time and 0 % load for 50 % of the time, which averages to the 50 % average load setpoint. If PWM dimming is used, the control loop bandwidth must be reduced significantly below the PWM dimming frequency. It should be noted that the PWMOUT duty cycle is not allowed to go to zero.

More application informations: http://www.intersil.com/content/intersil/en/products/power-management/led-drivers/led-lighting-drivers/ISL1903.html

Controller and Driver to Retrofit LED Bulbs



Controller/driver chips to retrofit LED bulbs

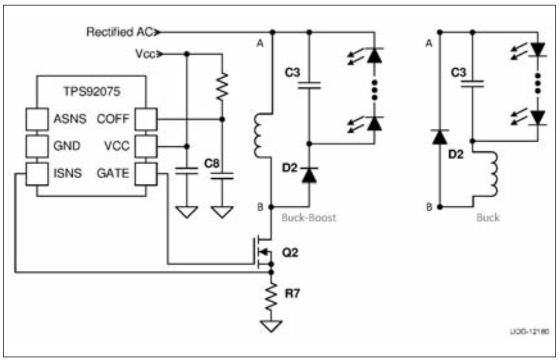
Texas Instruments introduced the off-line, phase-dimmable, constant-current lighting controller and a lighting driver that simplify the retrofit of a variety of LED bulbs, including E14, GU10, A19, PAR20/30/38, MR16 and AR111. The TPS92075 controller and TPS92560 driver reduce component count and solution size while improving compatibility with legacy lighting controls.

The TPS92075 is designed for phase-dimmable, offline AC/DC LED lamp and downlight applications. Offered in a very small 6-pin TSOT package, it achieves power factor correction (PFC) above 0.9 while delivering smooth, flicker-free dimming when used with conventional wall dimmers. The TPS92560 is intended for use in low-voltage AC or low-voltage DC LED lamp applications such as MR16 and AR111. It uses a proprietary input current control method, which improves compatibility with electronic transformers. A hysteretic, peak current, constant off-time approach implements the conversion.

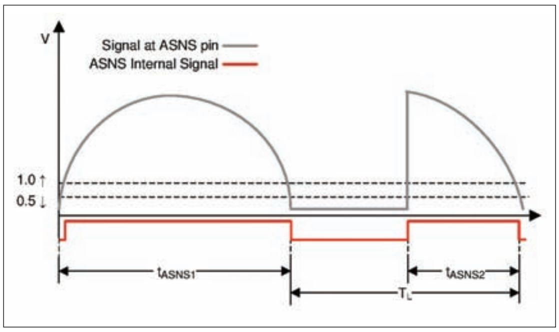
The TPS92075 controls the inductor current by controlling two features: (A) The peak inductor current, and (B) the cycle off-time. The following items summarize the basics of the switch operation in this hysteretic controller (see simplified TPS92075 schematic):

- The main switch Q2 turns on and current ramps in the inductor.
- The Q2 current flows through the sense resistor R7. The R7 voltage is compared to a reference voltage at ISNS. The Q2 on-time ends when the voltage on R7 is equal to a controlled reference voltage and the inductor current has reached its set peak current level for that switching cycle.
- Q2 is turned off and a constant off-time timer begins. Voltage begins ramping on C8.
- The next cycle begins when the voltage on C8 reaches 1.2V. This ends the constant off-time and discharges C8.
- Capacitor C3 eliminates most of the ripple current seen in the LEDs.

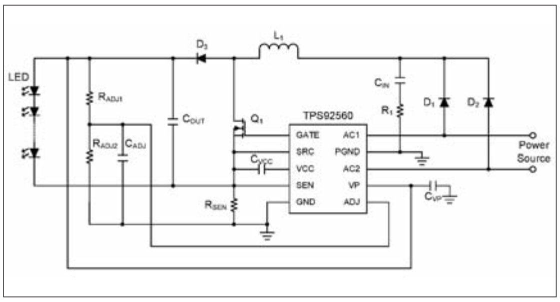
The TPS92075 incorporates a patent-pending control methodology to



Simplified TPS92075 buck-boost application schematic (right - buck section)



Angle Sense Operation



Typical application circuit of the TPS92560 using boost configuration

generate the reference for the conversion stage. The controlled reference used for the comparison of the ISNS signal may be DC or another shape depending on the mode of operation. Each mode controls the peak current level using a different methodology (see controlled reference derived power factor correction curves).

The TPS92075 is designed to achieve instant turn-on using an external linear regulator circuit. The start-up sequence is internally controlled by a VCC under-voltage lockout (UVLO) circuit. Sufficient headroom has been incorporated to support the use of an auxiliary winding with start-up linear, resistive or coupled capacitor start-up methods.

The TPS92075 can be configured to use a linear regulator with or without the use of an auxiliary winding. Using a linear regulator to provide VCC incurs more losses than an auxiliary winding, but has several advantages:

- allows the use of inexpensive off-the-shelf inductors as the main magnetic,
- speeds start-up time under deep dimming conditions,
- can reduce the size of the required VCC capacitor,
- the extra current draw when dimming can improve dimming compatibility.

Another consideration when selecting a bias method involves the OVP configuration. Because the feature is enabled via the VCC pin, an auxiliary winding provides the simplest implementation of output over-voltage protection.

A typical start-up sequence begins with VCC input voltage below the UVLO threshold and the device operating in low-power, shut-down mode. The VCC input voltage increases to the UVLO threshold of 9.8 V typical. At this point all of the device features are enabled. The device loads the initial start-up value as the output reference and switching begins. The device operates until the VCC level falls below the VCC(UVLO) falling threshold. (6.4 V typical). When VCC is below this threshold, the device enters low-power shut-down mode.

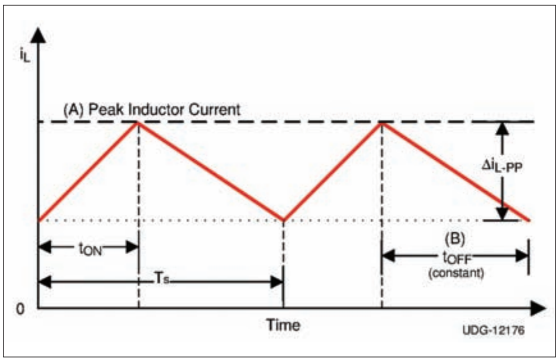
The ASNS (angle sense) pin is the only input to the digital controller. The time between the rising edge and the falling edge of the signal determines converter functions. The pin incorporates internal analog and digital filtering so that any transition that remains beyond the threshold for more than approximately 150 ?s will cause the device to record a change-of-state (see angle sense operation curves).

Basic operation and modes

The controller continuously monitors the line cycle period and the present conduction angle length to determine the state of operation and configure other control features. Control algorithms use a normalized line period of 256 samples from ASNS fall to ASNS fall and a normalized converter reference control of 127 levels over a range of 0 to 1 V.

The four main controller states are start-up, non-dimming, dimming, and ASNS signal lost. With the exception of start-up, the controller can enter any of the states at any time as conditions demand.

The two primary modes of controlling the converter reference are DC mode and Ramp mode. During active dimming, a DC control reference increases or decreases depending on the input AC duty cycle derived from the ASNS signal. The relationship follows the algorithm ASNS Length + Fixed Offset = Output Set point. When the conduction angle is long enough, the converter reference is changed to a triangular ramp to achieve a high power factor. The ramp is generated gradually over several cycles ensuring the implementation is undetectable. The controller maintains the ramp between the rising and falling ASNS signals.



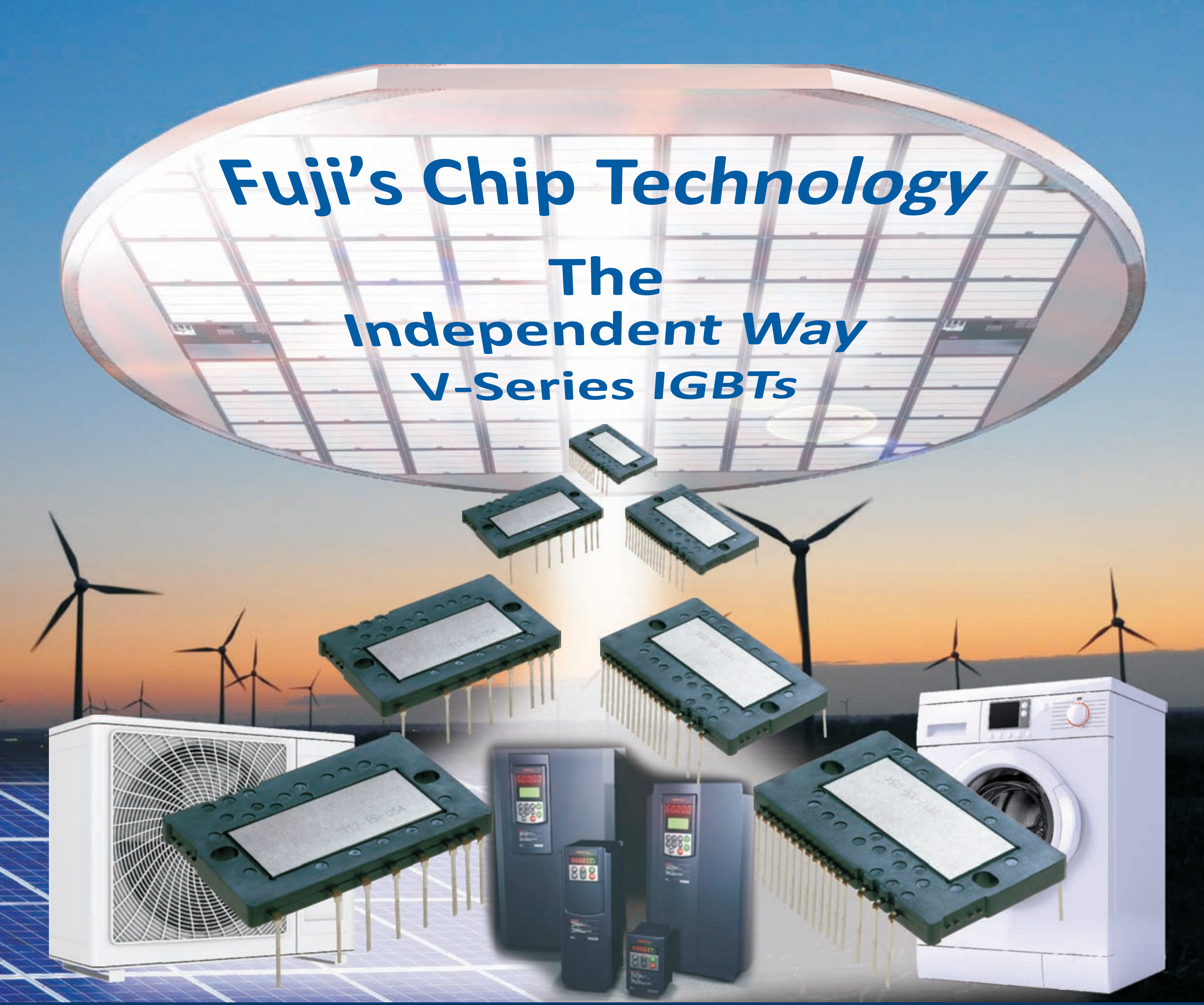
Controlled Reference Derived Power Factor Correction

Driver

The TPS92560 is a simple LED driver designed to drive high power LEDs by drawing constant current from the power source. The device is suited for MR16 and AR111 applications which need good compatibility to DC and AC voltages and electronic transformers. The hysteretic control scheme does not need control loop compensation while providing the benefits of fast transient response and high power factor. The patent pending feedback control method allows the output power to be determined by the number of LED used without component change. The TPS92560 supports both boost and SEPIC configurations for the use of different LED modules (see typical application circuit of the TPS92560 using boost configuration).

The TPS92560 can be configured to either a step-up or step-up/down LED driver for the use of different number of LEDs. The patent pending current control mechanism allows the use of a single set of component and PCB layout for serving different output power requirements by changing the number of LEDs. The integrating of the active low-side input rectifiers reduces the power loss for voltage rectification and saves two external diodes of a generic bridge rectifier to aim for a simple end application circuit. When the driver is used with an AC voltage source or electronic transformer, the current regulation level increases accordingly to maintain an output current close to the level that when it is used with a DC voltage source. With the output over-voltage protection and over-temperature shutdown functions, the TPS92560 is specifically suitable for the applications that are space limited and need wide acceptance to different power sources.

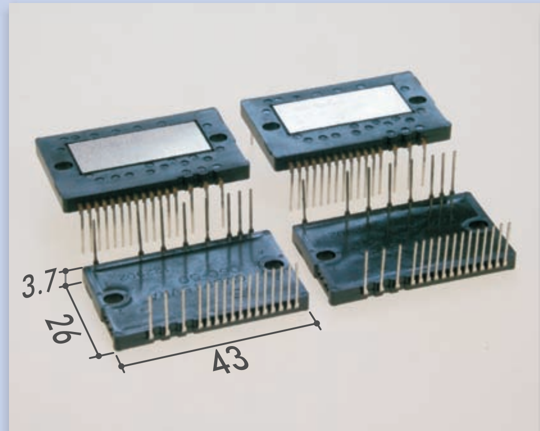
More technical and application informations: www.ti.com/tps92560-pr-eu and www.ti.com/tps92075-pr-eu



• Trench-FS IGBT • High thermal cycling capability • Low spike voltage & oscillation free • Excellent turn-on dI_C/dt control by R_G

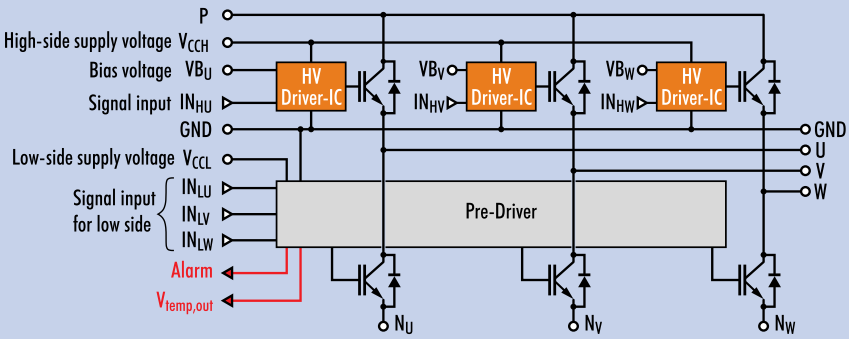
Mini-IPM , 6-Pack

- ▸ For 600V/15A , 20A , 30A
- ▸ Built-in High Voltage Driver-IC



▸ **Built-in protection functions**

+ Under voltage protection (→self shutdown & Alarm)
+ Short circuit protection (→self shutdown & Alarm)
+ Type A: Temperature monitoring (→$V_{temp,out}$)
+ Type B: Overheating protection (→self shutdown & Alarm)
+ Type C: Temperature monitoring (→$V_{temp,out}$) and Overheating protection (→self shutdown & Alarm)



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Bond Wireless Building Blocks Provide a New Approach to Power Modules

In the last edition the article 'COOLiR²DIE™ Bond Wireless Power Packaging for Hybrid and Electric Vehicles' took a look at how the advent of the Hybrid Electric Vehicle was bringing along new opportunities for power semiconductor packaging and in particular those without bond wires. We now move on to see how the discrete bond wireless building blocks of the CooliR²DIE can be used to develop a complete module.

Ben Jackson, Senior Manager, Automotive Power Switch & Power Module Product Management & Business Development, International Rectifier, El Segundo, USA

Power density is a phrase often associated with servers and computers, but rarely with respect to cars. This may lead people to think that in fact power density really is not important for a vehicle. But this could not be further from the truth. Take a look under the hood of a modern car and you will see there is barely room to get a wrench in between the tightly packed systems – every bit of space has been used up – the car by its very nature is space constrained and the trend is only to go to smaller and more compact vehicles in order to deliver batter fuel efficiency. At the same time the weight of the vehicle is being scrutinized evermore as simply put, weight equals fuel! To that end vehicle manufactures now proudly boast how many kilograms they have managed to shave off the car when a new model year is brought out.

So given this, why is power density so loosely associated with cars? The answer lies in the incumbent technology, the internal combustion engine. The high energy density of gasoline at about 45 MJ/kg means that the internal combustion engine and its belt driven pumps and fans is a very energy dense solution. Compare this to the energy density of a traditional lead acid battery at about 0.1 MJ/kg it is easy to see one obstacle that the new hybrid and electric solutions need to overcome. Of course battery technologies on (H)EVs are now well beyond that of a lead acid battery, but the gap is still large.

SFM for power modules

Previously the concept of the COOLiR²DIE™ was introduced (as shown in Figure 1). The COOLiR²DIE package

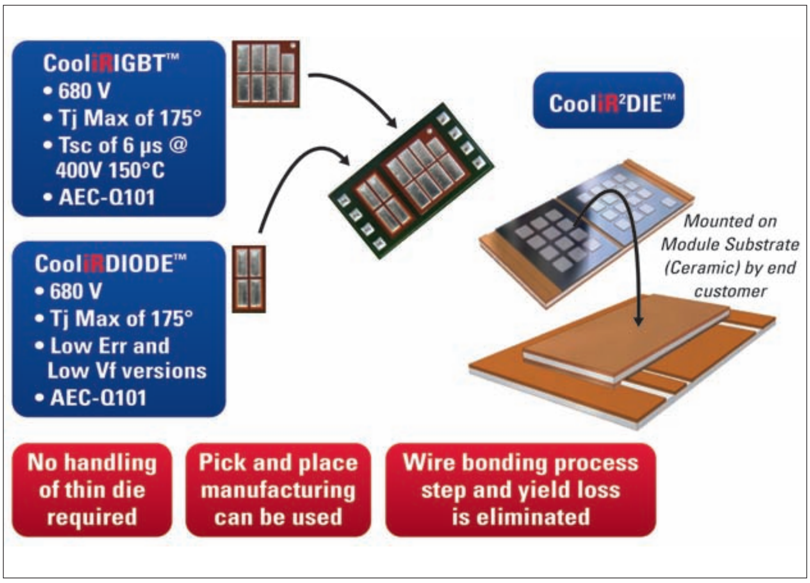

Figure 1: The COOLiR²™ bond wireless packaging concept

uses Solderable Front Metal (SFM) technology which enables the bond wires that are usually used to connect to the silicon to be removed entirely. Available as a discrete component the COOLiR²DIE is reflowed down to the substrate, this allows module manufactures to greatly simplify their manufacturing process and indeed system assemblers who had previously not been able to enter the module market to make inroads without the need for expensive die handling and wire bonding equipment. At the same time IR has taken the COOLiR²DIE technology and constructed a range of transfer molder power modules, COOLiR²MODULE in particular a half bridge module, COOLiR²BRIDGE™.

As can be clearly seen in Figure 1 the elimination of the bond wires along with the Direct Bonded Copper (DBC) sandwich construction means that there is an electrically isolated surface on both sides of the semiconductor, a surface that can be used for cooling and for adding thermal mass in close proximity to the IGBT and DIODE. Figure 2 gives an example of how the flexible cooling arrangement can be used to increase the current handling capability.

In a traditional wire bonded power module commonly found on the market today the system can be cooled from the bottom side, and usually the silicon is limited with a maximum junction temperature of 150°C. In the example shown in Figure 2 this would enable the module to carry around 212 A with a

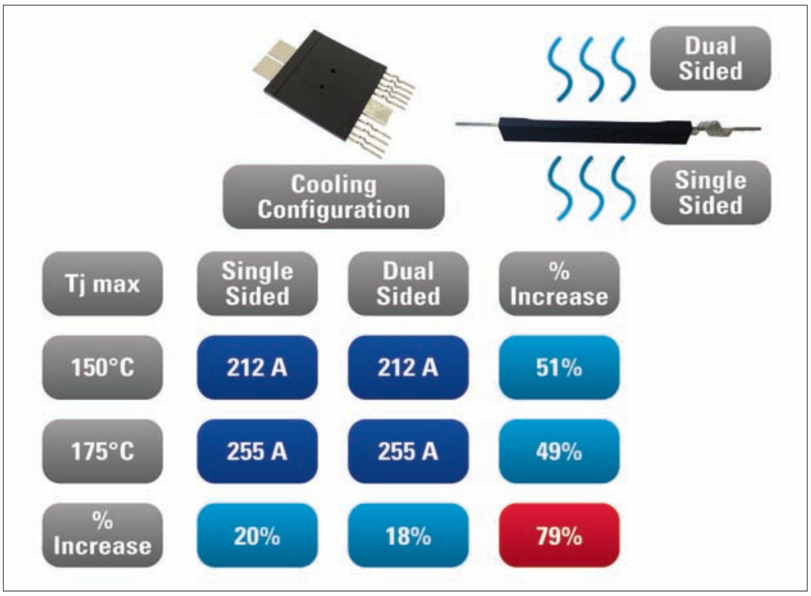

Figure 2: Enhanced current handing capability with dual sided silicon and a maximum junction temperature of 175°C

given size of IGBT and DIODE inside. With the COOLiR²BRIDGE (see Figure 2) a second cooling path through the top side of the module can be accommodated.

Depending on mechanical construction this can give the possibility to halve the thermal resistance from junction to ambient. In reality about a 50 % increase in current can be achieved with the same size of IGBT and DIODE as used in the traditional wire bonded module. Importantly this enables power handling performance to be improved without spending on costly larger IGBTs and DIDOES, and more over the power density is improved. By virtue of the COOLiRIGBT and COOLiRDIODE Silicon inside the module having a $T_{j\ maximum}$ of 175°C it is then possible to increase the rated current of the module by around another 20 %. Putting the two features together the same size of IGBT and DIODE can reach around 380 A rather than the 212 A in the traditional wire bonded module – almost an 80 % improvement!

Significant power savings

It is then important to look at the lower half of the equation when it comes to power density; how much space or volume the solution takes up.

Figure 3 shows a comparison between a popular 400 A wire bonded module and a 480 A COOLiR²BRIDGE. By eliminating the wire bonds the form factor is dramatically reduced allowing the current density to increase by a factor of two while the weight for a three phase solution is reduced by 260 g. Next the large SFM connections to the die provide a much lower inductance electrical path, up to a factor of 60 % lower at 1 2nH for the loop inductance of the module. This is a characteristic which translates to various system level benefits; with a lower parasitic inductance the voltage overshoot associated with the switching of high currents can be reduced. This in turn gives the system designer more margin and flexibility while of course the direct benefit of lower inductance, less ringing and smoother switching enabling a more efficient and EMC friendly system to be achieved.

Finally consideration should be given to the package resistance, as shown in Figure 3 this is reduced by 50 % to under 0.5 mΩ. At the low voltage end of the power electronics spectrum a 40 V MOSFET with an $R_{ds(on)}$ of 0.5 mΩ would be state of the art so it might seem trivial to be highlighting a such a reduction in package resistance on a high voltage system. But it is also critical to remember that the (H)EV main inverter is a high current system, so at a current of 400 A a saving of half milliohm in resistance results in a power saving of 80 W, significant for improving efficiency, reducing heat sink size and cooling requirements.

Conclusion

With the high energy density of gasoline and the ability to refuel a car in a matter of minutes it can be argued that energy density and the efficiency of the systems that feed off the internal combustion engine are not of concern. However on an (H)EV with limited and expensive battery capacity, and hours, rather than minutes required to 'refill the tank', how efficiently we use the energy stored on board the vehicle suddenly becomes a far more serious manner. Automobiles are considered an established piece of technology, perhaps even an 'old' invention, but innovation will be needed at every step to ensure the successful evolution from gasoline to electricity.

Literature

"Bond Wireless Power Packaging 1for Hybrid and Electric Vehicles", Power Electronics Europe 1/2013, pages 14 - 15

Figure 3: A comparison between a traditional gel-filled module using wire bonds and the bond wireless COOLiR²BRIDGE™

Module	Rating	No. Phases	Weight (g)	A/cm³	Package Inductance (nH)	Package Resistance (mΩ)
Traditional Wire Bonded	650V /400A	3	485	8.8	30	1.0
				2X	0.4X	0.5X
CooliR²Bridge™	680V /480A	1	225*	18.2	12	<0.5

*Weight for three single phase modules

Considerations for Developing Custom Power Module Solutions

In the last years the power module market demand quickly changed due to the stringent power design constraints of cost saving and efficiency increase. R&D engineers are working for innovative solutions where high integration level and latest chip technologies are the driving factors in the design phase. Power modules suppliers are compelled to fulfill these requirements and to deliver solutions that are optimized to meet customers' wishes. This article outlines all the aspects to consider when offering a custom solution in order to fulfill the continuous change in market demand of power modules design and performances.
Marco Di Lella - Product Manager SEMIKRON Italy

Power electronic engineers are working to develop electrical topologies which are able to ensure the best efficiency performances, power consumption and space reduction. There are some markets that are very sensitive to these topics. UPS and solar market are the best examples - the layout complexity can be very different from customer to customer and there is a continuous research to find out the best electrical solution and the minimum number of power modules to be used to achieve high performance level. Electrical vehicle application is a new emerging market where the above topics will become the challenging point when offering a power module solution. Some other markets, like welding or motor drive, are not affected by these constraints and quite standard electrical configurations are required; just slight changes in the existing configurations and possible redesign based on the latest chip technologies are required. For such kind of market, the most cost effective product is the winning factor for the power suppliers. Picture 1 shows how customer needs and power suppliers strategies are interconnected.

Depending on the market there are different strategies implemented:

a) non cost driven markets: the winning factor is the capability to offer solutions that meet customers specific needs. Differentiation is the key word in this case, so that customer can perceive the uniqueness of the solution that other competitors are not able to offer.
b) cost driven markets: it will be needed to offer quite standard solutions. This market is normally based on high quantities per year.

Semikron offers power module solutions to meet both market demands and recognizes that custom solution is an important market and with its subsidiary Italy it is to serve customers with special type products focused to the application, fast time to market, and customer differentiation.

Focus to the application

Offering the right chip technology in the right power modules in order to meet customers' requests leads to the advantage of a high power integration level and space saving. Available are power modules with or without baseplate, featuring different power contact interfaces such as soldering or screws terminals. The platforms can integrate the latest chip technologies like SiC diodes, MOSFETs even for high voltage applications and IGBTs for high switching frequencies (Figure 2).

The application support team suggests the best combination between chipset and power module. The experience in different application markets such UPS, PV, electrical drives, welding and railway help together with thermal and electrical simulations support to choose the right housing and

	Customer requirements		Power suppliers strategy	
	High integration level due to complex layout	High efficiency	Compact solution offer	Cost
UPS	o	o	++	+
Solar market	o	o	++	+
Motor drive	x	x	-	++
Welding	x	x	-	++
Power supply	x	o	-	+
EV applications	o	o	++	+

o required
x not required
++ Very important
+ Important
- Not so important

Figure 1: Customer demand and power supplier offer matrix interconnection

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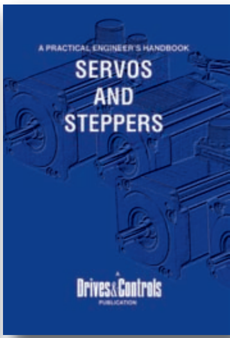

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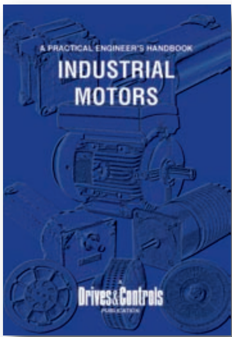

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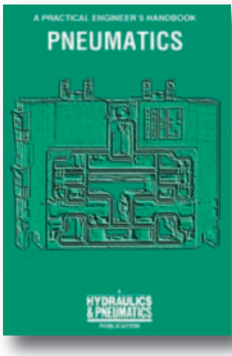

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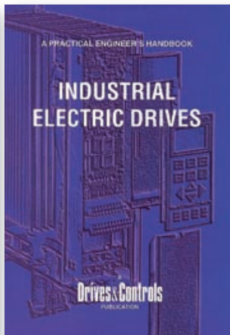

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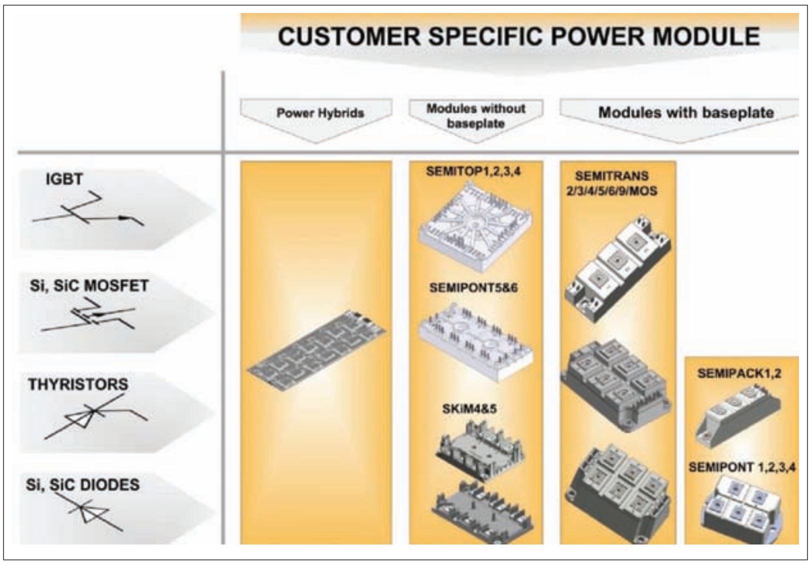


Figure 2: **Available platforms and chips to offer custom solutions**

the right number of modules to build up the required electrical configuration and thus ensuring the best thermal performances of the application.

The newest chip technologies are all qualified from reliability and dynamic perspective. Chip technologies that have passed more than 17 different reliability tests for more than 10,000 hours of tests are considered for a custom project.

Fast time to market

Power electronics is a dynamic market and product development and introduction are particularly critical. How fast the first prototypes can be ready and how fast the mass production can be released are essential market success factors for a customer: to be first in the market means to capture market share respect to the competitors.

Any new project starts with the customer and ends to the customer passing through the power supplier project evaluation, defining the product life cycle process.

Time-to-market is measured as the time between project release and volume release. Each validation phase consists of a series of steps to be fulfilled; at the end of each validation phase some prototypes are produced and delivered to customer for final approval in order to proceed to the next step. This means collaboration in all project phases - the customer is involved during the project definition to ensure a quick definition of engineering specifications. Software support is used to minimize the engineering workload so to ensure that every product performs according to customer requirements. Also SEMIKRON has built up a flexible production: similar products are grouped into families that can be processed in one same equipment in the same sequence. This allows to shorten changeover time between products. The production lead time is therefore reduced, resulting in high quality manufacturing products, with lower manufacturing costs and on time delivery.

Customer advantages

The power module market is often based on standard electrical configurations. In most cases a custom solution is not available in the market and customer has to put in place a lot of efforts to achieve the desired configuration. More than one power module could be necessary to assemble the final configuration; the

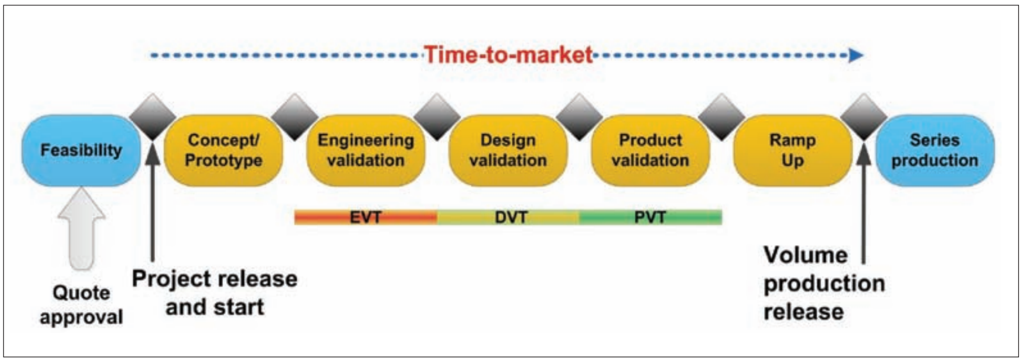


Figure 3: **Product life cycle process**

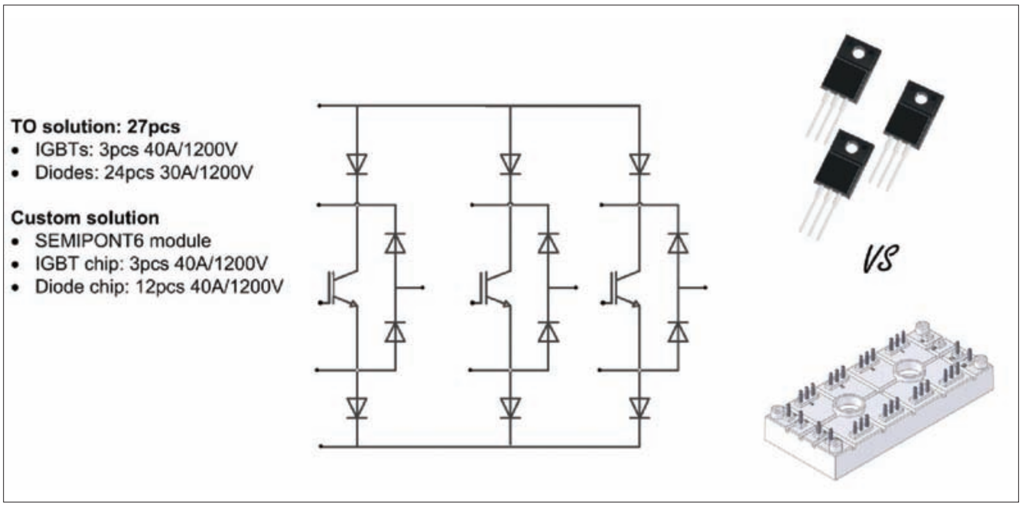


Figure 4: **Three-phase PWM rectifier buck converter design**

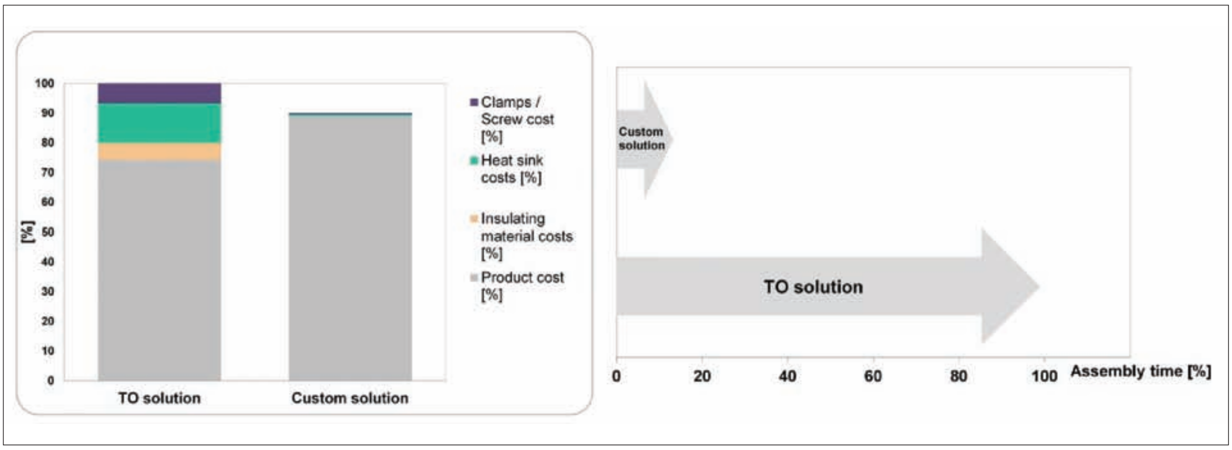


Figure 5: Material cost split and assembly time comparison

number of modules even increases with configuration complexity level. The required space for the application becomes relevant and PCB routing becomes more difficult, especially if the pinout is not optimized for this purpose. Customer is going therefore to face a huge bill of material management and a lot of efforts in the logistic. PCB routing issues enlarge the development time and the final application cost will increase. More time to enter the market is the result.

A custom-made solution becomes therefore the right solution to overcome the above issues. By using custom electrical configurations, the number of modules can be reduced and each power module will feature only the needed electrical requirements. PCB design efforts are reduced saving development time thanks to a match between module pinout and PCB routing needs. There is a significant reduction of bill of material and easier logistic and assembly process is achieved. Assembly error occurrence is reduced and manufacturing reliability is increased. As matter of fact a custom solution reduces the form factor of the final application with space saving and cost reduction respect to the use of standard modules.

A case study has been carried out by considering the development of a three-phase PWM rectifier buck converter featuring IGBTs and diodes rated for 40A/1200V as per Figure 4. Comparison between a standard solution based on TO devices and a custom solution based on SEMIPONT™6 platform has been performed.

Due to the very complex layout, 27 pieces of TO devices are needed compared to one SEMIPONT™6 module integrating the whole three-phase configuration. One screw per TO device is needed for heatsink assembly, while the power module needs one assembly step with only two mounting screws. There is a clear benefit in the PCB routing, since the power module pinout has been designed according to customer requirements while TO devices do not feature flexible power pins position.

The investigations confirmed therefore the benefits in using a custom solution especially about material costs, assembly time and manufacturing process:

- A significant bill of material reduction leads to a 10 % lower material costs for the custom solution. The cost breakdown is shown in Figure 5.
- Due to reduced parts to manage, the assembly time is reduced. Just one module against 27 pieces to handle, with an estimated assembly time reduction up to 85 %.
- Reduced parts to handle reduce the risk of assembly error occurrence. Manufacturing errors can be reduced up to 80%. Less parts to handle ensure higher manufacturing reliability and higher first-pass yield.

Conclusion

Besides volume driven standard configurations in power modules SEMIKRON offers also customer specific topologies in various housings addressing the market need for differentiation in dedicated applications. The company has established in its subsidiary Italy a support and production structure to handle specific customer demands in a short and effective way with dedicated application support team, experienced R&D team and a flexible module production. The benefits of a custom solution can be realized in terms of easy assembly process due to reduced material handling, form factor reduction due to high integration level and higher production reliability.

Digital Power Management Reduces Energy Costs While Improving System Performance

Digital power management is fast emerging as a key requirement in complex high reliability applications allowing complex multirail systems to be efficiently debugged via PC-based software tools, avoiding time-consuming hardware changes. Perhaps most significantly, DC/DC converters with digital management functionality allow designers to develop green power systems that optimize energy usage while meeting system performance targets (compute speed, data rate, etc.). Optimization can be implemented at the point of load, at the board, rack and even at installation levels, reducing both infrastructure costs and the total cost of ownership over the life of the product. **Andy Gardner, Design Manager, Mixed Signal Products, Linear Technology Corporation, Milpitas, USA**

How performance, reliability and energy efficiency are improved in network switches and routers, base stations and servers, as well as industrial and medical equipment through the use of the LTC2974 quad-channel digital power management IC, will be shown below.

Sequence any number of supplies

The LTC2974 simplifies the sequencing of any number of supplies (see Figure 1). By using a time-based algorithm, users can dynamically sequence supplies on and off in any order. Sequencing across multiple LTC2974s is also possible using the 1-wire share-clock bus and one or more of the bidirectional fault pins (see Figure 2). This approach greatly simplifies system design because channels can be sequenced in any order, regardless of which LTC2974 provides control. Additional LTC2974s can be added at any time without concern for system constraints, such as a limited supply of daughter-card connector pins.

Power-up sequencing can be triggered in response to a variety of conditions. For example, the LTC2974s can auto-sequence when the downstream DC/DC POL converters' intermediate bus voltages exceed a particular turn-on voltage. Alternatively, on sequencing can be initiated in response to the rising- or falling-edge of the control pin input. Immediate turn-off or off-sequencing in response to a fault condition is also available. Sequencing can also be initiated by a simple I?C command. The LTC2974 supports any combination of these conditions.

The bidirectional fault pins can be used to establish fault response dependencies between channels. For instance, on sequencing can be aborted for one or

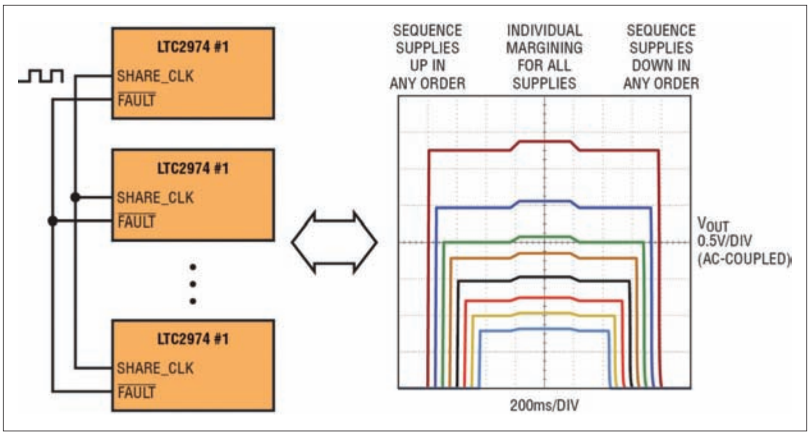
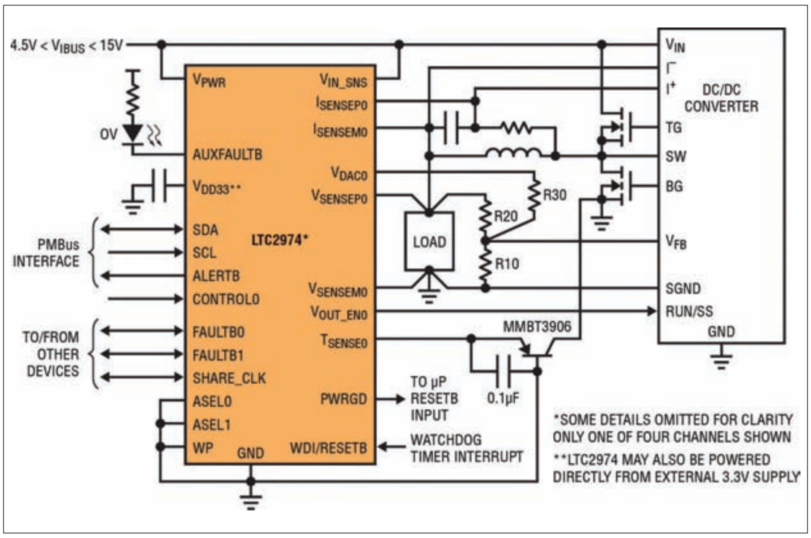


Figure 2: Multiple LTC2974s can be cascaded seamlessly using only two connections



LEFT Figure 1: Quad power supply controller with EEPROM (one channel is shown)

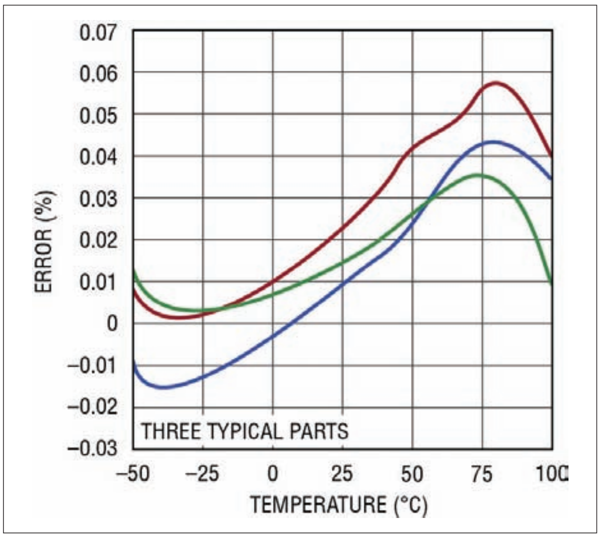


Figure 3: Voltage servo accuracy over temperature

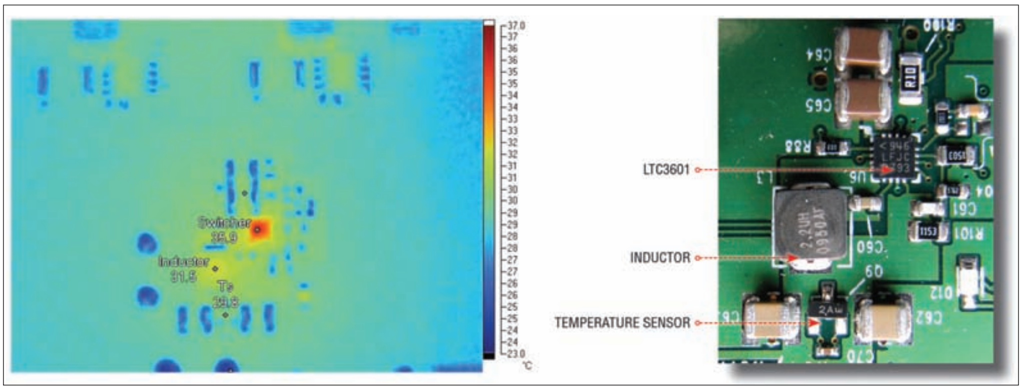


Figure 4: Thermal image of a DC/DC converter showing the difference between the actual inductor temperature and the temperature sensing point

more channels in the event of short-circuit. The overvalue and undervalue limit thresholds and response times of the voltage and current supervisors are all programmable. In addition, input voltage, die temperature, and four external diode temperatures are also monitored. If any of these quantities exceed their over- or undervalue limits, the LTC2974 can be set to respond in a number of ways, including immediate latchoff, deglitched latchoff, and latchoff with retry.

An integrated watchdog timer is available for supervising external microcontrollers. Two timeout intervals are available: the first watchdog interval and subsequent intervals. This makes it possible to specify a longer timeout interval for the microcontroller just after the assertion of the power good signal. If a watchdog fault occurs, the LTC2974 can be configured to reset the microcontroller for a predetermined amount of time before reasserting the power good output.

As voltages drop below 1.8V, many off-the-shelf modules have trouble meeting output voltage accuracy requirements over temperature. Absolute accuracy requirements of less than ±10mV are now common, making it necessary to trim the output voltage in manufacturing, a time-consuming process.

OEMs must margin test to ensure that they ship dependable systems in the face of drifting rail voltages, which can result in significant manufacturing yield fallout. A far better solution to this problem embraces the reality of inaccurate power modules, and enables the system to self-trim in the field. The LTC2974's digital servo loop minimizes rail-voltage drift by externally trimming the module's output voltage to better than ±0.25% accuracy over temperature (see Figure 3). In addition to improving manufacturing yields, the digital servo loop makes it easier to source power modules by avoiding the limitation of module accuracy.

Robust systems through easy margining

The LTC2974's digital servo loop 10-bit DACs allow users to margin power supplies over a wide range while maintaining high resolution for applications such as Shmoo plotting. Margining is controlled over the I²C interface with a single command, and the margin DAC outputs are connected to the feedback nodes or trim inputs of the DC/DC converters via a resistor. The value of this resistor sets a hardware limit on the range over which the output voltage can be margined, an important safeguard for power supplies under software control.

To achieve the desired savings in power consumption, it is necessary to characterize the loads during all modes of operation. FPGA users optimize their code to minimize power while ASIC users adjust core voltages depending on throughput requirements. Accurate real-time telemetry greatly simplifies this task.

Using the LTC2974, system health can be determined from the voltage, current and temperature status registers, while the multiplexed, 16-bit ∅∑ ADC monitors input and output voltages, output currents, and internal and external diode temperatures.

With the trend to lower and lower core voltages, accurate measurement of load currents has become a challenge, since the use of a precision current sense resistor can lead to unacceptable power losses. One option is to use the DC resistance of the inductor (DCR) as a current shunt element. This has several advantages, including zero additional power loss, lower circuit complexity and cost. However, the strong temperature dependence of the inductor resistance and the difficulty in measuring the exact inductor core temperature invariably introduces errors in current measurement (see Figure 4).

The LTC2974 makes accurate DCR sensing possible with a patent-pending temperature compensation algorithm that compensates for the thermal gradient from the sense diode to the inductor's core, as well as the time lag that occurs between changes in inductor current and temperature (see Figure 5). This capability, combined with the LTC2974's low noise 16-bit ∅∑ ADC, enable accurate measurement of load currents using inductors with vanishingly small DCR (see Figure 6).

PC-Based design and fault diagnostics

When used in conjunction with LTpowerPlay™ software, the LTC2974's fault and warning registers allow designers (and field users) to determine the status of their power infrastructure at a glance (see Figure 7). Status information, uptime, and

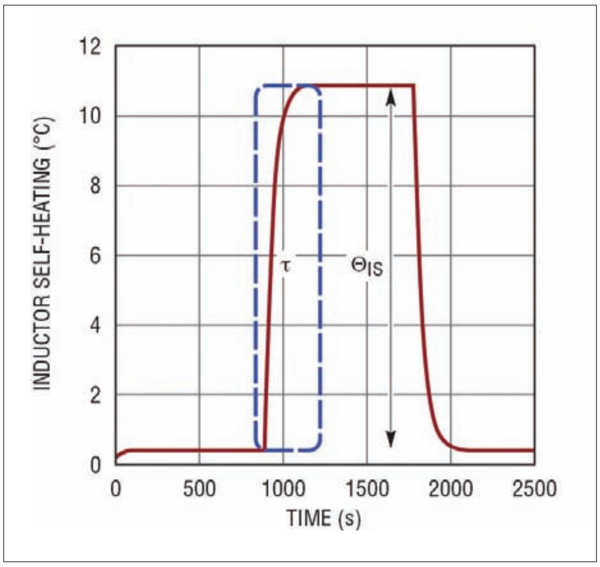


Figure 5: LTC2974 compensates for inductor self-heating using thermal resistance and delay parameters

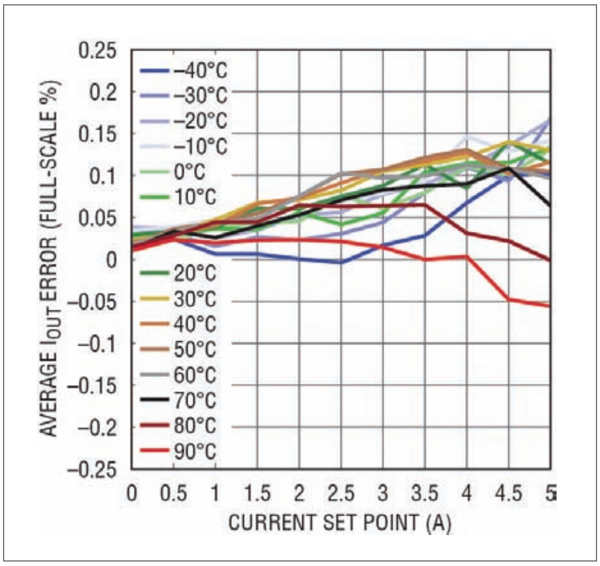


Figure 6: Total current measurement error of the LTC2974 for a DC/DC converter across the full range of temperature and output current

the last 500 ms of ADC telemetry are available in a data log. In the event a channel is disabled in response to a fault, the LTC2974's data log can be dumped into protected EEPROM. This 255-byte block of data is held in non-volatile memory until it is cleared with an I²C command.

Figure 7 shows the data log contents viewed in LTpowerPlay's LTC2974 interface. In this way, the LTC2974 provides a complete snapshot of the state of the power system immediately preceding the critical fault, thus making it possible to isolate root cause well after the fact. This is an invaluable feature for debugging both prerelease characterization and in-field failures in high reliability systems.

The PC-based LTpowerPlay software allows users to configure the LTC2974 via a USB interface and a dongle card. LTpowerPlay software, which is free and downloadable, takes much of the coding out of the development process and improves time-to-market by allowing the designer to configure all device parameters within an intuitive framework.

Once a device configuration has been finalized, the designer can save the parameters to a file and upload it to the Linear Technology factory. Linear can use the file to preprogram parts, thus allowing customers to bring up their boards with maximum ease. When the onboard EEPROM has been configured, the LTC2974 is capable of complete autonomous operation without the need for custom software. Furthermore, the addition of one tiny connector allows LTpowerPlay software to communicate with the LTC2974 in-system, providing field users access to telemetry, system status and the fault log as needed.

Conclusion

Design of complex multirail systems is simplified with the LTC2974. It uses an industry-standard PMBus interface, it interfaces directly with high powered, free PC-based LTpowerPlay control software, and it includes an integrated EEPROM for complete customization. Design your application with the LTpowerPlay design tool and simply upload the configuration to the Linear Technology factory. Linear can use your custom configuration to produce pre-programmed devices ready-to-use in your application.

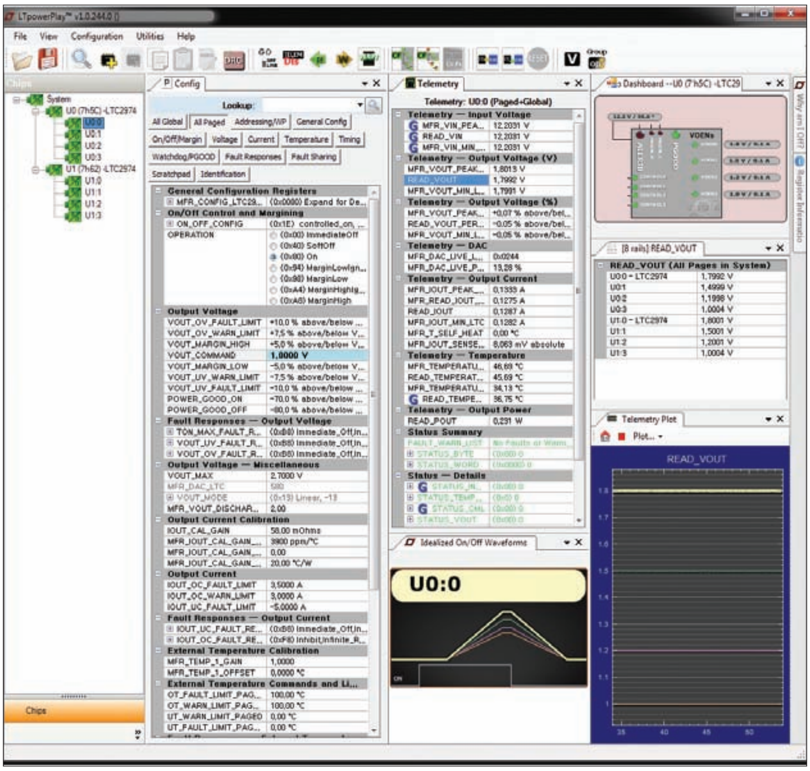


Figure 7: LTpowerPlay software allows the designer to plug a PC into the system via a tiny connector, enabling the power management system to be completely configured and controlled without writing a single line of code

Getting Heat Out of Sealed Enclosures

In harsh environments where a sealed enclosure is necessary, baseplate cooling is a simple and inexpensive solution to thermal management of power supplies. A new approach using discrete components can make baseplate cooled power supplies smaller, more efficient and more flexible.

Peter Blyth, XP Power, Pangbourne, UK

Demand for power supplies that can withstand harsh environmental conditions doesn't only come from the military. Telecommunications base stations and infrastructure for the smart electricity grid of the future place steep demands on their power supplies. These systems are subject to the extremes of temperature, dust and humidity. The equipment needs to operate continuously, as well as reliably, since performing maintenance at remote locations can be difficult and downtime is unacceptable. Sealed enclosures to prevent dust and moisture ingress are often used to protect the system from its environment, but this poses a problem for thermal management of power supplies.

Better cooling

A common power supply cooling solution for inside a sealed box is to use a small convection cooled power supply and over-rate it. For example, if you take a power supply that is rated for full power at 50°C ambient temperature, it might derate by 50 % at 70°C. So for operation at the elevated temperature, a power supply rated for twice the actual output would be needed. This works up to a point, but for the high power levels that are required for smart grid infrastructure or a telecoms base station, it's not feasible – in this example, a system that requires 500 W would need a 1000 W convection cooled power supply, which is not practical from a size and cost point of view.

If high power requirements have ruled out convection cooling, a way of getting heat out of the box must be considered. Sealed enclosures prohibit forced air cooling as fans can suck in dirt and dust. Filtering is possible but this cuts down the air flow significantly, meaning a larger fan is needed, and they are susceptible to blockages. This obviously affects the reliability and maintenance demands of the system. An alternative solution is therefore required to get the heat from the power supply out of the box; using a baseplate cooled unit is a simple and inexpensive way of doing this.

Baseplate basics

A baseplate cooled power supply has most of its heat generating components, such as the switching FETs, diodes and magnetics, mounted in direct contact with the metal baseplate so that heat can be extracted using thermal conduction (Figure 1). Typically the power supply is then bolted to the inside of the sealed box, so that the metal box itself can act as a heat sink, or heat can be transferred from the box to an additional externally mounted heat sink. It's wise to check whether the box can act as a large enough heat sink to conduct the heat out of the unit, or whether an additional external heat sink should be added, because getting this wrong will have a significant impact on the reliability of the power supply.

For example, let's consider the CCH series baseplate cooled power supply, which has a maximum baseplate

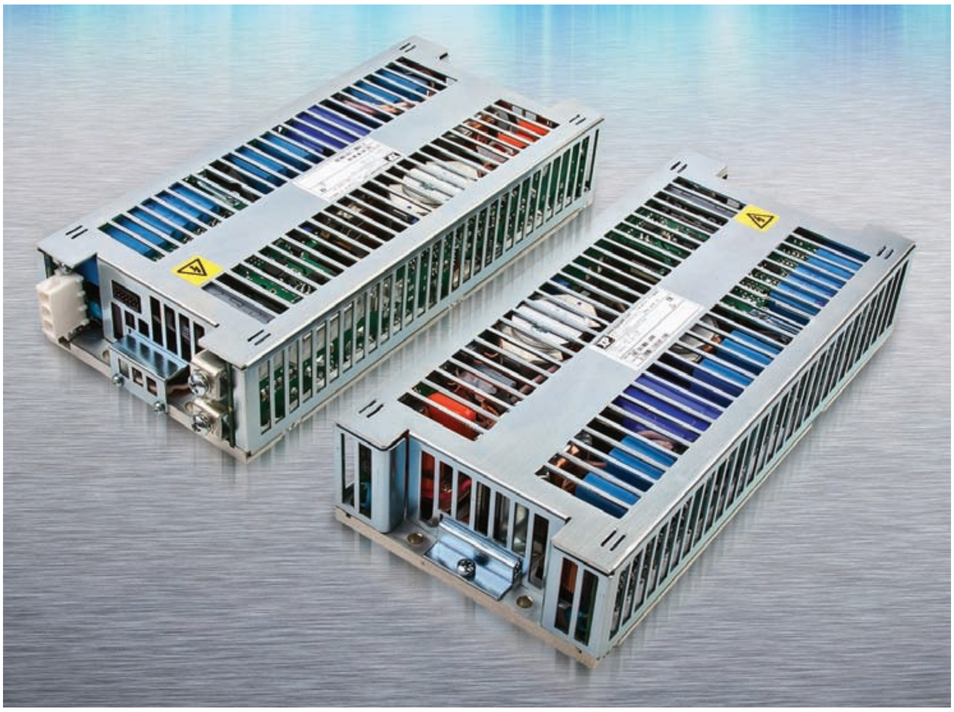


Figure 1: The CCH series of 400W and 600W power supplies from XP features a 6mm baseplate

Figure 2: Mounting a CCH power supply on the inside of a metal enclosure. The thermal resistance required can be calculated to determine whether an additional external heat sink is required

temperature of 85°C operating in an ambient air temperature of 40°C (Figure 2). Operating at 400 W, this power supply is 90% efficient (Figure 3).

Efficiency = Power out / Power in, so therefore: Power out / Power in = 0.9. We know the Power out of the system is 400 W, so: Power in = 400/0.9 = 444.5W. 444.5 - 400 = 44.5 W is therefore dissipated (wasted) as heat.

Assuming a perfect thermal impedance between the baseplate and heatsink, we can use the equation below, where Tbaseplate and Tambient are the baseplate and ambient temperatures and Rth-ba is the thermal resistance between the baseplate and the ambient air:

$T_{baseplate} = T_{ambient}$ + (Rth-ba x Power dissipated)

$R_{th\text{-}ba}$ = (85-40)°C / 44.5 W = 1.0 K/W

From this calculation we can deduce that a heatsink with a thermal impedance of 1.0 K/W or less is required to maintain the baseplate temperature at 85°C or below.

Be warned that this is only a basic check, though – heat sink design is a complex process. Once the calculations have been done, tests should be run to check the temperatures of key components, such as the baseplate and capacitors to ensure everything is cooling sufficiently as intended.

Power supply design

The design of the power supply unit itself can also have a significant impact on the success of baseplate cooled designs. Obviously, it helps if the power supply is as efficient as possible, and as waste heat generated is directly proportional to the efficiency, higher efficiency means a smaller heat sink can be used. Looking at it the other way around, if you kept the same heat sink and increased the efficiency of the power supply, the temperature inside the case would be lower, which would increase the expected lifetime of the power supply (as a rough yardstick, reducing ambient temperature by 10°C doubles the lifetime of a capacitor in a power supply). Temperature inside the case is the main contributor to the lifetime of a power supply, so this is especially attractive.

Traditional baseplate cooled power supply designs use third party power modules. These DC/DC modules, although designed for baseplate cooling, often require external components for filter compliance and power factor correction, and it can be challenging to place these parts for optimum EMC compliance and cooling. While the modules themselves have high efficiency, the overall efficiency can be affected by these extra filter components and the discrete PFC stage. Using discrete components instead of relying on modules, can alleviate this by allowing the efficiency of each stage to be optimized. All the key heat generating components to be placed with optimum circuit flow next to the baseplate, and components that are heat sensitive, like the reservoir capacitor, to be placed away from it or even insulated from the (hot) baseplate to extend its life. Heat generating components can also be spaced as evenly as possible around the baseplate to make heat transfer more efficient by avoiding hot spots.

Having the IP of the whole circuit means more flexibility is available. That is, it allows the manufacturer to cater for the many modified standard requests which are thrown up by the diversity of applications. It also means that the power supply can be designed with noise requirements and EMC compliance in mind from the start - protection from mains-borne transients can be added at the front end to make the design extremely robust. As an example, the discretely implemented CCH series meets industrial standard EN55022 Class B as well as MIL-STD-461 with ease. MIL-STD-461 for conducted noise covers frequencies down to 10 kHz, which even

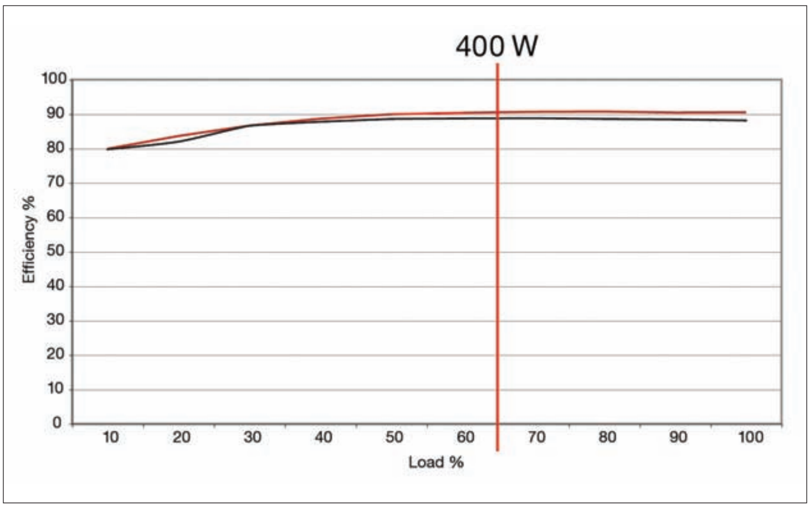


Figure 3: In our example, the efficiency of the CCH power supply is 90 % at 400 W output

with an inherently low power module would require external capacitors to maintain.

A final argument for an entirely discrete implementation in a baseplate cooled power supply is that third party modules are bound to the size of that module; in a discrete design the full volume can be utilised by optimizing the physical layout of the components.

Conclusions

In summary, for applications like smart grid infrastructure or telecoms base stations, baseplate cooled designs are a simple and efficient way of keeping power supplies cool. Advances in baseplate cooled power supplies using discrete components can offer more efficient heat transfer, effortless meeting of noise rules and compact design. These PSUs are designed from the ground up for the special conditions imposed by harsh environments and can be more easily tweaked to meet individual applications' requirements.

Discretes or Modules?

At Electronica 2012 XP Power announced the CCH400 and CCH600 series of compact single output baseplate cooled 400 W and 600 W AC/DC power supplies suited to harsh environment applications. With its highly efficient design, up to 90%, the CCH series generates substantially less waste heat that current product on the market, this being critical for use in sealed box applications. All heat-generating components are attached to the baseplate allowing heat dissipation through the sealed box chassis or heatsink. No forced air cooling is required.

The internal design is very conservative. "Switching frequency is 51 kHz, we use no SiC diode in the PFC circuitry – instead a mass-produced lamp ballast IC. The older module based version requires more space and has less efficiency, in total 8 percent", Marketing Manager Peter Blyth points out.

LEFT: Peter Blyth, XP Power's Marketing Manager, showing the older module-based power supply (left) and the new discretely version (right) featuring higher efficiency Photo: AS

Improved Thermal Transfer For Power Modules

Modern power semiconductors need an efficient and reliable cooling. The connection between the power module and the according heat sink is both, centerpiece and bottleneck at the same time. Here, often materials are in use that cannot cope with the demanding environment found in power electronic applications. Infineon has decided to cooperate with Henkel Loctite to create an interface material especially dedicated to power electronic modules. **Martin Schulz, Infineon Technologies, Warstein, Germany**

During the design phase of any power electronic equipment, special care has to be taken regarding the thermal aspects of power semiconductors. Temperature swing along with temperature levels forms the basis for the estimation of a useful lifetime of the design. The thermal resistance between semiconductor and heat sink as a consequence of the thermal interface material in use is of major importance. It has to be as small as possible and, in best case, may not change throughout the predicted lifetime.

Developers tend to use a simulation based on datasheet values given for a thermal grease. Assuming a homogenous layer between semiconductor and heat sink, a simplified model can be extracted that usually is of conservative nature. To predict, what options can be considered to refine a thermal interface material, this simplified model turns out to be inappropriate. Several important parameters are not included. To demonstrate the drawbacks of the simplified model, Figure 1 hints out an extended version.

The transfer path from the Chip to the base plate (R_{thJC}) and the thermal resistance from the heat sink to ambient (R_{thHA}) are given by the chosen materials. An improvement cannot be achieved without changing these materials. However, from the extended thermal model given in Figure 1, possible alternatives to optimize the thermal interface material can be derived:

- The thermal conductivity has to be maximized to reduce the bulk resistance R_{thTIM}
- Combining proper materials allows for a reduction of the contact resistance $R_{thContact}$ between metal surfaces and the thermal interface material
- Achieving largest possible areas that feature metal-to-metal contact with low R_{thM-M} is highly desired. Therefore a local variation of volumes applied is necessary, accompanied by smallest possible layer thicknesses
- The final system has to remain stable over the whole lifetime that is predicted for the application. It has to be immune regarding thermal mechanical load, capillary effects and drying.

Additionally, the material has to be conformal to RoHS, free of silicone and electrically non-conductive. Recent developments in the area of phase changing materials have been the decisive factor, to continue research in this field.

Improving thermal conductivity

The first step leading to an optimized solution is the improvement of the bulk conductivity of the raw materials. Copious tests were done and a multitude of different materials was generated for tests and measurements. Figure 2 depicts four steps taken during this development phase.

The General Purpose Grease (GPG) is a material widely used and accepted in power electronic applications, therefore it is considered as a reference. It can be concluded from the diagram, that the choice of fillers and combination of different filler systems lead to the desired improvements. The test results are generated according to ASTM 5470-12.

Using the available Filler1, the first material was not able to outperform the reference. By blending the material with a second filler with a different particle size and particle size distribution, a bimodal system is created featuring improved thermal properties. Stepping away from classical ceramic fillers and change over to fillers based on metal oxides lead to a further increase of the thermal conductivity. This approach too benefits

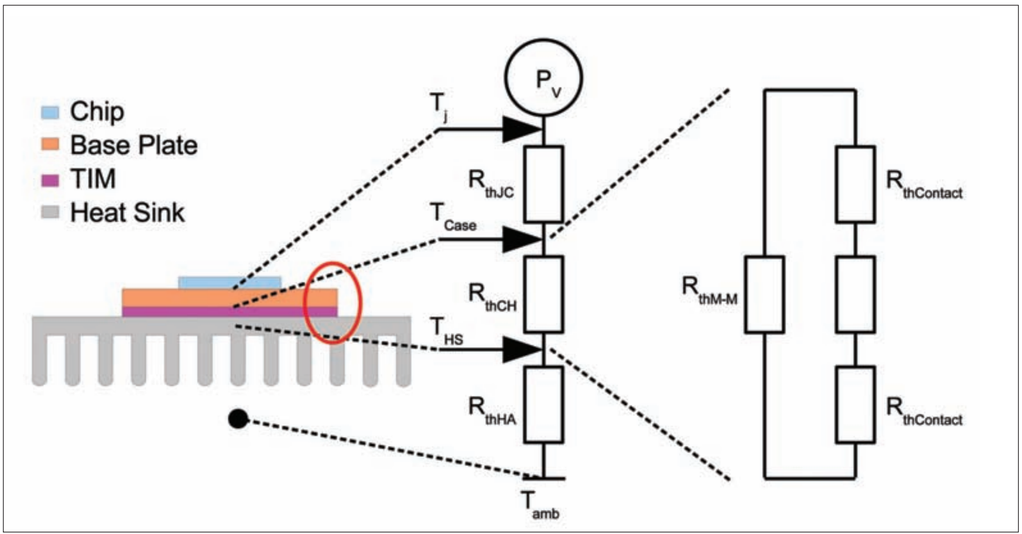


Figure 1: Sketch of the setup, simplified model and extended model of a power electronic system

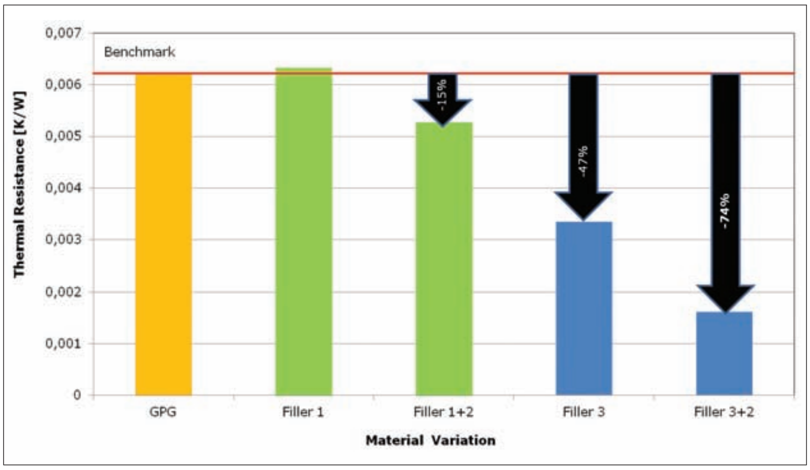


Figure 2: Comparing thermal resistances of a common grease and several new materials

from the idea of blending with a second filler. Compared to the reference, a reduction in thermal resistance of 74 % was finally achieved.

Minimizing the contact resistance

It can be concluded from Figure 1, that a reduction in contact resistance improves the overall system twice. The test done according to ASTM is inconclusive regarding contact resistances as the polished surfaces and the pressure applied differ from what is commonly seen in the application of power modules. Due to cost pressure, industrial designs prefer heat sinks with a milled surface. The roughness of these surfaces is about 10-15 μm and therefore in the range of the particle size found in common thermal greases.

To reduce the contact resistance, it is mandatory to generate the largest possible contact area between metal surfaces and the thermal interface material. To enhance the forming of direct metal-to-metal contact at the same time, further features of the desired material can be derived:

- The maximum particle size has to be below the roughness of commonly used heat sinks
- The raw material has to be a paste-like substance to enable screen printing. This way, areas predestined to for direct metal contact can remain uncovered.

A schematic overview is given in Figure 3 to hint out, how different particle sizes influence the forming of contact areas.

The bimodal system generates the largest number of contacts with the surrounding surfaces and therefore the lowest contact resistance. Additionally, the small particles enhance the capability to form thin layers and in turn maximize the areas forming direct metal contact. Both features improve the thermal situation. Figure 3 also supports an explanation why the ASTM test is incompatible to the application of power modules. The test consists of polished, planar surfaces with a roughness of <0.4 μm. A homogenous layer of TIM is applied, controlled by distance keepers. Within the application, these values are never reached, making it difficult, if not impossible, to compare these data. Power semiconductors greatly benefit from extremely thin layers and massive mounting forces coming from the screws. Both is not considered in the ASTM test.

Besides the material properties, the process of applying the material is of crucial influence. In case the macroscopic geometry of the base plate of a power module is known exactly applying thermal interface material can be done in locally optimized amounts. TIM can be printed to areas where it is needed. Areas that would form direct metal contact, or where TIM would lead to detrimental influences, remain clean. This especially is true for the areas below the mounting screws. Here, direct metal contact is enforced due to the high mounting forces. As an example, Figure 4 shows an EconopACK™ 4 with TIM applied.

The area around the screws is left without TIM and a larger volume is applied to the cavities below the chips' positions. In addition to detailed knowledge about the base plate's geometry, meticulous control of the printing process is unavoidable. This way, it is ensured, that the printed pattern is accurately aligned and the volume of each single dot is within specification. To achieve this level of precision, fully automated optical inspection systems (AOI) have been installed and every single module is scanned after printing. The precision of the system allows for determining volumes down to far less than 1 μm^3 per single dot.

Besides the thermal improvement, this method also leads to advantages in mounting and assembly. As no material is applied below the screws, changes due to displacement cannot occur. The torque applied to the screws remains the same even after the TIM has spread. Retightening the screws is unnecessary. The high filler content of the new material and the special properties regarding the contact resistances are warrantors for the high performance even at the first turn-on, eliminating the needs of special burn-in cycles.

Long-term stability

It is of utmost importance for the application, that the thermal conditions remain stable throughout the predicted lifetime. A most prevalent cause of failure is a loss of thermal transfer. Common thermal greases are often pumped away from the hot spots due to thermal mechanical movements or fail due to separation. As a consequence, chip temperatures rise and the thermal stress to the semiconductor increases as well.

An adequate test to substantiate a statement regarding long-term stability is a

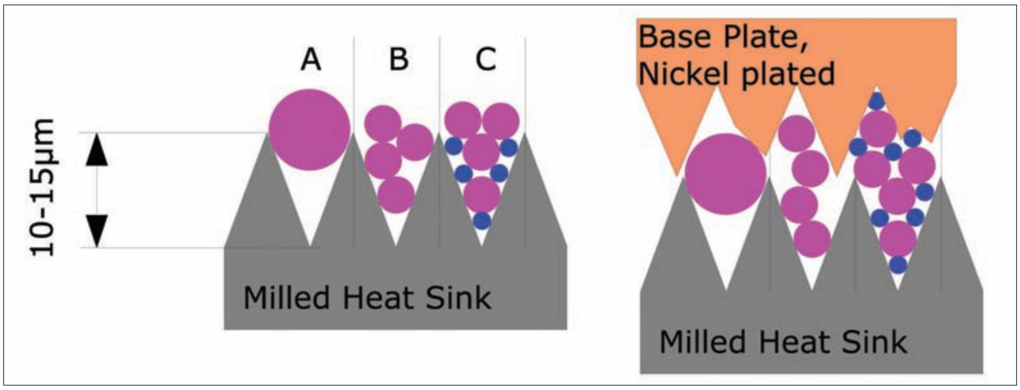


Figure 3: Influence of material properties to the forming of contact areas (A - Monomodal System, particle size 10 μm; B - Monomodal System, particle size 5 μm; C - Bimodal System, maximum particle size 5 μm)

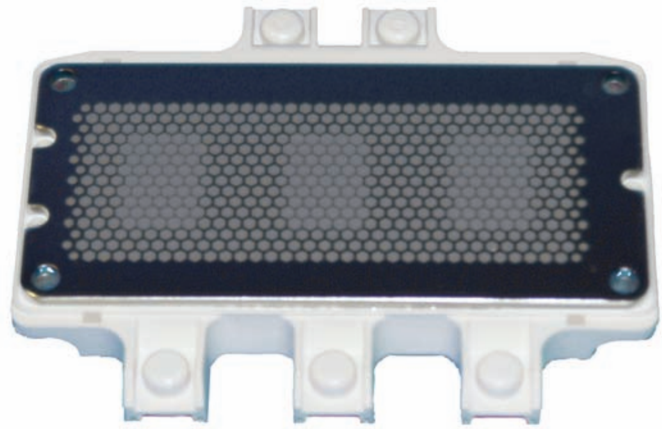


Figure 4: **EconoPACK™ 4 with TIM applied. Stencil printing enables the application of locally optimized volumes using inhomogeneous patterns**

high temperature storing test (HTS). Each specimen in the test consists of power module with thermal interface material applied, mounted to a heat sink. The initial thermal properties are measured and the specimen is subject to 125°C for one week afterwards. Again, the thermal properties are measured; the cycle repeats until 1000 hours at 125°C have been completed. After the development of TIM has lead to a final material that has survived all qualification tests within Infineon, a further test in a real inverter provided the final result. Additionally an accelerated test was conducted that was set up to simulate an operating time of 150.000 hours within 1000 hours of testing, representing 20 years of lifetime. The end of life criteria chosen was a maximum chip junction temperature of 150°C as beyond this the semiconductor would be operated outside its specification.

With the general purpose grease (GPG-1), the first test run was terminated after less than 600 hours with fatal results. The term “fatal” refers to the total destruction of the semiconductors due to massive overheating. A second test with a common material achieved almost 800 hours, the result remained the same. The material created by Henkel Loctite and dedicated to power modules lead to the lowest temperature from the beginning. Most noteworthy remains the fact, that the test was discontinued after 4000 hours without failure.

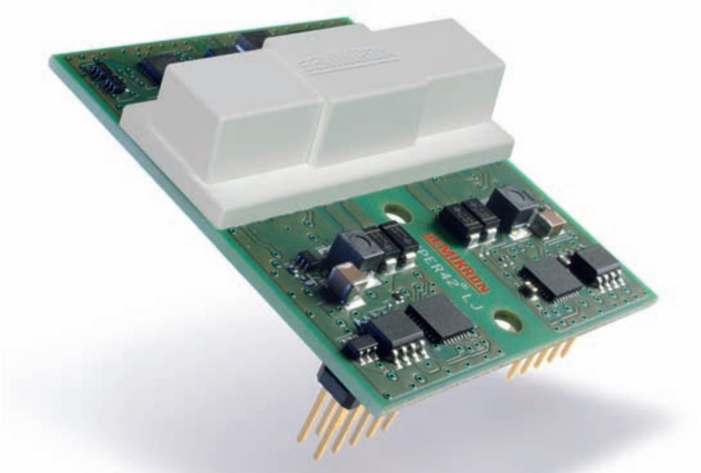
Conclusion

Modern power semiconductors have reached a state of development demanding a holistic approach to all components involved in setting up efficient inverters. From the often underestimated topic “Thermal Grease”, a high performance material arose that now has significance similar to other functional layers as for example solder joints connecting chips to substrates. The loss of thermal transfer capabilities is among the failure causes most often observed. This may also be a consequence of increased lifetime expectations and higher power densities. Using dedicated materials and releasing customer’s assembly lines from the process of applying thermal grease is a logical step to cope with the growing demands in power electronic designs.

Literature

SPS/IPC/DRIVES 2012 Report, Power Electronics Europe December 2012, pages 12 - 15, Power Electronics for Inverters

IGBT Drive Unit for 400 kW Inverters



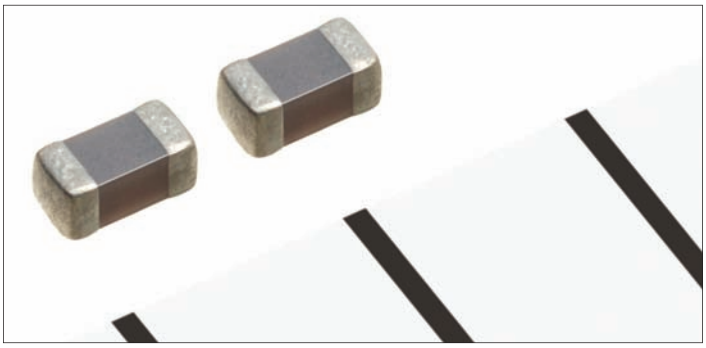
To increase the efficiency of inverters up to 400 kW, circuit topologies are developed that are optimized for specific applications. However, interleaved, multilevel and parallel circuits that improve IGBT efficiency also place higher requirements on signal performance. The new drive unit SKYPER 42 LJ by SEMIKRON combines the benefits of digital signal consistency while maintaining full functionality. The SKYPER 42 LJ is a dual-channel IGBT driver unit for 600 V, 1,200 V and 1,700 V IGBT modules. It reliably controls IGBT modules up to 1,000 A with an output current of 80 mA with a maximum switching frequency of 100 kHz. The highly integrated ASICs and a power supply concept guarantee signal precision with a maximum jitter of +/- 1.5 ns across the entire temperature range. In combination with the low tolerances of the ASICs the SKYPER 42 LJ achieves runtime differences below 20 ns. The SKYPER 42 LJ offers soft-off and over-voltage recognition securely switch off any current. The separate transfer of switching and error signals allows for rapid error feedback, even in 3-level applications. Thanks to the adjustable error management, both the integrated protection circuit and the paramount controller are able to quickly respond to system errors. The isolated information transfer uses square wave signals, which makes at significantly more robust than traditional inductive transfer. This way, the driver unit safely switches interfering voltages up to 4 kV on the signal wires.

www.semikron.com

SiC Power Modules

Microsemi Corporation announced the availability of a new Silicon Carbide (SiC) standard power modules. They are suited for use in high power switch mode power supplies, motor drives, uninterruptible power supplies, solar inverters, oil exploration and other high power, high voltage industrial applications. The power module family is also offered with extended temperature ranges to meet next-generation power conversion system requirements for higher power densities, operating frequencies and efficiencies. The majority of the new module product family uses aluminum nitride (AIN) substrates to enable isolation from the heat sink, which improves heat transfer to the cooling system. The industrial temperature module family includes the following devices: 1200 V boost chopper configuration, rated from 50 to 100 A; 1200 V phase leg configuration, rated from 40 to 200 A; 600 V neutral point clamped configuration (NPC), dedicated to three level inverters for solar or UPS applications, rated from 20 to 160 A; and NPC 600V/1200 V mixed voltage, rated from 20 to 50 A. Samples are available within short lead times.

www.microsemi.com



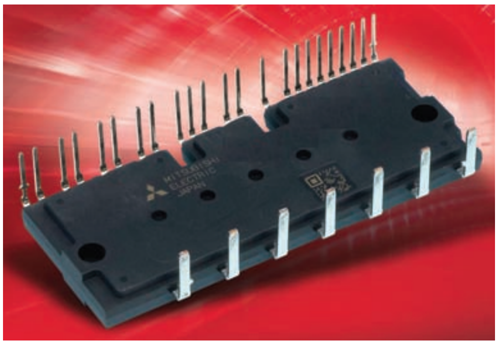
MLCCs for Automotive Applications

TDK offers the new CGA1 series of 0603 (EIA 0201) MLCCs for use in automotive electronics applications. With dimensions of 0.6 mm x 0.3 mm x 0.3 mm, the new components offer rated voltages from 6.3 V to 50 V, thus including the world's first 0603 X7R MLCC with a rated voltage of 50 V. The 0603 package is the smallest used by the automotive industry. The new high reliability component is designed for operating temperatures up to 125 °C and is qualified to AEC-Q200. The products are available with X7R temperature characteristics. Special customer requirements (such as a temperature rating up to 150 °C) can be met upon request. Mass production started in January 2013. The use of new high reliability dielectric materials optimized with fine-grain technology enabled the successful development and mass production of the new series, thus contributing toward more compact, lightweight, and multifunctional automotive units. Typical applications for the TDK CGA1 series include tire pressure monitoring systems (TPMS), remote keyless entry systems (RKE), in-vehicle infotainment systems (IVI), and various kinds of sensor systems.

www.global.tdk.com

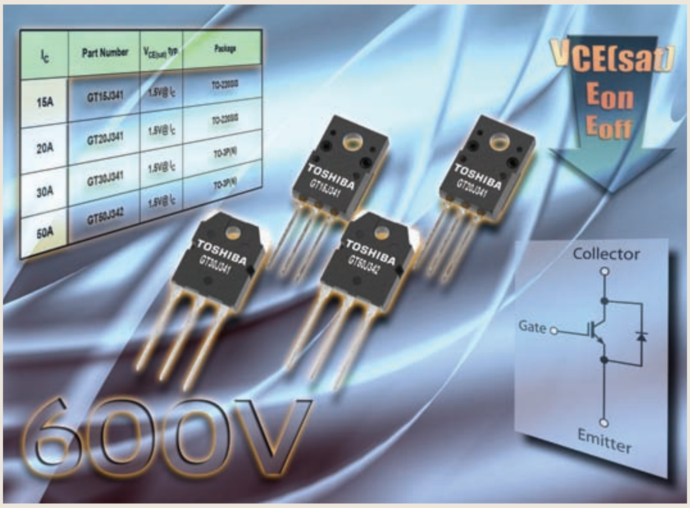
1200 V/50 A Large Type DIPIPM

Mitsubishi Electric offers a 1200 V large-type Transfer-molded Dual Inline Package Intelligent Power Module (DIPIPM) Version 4 (PS22A79) with current rating of 50 A. DIPIPMs were commercialized globally by Mitsubishi Electric in 1997 and are widely used in inverter-equipped appliances such as air conditioners, refrigerators and washing machines, as well as inverter motor drive systems for industrial applications. The new power module is designed for use in package air conditioners, refrigerators and other industrial motors. The new power module employs the newly developed 6th generation with LPT-CSTBT (Light-Punch Trough Carrier Stored Trench-gate Bipolar Transistor) chips, in which carrier storage is improved through cell pitch reduction and power loss is minimized through application of the thin wafer process. The model reduces power loss by 15 % compared to the preceding 5th generation IGBT. The module's built-in temperature sensor offers improved linearity and precision compared to that of the existing PS22A78-E (35 A) model, resulting in more efficient heat control. Manufacturers will benefit from further downsizing of their inverter systems, as well as reduced production costs.



www.mitsubishichips.eu

600V IGBTs for Improved Hard Switching Efficiency



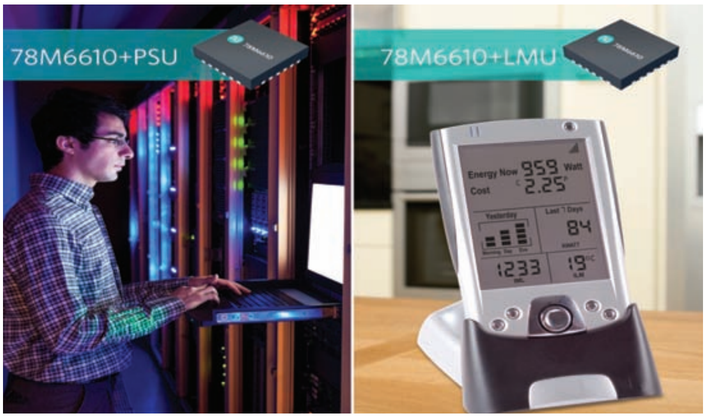
Toshiba Electronics Europe (TEE) has announced a 6th generation IGBT technology that offers improved switching loss/conduction loss trade off for increased efficiency and improved performance. The new technology is the basis for a new family of compact 600 V devices that will suit a variety of hard switching applications including motor drives, solar inverters and uninterruptible power supplies (UPS). The new IGBT technology combines a finer pattern design and a thinner 'punch through' wafer process than the previous generation, as well as a highly optimized vertical design providing lower conduction losses and reduced switching losses. Current ratings are 15 A (GT15J341), 20 A (GT20J341), 30 A (GT30J341) and 50 A (GT50J342). Each of the parts integrates both the IGBT and a fast reverse recovery diode in a single package. All feature a typical VCE(sat) of 1.5 V at the nominal current. The 15 A and 20 A parts are supplied in a isolated TO-220SIS package, while the 30 A and 50 A devices are available in an non-isolated TO-3P(N) (TO-247 equivalent) package. The efficiency and performance improvements can be seen by comparing the 50 A device and the 30 A device with their predecessors. At TC=150°C with a current of 50 A the GT50J342 provides a reduction in VCE(sat) of 32 % and respective reductions in Eon and Eoff of 13 % and 26 %. This reduces overall losses by 24 % (DC bus voltage 300 V and IGBT switching frequency of 20 kHz). At TC=150°C with a current of 30 A the GT30J341 provides a reduction in VCE(sat) of 30 % and respective reductions in Eon and Eoff of 12 % and 33 %. This reduces overall losses by 26 % (DC bus voltage 300 V and IGBT switching frequency of 20 kHz).

www.toshiba-components.com

Single-Phase Energy-Measurement Processors Accurately Monitor Power

Maxim Integrated Products is now sampling the 78M6610+PSU/ 78M6610+LMU single-phase energy-measurement processors. These processors are an energy-measurement subsystem in a single chip. They provide simple utility-grade sensing and diagnostics for existing designs without the traditional cost of a utility meter system-on-chip. Both devices contain unique firmware to meet end application requirements. The 78M6610+PSU is specifically designed for real-time monitoring of data centers, servers, and telecom and data equipment, while the 78M6610+LMU is a more general-purpose solution for applications such as white-good appliances, smart plugs, EV chargers, and solar inverters. Energy-measurement solutions traditionally required the use of an additional microcontroller, which adds significant design cost and months of development time. The 78M6610 allow users to conveniently add a complete energy meter to an already existing design without significant cost or redesign. Additionally, the processors' flexible measurement and host interfaces allow for easy integration into any system.

www.maximintegrated.com

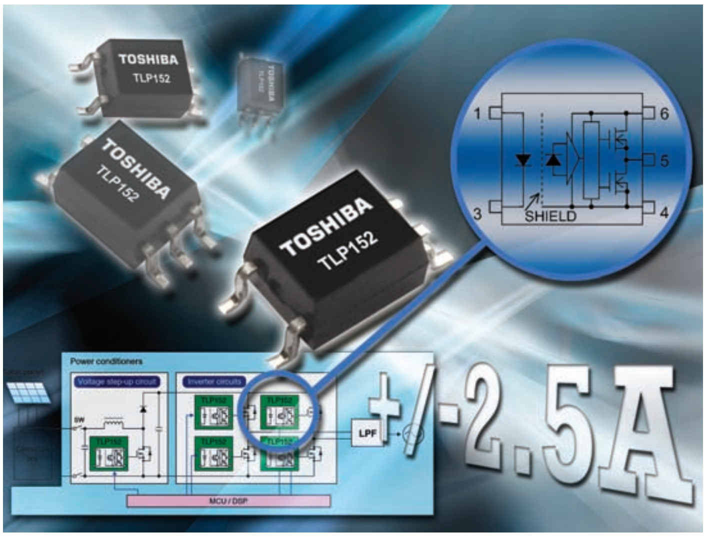


Digital AC/DC LED Driver Platform

iWatt Inc offers a digital AC/DC LED driver platform designed to address cost, performance and operating life in commercial and wireless solid state lighting (SSL) systems. The first device in this new platform, the iW3630 is a two-stage, Flickerless LED driver with output power up to 45 W and is believed to be the first SSL LED driver with a built-in 0 V to 10 V dimming interface for commercial lighting ballasts. It also supports a PWM digital dimming interface for wireless SSL applications. The highly integrated design of the iW3630 enables a 30 % to 40 % savings in bill of materials (BOM) cost in 0 V to 10 V applications and it maintains an extremely high power factor (PF) even at loads down to 20 % of full load. It also offers a low total harmonic distortion (THD) of < 15 %, to meet stringent global energy regulations, along with a built-in over-temperature protection (OTP) and derating function to improve the predictability and reliability of system operating life.

www.iwatt.com

IGBT/MOSFET Gate Drive Coupler



Toshiba Electronics Europe (TEE) has announced a photocoupler that will reduce PCB space and power consumption in IGBT and MOSFET designs that need galvanic isolation. The TLP152 gate drive coupler is designed to directly drive IGBTs and power MOSFETs without the need for additional components. A miniature S06 package reduces mounting area by 50 % compared to the widely used SDIP packaged devices. In addition, by lowering minimum supply voltage to 10 V, the new coupler also helps to reduce power consumption. SO6 package provides a minimum isolation voltage of 3750Vrms and is compatible with reinforced insulation requirements of international safety standards. Guaranteed minimum creepage and clearance distances are 5 mm and internal insulation thickness is 0.4 mm. An internal noise shield provides a guaranteed minimum common mode transient immunity of +/-20 kV/?s. The TLP152 is compatible with a wide 10 V to 30 V input range that minimizes the need for additional power conversion circuitry. Maximum supply current is 3 mA. A buffer logic type totem pole output can deliver a maximum peak output current of +/-2.5 A. Designed for high-speed operation, the TLP152 has a maximum propagation delay of 200 ns. Construction is based around a GaAlAs infrared LED optically coupled to an integrated high-gain, high-speed photodetector IC.

www.toshiba-components.com

60-V LED Drivers

Infineon introduced two new 60V DC/DC LED drivers that offer first-in-the-industry adjustable over-temperature protection that protects light elements from damage through overheating. The new ILD6070/ILD6150 drivers give lighting manufacturers the flexibility to produce multiple products using the same drivers, based on wide input voltage range (4.5 V to 60 V), adjustable output current of up to either 0.7 A or 1.5 A, and support of digital or analog dimming inputs, with a maximum dimming contract ratio as high as 3000:1. With the addition of 60 V devices to its portfolio, Infineon enables manufacturers to support as many as 18 LEDs in a light string, compared to a maximum of 12 LEDs in typically available 40 V devices. This helps manufacturers to lower costs or achieve higher lumens in a lighting system.

www.infineon.com/lightdesk

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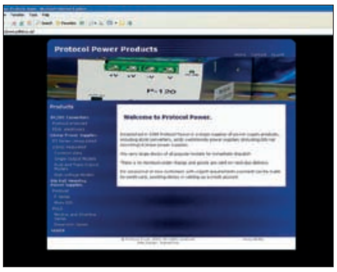

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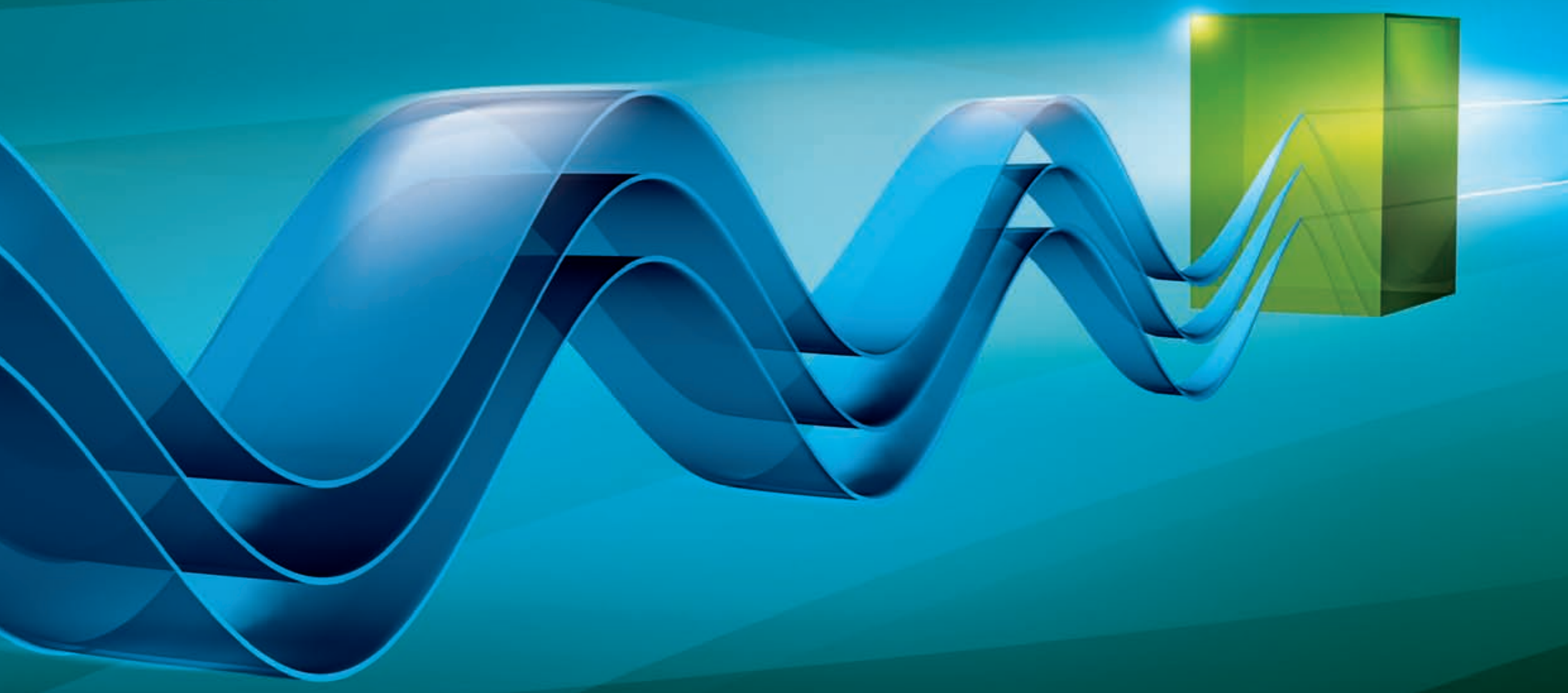

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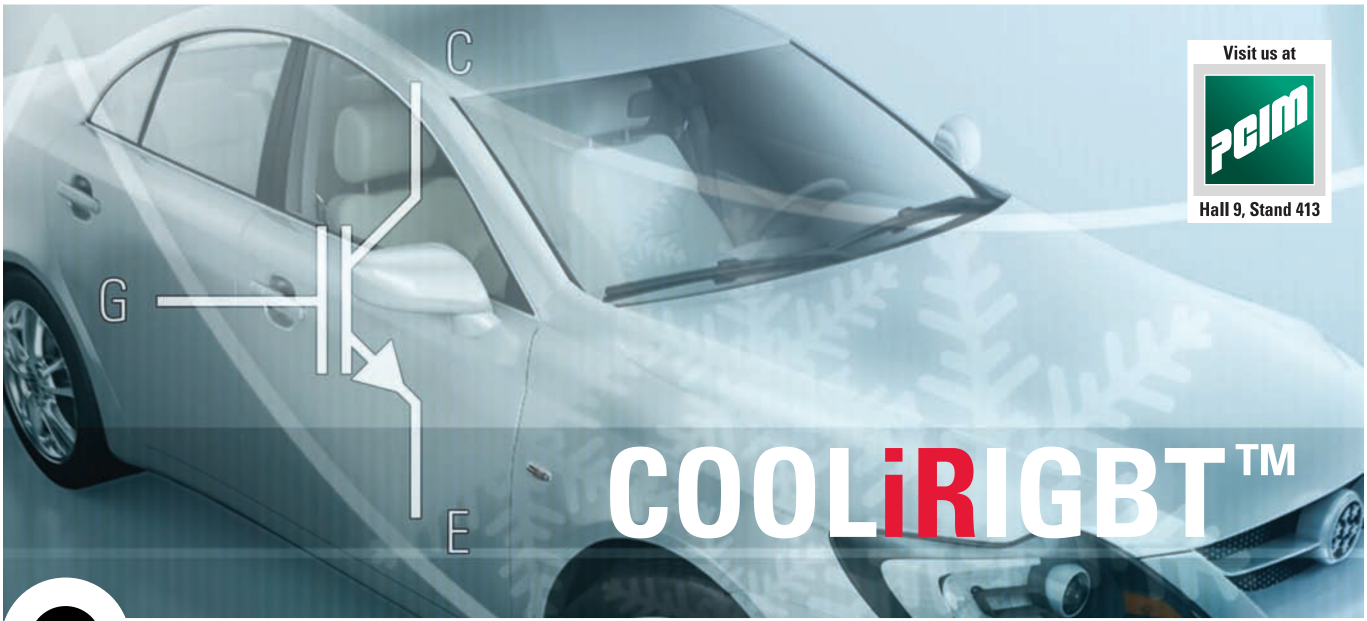

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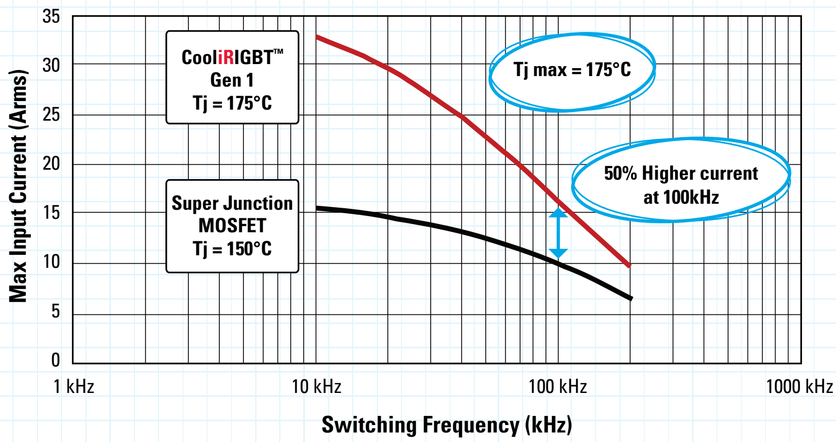

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