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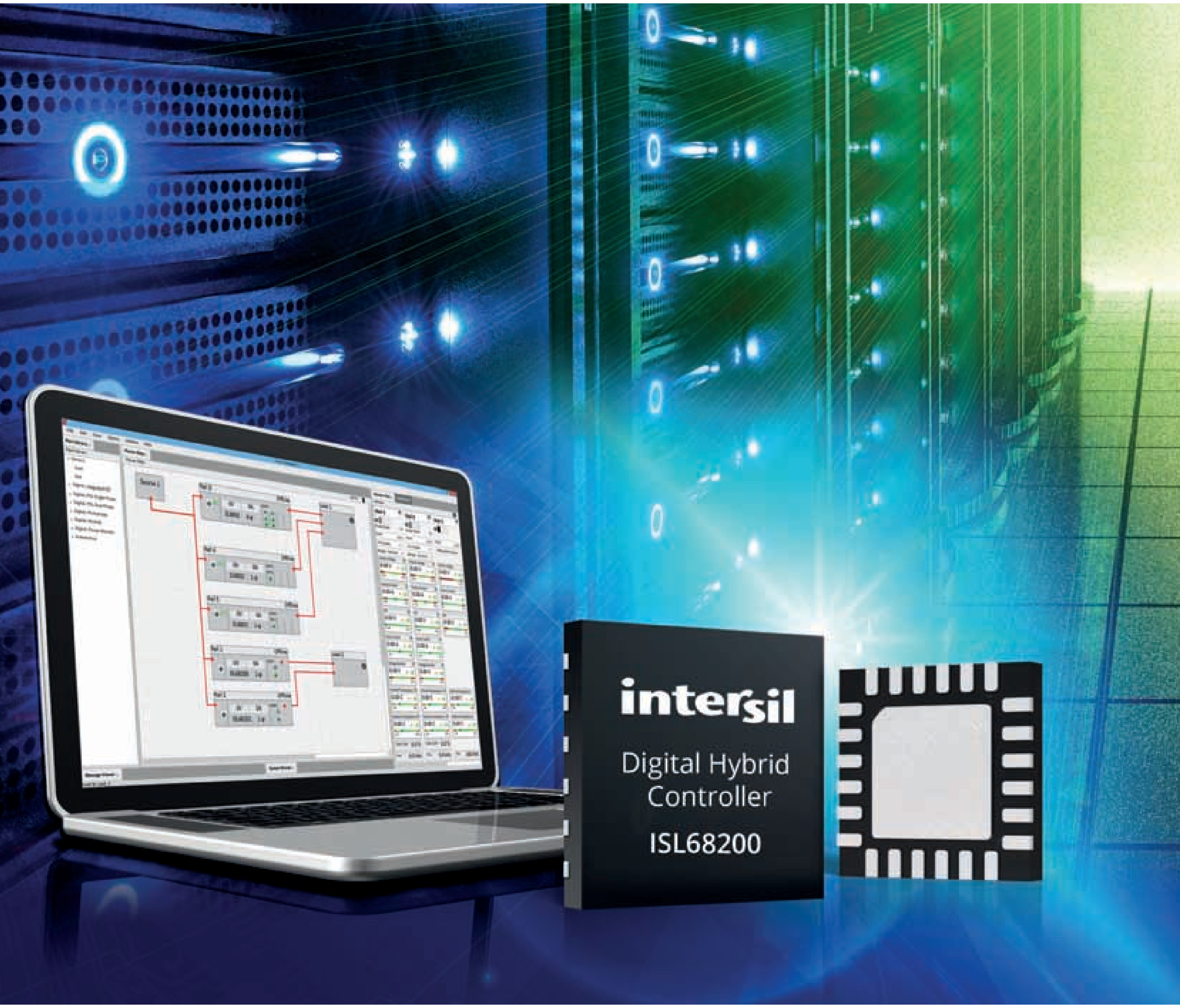
POWER SUPPLY DESIGN

Digital Hybrid Controller Simplifies Power Supply Design



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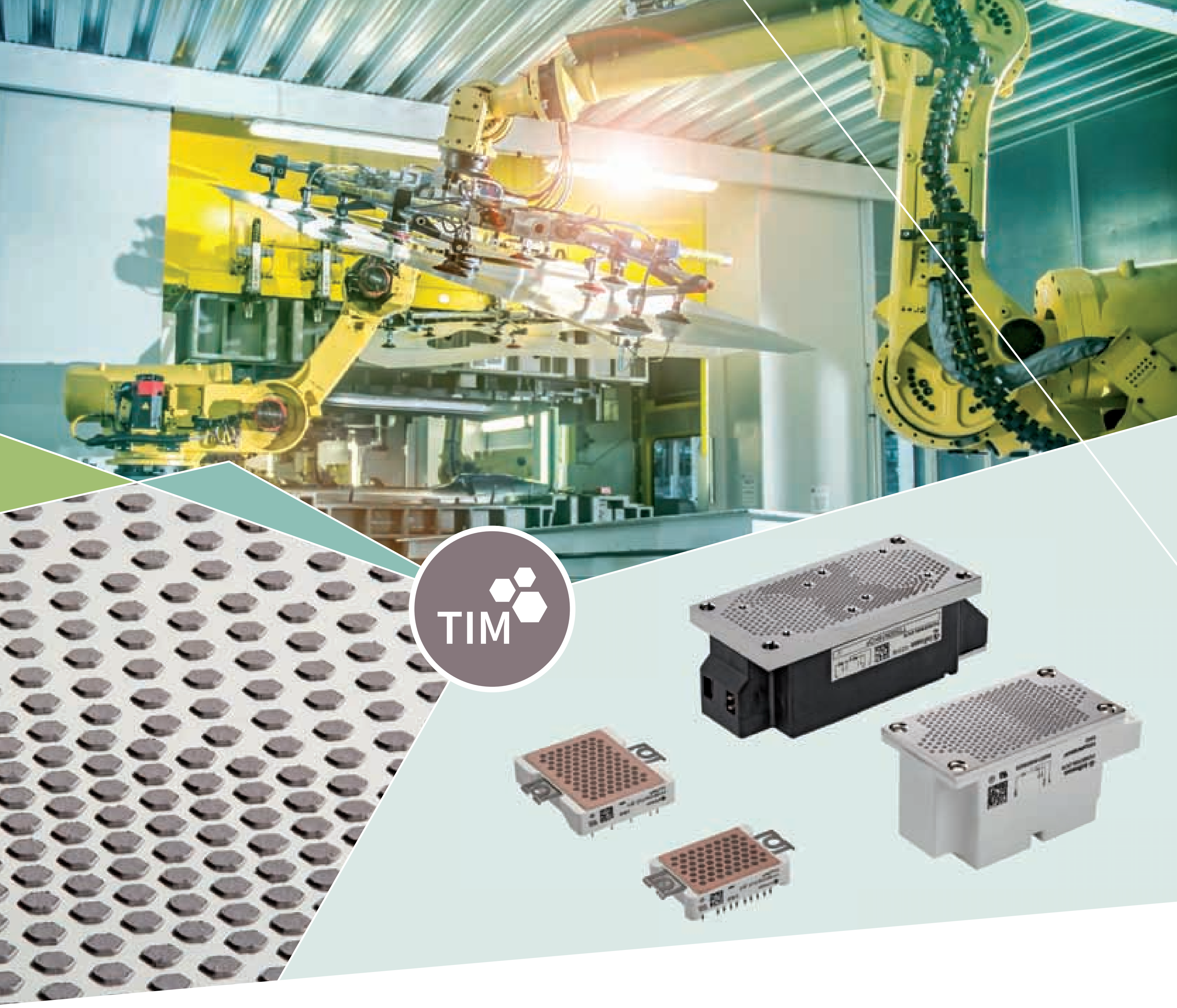
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COVER STORY

Digital Hybrid Controller Simplifies Power Supply Design

Data processing system complexity is growing fast, and the need for intelligent power system management is growing right along with it. Designers now require better system management capabilities like those offered by the new generation of digital PWM controllers. These controllers use on-chip Analog/Digital Converters (ADCs) and Digital/Analalog Converters (DACs) along with signal processing techniques to optimize performance. Designers can even modify the compensation of the control loop via the digital interface, without requiring a change in resistors or capacitors. While these digital controllers can use resistors to configure some basic parameters, the immense flexibility of the digital controller is its ability to provide full software control via the PMBus. This article describes how engineers can benefit from a new digital hybrid controller that combines an analog PWM controller with a PMBus interface. More details on page 29.

Cover supplied by Intersil Corp., Milpitas, USA

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Power Electronics Change the Automotive world

Electronica 2016 in Munich is an example how electronics, particularly in the automotive industry, will change the world. Moving toward a longer-term goal, vehicles are on a path to become fully electric, reducing fossil fuel usage. Global demand for semiconductors for automotive electronics was worth nearly 35 billion dollars in 2014, roughly ten percent of the global semiconductor market. The automotive semiconductor market is forecast to grow nearly twice as fast as the overall semiconductor industry over the next five years, due to increasing electronic content in vehicles. The power electronics market for EV/HEV will reach $13 billion by 2021.

A typical mid-class car today contains a semiconductor content of around $350, and in electric vehicles this content will be doubled. Though a lot of ECUs for motor management and the gearbox can be eliminated, this will be offset by more power semiconductors and the efforts for electrical power and battery management. But a first step towards automotive electrification respective hybridization is been seen in the move to a 48 V board net. By 2020, automotive 48 V systems will help reduce emissions by up to 15 percent, improve fuel consumption, capture energy typically lost while braking, and provide torque in the low RPM range for start-stop mild hybrids. The 48 V power net is needed to manage the next generation of energy efficient electrical systems that require more power than available with the existing 12 V subsystem. To reduce weight, many traditionally mechanical/hydraulic systems such as power steering, roll stabilization, heating, and air conditioning will be converted to 48 V electrical drive. A new electric turbocharger will provide on-demand horsepower and torque, enabling the use of smaller more efficient combustion engines without sacrificing drive ability. A high-power starter/generator will replace the 12 V alternator, reducing noise and vibration during engine starting while allowing regenerative braking to recapture up to 4x more of the available kinetic energy. The 12 V bus and 12 V lead-acid battery will handle the lighter loads, including ignition, interior lighting, navigation and audio systems.

Another very interesting market for the semiconductor industry is the trend towards self-driving. The Diesel discussion increases the pressure on the automotive industry to develop not only electric, but also self-driving or autonomous vehicles. The way towards self-driving can be split into four levels with level 1 incorporating front radar, level 2 incorporating ADAS, level 3 meaning semi-autonomous and level 4 meaning fully autonomous – ten years from now. Level 3 will double the semiconductor content of a car up to $700. Radar and LiDAR are the most promising technologies in the future, according to industry. Light Distancing and Ranging (LiDAR) sensors have recently begun to emerge in automotive sensing applications.
Initially LiDAR sensors were used to generate three-dimensional digital topographical maps used for landscape mapping and navigation software.
Because LiDAR chases the speed of light for improving resolution, Gallium Nitride (GaN) power transistors, with about a 10 times advantage in switching speed, have been used almost exclusively in these mobile applications. The imaging speed and depth resolution has become so good using eGaN FETs that manufacturers experimenting with autonomous vehicles are using similar LiDAR sensors for driverless navigation systems. In addition, several automakers are incorporating eGaN FET-based LiDAR sensors in their vehicles for general collision avoidance and blind spot detection. LiDAR has a very exciting future, since it is the detection and guidance system being used for driverless cars. Also the evolution – from an internal combustion engine, to hybrid vehicles, plug-in hybrids, and, finally, to fully electrically powered cars – is potentially a very large market for GaN technology. In the future, as electric vehicles gain acceptance and become more ubiquitous, motor controls for the powertrain has the potential to become an enormous market for GaN transistors. The issue among the competing technologies – GaN, SiC and IGBT – will be the cost. The automotive industry is undergoing a technological disruption and is taking advantage of high performance gallium nitride technology, the CEO of one of the GaN vendors expects.

GaN is the logical technological successor to Silicon for power conversion and analog devices, and possibly also for digital components as well. We are away by the factor of 800 of the theoretical GaN limits, this technology is able to be integrated up to the level of NMOS. A leading Taiwanese foundry now offers both 100 V and 650 V GaN foundry service in a 6-inch fab. The idea of bringing GaN from the power semiconductor market to the much bigger analog IC market is of interest of several other players, too. Using this 650 V GaN-on-Silicon process technology, a UK-based company has designed a monolithically integrated half-bridge serving as a core for travel notebook adapters - the exceptional performance of GaN transistors allow for more efficient and compact power adapter designs that meet today's market demands, the company stated. The new technology allows a reduction in the size of power electronics by up to 50 percent, enabling a typical 45 W adapter design today to fit into a 25 W or smaller form factor. This reduction in size will enable true universal chargers for mobile devices. And in research a V-shaped channel demonstrated record GaN threshold voltage of 1.7 kV plus a remarkably low on-state resistance.

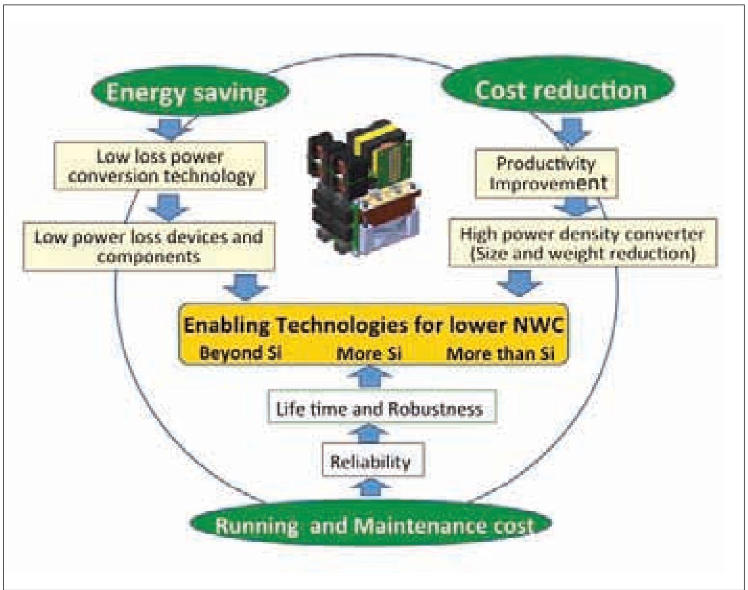
More informations on these subjects on the following pages – enjoy reading!

Achim Scharf
PEE Editor

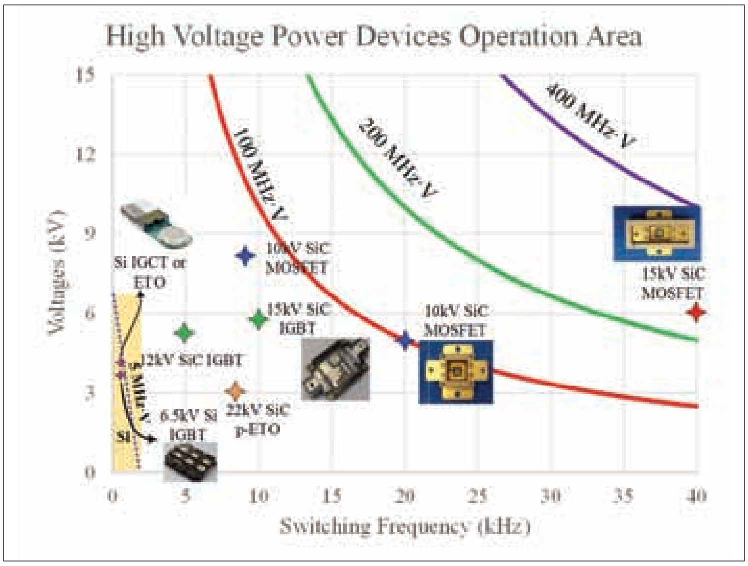
More Power Density for Power Semiconductors in Research

The 62nd annual IEEE International Electron Devices Meeting (IEDM) will take place at the San Francisco Union Square Hilton hotel from December 3-7, 2016. This year's conference will feature a program of 90-minute tutorials on Saturday, Dec. 3; two day-long Short Courses on Sunday, Dec. 4; and a Plenary session on Monday, Dec. 5 that kicks off the technical program. This year for the first time there also will be supplier exhibits.

While there are forums that serve circuit experts for the exchange of ideas and the reporting of breakthroughs, there hasn't been a suitable forum for bringing device and circuit experts together to consider impacts at the system level, even though that would be fruitful due to the interactions of circuits and devices. IEDM aims to serve as the forum for their dialogue, and so this Special Focus Session "System-level impact of power devices" has been organized. Papers are expected to explore the system-level impact of power devices, and also to describe various types of power devices targeting the full range of power/power conversion applications such as hybrid vehicles, utility and grid control, computing/telecom power supplies, motor drives, and wireless power transfer. Within the comprehensive program some of the more or less scientific presentations will cover power electronics such as wide bandgap or new MOSFET technologies.



Technology flow of nega-watt cost reduction



SiC-based alternatives can enable higher voltages and faster switching frequencies than Si-based devices

Negative-watt cost reduction

In an invited paper in the System-Level Impact of Power Devices Special Focus Session, Hiromichi Ohashi from Japan's New-Generation Power Electronics & System Research Consortium will discuss a concept called negative-watt, or "nega-watt," power cost reduction.

The idea is that power electronics devices and systems have already become so efficient and powerful, that further improvements in these areas alone will be insufficient to meet the world's energy-efficiency and climate goals. He will argue that to truly enable energy-efficient and climate-friendly societies, there must be a much greater use of affordable power electronics systems versus other technologies, so as to offset the power requirements that otherwise would be required. He will describe how these avoided power costs and avoided energy production, combined with other factors including lower costs from increased system reliability and higher productivity, can be quantified as nega-watts and then used to develop technology roadmaps.

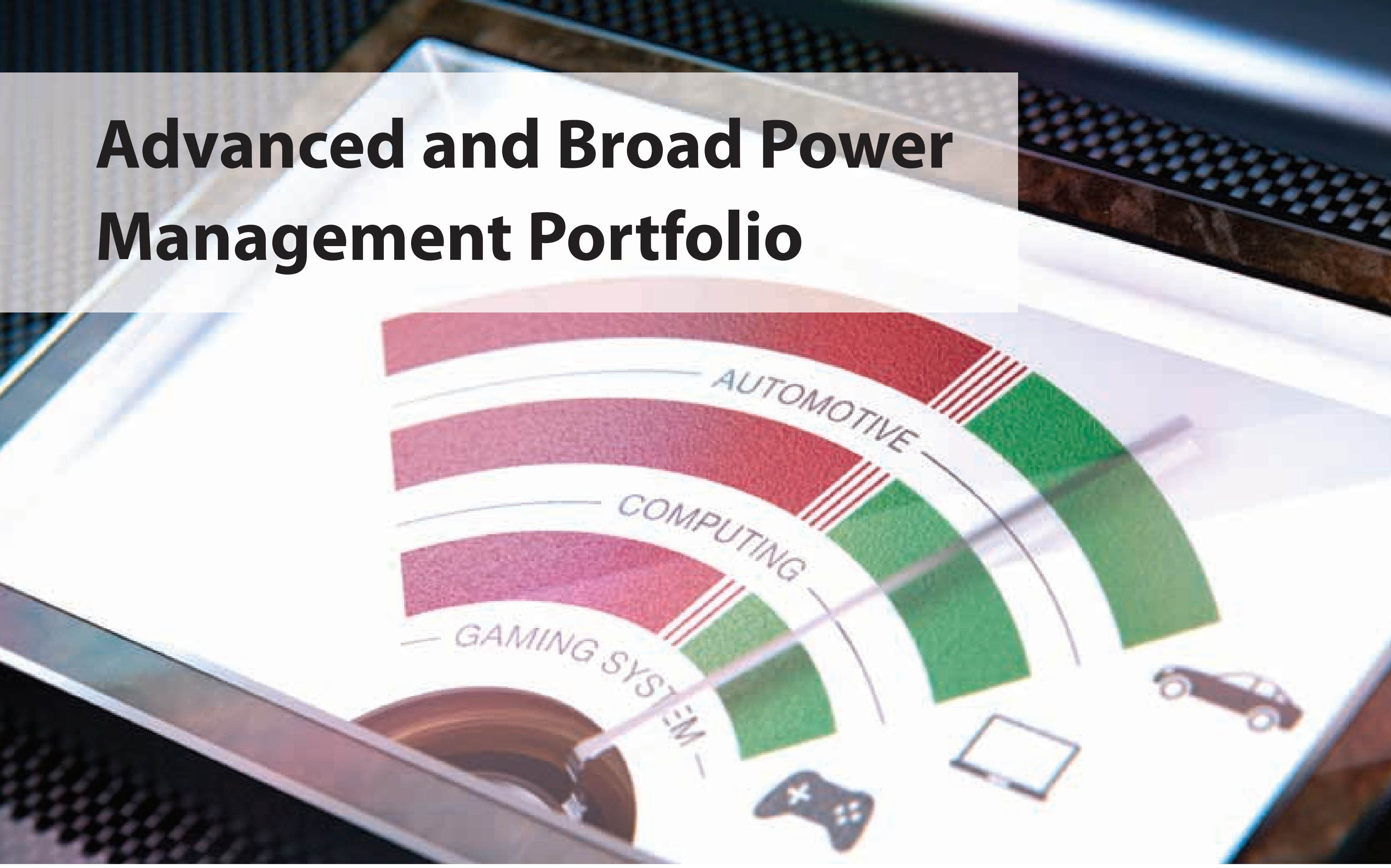
Wide-bandgap (WBG) power semiconductor devices have the capability to reach higher voltages, frequencies and temperatures than Silicon-based power devices. These capabilities have the potential to revolutionize the way we will deliver and manage power in the future. In an invited paper in the Special Focus Session on the System-Level Impact of Power Devices, Alex Huang of North Carolina State University will review progress in WBG devices and their potential transformative impacts on low-voltage, medium-voltage and high-voltage power delivery systems.

Silicon carbide (SiC) is a WBG material widely used for power devices and with great potential for future applications. SiC-based devices can enable higher voltages and faster switching frequencies than Si-based alternatives, what already have been described in numerous articles in Power Electronics Europe.

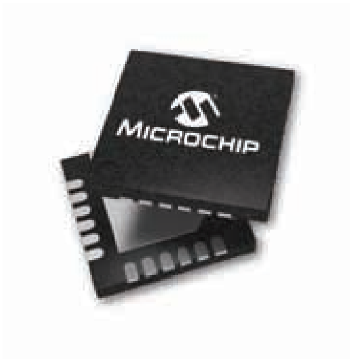
V-shaped channel for GaN transistors

V-Shaped Channel for Record GaN Threshold Voltage: Power transistors made from GaN alloys instead of Silicon are promising alternatives for high-power applications. Planar AlGaN/GaN transistors on silicon substrates are commercially available with blocking voltages of ≤600 V, but Panasonic researchers will describe vertical GaN devices on a bulk GaN substrate (p-GaN/AlGaN/GaN) that demonstrated a record-setting 1.7 kV threshold voltage plus a remarkably low on-state resistance of 1.0 mΩcm^2. One day

Advanced and Broad Power Management Portfolio



Microchip Technology has an expansive offering of power management solutions to fit virtually every type of design criteria. From the smallest form factor needed for mobile devices to complex industrial power management designs to automotive standards, you are sure to find a highly integrated solution to meet your needs. If you are looking for greater flexibility in your design, Microchip's digitally enhanced power analog devices integrate a microcontroller (MCU) or digital signal controller (DSC) for a fully programmable and flexible solution.



Applications:

- LDO and switching regulators
- Charge pump DC/DC converters
- Power MOSFET drivers
- Digitally enhanced and PWM controllers
- System supervisors
- Voltage detectors
- Voltage references
- Li-Ion/Li-Polymer battery chargers
- Power MOSFETs

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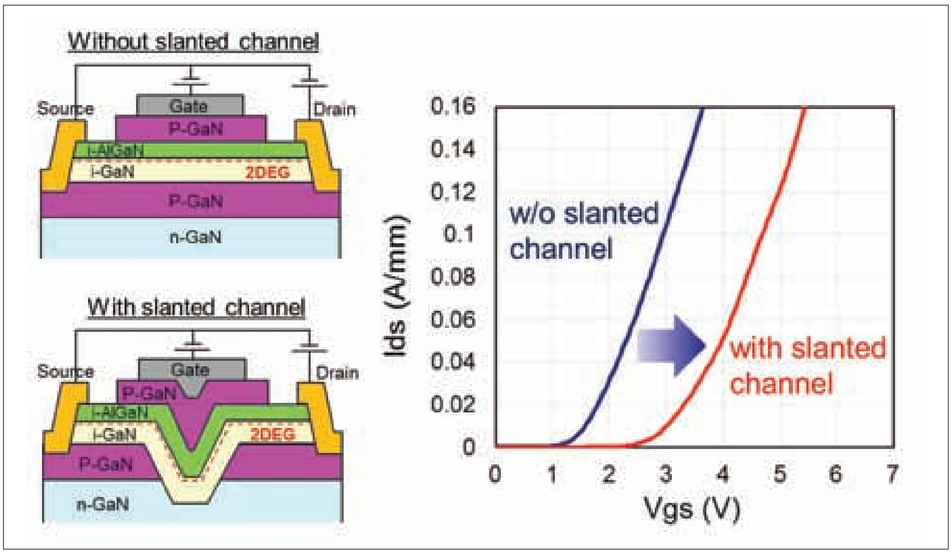


Schematic cross-sections of the lateral p-type gate GaN transistor without and with the slanted channel

such efficient devices may eliminate the need for liquid cooling in high-power electronic systems, thereby reducing their size, weight, complexity and cost. To achieve this performance, the researchers created a "semipolar" gate structure that propels charge carriers with great efficiency. They plasma-etched V-shaped grooves into an n-GaN drift layer atop the substrate. Because these grooves were cut at a slant, they exposed a second facet of the crystalline GaN material and thereby created the possibility of semipolar operation. The researchers then expitaxially grew p-GaN/AlGaN/GaN layers in these grooves and built a "slanted" channel with the gate on top.

Schematic cross-sections of the lateral p-type gate transistor without and with the slanted channel are shown in the corresponding image, along with their measured transfer characteristics. The lateral transistor with a slanted channel exhibits 1.5 V larger V_{TH} than the one without slanted channel.

Tunneling FETs

Tunneling FETs (TFETs), which operate according to the principles of quantum mechanics, offer a unique mechanism for low-voltage switching and may lead to dense, powerful circuits that operate at extremely low power levels. However, tunneling behavior typically greatly compromises the amount of current that is available, limiting their usefulness.

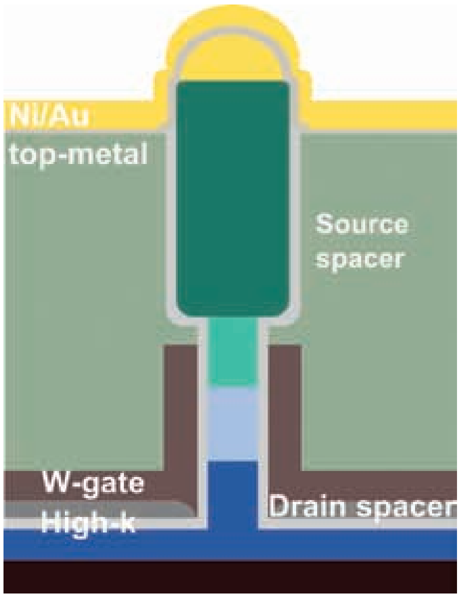
They are promising for ultra-low-power applications because they operate at low voltages, but it's difficult to build them so that they carry useful amounts of current. Researchers from Purdue University and partners will present a design methodology for heterostructure TFETs that have a high on-current of 265 A/m at 0.18V, and 1.95 A/m at 0.12V. These values, from calculations based on the essential physics of the device, derive from extensive modeling and simulation of theoretical device structures.

The computer simulations show the ballistic local density of both the ON-state (a) and OFF-state (b) bias of a (110)-confined triple-HJ TFET. While the two resonant states are clearly separated in ballistic simulations, inelastic scattering will increase off-current due to coupling between the two states.

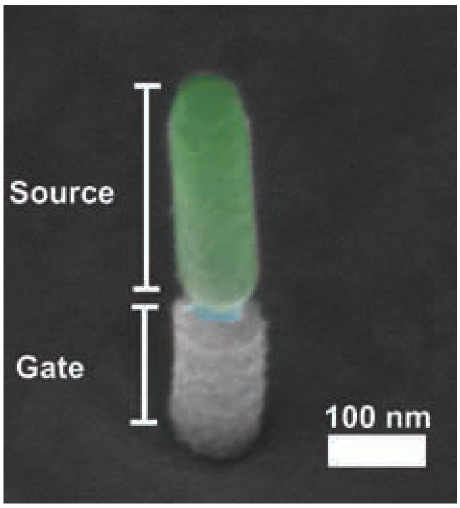
Tunneling FETs (TFETs), which operate according to the principles of quantum mechanics, offer a unique mechanism for low-voltage switching and may lead to dense, powerful circuits that operate at extremely low power levels. However, tunneling behavior typically greatly compromises the amount of current that is available, limiting their usefulness.

Lund University researchers will discuss a vertical nanowire-based TFET with a novel heterostructure design (InAs/GaAsSb/GaSb) that makes possible aggressive dimensional scaling along with improved electrostatic control. The result is a device with a record high on-current (10.6µA/µm) and extremely steep on/off behavior, as low as 44 mV/dec at 0.05V, which is less than the 60 mV/decade theoretical limit for MOSFETs.

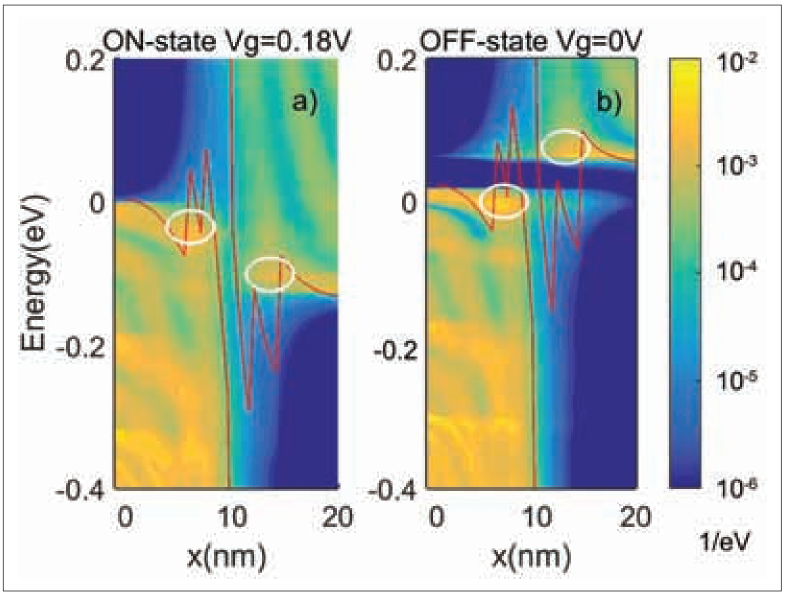
At left in the schematic illustration is the InAs/GaAsSb/GaSb TFET, while at right is a SEM image of a nanowire with gate metal applied. The physical gate length is 260 nm, whereas the effective gate length is 100 nm, corresponding to the length of the undoped InAs segment.



Schematic of the InAs/GaAsSb/GaSb TFET (top), below is a SEM image of a nanowire with gate metal applied



Simulations show the ballistic local density of both the ON-state (a) and OFF-state (b) bias of a (110)-confined triple-HJ TFET (resonant states are circled)

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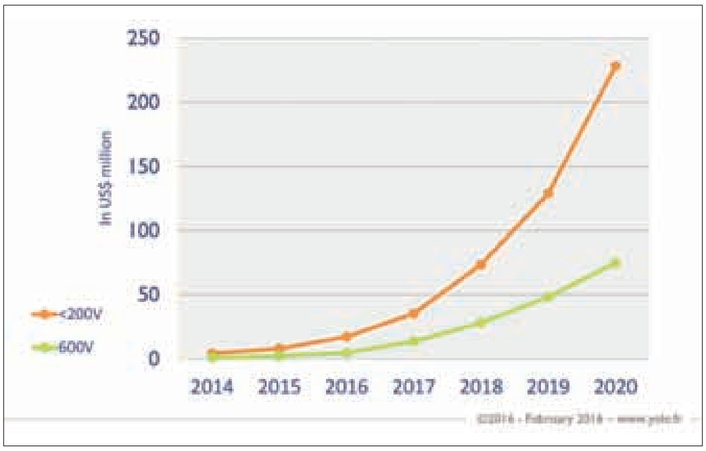
Gallium Nitride is Moving Forward

According to market researcher Yole 2015 - 2016 have been exciting years for the GaN power business - 600V GaN is today commercially available, after many ups and downs. And GaN power ICs have debuted, opening new market perspectives for GaN companies. GaN power business is expected to reach $280 million in 2021, with an 86 % compound annual growth rate (CAGR) between 2015 and 2021. The market is driving by emerging applications including power supply for datacenter and telecom, AC fast charger, automotive LiDAR, Envelope Tracking, and wireless power.

"In the digital arena Moore's law - doubling the transistor count on chip every 18 month – has now been broken, but in power electronics we are just in the beginning with the role of GaN", EPC's CEO Alex Lidow points out. "GaN is the logical technological successor to Silicon for power conversion and analog devices, and possibly also for digital components as well. We are away by the factor of 800 of the theoretical GaN limits, this technology is able to be integrated up to the level of NMOS.

"Numerous powerful developments and key collaborations have been announced during the last years - a promising and fast-growing industry", comments Hong Lin, Technology & Market Analyst at Yole (**www.yole.fr**). To mention are Integrated Device Technology (**www.IDT.com**), Efficient Power Conversion (**www.EPC-co.com**), Infineon Technologies (**www.Infineon.com**) and Panasonic (**https://eu.industrial.panasonic.com/**), Exagan (**www.exagan.com**) and German Xfab (**www.xfab.com**), TSMC (**www.tsmc.com**) and GaN Systems (**www.gansystems.com**). TSMC is the first company to offer both 100 V and 650 V GaN foundry service in a 6-inch fab. The idea of bringing GaN from the power semiconductor market to the much bigger analog IC market is of interest of several other players too. For example, EPC and GaN Systems are both working on a more integrated solution. In parallel Texas Instruments (**www.ti.com**) announced a 80 V power stage in 2015 and a 600V power stage in 2016. Fast-forward to 2016 end users can now buy not only low-voltage GaN (<200 V) devices from EPC, but also high-voltage (600V/650V) components from several players, including Transphorm (**www.transphormusa.com**), GaN Systems, and Infineon/Panasonic.

And Visic (**www.visic-tech.com**) announced in September 2016 a 1200 V power module. Based in Nes Ziona, Israel, VisIC Technologies, Ltd. was established in 2010 by experts in GaN technology. The GaN module have typical on-resistance down to 0.04Ω. Target applications are power converters for motor drives, three-phase power supplies and other applications requiring current switching up to 50A. "This technology supports reduced gate charge and capacitances without

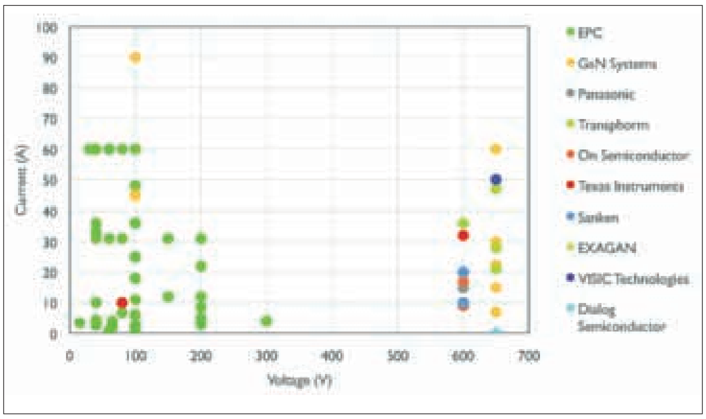


GaN device market split by voltage range **Source: Yole 2015**

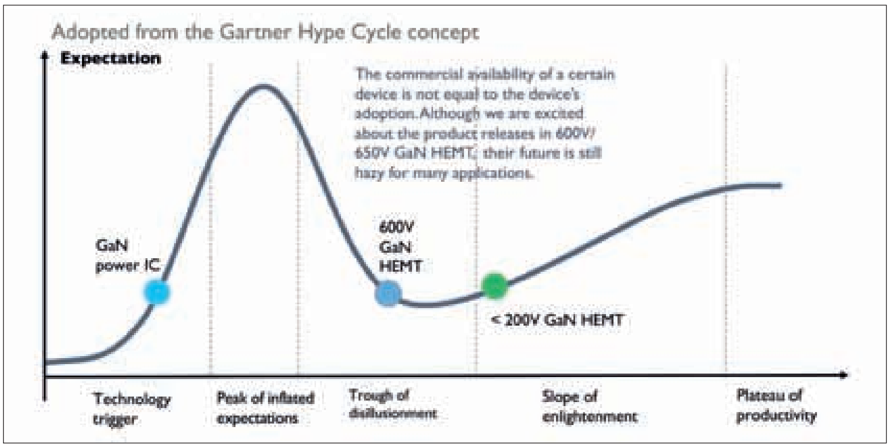
losing the benefits of low $R_{DS(ON)}$, offering an ultra-low maximum switching energy down to 140 ?J. Switching losses are three to five times lower compared to SIC MOSFETs", said CTO Gregory Bunin. Also in September the company launched a new 12 A GaN switch in a smaller bottom-side cooled package with an on-resistance of 0.080Ω.

A new start-up, Navitas Semiconductor (**www.navitassemi.com**), announced their 650 V GaN power IC based on Hughes Lab technology (**www.hrl.com**) at APEC in March 2016 and later in Europe at PCIM 2016. "GaN is ready for the market and we are integrating things which have not been integrated before", CTO Dan Kinzer stated. The company has designed a fully integrated GaN IC with integrated gate drive in QFN 5 mm x 6 mm package. "This e-mode device features 20 times lower drive loss than Silicon, the driver impedance is matched to the power stage. Also almost zero inductance leads to low switching losses – and our 650-V process allows switching frequencies of up to 27 and 40 MHz! The switch is not the limit, it is the magnetics". According to Kinzer this device can also be used as a 500-V synchronous rectifier.

AllGaN™ is the first platform which allows monolithic integration of 650 V GaN IC circuits (drive, logic) with GaN FETs. This 'GaN Power IC' contains features such as hysteretic input, voltage regulation and ESD protection – all integrated in the same GaN layer as the main power device. This monolithic integration of drive and switch is impractical using d-mode GaN, vertical GaN or SiC. Lateral 'GaN-on-Si' construction means immediate high volume capability using existing foundry processes. Within the AllGaN solution, the GaN FET gate is driven safely, precisely and efficiently by the upstream integrated GaN driver. Standard 3.3 V, 5 V or 15 V PWM signals are fed directly into the GaN Power IC for an easy, low component count design. Integrating the driver also reduces ringing and enables tight control of turn-on, turn-off for high-frequency half-bridge



Existing power GaN devices from various vendors **Source: Yole 2016**

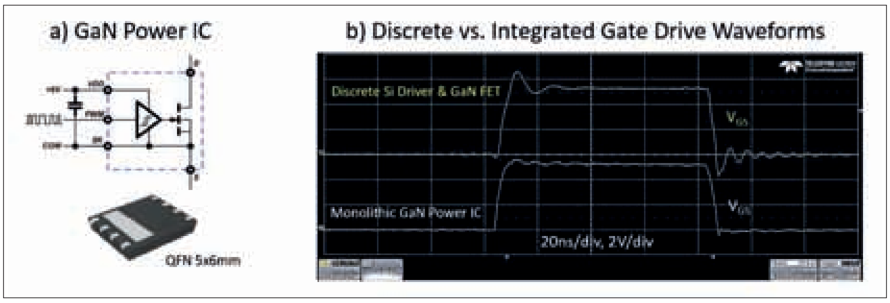


GaN hype/market cycle Source: Yole 2016

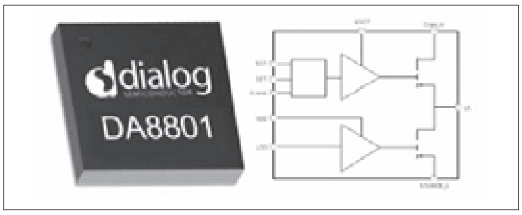
applications.

Dialog Semiconductor plc (**www.dialog-semiconductor.com**) announced end of August its first GaN power IC product offering, using TSMC's 650 V GaN-on-Silicon process technology. "The exceptional performance of GaN transistors allows customers to deliver more efficient and compact power adapter designs that meet today's market demands," said Mark Tyndall, SVP Corporate Development and Strategy, Dialog Semiconductor. "GaN technology offers the world's fastest transistors, which are the core of high-frequency and ultra-efficient power conversion. Our DA8801 half-bridge integrates building blocks, such as gate drives and level shifting circuits, with 650 V power switches to deliver an optimized solution that reduces power losses by up to 50 %, with up to 94 % power efficiency. The product allows for a seamless implementation of GaN, avoiding complex circuitry, needed to drive discrete GaN power switches. The new technology allows a reduction in the size of power electronics by up to 50 percent, enabling a typical 45 W adapter design today to fit into a 25 W or smaller form factor. This reduction in size will enable true universal chargers for mobile devices."

What the industry expects from GaN expressed Thomas Heckel from Fraunhofer IISB (**www.iisb.fraunhofer.de**) in Erlangen earlier this year at the CIPS conference: "We expect a normally-off characteristic, better performance



Navitas GaN Power IC schematic and gate switching waveforms



Dialog Semiconductor's 650 V GaN half-bridge

than Si and even SiC, and more vendors". At IISB a test system has been set up for the evaluation of various GaN transistors. A 200-V transistor switched at 100 V exhibited dynamic on-resistance (120 mΩ to 80 mΩ) which was not specified in the datasheet; a 650 V/150 mΩ cascode was opened which needs external gate resistor, this type exhibited poor controllability; a 650 V/45 mΩ with four GaN transistors showed better controllability – but is commercially not more available; a 650 V/50 mΩ normally-off device had better dynamic on-resistance but reached not the datasheet specifications. Only Panasonic's 600 V GIT device exhibited no dynamic on-resistance!

International Rectifier was the the first to introduce a cascoded GaN transistor and was acquired by Infineon for $3 billion due to its GaN leadership in late 2014. Meanwhile the cascode topology has been skipped and by licensing the Panasonic GIT an e-mode technology will be favored by Infineon. This turn obviously marks an industry change to support e-mode or normally-off devices in the future.

New application possibilities

"GaN technology is disruptive, in the best sense of the word, making possible what was once thought to be impossible", comments EPC CEO Alex Lidow. GaN technology is 10 times faster, significantly smaller, and with higher performance at costs comparable to Silicon-based MOSFETs. The inevitability of GaN displacing the aging power MOSFET is becoming clearer with domination of most existing applications and enabling new ones".

The explosion of digital content, big data, e-commerce, and Internet traffic is also making data centers one of the fastest-growing consumers of electricity in developed countries, and one of the key drivers in the construction of new power plants. In 2014, data centers (in the US) consumed about 100 billion kWh of energy and it is projected by the Natural Resources Defense Council (**www.nrdc.org**) that data center electricity consumption will increase to roughly 140 billion kWh annually by 2020, the equivalent annual output of 50 power plants. The power needed to support this rapidly growing demand comes from the electrical grid, and goes through multiple conversion stages before it actually feeds the remaining energy into a digital semiconductor chip. The losses due to the transmission and multiple conversion stages of electricity – from the power plant to the computer chip, shows that the power grid needs to supply 150 W to meet the demands of a digital chip that may need only 100 W of power. Thus the combined waste across the US due to power conversion for servers is 33 billion kWh, equivalent to almost a dozen power plants. But the overall wasted energy within the server farm is even more, because every watt of power loss through power conversion is actually energy that is converted into heat, and removing this heat demands even more power.

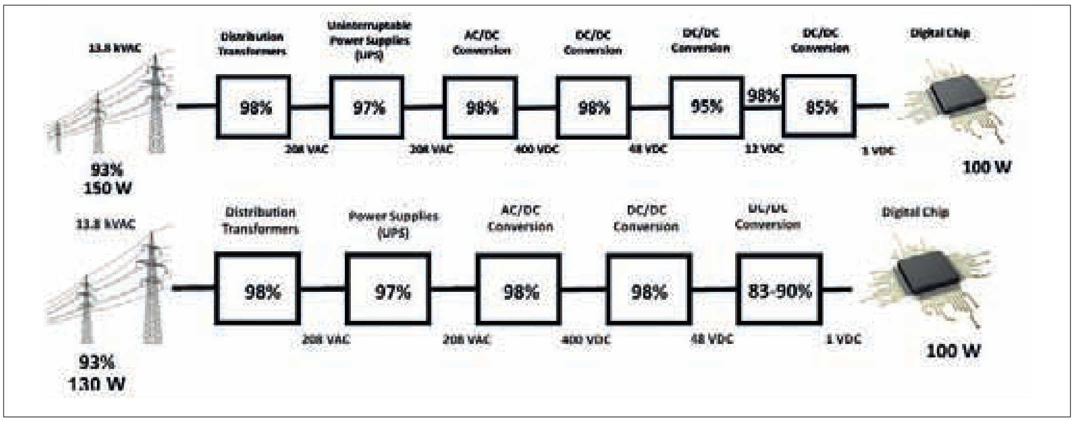
Since the adoption of the 12 V intermediate bus architecture (IBA), bus converters are currently approaching about an order of magnitude increase in output power, from around 100 W to current designs of around 1 kW in a quarter brick footprint. This means that the amount of current on the 12 V bus to the POL converters has also increased by a factor of 10 and, without reductions in busing resistance, a two order of magnitude increase in busing conduction losses follows. GaN-based solutions have already demonstrated significant efficiency improvements compared to Silicon based solutions in conventional IBA systems.

However, with the increasing conversion losses in the 48 V input bus converter, the mounting 12 V busing losses on the motherboards, and the higher performance of GaN technology, different architectures may now be considered, such as going directly from 48 V input to load using non-isolated POL converters. For the 48 V input, an 80 V eGaN monolithic half-bridge IC (EPC2105), embedded in an EPC9041 demonstration board, was selected for the much higher step-down ratio. "The direct savings by eliminating just the last stage in the server farm power architecture is not only a cost reduction, but also a reduction of power consumed between 7-15% depending on the GaN-based approach. This correlates to direct savings of up to 21 billion kWh per year when compared with Silicon-based solutions. This savings is increased further when air conditioning energy costs inside the server farm are added, bringing the total to almost 25 % of the 140 billion kWh consumed by servers in the US alone", Lidow calculated.

The 48 V power architecture is getting more attention since Google (**www.google.com**) has joined the Open Compute Project (**www.opencompute.org**) in early 2016. OCP will help to drive standardization in IT infrastructure. More specifically, Google will contribute a new rack specification that includes 48 V power distribution and a new form factor to allow OCP racks to fit into data centers. "Energy efficiency in computing is a topic that has been near and dear to our hearts since the early days. We began advocating for efficient power supplies in 2003, and in 2006 shared details of our 12 V architecture for racks inside our data centers - the infrastructure that supports and powers rows upon rows of our servers. In 2009, we started evaluating alternatives to our 12 V power designs that could drive better system efficiency and performance as our fleet demanded more power to support new high-performance computing products, such as high-power CPUs and GPUs. We kicked-off the development of 48 V rack power distribution in 2010, as we found it was at least 30 % more energy efficient and more cost effective in supporting these higher-performance systems. Our 48 V architecture has since evolved and includes servers with 48V to POL designs, and rack- level 48 V Li-Ion UPS systems. Google has been designing and using 48V infrastructure at scale for several years, and we feel comfortable with the robustness of the design and its reliability. As the industry's working to solve these same problems and dealing with higher-power workloads, such as GPUs for machine learning, it makes sense to standardize this new design by working with OCP. We believe this will help everyone adopt this next generation power architecture", commented Google's Technical Program Manager John Zipfel.

Another example - the automotive industry understands the trend to have the interior of the car a "living space" and has begun to show its vision of the future for the fully mobile lifestyle. The dashboard is being taken over by the smartphone, while sensors and computers are being added to increase its safety. Moving toward a longer-term goal, vehicles are on a path to become fully electric, reducing fossil fuel usage.

A rapidly emerging technology to enable the batteries in our electronic devices keep up with the demands added by the vehicle's infotainment system is wireless power transfer. The latest techniques enable wireless charging of multiple objects without contact with the power transmission unit (PTU) with efficiencies similar to wired chargers. Wireless phone charging in a car is becoming more critical as the smartphone itself is becoming the information receiver and router for



Typical multi-stage power conversion architecture used in modern server farms, which takes 150 W from the electrical grid to supply 100 W to a digital processor used in servers (above), whereas GaN devices enable the elimination of an entire stage (48/12 V) in the power conversion chain by 48/1 V), reducing total server farm losses by up to 20 W by taking 130 W from the grid (below) Source: EPC

the dashboard infotainment center. Several automotive manufacturers are adopting operating system standards that enable seamless interfaces to dashboards that become "slaves" to the information and entertainment available in the drivers and other occupants' smartphones.

The AirFuel Alliance (**www.airfuel.org**) wireless power transmission standard developed by a consortium of electronics industry leaders such as Samsung, Qualcomm, Intel, and EPC is undergoing rapid adoption in mobile phone and tablet charging applications. To implement this standard, several automotive manufacturers are developing embedded wireless charging stations in the center console of the vehicle so smartphones, as well as other mobile devices, can remain charged while the automobile is in operation, despite intense and continuous usage. Given that the AirFuel Alliance standard uses a 6.78 MHz standard frequency for power transmission, a stretch for Silicon power devices, GaN technology is the heavy favorite for adoption in both mobile and automotive applications.

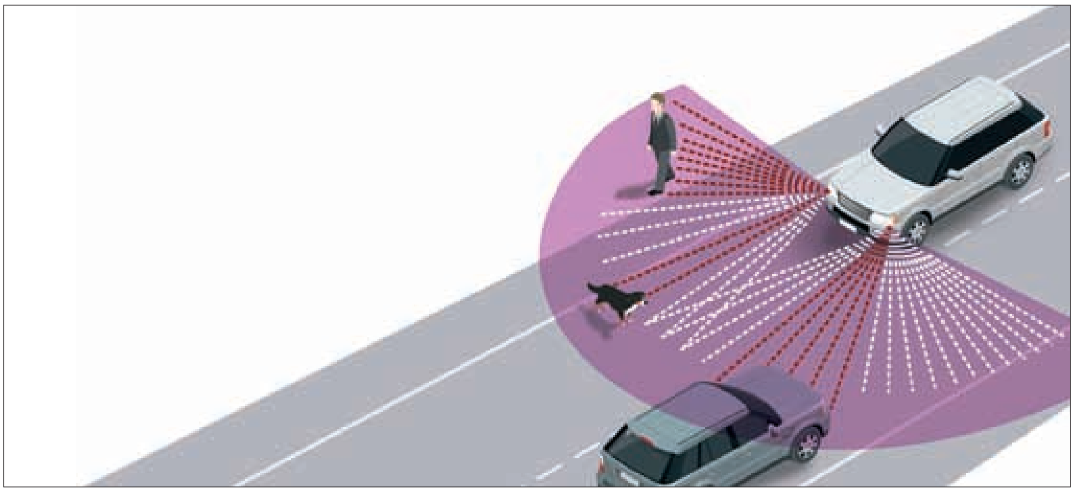
In addition to wireless charging becoming commonplace within the car's cabin, it is becoming available to charge fully electric cars or plug-in hybrids. With a "charging mat" as the power transmitter, one will merely have to place the mat on the floor of your garage and park the car over the mat without the need to "connect the car to an outlet."

To ensure safety and prevent collisions, it is critical that a vehicle be aware of its surroundings at all times. The higher the speed of the vehicle, the more rapidly the "situational awareness" system needs to sense, and the more precisely it needs to interpret the distance to the potential hazard.

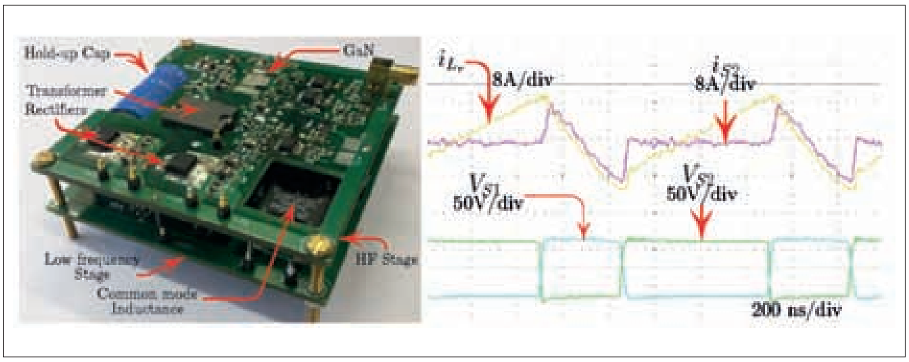
Today automotive manufacturers use a variety of sensors in these safety-related functions, including ultrasonic sensing, microwave radar short-range radar, and video pattern recognition. Light Distancing and Ranging (LiDAR) sensors have recently begun to emerge in automotive sensing applications. Although Lidow anticipates broad adoption in automotive, initially LiDAR sensors were used to generate three-dimensional digital topographical maps used for landscape mapping and navigation software. Because LiDAR chases the speed of light for improving resolution, GaN power transistors, with about a 10 times advantage in switching speed, GaNFETs have been used almost exclusively in these mobile applications. "The imaging speed and depth resolution has become so good using eGaN FETs that manufacturers experimenting with autonomous vehicles are using similar LiDAR sensors for driverless navigation systems. In addition, several automakers are incorporating eGaN FET-based LiDAR sensors in their vehicles for general collision avoidance and blind spot detection. LiDAR has a very exciting future, since it is the detection and guidance system being used for driverless cars", Lidow stated.

Also the evolution – from an internal combustion engine, to hybrid vehicles, plug-in hybrids, and, finally, to fully electrically powered cars – is potentially a very large market for GaN technology. The demand for electrical power grows in proportion to the amount of propulsion handled by the electric motor; according to Tesla (**www.tesla.com**) the model S delivers 310 kW of electrical power to the rear wheels. Delivering more power to propel a vehicle requires higher voltages in order to keep the current levels flowing through the motor windings with minimum conduction losses. Today the dominant transistor in electric or hybrid vehicle propulsion systems is the IGBT in voltages from 500 to 1200 V. "However, wide bandgap transistors made using either SiC or GaN technology hold great promise for this high power application, since they have higher efficiency at lower switching frequencies and possess the ability to operate at much higher temperatures. The requirements for electric motor drives sit at the interface between GaN, SiC and IGBT technologies. Ultimately, the cost and reliability of the electric drive system will determine the winner for this application, but for now, it is too soon to call", Lidow expects. "In the future, as electric vehicles gain acceptance and become more ubiquitous, motor controls for the powertrain has the potential to become an enormous market for GaN transistors. The issue among the competing technologies – GaN, SiC and IGBT – will be the cost. The automotive industry is undergoing a technological disruption and is taking advantage of high performance gallium nitride technology. GaN devices are appearing in an ever-increasing number of systems, with the future looking even more promising. Several areas are clearly emerging, as discussed above.

As a practical example a design methodology of a 50 W isolated DC/DC converter based on EPC's



To ensure safety and prevent collisions, it is critical that a vehicle be aware of its surroundings at all times through GaN-based LiDAR sensor Source: EPC



Prototype of a 50 W /1 MHz DC/DC converter with GaN transistor EPC2010C and transformer EQ20/PLT 3F45 (right), experimental waveforms V_{S1} and V_{S2} (20 V/div and 200 ns/div)

200 V GaN transistors serving as a power supply for aircraft equipment has been awarded as Best Paper of PCIM Europe 2016. The particularity of this work is the design of a full converter regarding two antagonistic requirements which are a wide input voltage and high efficiency. In high frequency applications, it seems clear that using GaN transistor creates a real improvement of the efficiency due to its low output charge. In a soft-switching topology the device output charge has an important impact on the energy required to achieve ZVS condition providing a larger power storage and transfer period means naturally a higher efficiency. The other GaN transistor benefits are its low total gate charge and its low drain to source on-state resistance, reducing the drive power (losses) and conduction losses respectively. All these features are implemented in a smaller packaging with less parasitic inductances compared to a Si MOSFET with similar power characteristics. The efficiency approaches 92 % at the nominal input voltage (28 V) and the peak efficiency is 95.5 % for an input voltage of 18 V.

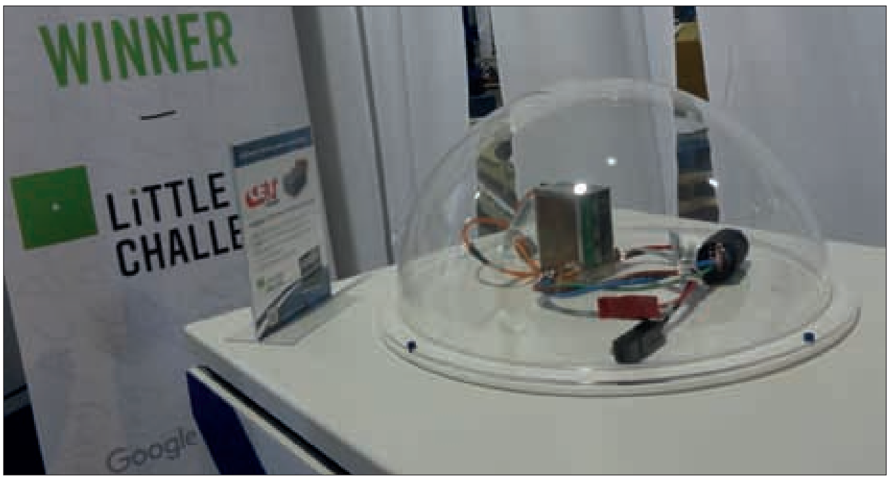
Certainly the most impressive design in the higher voltage range based on GaN System's devices (GS66508P e-mode GaN power transistor) was the winning design of Google's Little Box Challenge early this year. The Little Box Challenge was a design contest presented by Google and the IEEE Power Electronics Society to spur innovation in power inverter design with the highest power density (at least 50 Watts per cubic inch) and an efficiency of >95 % with a $1,000,000 prize. According to Google inverters will become increasingly important to economy and environment as solar PV, batteries, and similar power sources continue their rapid growth. The innovations inspired by this prize will have wide applicability across these areas, increasing efficiency, driving down costs, and opening up new uses cases that we can't imagine today. It also doesn't hurt that many of these improvements could make data centers run more safely and efficiently.

Google and the IEEE Power Electronics Society awarded the $1 million prize to Belgiums CE+T's Red Electrical Devils for designing, building and demonstrating an inverter with the highest power density and smallest volume. The key goal of the challenge was to reach an inverter power density in excess of 50 W/cubic inch in a volume of under 40 cubic inches – a feat which had never been done before. Their winning inverter design produced a power density of 143 W/cubic inch in 14 cubic inches, outperforming the Little Box Challenge power density goal by nearly a factor of 3 thanks to GaN power, which, according to Google, "is 10 times more compact than commercially available inverters".

Emerging market

Despite these developments, the GaN power market remains small compared to the gigantic $335 billion Silicon semiconductor market. According to Yole's investigation, the GaN power business was less than $10 million in 2015. "But before you think twice about GaN, remember that a small market size is not unusual for products just appearing on the market", comments Lin. Indeed first GaN devices were not commercially available until 2010. According to Yole's analysts, the most important point to be noticed is the potential of GaN power. Indeed they expect the GaN power business to grow, reaching a market size of around $300 million in 2021 at a 2016 – 2021 CAGR of 86 %. "The current GaN power market is mainly dominated by low voltage (<200 V) devices, but the +600 V devices should take off", comments Zhen Zong, Technology & Market Analyst at Yole.

More than 200 patent applicants are involved in the power GaN industry, stated KnowMade (**www.knowmade.com**) in its GaN for Power Electronics: Patent Investigation report in August 2015. Such figure is showing the strong interest from power players in the GaN business. The take-off of patenting activity took place in the 2000s with a first wave of patent publications over the 2005-2009 period mainly due to American and Japanese companies. A second wave started in 2010 while first commercial GaN products, collaborations and mergers and acquisitions emerged. "In the today's power GaN market, it is crucial to understand the global patent landscape thorough in-depth analyses. This approach helps the companies to anticipate the changes, identify and evaluate business opportunities, mitigate risks and make strategic choices." comments Nicolas Baron, CEO of KnowMade. "The time evolution of patent filings has reached a peak, and we expect a slowing down of new patent applications. Meanwhile, granted patents worldwide should increase after successful prosecution of the numerous pending patent applications. We believe the second peak of patent filings combined with the significant ratio of patents in force and the large number of patent applications still in the pipeline worldwide is an indication of the technology maturity heralding a future ramp-up of the GaN power market", he added. AS



Winning inverter design of the Google Little Box Challenge based on 650 V GaN power FETs
Photo: AS

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1 MHz Converter with 95 % Peak Efficiency…, Power Electronics Europe June 2016, page 16-18

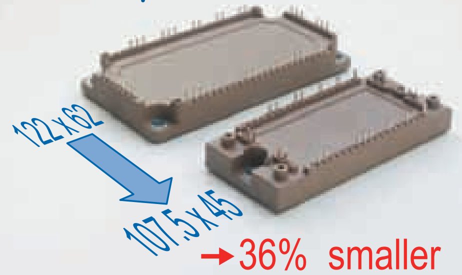
Fuji Electric's X-Series - 7G IGBT

with improved package technologies

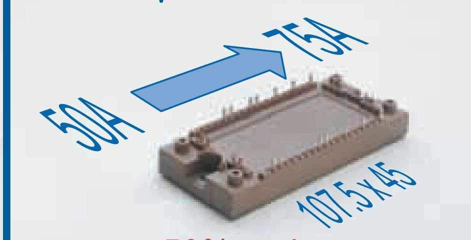
Main features

- Improved switching performance
- Reduced on-state voltage drop
- Enhanced power cycling capability
- Increased output power
- $T_{j(op),max}$=175°C *(except Small IPM=>150°C)*
- Downsizing package
- Expanded current rating

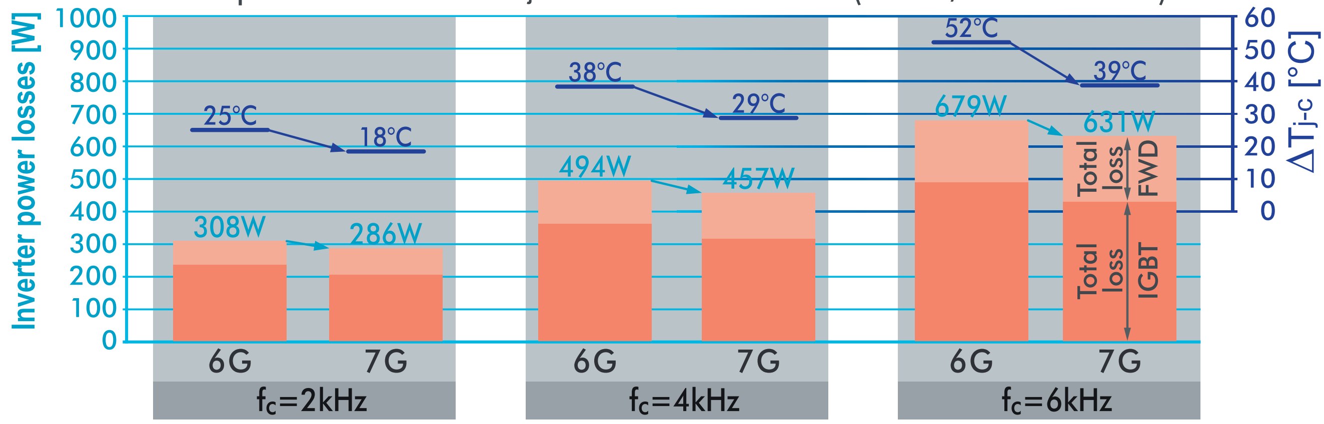
Downsizing package
Example 75A PIM-IGBT



Upgrading current rating
Example 50A PIM-IGBT

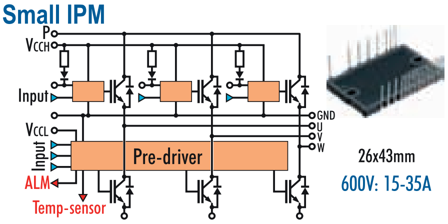


Comparison



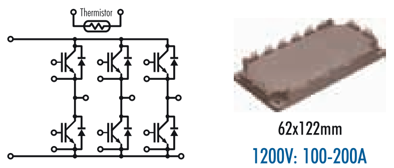
Line-Up

Small IPM



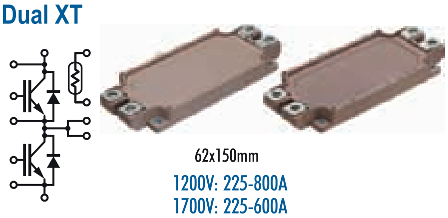
26x43mm
600V: 15-35A

6-Pack



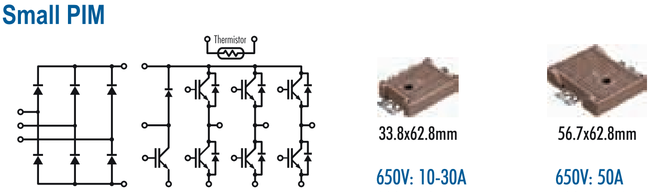
62x122mm
1200V: 100-200A

Dual XT



62x150mm
1200V: 225-800A
1700V: 225-600A

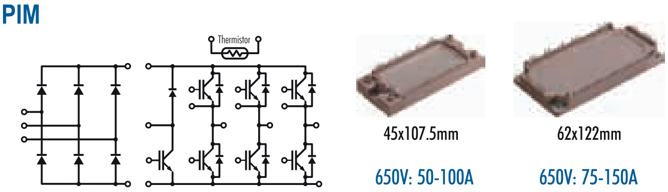
Small PIM



33.8x62.8mm
650V: 10-30A
1200V: 10-25A

56.7x62.8mm
650V: 50A
1200V: 15-35A

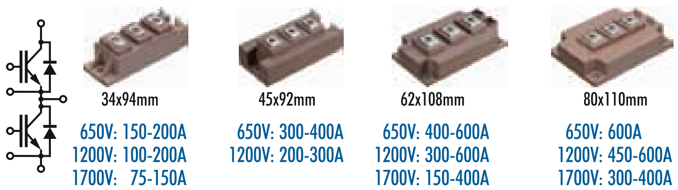
PIM



45x107.5mm
650V: 50-100A
1200V: 35-75A

62x122mm
650V: 75-150A
1200V: 75-150A

Standard 2-Pack



34x94mm
650V: 150-200A
1200V: 100-200A
1700V: 75-150A

45x92mm
650V: 300-400A
1200V: 200-300A

62x108mm
650V: 400-600A
1200V: 300-600A
1700V: 150-400A

80x110mm
650V: 600A
1200V: 450-600A
1700V: 300-400A

High power 2-Pack

89x172mm
1200V: 900-1200A
1700V: 650-1200A

89x250mm
1200V: 1400-1800A
1700V: 1000-1800A

Fuji Electric
Innovating Energy Technology

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info.semi@fujielectric-europe.com
www.fujielectric-europe.com

20 Year Warranty and 95% Power Guarantee for Stationary Energy Storage

ViZn Energy Systems Inc. announced an optional 95 percent power guarantee on their large scale energy storage systems for up to 20 years for their non-toxic flow battery energy storage systems, independent of battery duty cycle or energy throughput.

This guarantee is made possible because, unlike lithium-ion batteries, flow batteries avoid traditional wear out mechanisms that can degrade battery power and capacity over time. Contrast this with other stationary storage systems that are frequently oversized up to 40 % to account for anticipated degradation or wear-out and have life-limiting dependencies due to temperature variations, discharge power amounts, and discharge cycles. In economic terms, developers, installers, and integrators can count on a stationary storage system that delivers high power services and high energy capacity for the life of their system. There is no longer a need to account for added costs such as cell replacement, out-of-coverage O&M, and reduced performance typically experienced with today's lithium-ion battery systems. "Lithium-ion battery life and their limited warranties have been one of the limiting factors for the widespread adoption of energy storage," said Ron Van Dell, CEO of ViZn Energy Systems. "Our flow batteries have been thoroughly evaluated for longevity and performance over a long system life. The system's long term warranty will give utilities, developers, and banks confidence that their energy storage is engineered to last as long as the infrastructure or generation system it is typically coupled with." Flow batteries are manufactured by Jabil's ISO 9001-certified production team in Florida and the technology utilizes a non-toxic, low-cost zinc and iron chemistry. ViZn is currently building the largest flow battery in North America and is on track to be the largest global producer of flow batteries by the end of 2016.

www.ViZnEnergy.com

Global Transformer Industry Faces New Efficiency Standards

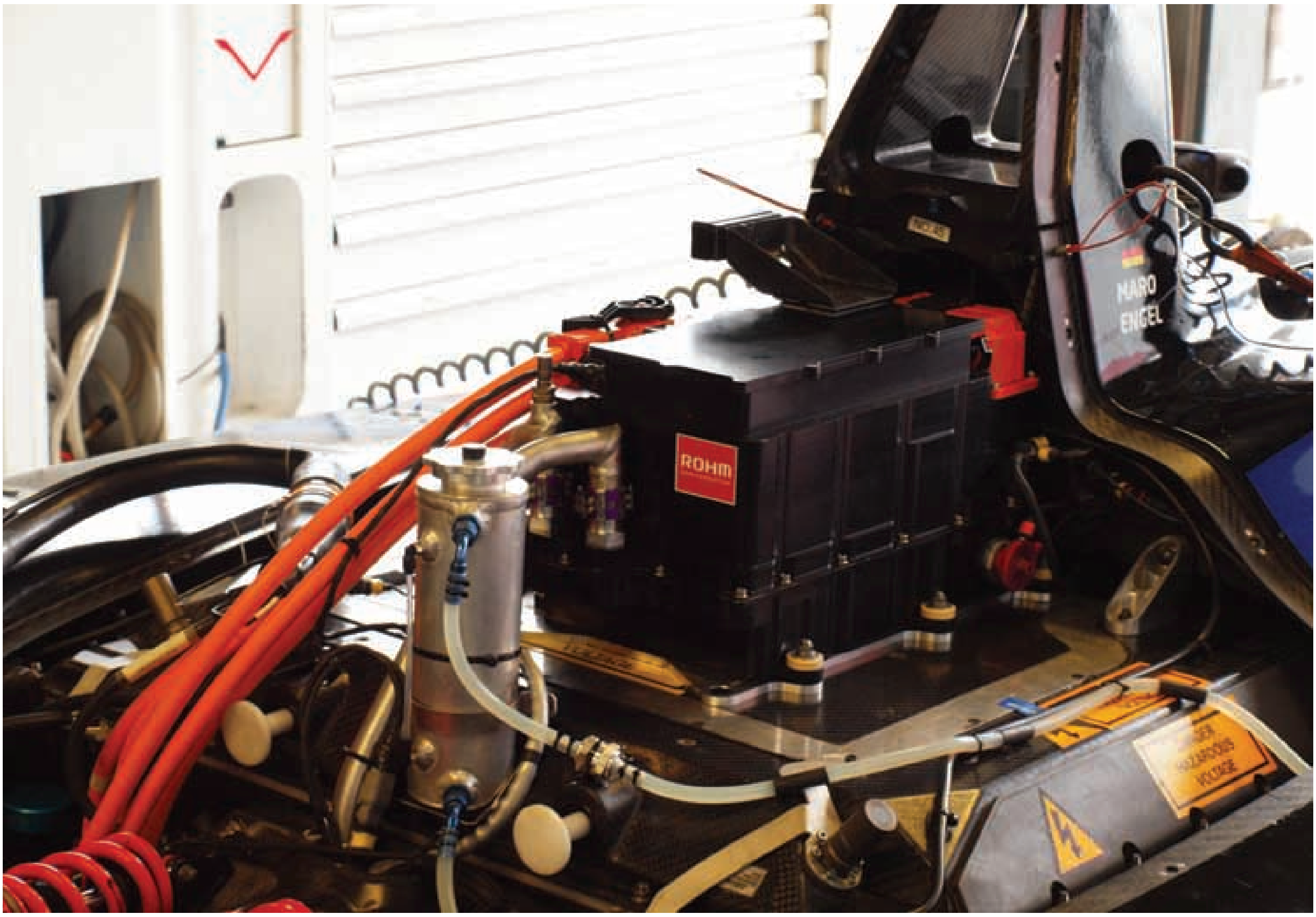
"Environmental concerns are creating a push for different generation sources and more efficient delivery methods in the transformer industry," stated Consultant Ben Ehmcke at CWIEME Chicago

Set to grow 6.7 % by 2020, the global transformer market is currently being affected by a number of headwinds that differ in kind and degree. As countries rush to ratify the Paris Environmental Agreement and to implement changes in several sectors and industries, the transformer community is struggling to find the consistency to plan long-term.

"The truth is the transformer industry and its place in energy policy across the world changes with every news headline," says Ben Ehmcke, president of Ehmcke Consulting. "During the past 12 months the industry has battled a constant onslaught of factors totally outside its control, which feeds uncertainty for manufacturers and suppliers." Protectionism is another volatile concern. In recent years, governments in every continent have felt pressured to hit the breaks on international trade, as countries grow skeptical of the advantages of open economic borders. "Protectionism is a growing trend impacting both raw materials and finished products. At the same time, environmental concerns are creating a push for different generation sources and more efficient delivery methods," states Ehmcke, who presided a seminar on the topic at CWIEME Chicago 2016, the coil winding and electro-magnetic event whch took place in early October. Entitled "Geopolitical Impact on the Global Transformer Industry," the discussion went over some of the market shifts helping to shape the industry, such as efficiency standards rules in the U.S., Japan and South Korea, import policies in India and other developing nations, the impact of renewables, the industry's latest mergers and the consequences of Brexit. "There are certainly more questions than answers out there at this time," Ehmcke says. "It's a subject nobody wants to talk about, but it's crucial to keep an eye on the developments so we can adjust and prepare for whatever comes our way."

www.coilwindingexpo.com

ROHM Supports SiC Technology for Formula E



At the start of season three, ROHM Semiconductor started sponsoring and officially partnering with the Venturi Formula E team. The collaboration highlights the key to success in the all-electric racing series – power management. The challenge of Formula E is to find the most efficient way of using the energy provided by the battery and applying it on the road. ROHM's Silicon Carbide (SiC) power semiconductors can withstand much higher electric fields than conventional Silicon, which results in extremely low losses of power and higher temperature resistance. Thus, ROHM and Venturi hope to gain an edge over the competition while also pushing forward the development of new technical solutions to increase power conversion efficiency.

The inverter for season 3 features embedded SiC Schottky diodes, making it 2 kg lighter than the inverter for season 2. Electric efficiency has been increased by 1.7 %, while the volume of heat extraction components has been reduced by 30 %. But this is just a start. In season 4, the SiC MOSFET integrated inverter will demonstrate drastic changes once again. Bringing SiC technology to Formula E and to e-mobility in general is an important step in changing drive technology. Furthermore, ROHM is taking an active role in revolutionizing energy policy. When the presentation with Venturi illustrates how effective the new technology works, SiC power devices will make their way into serial production. "Formula E is all about power management, and the partnership with ROHM improves the overall electronics of our car so we can reach higher performance with our electric motors.", commented Franck Baldet, CTO of the Venturi Formula E team. In the automotive sector, an increasing number of EVs and inverters are adopting the use of SiC. "In the coming years, we should see SiC devices increasingly find their way into power electronics for hybrid and all-electric vehicles, creating simpler and more efficient power systems. By making more economical technologies available for a wide array of industries and larger parts of society, we hope to take a prominent role in revolutionizing energy policy", stated Kazuhide Ino, General Manager of the Power Device Division at ROHM.

www.rohm.com/eu, http://rohm.com/fe/

Focus Automotive Electronics

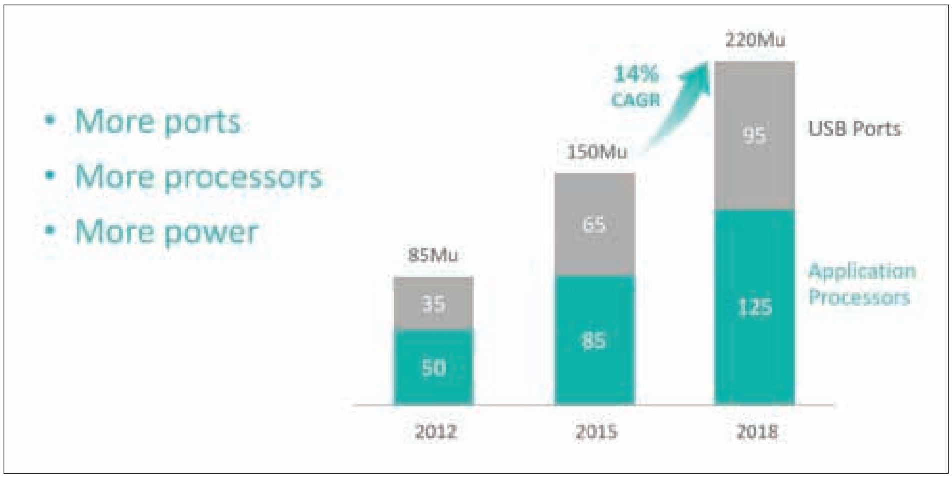
Electronica 2014 has achieved an outstanding result: more than 73,000 visitors from over 80 countries and 2,737 exhibitors from 50 countries. This number is outperformed at electronica 2016 on Munich's fairgrounds from November 8–11.

"Electronica 2016 attracted 2898 exhibitors, an increase of eight percent to 2014 in 13 halls, meaning one additional hall. And we welcomed again more than 70,000 visitors from around the world", said Frank Senger, General Manager Munich Fair. "This year's motto - connected worlds - can be experienced, particularly in the automotive sector."

Automotive electronics is on the rise around the world - according to the German Electrical and Electronic Manufacturers' Association (**www.ZVEI.org**), global demand for semiconductors for automotive electronics was worth nearly 35 billion dollars in 2014. This can be illustrated by the growing number of electronic control units (ECUs) within a car. "Today there are 200 ECUs in a BMW 3 model, in 1993 it was only 3", said Kent Robinett, VP Automotive Sales at Maxim Integrated (**www.maximintegrated.com**). "A typical mid-class car today contains a semiconductor content of around $350", explained NXP's (**www.nxp.com**) General Manager Automotive, Kurt Sievers. "And in electric vehicles this content will be doubled. Though a lot of ECUs for motor management and the gearbox can be eliminated, this will be offset by more power semiconductors and the efforts for electrical power and battery management". Another very interesting market for the semiconductor industry is the trend towards self-driving. "The Diesel discussion increases the pressure on the automotive industry to develop not only electric, but also self-driving or autonomous vehicles particularly for urban transport in megacities. The way towards self-driving can be split into four levels with level 1 incorporating front radar, level 2 incorporating ADAS, level 3 meaning semi-autonomous and level 4 meaning fully autonomous – ten years from now. Level 3 will double the semiconductor content of a car up to $700, and we would be very satisfied to reach this level. Level 4 would not lead to a significant increase. Radar and LiDAR are the most promising technologies in the future", Sievers explained. According to market researcher Gartner (**www.gartner.com**) the automotive semiconductor market is forecast to grow nearly twice as fast as the overall semiconductor industry over the next five years, due to increasing electronic content in vehicles. Thus Automotive will be a focal point of electronica, more than 800 exhibitors have registered for this section of the fair.

But a first step towards automotive electrification respective hybridization is been seen in the move to a 48 V board net. By 2020, automotive 48 V systems will help reduce emissions by up to 15 %, improve fuel consumption, capture energy typically lost while braking, and provide torque in the low RPM range for start-stop mild hybrids. The 48 V

Electronica 2016 attracted 2898 exhibitors, an increase of eight percent to 2014 in 13 halls, and morre than 70,000 visitors



New automotive features require more efficient power management (Automotive ICs in millions)
Source: Strategy Analytics/Maxim Integrated

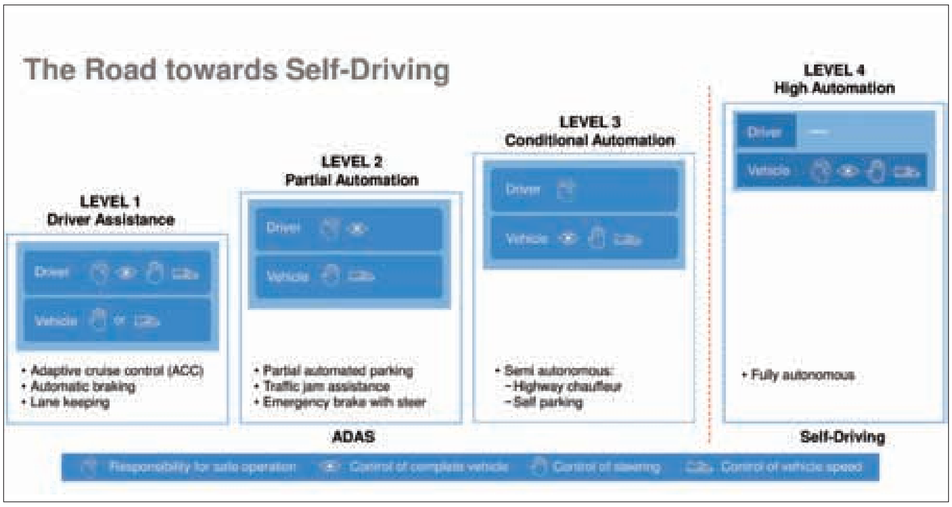
power net is needed to manage the next generation of energy efficient electrical systems that require more power than available with the existing 12 V subsystem. To reduce weight, many traditionally mechanical/hydraulic systems such as power steering, roll stabilization, heating, and air conditioning will be converted to 48 V electrical drive. A new electric turbocharger will provide on-demand horsepower and torque, enabling the use of smaller more efficient combustion engines without sacrificing drive ability. A high-power starter/generator will replace the 12 V alternator, reducing noise and vibration during engine starting while allowing regenerative braking to recapture up to 4x more of the available kinetic energy. The 12 V bus and 12 V lead-acid battery will handle the lighter loads, including ignition, interior lighting, navigation and audio systems. "The 48 V power net extends the available power from 5 to 15 kW, allowing for more electrification", explained Ed Kohler, Power Product Manager at Intersil (**www.intersil.com**). The company demonstrates a 6-phase bidirectional DC/DC controller for 12V-48V power supply systems at their booth.

Dedicated conference and forum

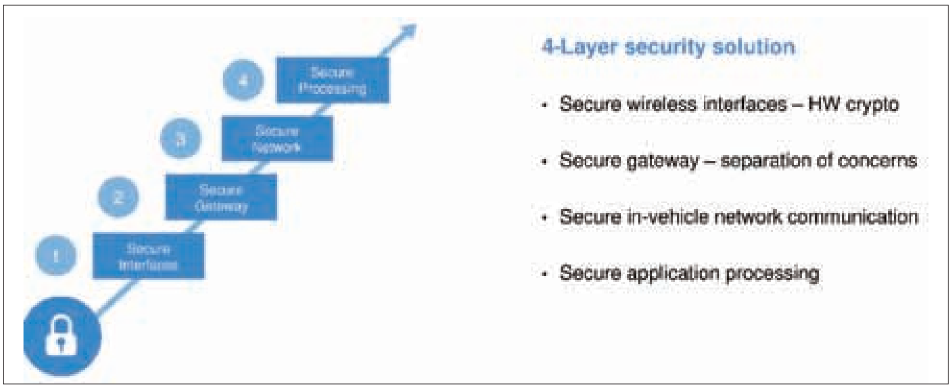
On November 7, the day before the fair begins, leading managers and experts will meet at the electronica Automotive Conference (**www.electronica.de/conferences/automotive-conference/index.html**) to discuss the industry's key issues. The main topics of this year's lectures are safety, automated driving and interior electronics. Steve Nadig from Daimler Trucks North America present a keynote address on "Autonomous Trucks: A Global Perspective." In another keynote address titled "Automotive meets CE," Dr. Ludger Laufenberg (Kostal) explains how autonomous driving is effecting interior electronics. And Dr. Reinhard Ploss (CEO Infineon Technologies) examines the current role of electronics in the automotive industry in a keynote titled "Semiconductors as a key enabler for the transition of the automotive industry." Another conference highlight is the concluding discussion on "The Secure Connected (Self-driving) Car." The participants in that roundtable discussion are Dirk Wollschläger (IBM), Lars Reger (NXP Semiconductors Germany), Dr. Thomas Wollinger (ESCRYPT) and Manfred Bauer (Flexera Software).

The conference's topics are also reflected in the program of the Automotive Forum (**www.electronica.de/supporting-program.html**). Whether it comes to partially or fully autonomous driving, new interior and exterior light functions or improved connectivity - new technologies are changing the development in the automotive industry more than ever. That is why the Forum not only presents the latest solutions and products from the industry's various sectors, but also gives visitors a look at the challenges of increasingly interdisciplinary collaboration in the future. In more than 130 events including panel discussions, technical lectures and roundtable discussions, participants will find out what current market and technology topics are moving the industry.

Exhibitors in this sector are expected to have a number of innovations on display. For example, NXP semiconductor (**www.nxp.com**, A6 #107/335) invites visitors to take a test drive into the future. In cooperation with Siemens, Honda and other partners, the company will present technologies that prevent accidents, reduce traffic and emissions and make drivers' lives easier. They are based on high-resolution radar systems the size of a stamp and compact communication devices in the vehicle that communicate with intelligent traffic lights and signs in real time. Cyber security is also a focus topic, which has been overseen by the automotive industry so far. "All internal bus systems in the car such as CAN, Flexray or Ethernet are open for hacking, Thus a central gateway controllers or hardware-firewalls are in development", Sievers pointed out. According to Infineon (**www.infineon.com/electronica**, A5 #1597506) this central gateway is crucial in the automotive security architecture. It interconnects all ECUs of in-vehicle domains, such as those used in the powertrain, driver assistance, chassis, as well as body and convenience control. The central gateway routes and controls the complete data communication between the ECUs. In addition, it is the central access point for software updates over the air (SOTA) and for diagnostics processes and maintenance updates via the On-Board Diagnostics (OBD) port. "With more connectivity embedded into a vehicle, the protection of critical system functions from cyber threats is paramount," underlined Thomas Boehm, Senior Director, Chassis & ADAS Microcontrollers at Infineon. "The team-up of AURIX with Argus IDPS provides a major building block of that protection enabling automotive system suppliers to benefit from an enhanced cyber security solution", he commented the recent signed cooperation. AURIX microcontrollers provide protection against hackers when trying to infiltrate the on-board systems. They offer up to six cores and scalability in memory (up to 16 MB Flash, more than 6 MB on-chip SRAM) in combination with a rich feature set supporting latest connectivity, such as up to 12 CAN-FD channels, eMMC interface, and Ethernet functionality. "Cyber security needs to be integrated into the entire design and manufacturing processes of vehicles. The Argus IDPS constitutes one significant protection layer



Autonomous or self-driving can double the semiconductor content in future automobiles **Source: NXP**



Cyber-security becomes also a major requirements in future automobiles **Source: NXP**

out of our multi-layered solution suites for the automotive industry", added Yoni Heilbronn, VP at Argus Cyber Security (**www.argus-sec.com**).

Renesas (**www.renesas.com**, A6 #342) will present the electric-drive Artega sports car, which showcases a range of applications driven by its versatile and scalable R-Car, RH850 and RL78 products. With Renesas' infotainment demo, visitors will be able to view a panorama using multiple displays and see how the application seamlessly moves between and across the monitors. They will also see how augmented reality boosts safety and convenience with an ADAS demo, which shows the surround view around the car based on R-Car SoCs and features an overlay of mirror and driver monitoring.

Around 63 % of Germans feel that artificial intelligence in future electronic devices is a good idea. However, consumers feel it is important for smart assistants to know their limits: 84 % want intelligent household robots, smart cars and medical electronics to help people—but they don't want them to make our own thoughts superfluous. That is the result of the Trend Index 2020 survey conducted by electronica by 7,000 consumers in seven countries - including 1,000 representatives of the German population. When asked about autonomous cars, the fact that consumers want smart electronics to help them, but not loose control completely, was very clear. One out of every two German consumers (54 %) said that they had reservations about letting a future smart car take control and drive them to their destination autonomously. But if an intelligent automobile monitors traffic like a driving instructor and only intervenes when the driver makes a mistake behind the wheel, that is completely different. Approximately 60 % of Germans were positive about that type of assisted driving. Obviously automakers should take these figures into consideration in planning next-generation automobiles.

On the first day of the fair the CEO Roundtable under the theme "Connected Worlds—Safe and Secure", will be held at the electronica Forum from 11:00 to 12:00 to discuss the role of the electronics industry when it comes to the security of intelligently networked devices. The participants are Carlo Bozotti from STMicroelectronics, Rick Clemmer from NXP, Prof. Frank H. P. Fitzek from TU Dresden and Deutsche Telekom Professor for Communication Networks and Dr. Reinhard Ploss from Infineon Technologies.

When it comes to developing high-performance LED systems, various technologies are used. The Solid State Lighting Forum at the Forum on November 10 will give an overview. Besides the current state of the art, presentations will deal with interaction between the various technologies that are involved and how they related to one another. After the keynotes and presentations on topics such as "Solid State Lighting and Green Product Design" or "Methods and Concepts for Optimized LED Drivers", tech-panel discussions will give experts a chance to examine trends and future prospects.

Demos on fairgrounds

Analog Devices (**www.analog.com/electronica**, A4 #141) will be back with a broad range of simplified solutions and innovative technologies across 6 application areas, and a total of 18 live demonstrations covering healthcare, instrumentation, process control, automotive, energy and Internet of Things. Separate from the live Automotive demonstrations, ADI experts will also be available to discuss ADAS (Advanced Driver Assistance System) technology solutions in detail, and how this next generation safety system will underpin next-generation autonomous driving automobiles. Of particular interest is the demo "Increase Power Densities for Wide Band-Gap Power Switching Using Isolated Gate Drivers": ADI isolation, process control, sensing and communication technologies directly address the challenges faced by the deployment of WBG power switching and increasingly complicated multi-level control topologies. In industrial power management – 36 V / 3 A step-down regulators for greater efficiency and low noise power converter - a demonstration of the new ADP5003, a 3 A step-down switching regulator with a low-noise linear regulator for post filtering included on the same chip.

Architects of Modern Power (**www.AMPGroup.com**) consortium consisting of CUI (**www.cui.com**, A2 #613), Ericsson Power Modules (**www.ericsson.com**, A4 #260) and Murata (**www.murata-ps.com**, B5 #107) announced a new standard aimed to keep designers of high-performance datacom and telecom equipment one step ahead as cloud computing and IoT continue to drive power density and power requirements higher. Initially supporting 1 kW of output power, the 'HPABC-qbAMP™' standard establishes common mechanical and electrical specifications for high power advanced bus DC/DC converters in distributed power systems. The new standard builds upon the previously released "ABC-ebAMP™' and 'ABC-qbAMP™' that defined standards for eighth brick and quarter brick advanced bus modules ranging from 264 to 300 W and 420 to 468 W, respectively. Measuring 58.42 x 36.83 mm, the 'HPABC-qbAMP' standard occupies the same board space as a standard quarter brick converter. The new specification defines the mechanical and electrical specifications for analog and digital versions, as well as compatible software configuration files for the digital version. The first products to meet with this new 'HPABC-qbAMP' standard will be announced by AMP Group members early next year.

Chomerics (**www.chomerics.com**, B1 #3709 showcase a range of new products and capabilities for shielding and protecting electronics subsystems in applications including automotive, military and aerospace. A custom made control unit that employs its latest technologies to handle EMI/RFI and protect against environmental and thermal effects will be demontrated. The assembly, which was originally developed for an ADAS control unit, includes an electrically conductive plastic cover, microwave absorber material, EMI co-extruded and form-in-place gaskets, and thermal interface materials. Cho-Touch Displays, which integrate touchscreens, optical bonding and high performance LCDs into a complete assembly, will be showcased for the first time. There will also be a preview of a new urethane antenna gasket, which provides an electrically conductive fluid and pressure sealing solution for aerospace applications. Also a newly board level EMI/RFI shielding compound enables significant reductions in shielding footprint.Knowles Capacitors (**www.knowlescapacitors.com**, B6 #336) has developed a range of capacitor products for automotive manufacturers (AEC-Q200 rev D), the company is poised to offer solutions not considered catalogue items. Three such products are 250 V AC Safety Certified Capacitors; high temperature - up to 150°C - X8R Capacitors and Surface Mount EMI Feedthrough Filters. All available with their FlexiCap™ flexible termination to reduce the risk of mechanical cracking. The Syfer branded X8R range incorporates a specially formulated termination to enhance the mechanical performance in harsh environments. X8R dielectric also operates from -55°C to +150°C with a maximum capacitance change ±15% (without applied voltage).

Intersil (**www.intersil.com**, A5 #278) designed the industry's first 6-phase bidirectional PWM controller designed to perform buck and boost power conversions between 12 V and 48 V automotive buses. A single automotive-grade ISL78226 delivers up to 3.75 kW at greater than 95 % conversion efficiency, and is able to

The 48-V Power Net is the base for next-generation mild hybrid vehicles

interleave in a modular master/slave architecture to deliver higher power. This design supports the rapid adoption of 48 V hybrid powertrains that provide improved emissions and better fuel economy for internal combustion engine/electric mild hybrids. One ISL78226 controller eliminates the complexity associated with previous 48V designs. The controller responds to changing load requirements by automatically adding or dropping phases to maximize system efficiency. It can also manage an abrupt change in power conversion direction. For example, if the 48 V starter/generator fails while the vehicle is driving, the DC/DC controller seamlessly reverses power conversion direction so the 12 V battery will temporarily supply the 48 V subsystems, such as power steering, allowing the vehicle to safely pull over and stop. The ISL78226 controller also integrates a digital PMBus™ interface for system control, telemetry and diagnostics that support ISO 26262 functional safety requirements.

Ohmite (**www.ohmite.com**, B6 #101) showcases with the LVM series of low value metal element SMD chip resistors a response to the growing number of current sense applications, featuring an overload rating of 5 times rated power for 5 seconds. LVM has values ranging from 10 to 100 mΩ and TCR values are down to 50 ppm. The industry standard sizes of 0603, 1206, and 2512 will be offered in wattage rating of 1/8, 1/2 and 1 W respectively.

ON Semiconductor (**www.onsemi.com**, A5 #225) who recently acquired Fairchild Semiconductor, will be demonstrating a broadened portfolio of low, medium, and now high voltage devices and solutions for a wide range of end markets including automotive, industrial high power, ultra-low power wearable, Internet of Things, and imaging. Technical demonstrations include solutions with power semiconductors for vehicle electrification such as an on-board charger and motor control, power semiconductors with Silicon and WBG devices (MOSFET, IGBT, SiC discrete and in modules), solutions for motor control and their power supplies, FET-bench online tool to simplify design of buck topologies; or the all new IIoT IDK (development kit) with a variety of sensor, actuator, communication and power supply solutions.

ROHM Semiconductor (**www.rohm.com/eu**, A5 #5429 showcases power management solutions for applications in the automotive, industrial and residential/home area. Based on latest SiC and Si technologies, proprietary processing and packaging technologies, and manufactured in the company's fully owned, vertically integrated production sites. Among others, 3rd gen SiC MOSFETs, SBDs and Modules, LED-Drivers for exterior lighting, design kits for wireless power delivery and the technology partnership with Formula E-car developer Venturi will be shown. Utilizing a proprietary double trench gate structure, the new generation of SiC MOSFETs reduces ON-resistance by 50 % and input capacitance by 35 % in the same chip size compared with planar-type SiC MOSFETs. Adding to the recently announced SBD TO220AC packages at 650 V/ 6, 8 and 10 A, ROHM will introduce D2pak (LPTL) packages and lower currents product like 2 A, 4 A. New full SiC modules including a chopper type module for converters leverage both trench SiC MOSFETs and SiC SBDs. Through the recently announced technical Partnership with Venturi contesting the FIA "Formula E series" for all-electric powertrain single-seater racing cars, ROHM shows the car and SiC-based inverter as an application example to further advance in the area of e-mobility.

Rutronik Automotive (**www.rutronik.com**, A5 #159/262) presents solutions for the 48 V Power Net. Core component is the new decentralized DC/DC converter from itk Engineering. A photo voltaic sunroof from Webasto allows energy harvesting during the drive. The 2 phase, bidirectional DC/DC converter is designed specifically for the energy conversion of 48V- and 12V-Power Nets. It is based on small planar inductors and the latest Power MOS technology. The decentralized point of load converter allows reduced cable diameter and variable implementation. No active cooling is required. Thanks to the extended temperature range (85-105°C), its power range of 400 W up to 700 W, an efficiency of > 98% and the flatness of only 12.5 mm, the DC/DC converter is ideal for many automotive applications, e.g. electrical sunroofs. The photo voltaic sunroof allows energy harvesting during daylight. The energy generated charges the battery for all high power applications.

Texas Instruments (**www.ti.com/electronica**, A4 #219) will showcase innovation focused on the future of industrial automation and automotive technologies, such as the following: GaN technology significantly increases the efficiency in variable speed motor drives; the Evolution Car 2020 (EvoCar) showcases how TI's automotive portfolio, including DLP products, enables ADAS, infotainment, haptic feedback and adaptive LED headlights. **AS**

Isolated Control ICs for Auxiliary Power Supply

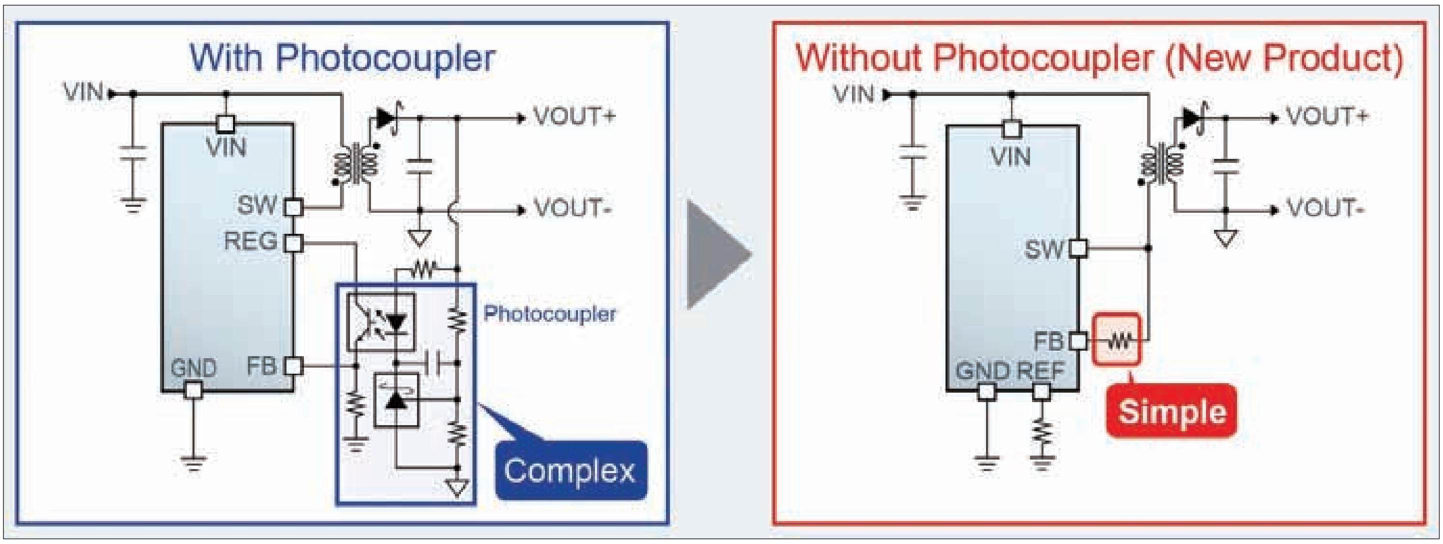
ROHM has recently announced the availability of isolated flyback-type DC/DC converter control ICs for auxiliary supply in industrial equipment such as solar inverters and power storage systems. Following the BD7F100, the company now expands the series with the new BD7F200, covering all applications with a power requirement from 1 to 10 W, and including two different packaging options.

In addition to the control ICs, an evaluation board (BD7F100HFN-EVK-001) is offered integrating the BD7F100HFN-LB, making it easy to evaluate isolated power supply operation (24 V input, 5 V/800 mA output). CE certified 6 variant evaluation boards (BD7F100HFN-EVK-30x) will also be available.

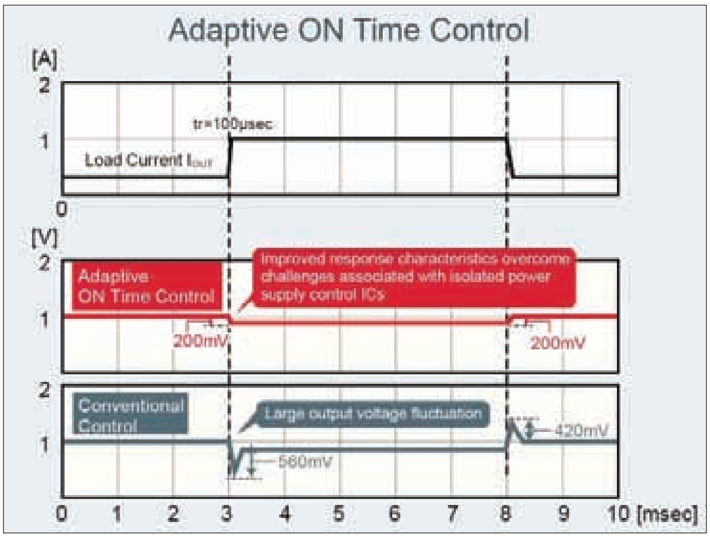
Highly reliable isolation

Isolation is almost always built into electronic equipment to provide protection against shock and damage. With this respect, a broad range of applications such as power metering, industrial programmable logic controllers (PLCs),

ROHM's new flayback controller IC for industrial power supplies



Photocoupler-less design (left) provides reliable isolation using just one resistor (Source: ROHM)



Principle of Adaptive On-Time-Control

Industrial Fieldbus, Industrial automation, IGBTs and SiC MOSFET gate drivers require isolated DC/DC converters. These devices provide galvanic isolation, improve safety and enhance noise immunity. They can generate multiple output voltage rails and dual polarity (positive and negative) rails. High voltage, high power industrial applications (including power storage systems and solar inverters which are seeing increased adoption) are no exception, requiring even more stringent reliability demands due to the harsher temperature conditions and the need for continuous, long-term operation.

Conventional solutions utilize an optocoupler and other components for flyback-type isolated power supply control for the feedback loop. However, this generates challenges associated with current consumption and reliability (including circuit scale and product life). The BD7F series, thanks to its optocoupler-less architecture, allows designers to simplify the development of the transformer and to reduce costs.

It decreases the number of external parts by nearly half by eliminating the need for a photocoupler and a phase compensation network, providing greater energy savings, reliability, and miniaturization. In addition, a newly developed adaptive ON time control method is used to improve load response time (a drawback of conventional isolated power supply ICs), while voltage fluctuation during the load transient is limited to under 200 mV.

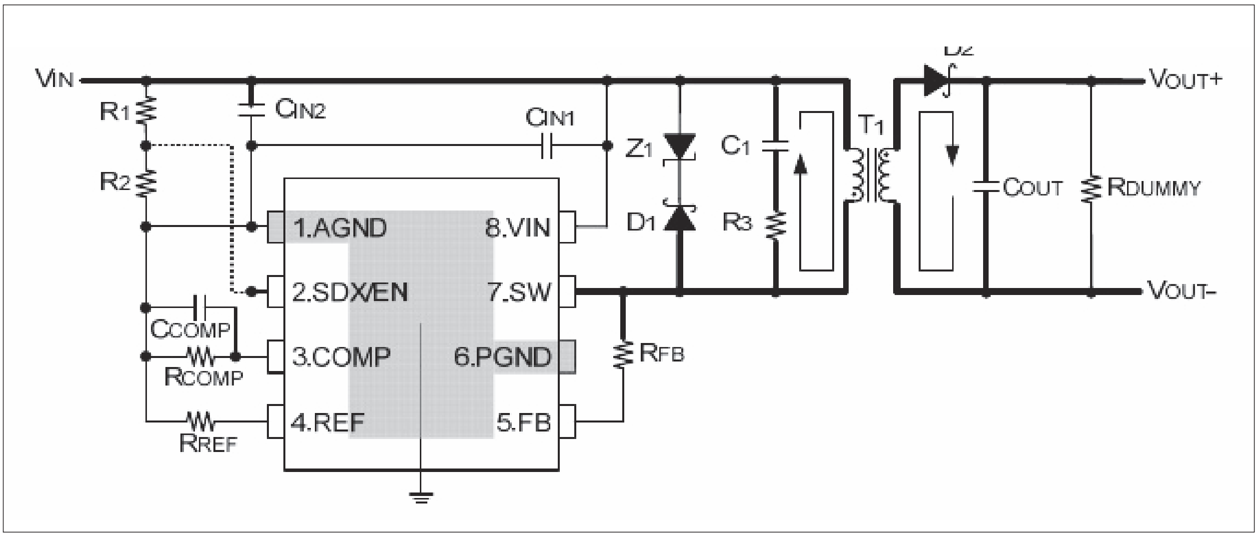
Improved load response

The BD7F series are optimized for industrial equipment requiring continuous, long-term operation under extreme conditions. Utilizing state-of-the-art power BiCDMOS processes and leveraging proprietary advanced analog technology allow ROHM to detect the secondary side voltage and current from the primary side. This eliminates the need for an optocoupler or tertiary transformer winding required with conventional configurations, reducing the number of external parts by half which contributes to greater reliability, power savings, and end-product miniaturization.

ON time control, typically used in conventional isolated power supply control ICs, is adopted to minimize output voltage fluctuations caused by instantaneous changes in load current.

ROHM's new adaptive ON time control method limits output voltage fluctuations to 200 mV, 65 % less than conventional solutions (at a load current of 1 A and rise time of 100 µs). As a result, load response against instantaneous load current fluctuations is improved, increasing reliability considerably.

Thus a highly efficient isolated type power supply application (~ 77 %) can easily be obtained by this control technology which eliminates the need for external phase compensation parts. The off time is determined by comparing the reference voltage inside the IC with the information which was obtained by the feedback of the secondary output voltage through primary flyback voltage. Initially the witching frequency is fixed at 400 kHz for PWM operation when the load stabilizes. During load current fluctuation, the ON-Time Control will operate and the switching frequency will change, thus high-speed load response is obtained. During light load, high efficiency is obtained because the



Typical application schematic (dotted area another PCD layer)

Part No.	Package	Output Power	Max. Input Voltage	Input Voltage Range	Overcurrent Limit	Switching Frequency	Operating Temp.	Functions
BD7F100HFN-LB	HSON8 (2.9x3.0x0.6mm)	1W (Vin=5V) 5W (Vin=24V)	45V	3.0 to 40V	1.25A	400kHz (Typ.)	-40°C to +125°C	Enable Soft Start Efficient Light Load Mode UVLO Over Current Protection Thermal Shutdown
BD7F100EFJ-LB	HTSOP-J8 (4.9x6.0x1.0mm)							
BD7F200HFN-LB	HSON8 (2.9x3.0x0.6mm)	10W (Vin=24V)		8.0 to 40V	2.75A			
BD7F200EFJ-LB	HTSOP-J8 (4.9x6.0x1.0mm)							

Line-up of ROHM's flyback ICs

Please take the following points into consideration when designing the PCB layout.

1. Place input ceramic capacitors C_{IN1} and C_{IN2} as close as possible to VIN terminal on the same PCB surface with IC.
2. Shorten the thick line as short as possible with wide width pattern.
3. Place R_{REF} as close as possible to REF terminal.
4. Place R_{FB} as close as possible to FB terminal.
5. Place transformer T_1 close to SW terminal and make the current loop indicated as an arrow (primary side) short. In addition, make the pattern of the SW node as thick and short as possible.
6. Place output diode D_2 close to SW terminal and make the current loop indicated as an arrow (secondary side) short.
7. In case of multilayer board, do not place GND layer or V_{OUT-} node pattern in the internal layer that is just below the SW node pattern and D_2 anode pattern.
8. R_{COMP} and C_{COMP} are for load compensation function. Short the COMP terminal to the GND when the load compensation function is not used.
9. Connect the exposed die pad to the GND plane.
10. Please note that temperature of the IC increase as BD7F200 has higher output power than BD7F100.

PCB layout considerations for a flyback power supply

switching frequency decreases. To achieve a stable output voltage, the built-in N-MOSFET senses and feeds back information on the output voltage on the secondary side (which was isolated by the transformer) by using the SW terminal voltage on the primary side (during OFF time). Meaning, the output will not be regulated in any case unless the MOSFET is in switching operation. During light load, the switching operation uses minimum ON time. The output voltage may rise when there is a small load current since it will supply the least amount of energy to the secondary side output. Therefore, it is necessary to add a dummy resistor etc. to the output in order to secure minimum load current.

www.rohm.com/eu

Solar Panels Can Gain Thirty Percent Additional Power with Cell-String Optimizer

Over the past several years, DC optimizers have become an important technological ingredient in many residential and commercial solar system designs. By adding these devices to each module, system designers can reduce the power loss from shade obstructions, thus safeguarding systems against long-term module mismatch from uneven soiling or debris.

Many researchers, engineers and scientists have developed over the past 20 years a variety of electronic solutions to improve the efficiency of solar module energy output. Many existing products, such as microinverters, DC optimizers, smart modules, and string-level performance monitoring systems, are available for those investors or home users who are looking for a better return on their investments. Up until now, however, there are no electronic solutions that effectively improve solar modules. A module-level optimizer prevents under-performing modules from harming overall system performance, but does little to minimize energy loss caused by shading, soiling, or hot spots within the module.

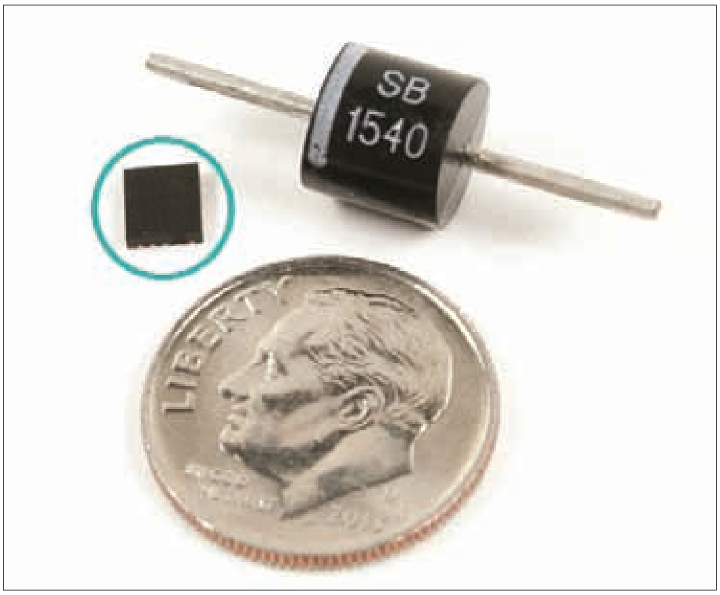
Increased Energy Harvest

Since solar modules are connected in series to form strings, the same current must flow through all the modules. But due to shading caused by moving clouds, leaves from trees, soiling, or module power tolerance, each module needs to work at a different current to achieve its maximum power point (MPP). Due to the series connection, the worst-performing modules wind up determining the string current, which in turn means that the other modules will deliver less power than they are capable of producing.

In a conventional solar module, three bypass diodes combine to serve as a protection mechanism, allowing the module to produce power even when one of its cell strings is shaded or damaged. When the bypass diode is active, the energy production of the entire cell string is lost, even when only a small portion is shaded. The active diode now carries current, which creates heat and stress that can lead to premature failure. Such a failure results in a permanent loss of cell-string output, and potentially presents a safety issue, as the under-performing cell-string is now forced to operate in a dangerous, reverse bias condition.

A growing number of module manufacturers have begun to include first-generation DC optimizers from various system integration manufacturers. PV module OEMs are now incorporating the next generation of DC performance optimization: a highly-integrated power regulator included on each cell-string within the solar module. This new solution brings more production upside while also addressing the limitations of first-generation solutions.

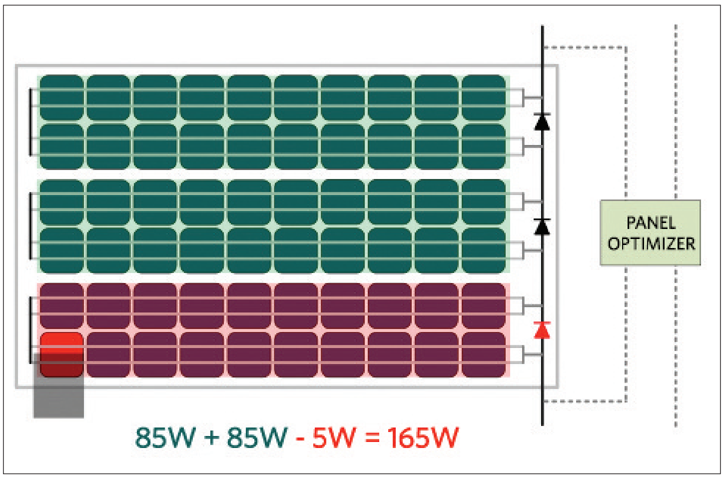
Widespread adoption of this technology is expected in geographies and solar market



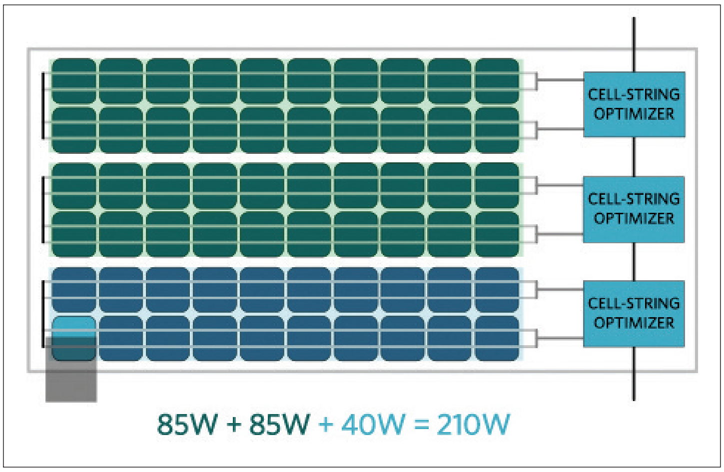
Power IC to perform MPPT and to be embedded within the PV module

segments that have never before considered DC optimizers. By designing it into a solar project, developers can

- have additional performance gains by building MPPT into the cells, rather than outside the module.
- address obstruction scenarios that module-level products can't improve, such as cross-bank shading or even soiling patterns.
- eliminate hot-spot conditions associated with diode operation, improving long-term module reliability.
- continue to deploy conventional installation processes, but without the increased labor needed to install optimizer boxes, additional wiring, communication devices, Internet connections, or proprietary inverters.



Conventional or panel optimizer panels



Cell-string optimizer panels

Solar cell optimizer

Conventional solar systems are limited in performance by the series connectivity of modules: forcing the string current to equal that of the least illuminated or weakest cells. Maxim solar cell optimizer works by boosting the current of the weak cells to match those of the stronger,

eliminating the corresponding performance penalty of the conventional system. The solar cell optimizer's MPPT function works alongside the inverter MPPT, to ensure that the system output is optimal under any environmental conditions. The module includes three Maxim solar cell optimizers, which replace the three diodes found in a conventional module junction box.

When one cell is shaded, the smart IC chip will increase the current output from the cell-string to match that of neighboring, unshaded cell-strings. The shaded cell-string will continue to contribute all available energy, without affecting the production of unshaded strings.

During the long-term operation of a PV power plant, the solar modules suffer aging, cell microcracks, potential induced degradation (PID) and so on, which will cause power loss. A module-level optimizer can prevent an under-performing module from harming overall system performance, but cannot reduce loss caused by degradation within one panel. Integrating solar cell optimizers into a module, by contrast, permits a redesign that brings MPPT to every cell string within the module. As a result, output can be optimized at the cell-string level - a far more finely-tuned solution.

Because the Maxim module does not utilize diodes to manage power production, a cell-string will not be bypassed even if fully shaded (the diffuse light will still generate some energy). And, because all available energy is being harvested, a shaded cell is not in reverse bias, thus eliminating the cause of hot spots and removing a common cause of long-term cell stress. Should environmental conditions still result in a cracked or otherwise degraded cell, this cell will only affect the performance of its local cell-string, without further affecting the module or array.

Flexibility in design

By incorporating modules with solar cell optimizers, system designers can accomodate differing string lengths, multiple orientations, and different module power levels. The technology expands the string's peak power output over a wider voltage range. This greater power output allows two uneven strings to be connected in parallel, so the inverter can find an operating voltage at which both produce their peak power. This flexibility, which accommodates the site location, is not possible in a conventional system, where an inverter finds a single operating point that does not achieve peak power from either string. "Unlike the diodes they replace, solar cell optimizers do not bypass weak cell strings. Instead, they allow each cell string to deliver maximum power under any environmental conditions, enabling you to harvest more energy, achieve denser panel layouts, and improve system reliability. The granularity of our cell-string optimizers offers best-in-class shade mitigation, enables flexible system design without adding complexity, and helps improve panel lifetime performance," said Seth Kahn, Executive Director, Solar Products, Maxim Integrated. "Major PV module companies have recognized the advantages of this unique technology, the first integrated power semiconductor for MPPT, and are ramping it in volume production." To mention are JinkoSolar, ET Solar, Fronius, Hanwha Q CELLS, Suntech, or Trina Solar.

http://bit.ly/SolarCellOptimizers, www.maximintegrated.com

Digital Hybrid Controller Simplifies Power Supply Design

Data processing system complexity is growing fast, and the need for intelligent power system management is growing right along with it. Designers now require better system management capabilities like those offered by the new generation of digital PWM controllers. These controllers use on-chip Analog/Digital Converters (ADCs) and Digital/Analalog Converters (DACs) along with signal processing techniques to optimize performance. Designers can even modify the compensation of the control loop via the digital interface, without requiring a change in resistors or capacitors. While these digital controllers can use resistors to configure some basic parameters, the immense flexibility of the digital controller is its ability to provide full software control via the PMBus. **Jerome Johnston, Intersil Corporation, Milpitas, USA**

This article describes how engineers can benefit from a new digital hybrid controller that combines an analog PWM controller with a PMBus interface (see Figure 1). The controller's unique hysteretic current mode topology and patented Resistor Reader interface is examined, and the controller's R4 modulator is compared to voltage mode and constant ON time (COT) modulators. In addition, a software GUI will show how to configure the controller's operating parameters via menu selection. The parameter selections then reveal the appropriate resistor values to be used with the Resistor Reader Interface.

Analog PWM controller with PMBus

Engineers benefit because a digital hybrid controller simplifies power supply design. It's a "digital hybrid" because it combines an analog PWM controller with PMBus. For simplicity of configuration, the digital hybrid controller employs Resistor Reader technology.

The Resistor Reader interface allows the majority of configuration parameters to be selected by choosing a proper resistor value that is connected to special programming pins. The Resistor Reader uses this information to set the controller's operating parameters. Before we further discuss the hysteretic current mode topology of the PWM and the specifics of the Resistor Reader technology, let's first look at the ISL68200's Figure 1 block diagram and present its basic operating capabilities. While the block diagram may look similar to other controllers, this digital hybrid controller offers unique features and performance capabilities.

The ISL68200 supports the single-phase synchronous buck circuit configuration. It operates from 4.5 to 24 V_{in} and provides output volltage from 0.5 to 5.5 V. The controller includes on-chip drivers and is designed to drive n-channel power FETs. It integrates an R4 modulator, Resistor Reader and PMBus interface. The PWM modulator with R4 (Rapid Robust Ripple Regulator) technology is designed to provide the ultra-fast power supply transient response needed by today's advanced CPUs and GPUs. The modulator is an analog control loop based upon a hysteretic current mode topology.

Figure 2 illustrates the control loop, which makes control loop decisions using an internally generated synthetic current signal. Its synthetic ripple generator creates a current ripple waveform using the V_{IN} voltage and the expected V_{OUT} voltage (set by V_{DAC}). Two identical current sources, I1 and I2 flow through resistors R_1 and R_2 to set the thresholds for a hysteresis window. The feedback signal sets the central threshold of the hysteresis window. Any change in the feedback signal due to variations of the

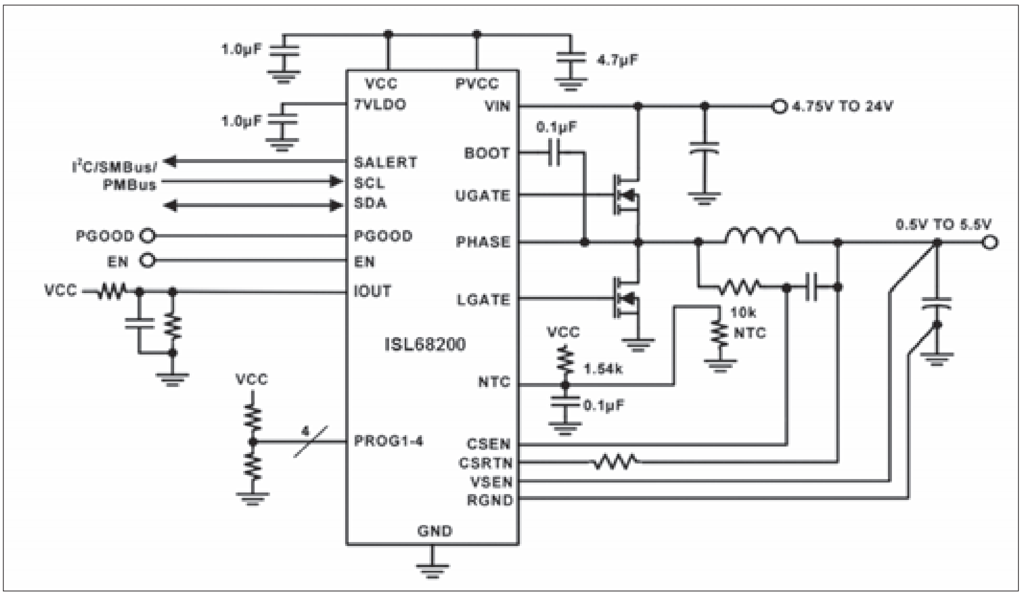


Figure 1: Digital hybrid PWM controller ISL68200 with PMBus output

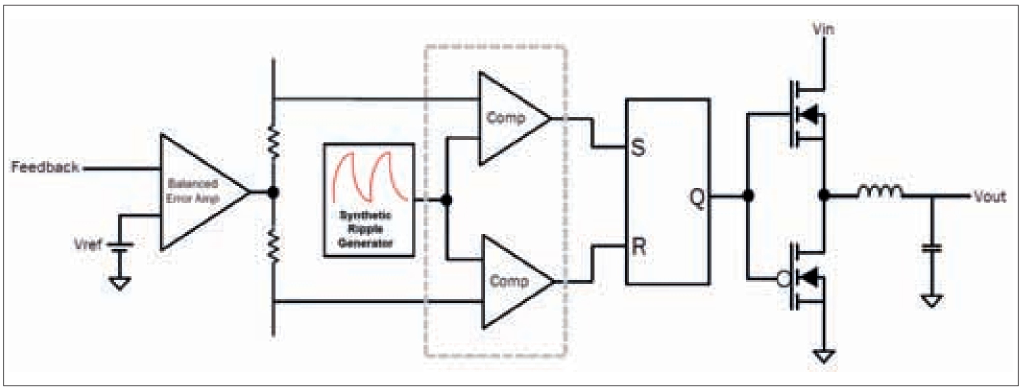


Figure 2: Block diagram of the ISL68200 control loop with synthetic ripple generator

regulator's output voltage modifies the hysteresis window voltages. These voltages are then compared to the synthetic ripple current waveform using two comparators. Both comparator outputs control the PWM flip-flop to determine the PWM duty cycle.

The modulator generates the PWM signal by comparing the output voltage to the synthesized ripple signal. A major advantage of this design is that it offers exceptionally high control loop bandwidth and it is inherently stable. The loop is compensation free and can adjust both the duty cycle and the switching frequency to provide very fast response to load transients.

Transient response evaluation

The ISL68200's transient response was compared in the laboratory to voltage mode controllers and COT controllers. All three circuits were similarly configured:

- V_{in} = 12.0 V
- V_{out} = 1.0V
- switching frequency = 500 kHz
- L_{out} = 220 nH, DCR = 0.25 mΩ
- C_{out} = 220 μF x 4, (ceramic MLCC caps).

Figure 3 shows the response with a 12 A load step. The load step deviation was lower than either the voltage-mode controller or the COT controller. Other parameters, such as load release deviation were also compared. The performance of the ISL68200 was superior in all aspects of transient load behavior.

The load transient performance for each controller circuit was compared and listed in Table 1. The superior transient behavior of the R4 modulator architecture is achieved due to its wide control-loop bandwidth. At the same time, R4's lower loop gain requires no frequency compensation, which makes the loop inherently stable – and there is no overshoot or undershoot, just increased efficiency.

ABOVE Figure 3: Transient response of ISL68200 with a 12 A load step

Configuration with the Resistor Reader Interface

The digital hybrid PWM controller offers an extensive set of configuration options. Configurations are set by selecting an appropriate pin-strap resistor to connect to the patented Resistor Reader interface. The pin-strap resistor is connected between the programming pin and the V_{CC} supply or between the programming pin and ground. An internal ADC determines both the resistor value and whether it's connected to V_{CC} or ground. The measurement result is then used to select register values in the controller that determine that particular resistor's configuration parameters. There are four programming pins (PROG1-PROG4) and the resistors on these pins allow the user to select the following parameters:

Function	R4	Voltage Mode	COT
Load Step Deviation	-14mv	-44mV	-38mV
Load Release Deviation	+33mV	+43mV	+38mV
Pk-Pk Deviation	47mV	87mV	76mV
Over/Undershoot	No	Yes	Yes
Transient Response	Variable Freq. Variable Duty	Fixed Freq. Variable Duty	Variable Freq. Fixed Duty

LEFT Table 1: R4 modulator technology compared to voltage mode and constant ON time (COT) controllers

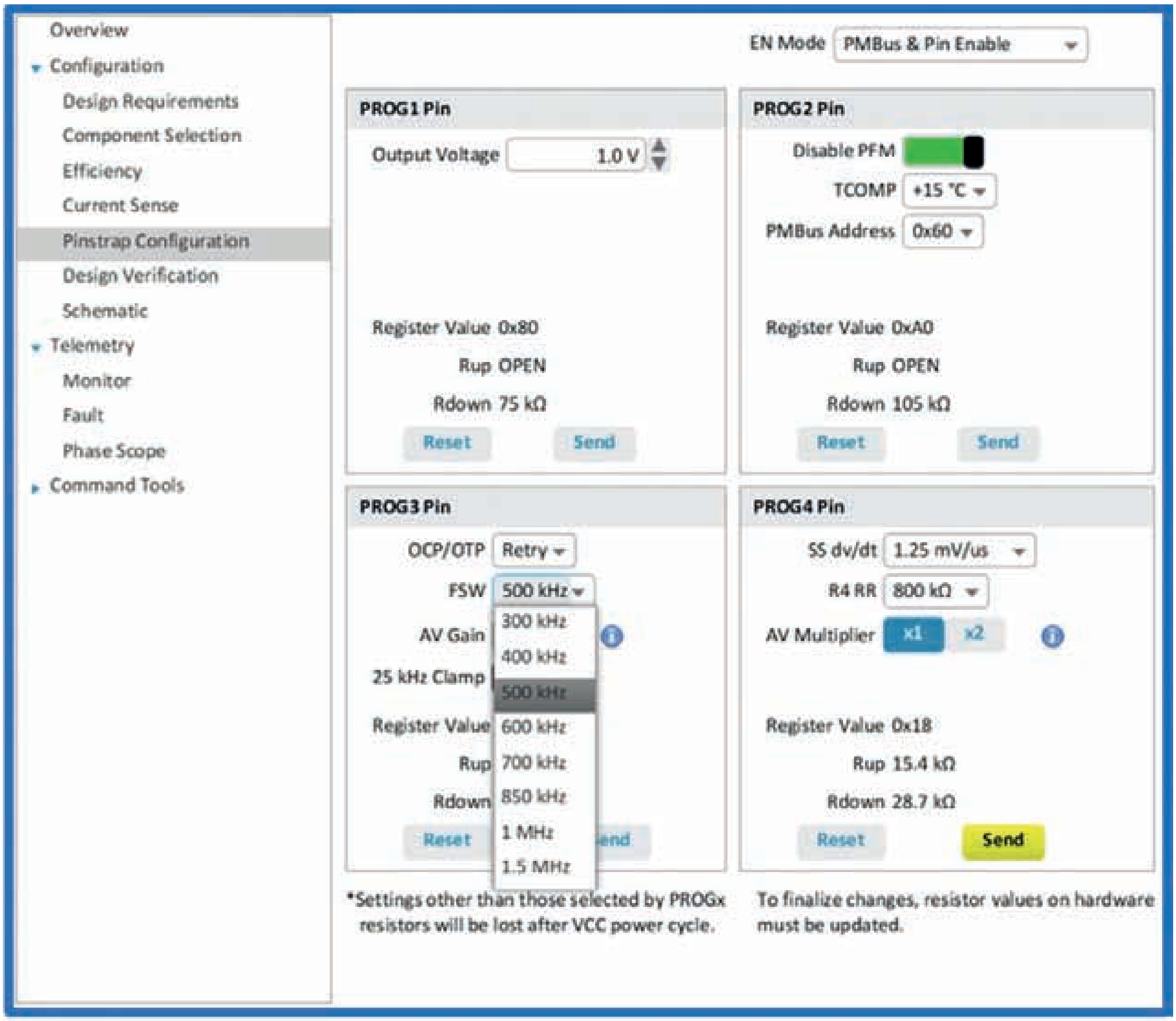


Figure 4. PowerNavigator GUI which guides user to select configuration parameters

PROG1
- Boot up voltage; 256 values between 0.5 and 5.5 V

PROG2
- Selection of forced PWM mode or PFM mode
- Temperature compensation options: four thermal coefficient options for monitoring inductor temperature
- PMBus address; 1 of 32 different addresses

PROG3
- Enable ultrasonic clamp on PFM mode (keeps operating frequency above 25 kHz)
- OCP fault behavior; either latch off or continuous retry
- Switching frequency: 8 options from 300 kHz to 1.5 MHz
- Set error amplifier gain; seven options from 1 to 42

PROG4
- Set soft start and DVID (Dynamic VID) ramp rate
- Select RR impedance for DC feedback into the ripple synthesizer; 4 options from 200 to 800 kΩ
- Set Gain Multiplier in the control loop; 1x or 2x.

For each of the PROG pins, a particular valued resistor connected to the appropriate reference point (V_{cc} or ground) will cause the chip to configure bits in registers to set the selected parameter options upon power up. A single resistor value sets a combination of the variables listed for that particular PROG pin. The data sheet for the device includes tables that show all the option combinations.

PMBus programming

The ISL68200 digital hybrid controller integrates the PMBus (two-wire) interface for telemetry, V_{out} margining, fault reporting or configuration modifications. Since the device has the Resistor Reader programming interface, the PMBus is optional. Telemetry via the PMBus supports reading V_{in}, V_{out}, I_{out}, and temperature. Faults can be read via the STATUS_BYTE. Reported faults include V_{out} over or under voltage, I_{out} over-current, and over-temperature.

The PowerNavigator GUI provides a quick means for users to define all operating parameters. Figure 4 shows the GUI window used to set parameters for setting the pin-strap resistor values. The switching frequency options are expanded in the view.

Conclusion

The ISL68200 digital hybrid PWM controller brings the benefit of superior transient performance to data systems were processors are the dominant load on the system, and the system requires the means to monitor power supply performance and report faults at the full system level. These devices and the software GUI that supports them offer design engineers a fast means to achieve superior power solutions for the most demanding applications.

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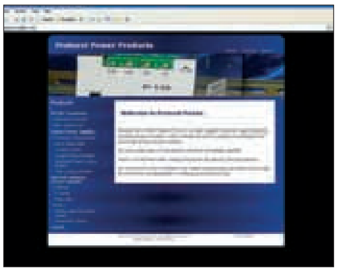

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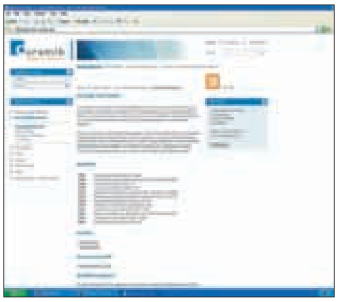

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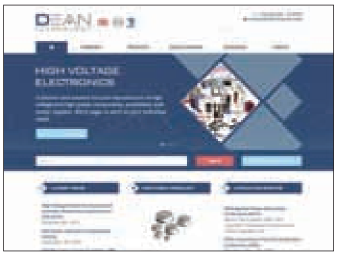

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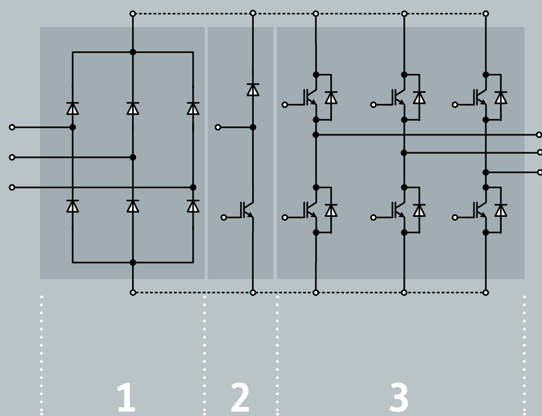

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