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*June 2008* 





**Special Report** -2008 GreenPower Leadership Awards

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Volume 5. Issue 5



# **Engineering Delivers Green Solutions**

flourish

popularity and the lively dialog stimulated

Getting back to our green solutions, I truly believe that despite this energy crisis,

is a crisis (see National's Brian Halla who

side to the problem which is very positive.

The best engineering brains throughout the

a common and united focus. Crises always

have on many occasions in our history,

and pragmatic solutions. Ingenuity born

engineer's toolkit.

do just that.

out of necessity is the greatest part of the

iSuppli recently reported that booming

global demand for solar energy has spurred

suppliers to realign their business structures

materials. I expect we shall see still more on

this and related green topics as we progress

a critical shortage of polysilicon used to

make Photovoltaic (PV) cells, causing PV

and strategies and to seek alternative raw

through what looks to be a pivotal year.

contributes to the greener environment.

a power module for white goods, power

management chips for portable devices,

lighting systems, PoE, regulators, or data

center power supplies, everyone has a part

to play. Politicians can legislate, committees

can postulate, but designers can deliver real

solutions. The recognition of this fact needs

to be elevated. Maybe the energy crisis will

In this issue, we have a terrific crop

of articles and features and some great

products such as Linear's 'Battery Back-Up

System' featured in the PowerLine article.

We also have special features, based on

insightful dialogs with Infineon's Snr. VP

Arunjai Mittal, and National's CEO Brian

I hope you enjoy this issue of the

valuable feedback, observations and

magazine. Please continue to give your

Halla, please check them out.

Editor-in-Chief, PSDE

recommendations

All the best

Everyone reading this magazine is playing

his or her part. Whether it's a wind turbine,

It's not just the PV industry that



Welcome to the green edition of PSDE!

This is a special edition to give you a good cross-section of the technology in our industry and a celebration of all that is green in power. We have seen much in the popular press and on our TVs and watched our politicians trying to get to grips with the potential vote-catcher that it probably is. What really matters is what our industry actually does and develops in order to make our short stay here on earth one that does much more than past generations to preserve the environment. Engineering is the key and the need has never been greater.

Before continuing further, I would like to say a few words about the PSDE GreenPower Leadership Awards. We conceived this program over a year ago and decided that we would like to recognize those who are making a real contribution, via editorial contributions to PSDE, to energy efficiency and the progress of 'green' as we know it from an engineering perspective. We had no committee, nor judging panel; we took an engineering approach and measured the popularity of the editorial content with our engineering readership community. This was a hard 'data click' count measurement of the readership to each of our PSDE eNewsletters.

The result was inspiring. We had two valued sponsors who helped us to get the program credibly off the ground; Infineon Technologies and National Semiconductor. We have feature dialog with the top management of these two great companies.

The outright winner was an article contributed by Power Integrations. with articles from ACAL Technology, International Rectifier, Vacuumschmelze and Zetex, coming in very close behind. We congratulate them all. See more details on this in our special "GreenPower Special Report" in this issue

We are delighted with the success,

Power Systems Design June 2008

Cliff.Keys@powersystemsdesign.com

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## 2008 GreenPower Leadership Awards Announced at **PCIM Europe**



Peter Rogerson, Director of Marketing Communications, Power Integrations accepts award from Cliff Keys, Editor-in-Chief, PSDE

educational donation given to the European Systems Design Europe have been voting for Engineering University of choice by the article the best editorial contribution in the area of energy efficiency from the engineering comauthor. This year's donation is awarded to: munity. The votes have been tabulated. In a very Donated to: Politecnico di Torino, Torino, Italy tight race, there are four finalists and one Institution Selected by: Silvestro Fimiani,

For the past year you the readers of Power

winner for the 2008 GreenPower Leadership Award The winner of the 2008 GreenPower Leadership Award is:

**Company:** Power Integrations Article: "New Power Supply Puts a Freeze on Air Conditioners" Author: Silvestro Fimiani

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# **FAE Appointment Gives Power Engineers Design-in** Support



Murata Power Solutions has appointed Wisam Moussa to the new position of Director of Global Field Applications. His primary role will be to expand the company's global FAE program and bolster the already comprehensive technical support to tier 1 accounts and broad market customers.

Wisam joined the company in 1984. He has advanced through the company's engineering organisation, gaining extensive experience in various aspects of power electronics including design and product development, power architecture, field application engineering, product marketing, and business development. Wisam has a Ph.D. in Electrical Engineering received in 1992 from Binghamton University.

The new position involves internal leadership and coordination of multi-functional teams, including sales, engineering, and business development, to most effectively address the technical requirements of customers and identify appropriate solutions. His team will also be responsible for coordination of technical field support of Murata Power Solutions' products at its customers' sites.

Power Leadership Awards there is an

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Power Integrations

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"Given his vast experiences across all aspects of power system design. I am confident Wisam will assure our FAE team provides the highest level of technical support and engineering expertise to all of our customers, for the entire product offering," said Tony Abrantes, VP Sales, Murata Power Solutions. "Time and time again Wisam has proven to be a significant asset to our customers in need of solutions for even the most advanced design challenges."

www.murata-ps.com

# Nu Horizons Expands into Eastern Europe



Nu Horizons Electronics has appointed Rafał Koper as Sales Manager for Poland and

Czech Republic. The appointment represents entry into the Eastern European markets for Nu Horizons. In his new role, Koper will be responsible for Nu Horizons' sales operations in Poland and the Czech Republic.

Koper has 11 years' experience in the electronics distribution industry. He worked for 10 years at Future Electronics, having responsibility for logistics in Eastern Europe for three years, and for Polish EMS customers for five years. In his previous role at rep. company 2BePresent, he was responsible for developing business in the Eastern European market. He is based in Warsaw

"We're delighted to announce the appoint-

ment of Rafał Koper as Sales Manager for Poland and the Czech Republic, said Phil Gee, VP Sales EMEA, Nu Horizons. "We see a wealth of opportunities in the Eastern European marketplace and are confident that Rafal's knowledge and experience will be invaluable in expanding our business in this territory.'

Franchises represented by Nu Horizons Electronics in Poland include Xilinx, Gennum, Exar, ISSI, Winbond and Pericom.

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# **TI Acquires Commergy Technologies for Energy-Saving Power Supply Innovation**

Texas Instruments has an-



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nounced the acquisition Irelandbased Commergy Technologies, Ltd., a power supply reference design provider that specializes in energy efficient and compact architectures. The acquisition allows TI to broaden its focus on improving energy efficiency in today's endequipment designs, especially in the areas of AC adapters and highpower-density computing and server systems. "Adding Commergy' s products and expertise in power conversion technology gives us a tremendous advantage when solving our customers' complex energy requirements and critical power design challenges," said Stephen Anderson, Vice President, System Power Management Business for High-Performance Analog (HPA).

New acquisitions such as this continue to enhance our portfolio of analog products that allow our customers to quickly adapt to the ever-changing computing and communications markets."

Dr. George Young, chief executive and technology officer of Commergy, said, "Combining our talent, technology and products with TI's manufacturing capabilities and power management business will give equipment designers quicker access to products that solve any energy management issue."

Commergy, based in Cork, Ireland, provides easy-toimplement standard and customized reference designs for applications in the notebook, PC, server and communications markets. The company develops extremely high-efficiency power supply solutions, such as those for notebook adapters, that meet and exceed the latest EN-ERGY STAR and Climate Savers Computing Initiative recommendations for PCs. Commergy has expertise in several design areas, such as planar magnetics, power factor correction (PFC), power topology design, thermal management, EMC design and high-power density design.

#### Industry-Leading Power Management Portfolio

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### **Power Events**

• European Fuel Cell Forum 2008, June 30-July 4, Lucerne, Switzerland, www.efcf.com/exhibition/

• EPE-PEMC 2008, September 1-3, Poznań, Poland, www.epe-pemc2008.put.poznan.pl

 23rd European Photovoltaic Solar Energy Conference, September 1-5. Valencia.Spain. www.photovoltaic-conference.com

- electronicIndia 2008. September 2-5. Bangalore, India. www.electronicindia.net
- Husum WindEnergy. September 9-13, Husum, Germany www.husumwind.com
- electronicAsia 2008, October 13-16, Hong Kong, China, www.electronicasia.net
- electronica 2008. November 11-14, Munich, Germany, www.electronica.de
- SPS/IPC/Drives 2008, November 25-27, Nürnberg, Germany, www.mesago.de/en/SPS/main.htm

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# 

# **Super-Efficient Battery Back-Up System**

# New chip does it all for mission critical networks

The hugely complex data centers controlling content for banking, space and military applications must be fully operational on a 365/24 basis. Absolutely no error margin is tolerable in these applications and their 'all possibilities covered' back up systems must be 100% dependable. Not only this, but they must operate in extremely hostile temperature environments and at the same time, help save precious energy.

inear Technology has just launched the LTC4110, an autonomous multi-chemistry, single chip, battery charge and discharge manager for server, memory backup, medical equipment, and high reliability system applications. The LTC4110 is a complete single chip, high efficiency synchronous flyback battery charger and low loss FET based discharge manager with automatic switchover between the input supply and the backup battery or super capacitor. This highly integrated chip features four operating modes: battery backup, battery charge, "noloss" battery calibration and shutdown. Combining all these in a single IC saves significant board area compared to existing and less effective, solutions.

The LTC4110 can provide a supply voltage to a system load from a main supply or battery and can also charge a battery, thereby providing an uninterruptible power source for the system. The IC is capable of working with battery voltages above or below the input supply rail in both charge and discharge modes. In charge mode, use of a flyback allows the designer to optimize the battery configuration absolutely independent of input supply considerations. When the main supply is present, the LTC4110's PowerPath™ control feature provides power to the system load and, if needed, preferentially and simultaneously charges the battery.

If the main supply fails, the LTC4110 uses the battery as a power source through low loss ideal diode FET switches to continue providing a supply voltage to power the load that need backup. The low loss, battery calibration mode discharges the battery (using the same high efficiency flyback converter in reverse) into the main system load, proportionally reducing the equivalent AC power consumption while not generating any extra heat. Reducing any heat source is crucial in these already heatintensive systems. When the battery reaches full discharge in Backup mode, Shutdown mode then disconnects the battery from the load to protect it from over-discharge damage.

The LTC4110 uniquely supports multiple energy storage media and battery chemistries: Li-Ion/Polymer, Nickel and lead acid, and is compatible with supercapacitors. Multiple LTC4110s can be combined to form a redundant battery backup system or increase the number of battery packs to achieve longer backup run times. The IC provides support for both standard and Smart Battery packs. If the optional SMBus/l<sup>2</sup>C



Battery backup system manager for multi-chemistry batteries & supercaps

interface is used, the host may access internal status, control the three GPIO pins as desired, and support battery capacity and gas gauge calibration to verify the battery's ability to support the load. The GPIO pins can also be configured as status outputs to drive LEDs by default on power up without any host required. The LTC4110 is housed in a low-profile (0.75mm) 38-pin 5mm x 7mm QFN package and is guaranteed for operation from -40°C to 85°C. Pricing is highly competitive when the highly integrated functionality and fewer external components are considered.

### www.linear.com



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# Power Player

# "Stewards of Energy"

A speech delivered in February 1908 by Willard A. Smith at the University of Illinois on the subject of the need for graduate courses in engineering contained this key phrase: "Engineering is the science of economy, of conserving the energy, kinetic and potential, provided and stored up by nature for the use of man. It is the business of engineering to utilize this energy to the best advantage, so that there may be the least possible waste." In my mind, this comes closest to describing the engineer's role as the "Steward of energy" in the systems under development. In fact, the power supply engineer is probably the most deserving of this title.

By Paul Greenland, Senior Marketing Director, Leadis Technology

onserving electrical energy in a power management solution covers a wide range of perspectives from the macro or system level to the micro level involving power device, integrated circuit design and process technology. In the past two decades energy efficiency standards have moved inexorably from suggested to advisory and latterly to mandatory status in a broad range of applications from white goods to consumer electronics and office automation. Furthermore, in portable battery operated applications such as cell phones, significant increases in bandwidth, content and functionality are expected without any reduction in standby or talk time.

This is also the case in smart phones where video content has pushed up display formats, resolution and usage to the extent that backlighting has become a major component in the overall power budget. In recent years server farm energy efficiency has come under scrutiny as the utilities place limits on the peak power consumption of these facilities. The Google server in San Francisco is a case in point. This server is alleged to have 300,000 blades, each consuming between 115W and 160W, depending on its configuration. Obviously a modest increase in overall efficiency has a major impact either in energy costs or the ability to handle an increase in bandwidth and content for a given power limit.

All the component manufacturers serving the power management market have a part to play in the stewardship of energy along with the engineer designing the system. Passive components in the power train should be selected



for minimum AC and DC losses in the application. AC losses are primarily governed by material selection and the physical configuration of conductors or electrodes. DC loss is usually set by the conductivity of windings, electrodes and terminations. In high-frequency applications you can dispense with the core material in the inductor altogether provided that the regulator in guestion is optimized for, or matched to the characteristics of that type of inductor. Topology selection, particularly the selection of the number and type of power switches and rectifiers in the power train is also crucially important.

High converter efficiency over a wide line or load range may be necessary for best utilization of an alternative energy source or load with power saving modes or power management software. Variable frequency operation, once the scourge of power supply designers struggling with self-oscillating ringing

choke converters, is now seen as a method to raise efficiency at light load by minimizing switching loss. Resonant power conversion, where switching loss is traded for a modest increase in circulating power, is going through a renaissance, particularly in DC-transformer applications where fixed duty cycle operation and impedance transformation can yield spectacular results. Benefits of resonant power conversion include the improvement in Electro-Magnetic Compatibility that comes with replacing abrupt or hard switching with soft switching resonant transitions with a low high frequency harmonic content and the absorption of parasitic elements into the resonant circuit. These benefits are not trivial when you consider that parasitic capacitance causes chargedumping, over-currents and harbors displacement current and parasitic inductance causes over-voltage, delays the commutation of energy, and in extreme cases, may case the breakdown of power devices.

All things considered, the energy steward has a full tool kit for conserving energy and minimizing its waste in today's designs. Power switches and rectifiers evolve continuously to minimize conduction loss, switching loss or both. Integrated circuit technology develops to offer more sophisticated control, protection and precision at the cost of what seems to be minimal operating current. The attention on alternative energy sources and the efficient utilization of the power therein is not a fad. Limited natural resources have made the power supply designer a pathfinder in technology development.

### www.leadis.com

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# The Power Management Chip Conundrum

# *High-volume applications generate low margins; what's a supplier to do?*

By Marijana Vukicevic, iSuppli Corp.

ower-management semiconductor suppliers today face a vexing challenge: The fastest-growing applications for their products also generate very weak profit margins. With competition intensifying in the powermanagement semiconductor business, how can suppliers structure themselves for long-term profitability?

### **Cutthroat applications**

Looking across the power-management semiconductor landscape, a certain group of large-scale applications is generating higher growth for Application Specific Standard Products (ASSPs): notebook computers, mobile handsets and LCD/plasma televisions.



The overall power-management semiconductor market is expected to expand at a Compound Annual Growth Rate (CAGR) of 8.2 percent from 2007 to 2012, according to iSuppli Corp.

In contrast, LCD/plasma televisions are expected to generate a 23 percent CAGR for power-management semiconductors during the same period, mainly due to the strong unit sales growth for these products. Notebook PC demand for power-management chips will rise at a CAGR of 19.7 percent and mobile handsets will increase at a CAGR of 8.9 percent.

However, the LCD/plasma television,



Figure 1: presents iSuppli's revenue growth forecast from 2007 to 2012 for power-management semiconductors in these applications.

	2007	2012	CAGR 2007-2012
Notebooks	1,005\$	2,472 \$	19.7%
Mobile Handsets	2,861\$	4,382 \$	8.9%
LCD/Plasma TVs	1,030\$	2,898 \$	23.0%
Total Power Management Semis	26,199\$	38,790 \$	8.2%

notebook PC, mobile-handset and desktop PC applications tend to deliver power-management semiconductor margins that are half the level of the industrial or other "non-consumer" type of applications.These markets are characterized by extreme Average Selling Price (ASP) pressure, with many suppliers providing solutions for the same sockets. OEMs serving these areas use multiple sources and can change their mix of suppliers considerably from quarter to quarter, intensifying pricing and margin pressure in the market.

### **Cutthroat competition**

iSuppli has been indicating for several quarters that there seems to be turmoil among the competitors in the power management market, with some faring better than others in succeeding at the business. With competition intensifying, this phenomenon is likely to become more prominent in the coming years.

The power-management space has evolved into a more predatory space, with some players growing significantly, partly due to market growth, but also largely due to commoditizing of various power management product lines or implementing the right approach to working with Original Equipment Manufacturers (OEMs) and Original Design Manufacturers (ODMs). Many of the discrete components in the power-management space are commodity products and some of the voltage regulation products became commodities also. At the same time, there will be suppliers that will capture market share due to their early introduction of innovative products or their implementation of the right business model.

### Power plays

Amid such challenging circumstances, what are the options for power-management semiconductor suppliers?

The key emerging markets that are expected to generate high growth and healthy margins in the future for power management have unlimited potential for improving efficiency and propelling power management to a new modern world of electronic design. These markets include:

- Solar power
- Ultra-low voltage components for mobile devices
- Servers

Furthermore, suppliers must move faster to develop reliable technologies that bring quality, greater cost efficiency and reproducibility. They also will be forced to decide on Intellectual Property (IP) strategies, either by developing their own IP, or by acquiring it from another company.







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# **Power Supply Control Design Tools – Part 3**

# Boost converter with voltage-mode control

In this article, Dr. Ridley presents a summary of the boost converter with voltage-mode control. Free analysis software – the third in a series of six – is provided to readers of this column to aid with the analysis of their voltage-mode boost converters.

### By Dr. Ray Ridley, Ridley Engineering

Voltage-Mode Boost Converter

The last two articles covered the buck converter in both voltage-mode and current-mode control. The buck is the simplest of all the converters, but as we have seen, the equations can still be very complex when the full range of operation is considered.

The boost converter offers a new set of complications in analysis and characteristics. It can be a challenging converter to stabilize when operating with voltage-mode control as shown in Figure 1.

For the boost converter of Figure 1, the equation for the control-to-output transfer function is:

$$\frac{\dot{v}_o}{\dot{d}} = \frac{V_g}{D'^2} \frac{\left(1 + sCR_c\right)\left(1 - s\frac{L_e}{R_L}\right)}{1 + \frac{s}{\omega_o Q} + \frac{s^2}{\omega_o^2}}$$

Where the resonant frequency is given by

$$\omega_o = \frac{1}{\sqrt{L_e C}}$$

And the equivalent inductance is determined by the duty cycle:

$$L_e = \frac{L}{D'^2}$$



The Q of the filter is a complex combination of the parasitic resistances shown

in the circuit, and the load resistance. For this equation, you can refer to either [3] or [5].

### **Boost Converter Right-Half-Plane Zero**

The boost converter adds a new complexity to the control problem - a righthalf-plane (RHP) zero. This is caused by the fact that when the boost converter switch is turned on for a longer period of time, the inductor is disconnected from the load for a longer period of time. That means that the output initially drops, even though the control command is trying to make it increase.

Figure 2 shows the effect on the gain



Figure 1: Boost converter with voltage-mode control.





# Power Amplifier Boosts 12V, 24V and 48V Standard Supplies To Drive Piezos With Up to 340V

New power amplifier eliminates external HV supplies by integrating a switch mode power supply able to boost standard 12V and 24V bus supplies up to 340V for op amp output.

The Apex Precision Power MP400 simplifies driving piezos off of standard 12V, 24V and 48V supplies. This new power amplifier is designed with internal voltage boost circuitry to allow the output voltages to be adjusted from 50V-350V. The result of this integrated boost feature eliminates the need to include a HV power supply just to drive the op amp. The external phase compensation for the MP400 also allows flexibility in setting gain, slew rate and bandwidth to suit the specific piezo actuation or deflection application



For more information on the MP400, visit us online today at http://apex.cirrus.com or to download the complete Cirrus Logic 2008 Product Summary Guide

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16

	MP400
Supply Voltage	10V to 50V Single Supply
Boost Voltage	50V to 350V
Slew Rate	350V/µs
Output Current	200mA
Power Bandwidth	200kHz



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loads, the RHP zero frequency is the lowest, and the phase delay is the greatest. At light loads, the RHP zero frequency is higher, and the converter is easier to control.

and phase of the RHP zero. At heavy

The operation of the boost converter also causes a shift in the resonant frequency with input voltage, as can be seen from the control equations. Figure 3 shows how the characteristics of the boost converter can vary dramatically with a wide input voltage.

The general rule of thumb for converters with RHP zeros is to design at the lowest input line and the maximum load. This causes the lowest value of RHP zero, and the lowest value of resonant frequency. However, when using voltage-mode control, the moving resonant frequency can create problems at different operating points, and the whole range of operation should be carefully checked with both prediction and measurements.

More equations are created when the boost converter operates in discontinuous-conduction mode (DCM). These are not given in this article, but the free software provided for the boost converter will automatically assess which mode of operation your converter is in, and provide the proper transfer function.

### Important Characteristics

There are several important points to remember about the boost converter operating in continuous-conduction mode:

1. There is a double pole at the resonant frequency of the LC filter. The frequency of this double pole will move with the operating point of the converter since it is determined by the equivalent inductance of the circuit, and this is a function of duty cycle. At low line, the resonant frequency has its lowest value.

2. As with all switching power supplies, there is a zero in the control-tooutput transfer function corresponding to the ESR of the output filter capacitor.

3. The boost converter has a righthalf-plane zero which can make control very difficult. This RHP zero is a function of the inductor (smaller is better) and the

Power Systems Design June 2008

load resistance (light load is better than heavy load). The bandwidth of the control feedback loop is restricted to about 1/5<sup>th</sup> the RHP zero frequency.

In discontinuous conduction mode, the resonant freguency of the filter is eliminated from the control characteristic, as predicted by the switch model in<sup>[5]</sup>. This simplifies the control loop design, but higher power boost converters are usually designed to operate in CCM for efficiency reasons.

### **Boost Converter Voltage-Mode Software**

Software is available for download that allows you to predict the small-signal response of your boost converter with voltage-mode control. After entering your power stage values and switching frequency, the transfer function gain and phase of the power stage is plotted for you, and the resulting poles and zeros given.

The software is designed to run under either Excel 2007 or Excel 2003. Make sure when you open the software that the macro features are enabled in order to use the program properly. Please go to http://www.ridleyengineering.com/freesoftware.htm to download the software.

### Summary

The boost converter is an essential topology for stepping up the input voltage, and is applied in many areas of power conversion. This includes dc-dc converters, lighting applications, power factor correction circuits, battery discharging circuits, and many other applications. It is a good topology, but care and time must be taken to properly design the control loop. The inductor should be chosen carefully for a controllable power stage RHP zero characteristic. As with all converters, measurement <sup>[2]</sup> is essential to ensure a stable and rugged product.

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Figure 3: Effect of input line variation on the control characteristic of the boost converter.





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# On the Road

Reported by Cliff Keys, Editor-in-Chief, PSDE

# **Texas Instrument**

I was invited to attend the TI Press conference here in Munich to hear about the company's latest in hot-swap power management and also their new, low power Zigbee<sup>®</sup> processor which has been designed with energy saving and simplified design implementation in mind.

# New hot swap power management controller for next-generation wireless, computing and communications systems

I introduced the industry's first single-chip, dual-slot hot swap manager for Advanced Mezzanine Cards (AdvancedMC<sup>™</sup>) used in wireless, telecom, and computing systems, including custom, AdvancedTCA (ATCA) and MicroTCA systems. The device significantly improves the flexibility and performance of hot-swap power management design in applications ranging from 3G/Beyond 3G wireless base stations and network equipment to high-end data communications.

The company's I<sup>2</sup>C-programmable TPS2359 hot swap controller performs all necessary power interface functions for two AdvancedMCs, while requiring the fewest possible external components. The controller eliminates up to 75 percent of the components required in competing solutions.

Enabling seamless "plug-and-play" insertion and removal of AdvancedMCs during system operation, the device's two fully integrated 3.3-V channels provide inrush control, over-current protection and FET ORing control functionality. In addition, two 12-V channels provide the same functions using external FETs and sense resistors. The controller's 3.3-V current limits are set at the factory to AdvancedMC-compliant levels and the 12-V current limits can be programmed using external resistors.



The TPS2359's integrated ORing control capability simplifies power design for MicroTCA power modules or other implementations that manage redundant power in the AdvancedMC slot. When used with a low Rdson N-channel MOS-FET, the controller seamlessly manages power distribution, while protecting the system from potentially dangerous reverse-current or transient events by providing an extremely fast turn-off response of 130 nanoseconds.

# Digital configuration and monitoring

The highly flexible controller's l<sup>2</sup>C interface allows a designer to digitally configure and monitor the AdvancedMC

hot swap solution over a two-wire bus -and with fewer required external components and pins.

This interface programs current limit, fast-trip threshold and fault time. The TPS2359 also features enable or disable of the ORing, multi-channel crossconnect and auto-retry.

For digital power supply systems, this allows designers to better manage the system's overall performance. For example, a hot swap solution with the TPS2359 can alert the system of any over-current, fast-trip and currentlimit situation. For designers who do not want to use a digital interface, TI offers the TPS2358 controller with dedicated output pins and configuration capability using external components.

# Building momentum for ATCA and MicroTCA

In 2002, the PCI Industrial Computing Manufacturers Group (PICMG) released the industry-wide ATCA as an open standard, which addresses the growth and changes in the communications infrastructure market. MicroTCA was developed as a follow-on standard, further extending the ATCA open platform into applications requiring scalability and redundancy in distributed environments.

François Malléus, EMEA Business De-



velopment Manager, High-Performance Analog (HPA) explained that internet capacity and the growth of wireless networks continue to place pressure on equipment makers and designers to adopt the ATCA or MicroTCA standards. The TPS2359 and TPS2358 are the only multiple-voltage output hot swap controllers compliant to ATCA and MicroTCA. This achievement will only increase TI's ability to solve this key power design challenges and open the door to allow more rapid adoption.

apid adoption. Th n-performance analog and com- now

High-performance analog and communications infrastructure solutions TI

### 2.4 GHz ZigBee<sup>®</sup> network processor Application Microcontroller Ultra-Low Power MCUs MSP430 Processor CZ480 Antenna



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offers innovation and support to meet the energy management design needs of wireless, telecom, computing and industrial manufacturers. In addition to power management, TI provides the industry's broadest communications infrastructure product portfolio, including digital up/down converters, high-speed data converters, RF products, timing, backplane interface, standard logic components and high-performance single and multi-core DSP solutions.

The TPS2359 and TPS2358 are now available in volume from TI and its authorized distributors and come in a

> space-saving 36-pin, PQFN package. The **TPS2358** is available in a 48-pin QFN. Evaluation modules of the TPS2358/9. design application notes and new Power Management Guide are available for download at power.ti.com.

### New 2.4 GHZ Zigbee<sup>®</sup> Low Power Wireless Network Processor

TI also introduced the first product from the company's new Z-Accel family of 2.4 GHz ZigBee-certified network processors. The CC2480 provides engineers complete ZigBee functionality without having to learn the complexities of a full ZigBee stack, making it easy to integrate ZigBee into a wide variety of applications, such as home and building automation and industrial monitoring and control, with minimal development effort. The device also allows customers the flexibility to work with any host microcontroller.

Geir Lauritsen, EMEA Business Development Manager, Low-Power RF Products said that the CC2480 ZigBee processor drastically simplifies the design of a new low-power wireless product, or the addition of wireless into an existing product, by allowing customers to separate the application code from the networking component of their systems.

Z-Accel is a comprehensive solution where TI's ZigBee-2006 stack, Z-StackTM software, runs on a ZigBee processor and the application runs on an external MCU. The CC2480 handles all the timing-critical and processingintensive ZigBee protocol tasks, while leaving the resources of the application MCU free to handle the application. The CC2480 communicates with any MCU via an SPI or UART interface, and it can be combined, for example, with TI's MPS430 ultra-low power MCUs.

The CC2480 targets ZigBee wireless network systems used in home and building automation, industrial monitoring and control, asset tracking, low-power wireless sensor networks, set-top boxes, remote controls, automated meter reading and medical applications.

The CC2480 is available now from TI and its authorized distributors in a 7 mm x 7 mm QFN-48 package.

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# Designing for Energy Efficiency and Consumer Appeal

# 4.5MHz dual phase converter configuration provides ultra-thin solution

### Introduction by Cliff Keys, Editor-in-Chief, PSDE

I would like to thank Markus for his article that follows. It never ceases to amaze me how in these days where energy is at a premium, it is becoming increasingly important for the designer to utilize available technology to conserve power, while still delivering in his or her design, the vital ingredients that will ultimately decide the success or failure of the final product in the competitive market. For consumers to invest in a product, it must not only possess the 'must haves' in terms of high functionality, form-factor and super performance, it must also be extremely frugal in terms of its energy needs which, apart from the 'green' issue, translates into a key selling point for the designed product. The pressure is on and as ever, falls squarely on the power designer's shoulders.

### By Markus Matzberger, System Engineer, Low Power DC/DC, Texas Instruments

odern portable devices such as digital cameras provide high resolution imaging and video processing, but these features demand more and more processor performance, which translates directly into higher current consumption. In most cases, however, the high processing power is only required for short periods, because the processor runs on reduced power, or, is even in idle mode for most of the time. This operation profile requires an efficient power supply, which is optimized for light and medium load current, but is also able to provide high peak currents. Furthermore, due to height limitations a thin solution is important.

This article describes a 1.6A / 1.2V power supply solution with 1.2mm maximum height based on a TPS62410 2x800mA dual step down converter from Texas Instruments. This device provides two independent step down converters in a small 3x3 10 pin QFN package. The two converters use the same internal 2.25MHz clock, and operate out of phase with 180° phase shift

ate two independent supply rails. In this case, the idea is to operate the two converters in parallel in order to get a higher output current for a single output rail. Due to the 180° phase shift operation of the two converters a dual phase operation mode is achieved.

Normally, this device is used to gener-



Figure 1: Schematic.





Figure 2: Dual phase block diagram.



Figure 3: 180° out of phase operation.

Compared to a single phase step down converter, the dual phase configuration gives the following advantages which will be discussed in detail:

1. A thinner total solution height, because instead of one big inductor, two smaller and much thinner inductors can be used;

Better load transient response;
180° out of phase operation results

in a dual phase operation leading to a twice higher effective switch frequency (4.5MHz instead of 2.25MHz).

### Schematic

Figure 1 shows the schematic. The

output voltage of the two converters is set to 1.2V by an external resistor divider network consisting of R<sub>11</sub>, R<sub>12</sub>, R<sub>21</sub>, R<sub>22</sub> and C<sub>ff</sub>. Each converter uses the same 2.7uH inductor connected to the converter's SW pin and a 10uF output capacitor. The outputs  $V_{\mbox{\scriptsize OUT1}}$  and  $V_{\mbox{\scriptsize OUT2}}$  are connected together via 22mOhm load balance resistors R<sub>BAI</sub>. These resistors are responsible for sharing the load current between the two converters more or less even handedly, otherwise, while one converter would run on its output current limit, the other would handle only a small fraction of the load.

It is important in this configuration that the power save mode operation is enabled for both converters in order to provide the highest efficiency at light loads. Therefore, the MODE/DATA pin is connected to ground. This allows the converters to skip switching at small output currents. To maintain the output voltage in regulation, the converters stop power conversion once the charge transmitted from the input to the output becomes more than the discharge through the load.

# DC/DC operation in dual phase configuration

Figure 2 explains the function of the dual phase configuration, showing a simplified block diagram of the TPS62410 with the two DC/C converters, their power stages, clock and internal reference. The dual phase operation is achieved because the high side switches of both converters operate with 180° phase shift.

At medium to high load currents, the DC/DC converters operate in PWM mode with 2.25MHz switch frequency. During each clock cycle the high side switch is turned on with the duty cycle D. The duty cycle for a buck converter is given in Equation 1.

$$D := \frac{V_{OUT}}{V_{IN}}$$

### Equation 1: Duty Cycle for Buck Converter

During this phase the current flows from the input capacitor via the high side MOSFET switch through the inductor to the output capacitor and through the balance resistor into the load. To close this loop, the current returns to the input capacitor. During this phase, the current in the high side switch and the inductor ramps up until the high side switch is turned off. After that, the Low Side MOSFET rectifier is turned on with the duty cycle 1-D and the current flows from the inductor to the output capacitor and through the balance resistors into the load. It returns to the inductor through the Low Side MOSFET rectifier. The inductor and rectifier currents ramp down.

Whilst rectification takes place, the input capacitor is charged up and the



Figure 4: Extracted signal waveforms.

next cycle begins. The same applies to the second converter but with 180° phase shift.

Figure 3 shows a scope plot of the switch nodes SW1, SW2 and the corresponding inductor currents. The 180° phase shift between the high side switches involves an effective switch frequency of 4.5MHz, which is twice the original clock frequency.

Designers might have reservations about connecting two output stages in parallel as illustrated in Figure 1 due to a risk of exceeding the current capability of the internal MOSFET switches, but there should be no cause for concern because the TPS62410 has internal over current protection for the MOSFET switches. The current in the switches is supervised cycle by cycle and once it hits 1.2A. the switch is turned off and only turns on again when the current is below this value.

Figure 4 illustrates the extracted

waveforms of the two current would be double. phases for the currents through the MOSFETS the input capacitor leads to lower AC I<sub>S11</sub>, I<sub>S12</sub>, I<sub>S21</sub>, I<sub>S22</sub>, the inductor currents I<sub>L1</sub>, ripple voltage on input cap CIN.  $I_{12}$  and the resulting current from the input

tude of the AC ripple

Two small inductors versus one big inductor The inductor is the dominating component which defines the total solution height of this 1.6A power supply. The impact of the IC package and the capacitors on the total solution height can be neglected, because their height is sub 1mm (capacitors in 0603 size).

> Despite its inductor value, a real inductor also has a DC series resistance DCR. For high output currents such as 1.6A, the parameter DCR cannot be neglected, because with increasing DCR, the losses in the inductor increase as well, which leads to less power conversion efficiency. For 1.6A output current a low effective DCR needs to be achieved. In this application circuit two 2.7µH (TOKO DE2812C Types) with a DCR of  $70m\Omega$  are used. The inductor type provides a size of 2.8x3.0mm<sup>2</sup> and maximum height of 1.2mm (10mm<sup>3</sup>). Due to the inductors being operated in parallel the effective inductor DCR is

In addition, lower AC ripple current on



Figure 5: Current balancing.



Figure 6: Load transient dual phase configuration.

reduced to half, i.e. 35mΩ. The inductor parameter DCR and also its saturation current depend on its physical dimensions. This means for a given inductor value with larger inductor size by volume the DCR decreases and saturation current increases.

In order to get into the same range of effective DCR with a single phase buck converter using a single inductor, the physical dimensions of an appropriate 2.7µH inductor with 35mΩ DCR is about 4x4mm in area and at least 1.8mm in height (28mm<sup>2</sup>). So the solution height can be pushed down to 1.2mm maximum height by using two thin small inductors instead of one big tall one.

#### Load Balance resistors for load sharing

The function of the two balance resistors is to share the load current fairly between the two converters. The two DC/DC converters are set to regulate the two nodes  $V_{OUT1}$  and  $V_{OUT2}$  to 1.2V.  $V_{OUT1}$  and  $V_{OUT2}$  are tied together via two balance resistors. In case the output current I<sub>OUT1</sub> of DC/DC1 was to be higher than I<sub>OUT2</sub>, the voltage drop over the balance resistor of DC/DC1 would be higher and  $V_{OUT}$  would drop. This drop will pull down node V<sub>OUT2</sub> via its balance resistor and DC/DC2 will provide more current in order to maintain V<sub>OUT2</sub> at its set value. In simple terms, the two regulators will regulate in such a way as to keep the voltage drop across its balance resistors the same. A current

of 500mA through one of the balance resistors causes a voltage drop of 11mV over this resistor. This is close to 1% of the nominal output voltage.

In reality the current balancing doesn't match exactly, due to the fact that output voltages  $V_{OUT1}$  and  $V_{OUT2}$  are not identical. This causes a current mismatch between the two converters. The output voltage accuracy of V<sub>OUT1</sub> and  $V_{OUT2}$  is mainly defined by the accuracy of the references and the tolerance of the external feedback resistors. The advantage of the TPS62410 is that both converters use the same internal reference with +-1% accuracy. A change in the reference applies to both converters in the same manner and can therefore be neglected. The feedback resistors should have a tolerance of at least 1% or better.

The scope plot in Figure 5 illustrates the current balancing between the two converters by measuring the inductor currents  $_{IL1}$  and  $I_{L2}$ . The output current ramps up and down from 20mA to 1.6A and the inductor currents  $_{III}$  and  $I_{I2}$ increase and decrease concurrently with a small offset.

The 22mOhm balance resistors used are available in very small 0603 case sizes with 1% tolerance. In order to reduce the component count, realizing the 22mOhm balance resistors by using appropriate dimensioned PCB board traces can be considered. As an ex-



Figure 7: Single phase configuration.

ample, to realize a 22mOhm resistance with a PCB board trace would require an 8.8mm long, 35um thick and 0.2mm wide copper trace.

### Improving load transient behaviour

Figure 6 shows the scope plot of a load transient response in the dual phase configuration and Figure 7 in a single phase configuration. In both cases the same load step of 100mA to 800mA is applied, but in Figure 6 DC/ DC2 is disabled. In dual phase configuration, the  $V_{OUT}$  drop is reduced by half giving an absolute drop of only 30mV compared to 70mv in single phase operation. The two converters react much faster and transfer more current to the output than the single converter operation.

### Conclusion

A dual phase step down converter configuration with 180° out of phase operation can be an attractive solution in applications with height limitations. Due to the load current being shared between two inductors instead of it all going through just one, smaller and especially thinner types of inductor can be used. This configuration leads to double the effective switch frequency with less AC ripple on the input and gives improved load transient performance, compared to single phase configuration.

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# 2008 GreenPower Leadership Awards Winner and Finalists Announced at PCIM Europe

For the past year the readers of Power Systems Design Europe have been voting for the best editorial contribution in the area of "energy efficiency". The 2008 GreenPower Leadership Awards program has been made possible by the financial contributions of our two Gold Sponsors: Infineon Technologies and National Semiconductor.

The votes have been tabulated. In a very tight race, there are four finalists and one winner for the 2008 GreenPower Leadership Award.

The winner is: Company: Power Integrations, Article: "New Power Supply Puts a Freeze on Air Conditioners", Author: Silvestro Fimiani.

The four finalists (in alphabetical order by company) are: Company: ACAL Technology, Article: "Extreme Capacitance", Author: Louise Early • Company: International Rectifier, Article: "Designing Energy Efficient 200W Class D Amplifiers", Author: Jun Honda • Company: Vacuumschmelze, Article: "Renewable Energy Savings Using SolarConverters", Author: Dipl.-Ing. Roman Klinger • Company: Zetex Semiconductors, Article: "Hysterertic Converters in Hi-Brightness LED Control", Authors: Colin Davies, Dr. Alan Dodd, Silvestro Russo & Dr. Kit Latham

### **Educational Donation**

A significant component of the *2008 GreenPower Leadership Awards* program is an educational donation, given to the European Engineering University of choice by the article author. This year's donation is awarded to: Politecnico di Torino, Torino, Italy.

### 2009 GreenPower Leadership Awards

Voting has already begun for our expanded 2009 GreenPower Leadership Awards Program and will continue through the April 2009 issue of Power Systems Design Europe. If you want to summit editorial content on "energy efficiency" to be judged for next years program, contact Cliff Keys, Editor-in-Chief, **cliff.keys@powersystemsdesign.com** • For sponsorship opportunities, contact Julia Stocks, Publisher, **julia@powersystemsdesign.com**.







# 2008 GreenPower Leadership Awards







Power Systems Design June 2008

### The four finalists (in alphabetical order by company) are:

Company: ACAL Technology Article: "Extreme Capacitance" Author: Louise Early



Steve Carr, Divisional Director, ACAL Technology accepts award

> Company: International Rectifier Article: "Designing Energy Efficient 200W Class D Amplifiers" Author: Jun Honda



Graham Robertson, VP Worldwide Corporate Communica-Frank Marx, Chief Sales Officer, Zetex Semiconductors actions, International Rectifier accepts award cepts award

> Gold Sponsor Infineon Technologies



Jörg Malzon-Jessen, Head of Marketing Communications Industrial, Infineon Technologies accepts Gold Sponsor award

### 2009 GreenPower Leadership Awards

Voting has already begun for our expanded 2009 GreenPower Leadership Awards Program and will continue through the April 2009 issue of Power Systems Design Europe. If you want to summit editorial content dealing with energy efficiency to be judged for next years program, contact Cliff Keys, Editor-in-Chief: cliff.keys@powersystemsdesign.com For sponsorship opportunities: Julia Stocks, Publisher: julia.stocks@powersystemsdresign.com

# **2008 GreenPower Leadership Awards Anounced** at PCIM Europe

Over the past year you the readers of Power Systems Design Europe have been voting for the best editorial contribution in the area of energy efficiency from the engineering community. The votes have been tabulated. In a very tight race, there are four finalists and one winner for the 2008 GreenPower Leadership Awards.

Moderated by Cliff Keys, Editor-in-Chief, PSDE

### **Educational Donation**

As a significant component of the GreenPower Leadership awards there is an educational donation given to the European Engineering University of choice by the article author.

This year's donation is awarded to: Politecnico di Torino, Torino, Italy Institution Selected by: Silvestro Fimiani, Power Integrations Donated by: Infineon Technologies, National Semiconductor & Power Systems Design Europe Magazine **Donation:** € 3.000

### The winner of the 2008 GreenPower Leadership Award is:

**Company:** Power Integrations Article: "New Power Supply Puts a Freeze on Air Conditioners" Authors: Silvestro Fimiani



Peter Rogerson, Director Marketing Communications, Power Integrations accepts award

**Company:** Vacuumschmelze Article: "Renewable Energy Savings Using Solar Converters" Author: Dipl.-Ing. Roman Klinger



Helmut Dönges, Director Sales Europe, Marketing and Communications, Vacuumschmelze accepts award

Company: Zetex Semiconductors Article: "Hysterertic Converters in Hi-Brightness LED Control" Authors: Colin Davies, Dr. Alan Dodd, Silvestro Russo & Dr. Kit Latham



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Solveig Loesch, PR Manager Europe, National Semiconductor accepts Gold Sponsor award

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### Special Report – 2008 GreenPower Leadership Awards



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# **Infineon's Green Philosophy** "Real Energy Solutions"

Arunjai Mittal, Senior Vice President and General Manager, Power Management & Drives business unit, summarizes Infineon's activities in energy efficiency in industrial, transportation, consumer and automotive applications.

Reported by Cliff Keys, Editor-in-Chief, PSDE

nergy efficiency, together with Security and Communications, is one of the three focus areas of Infineon – it is of vital importance now and will be crucial to the environment and the quality of life for generations in the future.

With an increased awareness on climate change influenced by our activities, stringent emission controls and the certainty of higher energy costs, it is more important than ever before, that we use the available energy efficiently.

As a technology leader in power technologies, Infineon's products minimize power losses and maximize energy savings along the entire energy supply chain: generation, transmission and consumption.

Our power semiconductors and module solutions are the key to efficient energy management in many market segments, including domestic and office appliances, HVAC, consumer digital, communications, lighting systems, factory automation and drives, traction, automotive and renewable energy. In addition, Infineon is delivering innovations for system miniaturization, increased quality, greater reliability, higher power density and improvement in price-toperformance ratio for given applications.

Power generation: With the growth in renewable energy sources, decentralized power generation will become an important part of the total electric supply chain. Renewables in particular will continue to increase its share as conventional sources get more expensive. There are many projections up to



year 2030 for the share renewables will contribute to total world energy consumption, from a conservative eight percent estimate by the Energy Information Administration (EIA) to a 30 percent estimate by Greenpeace and the European Renewable Energy Council. Infineon chips and modules enable the generation of renewable energies in windmills, hydro power stations and solar plants.

Power transmission: Our modules and disc thyristors are already widely deployed in low-loss electric power distribution networks. New high-voltage direct-current transmission (HVDC) projects incorporate Infineon's lighttriggered thyristors (blocking capability 8 kV) ensure low-loss and safe transport of energy over long distances. An example illustrating the point is the energy generation by hydro and coal fired power plants in the interior of China and its transport across thousands of kilome-





ters to the coast where it is consumed.

Power consumption: The worldwide electrical energy consumption is expected to double to 30 million GWh by the year 2030 (EIA: International Energy Outlook 2007) - mainly driven by the growing demands of China and India. The highest electrical energy savings potentials are in the areas of electrical motors, lighting systems and power supplies for electronic devices.

Infineon addresses each of these application segments. Using microcontrollers and power semiconductors in motor control, power consumption of electric devices can be reduced by 20 to 30 percent. The use of electronic instead of magnetic lamp ballast reduces energy consumption of lighting systems by 25 percent. Electronically controlled drives in air-conditioning systems could increase the energy efficiency by 30 to 40 percent. In household appliances, the substitution of electric ovens with induction cookers results in a decrease of electricity consumption of 25 percent.

Together with its customers and standardisation committees, Infineon is lobbying for the implementation of standards for energy efficiency in the European legislation.

Infineon's technology innovations in power conversion: Product designers are facing the daunting challenge of delivering smaller, smarter, more powerful and more energy-efficient appliances. The state-of-the art technology that powers our CoolMOS™, CoolSET™, EiceDRIVER™, TrenchStop® IGBT, Ci-





PoS<sup>™</sup>, MIPAQ<sup>™</sup> and PFC-IC products are here to help meet this challenge.

The innovative process technology of the CoolMOS MOSFET generations gives an industry-leading on-state resistance as low as 45 m $\Omega$  (in a standard package), yet still provides blocking of up to 600V. For lower blocking voltage (less than 500V), the OptiMOSTM family of products offers best-in-class figureof-merit (Qgd x RDS(ON)) ratings.

Trench/Field Stop IGBTs and latest generation emitter controlled diodes, optimized with regard to their losses are adjusted to the respective application conditions aiming to achieve a higher efficiency level. Today's range includes IGBT devices from a few amperes up to several thousand amperes and blocking voltages up to 6,500V. Infineon is ahead of competition and has already created Silicon Carbide (SiC) Schottky diodes, which can run 10 times faster or occupy 1/10th the space of a similar silicon-only circuit. It is only a question of time when SiC based concepts will replace today's silicon based solutions on a large scale. This would depend largely on the development of raw material prices.

Finally, with the acquisition of Primarion Inc., Infineon has positioned itself well for the conversion of standard analog-based integrated circuit concepts in power conversion applications to digital power based solutions, enabling higher system density, better control and higher efficiency.

Automotive sector: More stringent emission regulations in Europe and the United States and further strict measures in India and China increase the demand for semiconductors in cars. Challenging requirements with respect to fuel consumption, reliability, safety, and weight call for the use of innovative concepts in automobiles. Infineon's microcontrollers, power semiconductors and sensors enable vehicles to fulfil these needs. Pressure and gas sensors continually monitor the air-fuel ratio, while microcontrollers determine optimal injection and ignition times within a fraction of a second. Car parts of all types run on electric power, including electric motors (in fuel pumps, power windows and sunroofs), lighting devices (headlights and interior lighting) and air conditioning and heating systems. Powered via the alternator, the needs of these devices increase fuel consumption. Infineon's automotive power components help increase the efficiency of these systems. Furthermore, Infineon offers electronic power modules designed for hybrid electric vehicle (HEV) motor drive systems. The power modules HybridPACK1 (for use in "mild hybrid" vehicles) and HybridPACK2 (for "full hybrid") reduce the cost and complexity of HEV inverter system design by using up to 30 percent less semiconductor area to achieve the required power rating. Infineon systems reduce electrical power losses by one fifth enabling simpler cooling systems.

The world is rapidly moving to a point where multiple energy sources will be used. Power electronics in general and power semiconductor technologies in particular, are the enabling technology that will provide efficient, intelligent and optimal use of these energy resources, yielding a more secure, flexible and sustainable way of life. Infineon provides leading-edge technology and an innovative, broad product portfolio covering the complete power and energy management cycle. We thank our customers and all other participants in actively influencing the use of energy most efficiently.

www.infineon.com



### 2008 GreenPower Leadership Awards Winner and Finalists Announced at PCIM Europe

The votes have been tabulated. In a very tight race, there are four finalists and one winner for the 2008 GreenPower Leadership Award.

The winner is: Company: Power Integrations, Article: "New Power Supply Puts a Freeze on Air Conditioners", Author: Silvestro Fimiani. • The four finalists (in alphabetical order by company) are: Company: ACAL Technology, Article: "Extreme Capacitance", Author: Louise Early • Company: International Rectifier, Article: "Designing Energy Efficient 200W Class D Amplifiers", Author: Jun Honda • Company: Vacuumschmelze, Article: "Renewable Energy Savings Using SolarConverters", Author: Dipl.-Ing. Roman Klinger • Company: Zetex Semiconductors, Article: "Hysterertic Converters in Hi-Brightness LED Control", Authors: Colin Davies, Dr. Alan Dodd, Silvestro Russo & Dr. Kit Latham

#### **Educational Donation**

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### **PowerWise Metrics Help Designers Compare Analog Components**

PowerWise metrics are formulas and thresholds that distinguish energy efficient components from those that are less efficient. National has developed PowerWise metrics for 24 product categories and selected the best-in-class energy efficient products in each of these categories. Each PowerWise product has a PowerWise label and rating which summarizes its key specifications.

### **PowerWise® Efficiency Ratings** (4 out of 24 categories shown)

	Metric	Threshold	Units
lators	Peak Efficiency	≥ 95	%
Cs	$\frac{P}{2^{\text{ENOB}} \cdot F_{s} \cdot ch}$	≤ 2.5	pJ/conversion
	₽ Ţ,∙ch	≤ 20	pJ/bit
5	$\frac{P \cdot t_j}{ch}$	≤ 55	mW*ps

**PowerWise Resources Help Designers Improve System Performance to Power** Visit national.com/powerwise for white papers, app notes and design tools that help system engineers by highlighting the optimal balance between performance and power consumption at the component, subsystem and system level.





# **Energizing a New Era**

I had the great pleasure of interviewing National Semiconductor CEO and Industry Energy Luminary, Brian Halla. National, a leader in power management chips and founder of the fast-emerging industrywide PowerWise<sup>®</sup> brand of energy-efficient products, has moved into an area of energy conservation at a critical time in our world's crisis in energy.

### Reported by Cliff Keys, Editor-in-Chief, PSDE

rian was quick to confirm and stressed, "There is no doubt, no matter what the politicians say, that we are in a real crisis. In my work in 2006 as chairman of the Semiconductor Industry Association (SIA), it was clear that the evaluation of the high tech industry was made almost exclusively on stock market performance.

We have, what I call, a "crisis in three parts."

First, the energy crisis is not going to go away in the near future. People are complaining bitterly about gas prices and even if this is just a bubble, and I think it is not, we still have the legacy of dumping millions of metric tonnes of CO<sub>2</sub> into the atmosphere. This is what we really need to address.

Personal Mobile Devices are becoming part and parcel of everyday life and will continue to develop in functionality and capability. For example, some day, you will have one device to adjust your car settings, hotel requirements and individual preferences. It's not that far away. All these devices require charging, all consume power, and with the world's insatiable hunger for more functionality, this is going to put pressure on longer battery life, which translates to a need for better energy efficient chips. Analog does this.

Moore's Law, which states that gate density doubles every 18 months, is great until you consider the power damage this creates. Even Intel is running to four cores in an attempt to save power. We just cannot have it all ways.

Second, one of the obstacles for us in the semiconductor industry is that no-



one really cares any more. Tech companies' stock prices are low. Even companies like Cisco, turning in 15% growth, do not impress industry investors and politicians. PE ratings are about 20, not as it used to be at 25+.

The mood is one of continuous high expectation from our industry. People ask, "What have you done for us lately?" they complain, while dumping their 'old' mp3, printers, PCs and cameras to get the latest and greatest performance, which incidentally will need still more processing power and therefore energy, and then complain again that the industry produces products they don't really need!

The third area on my crisis checklist concerns the pressures applied by some customers on suppliers. As these customers get successful, they squeeze and commoditize suppliers on cost, minimizing their margins, forcing unrealistic liabilities e.g., on inventories, to maximize their own profits. Suppliers

then stop investing, and customers are put at a disadvantage. Not surprisingly, many suppliers have hit the wall and gone out of business.

As an example of a great relationship, when I was at LSI Logic in the 90's, I was doing business with Sun Microsystems. They accepted they would pay a premium price for a premium service. I then invested the profits in R&D for the future. Where do we see this spirit now and how can we help the energy crisis without cash for investment?

National is foremost a power management company. It is an analog company committed to energy conservation and long term protection against energy becoming an endangered species.

Alternative Energy. If energy consumption is an issue, energy generation for the future is for sure where we need to focus our attention. The Photovoltaic industry is taking off with governments in Europe leading the way with incentives and energy buy-back deals for those who generate more power than they need. In the US, this is not available, so the PV industry is slower on the uptake. Another great problem with PV is that it is not so efficient. Companies looking to large rooftop areas to install PV grids are avoiding those with antennas and other obstructions causing shadows because it is not viable.

National has the solution. We will be announcing a technology that will optimize the whole grid or even networks of grids, as could be installed in a housing community. The inefficiency caused by shadows will become irrelevant. This makes it a viable proposition and one that could very quickly with the right

Power Systems Design June 2008

support from government and utilities. help clean up what is now, a very dirty power generation industry.

Video Transmission. The whole consumer population is hooked on YouTube and other on-demand streaming video. Analog technology in video transceivers can save energy because they do not need to waste energy by oversampling techniques such as those required using DSP technology. And not just in the consumer market.

Medical. Ultrasound equipment can be truly portable. Not only this, but with our sensor and low power converter technology, equipment can be produced for the better early and accurate detection of heart disease and cancers that cause so much human miserv right now in our society. There is a solution and National has it.



Automotive. In the auto business, the industry is frantically trying to find an alternative to gas. The new all electric Tesla sports vehicle, which utilizes many of National's energy-efficient chips, has

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Never stop thinking

### Special Report – 2008 GreenPower Leadership Awards

a range of about 370 km before needing a three-hour recharge.

For general battery charging, National has a solution 'up its sleeve' for an instant recharge system, which Brian was keeping to himself, at least until the product became commercializable."

"We are putting more R&D investment into 'quality of life' megatrends to solve real-world problems. That is our goal."

Brian Halla is clearly a man with a mission in energy conservation and efficiency. His enthusiasm, vitality and dedication to this vital area are truly inspiring. He has recruited the very best brains for National's spearhead into this crucial area for the well-being of our environment and the legacy we leave for our future generations.

www.national.com

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# **Power Supplies Go Digital**

Adding value without adding cost is notoriously difficult in any sector, but even more so for applications which are already under enormous price pressure. When asked, respondents may instinctively cite the consumer market as being typical of these pressures but it is power supplies – across the board – that, arguably, suffer most from cost sensitivity.

### Patrick Le Fèvre, Marketing Director, Ericsson Power Modules AB

ecause of this, any innovation introduced to the conversion, distribution and management or power must prove its mettle in the face of staunch competition.

Digital technology is now being employed more widely to control and manage power supplies. There are significant differences between control and management in this scenario, and reflecting the trends within all sectors, Ericsson Power Modules believes there is also significant scope for digital technology within both.

To explain, power supply control can be referred to as monitoring and regulating the power at the point of generation, while power supply management takes a slightly more holistic view of how the power is distributed and consumed. This could and normally does involve multiple power supply modules or pointof-load solutions, operating almost symbiotically, under the authority of a single controller.

It follows that power supply control can be achieved through using either analogue or digital technology and to the user the difference may be transparent. With the same form, fit and function it may seem irrelevant whether digital or analogue technology is at the heart of it, particularly if the benefits aren't apparent.

However if the full benefits of digital management are to be exploited, then it also follows that there needs to be greater control over the power supply itself, which implies some form of digital control should also be adopted.



Using digital technology to control a power supply adds complexity and this if often measured in terms of cost. But the return on that cost is flexibility, far beyond that offered by an analogue solution. In addition to regulation, digital control can offer a wider range of variability in operation. In the simplest of terms, this allows for more control over power supply sequencing; ensuring the right supply voltages are applied to the right components of a circuit in the right order. As more devices operate at different supply voltages on the same board, the importance of correct sequencing is apparent.

But it goes much further than this. Using digital control, a power supply's operating parameters can be recalculated and adjusted during operation. Critical parameters, such as the 'dead time' time

in a synchronous point-of-load buck converter, can be adaptive or follow a nonlinear pattern, dependent on actual load rather than calculations.

With a traditional analogue based approach to control, the feedback mechanism is much cruder. Typically, by comparing the output voltage to the target, a 'crow-bar' effect is used to apply more or less drive. This can introduce 'hunting' depending on the window of tolerance, but invariably results in a less efficient supply.

Building a complete system using distributed digitally controlled power supplies introduces its own unique demands, too, if the level of flexibility delivered by a single supply is to be extended across the whole design.

Here, leading supply manufactures such as Ericsson Power Modules continue to put their considerable support behind open standards such as the PMBus protocol. By using a common protocol, power supplies from different vendors can be mixed and matched, giving the engineer more design freedom without sacrificing the benefits of digital technology.

Ericsson is shaping the future of Mobile and Broadband Internet communications through its continuous technology leadership. Providing innovative solutions in more than 140 countries, Ericsson is helping to create the most powerful communication companies in the world.

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The reliability of all electronic equipment is underpinned by the reliability of its power supply system. And the more vital the role of the electronic equipment - from telecommunications equipment to medical, avionics, military, space and industrial market segments the more crucial the quality and reliability of the power supply system. In this respect, Ericsson Power Modules is recognized as a leading supplier of miniaturized and high-density DC/DC power modules for distributed power architectures. Used throughout the world, these products combine the highest efficiency currently available with unprecedented reliability.

### 30 years of success

Ericsson has been researching and developing switching power supplies since 1977 and introduced PKA, the world's first highly-integrated power converter in 1983. We've introduced just about every major first in the field since then. Innovation is a company hallmark: our products have won several "Product of the Year" awards from the electronics industry, but perhaps the most significant award is client trust, built up over the years.

### **Over 60 million sold**

Today, over 60 million DC/DC converters and point-of-load regulators have been shipped to customers around the globe. The company offers standard DC/DC converters and regulators for 48/60V and selected 24V systems; dedicated solutions for specific applications such as ADSL, Advanced TCA, and RF Power Amplifiers; and custom-designed solutions based on standard product platforms.

### Some places you should start with:

Ericsson Power Modules AB, Headquarters & Europe Sales Office: Phone: +46 8 56 86 96 20, e-mail contact: pm.info@ericsson.com **Ericsson Power Modules Germany, Austria, Switzerland:** Josef Bose, Phone: +49 89 95 00 69 05. Ericsson Power Modules Italy, Spain (Mediterranean):

Daniele Guidarelli, Phone: +39 02 26 59 46 07.

The company, which employs around 250 people worldwide, has been ISO 14001 certified since 2000, and is active in predicting and preempting environmental regulations in all its manufacturing activities.

### Smaller size, greater efficiency

The design and efficiency of our products - such as the continuing reduction in size of the products and their ability to do more for a reduced power requirement enables customers to reduce the energy consumption of their products. As an example, Ericsson Power Modules are widely used in radio base stations, where their high efficiency directly reduces the need for fans and cooling systems, thus shrinking energy demands and, ultimately, lowering CO<sub>2</sub> output. Research into new technologies such as digital power will further reduce energy consumption, a fact that the company showed the world in several articles, and papers presented at international conferences.

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**TAKING YOU FORWARD** 



By Fabrice Bugnon, Maxwell Technologies

fficiency in public transportation is key. With petrol reaching a cost of 120\$ per barrel just 5 months after having crossed the 100\$ per barrel limit, and the CO2 produced by human kind increasing steadily, and new dynamic countries like India or China targeting the same level of consumption as in Europe or USA, the time of waste is over. The solution is to increase dramatically the efficiency of all our energy converting systems. Public transportation, thanks to its visibility, is an excellent way to promote new technology. The latest hybrid buses, more comfortable and more efficient than ever, are the proof that the technology is today available and ready for environment friendly solutions.

### **Bus hybridisation**

At its beginning, the main goals of the hybridisation were to propose more dynamic buses with higher comfort levels. The gain in fuel consumption was relativized by the poor general efficiency of the vehicle. During the last years, the hybridisation became a real mean to achieve the high efficiency required to limit fuel consumption and pollution. The associate challenge was to take into account all high comfort standards which are today a must.

The 2 main means of hybridisation are better control of the engine (steady rpm, start-stop) and the recuperation of the braking energy. To slow down a running bus, its kinetic energy will have to be dissipated mainly in form of heat at the brakes, which means that this energy is purely wasted to wear out a critical safety part. Furthermore, an internal combustion engine (ICE) works on an exothermic and unidirectional reaction. Until today, nobody has found a way to



convert the kinetic energy back into fuel. The addition of an electrical system, which is per nature efficient, very flexible and bi-directional, makes here total sense.

### A piano to the 30th floor

Recuperating 80% of the kinetic energy of a 15 tons bus running at 20km/h (average city bus speed), represents the recuperation of the energy necessary to lift a piano of 200kg to the top of a 30 floor building within a few seconds!

The supercapacitor is the perfect component to store this kinetic energy. In comparison with battery technology and its chemical reaction, energy storage in supercapacitor is based on an electrostatic reaction, with an extremely short time constant. The storage will start immediately when electrons are available. During the acceleration of the bus, this energy will then be resent to the wheels. Due to the extreme low internal resistance of Maxwell supercapacitors, the losses are reduced to a minimum and the energy transfer efficiency is maximized. Furthermore, supercapacitors can be cycled more than 1 million times, which correspond to the life of the bus (15 years).

The results is well represented by the Scania Serial Hybrid Bus Concept: the efficiency of the vehicle is so optimised that the fuel consumption is cut by 25% in comparison with a modern bus of similar capacity at the European standard, and thanks to the use of ethanol, the CO2 emissions are cut by 90%. Scania buses based on this technology will be running this year in Stockholm. Each bus is equipped with 4 HTM125 Maxwell modules, enough to store about 400Wh.

### Other opportunity in bus segment

In the bus retrofit market, special modules with supercapacitors can be installed on existing buses. Together with clever electronics, promising tests are on-going which prove that the fuel consumption can be reduced up to 8%, with a minimum addition of weight and with a return on invest of about 1 to 2 years. Thousand of buses could be rapidly be equipped with this technology, resulting in enormous reduction of CO2 and other polluting gas emission.

Time of efficiency in energy management has come. Maxwell supercapacitor, with perfectly adequate technology, has proven to be an essential part in any efficient hybrid system for public transportation. Every running bus could see its consumption significantly reduced, not later than today.

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By Ken Clithero, Quality Manager, Zetex Semiconductors

etex Semiconductors believes that one of the most important ways to achieve environmental recovery and eventual sustainability is through the continuous drive of its people to improve the business's environmental performance. Through workforce engagement and 'buy-in' to the corporate vision, Zetex believes it is achieving 'world class' environmental performance.

Employees receive environmental awareness training to outline the environmental issues facing society and highlight what businesses can do to alleviate or reverse problems. A substantial number are then trained in environmental risk assessment techniques designed to identify potential environmental impacts.

Before these become company environmental objectives, they are recorded and submitted to the Zetex 'Green Team' for evaluation and prioritisation. The Green Team is a volunteer group of employees, representative of the entire organisation, with the passion to see environmental objectives achieved.

Certified to the ISO14001 standard, the Zetex environmental management system has achieved the following in recent times:

• 90% HCI emission reduction.

 Reduction in the impact of VOC's through reuse as supplementary fuel for cement kilns

 5dB noise reduction at our perimeter fence.

 10% increase in re-cycled effluent volume

6% reduction in energy usage.

 Waste minimised through segregation that sees 75% of our waste go for recycling.



 90% usage reduction of Titanium etching chemical through the implementation of new process methods.

 Carbon Footprint 'sized' to enable identification of reduction actions.

In March 2008, on its audit of the Zetex environmental management system, Underwriters Laboratories Inc. issued a very rare 'zero non-conformance and zero opportunities for improvement' report.

To reinforce our commitment to the environment Zetex also actively encourages employee participation in activities beneficial to the community. Examples include:

 Advising a local school for disabled children on a project to introduce wind generated energy.

· Participation in a 'nest-box' challenge assisting primary school children in the construction and siting of nest boxes to encourage wild birds into their area

Engagement with the UK Energy

Efficiency Advice Centre for information and advice on environmental protection. Over 100 employees signed pledges to save energy.

 Implementation of a Ride2Work scheme to encourage cycling to work through the company purchasing and leasing back of bicycles to employees.

 Participation in an initiative run by a national UK utility company to educate and encourage people in how to use less water.

• Zetex employees planted over 100 trees to improve the environment for local residents.

These activities complement Zetex corporate strategy, offsetting the carbon dioxide produced in our local communities and helping employees to 'put back' into the environment.

Zetex Semiconductors' contribution to sustainability and the environment has already been recognised by the following:

• FTSE4Good index – A benchmark indicator for socially responsible investors. To be included in this prestigious register companies must meet stringent criteria in the area of environmental sustainability.

• CSR Challenge - Founded by 'Groundwork', a UK organisation whose aim is to connect companies with the communities in which they operate. Zetex was one of the first companies to take up the challenge and be awarded a certificate in recognition of its contribution to Corporate Social Responsibility.

 Green Owl Award – Given by Oldham Metropolitan Borough Council to the 'Environmental Business of the Year', whose environmental performance is deemed to be outstanding.

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# **Charging Mobile Applications** in the 21st Century *EuP guidelines for chargers and standby* losses save significant energy

This year, the EuP guidelines for chargers as well as the cross-functional guidelines regarding standby losses will be officially published. Their aim is to reduce energy consumption throughout the lifecycle of an application. As the number of battery chargers for portable applications is high, the energy-savings is significant, in terms of both the consumer and the environmental impact.

### By Alfred Hesener, Marketing Director Europe, Fairchild Semiconductor

obile electronic devices are invading everybody's life at an ever increasing speed. More and more of these useful little tools can be seen everywhere, and since they are mobile, they operate from batteries that need to be recharged. Thus, with each of these mobile devices we get at least one more charger, fighting for a socket (Figure 1). Given the typical consumer behaviour, these chargers stay plugged in all the time, humming away at their standby power consumption. On average, it is assumed that every household has between 5 and 12 chargers.

The European Commission has initiated activities to reduce both the monetary and the environmental impact. This is one of the reasons that the "EuP" guidelines have been developed. One of the 14 initiatives is aimed at battery chargers and external power supplies. With an estimated number of close to 800 million units to be sold in 2010,



Figure 1: Typical collection of chargers in a household.

adding to an estimated installed base of 2.9B (both numbers referring to Europe), the impact of reducing every milliwatt consumed, or reducing every gram of hazardous substance is clearly significant! Furthermore, the associated consumer expenditure is estimated at €7.8B, a significant amount of money.

In these guidelines, the impact on the whole life cycle of a charger is being analyzed, including production material and manufacturing, distribution, usage, disposal and recycling. The impact is quantified for materials, other resources (including electricity, water, and waste), and emissions into the air and water. This leads to a new concept, called "life cycle cost". When all of these contributions are quantified in a similar way, it is easier to understand where the big impact comes from and how to do something about it.

The process is broken down into eight tasks, and for each task a final report or final draft exists. After defining the scope and applications to look at, the existing state of the art has been analyzed, along with consumer behaviour. and the life cycle cost has been calculated. Looking forward, the best available and not yet available alternatives (BAT and BNAT) have been anticipated, with a consequential calculation of their life cycle cost, arriving at an anticipated savings. Recommendations about the

focus areas for improvements have been defined. As part of the analysis, different methods of calculating the efficiency are being compared, using a weighted average of the efficiency at different output power levels, thus measuring the performance across the whole output power range, not only at maximum power.

The possible savings are quite substantial! If chargers were to remain at their current state of performance, the estimated production of greenhouse gases is 26mt CO2eq, and a total consumer expenditure of €12592M. In contrast, using the best available technology, this could be reduced to 22mt CO2eq and €10543, respectively. It is interesting to note that the findings suggest that more energy and greenhouse gas emissions are used for distributing the chargers, as compared to the actual usage. And, in usage, about 58% of the energy is consumed in offmode (standby), and only 42% during operation. Given the fact that the power consumption in standby is significantly lower, it underlines the fact that these chargers are plugged in somewhere and simply forgotten.

A second initiative is looking at standby losses of many applications, not only for chargers but for many different applications, focusing on consumer devices like television sets and settop boxes, to name a few. At the same

# **EU Stand-By** Initiative



Figure 2: Logo of the 'EU Stand by

time, a non-binding initiative called "EU

standby initiative" or "Code of Conduct"

exists already, and has several com-

panies already signed up. This initia-

tive has come up with design targets

for both standby power consumption

as well as efficiency during operation,

specifying different operating points at

which to measure – a suitable method

to force improved efficiency throughout

the operating range of the power supply.

The three most-used topologies in

chargers for lower power are the ring-

ing choke converter (RCC), the flyback

converter, and a new derivative of the

latter, which is the primary-side regu-

lated flyback converter. Previously, linear

chargers using a 50Hz transformer have

been used, but due to their inherent dis-

advantages such as excessive weight,

cost, will not be explored in this discus-

sion. The three topologies are compared

The RCC converter clearly excels in

terms of circuit complexity, and result-

ing size, weight, and cost, but offers

no protection functions as such, and

will require a secondary-side regula-

tion for use with Li-Ion batteries, since

they are very sensitive to overcharging,

and can heat up significantly or even be

destroyed. The standby losses of a RCC

are high, since this converter operates

between discontinuous and continuous

conduction mode, and the switching fre-

quency will increase at no load, leading

high standby consumption, and high

in table 1.

initiative'.

		Standby	Size &	Bi <b>ll</b> of		Line / load
Topology	Efficiency	losses	weight	material	Protection	regulation
RCC	++	+	+++	+	+	+
Flyback	+++	+++	++	++	+++	+++
PSR	+++	+++	+++	+++	++	++

Table 1: Comparison of three most used charger topologies.

and standby losses. The primary side regulation circuit uses the voltage from the auxiliary winding of the transformer (usually for powering the control IC) to sense the output voltage, and this significantly reduces the number of components. However, since there is no direct control of the output voltage, achieving a high degree of accuracy is tricky, as well as having a fast protection against overvoltage or overcurrent at the output. This is where the classical flyback circuit is most effective, since the feedback loop from the secondary side - a circuit well-known in the industry - provides this security and accuracy at no additional cost.

Within the concept of the EuP analysis, it is not only standby losses and efficiency that matter - the amount of materials used play a significant role in the total life cycle cost as well. Another requirement for chargers (although not



The flyback and PSR converters are the state of the art in terms of efficiency



to high losses.

officially binding) is the need for reduced EMI, for both audible noise as well as radiated or conducted emissions, that need to be filtered away. A power conversion topology that produces less of these unwanted emissions does have a better life cycle cost, since the filter can be smaller, and efficiency is further improved.

Fairchild's Green power switch (FPS<sup>™</sup>) e-Series<sup>™</sup> offers a new control method called "valley switching". Here, a resonant operation mode is used, but not in the classical way. The control IC will look for a voltage "valley" across the switch and turn on the power switch accordingly, thus significantly reducing the switching losses and EMI. But the switching is not indefinitely delayed, but will occur in a pre-defined timing window, even if a voltage valley is not detected. This is done for two reasons: First of all, the switching frequency can

Figure 3: Schematic illustrating the use of Green FPS e-Series.





be kept in a certain range, making EMI filtering efforts much easier, and secondly, this approach allows to operate in resonant mode at higher power (where more energy is involved in the parasitic elements), and hard-switching at lower power levels (to avoid unwanted noise and reduce standby losses).

The control IC used in this FPS is a hybrid controller, capable of both classical PWM and guasi-resonant operating modes. The components shaded in yellow are required to implement valley switching, and serve to detect the voltage across the auxiliary winding before rectification and usage as supply voltage for the controller.

In this case, a FSQ0365 was operating at a line voltage of 375V DC, output power of 18W, and shows that after the energy transfer to the output capacitor is finished (and the output rectifiers

	Input Power [W]			
Output Power	85VAC	110VAC	220VAC	265VAC
No Load	0.0868	0.0878	0.0998	0.1113
0.2W (5.05V × 0.040A)	0.476	0.483	0.500	0.499
0.5W (5.05V × 0.099A)	0.921	0.929	0.954	0.983
0.6W (5.05V × 0.119A)	1.061	1.067	11	1.132

Table 2: Quasi-resonant flyback converters show outstanding electrical parameters.

turn off), the circuit enters resonant oscillation, and the controller chose the second valley to turn the switch on again. If no valley presents itself in the timing window, the switch would have turned on 'hard'. This keeps the switching frequency within a certain window, regardless of line and load variations.

With improved standby energy consumption and reduced switching losses, it is no surprise that these quasi-resonant flyback converters show outstanding electrical parameters, as shown in table 2.

It is clearly visible that standby losses except highline conditions are below 100mW, one third of the EU standby initiative targets! If such a charger would be forgotten in a power outlet somewhere, for five years, the 200mW of saved energy consumption would equate to:

200mW \* 5 years \* €0.18 / kWh = €7.10



Figure 5: Efficiency across the input voltage spectrum.

This is probably close to double the actual building cost of such a charger.

Figure 5 illustrates the efficiency across the input voltage spectrum, comparing the previous FSDM0365 with the new FSQ0365, showing strongly improved efficiency especially at lighter loads and low input voltage due to resonant operation, as well as improved efficiency at higher loads and high input power again due to resonant operation.

In conclusion, with state of the art technology, improved chargers are possible today. But new technical approaches may or may not be as costefficient to manufacture - technical innovation forced by new requirements such as government standards may force more expensive solutions.

The possible savings shown with the new valley-switching control mode may not look significant, but given the number of mobile phones sold every year, the savings in electrical energy quickly accumulate to a large number - money the consumers do not have to spend any more! Another significant savings potential is hidden in the interoperability of different chargers and end applications, currently not exploited due to two factors: First, the connectors used are different from application to application, and second, the implicit liability of a charger working with a battery of another manufacturer will probably be very difficult to handle, even if it is the same battery chemistry. It can safely be assumed that further improvements in chargers will have to mostly come from ever-improved efficiency across the whole output power range.

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# **Line Frequency PFC** for Enhanced Line and **Load Regulation**

# *Power levels up to 1 kW with high efficiency*

Power factor correction circuits have been a familiar topic of discussion in both journals and the industry at large. They are applied in a broad range of electronic equipment, ranging from lighting ballast circuits, to switch mode power supplies, to motor drives.

### By Cesare Bocchiola, Application Manager, International Rectifier; Pavia, Italy

or professional applications, high frequency boost topology is a state-of-the-art solution. Boost PFCs can shape input line current to be perfectly sinusoidal and in-phase with line volt-age, and can effectively regulate output DC voltage versus load and line variations. However, there are several drawbacks:

a) complex and expensive control and power electronics

b) high EMI level

c) limited efficiency, due to high switching frequency

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On the other hand, for cost sensitive applications with limited amounts of power (around or below 1 HP) very often simple line frequency inductors, together with bulk capacitors, are enough to filter out line current harmonics. While



When reviewing technical literature, several "low switching frequency", or, "line frequency" active filters can be found. The most interesting ones only handle a portion of the power drawn by the equipment, thus reducing their contribution to overall power dissipation. Their passive components may be much smaller and cheaper when compared to a simple passive fil-ter. Moreover, power dissipation and EMI are greatly reduced. On the other hand, while achieving



Figure 1 : Line frequency Commutated Rectifier from Ref.1.



quite good regulation of the DC output voltage versus load, they often suffer of poor regulation of the output voltage versus the input (line) voltage variations.

A different way to control line frequencv power factor correctors may, instead. enhance regu-lation of DC output voltage versus both line and load variations, keeping, at the same time, the low power dissipation, low EMI, reduced size and, of course, low input current distortion, typical of line frequency commutated topologies. Such control is quite simple, and can be eas-ily translated in the digital domain and integrated into an intelligent control engine such as the Motion Control Engine (MCE<sup>™</sup>) developed by International Rectifier.



Finally, part of the otherwise dissipat-

Figure 2 : Improved commutation strategy.



Figure 3 : Improved line frequency rectifier control scheme.

ed power can be advantageously used to feed a house-keeping power supply, as demonstrated in this article.

### Line Frequency Commutated Rectifier topology

A new control has been developed and tested starting from the topology reported in the paper (Reference.1) and shortly redrawn in Figure 1. This topology has been chosen because of its simplicity, elegance and high efficiency.

A "baby boost" stage (S1, L2 and D2) only manages a small amount of the total power deliv-ered to the load, while it is able to widen the conduction angle of the main filter inductor (L1), reducing iron and copper usage while complying with the limits imposed by EN61000-3-2.

Detailed behaviour of this circuit, and its comparison with a simple passive filter and a high frequency boost PFC are clearly described in the references 1 through 3 There, control is achieved by turning S1 - ON only once at the beginning of each line half period.

Pulse length affects both output voltage and line current harmonic distortion, and enables the achievement of a certain output voltage regulation versus load, while regulation capability versus line variations is quite poor.

Improved Line and Load Regulation A straightforward solution to improve

increase the number of S1 -ON pulses, as depicted in Fig. 2. However, on the contrary, choosing the right commutation strategy was not straightforward. In fact. while number of pulses and their duration only affect DC output voltage, their number, duration but also their spacing and positioning with respect to line voltage zero crossing have a heavy impact upon harmonic content of the

line and load

Optimal operating conditions were

line current.

Synchronization pulses drive a monostable oscillator, providing pulses of the desired length. The "Delay and Group-

limiter" circuit does this job.

found by Matlab/ Simulink<sup>™</sup> model and

a prototype circuit. Given the required

duration were found to cover line and

load variations. On the other hand, the

best harmonic distortion was achieved

by grouping pulses into a specific time

mask (see Fig. 2). Figure 3 shows how

the control can be designed to imple-

ment the "optimal" commutation strat-

The main error amplifier (EA) drives

whose aim is to provide a number (>=1)

a Voltage Controlled Oscillator (VCO),

of synchronization pulses. The pulse

number has to be limited, oth-erwise

S1 and L2 excessive switching losses

would occur and the advantage of this

control would be lost. The "frequency

egy.

output voltage, pulses number and





ing" circuitry, synchronized by the line zero crossing detector, generates the time mask, which the pulses must stay within. A further block is needed: the "Mode selec-tor". It provides the following control strategy

a) at low boost amplification, pulse length is kept to MIN and number of pulses is changed in response to the EA output.

b) When maximum number of pulses is reached (low line voltage or high load), pulse length is increased up to MAX.

Other features of the circuit shown in Fig. 3 will be explained later on.

### Test results from simulation and prototype

1. Circuit simulation

A Matlab/ Simulink<sup>™</sup> model gives more insight into the effect of the various control parame-ters.

Simulation results are shown in Fig. 4



 $V_{in} = 230V$  $V_{out} = 350V$  (set point)

L1 = 6mH

L2 = 1.5mH

 $C1 = 33 \mu F$  $C2 = 500 \mu F$ 

Boost ratio of about 112% was achieved, by changing pulse numbers from 1 to 10, and pulse length from 40 to 100usec. Voltage drop across L1 is thus completely compensated, while out-put voltage can be regulated well at the set point even if line voltage drops of more than 10%.

The line current harmonic spectrum is shown in Fig. 5, for 10 pulses and various pulse lengths.



Figure 5: Measured harmonic spectrum; brown bar: EN61000-3-2 Class A limits.



Figure 6: Measured efficiency versus line voltage at constant Pout = 650W.

Pout = above 1000W Pulse number = limited to 7 Pulse length = limited to 100µsec

Pout level indicates that the circuit can compensate line harmonics even

Figure 8 show (top to bottom) : a) Voltage across C1

above 1 HP.

b) L2 current

c) Output voltage

d) Line current

2. Test Results from prototype A prototype test circuit was built and tested up to 700W with the same components used for simulations. Only C1 was increased to 43uF. S1 was IRGB4059 trench IGBT by IR, but a standard speed IRG4BC30S could be used as well. D1 and D2 were 5A - 600V standard speed diode.

> At 650W output power, and for line voltage changing from 195 to 255Vrms efficiency is very high, as shown in Fig. 6. Because of the very low switching frequency (few hundred Hz) and because only part of the output power is handled by the "baby-boost", semiconductor compo-nents (S1, D1 and D2) only account for few Watts each, while attention has to be paid to aux-iliary inductor L2. The inductor used in

the experiment was a hand-wound one, with not opti-mized wire gauge, and accounted for almost 60% of the losses at 195Vrms input.

### Housekeeping Power Supply

One of the important sources of power dissipation in this circuit is the auxiliary inductor L2. Because of the variable flux linkage across L2, part of its accumulated energy can be success-fully used to drive a housekeeping power supply, as shown in Fig. 3. The auxiliary voltage will be, of course, changing with pulse number and length, but may be designed to stay within input voltage limits of standard integrated linear voltage post-regulators. Diode D1 (in Fig 1) was replaced by a small P-ch mosfet to increase efficiency at no-load conditions.

### Conclusions

A simple change in the control algorithm for line frequency commutated power factor correc-tion rectifier allows improvement in its line and load regulation capability. The resulting con-trol scheme can be easily implemented into IR's proprietary iMotion<sup>™</sup> digital control library. Simulation and prototype test results show full capability to limit line current harmonics within Class A European Standards, at least for power levels up to 1 kW, while maintaining high efficiency even at low input voltage.

The basic advantages of the line frequency commutated rectifier are kept; the total inductors size and weight reduction with respect to simple passive filters is achieved.

### References

[1] A Double-Line-Frequency Commutated Rectifier Complying with IEC 1000-3-2 Standards. Giorgio Spiazzi & Jose Antenor Pomilio. 1999 IEEE

[2] Comparison Among High-Frequency and Line-Frequency Commutated Rectifiers Complying with IEC 61000-3-2 Standards. Giorgio Spiazzi/Simone Buso/Jose Antenor Pomilio. IEEE 2000

[3] A Low-Inductance Line-Frequency Commutated Rectifier Complying with EN 61000-3-2 Standards, Giorgio Spiazzi & Jose Antenor Pomilio. IEEE 2002

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# **Factorized Power** Architecture

# *High performance computing – lower energy cost*

Today's high performance computing systems are power hungry and consume more each year. Overall growth in IT demand and increasing energy costs outstrip the improvements in performance per device, resulting in ever-higher electricity bills. In fact, the cost of the power to operating servers will soon surpass the cost to buy them.

### By Stephen Oliver, VP Marketing & Sales, V•I Chip, Vicor

ompanies are making major changes to control costs: for example Google, Yahoo and Microsoft have invested in building new data centers along the Columbia River in NW USA to be as close as possible to hydro-electric power, minimizing electrical transmission loss and the cost of the electricity.

Traditional "AC-to-12V DC Silver Box followed by 12V-to-1.xV synch buck" power supply designs have run aground in terms of system power density and efficiency due to a combination of distribution bus losses and fundamental restrictions in topology performance as processor voltages reach sub-volt levels. Higher voltage (48V or 350/380V) bus voltages reduce distribution losses, but usually mean the addition of an extra stage or stages to get down to the processor voltages, which increase size and may lower conversion efficiencies. A new approach is clearly needed for the next generation of servers, and one solution - Factorized Power Architecture (FPA) – offers the promise of optimizing efficiency, thus reducing power costs, while minimizing the area used for power delivery.

The benefits of the new approach can be demonstrated by comparing efficiency and space requirements for a typical mid- to high-end data process-

ing system comprised of one or more blocks of 8 microprocessors, each running at 1.2V and 100A for a total load of 960W per block. The system is fed via an AC-to-48VDC front end with a 208VAC input.

### **Baseline System Performance** (Efficiency & Size)

A typical AC-48VDC-1.xV system (Figure 1), using components and subsystems that are in mass production today, has an overall 67% efficiency from AC



Figure 1: Baseline System: Efficiency, Power Drawn from AC line and Size.



Figure 2: Traditional 48:1.2V system with 1/4 Brick and VRM/VRD solution.







Figure 4: PFA system: efficiency, power drawn from AC line and size.

to point-of-load (POL), meaning that for our 960W load, the system draws approximately 1430W from the AC line. The difference of 470W is lost as heat, which compounds the existing thermal management problem, requiring better heat sinking and air conditioning systems, which further increase the running costs of the datacenter.

The system that has been analyzed uses a common topology, with the ACto-48VDC unit comprising of a standard bridge, filter and boost PFC generating 380V, and then a two-transistor forward converter with diode rectification to 48VDC. The 48-to-1.2V conversion assumes four 48V:12V unregulated bus converters in 1/4-brick format followed by a 4- or 5-phase voltage regulator module (VRM) or a voltage regulator-down (VRD) to the processor.

The power density for a typical commercially-available AC-to-48VDC front ends would be 10W/in3. In 800W to

1500W designs, the PFC stage (including AC-bridge and input EMI filter) normally occupies around 40% of the whole converter. The PFC stage and HV (380V-to-48V) DC-DC stage can then estimated based on the output power level of each stage. The 1/4 bricks and VRM/VRD including 'oscon' bulk capacitors) dimensions are from specific examples.

### Factorized Power Architecture

FPA uses three flexible building blocks known as "V•I Chips" to redefine the boundaries of each conversion stage and enable higher densities and efficiencies. The Bus Converter Module (BCM) has a narrow-range input, and is an unregulated, high efficiency bus converter offering isolation and voltage transformation using a zero current switchingzero voltage switching (ZCS-ZVS) Sine Amplitude Converter (SAC). Both high Voltage (up to 384V) and Medium Voltage (48V) input versions are available. The Pre-Regulator Module (PRM) is a unique ZVS high efficiency buck-boost

converter. The final building block is the Voltage Transformation Module (VTM). The VTM is a wide range 48V input, high efficiency voltage transformation unit using the ZCS-ZVS SAC. The VTM works in combination with a PRM to give a low voltage output down to 0.82V.

FPA building blocks emable greater flexibility, scalability and efficiency in power system design. The SAC in the BCM runs at an effective frequency of 3.5MHz, using unique planar magnetics for high power conversion in a small package, and achieves power density of more than 1000W/in<sup>3</sup>, offering substantial reductions in size over other technologies.

In this article, we focus on the performance of the 48V-to-processor section. Using a PFC front end (e.g. FE375) upstream to create a HV bus and then HV BCM converters can produce 1200W at 48V with 95.5% efficiency: a significant improvement on a conventional front end.

Traditional VRMs/VRDs rely on the tried and trusted synchronous buck PWM converter. As processor voltages fall towards 1V and below, however, the duty cycle to generate this Voltage from 12V reaches 12:1 (Svnch FET:Control FET). Moving to a 48V bus may not produce the anticipated improved efficiency due to the challenges presented by the extremes of duty cycle, coupled with the higher FET voltage requirements and subsequent higher R<sub>DS(ON)</sub>.

FPA enables the separation of the PWM's regulation and voltage transformation stages into two separate blocks. The PRM generates a factorized bus, typically controlled to 48V, and the VTM (a current multiplier with very low output impedance up to 1 MHz) provides high-efficiency Voltage transformation directly at the processor or point of load (POL). For the 960W load in our example, 8 VTMs are used (1 per 100A processor). As PRM V•I Chips are capable of much higher powers (up to 320W each), only four are needed, and they are simply arranged in parallel with connected outputs.

FPA delivers several substantial benefits. The inherent high efficiency results in significant power savings. The physical separation of PRM and VTM allows





Figure 5: Baseline and FPA systems: size and efficiency.

the PRM to be placed at a distance from the VTM, with 94% reduction in distribution losses (W/ohm) as a 48V rather than 12V bus can be used. Additionally the separation enables minimized space requirements at the processor, because only the VTM is required to be at the processor to minimize the board area required and losses due to high current traces. A further unique benefit of FPA is that the high bandwidth bi-directional transformation within the VTM enables the removal of bulk capacitance from the processor and its replacement by a much smaller (typically 1/1000) capacitance at the factorized bus. This major reduction in bulk capacitors substantially reduces the space required for the power supply system. Owing to the VTM's high bandwidth and low Q characteristic, the ceramic bypass capacitor requirement at the POL is also greatly reduced as it only needed to support dynamic response within a time scale of 1 µS. Finally FPA offers outstanding transient response, meeting the rapidly fluctuating power demands of modern processors and ICs.

Figure 5 compares the power loss, size and efficiencies per stage of a typical solution with one using FPA. Using V•I Chips within an FPA solution increases overall efficiency by 8.6% and requires 45% less space than the original design. In practice FPA can achieve further size and efficiency gains could be achieved with improved connectors and distribution system.

### Conclusion

Factorized Power Architecture using Vel Chips greatly improves system efficiency and power density. This offers a substantial financial benefit, as the power drawn from the AC-line, as this is the major cost to data centres. The system will run cooler as losses are reduced by 36%, allowing other components to be more efficient and increasing reliability. Further energy and costs savings are made because 36% less heat must be removed by air-conditioning, which itself is inefficient. Taking into account operating duty cycles and the cost of energy per kWhr, the FPA system saves the end user more than €24 per processor, per year with the added advantage of reducing CO<sub>2</sub> emissions.

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# 27 – 29 May, Nuremberg, Germany

t this vital meeting place of the power electronics industry, the focus was very much on innovative solutions for the increase of energy efficiency.

Mesago, the show's organizer gave out the key statistics for the event. Visitor pre-registrations came from 50 countries and after preliminary counting, the number of visitors (approx. 6,500) exceeded the event's result from 2007

(6,258) by approx. 4%.

The conference, hosting a wide range of internationally renowned speakers, attracted 592 attendees (2007: 571) from more than 30 countries to Nuremberg.

The conference was very well received, comprising 120 previously unpublished presentations as well as 10 tutorials held by industry experts.

### New 3-Channel High Temp. **Optical Encoder Modules from Avago**



Avago, who recently received the 2008 Global Optocoupler Company of the Year Award from Frost and Sullivan, has announced a new series of compact three-channel high temperature optical incremental encoder modules for use in industrial and factory automation equipment. Avago's AEDT-9140 encoder

## AVX Has the Capacity

AVX has introduced a new range of product within its TRJ professional series tantalum chip which delivers significantly lower ESR while achieving reliability levels twice that of standard tantalum devices.

As a direct result of customer feed-

### PCIM Europe 2008 Roundup



nergy Efficiency Crown

Reported by Cliff Keys, Editor-in-Chief, PSDE

The unique combination of the PCIM Conferences with its clear user focus and the internationally leading PCIM exhibition, make PCIM Europe a 'mustsee' highlight for experts from all over the world.

PCIM Europe 2009 will take place in Nuremberg from 12 - 14 May 2009. I recommend a visit for anyone connected to the power industry.

module series, which are available in a variety of counts per revolution (CPR) and shaft diameter options, are priced competitively and designed to enable the reduction in overall motor sizes. This latest addition to Avago's family of easy to install optical encoders are designed to fit easily into a circular housed encoder or directly onto industrial motors to provide motor manufacturers with advanced motion control detection.

The AEDT-9140 encoder modules include a lensed LED source and a detector IC enclosed in a small plastic package. When used with a codewheel, this low-cost module series detects rotary position. Due to a highly collimated light source and a unique photo detector array, the AEDT-9140 modules are extremely tolerant to mounting misalignment. Typical industrial automation applications where the AEDT-9140 encoders can be used include industrial printers, plotters, tape drives, machine tools and industrial and factory automation equipment.

Avago's AEDT-9140 modules have two channel quadrature outputs plus a third channel index output and are designed for use with a codewheel that has an optical radius of 11mm (0.433 inch) for 100 to 512 CPR and 11.68mm (0.460 inch) for 1,000 CPR. The index output is a 90 electrical degree high true index pulse which is generated once for each full rotation of the codewheel.

www.avagotech.com

back, 124 new devices are now available in the professional TRJ series with maximum ESR reduced to levels previously only available in specialty low ESR

### PCIM Europe 2008 Roundup



TPS series devices. This enables designers of power supplies for use in long life expectancy applications - industrial, automotive, civil aerospace, medical etc. - to use tantalum capacitors with the combined benefits of enhanced reliability (0.5%/1000hrs) and low ESR.

AVX developed its TRJ tantalum professional capacitor series for use in demanding environments that call for higher performance under electrical and mechanical stress, and technical improvements were made to strengthen the structure of capacitor and make it more robust in such environments.

Low ESR TRJ capacitors are especially suitable for filtering in power supply applications where they can significantly contribute to smoother filtering performance and long-term stability. They can help reduce equipment size, help deliver a higher power output within a given instrument size, and contribute to reducing costs by using fewer capacitors in a parallel configuration.

Standard and low ESR TRJ capacitors are available in EIA standard A, B, C, D and E case sizes in voltages ranging from 6.3 to 50V and capacitance values from  $0.1 - 470\mu$ F. The 6.3V, 10V and 25V rated voltage parts target the most popular output voltages of DC/DC converters and battery applications (3.3, 5 and 12V).

### Cree

I met with Cree's Paul Kierstead, Director of marketing who gave me a great insight into the company's activities.

Cree, a market-leading innovator and manufacturer of semiconductors for LED solid-state lighting, power and communications products are renowned for significantly increasing their energy performance.

The company has unrivaled materials expertise in silicon carbide (SiC) with gallium nitride (GaN) to deliver chips and packaged devices that handle more power in smaller footprint area while producing less heat than other available technologies, materials and products. In addition, the company has the proven capability to deliver on its technology leadership promises by delivering 90% of the total SiC to the industry.

In the world of 'hot and hungry' data centers and server farms, this is great news for the environment with huge energy savings and therefore reduced pollution, possible by the use of Cree's SiC devices. "This is a technology that is at the end of the runway and ready to take off, and we can deliver it" said Kierstead.

Cree drives increased Return on Energy™ (ROE™) solutions into multiple applications in brighter and more-tunable LED light for general illumination, backlighting for more-vivid displays, optimized power management for highcurrent, switch-mode power supplies and variable-speed motors, and moreeffective wireless infrastructure for data and voice communications. Cree's customers range from innovative lighting fixtures makers to defense-related agencies.

Cree's product families also include blue and green LED chips, lighting LEDs, LEDs for backlighting, power-switching devices and radio-frequency/wireless devices. www.cree.com

## **CT-Concept Drives IGBT Technology Advances**

Perfectly flat: IGBT drivers in planar technology

The 1SD2020Al high-performance driver core has been designed specifically for high-frequency applications



1SD2020AI

up to about 300kHz. In addition to an extremely short transit time of 100ns the product features an extremely low jitter of less than ±2ns.

With this product, CT-Concept has introduced a new, patented planar transformer technology. Reliable planar transformers based on commercial circuit boards for voltages of more than 300V have been traditionally very difficult to produce because of CAF problems. The process patented by CT Concept now allows these planar transformers to be used for driving IGBTs up to a reverse voltage of 1700V while maximizing their operating life and reliability.

Planar integration of the high-voltage insulation represents a new way of satisfying space, cost and reliability demands in state-of-the-art power applications. The use of PCB integrated planar transformers, used for both signal transmission and power transmission, not only increases the power density but also allows better reproducibility, better process control and a higher degree of automa-

Power Systems Design Europe June 2008

tion during the production process.

### Prime time for SCALE-2

With its SCALE-2 series, CT-Concept launched a second generation of highly integrated IGBT drivers for high-power applications. SCALE-2 is a further development of the SCALE technology



2SD421A

already tested and proven for a decade.

CT-Concept presented the next generation of IGBT drivers for high-power applications based on the new SCALE-2 chipset. Plug-and-play drivers are complete, ready-to-use IGBT drivers that have been perfectly matched to a large selection of IGBTs. CT-Concept now offers over 200 versions of these drivers,

which cover all voltage classes between 1200V and 6500V and a current range from 50A to 3600A. The current family of plug-and-play drivers supports all known IGBT manufacturers.

As a direct result of SCALE-2 technology, the new 2SD421A and 2SD412B families comprise extremely compact, 2-channel plug-and-play drivers that can be used for the entire PrimePACKTM portfolio from Infineon with reverse voltages of 1200V and 1700V. All plug-andplay drivers are complete solutions and are equipped with DC/DC converters, short-circuit protection, active clamping, supply monitoring and more. Users need only mount these devices onto the corresponding IGBT module: the system can then be put into operation immediately with no further development or matching effort.

The 1SD421F2 series of modular plugand-play drivers is designed for single as well as parallel or series-connected 3.3kV to 6.5kV IGBTs. It thus offers designers a complete solution for the parallel connection of high-voltage IGBTs for the first time. Parallel connections are required in

### Infineon

I had the great opportunity of meeting with Arunjai Mittal, Senior VP and GM of Infineon's Power management and Drives, who gave me a concise overview of the vast breadth of products and technologies that this company is delivering. The company is providing solutions for all power applications from lowpower management to power generation and transmission, on to control and efficiency in locomotives. Truly, a company that touches our daily lives. I will expand on this in a future interview.

### New OptiMOS<sup>™</sup> 3 MOSFETs with lowest on-state resistance in SuperSO8

Infineon announced availability of its OptiMOS<sup>™</sup> 3 40V, 60V and 80V N-channel MOSFETs in SuperSO8 and Shrink SuperSO8 (S3O8) packages, allowing it to offer the world's lowest RDS(on) (onstate resistance) in leadless packages at



New OptiMOS<sup>™</sup> 3 MOSFET

www.powersystemsdesign.com

those breakdown voltages. Compared to standard TO (Transistor Outline) packages, the SuperSO8 products increase power density by as much as 50 percent, especially in synchronous rectification applications in server SMPSs (switched-mode power supplies).

Best-in-class RDS(on)max of as low as 1.8 milliohms for OptiMOS 3 40V, 2.8 milliohms for 60V and 4.7 milliohms for 80V set a new standard on the Super-SO8 footprint, re-ducing the on-state resistance by up to 50 percent compared to the next-best com-petitor. The FOM (figure of merit, calculated as on-state resistance times gate charge) of these the higher power applications, such as in locomotive traction systems.

The 1SD421F2 drivers are suitable for 2-level, 3-level and multilevel topologies. In order to ensure maximum flexibility in insulating the supply voltage, the DC/DC converters are not integrated in these driver families but are offered as external components. A new series of ISO5125I converter modules is consequently available with partial discharge extinction voltages of 4500V to 12,000V.

Optimized active clamping is integrated into both these drivers: it is based on the corresponding functionality of the SCALE-2 chipset.

Finally, CT-Concept presented the 1SD535F2 family of drivers derived from the proven 1SD536F2 and based on the tried-and-tested SCALE technology of the first generation designed for high-power IGBTs in the standard 190x140mm package. The new 1SD535F2 has identical functionality to its 'big brother' but is optimized for the smaller 130x140mm module.

www.IGBT-Driver.com

devices is as much as 25 percent better than that of similar parts in standard TO packages, enabling even faster switching while minimizing switching and gatedrive losses. This allows higher power densities and less heat generation in the driver. The low package inductance of the SuperSO8 package (less than 0.5 nH compared to 5 to 10 nH for a TO-220 solution) further improves overall efficiency and minimizes ringing under switching conditions.

These products meet the needs of fast-switching SMPSs and DC/DC converters in a variety of applications, such as synchronous rectifiers in AC/DC

### PCIM Europe 2008 Roundup

SMPSs, primary-side switches, and secondary side-switches in isolated DC/ DC converters and non-isolated (buck) industrial converters, where space, power density and maximum effi-ciency are key factors.

The 60V and 80V SuperSO8 devices can provide an efficiency increase of 0.5 per-cent for server SMPSs compared to solutions using TO packages, or similar efficien-cies at 20 percent higher RDS(on) ratings compared to standard solutions.

### Availability

OptiMOS 3 60V family is now available in production quantities and 40V and 80V devices are currently being sampled. For further information go to www.infineon.com/powermosfets and www.infineon.com/optimos



New MIPAQ<sup>™</sup> Family of power modules

# New MIPAQ<sup>™</sup> Family of power modules

Infineon also introduced its new MIPAQ<sup>™</sup> family of IGBT (Insulated Gate Bipolar Transistor) modules that offers a very high level of integration. The MIPAQ (Modules Integrating Power, Application and Quality) products enable highly efficient power inverter designs to be used in Uninterruptible Power Supply (UPS); industrial drives, such as compressors, pumps and fans; solar power plants; and air conditioning systems. The modules are characterized by enhanced testing and are delivered as known-good systems.

The MIPAQ family features an innovative packaging concept and utilizes the advan-tages of the Infineon IGBT4 chips. These chips feature excellent electrical rugged-ness, provide approximately 20 percent lower switching losses than IGBT3 and offer higher power cycling capability. All MIPAQ products feature an IGBT sixpack con-figuration. The MIPAQ family today includes three products.

MIPAQ<sup>™</sup> base: With only 17 mm in height, the "MIPAQ base" modules are ideally suited for use in low-inductive system design in industrial drives, such as compres-sors, pumps and fans, as well as machine tool inverters. With three specifically de-signed shunts for current measurement now integrated into the module, these appli-cations greatly benefit from space savings and elimination of PCB hotspots. The integrated shunts now handle all tasks formerly performed by external current sensors, which are costly and require valuable space. The integrated shunts also generate significantly less heat on an inverter's PCB. The integration into the "MIPAQ base" module provides

better heat distribution to the heatsink.

MIPAQ<sup>™</sup> sense: In addition to the IGBT six pack configuration and three highly so-phisticated current shunts, the "MIPAQ sense" modules also integrate a fully digital current measurement with galvanically isolated output signals using the Sigma Delta measurement method. With Infineon's Coreless Transformer Technology, optocou-plers are no longer required, saving additional board space. The "MIPAQ sense" modules manage currents of 50 A, 75A and 100A. They are available in EconoPACK<sup>™</sup>3 housing using PressFIT interconnection technology for fast, reliable and solderless mounting.

MIPAQ<sup>™</sup> serve: With the "MIPAQ serve", Infineon offers highly reliable modules in-tegrating an IGBT six pack configuration, a full set of driver ICs as well as a tempera-ture measurement. These functionalities enable "MIPAQ serve" to be a full plug-and-play solution for highcurrent drive applications. Inside the module, there are galvan-cally isolated drivers based on Infineon's Coreless Transformer Technology. With fewer optical couplers, it will further enhance the modules' long-term stability. The "MIPAQ serve" modules cover the 1200 voltage range and manage currents of 100A, 150 A and 200 A.

#### Availability

Samples of the modules "MIPAQ base" and "MIPAQ sense" will be available in Q3 2008. Further information is available at www.infineon.com/mipaq.

www.infineon.com

## IR Expands Industry Leading SupIRBuck<sup>™</sup> Family



IR has expanded its SupIRBuck™ portfolio of versatile wide input, single output integrated point-of-load (POL)

DC-DC voltage regulators with the introduction of the IR380x family for consumer embedded POL applications up to 14 amps. Size and feature set are optimized for high performance consumer applications, including set-top boxes, LCD TVs, game consoles, desktop PCs and graphics cards.

The new application-specific devices integrate IR's high performance control ICs optimized with benchmark HEXFET<sup>®</sup> MOSFETs in a compact 5mm x 6mm power QFN package to enable up to 70 percent space savings compared to discrete solutions, while maintaining an equivalent overall total solution cost.

"Because of its high level of integration and small footprint, the SupIRBuck family delivers significant space savings to help reduce overall system costs for consumer applications while offering superior flexibility and efficiency over traditional implementation using discrete components," said Goran Stojcic, executive director, IR Enterprise Power Applications and Technical Marketing.

The SupIRBuck family of voltage regulators is designed for 4, 7 and 12 amps of output load current at 600 kHz and 6, 9 and 14 amps at 300 kHz respectively. Key features include wide range input of 2.5 V to 21 V and output range of 0.6 V to 12 V, pre-bias start up, a choice of two fixed switching frequencies, hiccup current limit, thermal shutdown and precise output voltage regulation.

### LEM's New Automotive Battery Monitoring Transducers

Improved resolution and offset errors



LEM Automotive transducers do not

require the battery power bus to be

LEM introduced the HAB xx-S family

of current transducers for automotive-

specification battery-monitoring ap-

plications. A new approach for LEM,

these devices are finding success in

Hybrid Electric vehicles (HEVs). These

transducers, designed to measure DC,

interrupted

AC, or pulsed currents up to  $\pm 100$ A, do not require the battery power bus to be interrupted. A new, high accuracy Application Specific Integrated Circuit (ASIC) incorporated into the units offers resolution 2.5 times better than previous models and a two-fold improvement in offset error, coupled with a significant reduction in price.

The transducers use open loop, Halleffect technology that simplifies both installation and servicing by removing the need to cut the [primary] cable carrying the measured current. They provide a pulse-width modulated (PWM) output signal proportional to the primary current being measured and operate from a unipolar 5V supply. Temperature measurement capability can be integrated with the addition of a fourth connection

# Mitsubishi Powers Relentlessly Onwards

At Mitsubishi's press conference, the company outlined the broad range of products for industry sectors covering Industrial, White goods, Automotive and Locomotive. In short, Mitsubishi parts are present in our daily lives. Their renowned leadership in IGBTs, high voltage IC's and developments in Silicon Carbide were presented by Gourab Majumdar, PhD, Mitsubishi's Senior Chief Engineer for Power Devices.

### New R-Series 3.3kV/1500A High Voltage IGBT Modules: Lower Losses and Higher Robustness

HVIGBT modules have gained broad acceptance in many different high power applications such as railway propulsion



and large industrial drives, which all demand for increased rated currents and wider operation junction temperature ranges. In these applications parallel connections of IGBT modules must be easily possible and also a good switching controllability is necessary for low EMI levels.

In order to meet these requirements, the new IGBT generation of Mitsubishi Electric's 3.3kV R-Series adopts "Fine Planar MOS gate Light Punch Through HVIGBT (FP-LPT-HVIGBT)" and "Soft reverse Recovery HV-Diode with high The IR380x family's thermally enhanced packages with slim 0.9mm profile, allow mounting on the back-side of the motherboard for additional space saving and enable no-air flow operation without heat sink below 10 amps.

www.irf.com

pin to the transducer package.

Output resolution of the HAB 60-S transducer is 0.03A with a linearity of 0.2%. Electric offset error is typically 0.075A across the temperature range from  $-10^{\circ}$  to  $+65^{\circ}$ C, and 0.15 A across the full range from  $-40^{\circ}$  to  $+125^{\circ}$ C.

A water-tight housing and sealed connector provide full environmental protection in engine-compartment applications.

Principal applications are in the measurement of battery-pack currents in electric, hybrid, as well as in conventional vehicles. These transducers are fully certified to automotive standards.

www.lem.com

robustness (SR-HVDi)" structures, which reduce the power losses and increase the rated current while maintaining the mechanical compatibility with the already existing H-Series.

The new generation chip technology provides many important benefits:

• IGBT chip: Lower losses, controllability of di/dt and dv/dt

• Diode chip: reduced reverse recovery current (I<sub>rr</sub>)

• Higher SOA robustness, positive temperature coefficient (PTC) for easy parallel connection

### PCIM Europe 2008 Roundup

The current density of the new IGBT chip is 94% compared with a conventional IGBT while the diode chip's current density remains unchanged.

At rated current and 125°C the new IGBT operates with a 30% lower VCE(sat) than a conventional IGBT. In addition, the peak collector current (i. e. Irr of the diode) is reduced by 20% consequently reducing the IGBT turn-on switching energy (Eon) by 10%.

In brief, the advanced new IGBT improves the trade-off characteristic between V<sub>CE(SAT)</sub> and Eoff by 25% without deteriorating the robustness.

Additionally, Eon is improved by the reduction of Irr with an advanced new diode while the soft reverse recovery behaviour maintains the robustness capability of conventional diode designs. Moreover, maximum operation temperature is extended from 125°C to 150°C while the minimum storage temperature is further extended from -40°C to -55°C.

New Transfer Mold IPMs for 1200V/5-35A with heat dissipating insulation sheet

Mitsubishi introduced its new series of



New Transfer Mold IPMs for 1200V/5-35A

Intelligent Power Modules (IPM) available for rated currents of 5A, 10A, 15A, 25A and 35A at a rated voltage of 1200V. The new devices dubbed PS22A7X, which represents the Vers. 4 series of DIP-IPM (Dual In-Line Package IPM) devices for home appliances package air conditioners and small power drives became possible by combining Mitsubishi's own CSTBT™ (Carrier-Stored Trench Gate Bipolar Transistor) technology, shrink-process ICs, a novel heat dissipating insulation sheet and further innovations.

Compared to the previous DIP-IPM devices the new PS22A7X series comes in packages which are 30% smaller even though the on-state voltage and switching losses were reduced.

The reduction of size is achieved by developing a circular-shaped MOSFET replacing the traditional oval-shape MOSFET used for high voltage level shifting in the High Voltage IC so far, at the same time as changes to the traditional offset-structured transistor were made. This leads to increased output capabilities while the chip size remains unchanged. Even at high switching frequencies the DIP-IPM devices operate without oscillations. It is possible to drive the DIP-IPM devices without using any coupling devices like e.g. optocouplers.

### **Electrical Circuit Configuration and** Components

Internally the PS22A78-E (35A/1200V) comprises of IGBTs and Free Wheel Diodes (FWDs) in a three-phase inverter structure combined with control ICs. While this structure equals the previous version of DIP-IPM, the open-emitter type products offer three divided emitter terminals of low-side IGBTs to sense the inverter phase currents flowing through external shunts. The PS22A7X series offers logic filtering functions in order to obtain enhanced immunity against noise propagated from signal lines.

www.mitsubishichips.com

# Power Integrations' New LinkSwitch<sup>®</sup>-II Exceeds Global Energy-Efficiency Standards



Power Integrations, winners of PSDE's Green Power Award, has announced the introduction of its LinkSwitch-II family of highly integrated AC-DC switched-mode power conversion ICs with very accurate primary-side control. LinkSwitch-II dramatically simplifies constant-voltage, constant-current (CV/CC) converters, and enables consumer products to meet all worldwide energy-efficiency and no-load regulations, such as ENERGY

STAR 2.0 for external power supplies. The new devices are ideal for applications such as chargers for cell phones and cordless phones, high brightness LED drivers and other accurate CV or CC applications.

LinkSwitch-II, a new generation in Power Integrations' extremely successful LinkSwitch series of ICs, simplifies the design of accurate output CV/CC converters by eliminating the need for optocouplers and all secondary-side CV/CC control circuitry as well as all control-loop compensation circuitry. By integrating all control and protection circuitry plus a 700 V MOSFET in an 8-pin package, LinkSwitch-II significantly reduces component count, space and system cost while increasing reliability. Output CV/CC tolerances of +/-5% and +/-10% respectively are achieved

over a 0 – 100°C temperature range by incorporating precision-enhancing features that compensate for transformer inductance tolerances, input line variations, output cable voltage drop (LNK61x only) and external component temperature variations. LinkSwitch-II also offers frequency jittering to greatly reduce EMI filter costs.

Sophisticated protection and safety features include auto-restart output short circuit protection and hysteretic thermal shutdown, IEC 60950-1 HV creepage requirements between Drain and all other pins are met and all single point failures are handled safely.

In an example cellphone charger design of 5V/1A, 5 W, LinkSwitch-II offers a simple path to ENERGY STAR EPS 2.0 compliance by achieving aver-

age efficiency levels of up to 75% at 25%, 50%, 75% and 100% loads across a 115 to 230 VAC input range. The On/Off control scheme employed in LinkSwitch-II, coupled with low IC power consumption and elimination of secondary-side current sense resistor and control circuitry, provides practically constant efficiency across the entire load range and a no-load consumption of under 30 mW.

Comments Doug Bailey, vice president of marketing at Power Integrations: "LinkSwitch-II sets a new standard in the level of integration achievable in a switching power supply design. It uses primary side regulation to accurately control the output current and voltage, eliminating an expensive opto-coupler

and all of the secondary feedback and compensation components. A charger designed with LinkSwitch-II has 9 fewer components compared to the previous generation of LinkSwitch and up to 15 fewer components when compared to discrete designs. LinkSwitch-II offers accurate cable drop compensation which significantly reduces the cost of the output cable by minimizing its copper content, without sacrificing output performance. It also requires a smaller transformer using less copper and core material."

Bailey continues: "Lack of secondary feedback sensing components increases the efficiency of LinkSwitch-II-powered chargers to levels approaching 80%. Furthermore, LinkSwitch-II

### **New IPM from Semikron**

### Solder-free assembly handles power up to 15kW

Semikron introduced an IPM (intelligent power module) for quick and easy solder-free assembly at their press conference. The Miniskiip<sup>®</sup> IPM handles motor power up to 15kW and has a latch-up free SOI driver IC for reliable driving integrated. Compared to other intelligent power modules this new device demonstrates the lowest thermal resistance of 0.95K/W and the highest junction temperature of +175°C.



MiniSKiiP<sup>®</sup> IPM, the first IPM for solder-free assembly and motor power up to 15kW

Power, control and auxiliary contacts are connected directly to the printed circuit board via springs, instead of solder joints. The elimination of solder connections results in higher reliability of the assembly. With the simple snapon mounting with one standard screw a cost-efficient assembly of module, printed circuit board and heat sink is achieved. The user has the advantage of using a module where handling is reduced and the parts count is less compared to discrete designs.

A high voltage driver IC with an

advanced level shifter technology is integrated into the 600V Converter-Inverter-Brake IPM and the 1200V inverter (6-pack) Miniskiip<sup>®</sup> IPM providing IGBT driving without an optocoupler. The SOI technology provides complete latch-up immunity since all switches are dielectrically insulated. A down-level shifter for each channel allows the presence of negative secondary offset voltages. The integrated gate driver remains fully operational for any applied offset voltage down to -50V, providing flexibility in the design of a power system. The gate driver IC features an over-current shutdown circuit protection by using an external shunt resistor in the ground plane shutting down the IPM in case of overcurrent as well as an under-voltage lockout for all channels and fault signaling. A shut-down can be also forced by the system controller using the shut-down input. Cross-conductions are prevented by the interlock logic.

The MiniSKiiP® IPM achieves the best thermal resistance and an optimized current density, leading to high power

dramatically reduces no-load consumption, the power consumed from the wall when disconnected from the appliance, to levels that are difficult to measure. saving consumers money on their electricity bills. Overall, the LinkSwitch-Il solution greatly simplifies the design, is less expensive to build, and is easier on the planet's physical resources and energy supply."

Further underlining LinkSwitch-II's green credentials, all family members are produced in halogen-free, RoHScompliant packaging, which is increasingly being demanded by end customers such as Apple, Nokia Samsung and LG.

www.powerint.com

cycling capability and a longer lifetime compared to existing IPM technologies. These advantages are the result of the pressure contact technology which evenly distributes the vertical pressure, the spring contacts and the base plate free package.

MiniSKiiP<sup>®</sup> IPM is suitable for industrial and consumer drives up to 15kW as well as process control and solar applications. Using state-of-the-art Trench-Field-Stop IGBTs, the IPMs are available in 600V and 1200V and designed for nominal current ratings up to 72A. The module is RoHS compliant.

www.semikron.com

### **Semikron Drivers Go Digital**

### Control parallel connected IGBTs with a total current of up to 9,000 A

Semikron also unveiled a new IGBT driver generation. The new driver SKYPER<sup>®</sup> 52 is based on fully digital signal processing, allowing for the transmission of isolated sensor signals and individual protection level settings. Development engineers can now ignore costly discrete isolated circuits resulting in fewer components and improved overall system reliability.



The digital driver SKYPER<sup>®</sup> 52 is based on fully digital signal processing

Differential digital signal processing provides numerous technical advantages and ensures a high level of signal integrity and hence high noise rejection. With the digital driver SKYPER<sup>®</sup> 52, switching characteristics, shut down levels and error processing can be set to meet the given application requirements.

This part is a unique flexible IGBT driver. Digital signal processing does not depend on the component parameters, is highly robust and is unaffected by temperature fluctuations or the affects of ageing. For development engineers this means flexibility with the driver circuitry properties and consequently, control settings for the power electronics, which can be adapted to meet the individual needs.

If an error is detected, this then means that all of the power transistors can be switched off either individually or sequentially. Overvoltages, especially those that occur in short-circuit turnoff conditions, are reduced by the IGBT driver. To do so, the driver switches the power transistor smoothly. This is possible due to intelligent turn-off control. Furthermore, with the new graphic interface GUI (Generic User Interface) customers have the benefits of a userfriendly configuration platform that can run on Linux, Mac OS X or Windows systems. The digital driver SKYPER<sup>®</sup> 52 is RoHS compliant and suitable for 1200V and 1700V IGBT modules. It has two 9W output channels and a peak gate current of up to 50A, making it suitable for parallel connected IGBT modules with a total current of up to 9,000A. SKYPER<sup>®</sup> 52 is also suitable for high-frequency applications that require high driver output power and switching frequencies (up to 100 kHz).

The insulation voltage is 4 kVAC and the turn-off voltage -15V. The rugged LVDS-compatible and hence differential signal inputs and outputs correspond with the 3.3V and 5V I/O standards. The driver circuit can be directly connected to a micro-controller or DSP without level conversion.

www.semikron.com

PWM controller achieves up to 97% energy efficiency



control during start-up and shut-down and through transient conditions. Additionally, the UCC28230 provides stateof-the-art protection features, such as input under-voltage lockout, thermal shutdown protection and cycle-by-cycle over-current protection.

### DSC development kits jump-start digital power and embedded control applications

Making it easier to jump-start 32-bit based digital power and embedded control designs, Texas Instruments has launched five new experimenter and application-specific development kits for its TMS320F28x digital signal controllers (DSCs). The modular kits enable rapid prototyping of DSC based applications with interchangeable processor card modules, or controlCARDs<sup>™</sup>, Experimenter Kits with breadboard areas for full access to device signals, and application specific DC/DC and AC/DC Digital Power Developer's Kits. Each kit includes code examples and full hardware design details along with TI's Code Composer Studio <sup>™</sup> (CCStudio) 32 KB limited integrated development environment (IDE).

To accelerate development of software controlled digital power applications, the Digital Power Experimenter's Kit will be free to attendees of the oneday digital power workshops being held worldwide starting in June 2008.

For more information on the kits and workshops, see www.ti.com/f28xkits.

Workshops accelerate software controlled digital power applications

# Motion Control Evaluation Platform Speeds development of BLDC motor applications

Toshiba launched an evaluation platform that simplifies and speeds the development of brushless DC (BLDC) motor drives used in applications ranging from home appliances and pumps to industrial automation and automotive motion control.



The TB6582FG\_EVB3 brings together Toshiba's latest motor controller IC ASSP and the company's single-chip inverter drive technology to provide a complete sensorless sine wave motor control and driver solution on a single board. Engineers can quickly test and prototype sensorless motor drive applications with input main voltages of up to 220V(AC) by simply connecting power supplies for the circuitry and the target motor and providing a suitable speed control signal input.

www.powersystemsdesign.com

At the heart of the new platform is the Toshiba TB6582FG single-chip sensorless sine wave motor control ASSP. The TB6582FG takes analogue speed inputs from a host microcontroller and provides a complete full-wave sine wave PWM motor drive output without the need for additional processing. Using the evaluation platform, engineers can combine this IC with one of Toshiba's TPD412x single-chip inverters to provide a complete motor drive system with input main voltages to 220V(AC) and output currents from 1A to 3A. Control of motor rotation speed in both forward and reverse directions is then achieved simply by changing the PWM duty cycle based on the input from a host microcontroller.

The TB6582FG features integral circuitry that accurately calculates rotor speed and position using phase current information, eliminating the need for

# **Designers Utilize Digital Power**

With the imminent revolution into digital power, designers can no longer afford to ignore the true benefits available for their customer designs. Now there is no excuse for taking advantage of this technology: TI has developed training workshops to help the designer get up-to-speed. TI's extensive portfolio of solutions, optimized for applications ranging from point-of- load to high-power AC/DC and DC/AC conversion, enable designers to implement digitally controlled power designs with high system intelligence and functionality using high performance processors, optimized controllers and drivers, and easy-to-use, intuitive development environments.

### Intermediate bus PWM controller increases energy efficiency over entire load range

TI's new power supply controller for unregulated output voltages achieves up to 97 percent system efficiency in intermediate bus architecture to combine the highest energy savings, high powerdensity and low system costs in telecom and data communication systems with multiple downstream point-of-load conversions. The integrated UCC28230 PWM controller supports both halfbridge and full-bridge topologies and reduces overall size and the need for external components. Designers can set the operation to work in a fixed voltsecond or fixed frequency mode, which reduces the size of the transformer. The UCC28230 has a start-up frequency control feature that limits output inductor ripple current, allowing the use of a smaller, inexpensive inductor. The UCC28230 implements load-dependent dead-time control to improve efficiency over the entire output load range. It also has 1-D output that shorts the primaryside winding, which keeps the selfdriven synchronous rectifiers under



TI Accelerates Digital Power Design

The C2000 digital power workshops are a one-day hands-on session and serve as an introduction to the concept of software controlled digital power supply design and use the Digital Power Experimenter Kit for exploration of digital power concepts and techniques. Workshops will begin in June 2008 worldwide at a cost of \$229/ €229 including the kit or free if you have already purchased it. For more information on the digital power workshops, see www. ti.com/f28xworkshops.

www.ti.com

Hall sensors. A triangular wave generator with a carrier wave frequency of fosc/252Hz and an integrated dead time function are also incorporated into the device. In addition, a lead-angle adjustment capability allows applications to be tuned for optimum efficiency. Toshiba's new evaluation platform is fully compatible with the company's TPD4120 (2A), TPD4123 (1A) and TPD4125 (3A) single chip. 500V inverters. Housed in a DIP26 package, each of these chips combines high-and lowside drivers with six IGBTs to supply current to the motor stator coils. Additional integrated features include fast recovery bootstrap diodes and onboard protection against overtemperature, overcurrent and undervoltage conditions.

www.toshibacomponents.com

### Vacuumschmelze

I met with Helmut Dönges, Head of European Sales, Marketing and Communication for Vacuumschmelze, who presented the company's show portfolio.



VAC's new active current sensors are compensation current sensors with a patented magnetic probe as a zero field detector. VAC presented two new, ultra-compact series for rated current from 50 to 200 amp and peaks of up to + 390 amp. Designed for PCB mounting, sensor types available are for +5 volt or +12 to15 volt current output with current / voltage output. These new sensors feature ultra-high-precision measurement and minimized DC offset with ultra-low hysteresis, plus negligible levels of interference such as noise or periodic interference at the output. Temperature dependence, long-term drift of

the output variable and rise time are all extremely low, while the sensors offer a broad frequency range. VAC's compact new drive and trigger transformers provide isolation voltages of up to 10kV, fulfilling the most advanced requirements for clearance in air and creepage distance and also responding to the trend of increased lev-

els of reverse voltage for IGBTs (Insulated Gate Bipolar Transistors) and IGCTs (Integrated Gate Commutated Thyristors) and other modern semiconductors. Due to the use of innovative magnetic materials combined with intelligent "packaging", the transformers can be used in all applications where the magnetic or thermal properties of conventional materials would be inadequate.

The company has expanded its product ranges of nanocrystalline VIT-ROPERM tape-wound cores for EMC with both small epoxy-coated cores and large plastic-cased cores with outer diameters of 100-200 mm. The primary areas of application for tape-wound

cores are common-mode chokes in pulsed power supplies, UPS, frequency converters and welding devices. In the renewable energy sector, VAC cores are found in solar inverters and wind generators. In addition, VAC premiered its ready-assembled core stacks for EMI suppression which are easily and securely integrated into existing applications. The core stacks are available for two different diameters (approx. 75 mm and approx. 125 mm) for insertion of conductors.

The Permanent Magnet division presented VACCOAT 20011, a new adhesive coating which combines an array of functions. VACCOAT 20011 protects against corrosion and insulates, offering a high level of process security in segmented magnet production. Because corrosion protection is already effected by applying the spray coating, a complete work step can be omitted from the bonding process for segmented magnets, representing a significant cost saving.

www.vacuumschmelze.com

# VI Chip Launches New LED Constant Current Demo-board



Vel Chip, Inc., a subsidiary of Vicor Corporation, has announced a constant current (CC) PRM<sup>™</sup> regulator demonstration board for light emitting diode (LED) applications such as street & stadium lighting, high-end projectors, active outdoor advertising and architectural installations.

The board provides a precisely regulated current as required for direct-

drive multi-LED applications where the intensity and brightness are controlled by regulating the current through the LEDs. The board can be used to provide adjustable current up to 240W (5A at 48 V) when employed as an standalone non-isolated source or can be combined with the range of VTMTM transformers to provide an adjustable isolated current up to 100A.

A PRM+VTM pair uses less than 1W for every 1,000 Lumens generated by the LEDs for high performance applications. This solution is a perfect complement to using BCMTM bus converters with low voltage driver ICs for lower power applications such as LED TV backlighting.

The constant current board demonstrates the high power density of the

PRM with current accuracy of 99.7% across the load range. The board has Kelvin connections for measuring the efficiency of the V•I Chip<sup>™</sup> components independent of load connect losses. Oscilloscope probe jacks are available for measuring output voltage, including output voltage ripple. The board has fused PRM inputs, provision for mounting an optional V•I Chip pushpin heat sink, and system enable and disable.

www.vicoreurope.com

### Vincotech

### A new name with a long and successful tradition

Originating from the former Electronic Modules division of Tyco Electronics, Vincotech is now a stand-alone company focusing on industrial drives, solar power generation and telematics applications, headquartered in Munich Germany.

### flowPIM with IGBT4 technology

The flowPIM products 0, 1 and 2 in 1200V are equipped with IGBT4 for low saturation losses and improved EMC behaviour. All modules are based on low inductance layout, intuitive pinout and compact housing. The smallest PIM

### Sixpack Solutions for Motor Drives and UPS

Vincotech released new sixpack families for the motor drive and uninterruptable power supply markets. With this latest generation of modules in four different housings, Vincotech has completed its



flowPIM 0 3rd gen 600V/ 10-30A (IGBT3) 1200V/ 6-15A (IGBT4) 12 or 17x66x33mm

Module, the flowPIM 0 (P84X), is also available in 12mm height. The flowPIM 1 (P58X-A41), has extended output power by 10% due to an AIN DCB. The flowPIM 2 (P76X), a baseplate module, completes the PIM product spectrum with 100A at 1200V on a 108x47mm footprint.

flow0	flow1
P86x family	P82x family
A	A.S.
600V: 10A to 75A	600V: 50A to 100A
1200V: 10A to 35A	1200V: 35A to 75A
flow2	flow90
P68x family	P70x family
1	P

600V: 30A to 75A 1200V: 75A to 150A 1200V: 15A to 35A



flowPIM 1 3rd gen 600V/ 30-75A (IGBT3) 1200V/ 15-40A (IGBT4) 17x82x38mm

### sixpack spectrum from 10A to 150A.

Equipped with the latest IGBT technology for very low conduction losses, the four families cover every need in three phase motor drive and UPS inverting up to 30kW. High performance versions using an improved substrate are optional. These products are available in the flow0 and flow1 housings without baseplate for low/medium power, and in the flow2 housing with baseplate for higher power. The baseplate-less flow90 housing, especially designed for a 90° mounting angle between the heatsink and the PCB, rounds up the portfolio. Vincotech also offers the accompanying rectifiers (P64x, P59x, P60x and P70x families).

### Power Modules for Solar Inverters

Four new module families specially designed for solar inverter applications were on display. The modules, optimized for a powers ranging between 2kW and 6kW, satisfy the requirements of transformerbased (up to 400Vdc) and transformerless (400Vdc and 800Vdc) architectures.

600V: -

The chip technologies used are optimized for the individual requirements of each system. The two modules for transformer-based architectures enable the use of small transformers. A boost plus inverter circuit in one individual module covers transformer-less sys-



flowPIM 2 3rd gen 600V/ 50-100A (IGBT3 1200V/ 35-100A (IGBT4) 17x108x47mm

tems. NP architectures with the advantages of low leakage current, low switching losses and maximum power point optimisation between two input strings, are addressed by the symmetric boost and the NPC inverter modules.

All modules are housed in the compact flow0 package (66 x 33 x 17mm).



www.vincotech.com

# POWRPPARK Power Systems Design

### **Fairchild Semiconductor**



### **Enable Highly Efficient Two-Phase** Switched Reluctance Motors with Fairchild's SRM-SPM<sup>®</sup> Modules

The FCAS20DN60BB and FCAS30DN60BB integrate two HVICs, one LVIC, four NPT IGBTs, four fast recovery diodes (FRDs), two bootstrap diodes, a thermistor and various protection functions in a single package. By integrating 14 fully tested power components in a compact 45mm x 28mm SIP package, these products offer 40 percent space savings for two-phase

SRM motors in vacuum cleaners and other small motor applications. This space conservation allows vacuum cleaner designers to incorporate the controller into the SRM assembly, and also improves design productivity and manufacturability.

www.fairchildsemi.com/pf/FC/ FCAS20DN60BB.html www.fairchildsemi.com/pf/FC/ FCAS30DN60BB.html

### **Texas Instruments**



Texas Instruments offers a full line of high-performance products ranging from standard linear ICs to plug-in and integrated power solutions. And, TI makes designing easier with leading-edge support tools such as training, a broad selection of evaluation modules, application notes, data sheets and more. Visit www.ti.com/analogelab for complete

information on all TI's analog training opportunities. Free samples and small orders (shipped within 24 hours via TI authorized distributors) are available to help accelerate your time-to-market. Download your copy of TI's Power Management Selection Guide for a comprehensive review of TI's complete line of high-performance power products...

### **Linear Technology**



Linear Technology Corporation announces the LT3080, a 1.1A 3-terminal LDO that may be easily paralleled for heat spreading and is adjustable with a single resistor. This new architecture regulator uses a current reference to allow sharing between multiple regulators with a small length of PC trace as ballast, enabling multi-amp linear regulation in all surface-mount systems without heat sinks.

The LT3080 achieves high performance without any compromises. Featuring wide input

voltage capability from 1.2V to 40V, it has a low dropout voltage of only 300mV at full load. The output voltage is adjustable, spanning a wide range from 0V to 40V, and the on-chip trimmed reference achieves high accuracy of +-1%. The wide VIN & VOUT capability, tight line and load regulation, high ripple rejection, low external parts count and parallel capability make it ideal for modern multi-rail systems.

### www.linear.com

### **Magnetics**



Magnetics is pleased to announce the addition of **XF**LUX<sup>™</sup>, a distributed air gap 6.5% SiFe material, to our existing powder core line. A true high temperature material, with no thermal aging, XFLUX offers lower losses than powder iron cores and superior DC Bias performance. **XF**LUX cores are ideal for low and medium frequency chokes where inductance at peak is critical. One of the many challenges facing designers of high power circuits is maintaining

inductance in the power choke at maximum load. XFLUX is the cost-effective solution to getting enough inductance in a reasonable size package.

Seven toroid sizes (60 permeability) are currently available. Outside diameters range in size from 21mm to 47mm. New sizes and permeabilities will be added in the future.

www.mag-inc.com

### Microchip Technology



Microchip Offers Free Field Oriented Control Algorithm for New Low-Cost Motor Control **Digital Signal Controllers** 

Microchip announces 10 new 28- and 44-pin 16-bit Digital Signal Controllers (DSCs) for motor control designs requiring increased memory, performance, or enhanced peripherals, while obtaining cost and size savings by using lower pin-count devices. Additionally, Microchip

announced five motor control software solutions for: Power Factor Correction (PFC), sensorless Field Oriented Control (FOC) of a PMSM motor, sensorless FOC of an ACIM motor, sensorless control of a BLDC motor using Back EMF filtering and sensorless BLDC control with Back-EMF Filtering Using a Majority Function.

www.microchip.com/DSCMOTOR

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# **Green Investment Continues to Roll In**

With the huge inward investment in everything green, I have received the following reports, which underscore the importance of this fast growing industry. I believe this trend will continue with Venture Capitalists recognizing that this is not just another market spike, but a longer-term growth prospect.

Reported by Cliff Keys, Editor-in-Chief, PSDE

amSemi has announced an extension to its latest round of funding to bring the total sum raised to \$34 million (€22 million). BankInvest Group is taking an \$8 million (€5 million) equity stake in CamSemi through its New Energy Solutions VC fund and has become the second cleantech investor to back the company. Carbon Trust Investments also joined as CamSemi's first shareholder focused on clean energy technologies.

CamSemi develops sophisticated ICs that will allow manufacturers to introduce highly "cost-efficient" mainsconnected converters, battery chargers that are smaller, cheaper, and more power efficient than traditional wasteful solutions, now in full-scale production.

David Baillie, CEO at CamSemi was delighted with the investment round and said that it will allow the company to further strengthen its sales and support resources for the excellent products it has launched, as well as those still in the pipeline. See www.camsemi.com

Cissoid, a leader in high temperature semiconductor solutions and the pioneer of Silicon-on-Insulator (SOI) products, has also announced it has completed a

I DIDN'T HAVE ANY

ACCURATE NUMBERS

SO I JUST MADE UP

THIS ONE.

\$4.629.873



second round of investment with their initial investors. The main shareholders of Cissoid (VIVES, SRIW and SOITEC) confirmed their support to the growth strategy of the management by injecting additional capital into the company this month.

The company wants to diversify into a wider spectrum of high temperature applications. Cissoid leads in its traditional markets; Oil, Gas and Aerospace, and is demonstrating the high reliability of its products. Now, in other markets such as Automotive, Medical and Industrial applications, looking for reliable solutions above 150°C, Cissoid has viable solu-

THAT ACCURATE

NUMBERS AREN'T ANY

ONES YOU MAKE UP.

tions. They are discussing several partnership opportunities in these areas and with continued confidence from investors, Cissoid can look forward to a rapid growth phase. See www.cissoid.com

### Wake up call for UK renewable challenge

Shell has landed heavy blow on UK's renewable energy plans by its decision to pull out of the UK's flagship wind power project, making government renewable energy targets look increasingly unattainable.

Soaring costs, coupled with weak and inefficient government policies promoting renewable energy are slowing existing wind projects and making future investment in the sector less attractive, say industry experts.

The UK generates only 4% of its electricity from renewable sources, compared with 14% in Germany. Missing this target would also hinder the UK's CO<sub>2</sub> emissions-reduction goals, politically embarrassing for a government that regularly heralds climate change as the greatest threat the world faces.





### **Intersil Battery Authentication**



### Intersil's ISL9206 FlexiHash+™ Engine delivers high-security battery authentication at a low cost.

Intersil's ISL9206 is an easy-to-use, robust, and inexpensive battery authentication solution for 1-cell Li-Ion/Li-Polymer or 3-cell NiMH series battery packs.

### ISL9206 Key Features:

- Challenge/response-based authentication scheme using 32-bit challenge code and 8-bit authentication code.
- FlexiHash+ engine uses two sets of 32-bit secrets for authentication code generation.
- 16x8 one-time programmable ROM memory.
- Additional programmable memory for storage



64-bit Secret

32-bit Hash Function

32-bit Hash Function



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Control Register

32-bit

Patent pending FlexiHash+ engine consists of four separate programmable CRC calculators. Two sets of 32-bit secret codes are used for authentication code generation.

XSD single-wire host bus interface communicates with all 8250compatible UARTs or a single GPIO pin. Supports CRC on read data and transfer bit-rate up to 23Kbps.

16 bytes of one-time programmable ROM memory for storage of pack information and ID, device authentication secrets, device default settings, and factory-programmed trim parameters.





# Lower R<sub>DS(on)</sub> Higher Performance

Part Number	V <sub>DS</sub> (V)	l <sub>p</sub> (A)	R <sub>DS(on)</sub> Max V <sub>GS</sub> =10V (mΩ)	Qg (nC)	Package
IRF2804PBF	40	270	2.3	160	T0-220
IRF2804SPBF	40	270	2.0	160	D <sup>2</sup> -PAK
IRF2804S-7PPBF	40	320	1.6	170	D <sup>2</sup> -PAK -7
IRFB3306PBF	60	160	4.2	85	T0-220
IRFP3306PBF	60	160	4.2	85	T0-247
IRFB3206PBF	60	210	3.0	120	T0-220
IRFS3206PBF	60	210	3.0	120	D <sup>2</sup> -PAK
IRFP3206PBF	60	200	3.0	120	T0-247
IRFS3207ZPBF	75	170	4.1	120	D <sup>2</sup> -PAK
IRF2907ZS-7PPBF	75	180	3.8	170	D <sup>2</sup> -PAK -7
IRFB3077PBF	75	210	3.3	160	T0-220
IRFP3077PBF	75	200	3.3	160	T0-247
IRFS4310ZPBF	100	127	6.0	120	D²-PAK
IRFP4310ZPBF	100	134	6.0	120	T0-247
IRFB4110PBF	100	180	4.5	150	T0-220
IRFP4110PBF	100	180	4.5	150	T0-247

- Tailored for Synchronous Rectification
- Optimized for fast switching
- Up to 20% lower R<sub>DS(on)</sub>\*
- Up to 20% increase in power density\*
- RoHS Compliant
- Lead Free

\*Compared to previous generations

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