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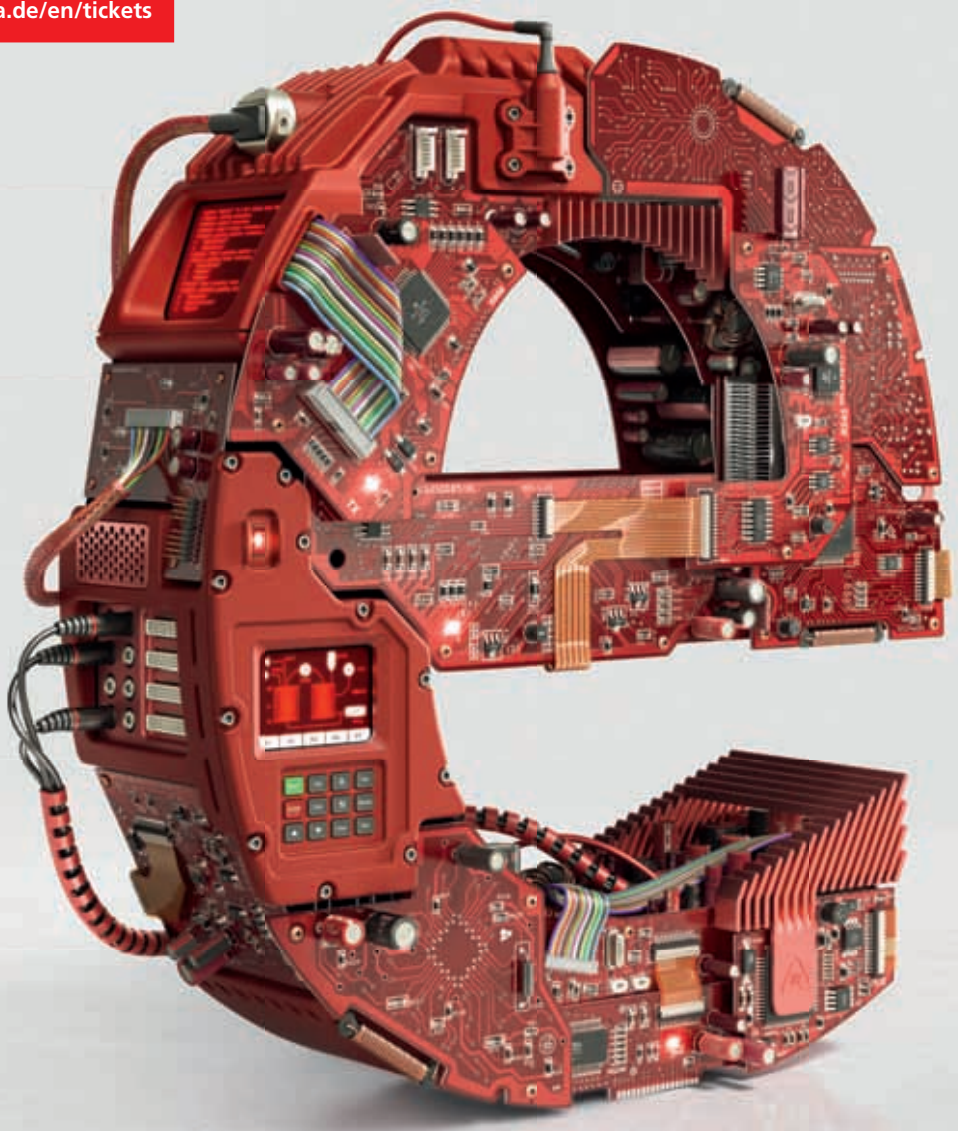

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Consolidation in Power Semiconductor Industry

Infineon and International Rectifier announced on August 20 that they have signed a definitive agreement under which Infineon will acquire International Rectifier for $40 per share in an all-cash transaction valued at approximately $3 billion. With this transaction a € 3.8 billion acquires a $ 1 billion company. The International Rectifier Board of Directors and Infineon's Supervisory Board have approved the transaction. The closing of the transaction is subject to regulatory approvals in various jurisdictions and customary closing conditions, as well as approval of International Rectifier stockholders. The transaction is expected to close late in the calendar year 2014 or early in 2015 subjected to regulatory approval. Infineon remained the world's leading supplier of power semiconductors for the tenth time in a row according to IHS with a share of 11.8 percent of the $15 billion market in 2012 compared with 12 percent in 2011. The number 2 Toshiba had a market share of 7.1 percent, followed by Mitsubishi with 6.9 percent. IR ranks with 5.4 percent at no. 6. "We will do everything possible to defend our leading role with product innovations and system solutions", Infineon's CEO Reinhard Ploss said in December 2013 and now underlined this statement with the acquisition of International Rectifier. He sees IR's activities as a complement to Infineon's product portfolio in Silicon Carbide with their efforts in Gallium Nitride – a promising technology for high-efficiency power electronic systems and power supplies and also sees some market opportunities to transfer some more power semiconductors to Infineon's 300-mm wafer fabs.

Infineon's power module segment revenue increased by 8 percent from €185 million in the second quarter to €200 million in the third quarter (ended June 2014), mainly due to increased demand in renewable energy. Revenue generated by products for home appliances increased, those for industrial drives grew only slightly. Business in traction remained at a high level similar to the previous quarter. Revenue for the power management segment went up from €252 million to €271 million. This 8 percent increase resulted from rising demand for power supply and cellular network infrastructure products, coupled with buoyant seasonal demand at mobile devices. The automotive segment revenue increased from €484 million in the previous three-months period to €510 million in the third quarter of the 2014 fiscal year. Good sales achieved by German premium manufacturers, in combination with high demand for medium-sized vehicles with a high proportion of optional equipment, were largely responsible for the 5 percent increase. At regional level, demand for vehicles was particularly strong in the North American and Chinese markets. Infineon expects further growth in the fourth quarter with an increase in revenue between 3 and 7 percent. For fiscal year 2013 Infineon reported revenue of €3,843 million. At International Rectifier revenue for the June (4.) quarter was $297.6 million, a 10.5% increase compared to $269.3 million in the prior quarter and a 7.6% increase from $276.5 million in the prior year quarter. Revenue for fiscal year 2014 was $1,106.6 million, a 13.3% increase from $977.0 million in fiscal year 2013. Net income for fiscal year 2014 was $58.7 million compared with a net loss of $88.8 million for fiscal year 2013.

Ploss said that intelligent power modules on the lower power side with IR and on the higher power with Infineon solutions will be a synergistic combination. Regarding the Automotive market, Infineon has excellent strength in that market , but the acquisition of IR brings along with it the US automotive relationships (i. e. IR supplies IGBTs for Tesla's main inverter and charger applications) that will make even stronger the company's offerings in this key market. According to current IHS Automotive forecasts, new light vehicle production in 2014 is on track to reach 87 million units globally. By 2021, production is expected to reach 106 million globally. And strong growth is projected for H(EV) vehicles exceeding 5 million annual units by the year 2017 - with additional power semiconductor content for the drive train in the range of $ 300. The accelerated velocity of the global automotive industry is expected to continue in the near term and portfolio expansion into new body styles is driving higher volume per platform as well, according to IHS Automotive. Electronics contents varies between 3 and 5 percent of the car value, thus increasing the market for automotive electronics significantly. Automotive electronics is one of the most important segments in the market for electronic components. Automobiles already have on-board computers as well as infotainment and assistance systems with a constantly growing range of functions. Electromobility, or the increased networking of automobiles and the development of autonomous driving, could mean additional potential for the industry. Thus all in all Infineon's acquisition makes sense – but one major supplier will disappear from the market.

Achim Scharf
PEE Editor

Infineon Technologies to Acquire International Rectifier

Infineon and International Rectifier announced on August 20 that they have signed a definitive agreement under which Infineon will acquire International Rectifier for $40 per share in an all-cash transaction valued at approximately $3 billion.

The acquisition combines two semiconductor companies with leadership positions in power management technology. According to market researcher IHS/IMS Infineon ranks no. 1 with 11.8 % share of the $ 15 billion power semiconductor market while IR ranks with 5.4 % at no. 6. By the integration of International Rectifier, Infineon complements its offerings and will be able to provide customers with an even broader range of innovative products and services also in the automotive market. Infineon will also benefit significantly from greater economies of scale as well as a larger regional footprint particularly in the USA and Asia. "The acquisition of International Rectifier is a unique opportunity. With their great knowledge of specific customer needs and their application understanding, International Rectifier employees will contribute to Infineon's strategic development from product thinking to system understanding and system solutions. The combination of Infineon's and International Rectifier's products, technological and innovative excellence, as well as distributional strength will unleash great potential. We see IR's activities as a complement to our product portfolio in Silicon Carbide with their efforts in Gallium Nitride – a promising technology for high-efficiency power electronic systems and power supplies. Additionally we will gain some new market share in hi rel applications such as aerospace. We also see some market opportunities to transfer some more power semiconductors to our 300-mm wafer fabs", commented Infineon's CEO Reinhard Ploss.

Infineon's CEO Reinhard Ploss expects synergies by acquiring International Rectifier and moving more power semiconductor families to 300-millimeter manufacturing lines Photo: AS

The International Rectifier Board of Directors and Infineon's Supervisory Board have approved the transaction. The closing of the transaction is subject to regulatory approvals in various jurisdictions and customary closing conditions, as well as approval of International Rectifier stockholders. The transaction is expected to close late in the calendar year 2014 or early in 2015 subjected to regulatory approval. "This transaction provides significant value to our stockholders and opens new strategic opportunities for both our customers and employees. By combining two complementary providers in power management solutions, International Rectifier will benefit from Infineon's products and technologies, manufacturing and operational excellence and greater R&D said Oleg Khaykin, CEO of International Rectifier. "We have been closing production lines and making other steps to cut costs during restructuring. Infineon will get the benefit of those savings. And our GaN technology, targeted higher than 600V, will now be renewed with Infineon's expertise in high voltage technology".

A first comment from industry: "We are gratified to see that Infineon recognizes the excellent technology developed by International Rectifier. Especially significant is International Rectifier's GaN technology. GaN-on-Silicon transistors are in the process of replacing Silicon-based power MOSFETs and IGBTs, and Infineon, through this acquisition, is showing their recognition of this major technology shift", said Alex Lidow, CEO of Efficient Power Conversion Corporation and former CEO of International Rectifier

www.infineon.com, www.irf.com

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First Chinese 8-Inch IGBT Production Line

UK-based Dynex Semiconductor recently announced that its parent company, CSR Times Electric Co Ltd in China opened a new $240 million IGBT production base in Zhuzhou. The new production base, the first of its kind in China, and the second worldwide, will produce high power IGBT chips and modules using 8-inch Silicon wafers. Annual output is expected to reach 120,000 wafers and 1 million pieces of IGBT modules.

This IGBT line is being operated by the newly formed Semiconductor Business Unit of CSR Times Electric, of which Dynex is the European subsidiary. CSR Times Electric is mainly engaged in the research, development, manufacture and sales of locomotive train power converters, control systems and other train-borne electrical systems, as well as the development, manufacturing and sales of urban railway train electrical systems. In addition, CSR Times Electric is also engaged in the design, manufacturing and sales of electric components including power semiconductor devices for the railway industry, urban railway industry and non-railway purposes.

The technology being used in the new facility has been developed at Lincoln in the UK by the multinational CSR Zhuzhou R&D Centre based at Dynex Semiconductor Ltd. The UK R&D centre was established in 2010 to focus on leading edge power semiconductor technology and specifically the next generation of IGBT products. The new line will initially produce high power modules using the latest soft punch through field stop and trench technologies. CSR began construction of the new 8-inch production line in May 2012. Throughout the build, equipment installation and commissioning Dynex has played a leading role in providing technical advice, support and staff training both in Lincoln and in China. "Since the acquisition of Dynex by CSR Times Electric in 2008 there has been a rapid development in our IGBT capability. We began with 4–inch wafers, then upgraded to 6-inch at our plant in Lincoln. We then extended our technology to support the design of this new facility. It complements our base in the UK by giving us access to a world leading 8-inch IGBT wafer fabrication facility and a high volume module assembly line", commented Paul Taylor, President and CEO of Dynex.

And the next phase of expansion is already being planned. "This targets key markets such as electric automotive and renewable energy. So at our UK R&D Center we are already working on designing the next generation of advanced Silicon and Silicon Carbide power devices, and are busy recruiting new staff to expand our multinational research, design and development teams to meet this exciting new challenge". Additionally, CSR Times Electric will contribute £15.9 million of R&D funding over a three year period commencing January 2014. Together the R&D projects that are being supported by the combination of UK government co-funding, China private funding, and Dynex's own investment will develop the next generation of high power semiconductor devices and production technologies at the Dynex R&D Centre in Lincoln. Most recently Dynex announced that it had been successful in its application to work within a consortium led by Cummins UK to support the development of new stop-start engine capabilities, improving commercial vehicle fuel efficiency and reducing CO2 emissions.

www.dynexsemi.com

Power GaN for India's Solar Industry

Transphorm Inc. is partnering with Tata Power Solar, to introduce India's most efficient solar inverter using Transphorm's GaN power transistorst. The GaN transistor combines low switching and conduction losses, offering reduced energy loss of more than 50 percent compared to conventional Silicon-based power conversion designs.

Under the partnership, Transphorm will supply GaN transistors, while Tata Power Solar will locally manufacture and market the GaN-powered solar inverters. Tata Power Solar was founded in 1989 as a joint venture between Tata Power and British Petroleum Solar (BP Solar). Headquartered in Bangalore, Tata Power Solar operates three manufacturing units in Bangalore, with a production capacity of 200 MW of modules and 180 MW of cells. The first PV Inverter product is scheduled to be released in early 2015. "We are pleased to partner with Transphorm to develop indigenous solar power conversion," said Ajay Goel, CEO, Tata Power Solar. "Our intent is to lead in green energy. The inverter technology being developed has broad applications beyond solar conversion and we anticipate these energy efficient applications will find usage across various Tata companies." Arul Shanmugasundram, EVP Projects and CTO for Tata Power Solar, added: "By designing our solar inverter product family with Transphorm's qualified GaN platform, Tata Power Solar will provide the Indian energy sector with a compact and higher efficiency PV Inverter as well as a roadmap of higher performance and smaller form factor solar PV power. This product family will accelerate India's adoption of solar energy, enabling the goal of using renewables to power 20 percent of India's energy needs by 2020."

www.transphormusa.com, www.tatapowersolar.com

Multi-Motor Electric Vehicles Create a $144 Billion Market

By definition an electric vehicle has an electric motor to propel it along some (hybrid electric) or all of the time (pure electric). The IDTechEx numbers projections finds that a $144 billion market awaits in 2025, boosted by around nine million extra motors for those multi-motor vehicles, most of them land vehicles - particularly cars - with industrial-commercial vehicles following close behind.

The new report presents a comparison of 157 electric traction motor suppliers, some of them the vehicle manufacturers themselves, out of what now may be 200 manufacturers - most of them doing the wrong thing. There are many surprises. Very small vehicle makers increasingly design their own superlative motors. Large companies increasingly integrate them with transmission or controls and simple gearing. In-wheel motors are making progress from a very small base but two in-board motors now appear in a large number of vehicles. For example, the best-selling Toyota Prius has the generator double as a traction motor when extra power is needed, something done on other series- parallel powertrains. Some vehicles have two standard motors ganged together for extra power and IFEVS is succeeding with microcars that have four wheel-drive thanks to one forward axle motor and one at the rear. The need for redundancy and high power to weight ratio leads to 2-30 electric traction motors being seen on electric aircraft. Multi-motors are commonplace on military marine craft for redundancy and space saving.

www.IDTechEx.com

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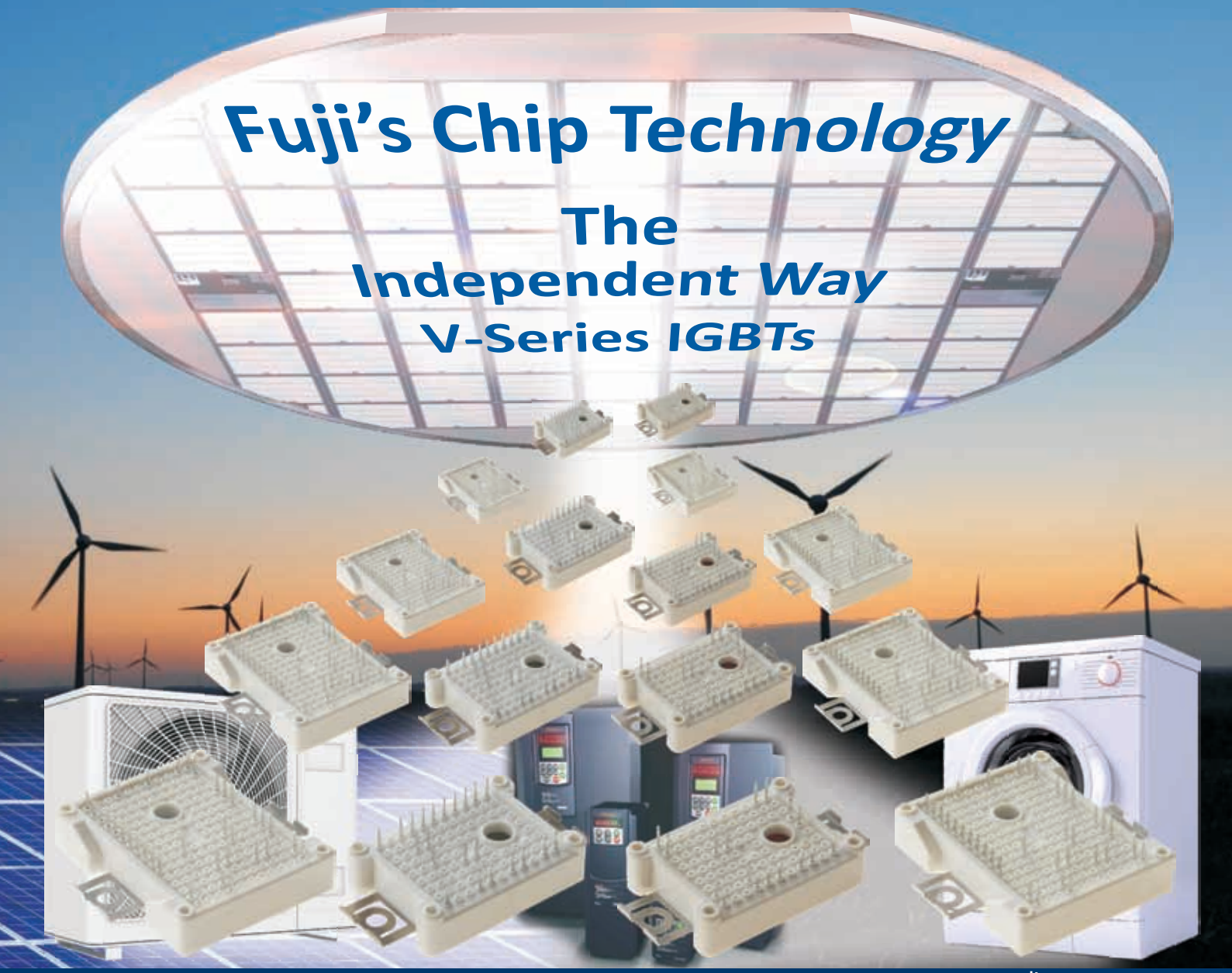

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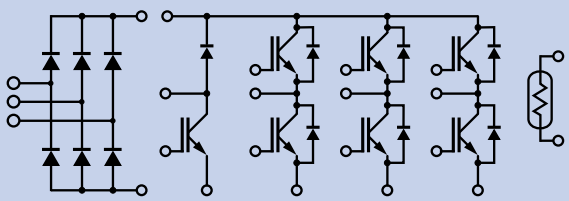
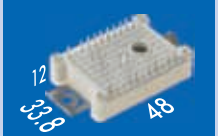


With solder pins

Package	I_C	600V	1200V
	10A	●	●
	15A	●	●
	20A	●	
	30A	●	
	15A		●
	25A		●
	35A		●
	50A	●	

With PressFit contacts

Package	I_C	600V	1200V
	10A	●	●
	15A	●	●
	20A	●	
	30A	●	
	15A		●
	25A		●
	35A		●
	50A	●	

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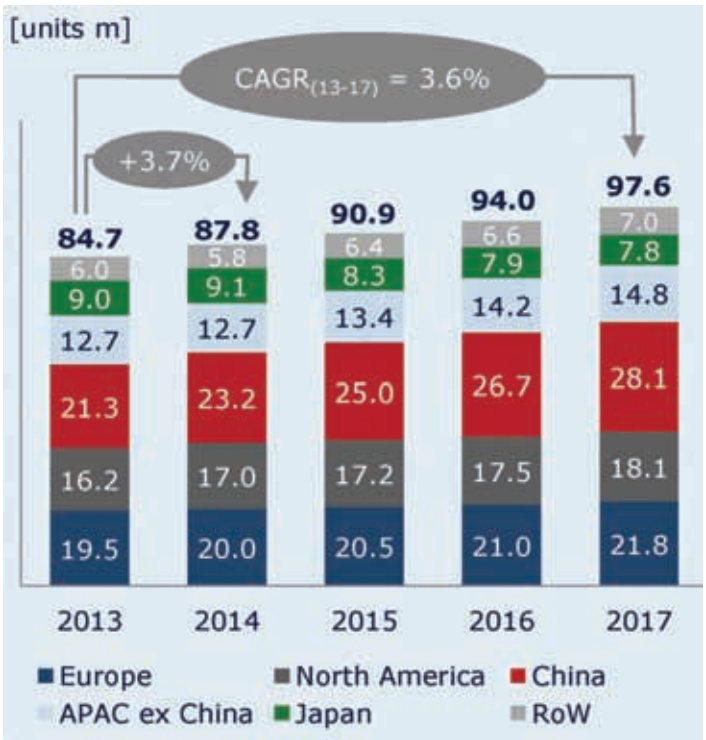
Automotive Industry Drives Power Electronics

The accelerated velocity of the global automotive industry is expected to continue in the near term and portfolio expansion into new body styles is driving higher volume per platform as well, according to IHS Automotive. Electronics contents varies between 3 and 5 percent of the car value, thus increasing the market for automotive electronics significantly.

OEMs are no longer launching vehicles by region; they are often launching the same vehicle at several facilities around the world – within a tightening timeframe. In addition, the integration of global platforms into North America, China and South America increases the cycle velocity. In addition, OEMs and suppliers also are working to implement increasingly complex vehicle and process technology for advanced safety, lighter weight materials, emissions reduction and fuel economy targets in tandem with a global convergence of emissions standards that will further enable the efficiency of global platforms. The strong recovery of the industry brings a new energy to the global market. New light vehicle production in 2014 is on track to reach 17 million units in North America, and 87.7 million units globally. By 2021, production is expected to reach 106.3 million globally and 18.5 million in North America, respectively.

Automotive electronics is one of the most important segments in the market for electronic components. Automobiles already have on-board computers as well as infotainment and assistance systems with a constantly growing range of functions. Electromobility, or the increased networking of automobiles and the development of autonomous driving, could mean additional potential for the industry. The economic development agency



Light vehicle production **Source: IHS**

Germany Trade and Invest expects that global market volume for automotive electronics last year will be worth some $190 billion. According to a forecast by the German Electrical and Electronic Manufacturers' Association (ZVEI), market volume is expected to increase to more than €430 billion by the year 2025. "The future of driving is electrified, automated and networked," says Klaus Meder, Chairman of the Automotive Electronics Division at Robert Bosch. Electronics plays a key role in that development. That is why the value of hardware and software in the automobile will continue to increase in the years to come. Expanded Euro NCAP guidelines, which are used to assess vehicle safety, are driving the spread of assistance systems such as advanced emergency braking systems. Customers and manufacturers alike are putting their money on more and more networked functions in the automobile. However, energy efficiency is also an important topic: "New drive solutions will make it possible to further reduce CO2 emissions and conserve resources," explains Meder. Electromobility in particular calls for new products, particularly when it comes to power electronics. To demonstrate how much progress developments in this area have already made, Robert Bosch is presenting its latest solutions in the semiconductor, sensor and power-module sectors at electronica in Munich from 11-14 November.

The fair not only allows visitors to see the latest technologies: The automotive Forum and the lectures and panel discussions also the perfect opportunity to gather information about the latest developments and trends. During the four days of the 2014 fair, the topics of power electronics and automotive software will be the focus of special attention. The electronica automotive conference is held on November 10. The lectures at this year's conference are divided into three subject areas, i.e. Lighting, Sensor Fusion and Connectivity. The conference will begin with keynotes from Dr. Wolfgang Huhn (Audi AG), Jean-Francois Tarabbia (Valeo) and Prof. Hermann Eul (Intel Corporation). Another conference highlight is the final discussion on the topic "What effects do massive market shifts eastward have on the European automobile industry's capacity for innovation?" Panel discussion participants include Klaus Meder (Robert Bosch), Kurt Sievers (NXP Semiconductors Germany), Karl-Friedrich Stracke (MAGNA STEYR Fahrzeugtechnik) and Prof. Siegfried Wolf (Continental Automotive).

www.ihs.com/automotive. www.electronica.de

PCIM Europe 2015 Call for Papers Open

PCIM Europe 2014 ended on May 22 with a positive outcome. Approximately 8,000 visitors have come to Nuremberg to inform themselves about new products and services in power electronics, power quality and intelligent motion. In total 391 exhibitors and 97 representing companies exhibited an extensive range of products and services to the trade visitors on an area of 20,000 square metres. The conference brought over 700 delegates together discussing the latest perspectives and developments in Power Electronics, Intelligent Motion, Renewable Energy and Energy Management.

PCIM Europe 2014 focused on the latest trends in power electronics components and systems for use in the wind and solar energy sector. Together the exhibition and conference have a role to play in the ambitious project to significantly increase the proportion of renewable energies in generating electricity. With more than 240 presentations on new technological trends in power electronics components and systems, the conference program offered a comprehensive overview of the latest power electronics topics. Special attention has been given to research carried out by young engineers; the presentation of the Young Engineers Award (€ 1,000 price money) and Best Paper Award (€ 1,000 price money + PCIM Asia 2015 visit) sponsored by PEE and Semikron at the opening ceremony ranked amongst the conference highlights.

Now it's time to think about participation at PCIM Europe 2015 with the opened Call for Papers! Deadline for abstracts is October 15, 2014.

www.pcim-europe.com

Power Semiconductor Circuit Breaker for DC Power Grids

Direct current offers many advantages compared to the conventional alternating current used today: For example, losses in power grids and electric devices are a total of 5 to 7 percent smaller than with alternating current. Direct current also makes it possible to more efficiently feed electric energy from regenerative sources into power grids and energy storage and to improve grid stability; with direct current it would be possible to build much more compact electric devices.

In the past the lack of efficient and cost-effective circuit breaker technologies has made it impossible to fully exploit the potentials of direct current, e.g. in distribution grids in data center, photovoltaics and telecommunication systems or in on-board grids for aviation and shipping, electric vehicles and railway technology. The only electromechanical circuit breakers available today implicate the risk of arcing when switching direct current and voltages; furthermore they are slow to react, heavy, unwieldy and expensive.

Funded by the German Federal Ministry of Education and Research (BMBF), the research project "NEST-DC" aims to investigate the foundations of an innovative semiconductor-based and completely electronic circuit breaker for DC power grids and applications. The new circuit breaker should be able to switch direct current on, and most importantly switch it off, as quickly and safely as possible at voltages of up to 1,500 V. Among other things NEST-DC will explore innovative semiconductor components such as the Over Current Blocking Field Effect Transistor (OCB-FET). New structure and connection technologies and switching topologies for the circuit breakers that will use OCB-FETs are to be formulated and tested. There will be demonstrators for the project results in the areas of on-board aviation grids, electromobility and photovoltaics, as well as for direct current distribution networks.

The NEST-DC research partners includes the University of Bremen's Institute for Electrical Drives, Power Electronics, and Devices (IALB) and the four companies Airbus Group, E-T-A Elektrotechnische Apparate GmbH, Siemens AG and Infineon Technologies AG (project coordination). Support is also being provided by the European Center for Power Electronics e.V. (ECPE).

NEST-DC aims to investigate the foundations of semiconductor-based circuit breaker technology for DC power grids
Source: Infineon Technologies

Within the project, the IALB will handle investigation and simulation of novel semiconductor structures for use in the OCB-FETs, static and dynamic measurement of the newly developed circuit breakers and testing their thermal behavior and destruction limits. Airbus Group Innovations will define the requirements for aviation applications, researching a suitable topology and developing a demonstrator together with the NEST-DC partners. The hardware tests will be carried out by Airbus Group in Ottobrunn, Germany. Siemens will concentrate on the structure and connection technologies of the circuit breakers. E-T-A will define the requirements for industrial applications and, together with the partners, will validate the circuit breakers for voltage classes up to 1,500 V. Infineon is leading the project, contributing its power semiconductor expertise and researching power semiconductors intended for use in the OCB-FETs.

The NEST-DC research project is receiving approximately Euro 2.3 million in support from the BMBF in the context of the funding focus area "Power Electronics for Increasing Energy Efficiency". The project began in October 2013 and will run for three years. NEST-DC abbreviates the German for " Innovative Electronic Direct Current Circuit Breakers for Renewable Energies and On-Board Power Networks".

www.ialb.uni-bremen.de

Nano-Supercapacitors for Electric Cars

Unlike batteries that offer limited charging/discharging rates, supercapacitors require only seconds to charge and can feed the electric power back. Supercapacitors are known to possess high power density, whereby large amounts of electrical energy can be provided or captured within short durations, albeit at a short-coming of low energy density. The nano-material graphene, whose extremely high specific surface area and high electrical conductivity practically cries out for use as an electrode material.

Electric cars are very much welcomed in Norway and they are a common sight on the roads of the Scandinavian country – so much so that electric cars topped the list of new vehicle registrations for the second time. This poses a stark contrast to the situation in Germany, where electric vehicles claim only a small portion of the market. Of the 43 million cars on the roads in Germany, only a mere 8000 are electric powered. The main factors discouraging motorists in Germany from switching to electric vehicles are the high investments cost, their short driving ranges and the lack of charging stations. Another major obstacle en route to the mass acceptance of electric cars is the charging time involved. The minutes involved in refueling conventional cars are so many folds shorter that it makes the situation almost incomparable. However, the charging durations could be dramatically shortened with the inclusion of supercapacitors.

These alternative energy storage devices are fast charging and can therefore better support the use of economical energy in electric cars. Taking traditional gasoline-powered vehicles for instance, the action of braking converts the kinetic energy into heat which is dissipated and unused. Per contra, generators on electric vehicles are able to tap into the kinetic energy by converting it into electricity for further usage. This electricity often comes in jolts and requires

storage devices that can withstand high amount of energy input within a short period of time. In this example, supercapacitors with their capability in capturing and storing this converted energy in an instant fits in the picture wholly. Unlike batteries that offer limited charging/discharging rates, supercapacitors require only seconds to charge and can feed the electric power back.

The amount of energy in which supercapacitors are able to store is generally about 10 % that of electrochemical batteries (when the two devices of same weight are being compared). This is precisely where the challenge lies and what the "ElectroGraph" project is attempting to address. ElectroGraph is a project supported by the EU and its consortium consists of ten partners from both research institutes and industries. One of the main tasks of this project was to develop new types of supercapacitors with significantly improved energy storage capacities.

In numerous tests, the researchers investigated the nano-material graphene, whose extremely high specific surface area of up to 2,600 m^2/g and high electrical conductivity practically cries out for use as an electrode material. It consists of an ultrathin monolayer lattice made of carbon atoms. When used as an electrode material, it greatly increases the surface area with the same amount of material. From this aspect, graphene is showing its potential in replacing activated carbon – the material that has been used in commercial supercapacitors to date – which has a specific surface area between 1000 and 1800 m^2/g.

"The space between the electrodes is filled with a liquid electrolyte. We use ionic liquids for this purpose. Graphene-based electrodes together with ionic liquid electrolytes present an ideal material combination where we can operate at higher voltages", explained project coordinator at Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, Carsten Glanz. By arranging the graphene layers in a manner that there is a gap between the individual layers, the researchers were able to establish a manufacturing method that efficiently uses the intrinsic surface area available of this nano-material. This prevents the individual graphene layers from restacking into graphite, which would reduce the storage surface and consequently the amount of energy storage capacity. "Our electrodes have already surpassed commercially available one by 75 percent in terms of storage capacity," Glanz emphasized. "I imagine that the cars of the future will have a battery connected to many capacitors spread throughout the vehicle, which will take over energy supply during high-power demand phases during acceleration for example and ramming up of the air-conditioning system. These capacitors will ease the burden on the battery and cover voltage peaks when starting the car. As a result, the size of massive batteries can be reduced."

In order to present the new technology, the ElectroGraph consortium developed a demonstrator consisting of supercapacitors installed in an automobile side-view mirror and charged by a solar cell in an energetically self-sufficient system.

www.electrograph.eu

Charging Electric Cars Efficiently Inductive

Information is transmitted wirelessly, and power needs can be met via an electromagnetic induction supply system. Researchers are in the process of developing wireless charging technology for electric vehicles, too. It would be much more convenient to charge these plug-in vehicles remotely with contactless technology.

Researchers from the scientific and industrial communities have been working for several years to find ways to use induction to charge electric vehicles. The current approach involves mounting induction coils on the underside of the vehicle and installing charging stations in the ground. But this brings with it a number of significant challenges. The coils need to be very powerful for the method to work because of the significant gap of up to 15 cm between car and ground. Powerful coils are large in size – and large coils are expensive, which pushes up costs. There is also the problem of objects or animals impeding the charging process by blocking the transmission of power. Cats, for example, are attracted by the gentle warmth emitted from the charging station in the ground, and so see this as a comfortable resting place. Another particularly problematic issue is that metallic paper such as chewing-gum wrappers or cigarette packaging can blow under the car and into the induction zone, where it can get so hot that it bursts into flame.

Researchers at the IISB began pursuing an alternative approach in a bid to resolve these problems. Working as part of the Energie Campus Nürnberg research platform it took them less than a year to develop a system for charging electric vehicles from the front end. Since this allows the car to be driven much closer to the induction source – essentially touching it – the coils themselves are much smaller in diameter than in the floor-based version, coming in at 10 instead of 80 cm across. The system is more efficient, more cost-effective and makes it less probable that obstacles will disrupt the flow of energy. The charging column is approximately waist-high and made of plastic. It bends backwards if pushed by the vehicle, and is even designed to flip down and out the way if the pressure applied is too strong. "The car could drive over it if necessary. Touching the charging station causes no damage to the car body," says Dr. Bernd Eckardt, head of the Vehicle Power Electronics department at the Fraunhofer Institute for Integrated Systems and Device Technology IISB in Erlangen, Germany. The coils are arranged in such a way that charging can take place even if the driver has not positioned the vehicle exactly in front of and centrally to the column. Clusters of coils that overlap vertically in the column and horizontally behind the license plate allow the current to flow irrespective of the vehicle's size or height.

Charging electric cars by induction is still a distant vision. By installing the charging system at the front of the vehicle, scientists have found a new efficient and cost-effective approach Source: Fraunhofer IISB

Scientists at the IISB have been working on power electronics for electric vehicles for some twelve years now, and have been researching inductive charging for the last two. During this time they have accrued extensive expertise in the fields of power electronics, field simulation and current distribution within electromagnetic induction systems. In order to keep exchange resistance to a minimum, for instance, they designed coils that themselves consist of several thin coils each insulated one from the other. The design of the wire coils is important because it is the coils that determine the direction and strength of the magnetic field. "We've been consistently upping the system's performance over the past year, and are now in possession of a prototype that is able to transmit three kilowatts (kW) at an overall efficiency of 95 percent. Today's electric car models can be recharged overnight," says Eckardt. The researchers are now looking to further increase the power of the coil, primarily to keep up with developing battery technology, and to cut the cost of the charge spot even further. "Nowadays, charge spots are offered as part of the sales package when customers buy an electric vehicle. This technology will only become a mass product if the price is right," Eckardt explains.

www.iisb.fraunhofer.de

Isolated Digital DC/DC Converter with Black-Box Functionality

The new ADP1055 from Analog Devices is a digital secondary side controller that targets AC/DC and isolated DC/DC secondary side applications. Features include differential remote voltage sense, primary and secondary side current sense, PWM generation, frequency synchronization, redundant OVP, and current sharing. The control loop digital filter and compensation terms are integrated and can be programmed over the PMBus™ interface. Programmable protection features include over-current (OCP), over-voltage (OVP) limiting, under-voltage lockout (UVLO), and external over-temperature (OTP). The digital power controller is available in a 5 mm x 5 mm LFCSP package, an optimal size for high-density, high-frequency, compact, isolated DC/DC power modules or embedded designs for networking, communications and industrial applications operating from 100 W and higher.

The built-in EEPROM provides extensive programming of the integrated loop filter, PWM signal timing, inrush current, and soft start timing and sequencing. Reliability is improved through a built-in checksum and programmable protection circuits.

A GUI is provided for easy design of loop filter characteristics and programming of the safety features. The industry-standard PMBus provides access to the many monitoring and system test functions. The ADP1055 is available in 32-lead LFCSP and operates from a single 3.3 V supply.

Controller architecture

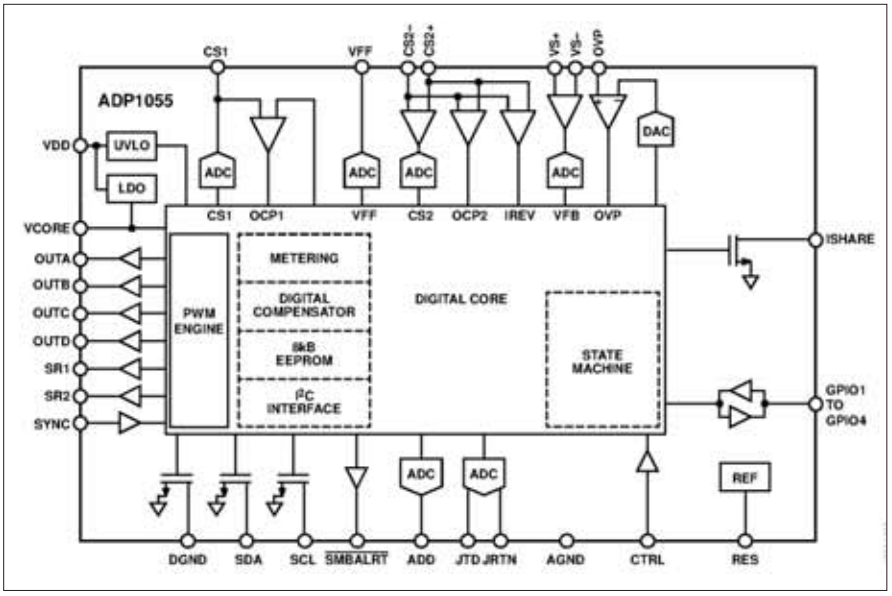
Dedicated ADCs and comparators constitute the analog front end of the controller, feeding information to the digital core. The information is processed and used to generate the programmable PWM signals and to take action for various features such as light load or over-voltage/over-current protection.

The ADP1055 has six PWM outputs: OUTA to OUTD for the primary side switches and SR1 and SR2 for the secondary side synchronous rectifiers. The ADP1055 allows individual programming of the PWM outputs to form the timing of the power switches for any power topology, such as full bridge, full bridge phase shifted, current doubler, or active clamp.

Primary side information (current or voltage) is sensed and processed via the CS1 and VFF pins, whereas secondary side information is obtained via the CS2±, ISHARE, VS±, and OVP pins. A dedicated temperature sensor uses the JTD and JRTN pins. The input voltage is measured using the VFF pin and is

used for line voltage feed-forward. Extensive fault protection schemes are provided, and the controller also has a black box to record the state of the device (all sensor information including voltages, currents, temperatures, and flags) upon shutdown.

I²C/PMBus communication is facilitated by the SDA, SCL, and SMBALRT pins. Four GPIO pins can be used as flag output signals or as an interrupt service routine (ISR) to trigger a PMBus fault action. The CTRL pin is used as described in the PMBus specification.



ADP1055 functional block diagram

Voltage loop autocorrection

Output voltage sampling is performed using the high speed Nyquist ADC. The output voltage is sampled just before the end of the switching period (t_{SW}) or just before half the switching period ($t_{SW/2}$) if double update rate is enabled. The output voltage ripple ramp changes as the input voltage changes, causing the sampling voltage to also change. Assuming a steady state condition, any DC offsets can be eliminated by sampling the output voltage synchronously with the switching frequency.

Due to the relationship between the output voltage ripple ramp and the input voltage, the average output voltage can drift to a higher value when the input voltage is at its maximum value. To correct for this drift, the ADP1055 uses a low frequency autocorrection loop based on the LF ADC on the VS± pins. Under ideal conditions, the voltage on this input is 1.0 V.

The LF ADC is trimmed in production and has high accuracy over supply, voltage, and temperature; therefore, the autocorrection loop eliminates all errors due to offsets in the high frequency ADC. The ADP1055 assumes that the voltage on the LF ADC is accurate and precise and changes the setpoint (or reference) accordingly so that the VS± pins measure 1.0 V. Any additional offset in the output voltage is due to the tolerances of the external resistor dividers alone.

Nonlinear gain/response

To enhance the dynamic performance

of the power supply during a load transient, the nonlinear gain can be used. The error voltage is the reference voltage minus the divided-down output voltage by use of a resistive divider. During steady state, this error voltage is 0 V. During a transient condition, the error voltage is not zero and the digital compensator acts on the error voltage and adjusts the control input to correct for the error.

This may take several switching cycles, especially during a transition from DCM to CCM. In such cases, a boosted error signal aids in reducing the settling time and can even avoid an overshoot in some cases. The ADP1055 has a programmable increase in error voltage depending on how far the absolute error voltage is with respect to 0 V. There are four ranges: 1% to 2%, 2% to 3.5%, 3.5% to 4%, and >4%.

Fast over-voltage protection

A dedicated OVP pin for redundant over-voltage protection is provided, a comparator compares the fractional output voltage by means of resistive dividers to the voltage set by a DAC. The nominal output voltage at the OVP pin is 1 V. The OVP threshold is programmable using Register 0xFE2F[7:2]. A debounce time (from 40 ns to 10 μs) can be added using Register 0xFE2F[1:0] before the fault response is taken. The fault response is set using the manufacturer specific command VOUT_OV_FAST_FAULT (Register 0xFE34).

External frequency synchronization

The SYNC pin is used for frequency synchronization. The internal digital phase-locked loop (DPLL) is capable of determining the master frequency on the SYNC pin (fSYNC) and locking the internal switching frequency to the external frequency. The lock or capture range is ±10% of the switching frequency, which is programmed using the FREQUENCY_SWITCH command (Register 0x33).

The PWM outputs are synchronized to the OUTA pin at the start of the switching period. For example, consider a duty cycle on OUTA where the rising (or falling) edge of OUTA is at a time of x μs after the t = 0 of the switching period. After synchronization, the time difference between the rising edge of the external master synchronization frequency (fSYNC) and the rising (or falling) edge of OUTA is x μs. The other PWM outputs are adjusted accordingly. In short, frequency synchronization also locks on to the phase.

Black box operation

Using a configurable black box feature, the device records to the EEPROM vital data about the faults that cause the system to shut down. When the ADP1055 encounters a fault with the action to shut down the device, a snapshot of the current telemetry is taken, as well as the first fault that caused the shutdown. This black box feature is extremely helpful in troubleshooting a failed system during testing and evaluation. If a system is recalled for failure analysis, it is possible to read this information from the EEPROM to help investigate the root cause of the failure.

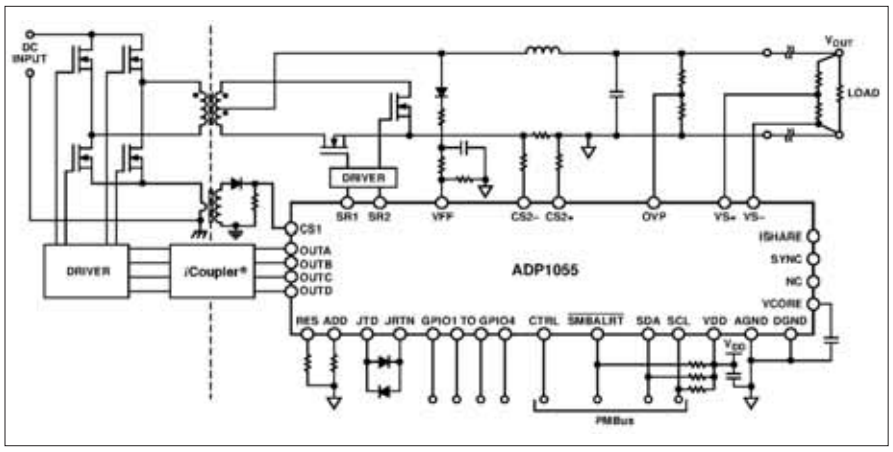
When the ADP1055 is powered up, the contents of the user settings in the EEPROM are downloaded into the internal registers. Immediately after this, the contents of the black box data are read from the EEPROM by the device to determine the last valid Rec_No saved and to determine whether a page erase operation is required before starting up the device in normal mode.

If the highest Rec_No is located on the last record of either page (that is, the next record to store data is at the start of the other page) and the other page has not been erased, the ADP1055 automatically initiates a page erase to the other page to prepare it for further black box recording. A soft start sequence is performed only after the page erase is completed.

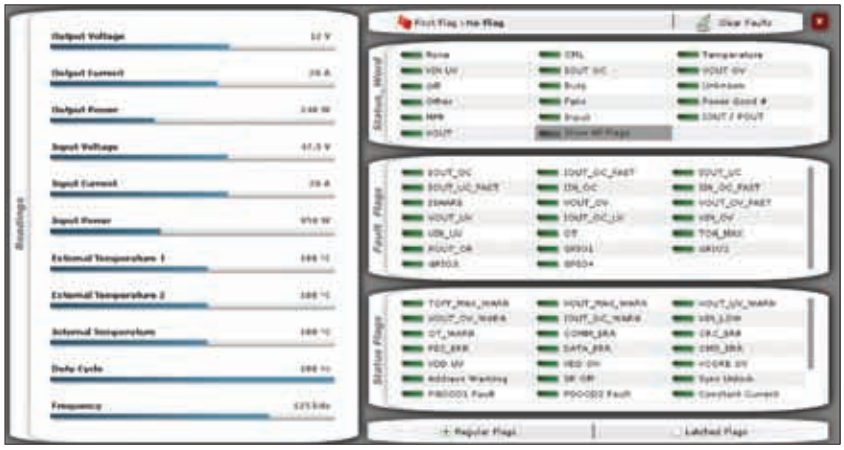
Power supply calibration and trim

The ADP1055 allows the entire power supply to be calibrated and trimmed digitally in the production environment. The device can calibrate items including the output voltage, input voltage, input current, and input power, and it can trim for tolerance errors introduced by sense resistors, current transformers, and resistor dividers, as well as for its own internal circuitry.

The device is factory trimmed, but it can be retrimmed by the user to compensate for the errors introduced by external components. The GUI allows the user to revert the trim



ADP1055 typical application diagram



ADP1055 graphical user interface

settings to their factory default values using the RESTORE_DEFAULT_ALL command (Register 0x12). The ADP1055 allows the user enough trim capability to trim for external components with a tolerance of 0.5 % or better. If it is not trimmed in the production environment, it is recommended that components with a tolerance of 0.1 % or better be used for the inputs to CS1, VFF, and VS± to meet the data sheet specifications.

Graphical user interface

The GUI software includes filter design and power supply PWM topology windows. The GUI is also an information center, displaying the status of all readings, monitoring, and flags on the ADP1055. The GUI takes into account all PMBus conversions; the user need only enter the voltage and current settings. All PMBus flags and readings are also displayed in the GUI.

More information is provided in the ADP1055 datasheet available under www.analog.com/static/imported-files/data_sheets/ADP1055.pdf

FPGA to Control Power Electronics

During the development of an inverter, control- and power section have to interact smoothly. Highest performance can be achieved by combining smart software with cutting-edge semiconductors and innovative thermal management in a well planned mechanical setup.

Thomas Vetter, ARADEX AG, Martin Schulz, Infineon Technologies AG, Germany

The basis for an athlete's success lies within an optimized use and interplay of brain and muscles. Combining both, mental and physical abilities in perfect manner also is the challenge when building an inverter for mobile applications.

This is especially true if additional functionalities besides driving motors and generators have to be considered. For mobile applications or decentralized drives, the VECTOPOWER concept as displayed in Figure 1, can handle a multitude of requirements like

- connection to the grid,
- AC/DC-converter, optionally bidirectional,
- bidirectional connection to batteries and/or capacitors, and
- creation of on-board supply or isolated networks.

Figure 2 summarizes the possible scenarios a VECTOPOWER could be used in.

Looking at economical issues, logistics and especially worldwide provision of spare parts, a progressive concept is required. The key is to provide a common hardware for any possible task and make use of proper software or parameters to achieve any functionality desired. This target can be met without compromises if a few major aspects are considered closely.

Figure 1: VECTOPOWER featuring peak power of 250 kW/350 kVA in 10 liters of space

FPGA as a control center

Having the same topology with six IGBTs installed to support a variety of applications that spans from motor control to DC/DC converters makes an FPGA a tempting solution for control. A special benefit arises, if the FPGA generates the pulse pattern for the power transistors and also administers the high-speed control loops, especially the current control.

The FPGA in the present application observes three voltage- and three current measurements, runs the control algorithms and generates the gate signals for the power transistors. The cycle time is reduced down to 2 µs. Flexible firmware is the door opener to enable the support of all the tasks sketched in Figure 2.

A wide spectrum of functional features combined with a swift and sensitive control is one thing. The other thing, especially in mobile applications, is the extraordinary demand towards protection. Additionally, a wide temperature range and massive mechanical stress, a high demand regarding thermal cycling and varying electric load have to be taken into account, not to mention the stipulation towards save operation under fluctuating system voltage.

Maximizing semiconductor utilization

During short circuit or similarly high overload conditions a proper reaction has to take place within microseconds. Thermal development inside the semiconductor as a consequence of varying the load usually have to be accounted for in the regime of milliseconds. Detailed, most accurate knowledge of the semiconductor in use is mandatory. Sophisticated methods and model based calculations are done in hard real time inside the FPGA. Depending on the application and the point of operation, this allows an increase in output power by up to 20 % from the same semiconductor. This is beneficial for the application both in economics as well as in size and weight especially if advanced protection from extreme operation conditions is achieved at the same time.

A prerequisite to fulfill the sum of requirements is a current control loop that is deterministic, predictable and fast enough to prevent transient overshoots in the load current even at extreme changes.

This particular requirement cannot be matched with common processors. The solution presented therefore is based on FPGA, running several processes in parallel using highly robust state machines.

Utilizing time constants to increase peak power

Especially drive trains demand high peak power for a matter of seconds. Changing the switching frequency on the fly even during active torque control allow to achieve higher peak power. The use of smaller IGBTs is a resulting alternative as well, leading to cost reduction. Choosing

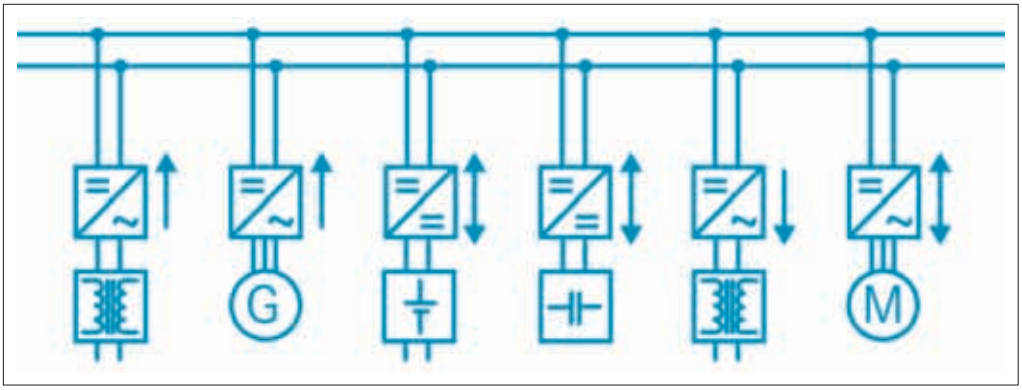


Figure 2: **VECTOPOWER in various applications**

a proper switching frequency has to be considered as optimization, taking different parameters into account. Higher switching frequencies lead to decreased losses in the motor due to a reduction of ripple currents. At the same time, it leads to increased switching losses in the power semiconductors. Comparing the thermal relations it can be calculated, that a change from 9 kHz down to 4.5 kHz leads to an increase in output power by 40-45 %.

The FPGA-based control allows changing the switching frequency on the fly without introducing distortions to the torque. During normal operation, the frequency remains at 9 kHz but may be changed to 4.5 kHz for certain points of operation.

The thermal time constants of power semiconductors typically are in a range below 100 ms while those for electric motors exceed 100 s.

During times of high acceleration or to manage a difficult driveaway situation, this correlation can be considered and the switching frequency can be reduced for a few seconds.

Reducing the amount of magnetics in PM machines

FPGA based control strategies enable a more cost efficient design of power electronics. Further possibilities arise in optimizing permanent motors. The magnets included are very sensitive towards magnetic overload. A few microseconds of overload are good enough to initiate an irreversible partial demagnetizing. This is why motor designers built in a corresponding magnetic reserve. If, like done with the FPGA, the current can be closely controlled even in a microsecond scale a motor can be designed featuring the same size, torque, power and efficiency with 30 % less magnetic material being used.

The strategic dependency on the raw materials along with the high prices for magnets illustrates, that savings in this dimension are economically essential.

Core piece power semiconductor

The power semiconductor is the core component to control the flow of energy. To live up to the expectations, electrical, mechanical and thermal challenges have to be mastered. During the development of an inverter, the semiconductor, the heat sink and the application's typical load profile have to be considered an inseparable unit. In-depth knowledge about this unit is mandatory to estimate the chip temperature and the temperature swing most accurately. Usually, semiconductor manufacturers provide the information needed by the power system designers to predict the load cycles a semiconductor will survive according to the temperature swing within the application. Knowing the load profiles and the number of cycles to be expected per time, an operating lifetime can be estimated.

For an all electric bus used in public transportation, 60.000 operating hours are demanded during a service life of 15 years representing 1 million kilometers. To

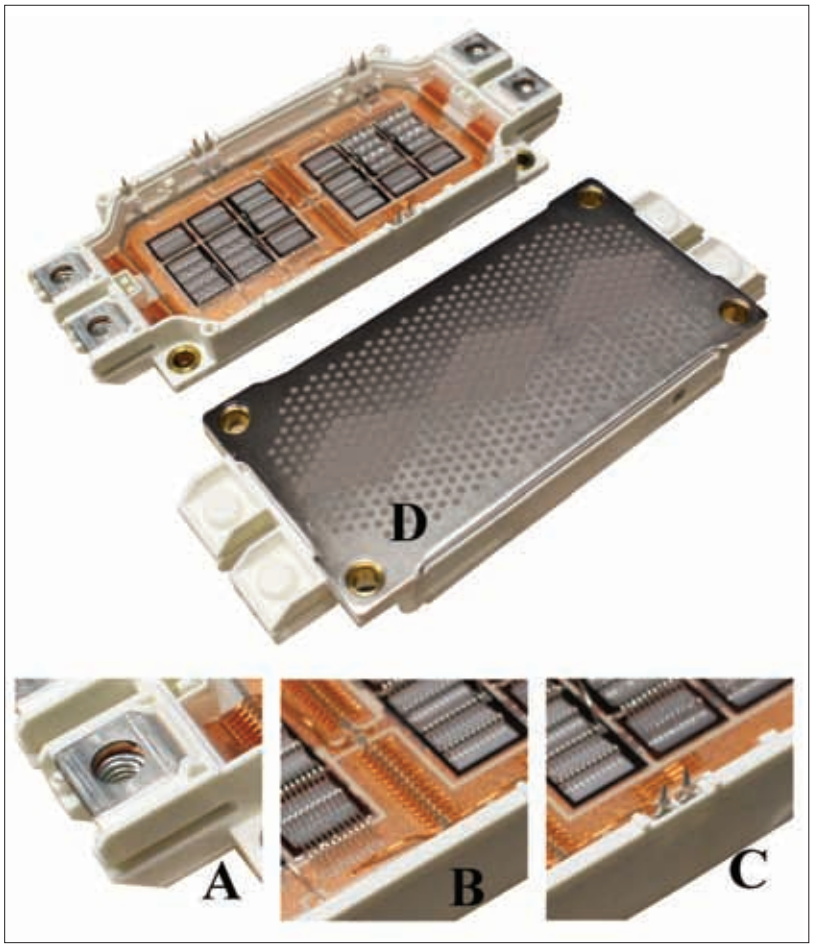


Figure 3: **Details inside the power module influencing the lifetime, EconoDUAL™3 600 A/1200 V**

comply with this demand, EconoDUAL™3 modules were chosen. Exhaustive upgrades have been introduced to the existing design, improving the mechanical robustness, the electric properties and the thermal connection. Figure 3 can best be used to take a look at the changes in detail and their influence to the design.

Interconnecting technologies

Formerly, the power terminals were plugged into the plastic frame. The new design now features injection molded terminals (A) which improves the resistivity towards vibration. Previously, micro-movements of the terminals in some cases induced additional mechanical stress to the bond wires connecting the terminal to the DCB.

A change that improves thermal properties along with electrical capabilities is the new system bonding. System bonds are all wires that interconnect the module's substrate to each other or provide electrical connection between DCB and terminals. In (B), a detailed view on a part of the new system bonding is given. Instead of using aluminum wires, the connection now is done utilizing copper. The higher specific conductivity enables the handling of higher currents without increasing the number of wires and the space consumed. As a consequence of the lower resistance, the temperature rise in the bond wires is reduced as well. Thus, the material helps to stay within the temperature limits given for the module's construction even at higher currents.

A further improvement results from replacing solder joints by PressFIT-technology. In demanding applications, solder joints degrade over time due to temperature swing and mechanical wear caused by vibrations. The continuous deterioration eventually leads to so-called cold solder spots. These spots bare the risk of intermittent or lost contact.

The PressFIT technology recently introduced (C) forms a connection to the PCB that is considered a cold welding joint. This is a gas tight, low resistive and mechanically highly robust interconnection. Compared to typical solder- or spring-force contacts, PressFIT-pins improve the connection's reliability by a factor 100.

Thermal connection

Improvement regarding the thermal interconnection was achieved by applying a dedicated thermal interface material (TIM) to the power modules. This layer (D) forms the thermal link between power module and heat sink. The new material composition consists of a phase changing carrier matrix that holds the thermally active filler components. The process of application became part of the manufacturing and is fully automated and monitored using a highly sophisticated optical inspection system. This sumptuous procedure ensures that the predefined amount of material is applied in the correct location. The pattern displayed in the picture correlates to the macroscopic geometry of the base plate. Changing the size of the honeycomb varies the amount of material applied locally. The enlarged area that is not covered with TIM later allows direct metal-to-metal contact, leading to further thermal improvement.

Copious tests, substantiated by years of field testing have proven the thermal quality and the long-term stability of the new compound. The critical failure mechanism 'Pump Out of Thermal Grease' is now eliminated.

Enhanced system soldering

One major novelty especially for power modules to support the application 'Commercial and Agricultural Vehicles (CAV)' is the high reliability system solder process. The system solder joint forms the connection between carrier substrate (DCB) and the module's base plate. Minute deviations between the thermal coefficients of expansion lead to thermal-mechanical stress inside this joint. Delaminating of the layer is a consequence.

This delaminating poses a perturbation of the thermal transfer path as the available area to conduct the heat is reduced. A positive feedback is introduced, as higher chip temperatures result from the diminishing area, leading to a higher temperature swing and increased mechanical stress in turn.

Figure 4 illustrates the evaluation of a system solder joint based on ultrasonic imaging. The images were part of the monitoring during cyclic testing. For comparison, a common solder joint of an industrial-grade device is depicted as well.

For IHM-type modules in the industry sector, the target to be achieved is 3000 cycles. With the newly introduced process for the EconoDUAL 3, more than 35,000 cycles have been done under the same conditions, exceeding the target set by factor 10.

Conclusions

During the development of an inverter, expertise from numerous different disciplines comes together. Only if measurement- and control techniques, software programming, mechanical issues, component selection and thermal management are considered an inseparable unit, outstanding devices with extraordinary capabilities come to existence. And mobile applications tend to be extreme regarding quality and durability, especially when it comes to vibration. The ARADEX' VECTOPOWER®, equipped with Infineon's half bridge modules, survived continuous shock tests acc. to IEC EN60068-2-27 with accelerations of 40 g. This is a fundament to support the application CAV with reliable and long-lasting power electronic equipment.

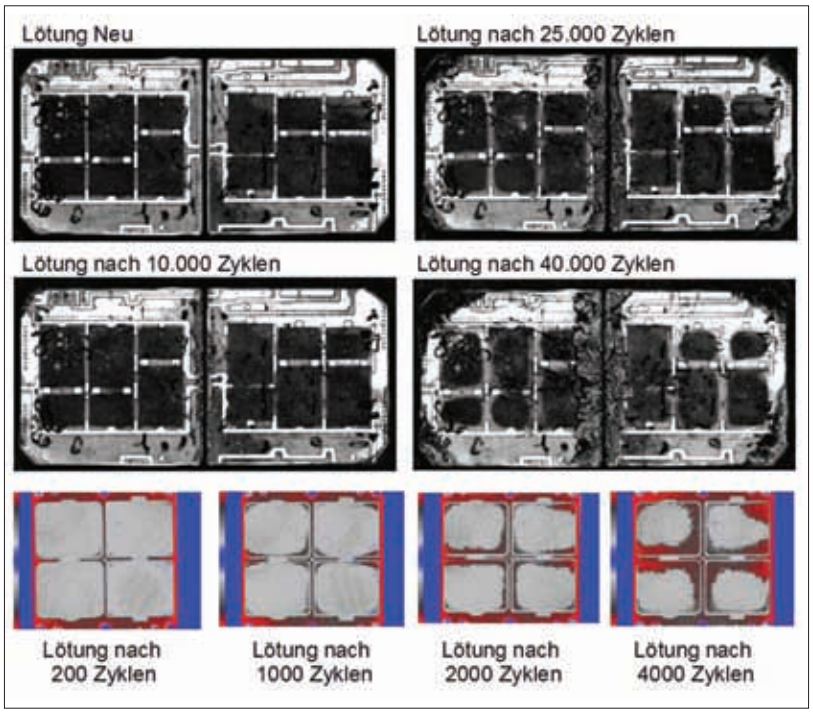


Figure 4: Ultrasonic microscopy (USM) to monitor stress tests for solder joints (Lötung – Soldered die attach after number of cycles)

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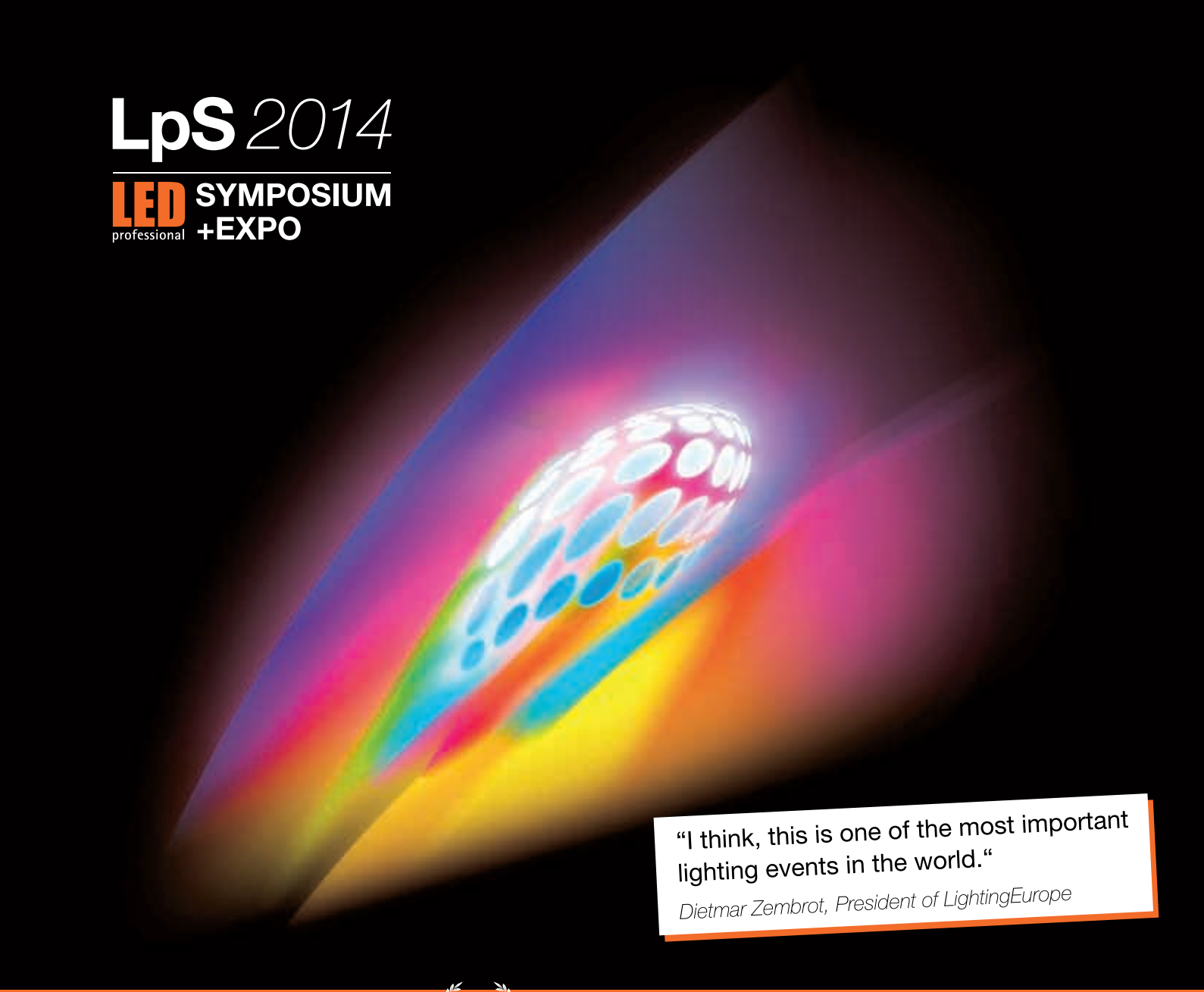

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The Emerging Role of Preventative Maintenance in Wind Turbines

In contrast to on-site staff at traditional power stations, or the ready road access to transformer stations, wind turbines are generally unmanned and located in remote rural areas, or in offshore wind farms. By nature, access for maintenance is difficult, with trips planned well in advance, but entirely contingent on prevailing weather conditions. When it comes to the reasons for wind turbine down-time, around half of all the faults are related to the inverter tripping out or failing. Combining the worlds of analog power electronics with the digital domain of deeply embedded digital control techniques gives more insight.

Richard Ord, Marketing Director, Amantys Limited, Cambridge, UK

In contrast to on-site staff at traditional power stations, or the ready road access to transformer stations, wind turbines are generally unmanned and located in remote rural areas, or in offshore wind farms. By nature, access for maintenance is difficult, with trips planned well in advance, but entirely contingent on prevailing weather conditions. When it comes to the reasons for wind turbine down-time, around half of all the faults are related to the inverter tripping out or failing. Combining the worlds of analog power electronics with the digital domain of deeply embedded digital control techniques gives more insight. Richard Ord, Marketing Director, Amantys Limited, Cambridge, UK

How many times have you driven past a set of wind turbines on a windy day and noticed that many aren't working? Is it any wonder the anti-green lobby gain traction in debating the move to cleaner energy sources when wind energy companies cannot consistently predict maintenance failures? What's surprising is that the majority of wind turbine issues aren't related to the core structure. In fact, around half of maintenance problems are actually related to the power electronics- a problem that isn't easily fixed.

A recent story highlights one of the challenges of power electronics in offshore wind farms, with the Carbon Trust recommending better barges for the North Sea to cope with the frequent unplanned maintenance demands of offshore wind farms.

This demonstrates one view of the problems created by the hectic pace of development and deployment in the industry, illustrating the need for more investment in infrastructure, maintenance and power electronics. But there's a different way to tackle this problem to improve offshore availability.

Current maintenance challenges

In the North Sea for example, some turbines are almost inaccessible for six months of the year, making quick fault response expensive and prohibitive. The Carbon Trust noted that five out of six annual maintenance visits to offshore wind farms are unplanned, leading then to the suggestion that new barges should be developed to enable greater accessibility.

The offshore industry is therefore investing in maintenance vessels that can access a turbine in heavier seas so that servicing visits can be made more often, but does this actually attack the root cause of the issue? Undoubtedly the industry would benefit from such vessels, but there is no doubt, either, that the industry would embrace advances in technology that can reduce the frequency of such visits and start to tackle those root causes.

Wind turbine power electronics

When it comes to the reasons for wind turbine down-time, around half of all the faults are related to the inverter tripping out or failing. And whilst there are sophisticated control systems for the converter, turbine, and wind farm as a whole, the heart of the power converter is built around IGBT modules; in current systems, this remains an analog world, and only very limited data is available in the control domain.

When the power converter has a fault in the inverter stack, typically the diagnosis available to engineers from the IGBT gate

Figure 1: **Bringing digital techniques to power electronics**

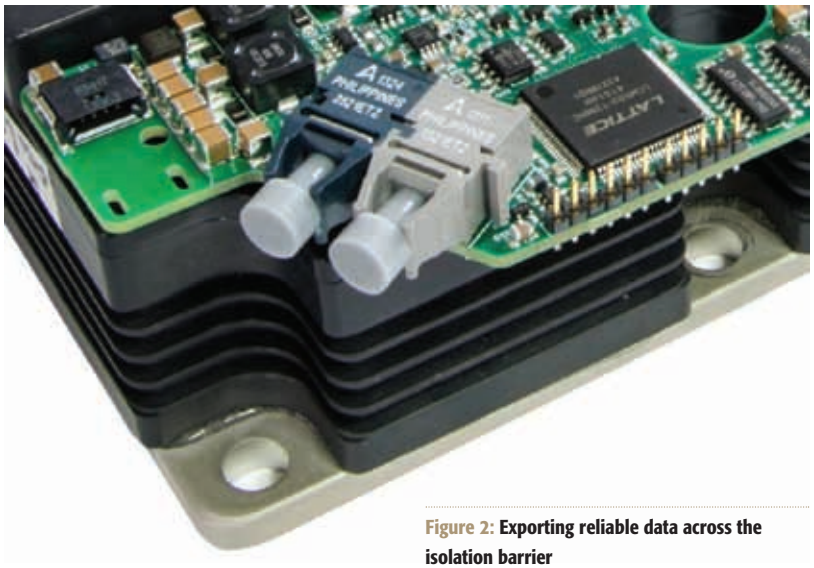

Figure 2: **Exporting reliable data across the isolation barrier**

drives consists of one of three signals - on, off or fault - and 'fault' can mean anything from a minor problem to a major problem that requires instant attention. There is no communications channel from the gate drive to the control environment, and to explore further demands a visit from an engineer to investigate, thus bringing us back to the problem of turbine accessibility, both onshore and on the high seas.

The consequence for wind turbine maintenance operators is a mixed schedule of planned and unplanned call-outs, resulting in engineers wasting time looking at systems and equipment that is functioning perfectly well – and being dragged away from more pressing issues.

In the absence of systematic data from the converter with respect to the power device performance in varying conditions and environment, and due to the relatively primitive nature of IGBT gate drives, limited opportunity to build up system knowledge exists. Without this, improvement of system reliability is hampered, and the cost of wind farm operations and maintenance remains a high priority.

Understanding the mission profile

The challenge then is to improve the understanding of what fault signals may indicate, what causes different problems, differentiating between trip conditions or non-critical faults, and flagging potential failing components. In fact, greater knowledge of how the system operates (and fails) in varying environmental and load conditions will allow better planning of repairs, increased availability, and fewer call-outs in adverse weather conditions.

Amantys brings a fresh approach, combining the dual worlds of analog power electronics with the digital domain of deeply embedded digital control techniques (Figure 1). Founded on expertise from both areas, the company has developed technology that solves the initial problem – how to export reliable data on key system parameters across the isolation barrier (Figure 2). Amantys Power Insight™ is a unique solution for sensing, monitoring, and communicating vital characteristics and behavior from the power device and gate drive to the control domain (Figure 3).

Intelligent control of power

A system with IGBT drivers enabled with Insight can help tackle these issues with real data on the core power electronics. Amantys Power Drives™ control the switching of IGBT modules from all leading manufacturers, providing more robust electronics at the heart of the switch. Programming of the on-board embedded microprocessor allows the system to determine what data to export and when, as a function of condition, environment and load, thus beginning to build that picture of turbine performance in real-time.

The key to learning about the system is the extraction of information from all the data available, so by analyzing fault codes as a function of the prevailing conditions, and by programming appropriate alarms, thresholds and fault codes, the operator can begin to understand how to adapt the system for better performance and more manageable maintenance schedules, which leads to greater warning that something is wrong, stronger

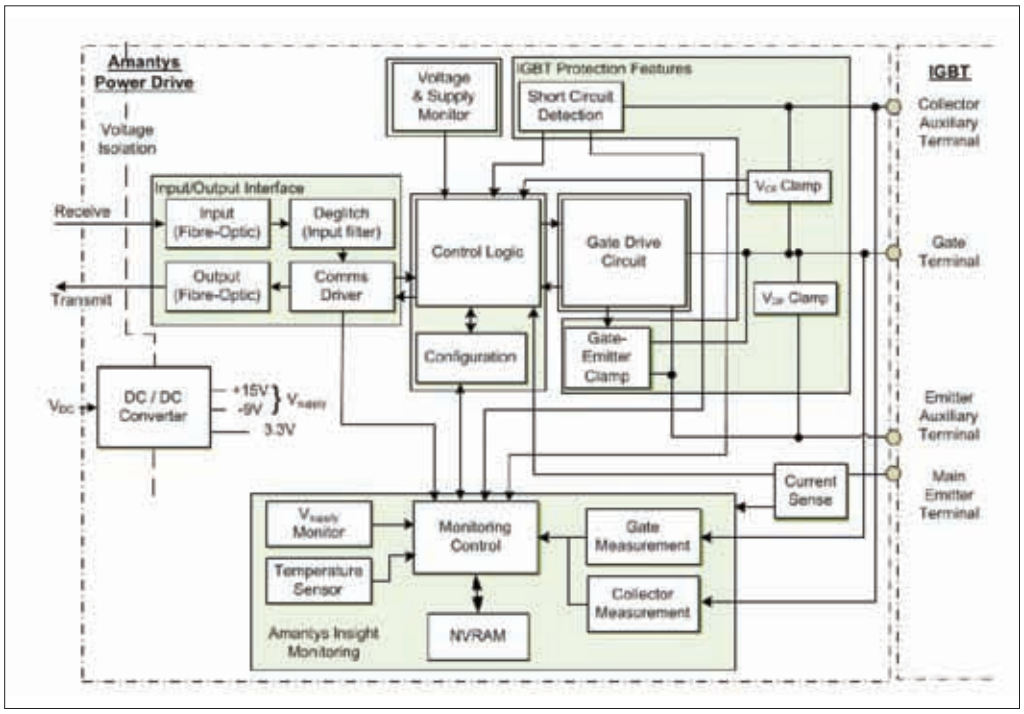

Figure 3: **Amantys Power Insight block diagram**

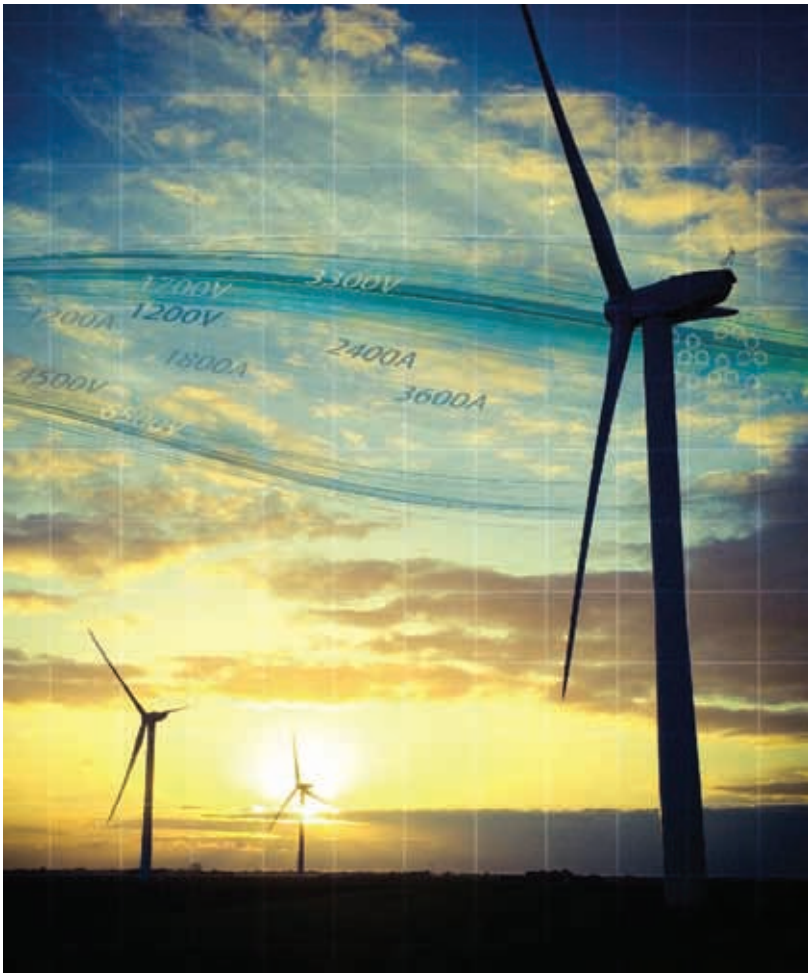

Figure 4: **A change in wind-farm operation**

understanding of essential component performance, and more cost effective operation all round. In an offshore installation this would also enable the part to be replaced during routine maintenance in better weather conditions, ensuring that availability is kept high.

The Insight protocol provides a future-proof platform for technology evolution, allowing system information to be separated from raw data today, and a vehicle to analyze performance diagnostics further down the road.

The inability to test performance or compare to external factors, and what is happening elsewhere, ought to be a thing of the past. New and innovative technologies are being developed to ensure greater insight is gained into the IGBT when actually operating in a converter to give operators a better understanding of their power electronics components.

Future for wind energy and power electronics

Visibility and analysis of switching performance can change how operators can manage power electronics and key components such as the IGBT modules - Amantys is helping to address this in an area where little intelligence has so far been available (Figure 4).

Industry in general is preoccupied with issues of big data, machine-to-machine communication and the Internet of Things. The key to such advances lies in extracting intelligence from the machines that are communicating with machines, and that demands digital techniques throughout the system.

Companies across the industry are looking for more informed knowledge on every aspect of how things are performing, which is an example of real machine-to-machine communications. The power electronics industry cannot afford to lag behind.

Amantys is already working with some leading companies in the renewable energy space to realize this vision and we expect more companies to follow the trend. The benefits are not just tangible, but quantifiable, and they can't be ignored.

Adaptive Intelligent Parallel IGBT Module Gate Drivers

At PCIM in May Amantys launched an IGBT Gate Driver operating at 3.3 kV, 4.5 kV and 6.5 kV, with significantly improved reliability and protection in high power modules targeting the most demanding applications including wind turbines, locomotive, HVDC, and industrial drives. At these power levels the gate driver must provide reliable and effective protection mechanisms for a variety of fault conditions. This new IGBT gate driver includes a variety of detection mechanisms for different short circuit types including a multi-threshold, programmable comparator which can identify slowly increasing fault currents, a fault mechanism which is not commonly detected in commercially available "plug and play" gate drivers. Once a fault is detected the driver is designed to implement a controlled switch off of the IGBT avoiding the potential for damaging voltage spikes.

This gate driver also includes the Power Insight™ condition monitoring and configuration capability to observe and report on critical power switching characteristics as well as enabling in-system configuration of the driver. Designed for the "intelligent control of power", the Power Drive is fully integrated and can measure and export critical performance parameters during operation as well as allowing configuration over the existing optical PWM and fault interfaces. These capabilities greatly simplify the design-in process.

The new Power Drive gate drive operates is configurable for industry standard 190 mm x 130 mm high isolation power modules from manufacturers including ABB, Dynex, Hitachi, Infineon, and Mitsubishi.

Open-Loop Transducers with near Closed-Loop Performance

LEM added three HO series of Hall-effect current transducers which extend nominal current measurement up to 250 A and offer a range of mounting options. Open-loop transducers using Silicon Hall-effect sensors are based on a simple design concept and are inexpensive to manufacture, but their simplicity gives rise to some performance limitations. These limitations may be overcome by using a closed-loop architecture for some current ranges, but with the penalty of a more costly and physically larger design. LEM's new open-loop transducers using a dedicated ASIC bridge the performance gap between today's open-loop and closed-loop transducers. **David Jobling, LEM Switzerland SA, Geneva**

The principle of operation of open- and closed-loop current transducers using the magnetic field of the current measured is shown in Figure 1. Both may use a Hall cell integrated in the ASIC as the magnetically sensitive element; both have the advantages of isolation from the measured current and a wide frequency range including DC.

In the open-loop transducer the Hall cell voltage output is amplified to output a copy of the measured current. However any variation in the Hall cell sensitivity, for example with temperature, gives an error. The electrical signal at the Hall cell is very low, so the desire for a fast response time tends to give a noisy output because the signal bandwidth must be wide. Typically the ASIC signal bandwidth must be larger than that of the current to be measured because in order to overcome the offset and 1/f noise of the Hall cell its output must be modulated to a high frequency by biasing the cell successively in the 4 orthogonal directions and then demodulated after amplification.

In the closed-loop architecture the magnetic field induced by the measured (primary) current is exactly cancelled by a secondary current whose value is smaller by the primary:secondary turns ratio and is easily measured at the precise resistance R_M. The exact sensitivity of the Hall cell is

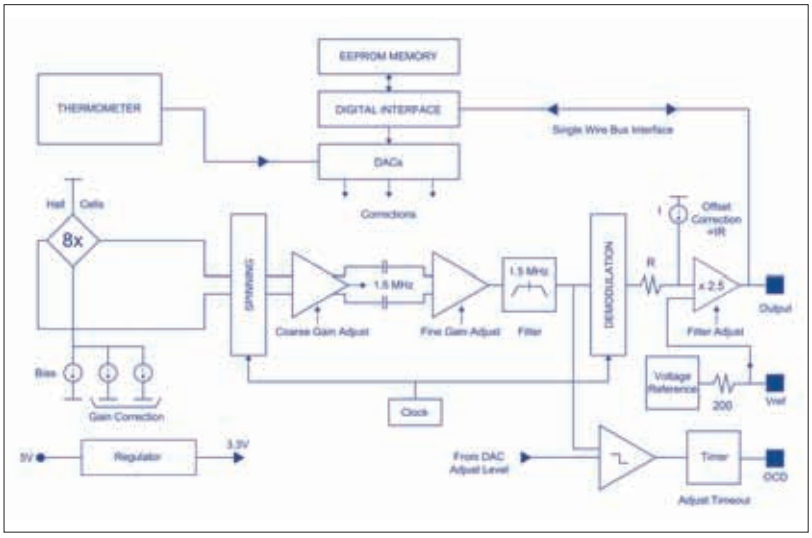

Figure 2: Block Diagram of the ASIC used in the new open-loop transducer

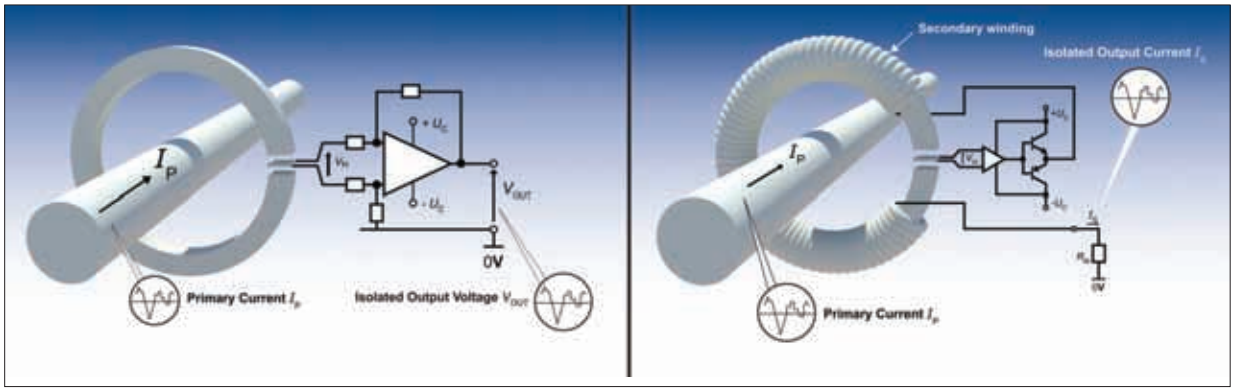

Figure 1: Open-loop (left) and closed-loop transducers

no longer of importance. Furthermore, the bandwidth of the signal from the Hall cell and hence its noise may be kept low since at frequencies above a few kHz the current in R_M comes directly from the primary:secondary transformer effect. These improvements, however, need a transducer construction which is more costly and which limits how small it can be made. Furthermore the maximum measureable primary current is limited by practical limits to the secondary current and the number of turns of the secondary winding.

An specifically designed ASIC (Figure 2) allows performance near to that of closed-loop transducer, thus the design complexity is in the ASIC, not in the transducer. Once designed, this ASIC may be used in a range of inexpensive open-loop transducers with different features.

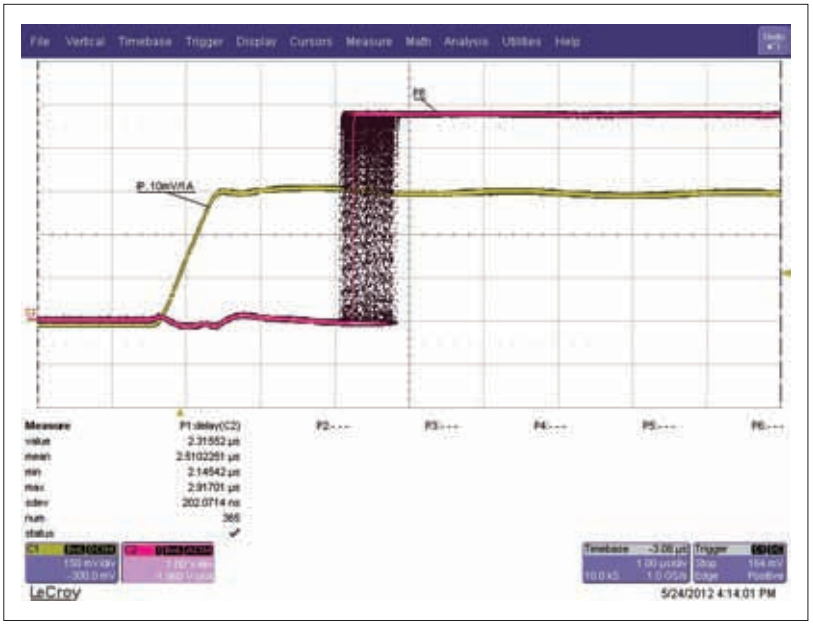

Figure 3: **Envelope of OCD response**

Hall-effect ASIC functionality

Eight Halls cells are used to mitigate the poor signal-to-noise ratio at the start of the signal path by a factor of $\sqrt{8}$ and spinning at 1.5 MHz eliminates the Hall cell offset. Where the signal levels are low a differential architecture is used to give immunity from external dv/dt interference. After the signal is converted from differential to single-ended to economize die area some selective screening is applied to critical nodes without using additional metal layers to maintain dv/dt immunity. A bandpass filter at the spinning frequency keeps the overall noise level low by limiting the noise bandwidth to that required for the response time and by stopping aliasing of high frequency noise components into the signal frequency range.

Quality standards in the automotive and increasingly in the industrial markets require that the ASIC be fully tested after packaging at 2 or preferably 3 temperatures – in order to measure errors inherent in the open-loop architecture and to store corrections in the on-chip EEPROM. The Hall cell temperature dependence and the offset of the amplifiers after demodulation are corrected in this way.

The EEPROM memory also means that transducers can be configured according to user's preferences - for example, different reference voltages may be chosen and the output filter may be made narrow to reduce noise or wider to reduce response time.

A new feature of this ASIC is the provision of a digital over-current detect (OCD) output from an intermediate point in the signal chain. The threshold level may therefore be above the level which saturates the conventional analogue output. Again, the exact threshold level may be chosen and stored in EEPROM according to different application needs.

Communication with the EEPROM is by a single wire bus to the ASIC output pin, this may be convenient even in the end user's final application since this pin is likely to be connected in any case to a microprocessor for signal processing.

Figure 3 shows the digital OCD response to a current step on the transducer input. The response time of about 2 µs is due partly to the delay of the transducer magnetic circuit and partly due to a circuit that validates the presence of the over-current for at least 1 µs, to avoid triggering the OCD on short spikes. The envelope of the response is about 600 ns wide since the current step is not synchronized with the internal 1.5 MHz clock of the ASIC.

Figure 4 shows the immunity of the new transducer to dv/dt interference compared with an older design where external screening or grounding of the magnetic circuit would be needed to obtain an equivalent performance. The slope of the dv/dt signal is 5 kV/µs, its amplitude is 1 kV. The delay between the

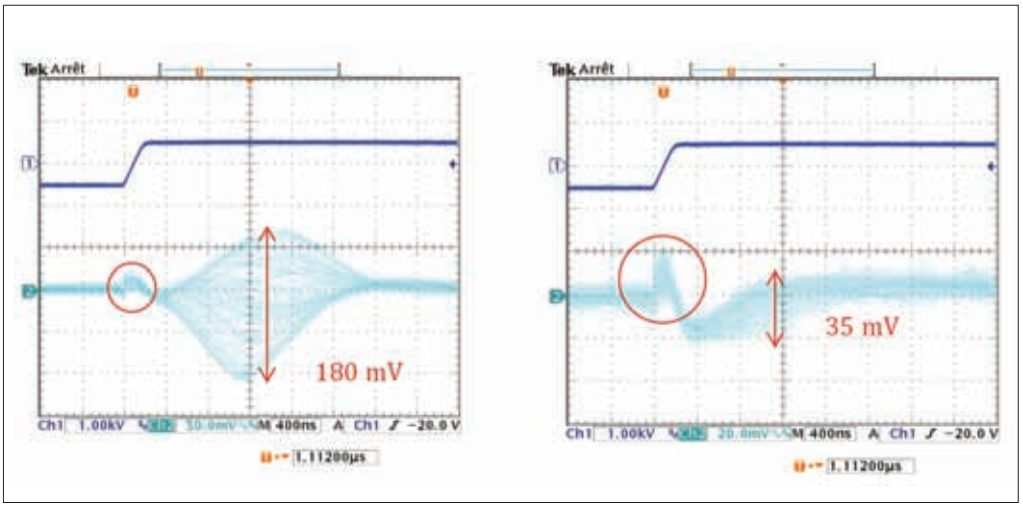

Figure 4: **Envelope of the dv/dt response of older open-loop transducer (left) and the new transducer**

dv/dt signal and its effect on the output is due to internal sample and hold functions and filter blocks. Figure 5 shows the step response of the new transducer to a primary current step: the response time is below 2 µs. However the bandwidth of the 2nd order output filter may be reduced to down to 1/6th of its largest value which increases the response time but gives a corresponding reduction in output noise.

Figure 6 shows examples of two different current transducers using the described ASIC. No electrical components other than the ASIC are needed so their physical volume is very small. The magnetic circuit which concentrates the magnetic field at the ASIC is made of a low-cost ferrite which may be left floating due to the dv/dt immunity inherent in the ASIC design. The same ASIC is used in the two transducers whose performances may be quite different due to the configurations defined by the EEPROM and due to the primary and magnetic circuit arrangements.

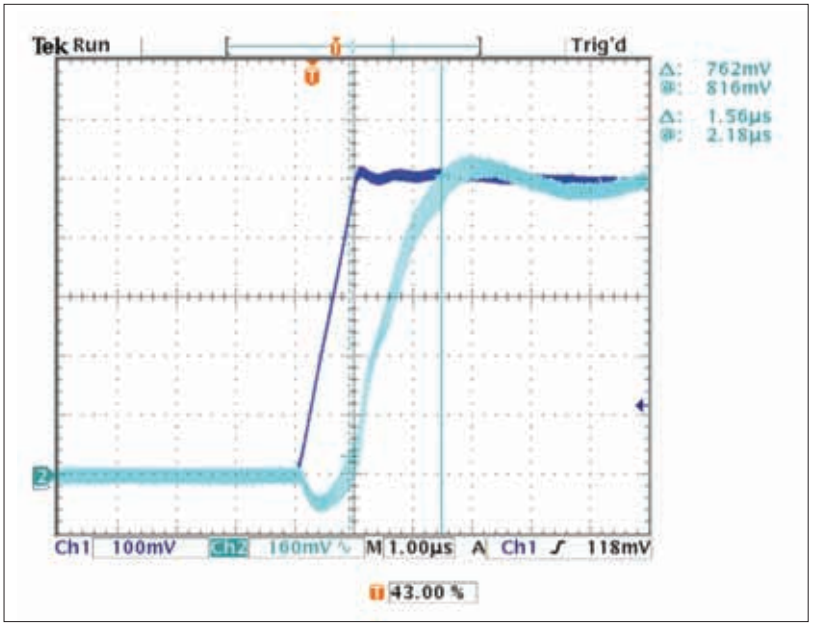

Figure 5: Response to a di/dt input

Conclusions

New open-loop current transducers have been presented whose performance approaches that of closed loop transducers. The key to the good performance is an ASIC which was specifically developed to target these improvements. Measured performance is at the level expected and increases the range of applications which may be addressed by open-loop transducers instead of more complex solutions. The range of options offered by HO transducers makes them suitable for a wide selection of applications where high performance and mounting flexibility are required. These applications include solar combiner boxes and solar-power inverters, as well as small smart meters, variable speed drives, uninterruptible and switch-mode power supplies, air conditioning, home appliances, static converters for DC motor drives, and robotics. The wide operating temperature range of -40 to +105°C also makes the HO series suitable for use in any industrial applications.

Literature

Jobling D., "New Open-Loop Current Transducers with near Closed-Loop Performance", PCIM Europe 2014 Proceedings, pp. 222-226 (http://www.mesago.de/en/PCIM/home.htm).

Figure 6: Examples of two different current transducers using the described ASIC

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Moving Towards 5 Kilowatt Boards

The twin server-rack challenges of supplying power and removing resultant heat means that both evolutionary advances and dramatically new approaches may be viable; only time will tell which proves to be the winning approach. **Patrick Le Fèvre, Marketing Director, Ericsson Power Modules, Sweden**

Power demand per board in the data-server segment has increased by a factor of four since the early 1980s, from just 300 W to 1200 W. It is further forecast to grow to 3 kW per board by 2015, with some studies forecasting as high as 5 kW/board consumption by 2020. This relentless trend brings two major challenges to power designers: how to develop highly efficient topologies and products to deliver this level of power from isolated bricks, and how to cool the circuit boards efficiently to ensure reliable, long-life operation.

According to sources such the Ericsson Mobility Report (www.ericsson.com/mobility-report) the amount of data transferred through networks is increasing at a tremendous rate. The mobile industry generates about 1.9 exabytes/month and it is estimated this will increase by a factor of ten between 2013 and 2019. Data centers are seeing corresponding growth: it is estimated that annual IP traffic was 2.6 zettabytes in 2012, and will be at 7.7 zettabytes by the end of 2017.

To respond to this demand and its power needs, data-center operators are considering two approaches such as modernization of existing data farms or new data centers using the latest technologies for higher energy utilization and efficiency, resulting in a reduction in both total cost of ownership (TCO) and environmental impact.

Figure 2: Datacom-input-range high-power-density 864 W quarter-brick module featuring double power pins and optimized design for cold-wall cooling

Upgrade and modernization

In the case of modernization, most data centers are reaching limits in terms of increased power per board. Chassis and cabling is already installed, power supplies and power backup are often limited to what is already in place, and refrigeration systems have limited room for extra cooling. This means that data center operators will have to select a critical part of the system for upgrade, especially when new cards might require 1.2 to 1.5 kW each, which is almost twice that of today's average power per board.

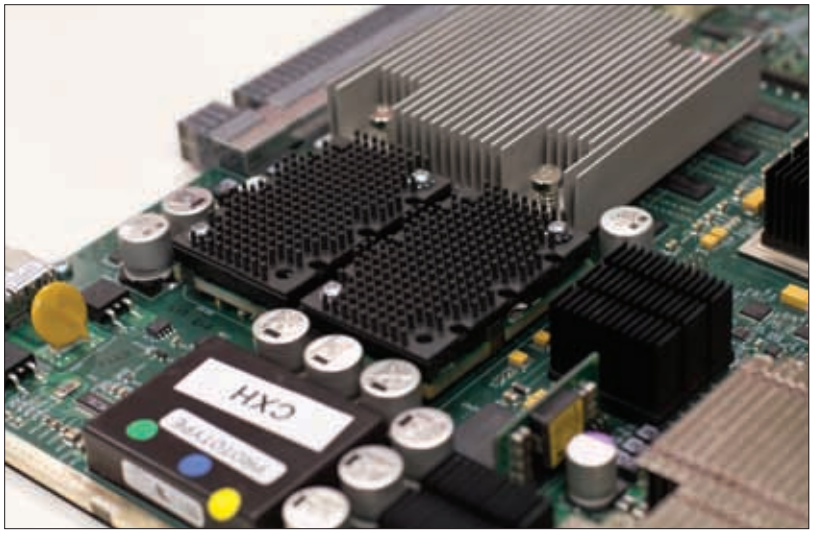
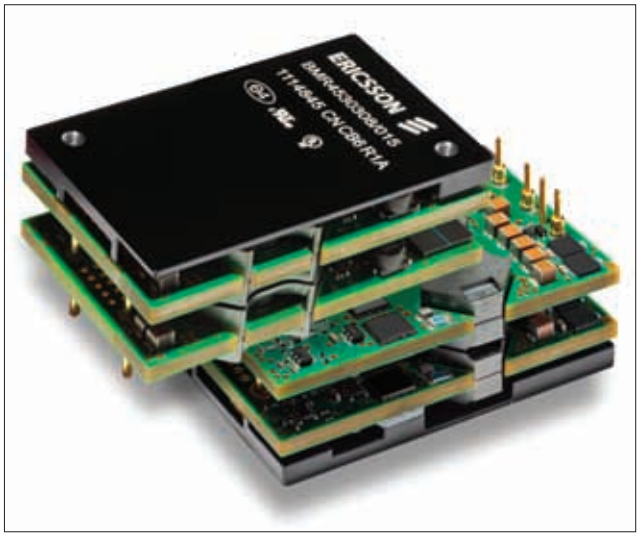


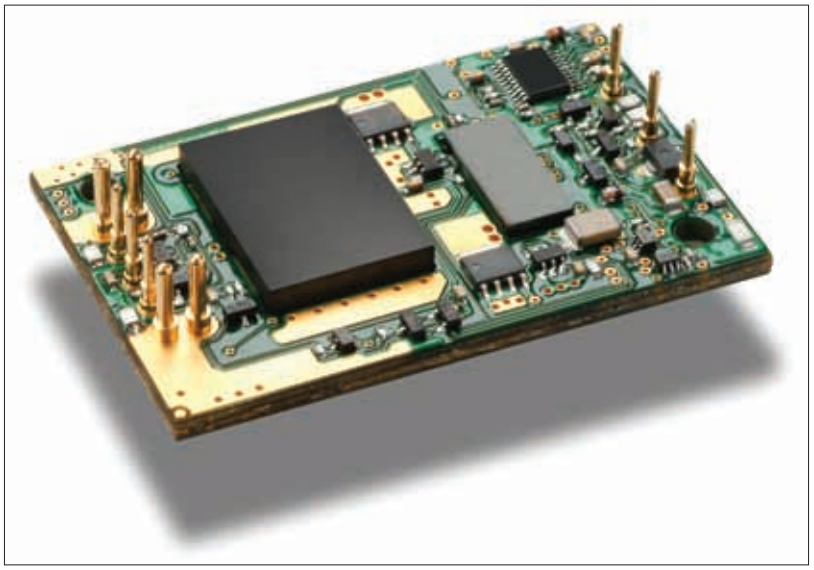
Figure 1: Today, two quarter-bricks in parallel deliver 900 W to IP switches and routers

Most present boards use two 450 W quarter-brick modules in parallel (Figure 1), delivering an average power of 900 W (actually, about 800W when thermal derating is taken into account). For next-generation boards, designers usually opt for higher-power quarter-bricks modules because they must use to existing footprints. These offer up to 860 W in their datacom version (45 V to 60 V input), Figure 2, or as stacked modules at the same power, but for wider input range of telecom standards (36V to 60V/75V), Figure 3. These upgrades do not offer the most efficient architecture when for demands per board in the 3-to-5 kW range.

The problem goes beyond supply



LEFT Figure 3: Wide-input-range telecom stacked power modules



BELOW Figure 4: The Double-P high-power-density module, launched in 2003

circuitry. PC boards have become thicker, with heavy copper layers to carry the 100 A of board-mounted power sources (1200 W/12 V) to the loads; at the same time, the board may have up to 30 layers.

Therefore, soldering of power modules to the boards – and rework in the case of defects – has become a critical factor. Board power architects have also started to question use of just a single pin per voltage rail, to deliver the power to the intermediate bus.

These issues led to a new power-brick concept in 2003, with the 'The Double-P' (Thermally Enhanced Double Power Pin) initiative which featured two power pins and a layout to optimize power dissipation through pins and ferrites (Figure 4).

Along with delivering power comes the cooling problem and conventional air circulation may no longer be adequate. Solutions include use of heat-pipes to move heat from processors and other dissipating components to cold plates and heatsinks. In these systems, the board-power module baseplates are also connected to master cooling elements, reducing thermal stresses and improving reliability. These techniques are acceptable when upgrading existing installations, but will likely not be suitable for the multi-kilowatt boards of the next generation.

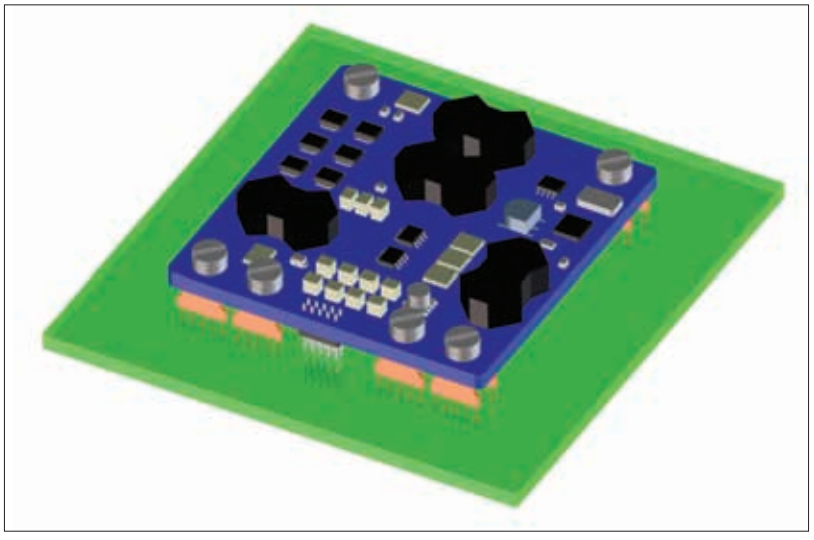


Figure 5: Simulation of 1.5 kW isolated power modules designed for efficient cooling and easy assembling required to power multi-kilowatt boards

New developments and data centers

As demands increase, system architects will have to reconsider overall routing, shortening connections and increasing the number of I/O points per board in order to limit interconnection losses which introduce performance-killing latencies. This will require bigger boards plus cooling via refrigerated cold-walls for greater efficiency than conventional ventilation.

Architects are also re-thinking the paralleling the quarter-brick unit, the packaging of which has not evolved significantly since high-density versions were introduced in the late 1990s. In addition to the difficulty of soldering bricks to boards with up 45 layers, the outputs of these power bricks must deliver current to the multiple rails to distribute the 250 A (and later, 415 A). As a result, architects may demand products optimized for cold-wall conditions, resulting in a new type of board-power source which actually takes up more space, but has improved thermal exchange, interconnections enhanced for the higher currents and new assembling techniques.

The final product could be similar to the 1.5 kW module (Figure 5), with modules including larger transformers with interconnection to high-power, press-fit sockets pre-installed during board preparation.

Conclusion

When the 'The Double-P' initiative started, 800 W boards were challenging enough yet 10 years later, boards are at 1.2 kW and quarter-bricks are nearly reaching a kilowatt. Achieving 3 kW/board soon and 5 kW/board by 2020 will almost certainly require new technologies which combine unprecedented levels of innovation across multiple dimensions.

Inverter Kits for Motor Control

Renesas Electronics Europe announced its new RX111 motor control kits. These inverter reference solution kits are designed to drive any 3-phase permanent magnet synchronous motors (PMSM), also called brushless AC motors. Based on Renesas' 32-bit RX family of MCUs running at 3 V, they deliver 50 DMIPS at 32 MHz. The RX111 reference kits are designed for equipment requiring medium and high dynamics and a low-cost bill of materials. The kits provide up to 7 A at 24 V DC and have been tested with more than 30 different motors. Additionally, an external power stage is available on demand. The inverter kits provide auto-tuning of the current proportional-integral (PI) coefficients; identification of intrinsic motor parameters; real-time visualisation of the motor phase, current and step response: and dynamic modification of the PWM frequency and control loop. Each kit contains the inverter board, a 24 V DC permanent magnet AC motor, a CD-ROM including the embedded software source code, the PC GUI, the board schematics, the bill of materials, Gerber files, user manual, quick start guide and the power stage schematics/Gerber files. Renesas will be launching additional kits over the coming months. Many of the kits will be showcased at electronica in November (Hall A6, Stand 243).

www.renesas.eu/motor

Primary-Side Switcher

Infineon Technologies expands its SiC portfolio with the 5th generation1200 V thinQ!™ SiC Schottky diodes. The new 1200V SiC diodes feature more than Diodes Incorporated offers the AP3988 off-line, side-switching controller designed to supply power for chargers, ADSL adapters and home appliances. By providing primary-side control, the device eliminates the requirement for opto-couplers and secondary-side control circuitry. Primary-side regulation results in higher efficiency with less heat generated in the power supply, which increases reliability. Additional benefits include improved output voltage and current accuracy, enhanced over-voltage and short-circuit protection, and better EMC performance, achieved by frequency dithering. The AP3988 switcher regulates output voltage using piece-wide pulse frequency modulation, in which analog levels are represented as fixed-duration pulses of varying repetition rate. 700 V transistors are built into the device and start-up current is typically 0.2 µA. The switcher has integral cable voltage drop compensation of 5 % of nominal voltage and adjustable line voltage compensation.

www.diodes.com

Isolated AC Current Sensor IC with Differential Output

The ACS726 from Allegro MicroSystems Europe is an AC current sensor IC featuring galvanic isolation and includes a fully differential back-end amplifier that can be used to adjust gain and bandwidth via external RC networks. The back-end amplifier is fully independent and, when unused, can be powered down to reduce power consumption. The fully differential output of this device gives better immunity to output offset drift as well as common-mode noise. The low-profile device package makes it easy to incorporate into customers' applications. Typical uses for the ACS726 include motor control, load detection and management, switched-mode power supplies, and over-current fault protection. The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic field to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilised BiCMOS Hall IC, which is programmed for accuracy after packaging. The output of the device has a positive differential voltage when an increasing current flows through the primary copper conduction path, which is the path used for current sensing. The internal resistance of this conductive path is 1.1 mΩ typical. The terminals of the conductive path are electrically isolated from the sensor IC signal leads, allowing the ACS726 current sensor IC to be used in high-side current sense applications without the use of high-side differential amplifiers or other isolation techniques.

www.allegromicro.com

100 V Trench MOSFETs in 6-Pack Configuration

IXYS offers an integrated 100V MOSFET 6-pack configuration (MTI145WX100GD) in one ceramic isolated surface mountable package (ISOPLUS-DIL). The 6-pack offers 3 electrically isolated half bridges with 100V MOSFETs featuring low on-resistance of 1.7 mΩ and real Kelvin gate connections for optimal gate control. The ISOPLUS-DIL package can be surface mounted with a standard pick and place machine and is suitable for reflow automated soldering processes. The use of the DCB ceramic substrate technology versus a non-isolated copper baseplate provides excellent isolation, reduced weight and better power cycling capability. Typical applications, among others, are high efficiency DC/DC converters, battery chargers, motor inverters such as fans, power steering or pumps in automotive applications or battery powered systems.

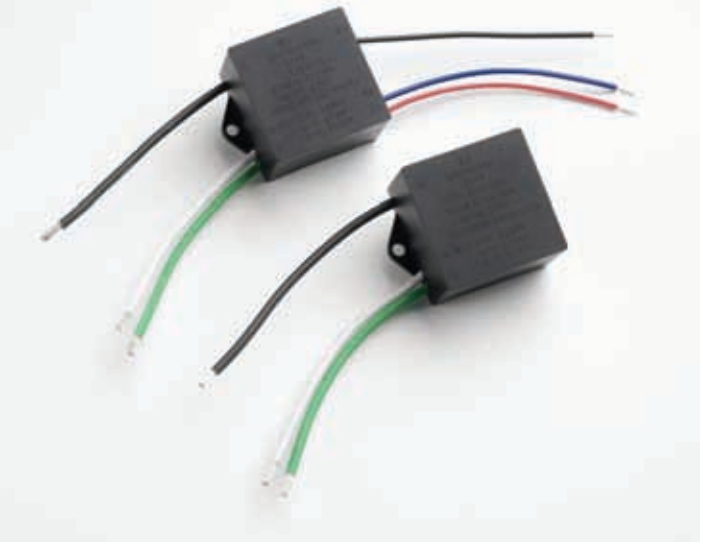
www.ixys.com

Automotive–Qualified Dual Low-Side Driver IC

International Rectifier launched the automotive-qualified AUIRB24427S high current dual low-side driver IC for Switched Mode Power Supply (SMPS) applications used in Hybrid Electrical Vehicles (HEV), Electric Vehicles (EV), and high power industrial converters. The device features high output current in excess of 6 A per channel across the full temperature range and is designed to drive large IGBT and MOSFET gates in modules or discrete packages. Due to the extremely low output impedance in turn-on and turn-off mode, power losses are also very low, allowing operation in harsh and high temperature environments such as HEV power supply stages as a primary or secondary side driver. The AUIRB24427S is available in a thermally enhanced PSOIC-8N package that delivers much higher thermal dissipation compared to standard DIL SMD packages enabling operation at a significantly higher ambient temperature. Additionally, the rail-to-rail output stage, using P-Channel MOSFETs in the high-side allows low internal dropout voltage to reduce power dissipation. The AUIRB24427S also features maximum output resistance of 650 mΩ sink and source at 125°C.

www.irf.com

Series-Connected 20 kA Surge Arrestor



Rutronik presents the new surge protection modules LSP05 and LSP10 from Littelfuse. Constructed with thermally protected varistors, they provide robust surge current handling capability for outdoor and commercial LED lighting fixtures. One of the modules includes world's first series-connected, 20 kA-capable indicating surge arrestor. The LSP05 Series with maximum lightning current ratings of 10 kA is configured with parallel connections, whereas the LSP10 Module is available with either parallel or series connections. This series-connected version is the world's first indicating surge arrestor capable of handling surges of up to 20,000 A. It cuts luminaire power off to provide a clearly visible indication the SPD (Surge Protection Device) should be replaced. With the parallel-connected versions, an indicator wire can activate an LED to tell maintenance personnel when to replace the SPD in order to ensure the luminaire remains protected. Both product lines, in the compact form factor of 48 x 48 x 30 mm, come with a built-in thermal disconnection function that provides additional protection from catastrophic failures and fire hazards, even under extreme circumstances of varistor end of life or sustained over-voltage conditions.

www.rutronik.com/cc3310f0

Wireless Power Transmitter Coils

The numbers of devices following the Qi standard of the Wireless Power Consortium (WPC) is increasing rapidly. Now, more than 560 Qi certified devices are in the market for the benefit of seamless interoperability. This ensures that users are able to charge their devices independent of the supplier. To increase its offerings in the 12V voltage range of wireless power transmitter coils, Wurth Electronics developed two new Qi complient coils. The 760308104113 (A13), as a single coil, and 760308104119 (A19), as a two coil array, have the advantage to increase the active wireless power transfer area. As well as all other transmitter coils of Wurth Electronics, the new coils offer high quality with litz wire and premium ferrite to get a high Q factor and a low DC resistance.

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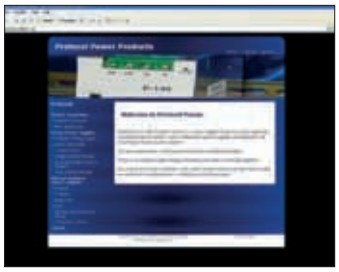

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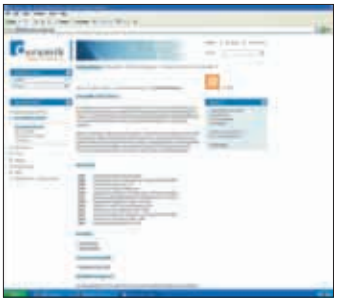

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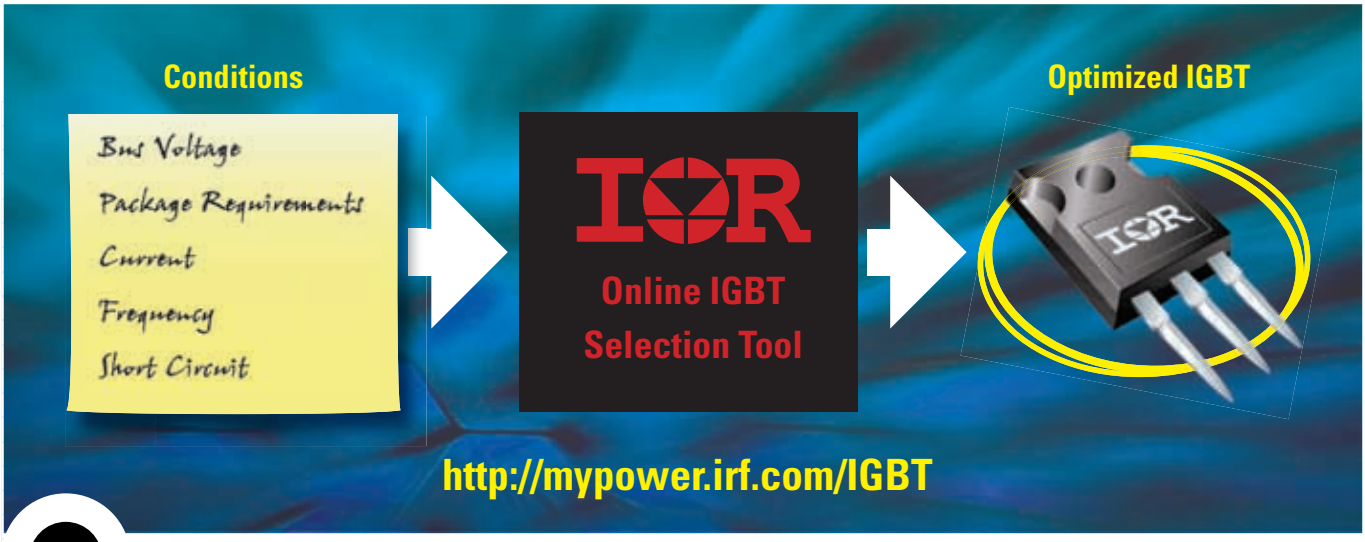

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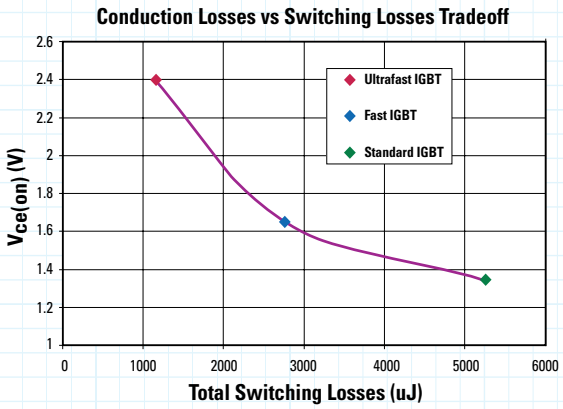

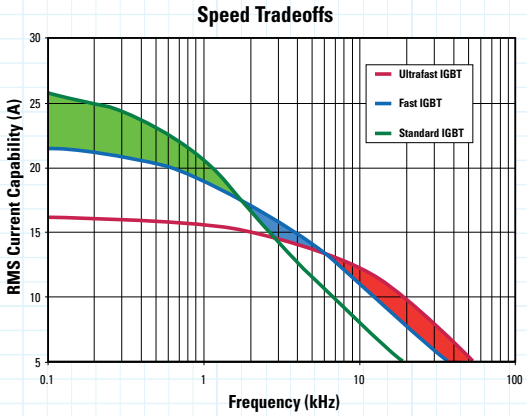

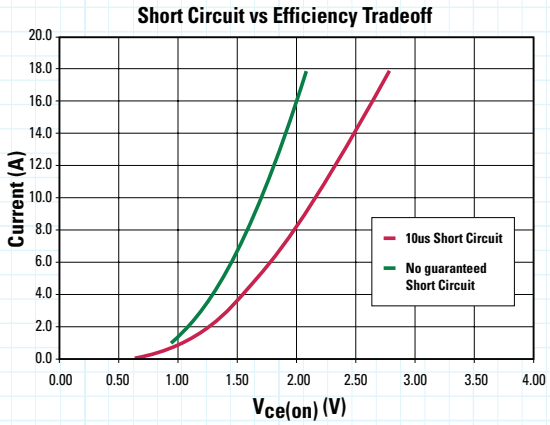

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