POWER ELECTRONICS EUROPE

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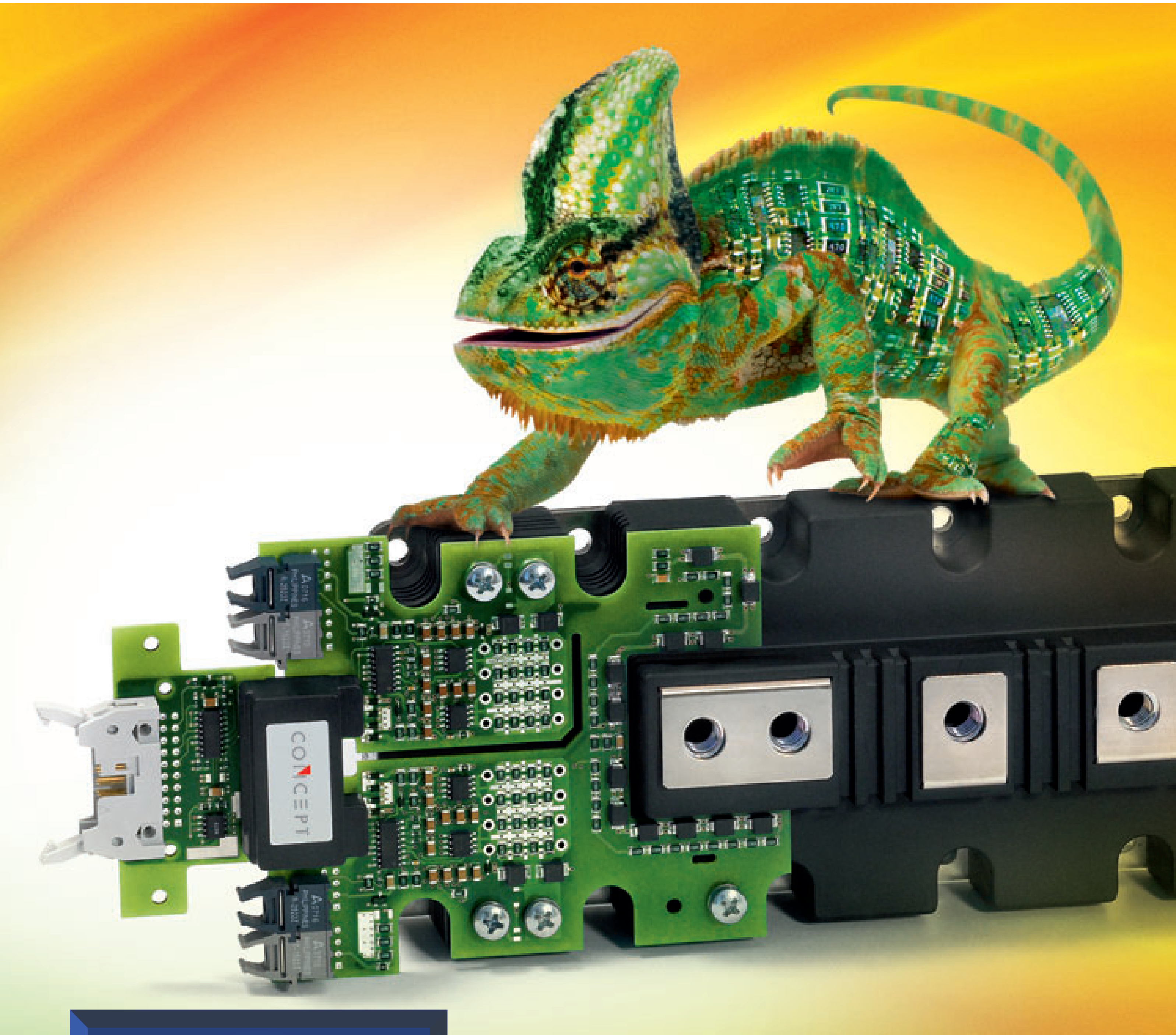
IGBT DRIVERS

Optimized Utilization of IGBTs by Plug-and-Play Drivers



THE EUROPEAN JOURNAL FOR POWER ELECTRONICS AND TECHNOLOGY

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Editor Achim Scharf
Tel: +49 (0)892865 9794
Fax: +49 (0)892800 132
Email: achimscharf@aol.com

Production Editor Elaine Gladwell
Tel: +44 (0)1322 380057

Editorial/Advertisement Administration
Clare Jackson
Tel: +44 (0)1732 886495
Fax: +44 (0)1732 886149

Circulation Manager Anne Backers
Tel: +44 (0)208 647 3133
Fax: +44 (0)208 669 8013

INTERNATIONAL SALES OFFICES
Mainland Europe:
Victoria Hufmann, Norbert Hufmann
Tel: +49 911 9397 643 Fax: +49 911 9397 6459
Email: pee@hufmann.info

Armin Wezel
Tel: +49 9568 897 097 Fax: +49 9568 897 096
Email: armin@eurokom-media.de

UK
Steve Regnier, Tim Anstee
Tel: +44 (0)1732 366555
email: Sales@starmediaservices.co.uk

USA West Coast Sales
Shelley Kelly
Tel: (310) 547 1777 Fax: (310) 519 0809
Email: shellyscott@sbcglobal.net
USA East Coast Sales
Karen C Smith-Kernc
email: KarenKCS@aol.com
Alan A Kernc
Tel: +1 717 397 7100
Fax: +1 717 397 7800
email: AlanKCS@aol.com

Italy
Ferruccio Silvera
Tel: +39 022 846 716 Email: ferruccio@silvera.it
Taiwan
Prisco Ind. Service Corp.
Tel: 886 2 2322 5266 Fax: 886 2 2322 2205

Publisher Ian Atkinson
Tel: +44 (0)1732 886495
Fax: +44 (0)1732 886149
Email: IATKINSONTMI@aol.com
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Market News

PEE looks at the latest Market News and company developments

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An Innovative Approach to Input Bridges

Power management is increasingly important in all areas of electronic engineering; from the distribution of high voltage supplies to the effective monitoring of very low core voltages in digital devices. Through the efficiency benefits of replacing conventional input rectification with a self-driven synchronous rectification technique called Active Bridge concept, the challenge of delivering better power management solutions will be met. **Davide Giacomini, European Director of SMPS Applications and Luigi Chiné, SMPS Application Engineer, International Rectifier**

COVER STORY

Optimised Utilization of IGBTs by Plug-and-Play Drivers

The extremely compact and high-performance IGBTs of the PrimePACK series from Infineon Technologies AG enable scalable power converter system solutions optimised for various industrial drives, windmills, elevators, traction and auxiliary drives. SCALE-2 IGBT drivers make a perfect match for scaling power and controlled efficiency. Thanks to SCALE-2 technology, the new 2SP0320 family comprises complete and extremely compact two-channel IGBT drivers equipped with DC/DC converters, short-circuit protection, advanced active clamping and supply-voltage monitoring. Users need only mount them onto the corresponding IGBT module. The system can then be put into immediate operation with no further development or matching effort. Full story on page 18.

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From Vehicle Drive Cycle to Reliability Testing of Power Modules

In hybrid electrical vehicles (HEV) the battery, motor and inverter are the core elements of the electric drive train. To qualify power modules for use in HEV inverters, amongst others, power and thermal cycling tests have to be performed. This paper presented at PEE's PCIM Automotive Power Session discusses the requirements on such power semiconductor modules in terms of reliability and lifetime in HEVs. **M. Thoben, K. Mainka, R. Bayerer, I. Graf, M. Münzer, Infineon Technologies, Warstein and Munich, Germany**

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Automotive Grade Gate Drive Optocoupler for HEVs

Hybrid electrical vehicles make use of electrical drives and advanced battery systems to improve fuel efficiency and enhance the driving experience. The high voltages used in these systems call for galvanic isolation, both to provide safe insulation for human beings and functional isolation between electronic systems. **Erik Halvordsson, European Product Marketing Manager, Avago Technologies, Böblingen, Germany**

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Novel Architecture for Capacitor-Free Low Drop-Out Regulators

A novel architecture is proposed for implementing external capacitor-free LDO regulators. By using both NMOS and PMOS differential input pairs in the error amplifier's first stage of a LDO, a push-pull stage is implemented in its second stage, offering very fast response speed. Compared to a traditional LDO, test results show this topology is stable and provides comparable performances without using external input and output capacitors. With external output capacitor employed, the LDO is still stable. **Shengming Huang, Power Management Division, National Semiconductor, Greenock, UK**

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Powerful Real-Time Controller for Digital Power

Developed under the code name Piccolo, the new F280xx microcontrollers (MCUs) feature architectural advancements and enhanced peripherals in package sizes starting at 38-pins to bring the benefits of 32bit real-time control to applications typically unable to justify the associated cost. Real-time control offers greater system efficiency and precision through the implementation of advanced algorithms for applications such as solar power micro-inverters, white goods appliances, hybrid automotive batteries, LED lighting, and digital power supplies. **Andreas Goergner, Field Application Engineer, Texas Instruments, Freising, Germany**

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High Efficiency Designs for Energy Savings

Worldwide energy efficiency legislation coupled with ongoing improvements in the performance of high brightness LEDs are accelerating the uptake of LED technology in the lighting market, and Power Integrations has developed a number of power conversion IC solutions that address the novel power needs of the emerging LED applications, such as the TinySwitch-III, TOPSwitch-GX and LinkSwitch-TN. The following design ideas show how designers can maximise the benefits offered by LED lighting technology, as well as simplifying and speeding up the design process. **Silvestro Fimiani, Product Marketing Manager, Power Integrations, USA**

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Product Update

A digest of the latest innovations and new product launches

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Website Product Locator

Growing with the Wind

According to the United Nations Environment Programme (UNEP), global investment in sustainable once again energy broke all previous records, with $148 billion of new money raised in 2007, an increase of 60% over 2006. Total financial transactions in sustainable energy, including acquisition activity, was $205 billion. Asset finance – investment in new renewable energy capacity - was the main driver for this surge in investment, rising 68% to reach $84 billion in 2007, fuelled mainly by the wind sector. Public market investment also raced ahead in 2007, with investment of $23 billion in 2007, more than double the $10.5 billion raised in 2006. According to New Energy Finance (Global Futures 2008) investment between now and 2030 is expected to reach $450 billion a year by 2012, rising to more than $600 billion a year from 2020. The sector's performance during 2007 sets it on track to achieve these levels, with the current credit crunch testing the markets resolve, but not dislodging it. Another aspect of this industry deepening has been greater activity in next-generation technologies, such as cellulosic ethanol, thin-film solar technologies and energy efficiency. Wind continues to dominate sustainable energy investment, but the portfolio of available technologies has both widened (as nascent technologies start to come into their own) and deepened (as existing technologies are refined). This is partly in response to changing supply/demand patterns (e.g. continuing silicon shortages), but also reflects improved efficiencies and decreasing costs as renewable technologies strive to reach grid parity.

Furthermore, the willingness to look beyond mature technologies suggests that investors are taking renewable energy and energy efficiency increasingly seriously. The year 2007 also saw a geographic broadening, with renewable capacity rollout continuing to shift away from Europe and towards China and the United States. In recent years, sustainable energy investment in China has been largely for manufacturing expansion as an export industry. In 2007, however, the 2008 Beijing Olympic Games sharpened the country's political resolve and strengthened programmes to promote cleaner generation and cut energy intensity. During 2007, investment in non-hydro renewables capacity in China increased by more than four times, to $10.8 billion. Acceptance of sustainable energy also became more widespread in the US, extending beyond its traditional heartland of California. A new administration in 2008 is expected to make renewable energy and energy efficiency a political priority and in recent months, regulatory uncertainty in the US (particularly over the possible introduction of a carbon tax) has put a number of coal-fired generation plants on hold.

Regarding the environment, the report 'Energy Technology Perspectives', released in June 2008 by the International Energy Agency (IEA), shows two alternative futures compared with the unsustainable 'business as usual' scenario. The most ambitious 'BLUE scenario' calls for a 50% reduction in CO2 emissions by 2050. The IEA's biennial publication responds to the G8 states' call for guidance on how to achieve a clean, clever and competitive energy future. The IEA report acknowledges that wind power, along with energy efficiency and fuel-switching will play a major role in reducing emissions in the power sector in the next 10 to 20 years, the critical period during which global emissions must peak and then begin to decline if we are to avoid the worst ravages of climate change. The BLUE scenario forecasts that wind energy will produce over 5000TWh of electricity per year by 2050, accounting for up to 17% of global power production. Over one third of the resulting CO2 savings will be achieved in China and India. The scenario estimates annual investment costs of $1.1 trillion per year (about 1.1% of global GDP) up to 2050. However, it clearly states that this cost is more than offset by fuel savings for coal, oil and gas over the same period. "For the first time, the IEA has clearly acknowledged that wind power is now a mainstream energy technology, and the central role it must play in combating climate change", said Steve Sawyer, GWEC's (Global Wind Energy Council) Secretary General. The New Energy Economy is to create a high quality platform to highlight the role of wind energy in economic development in regions around the world, this was the main subject at of Husum Wind Energy 2008. From Texas to Inner Mongolia, and from Schleswig-Holstein to Andalucía, the wind industry is building new factories, expanding local tax bases and creating thousands of new 'green collar' jobs. The wind energy industry now provides approximately 450,000 jobs around the world, in manufacturing, project development, maintenance and operation. Another opportunity is the global solar inverter market which is projected to grow by more than 40% in 2008 driven primarily by continued strong demand from both Germany and Spain. Growth will slow slightly in 2009 as feed-in tariffs are cut in these two countries; however, revenues from solar inverters are forecast to exceed $2 billion by 2010.

Thus, the future of the market continues to look very positive for power semiconductor suppliers, with energy efficiency and energy concerns as a major driver of growth, predicts IMS Research. The market researchers forecast that the power semiconductor discretes and modules market will grow at an average annual rate of 8 to 9% over the next five years.

Achim Scharf
PEE Editor

Top Power Semiconductor Rankings

The Global Market for Power Semiconductor Discretes & Modules survey published in August by IMS Research has collected and analysed sales data from all of the leading global suppliers to create a detailed assessment of the global market today, and its likely future development. Infineon retained its position as the world's largest supplier of power semiconductors (discretes and modules) in 2007 for the fifth consecutive year.

"The future of the market continues to look very positive for power semiconductor suppliers with energy efficiency and energy concerns a major driver of growth"

Infineon now commands a 9.7% share of the $13.6 billion market growing its power discretes and modules business by over 20% in 2007, outpacing the market, which grew at just under 10% and retained its position as the largest supplier to the market. The study found that the top ten suppliers to the power semiconductors market experienced mixed performances in 2007, with STMicroelectronics (7.4%), Fairchild Semiconductor (7.0%), Vishay (6.8%) and Toshiba (6.6%) on the following ranks. "The future of the market continues to look very positive for power semiconductor suppliers with energy efficiency and energy concerns a major driver of growth", added Research Director Ash Sharma. "We forecast that the power semiconductor discretes and modules market will grow at an average annual rate of 8 to 9% over the next five years".

The ranking in the power semiconductor market can be changed significantly by Vishay's recently announced bid to buy International Rectifier. Vishay, who last year paid $290 million for IR's Power Control Systems business, recently made an unexpected $1.6 billion bid to acquire IR's remaining business in a deal that dwarves its previous acquisitions. If the bid is accepted, the deal would create the world's largest supplier of discrete power semiconductors. The two companies held a combined share of close to 16% of the market in 2007, considerably higher than next closest rivals, STMicroelectronics and Fairchild Semiconductor. "Vishay's acquisition of the PCS

"We forecast that the power semiconductor discretes and modules market will grow at an average annual rate of 8 to 9% over the next five years"

"Power Integrated Modules have the highest growth forecast of 10.8% annually"

business helped it climb two places in the rankings for power discretes. This potential acquisition would see it surge past all competitors and lead the power discretes market by some way. It would also seriously strengthen its position in power ICs, particularly in segments that it has not traditionally addressed", Sharma added. Meanwhile, IR's Board of Directors has unanimously determined that the unsolicited, non-binding proposal by Vishay to acquire all of the outstanding shares of International Rectifier for $21.22 per share in cash is not in the best interests of IR and its shareholders.

Power semiconductors are widely used in industrial motor drives, this market is forecasted to grow from $1 billion in 2007 to $1.3 billion in 2010. "IGBT modules are used in the large majority of industrial motor drives", explained IMS Research analyst Jamie Fox. "As well as standard IGBT modules, Intelligent Power Modules and Power Integrated Modules are also used. Power Integrated Modules have the highest growth forecast of 10.8% annually." Most of the market is for modules; however there is also a small market for discretes and power ICs. Significant changes in the basic bill of materials are not expected in the next few years. Performance trends

"By the end of 2008, the global PV inverter market will have more than doubled from its 2006 size"

for power semiconductors include a demand for reduced heat losses, better temperature tolerance and higher power densities, IMS predicts.

Another opportunity is the global solar inverter market which is projected to grow by more than 40% in 2008 driven primarily by continued strong demand from both Germany and Spain. Growth will slow slightly in 2009 as feed-in tariffs are cut in these two countries; however, revenues from solar inverters are forecast to exceed $2 billion by 2010. "By the end of 2008, the global PV inverter market will have more than doubled from its 2006 size", Sharma commented. "Demand is still very high for solar inverters, however with cuts in tariffs in Germany already agreed and uncertainty in Spain, market growth in 2009 will be very much dependent upon what happens to module pricing", he added. The three-phase central inverter market is forecast to perform well over the next five years, driven by large-scale PV plants that are planned globally, whilst demand from residential and small-scale commercial systems will ensure that the single-phase market continues to expand.

www.imsresearch.com

Over 250,000 EVs to be sold in Europe by 2015

Depleting reserves of fossil fuels and rising levels of greenhouse emissions are expected to break electric vehicles (EVs) out of their niche end-user segments. The mainstream adoption of EVS will open up opportunities for utilities, suppliers and finance businesses, as efforts are being made to create a one-stop shop for vehicles and energy.

The OEMs have little choice but to be part of the EV market, if they are to address the escalating energy situation. They will be encouraged by novel financial models and the advent of lithium ion battery technology, which are expected to revolutionise the automotive industry. There could be a sudden movement towards the battery leasing business, which will be initiated by the EVs and sustained by the OEMs. It remains to be seen if the consumers adapt well to this innovative financial model. Apart from the possible opportunities created by battery leasing, the market is also getting a leg up from the federal and local governments, which are helping OEMs to match the prices of EVs through legislation, benefits and rebates. There are already several punitive legislation in place for gas-guzzlers in London, where offenders can be charged between £8.00 and £20.00. Congestion charging is expected being implemented in Milan, Oslo, Manchester, and Madrid, where the charges are likely to be between €1.00 and €25.00. On the strength of these favourable directives, the European EV market is estimated to roll out more than 250,000 vehicles by 2015.

OEMs have little choice but to be part of the EV market, if they are to address the escalating energy situation

"The rate at which the consumers accept the leasing model and the degree of benefit the end users derive from the business model will play a decisive role", says Frost & Sullivan Research Analyst Anjan Hemanth Kumar. "In parallel technological enhancements with respect to the battery packs is equally important. With the increase in driving range, the customer base increases beyond the city limits. A battery pack of up to 160km range can tap suburban population and neighbourhood cities; a pack with 240 plus km can tap rural population there by potentially touching more than 3 million likely EV buyers". OEMs and related companies are expected to adopt various financial models to increase sales, but leasing is expected to be the most popular and could account for 75% of sales by 2015. During the same period, bigger OEMs are likely to eat into 76% of the market currently occupied by small OEMs. "OEMs will compete in all customer segments - from economy to premium - and the prices are expected to range from €11,000 to €348,000", notes Kumar. "EVs could potentially offer monthly savings of €150-700 to drivers, encouraging buyers to make ROI-based purchase decision".

www.frost.com

Point-of-Load DC/DC Controllers

for multiple bus voltages

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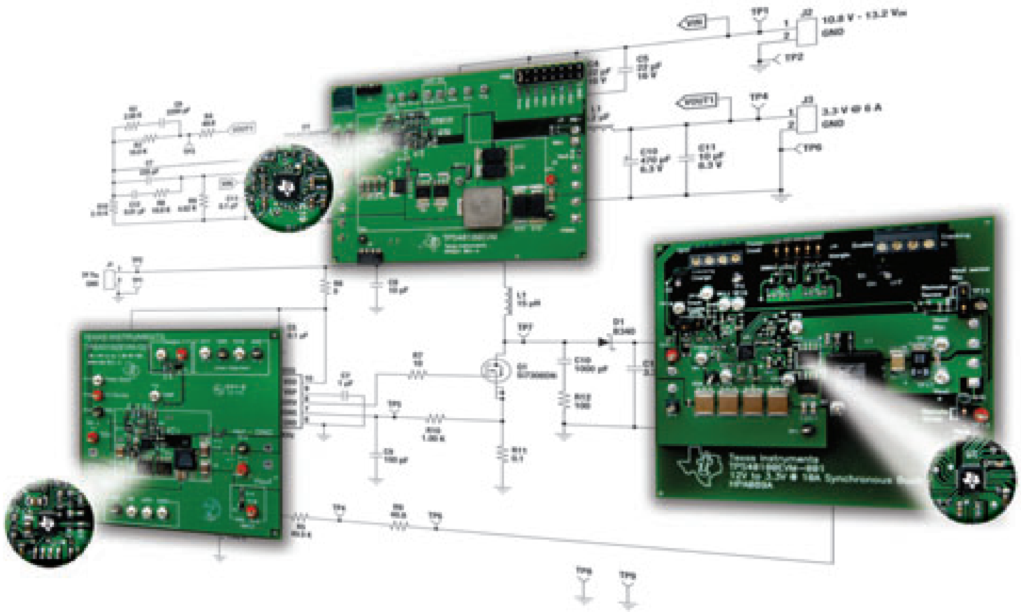
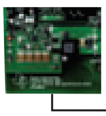


Power system designers can optimize their designs with **TPS40K™** DC/DC Controllers from Texas Instruments. These easy-to-use controllers support input voltage ranges from 2.25 V to 52 V and ensure flexibility, scalability and stackability regardless of your application.

Device	V_{IN} Range (V)	V_{REF}	Frequency	Key Feature (s)	EVM	Package (s)
TPS40040/41	2.25 to 5.5	0.6 V ±1%	300/600 kHz	Selectable short-circuit protection	√	3 x 3 mm 8 SON
TPS40042	3 to 5.5	External	600 kHz	Pre-biased output support	√	3 x 3 mm 10 SON
TPS40140	2 to 40	0.7 V ±0.5%	Adjustable to 1 MHz	One 2-phase output or two single-phase outputs stackable to 16 independent phases	√	6 x 6 mm 36 QFN
TPS40180	2 to 40	0.7 V ±0.75%	Adjustable to 1 MHz	Stackable to 8 independent phases	√	4 x 4 mm 24 QFN
TPS40192/3	4.5 to 18	0.591 V ±0.5%	300/600 kHz	Power good and enable pins	√	3 x 3 mm 10 SON
TPS40195	4.5 to 20	0.591 V ±0.5%	Adjustable to 600 kHz	Master/slave 180° out-of-phase sync pin	√	16 TSSOP or 3.5 x 4 mm QFN
TPS40200	4.5 to 52	0.7 V ±1%	Adjustable to 500 kHz	External synchronization pin	√	4 x 5 mm 8 SOIC
TPS40210	4.5 to 52	0.7 V ±2%	Adjustable to 1 MHz	Universal for boost, SEPIC, flyback	√	5 x 3 mm 10 MSOP or 3 x 3 mm 10 SON
TPS40211	4.5 to 52	0.260 V ±2%	Adjustable to 1 MHz	Boost, SEPIC, flyback for LED-driver	√	5 x 3 mm 10 MSOP or 3 x 3 mm 10 SON

*New products are listed in **bold red.***



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TEXAS INSTRUMENTS

TDK Acquires EPCOS

The concentration in passive electronic components is accelerating with the planned acquisition of Munich-based EPCOS AG by Japanese TDK.

As a first step, TDK will launch a public tender offer for all outstanding shares and will offer EPCOS' shareholders €17.85 in cash per share. The offer price represents a 29% premium over the closing price (Xetra) on July 30, 2008. Based on the number of EPCOS shares outstanding, this offer would value EPCOS at approx. €1.2 billion equity value. Including net financial liabilities, pension obligations and minority interests, this implies an enterprise value for EPCOS of approx. €1.4 billion. TDK currently holds 2.5% of the current registered share capital of EPCOS and has secured delivery of a further 7.0%. Following the successful completion of the public tender offer, TDK will immediately begin the process of carving out its relevant passive components business. The objective is to combine this business with EPCOS' business under a new company, provisionally named TDK EP Components KK.

www.tdk.co.jp

Standby Energy Savings of $3 Billion

Power Integrations' EcoSmart has saved consumers and businesses more than an estimated $3 billion on their energy bills. The technology has prevented an estimated 20 million tons of carbon-dioxide emissions from power plants since its introduction in 1998, roughly equal to the annual emissions of over three million cars.

Most electronic products require power supplies to convert high-voltage AC power from the electrical utility to low-voltage DC power. EcoSmart chips manage the flow of power through the power supply, improving efficiency and reducing standby power waste by up to 95%, all without adding to the cost of the end product. Worldwide consumer product and appliance efficiency laws, regulations and voluntary programs are contributing to the replacement of most of the outdated technologies such as discrete electronic components or the notorious copper-and-iron transformers known as 'energy vampires'. These older technologies deliver power inefficiently, often consuming two or three times the amount of power needed by the end product and wasting substantial amounts of energy while the product is in 'standby' or no-load mode, or otherwise not in use. "Energy savings from our EcoSmart technology are accumulating at an accelerating rate as market uptake of energy-efficient products continues to grow," said Balu Balakrishnan, CEO of Power Integrations. "It took seven years to achieve our first billion dollars in savings, and we've reached the three-billion mark just three years later. The growing demand for energy and the environmental impact of energy generation are among the greatest challenges facing the world today."

www.powerint.com

Call for Papers PCIM 2009

PCIM Europe 2008 from 27 to 29 May 2008 attracted 252 exhibitors and 56 represented companies from 26 countries on an exhibition area of 10,600 sqm. Once again the participation of numerous companies from overseas (57%) underlines the high international standing. The large number of companies from the USA, France, United Kingdom and Italy is particularly noteworthy. The number of new exhibitors was also worth mentioning: 31 additional exhibitors were at PCIM 2008 for the first time. Also, the number of visitors (6,500) and conference delegates (592) marked a new high.

PCIM Europe 2009 will take place in Nuremberg, Germany, 12 – 14 May 2009. Power Electronics have a large influence on the development of technology and are applied in all stages of energy flow - from Power Generation to Power Distribution and to Power Use. The rising demand for energy in all forms and the recent series of dramatic increases in energy prices have made it evident that energy must be used more efficiently. According to the European Commission, about 180 million tons of CO_2, the equivalent output of around 50 power stations, could be saved by 2010 with new and energy-efficient products and appliances alone in Europe. To reach these goals, new highly efficient power electronic technologies are needed as an enabling factor to reduce today's massive waste of energy while keeping the conveniences of technical progress. Power Electronics is playing a key role in the energy saving and energy efficiency fields. Consequently, the sector is seeing a significant rise in the use of power semiconductor technologies in fields of application such as the automotive, telecommunications and domestic appliances industries. It is therefore not surprising that energy efficiency was an important subject throughout the PCIM conference and exhibition in 2008, and will be even moreso in the year 2009.

Again, the Best Paper Award for 'Energy Efficiency in Automotive, Industrial and Mobile Power Electronic Applications', will be sponsored by Power Electronics Europe. The award is the participation at PCIM China 2010 in Shanghai including flight and accommodation.

Full PCIM 2009 Call for Papers at:
http://www.mesago.de/en/PCIM/Call_for_Papers/index.htm

Additionally, Mesago has released the Call for Papers for PCIM China 2009 to be held from 2 – 4 June in Shanghai. Deails under:
http://www.pcimchina.com

New Enterprise Power Business Manager at IR

International Rectifier appointed Tim Phillips as Vice President, Enterprise Power Business Unit. He will be responsible for product development, systems applications engineering and product marketing for IR's computing and communications product lines including DC/DC ICs, DirectFET MOSFETs, SupIRBuck integrated voltage regulators and iPOWIR power stage products.

Phillips previously held technical and leadership positions at Cherry Semiconductor in Power IC Design, Applications, Marketing and Business Development before joining IR in 2001 as Director of Applications and Business Development. He advanced to Executive Director, Sector Marketing and Field Application Engineers for the Computing & Communications Business Unit and was later promoted to Vice President, Corporate Marketing and Investor Relations. He became Vice President for the Enterprise Power Business Unit in April 2007 and briefly served as Vice President of Infineon's Industrial and Multi-market business in 2008.

www.irf.com

An Innovative Approach to Input Bridges

Power management is increasingly important in all areas of electronic engineering; from the distribution of high voltage supplies to the effective monitoring of very low core voltages in digital devices. Through the efficiency benefits of replacing conventional input rectification with a self-driven synchronous rectification technique called Active Bridge concept, the challenge of delivering better power management solutions will be met. **Davide Giacomini, European Director of SMPS Applications and Luigi Chiné, SMPS Application Engineer, International Rectifier**

Today, there is much talk about low power solutions, with a specific focus on portable, battery operated devices. In general, semiconductors that operate from ever-lower voltages allow these 'high profile' devices, such as mobile phones and media players, to operate for longer between charges, and it represents an important element of the overall direction of the industry. With this focus on portability, however, it is easy to overlook the equally important need to operate other, less portable devices more power-efficiently. Environmental issues and the rising price of utilities give this its own emphasis and there is now an increased appreciation for the need to consider overall power requirements in the kind of electrical devices we use everyday, such as home appliances, labour saving devices and even automated manufacturing.

Although we tend to think in terms of low voltages, the majority of electronic devices in operation are, in fact, powered through the nationally distributed high voltage power supply, in one way or another; either directly or through an adapter for rechargeable devices. Distributing power across large geographical distances is most efficiently achieved at very high voltages, but at the point of use these voltage levels are clearly too high and must be stepped down, a process that is inherently inefficient. Maximising the efficiency of converting large AC voltages to more useable DC voltages, particularly for appliances connected directly to the main AC power supply, is an area with scope for improvement.

Low efficient diode bridge

One of the most basic elements in this area of power electronics is the diode bridge, used extensively to provide full-wave rectification of an AC voltage to something that begins to resemble a DC supply. Further smoothing and filtering using resistor, capacitor and inductor networks normally follows.

Diodes are technically active devices, which are created through forming a P-N junction in a semiconductor material. However, they miss the control element found in other, more sophisticated active devices such as silicon controller rectifiers or even simple transistors. Standard diodes exhibit a forward bias voltage drop of around 0.7V all the time they are conducting, which in the configuration of a full-wave rectifier represents inefficiency. It also represents a form of power dissipation and, in high current applications, that can become significant, in terms of the heat dissipated and power used. Another characteristic of the venerable full-wave input bridge is that there are always two diodes conducting at any time, effectively exacerbating the power dissipation issue.

Despite its inherent weaknesses, in low load applications this topology still offers a cost-effective solution. It is also used extensively in high power applications and is probably on the increase. For instance, AC induction motors are now being replaced with DC motors and they will likely implement a diode bridge to provide the voltage conversion. In this case, the power penalties are clearer.

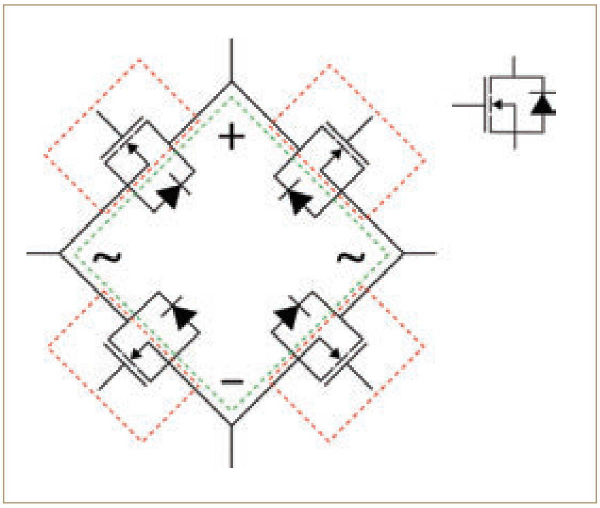


Figure 1: A bridge structure using four FETs instead of diodes reduces power dissipation significantly

More efficient synchronous rectification

Using the parasitic diode present in all MOSFETs, this problem can be addressed more efficiently. By creating a bridge structure using four FETs instead of diodes, as shown in Figure 1, the power dissipation exhibited using diodes can be avoided.

The synchronous rectification technique works by reducing the amount of time during any half-cycle that the body diodes in the transistors are conducting, by turning the transistor on for the majority of the half-cycle. When the transistor is on, the body diode is bypassed, drastically reducing the power that would be lost if it were conducting for the entire half-cycle.

In operation, as current starts to flow through the FET's body-diode during the start of a half-cycle in the AC supply, a negative voltage is generated across the transistor's drain and source terminals. By detecting this voltage drop the control circuit can turn on the FET, thereby reducing the power dissipated in the

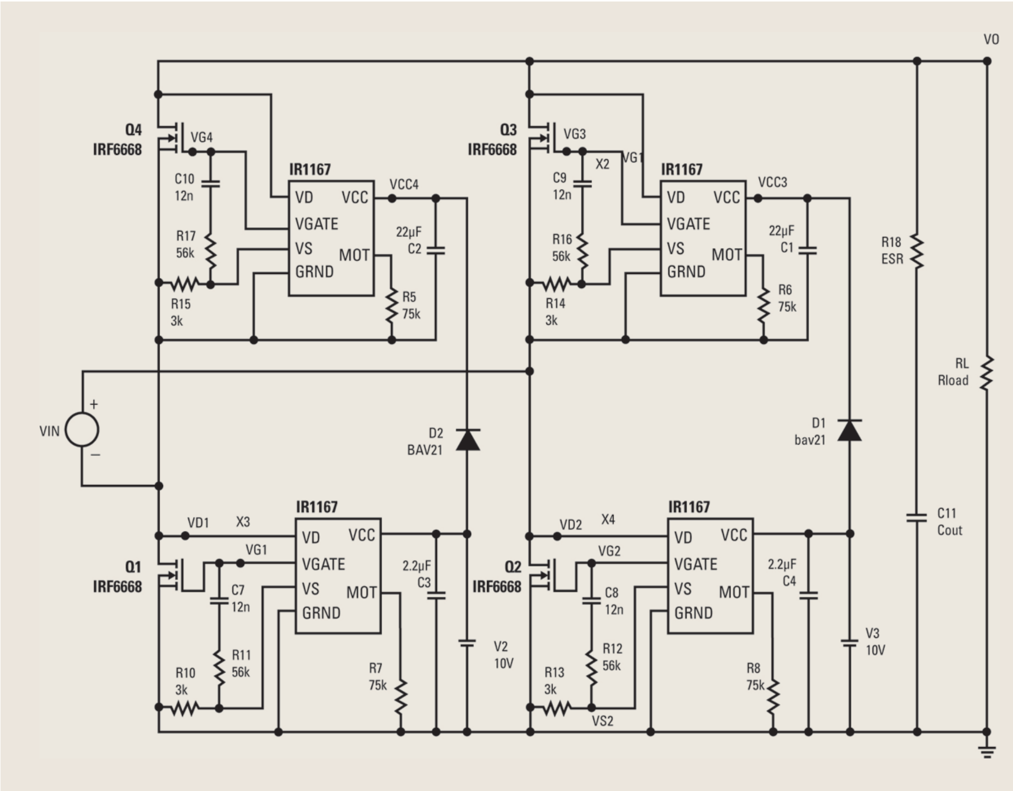


Figure 2: Discrete solution to implement synchronous rectification up to a maximum of 200V

device. The lower the $R_{DS(on)}$ of the transistors, the more effective the solution.

Up to 600V

The effectiveness of the technique depends largely on two elements; the FETs used and the accuracy of the control circuit. International Rectifier's synchronous rectification devices, the IRF1166 and IRF1167, were developed to provide a simple, discrete solution to implementing this control up to a maximum of 200V, as shown in Figure 2. This is a similar configuration to using four FETs to drive a brushless DC motor and, as in that application, it is important to ensure that the FETs switch on and off at the right time to avoid short-circuits. This is a factor of how effectively the control circuit senses the negative voltage generated across the FET as the current starts to flow through it, which happens as the AC voltage increases from 0V.

Another challenge in this implementation is ensuring the comparator in the control IC is capable of withstanding the high supply voltages, while still detecting the small reverse bias voltage across the body-diode. This has been achieved through Gen 5 HVIC technology, which integrates precision low voltage functions in a high voltage device using isolation barriers.

For maximum benefit, the FET must continue conducting until the half-cycle voltage returns to 0V or as close as possible without crossover. The danger here is that the relatively slow changes in voltage/current could cause the control circuit to misinterpret those small changes as the trailing or leading edge of the current or next cycle respectively. Until the current is high enough to cause a definite and detectable voltage drop, the circuit could repeatedly turn the FET on and off for a short time during crossover. This is most likely to occur in a circuit with a resistive load, where the rate of change in current is slower than, for example, a capacitive load.

The solution to this is to include an RC network, bootstrap capacitors and two bootstrap diodes in the control circuit. This injects additional current during the 0V range to ensure the threshold voltage is effectively breached long enough for the voltage drop across the body diode to pass through the uncertainty range.

In a single IC implementation, for voltages up to 600V, the bootstrap diodes

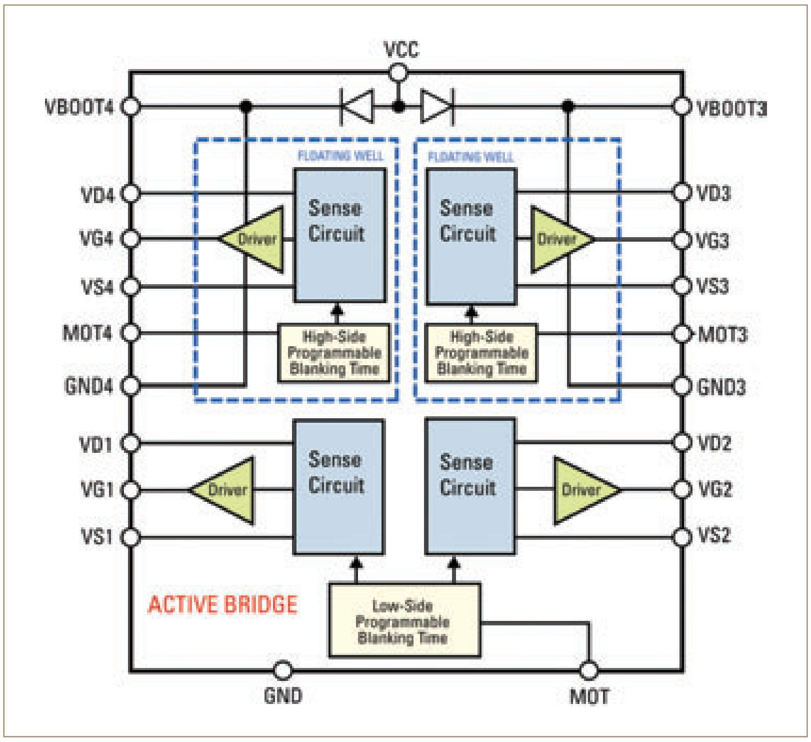


Figure 3: Integrated Active Bridge Controller for voltages up to 600V

could be integrated, while the RC network would likely be replaced with dedicated configurable blanking time blocks for each driver section, to allow different FETs to be accommodated. It is also possible to integrate the FETs, bootstrap capacitors and control functions in a single device, forming a direct replacement for existing diode based full-wave bridge rectifiers. This could provide not only significant power savings but also a substantial reduction in PCB space. Figure 3 shows how this integrated Active Bridge controller may be realised. Additionally a prototype using four IRAC-D2 daughter cards has been realised.

Great efficiency gains

To verify the effectiveness we compared two active bridge designs, at different input voltages of 100V and 40V and different output power, against standard schottky-diode bridge solutions. Figures 4 and 5 show the results obtained. For the 40V system we used 4x IRF6613 (DirectFet medium Can) compared with 4 x SS34 in SMC package; for the 100V instead we used 4x IRF6644 (DirectFet medium Can) against 4x MBR10H100 in TO263 package.

In the case of Figure 4, the amazing result is the 5.5% gain in efficiency at 20V input and about 50W output; the reason is the higher current flowing into the FETs showing much lower dropout than a diode.

At increasing input voltage and decreasing output current, the efficiency advantage drops to a still good 2 to 3%. The three curves are limited in power to limit the peak current into the devices to an acceptable operating level compared to their rated I_d and I_f. In Figure 5, the efficiency gain shows the same trend: at 60V and 250W output the current is much higher and the gain is exceeding 2%; at 100V this efficiency gain drops to about 1.1 to 1.3% depending on the load.

This last case seems to be less appealing in the balance of benefits and cost. We have to remember, however, that the four IRF6644s are much smaller than the comparing diodes in TO263: each DirectFet is about 80% smaller in area and 95% in volume than the diodes. This allows a much smaller solution and higher power density, often eliminating the need for a bulky heatsink.

Conclusion

Using SO8 FETs or better DirectFETs in an input active bridge configuration (with synchronous rectification control), is the way to increase efficiency and power density whilst reducing or eliminating the need for an heatsink. As shown from the graphs, efficiency improvement is quite noticeable and the benefits may be different according to the output power. If the output voltage is high, the efficiency increase may not be very important, especially if delivering kilowatts, but then the much lower power dissipation across the bridge allows for smaller and cooler solutions. If the output voltage is low, efficiency becomes the predominant difference, also for low current outputs.

Figure 4: Efficiency results at low voltage input

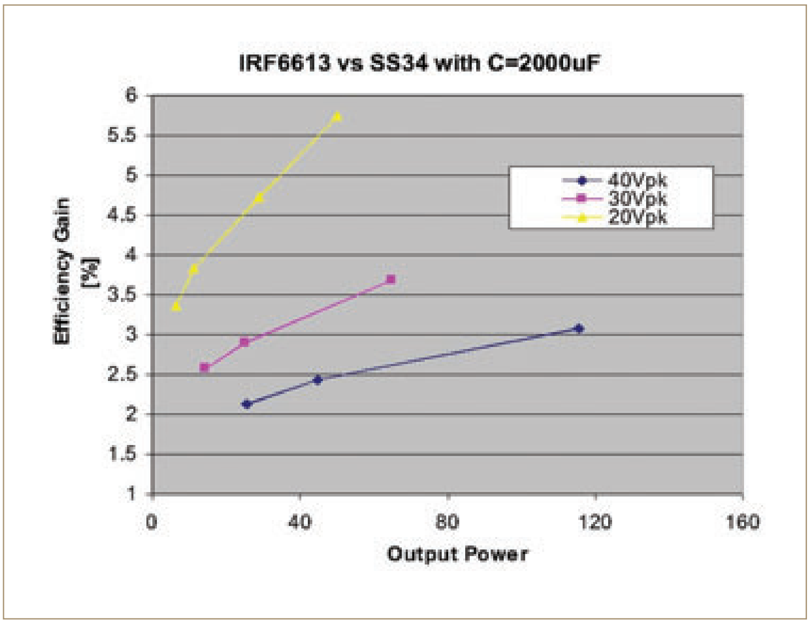
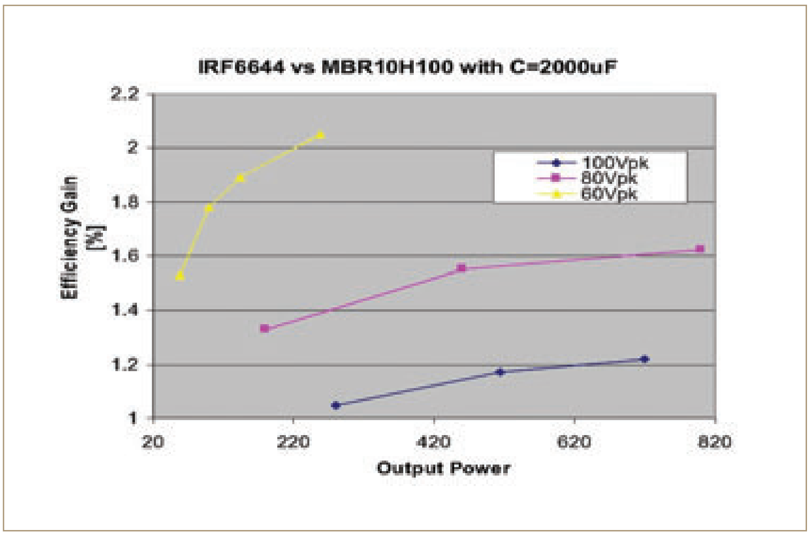


Figure 5: Efficiency results at medium voltage input



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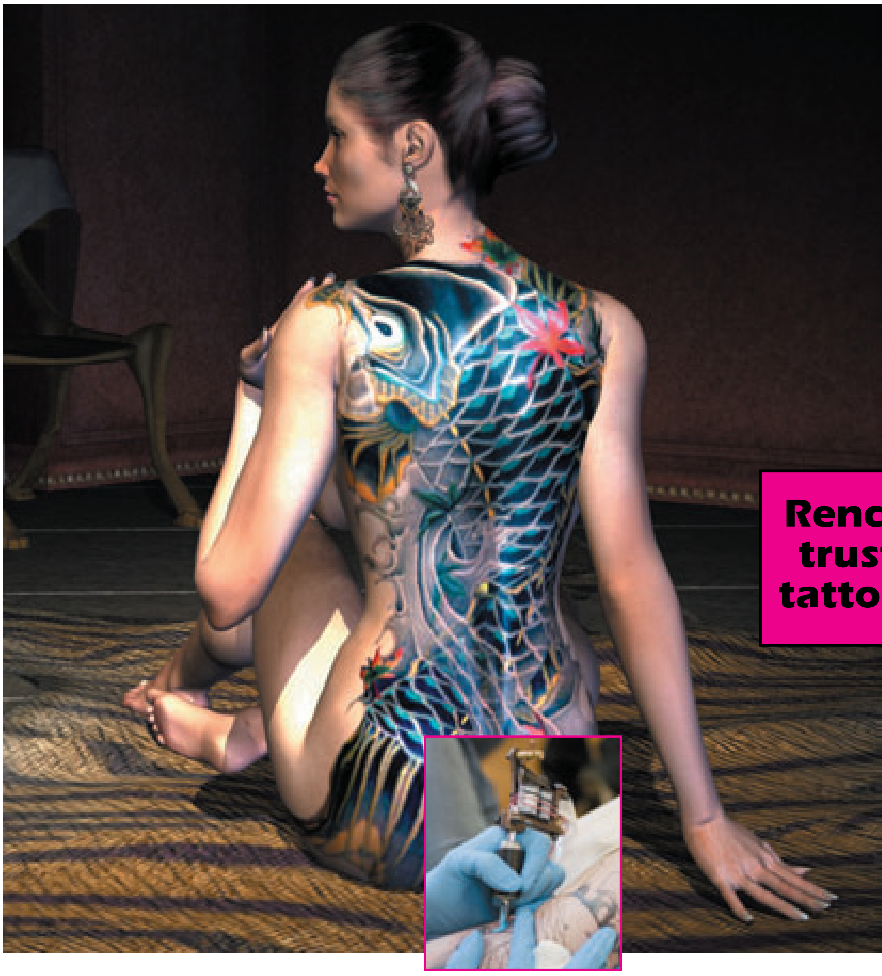

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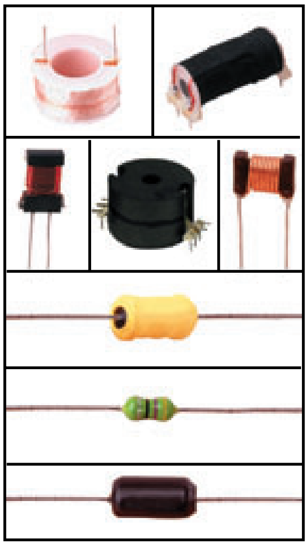

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Optimised Utilization of IGBTs by Plug-and-Play Drivers

The extremely compact and high-performance IGBTs of the PrimePACK series from Infineon Technologies AG enable scalable power converter system solutions optimised for various industrial drives, windmills, elevators, traction and auxiliary drives. SCALE-2 IGBT drivers make a perfect match for scaling power and controlled efficiency. **Jan Thalheim, Olivier Garcia, Peter Wassmer, Sascha Pawel, CT-Concept Technologie AG, Biel, Switzerland**

Thanks to SCALE-2 technology, the new 2SP0320 family comprises complete and extremely compact two-channel IGBT drivers equipped with DC/DC converters, short-circuit protection, advanced active clamping and supply-voltage monitoring. Users need only mount them onto the corresponding IGBT module. The system can then be put into immediate operation with no further development or matching effort.

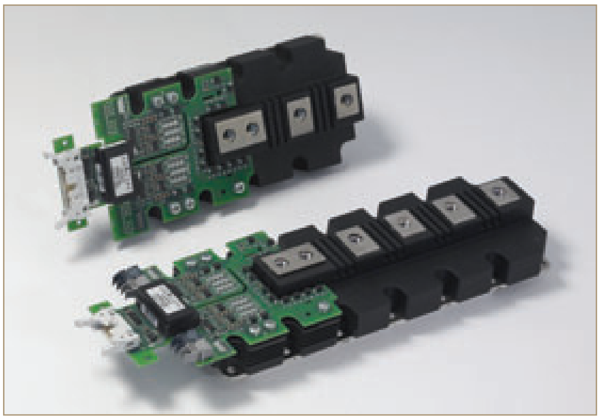


Figure 1: The modular layout of plug-and play drivers for PrimePACK allows several options to be implemented, including a signal transformer interface (background), a fibre-optic interface (foreground), leaded or surface-mountable gate resistors and dV/dt feedback

Driver chipset features

SCALE-2 is a further development of the SCALE technology already tried and tested since 1998 in large item numbers and in practically every conceivable application. SCALE-2 has a significantly higher degree of integration, thus reducing the number of components on the driver boards. This results in maximum reliability, a smaller space requirement and much lower costs.

The SCALE-2 chipset has integrated interfaces for signal transmission via optical fibers or transformers. In the latter case, the command and fault-feedback signals are transmitted via the same transformer. Thanks to a longer pulse duration, the fault-feedback signal dominates both the command signal and noise and can therefore be transmitted to the primary side within a microsecond. These drivers have an extremely short transit time of typically less than 80ns and a jitter of less than ±2ns. Parameter variations over the production process, temperature and supply voltage are widely compensated. The delay to shutdown after reporting a fault is also adjustable.

The SCALE-2 chipset inherently supports not only two-level, but also three-level and multi-level topologies and parallel-connected IGBTs. Optimised active clamping is integrated as in predecessor systems and is now also capable of directly controlling the rate of change of the collector current or collector-emitter voltage at the IGBT turn-off transition. The secondary-side gate driver chip has an integrated output stage for gate currents up to 6A. The output current can be increased to about 40A by simple means. The complete functionality of the DC/DC converter is integrated in the primary side interface chip. The user interface is compatible with all logic families from 3.3 to 15V.

The chipset provides high ESD and noise immunity, ensuring safe operation in rapidly switching systems and harsh environments.

Application options

Figure 1 shows the plug-and-play PrimePACK IGBT drivers with transformer and fibre-optic interfaces respectively. Upon request, the transformer and electrical interfaces are mounted on the underside to reduce the height of the driver.

For the PrimePACK drivers, the signal transformer version provides both direct driving mode and half-bridge mode with combined input and fault processing and an internally generated half-bridge dead time matched to the corresponding module. A command blocking time is also provided after a fault event to ensure proper reset and thermal stability of the system. These functionalities can be deactivated by connecting the corresponding pins to signal ground at the primary-side interface.

Although the superior noise immunity of the transformer version makes it first choice for reliable and low-cost systems, a dedicated fibre-optic version is also available. This stand-alone interface eliminates the transformer signal path and therefore outperforms the noise immunity of most other solutions available on the market. Each commmand is acknowledged by a short pulse of 650ns to monitor the fibre-optic connection. Any fault event is reported for a minimum of 8µs.

Switching behaviour

The easy adaptation of the drivers permits an optimum set-up to handle the special demands of a wide range of applications. The initial version allows 1700V IGBTs to be turned off at a DC link voltage of 1200V at DC link inductances of up to 65nH within the safe operating area. The DC link voltage may be increased up to 1300V and beyond by optional dV/dt or dI/dt feedback to enhance the power density or the safety margin.

This is made possible by keeping the MOS channel conducting during turn-off. The feedback signal is applied to both the driver input and the IGBT gate to improve the efficiency of the active clamping devices. This tried-and-tested architecture

Figure 2: **Turn-off transition of a 1700V/650A FF650R17IE4 PrimePACK module at I_C = 1300A, V_{DC} = 1200V, L_S = 45nH and T_J = 150°C. V_{DC} can be further increased by optional dV/dt feedback**

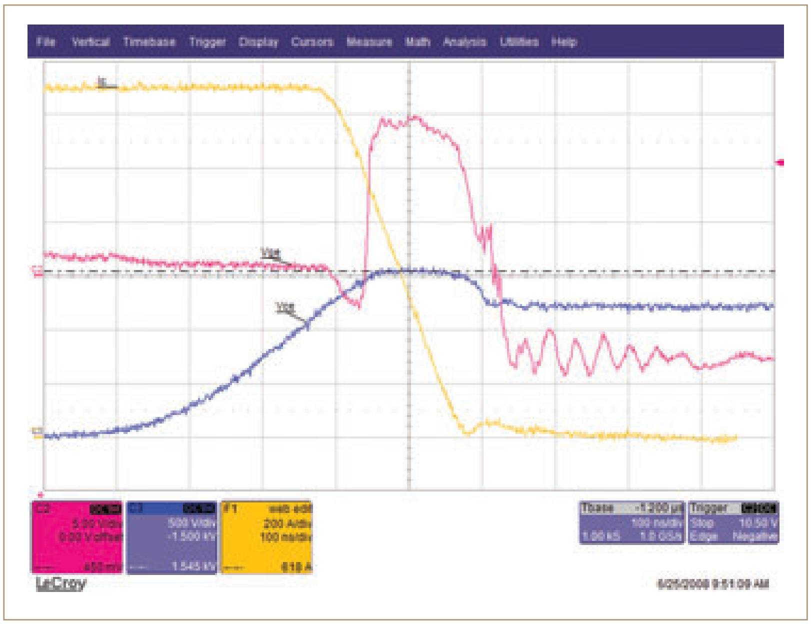
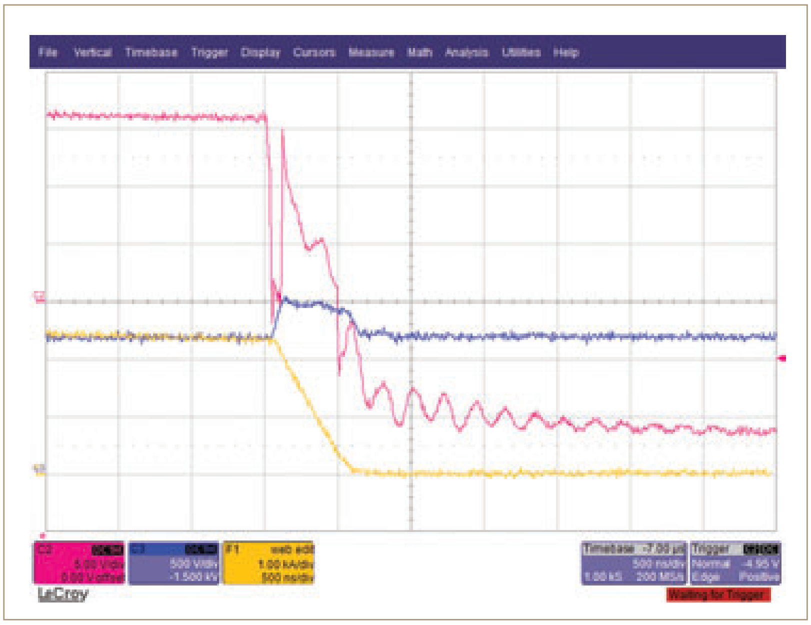


Figure 3: **Short-circuit turn-off of FF650R17IE4 at V_{DC} = 1200V, L_S = 65nH and T_J = 150°C**



has become a virtual standard ever since a plug-and-play driver solution for a high-voltage IGBT for the first time ten years ago has been presented. It should be noted that the use of simple gate drivers would exceed the safe operating area limit at DC link voltages beyond about 1000V for typical applications.

A gate capability of up to 4W and 20A per channel is available, which may be fully exploited by several design and application options depending on DC link voltage, switching frequency, number and type of gate resistors, IGBT internal gate resistance and components for active clamping. For the initial design using SMD components, switching frequencies of up to 15kHz are achieved by minimum gate powers of 3 and 2W at ambient temperatures of 70 and 85°C respectively. The operating ambient temperature range of the driver is defined as -40 to 85°C. Other operating ranges are available upon request. The driver chipset has been successfully verified for an operating ambient temperature range of -65 to 125°C and up to a junction temperature of 175°C.

High-performance turn-off transitions of a 1700V/650A PrimePACK module are shown in Figures 2 and 3, displaying the collector-emitter voltage V_{CE} (blue), the collector current I_C (yellow) and the gate-emitter voltage V_{GE} (red). Thanks to the advanced driver architecture with integrated active clamping, IGBT operation is kept within the safe operating area with a reasonable margin up to a total DC link inductance L_S of 65nH. This is verified for a collector current I_C of up to twice the nominal current, or under short-circuit conditions for the full operating range of the IGBT junction temperature T_J and a maximum permitted DC link voltage V_{DC} of 1200V, which can be further increased by optional dV/dt feedback.

The 1200V PrimePACK modules are controlled up to a V_{CE} of below 1100V for a maximum permitted V_{DC} of 800V.

Customised solutions

Samples will be available in Q4 2008. The initial design can be easily extended to provide direct paralleling of gate drivers and IGBTs, e.g. by a user-provided logic for the version with a transformer interface in direct driving mode, or by a factory-provided bus connector for the version with a fiber-optic interface. However, a series of dedicated gate drivers is also being developed to further improve the cost performance ratio for driving parallel IGBTs. Plug-and-play drivers and SCALE-2 ASICs are also offered in customised versions for applications produced in volume quantities.

From Vehicle Drive Cycle to Reliability Testing of Power Modules

In hybrid electrical vehicles (HEV) the battery, motor and inverter are the core elements of the electric drive train. To qualify power modules for use in HEV inverters, amongst others, power and thermal cycling tests have to be performed. These tests mainly ensure the reliability of the module regarding thermal stress conditions over the vehicle lifetime. This paper presented at PEE's PCIM Automotive Power Session discusses the requirements on such power semiconductor modules in terms of reliability and lifetime in HEVs. **M. Thoben, K. Mainka, R. Bayerer, I. Graf, M. Münzer, Infineon Technologies, Warstein and Munich, Germany**

Power and thermal cycling tests are performed under strong test conditions to reduce test time. A process is needed to convert real vehicle drive cycles into required test cycles. As development of the power electronics components and technology starts much earlier compared to the vehicle availability, a virtual process utilizing simulation is advantageous.

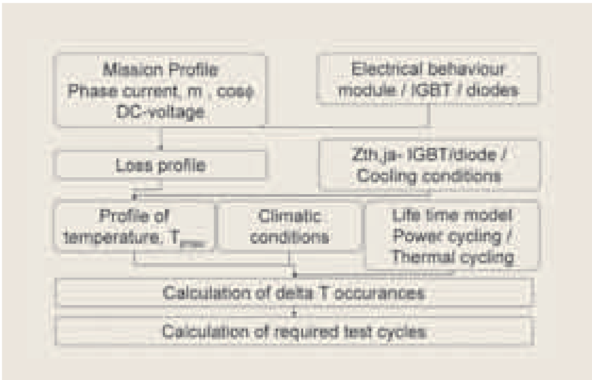


Figure 1: General approach for estimation of required test cycles

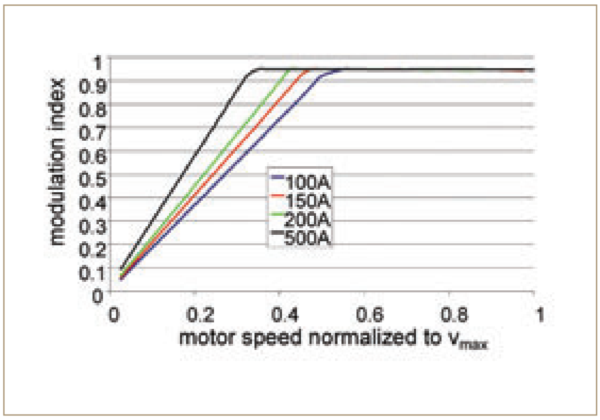


Figure 2: Modulation index as a function of motor speed and current

Estimation of required test cycles from vehicle operation

The estimation of test cycles requires the knowledge of system information as well as information of the power electronics components. Figure 1 shows a schematic with all steps that are necessary during this process.

The mission profile of the vehicle results in the motor speed and varying phase currents and DC voltages in the inverter. In combination with the electrical properties of the power module, a loss profile can be calculated. In combination with the thermal behaviour of the power module and the cooling system, these losses are generating temperature profiles on the IGBTs and diodes. Considering the climatic conditions, temperature cycling occurrences can be identified. Life-time models are needed to transform thermal cycling during the vehicle operation and coolant temperature change into test cycles, with accelerated test conditions.

The loss profile is influenced by different parameters according to equation 1:

$$P = f(I_L, V_{DC}, m, \cos(\varphi), f_s, T_j)$$

Besides the current Il and DC voltage VDC, the modulation index and power factor, which is for sinusoidal waveform equivalent to the cos(φ), have a strong influence on the loss sharing between IGBT and diode. Switching frequency and junction temperature also have to be considered.

One motor speed adjustment of a hybrid system uses a PWM inverter with PWM controller which can control both voltage and output frequency. The modulation index is used for Volts per Hertz control method. Below the base point, the motor operates with constant V_L/f_L ratio, where V_L is the amplitude of motor phase voltage and f_L is the synchronous frequency applied to the motor. Above this point, the motor operates under-excited.

As shown in Figure 2, the modulation index can be described as a function of motor speed and current. It is necessary to consider this when calculating the IGBT and diode losses, as for low modulation index the losses are more evenly shared between IGBT and diode. The power factor

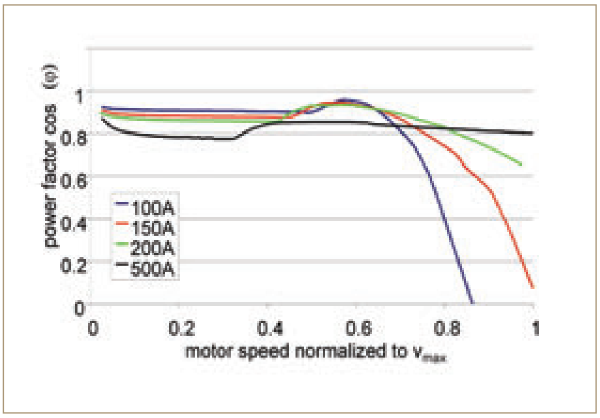


Figure 3: **Power factor as a function of motor speed and current**

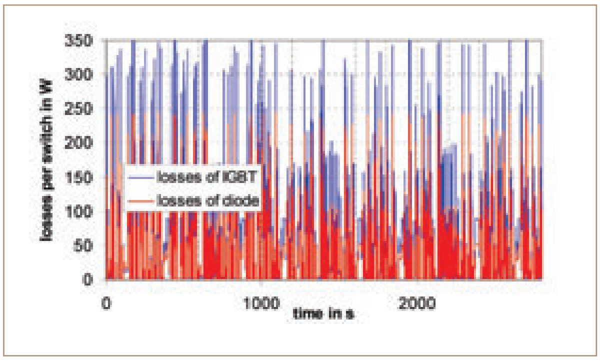


Figure 4: **Example of a transient loss profile for a vehicle mission profile**

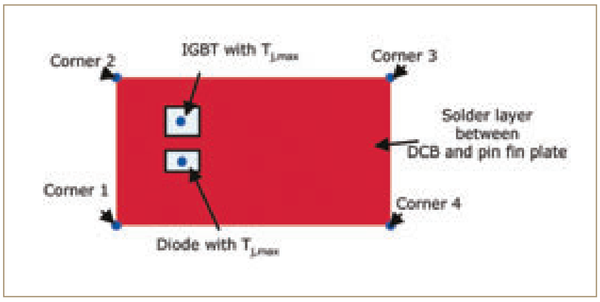


Figure 5: **Temperatures of solder joint which are considered for the thermal model**

depends on the dimensioning and type of motor used in the hybrid system. It can be described as a function of motor speed and motor torque, respectively motor current. The power factor of the considered motor reduces with increasing motor speed at low current as shown in Figure 3. It is complicated to describe the dependency in a closed formula. Therefore a look-up table is utilized to implement calculation of modulation index and power factor.

Calculation of IGBT and diode losses

The calculation of power losses is based on averaging the conduction and switching losses for sine-triangle modulation assuming a sinusoidal output current. For the calculation of IGBT and diode losses, a model based on linear approximations, e.g. for the device's forward characteristics, the derivation of switching losses and assumptions e.g. for the recovery energies is applied. The conduction losses of the IGBT and Diode are calculated with equations 2 and 3, where r, V_{CE0}, r_D and V_{F0} are temperature dependent.

$$P_{IGBT\_DC} = \frac{I^2 r}{8} + \frac{I \cdot V_{CE0}}{2\pi} + m \cdot \cos(\varphi) \cdot \left(\frac{I^2 r}{3\pi} + \frac{I \cdot V_{CE0}}{8} \right) \quad (2)$$

$$P_{Diode\_DC} = \frac{I^2 r_D}{8} + \frac{I \cdot V_{F0}}{2\pi} - m \cdot \cos(\varphi) \cdot \left(\frac{I^2 r_D}{3\pi} + \frac{I \cdot V_{F0}}{8} \right) \quad (3)$$

For the IGBT switching losses a linear dependency from current and voltage gives a good approximation (4).

$$P_{IGBT\_SW} = \frac{f_{sw}}{\pi} \cdot \left(E_{on\_nom} + E_{off\_nom} \right) \cdot \frac{\hat{i}}{I_{nom}} \cdot \frac{V_{DC}}{V_{nom}} \cdot \left(\frac{T_J}{T_{nom}} \right)^{\alpha}$$

For the dependency of Diode switching losses from current an extended function is used (5). This is necessary to describe these losses at low current operation. A bilinear approach from [1] would overestimate the losses for small currents.

$$P_{Diode\_SW} = \frac{f_{sw}}{\pi} \cdot E_{rec\_nom} \cdot \left(\frac{\hat{i}}{I_{nom}} \right)^{\kappa} \cdot \frac{V_{DC}}{V_{nom}} \cdot \left(\frac{T_J}{T_{nom}} \right)^{\alpha}$$

The coefficients for equations 1 to 5 can be easily extracted from power module datasheets. Switching losses at nominal currents and as a function of current are

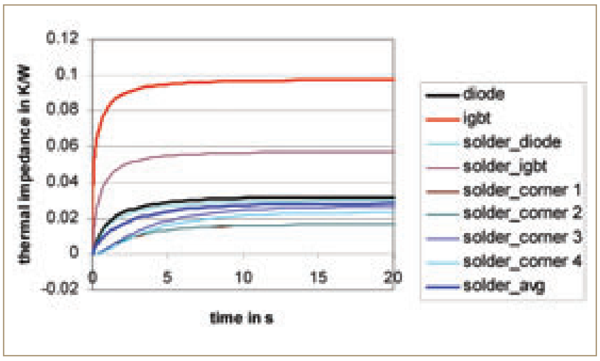


Figure 6: **Transient step response of temperature on IGBT-load**

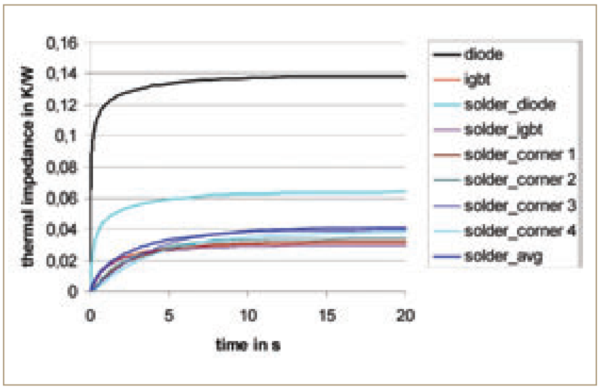


Figure 7: **Transient step response of temperature on diode-load**

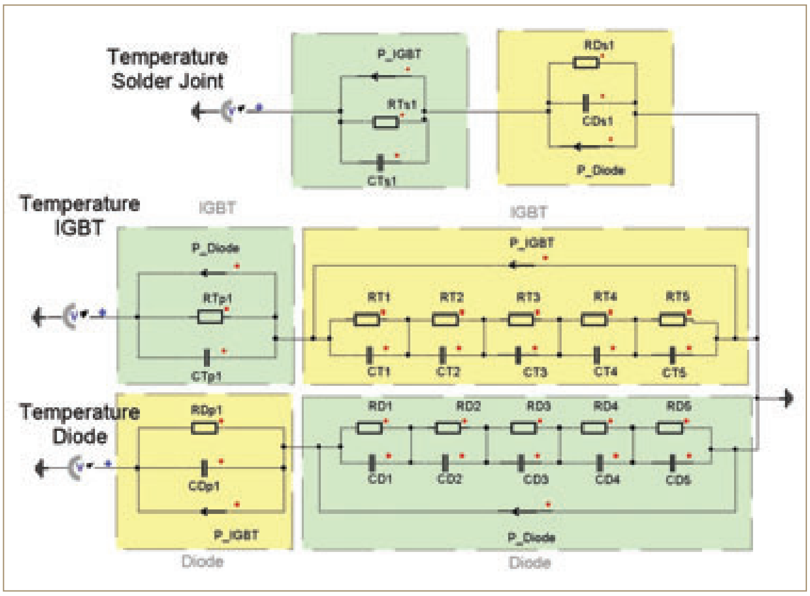


Figure 8: Model used for the temperature profile calculation

included. Also the coefficients for the forward voltage can be extracted from the described output characteristics of the IGBT inverter. To prevent the use of an electrical-thermal coupled simulation model, a good approximation is to calculate the losses for the maximum operation temperature. Figure 4 shows an example of a loss profile for a vehicle drive cycle. As the described curve mostly consists of motoring conditions, IGBT losses outbalance compared to diode losses.

Thermal model generation

To calculate a temperature profile from the losses, a thermal model of the power module including the cooling system is necessary. A direct cooled power module with pin-fin base plate was investigated. 3D transient FEM simulations were performed to extract the thermal model for the temperature on the IGBT and the diode. As degradation of DBC to baseplate solder joint could be lifetime limiting for the power module, a thermal model for the solder joint is needed as well (Figure 5).

The temperature of the solder joint during operation of the power module is not homogenous, especially for the direct cooled power module. Due to reduced heat spreading, only the solder directly below the chip is heated up. As shown in Figures 6 and 7, the corners of the solder joint have low temperature increase. Typically degradation of the solder joints starts at the corners.

To consider also the maximum temperatures below the chip, an average temperature for the corner and below the chips is used in the thermal model (6).

$$T_{solder\_avg} = \frac{1}{6}(T_{s\_c1} + T_{s\_c2} + T_{s\_c3} + T_{s\_c4} + T_{s\_IGBT} + T_{s\_diode})$$

The transient step response of the temperature on the diode results in higher temperature, as less silicon area is included in the power module. During the operation, losses in the diode generates a temperature increase on the IGBT. This effect has to be included in the thermal model. The thermal model consists of capacitor/resistor pairs. Five pairs are needed to describe the transient behaviour of the IGBT and the diode. The coupling between IGBT and diode can be described with only a capacitor/resistor pair, as well as the temperature behaviour of the average solder joint temperature.

Figure 8 shows the whole model, which is used for the temperature profile calculation. Simulations are performed with Simplorer, but the model can be implemented in several other Spice based simulation tools as well. In the yellow coloured areas of the model, the losses are generated by the IGBT; green coloured areas losses are generated by the diode. To verify the model, infrared measurement of a power module without potting and lid were realised (Figure 9). The transient step response of the IGBT was also measured to ensure the simulation model.

Extraction of thermal cycles

With the thermal model and the loss profile, a temperature profile for the IGBT, diode and the solder joint can be carried out. Although the losses in the IGBT for the example are higher compared to the diode shown in Figure 10, the temperature level is similar, because of the different thermal resistance values. A maximum temperature increase of 15K for the average solder temperature occurs.

An automatic algorithm is implemented

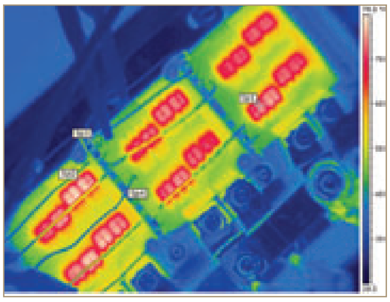


Figure 9: Infrared measurement of power module while operating all IGBTs

in Simplorer to extract temperature swings. Figure 11 describes how this information is extracted from the temperature profile. Additional information for the temperature cycle is useful, as the power cycling capability is also influenced by the duration of loss generation, the current and the junction temperature.

The lifetime limitation due to junction temperature swing is mainly related to wire bond lift-off and differs from the mechanism of solder joint degradation. Therefore different failure acceleration functions have to be taken into account when calculating test cycles. Equation 7, based on a large number of power cycling tests performed with different power modules, describes how each duty cycle can be transformed to test cycles with specific test conditions:

Assuming a test cycle with ΔT=100K, Δtestof 100K at T_{jmax}= 150°C, $t_{on,test}$= 2s at 800A the number of test cycles can be calculated by summation of all transformed duty cycles (8):

$$\frac{n_{duty\_cycle}}{n_{test\_cycle}} = \frac{\Delta T_{duty}^{-3.483} \cdot e^{\frac{1917}{Tj\_duty+273}} \cdot t_{on\_duty}^{-0.438} \cdot I_{duty}^{-0.717}}{\Delta T_{test}^{-3.483} \cdot e^{\frac{1917}{Tj\_test+273}} \cdot t_{on\_test}^{-0.438} \cdot I_{test}^{-0.717}}$$

For 10,000 occurrences of the

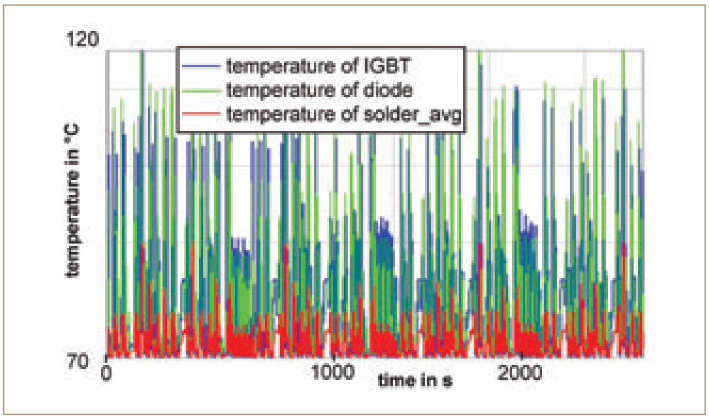


Figure 10: Example of a temperature profile for a vehicle mission profile

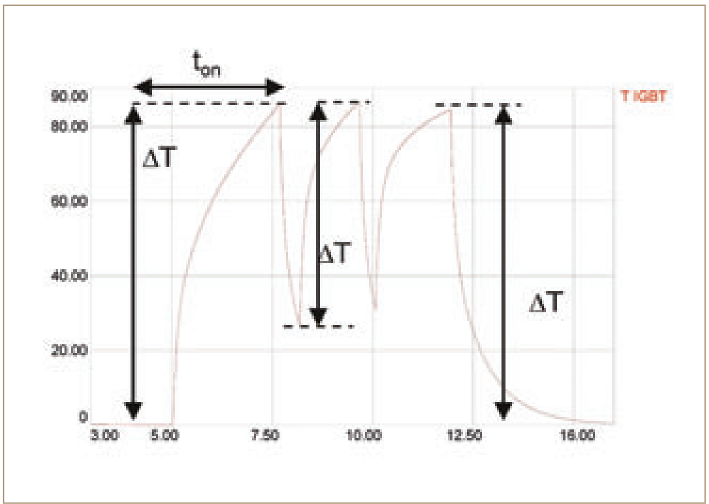


Figure 11: Extraction of ΔT and t_{on} from the simulated temperature profile

temperature profile for a vehicle mission profile in Figure 10 the number of test cycles is calculated, resulting in approx. 4000 power cycles with ΔT_{test} of 100K at T_{jmax}= 150°C, $t_{on,test}$= 2s on time for the IGBT and the diode. Passive temperatures due to heating up the coolant from ambient to operation temperature require additional test cycles. These cycles have a much longer cycling time. Equation 7 is developed for short time cycling operations. It is assumed, that power on time larger 15s have no effect on the power cycling capability. 11,000 coolant temperature cycles are assumed over the vehicle lifetime. Based on the formula a number of 23,000 required power cycles are calculated. Therefore a total number of 27,000 required power cycles is estimated. For solder joint reliability of lead-free solder joint a different acceleration exponent is reasonable for the transformation of test cycle to duty 0cycle.

Conclusion

A general approach is presented to evaluate duty cycles and estimate required test cycles for power modules in hybrid drive applications. The process offers to calculate test requirements at an early stage of the development process. For the investigated direct cooled power module a number of 27,000 required power cycles are calculated. A number of approximately 10,000 required thermal cycles with amplitude of ΔT 80K are calculated.

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Automotive Grade Gate Drive Optocoupler for HEVs

Hybrid electrical vehicles make use of electrical drives and advanced battery systems to improve fuel efficiency and enhance the driving experience. The high voltages used in these systems call for galvanic isolation, both to provide safe insulation for human beings and functional isolation between electronic systems. **Erik Halvordsson, European Product Marketing Manager, Avago Technologies, Böblingen, Germany**

Avago has been producing optocouplers for more than 30 years. Examples of traditional optocoupler applications are consumer products (washing machines, induction cookers), industrial applications (drives, field bus interfaces) and military/ aerospace systems (satellite, aircraft and missile). It is important to point out that each of these applications requires different types of optocouplers – in terms of the internal construction, type of packaging and manufacturing processes. Although they are all optocouplers, the type of device used in a military aircraft differs significantly from the type of device that sits in a refrigerator.

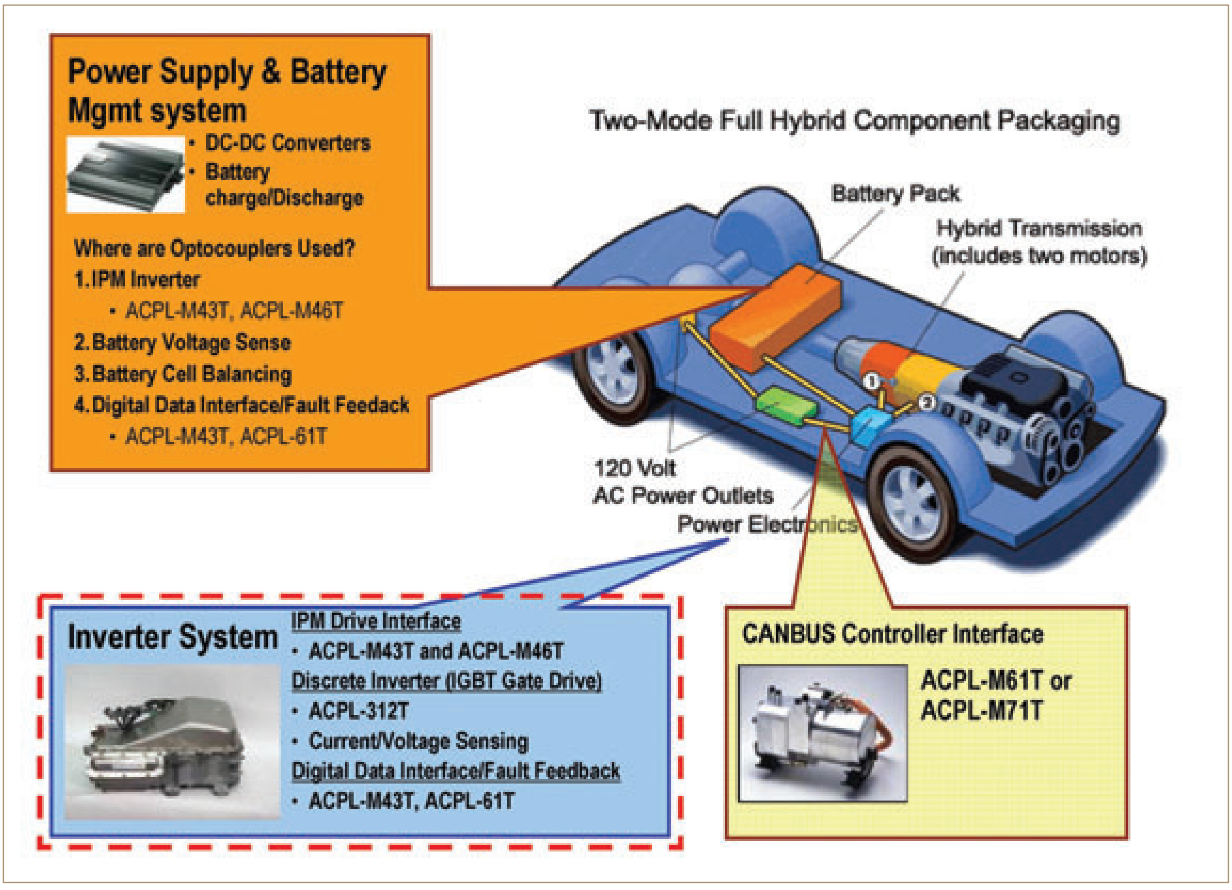
Modern industrial grade components and most newly released optocouplers are designed to operate up to an ambient temperature of 105°C. The most significant difference between industrial and automotive grade optocouplers is the increased requirement on temperature handling capability. There are two aspects to this – the temperature range and the capability of the component in handling temperature cycling.

In order to achieve a stable performance of an optocoupler over temperature and time, it is important to use very stable LEDs. All automotive grade optocouplers use special LEDs, designed and dimensioned for use in automotive applications. The harsh thermal environment of an engine compartment sets high requirements for electronic components. In order to increase the robustness of the design with regards to temperature cycling, a range of changes have been introduced, including a new lead frame material and several improvements to the quality of the bond wires.

High temperature capability

The ACPL-312T is the first automotive grade gate drive optocoupler on the market. Significant changes have been made to

Figure 1: **Isolation needs in hybrid electric vehicles**



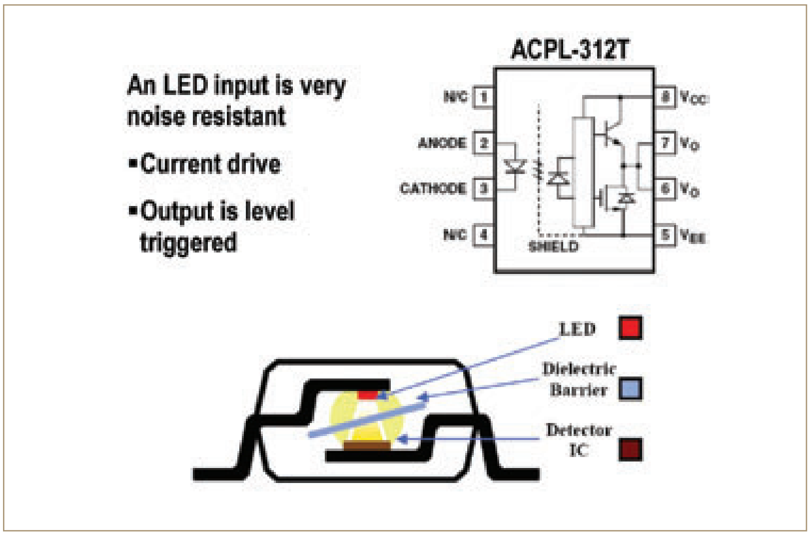


Figure 2: **Internal construction of automotive grade optocoupler ACPL-312T**

improve the temperature handling capability of the component, which is specified up to 125°C ambient temperature. The component is approved for reinforced insulation according to IEC 60747-5-2. Optocouplers are approved and recognised by this standard for reinforced insulation which means that they are suitable for safe electrical isolation. The insulation capability of an optocoupler is well known and directly linked to its internal construction. A robust internal construction is necessary, in order to build a product with reliable high voltage insulation over time and capability of withstanding ESD pulses across the insulation layer. The qualification of all automotive optocouplers complies with AEC-Q100 and the parts are produced in a production line compliant to TS16949.

In hybrid electric vehicles (HEVs) the electrical drive, the battery management system, the CAN bus and DC/DC converter all need galvanic isolation (Figure 1). Gate drive optocouplers, such as ACPL-312T, are used in high performance electrical drive systems as an interface between the IGBTs and the microcontroller. In this type of application, the optocoupler has a dual function, acting both as a high side gate driver and a provider of safe insulation.

Figure 2 shows the internal construction of ACPL-312T. The device contains an AlGaAs LED. The LED is optically coupled to an integrated circuit with a power output stage. This automotive optocoupler is suited for driving power IGBTs and MOSFETs used in automotive motor control inverter and DC-DC converters applications. The high operating voltage range of the output stage provides the drive voltages required by gate controlled devices. The voltage and current supplied by these optocouplers make them suited for directly driving IGBTs with ratings up to 1200V/100A. For IGBTs with higher ratings, the ACPL-312T series can be used to drive a discrete power stage which drives the IGBT gate.

On the microcontroller side, the designer has direct access to the LED (current controlled input). This is a very robust type of interface - ideal for inverters, where design engineers need to minimise the impact of noise on the control lines between the microcontroller and the gate drive circuit (Figure 3). The output of ACPL-312T is able to source and sink 2.5A (maximum peak output current). The optocoupler can either interface directly to the IGBT gate or drive a buffer stage. An integrated under-voltage lock out (UVLO) function makes sure that the output is off when the supply voltage ramps up or falls below a certain threshold. Additionally, a propagation delay of 0.5µs allows the circuit designer to reduce switching dead time and improve inverter efficiency. The device offers high CMR (min 25kV/µs @ V_{CM} = 1500V) for noise elimination.

For industrial applications, highly integrated gate drive optocouplers are available with advanced functions, such as for example DESAT detection and integrated Miller Clamp. Compared to such devices, ACPL-312T is a fairly simple design developed for high performance, reliability and cost efficiency - offering the most important functions without being overly complex in terms of features.

Literature

Gate Drive Optocoupler Simplifies Inverter Design, Power Electronics Europe March 2008 (2/08), pages 30-31.

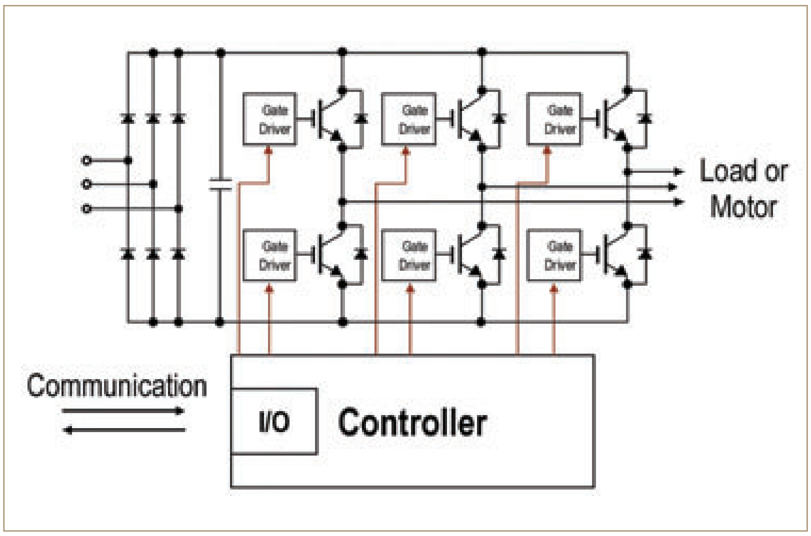


Figure 3: **Application for direct drive of IGBTs up to 1200V/50A in discrete inverter system**

Novel Architecture for Capacitor-Free Low Drop-Out Regulators

A novel architecture is proposed for implementing external capacitor-free LDO regulators. By using both NMOS and PMOS differential input pairs in the error amplifier's first stage of a LDO, a push-pull stage is implemented in its second stage, offering very fast response speed. Compared to a traditional LDO, test results show this topology is stable and provides comparable performances without using external input and output capacitors. With external output capacitor employed, the LDO is still stable. **Shengming Huang, Power Management Division, National Semiconductor, Greenock, UK**

A traditional LDO regulator requires an external capacitor at the output for stable operation. It is known that both the Equivalent Series Resistance (ESR) and capacitance of a capacitor affect the stability of a regulator. In addition to capacitance value range, a certain type capacitor with low ESR is normally specified in the datasheet of a LDO regulator. Mounting of these capacitors also leads to the increase of PCB area in applications. Therefore, there would be more limitations for the customer in certain applications (such as in PMU where many LDOs may be used) if capacitors have to be used with LDOs. Besides, additional costs are added to use input/output capacitors. A capacitor-free LDO is able to solve these problems.

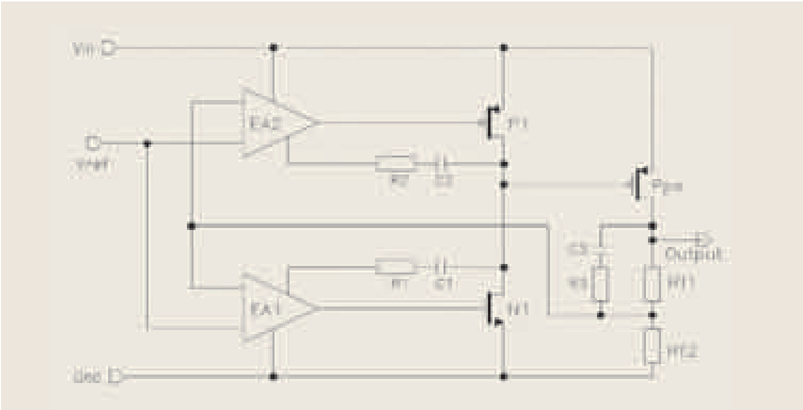


Figure 1: **Circuit architecture for capacitor-free LDO regulator**

Circuit Architecture

Figure 1 shows the novel regulator circuit architecture. EA1 and EA2 are the PMOS and NMOS differential input pairs and form the error amplifier's first stage. PMOSFET P1 and NMOSFET N1 form the second stage of the error amplifier. Pps is the power device (pass device), and Rf1 and Rf2 are feedback resistors. All other resistors and capacitors are used for phase compensation or performance improvement.

Due to the push-pull structure in the second stage of this LDO, it offers very fast response speed, although phase compensation RC networks are used. Since there is no external capacitor at the output, a fast start-up feature is obtained

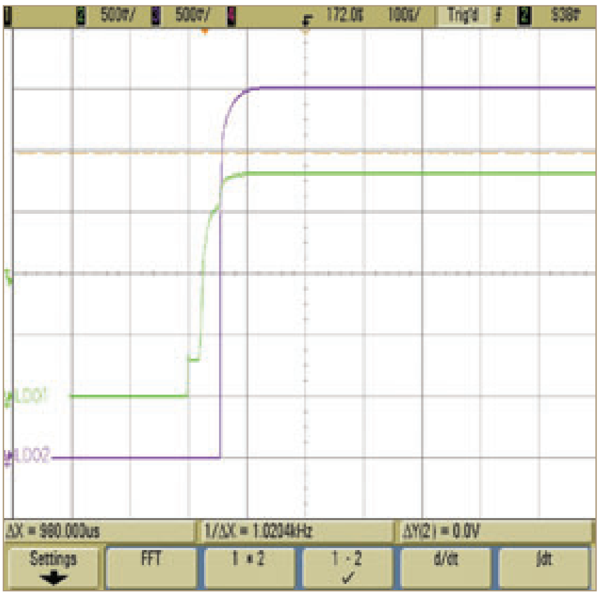


Figure 2: **Start-up under no load**

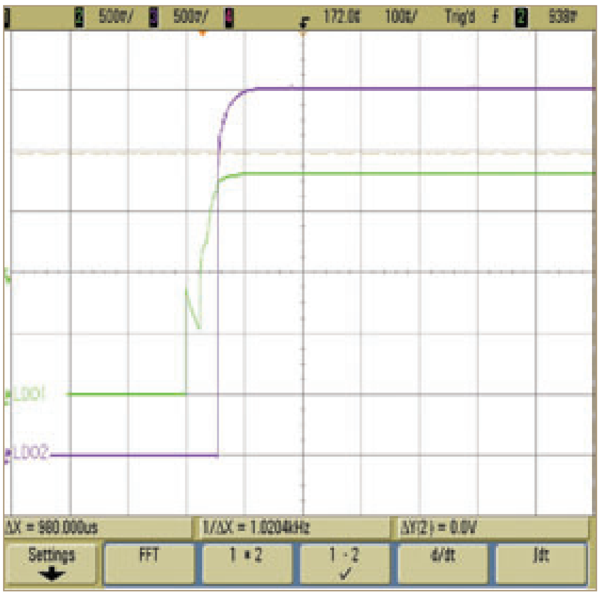


Figure 3: **Start-up under 300mA load**

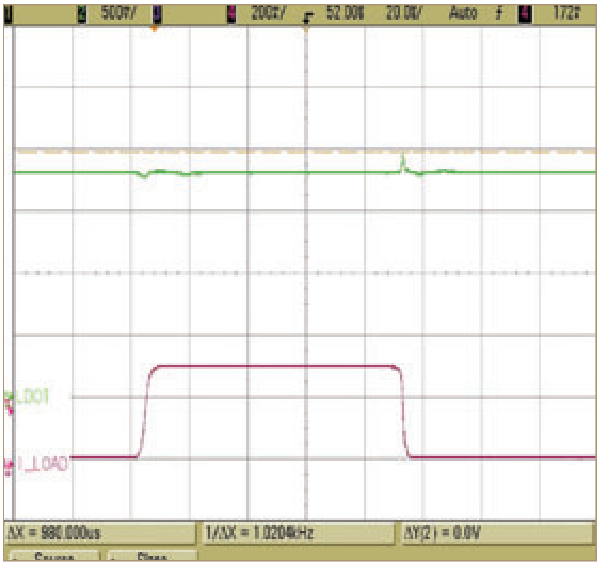


Figure 4: **Load transient performance of LDO1**

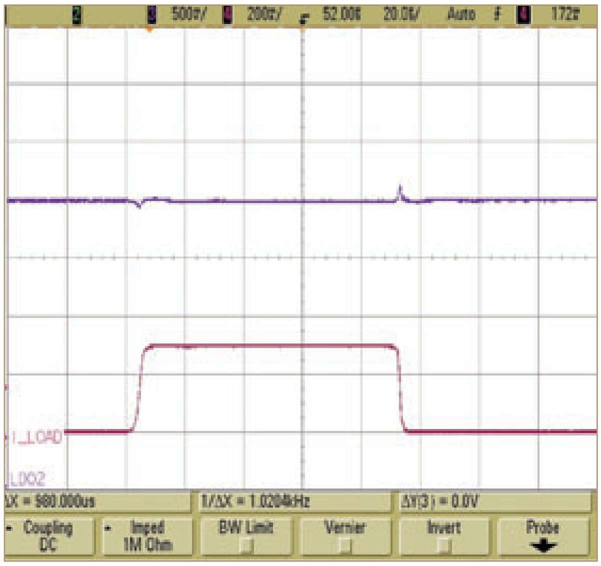


Figure 5: **Load transient performance of LDO2**

for this LDO without having high in-rush current from the power supply (input). The LDO regulator is able to offer maximum of 300mA load with only 0.18mm² chip area for the core circuit. Two LDO samples with 1.8V(LDO1) and 3.0V(LDO2) output voltage are fabricated and test results are shown in Figures 2 and 3, particularly the start-up for both LDOs under no load and full load (300mA) conditions respectively. The start-up time is less than 70µs over temperature and the outputs are stable.

Figures 4 and 5 show the load transient performance for both LDOs under the condition of 1 to 300mA switching. It can be seen that the transient variations are less than 100mV and the LDOs are still stable after load switching. Line transient variation is only 3mV for both LDOs under the condition of 3.6 to 4.2V input voltage switching in 10µs and at the load of 20mA. Figure 6 shows the output line transient performance for LDO1. It is seen from measurements that PSRR is 65dB at 1kHz and 45dB at 10kHz. Figure 7 shows the measured PSRR graphics of LDO1. Measured output noise is only 34µV for LDO1 and 42µV for LDO2.

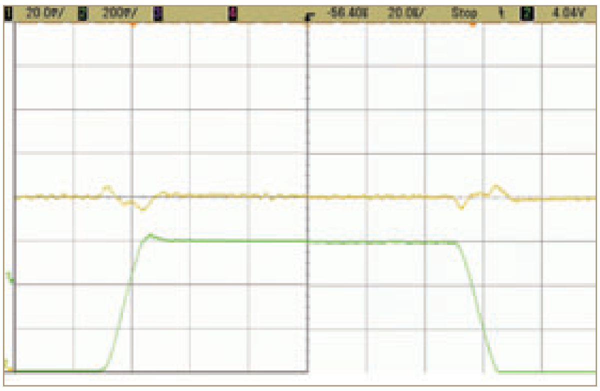


Figure 6: **Line transient performance of LDO1**

Conclusion

A capacitor-free LDO regulator architecture is proposed and fabricated. Without applying an external capacitor at the output, measurements show the LDO regulator offers high performance, which is comparable to those of a traditional one. The chip area of this LDO is not increased and has additional advantages of fast start-up and no high in-rush current when compared to the traditional one.

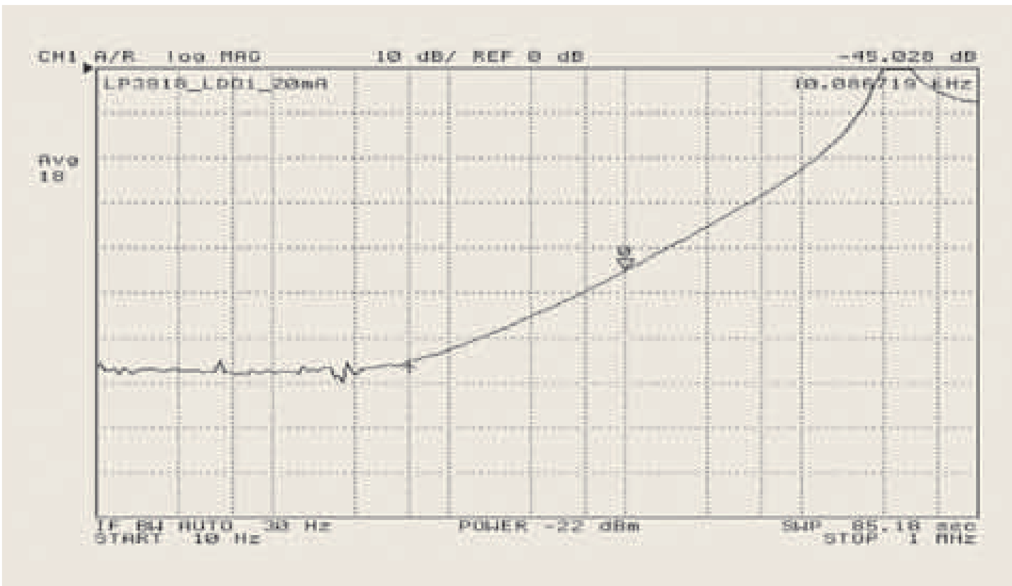


Figure 7: **PSRR of LDO1**

Powerful Real-Time Controller for Digital Power

Developed under the code name Piccolo, the new F280xx microcontrollers (MCUs) feature architectural advancements and enhanced peripherals in package sizes starting at 38-pins to bring the benefits of 32bit real-time control to applications typically unable to justify the associated cost. Real-time control offers greater system efficiency and precision through the implementation of advanced algorithms for applications such as solar power micro-inverters, white goods appliances, hybrid automotive batteries, LED lighting, and digital power supplies. **Andreas Goergner, Field Application Engineer, Texas Instruments, Freising, Germany**

The architecture of the F2802x (Figure 1) is based closely on that of its predecessor.
The new derivative likewise features the exact same 32bit C28xTM DSP core, and is therefore completely software-compatible with all other F28x controllers. Due to the similarities across all family members, hardware and software developers who have experience with one or more of the earlier controllers will be able to

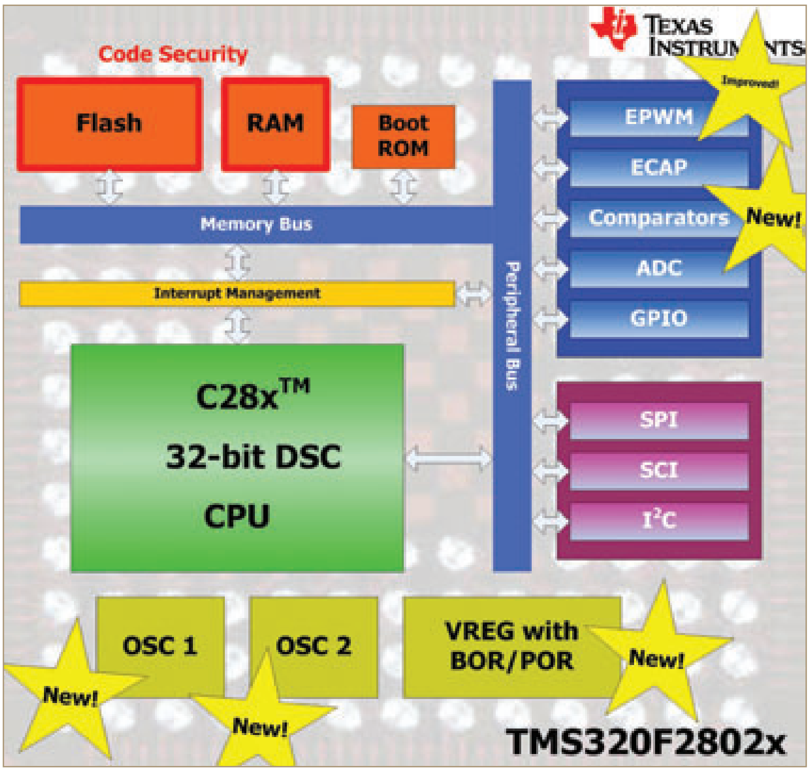


Figure 1: Architecture of the TMS320F2802x

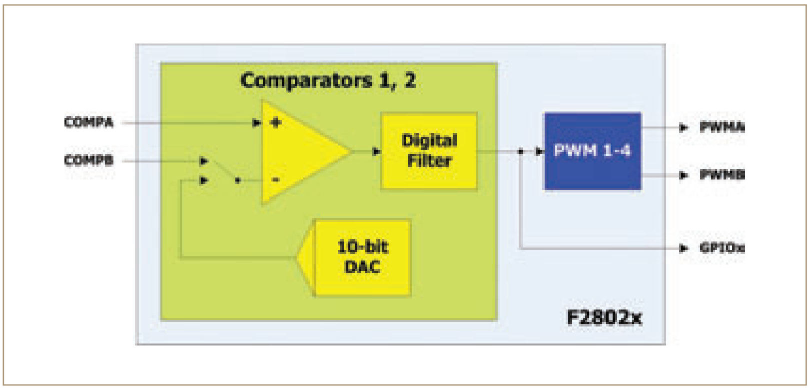


Figure 2: Inner connection of the analog comparators0

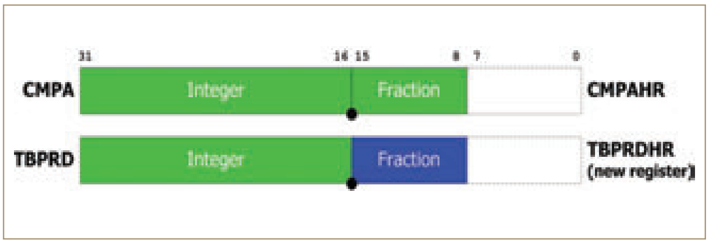


Figure 3: Expansion of the period register by the 'high-resolution' part

implement or migrate to the new 'small' DSP controllers with ease. Since the pricing of the new family members is also lower than that of the previous controllers, they will replace conventional microcontrollers wherever greater computing performance is needed or more demanding requirements are made of the realtime behaviour.

The F2802x has up to 64 kilobytes of flash and 12 kilobytes of RAM, for which a Code Security Module (CSM) prevents read-out of the memory if required.

The boot ROM contains a boot loader (for booting different peripherals – for example, serial interfaces) and mathematical look-up tables. The implemented peripherals, such as EPWM and ECAP modules, the 12bit analog-to-digital converters (ADCs), general purpose I/Os (GPIOs) and the serial interfaces are for the most part similar to the previous models, but have been modified somewhat to provide greater flexibility.

Four key new additions to the F2802x controllers are to mention: on-chip generation of the power for the processor core, integration of two oscillators, extensions in the enhanced pulse width modulators (EPWM) modules and integration of analog comparators. While the processor core in the previous F28x models had to be supplied externally, the F2802x models generate power for the core directly in the silicon layer, meaning that only a typical 3.3V power supply unit is required for the DSP controller. As is the case with many external power supply units, the supervisor functions of Brown-Out Reset (BOR) and Power-On Reset (POR) are integrated in order to meet the silicon requirements of the reset function when switching on and off the chip and also in the case of voltage fluctuations.

Two oscillators also for use in security-sensitive applications

The integration of two on-chip oscillators instead of just one, as is often the case, is notable. This is expressly targeted at security-sensitive applications in which the internal watchdog has to be clocked with a source other than the system clock, as defined in the IEC60730 standard, for example.

This can be achieved with the F2802x: the internal watchdog can be clocked with OSC1, OSC2 or also with an external source (it is still possible to connect a resonator, quartz crystal or crystal oscillator as an external clock supply). Both internal oscillators possess high degrees of accuracy: up to 1% at temperatures of up to 85°C and up to 3% at temperatures of up to 125°C (ambient temperature).

The chip designers also took redundancy behaviour into consideration when implementing the internal oscillators. The F2802x provides triple clocking redundancy: if an externally connected clock supply (resonator, quartz crystal or crystal oscillator) stops working for whatever reason, the OSC1 replaces it.

The system (or the software) is informed of this change by means of an interrupt. If OSC1 then immediately or later also stops functioning, the system will run in so-called 'limp mode' with a 4 MHz emergency clock signal generated by the PLL. The software can then, for example, issue an error signal and/or shut down the system in a controlled manner.

It is also possible to supply clocks separately to one of the three timers in the CPU, either with OSC1, OSC2 or with an external clock supply – to be more precise, CPU timer 2 can be configured accordingly. In this way,

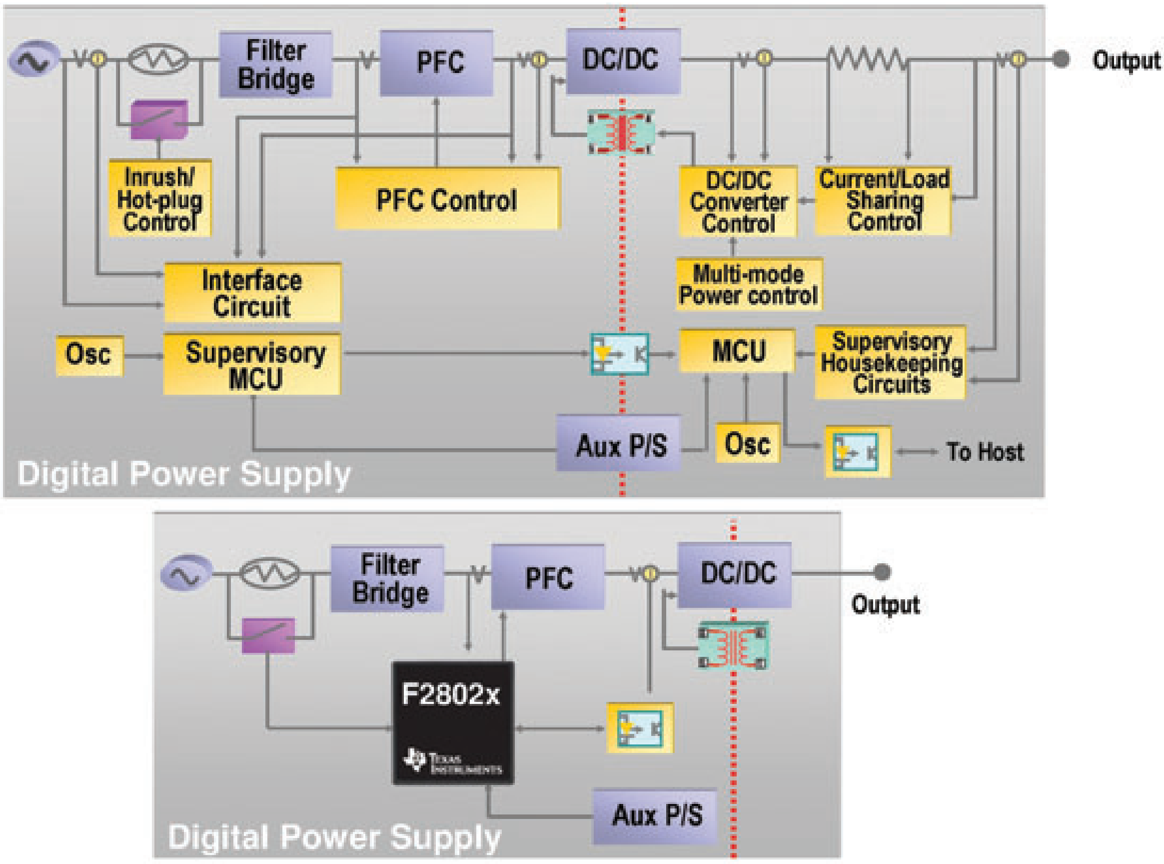
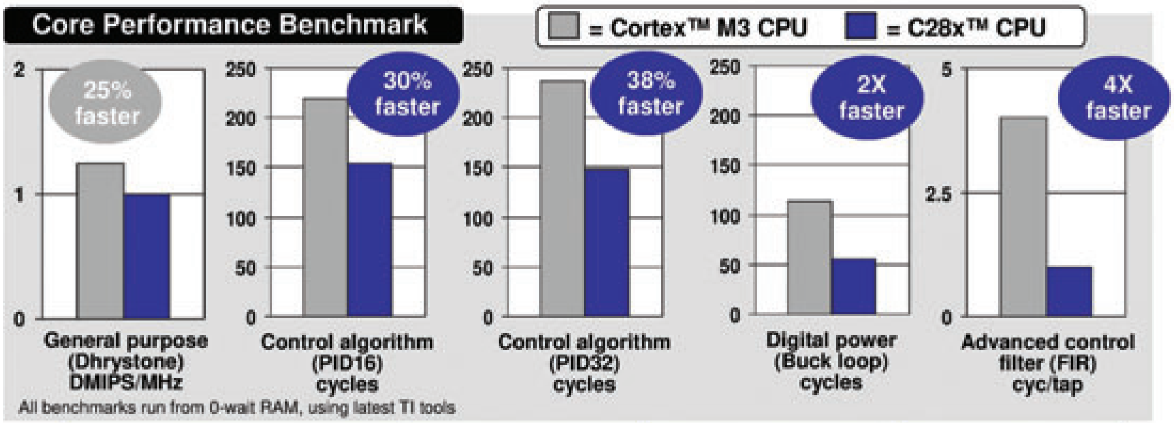


Figure 4: **Schematic of a discrete digital power supply compared to the highly integrated solution using the F280xx chip**



Operation	Cortex-M3 (72 MHz)	C28 (60MHz)	C28/CLA (60MHz)
Feedforward control cycles	786	482	482 / 0
Feedback control cycles	1762	1081	0 / 550
Total Control Law cycles	2548	1563	482 / 550
MHz used (20 kHz loop)	~51MHz	~32MHz	~10/11MHz
Dhrystone benchmark is industry standard, does not benchmark the math performance of a processor	**< 1/3 headroom**	**20% faster, lower frequency, 50% headroom**	**5X faster, lower frequency 80% headroom**

Figure 5: **Some benchmarks of C28xx compared to its predecessor Cortex M3x chip**

CPU timer 2 can be used as a clock monitor, for example, or it can supply time or clock information independently of the system clock.

Integrated analog comparators responses to external voltage changes

Many control applications demand the fastest possible response to changes in voltage or current in some form or other. For example, overcurrent in the intermediate circuit in motor control systems must be regarded as extremely critical. In this case, the power transistors (IGBTs) should be or must be switched off.

The F2802x has two integrated analog comparators. A comparison value is supplied either by an external voltage applied at one of the comparator pins, or an integrated 10bit reference (DAC with 10 bit resolution, see Figure 2) is used to generate this.

A programmable digital filter connected after the actual comparator filters out noise at the input of the comparator or prevents interference-related spikes and glitches from being interpreted as valid signals. However, the filter can also be disabled if required and the comparator then runs asynchronously to the system clock.

The comparators are, of course, connected in the controller's system with other peripherals and with the processor core. The result of the comparison at the comparator output can trigger the following events, each without interaction with the CPU: Put the PWM outputs into high-impedance (or switch it to logical 1 or 0 depending on the requirement), generate interrupts, synchronise with the PWM outputs, trigger the AD converter, and output to a GPIO pin.

High resolution for PWM frequency

Just like the F280x or the F2823x and F2833x, the F2802x also features 'high-resolution PWM' with which the duty cycle in a PWM period can be precisely resolved to figures of up to 150ps. This is an enormous advantage, particularly in digitally controlled voltage supply systems, since more accurate and smoother output signals (output voltage or current), as well as higher PWM or control frequencies can then be obtained. Higher PWM or control frequencies allow smaller inductors and capacitors, paving the way for considerable cost savings.

With the F2802x, not only the duty cycle, but also the PWM period or frequency can now be accurately resolved at up to 150ps. This is important for particular topologies in the area of current and voltage supply (resonance converters, digital controlled power supplies). In software terms, both registers – the comparison register as well as the period register – are expanded by an additional 8 bits to a total of 24 bits each (see Figure 3). Figure 4 shows the schematic of a discrete digital power supply versus the highly integrated solution using the F280xx chip. Figure 5 shows some benchmarks compared to its predecessor. Additional advancements such as a programmable control law accelerator (CLA) designed to offload control algorithms from the main CPU will run complex high speed control algorithms and free the main CPU to handle I/O and feedback loop metrics, resulting in up to a 5x performance increase for common closed loop applications.

'Piccolo' F280xx controllers can replace multiple electronic components to lower overall system cost while enabling advanced power electronics management. For example, in a variable frequency air conditioning unit, a single F280xx controller can precisely control two electric three-phase motors, as well as perform power factor correction (PFC) calculations.

F280xx devices also enable higher operating efficiency and control for solar panels. Typical systems use one inverter across multiple panels and initial investigations have shown that individual or micro inverters connected to each solar panel within a system can drive higher power conversation efficiencies. Micro inverters maximise the output of each panel compared to system wide inverters that maximize the average output of the panels.

The F2802x devices will be available for sampling in December with pricing at sub $2 each in volume.

High Efficiency Designs for Energy Savings

Worldwide energy efficiency legislation coupled with ongoing improvements in the performance of high brightness LEDs are accelerating the uptake of LED technology in the lighting market, and Power Integrations has developed a number of power conversion IC solutions that address the novel power needs of the emerging LED applications, such as the TinySwitch-III, TOPSwitch-GX and LinkSwitch-TN. The following design ideas show how designers can maximise the benefits offered by LED lighting technology, as well as simplifying and speeding up the design process. **Silvestro Fimiani, Product Marketing Manager, Power Integrations, USA**

The first design idea describes a high efficiency LED driver power supply circuit that uses the TNY279GN, a member of the TinySwitch-III offline switcher family. The circuit operates in high ambient temperatures of up to 75°C, and meets the requirements of energy efficiency standards including the proposed requirements of Energy Star 2.0, CEC 2008 and the EU CoC. The 14W design can be used for LED replacement of halogen spotlights and, coupled with high efficiency LEDs, replaces standard 60W incandescent bulbs in general lighting applications.

Constant current and voltage

The schematic shown in Figure 1 is a 20V, 14W constant voltage (CV) and constant current (CC) output power supply. The light output from an LED array is proportional to the current flowing through it. As such, LED drivers should have a constant current as opposed to a constant voltage output. In this design, the DC output is not isolated from the AC input, and therefore the LED array and enclosure must provide safety isolation from the user.

The AC input is rectified and filtered by BR1, C1 and C2. Inductor L1 forms a π filter with C1 and C2 and provides EMI filtering. Fuse F1 provides protection against catastrophic failure. To allow the supply to operate unloaded without damage, CV regulation at ~21V is provided by Zener diode VR2. The CC characteristic is achieved by sensing the voltage drop across the current sense resistor R7. Shunt regulator IC U3, together with R9, R8 and R8A, is used to generate an accurate voltage reference of 0.07V at the inverting input of op-amp U2. At the programmed current, the voltage across R7 exceeds the reference voltage, causing the op-amp output to rise. This forward biases D4, driving the base of Q1, which pulls current out of the EN/UV pin of U1. Capacitor C7 and resistor R6 provide loop compensation. An op-amp based current limit was used to minimise the current sense voltage and, therefore, losses to maximise efficiency. Figure 2 shows the measured output CVCC characteristic.

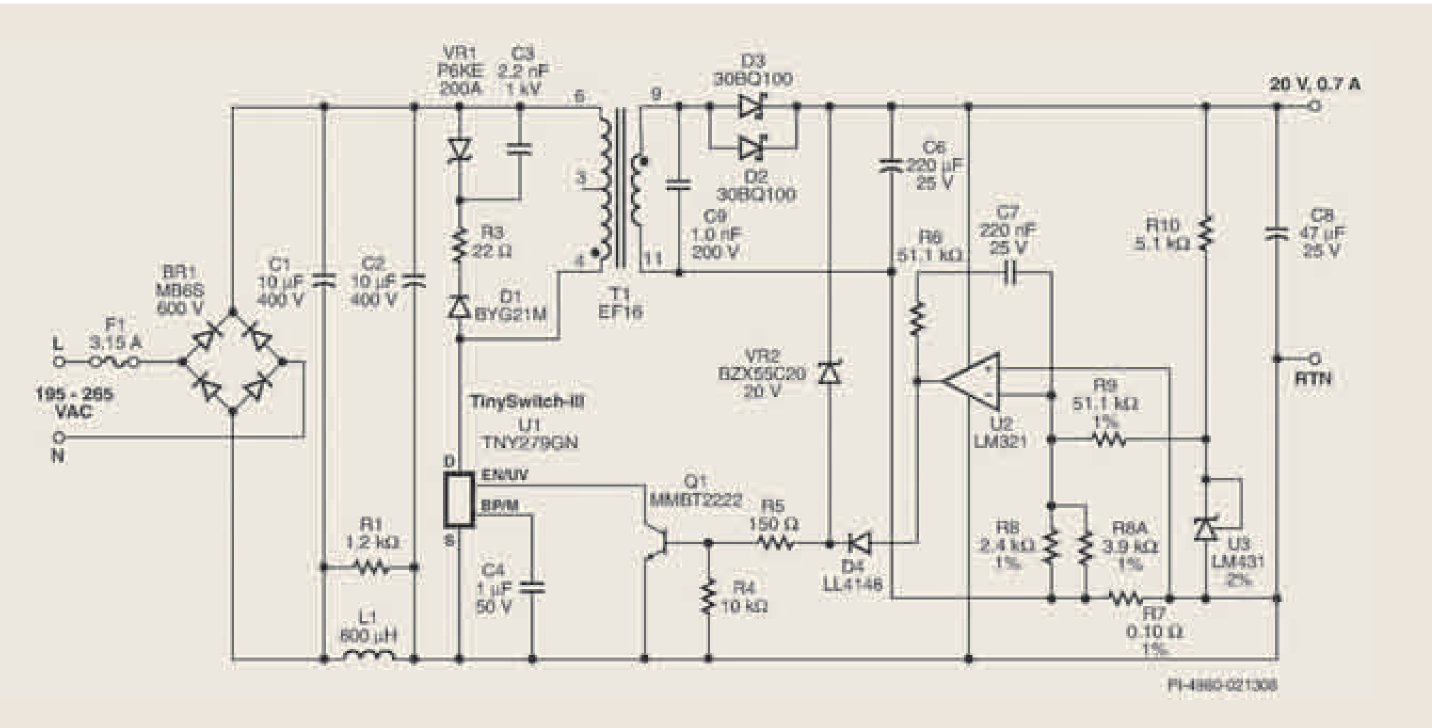


Figure 1: Schematic of 14W LED driver power supply using a TNY279GN in high ambient temperature applications

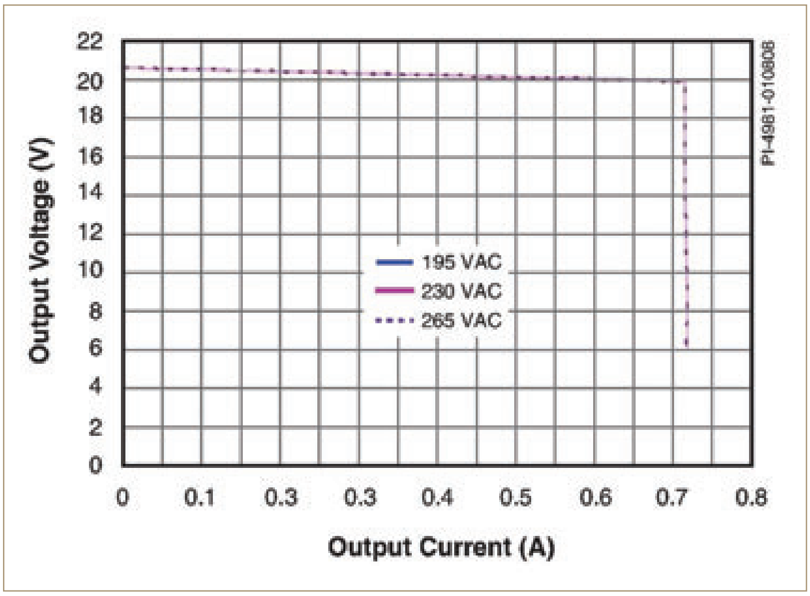


Figure 2: **Measured output C_{VCC} characteristic**

The MOSFET in U1 is disabled on a cycle by cycle basis (on/off control) whenever the current drawn out of the EN/UV pin is >115µA. By adjusting the ratio of enabled to disabled switching cycles, the feedback loop can regulate the output voltage orcurrent. On/off control also optimises the efficiency of the converter across load to ensure compliance with energy efficiency standards. Due to the high ambient temperature, U1 is operated in the reduced current limit mode. This allows for overall higher efficiency and better thermal management of the power supply.

The primary clamp (D1, VR1, C3 and R3) limits the maximum peak drain voltage to less than the 700V B_{VDSS} rating of the internal MOSFET. Resistor R3 reduces high-frequency leakage inductance ringing and thereby EMI. On the secondary side, the output is rectified and filtered by diodes D2, D3 and C6.

Key design points

Selecting a fast diode versus an ultra-fast diode for D1 will improve efficiency by recovering some of the leakage energy. Capacitor C9 is used to improve EMI. Resistor R10 is selected to provide a supply current of 1mA to U3 at a minimum output voltage of 6V.

The selectable current limit of U1 allows the current limit and device size to be optimised for the thermal environment. For example, to reduce dissipation, the TNY280GN device could be used in the same design by changing C4 from 1 to 0.1µF. Alternatively, in a less thermally challenging environment, the TNY278GN could be used by changing C4 from 1 to 10µF. The supply correctly operates over an LED string voltage of 6 to 20V. However, lower string voltages result in lower output power as output current remains constant.

Driving a long string of up to 20 LEDs

The second design idea details a circuit design for a high efficiency constant current, offline, buck converter able to drive a long string of up to 20 LEDs delivering a constant current of 130mA. The circuit is based on the LinkSwitch-TN family of lowest component count, energy-efficient, off-line switcher ICs. This circuit is optimised for LED based replacement of existing bulbs in domestic appliances and is dimmable for general LED lighting applications.

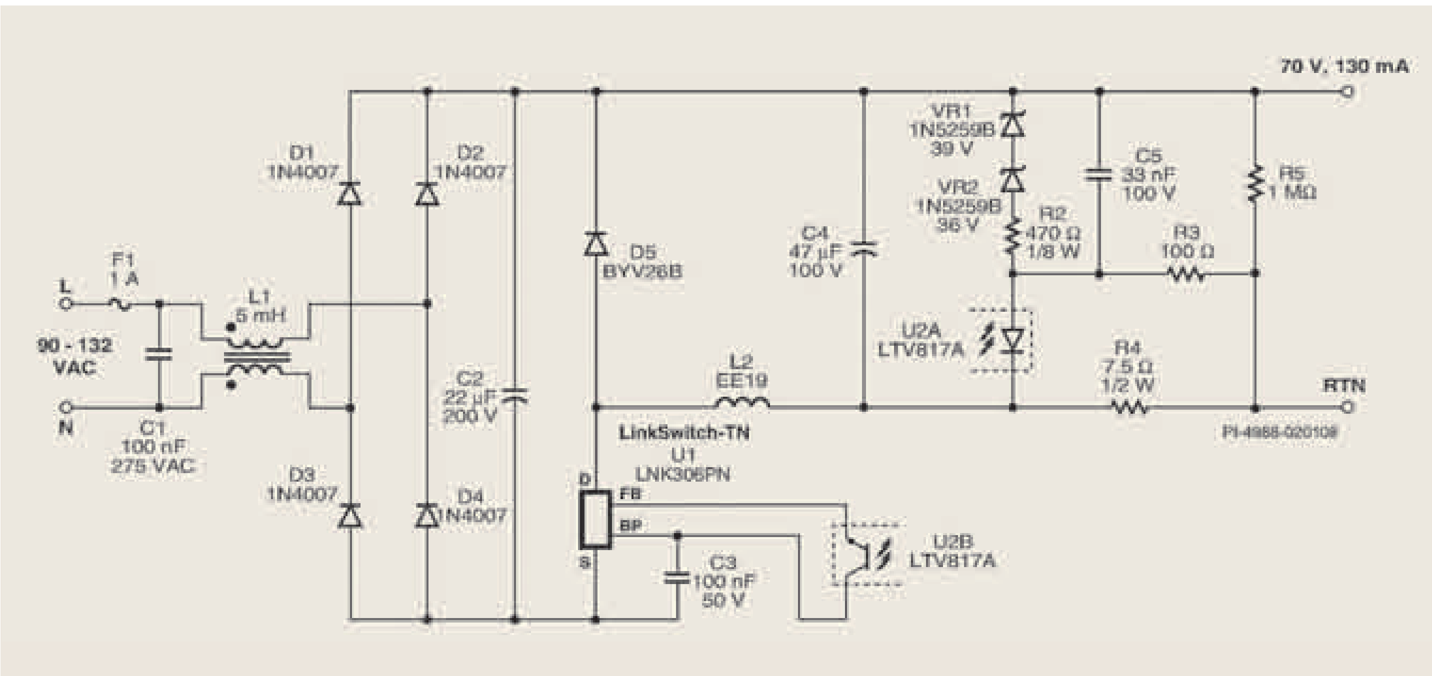


Figure 3: **Schematic of a 70V, 9.1W constant current Buck converter for driving LED string**

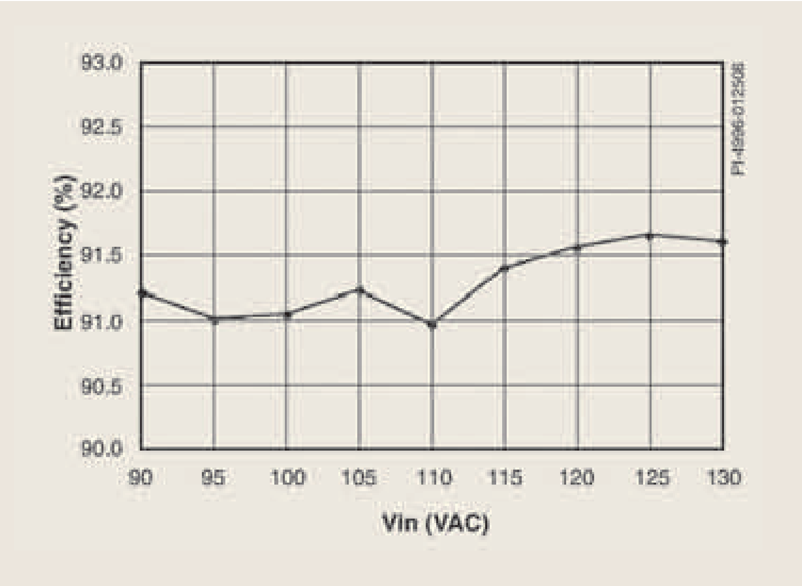


Figure 4: **Line voltage versus efficiency**

The power supply shown in Figure 3 uses a LinkSwitch-TN device in a low side buck converter confi guration to deliver a constant current of 130mA at a voltage of 70VDC. The supply provides an solution for driving LEDs that should be driven with a constant current rather than a constant voltage source.

During U1's on-time, current flows through capacitor C4, the load (70V LED string) and inductor L2. This current flow results in energy storage in L2 and energy delivery to the load. During U1's off-time, the polarity of L2 reverses in an attempt to maintain the current flow. This polarity reversal forward biases the freewheeling diode D5, which allows current to flow and energy continues to be delivered to C4 and the load.

Output regulation is maintained by an on/off control scheme, whereby switching cycles are enabled and disabled (skipped) in response to changing line and load conditions. The feedback (FB) pin of U1 is sampled at the beginning of each cycle. If current in excess of 49μA is delivered into the FB pin by the transistor of optocoupler U2, the current cycle is skipped. Capacitor C3 is the bypass capacitor for the LinkSwitch-TN device.

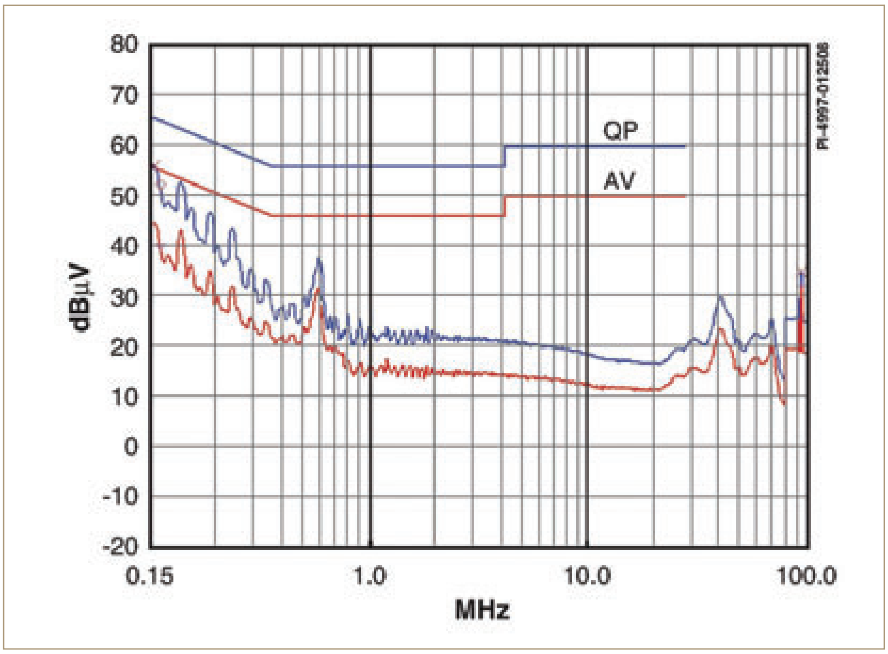
Resistor R4 acts as a current sensing resistor. Once the voltage across R4 exceeds the V_F of the opto LED, the feedback loop closes, and the output current is regulated. Resistor R3 sets the DC gain of the feedback loop. If the load is disconnected, the output voltage is regulated to a maximum of approximately 75V by Zener diodes VR1 and VR2. Capacitor C5 is used to reduce noise sensitivity and to help evenly distribute the switching cycles.

Optional resistor R5 bleeds the high voltage output capacitor when power is removed.

Key design points

Select diode D5 to be an ultrafast type with a reverse recovery time (t_{rr}) of 50ns or less. Although a slower diode like the UF4005 (t_{rr} = 75ns) may be used, it may cause larger current spikes at turn-on and result in reduced efficiency. Use of an optocoupler to derive feedback allows the placement of U1 on the low side of the DC bus. Due to the source connected tab of U1, this also results in reduced EMI. Zeners VR1 and VR2 may be removed if the supply will always operate with a load connected. Select the LED string such that the voltage is in the range of 50 to 70V. Figure 4 shows line Voltage (VAC) versus Efficiency, and Figure 5 shows a worst case EMI plot (115VAC, LED load at 70V, 135mA, EN55022B limits).

Figure 5: **Worst case EMI plot**



Improved 6.5kV Thyristor

Westcode Semiconductors (an Ixys company) has developed a higher current rating device for the smallest 6.5kV thyristors. The new 6.5kV device has a nominal RMS current rating of 890A, 20% more than the established prior product encapsulated in the same pole face hermetic pressure contact package.

The thyristors are available in two voltage classes and two package options: K0443LC600 and K04336LC650, which are rated at 6.0 and 6.5kV, respectively, and housed in a 26mm thick package. The types K0443LG600 and K0433LG650 are rated at 6.0k and 6.5kV, respectively, and housed in a 35mm thick package. These devices are suited for medium voltage applications, particularly where series operation of the devices is required. Typical applications include high power DC drives, soft-starts, utility applications such as HVDC, static VAR compensators, excitation and transfer switches.
www.westcode.com

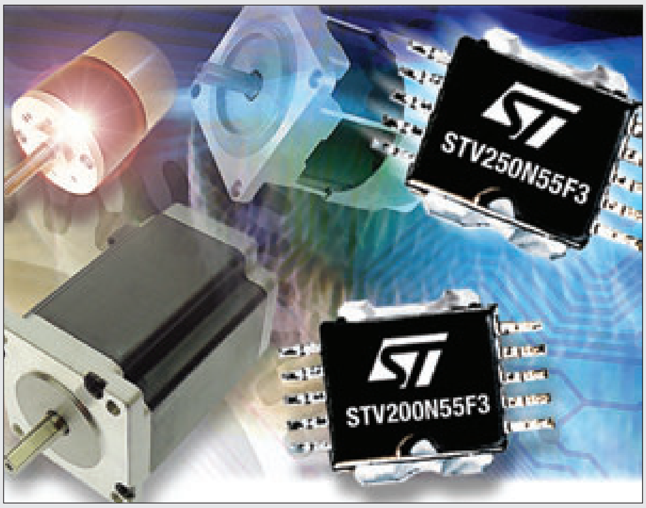
IGBT Power Modules for Three-Level UPS Inverters

SEMIKRON has introduced a new topology for three-level inverters designed for low commutation inductivity in contrast to half bridge modules. The IGBT SEMITOP module offers 60% lower switching and conduction losses compared to two-level inverters. The improved efficiency of the DC/AC conversion is available for UPS applications in the power range from 5 to 80kVA.

The three-level inverter is a cost-effective solution because one single module replaces two modules used for a standard two-level half-bridge topology. The topology for the three-level inverter is realised by series connection of IGBTs with which it is possible to obtain higher reverse IGBT blocking voltages. By merely connecting three of these modules, it is possible to achieve a complete three-phase three-level inverter topology with maximised electrical and thermal efficiency.

Due to the sinusoidal output waveform, it is possible to reduce harmonic contents and output filters. In comparison to a standard two-level half-bridge inverter overall dimensions as well as cost saving of 25% can be achieved. Current rating is from 20 to 150A by using 600V IGBT reverse blocking voltages. The IGBTs for three-level inverters are available in SEMITOP3 (55mm x 31mm) for current ratings up to 50A and SEMITOP4 (60mm x 55mm) for current ratings up to 150A.
www.semikron.com

250A Power MOSFETs for 55V Applications



STMicroelectronics' STV250N55F3 is the first power MOSFET to combine PowerSO-10 package with ribbon bonding to achieve ultra-low die-free package resistance.

The device is manufactured with the STripFET III process and offers a typical on-resistance of 1.5mΩ. Further benefits of this process include low switching losses and rugged avalanche characteristics. The nine-lead source connection also reduces on-resistance, in addition to aiding heat dissipation. Overall, the package is rated for 300W dissipation at 25°C. The ability to operate at temperatures up to 175°C makes the STV250N55F3 suitable for use in high-current electric-traction applications such as forklift trucks, golf carts and pallet trucks, as well as lawnmowers, wheelchairs, and electric bikes. Reliability and robustness are assured through 100% avalanche testing both at wafer level as well as on finished products. In the future, the device will be eligible for automotive-grade applications.

Within the same family, ST also has the 55V STV200N55F3, which implements a four-lead source connection and is rated for 200A continuous drain current. Pricing is $2.50 for 10,000 pieces.
www.st.com

28V LDO Regulators

Torex Semiconductor now offers the XC6701 series of 28V high speed low dropout voltage regulators. Suited for 24V systems and industrial applications, these devices are available in a range of standard packages, such as the SOT-25, SOT-89, SOT-223 and TO-252, as well as the ultra-small USP-6C measuring 1.8mm x 2.0mm x 0.6mm. The XC6701 regulator consumes only 50µA in full operation, falling to less than 0.1µA in standby mode with the XC6701B version. Output voltage can be factory set from 1.8 to 18V in 100mV increments, and the operating voltage range is from 2 to 28V. All voltage regulators within the XC6701 series have a low dropout voltage of 300mV at 20mA.

The XC6701 regulators are compatible with low ESR ceramic capacitors, which give added output stability, and include built-in over current protection and thermal shutdown circuits. Maximum output current is 200mA over an operating temperature range of -40 to 85°C, and fold-back current limiting is provided to protect the output in the event of overload or short circuit.
www.torex-europe.com

FEATURED ADVERTORIAL

Ultimate power delivery: choose, click & run

Configurable digitally programmable power supplies offer optimum flexibility

Today's short design-to-manufacture timescales, narrow market windows and whole-life cost reduction goals demand flexibility at all levels - especially in system power provision. Emerson Network Power's iMP™ series power supplies are designed to help.

Many system designers choose to defer power supply and power management decisions until near the end of the design cycle. This is partly because it is easier to avoid over-budgeting on power - and therefore less expensive - once the system's actual power requirements are known, and partly because power supply selection often proves cumbersome and frustrating, and is therefore best avoided until the very last minute!

This approach might have made sense in the days when the only ac-dc power supply options available to designers were fixed-output analog designs. Whatever would be, would be. But nowadays there is little or no excuse for ignoring power in this manner - it is much better to choose a configurable power platform that can be programmed to suit the application.

The advent of modular switch-mode power supplies introduced a welcome level of flexibility by enabling designers to configure solutions more optimised for their systems. However, these modules invariably used analog control loops and therefore suffered from highly limited and fixed functionality, demanding expensive and time-consuming custom engineering to address issues such as special voltages and currents, output sequencing, particular cooling requirements, operating noise limitations and fan speed adjustments.

Latest-generation power supplies

One of the world's leading power supply manufacturers - Emerson Network Power - recently began introducing modular digitally programmable ac-dc power supplies, designed specifically to overcome the limitations of traditional analog power modules. The company's *i*MP™ series of power supplies, for example, feature microcontrollers in each module as well as the containment case, and their PC-based control software employs a highly intuitive graphical user interface (GUI) that enables designers to easily adjust a wide variety of operating parameters.

iMP series programmable power supplies are completely modular

This modular, digitally programmable approach provides unprecedented flexibility. Designers can configure the power supply to precisely match their application requirements - and can even change their mind later, to accommodate unforeseen or new power requirements - and can then set it up to do exactly what they want, when they want.

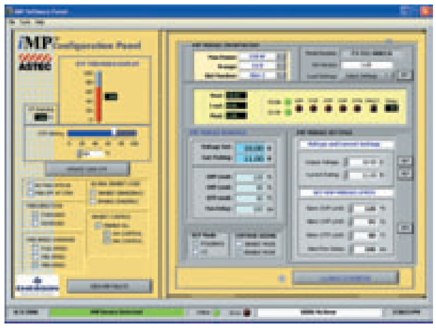
Intelligent digital control

All *i*MP series ac-dc power supplies are fully programmable. Both the case and the individual power modules feature integral microcontrollers to maximize control flexibility, with all communication between the host controller and the power supply handled via I²C bus, using the industry-standard PMBus™ protocol.

The control software supplied with every *i*MP series power supply runs under Windows® on any standard PC, using Microsoft's .NET™ framework. It uses a highly intuitive, easy-to-use graphical user interface.

Configuration made easy

Setting-up an *i*MP series power module is very easy - the same control screen is used for all modules and all operating parameters. So as well as defining a module's output voltage and current, users can just as easily adjust its OVP, UVP and OTP limits, change its OCP mode and control signal, and force fan speed override if required.



Powerful real-time monitoring

The *i*MP series control software offers exceptionally powerful real-time monitoring facilities. A single screen conveys all status information, to provide at-a-glance performance confirmation for the entire power supply, including the case and all its constituent modules. The monitoring screen displays correlated functions as sub-panels to ensure unambiguous visual interpretation, and data can be presented both numerically and graphically - at the same time, if required.

Wide-ranging applications flexibility

Emerson Network Power's *i*MP series power supplies are suitable for an extremely wide range of applications, including medical, laboratory and telecommunications equipment, test and measurement systems, and general industrial use. Their key features include:

- **6 types of power module - including single, dual & triple output units**
- **25 standard output voltages, from 2 Vdc to 60 Vdc**
- **Up to 1,500 watts & 21 separate outputs from one power supply**
- **Optional power hold-up (SEMI F47-compliant) and Oring modules**
- **Full medical approval to EN60601-1 Type B**
- **Advanced PMBus™ digital monitoring & control functions**
- **Programmable voltage, current limit & inhibit/enable**
- **Configurable current share on all outputs > 10 A**
- **Configurable signals & indicators**
- **Configurable output up/down sequencing**
- **Intelligent fans - speed control/fault status**
- **Processor-controlled PFC input with active inrush protection**
- **I²C monitoring of voltage, current & temperature (IPMI-compliant)**

EMERSON Network Power

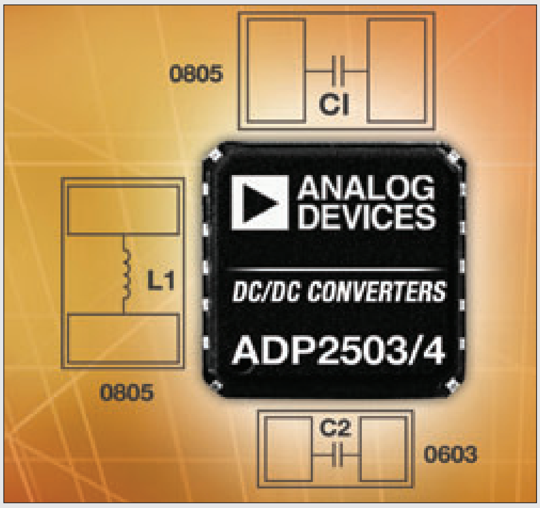
For more information about cost-effective ac-dc power flexibility, or to request a product demonstration, please call Emerson Network Power on +44 (0)1384 842 211, or visit www.powerconversion.com/imp

300W Eighth Brick DC/DC Bus Converter

Ericsson Power Modules' PKB4302NG converter provides an output power of 300W at 42A with high efficiency of 97% at 48V input from 50 to 100% load. The power available is up 15% compared to some of the existing quarter bricks on the market. The fixed ratio intermediate bus converter features an input voltage range of 38 to 55V and is configured with an industry standard footprint and pin-out. The converter meets the insulation requirements of EN60950 and comes with industry standard features such as remote on/off, over-temperature protection, output over-current and over-voltage protection, and input under-voltage protection. The most important application areas for the converter are datacom/networking, wireless networks, optical network equipment, server and data storage.

www.ericsson.com/powermodules

2.5MHz Buck/Boost Converters



Designed to regulate voltages above and below the battery output voltage in portable electronics, ADI's ADP2503 and ADP2504 step-up/step-down DC/DC regulators incorporate a patent-pending architecture that delivers seamless mode transitions.

The high switching speed allows for low-cost multilayer inductors that are half the size of other solutions. In addition, the total external component count has been reduced to three, resulting in a total PCB area of less than 13mm² and a height of less than 1mm, making the devices suitable for space constrained applications such as wireless handsets, digital still cameras, portable audio players and USB-powered consumer and industrial devices. The devices also feature lowest no-load quiescent current levels of 38µA in power-save mode. The proprietary H-Bridge buck-boost architecture improves the efficiency by more than 10% versus legacy cascaded boost-buck architectures by reducing switching losses.

The ADP2503 and ADP2504 operate at input voltages between 2.3 and 5.5V, which meets the requirements for single Li-Ion, Li-Ion polymer cell and multiple alkaline/NiMH cell applications. Fixed output voltages range from 2.8 to 5V.

www.analog.com/pr/ADP2503

Gap Filler Minimises Component Stress

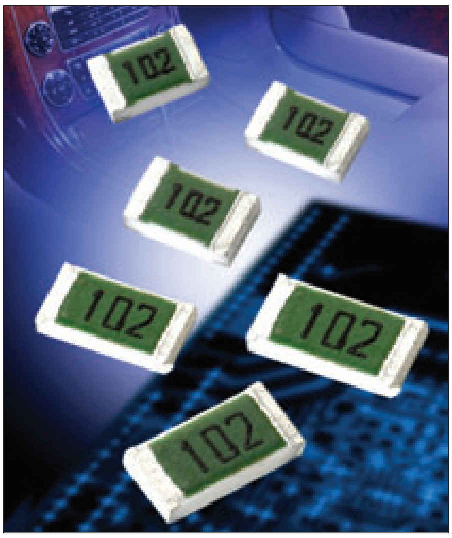
Bergquist's Gap Filler 1500 is a silicone based, two-component, room or elevated temperature cured product. It dispenses without 'stringing' and offers superiour thermal conductivity (1.8W/m-K). The mixed system will cure at room temperature and can be accelerated with the addition of heat. Unlike cured thermal pad materials, a liquid approach offers infinite thickness variations with little or no stress to the sensitive components during assembly. Gap Filler 1500 exhibits low level natural tack characteristics and is intended for use in applications where a strong structural bond is not required. As cured, it is ideal for fragile assemblies. Typical applications include automotive electronics, telecommunications, computer and peripherals, between any heat generating semiconductors and a heatsink, or as a thermally conductive vibration dampening.

www.bergquistcompany.com

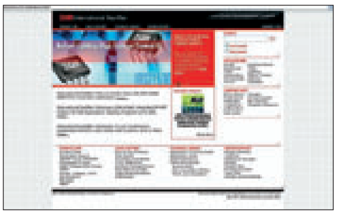
Pulse Prove Flat Chip Resistors

KOA expands its series of pulse proof flat chip resistors, SG73P and SG73S, with the size 0603. Due to its improved trimming this resistor series can withstand up to 10 times higher pulses and surge currents compared to standard flat chip resistors. The SG73S is suited for applications with ESD voltages or nanosecond surges of several kilovolts. The ESD limiting voltage for the 'human model' is up to 15kV in the package size 1206. The SG73P series in the new chip size of 0603 can handle a 1ms pulse of up to 14W. This is five times more power compared to KOA's standard resistor series RK73. Both series cover the resistive range from 1Ω up to 1MΩ. The whole range is available with tolerances down to 0.5% and a standard temperature coefficient of ±200 ppm/K.

www.koaeurope.de



AC/DC Connverters



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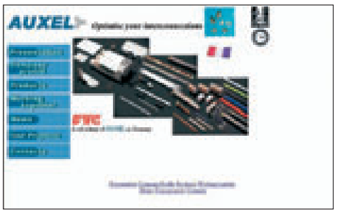

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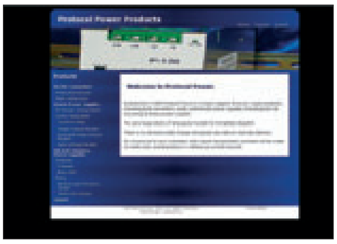

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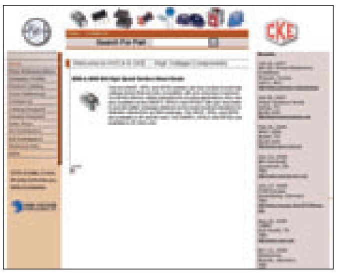

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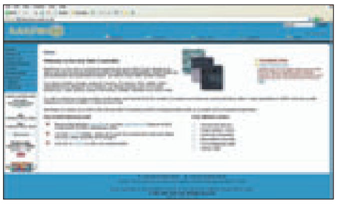

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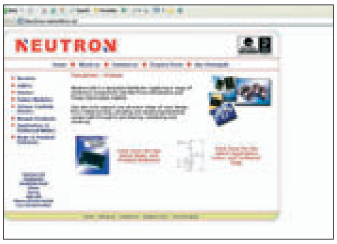

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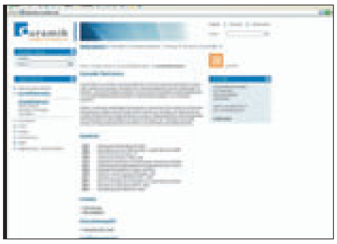

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The Best-Selling 2-Channel IGBT Driver Core

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

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

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

Chipset Features

- Short-circuit protection
- Supply undervoltage lockout
- Direct or half-bridge mode
- Dead-time generation
- High dv/dt immunity up to 100kV/us
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- Isolated status feedback
- 5V...15V logic signals
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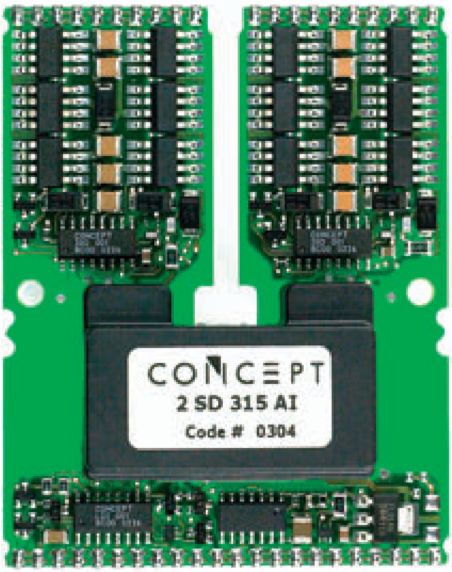
- Switching frequency DC to >100kHz
- Duty cycle 0...100%
- Delay time typ. 325ns



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

Specially designed transformers for creepage distances of 21mm between inputs and outputs or between the two channels. Insulating materials to UL V-0. Partial discharge test according IEC270.

Isolated DC/DC power supply with 3W per channel

More information: www.IGBT-Driver.com/go/2SD315AI

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

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

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

CONCEPT

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Let experts drive your power devices

The new IGBT Generation

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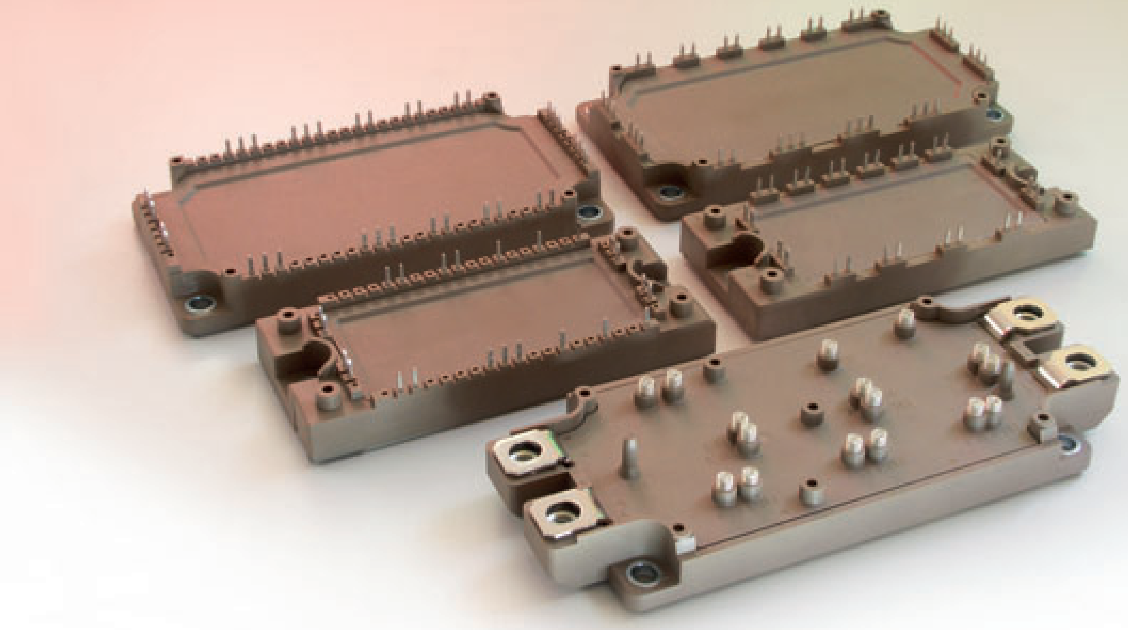

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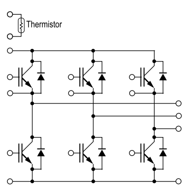
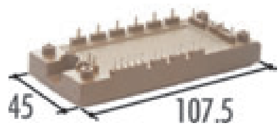
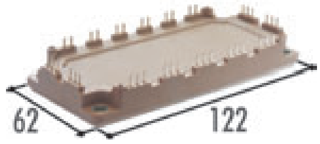
6-Pack IGBT
1200V



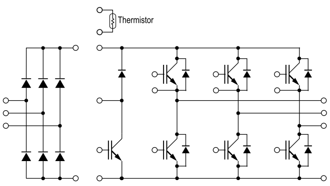


50A
75A
100A

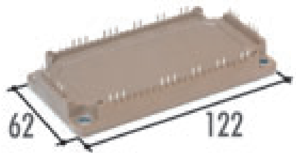


100A
150A
180A

PIM IGBT
1200V

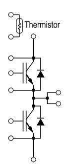


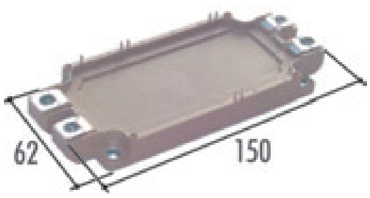
25A
35A
50A

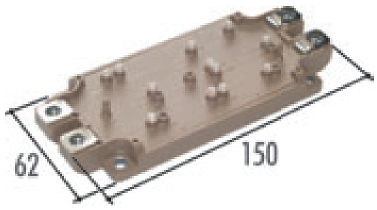


75A
100A
150A

2-Pack IGBT
1200V







225A
300A
450A
600A

FUJI ELECTRIC DEVICE TECHNOLOGY
e-Front runners

Fuji Electric Device Technology Europe GmbH
Goethering 58 · 63067 Offenbach am Main · Germany
Fon +49 (0)69 - 66 90 29 0 · Fax +49 (0)69 - 66 90 29 56
semi-info@fujielectric.de · www.fujielectric.de