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Power Systems Design EUROPE

Power Control Intelligent Motion

October 2005

Modular Inverters for High Power

PowerLine

Power Player

Marketwatch

Industrial Electronics

ISSN : 1613-0391

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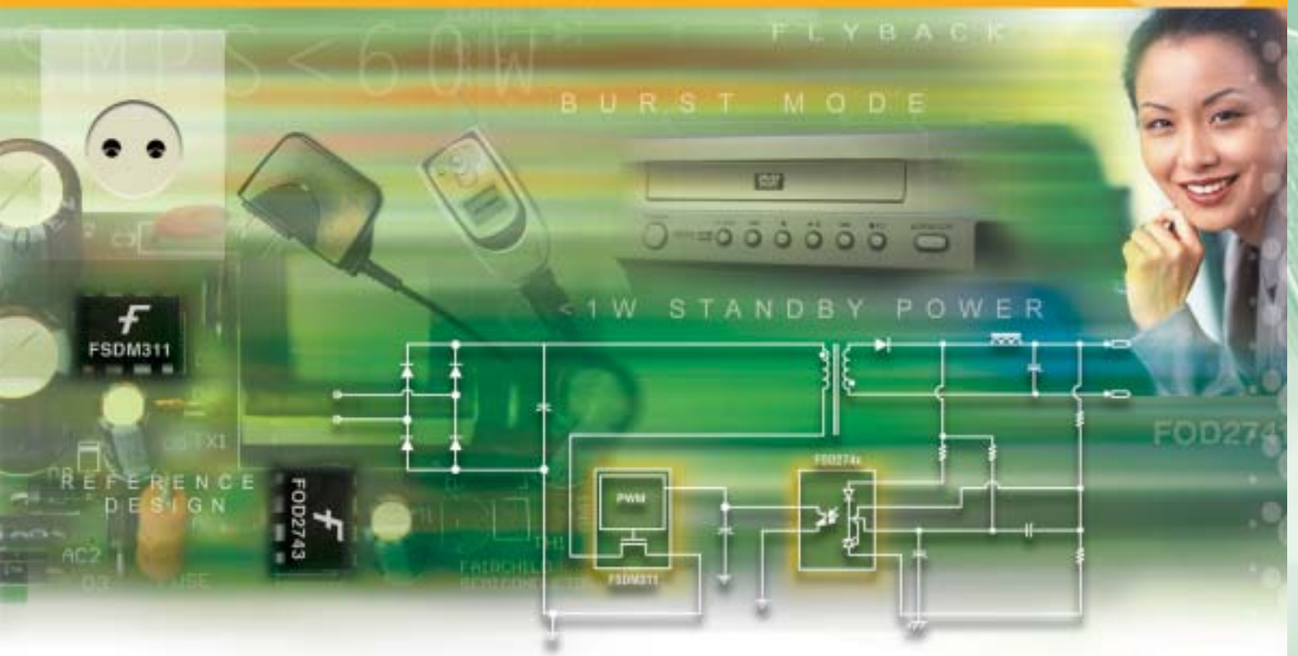
AC/DC SMPS. Optimized.



Optimize your 1W–250W AC/DC Switch Mode Power Supplies (SMPS).

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Simplify your designs.

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- Complete reference designs and online tools
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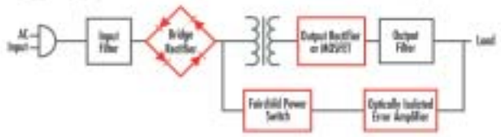

Our Green Fairchild Power Switches™ increase system efficiency and reduce standby power to <1W. Integrated functionality of Green FPS and optically isolated error amplifiers reduces design time.

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Volume 2, Issue 8

California Power Dream

Fall is good for Europeans to take off a few days and watch the Ocean in California. This time I watched the Pacific and learned more about the Power of Mother Nature.

Solar Farms and Wind Farms are an answer to generate green power and help to conserve our natural resources. Driving the pacific coast up to San Francisco you can see wind power at work with the many wind mills, too many to count.

The solar farm in the desert region is an other example of green power. The demand of power is the one side, the efficient generation and the minimizing of losses is on the other side, the challenge for the engineers.

The semiconductor technology makes it happen that solar cells have been developed and operate more and more efficient over time.

The MOSFET is the switch to handle the voltage and current levels for solar cells. Converters are needed to get the sinusoidal line voltage generated. Here is the IGBT ready to play its game at the mains.

The windmill generates sinusoidal current at higher voltage therefore the switches are IGBT modules to do the job. The driver IC technology is the complimentary part to have the devices optimized in their switching performance. All together it is power management that makes it the efficient solution for us.

In our October issue you will see Semikron telling us about IGBT modules and their applications. The industrial aspect of power semiconductors is a large market in Europe. IR tells us about motion applications. Fairchild and as well Infineon covers optimization of efficient fluorescent lamps. Not to underestimate today the simulation of thermal conditions as the die shrinks and but still carries the same current or more. All of it is important for industrial applications.

Mother nature has shown us our limits with hurricane Katrina, APEC 2006 has now moved from New Orleans to be in Dallas, Texas.

Looking forward to seeing you at the upcoming shows, SPS in Nuremberg, Productronica in Munich and APEC in Dallas.

Best regards,

Bodo Arlt
Editorial Director
The Power Systems Design Franchise

HTFS & HFIS LEM current transducers drive your low voltage applications

NEW LEM ASIC technology offers improved offset & gain drifts, along with linearity improvements

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LEM

C & D Technologies European Distribution Account Manager

C&D Technologies has further strengthened its distribution team with the appointment of Mark Hillier as distribution account manager for the company's Power Electronics Division.

Based at the Power Electronics Division's European headquarters in Milton Keynes in the UK, Mark will work within the EMEA (Europe, the Middle East, and Africa) group, where he will have responsibility for selected European distributors.

Mark brings a wealth of experience in the electronics industry to C&D Technologies, having previously worked in component sales for both IBM and NEC.

The Power Electronics Division of C&D Technologies, Inc. has its headquarters in Tucson, Arizona, USA, with manufacturing in USA, Mexico, UK and China plus sales locations in the USA, UK, France, Germany, China and Japan. The division designs, manufactures and distributes DC/DC converters, AC/DC power supplies and magnetics, and offers these products in custom, standard and modified-standard variations. These products, which are built to exacting requirements in ISO9000:2000-approved facilities, are typically used worldwide by Original Equipment Manufacturers (OEMs) within telecommunications, computing, industrial and other high-tech applications.

info@cdtechno-ncl.com

Sales Manager for Artesyn's Power Conversion

Artesyn Technologies announced the appointment of Robert Sobinger as EMEA Regional Sales Manager for the company's Power Conversion division. He will assume immediate responsibility for sales of all standard power conversion products in Central and Eastern Europe, the Middle East and Africa.

Mr. Sobinger has a solid background in electronics, including more than 13 years' experience of the power conversion industry. Immediately prior to joining Artesyn he was Director of Sales for the specialist German electronics distributor, Fortec Elektronik AG, whose key product lines include Astec ac-dc power supplies and dc-dc converters. Sobinger has also worked for Astec directly, holding various senior management positions in engineering and sales support during his 9-year tenure with the company.

"We are extremely pleased that Robert has joined our sales team", says Stephen Nolan, Artesyn's VP of Worldwide Sales for Standard Products. "His power background, combined with his customer and distributor knowledge, will prove to be key assets in helping us to grow market share, especially in central Europe. Robert is also renowned for his leadership qualities, and I know that our distributors will welcome having a strong champion to their cause."

www.artesyn.com

Analog Devices Celebrates 20th Anniversary

Analog Devices today celebrated the 20th anniversary of its office in Vienna, Austria, and of the successful operation in Eastern Europe and Russia that has been managed from this location.

Analog Devices' office in Vienna was opened in August 1985 by Walter Raiger, who continues today as the general director for Austria and Eastern Europe. In 1987, the Austrian team started working with customers in Hungary and the former Yugoslavia. Two years later, Analog Devices expanded its activities into Russia, and participated in its first electronics show in Moscow in September 1989. Since then, the company has steadily expanded its presence and grown its sales throughout the region.

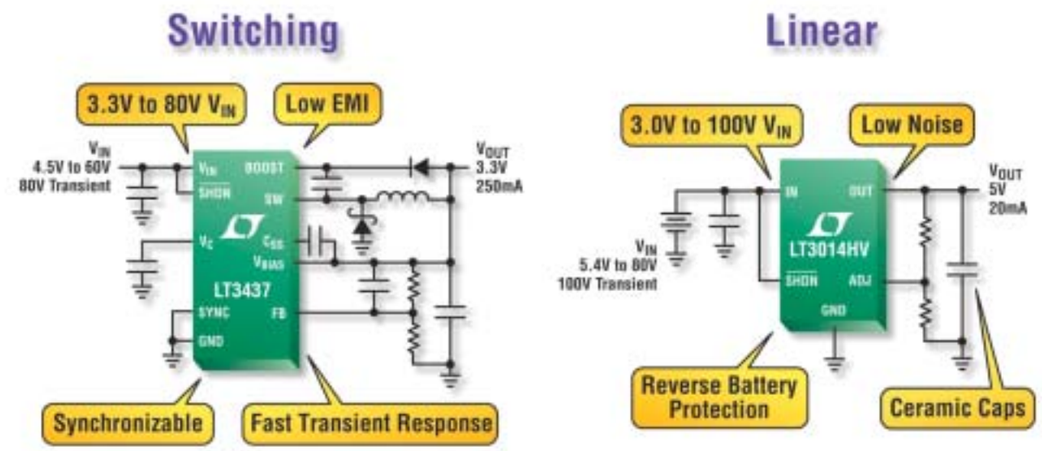
"Throughout the last two decades, ADI's successful strategy in Eastern Europe has been based around innovative customers, close links with local distributors, and a loyal and hard-working team," said Thomas Wessel, Managing Director for European Sales and Marketing, Analog Devices. "I congratulate Walter Raiger and his entire team on reaching this 20th anniversary milestone."

Today, the region spans 25 countries with direct sales and a strong presence of distributors.

The biggest industry sector for Analog Devices in Eastern Europe is industrial and instrumentation (I&I). I&I applications designed by Eastern European and Russia customers include power, heat- and flow-meters in addition to industrial controllers. The consumer and communications markets have also experienced considerable growth with a strong focus on the development of telephone exchange systems and the automotive segment is becoming increasingly important.

www.analog.com

60V to 100V$_{IN}$ Regulators– No Compromise



Rugged, Wide V_{IN} Range, Low I_Q & Low EMI

Linear's growing line of 60V to 100V input voltage capable regulators enables simpler DC/DC converter designs by eliminating the need for transient protection. The LT®3437 is a 500mA, 60V input capable monolithic step-down switching regulator in a tiny 3mm x 3mm DFN package. Its current mode topology provides fast transient response and excellent loop stability. The LT3014HV 20mA-rated linear regulator can take 100V input transients and has only 7µA of quiescent current, reverse battery protection and thermal shutdown. Our high voltage linear and switching regulators are well suited to telecom, automotive and industrial applications.

▼ High Voltage Regulators

Part Number	Device Architecture	V_{IN} Range	I_{SW} (A)	Frequency	I_Q	Package
LT3010	High Voltage LDO	3.0V to 80V	0.05†	N/A	30µA	MS8E
LT3014/HV	High Voltage LDO	3.0V to 80V/100V**	0.02†	N/A	7µA	DFN, ThinSOT™
LT3012/13	High Voltage LDO	4.0V to 80V	0.25†	N/A	55/65µA	DFN, TSSOP-16E
LT3433	Buck-Boost Regulator	4V to 60V	0.50	200kHz	100µA	TSSOP-16E
LT3437	Step-Down Regulator	3.3V to 60V/80V**	0.50	200kHz	100µA	DFN, TSSOP-16E
LT1976/77	Step-Down Regulator	3.3V to 60V	1.50	200/500kHz	100µA	TSSOP-16E
LT3434/35	Step-Down Regulator	3.3V to 60V	3.00	200/500kHz	100µA	TSSOP-16E
LT3800/LT3724	Step-Down Controller	4.0V to 60V	10.00*	200kHz	100µA	TSSOP-16E
LTC3703/-5	Synch. Step-Down Controller	4.1V to 100V	20.00*	600kHz	1.5mA	SSOP-16E

*Depends on MOSFET Selection, **Transient Capable, †I_{OUT} for LDO

▼ Info & Online Store

www.linear.com

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LINEAR TECHNOLOGY

Ericsson Signs Distribution Agreements

As part of its program to strengthen local support, gain a closer understanding of customers' culture and language, and as part of its ongoing strategy to achieve the highest levels of communication and service, Ericsson Power Modules has signed distribution agreements with European distributors Ultimate Renaissance and the French power expert BM Energie.

Under the agreements, Ultimate Renaissance will support Ericsson Power Modules' sales in Italy, France and Spain, serving global customers and expanding demand creation in many of the market segments addressed by EPM's products portfolio, while, by its specificity BM Energie will support industrial and computerized applications, without excluding demand creation in other business areas.

"By the nature of the industry in Southern Europe, and the extension of Ericsson Power Modules' portfolio to Intermediate Bus Architectures and its strong development of a broad range of POL (Point Of Load) products, both distributors will contribute to increase the level of support to all of Ericsson Power Modules' customers moving forward on the next generation of power management." Said Patrick Le Fèvre, Marketing Director at Ericsson Power modules. "It is exciting to be to moving forwards with Ultimate Renaissance and BM Energie and I feel very confident that our customers will appreciate their expertise and long term investment in the power industry."

www.ericsson.com/powermodules

Rutronik Announces New Franchising Partner

Rutronik has augmented its franchises in the electromechanics sector throughout Europe with leading manufacturers. The franchises will be expanded with Panasonic, Fujitsu and Comus to all Europe. In the batteries segment, Rutronik is cooperating with BMZ, one of the largest manufacturers of battery packs, also on a European level. The franchise for Panasonic batteries will be expanded from Germany to include Scandinavia, Benelux, Switzerland, Austria and Eastern Europe. The connector manufacturer FCI (until now only a partner in France) has expanded its franchise agreement with Rutronik to include Scandinavia and Eastern Europe. The long-standing successful cooperation with Molex in Germany and France was the decisive factor for expanding the franchise area to include Austria and Eastern Europe. Further connector manufacturers, such as ITW Pancon, expand the connector portfolio across Europe. For Odu, Rutronik will be operating with immediate effect in Scandinavia. The switches segment has been expanded with the European franchise for Diptronic products. For Rutronik, this step means a further expansion in the electromechanical business sector and a virtually pan-European harmonisation of its product portfolio for connectors, relays, batteries, fuses and switches. With this franchise situation Rutronik is becoming a leader for electromechanical products in Europe. The focus will mainly be on the automotive, mechanical engineering, medical technology and consumer electronics market segments.

www.rutronik.com

Micrel Announces Sub-Micron 0.35 Capability

Micrel announced it has achieved a major milestone towards implementing sub-micron 0.35 technology processing in its world class fab facility located in San Jose California. With the purchase of specialized equipment, Micrel's fab can now run more advanced sub-micron 0.35 CMOS processes. The new tool enables the fab to run sub-micron 0.35 technology in full production mode. This milestone effectively takes the fab technology from 0.5 to sub-micron 0.35 capability.

"We are excited about this new equipment, not just for its sub-micron 0.35 capability, but also because of the increased demand we are seeing from customers for our sub-micron 0.5 production," noted Guy Gandenberger, vice president of wafer fab and foundry operations, Micrel. "Not only were we able to secure this sophisticated piece of equipment at a significantly reduced cost, but we will also add much needed capacity at the sub-micron 0.5 level, to insure that we continue to meet world class standards for customer service."

Micrel's San Jose California-based wafer fabrication facility has been certified to ISO14001:1996, the International Environmental Management System Standard. The Company continues to focus on continuously improving its quality, safety and environmental practices and, to that end, was recently able to significantly reduce water and energy consumption, saving significant operating funds while continuing to preserve the environment. To ensure compliance with the European directive on the restriction of use of hazardous substances (ROHS) and other similar regulations, the vast majority of Micrel products may now be ordered in lead-free versions.

www.micrel.com

Power Events

- ***SPS/IPC/DRIVES,*** *Nov. 22 - 24, Nuremberg, www.mesago.de/sps*
- ***PRODUCTRONICA,*** *Nov.15 - 18, Munich www.productronica.com*
- ***New location and date to note!***
  APEC 2006, *March, 19-23, Dallas TX, www.apec-conf.org*
- ***PCIM China 2006,*** *Mar. 21 - 23, Shanghai www.pcimchina.com*
- ***PCIM Europe 2006,*** *May 30 - June 1, Nuremberg, www.pcim.de*

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POWER INTEGRATIONS®

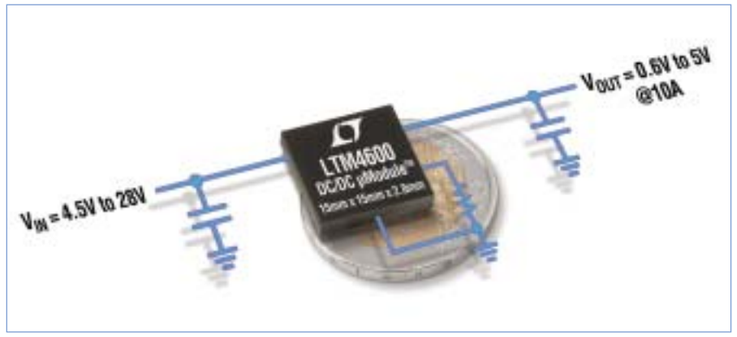
INNOVATION IN POWER CONVERSION™

10A DC/DC uModule™ Provides New Level of Power Density in a Compact Package

First in a New Line of Module Products

A new uModule™ (micro-module) from Linear Technology Corporation provides designers a complete 10A switching power supply in a tiny (15mm x 15mm) footprint, low profile (2.8mm) land grid array (LGA) package. The LTM®4600 is a synchronous switchmode DC/DC step-down regulator with built-in inductor, supporting power components and compensation circuitry. The LTM4600 is the first in a new family of uModules from Linear Technology that leverages the company's core strengths in power management and conversion. By simplifying power system development, this new high-density power supply reduces development time for a broad range of systems, including network routers, blade servers, cellular basestations, medical diagnostic equipment, test instrumentation and RAID systems.

The LTM4600 accommodates a wide input voltage range of 4.5V to 28V. The high level of integration and synchronous current mode operation allows the LTM4600 to deliver superior transient response and up to 10A continuous current (14A peak) at up to 92% efficiency. It simplifies power supply design and construction, requiring only input and output bulk capacitors and a single resistor to set the output voltage within a range of 0.6V to 5V. Containing all Linear Technology silicon and supported by Linear Technology's rigorous in-house testing and high reliability processes, the LTM4600 brings component-level reliability and industry-leading performance to demanding applications.



The LTM4600 DC/DC uModule is a complete stand-alone surface-mount power supply that can be handled and assembled like a standard integrated circuit. Moreover, its low profile design permits the LTM4600 to be soldered onto the back side of a circuit board, freeing up valuable board space.

The LTM4600 DC/DC uModules are self-protected against overvoltage and short circuit conditions. The devices' fast transient response minimizes required bulk output capacitance. Furthermore, two LTM4600s can be operated in parallel, increasing load current capability to 20A. The LTM4600 is offered in two versions: standard and high input voltage. The LTM4600EV operates from 4.5V to 20V, whereas the LTM4600HVEV has an operating voltage range from 4.5V to 28V.

Pricing for the LTM4600EV starts at $16.50 each and the LTM4600HVEV starts at $19.50 each in 1,000-piece quantities. The LTM4600IV and LTM4600HVIV, which are tested and guaranteed to operate over the -40°C to 85°C temperature range, are also available. The device is currently sampling and the company is accepting volume orders this quarter.

Summary of Features: LTM4600

- A Complete Switchmode Power Supply with Integrated Inductor & Power Components
- 10A Continuous, 14A Peak Output Current
- 15mm x 15mm x 2.8mm Land Grid Array (LGA) Package
- Wide Input Voltage Range of 4.5V to 20V (up to 28V for HV version)
- Output Voltages down to 0.6V
- Pb-free and RoHS compliant
- Current Mode Control
- Fast Transient Response
- Synchronous Rectification for up to 92% Efficiency
- Short Circuit and Overvoltage Protected

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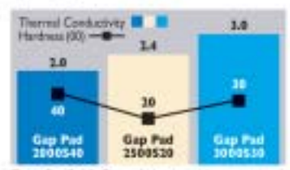

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Power Player

The Role of Power Semiconductors

By Arunjai Mittal, VP & GM, Power Management & Drives business unit Infineon

Doing more with less - a green paper on energy efficiency issued by the Directorate-General for Energy & Transport of the EU commission, states that in 2005 the world will consume approximately 1,725 Mtoe (Megatons of oil equivalent). According to experts, oil reserves are only enough to cover today's needs for about 40 years! Combined with the increasing demand in particular from China and India to power growth and to improve the standard of living for their citizens, there is an energy crisis looming over our heads. In 2002, buildings (residential & tertiary) consumed about 40% of the energy with industry and transport accounting for the remaining 60% (approx. 30% each). Electricity constituted about 20% of the energy demand.

Here comes the role of power electronics and in particular, power semiconductors in play. Be it the use of state-of-the-art LTT (Light Triggered Thyristor) in power generation/distribution systems, super-junction MOSFETs in consumer and computing electronics, or Silicon Carbide Schottky's in power conversion systems based on renewable energy sources (solar converters); Infineon together with it's customers are one-step ahead !

Electricity used in stand-by mode can reach between 5% to 10% of total energy consumption in the residential sector. CoolSET F3 devices incorporating CoolMOS can help reduce this. Thermal efficiency can also be increased by use of induction cooking methodology as compared to electric stoves or gas ovens – even cooking in a much faster and efficient manner, using inverter based technology. Reverse-Conducting IGBTs (Insulated Gate Bipolar Transistor) are specially optimized to suite this application. Recently it was demonstrated that using thinQ diodes (SiC based)

in combination with CoolMOS CS series, up to 99% efficiency could be reached in the PFC stage for a 1,500W power supply. As standard semiconductor fabrication techniques can be utilized in the manufacture of the above technologies, outstanding performance-cost trade-offs can be achieved.

An energy-saving bulb uses five times less power than a standard one. Estimates show that replacing bulbs can save up to _100 annually for a household. Digital control of power conversion is the next step. By implementing asymmetric regulation loops, highly effective and faster transient responses can be achieved and capacitors in the output filter saved. One such example is the use of lamp ballast controller ICB1FL01G.

Pumps, fans and compressors are traditionally controlled by valves while the motor is constantly running at rated speed, resulting in high power losses. Or they are using smaller, inefficient engines operated intermittently like in refrigerators or other small HVAC's. It is estimated that about 15 large electricity power stations are needed to fuel all the fridges of Europe. With installation of VSD (variable speed drives) a great amount of energy can be saved. Use of new trench-based field-stop IGBT3 in combination with EmCON (emitter-controlled) diodes enhances that further. Conduction and switching losses constitute for most of the losses occurring within these power semiconductors. Reduction in chip thickness especially for power switches (diodes & transistors) enhances the electrical and thermal performance of these devices further, resulting in compact systems at reduced system costs.

90% of energy used in 2002 by the transport sector in EU came from oil. Increasing oil prices combined with environmental concerns necessitate the move towards Hybrid Electric Vehicles (HEV). Once again, to have the highest possible efficiency, use of highly optimized IGBTs in combination with low-loss diodes (SiC based potentially) is a possibility. HEVs are gaining share and estimations are that in the next 5 to10 years a significant portion of the new cars manufactured will be HEVs.

In 2001, California faced a major energy crisis. To address this crisis, it launched a public information campaign and reduced energy use by more than 6%. With additional policies, it is expected that in the residential sector (EU-15) we could not only limit, but actually even consume less in 2010 (333TWh/y), than what we did in 2003 (378 TWh/y).

We congratulate and thank our customers for having taken together with us the first steps, towards making use of energy in a more efficient manner. This is clearly evident not only by the increase in market share of Infineon but also maintaining the number-1 position in field of Power Semiconductors in 2004, as reported by IMS.

www.infineon.com

European and Japanese Power Semis Face Currency Challenges

But can market share losses be entirely attributed to exchange rates?

By Chris Ambarian, Senior Analyst, iSuppli Corporation

The last few years have been great for power-management semiconductor suppliers—but only for those based in North America. For European and Japanese makers of ICs and discrete components that are used for the conversion and management of power, recent years have brought a rapid decline in market share relative to their North-American competitors.

During the period from 2003 to 2005, North American-based power-management semiconductor suppliers are expected to gain 6 percentage points of market share compared to companies headquartered in other regions. This will give the North-American suppliers a 49 percent share of worldwide market revenue by the end of this year, iSuppli Corp. predicts. In contrast, Japanese suppliers during the same period will have lost between 4 and 5 percentage points of share, and European suppliers will cede 1 to 2 points.

Figure 1 presents market share for power-management semiconductor suppliers based in different regions of the world, using U.S. dollars as a baseline.

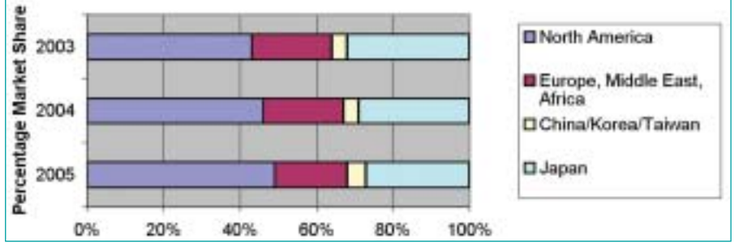
One of the major factors behind the regional market-share realignment is a dramatic swing in currency exchange rates for the U.S. dollar, the European euro and the Japanese yen.

As presented in Figure 2, the yen during the last 11 quarters has gained in value compared to the dollar, peaking with a 12 percent surge in the first quarter of this year. Although the rise began to reverse itself in the second and third quarters, the yen remained nearly 6 percent higher than it was in first quarter of 2003. All other factors being equal, a stronger yen means that a price charged by a Japanese supplier in yen is not as competitive as a price charged by a U.S. supplier in dollars.

Even worse, the Euro gained a whopping 18.2 percent in value versus the dollar up until the first quarter of 2005, before retreating to a degree during the second and third quarters. However, the euro remains nearly 12 percent higher compared to the dollar than it was in the first quarter of 2003.

Such dramatic swings in exchange rates can have an effect on global businesses, and certainly large fluctuations such as these can be expected to have an impact. To make matters worse for the European and Japanese suppliers, iSuppli measures market share on a U.S. dollar basis.

Figure 1: Power-Management Semiconductor Market Share by Region of Company headquarters, 2003-2005 (Percentage Share of Revenue in U.S. Dollars)



Source: iSuppli Corp. Power Management Service October 2005

Figure 2: Exchange Rates for the Japanese Yen and European Euro Compared to the U.S. Dollar, Q1 2003 to Q3 2005

Source: World Semiconductor Trade Statistics

If the shift in currency is accounted for, and we measure based on some compromise value, we can see that the North American suppliers effectively gained even more than the 6 percentage points mentioned earlier—probably closer to 8 points. In an industry that normally sees regional market-share fluctuations measured in tenths of a percentage point, these shifts come as a real shock to the system.

If the whole of the power-management semiconductor market consisted of commodity parts, then these shifts could be attributable largely to exchange rate movements. In a typical power application, pennies count—so even small shifts in currency value can make a big difference. Thus, if power-management were completely a commodity market, a European or Japanese supplier might reasonably anticipate that its share of sales will be restored once it attains a more favorable exchange rate.

However, nearly half of the power-management semiconductor market consists of non-commodity products. This raises a question: Is the recent shift in market share purely a result of exchange-rate fluctuations—or is some other factor also at play here?

This analyst believes that there are other issues involved that are related to competitiveness—issues that will persist even if exchange rates return to previous levels. It would behoove the management teams of European and Japanese power-management semiconductor suppliers to take a serious look at their competitiveness, beyond cost and exchange rates.

Both the European and Japanese suppliers have excellent base technologies from which to work. However, it appears that what North American suppliers are doing well at the moment—or perhaps what they are doing a higher percentage of the time—is applying new technologies cost-effectively in end products.

Of course, there are success stories in all three regions, so there are exceptions to this observation. But on balance, it appears that a disproportionate amount of innovation—not to mention loud marketing—is being generated by the North American suppliers, and the market share numbers are telling the story.

Hopefully, the response from Europe and Japan will be renewed vigor, innovative ideas and greater value delivered to the power-management semiconductor customer. The customer almost always benefits from healthy competition and a balanced supply base.

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Modular Inverters for High Power Applications

High power configurations to offer ratings from 320 to 1550A

Modular power systems must offer user benefits in terms of shorter lead times and lower costs. The modular SEMIKUB B6CI is a compact, easy to maintain and flexible system for forced air-cooled inverters from 300A up to 1550A.

By Paul Newman, Managing Director Semikron United Kingdom

Built around the latest IGBT technology for industrial modules by Semikron, this inverter/converter platform is also the result of 45 years of experience which Semikron has in the power stack business. A global network of solution centres provides worldwide support for local service with development and production capabilities as close as possible to the customers' market.

Designers of many high-power systems, particularly in developing market sectors such as distributed power generation, often act as systems integrators and in some cases may not have interest in the detailed knowledge of power electronics. The speed of development of silicon makes it necessary to adapt all interfacing components, such as heatsinks, drivers, capacitors, snubbers and busbars. These designers need reliable system building blocks to serve their power needs, but they also need versatile solutions, which can best be provided by a modular approach. Modular power systems can also offer user benefits in terms of shorter lead times and lower costs.

Figure 1. SEMIKUBE range.

SEMIKUBE Size	1	2V	2H	3V	3H
No. of blower fans	1	1	2	1	3
Airflow (m^3/hr)	1000	800	2000	500	3000
Maximum current (A) cont.	390A	665A	765A	1050A	1550A
Variable torque current rating A (110% overload 60sec)	385A	655A	760A	1040A	1504A
Variable torque motor rating (110% overload 60sec) kW / HP	220kW / 300HP	375kW / 500HP	400kW / 650HP	560kW / 900HP	850kW / 1350HP
Constant torque current rating A (150% overload 60sec)	305A	525A	600A	850A	1200A
Constant torque motor rating (150% overload 60 sec) kW / HP	160kW / 250HP	300kW / 450HP	355kW / 550HP	500kW / 750HP	710kW / 1100HP
All values calculated under following conditions: Vac = 400V/50HZ, 460V/60HZ, Vdc = 650Vmax, fsw = 3kHZ, Tamb.= 40°C, Cose 0.85					

Figure 2. Model ratings of the SEMIKUBE range.

Designers of many high-power systems, particularly in developing market sectors such as distributed power generation, often act as systems integrators and in some cases may not have interest in the detailed knowledge of power electronics. The speed of development of silicon makes it necessary to adapt all interfacing components, such as heatsinks, drivers, capacitors, snubbers and busbars. These designers need reliable system building blocks to serve their power needs, but they also need versatile solutions, which can best be provided by a modular approach. Modular power systems can also offer user benefits in terms of shorter lead times and lower costs.

Semikron has used modular techniques to develop SEMIKUBE – an inverter/converter platform for applications up to 900kW with forced-air cooling. The modular approach reduces the design time and simplifies on-site installation. It also reduces the space required for spares storage, because a small number of standard parts can be kept in stock and used in various configurations as required. The new platform can accommodate cubes in compact or high-power configurations to offer ratings from 320 to 1550A. In the high-power configuration, a system fan is attached to each module, thus eliminating "thermal stacking" effects by providing a flow of ambient-temperature air to each module in the system. This approach offers a power/volume ratio previously only available from water-cooled systems.

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Device	V_{IN} (V)	I_{OUT}	V_{OUT} (V)
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PTN78060W/H	7 to 36	3A	2.5 to 12.6/12 to 22
PTN78020W/H	7 to 36	6A	2.5 to 12.6/12 to 22
PTN78000A	7 to 29	1.5A	–3 to –15
PTN78060A	9 to 29	3A	–3 to –15
PTN78020A	9 to 29	6A	–3 to –15

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Figure 3. SKYPER 32 PRO core driver is incorporated into each cube.

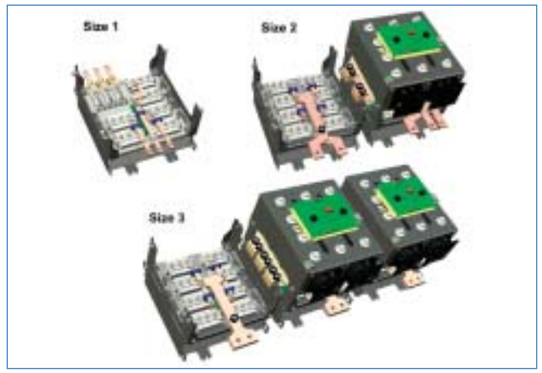

Figure 4. An inside view of SEMIKUBE 1,2 und 3.

A SEMIKUBE usually comprises one, two or three cubes, each of which contains two, three or four blocks. Each block can contain diodes, thyristors or two half-bridge IGBT modules mounted on a high-performance, purpose-designed heatsink. A cube also incorporates its own bank of capacitors, which is separately fan-cooled to reduce size and maximise reliability. By using different component blocks, a range of current ratings can be offered.

A purpose-designed, optimised driver, based on Semikron's SKYPER 32 PRO core driver, is incorporated into each cube. All functions and protection of SKYPER 32 PRO such as soft turn-off and external error input are maintained. The driver for each cube operates independently, but has a common user interface, which is accessible from the outside of the SEMIKUBE unit. Each driver is controlled by the user's application controller and provides all necessary protection and monitoring features, including galvanic isolation, a safe extra low voltage (SELV) interface, temperature monitoring, short-circuit protection, current and DC voltage scaling and

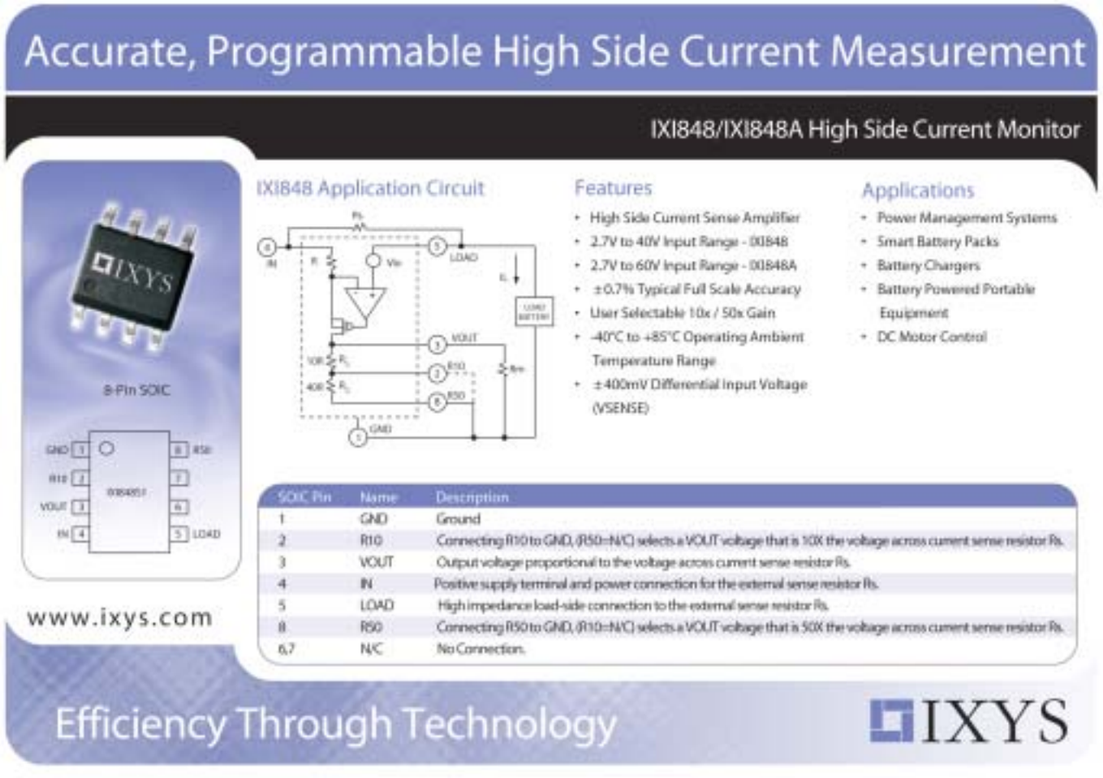

Figure 5. Horizontal arrangement of SEMIKUBE.

current balancing. In addition, for maintenance purpose, a set of LEDs has been added to detail the last fault detected by the driver. This is certainly helpful for the diagnosis and explanation of unattended shut down of the inverter.

Each block incorporates a high-speed, hall-effect current sensor. The monitoring of current balance between the modules is achieved by multiple current sensors whose signals are individually measured and compared. Any over-current or current imbalance would lead to the driver interrupting IGBT gate drive signals thus providing enhanced protection for the system. This principle offers triple protection against over currents:

- fast short-circuit via VceSat monitoring
- slow short circuit via current monitoring
- internal short circuit via current imbalance monitoring

Such a high level of protection guarantees a safe and reliable operation.

Blocks are interconnected by a modular, co-planar busbar system. This interconnection block achieves, in a couple of turns of a screw, a reliable and low inductive connection between the various DC blocks. SEMIKUBE™'s power connection system (patent applied for) is very easy to dismount and routes DC polarities together to reduce inductance and, therefore, oscillating currents. This results in improving the lifetime of the capacitors. In addition, the electrical connection is achieved by a system of spring bands to compensate the effects of thermal expansion, which guarantees a constant and long lasting connection. This configuration offers rapid and versatile assembly. The connection can be made from any side of each block, therefore many mechanical and electrical configurations are possible to suit almost any possible requirement in the stated power range.

The higher power ranges of the SEMIKUBE system requires up to 8 individual half-bridge IGBT modules to be connected in parallel. Paralleling without de-rating is a must for efficient design; therefore novel DC and AC connecting busbars have been developed. The AC busbar utilises electrically symmetrical, tin plated copper designs.

These busbars are designed such that they have the same resistance and inductance between the load's connection and each module's AC terminal. The DC connecting busbars have again been designed for low inductance and allow interconnection between DC terminals for each and every variant in the SEMIKUBE range.

A single cube can be used in a standalone application rated between 320 and 390 A, including the rectifier and the inverter. If more power is required, two cubes can be connected in two different layouts: one that uses a single system fan to save space or one that uses two system fans to maximise current handling. Ratings for these configurations range from 520 to 770A. Similarly, three cubes can be arranged in either of these formations, with one or three system fans, to offer current ratings from 830 to 1550A. Another arrangement is also possible, featuring three inverter cubes, plus a fourth cube containing a rectifier and additional capacitance. This configuration uses two system fans, providing the best of all worlds in terms of size and current handling. In fact, the system platform can accommodate any number of cubes, offering a very high degree of versatility, scalability and configurability.

Figure 6. SEMIKUBE Size 1.

The SEMIKUBE system allows very compact inverters, converters and other topologies to be constructed. The cubes themselves are small and, in addition, clever design of the interconnect busbars allows three cubes to be mounted very close to each other. Off-the-shelf cubes and off-the-shelf platforms allow rapid assembly of a very wide range of solutions.

The SEMIKUBE design, with its high standardisation of parts allows for easy adaptation to many different topologies. Even though some standard configurations are proposed, there are no limits to the combination of possible arrangements. Four quadrant inverters, single phase inverters, diode rectifiers with brake choppers, polypropylene or electrolytic capacitors, all of these variants can be included in the design to give the most optimized solution.

In the standard, converter/inverter SEMIKUBE, the following component parts are employed:

The rectifier section can be configured with the following topologies; uncontrolled (B6U), half-controlled (B6HK) and controlled (B6C). The semiconductor devices used are the latest IGBT generation of

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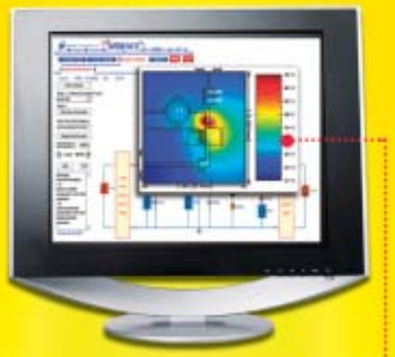

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SEMIPACK® 1600V isolated (3kVac) modules, incorporating the proven ruggedness and thermally efficient copper base plate technology. In addition to trigger modules, RC snubbers are standard and line fuses optional. The input voltage should be in the range 380 to 500Vac (-15%/+10%), 45 to 66Hz. The maximum rectified DC voltage is 707V.

The DC link capacitors fitted as standard, are long-life, electrolytic, screw terminal types. The types selected have been chosen for cost-effectiveness, without compromising performance and longevity. The sizing of the capacitors is decided by the nominal current of the inverter and will have an operating life time expectancy (LOP) > 60kHrs. The DC working voltage is carefully chosen to allow for sudden IGBT switch off which would result in a significant rise in DC link voltage. The capacitor bank is housed in the top half of a very robust frame for easy handling and mechanical protection. The top half of this frame, containing the capacitor bank is seated into its corresponding lower half of the SEMIKUBE frame, which has slotted fixing points. This allows, where volumes make it a cost-effective option, the top half to be lifted to accommodate larger capacitors without changing any other aspects of the mechanical design. The lower half of the SEMIKUBE frame is fixed firmly to the heatsink.

The heatsink used in all SEMIKUBE designs are highly efficient types but present a relatively high air pressure drop. Consequently, a high pressure centrifugal type fan is employed. The fan is a 230V, 50/60Hz type with noise levels that do not exceed 72dBA. Thermoswitch protection is incorporated and the fans have zero maintenance, long life bearings. Centrifugal fans may also be fitted to the capacitor bank frame as an option.

The inverter topology is a standard three phase (B6CI) and uses the latest 1200V soft punch through (SPT) silicon in the proven, cost effective SEMITRANS dual (half bridge) IGBT modules. SPT silicon offers efficient operation across a wide range of switching frequencies (up to 20kHz) with typical combined switching losses around 21mJ (@125°C, per 100A). The conduction losses are also low, being typically 2.0V @ 25°C. The standard inverter is optimised for a switching frequency of 3kHz, giving a system efficiency (conduction losses + switching losses + fan losses) of around 98%. The gate charge required for these IGBT modules is typically 1uC (VGE -8/+15V 100A) which is easily accommodated by the new SKYPER 32 gate drivers employed.

By using common diode, thyristor or IGBT modules, capacitors, heatsinks, fans, bus-busbars and current sensors across the range, Semikron can offer short lead times and easy maintenance with a reduced reference list of spares. All component parts of the SEMIKUBE system are fully qualified in areas such as temperature, humidity, EMC and safety. SEMIKUBE has been designed with the RoHS directive in mind.

SEMIKUBE has been developed for medium-sized customers for whom the benefits of an off-the-shelf, fully expandable, completely tested and characterised product is very attractive. In markets such as motor drives, solar inverters, wind-related power generation, uninterruptible power supplies and fuel cells, these new units offer designers the widest range of off-the-shelf power blocks in the industry. Because the component blocks can be manufactured in high volumes to meet many different medium-volume applications, prices are very competitive. Users will have the benefit of a single user interface across the range, the only difference for different power levels will be the number of boxes.

Semikron International Solutions Centres are located in Australia, Brazil, France, India, Korea, Slovenia, South Africa, the United Kingdom and the USA. The network designs, develops and manufactures custom power assemblies for a wide range of markets.

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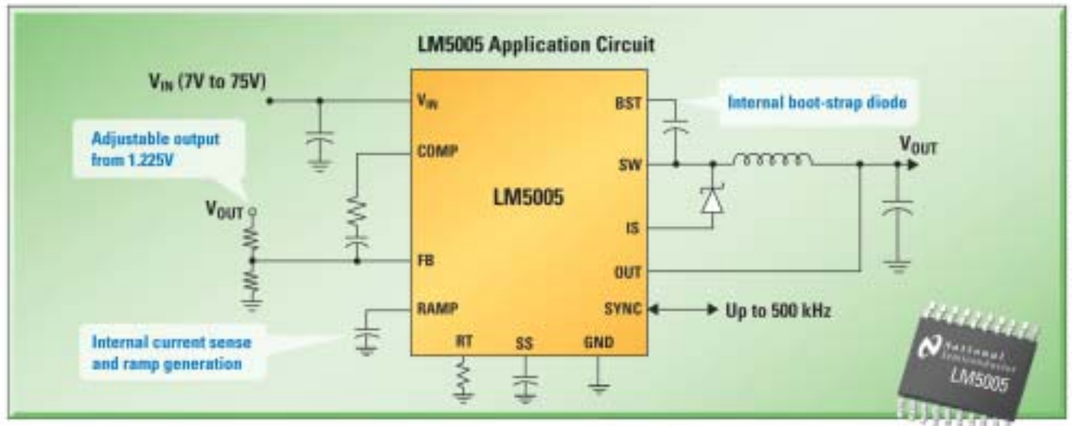

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LM5008	9V to 100V input, 350 mA step-down	Up to 800 kHz	✔	—	✔	MSOP-8, LLP-8
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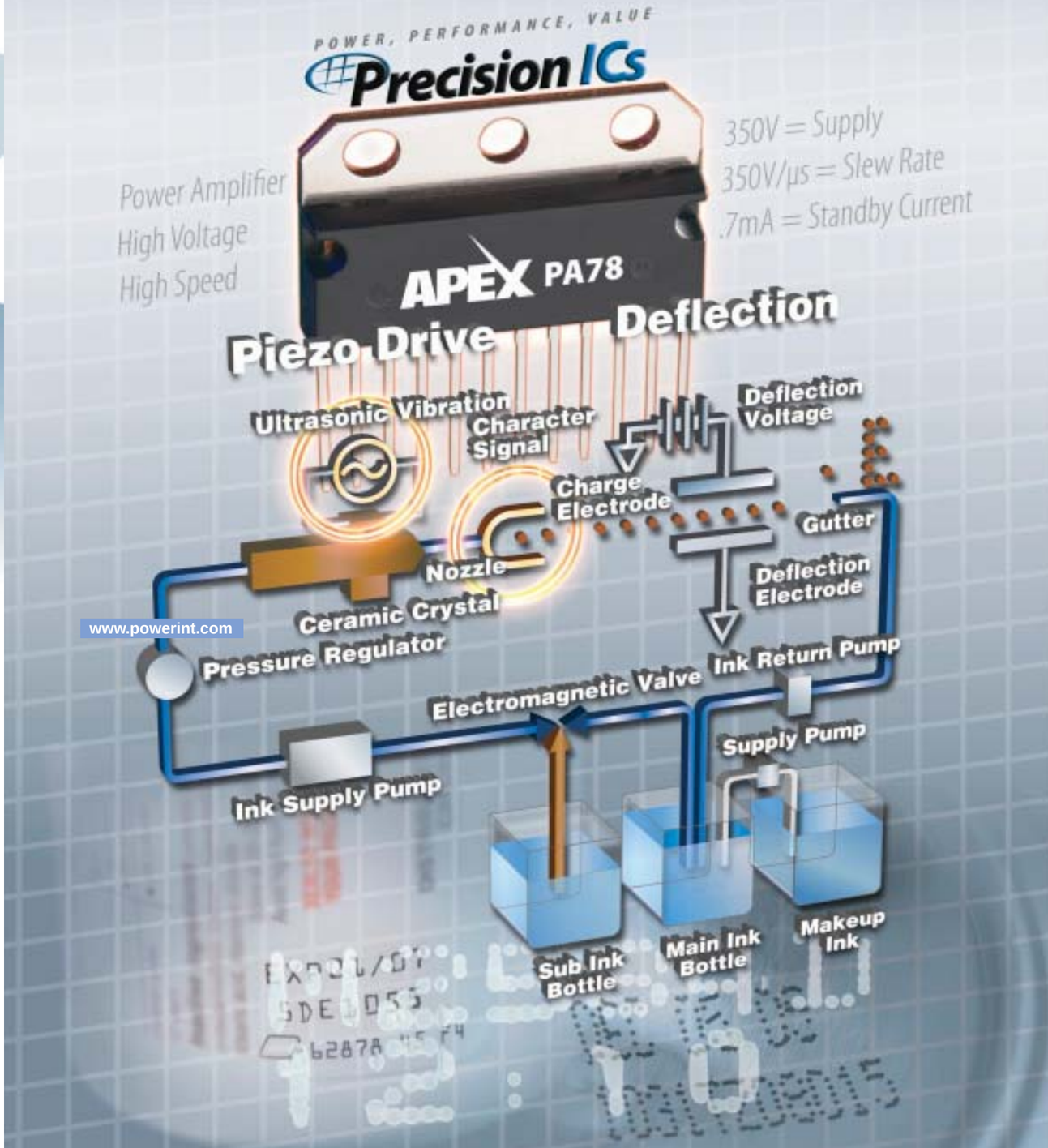

Amplifier ICs Driving Piezo Electric Devices

Industrial and medical are the applications

Piezoelectric actuators require high voltage drivers delivering hundred of volts, peak-to-peak, and since a typical actuator looks like virtually a pure capacitance to the driving amplifier, almost all the power dissipation becomes the burden of the driving amplifier.

By Sam Robinson, Senior Applications Engineer, Apex Microtechnology Corporation

Across the industrial and medical markets, piezo electric devices are gaining great favor with design engineers when their applications require the generation of very fine movement. The unique electro-mechanical properties of piezo ceramic materials are prized for their ability to perform the finest of tasks with precise accuracy while exhibiting virtually no degradation to the piezo device, thus reducing long-term operating costs within the system's they reside.

Beginning in the late 1980s, piezo elements made an entrance into more mainstream end products such as surgical tools and ultrasonic cleaning for one very good reason: Piezoelectric actuators are the fastest-responding positioning element available with microsecond-time constants. Also, they can produce motions in sub-nanometer increments. The development of more economically priced piezo elements is the driving force behind the dramatic widening of their popularity with designers.

Equally dramatic is the recent emergence of equally price competitive high voltage power amplifier ICs necessary for driving the elements.

Piezoelectric actuators require high-voltage drivers delivering hundred of volts, peak-to-peak, and since a typical actuator looks like virtually a pure capacitance to the driving amplifier, almost all the power dissipation becomes the burden of the driving amplifier. Until now, if a HV solution was found, then speed and quiescent current were issues. Slew rates of at least 300V/µs are a must to even be considered in the running. A quick look through the abundance of high-voltage, high-speed, small-signal operational amplifier ICs would disclose many amplifiers with bandwidths in the hundreds of megahertz. However, if you need to combine that speed with more than 12V, as you do if you are planning to drive a high-speed piezoelectric device; your choices of suitable amplifiers shrink pretty fast.

Compounding this sourcing challenge has been the very limited number of fabs with high voltage and high speed processes. Finding a power amplifier capable of operation at 100+ volts, with an IC form factor and an IC price, has been tough. Hybrid amplifiers have

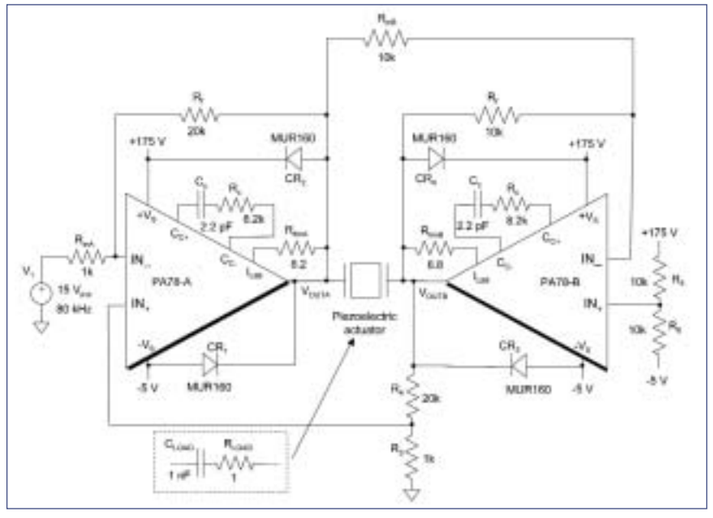

Figure 1. APEX ink jet schematic.

Precision ICs	Output Voltage	Output Current	Slew Rate	Power Bandwidth	Production Volume Pricing
Model	V	mA	V/uS	kHz	10K pcs USD
PA69	+/-100	50	200	200	$10.50
PA69A	+/-100	75	250	200	$13.60
PA86	+/-100	100	350	300	$18.15
PA86A	+/- 125	150	350	300	$21.60
PA78	+/-175	150	350	200	$24.85

Table1. Key Specifications for the PA78 Series.

been the most available solution, but at a price difficult to design in.

The availability of these highly sought after, but attractively priced, high performance power amplifier ICs is finally becoming reality. Leading the development is Apex Microtechnology Corporation based in Tucson, Arizona USA. Apex has a long-standing reputation as a leader in designing very high voltage power operational amplifiers, but as product design technology has dictated, their best offerings have been in hybrid form factors. The Apex design engineering team has bridged the IC technology gap by combining its own patented IC circuitry with a fabrication partner willing to evolve the high voltage, high speed silicon processes. As a result, the company is now able to offer designers power amplifier ICs that deliver the cost-effective, high power performance they seek.

One very popular industrial application for piezos is as an actuator providing precision placement of droplets by industrial ink printers (see Figure 1). These are the printers found in date coding and lot coding processes for everything from cereal boxes to pharmaceuticals.

In this type of application, designers seek to marry the rigorous voltage requirements with better amplifier speed. This tandem performance means the voltage can be applied quickly to the piezo thus allowing the overall system to work faster. The derived benefit from this combination of speed and voltage is critical to date coding operations. The production line moves faster when the ink jet printer does its job quickly. The new ICs in the Apex high voltage amplifier product offerings are the PA78, PA86 and PA69 (see Figure 2). These devices offer the sought-after combination of high speed and high voltage. This high speed trio provides customers with various combinations of high speed, high voltage, and as an extra bonus, very low standby current. Capable of achieving slew rates of up to 350V/µs on supply voltages of 350V, the PA78 series bests its nearest competitor by more than 2X. The PA78 series also delivers up to 150mA of output current while generating very little standby current – less than 1mA depending on performance requirements.

The intellectual property behind the PA78 series provides the secret to its success. The IC's design provides for extremely high slew rates in pulse applications while maintaining very low quiescent current of under 1mA. Slew rate performance is independent of supply current while exhibiting a functional relationship to voltage amplitude. More simply stated, as the input signal increases, so does slew rate.

Customers Can Simplify Design Challenges with PA78 Series

Target applications for the PA78, PA86 and PA69 will utilize the devices' abilities to deliver voltage with speed to control precise movement.

Figure 2. Apex high voltage amplifier products.

Customers designing piezo drive and deflection circuits will be extremely pleased with the performance options these ICs make possible. The ICs' unique input stage has the effect of adding variables to the power response and slew rate characteristics of the amplifier. This also translates to input related effects on open loop gain and phase.

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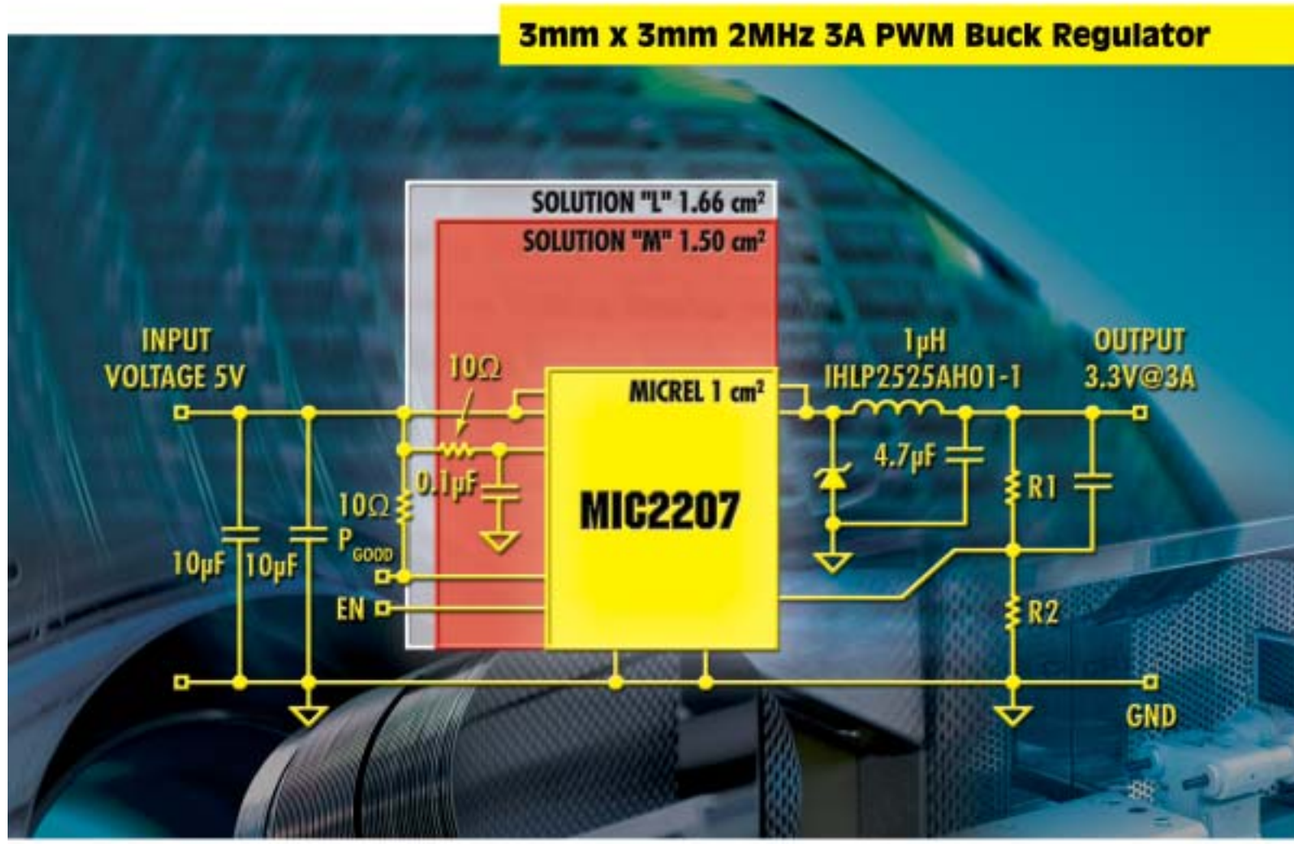

Micrel's MIC2207 is a high efficiency PWM buck (step-down) regulator that provides up to 3A of output current. The MIC2207 operates at 2MHz and has proprietary internal compensation that allows a closed loop bandwidth of over 200KHz.

The low on-resistance internal p-channel MOSFET of the MIC2207 allows efficiencies of more than 94%, reduces external components count and eliminates the need for an expensive current sense resistor. The MIC2207 operates from 2.7V to 5.5V input and the output can be adjusted down to 1V. The device can operate with a maximum duty cycle of 100% for use in low-dropout conditions.

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Fast Body Diode MOSFET

The device for ballast applications

Generating more light with less consumption of electric energy is very important but at the same time these ballasts have to work in very harsh conditions such as ones with wide input voltage variations as well as varying ambient temperature.

By Sampat Shekhawat; Fairchild Semiconductor

Electronic ballasts have become very popular due to the advantages these devices offer to the lighting industry. The MOSFET is one of the key components for electronic ballast. Saving in energy, green house effect, government regulations and technological advances are some of the key driving forces behind this market. Generating more light with less consumption of electric energy is very important but at the same time these ballasts have to work in very harsh conditions such as ones with wide input voltage variations as well as varying ambient temperature. Due to the harshness of these conditions, reliability is very important. Fairchild has released a new 400V fast body diode MOSFET which makes the half- bridge topology used for ballast applications very reliable and cost effective.

Introduction

Electronic ballasts have been available commercially since late eighties, but traditionally magnetic ballasts have been used for lighting. Magnetic ballasts are bulky and have several disadvantages and consume about 30% more electrical energy compared to electronic ballast. Although it is true that electronic ballasts cost more compared to magnetic ballast but the higher costs of electronic ballasts are compensated handsomely by reduced energy costs in the long-term. Even with these advantages it is very surprising that electronic ballast sales have barely started to exceed magnetic (copper-wound) ballasts, which are known to be physically bulkier, heavier, and much less energy efficient. It is a well known fact that electronic ballasts provide steady flicker-free light and an instant start capability. These features lead to stress-free working environments for the eyes. Power-factor correction capability can also be added with some additional cost. Lighting fixtures consume 10-12% of the total electrical power produced world wide.

There are different types of applications such as Compact Fluorescent Lamps (CFLs), Cold Cathode Fluorescent Lamps (CCFLs), High-Intensity Lamps (HIDs) and Light Emitting Diodes (LEDs). However, two types of gaseous discharge lamps are available in the market today. One is the high pressure type and other one is the low pressure type. The fluorescent lamp is a low pressure mercury vapor discharge lamp, and is the more commonly used lamp.These lamps are available in many sizes, shapes and power ratings. In case of the fluorescent lamp, the mercury vapor under low pressure is sustained in the ionized state by an external current source. This ionized mercury does not provide light directly. The fluorescent lamp has phosphor coating which emits light when bombarded by the ultraviolet radiation from conducting gas. Combining all these applications together, the total market for electronic ballasts is estimated to be above one billion units and is still rising at a slow pace. The input harmonics are controlled by either passive PFC or sometimes active PFC. A boost switch (MOSFET or some other power switch) is needed for an active PFC. The second stage for electronic ballast circuitry is generally a half-bridge topology. Recent improvements in power semiconductors and other components coupled with the increase in energy cost and increased concerns about the environment are making these electronic ballasts very popular. The efficiency of fluorescent lamps increases when operated at higher frequency compared to 50/60 Hz power line frequency. The electronics ballast when operated at high frequency at about 20-50 KHz can increase the lamp efficiency by about 10%.

Half-Bridge Inverter

The lamp current should be sinusoidal in shape to minimize EMI. The sine wave current also maximizes the life of the lamp. High the ratio of peak current to RMS current will reduce the life of the lamp cathodes. The DC component applied to the lamp should also be minimized to increase the life of cathode. Because of this a series-resonant based

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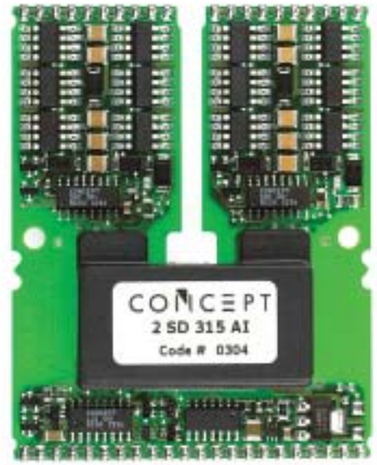

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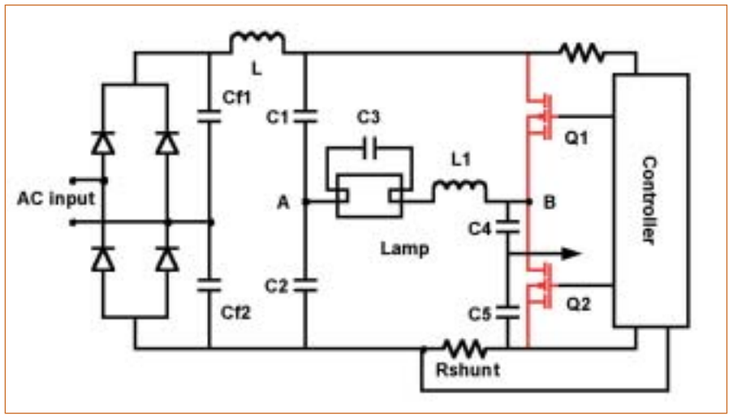

Figure 1. Voltage-fed half-bridge inverter for electronic ballast.

voltage fed half-bridge inverter is one of the most popular topology to drive the Compact Fluorescent Lamp (CFL). The controller used here is generally a high voltage IC that drives both high side and low side MOSFETs of the half bridge. The controller provides all of the required functions to the voltage fed half-bridge inverter required for the lamp. These functions include preheat, ignition, burn state and protection etc. These controllers also provide low side and high side gate driver. The controller has to be optimized for the electronic ballast so that it occupies the minimum printed circuit board area by reducing component count and lowering power dissipation as well as cost. The initial preheating time and frequency can be adjusted depending on the type of lamp used. The ballast has to work from low line AC to high line AC input. Sometimes these voltage excursions are more than is allowed. Under these excursions, the voltage fed half bridge inverter ballast can make the lamp flicker if the right MOSFET is not chosen.

Figure 1 shows the circuit diagram for the typical electronic ballast. The lamp and its series inductor L1 connected across A and B nodes act as a load to the voltage fed half-bridge inverter. The capacitor C3 across the lamp electrodes and in series with L1 forms the resonant network. The capacitors C4 and C5 are part of the network for the controller circuit. When Q2 is on these capacitors are discharged.

During normal conditions whenever either MOSFET is turned on, first its body diode conducts so the MOSFET turns on without switching loss as shown in Figure 2 (a) & (b). Figure 2(b) shows that when Q1 is turned off its output capacitance is charged and at the same time the output capacitance of Q2 is discharged because of the direction of load current under resonance, and Q1 turns off at ZVS. Once the output capacitance of Q2 is discharged the current flows through the body diode of Q2 and its drain to source voltage is clamped by its own body diode forward voltage drop. When gate voltage is applied to Q2 as shown in Figure 2(b) and when the current changes direction, the MOSFET channel starts to carry current in the forward direction, hence the MOSFET turn-on switching loss is negligible. When the current changes direction the voltage across the MOSFET is negligible compared to the DC bus voltage.

The starting frequency of the ballast is very high compared to the resonant frequency or burn state frequency. However, at low line or even at high line it may be in a hard switched mode before reaching to burn in state or this circuit can misbehave due to diode recovery problem since MOSFET body diode may try to recover under certain conditions before reaching a burn state. In this mode the diode recovers when its complimentary MOSFET is turned on and this current flows through Rshunt. The voltage across the Rshunt can

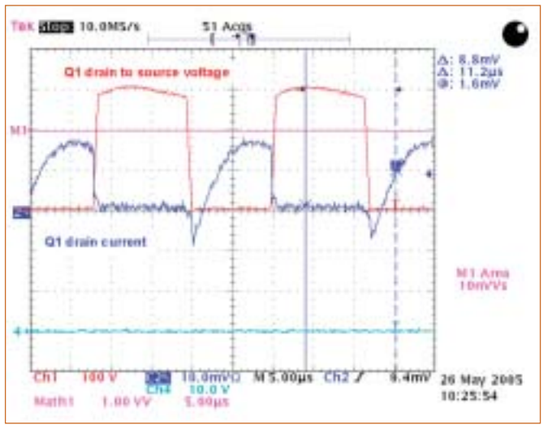

Figure 2a. Normal operation of ballast.

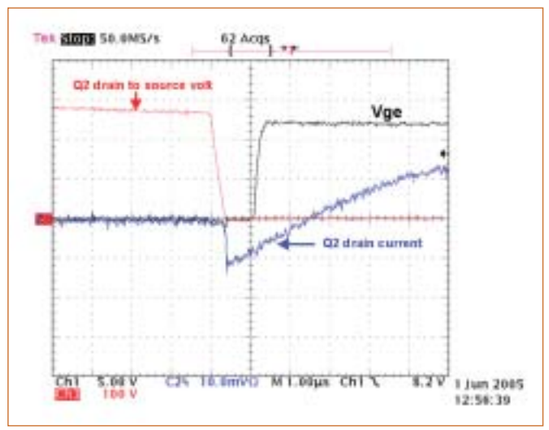

Figure 2b. Normal operation of ballast.

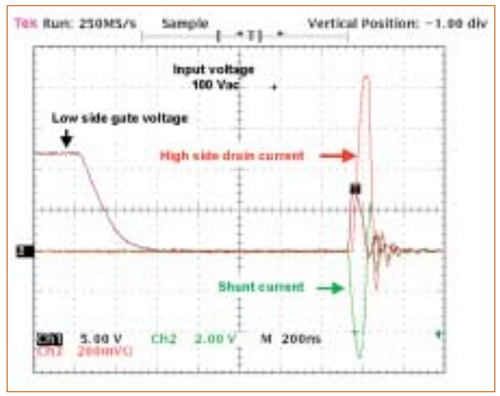

Figure 3. Body diode recovery of standard MOSFETs.

influence the controller. The C4 and C5 across Q2 also influence on this problem. The diode recovery current as well as the charging current for these capacitors passes through Rshunt when Q1 is turned on.

Sometimes when this current is very high the controller can shut-off the ballast thinking that there is a shoot through across the DC bus. The controller can also misbehave under this condition and can keep the lamp in an undesirable flickering mode. It was also found that this problem occurs only due to the low side MOSFET diode recovery and the charging of capacitors connected across the lower switch. The body diodes of Q1 and Q2 alone were not causing this problem. It was the combination of MOSFET body diode recovery current and the charging current of the capacitors across the power MOSFET Q2 that was causing this problem.

To eliminate and confirm this problem, a Schottky diode was connected in series with the drain of Q2 (between the drain of Q2 and node-B of the inverter) and then a fast recovery standard diode with low Qrr and Trr was connected across the series combination of the MOSFET and the Schottky diode (across the source of Q2 and node-B of the inverter). This eliminated the problem at both the low line as well as high line of AC input voltage.

Figure 4 shows that the diode recovery problem was gone and only a small current blip is there which is due to the charging of capacitors connected across Q2. Because of the smaller current blip, the controller did not misbehave. The ballast works fine without entering into flickering mode.

The body diode recovery characteristics of Fairchild MOSFET FQP6N40C, competitor-A and competitor-B were measured as shown in Figure 4. It was decided that the body diode was causing this problem.

A fast body diode MOSFET for ballast applications was designed. The MOSFETs Q1 and Q2 were replaced by Fairchild's MOSFET FQP6N40CF. Some standard MOSFETs worked fine from nominal AC voltage input to high line voltage, but had problem at low line voltage. Competitor-A's MOSFET worked fine from low line to nominal line voltage, but it had problem at high line AC input voltage. Competitor-B MOSFETs worked fine from low line to high line voltage but their breakdown voltages were lower compared to other MOSFETs, and were not reliable enough and had some failures. However a MOSFET with fast body diode eliminated these problems and worked well at all input line voltage conditions and at the same time there were no reliability problems. The peak current through the current monitoring resistance, Rshunt, was reduced and the on-off mode (flickering mode) of the ballast was eliminated.

Conclusion

This article demonstrates the value of using a fast body diode MOSFET for electronic ballast applications. This fast body diode MOSFET eliminates the ballast flickering problem from low line AC input voltage to high line AC input voltage without forcing the controller to misbehave.

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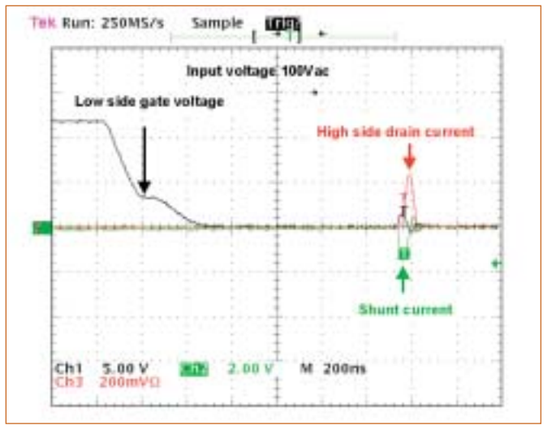

Figure-4a. Standard diode recovery waveform.

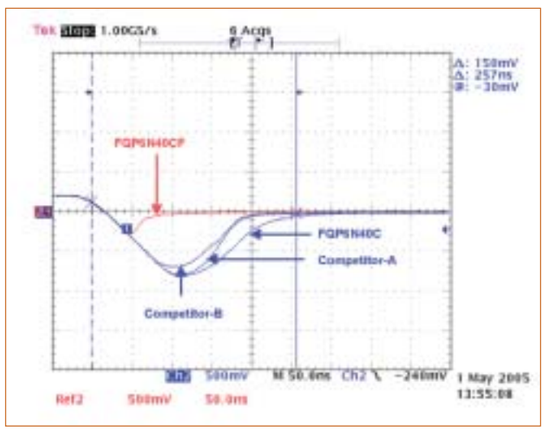

Figure 4b. Different MOSFETs body diode reverse recovery @ 2A, di/dt=200mA/Sec and Vdd=200V.

Lamp Ballast Design with Less Components

For new generation of lamps the IC offers optimized functionality

The new generation of fluorescent lamps of the T4 and T5 type are optimized for high efficacy. In order to achieve long lifetimes, they require a specific, more complex start-up procedure and an intensive monitoring of the operating behaviour compared to the older lamp T8 and T12 types.

By Michael Herfurth, Infineon Technologies AG

Infineon Technologies has introduced a new controller ICB1FL01G to the market, which controls electronic lamp ballasts for fluorescent lamps. The control concept offers a unique set of features and a comprehensive functionality to operate single and multiple lamps at a minimum effort of external components (see Figure1). The new generation of fluorescent lamps of the T4 and T5 type are optimized for high efficacy. In order to achieve long lifetimes, they require a specific, more complex start-up procedure and an intensive monitoring of the operating behaviour compared to the older lamp T8 and T12 types. For this new generation of lamps the IC offers an optimized functionality.

The ballast controller ICB1FL01G controls in a first functional block a boost converter as an active harmonic filter for the power factor correction. A second block of the IC controls a half-bridge inverter. The driver for the floating high-side MOSFET operates according to the level-shift method and makes use of the new Coreless Transformer technology. The inverter feeds the lamp via a resonant circuit.

Different operating modes such as softstart, preheating ignition and run mode according to a fixed and adjustable timing sequence are controlled by the operating frequency of the inverter. The adjustment of the parameters determining time and frequency is done solely by resistors, completely avoiding any capacitors for this task. The device detects a lamp removal as well as the dangerous rectifier effect at the lamp's end of life in configurations of one, two and four lamps (see Figure 2).

Figure 1. Reference design of an electronic lamp ballast with ICB1FL01G.

Operating behaviour during start-up of the ballast

After switching on the mains the capacitors C12 and C13 are charged via the start-up resistors R11 and R12. The current consumption of the IC is typically below 100µA until the supply voltage has reached Vcc=10V. Above this level a current source of typically 20µA at the RES pin is activated to detect the existence of the low-side filament. As long as the voltage level at the RES pin is below 1.6V the filament is assumed to be undamaged.

Via the resistors R24 and R25 a current is fed to the high-side filament and via the resistors R31, R32, R33 to the LVS1 pin. A filament is detected, if the current is above 15µA. For multi-lamp operation a second detection pin LVS2 is available, which can be deactivated by a ground connection in the same way as LVS1. In other words: if the existence of the filaments is detected and the voltage at the PFCVS pin has reached at least 0.375V, which is interpreted as closed regulation loop for the boost converter, the IC can activate its driver outputs as soon as the supply voltage Vcc has exceeded the turn-on threshold of 14V.

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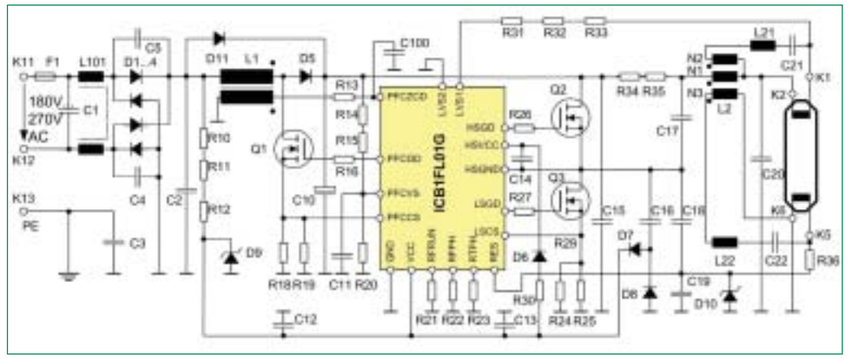

Figure 2. Application circuit of an electronic lamp ballast with ICB1FL01G for a single fluorescent lamp.

Inverter to feed the fluorescent lamp

The inverter starts at a frequency of 120kHz. Within 10ms the frequency is reduced in 16 steps to the preheat frequency adjustable by the resistor R22. The duration of preheating can be selected between zero and 2,000ms by the resistor R23. Subsequently the frequency is further reduced in 128 steps and a time period of 40ms to the run frequency adjustable by the resistor R21 (see Figure 3).

With the first pulse the low side MOSFET Q3 of the half-bridge is turned on. Then the floating capacitor C14, which supplies the high-side control logic like a battery, is charged from capacitor C13 via R30 and the diode D6. At the output of the half-bridge inverter the capacitor C16 together with the diodes D7 and D8 acts as a charge pump in order to supply the IC via C13. In addition C16 is used to limit the voltage slew rate and to produce zero voltage switching conditions.

During operation C16 is recharged without losses in the dead time periods of MOSFET Q2 and Q3 by the inductive driven current of the load circuit. So the succeeding turn on of the MOSFET occurs at zero voltage. At turn-off C16 limits the voltage slew rate in such a way, that the MOSFET channel is already turned off before the Drain to Source voltage has reached considerable levels. Therefore the inverter creates negligible switching losses at normal operation.

The load circuit of the inverter consists of a series resonant circuit with the resonance inductor L2 and the resonance capacitor C20. The lamp is connected in parallel to the resonance capacitor. For a voltage mode preheating the resonance inductor L2 has two additional windings. Each of those windings drives a current in the filament via the band pass consisting of L21/C21 and L22/C22. The band pass filter ensures a current flowing through the filaments only during the preheat phase.

During the ignition period a high voltage at the lamp and a large current in the resonant circuit is generated due to the unloaded resonant circuit (see Figure 4).

The current in the resonant circuit is monitored by the resistors R24 and R25. A voltage higher than 0.8V at pin LSCS increases the operating frequency of the inverter by a couple of frequency steps. As a result of this measure the ignition phase is enlarged from 40ms up to 235ms with a lamp not willing to ignite, while the voltage at the lamp keeps on the level of the ignition voltage with a certain ripple. If the run frequency is not achieved within 235ms after finishing, the preheating period the IC changes over into the failure mode. A restart is initiated either by lamp removal or after a new cycle of turn-off and turn-on of the mains voltage.

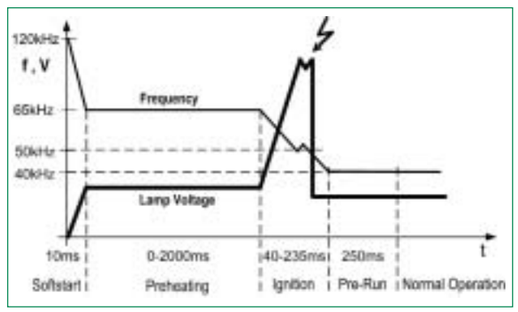

Figure 3. Exemplary variation of frequency and lamp voltage during start-up procedure with different operating modes.

Preconverter for power factor correction

Simultaneously with the inverter the MOSFET Q1 of the PFC boost converter starts the operation. Such a boost converter (L1, Q1, D5, C10) can transform the input voltage to any arbitrary higher output voltage. Using a suitable control method, this converter is used as an active harmonic filter and for the correction of the power factor. The input current follows the same sinusoidal wave form as the AC mains supply voltage. On the output of the PFC preconverter a feedback controlled DC voltage is available at capacitor C10 for the application. The PFC stage is operated with a controlled turn-on time without input voltage sense. A turn-on time set by the control unit is followed by a turn-off time which is determined by the duration until the current in the inductor and hence in the diode too has reached the level zero. This point of time is detected by the voltage level at the zero current detector winding on the inductor L1 and feed to the IC via the resistor R13 and the pin PFCZCD.

The result is a gapless triangular shaped current through inductor L1 (so called critical conduction mode) which is sustained for a turn-on time in the range of 23µs down to 2.3µs. A further reduction of the energy flow reduces the turn-on time down to 0.4µs while at the same time the turn-off time is extended causing triangular shaped currents with gaps

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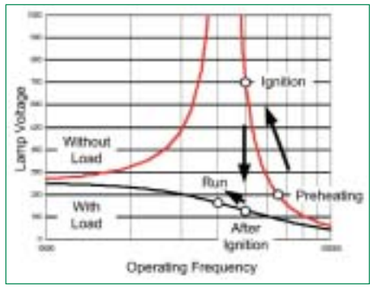

Figure 4. Lamp voltage dependent on operating frequency without load (red trace) e.g. before ignition and with load (black trace) e.g. after ignition assuming a constant load resistor.

(discontinuous conduction mode). Such a control method allows a stable operation of the boost converter over a large range of the input voltage as well as of the output power.

The ICB1LB01 includes the error amplifier with entire compensation build up by a digital PI regulator and a digital filter to suppress the 100Hz ripple.

Protection features

The PFC section is provided with a current limitation and a monitoring of the bus voltage in respect to overvoltage, undervoltage and open control loop. The inverter detects an overcurrent, when the voltage at pin LSCS exceeds the threshold of 1.2V for longer than 400ns. A single event is sufficient to change over into failure mode.

During run mode of the inverter a deviation from the typical zero voltage switching is recognized as an operation with capacitive load. In such an operating condition peak currents occur during turn-on of the MOSFETs due to switched charging of the charge pump capacitor C16. In a situation with partial recharge of capacitor C16 the IC changes over into the failure mode, when the situation happens for longer than 500ms. In a second situation, capacitor C16 is completely recharged by the MOSFETs switching. In such a critical operating condition with high power dissipation the IC changes into failure mode already after 605µs.

When the fluorescent lamp reaches the end of lifetime the lamp voltage can become unsymmetrical or increase. The resistors R31, R32, R33 measure the lamp voltage by evaluating the current through these resistors at pin LVS1. The maximum lamp voltage is detected when the current through the resistors R31, R32, R33 exceeds +/- 230µA. The rectifier effect with unsymmetrical lamp voltage is detected when the ratio of measured positive and negative peak value at pin LVS is higher than 1.15 or lower than 0.85. The change into failure mode will be initiated when an end-of-life criteria happens for longer than 500ms.

The integrated circuit ICB1FL01G has a unique combination of features that make a design of high-quality lamp ballasts with a low number of external components possible.

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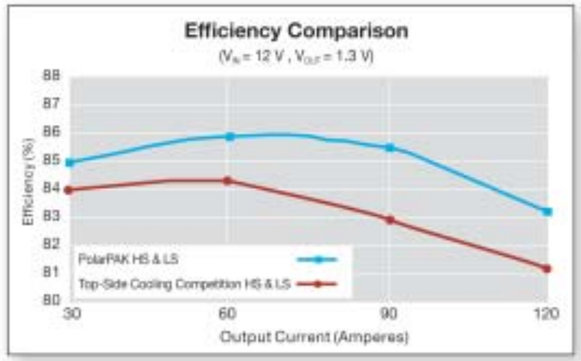

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The increased power density of the applications together with a general decrease in overall physical size creates a difficult environment for the MOSFETs employed; they are expected to handle more power.

By Chris Hill, Senior Applications; Philips Semiconductors

There is a general trend in today's DC-DC converter market towards products with smaller size and greater power density. The power semiconductors employed in those applications are typically N-channel MOSFETs, which usually act as the high frequency switches within the converter circuits. In most cases, the MOSFETs have become a significant source of power dissipation within such applications. However, the increased power density of the applications together with a general decrease in overall physical size creates a difficult environment for the MOSFETs employed; they are expected to handle more power, yet are placed in environments where cooling of the MOSFETs is increasingly more difficult. In all cases, it is essential that neither the MOSFET's maximum operating temperature nor the maximum temperature limit of the PCB is exceeded.

Thermal resistances

In all but the simplest cases, it is not possible to manually calculate the temperature of MOSFET device(s) in a typical application. The "traditional" measures of thermal performance usually found in device data sheets are the so-called "thermal resistances". Thermal resistances are analogous to electrical resistances and quantify the resistance to the flow of heat energy along a predefined path. Thermal resistances are defined in the following general manner;

$$R_{th} = \frac{\Delta T}{q}$$

Where;

Rth	is the thermal resistance between two points
ΔT	is the temperature difference between the points
q	is the heat flux flowing between the points

The thermal resistance figures found in MOSFET data sheets are $R_{th\ j\text{-}mb}$ and $R_{th\ j\text{-}a}$, and are applicable only under very specific conditions – conditions which rarely, if ever, match those found in a real application.

$R_{th\ j\text{-}mb}$ is the thermal resistance from junction to mounting base, as shown in Figure 1.

$R_{th\ j\text{-}mb}$ is relatively easy to measure and understand, however its usefulness in a design situation is limited as it only describes one small part of a thermal scenario comprised of many series and parallel paths.

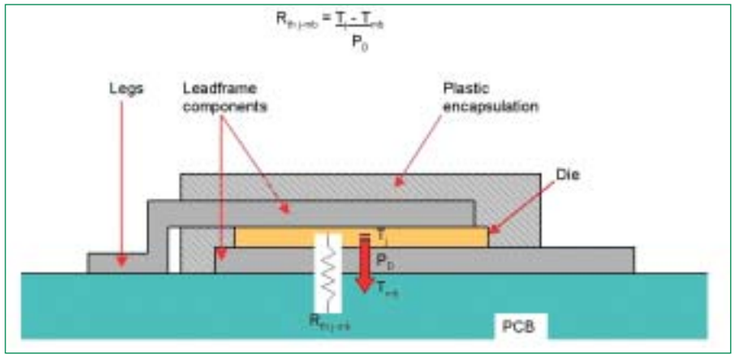

Figure 1. Definition of $R_{th\ j\text{-}mb}$ for an LFPAK MOSFET.

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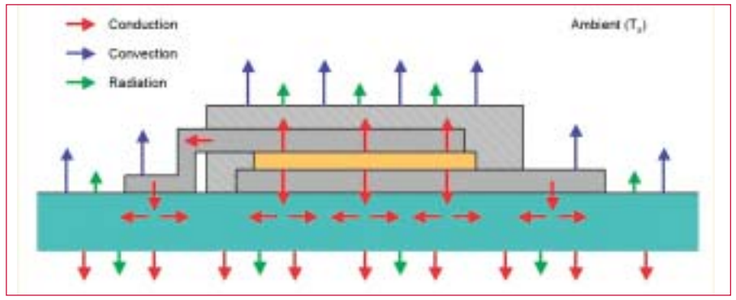


Figure 2. The numerous thermal pathways from junction to ambient for an LFPAK MOSFET.

$R_{th\ j\text{-}a}$ is a measure of the total thermal resistance from the junction to ambient and takes account of all thermal pathways, including those through the PCB. See Figure 2.

Whilst $R_{th\ j\text{-}a}$ may appear to be a useful figure for the circuit designer to use, any given value of Rth j-a depends heavily on test conditions, PCB construction, etc., and so probably will not be appropriate in a designer's specific application.

A full description of the test methodology for determining thermal resistances may be found in JEDEC specifications JESD51-1 through JESD51-10. It should be noted that the Rth figures described in these documents were never intended to be used in the design of real applications, despite widespread attempts in the industry to do so.

In summary, therefore, it is not usually possible to manually calculate the temperature of MOSFET device(s) in a typical application, and hence the circuit designer is often faced with the problem of needing to calculate device operating temperature, but having no practical means of doing so. It is to meet this need that thermal simulation techniques have been applied to the field of electronic circuit design.

What is thermal simulation software?

The thermal simulation software described in this article uses Computational Fluid Dynamics (CFD) techniques to analyse complex thermal scenarios involving coupled heat transfer by conduction, convection and radiation. Although the principles of CFD are generally applicable to many fields of engineering, Flomerics' "Flotherm" package is specifically targeted at users in the field of electronic and electrical engineering.

A particular strength of thermal simulation software is that it enables designers to eliminate unusable configurations from their designs at a very early stage in the design process. Hence a finished, working solution may be arrived at in a much shorter time compared to a situation where thermal simulation software is not used, and actual prototype construction may be unnecessary until much later in the design process.

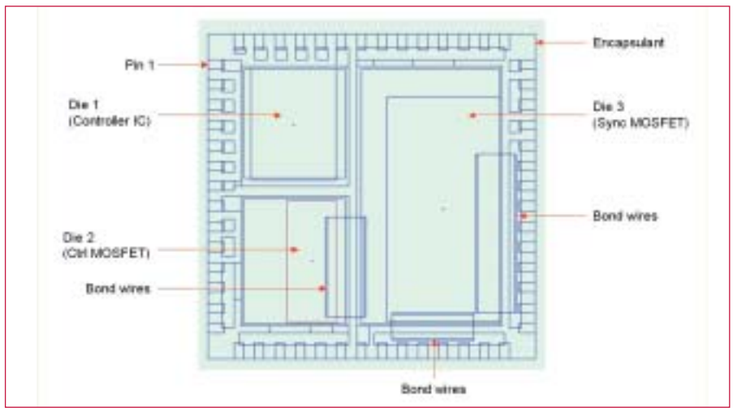


Figure 3. Wire Frame view of the PIP212-12M detailed model.

Thermal modeling of the Philips PIP212-12M Integrated Solution.

The "Wire Frame" view of the PIP212-12M thermal model is shown in Figure 3.

This is an example of a "detailed" model where internal components such as the silicon and leadframe have been included. The PIP212-12M Integrated Solution is a good example of a thermally complex device. The PIP212-12M is housed in a 56-pin Quad Flat Pack package and comprises three internal heat sources (two MOSFET die plus a driver chip) together with various conductive leadframe and wire-bond components. Heat energy is free to flow not only from the sources to ambient but also between the sources via the other internal conductive components.

Verification of the PIP212-12M thermal model.

A sample of the PIP212-12M was mounted on an aluminum test PCB measuring 35mm x 30mm x 1mm. The junction temperatures of the two MOSFETs were measured separately for known values of junction dissipation (PD) using the "body diode thermometry" method - see JEDEC specification JESD51-1 for a full description of the test method. Using the method described in JESD51-1 we are able to determine the junction temperatures of the PIP212-12M for a corresponding range of values of PD and hence the corresponding figures of $R_{th\ j\text{-}a}$. The results are shown in the table 1.

Die	Measured $R_{th\ j\text{-}a}$ (k/W)	Simulated $R_{th\ j\text{-}a}$ (k/W)	Error (%)
Ctrl MOSFET	8.1	7.7	-4.9
Sync MOSFET	5.1	5.4	+5.9

Table 1. The corresponding figures of $R_{th\ j\text{-}a}$.

Summary

The results of Table 1 show a good correlation between measured and simulated data – the simulated results are within ±6% of the measured results. Potential sources of error include the calibration accuracy of thermocouples and other test equipment and uncertainties as to precise thermal properties of the materials used in the simulation.

On the basis of these results, the user is able to have a high degree of confidence both in the PIP212-12M thermal model and the thermal simulation software itself.

Detailed thermal models for a wide range of Philips MOSFETs are available for download from http://www.smartparts3d.com. The models cover many popular package types including TO220, D-Pak, D²-Pak, LFPAK, SOT23 and TSOP6 and are provided free of charge.

Finally, Figure 4 demonstrates the use of the PIP212-12M thermal model in the simulation of a "Point of Load" (PoL) DC-DC converter application. In this example, the PIP212-12M is mounted on a small rectangular PCB and fitted with a heatsink on the topside of the device package in order to aid cooling. For clarity, the heatsink has been made "invisible" in this picture.

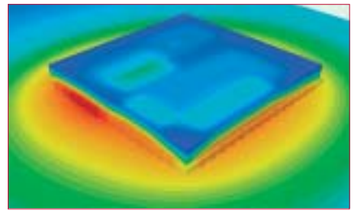
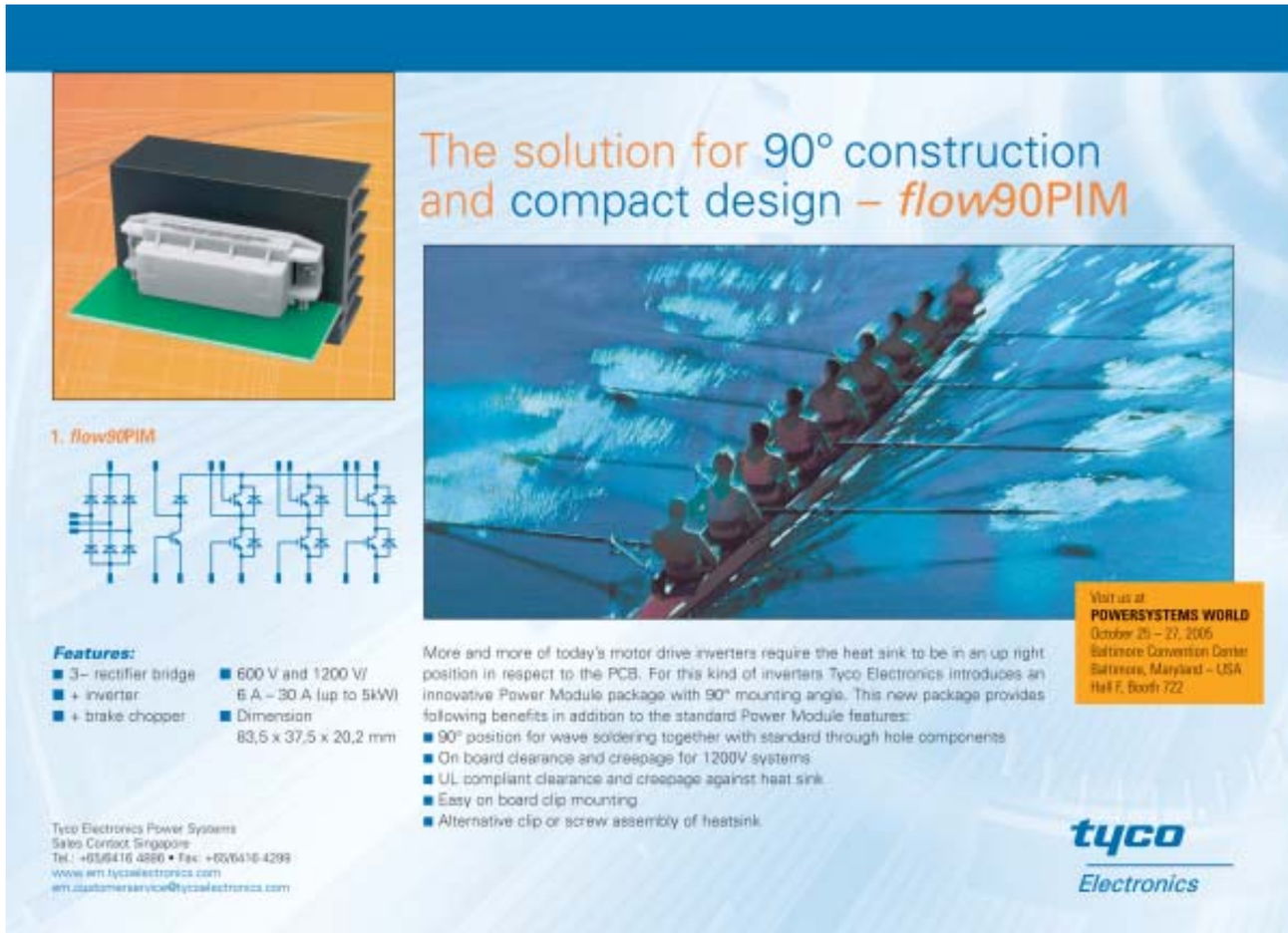


Figure 4. PIP212-12M detailed model after simulation, showing temperature plot.

Literature/resources

Flotherm
http://www.flotherm.com
JEDEC
http://www.jedec.org
Smartparts3d
http://www.smartparts3d.com



Integration Streamlines Industrial Motor Control Design

The IPM eliminates around 20 discrete components

The IRMCK203, implements all control algorithms in dedicated hardware logic, enabling very high bandwidth closed loop control. In practice, the device is faster than traditional motor control DSPs, and can perform a complete Field Orientation Control (FOC) loop in 6µs.

By Naresh Shetty, International Rectifier

Permanent magnet (PM) AC motors generally deliver more power and torque for their size than induction motors, and therefore enable numerous enhancements to a wide variety of industrial, scientific and medical (ISM) equipment. But developers must be able to configure suitable variable speed drives quickly, if they are to make the most of these inherent advantages. Bringing up a custom solution is lengthy and requires expensive design and integration skills. A well-conceived motor control design platform offers the opportunity to enhance performance while at the same time reducing time to market, design effort, and design risk.

PM AC motor designs

The favourable power and torque characteristics of PM motors, especially the higher torque at low shaft speeds compared to conventional induction motors, allows designers to design-out expensive gearboxes in favour of direct drive controls. The PM motor also does not display slip, which leads to improved dynamic control by eliminating the need for slip compensation.

Hence PM motors will allow ISM equipment such as CNC machine tools, aerospace controls, robotic equipment and light industrial machinery, and semiconductor processing equipment such as wafer handlers to become smaller, lighter, more efficient, and more cost-effective. Also, industrial appliances such as air conditioning units and commercial refrigerators can benefit from the same acoustic noise and efficiency advantages that PM motors bring to domestic appliance markets. Here, the ability to operate at the optimal speed for any given set of conditions and user demands, rather than running continuously at full speed, can dramatically reduce overall electricity consumption leading to significant savings in operational costs for commercial enterprises.

In many ISM applications, ranging from machine-shop automation to small, precision instruments such as dental drills, traditional software-based methods of motor control simply do not react quickly enough to suit modern requirements. In addition, equipment developers need a much more highly integrated – and easy to configure - solution to PM motor control, which will allow them to focus on additional value-added features while at the same time reducing time to market and leveraging the inherent PM motor performance benefits.

Solutions for rapid development

A suitable rapid development solution for PM motor control will comprise a digital control block – preferably a single IC - with register-customisable control algorithms already implemented in hardware. But this alone is not enough to significantly reduce the design and integration effort for state of the art motor drives. Developers also need compatible, plug and play components including driver stages, IGBTs from low to high current ratings, and functional blocks to perform analogue duties such as motor protection.

International Rectifier has created a digital control IC for sensor-less high-speed permanent magnet motors. The IC supports operation over a wide speed range, and is ideal for sinusoidal current control. This device, the IRMCK203, implements all control algorithms in dedicated hardware logic,

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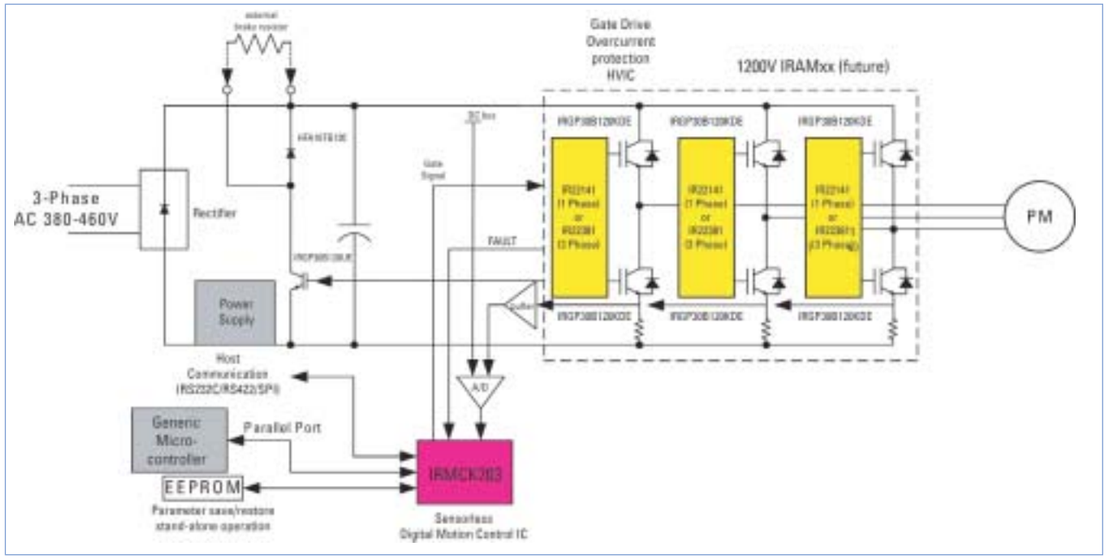

Figure 1. Implementing 380/460V sensorless PM motor system.

enabling very high bandwidth closed loop control. In practice, the device is faster than traditional motor control DSPs, and can perform a complete Field Orientation Control (FOC) loop in 6µs. By comparison, a high performance motor control DSP typically requires 15-20ms. Where a practical implementation may call for a torque control bandwidth of 4kHz, which implies a maximum computation update period of 25ms, the DSP has little headroom to implement other functions. These may include power management, start-up retry, phase loss detection, low loss and low EMI space vector PWM, and various drive protections. A single DSP or MCU using a real-time multi-tasking operating system will struggle to perform these diverse tasks in a timely manner, but the IRMCK203 performs all of these on-chip in addition to executing the FOC algorithm.

To configure a controller using the IRMCK203, the developer writes application-specific parameters into on-chip registers during system configuration, via a PC-based development environment. The actual inverter hardware can also be designed within this environment, which enables the added advantage of performing "hardware in the loop" system evaluation with a real, industrial quality drive, to by-pass time-consuming iterative bread-boarding of hardware and software. Hence this approach delivers a complete motor control system development platform that allows a small team to manage the complete design process while meeting the increasing demand for higher performance.

No programming effort is required to finalise complex PM motor control algorithms for execution in the IRMCK203. Combined with optimal IGBTs and high voltage gate drivers and current sensing fabricated using International Rectifier's High Voltage Integrated Circuit (HVIC) technology, the user can implement a complete AC servo and sensorless control with minimum component count and design effort.

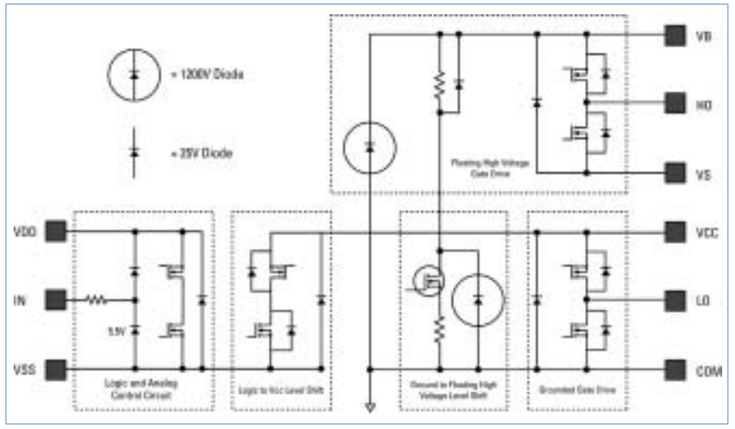

Figure 2 Common circuit blocks of HVIC.

Integrated Protection and Sensing

IGBT gate drive, protection and sensing functions can all now be integrated onto a single monolithic chip using HVIC technology as shown in Figure 1. HVIC essentially enables low voltage CMOS circuits to be referenced to a high-voltage floating supply level for high-side gate-drive and signal-processing circuits. This floating capability allows differential-mode signal processing on top of a 600V or 1200V common-mode voltage. Integrated HVIC gate drivers such as International Rectifier's IR2214 and IR22141, which combine as a high-side and low-side pair, save considerable design complexity, effort and risk. For example, the technology now allows designers to create a single-chip solution to the challenge of driving a MOSFET or IGBT in the high side position of a half-bridge topology or 3-phase inverter leg, where the gate voltage is referenced to the source rather than to ground.

With HVIC, implementing full protection - including ground fault protection – is now viable for a wide range of applications. In the past, this has only been feasible in high-end systems. The IR2214 and IR22141 gate drivers include parameter matching, such as propagation delay for high- and low-side channels as well as deadtime insertion. Low quiescent current on the high-side enables economical and space-saving bootstrap supply topology. There is also fault feedback on IGBT de-saturation, which automatically shuts down the IGBT when used in multi-phase configurations. The IR2214 includes desaturation detection for both sides as well as an internal biasing resistor, while the IR2241 includes an active de-saturation diode bias. The IR2214 and IR22141 can be connected together via a dedicated pin to protect the drive system from phase-to-phase short circuits. Finally, separate power and signal ground pins, enable emitter shunt configurations to simplify low-side IGBT current sensing.

Figure 2 shows how the IRMCK203 and IR22141 and IR22141 may be combined to create a 380/460V AC sensorless permanent magnet motor control system for use in a professional industrial application such as a high-speed spindle or pump.

One Step Further

An Integrated Power Module (IPM) enables even higher integration for lower voltage industrial drives, such as those in the range 85V-253V and 750-1200W. The IPM eliminates around 20 discrete components by combining HVIC gate drivers and sensing with a three-phase inverter power stage built using IR's non-punch-through (NPT) short-circuit-rated IGBT technology.

One example, international Rectifier's 20A, 600V IRAMY20UP60B has an internal shunt resistor as well as a built-in temperature monitor, and enables over-current and over-temperature protection as well as under-voltage lockout: all in a compact SIP3 package featuring internal heat spreaders for the power die. A similar device, the IRAMX20UP60A does not include the shunt resistor but is packaged in a more compact SIP2 outline. An open emitter configuration of the low-side IGBT switches offers easy current feedback and over-current monitoring for high precision and reliable control. Similar IPMs, rated to 16A, are also available.

Together with a few external components and a controller, the IPM enables a complete motor drive system. This greatly accelerates the design path compared to a multi-discrete solution. Other integrated features such as the bootstrap diodes for the high-side drive function and the single polarity power supply, simplify the system design while reducing overall cost and delivering the wider benefits of higher integration, including board space savings, enhanced reliability and easier inventory management.

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Unwinding the Mysteries of Switching Transformer Design

Decades of transformer design experience are built into the tool

PI Transformer Designer is the first tool that automatically creates complete transformer designs with detailed specifications. Considering the ever-shrinking design windows that today's marketplace demands, this tool will be indispensable to those who design low-cost, low-EMI power supplies.

By Peter Vaughan, Power Integrations

Introduction

Power supply ICs that include a MOSFET integrated with a controller on the same piece of silicon have been commercially available for about a decade now. Some of these ICs also have the most commonly used support functions, such as over-temperature shutdown, under- and over-voltage protection, and cycle-by-cycle current limiting integrated onto the chip. The reduction in component count, circuit complexity, size, cost and design cycle time that results from designing power supplies around these ICs has made them very popular with power supply design engineers.

The integration of support functions onto these ICs has also greatly simplified the process of designing safe, robust, energy-efficient power supplies. This has enabled engineers who are not expert power supply designers to produce solid designs quickly and easily. With the deadlines for complying with the newest energy-efficiency standards close at hand, many applications need to have compliant solutions quickly designed to replace line-frequency, linear-regulated power supplies, which will not be able to comply.

Tools, tools and more tools

Although these ICs have helped to greatly simplify switched-mode supplies, most models still require a custom high-frequency power transformer. With so many variables involved in the design of power magnetics, designing optimized transformers can be challenging, even for experienced magnetics engineers. Good transformer design is all the more important since high light-load efficiency, low no-load consumption and low EMI are all impacted by the performance of the transformer.

Most IC manufacturers provide application notes and software aids to support their devices, but these tend to focus mainly on the electrical circuit design. At best, some of these aids will produce a list of electrical transformer parameters, and at worst, many provide little more than a few rules of thumb for experienced transformer designers.

With the burden of designing commercial magnetics increasingly falling upon engineers who have little knowledge of the art, Power Integrations recognized the need for a solution more comprehensive than a list of electro-magnetic design parameters. With this in mind, the latest version of the company's easy-to-use PI Expert Suite design software contains a utility that provides a complete transformer specification.

Introducing PI Transformer Designer

PI Transformer Designer is the first tool of its type that automatically produces full specification, step-by-step transformer winding instructions and detailed winding diagrams. Decades of transformer design experience are built into the tool, which allows even a novice to create a design that can be wound in a lab, or sent out to a magnetics vendor with assurance that the samples built to the winding instructions will work properly the first time.

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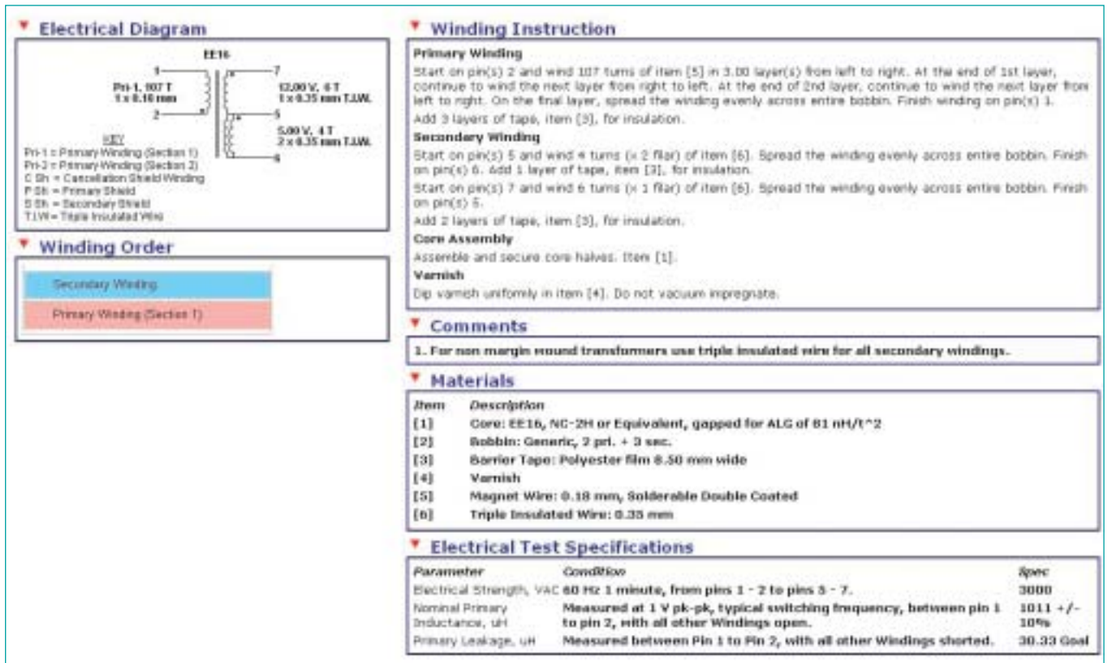

Electrical Diagram

EE16

Pri-1, 107 T
1 x 0.18 mm

12.00 V, 6 T
1 x 0.35 mm T.I.W.

5.00 V, 4 T
2 x 0.35 mm T.I.W.

KEY
Pri-1 = Primary Winding (Section 1)
Pri-2 = Primary Winding (Section 2)
C Sh = Cancellation Shield Winding
P Sh = Primary Shield
S Sh = Secondary Shield
T.I.W = Triple Insulated Wire

Winding Order

Secondary Winding
Primary Winding (Section 1)

Winding Instruction

Primary Winding
Start on pin(s) 2 and wind 107 turns of item [5] in 3.00 layer(s) from left to right. At the end of 1st layer, continue to wind the next layer from right to left. At the end of 2nd layer, continue to wind the next layer from left to right. On the final layer, spread the winding evenly across entire bobbin. Finish winding on pin(s) 1.
Add 3 layers of tape, item [3], for insulation.
Secondary Winding
Start on pin(s) 5 and wind 4 turns (x 2 filar) of item [6]. Spread the winding evenly across entire bobbin. Finish on pin(s) 6. Add 1 layer of tape, item [3], for insulation.
Start on pin(s) 7 and wind 6 turns (x 1 filar) of item [6]. Spread the winding evenly across entire bobbin. Finish on pin(s) 5.
Add 2 layers of tape, item [3], for insulation.
Core Assembly
Assemble and secure core halves. Item [1].
Varnish
Dip varnish uniformly in item [4]. Do not vacuum impregnate.

Comments

1. For non margin wound transformers use triple insulated wire for all secondary windings.

Materials

Item	Description
[1]	Core: EE16, NC-2H or Equivalent, gapped for ALG of 81 nH/t^2
[2]	Bobbin: Generic, 2 pri. + 2 sec.
[3]	Barrier Tape: Polyester film 8.50 mm wide
[4]	Varnish
[5]	Magnet Wire: 0.18 mm, Solderable Double Coated
[6]	Triple Insulated Wire: 0.35 mm

Electrical Test Specifications

Parameter	Condition	Spec
Electrical Strength, VAC	60 Hz 1 minute, from pins 1 - 2 to pins 5 - 7.	3000
Nominal Primary Inductance, uH	Measured at 1 V pk-pk, typical switching frequency, between pin 1 to pin 2, with all other Windings open.	1011 +/- 10%
Primary Leakage, uH	Measured between Pin 1 to Pin 2, with all other Windings shorted.	30.33 Goal

Figure 1. PI Transformer Designer Provides Detailed a Transformer Specification Automatically.

Simple to Use Yet Comprehensive

To use PI Transformer Designer, the engineer simply opens a design that has been produced using PI Expert. In the default mode, everything is calculated automatically, and a finished transformer spec is produced without any user interaction. In the fully manual mode, the user makes all of the design decisions. This flexibility allows the tool to be useful to engineers of all experience levels.

PI Transformer Designer provides support for designs that use tape margins and those that use triple-insulated wire to meet electrical isolation requirements. Wire gauges and filar count (the number of parallel strands wound together) are calculated based on many variables including input and output current limits, usable winding window area, etc. The tool also specifies foil windings when it makes the most sense to use them. The number of layers a particular winding occupies in the bobbin is dynamically calculated based on the specific wire / filar combinations or the foil sizes selected. Where necessary, split primary construction is used to reduce leakage inductance and improve efficiency. If directed to do so, the tool also specifies layers of tape between the primary winding layers in order to improve light-load efficiency and reduce no-load power consumption.

To aid the designer in selecting a suitable transformer bobbin, the minimum number of pins required on the bobbin is shown, taking into account the maximum number of individual strands of wire that can be terminated onto a single pin. This helps the user to select a suitable bobbin, and helps to ensure that the finished transformer can be successfully produced in high volumes. Once a bobbin has been selected and the number of actual primary and secondary pins has been chosen, the software automatically updates all of the pin references in the electrical diagram and the winding instructions, reducing the chance of errors.

Shield Windings Defend Against EMI

EMI is always a challenge in power supply design. Engineers often have to resort to expensive EMI filter components to make a power supply meet EMI standards. However with the click of a mouse, the user can incorporate Power Integrations' patented E-Shield winding techniques into a transformer design. The software automatically selects the most appropriate shielding scheme and optimizes it for the specific design. These winding techniques reduce the generation of EMI currents, the need for filter components, and the time and effort it takes to make a supply meet its EMI requirements, which shortens the time to market for the end product. To illustrate this, figure 2 compares the conducted EMI measurements (EN55022 B limits) of the same power supply using a transformer that was built without the E-Shield techniques (plot "a") versus one built with E-Shields enabled (plot "b").

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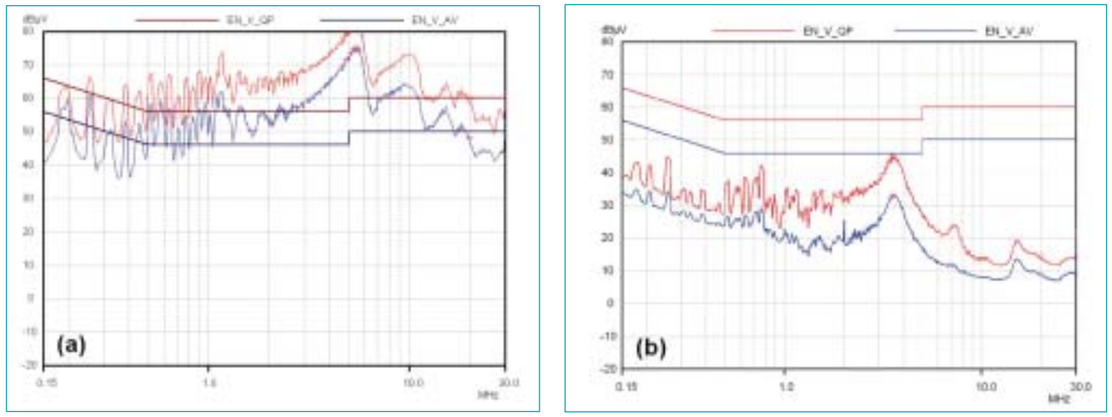

Figure 2. Enabling Shields Has a Dramatic Effect on Conducted EMI.

The difference can be dramatic, with typically 15-20 dBmV of noise level reduction occurring, especially in simple, low-power designs with limited input filtering. For designs where very low leakage currents (<10 mA) are specified, such as chargers for metal-encased cell phones, this reduction in EMI can allow the Y-class capacitor normally used to bridge the isolation barrier to be significantly reduced in value or removed completely.

Optimizing the shielding of a transformer to reach an acceptable EMI solution can take weeks of work, and require the winding of 10, 20 or even 50 transformer samples, each with subtle variations of shielding schemes, winding

arrangements, wire type, and numbers of turns. The process becomes even more laborious if taking EMI measurements means trips back and forth to a local test facility. Thus, this one feature of the software alone can save the design engineer weeks of work.

Speeding Prototypes

Once the transformer design is complete, the results can be used to make a prototype in-house, or sent to a vendor to have samples made. The detailed instructions and diagrams reduce the chance of construction errors. Many magnetics vendors prefer that samples be specified in this way because it eliminates several cycles from the sampling process. The design results can be exported in a variety of formats for documentation purposes. Finally, clicking the Transformer Vendor List button on the tool bar will open a web page that lists vendors who regularly work with PI transformer specifications.

Summary

PI Transformer Designer is the first tool that automatically creates complete transformer designs with detailed specifications. Considering the ever-shrinking design windows that today's marketplace demands, this tool will be indispensable to those who design low-cost, low-EMI power supplies for tomorrow's applications. Finally, can such a valuable tool be affordable?

Since PI Expert Suite 6.0 can be ordered or downloaded for free from the Power Integrations web site, (www.powerint.com/designsoftware) who can afford to pass it by?

www.powerint.com

Simplifying 'Smart' Electric Power Metering

STMicroelectronics has introduced a reference design platform for the emerging market for electronic power meters. Electronic energy meters are replacing traditional electromechanical meters in many residential, commercial and industrial applications because the versatility and low-cost afforded by electronic meter designs allows meter manufacturers to implement many features that were impractical with the older mechanical designs.

By drawing on its portfolio of dedicated and standard products and working closely with industry leaders in the power-metering field. The reference platform provides a modular solution that can be adapted by software to meet the utility company's particular needs. It comprises two printed circuit boards, one dedicated to the mains power measurement functions and one implementing sophisticated computational and supervisory functions. The measurement board supports all current measurement technologies, from the most accurate Rogowski coils to inexpensive shunt resistors. It can monitor both Live and Neutral current for tamper detection and complies with all international standards such as IEC-62052-11 and IEC-62053-2x for metering equipment (AC).

The STPM01 can be used as a stand-alone device in 1-phase kWh meters or as a peripheral in microprocessor-based 1-phase or 3-phase energy meters, in which case active (base and wide), reactive and apparent energy, V_{RMS}, I_{RMS}, instantaneous voltage and current, and line frequency readings are available through the SPI bus.

The Control Board is based on an ST7 microcontroller and is supplied with a library of C-code software, with many additional software routines available free of charge from the ST website. The reference design also includes the M41ST87 real-time clock chip, a 256-kbit serial SPI bus EEPROM and a dedicated 32-character alphanumeric LCD with on-glass driver.

www.st.com/metering

Multi-Output Power Supplies

Power-One has expanded its BLP55 Series by adding the BLP55-3000 and the BLP55-3300 triple-output ac-dc power supplies. These products are ideal for 1U "pizza-box" applications as they are very cost effective and can provide enhanced flexibility in the physical layout and power distribution architecture of the host system.

Host-system physical-layout flexibility is enhanced by reduced airflow requirements (eliminating the need to be directly adjacent to a cooling fan) and a low 1.25" height that reduces airflow shadowing to improve cooling of downstream devices. Power-distribution architecture flexibility is enhanced by the availability of 3.3 and 5V outputs, suitable for any desired combination of bus voltage and/or direct-power usage.

Both models accept a wide-range 85 to 264VAC input, and only need 10 LFM of cooling to provide full-rated power. The BLP55-3000 delivers +5V @ 5A, +12V @ 2.5A, and -12V @ 0.7A. The BLP55-3300 provides +3.3V @ 5A, +5V @ 2.5A, and +12V @ 0.7A. Additional features include a compact 3.00 x 5.00 x 1.25 inch (76.2 x 127.0 x 31.8 mm) package that is compatible with industry-standard footprints and connectors, remote sense, and output overvoltage protection.

Regulatory agency approvals include UL recognition to UL60950-1/CSA 22.2 No. 60950-1 and TUV approval to EN60950-1. Onboard EMI filtering provides Class B compliance to FCC CFR Title 47, Part 15, Sub-Part B - Conducted; and EN55022/CISPR 22 Conducted Class B.

www.power-one.com

Field Stop, Trench Gate IGBT Power Modules

Advanced Power Technology Europe announced a new product line of Field Stop, Trench Gate IGBT standard power modules. These new products broaden our offering of 600V products in the SP3 and SP6-P, and introduce a complete new line of 600V, 1200V and 1700V devices in SP4 and SP6 packages.

All these products offer minimum VCE(sat) saturation voltage (typically 1.5V for 600V, 1.7V for 1200V and 2V for 1700V). They are dedicated to low frequency operation where overall system efficiency is a concern. The ideal switching frequency is 20 kHz for 600V products, 10 kHz to 20 kHz for 1200V products and up to 10 kHz for 1700V products.

These modules are offered in buck, boost, dual buck, dual boost, dual common source, phase leg, full bridge, asymmetrical bridge, triple phase leg and triple dual common source configurations.

Current rating range from 20A to 600A for 600V devices, 50A to 400A for 1200V devices and from 50A to 300A @ for 1700V devices, all rated with Tc=80°C.

Key Features are: Very Low Profile – Same as Industry Package SOT-227 Height for SP3 and SP6-P; Space and Cost Savings - Small Footprint; Solderable Terminals - Easy PCB Mounting for SP3, SP4 and SP6-P Packages; M5 Screw Terminals for SP6; Wide Range of Voltage and Current Ratings; Very Low Inductance; High Efficiency - Low VCE(sat) Saturation Voltage; Very Short Tail Current; Isolated Package - Easy Mounting to Heat Sink and Easy to Parallel - Positive Temperature Coefficient.

Main applications for this extended family are motor drives, Uninterruptible Power Supplies, welders, plasma cutters, solar inverters, inductive heating, solid state relays for three phase mains and other applications where low conduction is of primary concern. The very low profile offering low parasitics inductances makes this product range a component of choice when space, electrical performance, weight and cost are a concern.

www.advancedpower.com

Gas Plasma Arresters

Littelfuse has introduced its Lead-free and RoHS compliant SL0902 series as a new addition to its Greentub family of proprietary gas plasma arresters (Gas Discharge Tube or GDT).

Designed for use in broadband and high-speed telecommunications the SL0902 series, is a miniature gas plasma arrester (GDTs) designed to be a viable alternative to silicon surge protectors when high bandwidth and low capacitance are required. The SL0902 is Littelfuse's smallest "Broadband Optimized" gas plasma arrester. For overvoltage components such as the SL0902, "broadband optimized" means that the product enables performance enhancement through a combination of low insertion loss, no capacitance variation with voltage and temperature, and excellent voltage clamping — all of which are requirements for broadband equipment in order to prevent surge damage while maintaining data integrity. The SL0902 meets these requirements within a very small footprint.

The SL0902 series is designed to work in conjunction with the Littelfuse TeleLink surface mount fuse in applications where both fusing and surge protection are necessary. The small footprint SL0902 series can be accommodated on D0-214AA solder pads, providing that a D0-214AA is present on the board allowing for replacement of a higher capacitance silicon device with the ultra low capacitance SL0902 series.

www.littelfuse.com

ABB Voltage Detector

ABB is producing the first Voltage Detector VD1500, adapted completely to meet the major specifications of the traction market. The new ABB Voltage Detector VD1500 has been designed incorporating a new ABB innovation, a 100% electronic solution. This safety product will be used in applications such as on-board railway equipment (main converters, auxiliary converters) and in power electronics systems (battery chargers, choppers, sub-stations, etc.). It allows the maintenance operator to verify the presence of a dangerous voltage (AC or DC) up to 1500V on any equipment. Dangerous voltage indication is provided via 2 independent LEDs that flash when the voltage detected is higher than a specified limit (maximum 50V according to standards such as CF60-100). The mechanical and electronic concept ensures an excellent reliability of the product through two independent electronic boards (redundancy of the same function in only one product). The Voltage Detector (VD) operates from –40°C up to +70°C. The VD range has been designed to comply with traction standards: EN50155 for high-tech electronic design and tests, EN50124-1 for electrical insulation and EN50163 for voltage. The VD range has also been designed in compliance with safety standard EN50129 for communication, signalling and processing systems.

The ABB Voltage Detector provides a cost-effective solution that is easy to install and use.

ABB has been concerned for long with the protection of the environment and has been ISO 14001 certified in 1998. This environmental approach is particularly noticeable in the production of the VD range with the reduction of the number of components, use of a low-energy manufacturing procedure and recyclable packing.

www.abb.com/lowvoltage

RAD-hard MOSFETs deliver 40% better on-resistance

International Rectifier has launched the R6 line of high-reliability (HiRel) 100V, 150V, 200V and 250V radiation-hardened (RAD-Hard) MOSFETs for power management circuits.

The R6 devices are designed for DC-DC converters, motor controls and solid-state switching circuits with input voltages of 24V to 48V in launch vehicles, satellites and other demanding applications enabling them to be made more compact, reliable and efficient.

For example, the IRHNJ67130, with 0.042Ohms device on-resistance reduces power dissipation in power supply applications. Its low total gate charge of 35nC further reduces power consumption.

The new R6 MOSFETs have SEE ratings to LET of 90MeV and improved prompt dose response and SEE absorption versus other equivalent devices. In addition, the new devices are optimized for use in Hybrid - MIL-PRF-38534 "Class K" modules for satellite applications, including low Earth orbit (LEO), middle earth orbit (MEO), geostationary earth orbit (GEO) and deep space missions. Devices are available in surface-mount as well as new low-ohmic TO-254 and TO-257 packages. Tab-less TO-254 and TO-257 packages are also available.

Radiation reports are available on the HiRel Radiation Reports page: www.irf.com/product-info/hi-rel/radrpt.html

The new R6 mid-voltage RAD-Hard MOSFETs are available immediately and are subject to U.S. export control laws and regulations.

www.irf.com

High Accuracy Current Transducers

LEM has introduced two new members of its IT family of current transducers to address high-current applications. The IT 400-S and the IT 700-S are specified respectively for 400 and 700 ARMS nominal. As with other members of the family, they offer very high accuracy, based on resolution better than 0.05 ppm, linearity better than 3 ppm and an initial offset between 30 and 50 ppm. Thermal offset drift is extremely low, at only 0.5 ppm/K.

Featuring galvanic isolation, the IT 400-S and IT 700-S can be used for current measurement of any kind of waveforms (including DC, AC, mixed and complex). They have been designed to operate from a bipolar +/-15 V DC power supply and will accommodate round primary conductors of 26 and 30 mm diameter respectively.

In addition to their normal current output, the transducers offer an additional output indicating the transducer state (opened or closed contacts), and an external LED showing the normal operation.

With an operating temperature range of +10 to +50°C, the transducers will find applications in high-precision power supplies and high-performance gradient amplifiers for MRI (Magnetic Resonance Imaging), as well as medical equipment such as medical X-Ray imaging, but also calibration test benches in laboratories and test departments. They can also be used as interfaces for power analysers when high accuracy is required.

www.lem.com

Efficient PFC/PWM Controller

Continuing to provide power supply manufacturers with innovative ways to reduce power consumption, ON Semiconductor (NASDAQ: ONNN) today introduced the NCP1603 – a combo PFC/PWM controller with integrated standby and high voltage startup capabilities.

The NCP1603 combines a power factor correction (PFC) controller chip and a pulse width modulation (PWM) control chip in a single, 16-pin SOIC package. This combination simplifies the task of designing an offline, ac-dc power supply that simultaneously meets governmental requirements for power factor correction and low standby power consumption. Target applications for this device include products such as notebook and LCD adapters, and other consumer electronics.

In these applications, PFC is typically required when a power supply is operating under normal load conditions. However, in light-load and no-load conditions, a PFC is not required and generates losses that make it almost impossible to meet the limits on standby power consumption established by the California Energy Commission, Energy Star, and other organizations.

Under light load conditions, the NCP1603 PWM controller disables the PFC function, saving in the range of 200 milliwatts (mW) of power. Currently, the most aggressive standards limit standby power consumption to 500 mW with plans to lower this limit to 300 mW in the future. Given those goals, the power saved by turning off the PFC is significant. Moreover, disabling the PFC ensures that the controller can meet even the 300 mW limit for standby power.

www.onsemi.com

Fast and Rugged Power MOSFET Technology

IXYS announces the release of a new family of 100V to 600V Standard and HiPerFET Power MOSFETs based on IXYS New Technology Platforms, PolarHT and PolarHV incorporating a proprietary cell-design that reduces on-resistance by 30%, enabling improved efficiency.

IXYS' proven HiPerFET process yields Power MOSFETs with a fast intrinsic body diode for low Qrr and enhanced dV/dt ruggedness. IXYS' HiPerFETs are targeted at hard switching inverter and power supply applications. These products are currently finding significant use in demanding IT and telecom switch-mode power supplies that require efficient switching and energy conversion in tight enclosures, as well as applications where high reliability is critical.

The PolarHT line is available to support applications requiring voltage ratings from 100V to 300V, ranging across a broad spectrum of consumer, industrial and automotive markets. Examples include telecomm switch mode power supplies and motor drives for the industrial market, plasma display and audio amplifiers for consumer applications and ignition systems and electric vehicles for the automotive market. These devices bridge the gap between high voltage technology and low voltage Trench MOSFETs.

PolarHV starts at 500V and 600V, with extension to higher voltages planned. IXYS offers one of the broadest ranges of current ratings, with product extending from 1A to 80A and above. Products will be offered in various standard packages, including the full spectrum of surface mount and discrete packages.

www.ixys.com

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Six-Channel Backlight Charge Pump from AnalogicTech

Advanced Analogic Technologies (AnalogicTech) has introduced the AAT2803, a multi-function, high efficiency, dual charge pump that supports both white LED backlight and camera flash applications for portable systems that run on lithium-ion/polymer batteries. The device offers independent control of three separate LED banks (two for backlight and one for camera flash) and features seven channels total (six for backlight and one for camera flash). The AAT2803 delivers major power and space savings for handsets featuring two displays, and adds a light load mode to minimize power consumption when the handset display is active in standby mode.

Most of today's handsets feature two displays, either in a clamshell design with a main display on the inside and a secondary display on the outside or in a bar design with a main display and a keypad backlight by combining independent control of two separate banks of backlight LEDs with flash capability and a light load mode in a single device, the AAT2803 charge pump helps designers minimize power consumption while reducing component count and package size.

www.analogictech.com

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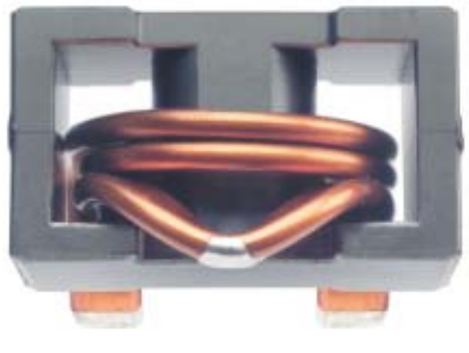
Our new 100 Amp power inductors should make everyone smile



Especially if you're working on low voltage, high current power applications!

Our new SER Series inductors are available with ratings up to 100 Amps *(actually, they aren't even* close *to saturation at that current)* which lets you maximize your current per phase. DC resistance is low and tight, with less than 5% tolerance. The cores exhibit no thermal aging. And their flat wire, self-lead construction assures maximum density, reliability and heat transfer.

Coilcraft's SER Series inductors are available with L values from 0.3 to 10 µH. Or we'll design a part for your specific L and current requirements.

For complete specifications, SPICE models and free evaluation samples of all our new SER inductors, visit us at **www.coilcraft.com/ser11**

Coilcraft

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CAN YOUR BRICK DO THIS?

IR's DC Bus Chipset Enables Bricks With $48V_{in}$, $9.6V_{out}$, 330W at 97% Efficiency

Full-Bridge Bus Converter Chipset (IRF6646, IR2086S, IRF6635)
$48V_{in}$ / $9.6V_{out}$ / 175kHz

Full-Bridge DC Bus Converter Reference Design
IRDC2086S-DF2

International Rectifier's new power management DC Bus converter chipset delivers $48V_{in}$, $9.6V_{out}$, over 330W at 97% efficiency for networking and telecommunications systems.

- Single DirectFET MOSFET can replace two SO-8 devices
- Reduces component count by >45%
- Achieves up to 1.5% better efficiency compared to industry standard quarter brick form factors
- Reduces temperatures up to 40°C
- Board space reduced by 29% vs. quarter brick form factors
- Industry Best $R_{DS(on)}$ for IRF6644 (13mΩ), IRF6646 (9.5mΩ), IRF6635 (1.8mΩ)

Design Services available at www.mypower.com

New DC-DC Chipset Solution from International Rectifier

DirectFET™ MOSFETs

Part #	Package	V_{DSS}	$R_{DS(on)}$ max @ V_{GS}=10V	Q_G Typical	Q_{SW} Typical
IRF6644	Medium can	100V	13mΩ	35nC	11.5nC
IRF6655	Small can	100V	62mΩ	8.7nC	2.8nC
★ IRF6646	Medium can	80V	9.5mΩ	36nC	12nC
IRF6613	Medium can	40V	3.4mΩ	42nC	12.6nC
IRF6614	Small can	40V	8.3mΩ	19nC	6.0nC
★ IRF6635	Medium can	30V	1.8mΩ	47nC	17nC

Control IC

Part #	Package	Voltage Rating	Description
IR2085S	SO-8	100V	Primary-side half-bridge control IC, fixed 50% duty cycle, self-oscillating
★ IR2086S	SO-16	100V	Primary-side full-bridge control IC, fixed 50% duty cycle, self-oscillating

★ – IR product featured in Full-Bridge Bus Converter reference design above

IR's proprietary DirectFET technology is covered by US Patent 6,624,522 and other US and foreign pending patent applications.
DirectFET is a trademark of International Rectifier.

for more information visit us at
www.irf.com/eu

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