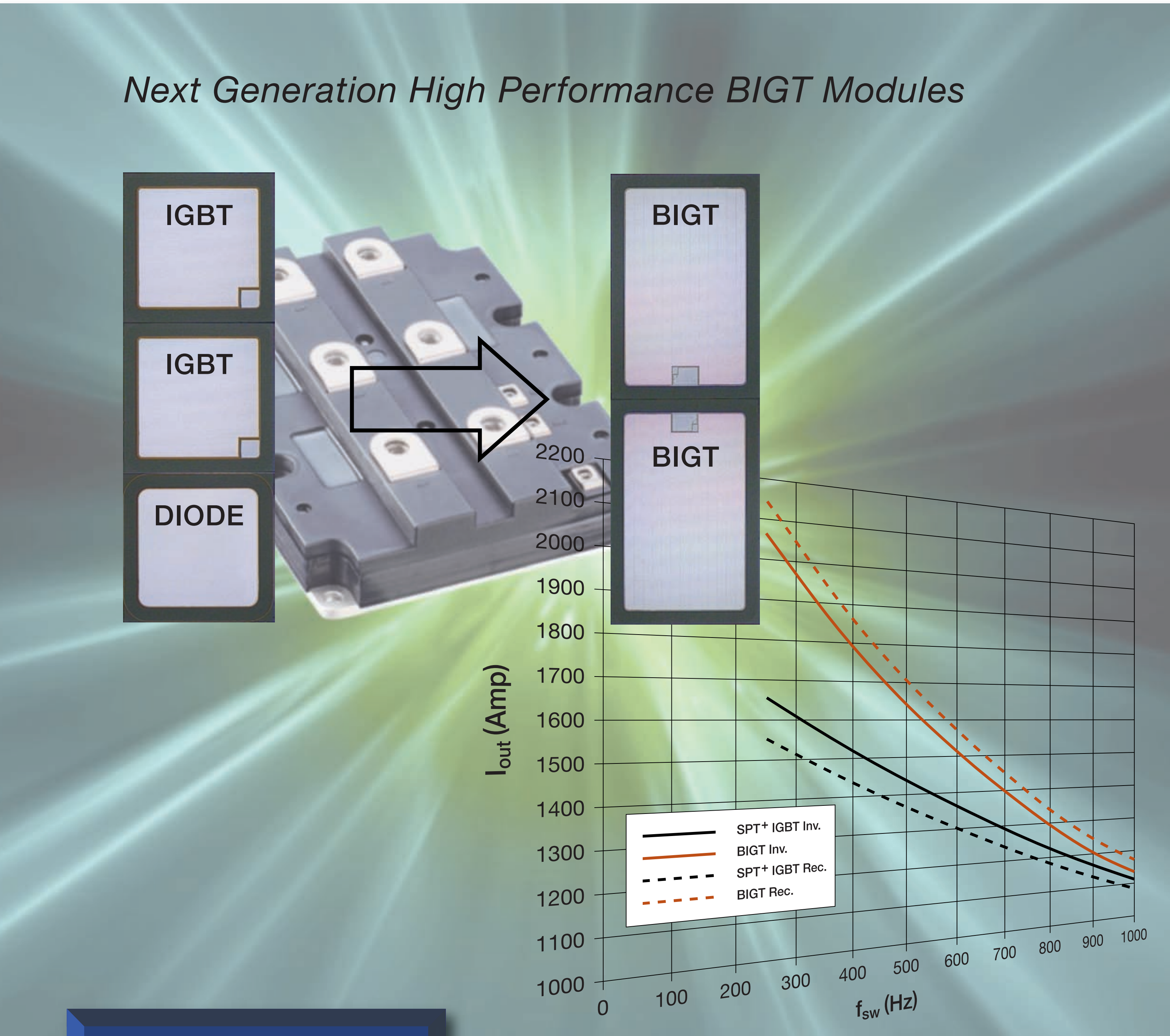
POWER
ELECTRONICS
EUROPE

ISSUE 5 – July/August 2010 www.power-mag.com

POWER MODULES

Next Generation High Performance BIGT HiPak Modules



THE EUROPEAN JOURNAL
FOR POWER ELECTRONICS
AND TECHNOLOGY

Also inside this issue

Opinion | Market News | Inverter Design |
IGBT Drivers | Power Modules | Low Power Design |
Products | Website Locator |


WORLDWIDE
DISTRIBUTION...
MADE EASY
FREE SHIPPING
ON ORDERS OVER €65!*
Digi-Key
CORPORATION
400,000+ PRODUCTS IN STOCK.
440+ SUPPLIER PARTNERS.
35,000+ NEW PRODUCTS ADDED IN THE LAST 90 DAYS.
The industry's broadest product selection available for immediate delivery
Find contact and ordering information for your region at
digikey.com/europe
*A shipping charge of €18.00 (£12.00) will be billed on all orders of less than €65.00 (£50.00). All orders are shipped via UPS for delivery within 1-3 days (dependent on final destination). No handling fees. All prices are in euro and British pound sterling. If excessive weight or unique circumstances require deviation from this charge, customers will be contacted prior to shipping order. Digi-Key is an authorized distributor for all supplier partners. New product added daily. © 2010 Digi-Key Corporation, 701 Brooks Ave. South, Thief River Falls, MN 56701, USA

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

Production Editor Chris Davis
Tel: +44 (0)1732 370340

Financial Clare Jackson
Tel: +44 (0)1732 370340
Fax: +44 (0)1732 360034

Circulation Manager Anne Backers
Tel: +44 (0)208 647 3133
Fax: +44 (0)208 669 8013
Email: anne@abdatalog.co.uk

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

Eastern US
Karen C Smith-Kernc
email: KarenKCS@aol.com
Western US and Canada
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 370340
Fax: +44 (0)1732 360034
Email: ian@dfamedia.co.uk
www.power-mag.com

Circulation and subscription: **Power Electronics Europe** is available for the following subscription charges. **Power Electronics Europe**: annual charge UK/NI £60, overseas $130, EUR 120; single copies UK/NI £10, overseas US$32, EUR 25. Contact: DFA Media, Cape House, 60a Priory Road, Tonbridge, Kent TN9 2BL Great Britain.
Tel: +44 (0)1732 370340. Fax: +44 (0)1732 360034. Refunds on cancelled subscriptions will only be provided at the Publisher's discretion, unless specifically guaranteed within the terms of subscription offer.

Editorial information should be sent to The Editor, **Power Electronics Europe**, PO Box 340131, 80098 Munich, Germany.

The contents of **Power Electronics Europe** are subject to reproduction in information storage and retrieval systems. All rights reserved. No part of this publication may be reproduced in any form or by any means, electronic or mechanical including photocopying, recording or any information storage or retrieval system without the express prior written consent of the publisher.

Printed by: Garnett Dickinson.
ISSN 1748-3530

PAGE 6

Market News

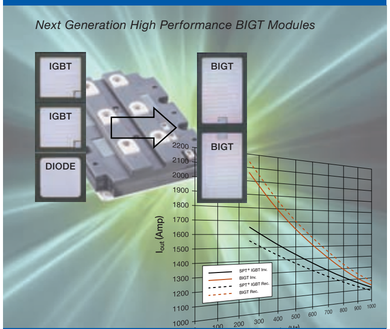
PEE looks at the latest Market News and company developments

PAGE 12

Market News: Renewable Energies on the Rise

A total of 27.5 GW of new power capacity was constructed in the EU last year. Out of this, 10.2 GW (38%) was wind power and 2.4 GW (8.7%) photovoltaics. For the second year in a row, wind energy is the leading electricity generation technology in Europe and the renewable share of new power installations was 62% in 2009.

COVER STORY



Next Generation High Performance BIGT HiPak Modules

In this article, ABB continues to report on the progress achieved towards the practical realization of a reverse conducting IGBT device concept referred to here as the Bimode Insulated Gate Transistor (BIGT). The introduction of the BIGT technology in the 3300V HiPak module line-up with current ratings exceeding 2000A is presented. Static and dynamic results are provided with the associated relevant parameters, outlining the basic performance levels that will be expected from the new technology. Other aspects are also covered with regards to the device SOA capability, softness and reliability performance up to a junction temperature of 150°C. In addition, the BIGT performance under hard switching frequency operation will be presented for the first time.
Full story on page 22

Cover supplied by ABB Semiconductors Switzerland

PAGE 17

Highly Efficient 3-Level Solutions for Renewable Energy Applications

Energy efficiency is one of the major criteria for photovoltaic (PV) and wind power inverters. The 3-level inverter topology proves to be one of the most attractive candidates for low and medium power, low voltage applications which require high switching frequencies, complex filtering and high efficiency.
The same advantages can be seen for Uninterruptable Power Supplies (UPS) which are connected and loaded 24/7. A new line of single modules which contain a full phase leg for a 3-level converter covers a wide power range from 4kW to 120kW. These modules combined with the latest and especially adapted semiconductor chip technology simplify the design of compact and efficient 3-level inverters. **Marc Buschkühle, Infineon Technologies AG, Warstein, Germany**

PAGE 26

Integrated Gate Driver Circuit Solutions

Power electronics systems are commonly used in motor drive, power supply and power conversion applications. They cover a wide output power spectrum: from several hundred watts in small drives up to megawatts in wind-power installations or large drive systems. Inside the system the gate driver circuit with its extensive control and monitoring functions forms the interface between the microcontroller and the power switches (IGBT). This article provides an overview of different gate driver topologies for different power ranges and shows examples for monolithic integration of the driver functionality. **R. Herzer, J. Lehmann, M. Rossberg, B. Vogler, SEMIKRON Elektronik, Nuremberg, Germany**

PAGE 32

Power Modules for Motor Control Applications

For applications in power electronics where significant power needs to be handled in confined spaces, often the choice for packaging is not a set of discrete power components, but a dedicated power module. For that purpose CoolPAK realizes an insert-molded shell which has an integrated metal lead-frame array. These lead-frames also present horizontal areas for housing bare die components as well as forming out the terminals for the outside contacts. **Jim Tompkins and Peter Sommerfeld, Electronic Motion Systems Canada and Germany**

PAGE 35

USB Compliance in Wireless Modem Design

With USB being a standard interface in PC peripherals, the number of applications that can be powered from a USB port is increasing at an exponential rate. The need for flexibility and continuous connectivity in our lives is becoming more important. In a growing wireless world, many applications are taking portable form allowing users the ease and flexibility of connecting to the web anywhere. With all the benefits this brings, there are a number of extra requirements that need to be taken into account when designing a device that is powered from a USB port. **John Constantopoulos, Systems Engineer, WW Low Power DC/DC, Texas Instruments, USA**

PAGE 38

Product Update

A digest of the latest innovations and new product launches

PAGE 41

Website Product Locator

MITSUBISHI
ELECTRIC
Changes for the Better

www.mitsubishichips.com

semis.info@meg.mee.com

Renewable Energies Push Power Electronics

According to the Joint Research Center of the European Commission a total of 27.5 GW of new electrical power capacity was installed in the EU last year. Out of this, 10.2 GW was wind power 5.8 GW (21%) and 2.4 GW (8.7%) photovoltaics. For the second year in a row, wind energy is the leading electricity generation technology in Europe and the renewable share of new power installations was 62% in 2009. The growth scenario for Europe, based on the 2001 to 2009 growth rate predicts, that more than 22 TWh of electricity could be generated in 2010. This would be about 0.7% of the EU 27 total net production of electricity of 3,042 TWh in 2009. Wind energy is already the number one in newly installed capacities in Europe. With more than 74 GW of cumulative installed capacity in 2009, it exceeded the target of 40 GW by more than 80%. The new target of the European Wind Association is aiming at 230 GW installed capacity (40 GW offshore) in 2020 capable of providing about 20% of European electricity demand.

Renewable energies directly push power electronics development. In example, Semikron, PCS Power Converter Solutions and the Technical University of Dresden are partnering in the research project "More efficient use of regenerative energies with multi level topologies - EEMT", a project which will receive around € 1.2 million in backing from the German Ministry for Education and Research (BMBF). The project is to run over a period of three years, ending in March 2013. The aim of the project is to develop innovative inverter technology to boost efficiency in the utilisation of power gained from renewable sources. As part of the EEMT project, an innovative inverter is to be developed to convert the DC generated by wind turbines or solar cells into AC that can then be fed into the grid. Conventional inverters need filter circuits to meet the minimum quality requirements for the power to be fed into the grid. The problem is, however, that these filter circuits are not particularly efficient, meaning some of the energy generated is lost. The multilevel topology circuit developed within the EEMT project is intended for use with such power inverters, with the aim of reducing filtering requirements substantially. The new circuit topology will also help reduce losses in the power lines to a minimum, boosting overall energy efficiency of the power generation unit. In terms of technology, such modules are more complex than the conventional inverter modules used today; in financial terms, however, the use of the new inverter modules offers very interesting prospects as a result of the increase in efficiency that they bring about.

Energy efficiency is one of the most critical aspects of today's information society. Reducing energy consumption of electronic devices, circuits and systems, coupled with improving energy generation, conversion, storage and management capabilities represent the biggest challenges that engineers and scientists operating in the electronics sector face in the next decade. Thus the three-year ENIAC (European Nanoelectronics Initiative Advisory Council) project is designed to enhance the competitiveness of Europe's semiconductor and electronics equipment companies in developing new products and technologies that are at the forefront of energy efficiency.

Renewable energies are also in the focus of EPE-PEMC Conference 2010 (6-8 September) in Ohrid, Republic of Macedonia. The special motto "Power Electronics and Motion Control for more efficient world" should contribute to enhance the use of energy conversion and conditioning technologies (ECCT). Next to the improved operation of systems, the reduction of energy consumption and the improvement of efficiency are the key factors, helping to achieve the Kyoto requirements and to address basic issues related to the reduction of greenhouse gases and pollutant emissions in industrial processes and transport, to increase the use of renewable energy sources and to allow their integration in the grid. Most of the electricity production, based on alternative energy sources undergo conditioning through ECCT equipment before use. ECCT is also a major means to achieve enhanced competitiveness of all industrial processes. Basic ECCT alone constitute a world market estimated at multi-billion Euros value, of which the EU has a 40% share. Significantly ECCT is a core enabling technology providing the central electrical, control, diagnostic and management systems. Accordingly, the three keynotes of this conference are entitled "Power Electronics and control for renewable energy systems", "Power quality challenges for flexible intelligent network operating under high penetration of distributed resources", and "Role of Green Electronics in a Non-Carbonated Society toward 2030".

Thus Green is the colour of choice for most power electronic manufacturers. They pave the way for a more energy-efficient world, of course in their own interest. Enjoy reading this issue.

Achim Scharf
PEE Editor

European Research Project Aims for Greener Electronics

The three-year ENIAC (European Nanoelectronics Initiative Advisory Council) project is designed to enhance the competitiveness of Europe's semiconductor and electronics equipment companies in developing new products and technologies that are at the forefront of energy efficiency.

Energy efficiency is one of the most critical aspects of today's information society. Reducing energy consumption of electronic devices, circuits and systems, coupled with improving energy generation, conversion, storage and management capabilities represent the biggest challenges that engineers and scientists operating in the electronics sector face in the next decade.

The END project will pursue the energy efficiency objective through an innovative holistic approach that unifies, under a common design platform, the development of modeling, simulation, design and EDA techniques for a wide range of devices and systems (digital blocks, analog/RF blocks, discrete components). The project will also address the conception and experimentation of new power supply systems, with particular emphasis on energy management aspects. This mission enables a synergic approach to energy-aware design, offering a comprehensive set of solutions covering the many different facets of the complex problem of accounting for energy effects during the design of heterogeneous circuits and systems, such as those that will be hosted by the electronic products of the future.

END brings together the expertise of user companies (IDMs, fabless), design centers, universities and institutes in a range of projects that will establish standards and contribute to building a solid energy-aware electronics design base for Europe. In particular, the project goals include the development of power models for non-bulk CMOS devices, a unified low-power design methodology for heterogeneous systems and SoC (System-on-Chip) devices, energy-efficient building blocks for heterogeneous systems, energy-efficient IP components for SoCs, energy management of systems based on multiple, heterogeneous supplies, and demonstrators of solar energy and wireless sensor systems.

The project will cost approximately 12.6 million Euros, with funding provided by both the ENIAC JU (Joint Undertaking) and from the public authorities of Belgium, Greece, Italy and Slovakia. The ENIAC JU is a public-private partnership with the European Commission, Member States, Associated States and European R&D actors and levers private and national investments. "The ultimate objective of the END project is to bring innovative energy-aware design solutions and EDA technologies into the product development of the industrial partners of the Consortium. We will enable the design and manufacture of electronic circuits that will be at the basis of the green information society of the future", commented Salvatore Rinaudo, END project coordinator and CAD R&D Director at STMicroelectronics. Other industrial project partners include NXP and On Semiconductor.

www.eniac.eu

Recovering Power Lost due to Solar-Panel Variability

At Intersolar STMicroelectronics has unveiled an IC to combine important power-optimization and power-conversion functions for solar generators, allowing multi-panel arrays to deliver more energy at a lower cost per watt.

ST's new SPV1020 chip allows Maximum Power-Point Tracking (MPPT) to be applied individually for each panel. MPPT automatically adjusts a solar generator's output circuitry to compensate for power fluctuations resulting from varying solar intensity, shadowing, temperature change, panel mismatch, or ageing. Without MPPT, the power from a solar panel can fall by 10% to 20% if even a small percentage of its surface is in shadow. This

disproportionate decrease may restrict the choice of site or force the use of a smaller array to avoid shadows. The SPV1020 enables Distributed MPPT (DMPPT), which compensates each panel individually, in contrast to a centralized MPPT scheme that applies a 'best-fit' compensation to all the panels in the array. DMPPT is the most promising technique to improve the energy productivity of photovoltaic systems because it maximizes the power extracted from each panel regardless of adjacent module performance, even if a module has failed.

Implementing DMPPT usually requires a network of discrete components for each panel in an array. The SPV1020 replaces this network with a single chip and also integrates the DC/DC converter to step-up the panel's low-voltage DC output to a larger DC voltage from which line-quality AC power is produced. By integrating MPPT and the DC/DC converter, the SPV1020 simplifies design and reduces part count, making DMPPT economical for solar generators across a range of power ratings and price points. ST has integrated all of the required functions in a monolithic chip using a 0.18-micron BCD8 multi-power process technology. BCD8 holds the key to combining power and analog functions for the DC/DC converter on the same chip as the digital logic performing the MPPT algorithm. This

technology enables a smaller, more reliable and longer-lasting solution than an alternative built with discrete components. "Maximizing efficiency and reliability are key elements to deliver cost-competitive power from renewable sources," said Pietro Menniti, General

Manager of ST's Industrial and Power Conversion Division.

The SPV1020 is available in a 36-pin PowerSSO (PSSO-36) package. Engineering

samples and evaluation kits are already available. Volume production is scheduled for November 2010.

www.st.com

ST's new SPV1020 enables Distributed MPPT which compensates each solar panel individually for power fluctuations

29 Palms

Lean on me

Reliable with HiPak modules from ABB

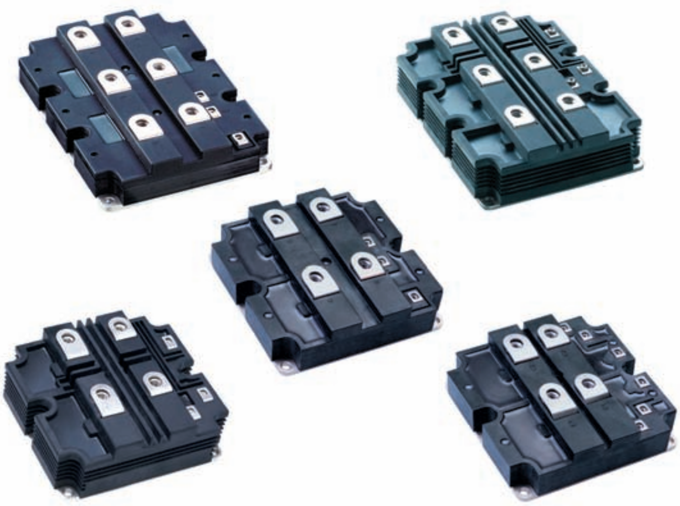


ABB Switzerland Ltd
Semiconductors
Tel: +41 58 586 1419
www.abb.com/semiconductors

Power and productivity
for a better world™

ABB

SEMIKRON
innovation+service

SKAI™

Most compact inverter systems: 20 kVA/l

For electric, hybrid and battery vehicles

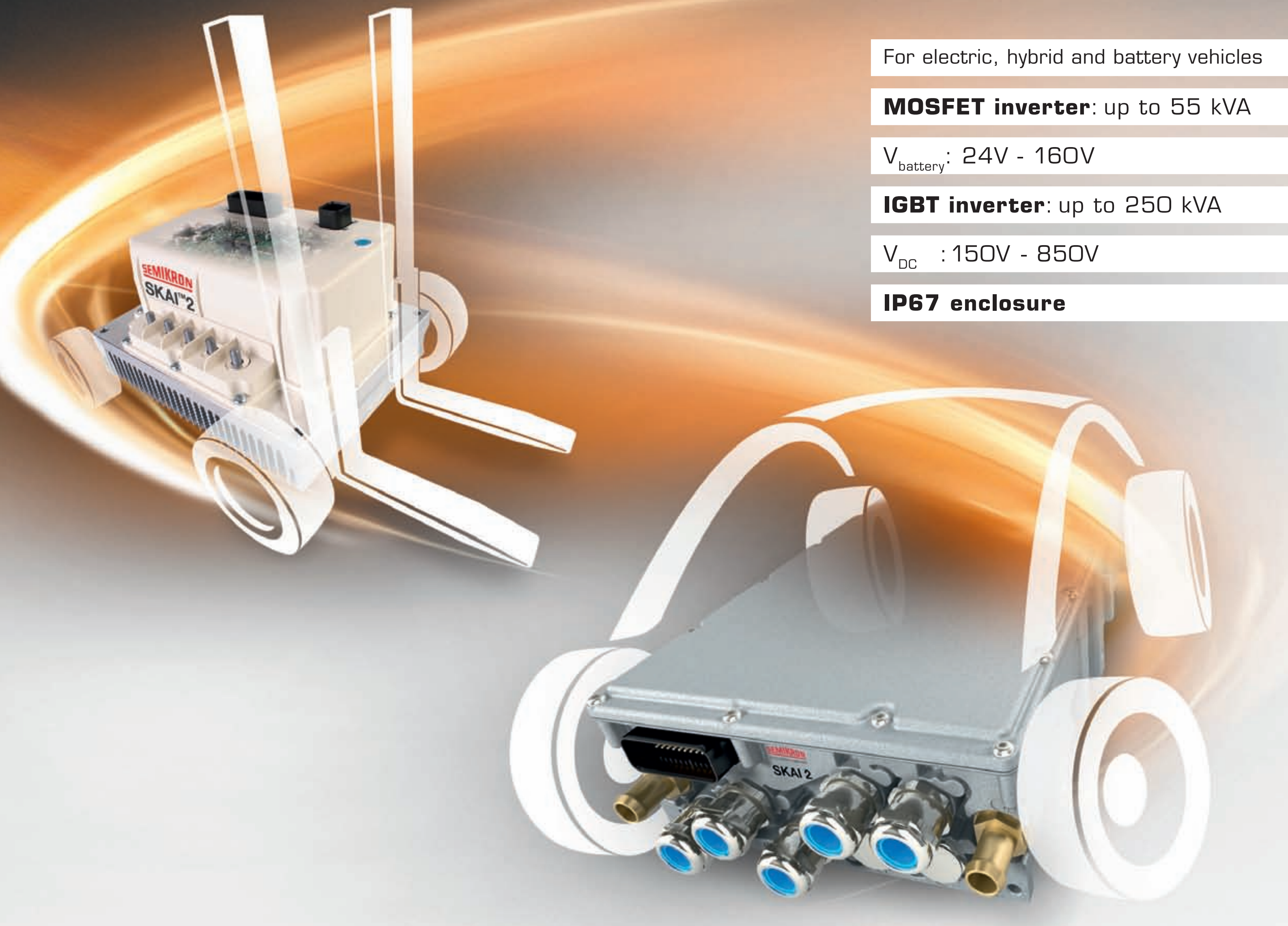
MOSFET inverter: up to 55 kVA

$V_{battery}$: 24V - 160V

IGBT inverter: up to 250 kVA

V_{DC} : 150V - 850V

IP67 enclosure



3-phase IGBT inverter system up to 250 kVA

- Voltage, current and temperature sensors
- Gate driver with protection
- IGBT and MOSFET power semiconductors
- Fully programmable digital signal processor
- Liquid and air cooling
- Integrated EMI filter

■ **Australia** +61 3-85 61 56 00 ■ **Brasil** +55 11-41 86 95 00 ■ **Cesko** +420 37 80 51 400 ■ **China** +852 34 26 33 66 ■ **Deutschland** +49 911-65 59-0 ■ **España** +34 9 36 33 58 90 ■ **France** +33 1-30 86 80 00
■ **India** +91 222 76 28 600 ■ **Italia** +39 06-9 11 42 41 ■ **Japan** +81 68 95 13 96 ■ **Korea** +82 32-3 46 28 30 ■ **Mexico** +52 55-53 00 11 51 ■ **Nederland** +31 55-5 29 52 95 ■ **Österreich** +43 1-58 63 65 80
■ **Polska** +48 22-6 15 79 84 ■ **Russia** +7 38 33 55 58 69 ■ **Schweiz** +41 44-9 14 13 33 ■ **Slovensko** +421 3 37 97 03 05 ■ **Suid-Afrika** +27 12-3 45 60 60 ■ **Suomi** +358 9-7 74 38 80 ■ **Sverige** +46 8-59 4768 50
■ **Türkiye** +90 21 6-688 32 88 ■ **United Kingdom** +44 19 92-58 46 77 ■ **USA** +1 603-8 83 81 02 **sales.skd@semikron.com** **www.semikron.com**

Texas Instruments names Sami Kiriaki SVP of Power Management

Sami Kiriaki, general manager of the Power Management division in TI's Analog business, has been elected a senior vice president of the company. He will direct all strategy, product development and delivery of TI's power management chips.

Kiriaki began at TI in 1984 as an analog design engineer. Most recently, he served as vice president and manager of TI's Mobile Integrated Solutions business unit in the company's High-Volume Analog and Logic division. There he managed business strategy and operations, including product development of highly integrated analog application-specific products used in mobile handsets, netbooks and eBook readers, to name a few. He earned his bachelor's and master's degrees in electrical engineering from the University of Rhode Island. He has been a member of the Institute of Electrical and Electronics Engineers for more than 20 years, and he has 15 US patents in analog integrated circuit design. "Sami has spent almost three decades in the Analog industry and brings to this job both an engineer's perspective for chip design, and a business leader's insights into global markets", commented Gregg Lowe, senior vice president of TI's Analog business.

www.ti.com

TI's new SVP Power Management Sami Kiriaki

Greater Yields from Renewable Energy Sources

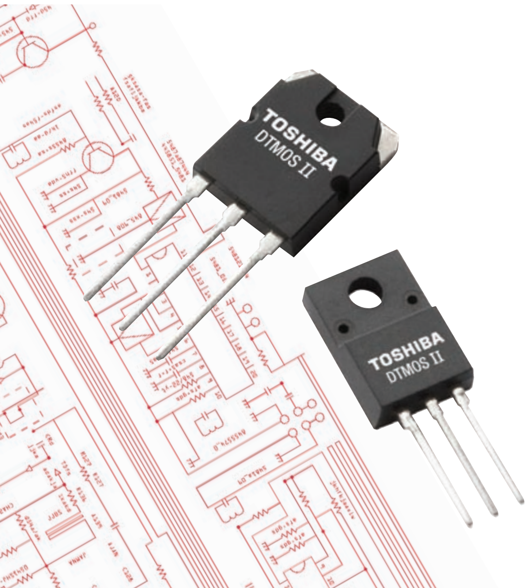
German Ministry of Education and Research backs joint research project between Semikron, PCS Power Converter Solutions and the Technical University of Dresden on the optimization of energy efficiency in wind and solar power modules.

Semikron, PCS Power Converter Solutions and the Technical University of Dresden are partnering in the research project "More efficient use of regenerative energies with multi level topologies - EEMT", a project which will receive around € 1.2 million in backing from the German Ministry for Education and Research (BMBF). The project is to run over a period of three years, ending in March 2013. The aim of the project is to develop innovative inverter technology to boost efficiency in the utilisation of power gained from renewable sources. It runs within the framework of the "Power Electronics for Improved Energy Efficiency" initiative, which is part of the German government's high-tech strategy and the "IT and communication technology 2020" initiative (ICT 2020). The ICT initiative focuses, amongst other things, on the expansion of the range of applications for electronics, with the purpose of achieving greater energy efficiency and reduced pollutant emissions with innovative power electronic systems.

As part of the EEMT project, an innovative inverter is to be developed to convert the DC generated by wind turbines or solar cells into AC that can then be fed into the grid. Conventional inverters need filter circuits to meet the minimum quality requirements for the power to be fed into the grid. The problem is, however, that these filter circuits are not particularly efficient, meaning some of the energy generated is lost. The multilevel topology circuit developed within the EEMT project is intended for use with such power inverters, with the aim of reducing filtering requirements substantially. The new circuit topology will also help reduce losses in the power lines to a minimum, boosting overall energy efficiency of the power generation unit. In terms of technology, such modules are more complex than the conventional inverter modules used today; in financial terms, however, the use of the new inverter modules offers very interesting prospects as a result of the increase in efficiency that they bring about.

During the research project, new intelligent integrated inverter modules are to be developed by Semikron for use in an innovative power converter developed by Power Converter Solutions. The driver circuitry and protective components are to be developed by the Electrical Engineering Institute's Chair for Power Electronics at the Technical University of Dresden.

www.bmbf.de, www.semikron.com



TOSHIBA'S COMPACT SUPER JUNCTION POWER MOSFETS - LOWEST RDS(ON) x Qg AND RUGGED CHIPS

Toshiba's innovative new family of DTMOS II power MOSFETs are now available not only with a maximum VDSS rating of 600V but also with 650V. The range makes your solutions more efficient, thanks to faster switching speed, linked with lowest RDS(ON) x Q(g) performance.

Our compact smart isolation TO220SIS package combined with the copper connector technology, have made the new Toshiba DTMOS II MOSFETs hard to resist. And, if you need higher power, our TO-3P(N) package are available too.

Visit us today at www.toshiba-components.com/power

TOSHIBA
Leading Innovation >>>

EPE-PEMC 2010 Conference in Macedonia

Power Electronics and Motion Control are becoming more and more important as the basis for many industrial processes, individual and mass transportation, but also for rational use of the energy as well as environmental requirements directed by climate changes. Due to the new rules published by the EC on the electric energy production, transport, distribution and interconnection, the role of Power Electronics is growing.

It is well known that over 50% of the electric energy production in highly developed countries passes through electronic conversion and conditioning equipment. Advances in energy conversion and conditioning technologies (ECCT), developing and exploiting new power electronic systems, energy conversion devices and system control methods, are all fundamental and crucial to the development of the clean, efficient and sustainable technology in the future. Next to the improved operation of systems, the reduction of energy consumption and the improvement of efficiency are the key factors, helping to achieve the Kyoto requirements and to address basic issues related to the reduction of greenhouse gases and pollutant emissions in industrial processes and transport, to increase the use of renewable energy sources and to allow their integration in the grid.

Most of the electricity production, based on alternative energy sources undergo conditioning through ECCT equipment before use. ECCT is also a major means to achieve enhanced competitiveness of all industrial processes. Basic ECCT alone constitute a world market estimated at multi-billion Euros value, of which the EU has a 40% share. Significantly ECCT is a core enabling technology providing the central electrical, control, diagnostic and management systems.

EPE-PEMC Conference 2010 (6-8 September) in Ohrid, Republic of Macedonia, is the 14th of conference series in Europe started in 1970 in the field of Power Electronics and Motion Control. Following the previous successful conferences, this time EPE-PEMC 2010 will move to South-East of Europe to narrow the gap not only between the West and the East, but also between the North and the South, and to accelerate the global integration process. “The main goal of both organizations, EPE-PEMC Council and EPE Association, is to promote and coordinate the exchange and the publication of technical, scientific and economic information in the field of power electronics and motion control. One of the main objectives of cooperation is the integration and unification of Europe in the field of our profession. Therefore in addition to keynotes, oral and dialog presentations according to topics, the conference will be joined by tutorials, special sessions, round tables, exhibitions and technical visits”, outlined Co-Chairman Dushan Boroyevich. The special motto “Power Electronics and Motion Control for more efficient world” should contribute to enhance the use of ECCT. The three keynotes are entitled “Power Electronics and control for renewable energy systems”, “Power quality challenges for flexible intelligent network operating under high penetration of distributed resources”, and “Role of Green Electronics in a Non-Carbonated Society toward 2030”.

The EPE - PEMC’2010 in Ohrid is following EPE - PEMC’2008 in Poznan/Poland which brought together about 500 participants from 60 countries, EPE - PEMC’2006 in Portoro_/Slovenia with about 500 participants from 45 countries and EPE - PEMC’2004 conference in Riga/Latvia with over 600 professionals from 35 countries.

www.epe-pemc2010.com

ECPE Workshop Advanced Multilevel Converter Systems

The benefits and challenges of advanced multilevel topologies in various applications will be presented and discussed in the ECPE Workshop “Advanced Multilevel Converter Systems”, taking place on 28 - 29 September 2010 in Västerås, Sweden.

In recent years, multilevel converters have become standard practice in the field of HVDC grids and Medium Voltage Drives. But lower voltage applications seem to take benefit from the usage of new multilevel solutions and topologies, as well. The increasing number of levels even allows using low voltage MOSFET devices to reach the goals of energy efficiency and improved performance. The Neutral Point Clamped topology which started this revolution is now one of several solutions, but there are also improvements.

With this mature technology, switching higher voltages and delivering higher power are not the only benefits, which allow other fields of application. Improved efficiency is a key feature for photovoltaic systems and uninterruptible power supplies, reduced harmonic distortion helps making lighter and more compact onboard systems, increased apparent switching frequency and bandwidth allows suppressing electrolytic capacitors in voltage regulator modules feeding microprocessors. Multilevel topologies have changed the world of power electronics, and this affects every part of the design of power converters: control and modulation techniques, technological requirements, system-oriented design and reliability issues.

The workshop is chaired by Dr. T. Meynard (University of Toulouse, ENSEEIHT - LAPLACE), Dr. G. Demetriades (ABB Corporate Research Sweden), and J. Koszescha (ECPE). A lab tour at ABB Corporate Research will be offered after the end of the workshop.

www.ecpe.org

Solar PV Micro-inverter for European and North American Markets

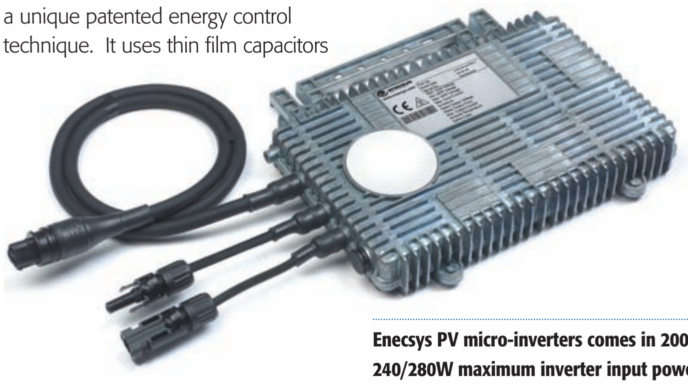
UK-based Enecsys Ltd launched at Intersolar fair in Munich its PV grid-connected micro-inverter for both the European and North American markets. A solar PV system based on micro-inverters will have improved energy harvest and therefore cut the cost of harvested power by up to 20% over the lifetime of the installation compared with a conventional system using string inverters. The micro-inverter have a life expectancy of at least 25 years, matching the life of solar modules to which they are directly connected. "A growing recognition of the economic and technical benefits of micro-inverter architecture has resulted in demand outstripping supply today", stated Enecsys CEO Paul Engle.

"Micro-inverter demand has lead to outstripping supply", stated Enecsys CEO Paul Engle

Its design embodies three key attributes: a rugged topology, a component set based on high temperature rating and reliability, and a unique patented energy control technique. It uses thin film capacitors instead of less reliable electrolytic capacitors and eliminates the use of optocouplers, which are also known to have relatively poor reliability. Reliability has been verified through industry-standard accelerated life tests including temperature cycling to IEC61215, the same methodology used to evaluate solar PV modules. It is specified to maintain full performance from -40°C to 85°C, and achieves peak efficiency of 94% over this temperature range. The micro-inverter is equipped with a ZigBee wireless communication system that connects to the Internet via a gateway. It provides detailed information on the performance of each solar module, a capability not available with string inverters.

The company recently has hired Paul Garrity to head the continued development of its micro-inverter. Garrity joins Enecsys after three years as VP of Engineering and Advanced Product Development at FlexPower (a subsidiary of Flextronics International) in Dallas/Texas and over 20 years international experience in the power electronics industry, having successfully transferred over 90 projects into production whilst working for major OEM and electronic manufacturing services companies. Garrity has filed 12 patents related to power conversion technology. "Solar PV is one of the most exciting industries to be involved with at this time. The micro-inverter represents a remarkable breakthrough in energy harvest, reliability, and safety that will have a positive impact on system economics", Garrity commented.

www.enecsys.com



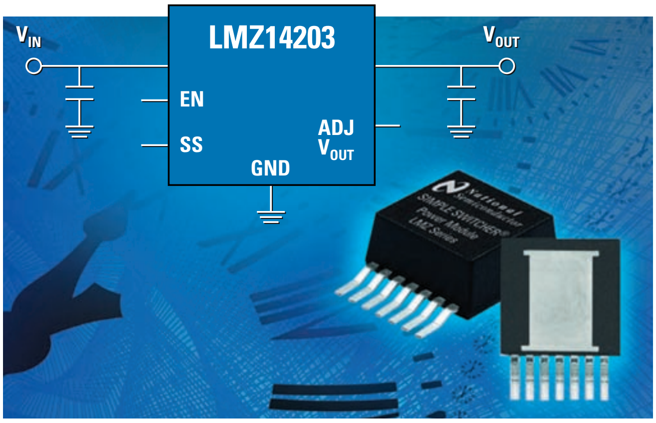
Enecsys PV micro-inverters comes in 200/240/280W maximum inverter input power

DESIGN MADE EASY
1 EXPLORE & LEARN 2 COMPARE & SELECT 3 DESIGN & BUILD

Save time. Design with Ease.

New SIMPLE SWITCHER® Power Modules

SIMPLE SWITCHER power modules deliver a highly efficient, all-in-one power solution with superior EMI and thermal performance in an innovative package.



New, Industry-Leading Integrated Package
An easy-to-use package provides a single copper bottom for superior thermal performance and simplified prototyping and manufacturing.

Excellent EMI
Ideal for noise-sensitive applications, the power modules provide excellent radiated EMI performance.

Superior Thermal Performance
Thermal performance with no airflow required, combined with low operating temperature and low system heat generation, make the power modules reliable and robust.

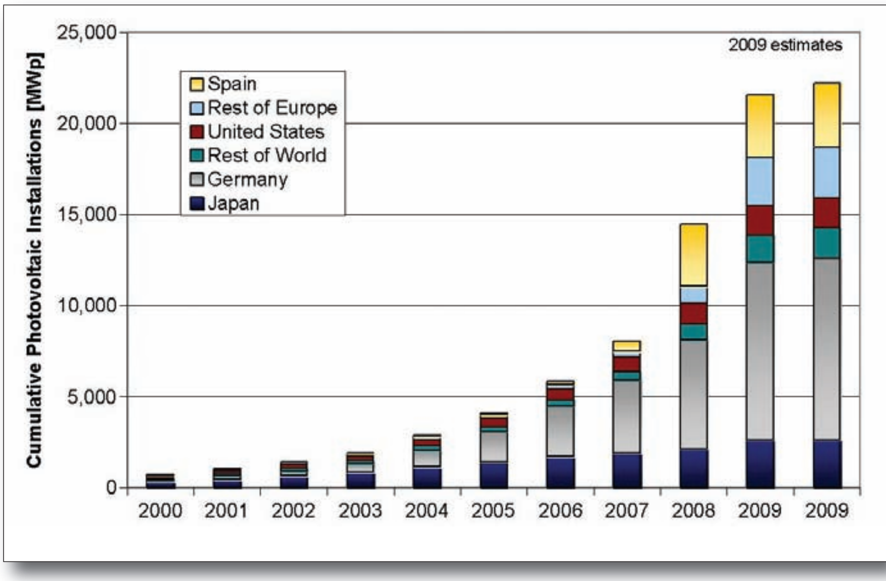
National Semiconductor

national.com/switcher

© National Semiconductor Corporation, 2010. National Semiconductor, and SIMPLE SWITCHER are registered trademarks. All rights reserved.

Renewable Energies on the Rise

A total of 27.5 GW of new power capacity was constructed in the EU last year. Out of this, 10.2 GW (38%) was wind power and 2.4 GW (8.7%) photovoltaics. For the second year in a row, wind energy is the leading electricity generation technology in Europe and the renewable share of new power installations was 62% in 2009.



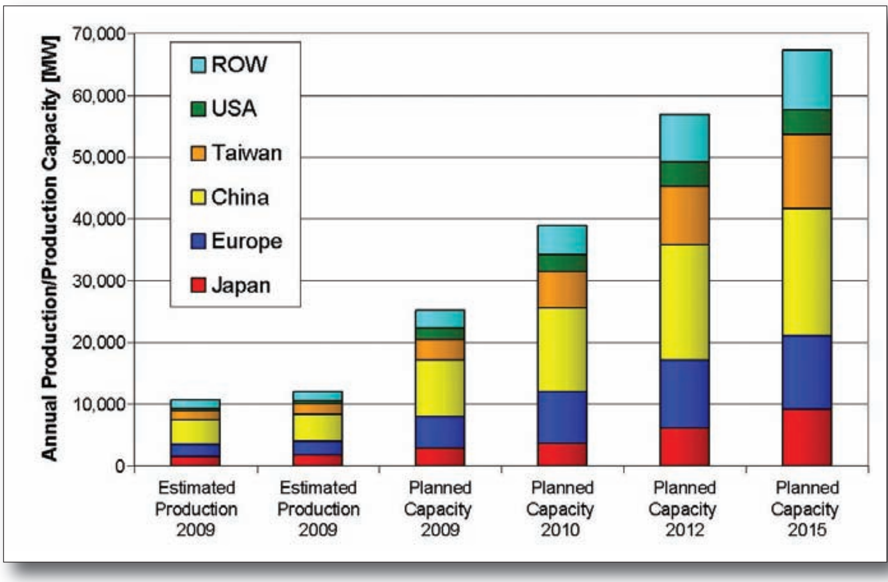
Cumulative photovoltaic Installations from 2000 to 2009 Source: EPIA, Euroobserver, JRC

In Europe solar photovoltaic electricity generation has again increased its cumulative installed capacity by more than 50% to 16 GW in 2009 and for 2010 installations of up to 10 GW are expected, according to figures published in June by the Joint Research Center of the European Commission. This would result in a capacity almost 9 times as high as was foreseen as the target for 2010.

The European Photovoltaic Industry Association published their ambitious vision plan for 2020 last year. The new target calls for up to 12% of the European electricity generated with solar photovoltaic electricity generation, or 380 to 420 TWh. The necessary growth rate would be 36% annually, which is much lower than what the industry has seen in the last eight years. "From an industry point of view the target is ambitious, but achievable, however it will need accompanying measures to ensure that the electricity grid will be able to absorb and distribute the generated solar electricity. This is especially important, because 12% of total electricity from solar photovoltaics translates to a cumulative installed PV capacity of 350 GW or close to 60% of the current total European thermal electricity generation capacity (590 GW in 2008) or more than 40% of the current total European electricity generation capacity (800 GW in 2008). Therefore, efficient transmission and storage systems, as well as modern supply and demand management, have to be available to fulfil this vision", said principal researcher Arnulf Jäger-Waldau.

Production data for the global cell production20 in 2009 vary between 10.5 GW and 12 GW. This is again an increase of 40% to 50% compared to 2008. The significant uncertainty in the data for 2009 is due to difficult market situation, which was characterised by a declining market environment in the first half of 2009 and an exceptional boom in the second half of 2009.

Since 2000, total PV production increased more than 30 fold with annual growth rates between 40% and 80%. The most rapid growth in annual production over the last five years could be observed in China and Taiwan, which now account for about 50% of worldwide production. By 2015, China could have about 31% of the worldwide production capacity of 67 GW followed by Europe (18%), Taiwan (18%) and Japan (14%).

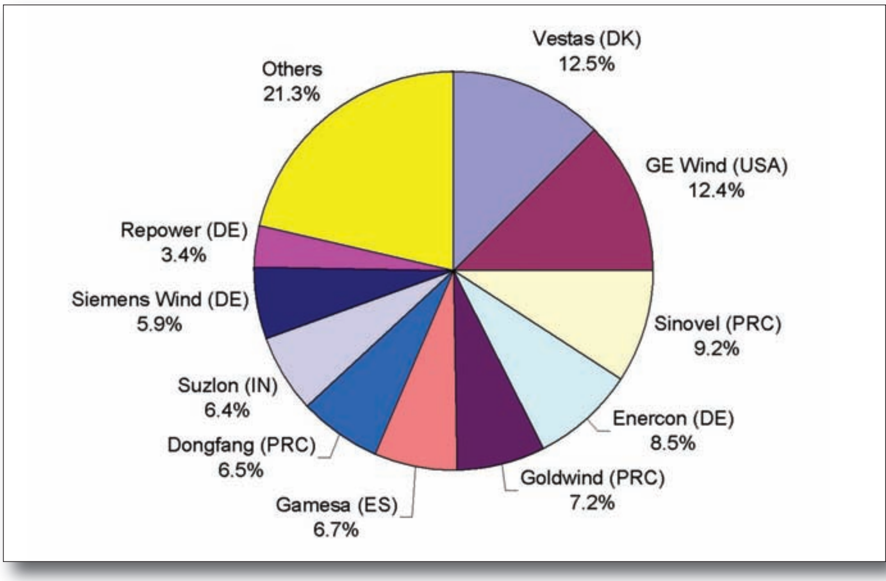


Expected worldwide PV production 2009 with future planned production capacity increases Source: JRC

Photovoltaic trends

All these ambitious plans to increase production capacities at such a rapid pace depend on the expectations that markets will grow accordingly. This however is the biggest uncertainty as can be seen with the market estimates for 2010 which vary between 9 GW and 24 GW with a consensus value in the 11 to 12 GW range. In addition most markets are still dependent on public support in the form of feed-in tariffs, investment subsidies or tax-breaks.

Wafer based silicon solar cells is still the main technology and had around 80% market shares in 2009. Polycrystalline solar cells still dominate the market (45 to 50%) even if the market shares are slowly decreasing since 2003. The massive capacity increases for both technologies are followed by the necessary capacity expansions for



Cumulative worldwide installed wind power capacity from 1990 to 2009 Source: GWEC, WWEA

polysilicon raw material.

The rapid growth of the PV industry since 2000 led to the situation where between 2004 and early 2008, the demand for polysilicon outstripped the supply from the semiconductor industry. Prices for purified silicon started to rise sharply in 2007 and in 2008 prices for polysilicon peaked around 500 $/kg and consequently resulted in higher prices for PV modules. This extreme price hike triggered a massive capacity expansion, not only of established companies, but many new entrants, as well. In 2009 more than 90% of total polysilicon for the semiconductor and photovoltaic industry was supplied by seven companies: Hemlock, Wacker Chemie, REC, Tokuyama, MEMC, Mitsubishi and Sumitomo. However, it is estimated that now about seventy producers are present in the market.

The massive production expansions as well as the difficult economic situation led to decreased prices throughout 2009 reaching about 50-55 $/kg on average by year's end. Prices are expected to continue to drop over the next three years, but at a much slower rate levelling in the 40 to 50 $/kg range in 2012.

More than 150 companies are involved in the thin-film solar cell production process, ranging from R&D activities to major manufacturing plants. The first 100MW thin-film factories became operational in 2007. If all expansion plans are realised in time, thin-film production capacity could be 20 GW or 36% of the total 56 GW in 2012 and 23 GW or 34% in 2015 of a total of 67 GW. The first thin-film factories with GW production capacity are already under construction for various thin-film technologies.

2009 was the year of speculations about a contracting or increasing photovoltaic market. The latest market estimates in spring 2010 came as a surprise for most people. The current estimates are between 7.1 and 7.8GW, this represents mostly the grid connected photovoltaic market. To what extent the off-grid and consumer product markets are included is not clear. After a slow start, the markets began to pick up pace in the second quarter, but the real boom happened in the last quarter of 2009 when in Germany alone, according to the German Federal Network Agency, 1.46 GW of new capacity were added.

The growth scenario for Europe, based on the 2001 to 2009 growth rate - taking the Spanish installations in 2008 as an exception - predicts, that more than 22 TWh of electricity could be generated in 2010. This would be about 0.7% of the EU 27 total net production of electricity of 3,042 TWh in 2009.

Wind power trends

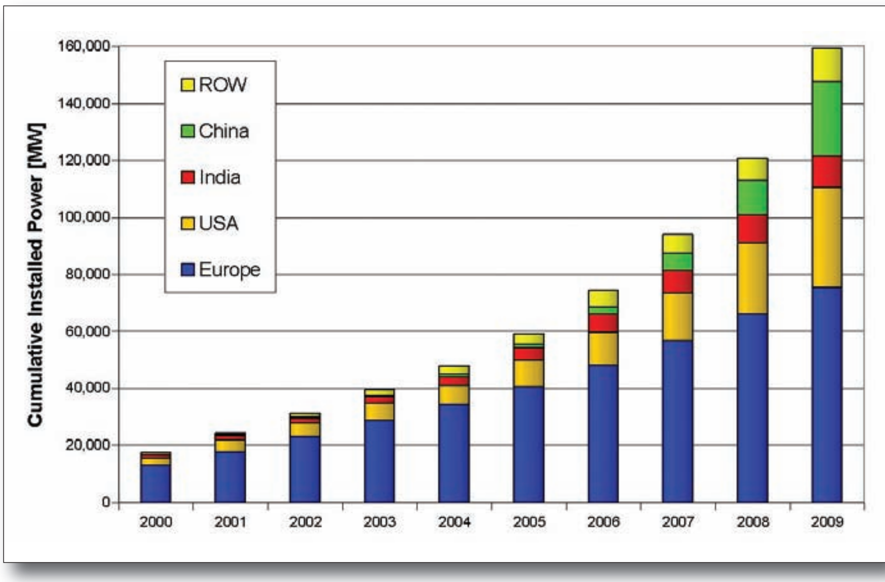
Wind energy is already the number one in newly installed capacities in Europe. With more than 74 GW of cumulative installed capacity in 2009, it exceeded the target of 40 GW by more than 80%. The new target of the European Wind Association is aiming at 230 GW installed capacity (40 GW offshore) in 2020 capable of providing about 20% of European electricity demand.

In 2009, 38 GW of new wind turbine capacity went into operation bringing the world wide total installed wind capacity to 160GW. The United States kept its first place in overall installed capacity, with 35.2GW followed by China (26GW), which for the second year in a row again more than doubled its total installations, Germany (25.7GW) and Spain (19.1GW). China more than doubled its total installations in 2008, bringing its overall wind capacity to 12.2GW and moved ahead of India with 9.6 MW. The total installed wind capacity at the end of 2009 can produce about 340TWh of electricity or 2% of the global electricity demand. The European Union Member States added 10,163MW and reached a total installed capacity of 74,767MW. Other European countries and Turkey added 418MW, bringing the total wind installations in Europe and Turkey to 76,152MW.

In 2009, the European Union's wind capacity grew by 15.7 %, and can now produce approximately 165TWh of electricity in an average wind year, equal to 5.5% of the total 2009 EU 27 electricity consumption. The German and Spanish markets still represent 43% of the EU market, but there is a continuous trend towards more diversification.

The general trend shows that the wind energy sector is broadening its market base and more and more countries are increasing the installation of wind energy capacities. In 2009 a total of 82 countries used wind energy on a commercial basis and 49 out of them increased their installations in that year. The European market accounted for about 27% of the total new capacity, a significant percentage decrease from the 75% in 2004. In 2009 454MW of offshore wind capacity were added

Market shares of wind power manufacturers 2009 (38.1 GW installations) Source: JRC



increasing the total installed capacity to almost 2GW or 1.2% of the total wind capacity worldwide.

The European Wind Energy Association (EWEA) has increased its 2020 target from180 GW installed capacity in 2020 to 230 GW including 40 GW offshore. This cumulative installed capacity would be able to produce some 600TWh of electricity or 14 to 18% of the European Union's expected electricity demand in 2020.

Three of the top 10 wind turbine manufacturers are from the People's Republic of China and there are more than 70 companies involved in wind equipment manufacturing. So far most of the Chinese wind turbines are only sold inside China, but a number of players have already announced to expand outside China in the future. The major reasons is the overcapacity and fierce competition within the domestic market where the total quoted manufacturing capacity of the leading three companies in China exceeds 12GW or more than 90% of the 2009 installations.

Up to 50% supply in 2020

"It can be concluded that if the current growth rates of the renewable electricity generation sources can be maintained, up to 1,600 TWh (45 - 50%) of renewable electricity could be generated in 2020. With this contribution the renewable electricity industry would significantly contribute to the fulfilment of the 2020 targets. But it has to be pointed out that this significant contribution of the renewable electricity sector will not come by itself. Without increased political support, especially in the field of fair grid access and regulatory measures to ensure that the current electricity system is transformed to be capable to absorb these amounts of renewable electricity, these predictions will not come about. In addition, the different renewable energy sources will need for the next decade substantial public R&D support as well as accompanying measures to enlarge the respective markets, as cost reduction and accelerated implementation will depend on the production volume and not on time", Jäger-Waldau commented.

http://www.jrc.ec.europa.eu/

Bright Start to 2010 for PV Modules

PV module shipments increased for the fifth consecutive quarter in Q2'10 to 3.7GW, generating $7.1 billion in revenues, according to IMS Research's latest quarterly report on the solar cell & module market. The first half of 2010 saw high demand from major PV markets, particularly Germany where proposed feed-in-tariff cuts drove demand to new levels. Solar module shipments are forecast to increase once again in Q3'10 to reach 4.3GW.

"In contrast to the first half of 2009, when declining module prices and poor economic conditions stalled the market, current market conditions have led to a huge surge with PV module shipments in Q1'10 increasing by over 60% compared to the same quarter of the previous year", commented analyst, Sam Wilkinson. "PV module suppliers are undoubtedly enjoying this surge in demand and results have improved significantly. We predict that average gross margins will reach over 30% this quarter".

First Solar, which currently enjoys some of the highest gross margins of PV module manufacturers, remained the largest supplier in Q1'10. However, its share of module shipments decreased for the fifth consecutive quarter and the gap between it and its crystalline competitors closed further, a trend that is likely to continue throughout this year. Whilst IMS Research predicts that total PV module shipments will grow by 60% in 2010, shipments of Cadmium Telluride (CdTe) modules (dominated by First Solar) are forecast to increase by just 20% due to limited capacity increases for the technology until 2011; these results will mean that CdTe's share of shipments will decrease from nearly 11% in 2009 to just over 8% in 2010. In contrast, the five largest Chinese module manufacturers (Suntech, Trina, Yingli, Canadian Solar and Solarfun), all suppliers of crystalline technology, continued to increase their command of the market and their combined share of global shipments reached 28% in the first quarter.

Shortage in PV inverters

Q1'10 was also an outstanding and unique quarter for PV inverter suppliers for two very different reasons. All suppliers reported incredible performance making Q1'10 the largest first quarter on record in terms of inverter shipments. Despite this strong result, demand for inverters still outstripped supply; and the component shortage and inverter production problems that began in Q4'09 in fact worsened in Q1'10 with quarter-to-quarter supply falling.

"Although Q1'10 presented some incredible results for inverter suppliers, with shipments up more than 300% year-on-year, sequentially shipments fell in all regions, including Germany. Total global inverter shipments were 3.7 GW in Q4'09, some 16% higher than Q1'10. In a 'normal' year this kind of seasonality would be expected; however, as strong demand has continued into early 2010 with the impending cut to Germany's feed-in tariff, this sequential decline of inverter shipments contrasts the increasing shipments of PV modules and highlights that the supply of inverters may still be restraining growth of the PV industry", commented PV research director Ash Sharma.

"Production constraints still blight the PV inverter industry, with even market leader SMA having to issue a formal apology to its customers; it recently indicated its production capacity would be limited to around 1.3 GW in the second quarter and supply constraints would not ease until July at the earliest. Despite the supply of components strongly affecting SMA's abilities to raise its production output, it did in fact gain market share in Q1'10, illustrating that this shortage is also impacting its competitors' business and the issue is affecting the entire inverter industry".

www.pvmarketresearch,com

PV Module Suppliers - Market Shares
Quarterly - MW Shipments

	Company Name	Q1'10 Share
1.	First Solar	8.4%
2.	Suntech	8.1%
3.	Sharp	6.8%
4.	Trina Solar	5.3%
5.	Yingli	5.3%
6.	Canadian Solar	5.2%
7.	Solarfun	4.2%
8.	Kyocera	4.1%
9.	Sunpower Corporation	3.4%
10.	Sanyo	3.0%
	Others	46.2%

Market share of PV module suppliers Q1 2010 Source: IMS Research

Messe München International

24th International Trade Fair
New Munich Trade Fair Centre
09–12 November 2010

Automotive | e-Mobility | Displays / e-Signage | Embedded systems / software | Medical / MEMS | Photovoltaics

Time for electronics. Time for the future.

Key topics, trends and technologies. The latest components, systems and applications. Visit electronica 2010, the international trade fair that will show you today what is important tomorrow and generate momentum for real growth.

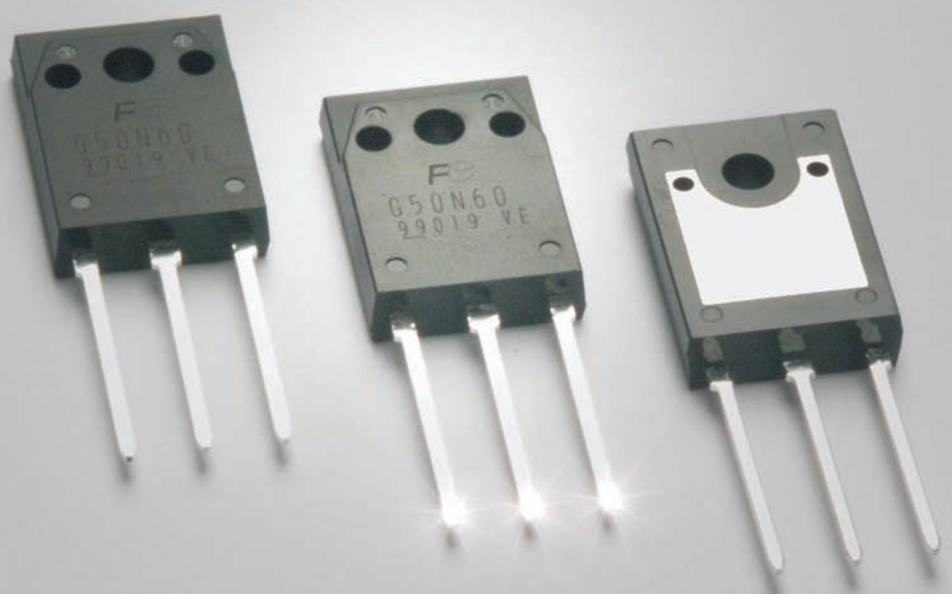
Parallel event: hybridica. Trade fair for hybrid-component production. www.hybridica.de

get the whole picture

electronica 2010
components | systems | applications

www.electronica.de/en

New Discrete IGBTs



We never sell a product alone

It always comes with Quality

◆ $T_{j(max)}$ = 175°C ◆ $T_{op(max)}$ = 150°C ◆ Rated I_C at 100°C	**Low loss V-series** High Short Circuit Ruggedness **for Motor Drive** **up to 20kHz**	**High speed V-Series** **for UPS, PV, Welding** **20kHz ~ 50kHz**
600V	**TO-247: 30A . 50A** **TO-246: 75A** **With Soft Recovery Diode**	**TO-247: 30A . 50A . 75A** **With Ultra Fast Diode** **Without Diode**
1200V	**TO-247: 15A . 25A . 40A** **With Soft Recovery Diode**	**TO-247: 15A . 25A . 40A** **With Ultra Fast Diode** **Without Diode**

FUJI ELECTRIC EUROPE
e-Front runners

Fuji Electric 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

Highly Efficient 3-Level Solutions for Renewable Energy Applications

Energy efficiency is one of the major criteria for photovoltaic (PV) and wind power inverters. The 3-level inverter topology proves to be one of the most attractive candidates for low and medium power, low voltage applications which require high switching frequencies, complex filtering and high efficiency. The same advantages can be seen for Uninterruptable Power Supplies (UPS) which are connected and loaded 24/7. A new line of single modules which contain a full phase leg for a 3-level converter covers a wide power range from 4kW to 120kW. These modules combined with the latest and especially adapted semiconductor chip technology simplify the design of compact and efficient 3-level inverters.

Marc Buschkühle, Infineon Technologies AG, Warstein, Germany

Today's PV-inverter- and UPS designs are searching for new solutions with highest efficiency. The continuous improvement of the power devices is one aspect. Another important item is to find special topologies for optimizing the overall efficiency.

The Neutral-Point-Clamped (NPC) topology leads to an enormous reduction of the switching losses, the size and respectively the costs of the filter by better spectral performance of the output voltage. The key for this gain is the ability to reduce the specific voltage class of implemented IGBTs. In contrast to 2-level inverters the IGBTs just need to block half of the DC-link voltage. A typical range of switching frequency is 15 to 20kHz.

Furthermore, from a legal viewpoint, this topology is uncritical. Contrary to several high performance topologies for PV inverters like the so-called HERIC- (Sunways) or H5-topology (SMA), the NPC-topology is not patented by any

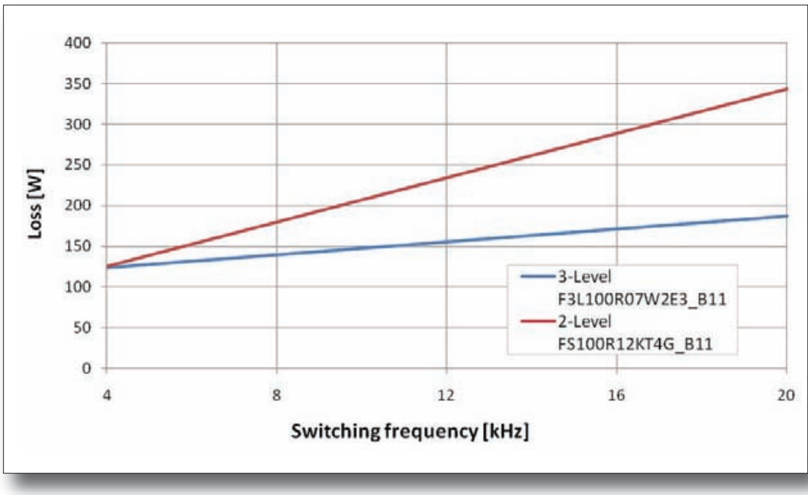


Figure1: Easy2B 3-level module shows up to 50% lower losses compared to 2-level solutions

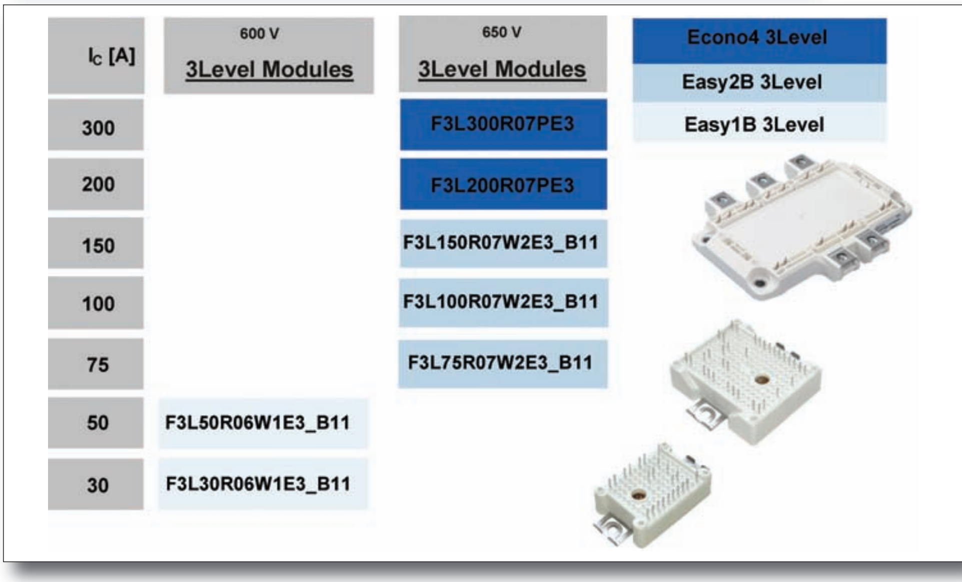


Figure 2: Infineon's 3-level portfolio 30A -300A

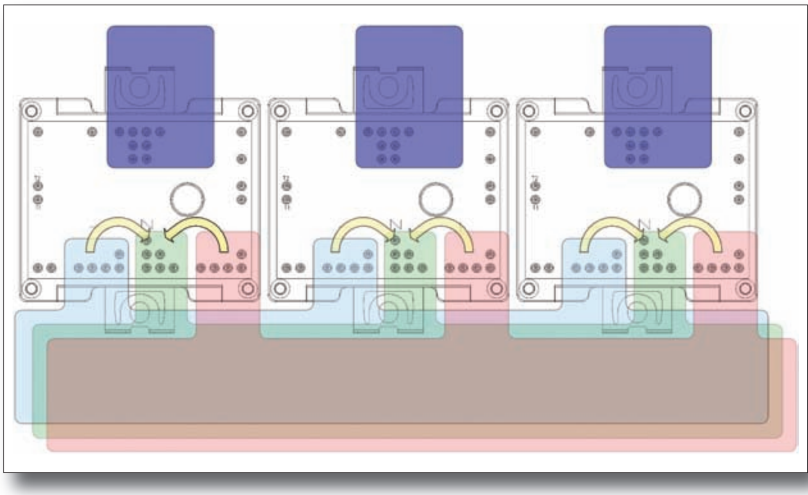


Figure 3: **Simple PCB inverter layout**

specific inverter supplier.

Figure1 shows the difference in losses between an EasyPACK 2B 3-level F3L100R07W2E3_B11 (100A/650V) and a standard 2-level solution in FS100R12KT4G_B11 (100A/1200V). The latest chip generations were compared.

The conventional 2-level solution only shows an advantage in losses at low switching frequencies where on state losses dominate and a single 1200V device has a lower on-state saturation voltage than two 650V devices in series. Above 4kHz switching frequency the lower switching losses of the three level solution overcome the higher on-state losses and a loss reduction of 50% is feasible at 15-20kHz. A big step in efficiency!

NPC-IGBT module scope

For the lower power range up to 40kW, the EasyPACK 1B and 2B package can integrate a complete 3-level phase leg at 50A and 150A respectively. This is facilitated by the grid based design of the package which enables pins to be placed in the optimum position relative to the DCB. For the medium power range the new EconoPACK™ 4 package is used for implementation of a phase module up to 300A. The wide portfolio from 30A up to 300A is shown in Figure 2.

All modules rely on the well-established reliable PressFIT technology which offers the possibility of simple and solder-less PCB mounting. Furthermore all the modules from 75A-300A use new enhanced IGBT and diode chips with an increased blocking voltage of 650V (50V extra compared to standard modules) without compromising conduction and switching losses.

Benchmark with EasyPACK 3-level

The requirement for low switching losses by using fast IGBTs, for example the IGBT3 650V silicon, means that low stray inductance is a critical design parameter especially as the trend is for increased DC-link voltages.

During the design phase of EasyPACK1B and EasyPACK 2B 3-level solutions this was

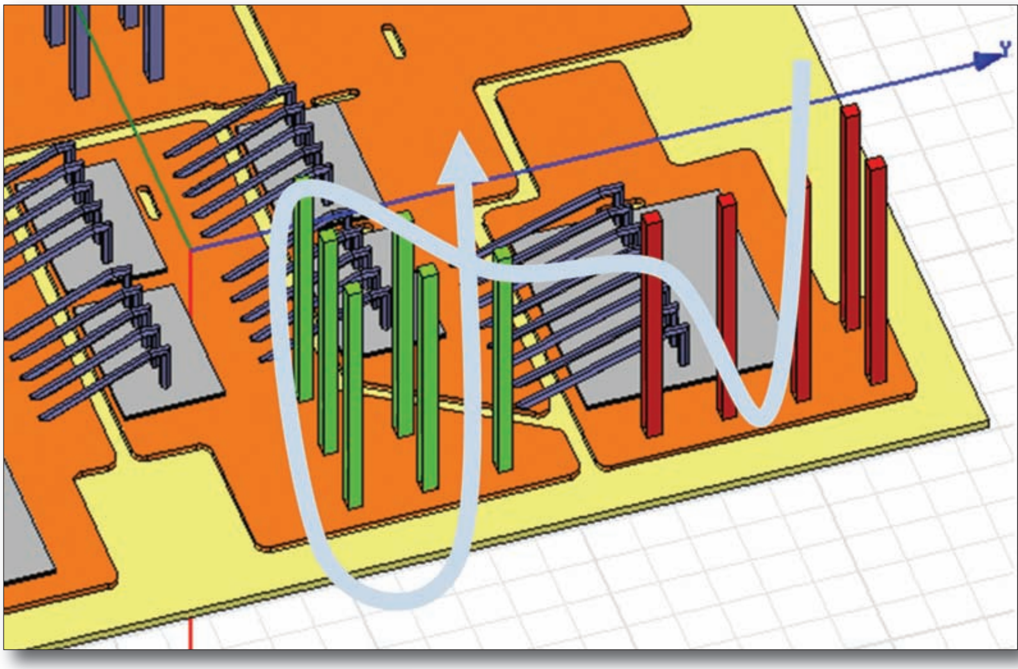


Figure 4: **Ultra-low inductive design of EasyPACK 3-level modules**

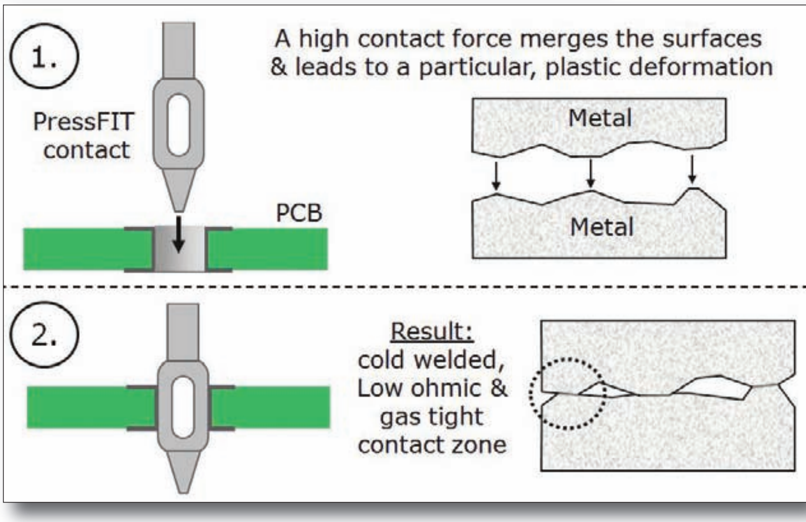
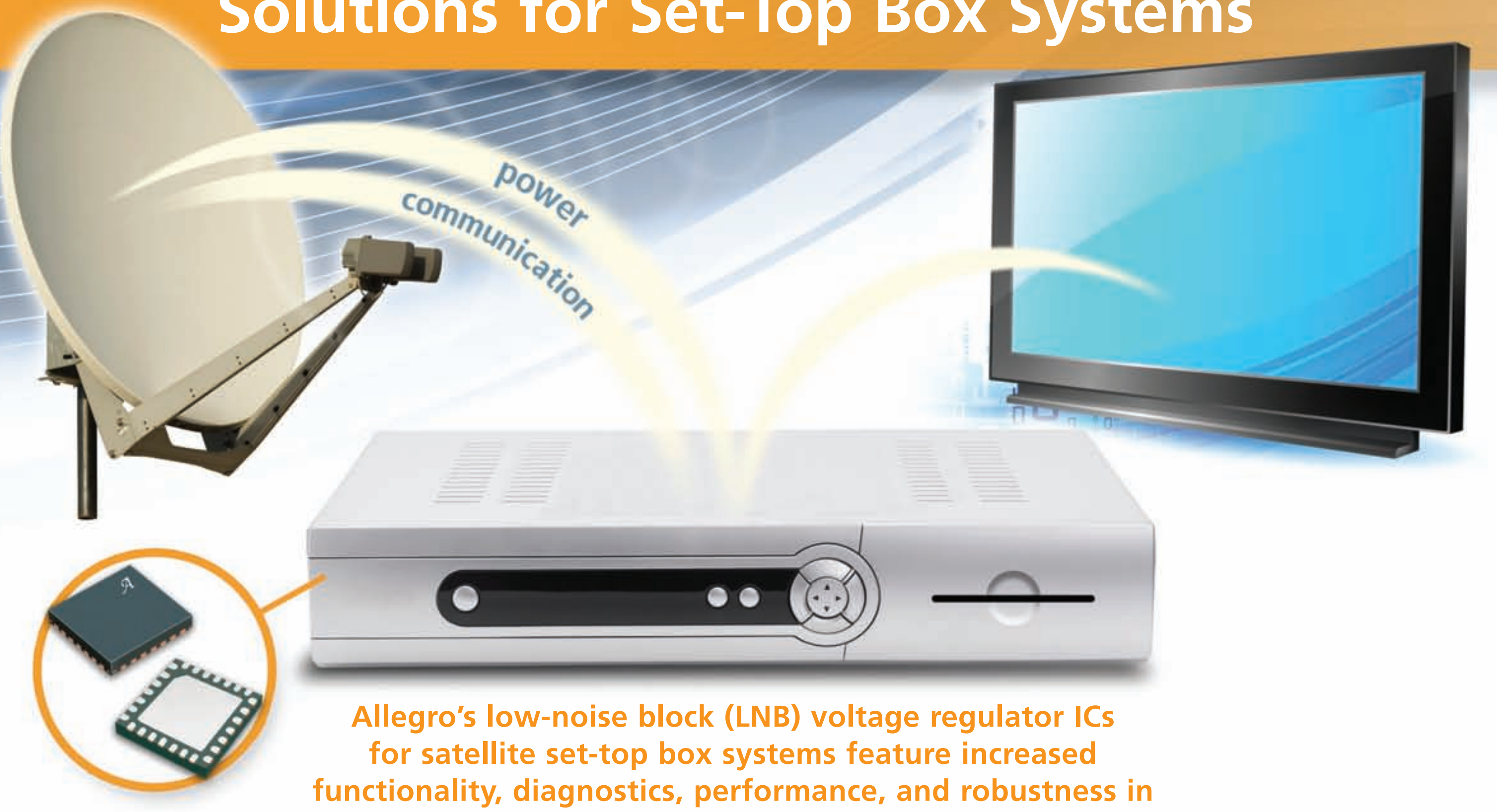


Figure 5: **Fast and simple mounting and highly reliable cold welded interconnections through PressFIT**

Allegro's World Class LNB Voltage Regulator Solutions for Set-Top Box Systems



Allegro's low-noise block (LNB) voltage regulator ICs for satellite set-top box systems feature increased functionality, diagnostics, performance, and robustness in the smallest available integrated solution. Single- and Dual-Output versions are available at varying output current capabilities.

Features

- Family of high efficiency boost/linear regulators to provide adjustable output voltage for LNB power
- Full DiSEqCTM communications compatibility, including 22 kHz tone generation and, in some models, tone detection
- Fully integrated converter switches and current sensing minimizes component count and increases reliability
- Comprehensive protection, including internal over-temperature, output short-circuit, and reverse current protection
- Static current limit circuit allows full current at startup and 13 V to 18 V output transition; reliably starts wide range of loads
- Source-sink output stage minimizes 13 V to 18 V and 18 V to 13 V output transition times even for highly capacitive loads, and allows for 22 kHz tone generation even with no load current

	Output Current	Package
A8290 Single LNB Output with integrated tone detection	900 mA current limit (typ)	5 x 5mm QFN
A8291 Single LNB Output with integrated tone detection	600 mA current limit (typ)	5 x 5mm QFN
A8286 Dual LNB Output with integrated tone detection	900 mA current limit (typ) per channel	5 x 5mm QFN
A8292 Dual LNB Output with integrated tone detection	600 mA current limit (typ) per channel	5 x 5mm QFN
A8293 Single LNB Output (Also **A8296** is coming soon)	600 mA current limit (typ) (**A8296** is adjustable 300-550 mA)	4 x 4mm TQFN (contact factory for **A8296** pkg)

Representative

MSM Ltd. Walton Business Centre, 44/46 Terrace Road, Walton-on-Thames, Surrey KT12 2SD
Tel: 01932 254902 Fax: 01932 254903 Email: msm@intonet.co.uk

Distributors

Avnet Memec UK. Aylesbury HP19 8TW Website: www.avnet-memec.eu
Solid State Supplies plc., Paddock Wood TN12 6BU Website: www.sssplc.com

Allegro® MicroSystems Europe Ltd.
High Performance Power and Hall-Effect Sensor ICs

www.allegromicro.com/promo897
115 Northeast Cutoff, Worcester, Massachusetts 01606 USA ■ 508.853.5000

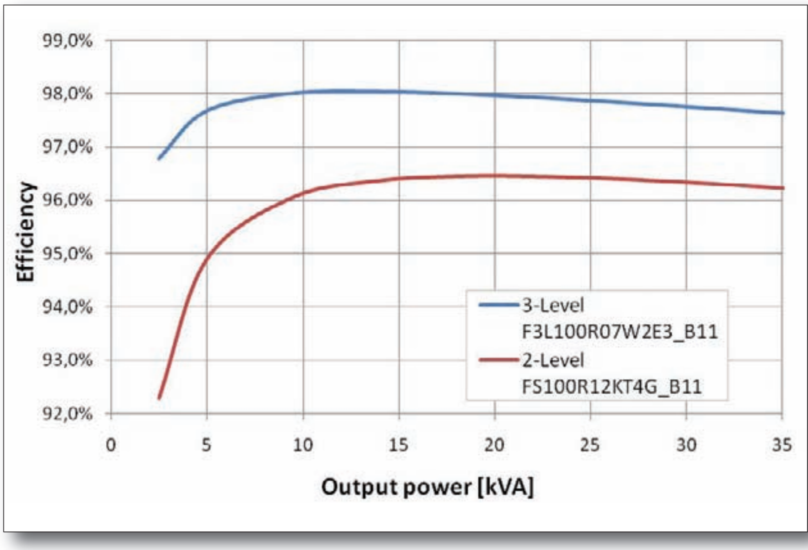


Figure 6: Increase in efficiency by using EasyPACK 3-level modules

carefully considered. The external connection of the DC-link is designed to be simple and compact. Figure 3 shows a possible example of the PCB layout. All DC connections are located in a single line next to each other. This greatly simplifies a low inductance PCB layout. The output connections are on the opposite side of the module again facilitating the PCB design process.

An external low inductance design is good, but the module itself also has to have a low internal inductance. With respect to stray inductance the internal structure of the EasyPACK 3-level modules is a benchmark with values as low as 10nH.

All commutation loops are designed to be symmetrical and reduced to a minimum. The most important commutation loop for 3-level applications is between one of the outer IGBTs and the clamping diodes. In Figure 4 can be seen even the bonding direction is optimized. Up to six pins are used in parallel to minimize stray inductance to the DC-link with the added benefit of reducing PCB heating.

Auxiliary emitter terminals are available to enable even faster switching. Last but not least an NTC is fitted to enable feedback of the DCB temperature.

For simple assembly and high quality PCB connections all modules offer the option of PressFIT contacts. This can reduce some of the constraints imposed by wave soldering, for example height and placement of components is faster and can reduce production costs when compared to traditional soldering methods. With this simple procedure of pressing in the pins into the PCB holes a cold welded connection is formed (see Figure 5).

This connection is gas-tight and low ohmic resistance that is highly insensitive to hazardous atmospheres. It is also robust against contact overlays, has a low fretting risk due to high contact forces and works stable also with low level signals.

Efficiency

As mentioned before by using the EasyPACK 3-level modules a loss reduction of 50% at 20kHz is possible. A data sheet comparison in Table1 shows the benefits in switching performance of the F3L100R07W2E3_B11 compared to the 2-level FS100R12KT4G_B11 module.

The second part of Table 1 and Figure 6 shows the big gap in loss and efficiency at standard operations. It can clearly be seen that the EasyPACK 3-level modules have essentially much lower switching losses. The efficiency can be improved easily over the whole output power range and achieves value higher than 98% in consideration of assumed copper losses.

Conclusions

The 3-level topology show several advantages especially for solar and UPS inverters. The most important benefit is a reduction of up to 40-60% in semiconductor losses. With this big drop inverter efficiencies higher than 98% are possible. By using Infineon's new 3-level IGBT family a big step in efficiency can be accomplished with the reduced design and assembly effort due to the module packaging and use of PressFIT technology. The module design with 650V IGBT3 silicon and very low stray inductances is optimized for fast switching at high DC-link voltages.

Data sheet comparison
@I_{Nom}, 25°C (150°C)

	2-Level FS100R12KT4G_B11	EasyPACK 3-Level F3L100R07W1E3_B11	Improvement with EasyPACK 3-Level
E_{on} [mJ]	4 (7,5)	0,55 (0,95)	627 %
E_{off} [mJ]	5,5 (9,50)	2,50 (3,50)	120 %
E_{rec} [mJ]	4,1 (8)	1,20 (2,40)	240 %
V_{CESat} [V]*	1,75 (2,1)	1.45 (1.70)	20 %

* 3-Level uses mostly two IGBTs in series connection

Calculation results per leg @10 kVA,fs 20kHz, U_{DC}800V

	FS100R12KT4G_B11	F3L100R07W1E3_B11
IGBT Switching losses	53 W	15W
IGBT on state losses	12 W	20W
Total losses (incl. Diodes)	92 W	48 W
System Efficiency	96,0%	98,0%

Table 1: Comparison 3-level to 2-level solutions

POWER ELECTRONICS EUROPE
To receive your own copy of
subscribe today at:
www.power-mag.com
POWER ELECTRONICS EUROPE

MORE OPTIONS FOR POWER ELECTRONICS

TYPE 947C POWER FILM CAPACITORS

85, 90 & 116 mm CASE SIZES

CAPACITANCE VALUES TO 1500 µF

APPLIED VOLTAGE TO 1300 Vdc

RIPPLE CURRENT RATINGS TO 100 A_{rms}

Next generation inverter designs for renewable energy applications demand reliable DC link capacitors with higher capacitance values, voltage, and current ratings. Now available in new case sizes, Cornell Dubilier's expanded range of Type 947C power film capacitors meet or exceed the requirements for bulk energy storage, ripple filtering and life expectancy for wind and solar power inverter designs, as well as electric vehicle applications. Select from hundreds of standard catalog listings, or connect with CDE engineers to develop special designs to your requirements.

For sample requests or more technical information, visit www.cde.com/pe

CAPACITOR SOLUTIONS FOR POWER ELECTRONICS

CDE CORNELL DUBILIER

Next Generation High Performance BIGT HiPak Modules

The practical realization of the Bimode Insulated Gate Transistor (BIGT) will provide a potential solution for future high voltage applications demanding compact systems with higher power levels. In this article, we give an outlook into the new technology and the basic performance levels which could be achieved as the BIGT progresses towards the product development stage, **Arnost Kopta, Munaf Rahimo and Raffael Schnell, ABB Switzerland Ltd. Semiconductors**

The BIGT is an advanced reverse conducting IGBT device concept which mainly targets an increase in the power density levels of high voltage IGBTs for next generation power electronics systems. The new device can operate in both freewheeling diode mode and (IGBT) transistor mode by utilizing the same available silicon volume in both modes. Therefore, the BIGT targets to fully replace the state-of-the-art two-chip IGBT/diode approach with a single BIGT chip. This is achieved while also being capable of improving on the overall performance especially under hard switching conditions with low losses, soft switching characteristics and high safe operating area (SOA).

The BIGT development has resulted in a clear breakthrough in device performance by adopting an advanced shorted collector backside layout design, optimum doping profiles and controlled lifetime reduction for enabling best possible operation in both IGBT- and diode mode. In this article, we present the latest electrical and reliability results achieved by demonstrating the 3.3kV BIGT in two HiPak module footprints up to Tj=150°C.

The BIGT concept

The BIGT consists of a hybrid structure integrating an IGBT and an RC-IGBT into a single chip as shown in Figure 1. The main target of this combination is to eliminate snap-back behavior at low temperatures in the BIGT transistor on-state mode by ensuring that hole injection occurs at low voltages and currents from the P+ collector region in the IGBT section of the BIGT. The BIGT concept provides an optimum solution especially for thin devices with punch-through type buffer designs where the snapback phenomenon is pronounced in standard RC-IGBTs.

The backside layout design and dimensioning of the IGBT region is optimized to provide smooth transition into full chip conduction as the RC-IGBT section will also provide holes at higher currents maximize the RC-IGBT area for diode conduction and minimize any current non-uniformities especially during switching due to the integrated structure. Furthermore, the introduction of the IGBT will enable the RC-IGBT part layout design to be independently optimized for maximizing the diode area and ensuring that the BIGT utilizes the whole chip during transistor conduction for providing the same technology curve as for a state-of-the-art IGBT chip. The BIGT concept has resulted in a better trade-off between the above mentioned parameters compared to the standard RC-IGBT design. On the other hand, to optimize the BIGT for low dynamic and switching losses, the main challenge was to enable low diode mode recovery losses while not having a considerable effect on the transistor mode on-state losses.

A three step approach is utilized to achieve this target. The first step is the fine control of the doping profiles of the emitter P-well cells and collector P+/N+ regions. As shown in Figure 1, the Enhanced-Planar (EP) cell technology does not include any highly doped P+ well regions and also exhibits a compensation effect due to the N-enhancement layer. These two features provide the BIGT with a fine pattern P-well profile for obtaining low injection efficiency for a better diode performance while maintaining the typical low IGBT losses associated with EP designs. The second optimization step employs a Local P-well Lifetime (LpL) control technique (see Figure 1 top) utilizing a well-defined

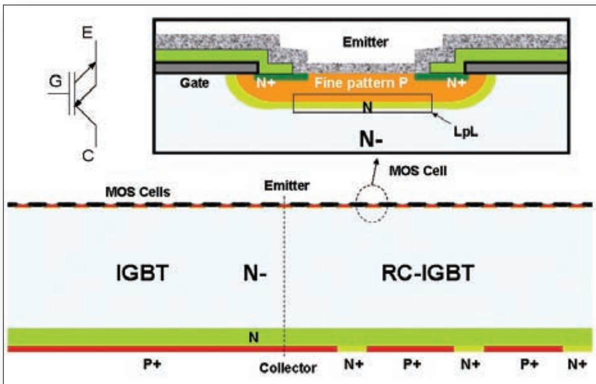


Figure 1: BIGT cross-section

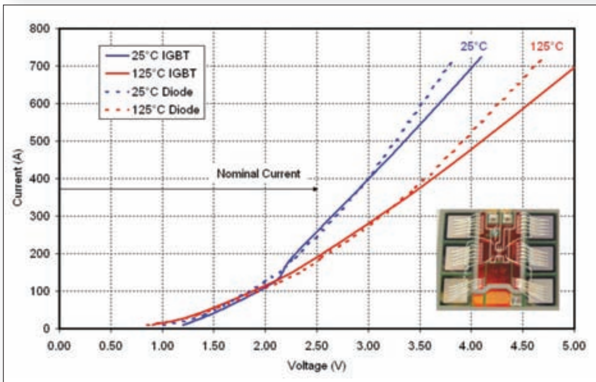


Figure 2: On-state characteristics of the 3.3kV BIGT substrate

particle implantation which further reduces the diode recovery without degrading the transistor losses and blocking characteristics. A further reduction in the reverse recovery losses is achieved with a uniform local lifetime control employing proton irradiation.

Characteristics of the 3.3kV BIGT

The BIGT technology has mainly been developed for high voltage devices. The work presented here was carried out on a 3300V/62.5A BIGT chip with an active area of approximately 1cm^2. High current 3.3kV HiPak1 (140 x 130mm) and HiPak2 (140 x 190mm) BIGT modules were fabricated and tested under conditions similar to those applied to state-of-the-art IGBT modules.

The BIGT advantage is demonstrated since the HiPak1 module containing 4 BIGT substrates for a total of 24 BIGT chips can practically replace the larger 1500A HiPak2 SPT$^+$ IGBT module which normally contains 6 substrates having a total of 24 IGBTs and 12 diodes. The larger standard IGBT module has the further disadvantage of employing much less diode area which is normally a limiting factor in rectifier mode of operation and for the surge current capability. On the other hand, the larger HiPak2 BIGT module employs a total of 36 BIGT chips and its rating can potentially exceed 2000A.

Electrical characterization of the 3.3kV BIGT HiPak modules was carried out and is presented below, including static and dynamic measurements under nominal and SOA conditions. For the dynamic measurements at nominal conditions the DC-link voltage was set to 1800 V, while for SOA characterization it was increased to 2400 V. The R_{Gon} and R_{Goff} values were fixed for all dynamic tests at 1.0Ω and 1.5Ω respectively. Also, a 220nF gate-emitter

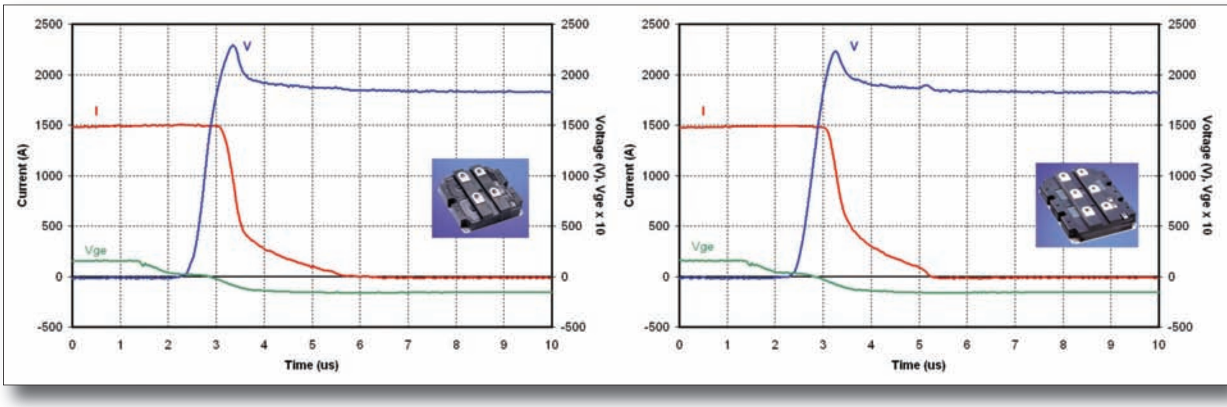
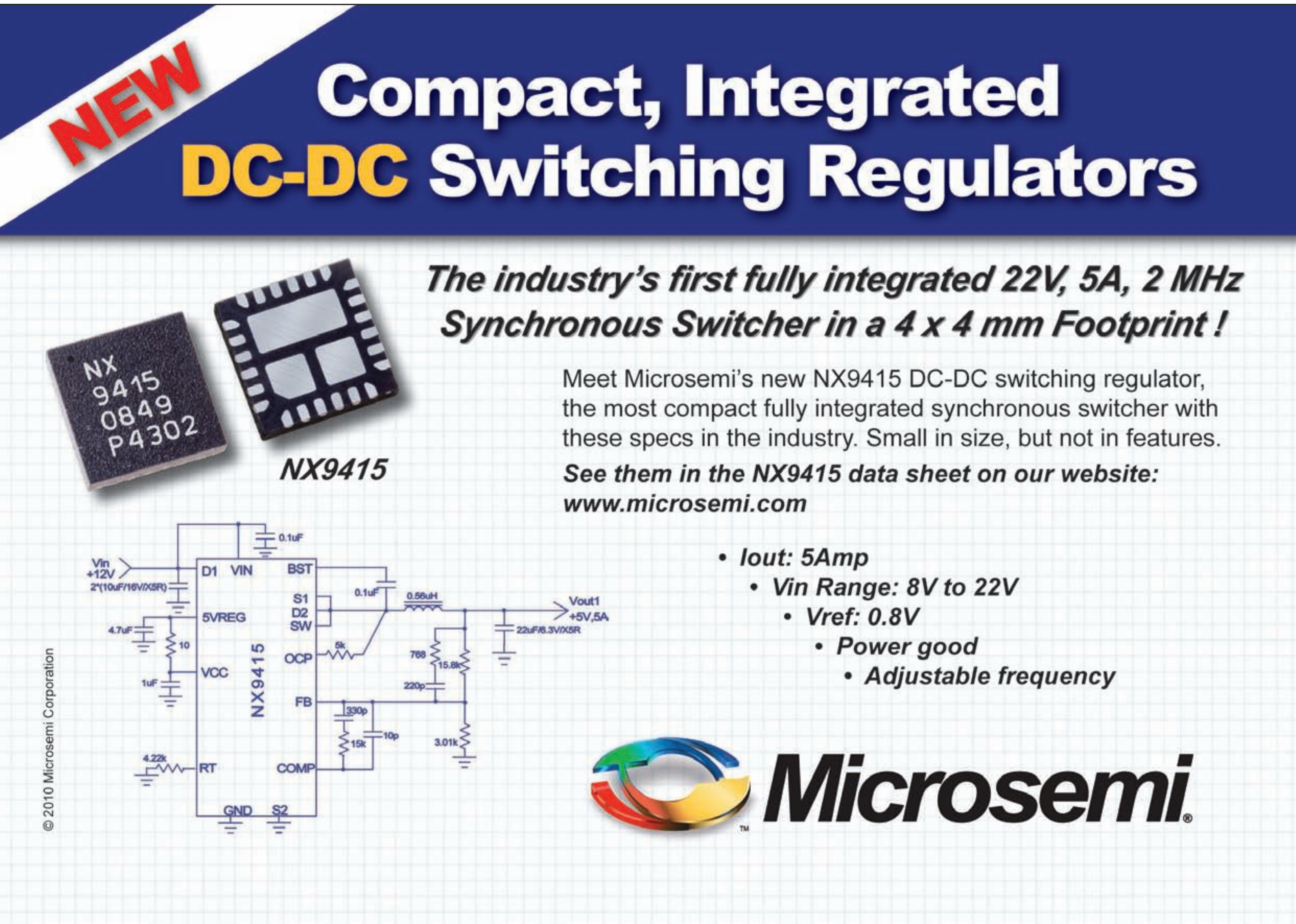


Figure 3: **3.3kV BIGT HiPak1 (left: E_{off} =2.8J) and SPT+ IGBT HiPak2 (right: E_{off} =2.7J) turn-off nominal waveforms**



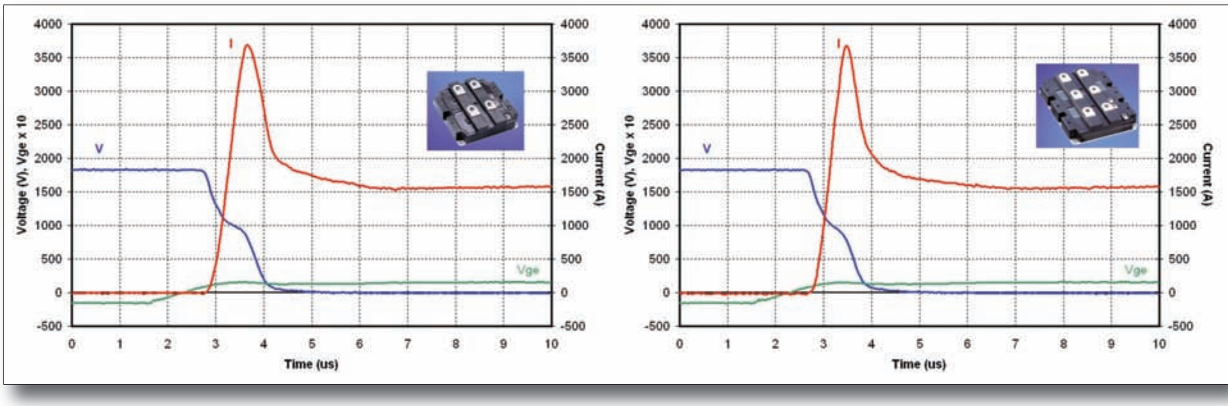


Figure 4: 3.3kV BIGT HiPak1 (left: E_{on} =2.2J/ E_{rec} =2.3J) and SPT$^+$ IGBT HiPak2 (right: E_{on} =1.9J E_{rec} =2.2J) turn-on nominal waveforms

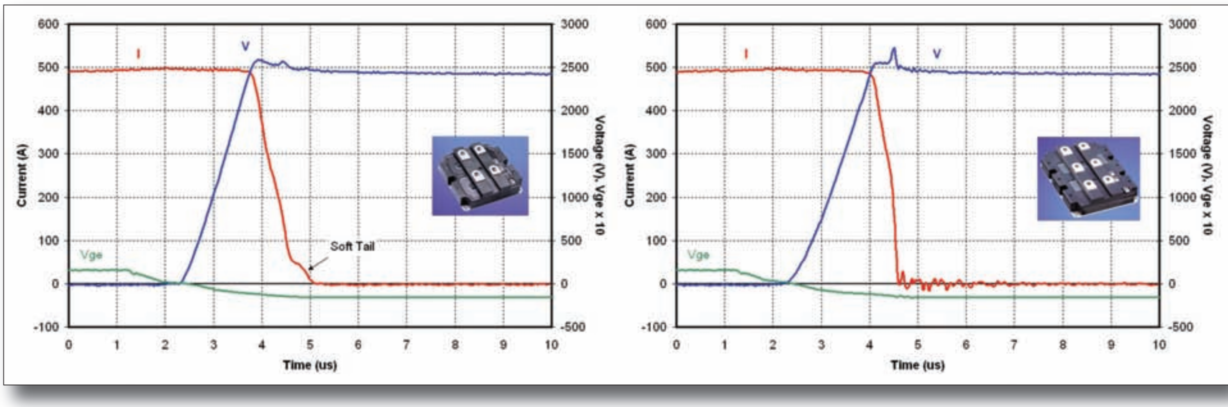


Figure 5: 3.3kV BIGT HiPak1 (left) and SPT$^+$ IGBT HiPak2 (right) turn-off softness

capacitance C_{ge} was employed.

The on-state characteristics of the BIGT in IGBT and diode modes are shown in Figure 2 at 25°C and 125°C. The results were obtained from the HiPak substrate test with a nominal current of 375A. For both IGBT and diode modes, an on-state of 3.5V at 125°C is shown at the nominal current. For safe paralleling of chips, the curves show a strong positive temperature coefficient even at very low currents in both modes of operation due to the optimum emitter injection efficiency and lifetime control employed in the BIGT structure.

Figures 3 and 4 show the 3.3kV HiPak1 BIGT and HiPak2 SPT$^+$ IGBT turn-off and turn-on waveforms respectively measured under nominal conditions (V_{DC}=1800 V, I_C=1500 A, T_j=125°C). The respective module switching losses are also indicated. The waveforms demonstrate the normal BIGT switching behavior in both IGBT and diode modes when compared to a state-of-the-art device. A similar comparison is shown for the nominal reverse recovery performance as shown in Figure 5. The di/dt during switching exceeds 6kA/µs for all tests.

Softness performance

The new BIGT technology has inherently extremely soft switching behavior in both IGBT and diode mode of operation. The optimized collector P+ doping profiles will ensure that during the turn-off tail in both modes, the passing electrons towards the N+ regions will induce a large potential across the PN junction forcing a controlled level of Charge Extraction (or hole injection) into the base.

Figure 5 demonstrates this softness during turn-off for both the BIGT HiPak1 and the SPT$^+$ IGBT HiPak2 modules at 500A and V_{DC}=2400V and T_j=125°C. The reverse recovery softness performance of the BIGT is also demonstrated in Figure 6 at a very low current of 50A and V_{DC}=2400V and T_j=125°C.

This feature is of particular importance for the realization of the BIGT technology since it overcomes the expected trend of reduced softness due to the non-

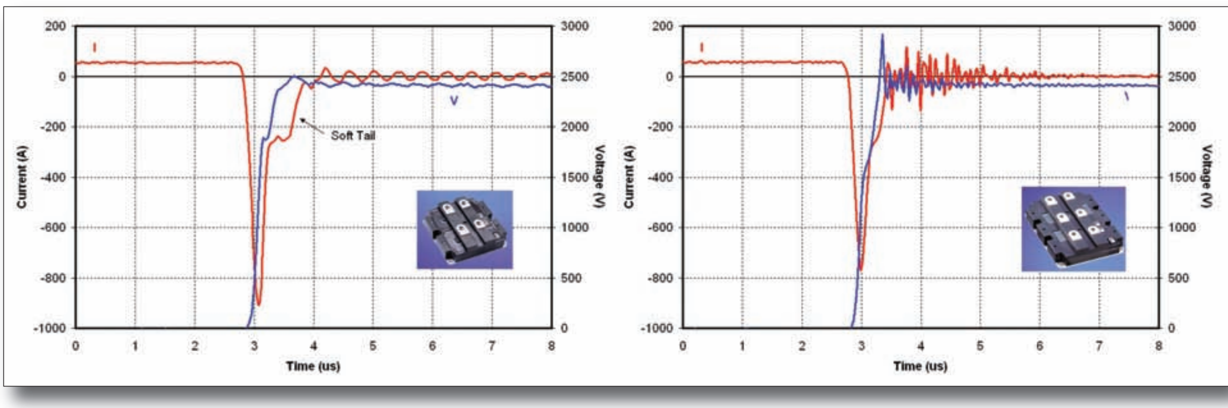


Figure 6: 3.3kV BIGT HiPak1 (Left) and SPT$^+$ IGBT HiPak2 (Right) reverse recovery softness

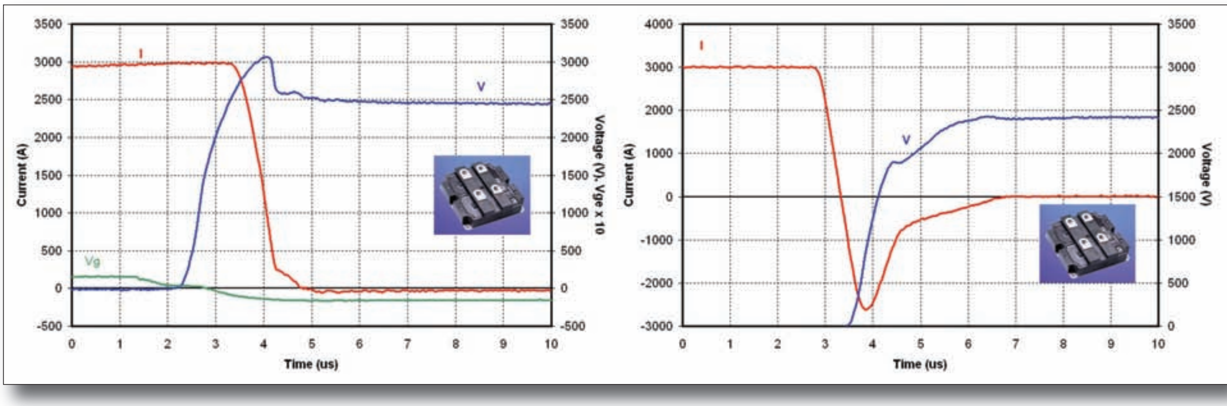


Figure 7: 3.3kV BIGT HiPak1 turn-off (left) and reverse recovery (right) SOA at 150°C (peak power = 7.9MW and 3.5MW respectively)

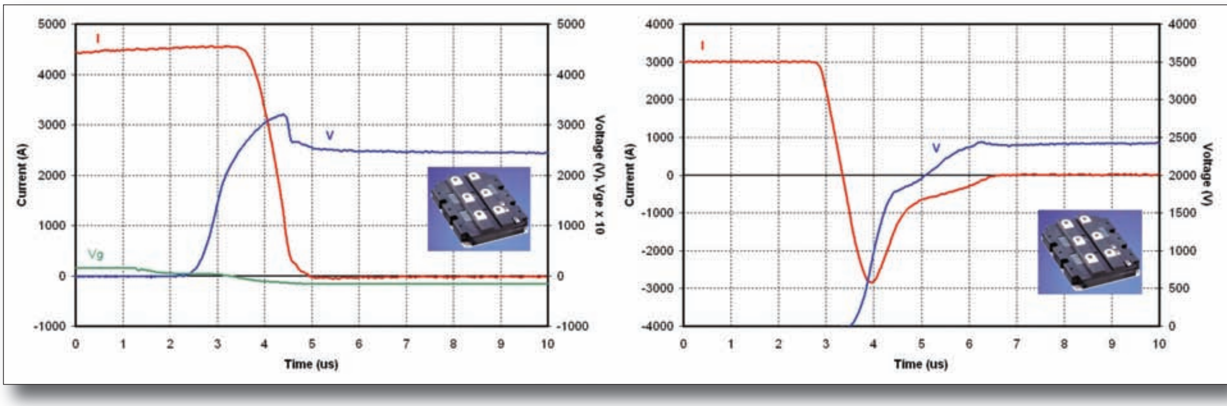


Figure 8: 3.3kV BIGT HiPak2 turn-off (left) and reverse recovery (right) SOA at 150°C (peak power = 12MW and 4.2MW respectively)

optimum silicon design of the BIGT for diode mode operation and the increase diode area provided with the new concept.

SOA performance

The SOA switching performance will be presented here at T_j=150°C to demonstrate the robustness of the BIGT modules. Figure 7 shows the turn-off waveforms at 3000A and V_{DC}= 2400V in both IGBT and diode modes.

Similar SOA tests were carried out for the larger HiPak 2 module at 4500A, V_{DC}= 2400V and 150°C as shown in Figure 8. The BIGT also shows rugged short circuit performance with an average short circuit current of 6500A when measured under these conditions.

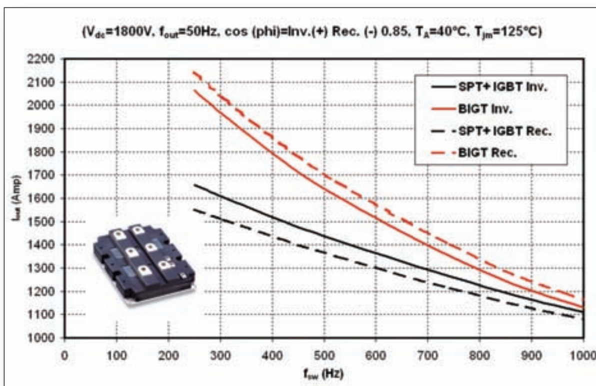
Frequency operation and reliability testing

3.3kV HiPak1 BIGT modules were subjected for the first time to a PWM frequency test in an H-bridge configuration. The test was carried out at a maximum junction temperature of 120°C for approximately 30 minutes at three operational frequencies (500Hz, 1000Hz and 1500Hz). At a DC link voltage of 2.1kV, peak currents up to 800A were achieved during the tests. The frequency test results provide a first insight into the feasibility of a single chip operating in both IGBT and freewheeling diode modes under hard-switching conditions.

Reliability measurements were also carried out on BIGT chips. The BIGTs successfully passed the standard verification High Temperature Reverse Bias (HTRB) stress test at 2640V both at 125°C for 168 hours followed by a second run for the same chips at 150°C for a further 168 hours. In addition, the BIGT successfully passed the High Temperature Gate Bias (HTGB) test at V_{ge} = 25V at 150°C for 168 hours and a humidity (HAST) test at 125°C, V_{ge} = 25V, and V_{ce} = 80V with 85% humidity for 168 hours.

Figure 9 shows the expected output current performance for the BIGT HiPak2 module compared to today`s SPT$^+$ IGBT equivalent module at 125°C in both Inverter and Rectifier modes. It was assumed that an optimized chip/package layout design and loss trade-offs were employed in a fully developed BIGT module. The curves show that the diode performance is a limiting factor for the standard module approach while for the BIGT module the transistor mode defines the limit. The curves show that with BIGT technology a 25% and 38% increase in inverter and rectifier output current capability is achieved respectively. Furthermore, the BIGT technology will pave the way for future generations of IGBT based designs to provide higher power densities without any limitations imposed by the diode performance.

Figure 9: Output power capability of the 3.3kV SPT+ IGBT against the BIGT Hipak2 modules in both inverter and rectifier modes



Integrated Gate Driver Circuit Solutions

Power electronics systems are commonly used in motor drive, power supply and power conversion applications. They cover a wide output power spectrum: from several hundred watts in small drives up to megawatts in wind-power installations or large drive systems. Inside the system the gate driver circuit with its extensive control and monitoring functions forms the interface between the microcontroller and the power switches (IGBT). This article provides an overview of different gate driver topologies for different power ranges and shows examples for monolithic integration of the driver functionality. **R. Herzer, J. Lehmann, M. Rossberg, B. Vogler, SEMIKRON Elektronik, Nuremberg, Germany**

Today's power conversion architectures are based on pulse width modulation (PWM) to control the power, the frequency and the voltage supplied from the mains to a given or unknown, fixed or variable load [1]. Switches, controlled by a driver, repeatedly connect the load either to a supply voltage or to ground. Depending on the switching pattern, many implementations of the basic principle are employed. For instance, current continuity can be ensured either by turning the switches on and off interchangeably or by switching only one of them and using the free-wheeling diode of the other. Generally, it will be possible to alter the shape of the current waveform passing through a load by varying the PWM high/low ratio [2].

Basic gate driver functionality

In power conversion systems using IGBTs (or MOSFETs) as semiconductor switches, the topology shown in Figure 1 is often adopted for each half bridge. The appropriate PWM patterns for the switches are generated by a microcontroller. The gate driver circuit with its extensive control and monitoring functions forms the interface between the microcontroller and the switches. The driver can be divided into a primary and a secondary side. The main functions of the primary side unit are shown in Figure 1.

A potential separation (insulation) between both sides is necessary because the primary side is normally related to the logic level and the secondary side to the emitter potential of the power device. Any control signals, and power supply to the secondary side gate driver circuits of both the high side and low side have to be transferred via this electrical insulation. Today there are many cases in which information (status or sensor information etc.) are also sent back via the insulation.

The secondary side gate driver circuit is mainly responsible for the optimal control of the active switches. The driver should utilise the potentials of the device in terms of current and voltage capability, losses and temperature. Furthermore sensor and monitoring functions are implemented to handle critical operation modes and to keep the device within the specified safe operating area (SOA). If a critical mode is detected by the gate driver or the additional sensor monitoring circuits, the driver circuit normally reacts independently of the supervising system (MC). To establish a 3-phase motor control, three branches on similar lines to those depicted in Figure 1 are needed. Additionally, a seventh switch is often employed to perform power factor correction. This low side switch could also be used as a brake chopper.

Gate driver topologies and insulation principles

In the range of 600V to 1700V (6,5kV) IGBT switches are commonly used in motor drives, power supplies and other power conversion applications. They cover a wide output power range from several hundred watts in small drives up to megawatts in wind power installations or large drive systems. The topology of the power system and the voltage and power range of the specific application are what determine the choice of the potential separation (insulation) between primary

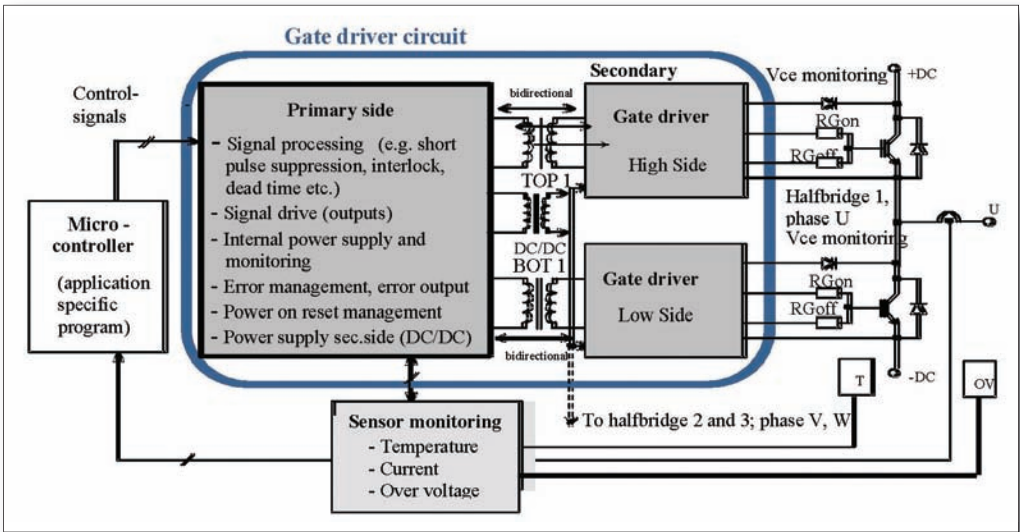


Figure 1: Basic topology of a power electronic system

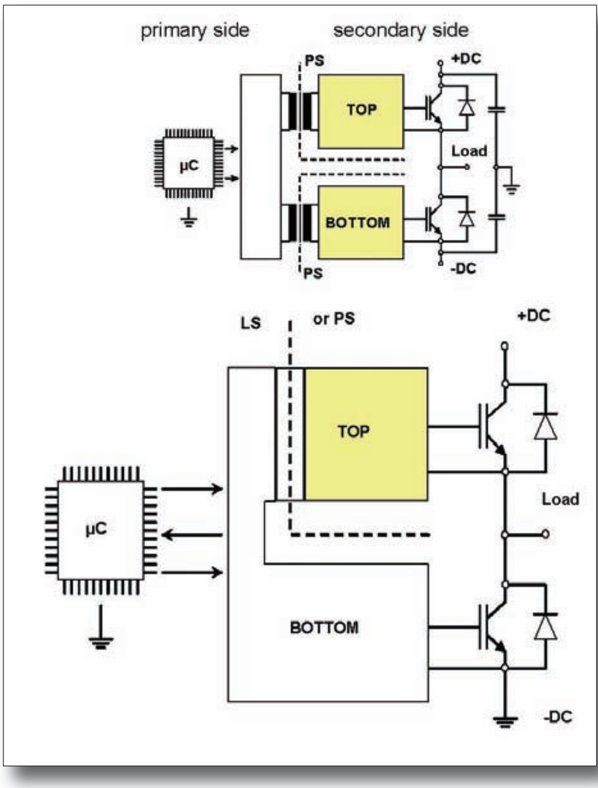


Figure 2: Example of symmetric (a) and asymmetric (b) grounded DC link and different potential separation (PS)

and secondary side. On the other hand, the form of potential separation selected has a significant influence on the driver circuitry, the reliability, noise immunity and the costs of the driver.

In a symmetrically grounded DC link circuit (Figure 2a) for medium and high power applications, external devices such as optocouplers, transformers or fibre optics are used for the galvanic insulation and the signal transfer. For an asymmetrically grounded DC link (Figure 2b) and low power applications, it is in principle possible to realise the potential separation only for the high side switch (TOP). The easiest way is an integrated level-shifter (LS, no galvanic insulation). In this case the microcontroller, the primary side, the emitter and secondary side gate driver of the low side switch (BOT) have to be on the same ground potential. Table 1 summarises the different techniques for insulation, signal and energy transmission in dependence on the application range.

IGBT gate driver solutions and ICs for high power applications

For some time now, effective system integration solutions have existed in the low power sector, [e.g.3-6]. In this mass-market environment, it is the ever-present need to cut costs which acts as the main impetus towards monolithic integration. State-of-the-art designs in the high power range, however, rely much less on dedicated ICs, because production quantities are smaller and the variety of product customisations, even for a relatively small number of units, is wider. Yet it is the conceptual difference between low power and high power designs which is actually most important. Only ICs specially developed under high power criteria [7 - 9] can adequately replace existing discrete solutions. But such ICs are necessary to reduce the number of discrete components at increasing functionality and lead to higher reliability, smaller volume and lower costs.

Primary and secondary side IGBT driver ICs for pulse transformer

A system structure particularly suited for coping with high currents has already been shown in Figure 1. The concept is centered on physical potential separation by pulse transformer (signals) and DC/DC converter (power supply) to divide the gate driver into one primary (per system) and one secondary side IC (per switch).

The SIXPACK configuration suggests that it is straightforward to merge all control functionality into a single IC. A six-channel primary side controller has thus been designed following the principle depicted in Figure 3.

Three TOP and three BOTTOM input signals come from the microcontroller. All incoming signals are synchronised with the clock generated on-chip. They are subjected to short pulse suppression and checked for potentially hazardous patterns. An interlock time digitally adjustable by the user is inserted between TOP and BOTTOM signals of each channel (TD1, TD2). Alternatively, a freely overlapping operation can be programmed (SELECT). The three main digital cores perform most of the functional signal processing. Several different modes of operation can be selected. A dedicated high power configuration is activated by the GBSYNC signal, allowing all three channels to be operated synchronously. By this means, IGBT half-bridges are driven with minimal mutual delay, whether they are connected in parallel for high output currents or in series for high voltage operation. The result is enhanced reliability and performance.

The logic signals to be transmitted to pulse transformers pass through level shifters and are then amplified by CMOS output driver stages.

Fault events such as supply voltage monitoring being triggered, or error flags being fed into the IC, are stored in an error memory. Errors specific to each half-bridge (e.g. short circuit) are preprocessed in the relevant main core. Depending on the error type, a characteristic pattern is generated by the error-coding unit.

A chip photograph of an IC realised in 1µm CMOS technology is shown in Figure 4. In the internal design, great emphasis has been placed on fault-insensitive, rugged design. As a part of the complex power-on-reset management, signal paths are safely blocked with supply-independent structures. Six 1A drivers serve to transfer the output patterns onto pulse transformers. Additional DC/DC control circuitry and output stages (2x 1A) are present for the secondary side power supply.

On the secondary side, single gate driver ICs are utilised. The functional block diagram of the IC selected is given in Figure 5. Any incoming signal is recognised

Driver type	Insulation	Signal transmission	Energy transmission	Application
Driver IC (Single, Halfbridge, Sixpack etc.)	no galvanic insulation	Level shifter (mainly for high side)	Bootstrap-circuit (for high side)	low power < 5kW
Hybrid driver (Single, Halfbridge, Sixpack etc.)	galvanic insulation	Opto-coupler Pulse transformer Fibre optic	DC/DC converter	medium power (5 …100 kW) high power (> 100kW)

Table 1: Gate driver topologies, insulation and transmission principles depending on the power range

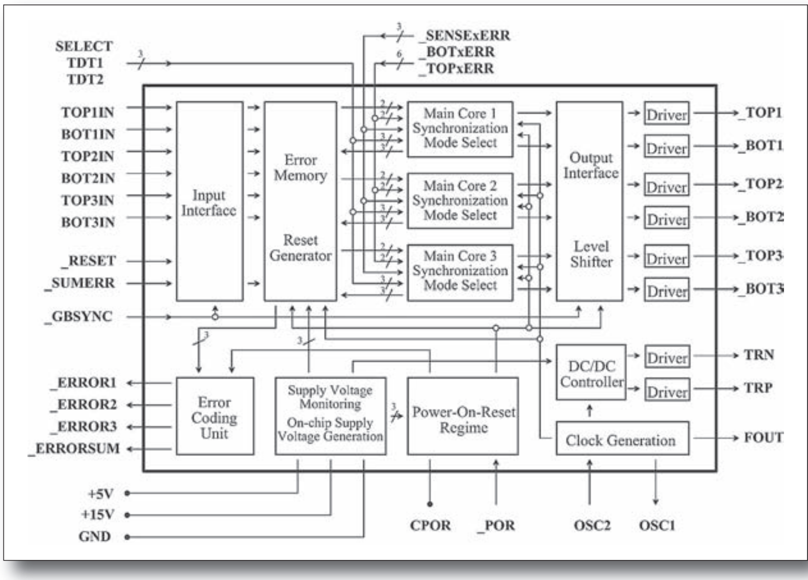


Figure 3: **Primary side IC block diagram [10]**

by the input interface. Depending on the system configuration, the signal patterns will be differently transformed for internal use. They are then fed into the central logic and error-processing unit. Finally, level shifters send them to the main output drivers, which deliver up to 3A of peak current to the IGBT gate. Thus, the IC is able directly to control IGBT modules up to 300A. If higher system power is required, external post amplifiers can be applied.

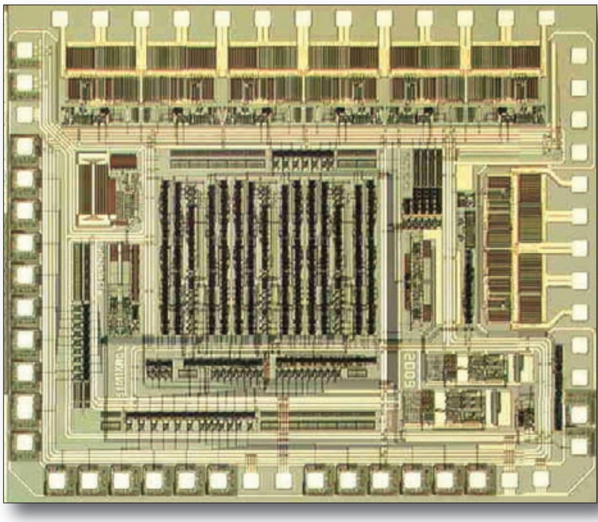


Figure 4: **Chip photograph, primary side controller (approx. 5.2mm x 4.3mm)**

It was essential to design the input interface for high flexibility. Fig. 6 illustrates typical operating conditions at the input. Signal patterns transferred from the primary side are either optically coupled square waves with the IGBT turn-off voltage (DC-) as reference, or characteristic pulse transformer waveforms.

While the normal input IN recognises square waves, a pulse edge storage block (PES) connected to IN sets up the chip for pulse transformer environments. In this configuration, pulses are reliably latched by a feedback loop, ensuring high back swing immunity. There is an additional complication possible which will make it feasible to drive negative turn-off voltages at the output. For optimised turn-off losses and noise immunity, it is desirable to draw the IGBT gate potential below common ground. Internally, however, all circuits have to refer to the lowest potential on-chip. The required level shifting also takes place inside the input interface. As far as the negative turn-off voltage is concerned, system designers can choose freely between 0V and -8V.

The central logic is responsible for filtering out all signal patterns that could jeopardise the power semiconductor switches. External and internal voltages are monitored to identify threatening conditions. If the driver supply voltage were not monitored, the IGBTs might be switched on with too low gate voltage, thus leading to excessive power dissipation in the system. Likewise, any failure of the on-chip 5V supply requires to be handled to keep the system controllable.

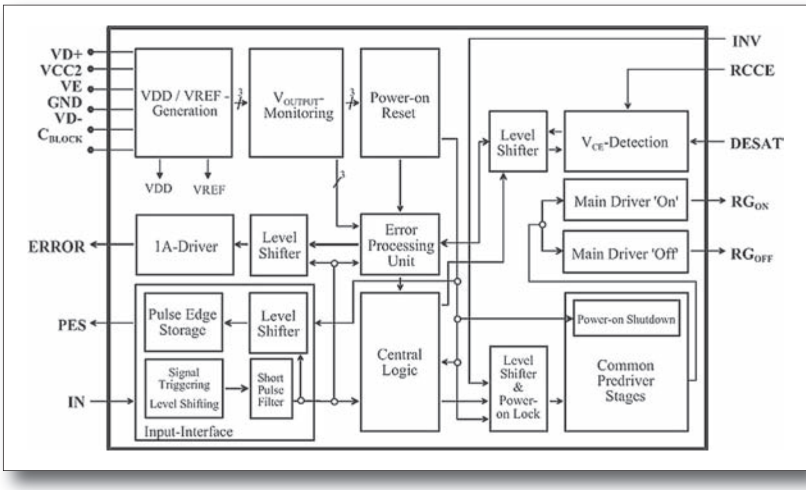


Figure 5: **Secondary side IC block diagram [11]**

The most common external fault situation is IGBT current overloading. In this case, desaturation and strongly increased current will lead to a high V_{CE} voltage drop across the switch. Dynamic V_{CE} detection therefore monitors the IGBT on-state voltage with a customisable inhibit time and V_{CE} threshold.

If an error is detected, the central logic stores the error code and turns off the IGBT. An error signal is then transferred back to the primary side where the control IC reacts, either generating a secondary side reset or turning off the system globally.

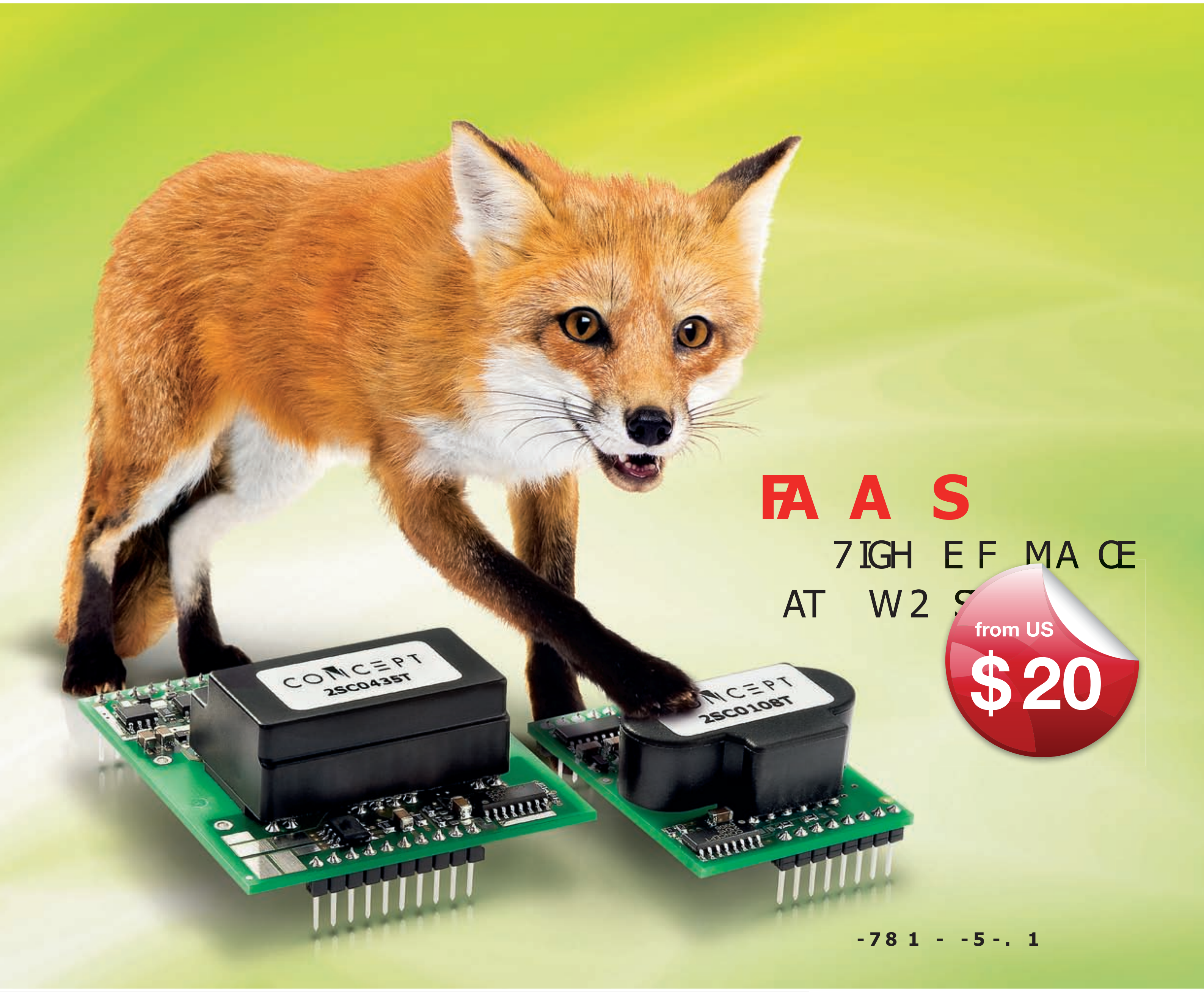
Errors are treated differently at power-on of the IC. On ramping-up of the external supply voltages, a power-on-reset regime controls the chip initially. Redundant mechanisms prevent unintended switching on of the drivers. No errors are reported to the primary side during power-on-reset.

Combining the concept of value-independent level shifting with internal supply and reference voltage generation allowed the IC to be realised with cost-effective 1μm, 12 mask, double metal, HV-CMOS technology. Figure 7 shows a chip photograph of the manufactured IC. The high voltage transistors' area consumption and SOA require thorough optimisation of the large 3A on-chip output driver stages. The IC has to be able to drive the gates continuously and long-term at up to 100kHz. The theoretical maximum frequency was determined using 15V output swing and a load of 4.75Ω in series with 33nF capacitance. If power dissipation issues are disregarded, the peak current is not internally limited by driver delay until >180kHz.

IGBT driver ICs with digital core

In order to get a higher functionality and flexibility of IGBT driver for different

CONCEPT
INTELLIGENT POWER ELECTRONICS



- 1 IP ILM0 EA I AL

HE TW EW C ES , A D A E E DEFI I G THE STA DA D F - 861 D IVE S HA S T C SISTE T I TEG ATI A SE SATI AL P ICE PE F MA CE ATI HAS BEE ACHIEVED 5 AS LITTLE AS **AL A NE AF** F ITEMS D IVE S A E AVAILABLE THAT FFE T L ELIABLE SEPA ATI A D > C MPLIA T DESIG BUT ALS THE P ECISE TIMI G THAT IS CHA ACTE ISTIC F THE 20 4 (D IVE FAMIL PICAL APPLICATI S A E WI D P WE A D S LA I STALLATI S I DUST IAL D IVES AS WELL AS P WE SUPPL E UIPME T FAIL I DS

2A M AL

AFE IS LATI T 842 , ,,
. 0)+0 GATE D IVE CU E T
((UTPUT P WE
\+ GATE V LTAGE
>P T 7 SWITCHI G FE UE C
. S DELA TIME
. S ITTE
8 TEG ATED 32 32 C VE TE
WE SUPPL M IT I G
H T CI CUIT P TECTI
4MBEDDED PA ALLELI G CAPABILIT
UPE I 4 2 DV DT/ -+ S

IH A M A DHIFICEA - 3 AHBA LM LLA 4 . EAF PENRA F H 8DIHA ! + +

PPP$53. 0 EA $IG

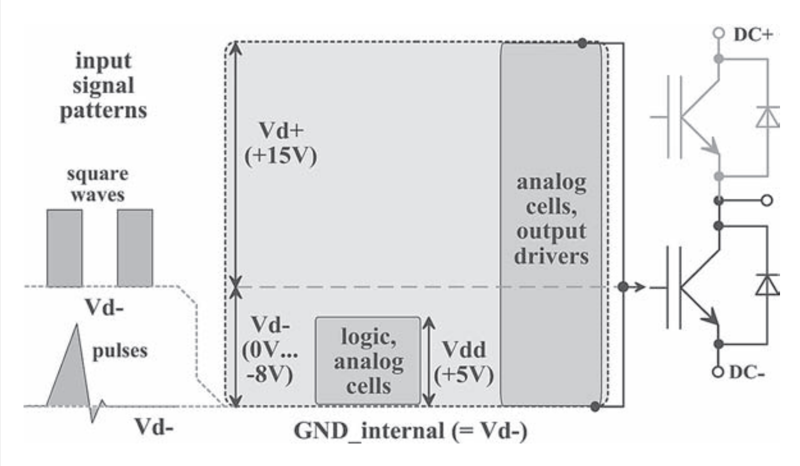


Figure 6: **Typical waveforms and potentials at the interfaces**

applications and/or to achieve sophisticated and repetitive signal transmission for all signals, including sensing signals, a fully digital driver is the most favourable and universal solution in the high power range [12]. Figure 8 shows the block diagram of such a new and innovative concept with the main features of the primary and secondary side control IC.

The principle block structure is similar to Figure 1 but the functionality of the primary and secondary side control IC is much higher and more flexible (programmable). The insulation and signal transmission between both sides is realised in both directions by modems. The digital-based signal transmission uses pulses with a defined length and shape generated by an internal digital logic. The pulses are almost independent of component parameters and are, in additional, evaluated differentially. Transmission reliability is achieved with high transformer currents and the far lower terminating impedance of the receiver. As a result of this and also of the relative independence from component parameters (modem), a high supply voltage for pulse generation is no longer necessary (3.3V is used).

On the primary side a bidirectional data transfer with the microcontroller is implemented (3.3V or 5V interface). Input signals from µC are monitored for critical frequencies. Short pulse suppression, interlock and dead time etc. are user configurable. Further features are listed in Figure 8. On the secondary side, the transferred signal is received by a differential windows comparator and transmitted to the digital logic for the secondary-side encoding and signal processing. By modulating the repetitively transmitted pulses, communication forth and back between the primary and secondary side can be achieved. Differentiated status or error signals, data and furthermore sensor signals (e.g. temperature of IGBT module) can be transmitted continuously.

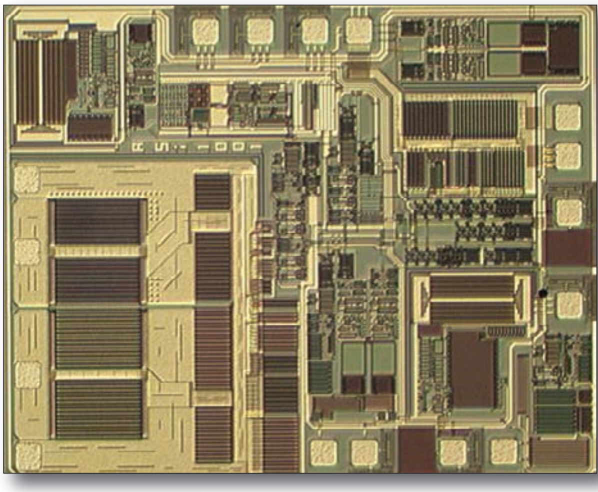


Figure 7: **Chip photograph, secondary side IC (approx. 3.2mm x 2.6mm)**

Powerful 15V output stages are implemented to drive the gates of external post amplifiers (two MOSFET in a push-pull output configuration) separately, to avoid cross currents during switching. The output stage has two outputs for easy asymmetric gate control. This allows for the gate resistor to be split into two resistors for turn-on and turn-off, respectively. The main advantage, however, is that this solution allows for separate optimisation of turn-on and turn-off with regard to turn-on over-current, turn-off over-voltage spikes and short-circuit behaviour. Additionally, the digital logic core can be used to drive and control two output stages with different paralleled gate resistors. This allows for time dependency to be defined for effective gate resistor switching of the IGBT and, thus, for the IGBT switching

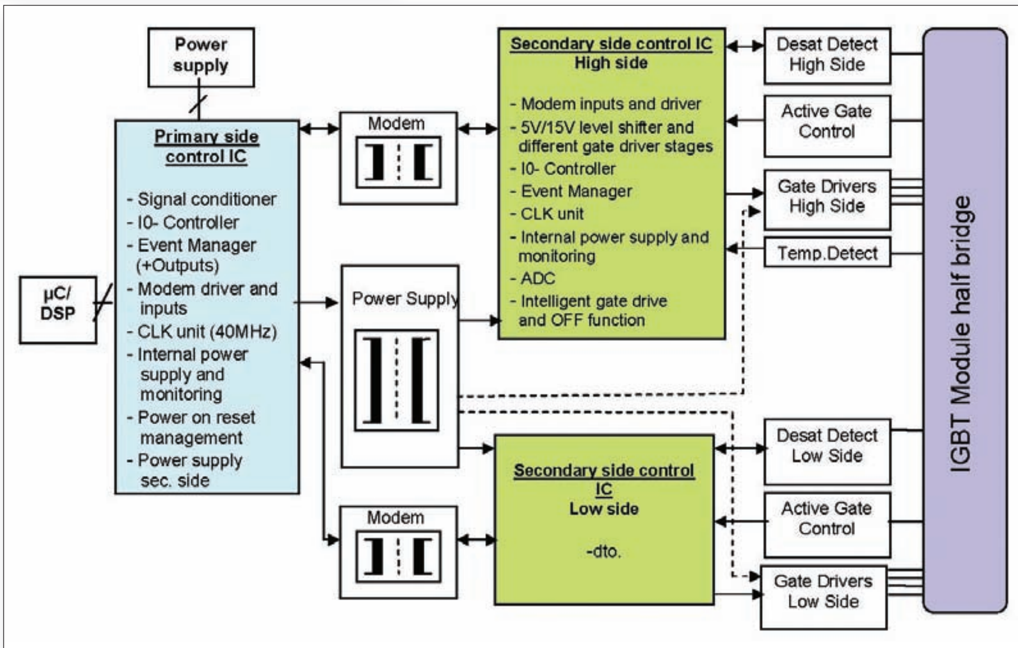


Figure 8: **Block diagram and features of the digital driver concept**

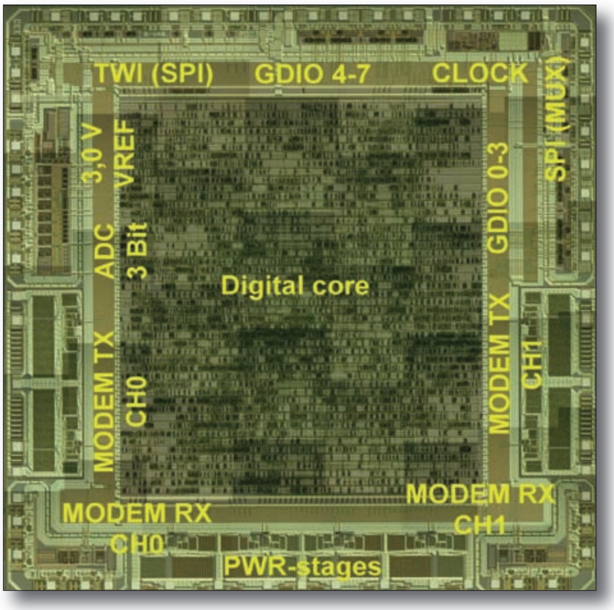


Figure 9: **Chip photograph of digital driver primary side control IC (chip size 5.75mm x 5.9mm; digital core 3.5mm x 4mm)**

time sequences to be modulated. This in turn means reduced switching losses and still allows for the over-voltage peak to be limited.

Starting the development with FPGAs on primary side and secondary side for digital signal processing [12], the complete digital and analogous functions of each side were integrated in a mixed-signal ASIC. Figure 9 shows the chip for the primary side control IC. The most important and visible circuit parts are marked. The ICs are realised in a CMOS technology which allows on the one hand synchronous design of the 3.3V digital core working at 40MHz and on the other the integration of powerful output stages (3.3V, 15V) and of circuit topologies suitable for +15V/-15V operation voltages. (To be continued in PEE 6/2010).

Literature

[1] B.Murari, F.Bertotti, G.A.Vignola: Smart Power ICs: Technologies and Applications; Springer, Berlin, Heidelberg, New York, 1996

[2] U.Nicolai, T.Reimann, J.Petzhold, J. Lutz, P. Martin (Editor): SEMIKRON Application Manual; ISLE, Ilmenau; 1998

[3] K.Watabe, K.Shimizu, H.Akiyama, T.Araki, J.Moritani, M.Fukunaga: A half-bridge driver IC with newly designed high voltage diode, Proc. ISPSD 2001, pp. 279-282

[4] International Rectifier; Data Sheet IR 2135, IR 2235

[5] A.Nakagawa: Single chip power integration- High voltage SOI and low voltage BCD, Proc. CIPS 2000, pp. 8-15

[6] S.Pawel, R.Herzer, M.Roßberg: Fully integrated 600V Drive IC for medium power applications operating up to 200°C, Proc. ISPSD 2005, pp. 55-58

[7] M.Ramezani, C.A.T.Salama: A monolithic IGBT gate driver implemented in a conventional 0.8_m BiCMOS process, Proc. ISPSD 1998, pp. 109-112

[8] R.Herzer, S.Pawel, J.Lehmann: IGBT driver chipset for high power applications, Proc. ISPSD 2002, pp. 161-164

[9] J.Thalheim: Chipset for flexible and scalable high-performance gate drivers for 1200V-6500V IGBTs, Proc. ISPSD 2008, pp. 197-200

[10] SEMIKRON; Data Sheet SKIC 6002

[11] SEMIKRON; Data Sheet SKIC 1003, SKIC 1002

[12] New PCIM 2008 Exhibits, Power Electronics Europe, July/August 2008, pp. 16-21

PRACTICAL ENGINEER'S HANDBOOKS

From the publishers of

Drives & Controls

Hydraulics & Pneumatics

If you would like to obtain additional copies of the handbooks, please complete the form below and either fax it on *01732 360034* or post your order to:

Engineers Handbook, DFA MEDIA LTD,
Cape House, 60a Priory Road, Tonbridge, Kent TN9 2BL

You may also telephone your order on *01732 370340*

Cheques should be made payable to *DFA MEDIA LTD* and crossed A/C Payee.

Copies of the handbooks are available at £4.99 per copy.

Discounts are available for multiple copies.
2-5 copies £4.30, 6-20 copies £4.10, 20+ copies £3.75.

Postage and Packaging:
1-3 copies £2.49 4 copies and over £3.49

There are now 6 of these handy reference books from the publishers of the *Drives & Controls* and *Hydraulics & Pneumatics* magazines.

Published in an easily readable style and designed to help answer basic questions and everyday problems without the need to refer to weighty textbooks.

We believe you'll find them invaluable items to have within arms reach.

PLEASE ALLOW UPTO 28 DAYS FOR DELIVERY

Name: ____________________

Company Name: ____________________

Address: ____________________

____________________ Post Code: ____________________

Tel: ____________________ Total Number of Copies [ ] @ £ ________ p+p ________ Total £ ________

Drives H/B [QUANTITY] S & S H/B [QUANTITY] Hyd H/B [QUANTITY] Pne H/B [QUANTITY] Ind Mot [QUANTITY] Comp Air [QUANTITY]

DFA MEDIA LTD,
Cape House, 60a Priory Road, Tonbridge, Kent TN9 2BL

Power Modules for Motor Control Applications

For applications in power electronics where significant power needs to be handled in confined spaces, often the choice for packaging is not a set of discrete power components, but a dedicated power module. For that purpose CoolPAK realizes an insert-molded shell which has an integrated metal lead-frame array. These lead-frames also present horizontal areas for housing bare die components as well as forming out the terminals for the outside contacts. **Jim Tompkins and Peter Sommerfeld, Electronic Motion Systems Canada and Germany**

The standard approach to power module design is to choose a suitable substrate which is typically copper on ceramic (DBC - Direct Bonded Copper) or a laminate on a metal plate (IMS - Insulated Metal Substrate). This substrate holds the bare die power components and is typically attached to a plastic frame, which holds the metal terminals for the outside electrical contacts and also forms out fixation features if required. A metal base-plate below the substrate may also be required to increase the thermal spreading capability of the substrate. With the CoolPAK-Technology a different solution to power module design is offered.

Coolpak design

The CoolPAK power module consists of six FETs arranged in a three-phase full bridge configuration. Further components are the thermistor to monitor the power module's temperature, a shunt for current measurement in the ground line of the module and an EMC decoupling capacitor. The lead-frames also form the outside contacts for supply (B+, GND), the motor phases (U, V, W), and the control and monitoring signals (Figure 1).

A central component of the CoolPAK power module is the insert-molded lead-frame shell (see Figure 2 for an unpopulated and a populated shell).

The plastic molding holds an array of metal lead-frames, which present open areas uncovered by plastic. The areas of the lead-frame opening into the cavity of the plastic shell will hold the bare die FETs and the other components required for the power module. The cavity of the shell is potted with silicone gel for the protection of the components and is covered with a plastic, snap-on lid.

Thermal stack

A power module's performance is largely determined by its thermal resistance, i.e. its ability to conduct dissipated heat away from the active bare die components. The thermal stack-up of the CoolPAK module consists of the bare die FETs soldered to the metal lead-frame made of copper core material and attached to a heat sink by thermal adhesive. For comparison, we show also a DBC-based power module, where the bare die FETs are soldered onto the DBC substrate consisting of a ceramic with copper layers on both sides, which is then attached to a heat-sink by thermal adhesive.

Figure 3 shows both thermal stacks and approximate thermal resistances of the various layers. The CoolPAK module does not have the ceramic substrate which is missing from its thermal stack, lowering its thermal resistance significantly. More so, the copper thickness of the metal lead-frame is much larger than the copper layers of the DBC module.

This acts as a further contributor to reducing the overall thermal resistance of the stack for the module by increasing the lateral spreading the heat generated in the MOSFET. A similar effect can be seen regarding the electrical loop

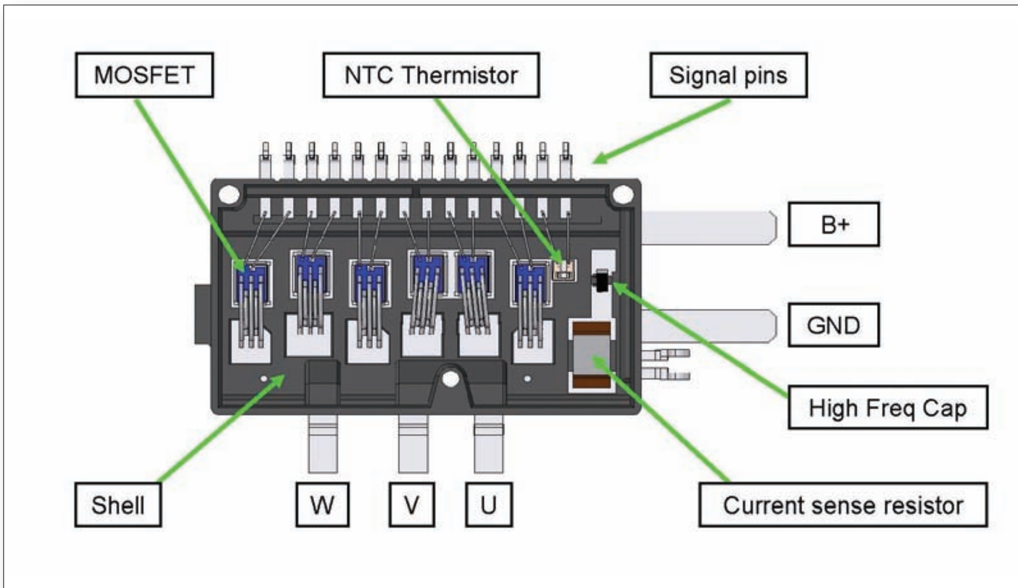


Figure 1: CoolPAK components and placement

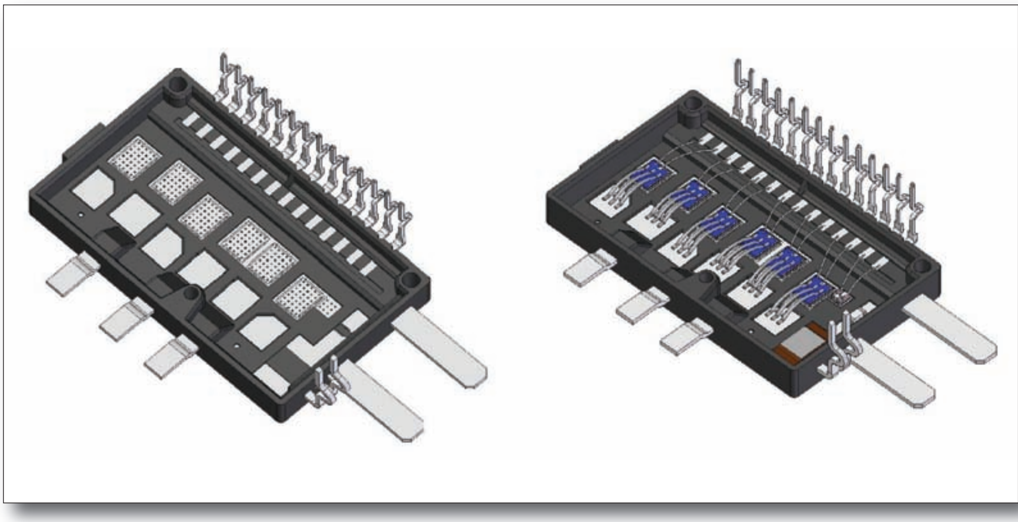


Figure 2: Unpopulated (left) and populated lead-frame shell

resistance of the module. Due to the lead-frame technology the resistance is reduced significantly.

Shell and thermal interface

The CoolPAK shell has to facilitate the conduction of heat away from the bare die FETs. This is done very effectively through the metal lead-frame, but care also has to be taken to have an efficient thermal transfer to the underlying heat-sink.

The CoolPAK module has the lead-frames exposed on its bottom-side as well. This way the thermal adhesive can bond directly to the lead-frame and establish thermal contact to the heat-sink directly. With this method, care has to be taken that no lead-frame accidentally makes contact to the heat-sink and thereby causes short circuit conditions. To avoid this, two precautions are taken. Firstly, the plastic shell contains small nubs, which establish a defined gap between lead-frame and heat-sink when the module is placed onto the heat-sink according to Figure 4.

Secondly, the module can be attached by a thermal adhesive filled with glass beads of defined size so as to ensure electrical isolation between lead-frame and heat-sink. The shell also has to withstand the high process temperatures during soldering of the components. The plastic material (PPA) is such that even lead-free soldering operation can be carried out with the shell.

The metal lead-frames are made from copper for high thermal and electrical conductivity. The lead-frame thickness is chosen to be 1mm, which facilitates thermal spreading and increases the thermal transfer per component. Also the current carrying capability of the lead-frames is significantly improved, which reduces the resistive power losses of the module.

In order to run the wire bond interconnection process, the copper lead-frames are Nickel-plated in the relevant areas to provide large wire-bond reliability and manufacturing consistency. For the lead-frames of the signal contacts Aluminium inlays enhance small wire-bond reliability.

Temperature and current monitoring

The power module is fitted with an NTC thermistor, which sits on a small substrate providing the contact pads. This thermistor assembly is attached directly to a lead-frame by a soldered contact, providing good thermal contact. This causes very little thermal lag between the thermistor and the junction temperatures of the FETs, which allows

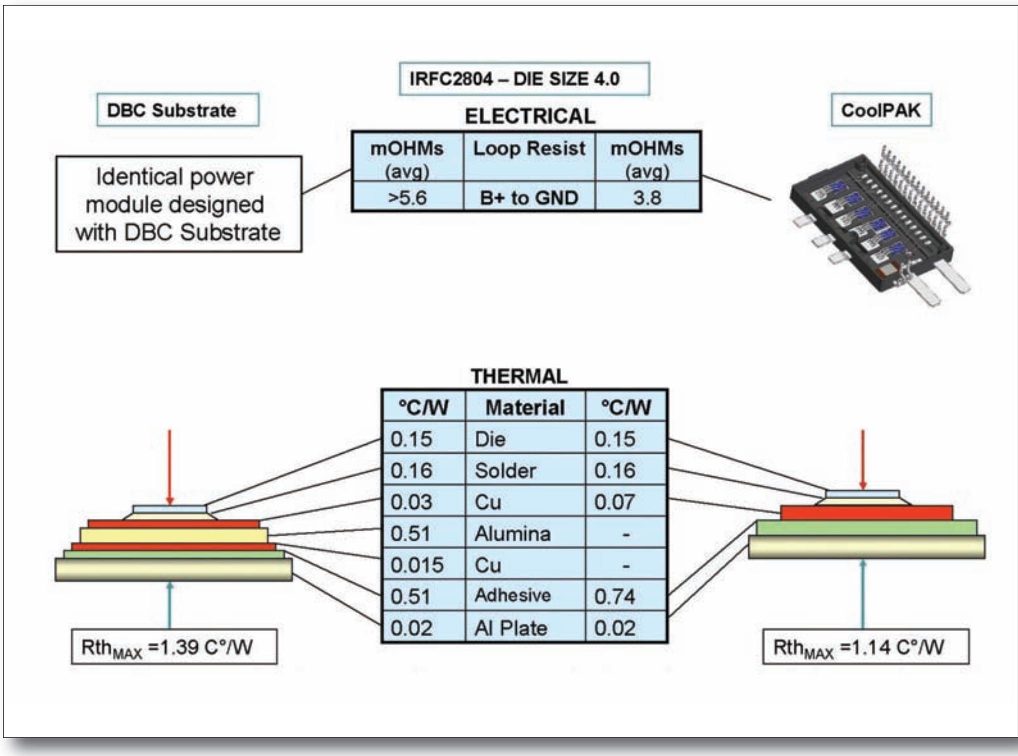


Figure 3: Thermal stacks and approximate thermal resistances of the various layers for DBC and CoolPAK module

the active protection of the module against over-temperature. The input current and output voltage of the thermistor are provided via the signal pin outputs.

A shunt resistor in the ground path of the module allows for current measurement. The shunt is chosen to have as low a resistance as possible to keep dissipation down and still provide a good signal-to-noise behavior. The shunt is directly soldered to the lead-frames of the shell. The voltage measurement is realized via the signal pads.

The supply terminal B+ and GND are plated to allow both contact by resistance welding as well as a soldering operation. The same is the case for the three phase terminals U, V, W.

The signal pins are through-hole leads for attachment to a controller board to generate the gate driver signals and measure current and temperature. The signal leads also include a contact to the source of each FET for sensing the voltage.

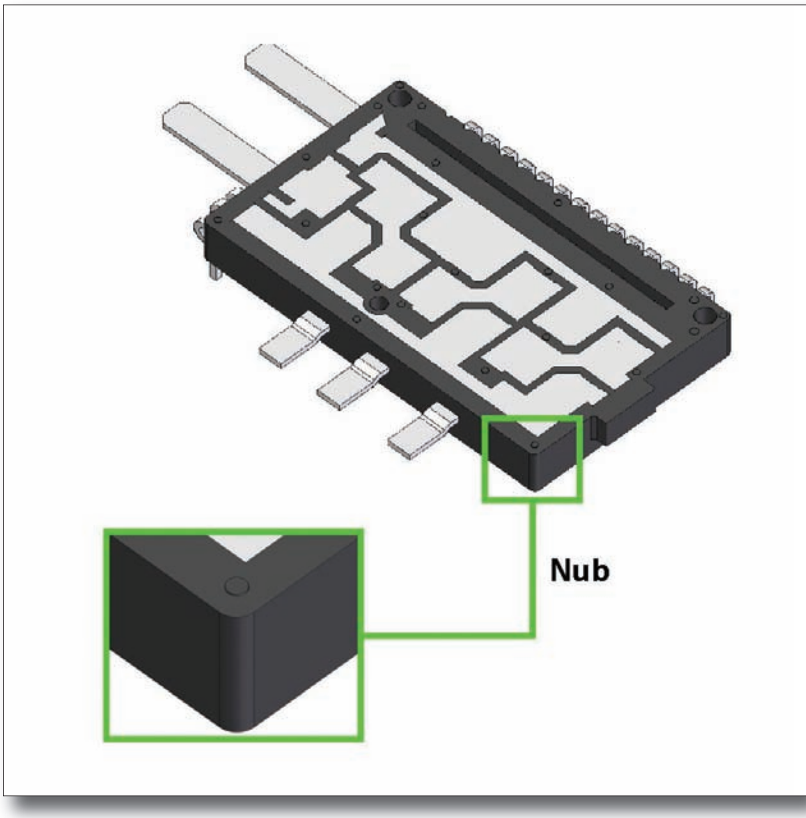


Figure 4: **Small nubs establishing a defined gap between lead-frame and heatsink**

Process technology and reliability

The manufacturing of the CoolPAK technology uses common module assembly technology. The areas for the placement of the bare die FETs are defined by dispensing solder resist, which is cured. Within the confines of the solder resist pattern the solder paste is dispensed into which the bare die FETs are placed.

The soldering process is conducted in a multi-chamber vacuum oven. This allows the solder joints to reflow and minimize the amount of solder joint voiding. This is of particular importance for this power module since the solder joint is the first thermal contact layer to the bare die FET and needs to be as thermally conductive as possible.

The reflowed modules undergo a cleaning process. After this the bare dies are wire bonded to the relevant areas on the lead-frames and contact pads. The wire bond process is being controlled regularly to ensure quality of bonds. Finally the module is potted with silicone gel which protects the electronic components from dust and moisture.

The parametric test of the power module tests every FET and the other components. For the FETs a batch related analysis is performed on the parameters stored. Over and above the requirement of every parameter being in between a lower and an upper limit a further constraint is applied in that statistically every module is discarded whose FETs have measurement values on any parameter more than a certain multiple of the standard deviation away from the mean of the batch. This applies even if the value itself is between the lower and upper limit. This "maverick test" method has been taken over from semiconductor manufacturing, where it proved out to be very efficient in rooting out a suspect product.

The reliability performance of this module has been tested extensively. The most important test which addresses the central innovative components of the module is the power cycling test. In this test the module is subjected to cyclic periods of passing significant current and off-periods. This leads to a cyclic variation in the junction temperature of the FETs and of the entire thermal stack. The CoolPAK technology has proven itself to conform to all application specific specifications for automotive applications.

Application examples

The CoolPAK technology is currently being used in high volume production for an automotive electro-hydraulic steering ECU for a 14V system voltage. The module is required since the discrete solution is not able to handle the required electrical power. It is also being trialed for automotive electro-hydraulic steering ECU for a 28V system. Again the power handling capability of the technology is required to comply with the power requirements of this application. Further areas of use could be general brushless DC motor drives, electric heaters for automotive applications, active rectification and electric resistance welding.

Conclusions

CoolPAK shows significant advantages in thermal performance and cost over conventional power module technology. This is due to fewer components, simpler assembly technology at good current carrying capability. The technology lends itself particularly to applications where high power handling is required in constricted space envelopes.

USB Compliance in Wireless Modem Design

With USB being a standard interface in PC peripherals, the number of applications that can be powered from a USB port is increasing at an exponential rate. The need for flexibility and continuous connectivity in our lives is becoming more important. In a growing wireless world, many applications are taking portable form allowing users the ease and flexibility of connecting to the web anywhere. With all the benefits this brings, there are a number of extra requirements that need to be taken into account when designing a device that is powered from a USB port. **John Constantopoulos, Systems Engineer, WW Low Power DC/DC, Texas Instruments, USA**

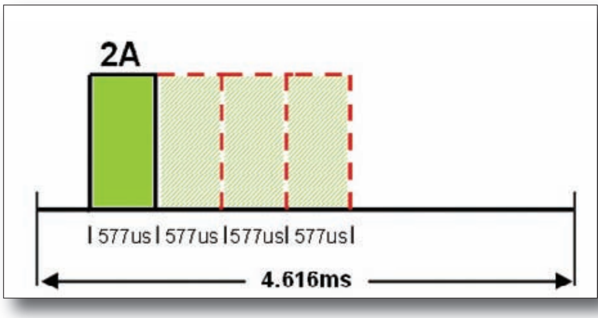


Figure 1: Transmission period of a typical GSM/GPRS pulse

A growing variety of portable wireless modems for data communication applications use TDMA techniques which require peak current during the transmission of signals which can exceed the maximum current specified by the USB standard. Therefore the modem must be designed to limit the input power and draw on card-based storage for most of the energy requirement during a typical transmission cycle.

As shown in Figure 1, the GSM signal is transmitted over the carrier at a rate of 216Hz (4.616ms pulse repetition interval). The transmission period is divided into eight time slots and depending on the power class being used (8, 10 or 12) , the duty cycle of this high current pulse can range anywhere between one-eighth of the cycle (577μs) up to half of the transmission cycle (2.308ms).

Much of the work in GSM power supply design revolves around the transmission cycle due to the high current consumption in this mode. The main problem with the GSM or GPRS requirement is that in portable wireless modem applications, the average input current being drawn at the USB host is limited to 500mA, while most transmitters will need 1.5A to 2A peak bursts to transmit at full power.

For example, when transmitting in GPRS Class 10, a maximum of two of the eight 577_s slots are used, while the remaining six slots are used to recharge the capacitor, during which the supply current is reduced to less than 100mA. Therefore the power supply must be able to supply at least the average current over one transmission period, as well as be capable of handling the 2A transmission bursts.

There are numerous different topologies which can be used to support these power requirements, many of which exceed what is specified in the USB specification. But there are many PC manufacturers that strictly abide to the USB specification, and these solutions will either not be compatible with them causing the system to fail or worst case the PC to crash. As a result of this, many vendors are placing stricter requirements on USB applications to maintain USB compliancy.

It is therefore clearly not possible for a DC/DC converter used in a USB wireless modem to operate correctly without any special design measures and features which allow the system to be USB compliant.

Buck converter with integrated current limit switch

The TPS62750 is a 94% efficient step-down converter optimized for USB powered applications. It features a highly accurate adjustable average input current limit (± 5% at 500mA), and key protection features such as hot-plug and reverse current protection. Figure 2 shows how the TPS62750 is used to power a typical USB wireless modem.

As the USB port can only supply up to 500mA, it is especially important to maximize the amount of current drawn from the USB port. This can be achieved by using a highly accurate current limiting circuitry, allowing the amount of current drawn from the USB port to be as close to 500mA as possible.

TPS62750 incorporates two highly accurate adjustable average input current limits which can be digitally selected by the H/L pin. This allows the designer to set an input current limit of 100mA during Low Power Mode for enumeration (effectively charging up the output cap), and then by pulling the H/L pin high, shifting into High Power 500mA mode when requested.

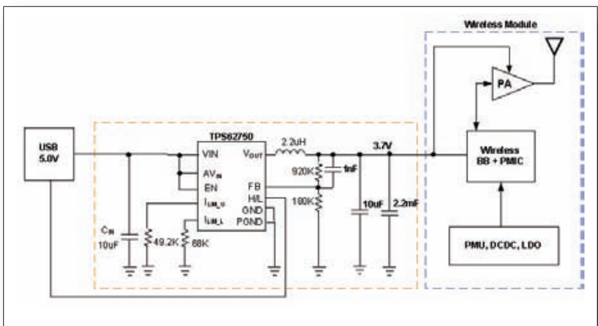


Figure 2: Overview of Buck converter only solution

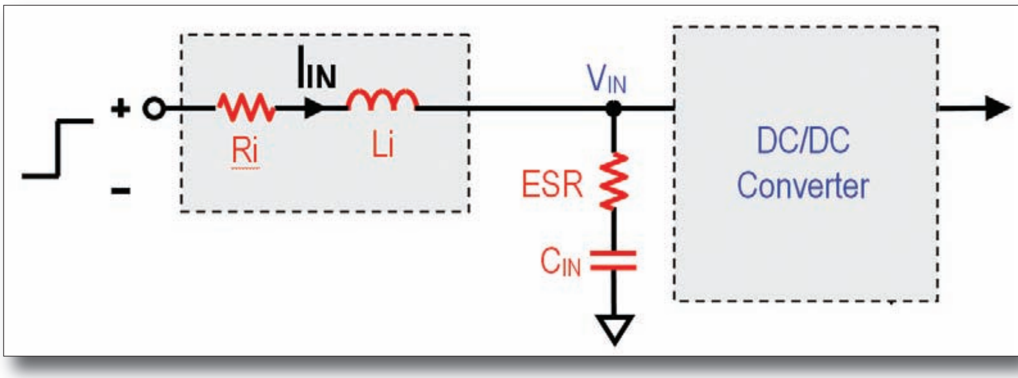


Figure 3: **Basic overview of hot-plug system**

The high accuracy of ±5%, is achieved by sensing the current ripple over the high-side transistor. This is then amplified by a high-speed amplifier which allows the fast detection of the current pulses, allowing for the high level of current accuracy. This signal is then averaged by an integrator circuit, creating the required average input current which is set by the external resistor.

Most DC/DC converters used in portable applications use ceramic capacitors to filter DC/DC converter inputs. Ceramic capacitors are often chosen because of their small size, low equivalent series resistance (ESR) and high RMS current capability (see Figure 3).

When power is supplied via the USB bus or a USB dongle is plugged into the USB port, the cable inductance along with the self resonant and high Q characteristics of ceramic capacitors can cause substantial ringing which could exceed the maximum voltage ratings and damage the DC/DC converter without any dedicated protection. As shown in Figure 4, these voltage spikes can easily be twice the amplitude of the input voltage step.

One possible protection option is to use a TVS (transient voltage suppression) Zener diode to clamp such high-pulse transient voltages. But these devices are generally expensive and in space limited portable applications this may not be an option at all.

A key feature of the TPS62750 is that it incorporates internal hot-plug protection circuitry which limits the transient voltage during a hot-plug event to a level below the absolute maximum rating of the DC/DC converter.

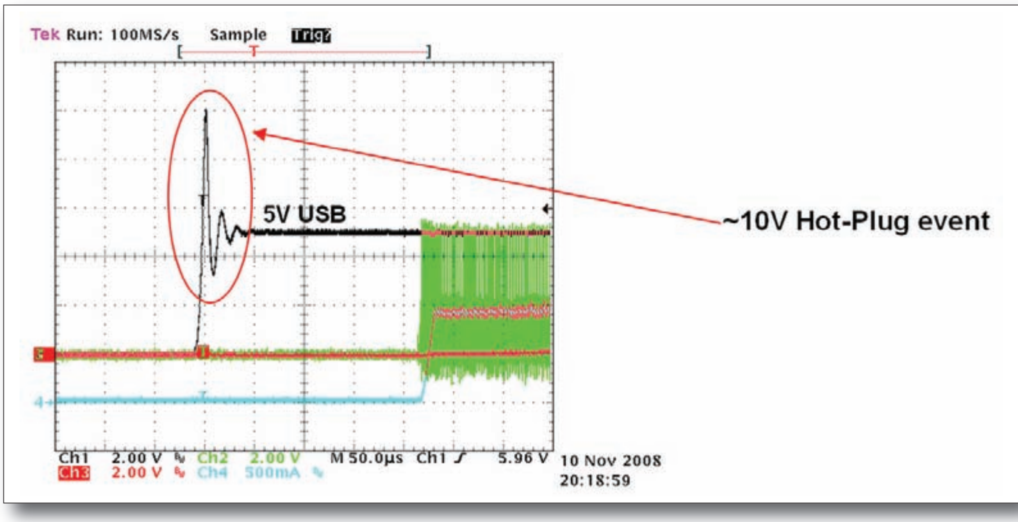


Figure 4: **Voltage spikes at USB hot-plugging**

Figure 5 shows how the internal clamp circuitry reacts to a hot-plug event, limiting the voltage on the input of the DCDC converter to a level below where the device may potentially be damaged. This allows the design engineer to develop his circuitry without any extra protection circuitry.

Design example

Assuming that the DC/DC converter has a set input current of 500mA, with the supply voltage directly from the USB port (5V) and an output supply for the RFPA of 3.7V, allows for effectively supply around 675mA directly from the DC/DC converter (no switching losses taken into account).

Assuming 90% efficiency, the total amount of current delivered by the DC/DC converter is 610mA. The rest of the energy for a GSM/GPRS transmission slot needs to come from a bulk capacitor according to $I_{CAP} = I_{GSM} - I_{DC/DC}$ and $I_{CAP} = 2.0A - 610mA = 1.39A$.

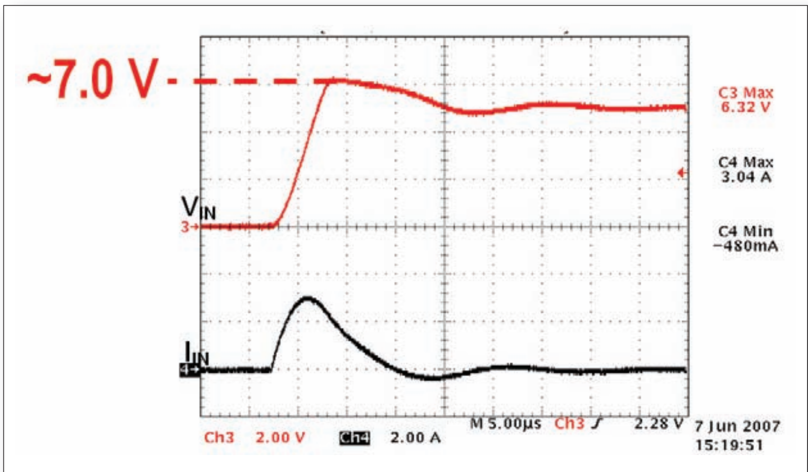


Figure 5: **TPS62750 internal clamp of hot-plug event**

The voltage drop in the circuit comprises two components, the I x R drop associated with the capacitor's internal resistance (as approximated by ESR) and the drop in capacitor voltage at the end of the pulse. Therefore the effective capacitance required to buffer each pulse, assuming class 8 transmission (0.577ms slot), is equal to:

$$C_{OUT} = \frac{(I_{PULSE} \bullet t_{PULSE})}{V_{DROOP} - I_{PULSE} \bullet R_{ESR}}$$

$$C_{OUT} = \frac{(1.39A \bullet 0.577ms)}{400mV - 1.39A \bullet 50m\Omega}$$

$$C_{OUT} =\sim 2.4mF$$

where V_{DROOP} is the change in output voltage, I_{PULSE} and t_{PULSE} are the peak pulse current and duration respectively, R_{ESR} is the capacitor ESR and C_{OUT} is the output capacitance.

Figure 6 shows the screen plot of the TPS62750 configuration as calculated above. Using a 2.2mF bulk capacitor, while being loaded with typical 2A pulses at power class 8 (577µs). During the period where no transmission occurs, little or no current is being drawn from the device and the output voltage remains stable at 3.7V.

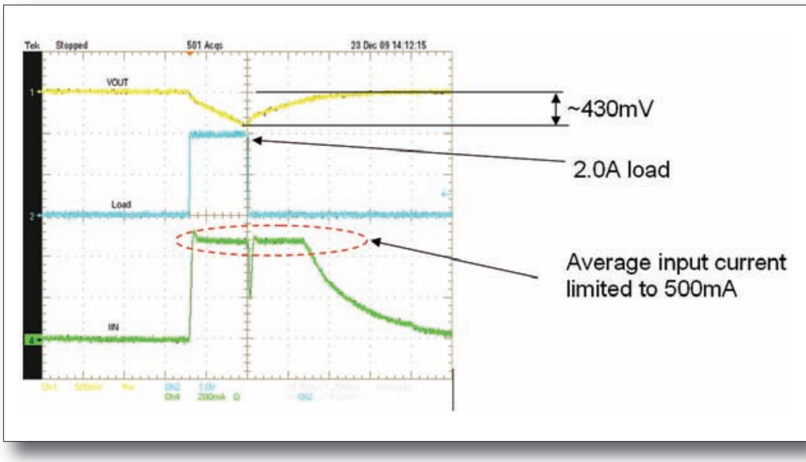


Figure 6: Screen plot of Class 8 transmission

As soon as transmission occurs, the output voltage of the DC/DC converter starts to droop while the required power level is supplied to the load.

Conclusions

Until recently, designers of portable systems have rarely used large capacitors for applications other than back-up or standby functions where currents are low and charge times are fairly long. But a growing range of new applications, led by a new generation of high performance Wireless Modems, demand high peak currents that are forcing designers to consider different approaches to reduce solution size and total cost, while still being able to deliver the high required peak currents. The compact solution TPS62750 step-down converter is a power supply solution for USB powered peripherals. Its small solution footprint, combined with today's low profile polymer and tantalum capacitors elegantly solves the pulsed load problem, providing a cost-effective, compact solution.

The
Drives and Controls Exhibition & Conference 2012

www.drives-expo.com
17-19 April 2012 NEC Birmingham
Contact Doug Devlin on 01992 644766 – E-mail doug@drives.co.uk

High Temperature 80V Power MOSFET

CISSOID now offers a high temperature 80V N-channel power MOSFET (Earth) guaranteed for operation from -55°C up to +225°C. It enhances the existing family that comprises Venus (PMOS), Saturn (40V NMOS) and Mercury (small signal transistor).The new device is available in two versions, rated for 5A and 10A maximum drain current respectively. Both versions of Earth MOSFETs, referenced CHT-NMOS8005 and CHT-NMOS8010, exhibit outstanding high temperature performances. At 225°C, CHT-NMOS8005's gate leakage current remains below 500nA, while its drain off current is as low as 20μA and its turn-on delay time is 30ns. On-resistance and input capacitance of the family range respectively from 0.25Ω to 0.5Ω and from 410pF to 850pF. The Earth family enables the design of any system requiring reliable power control in a harsh environment whilst eliminating the need for fluid cooling in applications such as industrial process control, car battery chargers and aircraft actuatos. The CHT-NMOS8005 and CHT-NMOS8010 are available for sampling and evaluation in TO-254 metal can packaging. Pricing starts at Euro 214.15 up to 200 units.

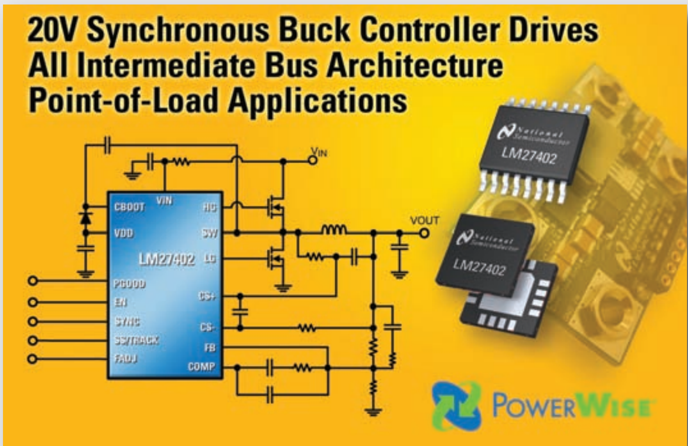
www.cissoid.com

650V Superjunction MOSFET

Infineon launched the new 650V CoolMOS(tm) C6/E6 series of power MOSFETs, combining the advantages of modern superjunction (SJ) devices such as low on-resistance and reduced capacitive switching losses with easy control of switching behaviour as well as high body diode ruggedness. The new sixth generation C6/E6 devices complements its earlier released 600V C6/E6 product family where 650V blocking capability is desirable such as notebook adapters, solar, and other switched mode power supply designs where extra breakdown voltage headroom is required. Compared to the C3 650V family, the new C6/E6 devices offer up to 20% lower energy storage in the output capacitance, and additionally the improved body diode of the C6/E6 devices shows higher ruggedness against hard commutation and reduces the reverse recovery charge by 25%. The switching behaviour of the C6/E6 series is capable of avoiding excessive voltage and current slopes thanks to its balanced design with tuned gate resistors. Pricing for the IPA65R280C6 / IPA65R280E6 is at $ 2.90 each for an order volume of 10,000 pieces.

www.infineon.com/c6e6

20V Synchronous Buck Controller

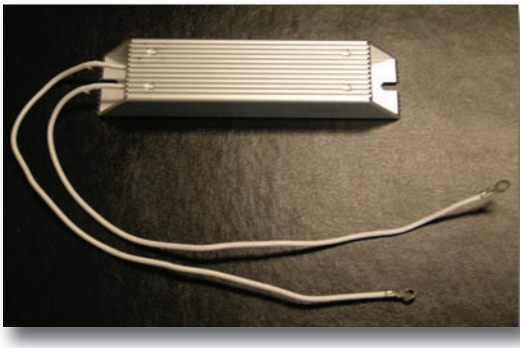


National Semiconductor announced a new synchronous voltage-mode buck controller that drives a variety of high-current point-of-load applications in printers, telecom, networking or embedded computing applications. Until today, point-of-load controllers have incorporated one or two complex features, such as a wide input voltage range, integrated high-current gate drivers with adaptive dead-time, inductor DCR current sensing or on-chip bias supply sub-regulator. National's LM27402, however, is an universal point-of-load controller to integrate all these advanced features into a single chip. A wide input voltage range of 3V to 20V allows the LM27402 to interface with all intermediate bus voltages, including 3.3V, 5.0V and 12V rails. Integrated inductor DC resistance current sense eliminates the need for resistive power train elements to detect output current. The current sense threshold level is programmable to accommodate a wide range of load current levels using the smallest inductor possible. Output voltage is adjustable down to 0.6V with a 1% voltage reference providing output voltage set-point accuracy over the full -40°C to 125°C operating temperature range. An integrated bias supply sub-regulator eliminates the external bias voltage supply to simplify PCB layout. Integrated, high-current MOSFET gate drivers with adaptive dead-time control enable efficient power conversion with load currents up to 30A. It also supports programmable soft-start, tracking and pre-biased start-up.

www.national.com/pf/LM/LM27402.html

1000W Aluminum Clad Wirewounds Resistors

Stackpole announced its aluminum housed low profile wirewounds, the MHL Series. Available in power ratings from 60W up to 1000W, this series offers a high power wirewound solution that is typically less than half the height of traditional aluminum housed wirewounds. This product has standard lead wire terminations coming out of one end, and can also be provided with leads coming out of opposite ends or with quick connect tabs. The element is cemented into the aluminum case which provides a flameproof part with outstanding stability that is resistant to moisture and other harsh environmental conditions.



The MHL Series performance will be useful in a variety of applications and end products that require a low profile, high power wirewound resistor such as motor controls for elevators, escalators, and moving walkways, welding equipment, plasma cutters, power supplies or robotics. Pricing will vary depending on size and tolerance and ranges from $5 each to $70 each in minimum quantities.

www.seielect.com

Half-Chip PRM Regulator

V•I Chip, a subsidiary of Vicor Corp. offers a so-called half-chip PRM(tm) regulator in half-chip package (16.5 x 22.0 x 6.7mm). This converter is 97% efficient at 200W with the same power density as a 400W full-size PRM. The PRM48BH480T200A00 operates from 48V DC (38 to 55V) to generate a regulated, adjustable 5V to 55V output. The ZVS (zero-voltage-switching) Buck/Boost topology and high switching frequency (~1MHz) operation enable high efficiency and reduced size. The half-chip PRM can be used as a stand-alone, non-isolated voltage regulator or combined with V•I Chip's full-chip or half-chip VTM(tm) current multipliers for a complete, isolated DC/DC solution direct to the point-of-load, with extremely fast transient response and isolation to 2,250V DC. An external control loop and current sensor maintain regulation and enable flexibility in the design of voltage and current compensation loops for precise power delivery. All V•I Chips are compatible with standard pick-and-place and surface mount assembly processes.

visit www.vicorpower.com/products/vichip

MAKING MODERN LIVING POSSIBLE

Danfoss

DANFOSS SILICON POWER

The coolest approach to heat transfer

Benefit from the most cost-efficient power modules available

It cannot be stressed enough: Efficient cooling is the most important feature in regards to Power Modules. Danfoss Silicon Power's cutting-edge ShowerPower® solution is designed to secure an even cooling across base plates, offering extended lifetime at no increase in cost. All our modules are customized to meet the exact requirements of the application. In short, when you choose Danfoss Silicon Power as your supplier you choose a thoroughly tested solution with unsurpassed power density.

Please go to siliconpower.danfoss.com to learn about Power Modules that are second to none.

SILICONPOWER.DANFOSS.COM

20V Buck Regulators

Analog Devices (ADI) ntroduced the ADP2302 and ADP2303 DC/DC non-synchronous switching regulators for 2 A (ADP2302) and 3 A (ADP2303) output at inputs up to 20V. They support a wide input voltage range from 3V to 20V to accommodate a diversity of point-of-load applications, including consumer electronics and industrial and communications infrastructure equipment. The output voltage is adjustable from 0.8V to 80% of input voltage. The regulators' current-mode, fixed-frequency PWM architecture provides high stability and transient response. Under light loads, the regulators automatically operate in PFM (pulse frequency modulation) to reduce light load losses. A precision-enable pin allows the regulator to be turned on at a precise input voltage for sequencing of multiple devices. These power management switching regulators are supported by the ADIsimPower(tm) design tool, which makes selecting components, simulating power supply performance and building evaluation circuits easy and fast.

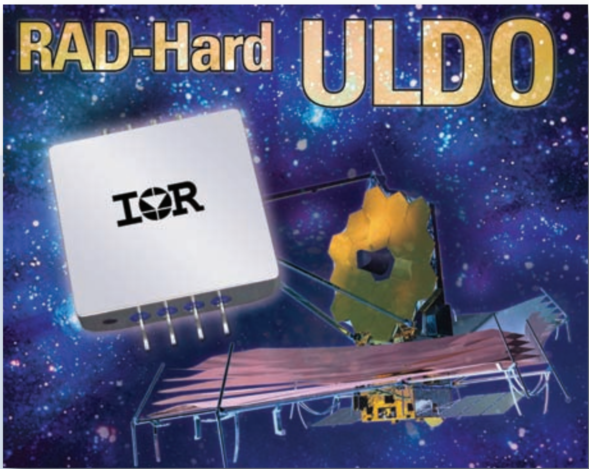
www.analog.com

300W Quarter-Brick Isolated DC/DC Converters

Murata Power Solutions extends its HPQ range of quarter-brick isolated DC/DC converters with the HPQ-12/25-D48, a 300W model with 12V output. It features a wide 2:1 input range of 36V to 75V and output of 12V, plus high output current of up to 25A at high efficiency up to 94.5%. For systems requiring controlled startup/shutdown, remote on/off control is available with negative or positive polarity. Users can also trim the output voltage up or down by ±10% with an external trim resistor. It also offers input-output isolation with basic insulation up to 2250V DC. In addition, with a low profile open frame package, the HPQ-12/25-D48 operates within the industrial temperature range of -40°C to 85°C.

www.murata-ps.com

RAD-Hard Ultra-Low Drop Out Voltage Regulators



International Rectifier introduced the first in a series of high current, ultra-low dropout (ULDO) RAD-Hard(tm) hybrid linear voltage regulators for space applications including satellites and launch vehicles. The space level screened devices, designed for point-of-load and post DC/DC power conversion, offer a low dropout voltage of 0.4V at full 3A load. The new regulators feature a SOI CMOS Regulator IC, latch-up and SEU immunity, as well as outstanding TID and ELDRS testing in excess of 100K rad with negligible effect on regulation tolerance. In addition, the devices provide fast transient response, timed latch-off over-current protection and internal thermal protection, and on/off control via shutdown pin. The new ULDO devices' adjustable regulators provide output voltages as low as 0.8V compatible with the newer FPGA used in space equipment. Pricing ranges from $600 for the unscreened non-flight model IRUH330125AP to $1290 for the IRUH330125AK each in 100-unit quantities.

www.irf.com

10A Hold-Up Module

XP Power announced the MTH100 hold-up module designed for maintaining short-term power to critical avionic and vetronic systems in the event of power dropouts. These modules significantly reduce the amount of bulk hold capacitance required, often by as much as 80%. The MTH100 is designed for use in systems with an input current up to 10A. The charger output voltage can be programmed allowing it to work with both military and industrial DC/DC converters. Accommodating a wide input range of +10 to +40V DC, the MTH100 module automatically detects the input drop-out and initiates extended hold-up utilizing capacitors charged to a high voltage. Charging the capacitors to a higher voltage than the nominal system voltage of 28, typically 36 or 45 V DC, significantly reduces the amount of capacitance required. Consider a power supply system that needs to operate through a power dropout of 200ms while supporting a 30W load without interruption using a DC/DC converter with a minimum input of 10V - without a hold-up module, if the power dropout occurs at 16V input, the system would need over 90,000µF of capacitance. Using the MTH100 module, the system needs only 7,000µF or 92% less.

Measuring 40 x 26 x 12.7mm, the base plate cooled MTH100 module is typically 98% efficient and operates across the temperature range of -55°C to 100°C.

www.xppower.com

AC/DC Connverters

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

Busbars

www.auxel.com
Auxel FTG
Tel: +44 (0)7714 699967

Capacitors

www.powersemiconductors.co.uk
Power Semiconductors Ltd
Tel: +44 (0)1727 811110

Certification

www.productapprovals.co.uk
Product Approvals Ltd
Tel: +44 (0)1588 620192

Connectors & Terminal Blocks

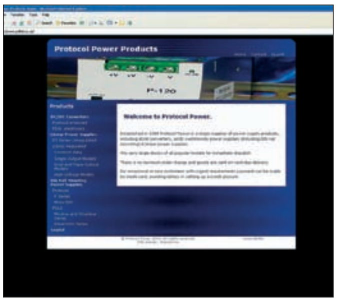
www.auxel.com
Auxel FTG
Tel: +44 (0)7714 699967

DC/DC Connverters

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

DC/DC Connverters

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399



www.protocol-power.com
Protocol Power Products
Tel: +44 (0)1582 477737

Diodes

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

www.neutronltd.co.uk
Neutron Ltd
Tel: +44 (0)1460 242200

Direct Bonded Copper (DPC Substrates)

www.curamik.co.uk
curamik® electronics GmbH
Tel: +49 9645 9222 0

Discrete Semiconductors

www.digikey.com/europe
Digi-Key
Tel: +31 (0)53 484 9584

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

Drivers ICS

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Fuses

www.powersemiconductors.co.uk
Power Semiconductors Ltd
Tel: +44 (0)1727 811110

GTO/Triacs

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

Hall Current Sensors

www.dgseals.com
dgseals.com
Tel: 001 972 931 8463

Harmonic Filters

www.murata-europe.com
Murata Electronics (UK) Ltd
Tel: +44 (0)1252 811666

IGBTs

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

www.neutronltd.co.uk
Neutron Ltd
Tel: +44 (0)1460 242200

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Magnetic Materials/Products

www.rubadue.com
Rubadue Wire Co., Inc.
Tel. 001 970-351-6100

Mosfets

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

www.neutronltd.co.uk
Neutron Ltd
Tel: +44 (0)1460 242200

Optoelectronic Devices

www.digikey.com/europe
Digi-Key Tel: +31 (0)53 484 9584

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Packaging & Packaging Materials

www.curamik.co.uk
curamik® electronics GmbH
Tel: +49 9645 9222 0

Power ICs

www.digikey.com/europe
Digi-Key Tel: +31 (0)53 484 9584

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Power Modules

www.auxel.com
Auxel FTG
Tel: +44 (0)7714 699967

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

www.microsemi.com
Microsemi
Tel: 001 541 382 8028

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Power Protection Products

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Power Substrates

www.universal-science.com
Universal Science Ltd
Tel: +44 (0)1908 222211

Resistors & Potentiometers

www.isabellenhuette.de
Isabellenhütte Heusler GmbH KG
Tel: +49/(27 71) 9 34 2 82

RF & Microwave Test Equipment.

www.ar-europe.ie
AR Europe
Tel: 353-61-504300

Simulation Software

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

www.universal-science.com
Universal Science Ltd
Tel: +44 (0)1908 222211

Smartpower Devices

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

Switches & Relays

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

Switched Mode Power Supplies

www.biaspower.com
Bias Power, LLC
Tel: 001 847 215 2427

Switched Mode Power Supplies

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

Thermal Management & Heatsinks

www.curamik.co.uk
curamik® electronics GmbH
Tel: +49 9645 9222 0

www.dau-at.com
Dau GmbH & Co KG
Tel: +43 3143 23510

www.denka.co.jp
Denka Chemicals GmbH
Tel: +49 (0)211 13099 50

www.lairdtech.com
Laird Technologies Ltd
Tel: 00 44 1342 315044

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

www.universal-science.com
Universal Science Ltd
Tel: +44 (0)1908 222211

Thyristors

www.irf.com
International Rectifier Co. (GB) Ltd
Tel: +44 (0)1737 227200

www.mark5.com
Mark 5 Ltd
Tel: +44 (0)2392 618616

Voltage References

www.irf.com
International Rectifier Co.
(GB) Ltd
Tel: +44 (0)1737 227200

www.power.ti.com
Texas Instruments
Tel: +44 (0)1604 663399

ADVERTISERS INDEX

ABB	7	Fuji	16
Allegro Microsystems	19	HKR GmbH	34
Cornell Dubilier	21	International Rectifier	OBC
CT Concepts	29	Microsemi Power	23
Danfoss	39	Mitsubishi	4
DFA Media Ltd	31	National Semiconductor	11
Digikey	IFC	Plant & Works 2012	IBC
Drives and Controls 2012	37	Toshiba Europe	9
Electronica 2010	15		

plant&works EXHIBITION
Solutions for Industry

INDUSTRIAL MAINTENANCE

HEALTH & SAFETY

ENERGY, THE ENVIRONMENT & WATER

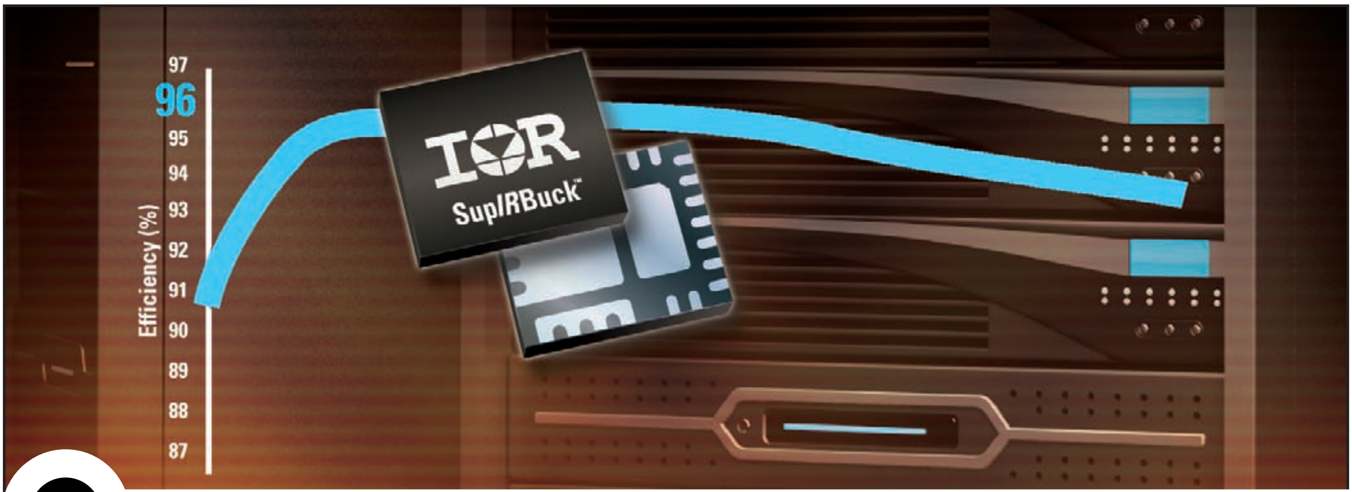
HANDLING & STORAGE

PREMISES & FACILITIES MANAGEMENT

plant&works EXHIBITION
Solutions for Industry

NEC, BIRMINGHAM
APRIL 17-19
2012

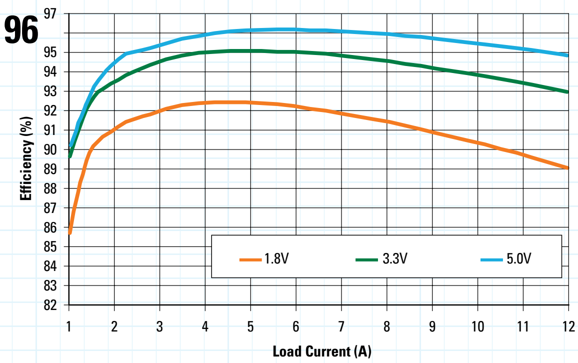
Tel: 01732 370340
www.pwe-expo.com



Exceed 96% Peak Efficiency With Gen2.1 Sup*IR*Buck™ Integrated Voltage Regulators

IR's Gen2.1 Sup*IR*Buck™ devices save time, space and energy for your POL design

IR3840W Efficiency vs. Load Current at 600kHz fs, 12Vin



FEATURES:

- Wide input voltage range (1.5V to 16V with 5V bias)
- Small footprint (5x6mm) and low height (0.9mm)
- Programmable frequency up to 1.5MHz
- 1% accurate 0.7V reference voltage
- Programmable hiccup current limit and soft start
- Enhanced pre-bias start up
- Thermal protection
- Enable pin with voltage monitoring capability
- Power Good output for over-voltage and under-voltage detection
- Optimized solutions for sequencing (IR3840/1/2/3W) and DDR memory tracking (IR3831/32W)
- -40°C to 125°C operating junction temperature (Tj)
- Pin compatible with Gen2 Sup*IR*Buck products

IR384XW/ 3XW Sup*IR*Buck™ FAMILY IMPROVEMENTS

- Added Over Voltage Detection (PGOOD window comparator)
- Shorter dead-time to reduce power loss
- Reduced SYNC FET $R_{DS(on)}$ maximum value for better over-current limit accuracy
- New current options

Part Number	Package	Input Voltage	Maximum Current	Maximum Frequency	Additional Features
IR3843WM	5x6 PQFN	1.5V to 16V	2A	1.5MHz	OV detection, Sequencing
IR3842WM	5x6 PQFN	1.5V to 16V	4A	1.5MHz	OV detection, Sequencing
IR3841WM	5x6 PQFN	1.5V to 16V	8A	1.5MHz	OV detection, Sequencing
IR3840WM	5x6 PQFN	1.5V to 16V	12A	1.5MHz	OV detection, Sequencing
IR3832WM	5x6 PQFN	1.5V to 16V	4A	1.5MHz	OV detection, DDR tracking
IR3831WM	5x6 PQFN	1.5V to 16V	8A	1.5MHz	OV detection, DDR tracking

For more information call 49 (0) 6102 884 311 visit us at www.irf.com

Sup*IR*Buck™ is a trademark of International Rectifier

International
IOR Rectifier
THE POWER MANAGEMENT LEADER