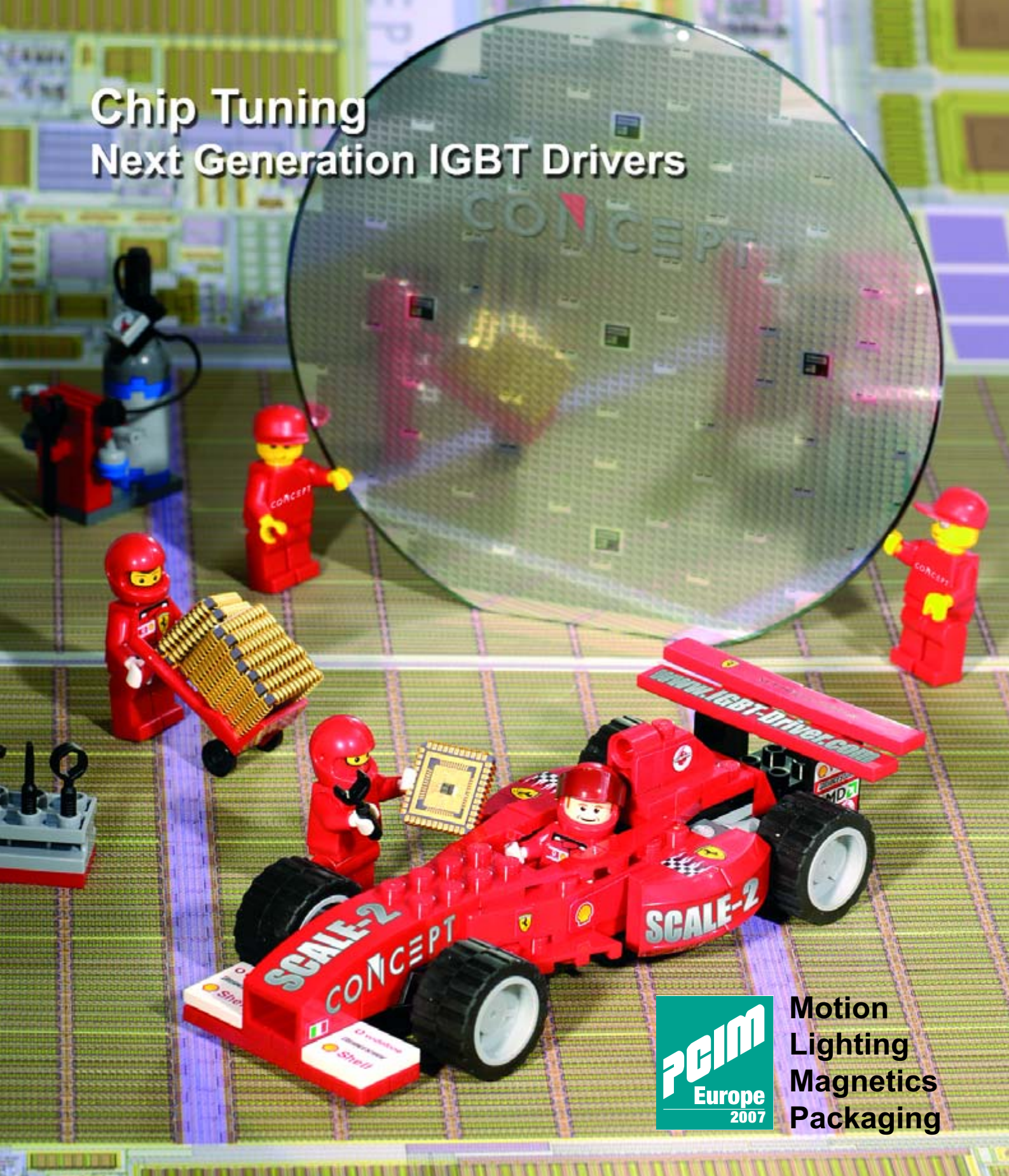


# **Bodo's Power Systems**

Systems Design Motion and Conversion

May 2007

## Chip Tuning Next Generation IGBT Drivers



Motion  
Lighting  
Magnetics  
Packaging

# Everything you need to save our world, 1mW at a time.



## The Power Franchise®

Developing more energy-efficient designs has never been so challenging—or so critical. No wonder power engineers everywhere turn to Fairchild. The Power Franchise offers more power-efficient solutions and support services across a broader range of designs than anyone.

## Advanced technologies inside, leading packaging outside

Leveraging innovative process technologies across power analog, power discrete and optoelectronics products from 1W to 1200W, Fairchild provides the industry's most comprehensive portfolio of standard components and application-optimized ICs. The result? Solutions that maximize energy savings in power-sensitive applications.

## More ways to optimize your designs

Improving energy efficiency is one of many ways Fairchild can help to optimize your designs. For example, our overall component performance and functional integration reduce board space, design complexity and system cost. And with online tools, FAEs and regional centers staffed by PhD-level power engineers, our Global Power Resource™ represents the industry standard in customer design support.

## Satisfy regulatory requirements and exceed customer expectations

Around the globe, discover how Fairchild's power designs can help you meet the most demanding energy efficiency regulations and OEM application requirements.

<b>Viewpoint</b>	
Ready for Nuremberg and PCIM Europe .....	2
<b>Events</b> .....	2
<b>News</b> .....	4-6
<b>Product of the Month</b>	
1200V Converter-Inverter- Brake (CIB) with dedicated Evaluation Board .....	8
<b>Guest Editorial</b>	
The „Plug and Play“ Motor Drive Solution By Alfred Hesener, Marketing Director Europe, Fairchild Semiconductor .....	10
<b>Market</b>	
The Lennox Report; By Robert Lennox .....	12
<b>Market</b>	
Both Europe and the United States Strive to Adopt Renewable Energy Resources By Richard Ruiz Jr., Research Analyst, Darnell Group .....	14-16
<b>VIP Interview</b>	
Interview on Power Device Technology with Alex Lidow CEO, International Rectifier .....	18-19
<b>Cover Story</b>	
Next Generation of Highly-Integrated IGBT Gate Drivers; By Jan Thalheim and Heinz Rüedi, CT-Concept Technologie AG .....	20-23
<b>Packaging Technology</b>	
Thermal Paste Spread and Ready for Use; By Dr. Michaela Strube, Manager Service Engineering, Semikron .....	24
<b>Lighting</b>	
Simple, Efficient, High-Brightness-LED Control By Peter Green, International Rectifier .....	26-28
<b>MOSFET</b>	
Low QGD 200 to 250V Power Trench MOSFETs with Low tRR	
and QRR; By Praveen Shenoy, Sampat Shekhawat, Mark Rinehimer and Bob Brockway, Fairchild Semiconductor, Mountaintop, PA, USA. ....	30-33
<b>Power Supply</b>	
The Effects of Turning off a Converter with Self-Driven Synchronous Rectifiers; By John Bottrill, Senior Applications Engineer, Texas Instruments .....	34-36
<b>Magnetic Components</b>	
Permanent-Magnet Synchronous Generators in Wind Energy Systems; By Dr. Roland Zoller, Product Marketing DM-PM, Vacuumschmelze .....	38-39
<b>Capacitors</b>	
Polycarbonate Capacitors Yesterday, Today and Tomorrow By Sal Cesario, Electronic Concepts, Inc. ....	40-44
<b>Lighting</b>	
From the LAMP to LEDs; By Giorgio Fusari, Freelance Editor and Fabio Luconi Eu Field Application Engineer, Roal .....	46-47
<b>PCIM Show Preview</b>	
System Integrated Drive for Hybrid Traction in Automotive By Fraunhofer Institute of Integrated Systems and Device Technology (IISB) Center for Automotive Power Electronics and Mechatronics, Dr. M. März .....	48-50
<b>Packaging Technology</b>	
Heavy Wire Bonder Set a New Standard By Herbert Stürmann, Hesse & Knipps .....	52-53
<b>Motion Control</b>	
Motion Control and Mixed-signal FPGAs; By Glen Young, product marketing manager, Actel Corporation .....	54-56
<b>Motion Control</b>	
Sensorless Field Oriented Control using an 8-Bit Microcontroller By Arno Rabenstein, Infineon Technologies AG .....	58-60
<b>New Products</b> .....	61-64



**Bodo's Power Systems****A Media**

Katzbek 17a  
D-24235 Laboe, Germany  
Phone: +49 4343 42 17 90  
Fax: +49 4343 42 17 89  
editor@bodospower.com  
www.bodospower.com

**Publishing Editor**

Bodo Art, *Dipl.-Ing.*  
editor@bodospower.com

**Creative Direction & Production**

Repro Studio Peschke  
Repro.Peschke@t-online.de

**Free Subscription to qualified readers**

Bodo's Power Systems magazine is available for the following subscription charges:  
Annual charge (12 issues) is 150 € world wide  
Single issue is 18 €  
subscription@bodospower.com

**Printing by:**

Central-Druck Trost GmbH & Co  
Heusenstamm, Germany

A Media and Bodos Power magazine assume and hereby disclaim any liability to any person for any loss or damage by errors or omissions in the material contained herein regardless of whether such errors result from negligence accident or any other cause whatsoever.

**Events**

**TI Power Supply Seminars Q2,**  
<http://www.ti.com/europe/power07-b>

**National Power Management Design Seminars,**  
April 25 – May 16  
[http://www.national.com/analogseminar/eu\\_index.html](http://www.national.com/analogseminar/eu_index.html)

**PCIM Europe,** May 22-24,  
Nuremberg, <http://www.pcim.de>

**Sensor+Test 2007,** May 22-24,  
Nuremberg, <http://www.sensor-test.de>

**euroLED2007,** June 5-7,  
Birmingham UK, <http://www.euroled.org>

**EPE,** September 2-5, Aalborg DK,  
<http://www.epe2007.com>

**Husum Wind,** September 18-22, Husum D,  
<http://www.husumwind.com>

**Electrical Power Quality and Utilisation,**  
Oct. 9-11, Barcelona.  
<http://www.epqu2007.com>

# Ready for Nuremberg and the PCIM Europe

Those who have been there know that Sauerkraut and Bratwurst is the traditional meal in Nuremberg - but there is so much more to know about this city and its long history of innovation. The very first train in Germany ran between Nuremberg and Fürth and was pulled by a British steam locomotive.. Tin plate toys and especially toy trains have a long history and were manufactured by some great names in this field. Not all of them made it into our computer millennium, but a few are still very successful. Trains have, over the years, fascinated millions and build on the power engineer's knowledge, starting with steam, then diesel, and then electric locomotives. Electric trains have had a lot of influence in my career - as an Engineer I helped establish the right MOSFETs for efficient digital motor controls for toy trains, at a time when higher cell densities were becoming available, the d-pack popular, and smd reflow mounting was under discussion.

Toy trains are still a good place to start for youngsters interested in technology. Stop by at Bodo's Power Systems booth for your chance to win a young engineers education kit: an original Märklin starter set. Just drop off your business card at Hall 12, Booth 457, noting your child's name and age on it. The drawing will take place on Wednesday, May 23rd at 2pm. The winner must be present at the booth to claim the prize, not your child – just you yourself !



Remember, my special focus at PCIM will be Green Power. Mark your calendar for the podium discussion "Green Power - The Challenge of Smarter Design" on Wednesday, May 23rd from 12:05-12:50 in Hall 12, Booth 357. Green power is a very



important thinking process for us. Renewable energy, such as solar and wind power will help to develop a clean future. I am committed to giving Green Power attention in my magazine to design for efficiency, with solar and wind power, worldwide. The Power in Bodo's Power Systems has become green since February.

Also I see a great deal of potential to save energy in our own individual behaviour and habits. Do we turn off unneeded lights in our homes? How long does it take us to decide what to take out of the fridge, while the door is open? Should our fridges have glass doors so that we can see what's in there without opening it? These are just some ideas that might increase awareness of ways to more carefully use and preserve our resources. They can be our own personal contribution to Green Power in our own backyard. Energy is not free and we have to pay for it, not only at the meter, but also with our environment and the risk of increased pollution. Global warming is already a problem and continued industrial development is at risk if we do not take the subject of Green Power seriously.

Looking forward to your visit at my booth and to giving your young engineer a chance to take home the train set!

See you in Nuremberg

Best regards



To help your innovation  
we make ourselves small.



### Minisens, FHS Current transducer

Minisens is taking miniaturization to the next level as it is a fully fledged current transducer for isolated current measurement including magnetic concentrators in an IC SO8 size. This allows you to include all the functionalities you are looking for into the space that you have available.

- Non-contact current measurement with no insertion loss
- Isolation provider
- Attractive price
- Flexible design allows a wide range of current measurement from 2-70 A<sub>RMS</sub>
- +5V power supply
- Access to voltage reference
- Ratiometric or fixed gain and offset
- Standby mode pin
- Dedicated additional fast output for short circuit detection
- High performance gain and offset thermal drifts

[www.lem.com](http://www.lem.com)



Booth 12/402

At the heart of power electronics.





## David Bell as President and COO at Intersil

Intersil Corporation announced the appointment of David Bell as Intersil's President and Chief Operating

Officer, effective April 2, 2007. In addition, Mr. Bell will become a member of the Company's Board of Directors.

Most recently, Mr. Bell served as President of Linear Technology from June 2003 until January 2007. Prior to becoming President, Mr. Bell served as Vice President and

General Manager of Power Products from 2002 to 2003 and as General Manager of Power Products from 1999 to 2002. Mr. Bell started his career at Linear Technology in 1994 as the Manager of Strategic Product Development. He holds a Bachelor of Science degree in Electrical Engineering from the Massachusetts Institute of Technology.

Rich Beyer, Intersil's CEO commented, "We are very pleased to have Dave Bell join Intersil as our President and Chief Operating Officer. We believe that Dave's background and experience with a top tier, high performance analog company make him an ideal fit for this position. I am looking forward to partnering with Dave as we continue to build

upon our success in the high performance analog space."

"I am excited about the opportunity to join what is already a talented high performance analog team," noted Dave Bell. "Intersil has a unique position that balances general purpose products with application specific products to address its four targeted end markets: high-end consumer, computing, industrial and communications. The Company has an extensive analog, mixed-signal and power management portfolio and has exceptional technical and manufacturing expertise."

[www.intersil.com](http://www.intersil.com)



## ACE Awards Honor IR's Chairman for Lifetime Achievement

IR announced that its chairman and founder Eric Lidow received the Lifetime Achievement Award at the

third Annual Creativity in Electronics (ACE) Awards Gala, in recognition of his contributions to the power management industry over the last 60 years.

Brian Fuller, editor-in-chief of EE Times, the award's sponsor, said, "Lidow's achieve-

ments as an entrepreneur, an innovator and businessman with a penchant for green engineering make him a natural for our Lifetime Achievement Award." He added, "Long after most electronics executives have retired, Lidow comes to work every day, driving a hybrid vehicle."

Reflecting on the award, Mr. Lidow said, "This is a wonderful personal honor. Moments like these also create opportunities to look ahead. We, in the industry, must continue to foster innovation in our business."

Eric Lidow was born in Vilnius, Lithuania, he graduated in 1937 from the Technical

University of Berlin with a degree in Electrical Engineering. He immigrated to the U.S. from Germany in 1937. In 1944, Mr. Lidow co-founded Selenium Corporation of America which was acquired by Sperry Corporation in 1944. Three years later, he founded International Rectifier where he continues to serve as Chairman of the Board. He is a Life Associate of Caltech, a Life Member of IEEE, and an Honorary Life Trustee of the Los Angeles County Museum of Art, and holds an Honorary Doctorate from Technion Israel Institute of Technology.

[www.irf.com](http://www.irf.com)



## Sales Office in Shanghai, China

Maxwell Technologies announced that it has opened a sales office here to market its BOOSTCAP® ultracapacitor prod-

ucts, service customers and support its distribution channel partners throughout Asia.

Maxwell senior vice president Alain Riedo said, "We see virtually unlimited opportunities for our BOOSTCAP products in the

Asian transportation, industrial and consumer electronics markets, and Shanghai's central location makes it ideal for servicing the rapidly growing Chinese market and the entire South Eastern Asia region."

The office, which is located at the Swiss Center in Xinzhuang Industrial Park, is staffed by sales and application specialists as well as support personnel, all of whom are fluent in both Chinese and English.

BOOSTCAP ultracapacitors are based on an innovative energy storage technology ideally suited for applications needing repeated bursts of power for fractions of a second to

several minutes. Ultracapacitors have much higher energy density than electrolytic capacitors and many times the power density of batteries. They require no maintenance, and operate reliably in extreme temperatures.

Maxwell also has established a contract manufacturing alliance in China for assembly of its BOOSTCAP products and is supplying its proprietary ultracapacitor electrode material to other manufacturers in Asia.

[www.maxwell.com](http://www.maxwell.com)

## LED Lighting Products and Solutions Website

Avago Technologies announced the launch of a new user-friendly lighting portal that contains all of its light emitting diodes (LED) lighting components and solutions in one convenient location — [www.avagotechlighting.com](http://www.avagotechlighting.com). This new web-based comprehensive resource center was developed specifically for lighting designers who are constantly faced with time-to-market issues and need to quickly find the right LED solution to shorten their design cycle.

Today, new generations of energy-efficient, high brightness light emitting diodes (LEDs) are appearing everywhere in a wide range of applications - from solid-state lighting and electronic signs and signals to consumer, automotive, and industrial applications.

Avago has taken the "one-stop-shopping" approach by developing a web portal that contains all of its LED products and solutions in this new easy-to-use web portal. Moreover, designers can also use the "Ask the Expert" feature on the website to get their specific LED lighting design questions answered directly from one of Avago's best-in-class technical experts.

For lighting designers, being able to quickly find the LED components they need for their applications in one location saves time and is a convenience that will help them meet their design-time-to-market objectives in today's competitive lighting marketplace.

With the broad portfolio of LED lighting products and solutions that Avago provides for electronic sign and signals, automotive, industrial and consumer lighting applications, this new lighting portal will enable designers to find most, if not all, of the LED products and solutions they need in one location.

[www.avagotechlighting.com](http://www.avagotechlighting.com)

[www.avagotech.com](http://www.avagotech.com)

## PCIM Europe 2007 Nuremberg, May 22 - 24, 2007

Product and system developers, Production and Development Managers, Directors and Purchasers from the branches industrial electronics, automotive electronics, office and data technology, medical technology, telecommunication and the energy industry use the PCIM Europe as an information platform for topics of power electronics, intelligent drives and power quality / energy management.

The combination of trade fair and conference presents important synergy effects for participants.

The PCIM 2007 starts off with thirteen tutorials. On Monday, May 21, 2007, top notch specialists from the USA, France, Switzerland and Germany will convey their knowledge on key questions of power electronics in half- and full-day events. The PCIM conference takes place in parallel to the exhibition from May 22 - 24, 2007. The program with its focal points on power electronics, intelligent drives and power quality / energy management offers more than 150 first publications by international speakers.

[www.pcim.de](http://www.pcim.de)

[www.bodospower.com](http://www.bodospower.com)

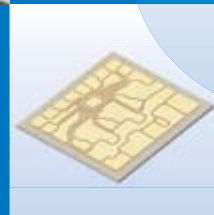


Hall 12  
Booth  
12-310



### Your solution for high power density and extreme environmental conditions

- DBC Substrates for power converters and intelligent power modules
- Moisture-proof casings for sensors, airbag release systems and optoelectronic components



[www.electrovac.com](http://www.electrovac.com)

## High Current Inductors with flat wire coil

SMD Inductors WE-HC & WE-HCA

Current capability up to 65 A

Reference design of all major  
IC manufacturers

Flat wire coil for lower losses  
at high frequencies

No thermal aging

New core material for  
lower core loss

Available ex stock

Samples free of charge

Design-In support included

EMC COMPONENTS  
INDUCTORS  
TRANSFORMERS  
RF COMPONENTS  
PRESS-FIT TECHNOLOGY  
WERI CONNECTORS  
ASSEMBLY TECHNIQUE  
PCIM Booth 12/337



[www.we-online.com](http://www.we-online.com)

## SENSOR+TEST 2007 Nuremberg, May 22 - 24, 2007

A special highlight will be the action area (hall 8), in which visitors can experience sensor and measuring technology live. Also, at the two forums in hall 7 and hall 9, numerous lectures on interesting novelties and podium discussions will be held.

Especially in the action area, visitors can experience sensor, measuring and testing

technology in a way that is simply not possible at a trade-fair stand. Live demonstrations, for instance with test driving, show innovative technologies for real-life applications.

And the exhibitors are right there to answer questions. In interviews and small discussion groups, visitors can gain insights in live pre-

sentations and vehicle trials. Moreover, demonstrations of industrial technology will also be held in the action area. For example, seven models under the slogan "Sensor Integrated" will present sensor technology in motion.

[www.sensor-test.com](http://www.sensor-test.com)

## Power Product of the Year

The Liebert FS flywheel system, manufactured by Pentadyne Power Corporation has been named a Backup Power Product of the Year 2006 by SearchDataCenter.com, a leading information technology industry website. Pentadyne is the original equipment manufacturer of the Liebert FS, which is marketed by Emerson Network Power.

The Pentadyne/Liebert flywheel system can supplement or replace lead-acid battery

arrays used with uninterruptible power supply (UPS) systems. Chemical battery plants require extensive, costly and lengthy permitting, testing and monitoring processes because of their corrosive materials, fire dangers, hazardous fluids and explosive gas emissions.

Batteries are commonly acknowledged as the weakest reliability link in a UPS system, demanding frequent and costly maintenance

and replacement. The Pentadyne/Liebert flywheel system is a more reliable method of energy storage that is far less costly to operate than a 5-minute string of VRLA batteries.

[www.liebert.com](http://www.liebert.com)

[www.socomec.com](http://www.socomec.com)

## E-commerce Platform

Rutronik Webg@te is a modular e-commerce platform consisting of an online catalogue, product change notifications (PCN) database and procurement. Around the clock, Webg@te presents real-time information in an easy to use and comprehensive manner, while also accepting orders and responding to status requests.

The online platform has been in operation

since 2005. The latest new function is the option to place orders for component samples, which was previously only possible "offline". With the inclusion of orders for component samples, the entire Rutronik product range is now available through Webg@te, from semiconductors, passive and electro-mechanical components, to displays & embedded boards and wireless products. In the case of sample orders, the customer will

be requested to provide manufacturer-related project information. For "normal" online orders, the minimum order volume is just one packaging unit. When ordering component samples, customers can even opt for single items.

[www.RUTRONIK.com](http://www.RUTRONIK.com)

## Maxwell at PCIM07

At this year's PCIM exhibition in Nuremberg, Maxwell Technologies will be showing its latest BOOSTCAP® ultracapacitors at Booth 12-333, and will also be presenting a tutorial on advanced energy storage.

The tutorial takes place on Monday, May 21st from 09:00-12:30, and is titled

"Ultracapacitors: Advanced Energy Storage for Peak, Bridge and Emergency Power applications". It is designed for anybody who is interested in

exploiting ultracapacitor technology. It provides the basic understanding, necessary tools, and detailed information so that attendees will be able to confidently and success-

fully use ultracapacitors in large and small cell applications.

[www.pcim.de](http://www.pcim.de)

## IR Completes Sale of Power Control Systems Business

International Rectifier Corporation announced that on April 1, 2007 the company completed the previously announced sale of its Power Control Systems (PCS) business to Vishay Intertechnology, Inc. for approximately \$290 million in cash.

The PCS business consists of the company's Non-Aligned Product and Commodity Product segments. Product lines included in the divestiture are certain discrete planar MOSFETs, discrete diodes and rectifiers, discrete thyristors, multi-chip modules not

including integrated circuits and certain other specified products.

[www.irf.com](http://www.irf.com)





# POWERSEM

OVER 20 YEARS OF INNOVATION

Customised ECO-LINE™ and Standard BASE-LINE™

## POWER SEMICONDUCTOR MODULES

developed and manufactured  
by POWERSEM GmbH, Germany  
by POWERSEM Semiconductors  
Pvt. Ltd., India

Diode/Thyristor Modules

IGBT Modules

MOSFET Modules

IPM Modules

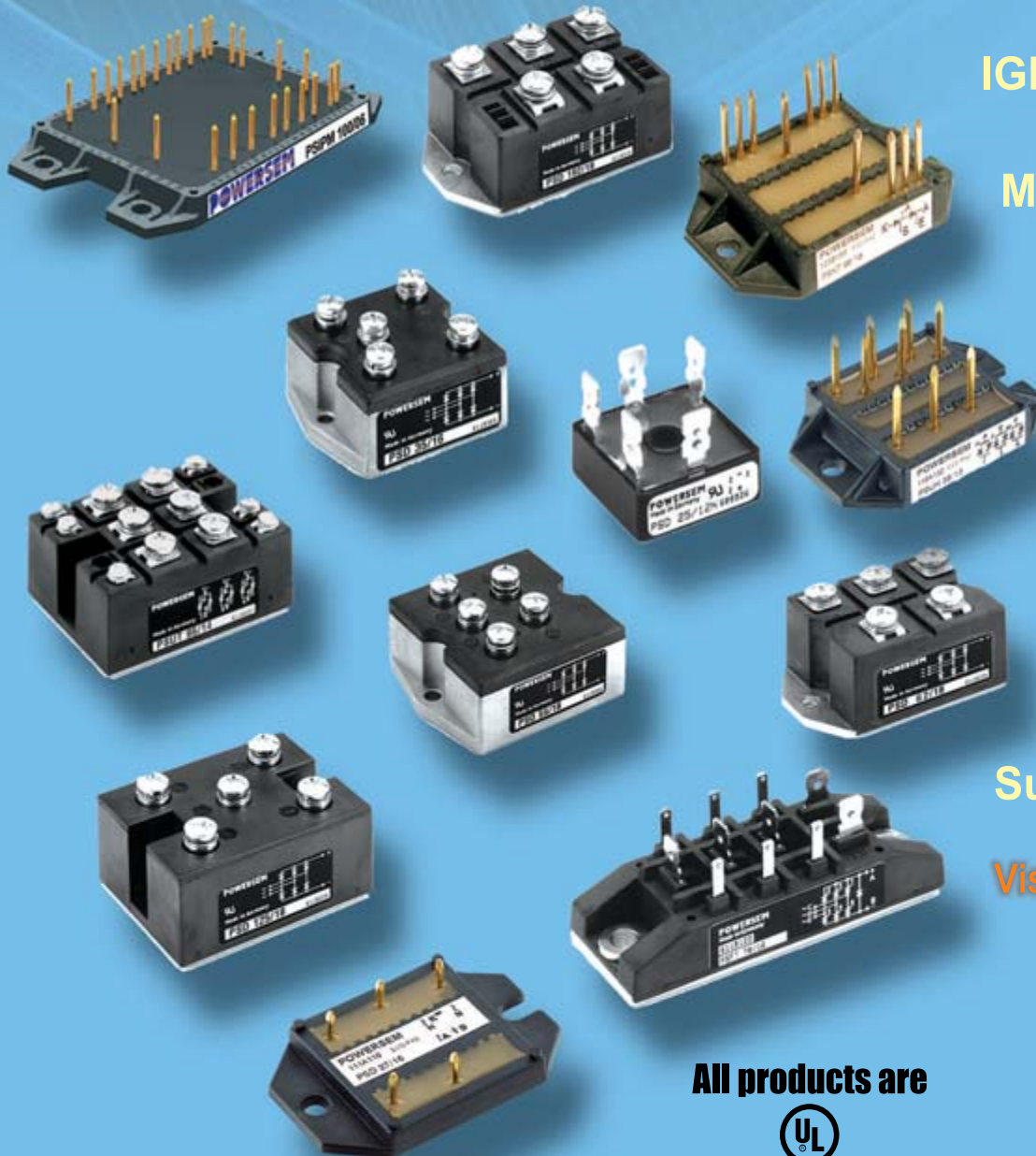
Diode Modules

Thyristor Modules

AC/DC Controllers

Subassemblies

Visit us in May 2007 at :



All products are



certified



International Exhibition & Conference for  
POWER ELECTRONICS  
INTELLIGENT MOTION  
POWER QUALITY  
22 - 24 May 2007  
Exhibition Centre Nuremberg Germany

Booth # 321 / Hall 12

[www.powersem.com](http://www.powersem.com)

[support@powersem.com](mailto:support@powersem.com)

# 1200V Converter-Inverter-Brake (CIB) with dedicated Evaluation Board

By Prasad Bhalerao, Robert Wiatr, Mitsubishi Electric Europe, Germany

Mitsubishi, a pioneer in Transfer Mold Technology has introduced 1200V Dual-in-Line Converter-Inverter-Brake (DIP-CIB) for up to 4kW inverters. The complete one package power platform including 3 phase input rectifier, brake chopper and 3 phase inverter including NTC for the thermal sensing is integrated by transfer mold technology.

The DIP-CIB available in the range from 10A to 25A in 1200V and 20A to 30A in 600V exhibits excellent electrical and thermal dissipation characteristics. It offers a very compact and cost-effective solution for small kW range Drives.

Table 1 shows the line up of 1200 V DIP\_CIB while Figure 1 depicts the picture of 1200 V DIP-CIB.

Type Name	Ratings (Ic/Vces)
CP10TD1-24A	10A/1200V
CP15TD1-24A	15A/1200V
CP25TD1-24A	25A/1200V

Table 1: 1200 V DIP-CIB Line-up



Figure 1: Transfer Mold 1200V Dual-in-Line Converter-Inverter-Brake

The compact package of DIP-CIB assures the minimum creepage distance required by UL and IEC. The DIP-CIB includes the latest CSTBT chip technology already proved in applications like Motor Drive and UPS etc show a good trade-off performance between switching and DC losses.

#### DIP-CIB Features:

- Complete power stage (Converter + Inverter + Brake) in the same package
- Thin transfer mold package (5.7 mm)
- Superior thermal dissipation structure
- CSTBTM (Carrier Stored Trench Bipolar Transistor) for higher performance
- Isolated NTC thermistor integrated
- Full lead-free soldering technology (RoHS)



Figure 2: Evaluation Board for 1200V DIP-CIB (EVBCP25TD1-24A) (1200V HVICs, Shunts, bootstrap circuit and a driver for the brake)

Furthermore, a DIP-CIB evaluation board (as shown in Fig. 2) using dedicated control IC drivers for the evaluation of these DIP-CIBs allows the customers to ensure the quality performance of whole range of DIP-CIBs. A complete compact package of DIP-CIBs with its evaluation tool eases selection of the appropriate device for the application.

#### DIP-CIB Demo-Board Features:

- A specially designed common platform to evaluate the complete performance of the whole range of 1200V DIP-CIBs
- A compact PCB with dedicated HVICs on board to drive the gate and to protect IGBT against SC and UV conditions and LVIC to drive the brake IGBT
- A PCB design layout enabling a low inductive connection between the IGBT and DC link snubber capacitor
- Easy guidelines of evaluation board to the user for the selection of appropriate IGBT gate resistance (Rg) to optimize the switching performance as per the selection of DIP-CIBs
- Simple additional circuitry requirements for the operation
- A package with complete detailed instructions for easy mounting and handling of Demo-kit.
- Further possibility to simulate the power losses by Mitsubishi power loss simulation software MELCOSIM

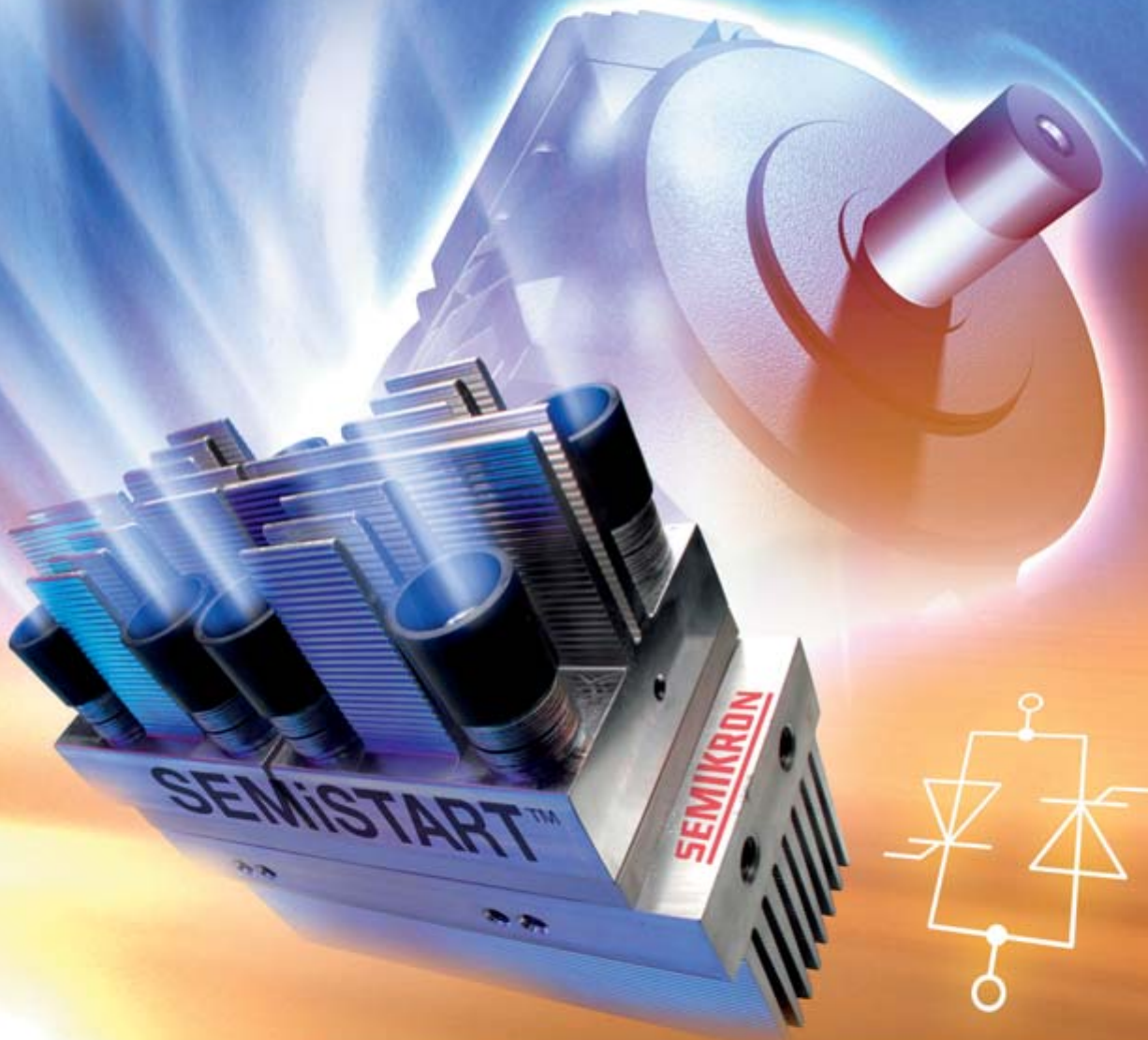
For Further Details Contact:  
 Mitsubishi Electric Europe B.V  
 Semiconductor Division  
 Gothaer Str. 8  
 D-40880 Ratingen  
 Tel : +49 (0) 2102 / 486-0

PCIM Booth 12/421

[www.mitsubishichips.com](http://www.mitsubishichips.com)

# SEMiSTART™

for **compact** soft-starters



- Overload current: 560 A – 3000 A @ 20 sec.
- Max. blocking voltage: 1400 V, 1800 V
- Low thermal resistance
- Heat sink for double-sided cooling
- High load cycle capability
- Pressure contact technology



Booth 12/411

# The „Plug and Play“ Motor Drive Solution

By Alfred Hesener, Marketing Director Europe,  
Fairchild Semiconductor

It is fascinating how many small and medium-sized motors are around us in our daily lives – even with the realization of so many features in an electronic or software way, more and more features are being added to our lives requiring some mechanical motion, adding motors. And, these features require not only simple movement but control in some way, implying the use of more electronics to achieve that.

Examples range from kitchen appliances like dishwashers and refrigerators, hairdryers, printers, armchairs and many more, to applications like a remote control unit that changes shape once you pick it up.

Given the increasing number of these applications, the restricted space and cost as well as the current activities of our governments to improve energy efficiency, it comes as no surprise that – in spite of a BOM cost disadvantage – more and more brushless DC motors are being used, since the advantages of this motor type are significant, and almost recognized as such even by the end users. The efficiency can be improved both at drive as well as system level, features like motion control are handily available, and the system is more reliable and often smaller than a comparable, “old-style” realization.

To quantify the advantages, the system efficiency for the same mechanical output power can move from low the seventies to over 80%, reliability can improve by a factor of 5 or more, and the space requirements are reduced up to 20%. This has led to a sustained unit growth of the motors used in above application in the range of 8% per year, according to ZVEI.

The additional features that make the end applications more attractive are sometimes not so obvious. The increased efficiency allows to reduce the system size and dissipated power (= heat), and will reduce the energy consumption over lifetime, an advantage that can be calculated in euros and cents! The ability to control the speed allows to reduce the noise generation, and increases the efficiency even further, since the drive



only has to run just as fast as needed, at a optimum operating point. And, from a user interface point of view it is possible to move away from simple mechanical switches and use electronic user interfaces with displays and sensor buttons, microcontrollers, and link the application into a larger system (potentially with an information flow in both ways!). Think of a heating pump that communicates its status back to the computer system controlling the house, or a refrigerator, that – instead of a “bang-bang” type of control – is humming away at a constant speed, blending in with the background noise, as modern apartments have open-plan kitchen and living room.

With all these advantages being so obvious, how about the realization? Typically these drive systems were derived from larger industrial drives, using discrete devices in a relatively complex circuit. New module solutions allow a much faster design cycle (since the complex wiring and high-voltage driving are pre-fabricated), higher reliability (all components are tested together), and high flexibility (pin-compatible modules can be swapped for a higher- or lower-power version if need be). And SMD versions of these modules render the manufacturing on

automated tape&reel SMD assembly stations, together with the other components like microcontrollers etc very cost-effective. Gone are the days of a complex, manual assembly process.

A 3-phase inverter module for offline-powered motor applications up to 80W as used in a pump is assembled as a module together with other active and passive SMD components on the PCB in one go through IR reflow, reducing the manufacturing time and complexity significantly.

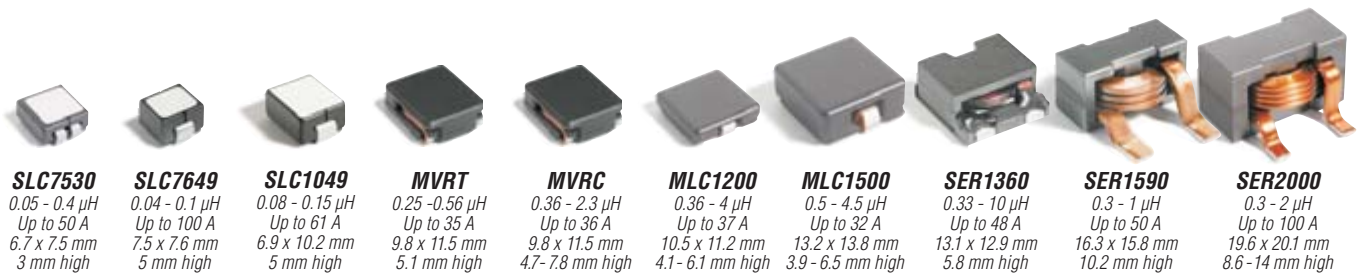
An important aspect that was difficult to cover in low-power motor drives so far is security features. Additional sensors and electronics had to be integrated into a system where the infrastructure for that just wasn't there. Modern smart power modules contain protection circuitry for overtemperature, overcurrent and other abnormal operation modes that will protect not only the module, but the system and thus the user to a certain extent. If some mechanical object were to block the propeller of a fan, it could go up in smoke worst-case – where a protection function is available, the motor would stop and the system could indicate a failure mode, but nothing harmful would happen.

Continued improvement of the power discretes technologies used for the switches in the modules, and integration capabilities in the control ICs of the modules will lead to expansion of their use in many more applications. We have seen a widespread use of multichip-module solutions in power supplies first, now the low-power motor drives experience the same technological breakthrough. And, not only is this in the interest of environmental protection, it helps to reduce system cost and adds more features. With these plug-and-play motor drive solutions available now, it probably is no exaggeration to say that we are in the middle of a “low-power” revolution!

PCIM Booth 12/601

[www.fairchildsemi.com](http://www.fairchildsemi.com)

# If you're doing POL or VRD, check out our SLC, MVR, MLC or SER.



## And get samples NOW!

Only Coilcraft offers such a broad range of high current, low DCR power inductors.

They're perfect for Point of Load and Voltage Regulator applications. Or any place you need maximum current handling in minimum space.

Several models are rated up to 100 A rms. Others have powdered iron cores for maximum saturation current and minimum thermal aging.

Still others offer 5% DCR tolerance, making them ideal for current sensing applications.

As always, you can get free evaluation samples from our web site with just a click of the mouse. We ship same day!

Check out our full line of POL and VRM magnetics ASAP. Visit [www.coilcraft.com/POLd](http://www.coilcraft.com/POLd)



Booth 12/111

# Coilcraft®

21 Napier Place, Wardpark North, Cumbernauld Scotland G68 0LL  
+44/1236/730595 Fax +44/1236/730627

# THE LENNOX REPORT

## ELECTRONIC COMPONENTS INDUSTRY



### GENERAL

The European Union is celebrating its 50th anniversary having meanwhile expanded to 27 member countries and moved far beyond the economic sphere with a

European Commission, European Council, European Parliament and a European Court of Justice increasingly dominating the life of its member states. Major issues to be resolved include "social harmonization", a constitution, enlargement-associated aspects such as adoption of the Euro (now 13 out of 27 states) and NATO membership (23 out of 27). The diversity of membership and deficit-related issues will continue to test the EU on its way to further consolidation.

### SEMICONDUCTORS

The ZVEI reports January 2007 semiconductor sales in Germany (in Euros) down 7% compared to prior year after -9% in December (adjusted) and -4% in November. The 1.02 B/B ratio does not contribute to optimism while members of France's SITE-LESC saw February revenue in France decline 1.4% (in Euros) compared to prior year and even 12.8% compared to the 2006-year-average. However February was up 5.9% and order input 10%, both sequentially. Texas Instruments has introduced a 65 nm implementation of CMOS for Wi-Fi, Bluetooth and FM radio and decided to use foundry partners for future process technologies. It appears that with logic processes fast becoming commodities IC design not manufacturing is the key factor. TI will close its Kilby fab in Dallas and cut 500 jobs by year-end, has introduced battery-management ICs to protect multi-cell, Li-Ion battery packs used in notebooks. Infineon's share price has risen on news that the firm will supply Nokia with some devices for its entry-level GSM phones and speculation that it will provide the main chip for Apple's iPhone.

About 37% of STMicroelectronics' 2006 revenue of \$ 9.85 B, +10.9%, came from telecommunications and especially from Nokia, 17% each from consumer and IT, 15% automotive and 14% industrial. Globally

ST was in N° 5 position last year with a 3.8% share behind Intel, Samsung, TI and Infineon.

News from NEC includes continued cost cutting particularly in the loss making mobile phone business where it has lost share to Sharp and Toshiba and reduced its holding in memory maker Elpida from 8.3% to 6%. The firm has missed a US reporting deadline which could affect its listing at Nasdaq. NEC Electronics will consolidate nine Japanese front-end production lines into four and shift engineering efforts to digital consumer and automotive applications.

### OPTOELECTRONICS

Sharp has been expanding capacity to overcome recent shortages which saw its market share drop, is increasing large size LCD TVs to compete with plasma and will step up production in Poland of LCD TV components. Sony overtook Sharp and Samsung as global leader in LCD TV sets last year occupying a 16% market share ahead of Samsung's 15% and Sharp's 11.5%, so DisplaySearch, while Showa Denko will make compound (gallium nitride, GaN) semiconductors for use in blue and white LEDs.

### PASSIVE COMPONENTS

Consultant Pier Sacchi expects European passive component market growth this year at about 2% after close to 3% with strength coming mainly from Germany and Eastern Europe. Epcos has acquired Aktiv Sensor, a Berlin-based pressure sensor and system producer employing 60 with € 5 M sales last year. This move complements Epcos' temperature sensor program in a growing market. The firm is exploring cooperation and acquisition possibilities and has installed an online service to comply with China's RoHS regulations. Omron is expanding its pioneering work in face recognition called OKAO Vision. The company employs 24 000 worldwide, has European offices in Sweden, UK, France, Germany, Italy, Spain and the Czech Republic.

### OTHER COMPONENTS

According to iSuppli the image sensor market is driven by cellular phones with about 65% of the nearly 1 B units sold last year featuring integrated cameras, a ratio to grow

to 85% by 2010. Camera-less handsets are expected to decline to 14.8%. Mobile phones are the dominant application for CMOS sensors accounting for 88% of shipments in 2005. The purchase by Linde of the UK's BOC propelled the firm into leadership in the industrial gas supply industry with estimated sales of \$ 12 B, is now re-organizing including the disposal of its BOC Edwards Components division to CCMP Capital. Linde's market share is put at about 21% followed by Air Liquide, 19%, Praxair 13%, Air Products 10%, Nippon Sanso 4% and Airgas 3%, others 30%.

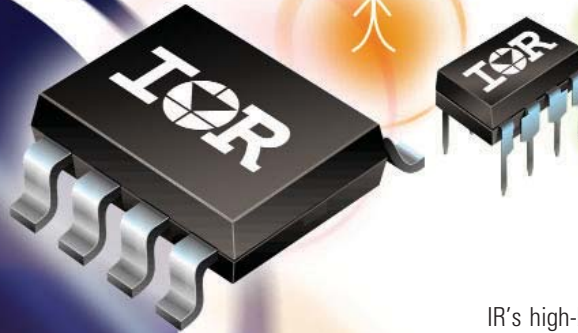
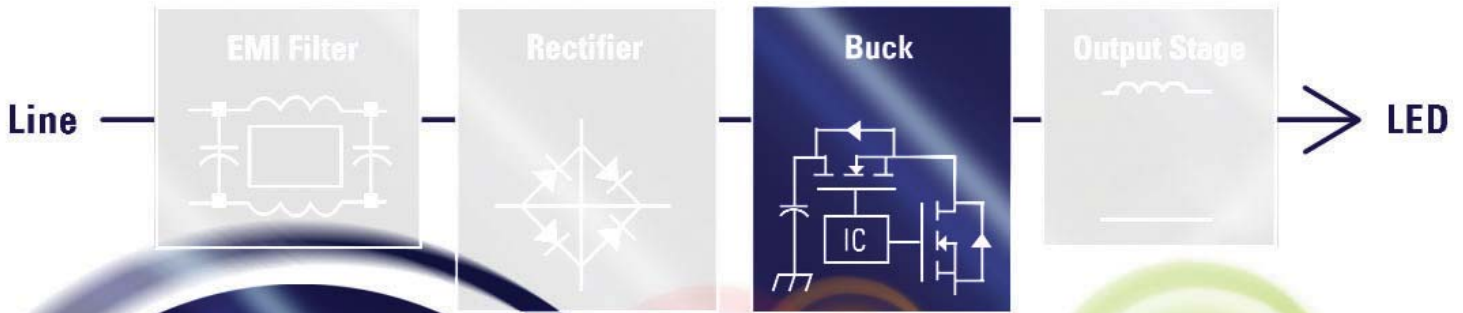
Schurter has acquired the Swiss firm TICOMEL, a 500-person, SFr 24 M sales producer of electromechanical components boosting its total employment to about 1600 with now ten production companies.<

### DISTRIBUTION

IDEA reports a 12.1% growth last year of its members in Germany, UK, Italy, France and the Nordic Region. Issues facing distributors in 2007 include the need to perform demand creation instead of simply accumulating franchises coupled with an effective design registration/remuneration system operated by suppliers, out-of-franchised territory shipments increasingly gaining in importance and the ability to identify growth markets. Rutronik is extending its Infineon franchise beyond Germany, Switzerland, Italy, France, Benelux and Eastern Europe to the UK, Ireland, Spain, Portugal and South Africa, has named Jose Alemany general manager of its French affiliate replacing Alain Bardy who assumes other responsibilities. Germany. The FBDi reports that the German distribution market (DTAM) grew 17% last year to € 2.53 B with semiconductors up 16.5% to € 1.78 B, passives +12.1% to € 393 M and electromechanicals +22% to € 283 M. America's Nu Horizons, already established in the UK, reportedly will open a branch in Munich next month headed by Mr. Reisinger, ex-Future and Azego. Xilinx rep Intercomp is supporting the new firm which will handle Xilinx, Hynix, SMSC and Oki among others. Ecomal's European Technical Support Center has been holding group discussions for design optimization while Glyn promotes the new Renesas 32 bit microcontroller line.

# PRECISE, RELIABLE, HIGH BRIGHTNESS LED DRIVER ICs

*For Constant LED Current Regulation*



IR's high-brightness LED driver IC's, adapt and compensate to LED parameter variations to enable a highly accurate and inherently stable design.

## FEATURES

- 200V or 600V control IC in compact 8-pin DIP or SO package
- Incorporates continuous mode, time-delayed hysteretic buck regulator
- External high-side bootstrap circuit delivers frequencies up to 500kHz
- Low-side driver provided for synchronous rectifier designs
- Micro-power startup of less than 500µA
- 140ns deadtime for continuous current regulation
- Auto restart, non-latched shutdown and PWM dimmable capability

Part No.	Package	Voltage	Load Current Regulation	Micro-power Start-up	Deadtime	Frequency
IRS2540PbF	DIP8, S08	200V	+/-5%	<500µA	140ns	<500kHz
IRS2541PbF	DIP8, S08	600V	+/-5%	<500µA	140ns	<500kHz

# Both Europe and the United States Strive to Adopt Renewable Energy Resources

*Germany and Denmark are at the forefront of this technology*

*In an attempt to become more energy independent, industry and government agencies in both Europe and the United States are looking for ways to effectively utilize alternative energy resources.*

*By Richard Ruiz Jr., Research Analyst, Darnell Group*

Europe is well on its way to achieving its pledged target of providing nearly 22% of energy sources as renewable energy by the end of the decade. In contrast, US renewable energy resources currently provide just over 6% of the total energy output, but in the next few years that figure could increase considerably. According to a new report by the Worldwide Institute and the Center for American Progress, many of the new technologies that harness renewables such as wind and solar power are, or soon will be, economically competitive with fossil fuels. In fact, in an effort to encourage the use of alternative power, lawmakers in Washington, DC recently enacted a number of measures designed to promote the use of renewable power on a national scale. In a big step toward achieving that goal, Congress extended the renewable energy production tax credit for an additional year. This tax credit offers 1.9 cents per kilowatt hour of energy created by new investments in geothermal, solar and wind technologies. The credit was set to expire in early 2008, but will remain in effect through to the end of December 2008. Although not considered a windfall, the tax break could mean US\$1 million or more to investors in new energy production. It is anticipated that the tax credit could stimulate further alternative energy investments, at least for the duration of the credit extension. In addition to federal efforts, many states are becoming increasingly involved in the expansion of renewable energy projects.

The European Commission estimates that the European Union (EU) could be forced to import 70% of its energy and up to 90% of its oil in the next 20 to 30 years, if no new measures are taken. In light of this, the EU has adopted an aggressive policy of developing and promoting alternative energy resources. In addition to the security and diversity of the region's energy supply, alternative energy also solidifies Europe's commitment to environmental protection by complying with the Kyoto protocol. Countries like Germany and Denmark are at the forefront of this technology and are leading the way for the rest of Europe. Germany, by far the world's leading producer of wind power has decided to phase out nuclear power entirely, and focus on clean alternative energy. In addition, the European photovoltaic PV power electronics market is growing and is the largest in the world. The continued demand for PV is expected to fuel the demand for inverters, which are needed to condition the power and make it useable to end users. According to the Darnell Group, the European inverter market is projected to grow from US\$969 million in 2006 to almost US\$2.1 billion in 2011, a compounded annual growth rate (CAGR) of 16.5%.

This growth is expected to continue and can be seen in Bavaria, Germany, where Powerlight Corporation, K&S Consulting and Deutsche Structured Finance recently completed the world's largest solar photovoltaic project. Together with Siemens AG; the regional German Utility, E.ON, secured interconnection to the electrical grid at each site. Along with the production of electricity, the creation of jobs is considered to be one of the most important driving factors in the development of alternative energy sources in this region. Critical to this project's development was the German Renewable Energy Law, which is considered to be landmark legislation that promotes the most advanced renewable energy policies in the world. This type of legislation is expected to spread to other areas of the region and further drive growth in the PV market.

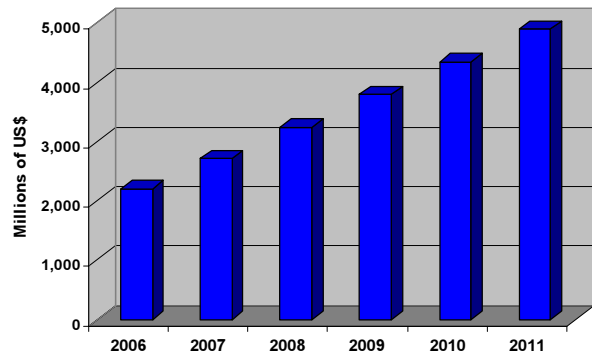


Figure 1 – Worldwide Inverter Sales

Currently, all but four US states have incentives in place to promote renewable energy, while more than a dozen have enacted new renewable energy laws. One of the most prominent programs is in California, where the California Independent System Operator (ISO), a not-for-profit public-benefit corporation charged with operating the majority of the states' high-voltage wholesale power grid, is asking the Federal Energy Regulatory Commission (FERC) to approve a new financing plan that allows renewable generation developers in the state to begin paying their fair share for efficiently sized transmission after their generation begins operating, as opposed to shouldering the costs up front. The state of California's Renewable Portfolio standard (RPS) requires most utilities in the state to obtain 20% of the electricity they deliver from environmentally friendly resources by 2010. The purpose of the plan is to encourage the expansion of alter-





## Cure for the Uncommon Power Source

Barrel jacks are a simple and effective way of connecting portable electronics to an external power supply. But what happens when the user plugs into a supply operating at the wrong voltage? Or what about when the supply is dirty and full of nasty voltage surges, as is often the case when power is supplied from an automobile power jack? Raychem Circuit Protection PolyZen™ devices can help protect your DC power ports by clamping excess voltages and smoothing inductive voltage surges. The PolyZen device's unique polymer-protected precision Zener design can help cure these all-too-common power problems.

To learn more, visit [www.circuitprotection.com/polyzen](http://www.circuitprotection.com/polyzen).

### Features

- Overvoltage transient suppression
- Stable Vz vs fault current
- Time delayed, overvoltage trip
- Time delayed, reverse bias trip
- Power handling on the order of 100 watts
- Integrated device construction
- RoHS compliant

### Benefits

- Stable Zener diode helps shield downstream electronics from overvoltage and reverse bias
- Analog nature of trip events minimizes upstream inductive spikes
- Minimal heat sinking
- Single component placement
- Helps reduce warranty returns & replacement costs

### Applications

- Cell Phones
- PDAs
- MP3 Players
- DVD Players
- USB Hubs
- Media Players
- Wireless Base Stations
- Printers
- Scanners
- Hard Drives
- Desk Phones
- PBX Phones
- Digital Cameras

[www.circuitprotection.com](http://www.circuitprotection.com)

Diestsesteenweg 692 • 3010 Kessel-Lo Belgium • Tel +32 16 351708 • Fax +32 16 351319

© 2007 Tyco Electronics Corporation • [www.tycoelectronics.com](http://www.tycoelectronics.com)  
Raychem, PolyZen, TE Logo and Tyco Electronics are trademarks

 **Tyco Electronics**

Our commitment. Your advantage.

native energy resources, such as solar and wind, to a wider geographical area. According to the California ISO, as more wind, solar and other alternative energy sources are developed in the state, a new type of financing mechanism needs to be in place to facilitate the development of transmission projects that reach remote locations, where companies are developing renewable energy resources.

One area expected to immediately benefit from both federal and state efforts is the solar power industry, which is expected to see tremendous growth over the next several years. The solar photovoltaic market has demonstrated an aggregated global growth rate of more than 40 percent per annum over the last 10 years. This growth can be seen in the Worldwide Inverter market, which the Darnell Group expects to grow from US\$2.2 billion in 2006 to US\$4.9 billion in 2011, a CAGR of 17.3%. In fact, the installation of new solar photovoltaic devices in the United States increased approximately 33% in 2006 over the previous year. Worldwide PV installations totaled 1,744 megawatts (MW) in 2006, a new record growth of 19% over 2005, with 8% of those installations, or about 140 MW, installed in the United States. Also, according to the US Department of Energy's Energy Information Administration's (EIA) latest data, domestic shipments of photovoltaic cells and modules reached a record high of 133,465 peak kilowatts in 2005, and are expected to exceed that total in 2006, when numbers are released. This is a 72% increase over the 2004 record of 78,346 peak kilowatts and an increase of more than 176% over the 2003 level. Despite the fact that prices for solar panels, and photovoltaic cells and modules, rose due to material cost increases, the US manufacture of both thermal collector and PV cells and modules continues to grow at a strong pace. So far, the solar industry has been able to absorb most of the rising material costs because it has become more flexible in its production methods and supply arrangements over the past years.

In addition to regulatory incentives at both the state and federal level, other factors such as advancements in technology and innovation, which drive down the price of solar power, growing economies of scale, net metering and concern regarding the volatility of foreign oil and conventional energy supplies have contributed to the growth of PV installations in the US, which is fueling growth in the inverter market. The North American inverter market is expected to grow from US\$196 million in 2006 to US\$415 million in 2011, a CAGR of 16.2%. A number of ongoing or proposed projects reflect one or more of these factors. In February, the Colorado Public Utility Commission (PUC) approved an 8MW PV installation which SunE Alamosa, LLC will construct in Alamosa before the end of the year to provide solar power to Xcel energy and its customers. The project will call for the facility to be in operation by December 31st, 2007 in order for Xcel Energy to start generating solar renewable energy credits as soon as possible. It will also ensure that the developer, SunE Alamosa1, LLC, can take advantage of a 30 percent federal investment tax credit available for non-utility solar facilities placed into service before Jan. 1, 2008, which will benefit Colorado ratepayers. In March, the Nevada PUC approved a 20-year contract between the Nevada Power Company and Solar Star NAFB for the installation of an 18MW installation at Nellis Air Force Base. The Nevada PUC also approved 562 applications for customer sited PV installations that will

qualify for the state's Solar Generations program, which is designed to facilitate the installation of PV systems in the state of Nevada through subsidized rebates.

One of North America's unique PV energy projects is the Frito Lay distribution center located in Rochester, New York. The facility was intended to be an environmental distribution center prototype, with the goals of using alternative energy sources, energy independence, reduced reliability on the utility grid and peak energy demand cost

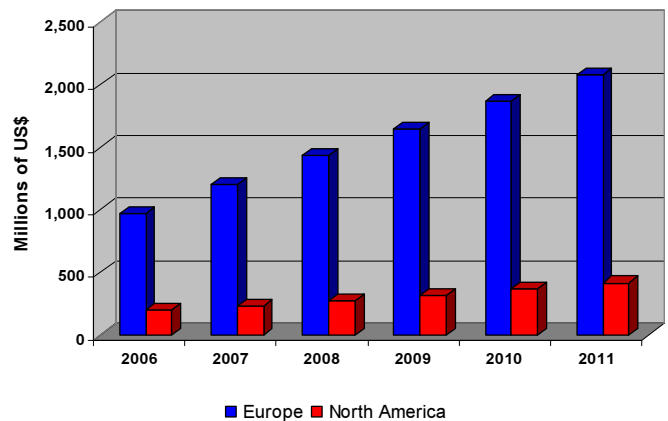


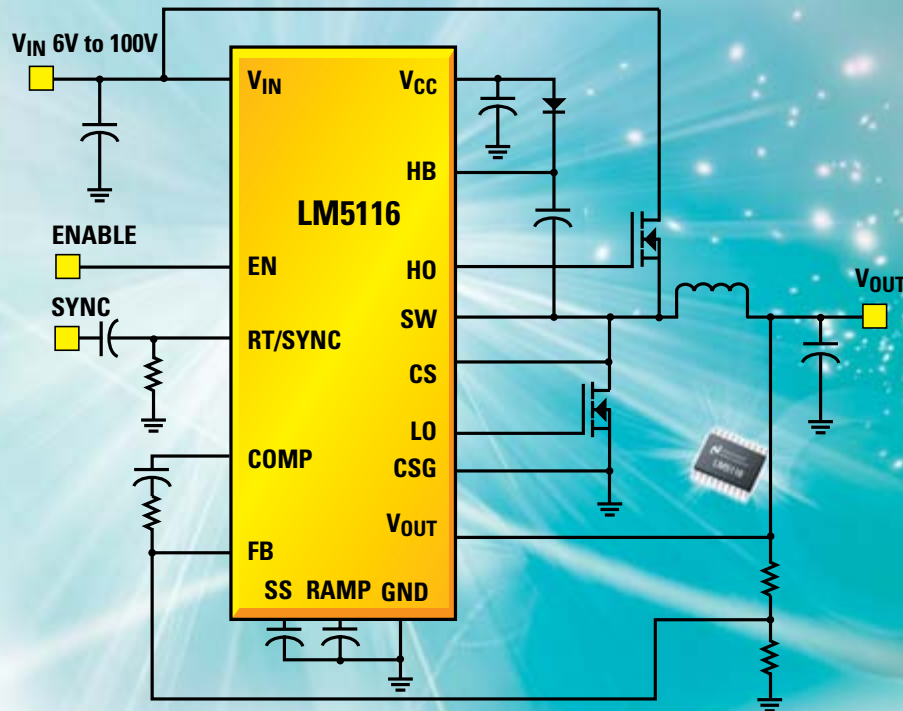
Figure 2 – Worldwide Inverter Sales (A Comparison) saving. The New York-based Nextek Power Systems Company designed and installed a high-efficiency lighting system for this facility that utilizes dc fluorescent ballasts, roof integrated solar panels, occupancy sensors, and daylight sensors for efficiency. The warehouse is equipped with 21kW of solar panels, and a canopy in the office is equipped with 2.1kw of Sharp panels. Nextek has developed a proprietary power system, the Nextek Power Gateway, which uses a technology called Direct Coupling®. With Power Gateway, power generated as dc remains dc and is used without conversion, bypassing both the inverter and rectifier inside the device. Since the system never converts the power to dc, it avoids inverter losses, grid interconnection issues and often requires no utility permitting. The system uses all available energy from locally generated sources (such as photovoltaic cells) first, then “fills in” with power from the grid or, when the grid is not available, from batteries. Power generated as direct current is used as dc to support fixed dc loads in the building such as dc fluorescent lighting, motor controls, and more.

As technology improves, the cost of solar PV power continues to decline to the point where it is becoming more competitive with other types of less expensive alternative energy sources. However, despite the strong demand for PV power, the industry still relies on some form of government intervention or support. If any of the government incentives are scaled back or withdrawn, the negative effect on the development of future solar energy projects would be substantial.

[www.darnell.com](http://www.darnell.com)

# Industry's First 6V to 100V Current-Mode Buck Controller

## LM5116 Synchronous Controller Features Emulated Current Mode (ECM) Control for High Step-Down Ratio

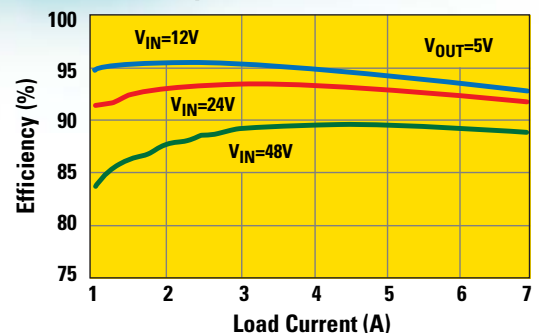


### LM5116 Features

- Ultra-wide input range: 6V to 100V
- Programmable output from 1.215V to 80V
- Less than 10  $\mu\text{A}$   $I_{\text{Q}}$  in shutdown mode
- Frequency adjustable to 1 MHz with sync capability
- Programmable soft-start
- Drives standard or logic-level MOSFETs
- $R_{\text{DS(ON)}}$  or resistor current sensing
- Controlled start-up into pre-biased load
- Available in thermally enhanced TSSOP-20 packaging

Ideal for use in telecommunications, automotive, and industrial control applications.

Typical Circuit Efficiency



For samples, datasheets, and more information  
on the LM5116, contact us today at:

[power.national.com](http://power.national.com)

Phone: +44 (0) 870 240 21 71

Email: [europe.support@nsc.com](mailto:europe.support@nsc.com)

**National  
Semiconductor**  
The Sight & Sound of Information

# Interview on Power Device Technology

*with Alex Lidow CEO, International Rectifier*

*By Bodo Arlt, Editor BPSD*

**Bodo Arlt:** What end markets will drive IR for power management technology?

**Alex Lidow:** IR's key focus remains on areas where we can bring the greatest power-savings benefit. These are computing, communication, appliances, lighting, and motion control.

**Bodo Arlt:** What is IR's position besides the wide range of discretes and ICs?  
**Alex Lidow:** IR is very much applications focused. Our experiences in fast-growing applications show ample opportunities where we are applying our expertise to our customers' most difficult power-management challenges.

**Bodo Arlt:** What are the technologies that can offer innovation for leadership?

**Alex Lidow:** IR's digital control algorithms, digital control ICs, analog ICs, mixed signal ICs, discrete transistors, and specialized power packaging technologies continue to lead the industry. IR is building on these platforms to meet the needs of evolving applications.

**Bodo Arlt:** What impact had the sales of your commodities to Vishay?

**Alex Lidow:** We have a clear strategy and mission within IR to focus on energy savings. The non-focused items we sold to Vishay did not fit our mission. Our focus products grew 31% y/y and contribute well to the IR strategy.

**Alexander Lidow,  
Ph.D. Chief Executive Officer  
International Rectifier Corporation**



Alexander Lidow joined International Rectifier in 1977 as a Research & Development engineer. Subsequently, he served the Company as Vice President of R&D. He was promoted to Executive Vice President of Manufacturing & Technology in 1985 and served as President of IR's Electronic Products Division beginning in 1989. He advanced to Executive Vice President of Operations in 1992 and was named to his current position as Chief Executive Officer in March 1995. A co-inventor of the HEXFET® power MOSFET, Dr. Lidow holds nine patents on power semiconductor technology and has numerous publications on related subjects. Dr. Lidow earned a B.S. degree in Applied Physics from California Institute of Technology in 1975. He received a Ph.D. in Applied Physics from Stanford University as a Hertz Foundation Fellow. His professional associations include the Institute of Electrical & Electronics Engineers, the Electrochemical Society and Tau Beta Pi.

**Bodo Arlt:** Is power management more in silicon, or is it also part of packaging technology?

**Alex Lidow:** In power electronics, you must have both—the silicon and the packaging. At today's currents and switching speeds, the package is part of the circuit.

**Bodo Arlt:** What makes IR different from traditional IC suppliers?

**Alex Lidow:** IR practices technology-pull. Rather than determine what a favourite technology can make, we analyze customers' needs and pull together those technologies necessary to best address them. . We are able to drive the best discrete devices with specially designed drivers in specially designed packages. The combination of all these technologies yields a system performance that is better than can be achieved using anybody else's IC products in our focus applications.

**Bodo Arlt:** What makes IR different from traditional discrete semiconductor suppliers?

**Alex Lidow:** IR is in a unique position due to our complete focus on all elements of power management. We are able to drive the best discrete devices with specially designed drivers in specially designed packages. The combination of all these technologies yields a system performance that is better than can be achieved using anybody else's discrete products.

**Bodo Arlt:** How much is IR involved in the end customer's application?

**Alex Lidow:** IR works to understand our customers' problems by deploying a technical sales team with the best expertise in the industry. Most commonly, solving our customers' problems involves developing an understanding of their customers' problems. An example would be in white goods appliances where we make products for controlling electric motors. Without an understanding of what the end consumer wants, things like faster wash cycles and gentler agitation, we cannot design digital controllers with the right features and functions.

**Bodo Arlt:** How much is IR involved in automotive applications using the advantage of ICs?

**Alex Lidow:** The "electronification" of energy-efficient automobiles fits perfectly into IR's focus. This is particularly true of hybrid-electric vehicles. Their high-voltage power systems fit with IR's established strengths in high-efficiency motion control

**Bodo Arlt:** What will be the future for line voltage and driver technology?

**Alex Lidow:** While it appears unlikely that the distributed power line voltages will see a significant change in the near future, there are several new application areas which may involve higher bus voltages for inverter and motor drive applications. 600 and 1200 V switches will continue to be the dominant choice for off line motor drive application for the foreseeable future.

**Bodo Arlt:** Do we expect more monolithic components in power including ICs and switches at line voltage?

**Alex Lidow:** Packaging technology is developing as quickly as semiconductor technology. Package technologies such as used in DirectFET and iPOWIR products change the equation in power management such that discrete switches integrated with ICs in thermally-efficient multichip packages may be more economical than monolithic power ICs for many years to come.

**Bodo Arlt:** Do we expect to see more high voltage IC technology in the line voltage range?

**Alex Lidow:** Absolutely. We are already there. IR's expertise in analog and mixed signal ICs at 600 and 1200V nodes provide strong foundations for many applications operating off of line voltage.

**Bodo Arlt:** Who are your competitors you believe will stimulate the race for leadership?

**Alex Lidow:** We at IR see a myriad of opportunities for our products and this mix of opportunities produce various competitors with not one dominate player.

**Bodo Arlt:** Thank you Alex for the time. We look forward to a successful future for power management.

**Alex Lidow:** Thanks Bodo.

PCIM Booth 12/202

[www.irf.com](http://www.irf.com)

**PCIM Europe 2007** Booth 12/648

**Easy to insert, clip around, Rogowski ac current sensors**

**CWT**

- Peak currents from 30A to 600kA
- Peak coil insulation voltage 10kV

**CWT ULTRA MINI**

- Peak currents from 30A to 300A

**CWT MINI**

- Peak currents from 30A to 600kA
- Peak coil insulation voltage 2 or 5kV

• Wide-bandwidth from 0.01Hz up to 20MHz

**Custom Designs - contact Power Electronic Measurements Ltd to discuss your current measurement needs**

Tel: +44 (0)115 925 4212 • Email: [info@pemuk.com](mailto:info@pemuk.com) • Fax: +44 (0)115 967 7685 or visit [www.pemuk.com](http://www.pemuk.com)

MAKING MODERN LIVING POSSIBLE

*Danfoss*



## Simplify your design!

E0 to E3 size • Short and long pins • Flexible pin-out  
IGBT's and MOSFET's from world class manufacturers • Low and high voltage  
For industry, transportation and automotive

PCIM Booth 12/325

**We design and manufacture to your needs.**

# Smart Power Chip Tuning

## *Next Generation of Highly-Integrated IGBT Gate Drivers*

*The SCALE-2 chipset helps designers to optimize switching performance, reliability and scalability as well as application flexibility and time-to-market. It is specifically optimized to fit various IGBTs and applications ranging from 150A to 3600A and 1200V to 3300V but is also preconfigured to allow application-specific customization.*

*By Jan Thalheim and Heinz Rüedi, CT-Concept Technologie AG*

With the SCALE-2 chipset, CONCEPT introduces its next-generation technology platform for scalable IGBT and power MOSFET gate drivers introducing major advances in dynamic performance, accuracy, functionality, flexibility and time-to-market. The design

fully employs the methodology of the SCALE drivers that are used in large item numbers and have been tried and tested within a great diversity of applications. The chipset includes several variants of secondary-side Intelligent Gate Driver (IGD) ASICs and a

primary-side dual channel Logic-to-Driver Interface (LDI) ASIC and was implemented in an extended-drain double-well dual gate oxide submicron CMOS foundry process. This combination of state-of-the-art analog capabilities with moderate digital feature size yields an optimum cost-performance ratio.

The highly integrated gate driver core implements all required functionality and allows easy power scaling up to 20W / 20A and beyond. The pre-driver stages are primarily designed to assure optimum performance for direct driving of external n-type DMOS up to a gate charge of typically 15nC by using separate gate resistors for independent control of turn-on and turn-off.

For a prototype IGBT driver aimed at high-power induction heating appliances with 20A and 20W gate driving capability, switching frequencies of up to 750kHz (burst), 300kHz (continuous) and less than 50ns delay time and 1ns jitter are achieved.

### **Key features of the SCALE-2 chipset include:**

- Integrated 5.5A / 0.8W driver core
- Separate gate current paths
- Regulated gate-emitter voltage
- DC/DC power supply circuitry
- Signal transformer interfaces
- Fiber optic interfaces
- Secondary-side fault input / output
- Flexible fault management
- Advanced active clamping modes
- Direct and half-bridge modes
- 3.3V to 15V logic compatible
- Fast setup and superior adaptability

### **Typical applications include:**

- Low jitter and drift IGBT drivers
- Switching frequencies up to 750kHz
- Parallel and series-connected IGBTs

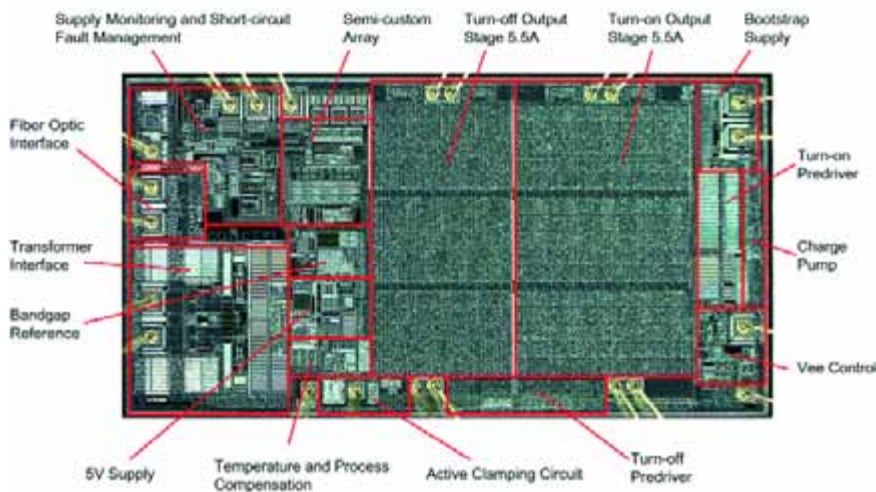


Figure 1: Intelligent Gate Driver (IGD) micrograph and partitioning.

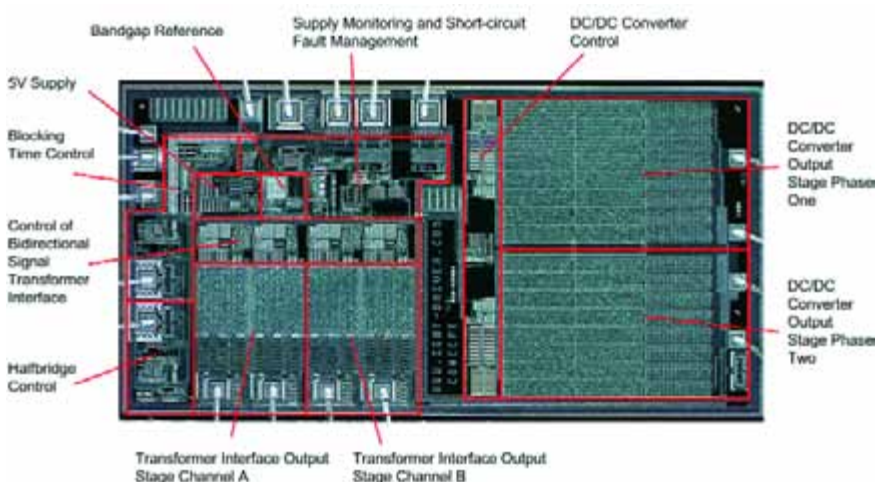


Figure 2: Logic to Driver Interface (LDI) micrograph and partitioning.

# The Best-Selling 2-Channel IGBT Driver Core

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

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

## Chipset Features

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

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



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

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

Isolated DC/DC power supply with 3W per channel

More information: [www.IGBT-Driver.com/go/2SD315AI](http://www.IGBT-Driver.com/go/2SD315AI)



Booth 12/102

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

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

By providing leading-edge solutions and expert professional services, CONCEPT is an essential partner to companies that design systems for power conversion and motion. From custom-specific integrated circuit expertise to the design of megawatt-converters, CONCEPT provides solutions to the toughest challenges confronting engineers who are pushing power to the limits.

As an ideas factory, we set new standards with respect to gate driving powers up to 15W per channel, short transit times of less than 100ns, plug-and play functionality and unmatched field-proven reliability.

In recent years we have developed a series of customized products which are unbeatable in terms of today's technological feasibility.

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

# CONCEPT

**CT-Concept Technologie AG**  
Renferstrasse 15  
2504 Biel-Bienne  
Switzerland

Tel +41-32-341 41 01  
Fax +41-32-341 71 21

Info@IGBT-Driver.com  
[www.IGBT-Driver.com](http://www.IGBT-Driver.com)

**Let experts drive your  
power devices**

### Integrated Gate Driver Core

A micrograph of a prototype gate driver ASIC is shown in Figure 1. The active die area is about 4mm x 2mm. Very low-cost bonding variants are used to control the specific functionality of different standard products including options for bidirectional-signal-transformer and fiber-optic interfaces. The ASIC also contains a semi-custom array for additional degrees of customization. Advanced control options may be realized through a single programming metal mask. The semi-custom array contains preconfigured cells such as analog comparators, logic gates, primitive devices and pads.

A micrograph of a Logic-to-Driver Interface ASIC is shown in Figure 2. The active die area is about 4mm x 2mm. The ASIC implements a dual-channel bidirectional transformer interface, a scalable DC-DC converter with dedicated startup sequence as well as scalable setup and fault management.

The IGD ASIC provides a regulated +15V gate-emitter voltage for the turn-on and on-state by adjusting the emitter potential at the "Vee" pin (see Figure 3) with options to set a custom-specific gate-emitter voltage.

Both the turn-on and turn-off gate-driver output stages use lateral n-type DMOS transistors based on an extended standard CMOS process. The limiting factors of lateral devices are their high silicon cost per on-resistance and the large variance of their saturation current and on-resistance over the process and temperature at a given gate-source voltage. The resulting timing divergences may have a severe impact on the current distribution between parallel-connected IGBTs with separate gate drivers. The large integrated DMOS transistors are therefore driven by a regulated gate-source voltage which tracks the process and temperature variations. This measure also permits accurate control of the transient behavior of IGBTs. The ASIC incorporates circuitry to realize closed-loop control of both the rate of rise [1] and clamping level [2] of the collector-emitter voltage of the IGBT at turn-off. Faster response of the Active Clamping process, reduced turn-off switching losses and enhanced short-circuit turn-off capability can then be achieved.

For the turn-on output stage, a process and temperature-compensated gate-source voltage is provided by combining an adaptive charge pump circuitry with a regulated bootstrap power supply. This enables a range of duty factors for the output pulse from 0 to 1 and also supports the direct driving of auxil-

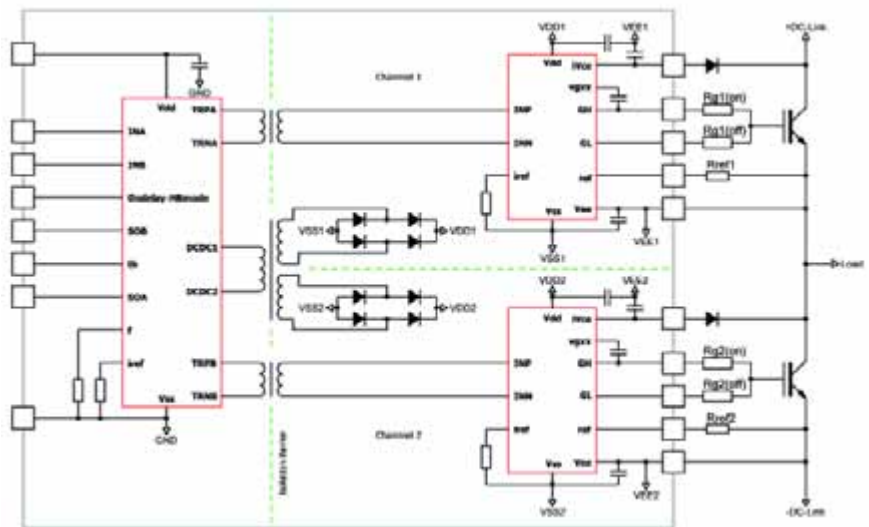


Figure 3: Schematics of a highly integrated SCALE-2 dual-channel IGBT driver core.



Figure 4: Dual-channel IGBT driver cores with external n-type DMOS driver stages for 20A / 4W gate capability (left), and a fully integrated version for 5.5A / 0.8W gate capability (right).

iary n-type driver MOSFETs for easy scaling of gate power and current. Despite the increased complexity, this solution consumes no more silicon area than a simple p-MOS output stage.

The bidirectional transformer interface transmits both command and fault signals via short single pulses to achieve minimum command delay. In case of a collision, the fault signal dominates both the command signal and dv/dt induced noise currents by means of a longer pulse duration. The asynchronous fault transfer method also allows the special timing requirements of parallel-connected IGBTs or multi-level converter topologies to be managed, since any fault condition will be available at the primary side within one microsecond. A preferred fault-management mode thus reports the fault event in advance of a turn-off of the relevant IGBTs. The delay to shutdown is adjustable at the IGD ASIC.

Direct Mode does not allow any combinational or sequential logic interaction between the driver channels. This mode offers the highest flexibility to the customer and is therefore preferred for advanced microcontroller-assisted systems. In a second (half-bridge) mode, the ASIC uses only one input as a common command signal and generates two (non-inverted and inverted) outputs. The mode and dead time are adjustable to the needs of the particular application by a single resistor component for groups of two and typically up to six channels. A third mode is preconfigured to implement interlock or mutual exclusion upon customer request.

On the primary side, any fault state may be stretched by a Blocking Time. During this time, the relevant channel is kept in the off-state. This time is adjustable and can also be set to zero by a single resistor component for groups of two and typically up to six channels.



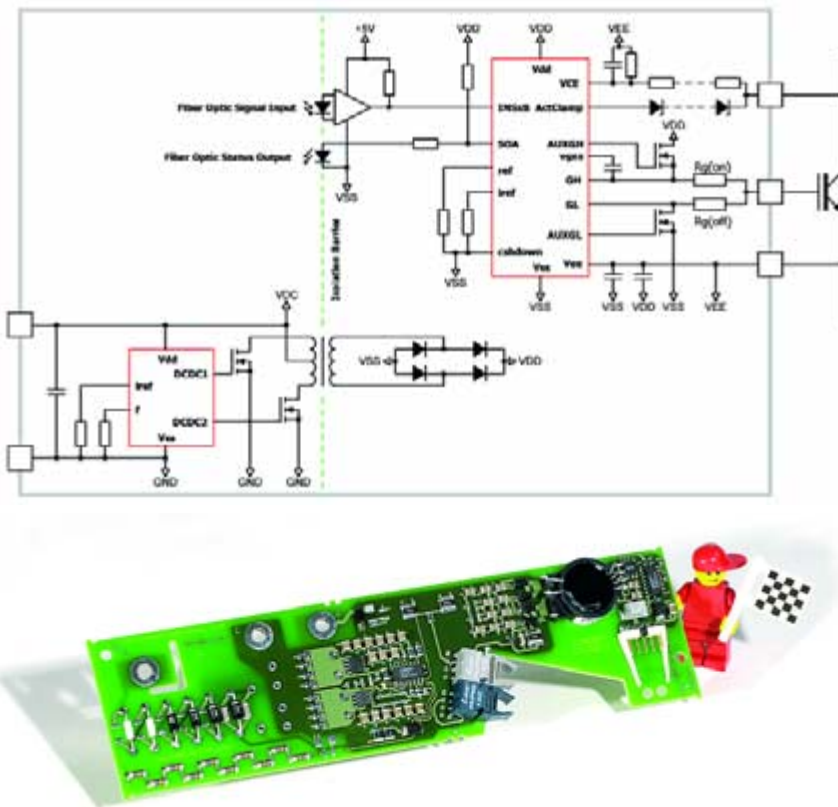


Figure 5: Plug-and-Play SCALE-2 IGBT driver for IGBT modules up to 3300V. Schematics (top) and implementation (bottom) for a 1700V / 3600A module.

#### Applications

CONCEPT's proprietary SCALE-2 chipset serves as a core platform for implementing the next generation of IGBT driver series. Figure 4 (left) shows a dual-channel gate driver core with 20A, 4W, +15V / -10V driving capability achieved by using external n-type DMOS for both the gate drive and DC-DC converter output stages: it has bidirectional signal transformer interfaces and offers an adjustable operation mode, dead time and blocking time, advanced Active Clamping and a secondary-side fault input.

Figure 4 (right) shows a similar dual-channel gate driver core with 5.5A, 0.8W driving capability with fully integrated gate drive and DC-DC converter output stages. One-side assembly is required only. The typical delay time is 88ns. Compactness, easy scaling up to seven channels and low cost make these drivers an optimized solution for driving IGBTs up to 1700V and 225A. Typical applications include half-bridge control of 1700V / 100A IGBTs at switching frequencies up to 25 kHz and 600V / 50A IGBTs at switching frequencies up to 75kHz.

Figure 5 shows a Plug-and-Play IGBT driver for IGBT modules up to 3300V with an advanced Active Clamping function. The driver achieves a gate capability of 40A, 6W by using external n-type DMOS for both the gate drive and DC-DC converter output stages. The overall component count is reduced by more than 60% compared to the previous chipset [3]. One-side assembly is required only.

#### Acknowledgements

We acknowledge discussions with Peter Köhli, Olivier Garcia and Sascha Pawel.

#### References

H. Rüedi, P. Köhli: "Dynamic Gate Controller (DGC), A new IGBT Gate Unit for High Current / High Voltage IGBT Modules with di/dt and dv/dt control", Proc. of PCIM Nuremberg, 1995.

H. Rüedi, P. Köhli: "SCALE Driver for High Voltage IGBTs", Proc. of PCIM Nuremberg, 1999.

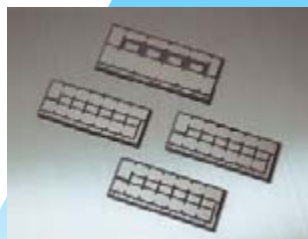
H. Rüedi, P. Köhli: "The SCALE IGBT Driver: A new Scalable, Compact, All-purpose, Low Cost, Easy to use Driver for IGBTs", Proc. of PCIM Nuremberg, 1998.

PCIM Booth 12/102

[www.IGBT-Driver.com](http://www.IGBT-Driver.com)



DENKA THERMALLY CONDUCTIVE SHEET, SPACER, GREASE



DENKA AN PLATE (AlN substrate)



DENKA HITT PLATE (Al-base substrate/IMS)



DENKA ALSINK (Al-SiC composite)

## High Thermally Conductive Materials

# DENKA

DENKI KAGAKU KOGYO KABUSHIKI KAISHA  
URL <http://www.denka.co.jp>

Contact **Tokyo** e-mail: 010282@denka.co.jp **Dusseldorf** e-mail: info@denkagermany.de **New York** e-mail: info@denkany.com  
Tel: +81(03)3507-5295 / Fax: +81(03)3507-5078 Tel: +49(211)130990 / Fax: +49(211)329942 Tel: +1(212)688-8700 / Fax: +1(212)688-8727

PCIM Booth 12/615

# Thermal Paste Spread and Ready for Use

*New technical and logistics service*

*Semikron, specialist in power module manufacturing and processing, has increased its portfolio of technical and logistics services to include the application of thermal paste to power modules. The introduction of this new service sets Semikron apart from other power semiconductor manufacturers.*

*By Dr. Michaela Strube, Manager Service Engineering, Semikron*

The optimum application of thermal paste onto the semiconductor module ensures good thermal performance once the module is assembled on the heat sink. Too much thermal paste reduces the thermal impedance and can in extreme cases lead to cracking in the insulating ceramic substrate during assembly. Too little thermal paste results in thermal overload of the power semiconductor which shortens module service life.

Thermal paste is normally applied in printing processes or using a sponge rubber roller. The manual rolling process, however, is not reproducible, which means that quality control is very difficult. Thermal paste application is therefore a step in the production chain that cannot be reproduced or quality checked and is a real headache for quality control and production managers. Printing processes, by way of contrast, produce reproducible results, but require costly purpose-built tools. To solve this problem, it makes good sense for the manufacturer, rather than the user of the power module to apply the indispensable thermal paste layer. For the module manufacturer can provide a controlled quality and offer thermal paste application at attractive prices thanks to the large production volumes.

For more than 10 years Semikron has continually expanded its know-how in the field of screen and stencil printing. This ever growing expertise is what has enabled Semikron to develop a volume-production-viable thermal paste application process for semiconductor modules. This new automatic screen printing process has now been added to the service portfolio. The thermal paste layer thickness is module-specific and is moni-

tored using Six Sigma tools. The application process boasts an accuracy of  $\pm 10\mu\text{m}$ . With a process capability of 1.33, as few as 60 prints in 1 million lie-out with the specified tolerances. With such properties, this process fully meets the requirements for power semiconductor modules.



Figure 1: Thermal paste spread and ready for use

Modules with thermal paste layer are transported in purpose-built patented packaging known as blister packaging. Blister packaging guarantees contact-free transportation. Plus, modules with thermal paste layer can be stored in blisters for up to 18 months. The storage properties of Semikron blisters were tested in high-temperature, low-temperature, warm, moist and humid conditions with subsequent thermal resistance and power cycling tests.

The next stage is just as uncomplicated: once the modules reach the customer, they can be simply removed from their packaging and placed onto the heat sink. Heat sink assembly to the module is therefore a quick and straightforward procedure. With no additional assembly stage, production logistics is also simpler. Production workers do not come into contact with the thermal paste,

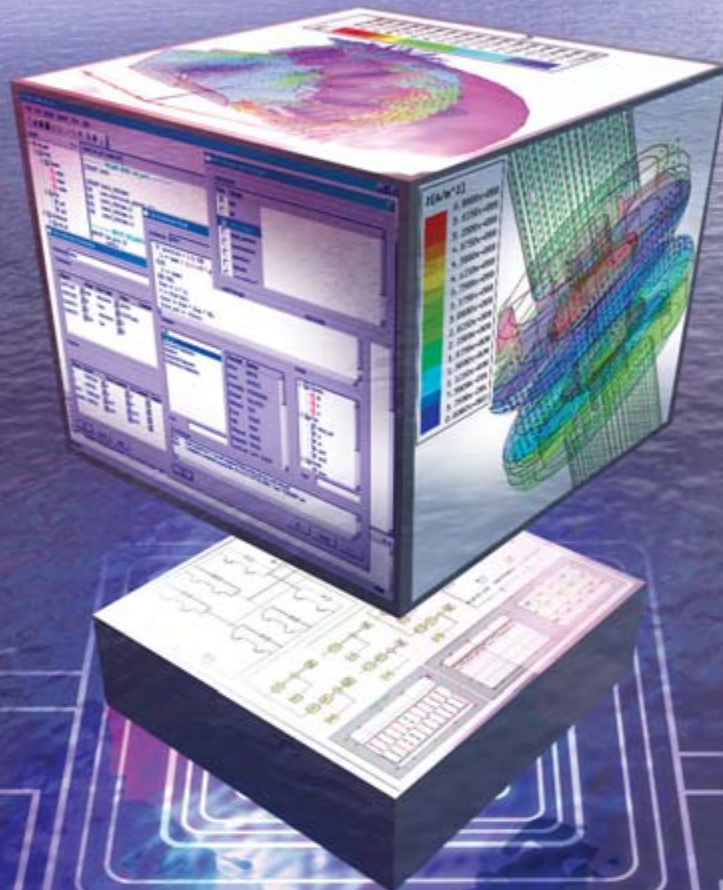
which means there is no risk of thermal paste being carried over into production. Thermal paste application at Semikron ensures that the paste is applied homogeneously with the optimum layer thickness. This reduces DCB cracking and ensures optimum heat dissipation and optimum module function. The automatic screen-printing process and statistics-based process control assure high process capability. The use of tested thermal paste systems and statistic process control provides an excellent long-term reliability.

Semikron first introduced thermal paste application as an optional additional service for its MiniSKiiP® product family. Every product in this family is available with a thermal paste layer, if required. MiniSKiiP®s are available as CIB (up to 100 A) and sixpack modules (up to 150 A) with the corresponding input bridge modules. MiniSKiiP® modules are used as power switches in converters, UPS systems and power supply systems. The customer can choose between a silicon-based and a non-silicon-based thermal paste. The high order numbers are testimony to the success of the new service. The focus is therefore on expanding the service to other module families. Greater capacity is currently being created to enable the company to increase the print volume over the coming years to as many as 2 million modules per year. Thermal paste application is soon to be available as an optional service for the standard bipolar SEMIPACK® range, which are used in drives, temperature control systems or in general control systems.

PCIM Booth 12/411

[www.semikron.com](http://www.semikron.com)

# HIGH-PERFORMANCE ELECTROMECHANICAL SYSTEMS DESIGN SOFTWARE



Booth 12/344

## **MAXWELL®**

3D electromagnetic-field simulation and parameter extraction for component design and optimization

## **SIMPLORER®**

System/circuit simulation and statistical analysis for multi-domain, mixed-technology design

## **ePHYSICS™**

Thermal and stress analysis for electromechanical components

## **OPTIMETRICS™**

Parametric, optimization, sensitivity analysis



**UK / EUROPEAN HEADQUARTERS**  
TEL: +44 (0) 1256 347788  
EMAIL: [uksales@ansoft.com](mailto:uksales@ansoft.com)

**COPENHAGEN, DENMARK**  
TEL: +45 32 88 22 90  
EMAIL: [nordic@ansoft.com](mailto:nordic@ansoft.com)

**MUNICH, GERMANY**  
TEL: +49 89 68 086 240  
EMAIL: [info\\_de@ansoft.com](mailto:info_de@ansoft.com)

**PARIS, FRANCE**  
TEL: +33 01 39 56 67 99  
EMAIL: [info@ansoft.com](mailto:info@ansoft.com)

**ROME, ITALY**  
TEL: +39 06 591 6845  
EMAIL: [italy@ansoft.com](mailto:italy@ansoft.com)

# Simple, Efficient, High-Brightness-LED Control

*LEDs are also less vulnerable to moisture ingress*

*A variety of lighting applications are adopting HBLEDs (high-brightness light-emitting diodes), making them the fastest growing light source worldwide. Today's advanced devices boast luminous efficacies in the 35-to-50-lm/W (lumens-per-Watt) range. Prototype devices emit more than 100 lm/W.*

*By Peter Green, International Rectifier*

Current trends suggest that ongoing improvements in LED technology can produce devices with greater luminous efficacy than fluorescent lamps and eventually, will match HID lamp outputs. HBLEDs already surpass incandescent and halogen lamps' and provide longer life, greater reliability, smaller size, and superior low-temperature characteristics. Additionally, LEDs are solid-state devices containing neither toxic gases nor filaments.

Designers are increasingly using HBLEDs in architectural lighting, street lighting, decora-

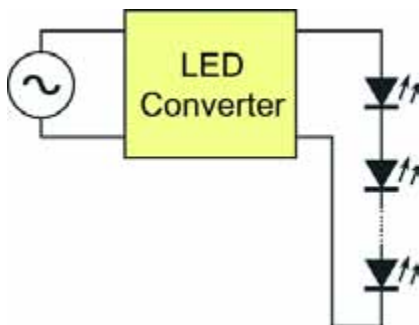


Figure 1: A basic LED converter provides constant current to series strings of LEDs.

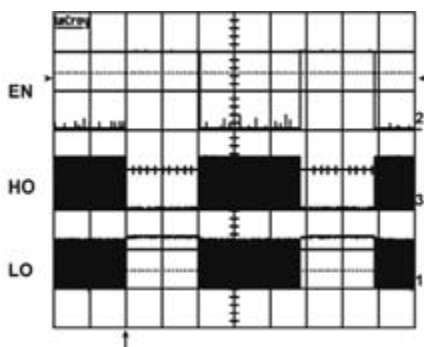


Figure 2: Burst-mode dimming provides excellent control of the LED string's light output while maintaining excellent color fidelity.

tive lighting, signage, and backlighting for high-end televisions and monitors. These applications must derive a regulated DC current from the AC line or DC-voltage supply.

International Rectifier's IRS2540 control IC implements a constant-current source for non-isolated applications. These include, for example, where a low-voltage isolated power supply already exists or where a class-2 fixture houses the LEDs in an inaccessible location, as is the case with traffic lights. This arrangement is similar to electronic ballasts for fluorescent or HID lamps, which typically do not provide galvanic isolation.

Buck converters are suitable for applications where the input voltage is greater than the output voltage, which includes most signage, decorative, and architectural lighting. Typical arrays use series-connected LED stacks to ensure equal current through all devices (Figure 1).

The series connection avoids the additional circuitry that would otherwise be necessary to maintain equal currents in parallel strings. Nonetheless, large arrays require parallel strings when the forward voltage across a single series stack would exceed either the available compliance voltage or the converter's maximum operating voltage.

The most common LED failure mode is a short circuit. When an LED fails in a series string, the others will all continue to operate normally. A failure of LEDs in parallel, however, prevents the remaining LEDs from operating. The combined forward voltage drop for series LEDs varies with temperature and with LED color. The forward voltage also has a wide tolerance in production.

Many applications require dimming. Combinations of primary-color LEDs can create any color in the spectrum by adjusting the intensities of each color, allowing many possibilities for display lighting, signage, and mood lighting. A buck regulator system based on the IRS2540 can dim over the full range from a logic-level PWM control signal.

The low-frequency PWM signal switches the average LED current by driving the converter in burst mode, changing the light intensity (Figure 2).

Unlike current modulation, PWM accomplishes the dimming without changing the LED's color. The PWM frequency is sufficient to prevent visible flicker.

HBLEDs enable architects, designers, specifiers, and manufacturers to create never-before-possible lighting effects and design luminaires for theaters, studios, nightclubs, restaurants, and other high-visibility venues. Digital scene controls and protocols such as DMX512 provide means for dramatic and dynamic lighting displays. The IRS2540 suits these applications allowing simple interfacing with microcontroller-based dimming circuitry.

LED light sources also naturally lend themselves to landscape and outdoor lighting, offering longer life correspondingly lower maintenance costs than incandescent and fluorescent lamps. LEDs are also less vulnerable to moisture ingress. Unlike conventional bulbs, LEDs have no fragile components to break, even when roughly handled. Flexible digital-control systems can produce dramatic lighting effects as they do in interior applications. Lighting schemes can change without rewiring or installing new systems.

# Knowledge is power power is our knowledge



**DualPack  
with Soldering Pins**  
1200V : 225A - 450A



**DualPack  
with Spring Contacts**  
1200V : 225A - 450A



**6-Pack IGBT**  
600V : 15A - 150A  
1200V : 10A - 150A  
1700V : 100A - 150A

**PIM IGBT**  
600V : 30A - 100A  
1200V : 10A - 75A



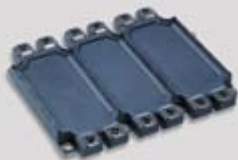
**1-Pack**  
1200V : 1200A - 3600A  
1700V : 1200A - 3600A

**2-Pack**  
1200V : 800A & 1200A  
1700V : 600A & 1200A



**2-Pack IGBT**  
600V : 50A - 600A  
1200V : 50A - 450A  
1700V : 150A - 400A

**1-Pack IGBT**  
600V : 600A  
1200V : 200A - 800A



**High Power 6-Pack**  
1200V : 225A - 450A  
1700V : 225A - 450A

*Special version available  
for rough environments*



**Discrete IGBT**  
600V : 5A - 75A  
1200V : 3A - 25A



**IPM-IGBT**  
600V : 15A - 300A  
1200V : 15A - 150A

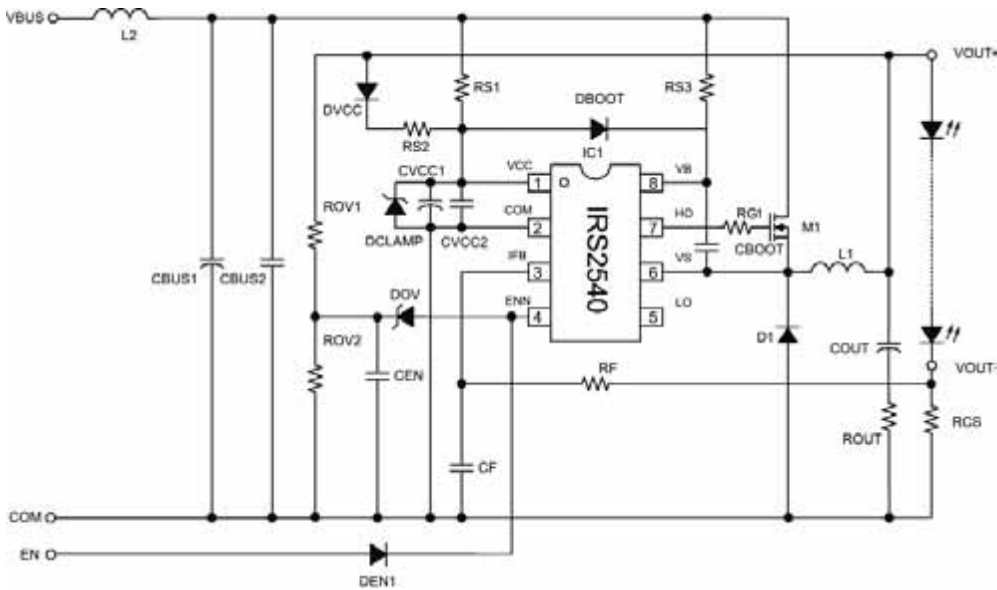


Figure 3: The IRS2540 provides conversion continuous-time current monitoring for true average current control.

Lighting designers are increasingly turning to high-power LEDs for their long life, ruggedness, flexibility, small size, and energy efficiency. They now have access to larger LEDs than those available just a few years ago—1, 3, and 5 W/package—that operate on currents up to 1.5 A.

By integrating a floating high-side driver, IRS2540 is able to use a current-sensing scheme that continuously monitors LED current (Figure 3).

Other controllers are limited to monitoring the current only during the time when the buck-converter switch is on. This allows the IRS2540 to realize average-current control as opposed to peak-current control and pro-

vides an inherently stable regulation that operates over a wider line and load range without running into design limitations.

The converter IC accurately regulates the current by means of its patented time-delayed hysteretic-control method. The overall system is simple, flexible, and able to power LEDs from a DC bus or directly from a rectified AC line. Controlling current accurately is a challenge when the forward voltage of each LED has a large manufacturing tolerance. For example, in the case of Lumiled's popular Luxeon III emitter, the forward voltage,  $V_F$ , varies around a nominal of 3.70V from 3.03 to 4.47V for white, green, or blue, per the manufacturer's datasheet. This slightly asymmetrical tolerance allows a -18%, +20% variation in the device's forward voltage at 700 mA. The  $V_F$  also varies over temperature, with a negative temperature coefficient of -2mV/C. At 100C, this is another 0.15V voltage change. Typical strings of multiple LEDs further magnify these variations, requiring medium to high bus voltages.

The IRS2540 achieves accurate current control with a simple design that is inherently stable and requires no complex circuit analysis. Because this method uses continuous-current mode, the design must limit stress during hard switching. It achieves this simply by controlling the control-circuits' delays. The design's peak currents are far smaller than in a peak-current control-mode topology. As a result, the LED converter can use smaller, more efficient MOSFET switches and a smaller inductor.

The control-circuit delays do cause a current ripple in the inductor, but an output capacitor

in parallel with the load reduces the ripple current. The output capacitor also reduces the frequency by adding delays to the current feedback, which improves the system's efficiency by reducing switching losses. Overload and short-circuit protection are inherent to this configuration. Implementing open-load protection and PWM dimming is also easy.

Two variations of the high-voltage LED-converter IC drive LED strings with forward voltages as great as 200 V (IRS2540) and 600 V (IRS2541). The design achieves efficiencies greater than 85% at 175 kHz (Figure 4). The converter operates at PWM duty cycles to 100% with no stability issues above 50% as can occur in peak-current-controlled systems.

Manufacturers of LCD Televisions, monitors, laptop displays, and various custom-sized panels are now replacing CCFL (cold-cathode fluorescent lamp) with LED backlighting sources, which offer substantial advantages. The LED-based backlighting system expands the palette of reproducible hues by as much as 45 percent. LED-based systems have already achieved 105% reproduction of the NTSC color space compared with the best CCFL lit LCD TVs, which only reproduce 65-75%. Not even a CRT (cathode-ray tube) display can match the color reproduction and brightness of an LED-based system. An LED-based system also has the potential for dynamic tuning to reproduce images with even greater accuracy.

PCIM 12/202

[www.irf.com](http://www.irf.com)



Figure 4: The IRS2540 and its sibling, the IRS2541, support bus voltages as large as 200 and 600 V, respectively.

# Efficient POWER for your applications



**PCIM 2007**  
**Nuremberg**  
**Hall 12**  
**Booth 404**

WITH FOCUS ON THE INDUSTRIAL INVERTER MARKET the PrimePACK™ is the new trendsetter in the power range up to 1 Megawatt. PrimePACK™ IGBT modules present a specially optimized concept for integration in modern converters.

Our contribution to your success at the glance:

- Improved thermal properties
- Low stray inductance
- Wide range of operating temperatures
- Infineon's 1200 V and 1700 V TrenchStop® technology

[www.infineon.com/PrimePACK](http://www.infineon.com/PrimePACK)



Never stop thinking

# Low $Q_{GD}$ 200 to 250V Power Trench MOSFETs with Low $t_{RR}$ and $Q_{RR}$

*Synchronous Rectification, AC/DC and DC/DC Applications are the focus*

*We present a new Power Trench™ trench MOSFET technology with optimized  $r_{DS(on)}$ ,  $Q_{GD}$  and  $Q_{RR}$ . In SMPS power supply applications such as AC/DC, DC/DC, DC/AC, and synchronous rectification, these parameters are important in order to increase efficiency and power density.*

*By Praveen Shenoy, Sampat Shekhawat, Mark Rinehimer and Bob Brockway, Fairchild Semiconductor, Mountaintop, PA, USA.*

Class-D audio is an application where both  $r_{DS(on)}$  and the additional characteristics of fast switching speed, low body diode  $t_{RR}$  and  $Q_{RR}$  and high  $V_{GS(th)}$  are important for noise reduction and sound quality. The new medium voltage Power Trench™ trench technology MOSFET has very low specific  $r_{DS(on)}$ , low  $Q_{GD}$ , and  $Q_{GD}/Q_{GS}$  ratio. It also has a Stealth diode type structure which results in a softer reverse recovery body diode with low  $Q_{RR}$  and  $t_{RR}$ . The excellent body diode characteristics not only reduce the power loss to improve efficiency, but also improve reliability. This trench-gate MOSFET has improved performance over planar gate power MOSFETs and other trench MOSFETs for the above mentioned applications.

## Introduction

Trench gate power MOSFETs are widely used in favor of planar gate power MOSFETs applications at 60V and below. This is because the increase in channel density gained by using a trench gate structure (Figure 1A) dramatically reduces the channel resistance. Additionally, the structure eliminates the JFET resistance component present in the planar MOSFET (Figure 1B)

In the case of planar MOSFETs, an increase in channel density causes significant increase of JFET resistance component as the current conduction path becomes narrower. Conventional trench gate power MOSFETs tend to be designed mainly for reduction in on-resistance. Accordingly, these devices show larger gate charge, particularly  $Q_{GD}$ . This increases switching losses, especially at higher switching frequencies. Since the channel resistance component is only a small part of the total on-resistance for medium voltage devices (200-300V), trench devices do not offer the conventional advantage of significantly decreased on-resistance with increased channel density. Hence this voltage range is still dominated by planar MOSFETs. However, planar devices have much higher than ideal on-resistance in this voltage range due to:

## JFET resistance

Current spreading resistance under the P-well

Lower BV due to junction curvature which forces designers to increase epi thickness and or resistivity.

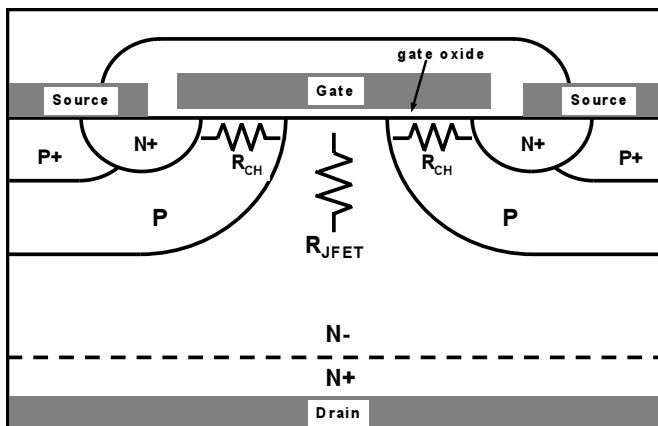


Figure 1A: Typical Trench Power MOSFET

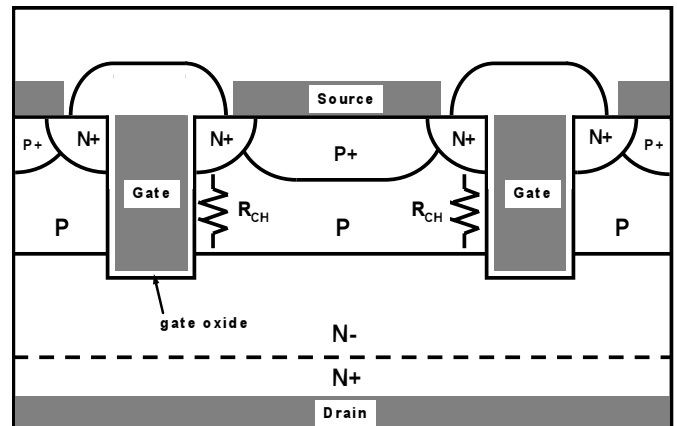


Figure 1B: Typical Planar Power MOSFET



Considering the challenges and requirements of medium voltage devices, a trench gate power MOSFET could be designed optimizing the  $r_{DS(on)}$  and  $Q_{GD}$ . In a trench device, there is neither a JFET resistance nor a P-well junction curvature. This allows almost ideal plane parallel BV for the trench cell.

### Design & Simulation

Fairchild designed the medium voltage trench device using extensive two dimensional numerical simulations to optimize the performance. We used a drain doping modification under the P-well and trench to improve the current spreading under the P-well/trench as shown in Figure 2.

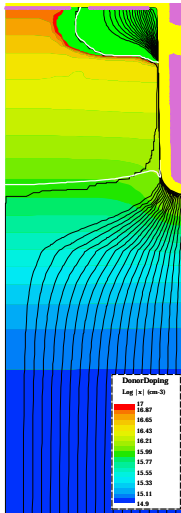


Figure 2: Cross section of Power Trench™ during forward conduction showing lines of equal current flow

As explained above, the trench cell BV is very close to the ideal  $BV_{PP}$  and so the actual BV will be limited by the edge termination. However, it is usually not desirable for breakdown to occur at the edge, particularly for large devices. The drain doping modification in the active area also helps to reduce the trench cell BV to a value just below the edge BV and thereby ensures active area breakdown. The drain doping modification under the P-well also improves the body diode characteristics significantly by giving a 'Stealth' effect. The increased donor concentration under the junction inhibits injection efficiency and reduces the duration of the initial phase of the recovery event,  $t_A$ . This results in a reduction of the peak reverse recovery current,  $I_{RRM}$ , and also makes the diode softer with reduced EMI. Thus, the drain doping modification serves multiple purposes:

### Reduction in on-resistance

Increased UIS capability due to active area clamping of avalanche breakdown  
Improved body diode recovery: reduced  $I_{RRM}$  &  $Q_{RR}$ , and increased softness ( $t_B/t_A$ )

The cell pitch is increased to reduce  $Q_{GD}$  while the presence of the drain doping modification prevents any negative trade-off of  $r_{DS(on)}$  due to decreased channel density and current spreading. Since the contribution of the channel to the total resistance is small for devices of this voltage, a thick gate oxide was used to achieve a further reduction in  $Q_{GD}$  with minimal impact on  $r_{DS(on)}$ . Two-dimensional numerical simulation was used to determine the optimal design parameters to achieve a minimum of on-resistance,  $Q_{GD}$ , and  $Q_{RR}$ . Additionally, the threshold voltage is increased to 3 to 5V range for improved noise immunity.

## High Voltage. Higher Standards.

### VMI - So Much More Than Multipliers



**VMI** <http://bodos.voltagemultipliers.com>  
**001.559.651.1402**

Voltage Multipliers Inc. 8711 W Roosevelt Ave. Visalia CA USA 93291

### Experimental Results

The new Power Trench™ trench device (FDB2710- 50A, 250V) was compared with the state of the art planar MOSFET of similar die size (FDB44N25 – 44A, 250V) as shown in Table 1.  $Q_{GD}/Q_{GS}$  ratio should be as small as possible with a target value less than unity. This is desirable due to re-applied  $dV/dt$  issues. During turn off of the device, the displacement current through the Miller capacitance ( $C_{RSS}$ ) can force the gate voltage to rise above  $V_{GS(th)}$  and either turn-on the device or increase the turn-off loss. A similar event may occur if the complimentary device turns-on in a half bridge or full bridge leg. However, the Power Trench™ device has the very low  $Q_{GD}/Q_{GS}$  ratio of 0.53. This provides a high degree of immunity to displacement current induced turn-on. The measured  $r_{DS(on)}$  of the device matches very well with simulations and also shows that near ideal specific on-resistance is achieved.

Part	$r_{DS(on)}$ maximum (m $\Omega$ )	$V_{GS(th)}$ range (V)	$Q_{GD}$ (nC)	$Q_{GS}$ (nC)	$Q_{GD}/Q_{GS}$	FOM ( $r_{DS(on)} \cdot Q_{GD}$ )
FDB2710	42.5	3 - 5	18	34	0.53	765
FDB44N25	69	3 - 5	24	18	1.33	1656

Table 1: Comparison of trench (FDB2710) and planar (FDB44N25) devices

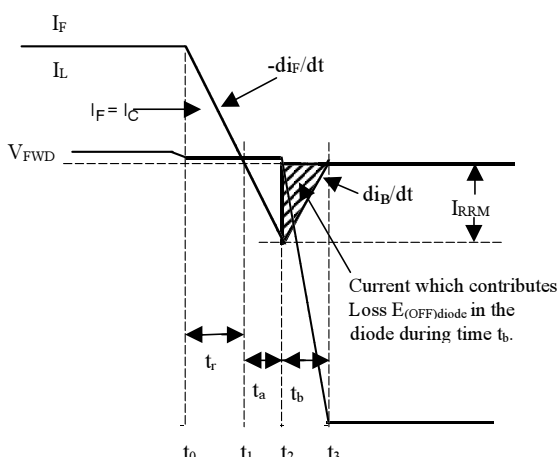


Figure 3: Diode Reverse Recovery with Loss Components

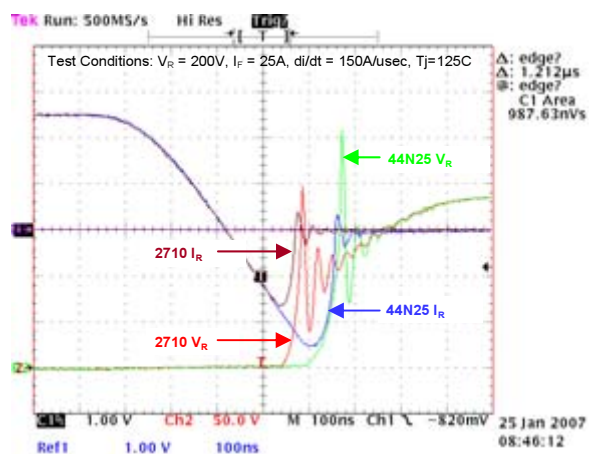


Figure 4: Reverse Recovery comparison of Power Trench™ trench (2710) vs. planar MOSFET (44N25) at 125°C

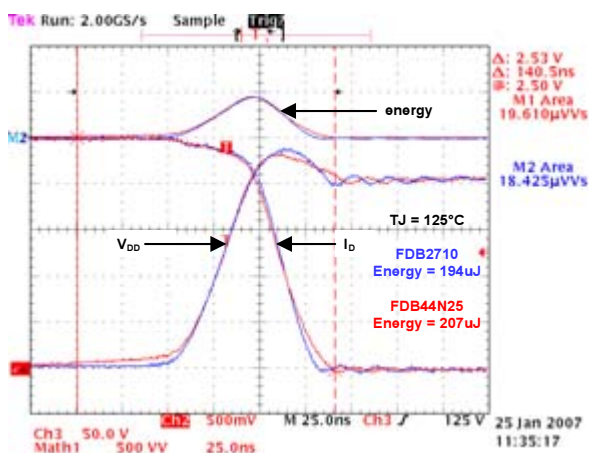


Figure 5: Turn-off comparison of Power Trench™ trench (2710) vs. planar MOSFET (44N25) at 125°C

The ideal one dimensional specific on-resistance is given by the equation:

$$r_{DS(on),SP} = 5.93 \times 10^{-6} BV^{2.5} \quad [1]$$

which gives an  $r_{DS(on),SP}$  of 7.64mΩ/cm<sup>2</sup> for 278V (measured BV). This compares very well with a measured  $r_{DS(on),SP}$  of 7.8 mΩ/cm<sup>2</sup> for FDB2710 device. The measured  $r_{DS(on),SP}$  is only 2% higher than ideal and shows the amount of optimization done using the simulations. Conversely, the planar device shows a measured value 83% higher than the ideal. A comparison of measured and ideal specific on-resistance is summarized in Table 2.

Specific On-Resistance, $r_{DS(on),SP}$ (mΩ cm <sup>2</sup> )				
1D Ideal	Power Trench™	$r_{ACT}/r_{IDEAL}$	Planar	$r_{ACT}/r_{IDEAL}$
7.64	7.8	1.02	14	1.83

Table 2: Measured & ideal specific on-resistance

**Reverse Recovery**

The body diode reverse recovery characteristics are very important for synchronous rectification, AC/DC and DC/DC applications. The reverse recovery process begins when a diode is commutated from a forward to reverse bias condition. During forward bias, the intrinsic region of the P-i-N diode is flooded with minority carriers. These carriers must be removed from the vicinity of the P-N junction in order for the diode to begin to support the reverse bias during recovery. A typical reverse recovery waveform is shown in Figure 3. The magnitude of the recovery current increases linearly during the time interval between  $t_1$  and  $t_2$ . At  $t_2$ , the diode begins to support the supply voltage, and the reverse current reaches the peak value ( $I_{RRM}$ ). By  $t_3$ , the diode has fully recovered with current reduced to zero and voltage reaching the clamp voltage.

The MOSFET body diode switching speed and reverse recovery current is very important for inverter and DC to DC power supply circuits due to the fact that high  $t_{RR}$  and  $Q_{RR}$  values increase complimentary MOSFET turn-on loss. Diodes which have a “snappy” recovery characteristic (low  $t_B/t_A$  ratio) show increased EMI as well. Therefore, the MOSFET body diode should be optimized for reduced turn-on loss. The body diode reverse recovery measurements were done to compare the two parts. The results are shown in Fig.4 and clearly demonstrate the superior performance of the new trench device. The trench device has much lower  $I_{RRM}$  of 16.6A (vs. 25.4A for planar device) and a 60% lower  $Q_{RR}$  of 1436nC (vs. 3573nC). The reverse recovery waveform is also softer with lower voltage spike and ringing.

The reverse recovery current produces extra loss in MOSFET during turn-on which puts extra stress. Therefore, one has to consider the body diode design while designing MOSFET cell structure very carefully. As the circuit frequency is increased this loss can become significant. The Power Trench™ Trench MOSFET body diode has very low  $t_{RR}$  and  $Q_{RR}$  as shown in Figure 4 and hence it reduces turn-on loss and stress on the MOSFET when it turns-on while complementa-

Reverse Recovery									Switching			
$V_R = 200V, I_F = 25A$									$V_{DD} = 200V, I_b = 25A$		$I_b = 25A$	
di/dt	T <sub>J</sub>	I <sub>RRM</sub>	t <sub>A</sub>	t <sub>B</sub>	t <sub>RR</sub>	Q <sub>A</sub>	Q <sub>B</sub>	Q <sub>RR</sub>	E <sub>OFF</sub>	E <sub>ON</sub>	r <sub>DS(on)</sub>	
(A/μs)	(°C)	(A)	(ns)	(ns)	(ns)	(nC)	(nC)	(nC)	(μJ)	(μJ)	(mΩ)	
44N25	150	25	22.2	160	40	200	1804	726	2530	162	860	63
2710			14	100	26	126	692	274	966	178	1260	35
44N25		125	25.4	186	54	240	2482	1091	3573	194	1140	-----
2710			16.6	120	34	154	986	450	1436	207	1652	-----

Table 3: Switching comparison of trench (FDB2710) and planar (FDB44N25) devices

ry MOSFET body diode is recovering. The body diode is also less snappy compared to the planar MOSFET body diode as shown in Figure 4.

### Switching

MOSFET switching losses are a main concern, particularly at higher operating frequencies. Turn-off measurements were done to compare the  $E_{OFF}$  losses of the new trench device compared to the state of the art planar device. The waveforms are shown in Figure 5 which indicates that both parts have very similar curves and the trench device has slightly lower  $E_{OFF}$ . The  $Q_{GD}$  of this MOSFET is approximately 25% lower than a comparable MOSFET. Accordingly, the turn-off losses are reduced as shown in Figure 5.

Figure 6 compares the turn-on waveforms of the two devices under identical conditions. The trench device has 30% lower  $E_{ON}$  loss of  $1140\mu J$  compared to the planar part at  $1652\mu J$ .

The lower peak current during turn-on also improves device reliability. The turn-on loss of the trench MOSFET is about two-thirds of planar MOSFET turn-on loss. The dynamic measurement results are summarized in Table 3.

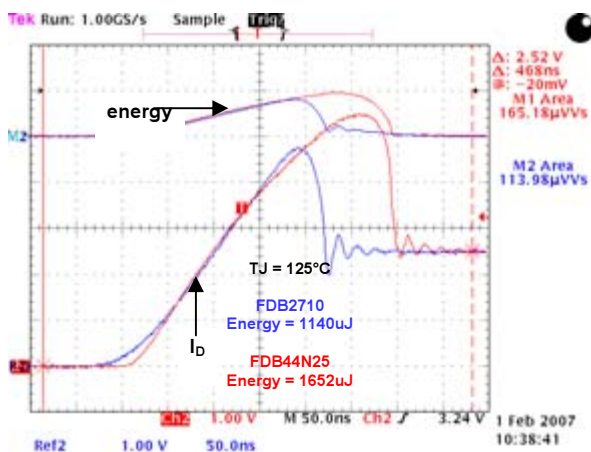


Figure 6: Turn-on comparison of Power Trench™ trench (2710) vs. planar MOSFET (44N25) at 125°C

### Conclusions

The new device has 40% lower  $r_{DS(on)}$  and less than half  $Q_{GD}/Q_{GS}$  ratio which improves noise immunity. Despite being a trench device, it has 25% lower  $Q_{GD}$  due to optimized device design and this improves the switching speed. The best competition trench part has 25% larger die for same  $r_{DS(on)}$  and hence has a worse  $F_{OM}$ . The switching losses of the Power Trench™ trench are much less than comparable planar MOSFET technology. The comparison data shows that body diode of Power Trench trench is superior to the body diode of planar MOSFETs. The Power Trench™ device has 60% lower  $Q_{RR}$  than the best planar device of the same die size. The performance of the Power Trench™ device is well suited for a wide array of applications including: secondary side synchronous rectification, high frequency DC/DC converters, high speed motor drive applications, PFC boost switches for 115V AC to 180V DC application and class-D audio.

PCIM Booth 12/601

[www.fairchildsemi.com](http://www.fairchildsemi.com)

[www.bodospower.com](http://www.bodospower.com)



## For superior solutions in industrial electronics

- Aluminum electrolytic capacitors for temperatures up to 150 °C
- PFC products with high reliability
- EMC filters for currents up to 8,000 A
- Thermistors for temperature measurement
- Inductors with high current capability
- Ferrite materials with reduced power losses

[www.epcos.com](http://www.epcos.com)



PCIM Nürnberg, Germany  
May 22 to 24, 2007 • Hall 12, Stand 12-535



SENSOR + TEST Nürnberg, Germany  
May 22 to 24, 2007 • Hall 7, Stand 7-247

# The Effects of Turning off a Converter with Self-Driven Synchronous Rectifiers

*This type of circuit can never be used in a load-share configuration*

*Synchronous rectification is one of the best ways to improve the efficiency of the low-voltage pulse width modulated (PWM) power converter.*

*By John Bottrill, Senior Applications Engineer, Texas Instruments*

The self-driven synchronous rectifier configuration has many advantages. It is simple and highly efficient. Combined with a low parts count, it can be applied to a number of topologies. The waveforms and data presented here are taken from an active clamp configuration that lends itself particularly well to this topology.

There is, however, one problem with the synchronous rectifier configuration. When the converter is being turned off, it exhibits some undesirable behavior as shown in Figure 1. (A simplified circuit is shown in Figure 2).

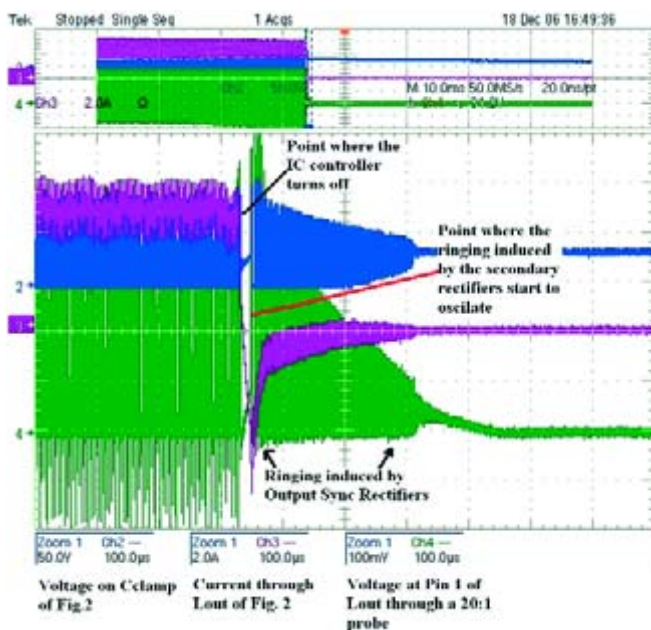


Figure 1. Turnoff Waveforms of a Converter with Self-Driven Synchronous Rectifiers

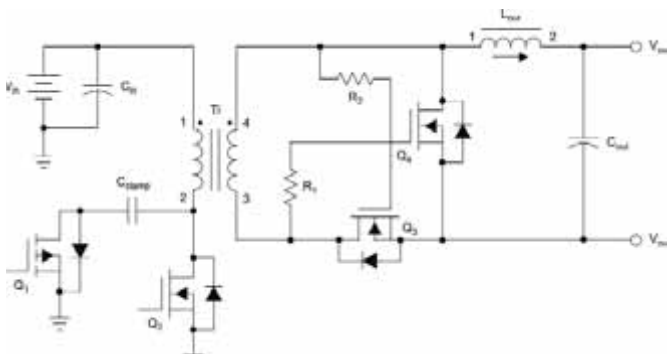


Figure 2. Simplified Schematic of Active Clamp PWM with Self Driven Synchronous Rectifiers

After the converter controller is shut down, there is a brief period of no switching. This is followed by a period of switching present even though the controller is off. This spontaneous behavior is the cause for concern and the topic of our discussion.

Initially, the converter is in operation and current is flowing out of the converter as indicated by the arrow under  $L_{OUT}$ . In the output inductor,  $L_{OUT}$ , there is a current  $I_{OUT}$  plus some ripple current flowing to the right.

When Q2 is on the input voltage,  $V_{IN}$  appears across T1 Pins 1-to-2. This results in a positive voltage on Pin 4 of T1 with respect to Pin 3. Thus, turning on Q3, and reducing the voltage across Q3 below the voltage that would be present if the current were flowing through the body diode of Q3 alone. Because the voltage across T1 is greater than the output voltage, the current through  $L_{OUT}$  increases.

When Q2 turns off, Q1 is turned on and the voltage is reversed across the primary of the T1. The results are Q3 being turned off, and Q4 being turned on. The current through  $L_{OUT}$  continues to flow. But now it comes through Q4. The voltage on Pin 1 of  $L_{OUT}$  is effectively grounded, resulting in a decrease in current flow through  $L_{OUT}$ .

At the end of the cycle, Q1 is turned off and Q2 is turned on – and the cycle repeats itself again. This is the normal operation of this converter.

At some point in the cycle, the converter's primary controller is turned off, in this case by an undervoltage condition. Figures 3a and 3b show the effects of turning off the converter.

The turnoff sequence of this controller is to turn on Q1 last. So let's start the description of the events with that in mind.

When the converter is turned off at "A" in Figure 3, the current, "B" through  $L_{OUT}$  will decrease at a rate equal to  $V_{OUT} / L_{OUT}$  – as long as Q1 remains on. When Q1 turns off at "C," the magnetizing current in Q1 causes a polarity reversal on T1. This causes Pin 4 of T1, Q4 drain, and the gate of Q3 to start to go high at "D." This turns Q4 off

and Q3 on. Because of this transition, the voltage on Pin 4 of T1 goes to a voltage set by the secondary inductance and the primary to secondary ratio of the transformer (approximately five-to-one in this case), and the output voltage. The residual magnetizing current in T1 affects this voltage divider, so this is not exact.

The ringing at "E" induced by the magnetizing current appears as a voltage on the drain of Q4. This raises the voltage on the drain of Q4, slowing down the  $di/dt$  of the current through L<sub>OUT</sub>. Further, it positively biases the gate of Q3. The ringing is short-lived and rapidly dies out.

The current continues to fall because Q3 is on. L<sub>OUT</sub> and the secondary of T1 form an inductive voltage divider. This keeps a positive voltage on Q4 drain and, hence, on Q3 gate – perpetuating this condition and allowing the current to go through zero at "F." Now, a current in the reverse (to the arrow) direction starts to build through L<sub>OUT</sub>.

As the current through L<sub>OUT</sub> increases in the negative direction, voltage starts to appear across Q3 drain. This voltage starts to apply voltage to the gate of Q4. At some point represented by "G," this voltage is enough to cause Q4 to start to turn on.

This transition is a positive feedback transition because Q4 steals the current from the T1 secondary, causing Pin 4 of T1 to go low. In turn, this turns Q3 off and the magnetizing current in T1 causes a high voltage to appear on the drain of Q3 – further turning on Q4, shorting the drain of Q4 to ground.

correlec.pro™

The On-line reference tool for the electronic industry

Hundreds of thousands of part numbers.  
Up to 25 parameters per part number.  
All major manufacturers covered.

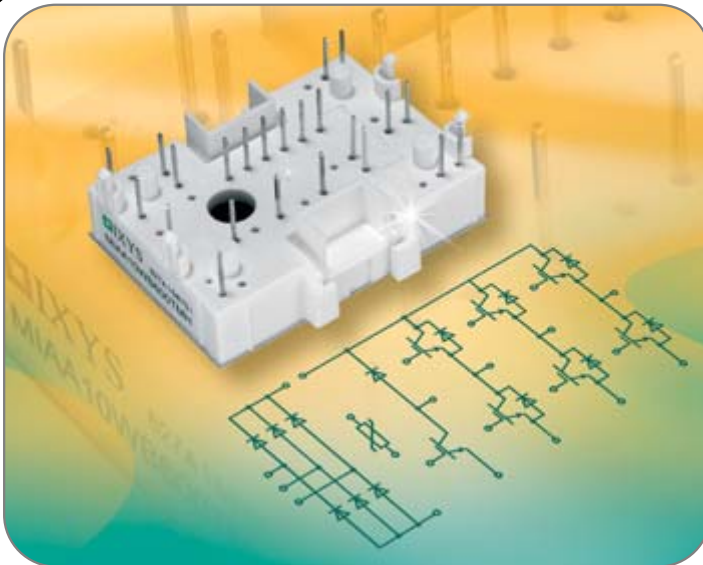


Search by part number - Search by product type  
Filter & compare by parameters - Filter & compare by case style - Filter & compare by circuit

[www.correlec.com](http://www.correlec.com)

PCIM Booth 12/347

## MiniPack 2 - IGBT Module with Converter Brake Inverter



[www.ixys.com](http://www.ixys.com)

Available in latest NPT and trench IGBT technologies

### Features

- 10 - 30 A, 600 - 1200 V
- Insulated base plate (DCB)
- Pins suitable for wave soldering
- High level of integration (NTC included)
- Hiperfast free wheeling
- Custom and standard configurations
- Assembly clips available

### Used in:

- AC motor drives:
  - Pumps, fans
  - Washing machines
  - Air-conditioning systems
- UPS



Booth 12/401

Efficiency Through Technology

EUROPE:  
IXYS Semiconductors GmbH  
marcom@ixys.de

USA:  
IXYS Corporation  
sales@ixys.com

ASIA:  
IXYS Taiwan  
sales@ixys.com.tw



This increases the negative voltage across  $L_{OUT}$  and causes the negative current in  $L_{OUT}$  to further increase. With a higher  $di/dt$  at "H," this causes the current in T1 secondary to drop to zero because Q3 is now off. The voltage induced on the secondary of T1 at "Is" in Figure 3a is transferred to the primary, causing resonant currents in parasitic elements such as the interwinding capacitances and  $C_{ds}$ , the parasitic drain to source capacitance of Q1 and Q2. This result is ringing voltages on the primary side at "Ip" (see Figure 4).

The voltage on the transformer winding resonates up, and then starts to fall. As it does, it forces the FETs Q3/Q4 to change again, with Q4 turning off and Q3 turning on at "J."

In this configuration, the voltage on the drain of Q4 is clamped by the parasitic diode of Q2 at "K." The voltage remaining across  $V_{IN}$  is reflected across the secondary winding of T1. Current is actually pumped back to the primary and into the voltage source.

The current through  $L_{OUT}$  at "L" decreases because the voltage across  $L_{OUT}$  is now reversed. This causes Pin 1 of L1 to be positive with respect to the output. After a brief period, the resonances cause the voltage to reverse. Once again, Q4 is shorted-to-ground and Q3 is turned off.

This leads to a positive voltage on the drain of Q2. If there is sufficient energy, it drives the drain of Q1 above ground and causes the body diode of Q1 to conduct-to-ground. If enough energy is transferred, it can pump up the voltage on the clamping capacitor, leading to a voltage build-up that could harm Q1.

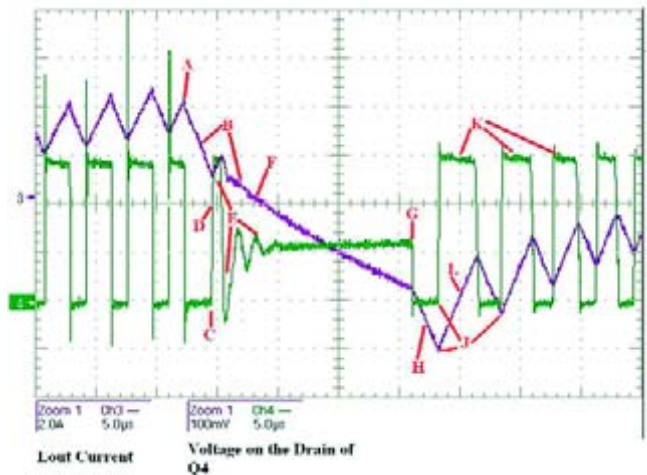
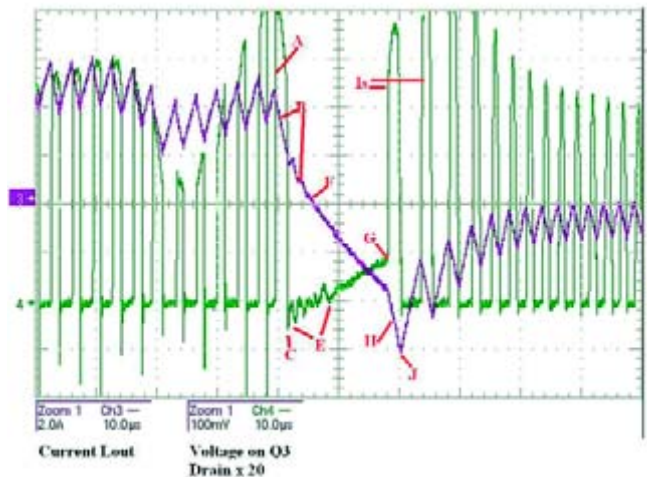
This switching on the secondary repeats itself until most of the energy on the output is dissipated. These oscillations appear as an envelope of oscillations, exponentially decreasing until it reaches a critical value where it shuts off entirely as shown earlier in Figure 1.

**This behavior gives cause for two concerns:**

The designer must be aware of the problem and understand it. It will induce noise into the unit, which may be acceptable. It could also induce voltages on the various components. This could result in a break down of the gates of the FETs, or avalanche energy in the drain-to-source voltage being exceeded. This could be either on the primary or secondary side.

Energy stored in the output capacitance is going to be dissipated, either in the FETs or by transfer back to the input. Most likely it will be by a combination of both.

This also shows why this type of circuit can never be used in a load-share configuration. If used in this configuration without diode isolation and something turned off one of the converters, that converter output would sit and oscillate until the parts died.



Figures 3a and 3b. Turning off the converter, Trace 4 is through a 20-to-1 Isolation Probe.

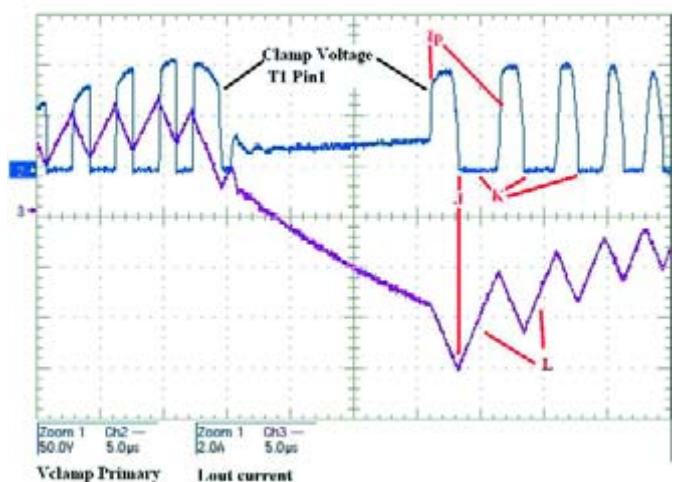


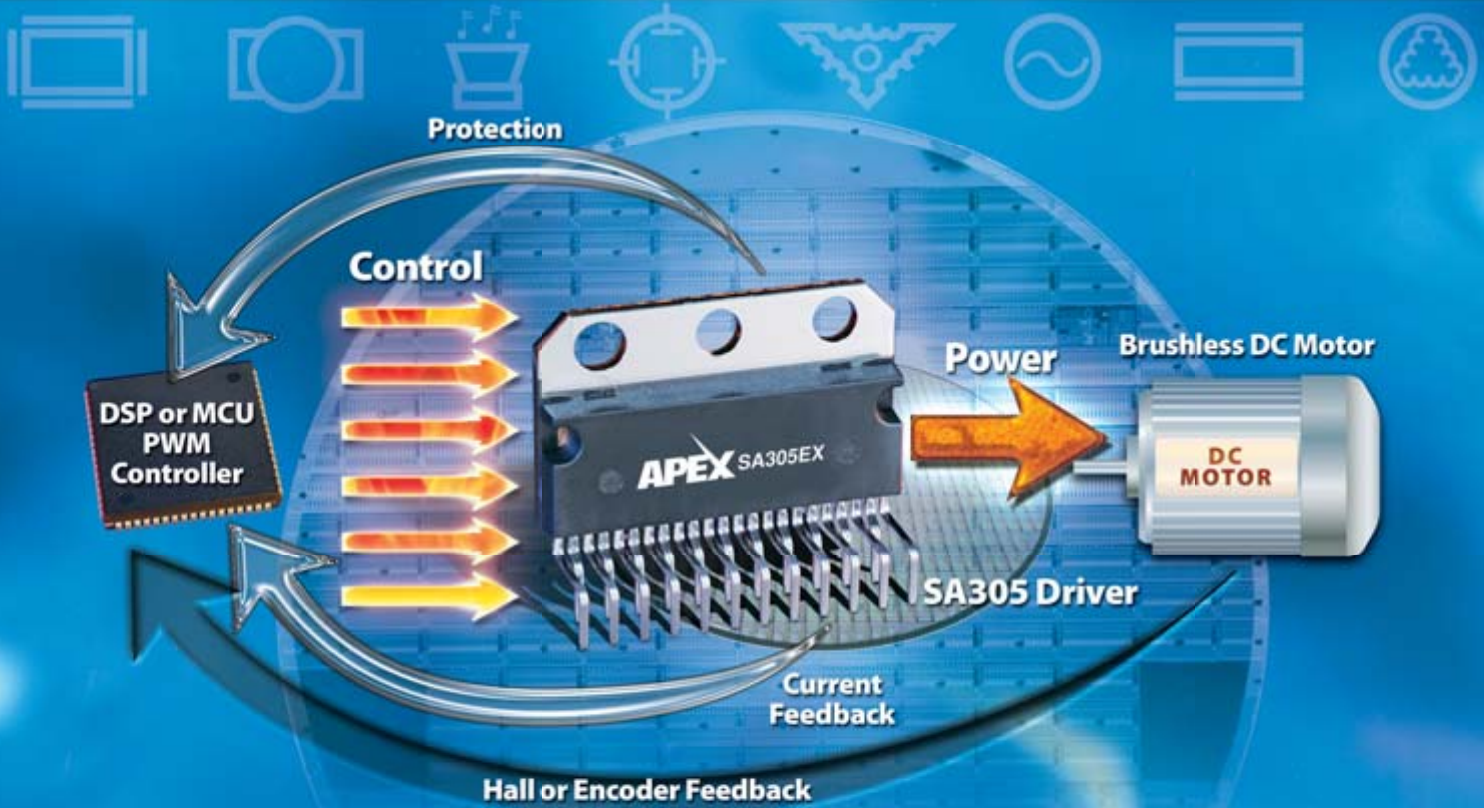
Figure 4. Reflected Voltage to the Primary Side

PCIM Booth 12/134

[www.ti.com](http://www.ti.com)

Free Magazin Subscription at [www.bodospower.com](http://www.bodospower.com) for qualified readers in Europe

**Bodo's Power Systems**



**New PWM Precision IC operates on supplies up to 60V and features 3-phase current monitoring.**

**Control brushless motor drives with either DSP or MCU  
5A PWM 3-phase driver IC works with your choice of digital control!**

The Apex SA305 charts a new direction in PWM 3-phase drivers for brushless motor control. The SA305 allows users to make their own choice in terms of digital control with an ability to interface with either a DSP or MCU. The SA305 bundles this performance with 10A PEAK of output current, superior circuit protection and IC cost effectiveness. It's the complete price and performance package for driving 3-phase brushless motors.

<b>Precision ICs</b>	<b>SA305</b>	
	<b>Digital Control</b>	DSP or MCU
	<b>Output</b>	Three Half Bridges
	<b>Supply Voltage</b>	60V
	<b>Output Current</b>	5A Continuous, 10A PEAK
	<b>Power Delivery</b>	300W

Visit us online today at [www.apexmicrotech.com/BPS](http://www.apexmicrotech.com/BPS) to request your FREE V12 Apex Power Integrated Circuits data book!

- Data sheets
- Design tools
- Application notes
- Spice models
- Eval kits
- Request v12 data book



# Permanent-Magnet Synchronous Generators in Wind Energy Systems

*Reducing the losses by one-third for this type of generator*

*Renewable energy sources already account for around 11.81 per cent of today's energy mix. The most successful of these is wind energy, occupying top place and delivering 5.7 per cent of power consumption with an output of over 30 billion kilowatts in 2006<sup>2</sup>. The technology has advanced in leaps and bounds since the first systems for exploiting wind energy – windmills – were introduced.*

*By Dr. Roland Zoller, Product Marketing DM-PM, VACUUMSCHMELZE GmbH & Co KG*

The first wind energy systems of the early 80s notched up a mere 55 kilowatts in nominal output: by comparison, the largest of today's modern systems have an output of 6 megawatts, although these "powerhouses" are still the exception. The majority of wind energy systems today are based on a double feed asynchronous geared generator, and reach outputs between 500 kilowatts and one megawatt.



Figure 1: Wind Energy Systems

The system has a number of advantages which have contributed to its widespread popularity. Its modular structure of gear, generator and inverter is a widely accepted standard involving relatively low start-up investments. In addition, double-feed asynchronous generators are low in weight, and transformers are unnecessary since the stator windings can be connected directly to the power grid while the rotor windings are connected to an inverter. As a result, the inverter need only be dimensioned for one-third of the generator's nominal output, a further factor that lowers costs.

The gears are an essential part of this system, which cannot be designed as a multi-pole system and requires high speeds to operate. However, the costs of the gear system and the complex maintenance they require – for example, oil must be regularly checked and changed – represent disadvantages of this type of generator. Slip rings are also high-maintenance components. The output of these

systems is lower than, say, electrically excited synchronous generators.

## **Electrically excited synchronous generators – geared and gearless**

Today, very few of the wind energy systems in operation use rotor induction generators with electrically excited synchronous generators.

These generators deliver higher efficiency than asynchronous generators, owing to the lack of remagnetization loss in the rotor. An exciter coil in the rotor produces the magnetic field. Although high-speed variations do not require sliding contacts since they include a rotating rectifier with pilot exciter. However this type of system also requires gears. The frequency generated depends on the generator's rotation speed. Since this is not at a constant level in wind energy systems, the power generated cannot be fed directly into the grid, and an additional transformer is generally required.

A similar principle applies to direct-driven electrically excited synchronous generators. While they do not require gears, they require a transformer and inverter. Because this type of generator can support a high number of poles, a gear system is unnecessary or a single-stage planetary gear is sufficient. Direct drive involves a number of disadvantages: the structure is not modular, since all components must be designed as integral parts of the wind energy system. The diameter, and thus the weight, of the synchronous generator increases with the pole number. In addition, electrically excited synchronous generators require slip rings, involving expensive maintenance procedures.

## **Permanently excited synchronous generators – the model of the future?**

Supported by statutory innovation incentives, the technological development of wind energy systems will continue to advance. Given the annually falling remuneration scales in Germany's Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG), an increasingly efficient method of converting wind energy into electric power is required. "Repowering", the term used for the replacement of wind energy systems which may be considerably over 20 years old, is also a major



concern for wind farm operators. In addition, these old, comparatively inefficient systems often occupy prime sites in coastal regions or mountainous areas.

Wind energy system prototypes using permanently excited synchronous generators are currently in operation at an array of test sites. In this design, the exciter output is replaced by permanent magnets, reducing the losses by one-third for this type of generator in comparison to electrically excited synchronous generators, and thus increasing output. The generator can be designed as a multi-pole system for smooth adjustment to lower rotation speeds. Here too, a gear system is unnecessary or a single-stage planetary gear is sufficient, although an inverter and transformer for grid feed-in are required.

Permanently excited direct-drive systems are lower in weight than electrically excited synchronous generators. Their permanent magnets are maintenance-free and do not require slip rings, so that it can be assumed that this generator type incurs significantly lower maintenance and operating costs throughout its lifespan.



Figure 2: Vacuumschmelze Permanent Magnet System

#### Future prospects

Land sites favourable to wind generation are scarce, and are artificially rendered scarcer by the imposition of regional regulations restricting maximum height and distance. The solution to this problem is advanced development of offshore wind farms, for instance off Germany's North Sea coast – a vision for which it is particularly important that the systems combine minimum maintenance with maximum efficiency. Here, the advantages of wind energy systems based on permanently excited synchronous generators come to the fore.

Permanent magnets from Vacuumschmelze GmbH & Co KG are designed for outstanding corrosion stability, an essential property in an environment of salt air and damp. The permanent magnets are also demagnetization-proof in specific constructions.

Vacuumschmelze is primarily known as a leading supplier of magnetic sub-systems; these simplify assembly and operation for the customers since the magnetic poles are attached to metal pole pieces during manufacture by Vacuumschmelze, enabling customers to mount the magnetic poles directly onto the rotor. Vacuumschmelze GmbH & Co KG has extensive expertise in system assembly and magnetic design, and is thus a reliable partner in the development of permanently magnetically excited wind energy systems.

PCIM Booth 12/130

[www.vacuumschmelze.com](http://www.vacuumschmelze.com)

1 Information for 2006 from German Ministry for the Environment, Conservation and Reactor Safety

2 Information from German association Bundesverband WindEnergie e.V.

[www.bodospower.com](http://www.bodospower.com)



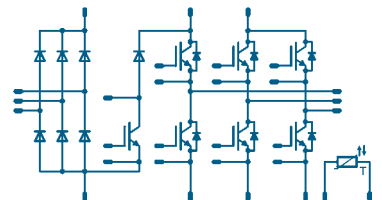
## New: 100A flowPIM 2 using IGBT4 Technology

#### Main Features:

- Very compact (17x108x47mm) and low inductive design
- IGBT4 trench technology with improved EMC behavior
- Mechanically isolated temperature sensor
- Improved pinout

#### Power Range:

- Up to 100A at 600V and 1200V



Visit us at:  
PCIM Europe  
Nuremberg  
May 22-24, 2007  
Hall 12, Booth 422

Tyco Electronics Power Systems • Finsinger Feld 1 • 85521 Ottobrunn, Germany  
Tel.: +49 (0)89 6089 830 • Fax: +49 (0)89 6089 833  
[em.customerservice@tycoelectronics.com](mailto:em.customerservice@tycoelectronics.com) • [www.em.tycoelectronics.com](http://www.em.tycoelectronics.com)

 **Tyco Electronics**

Our commitment. Your advantage.

# Polycarbonate Capacitors Yesterday, Today and Tomorrow

*They are a strong candidate for applications requiring  
a long projected life*

*With a strong market need for high precision, high temperature, high reliability and long life film capacitors, a viable business still exists to produce the industry accepted Polycarbonate film. Military grade capacitors are especially in high demand; however, many producers of Polycarbonate film capacitors have discontinued production. Today's challenge is to continue processing the raw film.*

*By Sal Cesario, Electronic Concepts, Inc.*

Electronic Concepts manufactures military (Qualified Product List, QPL) and non-military grade polycarbonate capacitors, built using Bayer or Electronic Concepts manufactured film. From 1960s to 1980s, Electronic Concepts used Peter Schweitzer (a Division of Kimberly Clark) manufactured film, the only United States supplier of material, by license agreement with Bayer. In 1984, Electronic Concepts acquired the Peter Schweitzer film division, terminating the license, allowing Bayer to market the film in the United States. For economic considerations, Electronic Concepts started manufacturing capacitors using a balance of Bayer and Electronic Concepts film.

## **Basis of Producing Good Film**

In 1990, the conclusion of a polycarbonate film capacitor paper [1] stated, "both the orientation and crystal structure of PC (polycarbonate) film affects its mechanical properties and electrical dissipation factor". The paper was a cooperative investigation by the Jet Propulsion Laboratory and Electronic Concepts' film manufacturing division, Capfilm. Solvent casting Polycarbonate material will produce high quality, capacitor grade film; however, stretching the film is one of the most critical processes for the final production. Other higher volume production methods are used to produce Polycarbonate film, although, film thickness and electrical properties prohibit the materials use for capacitor manufacturing application.

## **The Casting Process**

Casting is a chemical process, by mixing Polycarbonate into a liquid state, and reforming the composition into sheets or log rolls. The liquid material flows onto a matte finished drum. The drum provides a critical component to successfully process the film. The matte finish on the casting drum prevents "blocking" or the elimination of the fusing of layers of plastic under wound tension. Another benefit, of the surface texture, is increased instantaneous peak current (Ipk). Ipk is rated on a linear per inch basis of the wound dielectric edge length. Increased Ipk corresponds to an increase in the capacitor's voltage rate of change. The relationship of base peak current is  $Ipk = C(dv/dt)$ . By example, Polycarbonate film would have around 1A per inch of wound film length, compared to Polypropylene experiencing around  $\frac{1}{4}$ A per inch of wound length.

By comparison, Polyphenylene Sulfide (PPS) or Polyester (PET) are

processed by heat extrusion and requires additives, which provide the surface texture, to prevent blocking. Particulate additives used in heat extruded dielectrics like PPS, PEN and PET although increasing Ipk are foreign particles to the base dielectric material. The particle distribution size, in the materials, is often thicker than the final stretched film thickness. Therefore, the dielectric properties and mechanical strength around the particles is compromised compared to a pure polymer dielectric. Decreases in voltage strength and insulation resistance are typical affects of particulate additives.

Polycarbonate produced specifically for dielectric applications, by an ultra-filtered solution casting, retains the polymer's intrinsic properties without the affects of the heat required in melt extrusion. The surface roughness of Polycarbonate is achieved through the finish of the casting drum without particulate additives or other contaminants. The homogenous nature of the mix slurry in solvent cast polycarbonate allows for ultra-filtration, a process not possible in films requiring particulate additives. The properties and characteristics of polycarbonate dielectric produced by solvent casting approaches the pure resin. Cast film, when correctly processed, will yield very high voltage strength and insulation resistance.

## **Stretching Solvent Cast Film, the Key**

One of the most important processes in film production is controlling thickness and uniformity of the film during the stretching phase. The sheet film has three critical dimensions, thickness; length or the machine direction (MD); and, width or the transverse direction (TD). The MD orientation correlates to the diameter of the capacitor, and the TD orientation correlates to the length of capacitor. Stretching the film aids in the manufacturing process to: align the polymers, or crystalline structure; increase machine direction shrinkage; nullifying the transverse direction shrinkage and decrease film thickness.

The alignment of the crystal structure is important for increasing the mechanical strength of material (especially in the MD), increasing the voltage strength, and adding increased thermal stability. Controlling shrinkage of the material during the manufacturing process of the capacitor is critical for maintaining good capacitor tolerances and high (dv/dt). During the capacitor winding process, shrinkage in the winding direction will yield a tighter section with tighter tolerance drift.

# Intersil Switching Regulators

High Performance Analog



Take Control.

Intersil's ISL65426 dual-channel, synchronous buck regulator has **user-configurable power blocks that enable quick design and reconfiguration of power supply systems** for FPGAs, CPLDs, core processors, and ASICs.



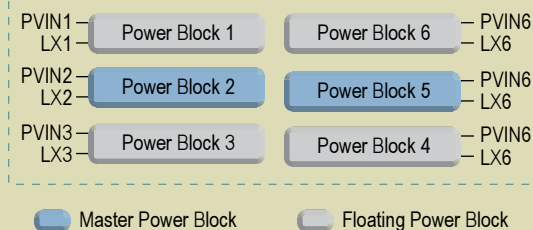
### Key Features:

- 180° out-of-phase operation
- Startup in a pre-biased load
- Independent output soft-start
- Stable all ceramic solutions
- High efficiency: 95%
- ±1% system accuracy over temperature

### Output Current Configurations

I <sub>1SET</sub>	I <sub>2SET</sub>	I <sub>OUT1</sub>	Channel 1 Connections	I <sub>OUT2</sub>	Channel 2 Connections
1	1	3A	LX1, LX2, LX3	3A	LX4, LX5, LX6
1	0	4A	LX1, LX2, LX3, LX4	2A	LX5, LX6
0	1	5A	LX1, LX2, LX3, LX4, LX6	1A	LX5
0	0	2A	LX1, LX2	4A	LX3, LX4, LX5, LX6
Invalid LX Configurations: SS Prevented					
X	X	1A	LX2	5A	LX1, LX3, LX4, LX5, LX6

### Six Integrated 1A Power Blocks



Go to [www.intersil.com](http://www.intersil.com) for samples, datasheets and support



Intersil – Switching Regulators for precise power delivery.

©2007 Intersil Americas Inc. All rights reserved. The following are trademarks or services marks owned by Intersil Corporation or one of its subsidiaries, and may be registered in the USA and/or other countries: Intersil (and design) and i (and design).



Conversely, a wound section undergoes an end spray, where, shrinkage in the TD (length of capacitor) can cause a lower (dv/dt) and raise the ESR (equivalent series resistance). Effectively controlling the stretch process of a cast polymer proves critical in producing mechanically and electrically strong capacitors.

**Thermal Characteristics of Polycarbonate Film**

Differential Scanning Calorimeter measurements are used to characterize the Polycarbonate film for melt point, glass transition and crystallinity. Melt point analysis as shown in the figure(1) occurs at 242°C (typical range is 230 °C to 260°C).

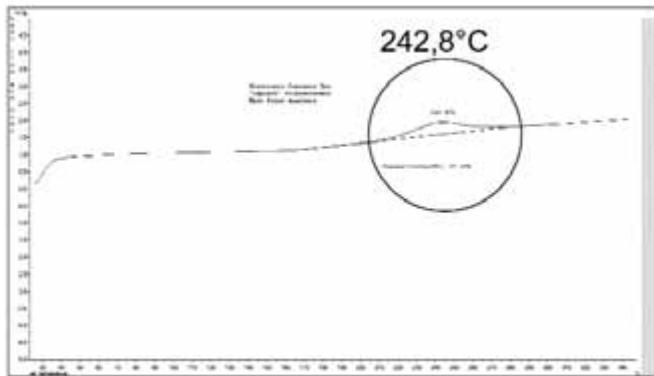


Figure 1: Melting Point Analysis

Glass transition is shown in figure(2) at 160°C. Notice the smooth curves with no other events evident over the temperature range of 200°C to 300°C indicating purity of the polymer. Foreign materials in the film would appear as additional “bumps” due to the different melting characteristics.

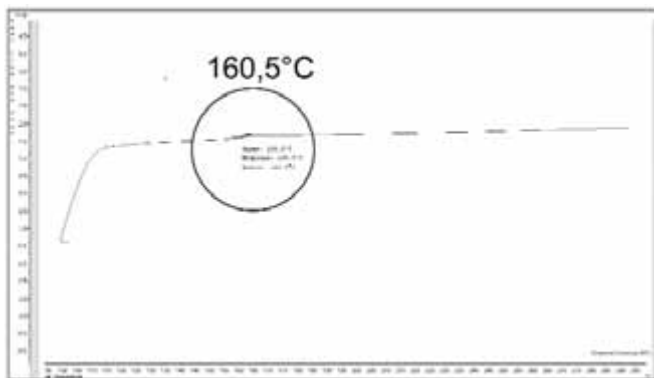


Figure 2: Glass Transition Analysis

To better understand the effects of stable thermal break down, tests were executed to characterize Polycarbonate film capacitors for DF against varying temperatures and frequencies. Additionally, measurements for capacitance fluctuations against varying temperatures were recorded.

**Technical Attributes of Polycarbonate Film**

Through good manufacturing processes and base chemical composition of Polycarbonate material, good electrical characteristics are achieved. Polycarbonate material, used in a capacitor, will yield key advantages, like, a continuously high reliable operation up to +125°C, low loss or stable dissipation factor, high current capability and stable capacitance changes over fluctuating temperatures.

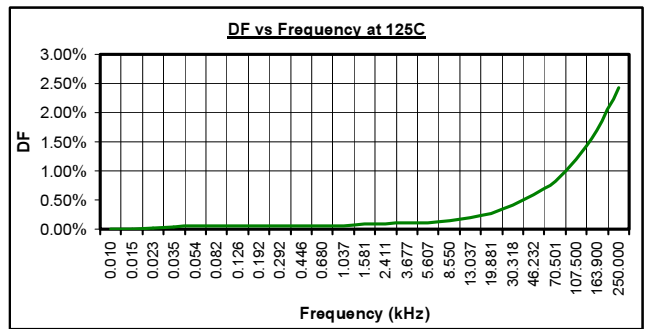


Figure 3: Dissipation Factor vs Frequency

Capacitor’s capability of controlling low loss or dissipation factor (DF) is effected by two key conditions; change in the application circuit’s operating frequency and temperature.

A Polycarbonate capacitor will only vary by about 2.5% over frequency sweeps from 10Hz to 250,000Hz, running at an elevated operating temperature of 125°C. Actual test data can be shown in figure(3), highlighting the stability of a Polycarbonate film capacitor.

Equally important, in controlling low loss, is to stabilize the effects of temperature variations when producing a capacitor. As illustrated in figure(4), test data showing how a Polycarbonate film capacitor’s DF changes against varying temperature ranges. The DF will only fluctuate by around 0.5%, with temperatures ranging from -55°C to +125°C, at a fix frequency of 1kHz.

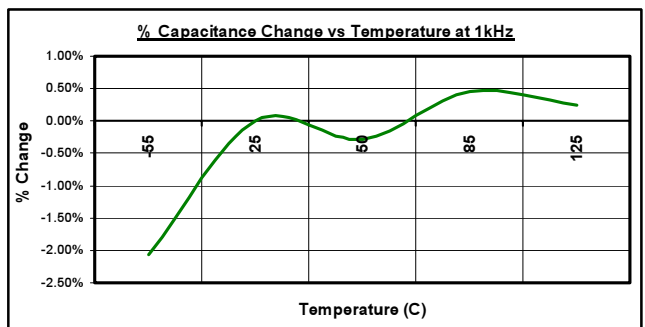


Figure 4: Dissipation Factor verse Temperature

As a side note, increasing temperature decreases DF. When the capacitor runs under power, heat is generated as reactive heating losses in AC or I<sup>2</sup>ESR heating losses in DC. As the internal temperature of the capacitor increases, the DF of the capacitor decreases and increased efficiency is realized.

A further look at the DF verses Temperature graph shows an extremely stable DF drift over normal (25°C) to elevated (125°C) temperatures would be around 0.5%.

One final measure of a good temperature property, found in a Polycarbonate film capacitor, is the measured constancy of capacitance value changes. As demonstrated in figure(5), the capacitance value will experience around a 2.3% change over the full temperature range of -55°C to +125°C.

Furthermore, over normal (25°C) to elevated (125°C) temperatures, the capacitor will only change around 0.5%.

Stable DF against temperatures and frequencies, and stable capacitance changes against temperature, provides a solid foundation to

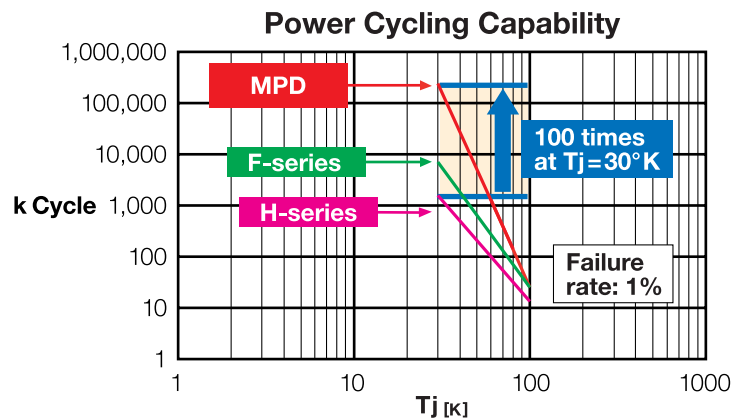
# All the power you need...

## For a clean future

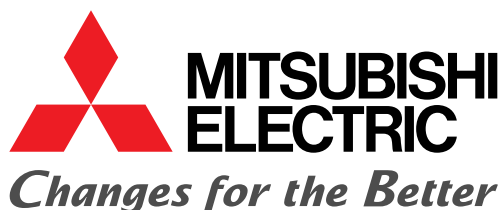


### Mega Power Dual IGBT Modules

- Latest Mitsubishi Carrier Stored Trench Gate Bipolar Transistor (CSTBT™) Chip Technology
- LOW  $V_{CE(sat)}$  vs.  $E_{off}$
- Reduced Gate Capacitance
- Unique compact package
- Multi hole terminals for safe low contact resistance and reliable long-term electrical connection
- DC terminals at different heights – designed to directly connect to a laminated bus bar
- Module ratings available are 900A and 1400A at 1200V and 1000A at 1700V (customized choppers on demand)



Booth 12/421



semis.info@meg.mee.com · www.mitsubishichips.com

Please visit us at the PCIM 2007, Hall 12, Stand 421

have long lasting, reliable capacitors. Actual life and reliability can be measured and calculated by applying test data.

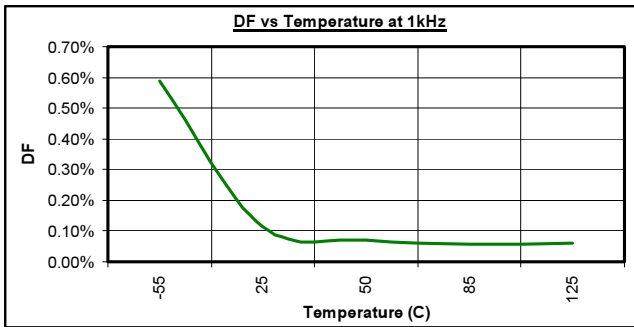


Figure 5: Capacitance Change with Temperature

**Long Life, Low Failure Rate**

Polycarbonate capacitors have maintained an excellent reliability rating. Failure rates can be expressed by a Failures In Time (FIT) calculation using accumulated test data. The formula,

$$FIT = (n/N)(1/t)$$

FIT = 1 failure in 10<sup>9</sup> component hours, and  
 n = number of failures  
 N = number of components tested  
 t = duration of testing, in hours

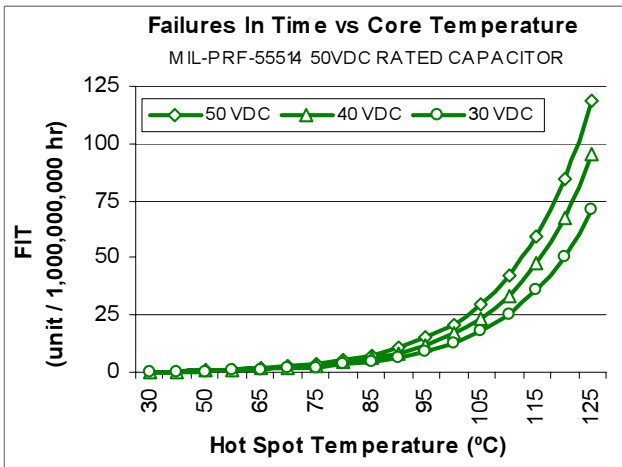


Figure 6: FIT Rate Example for MIL-PRF-55514

Applying test data accumulated against the FIT calculation, over a varying temperature range, shows a highly reliable part.

In fact, less than twenty five units would fail running over one billion hours (25x10<sup>-9</sup>), at fifty (50) volts, even at an elevated temperature of around one hundred degrees Celsius (100°C)

Electronic Concepts accumulated almost five hundred million hours of testing military grade Polycarbonate capacitors; and, currently meet established reliability failure rate level "R."

Polycarbonate capacitors are a strong candidate for applications requiring a long projected life. Using a projected life calculation, derived at Electronic Concepts, using base calculation from information published in "Selection and Application of Capacitors [2]", can be expressed as follows:

$$L_2 = \{L_1 / [(E_2/E_1)^{2.6087((E_2/E_1)+0.5167)}]\} \{2^{(T_1-T_2)/n}\}$$

- L1 = Test time in hours
- L2 = Projected life expectancy in hours
- T1 = Test temperature applied
- T2 = Temperature at which the life is projected
- E1 = Test voltage applied
- E2 = Voltage at which the life is projected
- n = °C rule for the temperature stress
- (n = 10 for organic materials)

By way of an example, if capacitors accumulated one million test hours at 100°C and 50VDC rated voltage; then, an application calling for a part to operate at 125°C at rated voltage, the projected life would be 177 thousand hours or over 20 years.

**Key Established Applications**

Polycarbonate film capacitors have been produced for decades, lending to an established product. Electronic Concepts have been producing military grade capacitors, especially MIL-PRF-55514, MIL-PRF-83421 and MIL-PRF-39022, for over thirty (30) years with great success. The forecast for the product shows a strong market demand.

**Supply of High Temperature Film**

Electronic Concepts remains a viable supplier of Polycarbonate film and capacitors, and will continue to produce given a strong market demand.

**Other Solvent Cast Pure Polymers**

Polycarbonate meets the market need for a reliable, stable (tight tolerance), high temperature material. Solvent casting process can produce Polysulfone at 150°C, Polyetherimide (PEI) at 200°C and aromatic Fluorene Polyester (FPE) at 250°C or greater.

**Conclusion**

Several manufacturers of Polycarbonate capacitors have exited the business; however, product specifications, tangible and intangible key features and customer benefits have created a product demand resulting in Electronic Concepts' long term plan to continually support the production of Polycarbonate film and Polycarbonate film capacitors.

The reliability, longevity and military specification conformance solidifies the Polycarbonate capacitor as a viable product for today and tomorrow.

**Acknowledgment**

The original paper was written and presented at the CARTS 2007 symposium held in Albuquerque, New Mexico.

**References**

- [1] S. P. S. Yen and C. R. Lewis, "Effect of structure and morphology on thermal and electrical properties of polycarbonate film capacitors". Published in IEEE, 1990.
- [2] John D. Moynihan, described in "Selection and Application of Capacitors", Second Edition, Copyright 1987 by Components Technology Institute Inc.

**Mark your calendar now**



# **SENSOR+TEST 2007**

## **DIE MESSTECHNIK-MESSE**

### **The Measurement Fair**

**Nürnberg, Germany**

**22. – 24.5.2007**



**Measurable better solutions for  
even more precision, quality  
and reliability**

Organiser:

AMA Service GmbH · phone +49(0)5033.96390 · [info@sensor-test.com](mailto:info@sensor-test.com)

**[www.sensor-test.com](http://www.sensor-test.com)**

# From the LAMP to LEDs

*So power supply changes*

*ROAL Electronics is focusing also on the wide Solid State Lighting (SSL) Technology applications using High Brightness LEDs*

*By Giorgio Fusari, Freelance Editor and  
Fabio Luconi Eu Field Application Engineer, Roal*

In its various forms, the economic and energetic subject is nowadays extremely important for the future of our planet. It is an issue that can not be postponed any longer, as the last WWF's Report, Living Planet Report 2006, pointed out. This Report has analyzed the ongoing process of erosion of the natural sources, the difficulty to regenerate them and also speaks about the necessity to transform a sustainable economy and society.



Figure 2: Satellite night view of Europe — [www.savethenight.eu](http://www.savethenight.eu)

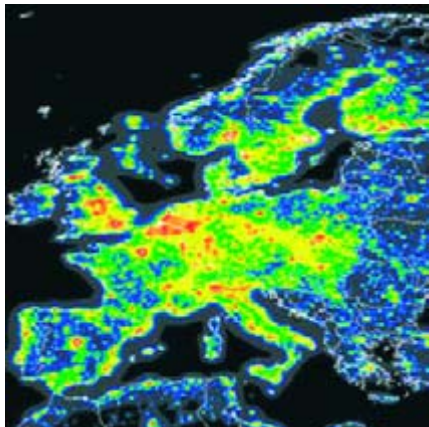


Figure 3: False colors show the intensities of artificial light, both direct and indirect, scattered in the atmosphere (sky glow produced by light pollution) — [www.lightpollution.it](http://www.lightpollution.it)

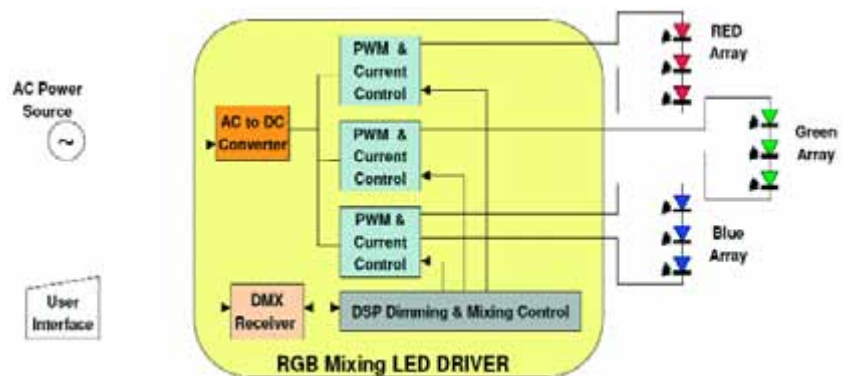


Figure 1: Example of RGB Mixing LED Driver with Digital Light Control

ROAL Electronics takes even this into consideration when it affirms that in its R&D activities and creation of new technologies of powering, one of the most important reasons to change direction is to improve the quality of life, to reach a more harmonious environment.

In this way Mr Leopardi (General Manager), presented the company on the press-conference held in the Italian Headquarters, during which a visit to Castelfidardo facilities was organized.

The powering systems are already playing a more delicate role in the electronic field, computer sciences, and in the service areas that we use every day and that are not very often considered important and are taken for granted and neglected at least till the moment a blackout occurs.

It would be good enough to think just about the powering systems for the IT or Telecom infrastructures or about the Illumination systems for streets and buildings in our cities. Established in 1985, with a business focused on designing, engineering, producing & testing of standard, modified & customized SMPSs (switch mode power supplies), ROAL Electronics, made its first agreements of supply with IBM Semea, IBM Greenock & Alcatel Europe in 1988.

In 1992 ROAL obtained the ISO9001 certification, signing contracts with others historic customers as Bull, in 1993, Ascom, in 1995,

Phillip Medical Systems Italy, in 1997 and Hitachi, in 1998.

In 2001 it celebrated the grand opening of the business unit in North America to supply a better service to the customers overseas. In 2005 ROAL made the first supply contract with OTE Finmeccanica and National Instruments. And it was only last November that Roal opened its sales, design and services division in Stroudsburg, Pennsylvania, according to its strategic plan of expansion in the US.

ROAL has an intention to open an office in the above mentioned branch with sales and engineering departments in order to consolidate the position obtained.

The objective of the new design center, as Mr Don Mulvey, Executive Vice-president, said, is to provide local support to the customers in real time establishing links between the current European facilities and R&D centers.

The most significant reference markets are IT, Networking, Telecom, Medical, Test & Measurement, ATM, and the applications in Media & Entertainment field. There is, as well, a very well-qualified team for PCB boards design used in the House Hold appliances.

## DIGITAL LIGHT CONTROL

Nowadays ROAL has been paying its greatest attention to the power supply digital tech-



nologies for the emerging and enormous sector of the SSL (solid state lighting), namely the market of the systems of illumination using the LED technology. In this field of the digital control of the light, if appropriately applied and used on a world wide scale, could bring about several benefits and savings in different aspects of human activities.

Currently, ROAL has a strategic & technological collaboration with TEXAS INSTRUMENTS, with the objective to reach a new level of DIGITAL POWER management introducing DSP devices.

It would be possible to save energy with a more clever management of the power control thus reducing the dissipated one with benefits not just to the environment but also to the customers and the maintenance of systems.

The Digital control (See Figure 1) allows to monitor the system in real time, by writing reports, detecting and preventing potential failures, making a dynamic re-configuration or optimizing operative parameters, such as through an intelligent control of the fan-cooling, depending on the system function.

This intelligence applied in the SSL field, redefines the classic paradigms.

The traditional illumination systems, working on lamps, says ROAL, generate a lot of heat which is emitted through dissipation. These systems also contain toxic material, break down regularly and have a limited control. On the other hand, the systems of control using LED technology are environmentally friendly, more efficient from the energetic point of view and are more flexible to manage as well.

**LIGHT POLLUTION**

The alteration of the natural quantity of light in the night environment due to the introduc-

tion of artificial light (Light Pollution) is a serious problem because it endangers the perception of the Universe around us (see figures 2, 3, 4 and 5), on which the starred sky constitutes the only window available for the population. A fundamental element for the culture, both humanistic and scientific, and one important part of the landscape patrimony is disappearing.

Light pollution finally means energy and money waste.

SSL Technology favors the use of more efficient fixtures, the design of lighting installations with larger utilization coefficients, the use of light sources with higher efficiency and the direct upward light emission reduction.

For instance, in the street illumination field or in big cities, it is possible to install sensors of proximity that switch on the light only when it is strictly needed while a constant power supply Digital control makes it possible to promptly intervene at functional anomalies.

The SSL technological challenges imply to be successful in managing the process of LED powering that requires a well modulated power source and a constant control of the current.

Namely, it is not an easy task to control this kind of light and to build robust final products. An intelligent design of the LED driver control circuits consent energy loss reduction and it is possible to increase the life cycle of the product by DIMMING.

The major technological difficulties in distributing and powering LEDs are present, for instance, in the Video Wall Displays, used during sport events, at football or basketball matches.

In these applications the architecture of pixel RGB actually requires a very high power level and also a reliable power supply. Furthermore, when it comes to thermal man-



Figure 4 : Satellite night view of USA — [www.savethenight.eu](http://www.savethenight.eu)



Figure 5: Composite image of the Earth at night, as viewed from a satellite — [www.wikimedia.org](http://www.wikimedia.org)



Figure 6: LED Boards: HB LEDs mounted onto Metal Core PCB

agement, in order to maximize the heat dissipation when the system is being used, special packaging techniques are required: High Brightness LEDs have to be mounted onto the MPCB ( Metal Core Printed Circuit Board, See Figure 6) to facilitate the dissipation and improve the system cooling.

[www.roallivingenergy.net](http://www.roallivingenergy.net)



**Sixteenth Bricks**

Complete product range from 1.2v to 15v outputs

Color-coded by output voltage for handling ease

DOSA compatible

Samples available... In stock TODAY!

**ROAL**  
living energy

RoHS  
Compliant

[www.roalelectronics.com](http://www.roalelectronics.com)

# System Integrated Drive for Hybrid Traction in Automotive

## *ECPE Demonstrator Programme*

*The pre-competitive research in power electronic systems in ECPE is based on long-term research roadmaps, and has its focus on automotive and industrial power electronic systems. With ECPE it could be managed to jointly formulate research topics in a European industrial consortium of main players in power electronics*

*By Fraunhofer Institute of Integrated Systems and Device Technology (IISB)  
Center for Automotive Power Electronics and Mechatronics, Dr. M. März*

The ECPE research activities funded by the ECPE partner industries is focussing at so-called demonstrator projects where new ambitious power electronic systems or sub-systems are developed and realized by leading European Competence Centers. This article describes results of the "System Integrated Drive for Hybrid Traction in Automotive" Demonstrator Programme performed by the Fraunhofer Institute of Integrated Systems and Device Technology (IISB) in Erlangen/Germany.



*Figure 1: Electric drive with the power electronics, both integrated into the clutch-box of a car.*

*The picture shows the drive unit screwed at the gear-box.*

The integration of the power electronic inverter with an electrical machine in the automotive powertrain is in the focus of the automotive Demonstrator Programme where the existing cooling circuit from the internal combustion engine is used also for the direct liquid cooling of the power electronics. The mechatronic integration of motor and power electronics leads to an ultra-high power density of 75 kVA/l for the inverter. The high temperature of the cooling medium of up to 115°C in combination with this high power density poses a unique challenge.

An optimised thermal design is necessary to master this thermal challenge. All temperature-sensitive components, passives and semi-conductors, have to be thermally connected to the cooling system which provides a sufficient cooling capacity although working on a very high temperature level.

## Results of the ECPE Research Programme

ECPE European Center for Power Electronics is driving pre-competitive research in power electronics jointly financed from an industrial research fund. Three Demonstrator Programmes have been started in 2003/2004 involving leading Competence Centers in Europe.

Experts from the Fraunhofer Institute of Integrated Systems and Device Technology (IISB) will present the Integrated Hybrid Traction Demonstrator during the PCIM Europe 2007 exhibition. Presentations will take place at the ECPE Joint Stand 12-466 just vis-à-vis the PCIM Forum.

The integration of the power electronic inverter with an electrical machine in the automotive powertrain is in the focus of the automotive Demonstrator Programme where the existing cooling circuit from the internal combustion engine is used also for the direct liquid cooling of the power electronics. The mechatronic integration of motor and power electronics leads to an ultra-high power density of 75 kVA/l for the inverter. The high temperature of the cooling medium of up to 115°C in combination with this high power density poses a unique challenge.

An optimised thermal design is necessary to master this thermal challenge. All temperature-sensitive components, passives and semi-conductors, have to be thermally connected to the cooling system which provides a sufficient cooling capacity although working on a very high temperature level.

On the module level, the optimized thermal design has to provide a homogeneous distribution of the chip temperature of the power semiconductors.



[www.ecpe.org](http://www.ecpe.org)

# Innovative Analog Components



## Innovative Analog Components from the Leading Supplier of 8-Bit Microcontrollers

In response to ever increasing requirements to minimise power, space and noise, and maximise accuracy in embedded system designs, Microchip has integrated its CMOS design and manufacturing expertise into a broad range of analog and interface components.

The products include a large family of operational amplifiers and comparators, alongside Microchip's innovative Programmable Gain Amplifiers (PGAs);

power management and conversion devices; thermal measurement and management devices; mixed signal products and interface devices.

Key attributes across the product families include low power operation and standby capabilities, high accuracy and low noise operation, wide operating voltage and temperature ranges, tiny packaging options and innovative design features.

### Key Product Families:

- Temperature Sensors
- Voltage Regulators
- Charge Pumps and Switching Regulators
- System Supervisors
- Power MOSFET Drivers
- Battery Chargers
- Operational Amplifiers
- Programmable Gain Amplifiers
- Comparators
- A/D Converters
- D/A Converters
- Digital Potentiometers
- CAN Interfacing Products
- Infrared Interfacing Products

For more information go to: [www.microchip.com/analog](http://www.microchip.com/analog)

**microchip**  
**DIRECT**  
[www.microchipdirect.com](http://www.microchipdirect.com)

Now  
**Pb-free!**  
RoHS Compliant

 **MICROCHIP**  
[www.microchip.com/analog](http://www.microchip.com/analog)

On the module level, the optimized thermal design has to provide a homogeneous distribution of the chip temperature of the power semi-conductors.

### Towards an Integrated Inverter Drive

For the latest generation hybrid drive there was a strong request for a solution that completely fits into the existing drivetrain of a passenger car. The clutch-box was designated as the housing, in which an electrical drive unit with a mechanical output power of 50kW and a maximum torque of 220Nm had to be integrated together with the complete inverter. But the conical, tuba-shaped housing with internal studs and ribs considerably complicated the integration challenges.

The basic internal arrangement of the components is shown in Figure 2. A permanent magnet excited synchronous machine (PM machine) provides a very high power density and a high efficiency even in the low speed range. By using a whole-coiled winding (single teeth coils), the winding overhang could be greatly reduced, resulting in an increased active motor length. The torque disadvantage, caused by the conical housing and the thereby restricted motor diameter, could be equalized this way. The electrical circuitry of the motor windings corresponds to that of a classical three phase machine. Thus only three power interconnections between motor and inverter are necessary. Multifunctional winding interconnections prevent a heat transfer out of the hot windings into the power electronics.

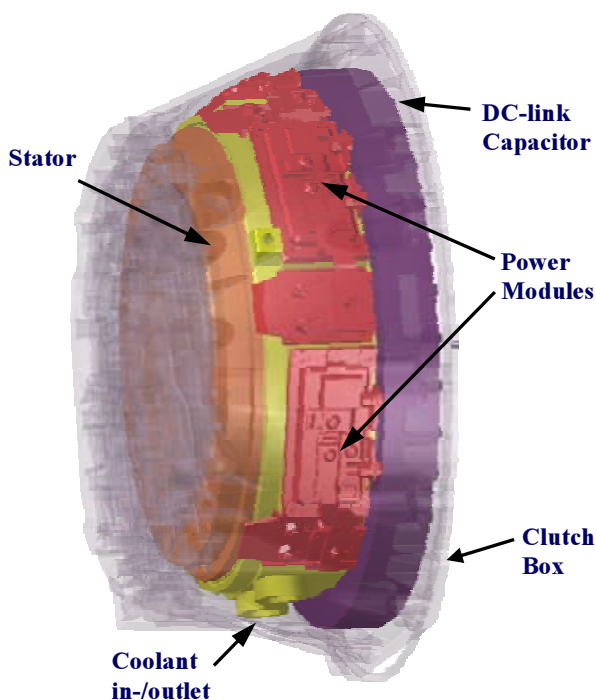


Figure 2: X-ray view on the second generation inverter drive (50kW), integrated into the clutch-box of a passenger car.

In order to achieve an optimum usage of the available package volume, a ring-shaped dc-link capacitor has been developed in cooperation with EPCOS AG. This capacitor provides a capacitance of 500 $\mu$ F (450V). Its concentric, nearly coaxial terminals form the dc-link busbar and allow the realization of a very low parasitic dc-link. The ripple current rating of this capacitor is several hundred amperes and thus far beyond the actual ripple current load. The self-heating, caused by the inverter ripple current, is therefore negligible. However, in

order to protect the capacitor against the high ambient temperature of up to 140°C, it is thermally coupled to the cooling jacket.

As can be seen from Figure 2, three half-bridge power modules are placed at the periphery of the water cooling jacket that surrounds the whole electric machine. The remaining sections at the periphery are used for the control board, the current sensors and the EMC filter. Since the system is also intended as a test platform for different power module designs, special attention has been put on a modular and assembly friendly construction.

Special attention has been paid to an optimized thermal design of the power modules. The inverter drive is inserted in the existing coolant cycle of the ICE. The available coolant flow is about 8 litre/min and the maximum allowable total pressure drop 200 mbar. An optimization of the back-side structure of the modules is necessary in order to minimize the thermal resistance between the power semiconductors and the coolant, but not to exceed the maximum allowable coolant pressure drop. The cooling efficiency of a finger-structure varies with its geometry - namely the finger thickness, shape, height and surface roughness - as well as the spacing and arrangement of the fingers. An important issue in this context is that the parameters of the coolant, especially the viscosity of the water-glycol mixture, greatly vary along with the temperature.

The realized power modules showed a specific thermal resistance junction-coolant ( $R_{th,jc}$ ) of 0,45Kcm<sup>2</sup>/W at a coolant flow rate of 8 litre/min and a pressure drop of 60mbar, both of which were close to the predictions from simulation. With respect to the coolant flow, the three power modules are connected in series, thus the specification of a total pressure drop of 200 mbar was achieved.

The prototype was built on a machined Cu base plate. This, of course, is no solution for series production, partly because of cost issues, but mainly because of reliability issues of the DCB to base plate solder joint. Due to the passive temperature cycles to be sustained (ca. 11.000 cycles with a mean temperature swing of ca. 100 K), an AISiC base plate could be a choice to reduce the thermal mismatch between base plate and DCB substrate to an acceptable low level at a small expense of thermal efficiency.

### Conclusions

Simultaneous engineering (electrical, mechanical, thermal) is an imperative prerequisite for a mechatronic integration of power electronics. Consistently following this way, an inverter drive for hybrid traction could be integrated into the clutch-box of a passenger car, i.e. in an environment and package volume that had been considered as absolutely useless for high power electronics so far. 3D integration, new components and sophisticated thermal management solutions opened the way to a system with unique power density. The next steps aim on a further optimization of the system reliability, manufacturability, and modularity.

### Reference sources

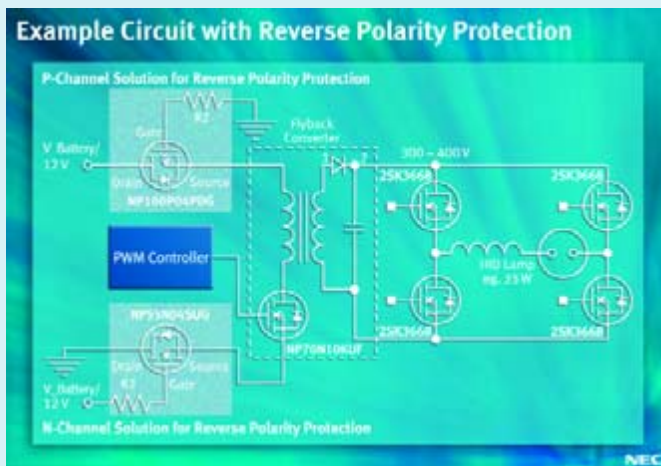
M.März, M. H. Poech, E. Schimaneck, A. Schletz  
 "Mechatronic Integration into the Hybrid Powertrain – The Thermal Challenge"  
 International Conference AUTOMOTIVE POWER ELECTRONICS – APE, Paris (France), June 2006

# Introduction of New P-Channel PowerMOSFET NP-Series for Automotive Applications

By Stephan Rex, Power Semiconductors Product Unit, NEC Electronics (Europe) GmbH

There is a growing trend in automotive power electronic applications to use a P-channel trench PowerMOSFET as an alternative to an N-channel trench PowerMOSFET or even a simple relay. Using a P-channel PowerMOSFET gives the designer a further easy alternative to optimize and improve the circuit design. Basically, a P-channel PowerMOSFET can do anything that an N-channel PowerMOSFET can do. An N-channel PowerMOSFET as a high-side switch requires an additional driving circuit for the gate, whereas the P-channel PowerMOSFET does not. This naturally affects the complexity and design effort of the circuitry.

Reverse polarity protection is a mandatory automotive application and demonstrates the benefits of a P-Channel PowerMOSFET. The figure below shows the basic configuration of a reverse polarity protection with an N-channel and P-channel PowerMOSFET for a basic operating principle of a Xenon lamp (HID).



The drain of the P-channel PowerMOSFET is connected to the positive pole of the power supply and the source to the ECU (electronic control unit) side. The gate is tied to the ground with a resistor of say 10 k $\Omega$ . At first glance, this solution seems incorrect because the PowerMOSFET is connected backwards. For correct operation the source should be more positive with respect to the drain. In fact, with a positive power supply the P-channel PowerMOSFET provides outstanding forward conduction. Now consider one indispensable part of the PowerMOSFET – the intrinsic body diode. Basically, the anode of the intrinsic body diode is connected to the drain and the cathode to the source. If the P-channel PowerMOSFET is connected in backward direction, the intrinsic body diode is forward-biased for positive polarity at the drain, and reverse-biased for negative polarity at the drain.

From a practical point of view, there is one major advantage to using a P-channel device instead of the N-channel PowerMOSFET. The ECU can be tied to the ground connection to warn the designer of a floating ground connection. If an N-channel is used, the load cannot be referenced to ground because of the voltage drop across the PowerMOSFET channel which can result in a floating ground connection of the ECU.

## New P-Channel PowerMOSFET NP-Series

In the past, the main advantage of a P-channel PowerMOSFET was the circuit simplification in low and medium power applications. Now very low RDS(on) P-channel PowerMOSFETs suitable for high-power applications are available. Key features of the new P-channel NP-Series are:

- Super low RDS(on), max with 3.5 m $\Omega$  in D<sup>2</sup>PAK for a VDSS = 40 V
- High current capability with up to 100 A DC
- Maximum channel temperature of 175 °C
- Avalanche energy rated
- RoHS compliant with pure Sn plating

## P-Channel NP-Series in UMOS-4

V <sub>DS</sub> [V]	R <sub>DS(on)</sub> max. [m $\Omega$ ] @ V <sub>GS</sub> =		I <sub>D</sub> [A]	P <sub>D</sub> [W] @ T <sub>c</sub> = 25 °C	SMD	
	10 V	4.5 V			TO-252ZK	TO-263ZK/ZP
-40	4.3	6.1	-1.5	3.5	NP15P04SLG*	
	2.8	4.0	-2.0	4.5	NP20P04SLG*	
	17.5	2.5	-3.6	5.6	NP36P04SDG*	
	17	23.5	-3.6	5.6		NP16P04KDG
	10.5	15.5	-5.0	9.0	NP10P04SDG*	
	10	15	-9.0	9.0		NP10P04KDG
-60	5.1	8	-8.3	15.0	NP83P04PDG	
	3.5	5.1	-10.0	20.0	NP100P04PDG	
	7.5	9.6	-1.5	3.5	NP15P04SLG*	
	5.0	6.4	-2.0	4.5	NP20P04SLG*	
	3.0	4.0	-3.6	5.6	NP36P04SLG*	
	29.5	37.5	-3.6	5.6		NP16P04KDG
-100	17.5	23.5	-5.0	9.0	NP10P04SDG*	
	17	23	-9.0	9.0		NP10P04KDG
	8.8	12	-8.3	15.0	NP83P04PDG	
	6	7.8	-10.0	20.0	NP100P04PDG	

\* Product is under development and might be subject to change without notice.

All devices are qualified for automotive applications, based on the AEC-Q101 qualification flow, and meet the quality requirements for automotive applications. Samples are available now!

For more information about NEC Electronics (Europe) products for automotive power devices visit [www.eu.necel.com/mosfet](http://www.eu.necel.com/mosfet).

[www.eu.necel.com](http://www.eu.necel.com)

# Heavy Wire Bonder Set a New Standard

## Quality and machine integrated tests

*The designers have implemented an abundance of measures to reach a significant improvement in bond quality for fully automatic heavy wire bonders.*

*By Herbert Stürmann, Hesse & Knipps*

### Quality assurance

Industry's target is the reduction of the failure rate to "0 ppm". Innovations are demanded to achieve this challenge in an acceptable timeframe.

### Bondhead integrated quality tests

For many years now a non-destructive test for heavy wire bonders has been called for which allows 100% control and can examine a wide range of possible quality errors. Generally, the integrated pull and shear test are suitable for this. Pull tests show in particular bad or non-bondable surfaces and cratering. Shear tests show weak points in the intermetallic connection.

The newly developed Hesse & Knipps bondhead is worldwide in its uniqueness as it is the only head containing the integrated pull-test and the integrated sheartest. The sensors integrated in the bondhead enable fast and safe pull and shear tests which can be set by the user with regard to his qualitative targets.

Both functions are integrated in the bondhead in such a way that the freespace

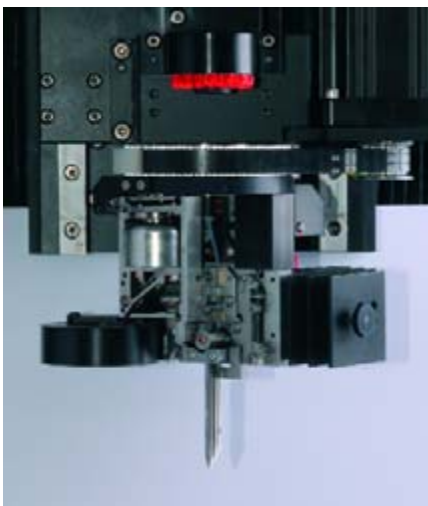


Figure 3: Bondhead

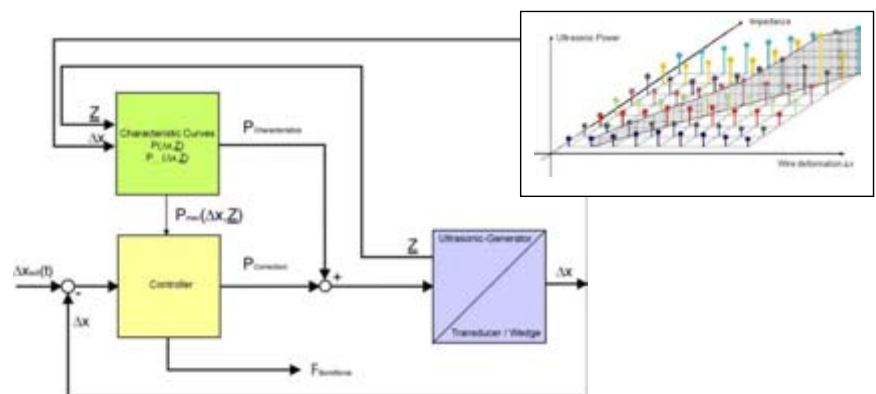


Figure 1: PIQC (Process Integrated Quality Control)

around the bondhead is not at all constricted and the heavy wire bonder can be used in all applications without restrictions. The newly developed technical solution is applied for worldwide patent.

The Hesse & Knipps PIQC – Process Integrated Quality Control (patent EP1 023 0139 B1) is being integrated in the heavy wire bonder BJ920. PIQC enables the acquisition and assessment of several feedback values which influence bond quality. This quality control method is currently being tested in the field.

### E-Box: reproducible set-up system for cutter, wire guide, bond wedge

Maximum accuracy is required when exchanging the wedge, the cutter and the wire guide in order to avoid quality reduction because of incorrect tool settings. The E-box allows micron-precise settings of the tools, allows immediate visual control by the operator and prevents shift-shift and technician-technician set-up variations. Control procedures and re-adjustments become unnecessary while the life time of the tools is increased. The time required for tool set-up compared to the usual procedure is reduced by about 70%.

### Vibration elimination

It is widely known that the axes movements of the bonder can bring the complete assembly to vibration. If residual vibrations have not subsided during the bond process, it can negatively influence the bond process: considerable quality problems can occur due to lack of reproducibility and measurement methods of the bond process. State of the art sensor and control technology ensure that machine vibrations have no disturbing influence on the welding process or do not even occur. Beside the optimum touchdown detection (300ms), a high precision bond-force control is integrated. The touchdown and deformation sensor has practically no signal propagation delay. Its resolution is 0.1m, the bond force is controlled to  $\pm 1$  cN accuracy. Furthermore, no sensor calibration is necessary.

The risk of damaging components with increasingly sensitive semiconductors is considerably reduced. The control system VC920 plays an important role in reducing the risk of field failures.

### „Active“ cutter system

The newly developed active cutter system is decoupled from the Z-axis and requires no

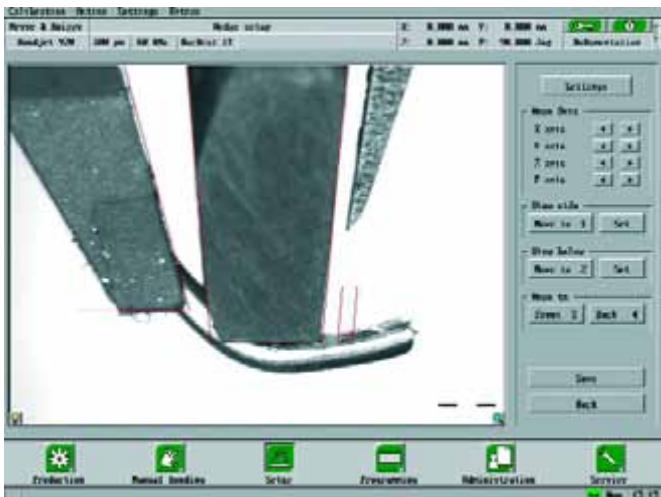


Figure 2: The E-box allows micron-precise settings of the tools pusher. This increases the free space for bonding inside packages. The system enlarges the setting window for cutting and so allows a much quicker cut process. The absolute repeated accuracy of the cutting system improves the quality as the risk of cutting into the substrate is prevented. The cutter life time is increased considerably. The system produces constant cut depths even with tolerances in the product.

**Further features**

The heavy wire bonder BJ920 has numerous other features: large working area (380 mm x 500 mm), intelligent and complete software concept, specifically developed pattern recognition system, transducers with different frequencies, fully digital generator with a wide frequency range and much more. The machine concept fulfils the most demanding user requirements from automotive to leadframe applications. Preparations are underway for the adaptation for ribbon applications.

PCIM Booth 12/462

[www.hesse-knipps.com](http://www.hesse-knipps.com)

**Now You Can Smile**  
 With SanRex™ 17mm LOW PROFILE RECTIFIER MODULES.  
 Enables Connection with IGBT or MOSFET Modules At The Same 17mm Case Height.

**3 $\phi$  RECTIFIER**  
 $I_T$  (AV) = 75A-200A  
 up to 1,800V

**DUAL RECTIFIER**  
 $I_T$  (AV) = 100A-200A  
 up to 1,800V

**Connection on the Same Level**

**Easy Parallel Connection**

**For further info please contact us:**  
**E-mail: [info@sanrex-europe.de](mailto:info@sanrex-europe.de)**  
**Web: [www.sanrex.com](http://www.sanrex.com)**  
**SanRex® Europe GmbH**

PCIM Booth 12/343

- \* hard switching versions
- \* scalable hard/hard-soft versions
- \* min. ON-time upon request
- \* single- & dual Interface Cards with optical R/T

### ALL AROUND DRIVER PRODUCTS

including SAFE INSULATION & PARTIAL DISCHARGE FREE Quality acc.  
 EN50124-1 and -2 further EN50178 and EN61800-5-1 as part of:

- DC/DC Converters starting with 2kV AC RMS and much more
- DC/DC supply boards with wide  $V_{in}$  and set  $V_{out}$ , insulation from 2-7kV
- HV/Single IGBT Driver Modules

**NEW DRIVER PRODUCT**

100W Power Driver for up to 300kHz operation for Induction - Heating - Welding purposes with magnetic current sensor and scalable Collector Current trip point following an automatic SOFT turn off.  
 Driver includes as well a jumper selectable OSA turn OFF and Active Clamp overvoltage protection.

**FLOETH ELECTRONIC GmbH**  
 Am Malfinger Steig 13 86920 Denklingen  
 T. xx49-8243-9693-0 F. xx49-8243-9693-33  
[www.floeth-electronic.com](http://www.floeth-electronic.com) [www.IGBT-drivers.com](http://www.IGBT-drivers.com)

Booth 12/659

# Motion Control and Mixed-signal FPGAs

*FPGAs enable tighter control loops*

*Recent advances in electronic component performance and integration at a lower price point have spurred the proliferation of electronic control units. Crossing many technologies and applications – from home appliances to automated industrial manufacturing lines – the focus is on increasing design and power efficiency while reducing design, development and total system costs.*

*By Glen Young, product marketing manager, Actel Corporation*

Simultaneously, motion control applications are increasing in complexity from simple on/off-type controls to variable speed applications with precise control systems that operate in a highly-integrated environment. The key components that apply to multiple control schemes across AC, DC, brushed, and brushless motors are: user interface, microcontroller (MCU) and control logic. A sensor interface is an add-on component for closed-loop motion control (Figure 1). Moving motion control logic into the digital domain allows for control via distributed control environment. The pairing of motion control electronics and a distributed network brings new capabilities to the manufacturing floor, including remote management; ability to respond to changing protocols; performance monitoring; and scheduled maintenance at planned intervals.

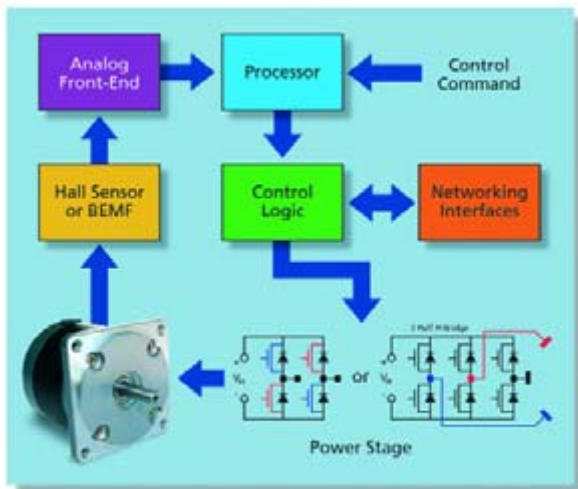


Figure 1: Traditional motion control implementations can require several discrete components. This closed-loop motion control system uses a networking interface, microprocessor, analog, a hall sensor interface and control logic.

For example, robotic arms driven by stepper motors are widely deployed in today's automobile assembly lines. Robotics complicate the distributed control scheme with various robot arms screwing different parts on several vehicles simultaneously. One of the system designer's primary challenges is to synchronize with other robot arms and other industrial automation equipment through a local area network. To complicate matters further, remote management capabilities,

such as monitoring, data sharing and remote configuration, are often critical to the complex central control topology, making an effective distributed control mechanism even more essential.

With technology improvements in semiconductor processes and integration, field-programmable gate arrays (FPGAs) have emerged as an important platform alternative for many electronic motion control applications. FPGAs continue to outpace market growth, replacing application-specific integrated circuits (ASICs) in many applications. Nonvolatile FPGAs are a cost-effective alternative to ASICs, thus eliminating ASIC-related development costs and speeding time to market. Further, using FPGAs in lieu of fixed logic, designers have an efficient and reliable way to upgrade and customize features, at design time, or in the field.

A flash-based mixed-signal FPGA, such as the Actel Fusion Programmable System Chip, can offer unprecedented integration in a single-chip implementation. Thus, these solutions can replace a host of discrete components at less than 50 percent of the cost and board space while maintaining system reliability (Figure 2). Further, the integrated flash memory of the mixed-signal solutions allows designers to store design files, eliminating the need for a separate configuration PROM, like those associated with SRAM-based FPGAs, on the board. Further, much like other reprogrammable FPGA solutions, a configurable and flexible mixed-signal FPGA device enables design changes to be easily implemented whether during development or even after the unit is deployed.

The FPGA's ability to accelerate mathematical computations via parallel processing is well documented, making them ideal for control logic implementation for motor control. FPGAs enable tighter control loops; therefore, they offer better control and reduced ripple and noise. With the emergence of mixed-signal FPGAs with integrated flash memory, designers can also integrate a soft processor core, run directly from on-chip memory, and tightly couple control logic and interrupt-driven processing needs. The amount and type of logic, as well as the functionality of control logic in the design varies for each application, based on performance requirements. Therefore, programmable logic is often preferred for implementing the various user interfaces and digital control logic, including network and peripheral interfaces, pulse width modulation (PWM), quadrature-encoder interface and sensor inputs, critical to today's motion control systems.



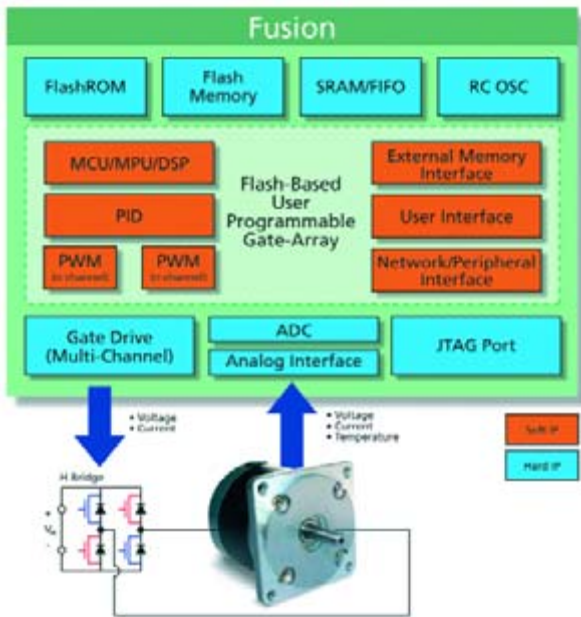
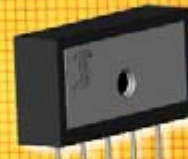


Figure 2: The Actel Fusion Programmable System Chip delivers unprecedented integration for motion control systems in a single-chip implementation. This integration includes configurable analog, large flash memory blocks, comprehensive clock generation and management circuitry, and high-performance programmable logic in a monolithic device. The architecture can be used with Actel's soft ARM or 8051 cores and other application-specific IP such as a pulse width modulator.

# High Power



PCIM 2007  
Stand 12-539

in small packages

Three Phase Bridge Rectifier DBI  
6 to 25 Amp / 50 to 1600 Volt

- Easy Assembly
- New Generation Chip inside
- Isolated Case, UL approved

**Diotec**  
Semiconductor

Your Specialist for Diodes and Rectifiers!  
[www.diotec.com](http://www.diotec.com)

# PEAK PERFORMANCE

## FOR YOUR POWER APPLICATION

Visit Maxwell  
At PCIM Europe  
BOOTH 12-333

Need Flexible Power Storage And Energy Delivery?



Explore the design solutions that Maxwell's BOOSTCAP® ultracapacitors offer. Designed to work with your application's batteries, BOOSTCAP ultracapacitors are providing the power needed to engineer today's complex applications.

Learn More About BOOSTCAP® Solutions For Your Power Design At [www.maxwell.com/power](http://www.maxwell.com/power)

### Network and Peripheral Interfaces

In motion control systems, network and peripheral interfaces allow users to issue commands for initializing, configuring, and controlling the control logic in addition to remotely managing the control systems. Depending on the function and topology, each implementation may have its own unique network and peripheral interface scheme. However, common across all motion control systems is the use of interfaces to enhance system accessibility.

A variety of industry-standard interfaces exist, such as Universal Serial Bus (USB), RS232-based serial, and Controller Area Network (CAN) interfaces for local access as well as 10/100 Ethernet for a TCP/IP-based networking scheme. In harsh environments, such as an automotive manufacturing floor, a wireless network interface may be required. This interface enables system synchronization, data sharing, status monitoring, and failure alarms on the manufacturing floor. Further, a TCP/IP-based network interface extends the ability to remotely access the central manufacturing control from any distance.

In many cases, the industrial automation applications require special control algorithms and mechanisms to perform unique tasks. For functions outside standard interfaces, proprietary interfaces are considered. To achieve the full potential that a distributed control environment can offer, industry-standard interfaces or proprietary networking protocols have to be added at the board level or embedded in programmable logic. An FPGA is an excellent platform on which all interfaces can be implemented. In particular, with their analog front end, today's mixed-signal FPGA solutions can support a wide variety of user input types as well as providing the voltage, current, and temperature monitoring capabilities related to motion control.

### Pulse Width Modulation (PWM)

PWM logic is not a "one size fits all" for all motion control applications. As the number of windings, voltage/current ratings, torque profiles and other parameters widely vary, each PWM system needs to account for these variances. In a PWM-controlled system, the sequence in which voltages are applied determines the rotational direction. Based on the inductance of each winding, the duty cycle, or frequency and duration of each pulse, determines the peak current and magnetic flux, or torque, achieved. The mechanical momentum and winding inductance, which is partially set by the number of turns used, will integrate or smooth out the PWM voltages. By controlling the sequencing, frequency, and duty cycle of the drive electronics, PWM systems can control direction, speed, and average torque. With an FPGA implementation, the designer can build the PWM solution that best suits the system requirements instead of having to "make do" with the capabilities of the traditional MCU/DSP solution.

### Quadrature-encoder Interface

Most high-precision motors, like the servo-type stepper motors used in robotic arms, support quadrature-encoder interfaces. The control system must provide quadrature-encoder interface logic to determine accurate speed, position, and acceleration of the motion rotors. Certainly, with a programmable logic implementation, accuracy and dynamic speed can be adjusted to fit in various modes, depending on the characteristics of the motors used in the motion control system.

### Sensor inputs

For closed-loop motion control systems, rotor position and/or tachometer inputs are needed. These may be hall-effect sensors built in or externally mounted optical position encoders, synchro-resolvers, or magnetic induction sensors. With an integrated analog front end, the mixed-signal FPGA offers a more integrated solution, reducing part count, system cost, and increased reliability.

### Reliability and System Uptime

For today's electronic systems, high performance, lower integration costs, and rapid diagnostics are critical. Diagnostics and prognostics, or the ability to determine failure modes and predict them, are quickly gaining momentum in system management implementations. The ability to read back time-stamped system parameters about board operation or review post-production failure analysis is invaluable to system development. Similarly, the ability to put together a "black box" would save valuable time and effort when trying to identify failure modes and design weak spots.

The on-chip flash memory of a mixed-signal FPGA offers the designer the ability to save and time stamp key system parameters, such as current consumption of power rails, device temperatures, and voltage rail fluctuations. Not only can this data be analyzed post-failure to identify the root cause of failure, but innovative designers are looking to analyze system trends during operation. For example, a designer might measure the current to the windings as well as motor vibration (as a voltage input) to determine when to bring the equipment down in a planned fashion. In industrial applications, a planned shutdown is dramatically less expensive than an unplanned one due to the cost to fix the problem as well as the possibility of lost profit from equipment shutdown. By analyzing how a particular parameter varies over the life of the board, a mixed-signal FPGA enables designers to predict a failure before it occurs, thereby maximizing machine availability, increasing system up time and reducing the risk of costly crashes.

Electric motors are employed in a wide variety of applications and many of which are evolving from electromechanical to electronic designs. One obstacle to wide-scale use of electronic motor controls has been the costs of computer and power electronics. With technology improvements in semiconductor processes and functional integration, this obstacle is diminishing. Still, FPGAs have become an important alternative for many motion control applications as today's fixed-function implementations incur high design costs, often requiring different components and board-level changes with each minor design iteration.

Flash-based mixed-signal FPGAs, like the Actel Fusion PSC, supports both algorithmic and control logic updates to support industry-standard or proprietary user interfaces, remote management capabilities, advances in control algorithms and sensor inputs. Because an ideal motion control design consists of a few interoperable components designed to plug together and operate with minimal hassle, mixed-signal FPGA solutions address this need with unprecedented integration, thereby reducing component count, board space, and total system cost and thereby increasing reliability and uptime.

# PCIM

## Europe

---

### 2007

International Exhibition  
& Conference for

**POWER ELECTRONICS  
INTELLIGENT MOTION  
POWER QUALITY**

**22 – 24 May 2007**

Exhibition Centre Nuremberg

# Power On!



Organizer:  
Mesago PCIM GmbH  
Rotebühlstraße 83-85  
D-70178 Stuttgart

Exhibition:  
Linda Raidt  
Tel. +49 711 61946-56  
E-Mail: [raidt@mesago.de](mailto:raidt@mesago.de)

Conference:  
Lisette Hausser  
Tel. +49 711 61946-85  
E-Mail: [hausser@mesago.de](mailto:hausser@mesago.de)

# Sensorless Field Oriented Control using an 8-Bit Microcontroller

*The PWM unit directly triggers the AD-converter via hardware events*

*Field Oriented Control (FOC) is increasingly being used in consumer and industrial motor control applications because it results in higher efficiency by running the motor at optimum torque at all times; better dynamic response to enable very precise variable speed control; and lower torque ripple to provide even and steady motor rotation at speed and also during start and stop operation. Typically a 16- or 32-bit MCU or digital signal processor (DSP) is required to handle the complex trigonometric equations.*

*By Arno Rabenstein, Infineon Technologies AG*

Compared to current solutions on the market, in which FOC execution engages almost the whole central processing unit (CPU) load, FOC execution on the Infineon 8-bit microcontrollers XC886 and XC888 - e.g. with 15 kHz PWM frequency and 133  $\mu$ s current control response time - only requires 58 percent of the CPU's performance, providing ample headroom for application specific functionality. The execution of a sensorless FOC on a standard 8-bit microcontroller is enabled by the highly optimized PWM unit CAPCOM6E that triggers the AD-converter for measuring the DC-link current via a single shunt resistor. The calculations of the sensorless FOC algorithm in 16-bit arithmetics can only be realized by a nested utilization of the co-processors MDU and CORDIC - called vector computer - and the 8051 compatible CPU itself. The MDU is a 16-bit multiply and divide unit, the CORDIC is a 16-bit co-processor dedicated for vector rotation and angular calculations.

Sensorless Field Oriented Control implemented on 8-bit microcontrollers XC886 and XC888 is the perfect answer to energy related regulations and pricing pressure for appliance manufacturers. Unlike most competitive FOC implementations that are hard-coded, XC886 and XC888 microcontroller-based solutions offer the added benefit of software reprogrammability to offer more versatile application options.

**Sensorless Field Oriented Control**  
A field oriented control algorithm requires

information about the rotor position. This can be achieved by position sensors like an encoder or resolver. Another approach is a sensorless FOC for BLDC motors, which is more suitable for cost critical applications. It is based on the interaction between the permanent magnet of the rotor and the magnetic field of the stator.

In order to determine the actual angle of the rotor, the flux vector  $\Psi$  can be calculated by integrating dedicated voltages.

$$\vec{\Psi} = \int (\vec{v}_s - \vec{i}_s \cdot R) dt - (\vec{i}_s \cdot L)$$

The voltage model is a simple model for rotating field motors which is based on dedicated differential equations. The stator cur-

rent vector  $i_s$  requires a precise measurement of the phase currents. The integration is simplified by replacing it by a lowpass filter with a very low cut-off frequency.

A sensorless field oriented control (FOC) implemented on a standard 8-bit microcontroller offers the full benefits of sinusoidal commutation at a minimum of system cost. When using just a single shunt in the DC-link in order to acquire the phase currents, there are demanding requirements on fast and accurate AD-conversion. The phase currents must be reconstructed out of the DC-link current signal which is the response of a three phase space vector pulse width modulation.

A space vector is a sinusoid whose center is

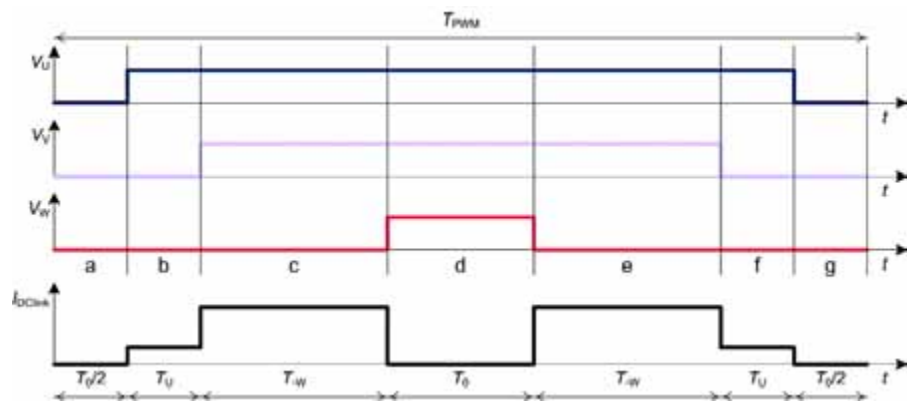


Figure 1: Space Vector Pulse Width Modulation: Three-phase inverter output signal and DC-link current  $I_{DcLink}$

able to "float" in space. A three-phase space vector is represented by a hexagon which can be divided in six sectors. Any desired voltage-space vector will consist of a "real" voltage from one of the phases and an "imaginary" right-angle voltage created from the other two phases. The space-vector algorithm will determine the time required at a first active state, a second active state, and an inactive state to produce the desired magnitude and angle of the space vector.

Figure 1 gives an example. The first active state (b&f) is  $T_U$ , the second active state (c&e) is  $T_W$ , the inactive state is  $T_0$  which appears twice, first as (000) vector (a&f), second as (111) vector (d).

In order to reconstruct the phase currents out of the DC-link current, the AD-converter has to be triggered during the active states. A perfectly sinusoidal commutation will require space vectors also pointing exactly onto the corners of the hexagon. Then only one phase current could be measured at the DC-link and only one phase current could be reconstructed. This is not tolerated by the FOC algorithm itself. As a result, the corners of the hexagon have to be blanked by the space vector pulse width modulation. This blanking causes some ripple in the output signals which have to be reduced to a minimum.

#### Acquisition of Actual Values

Figure 2 shows the block diagram of the sensorless FOC with speed control for a permanent magnet synchronous motor (PMSM). In order to estimate the rotor position by a single shunt measurement, the PWM pattern generation and the triggering of the AD-converter for current measurement must be very fast and accurate. Any jitter in the trigger point will influence the actual rotor's angle estimation. As a result, the total harmonic distortion of the sinusoidal current signals will increase.

The XC886/888C(L)M microcontrollers implement the above requirement using an event based hardware trigger from the PWM unit CapCom6E towards the AD-converter. The green lightning symbols in the second PWM period in Figure 3 represent the hardware events which directly trigger the AD-converter sampling. The event based trigger eliminates any interrupt latency and enables fast and accurate current measurement. After sampling of the signal, the conversion phase does not require a valid signal at the input, because the sampled voltage is stored internally. After conversion the result is stored in one of four result registers. Two result registers are used to hold the appropriate DC-link current values  $I_{DClink}$ . The ADC sample time is as low as 250ns. As the current is measured in time slot (b) and (e) of Figure 1, there is always enough time for conversion available.

The moment of triggering is adjusted by the compare and period values of the unit CAP-COM6E. There are two timers implemented which can be synchronized against each other. Timer T12 is responsible for generating the space vector pulse width modulation pattern. There are shadow registers for the compare values implemented in the device which allow a glitch-free operation. Start of

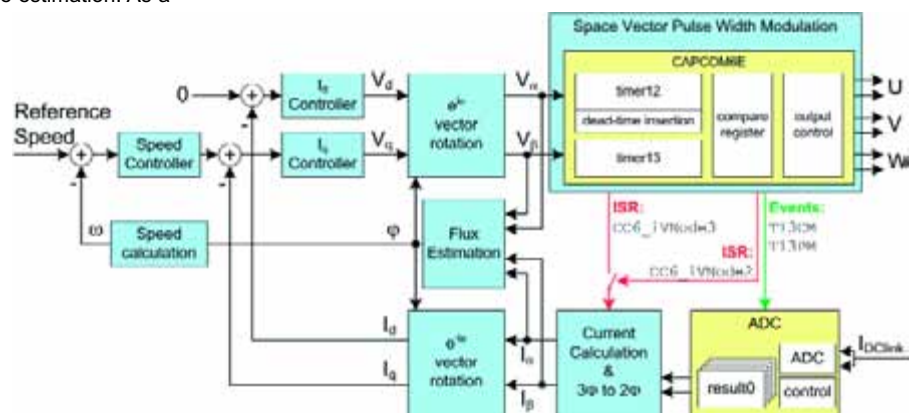


Figure 2: Sensorless Field Oriented Control of PMSM motor

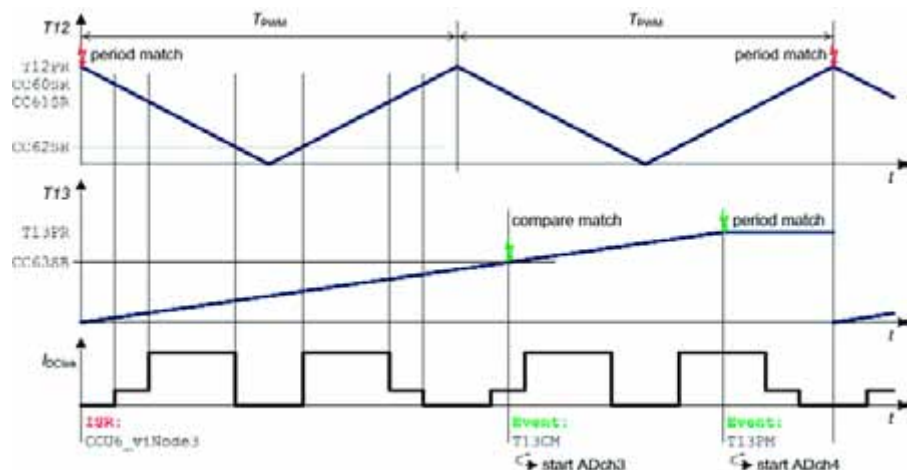


Figure 3: Timing diagram of Space Vector Pulse Width Modulation and AD-Converter

timer T13 is synchronized to the period match of timer T12 and is responsible for triggering the AD-converter. The compare value and period value is adjusted suchlike that the current is measured in the middle of the active states. Two AD-converter channels are used in parallel to sample the amplified shunt resistor signal. It is configured to store the results in two different result registers. Hence the FOC calculations can directly read the result registers and do not care about triggering the measurement in time.

### Field Oriented Control Calculations

From a control point of view, the field oriented control is comparable with that of a dc motor. The basic concept is a cascade control with the important difference that the electrical variables ( $V_d$ ,  $I_d$ ,  $V_q$  and  $I_q$ ) are turning with the rotor. Thus the currents measured at the stator ( $I_\alpha$  and  $I_\beta$ ) have to be transformed in the rotor coordinates ( $I_d$  and  $I_q$ ). The controller for the currents is realized in the rotating system as PI-controller, whereas the field exciting d-component and the torque exciting q-component is controlled separately. The speed controller adjusts - as for a dc motor - the reference value for the torque exciting current  $I_q$ . Due to the permanent magnets at the rotor, the reference value for the field exciting current  $I_d$  is set to zero.

The outputs of the current controllers represent the reference voltages ( $V_d$  and  $V_q$ ) in the rotor coordinates. These values are transformed into the stator coordinates ( $V_\alpha$  and  $V_\beta$ ) in order to calculate the polar coordinates (norm and angle). Using space vector pulse with modulation, the norm and

angle values are converted in three phase currents by modulating the high-side and low-side switches of the power inverter accordingly.

All calculations are executed step by step in one interrupt service routine which is called at timer T12 period match. The execution takes more than one PWM cycle. As a result, the control loop time is twice a PWM period, e.g. at 20kHz PWM frequency, the control loop is calculated every 100 $\mu$ s.

### FOC Drive Application Kit: CANmotion

The FOC Drive Application Kit provides a cost-effective method of evaluating and developing sensorless brushless DC (BLDC) motor control applications using the Sensorless Field Oriented Control technique.

The kit is featuring the CANmotion evaluation board which integrates the XC886CM MCU (TQFP-48) and a 3-phase power inverter providing all the necessary functions to control a 24V BLDC motor. The complete sensorless FOC source code with a comprehensive documentation allows the users to jump start with FOC development.

A CAN to USB bridge, built by using the XC886CM again, is available in the kit for hex code download and parameter adjustments. A CAN message based user interface enables the users to set and modify all motor control parameters for speed and current control. The unique CAN based monitoring offers real-time control of the motor control application. The 24V BLDC motor and a plug-in power supply make the kit ready-to-use.

The pre-compiled demos provide a platform for easy evaluation and performance measurement of the FOC algorithm. The complete development environment including a free tool chain allows the users to advance to the next stage of application development and customization using the same application kit.

For further details on Infineon's Sensorless FOC algorithm and the FOC Drive Application Kit, please refer to following webpage: <http://www.infineon.com/XC800-FOC>.

### Internet Links:

FOC Drive Application Kit  
<http://www.infineon.com/XC800-FOC>  
 XC800 8-bit microcontroller  
<http://www.infineon.com/XC800>  
 Datasheet and usermanual XC886  
<http://www.infineon.com/XC886>  
 Datasheet and usermanual XC888  
<http://www.infineon.com/XC888>

PCIM Booth 12/404

[www.infineon.com](http://www.infineon.com)

### Key Features of XC886 and XC888 which enable Sensorless Field Oriented Control:

- High performance 16-bit vector computer (CORDIC + MDU)  
 Vector rotation and transformations like Park transform  
 Normalizing and scaling  
 Interrupt based operation with minimum CPU load
- PWM unit for advanced motor control (CapCom6E)  
 16-bit resolution for high precision space vector  
 PWM generation  
 Dead time control for minimum hardware effort (direct control of MOSFET/IGBT)  
 CTRAP provides hardware overload protection
- A fast 10-bit A/D Converter (sample time of 0.25  $\mu$ s)  
 Hardware synchronization to PWM unit reduce CPU load  
 Use of two out of four result registers to maximize sampling performance  
 Enables single shunt current measurement  
 Fast ADC reduces torque ripple due to minimized blind angle in sensorless FOC

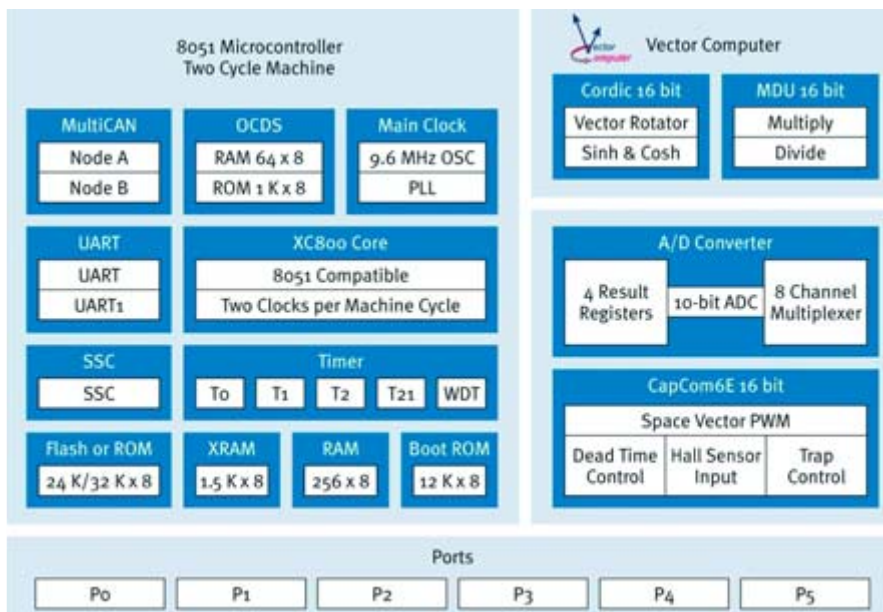


Figure 4: Block diagram of the XC886/888 8-bit microcontrollers with vector computer.

## 36W PoE Solutions for Ethernet Switches

Microsemi has announced the industry's first pre-standard IEEE802.3at power over Ethernet integrated solution family, delivering 36 watts of power for devices ranging from video screen phones and WiMAX transmitters to pan-tilt-zoom cameras, thin-clients and laptop computers.

The product family includes the PD64012GH 12-port PSE PoE Manager and the PD64004AH 4-port PSE PoE Manager. Both feature integrated power FETs, enabling switch manufacturers to build switches that can drive 36W for every 2-pairs and interface to devices consuming up to 30 watts. Customers requiring up to 60 watts can use the same Microsemi integrated circuits in a 4-pair configuration. The ICs support Layer-2 Classification.

Both the PD64012GH and PD64004AH include all of the features found in lower power PD64012G and PD64004A circuits, including detection of pre-standard devices, dynamic power management and emergency power management. In addition, the new devices also add support for power management based on Layer-2 classification. With increases in the maximum theoretical power per port, advanced power management features become critical for the design of PoE switches, saving integrators an average of 50% of the cost of adding PoE to a switch.

The PD64012GH and PD64004AH not only operate in pre-standard IEEE802.3at mode, but also are 100% IEEE802.3af compliant when detecting IEEE802.3af PD's. The PD64012GH and PD64004AH are managed by the PD63000G PoE MCU using Firmware Release 6 or above.

PCIM 12/418

[www.microsemi.com](http://www.microsemi.com)

## TUG Tube Cases

Fischer Elektronik, the manufacturer of heat sinks, connectors and 19" subracks, are now able to offer their customers with immediate effect an extended range of tube cases. The multi-purpose aluminium cases with integral guide slots in 5.08 mm grid spacing (1HP) for 100mm Eurocards is proposed in four different heights (ranging from 34 mm to 105 mm). Using the lateral fixing straps without screws, the tube case can be fastened to a wall or a ceiling.

The case is available in five standard lengths (from 100 mm to 220 mm) and with three different surface finishes. An EMC version with an electrically conductive surface and additional electrically conductive seals is also available.

Using these seals, type IP 54 protection can be achieved. Other lengths, surfaces and other forms of machining and printing are available according to customers' requirements.

The tube case is supplied as unassembled set, including covers and mounting materials.


[www.fischerelektronik.de](http://www.fischerelektronik.de)
[www.bodospower.com](http://www.bodospower.com)

**AEP group**  
ALEXANDER ELECTRIC

AC/DC power supplies  
DC/DC converters



...for commercial and industrial purposes



...created for work in heavy using conditions

Podebradska 56\186, Prague 9, Czech Republic  
Tel. +420 266 107 455, Fax +420 266 107 609  
e-mail: aeps@aeps-group.com

[www.aeps-group.com](http://www.aeps-group.com)

PCIM Booth 12/252



**Electronic Concepts**

## DC Filter Capacitors

The Superior Alternative to Electrolytics for 'DC Link' and 'Energy Storage' Applications

Short  
Lead-Time

- Dry Metallised Film
- Capacitance 6.5µF to 12 millifarad
- Voltages to 6000VDC
- High Current Capability
- Low inductance
- Operational from -55 °C to +105 °C



I.D.A. Estate Oughterard, Co. Galway, Ireland · Phone: +353 91 552385  
E-Mail: sales@ecicaps.ie · [www.electronicconcepts.ie](http://www.electronicconcepts.ie)

**PCIM: Hall 12, Booth 343**

## Schottky Barrier Diode Module

Sansha Electric Manufacturing Co., Ltd. the parent company of SanRex Corporation introduced a new High Power & Low Loss device.

SanRex expands its Schottky Barrier Diode family to include modules with 400A, 100V capability. Thanks to SanRex outstanding metal barrier technology, BKR400AB10 offers lowest forward voltage drop, lowest thermal resistance and 50% lower leakage current compared to other brands. In addition, improved avalanche energy rating and high case temperature provides for high efficiency and reliable operation in wide variety of applications.

Product range :

Part Type	IF(AV)	VRRM	VFM	EAS	Rth(j-c)
BKR400ABZ50	400A	50V	0.52V	320mJ	0.1 oC/W
BKR400AB10	400A	100V	0.68V	15mJ	0.2 oC/W

Main Features :

Extremely Low Forward Voltage Drop / Very Low Leakage Current

Avalanche Energy Rated.

Typical Applications :

Rectifier in Switch Mode Power Supplies (SMPS) / Power Supplies



for Plating / Uninterruptible Power Supplies (UPS)

Free Wheeling Diode in Converters

For further information, please contact us

by E-mail at: info@sanrex-europe.de

By phone: +49 89 311 20 34

PCIM 12 / 343

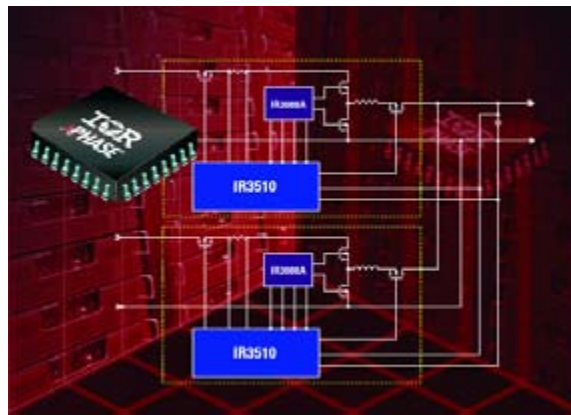
[www.sanrex.com](http://www.sanrex.com)

## Multi-phase DC-DC Buck Converters

International Rectifier has introduced a new chipset in its XPhase<sup>®</sup> family of control ICs and phase ICs for scalable multi-phase, interleaved buck DC-DC converters, adding N+1 redundancy, hot-swapping capability and a host of protection features.

IR's new chipset, comprising the IR3510 XPhase Control IC and companion IR3086A and IR3088A Phase ICs, is ideal for powering high-availability CPUs and servers in fault-tolerant applications where live insertion is required.

The IR3510 Control IC implements a simple and efficient synchronous buck topology, combined with input MOSFETs for hot-swapping and output MOSFETs for ORing, to ensure complete system protection



against failures such as short circuits. To extend MTBF, average current mode control is used to implement droop sharing between converters without any single point failure

modes, thus enabling N+1 redundancy.

Additionally, the chipset provides input isolation protection, allowing hot-swapping of power modules without damage, while enabling 100% availability of power to the system.

Hot Swappable N+1 redundant AC-DC and DC-DC converters using transformer-based power topologies have been available for many years to provide board-level bulk power in server, telecommunication and net-

com systems.

PCIM 12 / 202

[www.irf.com](http://www.irf.com)

## High Current ISOPLUS i5-Pak MOSFETs

IXYS announces the release of a new line of High Current Mid-Voltage Power MOSFETs in versions ranging from 55V to 100V, featuring extremely low power dissipation and ultra-low Rds(on). This new family of Mid-Voltage Power MOSFETs is a part of IXYS growing product line aimed at high power, low voltage power conversion applications. The new IXYS High Current Mid-Voltage Power MOSFETs capitalize on the benefits of proprietary ISOPLUS packaging technology, in this case the ISOPLUS i5-Pak. IXYS Mid-Voltage MOSFETs provide for very low

conduction and switching losses, and are avalanche rated for hard-switching applications.

The principal feature of this set of i5-Pak MOSFETs arises from the joining of two IXYS Mid-Voltage MOSFETs with the reliable, high power handling capability of IXYS discrete ISOPLUS i5-Pak. Additionally, the ceramic alumina substrates used also dramatically enhance device reliability due to their superior thermal and power cycling. The DCB can be patterned like a printed circuit board, which enables the unique integra-

tion capabilities of IXYS ISOPLUS packages. Mid-Voltage Power MOSFETs find homes in many applications. These devices are designed to withstand even the most robust switching conditions commonly required by the automotive market, as well as the industrial sector. Other applications include DC/DC converters, battery chargers, motor drives.

PCIM 12 / 401

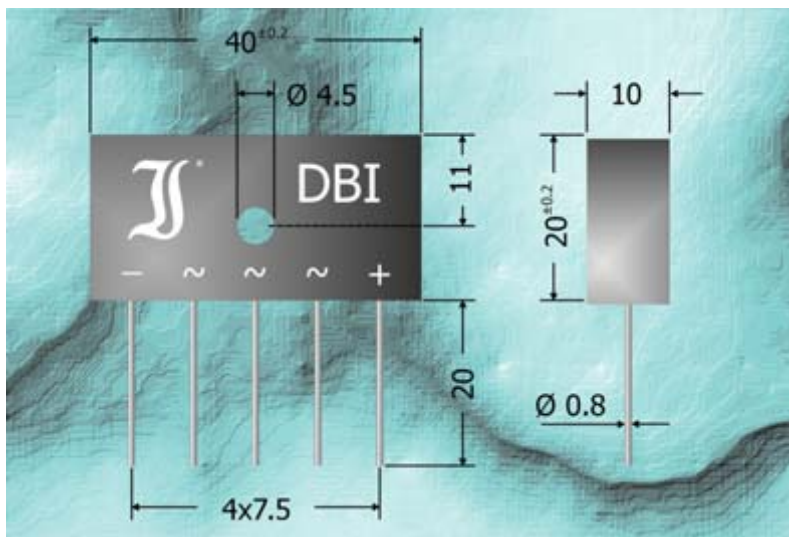
[www.ixys.com](http://www.ixys.com)



## Three Phase Bridge Rectifiers

New Generation of improved reliability in connection with easier assembly.

and is UL certified.



Diotec has improved the existing range of three phase bridges with the description "DBI". The new generation of the internal used semiconductor chip leads to reduced hot leakage currents and therefore to increased reliability even at higher requirements in industrial applications. The package is reworked and provides now enlarged creepage and clearance distances, which simplifies the meeting of current standards and in many cases makes it possible to assemble without so far required isolation measures. The components are available with output currents of IFAV = 6, 15, and 25 Ampere. They provide a peak reverse voltage of VRRM = 50 to 1600 Volt. The case is proofed on isolation up to VISO = 2500 Volt

Typical applications of the DBI-Bridge are industrial power supplies at three phase mains with medium power. This includes uninterruptible power supplies (UPS) as well as input rectifiers for electrical drives. The contact leads in single-inline configuration allows a simple and direct solder assembly on the printed circuit board. For mounting on a heat sink there is only one single screw needed.

The start of mass production is planned for the third quarter of 2007.

PCIM 12 / 539

[www.diotec.com](http://www.diotec.com)

## Magnetics Introduces L Material

Magnetics is pleased to announce that L material, a new power ferrite material, is now available. Magnetics' existing power ferrite offerings R (2300 P (2500µ and F (3000µ are well established for applications up to 500kHz. L material extends this frequency range for Magnetics' ferrite materials up to 3MHz.

L material is suitable for power supplies with switching frequencies above 800 kHz, and is optimized for transformer and inductor applications from 500 kHz to 3 MHz. Within this range, AC core losses are minimized and the loss versus temperature curve exhibits its minimum at a suitable elevated temperature (70°C to 100°C). (see graph)

In addition, the Curie temperature is quite high (>300°C), so that saturation (Bmax) is good across a wide temperature range. L material is an excellent solution for many circuit requirements, especially DC-DC converters and high frequency filters.

L material is offered in a wide variety of core shapes and sizes up to 30 mm. A range of toroids, EFD, ER, Planar E and I, PQ and RM cores in popular sizes are currently available for shipment. Larger sizes are also available for special applications.

PCIM 12 / 246

[www.mag-inc.com](http://www.mag-inc.com)

[www.bodospower.com](http://www.bodospower.com)

**Mike Shubert**  
power transformer specialist

**DATATRONICS**

**MagNETics Custom Design Tool**  
ONLINE TOOL  
**DATATRONICS**

### Your Power Transformer Can-Do Man

Tired of hearing the custom power transformer that you want can't be done. You need to talk with Mike Shubert at Datatronics. Mike's a power magnetics expert who never says no. He'll work with you from design to test to delivery.

Ask him about the demanding world class standards that we meet.

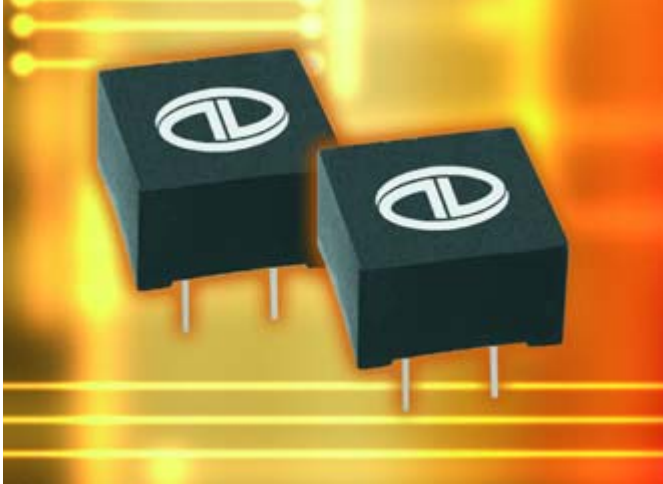
RoHS Compliant | UL | BABT | CSA  
QS9000 Certified | ISO 9001/9002

Free Online MagNETics Custom Design Tool

Check out Mike's Custom Design Tool and our Product Catalog at [datatronics.com](http://datatronics.com) or give Mike a call toll free at 1-888-889-5391.

## Low Profile Sealed Line Matching Transformers

Designers of devices or equipment with telecom interfaces will find the LM302-1L Line Matching Transformer from Datatronics meets both rigorous safety and telecom industry standards while combining high performance coupling characteristics with a high dielectric strength in an economical low profile package compliant to RoHS standards.



The Model LM302-1L is compatible with all major standard modem circuitry that meets V.32, V.32 bis and V.34 industry requirements. It is suitable for a wide range of voice and data applications telecom equipment, instrumentation, portable devices, office equipment, security systems and more.

The Model LM302-1L provides space-efficient isolation between sensitive electronics and telephone lines. With a dielectric strength tested to 6500 VDC, it meets various international safety standards including UL60950 and BABT.

Developed for high performance, the LM302-1L is a symmetrical design meaning that there is no real primary or secondary winding. Key circuit specifications include: impedance at 600 ohms (both primary/secondary), turns ratio is 1:1 and insertion loss at 2Khz is 1.5 db max.

A through-hole device, the LM302-1L comes in a 0.706 (17.9 mm) square package. It features a seated height on only 0.422 inches (10.7 mm), which makes it useful in many high density designs. With its vacuum encapsulated package, the sealed LM302-1L withstands high temperature soldering and operating temperature environments from -20°C to +85°C and a storage range of -40°C to +85°C.

[www.datatronics.com](http://www.datatronics.com)

## Semiconductor Lighting Direct from AC Supplies

Seoul Semiconductor released "the Acriche 2W single emitter of octagon type", a new type of package, of which brightness has improved by 20% than the previous ones in only 3 months after that SSC announced the mass producing availability of Acriche, last November, 2006.

Acriche is an innovative semiconductor lighting source, which can be running direct from AC supplies without converters. SSC is planning to improve Acriche's brightness from current 48 lm/W (It is assumed that this level of brightness is almost same as 57 lm/W, considering the loss by 20% due to conversion of conventional LEDs) up to 80 lm/w in the fourth quarter of 2007, and 120 lm/W in 2008.

Seoul Semiconductor has been devoting all its strength to improving the brightness and package design so that customers can conveniently use more improved products, since

last November's announcement of Acrich's mass production, economical and environment-friendly semiconductor lighting.

In result, in only 3 months, the maximum brightness of Acriche reached 96 lumens for two watts, and the luminous efficacy became 48 lumens per watt, which is more improved by 20% than before. Also, the new package type of "the Acriche 2W octagon type" is a single emitter and its diameter is 25 mm. It was designed to make it easier for customers to apply to various kinds of applications.



[www.seoulsemicon.com](http://www.seoulsemicon.com)

### ADVERTISING INDEX

ABB semiconductors	C3	Electrovac	5	National Semi	17
AEPS	61	Epcos	33	NEC	51
Ansoft	25	Eupec / Infineon	29	PCIM Europe	57
Apex	37	Fairchild	C2	Pemuc	19
Correlec	35	Flöth	53	Powersem	7
Coilcraft	11	Fuji Electric	27	Raychem	15
CT Concept Technologie	21	International Rectifier	13 + C4	Roal	47
Danfoss Silicon Power	19	Intersil	41	Sanrex	53
Datatronic	63	IXYS	35	Semikron	9
Dau	59	LEM	3	Sensor + Test	45
Denka	23	Maxwell	55	Tyco Electronics	39
Diotec	55	Mircochip	49	VMI	31
Electronic Concept	61	Mitsubishi Electric	43	Würth Elektronik	5

# Natural Selection



## HiPak with SPT+

*Revolutionary Evolution!*



22 - 24 May 2007  
 PCIM Nuremberg  
 Hall 12, Stand 408

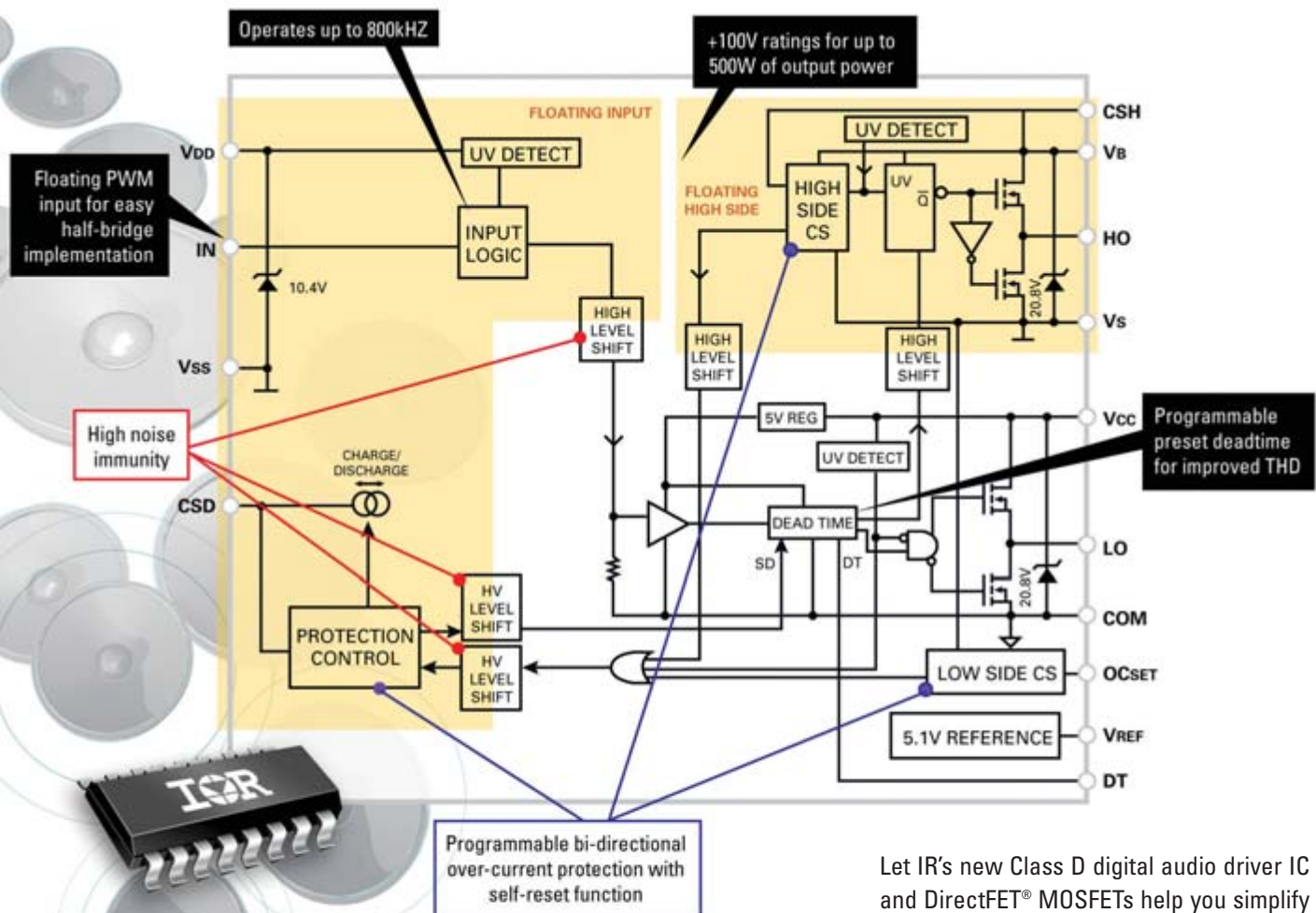
ABB Switzerland Ltd  
 Semiconductors  
 Tel: +41 58 586 1419  
[www.abb.com/semiconductors](http://www.abb.com/semiconductors)

Power and productivity  
 for a better world™



# CUT YOUR CLASS D CIRCUIT FOOTPRINT BY 50%

*Performance, Protection and Efficiency in One*



Let IR's new Class D digital audio driver IC and DirectFET<sup>®</sup> MOSFETs help you simplify and shrink your design.

## Advantages

- Reduces PCB area by 50% in Class D audio amplifiers from 100W to 500W per channel
- Reduces external part count by up to 27 components
- Integrated protection features

For the latest in high performance audio power management, look to International Rectifier – the power management leader.

Digital Audio Driver IC					
Part Number	Package	V <sub>OFFSET</sub>	Selectable Deadtime	Propagation Delay	OC Protection Delay
IRS20955PBF	DIP16	0 - 200 V	15/25/35/45ns	90ns	500ns
IRS20955SPBF/ IRS20955STRPBF	SO16N	0 - 200 V	15/25/35/45ns	90ns	500ns
Companion DirectFET <sup>®</sup> MOSFETs					
Part Number	Package	V <sub>DS</sub>	R <sub>DS(on)</sub> @10V typ	Q <sub>G</sub> typ	Q <sub>sw</sub> typ
IRF6645	SJ	100V	28mΩ	14nC	5.6nC
IRF6665	SH	100V	53mΩ	8.7nC	3.4nC

DirectFET<sup>®</sup> is a registered trademark of International Rectifier Corporation.

For more information call +44 (0)1737 227215  
or +49 (0) 6102 884 311 or visit us at  
<http://audio.irf.com>



Hall 12, Stand 202

International  
**IR** Rectifier  
THE POWER MANAGEMENT LEADER