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Power Systems Design
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Power Control Intelligent Motion
November 2005

Integration of Power Devices

Power Line
Power Player
Marketwatch Exclusive:
iSuppli Dissects New Xbox 360
Industrial Electronics II

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Power Systems Design EUROPE

Viewpoint

Industry News

PSDE PowerLine

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Marketwatch

Cover Story

Features

Industrial Electronics II

New Products

Power Systems Design Europe

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Volume 2, Issue 9

Change in Temperature

The first signs of cold weather makes me wish I was back in California. The California trip gave me a new perspective of what the "new world" does different than the "old world". It was special for me to have the opportunity to meet with some of the steering committee members of Power Systems Europe Magazine. The wisdom of age, Mr. Eric Lidow the founder of International Rectifier has always something fascinating to tell me. Mr Lidow started his career in the "old world" before semiconductors had been the efficient switches for electronics. His work and his company in the "new world" has made a major contribution for semiconductors for more efficient use of energy resources. In the beginning IR started with the discretes in electronic. The industrial side is important for discrete electronics and this issue has part II of our focus on the applications in industrial electronics. Here is a quick synopsis of this month's technical features.

Mitsubishi reviews the power chip concepts such as Reverse Conducting IGBT (RC-IGBT) and Reverse Blocking IGBT (RB-IGBT). Both are an integration of the IGBT and the Diode into one chip.

To improve performance and reduce the size and cost of power electronic systems, the development trend in high power semiconductors continues towards higher current and voltage capabilities. The IGCT is no exception and in ABB article, the high SOA capability of a new range of IGCTs with voltages up into the kilovolt range is described.

By managing the Miller effect in an active way and using a 2-step turn-off sequence, new devices from STMicroelectronics simplify IGBT driving, and help system designers to build reliable and cost-effective solutions for 1200V 3-phase applications.

Eupec developed a novel 600 V/0.3 A 6-pack IGBT/MOSFET driver IC named 6ED003L06-F based on the SOI technology. It realizes 3-phase level-shift, gate drive and protection functions in a single IC with reduced chip size and improved performance such as the robustness to negative transient voltage.

IR's One Cycle Control (OCC) eliminates the requirement for a sinusoidal current reference. Instead, by assuming the modulation voltage produced by the voltage error amplifier is constant during a given switching cycle.

The LTC3455 seamlessly manages power flow between an AC adapter, USB cable and Li-ion battery, while complying with USB power standards, all from a 4 x 4mm QFN package for portable applications.

The LinkSwitch-LP family from Power Integrations is designed specifically to replace unregulated supplies that deliver up to three watts of power. Supplies using these new ICs require only 14 components, making them the simplest switched-mode chargers available anywhere.

This first version of VD1500 detector from ABB allows the operator maintenance to check the presence of a dangerous voltage up to 1500V d.c. nominal or 1000V a.c. under certain conditions.

As always, I hope to see you at one of the upcoming trade events.

Best regards,

Bodo Arlt
Editorial Director
The Power Systems Design Franchise

Dr. Werner Faber Appointed to EPCOS Management Board

Dr. Werner Faber (57) has been appointed by the Supervisory Board to the Management Board of EPCOS AG with effect from November 1, 2005. He will hold the position of Chief Technology Officer (CTO). Faber will also be responsible for the three divisions Surface Acoustic Wave Components, Ceramic Components, and Capacitors.

Over more than 25 years, Dr. Werner Faber has acquired extensive experience in passive electronic components. After studying physics in Aachen and gaining a doctorate in Bochum, he began his career in 1980 at the Siemens Components Group in Munich. In 1984, he was promoted to head of development of surface acoustic wave (SAW) filters, taking charge of production of these products in 1986. In 1990, Faber became deputy head of SAW filter operations in the joint venture Siemens Matsushita Components.

Faber subsequently served as President of the Film Capacitors Division in Málaga, Spain, from 1996, and of the Capacitors Division in Heidenheim, Germany, from 1999. He has been in charge of the SAW Components Division of EPCOS since 2001 and, additionally, the Capacitors Division since 2004.

www.epcos.com

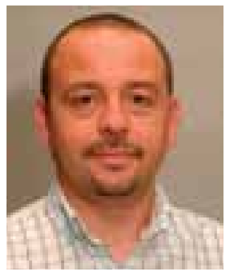
APEC 2006 Moves to Dallas

The Applied Power Electronics Conference (APEC), the premier global event in power electronics, has been rescheduled to the week of March 19-23, 2006 and relocated to the Hyatt Regency Hotel in Dallas, Texas. The conference is jointly sponsored by the Institute of Electrical and Electronic Engineers (IEEE) Power Electronics Society (PELS), the IEEE Industry Applications Society (IAS) and the Power Sources Manufacturers Association (PSMA).“The devastating effect of Hurricane Katrina on the city of New Orleans has made it necessary for the APEC executive steering committee to secure an alternate venue for next year’s conference and exhibition,” said Kevin Parmenter, publicity chairman for APEC 2006. “We are truly saddened by the hurricane’s devastating impact on New Orleans and the whole gulf coast region. At the same time, we’re grateful for the support that the city of Dallas and the Hyatt Regency Dallas have shown in accommodating our conference needs on such short notice,” Parmenter added.“The regions many leading producers, consumers, designers and distributors of power electronic products and components make the Dallas/Ft. Worth area an ideal venue. As in previous shows, this year’s event in Austin saw conference participation climb with 328 peer-reviewed papers presented by speakers from 28 countries, a growth trend we fully expect to meet and exceed next year in Dallas,” he said.

Now in its 21st year, APEC's continuing popularity is due in large measure to its unique combination of high-quality technical presentations and the collegial, informative atmosphere in which a broad spectrum of manufacturers can exhibit their latest product innovations. Popular with conference attendees, lively “rap sessions” feature panelists and audience members engaging in lively exchanges about emerging technologies and often controversial subjects.

www.apec-conf.org

Arrow Appoints Steve Session for Power Supply Business



Arrow Electronics has further strengthened support for its growing UK power supply business with the appointment of Steve Sessions as PSU marketing manager.

In his new role, Steve is responsible for supporting Arrow sales and technical teams in meeting the growing demands for PSU product and support throughout the UK and Ireland. Key to this new role will be building and strengthening relationships with Arrow’s power supply customers and suppliers.

Steve brings many years of experience of both power supplies and the distribution channel to his new Arrow role, and most recently was the European business unit manager for power supplies at Eurodis. Prior to this Steve spent 10 years running the power supply business at Acal.

Commenting on the new appointment, Chris McAneny, Arrow’s northern European marketing director, states: “Arrow has always combined a broad range of power supply products with comprehensive technical support. This new appointment further increases our focus on PSUs, and will help us to address the growing demand we are seeing from the UK market.”

www.arrowne.com

Fairchild Motion-SPM Chosen by Toshiba Carrier

Fairchild Semiconductor announced that Toshiba Carrier Corporation, a leading global manufacturer of industrial and household air conditioners, has selected Fairchild’s Motion-Smart Power Module (SPM) for its air-conditioning systems. The FSBS10CH60, which integrates 16 discrete devices in a compact and thermally efficient Mini-DIP package, optimally drives Toshiba Carrier’s highly energy-efficient DC rotary compressor.

Fairchild’s Motion-SPM devices integrate three high-voltage ICs (HVICs), one low-voltage IC (LVIC), six IGBTs and six fast-recovery diodes (FRDs) into a compact transfer-molded package.

Fairchild offers the most comprehensive portfolio of power modules covering the full range of consumer appliances from 50W to 3kW. The Motion-SPM series is an example of how Fairchild is leveraging its design and manufacturing expertise, as well as its deep understanding of the markets it serves, to offer highly integrated solutions that meet specific application requirements.

www.fairchildsemi.com

Power-One RoHS Lead-Free Products

In accordance with the full range of compliance options described in the European Union's RoHS Directive, Power-One is offering products in lead-free and lead-solder-exempted versions. This two-tiered strategy provides customers with compliance choices that will not be offered by all power-system manufacturers. This strategy also provides a migration path from lead-solder-exempted to lead-free products in the event that the lead-solder-exemption should expire when reviewed by the European Union in three years.

Power-One's RoHS-compliant lead-free-solder (comprised of tin, silver, and copper) process has been rigorously tested through 6,000 temperature cycles without any failures. Because there is still some industry concern regarding the long-term reliability of lead-free-solder joints in high-availability infrastructure applications, a number of companies, especially in the communications industry, have chosen to exercise the lead-solder exemption at this time.

RoHS-compliance certificates are available at www.power-one.com by selecting the green "RoHS Update" link. All Power-One products are scheduled to be RoHS-5 compliant by the European Union's July 1, 2006 deadline, with most being completed before January 15, 2006. No special part number designations will be required when ordering RoHS-5 products. RoHS-6 compliant versions will be designated with a "G" in the part number suffix. A listing of all product families scheduled for RoHS-6 compliance is available on the Power-One web site.

www.power-one.com

Freescale Automated Meter Reading System

Utilizing the Freescale Semiconductor ZigBee-compliant platform, NESA, a leading Danish Electricity company, will deploy the first ZigBee-enabled system for Automated Meter Reading (AMR) in Europe. This heralds a new method for automated communications updates to utilities and energy and security-conscious consumers. The innovative system uses Freescale's ZigBee-compliant platform along with system design by alliance partner Develco. Develco is an independent design house specialized in product engineering and integration of ZigBee.

The AMR system provides utility companies the ability to wirelessly monitor electricity usage. Additionally, consumers will have the capability to monitor and control home appliances and receive home intruder alerts remotely through short messaging system (SMS).

As other manufacturers deploy the ZigBee standard, the NESA system will expand its level of service to include additional features such as allowing customers to access and control the temperature of their home and receive security alerts while they are miles away, or even in another country.

NESA expects to deploy the automated meter system to all its customers in Q4 of 2005 in Denmark, followed by further adoptions in the Nordic region expanding through Europe.

www.freescale.com

www.nesa.dk

www.develco.com

ON Semiconductor Launches New Website

As part of its ongoing commitment to effectively support its customers world-wide, ON Semiconductor has launched a re-designed corporate website with improved access to product information, design support materials, and both product availability status and budgetary pricing quotes.

The updated www.onsemi.com Home page puts design engineers no more than two "clicks" away from specific product information and full parametric data. The "Design Support" page offers a comprehensive list of links to critical support materials - including evaluation boards, simulation tools, reference designs and more.

An expanded "parametric" search capability gives designers and purchasing agents tremendous flexibility in searching for products to meet their specific needs. Additionally, it enables them to simply compare functionality among similar products. This new parametric search function enables the user to filter the table on all parametric data – from voltage and temperature rangers to packages offerings. Basically, users can add and delete columns of information, reorder columns and download the results to either a spreadsheet or a database.

Another core improvement is that the web-site's overall "keyword" search capability has been greatly refined and expanded. Now, using only keywords, customers can quickly locate all relevant part numbers, design support materials, documents and press announcements related to the products they are researching.

www.onsemi.com

Power Events

- ***EMV 2006,*** *March 7-9, Düsseldorf www.mesago.de*
- ***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*
- ***SMT/HYBRID 2006****, May 30-June1, Nuremberg, www.mesago.de*
- ***SENSOR/TEST 2006,*** *May 30-June1, Nuremberg, www.sensor-test.de*
- ***MICROSYSTEM,*** *October 5 –6 , Munich, www.mesago.de*
- ***ELECTRONICA 2006,*** *Nov. 14 – 17, Munich, www.electronica.de*
- ***SPS/IPC/DRIVES 2006,*** *Nov. 28 - 30, Nuremberg, www.mesago.de/sps*

TI Unveils Next-Generation Point-of-Load Power Modules with Ultra-Fast Transient Response

High-performance power converters reduce capacitance by 8x and occupy a 50 percent smaller footprint

Texas Instruments has announced a family of non-isolated, plug-in power modules with a new technology that provides ultra-fast transient response rates and dramatically reduces engineers need for output capacitors. Featuring a tight 1.5 percent output voltage regulation, the point-of-load modules offer increased performance in a smaller footprint for designers of 3G wireless infrastructure, networking and communication systems that use advanced DSPs, FPGAs, ASICs and microprocessors.

High-end communication system designers continue to develop systems with complex power requirements that must support more functionality, yet meet lower processing core voltage levels. To help engineers meet these challenges, Texas Instruments has introduced this new generations of state-of-the-art, plug-in power modules that leverage their analog manufacturing and power system expertise and understanding of future digital signal processing power requirements.

Extending TI's popular line of PTH devices, the new T2 series of point-of-load modules will support step-down DC/DC conversion from a wide 4.5 V to 14 V input with adjustable output voltages down to 0.7 V at output currents up to 50 A making them ideal for intermediate bus architecture (IBA) applications. The power modules offer several advanced features to reduce the overall power solution footprint by as much as

50 percent compared to TI's previous generation devices.

Faster Transient Response and Less Output Capacitance

Advanced processing platforms, such as TI's new 1-GHz TMS320TCI6482 DSP for 3G wireless base stations, requires extremely fast transient responses for a system to perform at a high-level. To achieve certain transient targets, thousands of microfarads of capacitors must be added to most power supply systems. Even with higher volumetric efficiency, the added level of capacitance may expand the size of the overall power solution to more than that of the power supply alone - space that may have not been budgeted for or available.

The T2 power modules feature an innovative new TurboTrans™ technology, which allows a power supply designer to dynamically "tune" the modules using a single external resistor to meet a specific transient load requirement. The end-result is faster transient response with 40 percent less output voltage deviation and a five to eight times reduction in output capacitance. In addition, system stability is enhanced when using ultra-low equivalent series resistance (ESR) polymer tantalum or ceramic capacitors.

Increased Performance and Design Flexibility

In addition to TurboTrans technology, the T2 modules incorporate an innovative SmartSync function that allows the designer to synchronize the switching frequencies of multiple T2 devices to maximize power efficiency and minimize electromagnetic interference (EMI). SmartSync also allows the T2 modules to synchronize at different phase angles using external circuits to help balance source loading and minimize input capacitance. The synchronized modules also make EMI filtering easier by eliminating beat frequencies.

Additional features of the T2 modules include TI's proprietary Auto-Track™ sequencing technology, which allows multiple modules to power up and down in sequence without external circuitry. The unique Auto-Track sequencing feature permits non-isolated power modules to track each other or any external control voltage. Meeting 260C re-flow requirements, the T2 series also provides advanced pre-bias startup capabilities.

www.ti.com

High Temperature Packaging, Problem or Resource?

By Dr. Thomas Stockmeier, Semikron

The intensified need for high temperature packaging is driven by the automotive industry. The vehicle liquid cooling system should be used to cool the power electronic drive system. This is in particular true for highly integrated systems which are planned for the next generation of hybrid vehicles. The specification calls for 110°C cooling liquid and higher.

To get efficient cooling means power semiconductors at junction temperatures of 175 °C and higher. Although recently IGBT and diodes in 600V and 1200V have become available with such a maximum specified junction rating, in practice many designers may stay approximately 25 °C below the maximum to give some margin to the design. Therefore, despite an already sufficient rating, some improvement on the IGBT and diode chips is still needed.

In addition, the packaging still has some miles ahead to meet the requirements: Although the plastic housing content may be greatly reduced by sophisticated mechanical integration, the interconnect techniques such as wire bonding and soldering will either have to be greatly advanced or have to be replaced.

Some technologies are already available. Pressure contact systems can be used to replace the large area solder joint between the electrically isolated substrate and the base plate or heat sink. In pressure contact technology, the power terminals are pressed down to the substrate to provide electrical contact and simultaneously press the substrate to the heatsink, enabling the thermal contact. By careful selection of design and material, such cost effective pressure contacts can work reliably over a very long time – even at high tempera-

tures. And they are particularly suited for extreme shock and vibration conditions.

The remaining solder joint between chip and substrate can be replaced by new technologies such as electrically conductive glue or low temperature joint technology, where a silver layer is formed between the materials in contact under moderate temperature and high pressure.

In a next step towards high temperature packaging, the widely used thick wire bond technology needs some improvement. Although the technology is very flexible and cost effective, this type of interconnect exhibits degradation over time, in particular if the application calls for extended thermal cycling and high ambient temperature. A replacement of the ultrasonically bonded wires by ribbons provides some improvement without changing the technology.

All of the above provides solutions for power semiconductor devices at high temperatures. But there are more weak links in the system to address. One is the gate drive and protection technologies. Recently, remarkable progress has been made by employing SOI technology for gate drive ICs. Circuits which are latch-up free up to 200 °C have been demonstrated.

In current sensor technology, a cost effective sensor will be needed, operating at high temperature and exhibiting lower power consumption to not generate extra heat from the driver power supply.

Although today´s printed circuit board technology may prove to be sufficient for the future high temperature need, it will greatly depend on where the circuit boards are located within the integrated system to yield a reliable, cost effective solution.

A big obstacle which remains is a suitable DC-link capacitor which can provide sufficient lifetime at high ambient temperature. Because of its size, the capacitor will have to be specially formed to fit into such a homely compartment as a gear box – with all the challenges associated with it.

When all technical and commercial issues in power devices, interconnect and housing technology, sensing, driving and controlling have been resolved, the automotive industry will have a reliable and robust solution at hand to effectively provide benefits to their customers such as improved fuel economy in city traffic and the feel and fun of driving a hybrid car.

However, there is also another large beneficiary of all these advances in technology which is the motor drive industry. AC drives employing high temperature technology can be significantly more cost effective thus accelerating the trend of replacing DC drives across all power ranges. And this will ultimately lead to a large saving in electrical power.

www.semikron.com

New Xbox: Power Design a Win for ON—and for Discretes

iSuppli teardown analysis reveals a plethora of discrete FETs

By Chris Ambarian, Senior Analyst, iSuppli Corporation

Microsoft Corp.'s brand-new Xbox 360 debuted in November, sporting more processing power than any video-gaming console to date, and in turn requiring more current from the DC/DC sections to supply those processors.

There has been a lot of speculation in the power-supply world about the design of the next generation of video-game consoles. Rumor has it that a certain company will be supplying a phalanx of converter modules to Sony for its upcoming PS3 release next year. Thus, iSuppli Corp.'s Teardown Analysis Service has been waiting anxiously to crack open this first new console from Microsoft to see what its power-management strategy is.

A peek under the hood of the new Xbox 360 reveals that the buck converters that supply the current to the console's powerful new microprocessor and graphics chips are laid out on the board in discrete form using venerable TO-252 (D-Pak) power MOSFETs. All of the layout and thermal management was achieved on the main circuit board, with no hybrid or integrated packaging, and no heatsinking.

ON inside

iSuppli is estimating that 10 million Xboxes will be sold in 2006, every one containing seven buck converters and each using some combination of 22 D-Pak 20V MOSFETs to do the bulk of the DC/DC conversion, plus a few linear regulators and LDOs thrown in for good measure. In the Xbox 360 dissected by iSuppli, ON Semiconductor has the bulk of that MOSFET business—by far.

ON Semiconductor won most of the controller and IC business as well. In the Xbox 360 analyzed by iSuppli, ON's NCP5425DB dual sync buck controller, its NCP5331FTR2 2-phase controller/driver and a half-dozen of its LDOs were found. That leaves only a half dozen or so other parts to be shared among fellow Xbox 360 suppliers Philips, Vishay, Analog and Samsung. Figure 1 presents a photo of the XBox 360 motherboard, showing the microprocessor and GPU chips being literally surrounded by the D-Pak MOSFETs that are supplying their power.

Figure 1. Photo of the XBox 360 motherboard, showing the CPU and GPU chips being literally surrounded by D-Pak MOSFETs that are supplying their power.

These findings bring up several issues that are of interest to designers and strategic procurement people who are in the decision chain for similar projects.

Discretes, or modules?

The first issue is the overall project-management decision of whether to use discretes or complete converter modules in a design.

One of the areas of great excitement in the industry now is the number of suppliers entering the DC/DC module business. For system designers who face space or time constraints, and who can meet their cost requirements using off-the-shelf DC/DC converters, this is an attractive route to take. With just a few clicks at the right website, a converter design can be mostly completed and optimized for space.

Conversely, if a designer has time and resources, and a huge production volume to amortize costs over, it may make sense to spend a lot of effort to drive every last little bit of cost out of the power supply by optimizing a custom design. And, generally speaking, if a designer has enough space to work with, he can employ lower power-density discrete designs to minimize his costs.

That certainly appears to be what Microsoft has done here, freeing up space in the main console by moving the AC/DC section outside the box and by providing enough circuit board to allow traditional low-cost discrete packaging and assembly techniques.

Discrete advantages?

Second, there's the question whether a designer can capitalize on what "going discrete" potentially offers.

Cost and second-sourcing likely are key considerations in which discretes might have a potential advantage. Certainly for Microsoft, which like other game-console manufacturers loses money on each console shipped, achieving the absolute minimum cost that can be achieved in any given form factor is a key criterion. Likewise for Microsoft's equipment assembly subcontractors, which have operating margins in the neighborhood of 1 percent, any costs that can be driven out must be driven out. Given the very high volumes on these products, it can thus confidently be presumed that Microsoft put a critical eye on the subject of DC/DC point of load conversion.

In the face of this scrutiny, discrete D-Paks apparently have been deemed to be Microsoft's best option in this form factor. That is a strong statement for similar applications, and it issues a significant challenge to any technologies that wish to succeed in this market. In power, cost is still king.

Having said that, second-sourcing is also a significant criterion on projects that are not even as large as the Xbox 360, and strategic procurement groups often will dictate that multiple sources be specified in order to ensure reliable supply and to encourage competition for the socket. Despite the existence of the DOSA and POLA alliances, DC/DC converter modules for the most part have not really been truly second sourced (i.e., functionally swappable).

So in theory at least, commodity discretes should have an advantage in this area. However, according to an ON Semiconductor spokesperson—although Microsoft intended to have multiple sources for the power FETs, and even though in theory it is possible to have multiple sources for D-Pak power FETs—it is looking more and more like ON will in fact be the sole source for the Xbox 360.

It remains to be seen whether this is an artifact of something non-technical—e.g., limited supply from other suppliers, or better pricing from ON, or other terms—or of something technical, such as "other parts don't switch correctly in our circuit," etc. The point here is that if second sourcing is one of the desired benefits in going with discretes, good technical due diligence is required in order to ensure that multiple vendors' parts actually do work as fungible alternatives in a converter design.

Getting Technical

And then there are the definitely technical considerations: How much performance can be delivered, and how?

In the case of the new Xbox, in going with discrete D-Paks, Microsoft's power designers took a nifty building-block approach to spec'ing transistors in which the number and type of D-Paks used is varied according to the needs of the load. Some of the converters use two FETs (one per switch), one optimized for switching and the other for conduction. Others use three FETs (two in parallel for the conducting FET). Still others use four FETs—two in parallel for each switch—and on some, FETs optimized for switching were nonetheless used for conduction in order to minimize the cost.

This is a good example of cooperation between engineering and procurement to optimize the bill of materials. The Microsoft power designers managed to facilitate probably four or five different regulator ratings on the board using only two FET part numbers and effectively minimizing their cost.

Even the thermal management is an exercise in wisdom in overall costs. If you realize that only 10 to15 percent of the heat in the system is coming from the power MOSFETs, it definitely looks inappropriate to spend a tremendous amount of money thermally managing them. And Microsoft doesn't.

The heat from the power MOSFETs is conducted through heavy traces into the large, openly-laid-out main circuit board—which just happens to be directly in the path of the main cooling air stream that comes in to cool the fully-heatsinked processor chips that are generating the real bulk of the heat in the box.

So overall, the regulator functions accomplish their job at an apparently good cost point. The only questionable design decision iSuppli noticed in the Xbox 360 was that a large amount of output cap was used, a traditional but expensive practice. Given some of the latest fast-responding controller chips, this looks like a brute-force approach that perhaps could have been improved upon, but that is speculation. This may still have been the lowest-cost route and Microsoft has plenty of space available in the box.

In summary

There are a limited number of products such as the Xbox 360 that are both high-cost and high-volume, products for which the pressure to optimize for the application conditions are at their absolute maximum. And in the face of that pressure to optimize, tried-and-true discrete power devices have won the day in this video game console, suggesting that there's probably quite a bit of life left in them yet.

It will be interesting to see how the other game consoles' power sections have been designed.

Christopher Ambarian is a senior analyst with the market research firm iSuppli Corp., El Segundo, Calif.

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www.iSuppli.com

Integration of Power Devices

A view into the future

Power chip concepts such as Reverse Conducting IGBT (RC-IGBT) and Reverse Blocking IGBT (RB-IGBT)are up for review. Both are an integration of the IGBT and the Diode into one chip.

By Toru Araki and Robert Wiatr, Mitsubishi Electric Corporation

The RC-IGBT will have a significant impact on the power module market due to a more efficient use of resources such as less silicon, lower production energy and reduced packaging materials. Moreover, with these semiconductors, Power Control Systems such as AC Matrix Converters with no need for large DC link capacitors come within reach.

High Voltage ICs (HVIC) are already used to realize a simple gate drive circuit in the low power area. By employing HVICs, a single gate power supply is sufficient for driving all six inverter switches.

With the transfer-mold package Mitsubishi has developed a novel module packaging concept utilizing a new thermal dissipation structure. This allows a reduction in package size and weight. Consequently the new package will save resources of packaging, logistics and energy for transportation.

This new power module, whose key concept is “Environmental Compatibility”, will be a combination of RC-IGBT (or RB-IGBT), HVIC and new packaging technologies. The Key Word “Environmental Compatibility” is indicating the new power device’s direction: saving resources.

Environmental Compatibility Concept

The reduction of power losses in power devices has always been the top priority. Therefore “low loss” is still the major criterion for the development of new power switches. However, recently “low noise” has gained high importance too, because of the desire to reduce the size of the noise filter and the “ease of use” concept for developers.

The “ease of use”-strategy is very important in order to enlarge the market of power devices. The particular items “Small Size” and “Light Weight” are key points in the “ease of use”-strategy. They also contribute to the saving of resources in packaging, logistics and energy for transportation. The most important topic today is the reduction of hazardous substances in order to meet the RoHS directive. By using the new transfer-mold packaging technology, it will be simple to realize lead-free packages without additional cost.

Eventually the “Environmental Compatibility” concept will bring the total cost down for both—the power module manufacturer and the customer.

Table 1 specifies the core principles of Mitsubishi Electric’s “Environmental Compatibility” concept as well as the technological approach to realize these principles.

Power Chip Technology

A large part of the latest power chip technology is based on the thin wafer process. This will make a significant contribution to the characteristic improvement of conventional IGBTs. An important property for IGBT evaluation is the trade-off relationship between On-state Loss (VCE(sat)) and Switching Loss (Eoff). By utilizing the thin wafer process technology, an improvement of

Target	Technology	Realisation
Low Noise	• RC-IGBT • Gate drive IC • Low inductive package	• Thin wafer process technology • Soft switching technology • Direct lead bond technology
Low Loss	• RC-IGBT, RB-IGBT • Low resistive emitter wire	• Thin wafer process technology • Direct lead bond technology
Light Weight	• Transfer-molded package	• Transfer-molded packaging technology with insulating sheet
Small Size	• RC-IGBT • HVIC • Transfer-molded package	• Thin wafer process technology • Submicron process technology in HVIC • Transfer-molded packaging technology with insulating sheet
Reducing hazardous substances	• Transfer-molded package with Pb Free solder	• Transfer-molded packaging technology with insulating sheet

Table 1. New Technologies for Environmental Compatibility

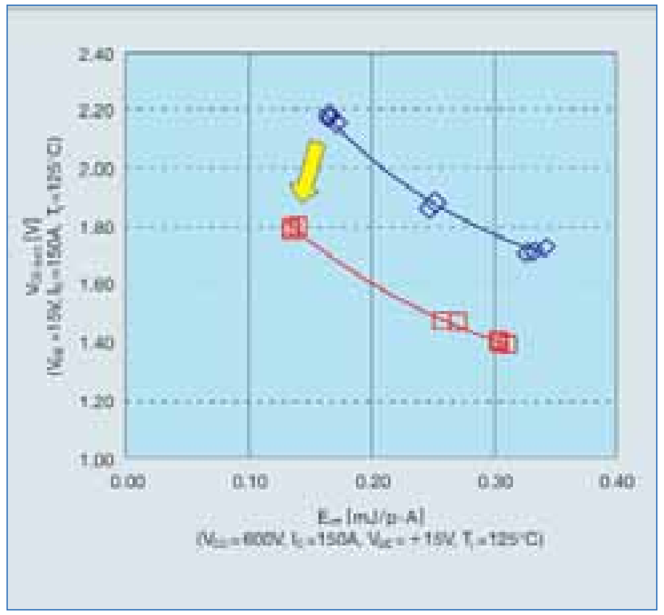

Figure 1.VCE(sat) vs. Eoff Trade-off characteristics for 1200V IGBTs.

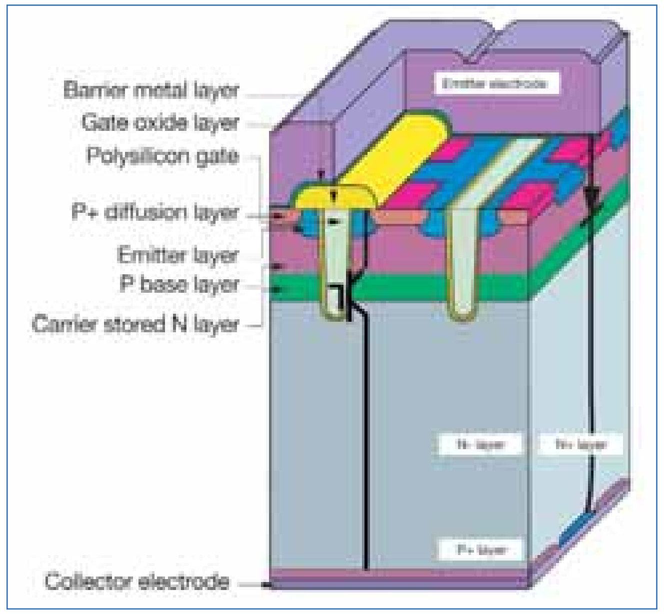

Figure 2.Three Dimensional Cross Section of the RC-IGBT.

this trade-off relationship by about 20% can be achieved (see Fig. 1).

Furthermore, by using the thin wafer process technology, a new IGBT concept can be realized by integrating the IGBT together with a diode in a single chip. The first integrated IGBT with a diode is the Reverse Conducting IGBT (RC-IGBT). This is an integrated trench gate IGBT with a paralleled Free Wheeling Diode (FWD). Fig. 2 shows the three-dimensional cross-section of the RC-IGBT.

Usually, the conventional voltage source inverter system comprises twelve power elements, six IGBTs and six FWDs (see Fig. 3). However, by using RC-IGBTs, the number of power elements is cut by half, with only six RC-IGBTs in the inverter. This fact has a significant effect on power module packaging. It allows either a reduction of package size or almost a doubling of chip size for an existing package. Use of the RC-IGBT is one of the “Environmental Compatibility” concepts.

On the top of RC-IGBT there is a trench gate IGBT, while a striped n-region and a striped p-region are located independently of each other on the underside of RC-IGBT.

During IGBT operation, the striped p-region on the RC-IGBT’s underside works as collector of the IGBT. In FWD operation, the n-region on RC-IGBT’s underside functions as cathode of the FWD. Hence, the RC-IGBT alternates between IGBT and FWD operation and the junction temperature swing is lower resulting in an improved power cycling lifetime. This new RC-IGBT structure has been realized recently by using thin wafer process technology.

Figure 4 shows a comparison between the power chip bonding areas of a conventional IGBT with FWD and the RC-IGBT. By using RC-IGBT, the number of emitter wires is almost reduced by half. Therefore the wiring inductance is low. Because of the reduction of the PN junction area by about 40%, the junction capacitance is reduced as well.

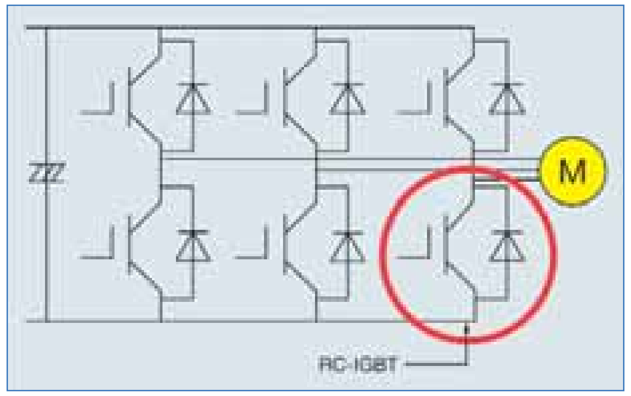

Figure 3. Inverter Circuit configuration.

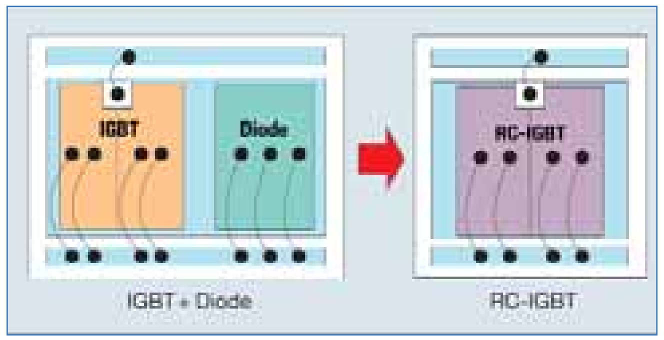

Figure 4. Comparison of Power Chip Areas.

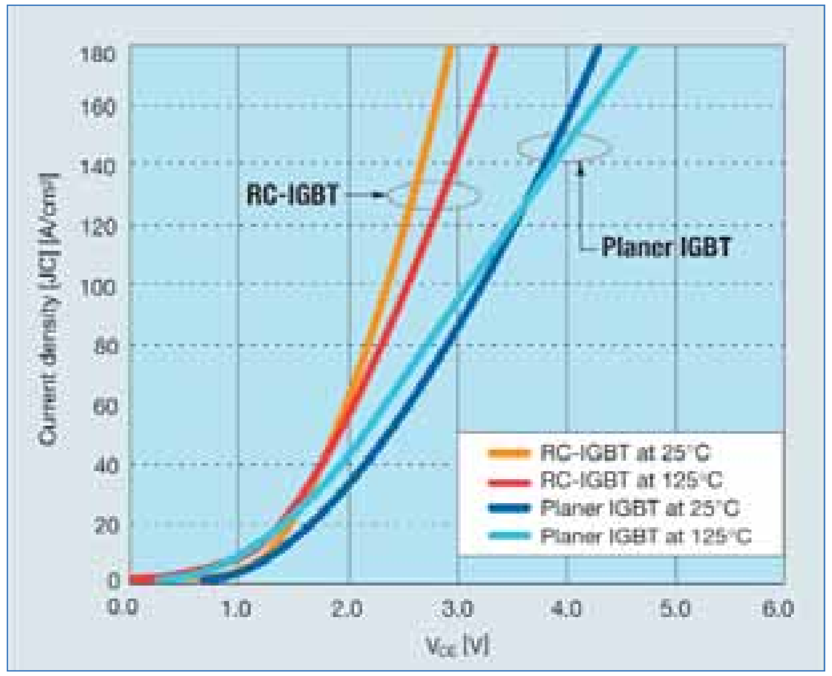

Figure 5. Output Characteristics of the RC-IGBT.

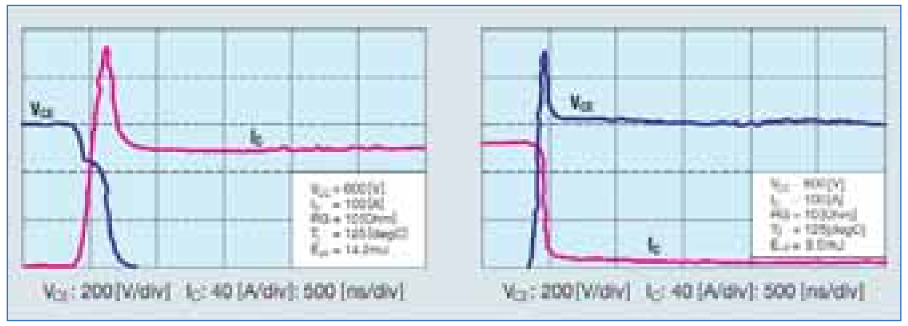

Figure 6. Switching Waveforms of the RC-IGBT.

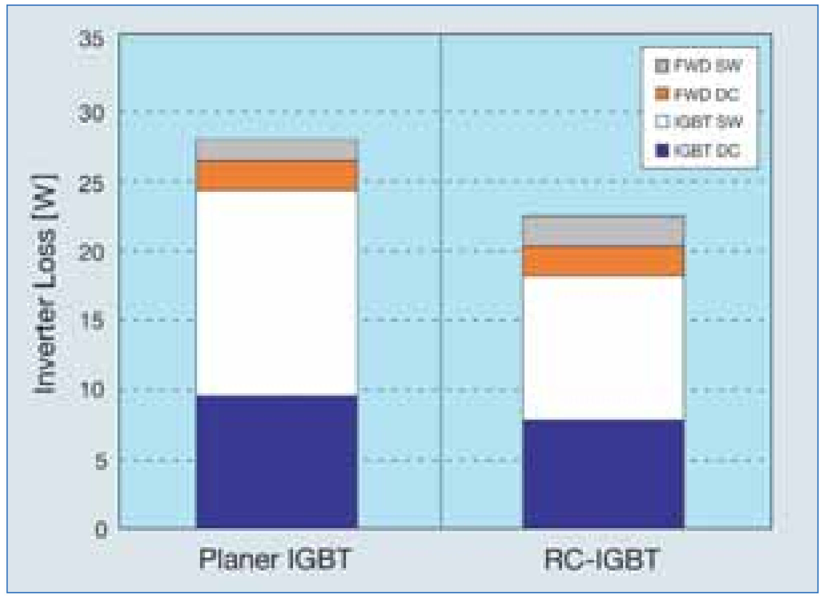

Figure 7. Comparison between Inverter Losses.

Thus the resonant frequency of the power chip increases. Due to this increase of switching noise frequency, the noise filter circuits may become smaller compared with conventional designs.

Figure 5 shows output characteristics of the RC-IGBT. VCE(sat) of the RC-IGBT compared with VCE(sat) of a conventional planar IGBT is improved by about 30%. Moreover, the RC-IGBT has a positive temperature coefficient of VCE(sat) at rated current density (80 to 100A/cm2). This characteristic of negative temperature coefficient of VCE(sat) at rated current is more favourable than that of the conventional planar IGBT which has a negative VCE(sat) temperature coefficient at rated current. A negative temperature coefficient has the effect that the emitter current concentrates on the IGBT with the lowest VCE(sat) in a paralleled structure. Therefore, such RC-IGBTs are not only suitable for low and middle power applications, but also for large power applications, where parallel operation of chips (or modules) is required.

Figure 6 shows a switching waveform of the RC-IGBT. It can be seen that the fundamental switching characteristics of the RC-IGBT reaches a level that is comparable to those of conventional IGBTs with an external FWD. The turn-off tail current is very small and short. The n-region on the underside of the RC-IGBT is the reason for the short time the tail current requires to subside.

Figure 7 presents an inverter loss comparison between a conventional planar IGBT with FWD and RC-IGBTs. The RC-IGBT switching loss is significantly lower than that of conventional planar IGBTs. The reason is the aforementioned very short turn-off tail current of the RC-IGBT (see Figure 6), and thus a lower turn-off loss compared with the conventional planar IGBT. As a result, the total inverter loss of RC-IGBT is improved by more than 20% against the losses of conventional planar IGBT with FWD.

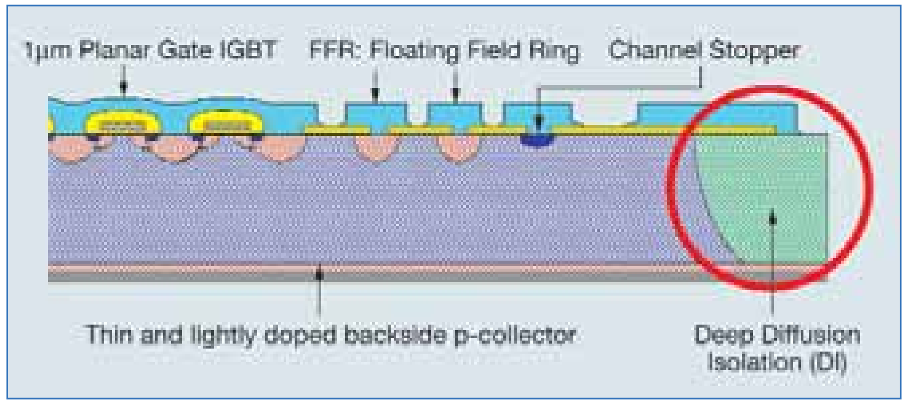

Figure 8. Cross-Section of the RB-IGBT.

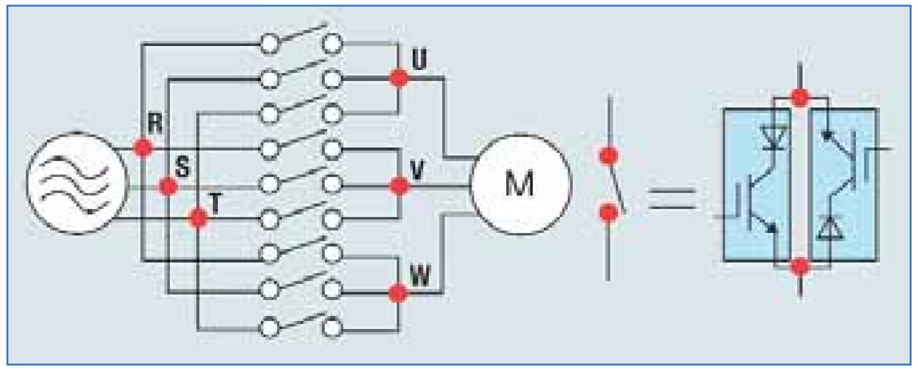

Figure 9. Three Phase Matrix Converter Circuit Configuration.

The RC-IGBT also competes with the super junction MOS-FET, which has also an integrated FWD. However, in terms of production costs, the RC-IGBT is superior to the super junction MOS-FET. The next target is to start mass-production of the RC-IGBT. In the near future, it can replace the conventional IGBT with external FWD.

The second integrated IGBT with diode is the Reverse Blocking IGBT (RB-IGBT). The RB-IGBT has an integrated diode connected in series with IGBT. Figure 8 shows the cross-section of the RB-IGBT. The RB-IGBT is very suitable for AC matrix converters (see Figure 9). By using two RB-IGBTs in anti-parallel, it is easy to realize bi-directional switches. The equivalent circuit of the RB-IGBT shows the IGBT and reverse blocking diode in series (Figure 9).

The RB-IGBT does not actually have a series diode to block the reverse voltage. It blocks the reverse voltage by means of a deep diffusion isolation area. VCE(sat) of the RB-IGBT is therefore lower than VCE(sat) of conventional IGBTs with reverse blocking diodes in series. This is the outstanding advantage of the RB-IGBT in comparison with the conventional IGBT with reverse blocking diode.

As shown in Figure 8, the RB-IGBT needs a deep and wide diffusion area for isolation. This is not an acceptable solution due to manufacturing costs. This has necessitated the development of Trench Isolation RB-IGBT (TI-RB-IGBT) utilizing deep trench technology to achieve the isolation area. This technology has already been applied for the super junction high voltage MOS-FET. The isolation area of TI-RB-IGBT is much smaller than that of the deep diffusion RB-IGBT. This provides a reasonable chip size as well as ensuring that the cost structure is comparable with a conventional IGBT with reverse blocking diode.

With AC matrix converters, the DC link capacitor, which usually has a rather large capacitance, can be eliminated. This is a big advantage for the size and reliability of an inverter system. At the same time it is also a contribution to the "Environmental Compatibility" concept.

Conclusion

Mitsubishi's "Environmental Compatibility" concept is based on a new power chip, a new gate drive and new package technologies. The goal is to combine all these technologies to save resources, energy and time. This will lead to further cost reductions for both — manufacturers and customers, and will contribute to a further propagation of power control systems. A next article will explain gate Mitsubishi gate drive and packaging technology.

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Maximize Battery Run Time in a Portable Media Player

Take any power not being used to charge the battery

A growing trend for consumers is the use of a portable media player (PMP) for mobile entertainment purposes. The advantages of a PMP are that they can play both MP3 and MP4 formats. Therefore, a single device can be used to listen to music or watch a movie from a DVD-CD.

By Tony Armstrong, Product Marketing Manager, Power Products Group, Linear Technology

Many of these PMPs include a hard disk drive (HDD) for high capacity storage capability. Typically, this allows a typical device to store over 150 hours of video or 1,200 hours of music. However, manufacturers of these PMPs are under ever increasing pressure to pack all of these features into an already constrained form factor while simultaneously gaining longer runtimes.

Since most PMPs have the functionality of both a video player and MP3 player, the internal electronics requires more low voltage output rails at varying power levels. The reason for this is clear; the majority of the digital large scale integrated (LSI) ICs have operating voltage of 1.5V or less. It is impractical to use point-of-load (POL) DC/DC conversion directly from the Lithium Ion (Li-Ion) battery nominal output voltage of 3.6V down to these lower voltages due to space, efficiency and cost constraints. Therefore, designers have elected to adopt a two-stage conversion approach instead. Thus, they use a high efficiency step-down converter to drop the Li-Ion battery voltage down to 1.5V. Then, from this 1.5V main rail, they can simply use very low dropout (VLDO) regulators to supply the low voltage digital LSI ICs. This is possible in large part due to the low nominal operating currents and the fact that the efficiencies of conversion between low voltage rails can be in the 80 to 90% range. Another compelling reason to use these VLDOs is that many of the low voltage ICs being powered are noise sensitive. As such, the output ripple from these regulators may need to be less than $1mV_{P-P}$. Clearly, one could just as easily use a VLDO as a post regulator from a step-down switching regulator to ensure low ripple.

The Use of a HDD in a PMP

A key driver for the adoption of a HDD inside a PMP has been the need for large and easily read/writeable compact storage. PMPs can usually be powered from an AC adapter, a Universal Serial Bus (USB) cable, or the Li-ion battery; however, managing the power-path control between these power sources presents a significant technical challenge. Until most recently, designers have tried to perform this function discretely by using a bunch of MOSFETs, op-amps and such, but have faced tremendous problems with hot plugging and having large inrush currents, which cause big system problems.

Most of the HDD's that will be used in PMP will use platters that are less than 2" in diameter. Toshiba has a 30GB capacity drive on a single platter that is only 1.8" in diameter and Hitachi has a 4GB micro-drive on a single platter that is only 1" in diameter and 0.85'' diameter platters are on the horizon. In either case, these disk drives only need about 300mA at 3.3V for normal operation; however, during spin-up peak current can be as high as 1.2A. This can be troublesome when designing a DC-to-DC converter to deal with this wide operating current range.

Most PMPs have used an application specific integrated circuit (ASIC) to deal with the requirements of battery charging, power-path control, providing multiple supply voltages, as well as protection features such as true output disconnect and accurate USB current limiting. The reasons for adopting this approach are clear; they can obtain a single

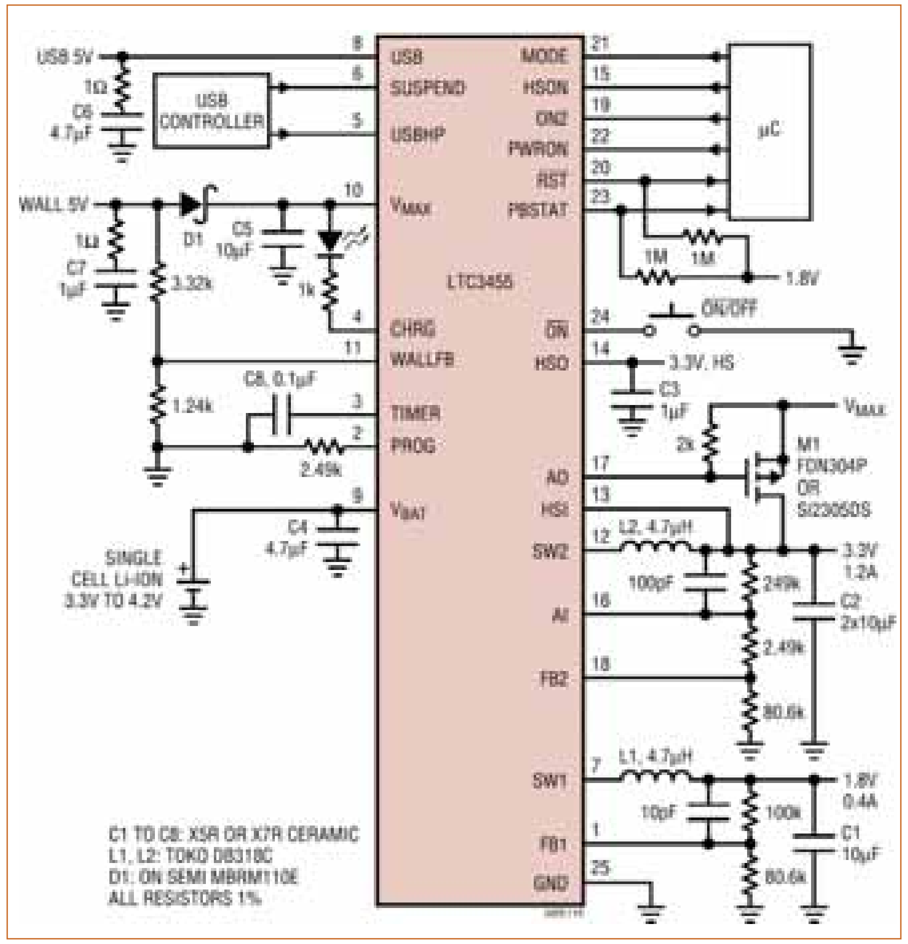

Figure 1. LTC3455 Schematic with 3.3V Output Current Increased to 1.2A.

device that meets all of their power management needs. However, there are also drawbacks to this approach. First of all, ASICs are manufactured on a specific wafer fabrication process – making it difficult to maximize their performance for each of these functions. Secondly, and becoming more important in these times of short, dynamic design cycles, is the long lead-time associated with the definition and development of an ASIC. It is not uncommon for a power management ASIC to take over one and a half years to produce from conception to delivery. During this time, the design needs for a particular product could have change three or more times.

A New Approach

There exists a commonality of features and functions inside a PMP for which an application specific standard product (ASSP) could be used without any of the usual performance compromises normally associated with manufacturing an IC on a single wafer fabrication process. Linear Technology recently introduced the LTC3455, which represents the highest level of functional integration for these applications.

The LTC3455 seamlessly manages power flow between an AC adapter, USB cable and Li-ion battery, while complying with USB power standards, all from a 4 x 4mm QFN package. As if that is not enough, it has a full feature Li-ion linear battery charger that can provide up to 800mA of charge current plus two high efficiency synchronous buck converters to generate low voltage rails which most USB peripherals require. Furthermore, the LTC3455 also provides power-on reset signals for the microprocessor, a HotSwap output for powering memory cards as well as an uncommitted gain block suitable for use as a low-battery comparator or LDO controller.

An application schematic of the LTC3455, as shown in figure 1, illustrates how it to accomplishes multiple functions. The DC/DC conversion is relatively straightforward buck converter function. Each of the LTC3455's two on-chip buck converters operate under current-mode control and achieve efficiencies as high as 96% with pin selectable Burst-mode operation – see figure 2. These DC/DC converters operate at a fixed 1.5-MHz switching frequency that allows the use of very small external inductors.

The LTC3455's method of power delivery differs from existing battery and power management ICs, which are charger-fed systems. In such systems, the external power source doesn't power the loads directly. Instead, the adapter or USB port would be used to charge the battery, which then powers the loads. In the event that the battery has been deeply discharged, there will be a delay in getting power to the loads. That's because power cannot be taken from the battery until it has obtained the required minimum amount of charge.

With the LTC3455, this delay is eliminated so that the handheld device can be powered up as soon as the AC or USB power source is connected. In addition, the chip will take any available power not being used by the loads and use it to charge the battery.

The internal USB power controller also automatically throttles back the battery charge current to help keep the total system current under the strict 500mA or 100mA USB limit. The rest of the system draws whatever current it needs, but the battery charge current is reduced to try to keep the total system current below the USB current limits. The graph in Figure 3 shows how the charge current, IBAT, decreases as the current needed for the rest of the system increases (both switchers and all other external devices pull current form the VMAX pin). The total USB current, IUSB, always stays below 500mA.

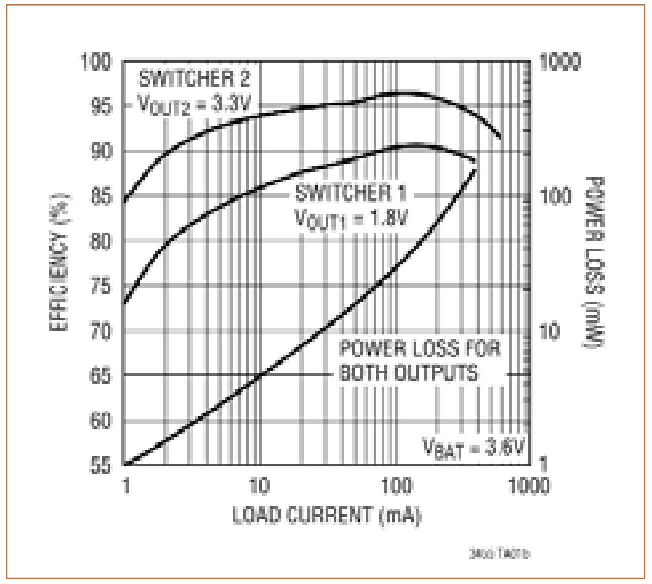

Figure 2. Efficiency and power loss vs. load current for the regulators 1 & 2 in the LTC3455.

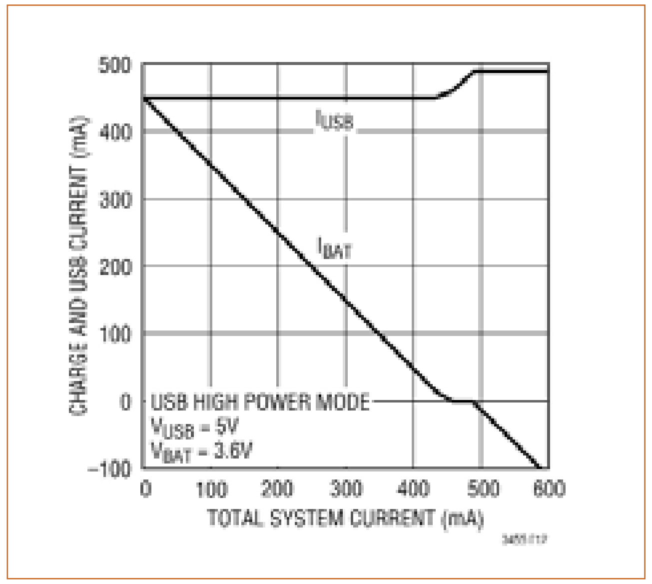

Figure 3. I_{BAT} vs. total system current.

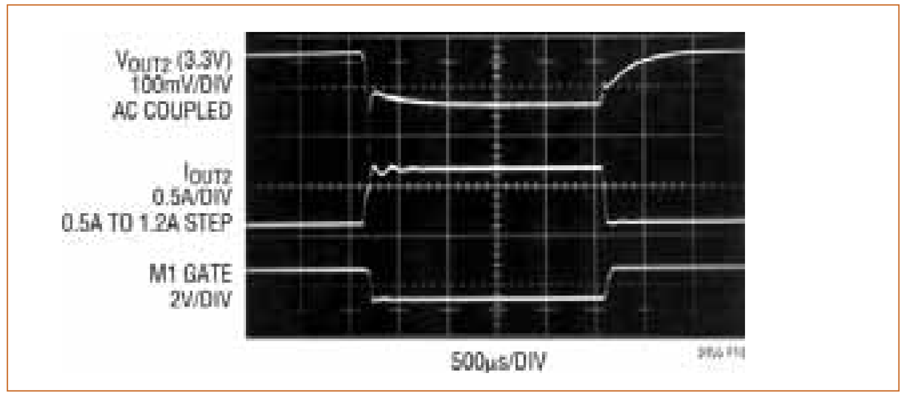

Figure 4. Load current step (0.5A to 1.2A) for 3.3V output (SW2).

These two benefits—elimination of charging delays and simultaneous battery charging and powering of loads—extend the effective runtime of the application and accelerate charging when attached to the USB cable. Another advantage of this power management technique is increased efficiency whenever the AC or USB power source is available. In these instances, an unnecessary stage of power conversion (that is, battery charging) is eliminated.

Supplying 3.3V at 1.2A for HDD Spin-up

With an internal current limit of 900mA, Switcher 2 (see SW2 in figure 1) typically provides a 3.3V, 600mA output. While its current is sufficient in typical cellular phones, if a HDD is present, the need exists for a 3.3V supply capable of providing more than 1A. The LTC3455 can easily accommodate this requirement by simply adding one tiny SOT-23 PMOS FET and using the gain block as an LDO - the 3.3V output now provides 1.2A of output current sufficient to meet the peak current requirements associated with a HDD when the platter initially spins-up.

Switcher 2 is programmed for an output voltage of 3.3V, and the LDO is programmed for an output voltage of 3.2V (3% lower). As long as the load current is low enough for Switcher 2 to supply, as is the case when a HDD platter is already spinning, the LDO is turned off completely. However, when the load current exceeds what Switcher 2 can supply, as is the case when a HDD platter needs to spin-up from rest, the 3.3V output drops slightly and the LDO provides the additional current needed. Figure 4 shows the transient response when the 3.3V output current is stepped from 0.5A to 1.2A. More output capacitance can be added to improve the 3.3V transient response during these high current load steps.

It is clear that designers of portable media players have a number of options available to ensure that battery life is optimized for their particular configuration. A combination of multifunction ASSPs and VLDO regulators can provide the necessary voltages and power levels to provide optimum system performance while ensuring that the power drain on the battery is minimized during normal operation.

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Most Efficient Low Power Chargers

The world's simplest switched-mode chargers

The LinkSwitch-LP family is designed specifically to replace unregulated supplies that deliver up to three watts of power. Supplies using these new ICs require only 14 components, making them the simplest switched-mode chargers available anywhere.

By Richard Fassler, Director of Product Marketing, Power Integrations

For low-power battery chargers, passive power supplies have historically been the most popular choice due to their simplicity and low cost. This is especially true at the very lowest power levels (i.e., three watts and below), at which OEMs often select unregulated supplies consisting only of a line-frequency transformer, a capacitor and a few diodes. Switched-mode power supplies (SMPS) built with discrete components have been slow to displace these low-tech devices because switcher benefits (e.g., smaller size and weight) have not been enough to offset the extra cost of designing and manufacturing them. Furthermore, low-end chargers built with discrete components lack thermal protection, a key safety feature found even in very inexpensive passive supplies.

However, passive power supplies are now becoming obsolete thanks to a convergence of factors. Recently enacted energy-efficiency standards for external power supplies (EPS) practically rule out the use of passive chargers in a number of key markets, including California. Also, advanced integrated circuits now make it possible to design SMPS that actually rival passives in terms of cost and simplicity, even at the very lowest power levels. Power Integrations' new LinkSwitch-LP family, for example, is designed specifically to replace unregulated supplies that deliver up to three watts of power. Supplies using these new ICs require only 14 components, making them the simplest switched-mode chargers available anywhere. They also meet the EPS efficiency standards while delivering superior safety and reliability.

The features that enable low-cost replacement of passive supplies

Each of the three members of the LinkSwitch-LP family has a high-voltage (700 V) power MOSFET and a low-voltage controller on the same piece of silicon. These ICs are housed in standard 8-pin DIP through-hole and SMD packages that meet the high-voltage creepage and clearance requirements of most safety standards. The ICs work in a current-limited, high-bandwidth, ON/OFF control mode.

Power supplies designed around these ICs start up quickly without any output overshoot, have excellent transient load response, and require no control-loop frequency compensation components. Each IC is self-biased from an internal high-voltage current source connected to the DRAIN pin of the device package, which eliminates external start-up and bias supply circuitry. Each LinkSwitch-LP IC also has a modulated switching frequency that reduces the number and the size of EMI filter components. Other features include an auto-recovering hysteretic thermal shutdown function for over-temperature protection and an auto-restart function for output short-circuit and open feedback loop protection. These features result in a very low parts count and cost for power supply solutions designed around the new ICs.

LinkSwitch®-LP Output Power Table		
Part Number	Oscillator Frequency	Input Voltage (85-265 VAC)
LNK562 P or G	66 kHz	1.9 W
LNK563 P or G	83 kHz	2.5 W
LNK564 P or G	100 kHz	3.0 W

Table 1. LinkSwitch-LP part numbers, oscillator frequency, and output power capability

Each device operates over the universal input voltage range. This allows one power supply model to be used worldwide, whereas line-frequency transformers must be designed for narrow and specific input voltage ranges. Each LinkSwitch-LP family member has a different oscillator frequency (see Table 1), which allows the maximum output power and current of a solution to be scaled up or down by simply installing a different IC into the supply's PCB. No other changes are needed—not even to the transformer. Proprietary IC design and innovative transformer winding techniques eliminate the need for a drain-node clamp circuit. This Clampless approach further reduces component count.

Step	Description	*PI XIs* used?
1	Enter application variables: VACMIN, VACMAX FL, VO, IO, Z, η, tC, CV/CC vs CV, CIN, feedback type, clamp used	Yes
2	Enter device & rectifier variables: P/N, VOR, VDS, and VD	Yes
3	Select transformer core and bobbin (see table in AN-39)	Yes
4	Altering adjustable values until warnings disappear	Yes
5	Input stage selection (see table in AN-39)	No
6	Feedback and bypass component selection	No
7	Output diode & pre-load resistor selection (see table in AN-39)	No
8	Output capacitor selection: I_{RIPPLE}, voltage, capacitance, ESR	No
9	Use *PI XIs* calculations to build the first transformer prototype	N/A
10	Build and test the first prototype of the power supply	N/A

Table 2. The 10 steps in the LinkSwitch-LP design process.

Software tools simplify the design process

Creating low-cost charger designs with LinkSwitch-LP is a quick and easy process, with only 10 steps required to complete a design (see Table 2).

Power Integrations' PI Expert™ Suite design software contains a spreadsheet

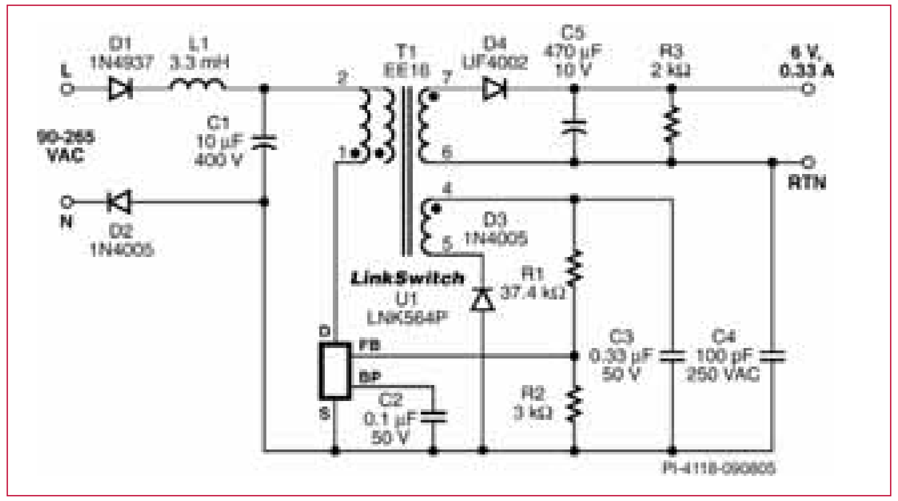

Figure 1. Circuit diagram of a 2 W LinkSwitch-LP based power supply.

Figure 2. Part of the PI Xls spreadsheet for the example 2 W LinkSwitch-LP design.

tool called PI Xls that automatically updates all design calculations as user-adjustable values are altered within a spreadsheet file. During the first four steps of the design process, the spreadsheet updates over 30 power train and transformer calculations for the power supply. PI Xls results may be exported in many different formats making documenting designs a simple task.

The design process: a worked example

Figure 1 is the circuit diagram of a 2 W supply designed around the LNK564P IC (U1). This supply meets the new energy-efficiency standards for external power supplies and complies with CISPR22-B conducted EMI requirements. The following describes the 10-step power supply design process, which is based on the design guide for the LinkSwitch-LP family, Application Note AN-39.

Step 1: altering application variables

After a new PI Xls spreadsheet file has been opened and saved with a suitable filename, the designer can change any of a dozen user-adjustable application variables (see Figure 2). In this design example, the 'VACMIN' variable was increased from 85 to 90 V to match the solution specification.

If a supply has an output voltage (VO) different from the default value of 6 V, the correct output voltage and current values would need to be entered in their respective cells on the spreadsheet. If any spreadsheet calculation, such as the output power (PO), exceeds a design limit, a warning is displayed along with a suggestion to eliminate that warning. AN-39 describes all of the user-adjustable variables in the PI Xls spreadsheet, showing when, how and why each variable can or should be altered, and gives instructions for dealing with the warnings that may arise as values are changed.

Step 2: altering device and output diode variables

In the next section of the spreadsheet, the designer can select a different LinkSwitch-LP device (if PO is less than 3 W), change the value of the reflected output voltage (VOR), and alter the values of the device drain-to-source voltage (VDS) or the output diode forward voltage (VD). For this design example, the default values were used for these four parameters.

Step 3: choosing a transformer core and bobbin

If the user input cell for the 'Core Type' is left empty, PI Xls uses an EE16 core for the transformer parameter calculations. PI Xls contains specifications for six other cores that might be used in sub-three-watt applications, which are also listed in a table in AN-39. Although changes may be made to nine variables that affect the transformer calculations, only an experienced magnetics engineer should alter them. In this design example, the default EE16 core and bobbin were used and no transformer variables were changed.

Step 4: alter adjustable values until warnings disappear

When PI Xls flags a parameter in the spreadsheet with a warning, it also suggests what could be done to eliminate that warning. This involves adjusting the values of specific variables until all warnings disappear. In this design example, no variables required adjusting.

Step 5: input stage selection

AN-39 suggests four possible input stage configurations that depend on the supply's maximum output power, the allowable component size and count, and the solution cost objectives. The input stage used in this design example meets conducted-EMI requirements with only a single input capacitor (C1) and a series differential mode choke (L1) as EMI filter components. This was made possible by the modulation–or jittering–of the IC's internal oscillator frequency and the innovative transformer winding techniques that were used in constructing the transformer (see step 9).

Step 6: feedback and bypass components selection

The IC requires that a 0.1 _F 50 V bypass capacitor (C2) be connected between the BYPASS (BP) and the SOURCE (S) pins, right beside the chip on the PCB. PI Xls calculates the values of the voltage divider resistors (R1 and R2) that connect to the FEEDBACK (FB) pin of U1. The designer chooses standard resistor values that are the closest to the calculated values. The bias winding also requires a diode (D3) and a capacitor (C3). The diode should be a standard recovery type, such as a 1N4005GP. The capacitor should be at least 0.33 _F and rated for 50 V. Higher capacitance can reduce the no-load power consumption of the supply. In this design example, the suggested diode and capacitor were used and 37.4 k_ and 3 k_ resistors were used for R1 and R2 respectively.

Step 7: output diode and pre-load resistor selection

A table in AN-39 provides a dozen series of ultra-fast and Schottky diodes that are suitable for use as output diodes AN-39 also describes how to use values calculated in PI Xls to determine the reverse voltage and forward current ratings of the output diode. The value of the pre-load resistor (R3) should be calculated so that 3 mA of current flow through it at VO. In this design example, R3 is 2 k_ and a UF4002 was used for D4.

Step 8: output capacitor selection

Of the four output capacitor parameters, the ripple current and voltage ratings are the two most important. The selected output capacitor should have a ripple current rating that exceeds the value of IRIPPLE calculated in the spreadsheet. The voltage rating of the selected output capacitor should be 25% higher than VO. The value of the output capacitor's ESR is determined by dividing the supply's output ripple voltage specification by the spreadsheet's peak secondary current calculation (ISP). A 470 _F 10 V aluminum electrolytic capacitor with a ripple current rating of 760 mA and an ESR of 72 m_ was used to meet the specifications of this design example.

Step 9: build a prototype transformer

Once the adjustable values have been altered (in step 4) so that the PI Xls spreadsheet has no warnings in it or the designer has determined that a particular warning is tolerable, the calculated transformer parameters can either be used to build a prototype of the transformer in-house or be sent out to a magnetics vendor to have samples built.

Step 10: build and test the first prototype supplies

While the first transformer samples are being built, the PCB should be laid out and a parts kit pulled so that one or more prototypes can be built. The results from prototype testing should be entered into the PI Xls spreadsheet to fine-tune the design before it is put into high-volume manufacturing.

The new LinkSwitch-LP IC family enables engineers with little experience in SMPS design to create energy-efficient, cost-competitive solutions to replace the line-frequency-transformer based power supplies that will soon become obsolete. Additionally, the comprehensive design guide AN-39, the PI Xls spreadsheet, and the many features that have been integrated into the IC family make designing power supplies with the LinkSwitch-LP IC family a quick and easy process. PI Expert Suite software, AN-39 and the datasheet for the LinkSwitch-LP family of ICs are all available from Power Integrations' web site.

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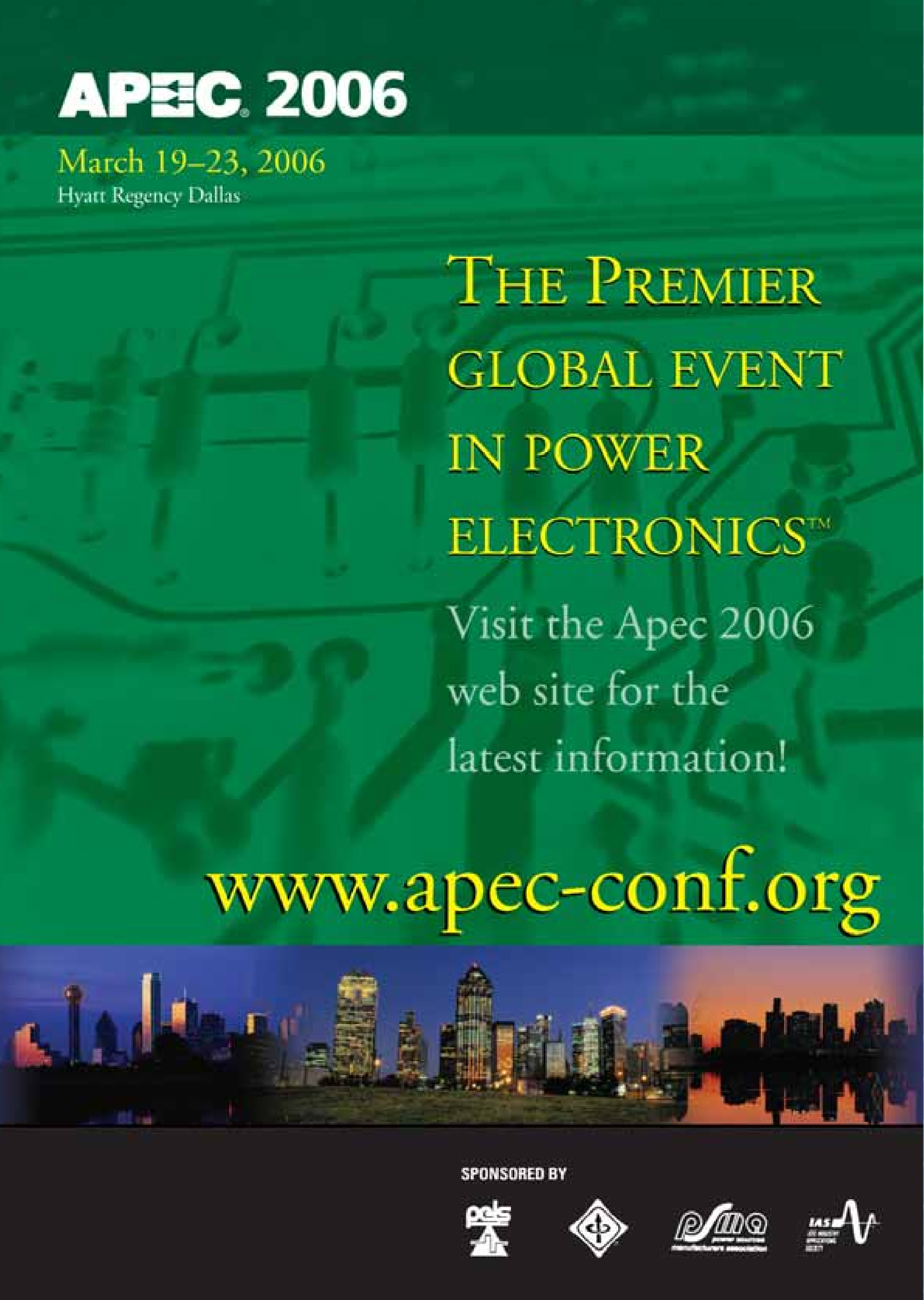

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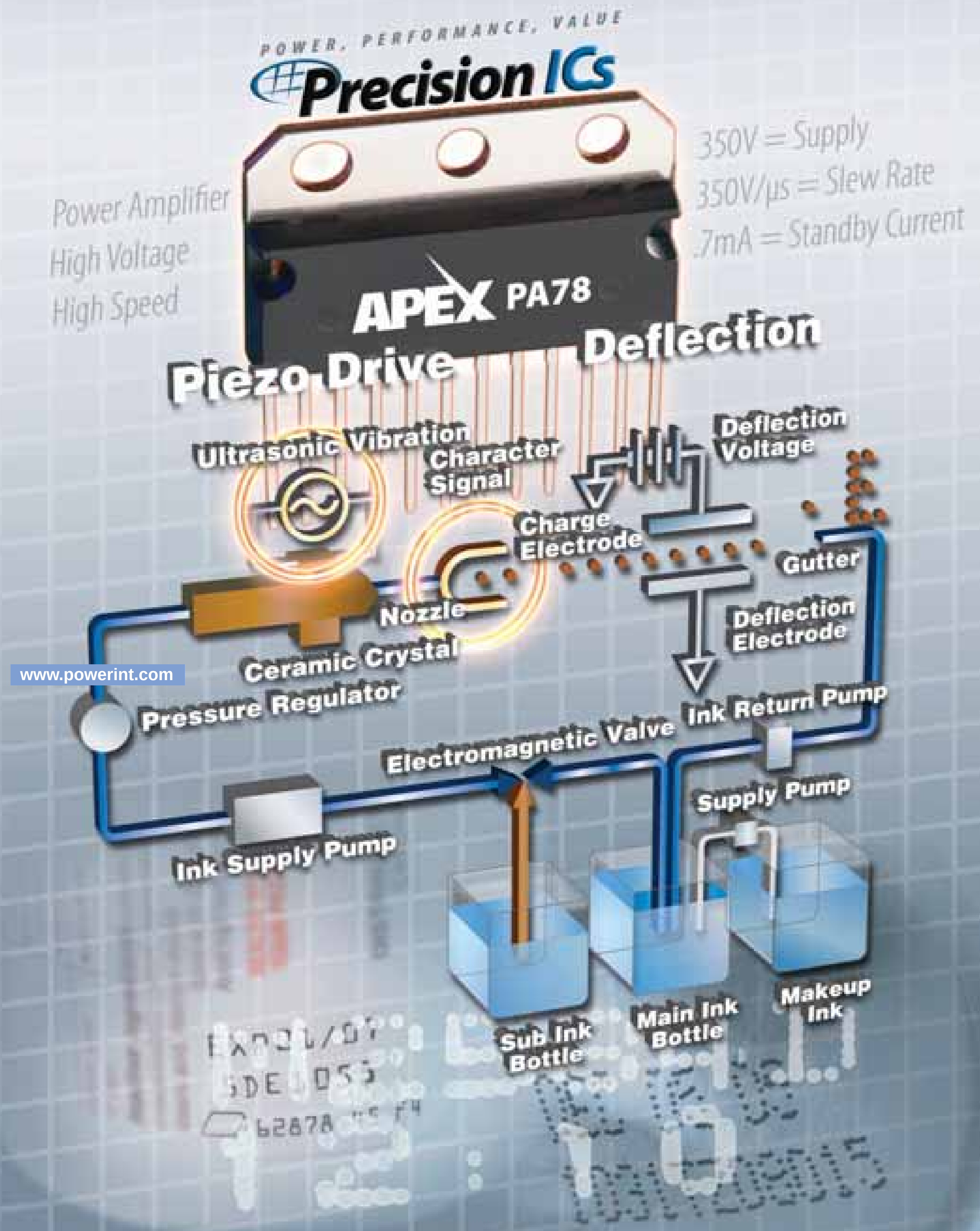

Next Generation IGCTs with Increased SOA

High SOA reduce the cost of conversion

To improve performance and reduce the size and cost of power electronic systems, the development trend in high power semiconductors continues towards higher current and voltage capabilities. The IGCT is no exception and in this article, the high SOA capability of a new range of IGCTs with voltage rating of 4.5kV is described.

By Th. Stiasny, P. Streit, M. Rahimo, E. Carroll, ABB Switzerland

The Integrated Gate Commutated Thyristor (IGCT) has continued to gain wide acceptance in the market since its introduction a decade ago. In many high power applications such as medium voltage drives, power quality, static breakers and others, the IGCT is well-established due to its very low on-state losses and fast switching performance. IGCTs are employed normally in voltage or current source inverters in two or three level topologies as single or series-connected devices. IGCTs with blocking capabilities ranging up to 6.5kV and current turn-off capabilities of up to 4kA are commercially available as asymmetric, reverse-conducting or reverse-blocking types (see Figure 1).

Previous experience and data has shown that the SOA of high voltage devices up to 6500V degrades due to the physical stresses at very high voltage. Although improvements in Safe Operating Area (SOA) have been achieved, the turn-off capability of large area IGCT devices is still the main parameter limiting higher system ratings, especially at low temperatures. For larger converter systems, still higher turn-off capabilities are required.

IGCT SOA Capability

The IGCT consists of a large number of parallel-operated thyristor cells (see Figure 2) driven by a single gate unit.

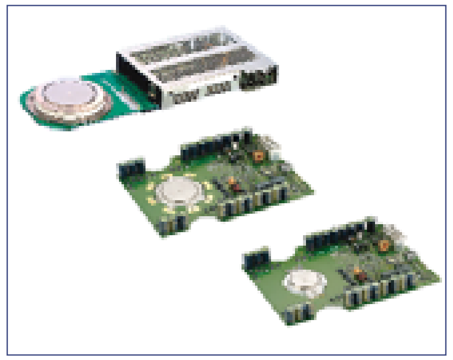

Figure 1. 4.5kV to 6.5kV IGCTs with 200A to 4000A current ratings.

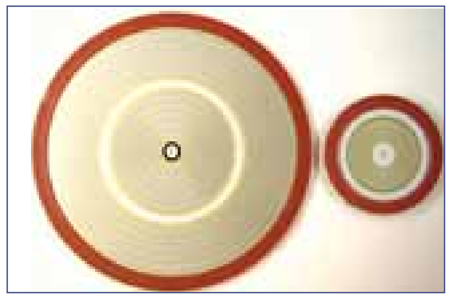

Figure 2. Cathode side of Ø91mm (left) and Ø38mm (right) 4.5kV IGCT wafers.

SOA performance can be limited by the following factors:

a) ruggedness of the individual cell
b) current sharing effects due to heavy paralleling of the cells
c) performance of the gate-driver.

Analysis of the SOA limits for large area IGCTs has led to the following observations:

- A larger active area of an IGCT always results in a lower average switching power density, even when accounting for the scaling of the switching circuit.
- An increase by a factor of 10 in active area only leads to an increase in turn-off current capability of a factor of 4.
- The SOA limit of a large area IGCT is typically reached while still operating in the macroscopic hard switching regime (i.e. the current commutation from cathode to gate is completed before the anode voltage starts to rise)
- SOA failures are typically found in areas remote from the gate contact.

Based on these observations, it has been concluded that improving the SOA of an IGCT must take into account both the robustness of the single cell and the current sharing during turn-off.

Device Optimisation

For local SOA optimisation, a small 4.5kV reverse-conducting IGCT was chosen having a Ø38mm diameter. Two versions were manufactured, a larger version with an active IGCT area of 3.5cm² and a smaller one with an active area of 1.5cm². This approach ensures that the effects of lateral inhomogeneity during device turn-off are less dominant.

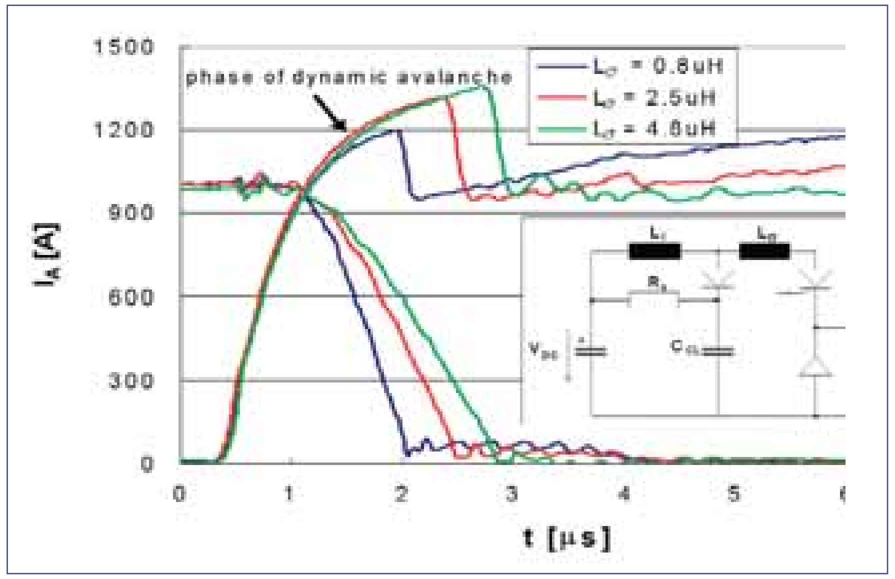

Figure. 3. The effect of stray inductance on the turn-off of a small area IGCT (active area: 3.5cm^2).
(V_D =2.8kV, I_{off} = 1.0kA, T_J = 125°C, no dv/dt snubber) I/V SOA curve.

The SOA testing for the IGCTs was done in a di/dt clamp circuit without dv/dt snubbers (see insert of Figure 3). Comparing switching power densities of different sized IGCTs requires scaling the stray inductance L_ of the clamp circuit such that it is inversely proportional to the device's active area. The influence of the stray inductance on the switching characteristic is shown in Figure 3. The clamp circuit is inactive prior to the IGCT voltage reaching the DC link level, V_{DC}. Beyond this, the device reacts to higher stray inductance by sustaining dynamic avalanche for longer times. This leads to slower decay of the anode current together with higher peak power and turn-off losses.

The improvement of the cell design by optimising doping profiles resulted in a maximum switching power density of 1.5MW/cm^2 for snubberless operation even when scaling up the clamp stray inductance to 9.1_H for a device with 1.5cm^2 active area (see Figure 4). Here 'Switching-Self-Clamping-Mode' (SSCM), as recently reported for advanced planar IGBTs, was also achieved for the new IGCT design when turned-off against a high DC-voltage and high clamp stray inductance.

This is the first time that SSCM operation has been achieved for an IGCT. As the voltage rises, the IGCT goes into dynamic avalanche due to the recovering charge, which modifies the effective background doping and subsequent electric field distribution. The dynamic avalanche is characterized by lower dv/dt during turn-off. Unless device failure occurs, dynamic avalanche continues until the remaining excess carriers are used up at which point dynamic avalanche ceases. With sufficiently high stray inductance, the voltage increases rapidly and eventually reaches the breakdown voltage of the pn-junction, which then safely self-clamps. Careful design of the IGCT buffer and anode regions enables the device to withstand these conditions. Due to the high turn-off currents reached in these tests, it was necessary to drive the IGCT with a special low-inductance gate unit to maintain operation of the IGCT in the hard drive mode. Exiting this mode (anode voltage rise prior to complete commutation of the cathode current to the gate) leads to GTO operation which is destructive in snubberless mode.

Applying this local SOA optimisation to large area devices led to significant improvements in current turn-off capability (although remains significantly

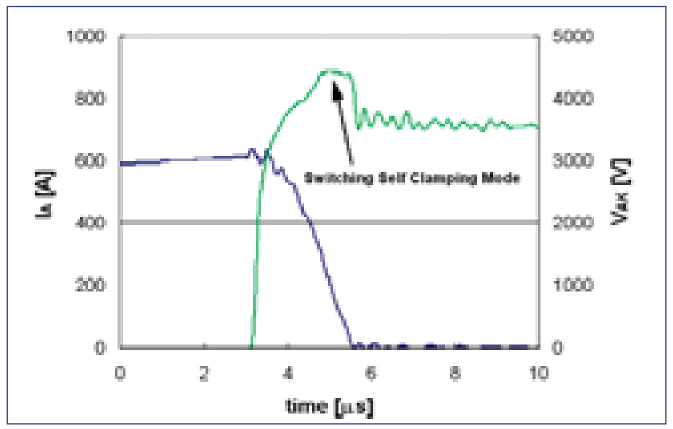

Figure 4a. Turn-off characteristic of locally optimised Ø38mm reverse conducting IGCT (active area: 3.5cm2). (VD = 3.65kV, Ioff = 0.63kA, L_ = 9.1_H, no dV/dt snubber) turn-off waveform.

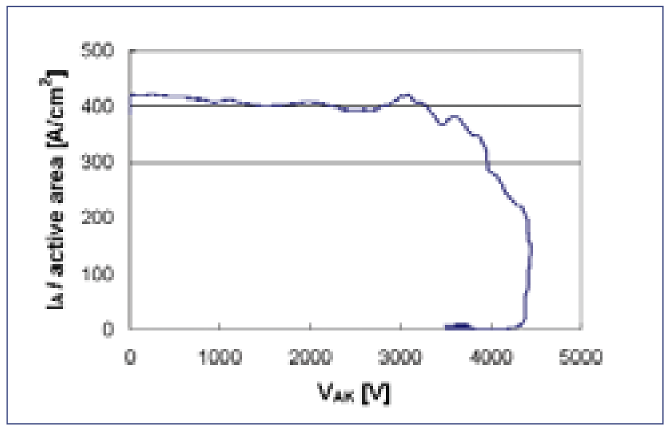

Figure 4b. Turn-off characteristic of locally optimised Ø38mm reverse conducting IGCT (active area: 3.5cm2). (VD = 3.65kV, Ioff = 0.63kA, L_ = 9.1_H, no dV/dt snubber), I/V SOA curve.

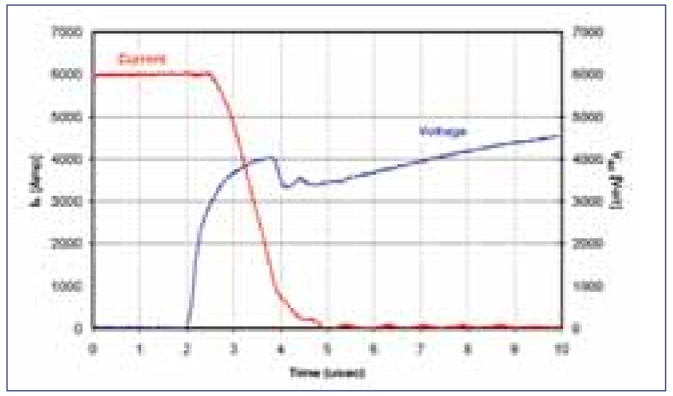

Figure 5a. SOA Turn-off waveform of the new Ø91mm 4.5kV asymmetric IGCT. (VD=2.8kV, L_=0.3_H) @ TJ= 25°C.

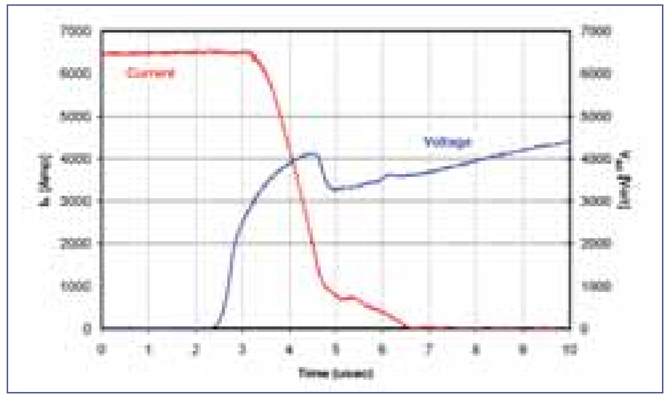

Figure 5b. SOA Turn-off waveform of the new Ø91mm 4.5kV asymmetric IGCT. (VD=2.8kV, L_=0.3_H) @ TJ= 125°C.

below the average power density of small devices due to current redistribution during turn-off). To minimise the scaling problems of large area devices, further work was carried out on Ø91mm 4.5kV and 6.5kV asymmetric IGCTs employing a new cathode. The combination of a new cathode design and cell optimisation resulted in a substantial increase in SOA for large area devices.

High SOA for Large Area IGCTs

The improved technology is demonstrated under snubberless SOA conditions for the Ø91mm 4.5kV asymmetric IGCT at both room temperature and 125°C. Figure 5 shows the turn-off waveforms for the 4.5kV IGCT. The device was capable of turning off currents in excess of 6000A at a DC link voltage of 2800V with a peak power dissipation exceeding 20MW at both 25°C and 125°C. Similar measurements were made for the Ø91mm 6.5kV asymmetric IGCT as shown in Figure 6. At a DC link voltage of 3.6kV, the current turn-off capability exceeded 5000A with comparable power dissipation levels to those of the 4.5kV IGCT at both temperatures. The waveforms show that the devices can withstand extreme dynamic avalanche conditions. In present generation IGCTs, turn-off capability decreases with decreasing junction temperature but this new generation eliminates this former short-coming.

The new technology exploited here, not only reduces the former temperature dependence of SOA, mentioned above, but also strongly reduces (and will perhaps eliminate) the reduction of SOA with increasing DC voltage. This will enable developments for 5.5 and 6.5 kV devices with similar 20 MWPK capabilities to be started in the course of 2006. These are needed for 15 MW 3-level inverters on the 4.16 kVRMS medium voltage lines as well as for special 2-level inverters on 3.3 kVDC traction supplies.

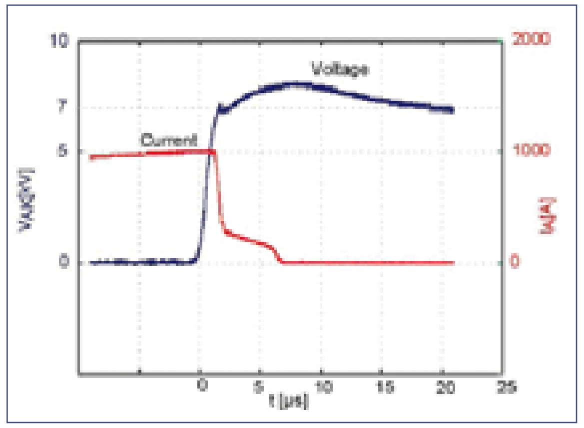

Figure 6. Turn-off waveform of a Ø68mm 10kV asymmetric GCT VD=7.0kV, Ioff = 1.0kA, T_J= 85°C.

10kV IGCTs

Experimental devices first made in 2002 using present technology showed that a significant increase in voltage class is possible. A blocking capability of more that 11kV was reached at 25°C for asymmetric Ø68mm IGCTs. The 10kV IGCT achieved low conduction losses of 4.4V at 125°C at a nominal current of 1000A (~35A/cm2). The turn-off losses were 7.5J at 125°C, 4.5kVDC and 1000A. The dynamic performance of the 10kV IGCT was evaluated in an inductive load circuit. Figure 6 shows turn-off of the 10kV device at 85°C and 1000A at 7kVDC. These early results showed that a 10kV IGCT with similar SOA to current 4.5 kV devices was feasible—despite the usual SOA voltage degradation referred to above. The newly developed high SOA technology will soon be applied to very high voltage devices and the same rating increases as reported here are expected.

10 kV devices are of particularly interest for multi-level inverters on the 6.9 and 13.8kV lines as they will allow HP/MV drives to be realised without series or parallel connection of components.

The newly developed technology endows IGCTs with a 50% increase in turn-off capability and it is expected that a new generation of devices will become commercially available within two years. This means that with very little redesign, today's 10 MW inverters, using 91 mm IGCTs, can be upgraded to about 15 MW. Such ratings are increasingly required for marine drives, steel mills, gas compressors and a variety of Energy Management applications such as reactive energy compensation and network interties. The ability to achieve high SOA at high voltage will further reduce the cost of high-power conversion.

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Active Miller Clamp and 2 Level Turn off Features

Making IGBT driving simpler in 1200V 3-phase applications

By managing the Miller effect in an active way and using a 2 step turn off sequence, new devices from STMicroelectronics simplify IGBT driving, and help system designers to build reliable and cost-effective solutions for 1200V 3-phase applications.

By Jean-Francois Garnier and Anthony Boimond, STMicroelectronics

Handling the Miller effect during IGBT switching

A common problem in many IGBT switching applications is related to the Miller effect; due to gate-collector coupling, high dV/dt transients create voltage spikes on the IGBT gate that can induce parasitic turn-on and are potentially dangerous.

Classic solutions include the use of an additional capacitor to increase the gate-to-emitter capacitance, or use a method of negative voltage gate-driving. This first method has the benefit of simplicity but doesn't allow for efficient gate-driving, and is restricted to low-power applications. The second method is more efficient and suitable for higher-power applications, but has the drawback of increasing the complexity of the power supply system.

The TD35x family offers an alternative solution to this problem. Instead of driving the IGBT gate to a negative voltage to increase the safety margin, the TD35x devices use a dedicated CLAMP pin to control the Miller current. When the IGBT is off, a low impedance path is established between the IGBT gate and emitter to carry the Miller current, and the voltage spike on the IGBT gate is greatly reduced (see Figure 1).

The Active Miller Clamp function

The Active Miller Clamp function is implemented using a comparator that monitors the IGBT's actual voltage. When the gate voltage goes lower than about 2V relative to the GND level, an internal latch is set and the CLAMP pin is pulled to ground. Even if the voltage spikes due to the occurrence of Miller current, the clamp is not released because it is in a latched state. The clamp is released only when the output is driven to the high level again. In this way, the CLAMP function doesn't affect the turn-off characteristic, but simply keeps the gate to the low level during the entire OFF time. The clamp switch characteristic is similar to the sink part of the output stage, i.e. 1.2A peak minimum, and a maximum VOL=3V at 0.5A over the full temperature range.

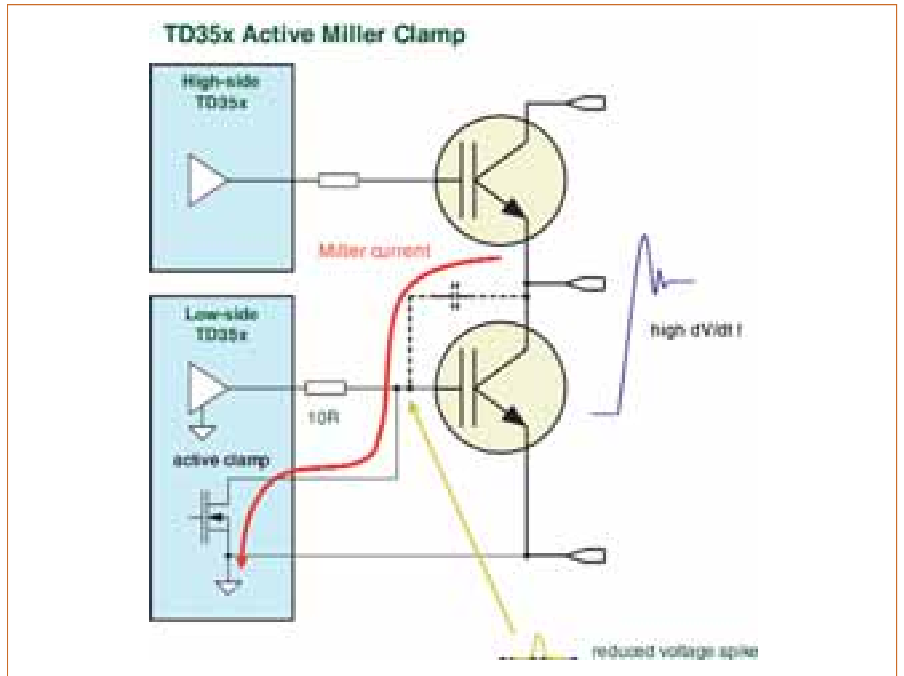
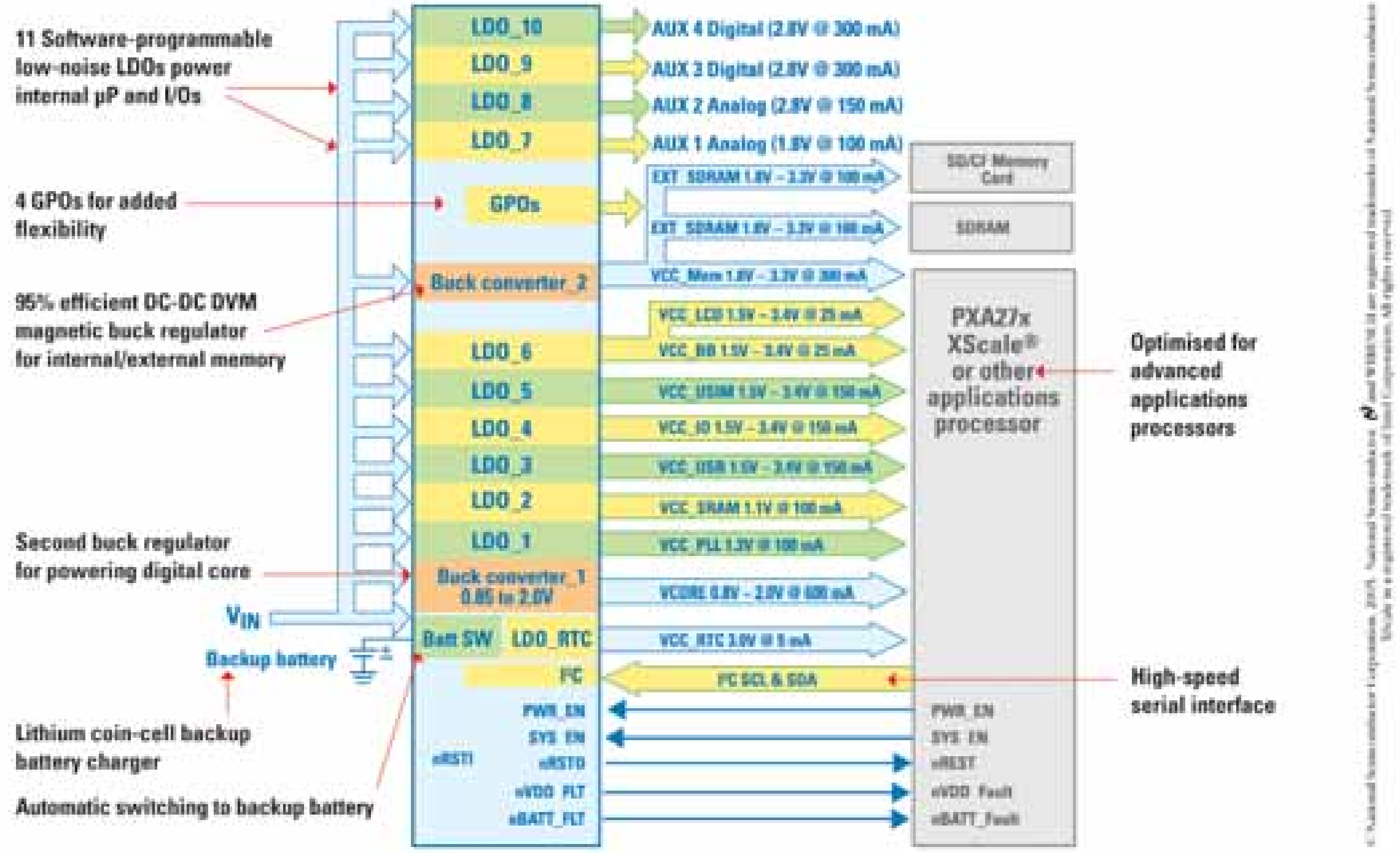


Figure1. The Active Miller Clamp principle.



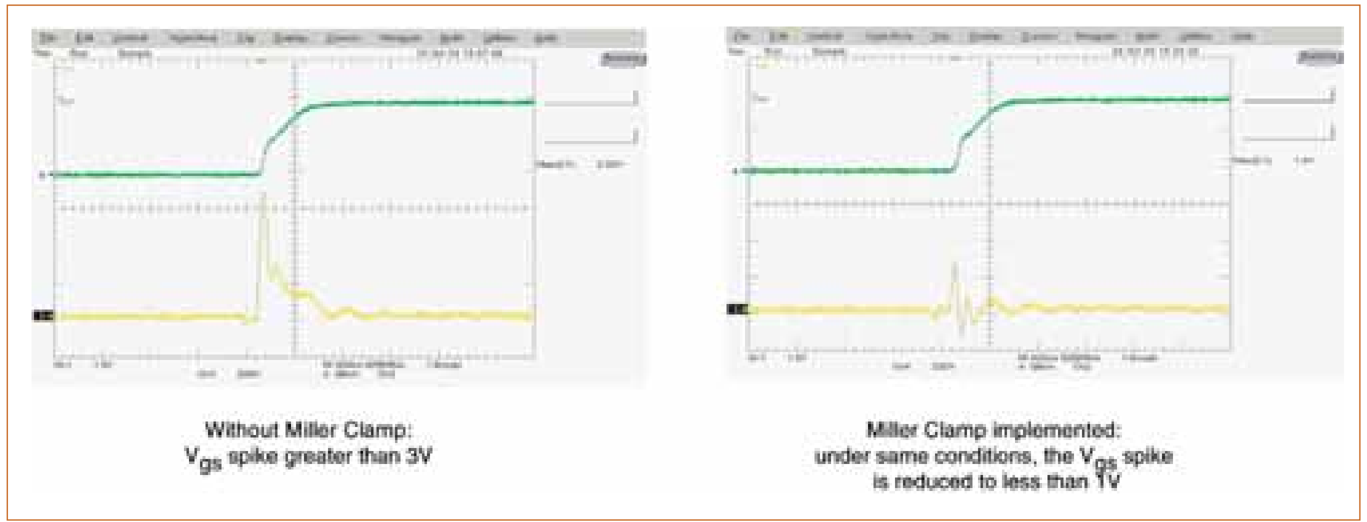


Figure 2. Vce and Vge waveforms without and with Active Miller Clamp function.

The main benefits of the Active Miller Clamp are: no need to use a negative gate voltage to keep the IGBT in safe off-state (allowing bootstrap technique for the high-side driver supply), and the possibility to adjust the gate resistor to optimize the turn-off characteristics (commutation losses and EMI behavior) independently of the Miller current issues.

The waveforms shown in Figure 2 show how the Active Miller Clamp results in a consistent reduction of voltage spikes on IGBT gate, both in amplitude and duration. These waveforms were done on a 1200V, 25A IGBT module with a gate resistor Rg=47 Ohms.

Two Level Turn off Function

An additional feature of two members of the TD35x family (TD350, TD351) is the Two Level Turn off Function.

If there is a short-circuit or over-current in the load, a large voltage overshoot can occur across the IGBT at turn-off which can exceed the IGBT breakdown voltage. By reducing the gate voltage for a short time before turn-off, the IGBT current is limited and the potential over-voltage is reduced. This technique is called 2 level turn-off. Both the level and duration of the intermediate OFF level are adjustable. The level can be easily set by an external Zener diode; its value depends on the IGBT's characteristics and is about 11V for a typical IGBT.

The duration is set by an external resistor/capacitor in conjunction with the integrated voltage reference for accurate timing, and is in the range of a few microseconds. This 2 level turn off sequence takes place at each cycle, and has no effect if the current doesn't exceed the normal maximum rated value, but it protects the IGBT in case of over current event (with a slight increase of conduction losses)

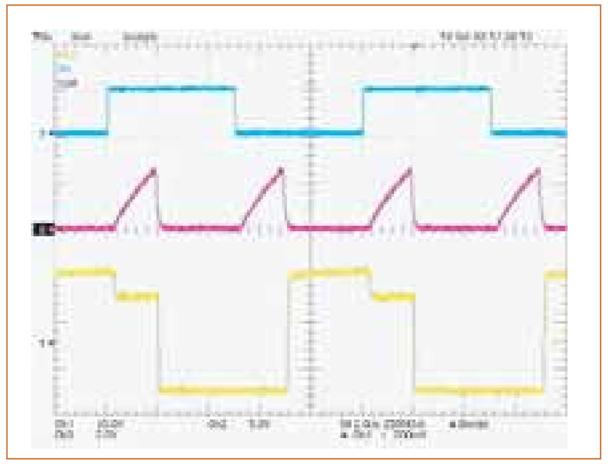


Figure 3. Input signal, COFF timing and output waveform with the 2-level turn-off function (the COFF timing is exaggerated for illustration).

To keep the output signal width unchanged relative to the input signal, the turn-on is delayed by the same value as the 2 level turn off duration (see Figure 3). Using the same timing element guarantees minimum pulse distortion. The turn-on delay also provides a minimum on-time function, as input signals smaller than this delay are ignored. Minimum on-time and low pulse width distortion allow safe and easy driving from a microcontroller or DSP system.

Table 1 shows results with a standard 1200V, 25A IGBT module driven with or without 2 level turn off. Tests were done at a current level of 150A, which simulates an over-current event. Maximum voltage reached on the IGBT collector and commutation losses are shown for both nominal rated current at 25°C (40A) and over-current (150A) conditions. There is no noticeable difference at nominal current, and the over-voltage is greatly reduced in the case of an over-current event.

Application concept using Active Miller Clamp and Two Level Turn off

The TD35x application design presented here is based on the Active Miller Clamp concept. With this function, the high-side driver can be supplied with a bootstrap system instead of using a floating positive/ negative supply. This concept is applicable to low and medium power systems, ranging up to about 10kW. The main benefit of this is to reduce the global application cost by making the supply system simpler. The Active Miller Clamp is fully managed by the TD35x and doesn't require any special action from the system controller.

	nominal 400V/40A		overcurrent 400V/150A	
	Eoff (mJ)	Vce max (V)	Eoff (mJ)	Vce (V)
Classical turn-off	2.5	620	15	1000
2-level turn-off with LVOFF=11V	2.5	620	23	840

Table 1. Comparison between classical turn-off and 2-level turn-off.

Figure 4 shows the half-bridge design concept using the TD35x. A voltage regulator is used in front of the TD35x high side driver. In this way, the bootstrap supply voltage can be made significantly higher than the target driver supply, and the voltage across the Cb bulk capacitor can exhibit large voltage variations during each cycle with no impact on the driver operation. The value of the gate resistor Rg depends upon the IGBT. It should be noted that these applications only use two supplies referenced to the ground level.

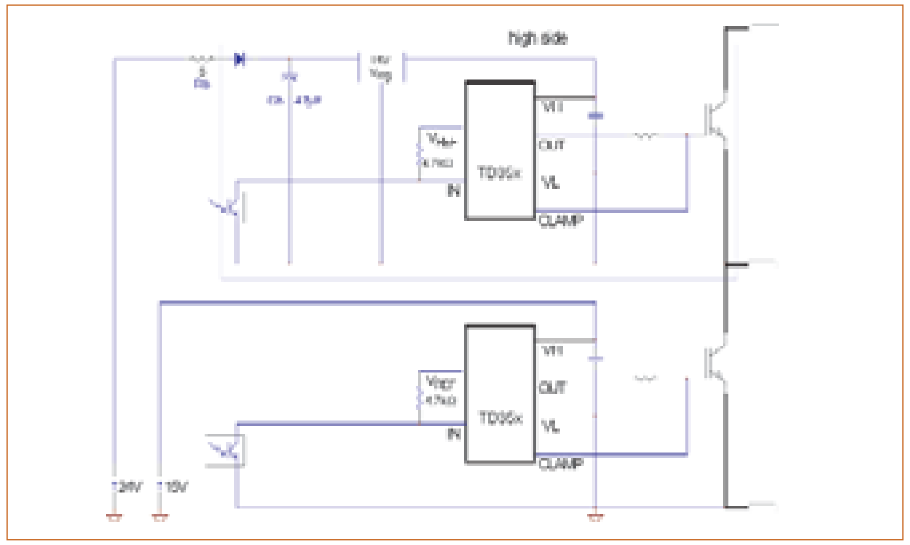
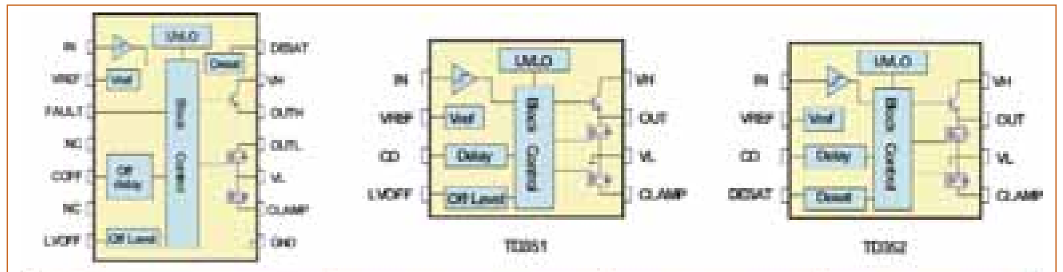


Figure 4. TD35x Application Concept

The TD35x devices are able to drive 1200V IGBT modules up to 50A or 75A (depending on IGBT technology and manufacturer). Key parameters to consider are the TD35x peak output current (0.75A source/1.0A sink minimum over the full operating temperature range) and the IGBT gate resistor. This value should be chosen starting with the recommended value from the IGBT manufacturer. Thanks to the Active Miller Clamp function, the gate resistor can be tuned independently from the Miller effect that normally places some constraints on the gate resistor. The main benefit is to optimize the turn-on and turn-off behavior, especially regarding switching losses and EMI issues.



Feature / Part	TD350	TD351	TD352
Peak current src/sink (min.)	+0.75A / -1.2A	+0.75A / -1.0A	
Active Miller clamp	yes	yes	yes
Negative gate drive ability	yes	yes	yes
2-level turn-off control	yes	yes	no
Desaturation protection	yes	no	yes
Fault output	yes	no	no
Separate sink/src outputs	yes	no	no
Input - pulse transf. - optocoupler	yes yes	yes yes	no yes
Package	SO14	SO8	

Figure 5. TD35x Family.

The TD35x Family

Three different devices are offered:

- TD350 is a flexible solution for high performance designs with advanced control and protection features.
- TD351/352 are cost effective solutions with minimum external component count, although providing the most valuable features

Figure 5 summarizes the features depending upon the different versions.

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Novel SOI Driver for Low Power Drive Applications

The base substrates for the SOI process are SIMOX-wafers

A novel 600 V/0.3 A 6-pack IGBT/MOSFET driver IC named 6ED003L06-F is developed based on the SOI technology. It realizes 3-phase level-shift, gate drive and protection functions in a single IC with reduced chip size and improved performance such as the robustness to negative transient voltage.

By R. Keggenhoff[1], Z. Liang[2], Andre Arens[1], P. Kanschat[1], R. Rudolf[3], Infineon

Low-power drive applications call for semiconductor devices with high power density and high level of integration. This is not only due to the demand for cost saving and miniaturization, but also due to the desire for design and process simplifications. Semiconductor devices in the power unit – inverter of the drive application have been the main targets in the increase of power density and integration level, since this unit is normally more costly, more space taking and tougher in design than other electronic units.

Power density and functional integration of IGBT modules rely on the chip and packaging technologies. Performance, reliability and cost of 6-pack full-functional level-shift drivers highly depend on IC design and fabrication techniques. Development in IGBT chip technologies, module technologies and IC fabrication techniques has allowed us to continuously improve the level of power density and integration of power devices.

Thin-Film-SOI Technology

SOI is the abbreviation of Silicon-On-Insulator and is an advanced technique for MOS/CMOS fabrications. It differs from the conventional bulk process by placing the active transistor layer on the top of an insulator, as shown in Figure 1.

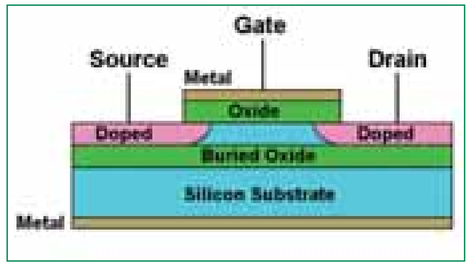

Figure 1. SOI-Transistor.

The silicon is separated by a buried silicon oxide layer to one layer on the top and the other on the bottom. The one on the top, which is the silicon film, is used to produce the transistor and the one on the bottom is used as the silicon substrate. The buried silicon oxide provides an insulation barrier between the active layer and silicon substrate and hence reduces the parasitic capacitance tremendously. Moreover, this insulation barrier disables leakage or latch-up currents between adjacent devices.

The base substrates for the SOI process are SIMOX-wafers or wafer bonded SOI substrates. At the beginning of the process it exhibits a buried oxide layer with a thickness of 400 nm and a silicon film about 200 nm thick. During the process flow the silicon film thickness is reduced by various oxidation steps. The subsequently implemented CMOS-like process is capable of producing various circuit elements. The available devices are high-voltage and low-voltage MOS transistors, different diodes and passive elements like capacitors and resistors of various values (Table 1).

A main technological advantage of the Thin-Film-SOI technology is the easy way of lateral insulation of elements inside the silicon film. While some SOI technologies with thick silicon films need an expensive trench etching process, the thin film allows each device to be separated from all other devices by a simple local oxidation (LOCOS) process. Thus, there is no need for CMOS-wells for preventing the "latch-up" effect and reducing the chip size.

Element	Characteristics
CMOS analogue transistors	30 V / 12 V / 10 V
CMOS digital transistors	5 V
SOI-PIN-diode	30 V
Z-diodes	5.2 V
Resistors	18.5 Ω/□ – 10.5 kΩ /□
Capacitor	0.84 fF/µm²
High-voltage SOI-diode	600 V, 30 V
High-voltage SOI-transistor	600 V (N-Channel)
Gate Oxide	40 nm
Metal	one layer

Table 1. Characteristics of the Thin-Film-SOI Process.

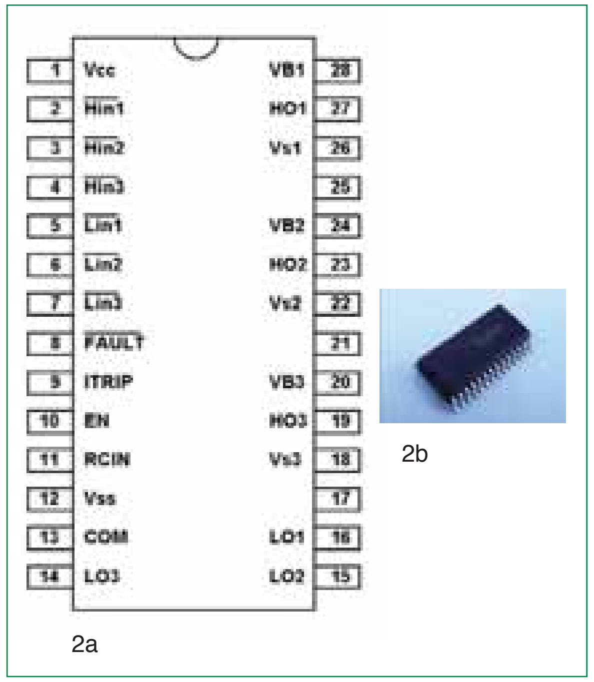

Figure 2a and 2b. SOI Pinning and SOI Housing.

The small size of PN-junctions inside the thin silicon film leads to higher switching speed, lower leakage currents and consequently higher temperature stability. In order to obtain a proper body contact for the thin SOI-MOS transistor the channel doping is extended and connected to a common source contact (split source contact). Hence the thin-film SOI-MOS transistor exhibits an anti-paralleled diode that safeguards the device in case of polarity reversal.

In spite of the thin drift regions inside the silicon films, reasonable low on-resistance per area is achieved. This allows a cost effective layout of the output driver transistors.

The SOI technology is also implemented for the 600 V level-shift transistors and high-voltage diodes. The 600V-NMOSFET is made based on the low-voltage SOI-NMOSFET structure in conjunction with a very long Drain-extension. The buried oxide insulation barrier cuts off parasitic current paths between substrate and silicon film. This prevents the latch-up effect even in case of high dv/dt switching under elevated temperature and hence provides improved robustness.

Besides these improvements, the Thin-Film-SOI technology provides additional benefits like lower power consumption and higher immunity to radioactive radiation or cosmic rays.

SOI Driver

The SOI driver named 6ED003L06-F is a 600 V/ 0.3 A 6-pack IGBT/MOSFET driver IC fabricated using the Thin-Film-SOI technology and developed by eupec and her mother company Infineon Technologies. A snap-shot of this preliminary sample of this driver with 28-lead SOIC package is shown in Figure 2b.

Driver 6ED003L06-F is designed to control six IGBTs / MOSFETs in 3-phase applications with full functionalities. It contains six independent output channels for three high- and low-side gate drives. 600 V level-shift circuits are employed to transfer control signals from low-side potential to three high-side potentials. All logic inputs are CMOS/LSTTL compatible inputs. The embedded interlocking function prevents cross-conduction caused by input logic error. A short-circuit (SC) / over-current (OC) trip function is given to shut down all six outputs when the trip input signal is over level. An enable function is also given to shut down all six outputs simultaneously. The enable input can either be a digital signal or an analog signal, e.g. a temperature signal sourced from a thermal sensor. Under-voltage (UV) detection is embedded to shut down the output channel for which the power supply is under-voltage. An open-drain output is given to indicate fault conditions such as SC/OC or UV. An RCIN input is used with an external capacitor to extend the output shut-down status and fault signal. The internal clamping diodes allow the input signal and power supply voltages to go up to 10 V and 20 V, respectively. The functional block diagram of the driver is shown in Figure 3.

6ED003L06-F comprises not only low-voltage CMOS and Zener-clamping circuits but also a differential level-shift concept with both SET- and RESET-high-voltage transistors in series with high voltage diodes. With this design, the SOI driver will be able to withstand high electrostatic noise and negative voltage spikes up to -50V (t < 10 µs), which is about 10 times the limiting value of the existing level-shift drivers. Here, the negative voltage spike refers to the transient negative voltage appearing on the high-side ground pin (VS1,2,3) of the driver IC with reference to the low-side ground pin (VSS/COM). Exceeding the limit may cause the outputs of the driver to fail to follow the inputs or even damage the driver IC. Negative voltage spikes can be excited at IGBT switching transient due to the parasitic inductance and capacitance within the circuit layout of the inverter. Figure 4 demonstrates the immunity of 6ED003L06-F-driver to negative spikes up to -50 V. With this improvement the circuit and layout design of the inverter stage would be much less critical than ever.

A cross-section of the driver chip is shown in Figure 5 and a photo of the chip is shown in Figure 6.

Some preliminary data of 6ED003L06-F is shown in Table 2.

A typical application circuit for 6ED003L06-F is shown in Figure 7. In the low-side, six logic inputs $H_{IN}1,2,3$ and $L_{IN}1,2,3$, which are active-low inputs accept CMOS or LSTTL signals from the control unit. Outputs $L_O1,2,3$ are

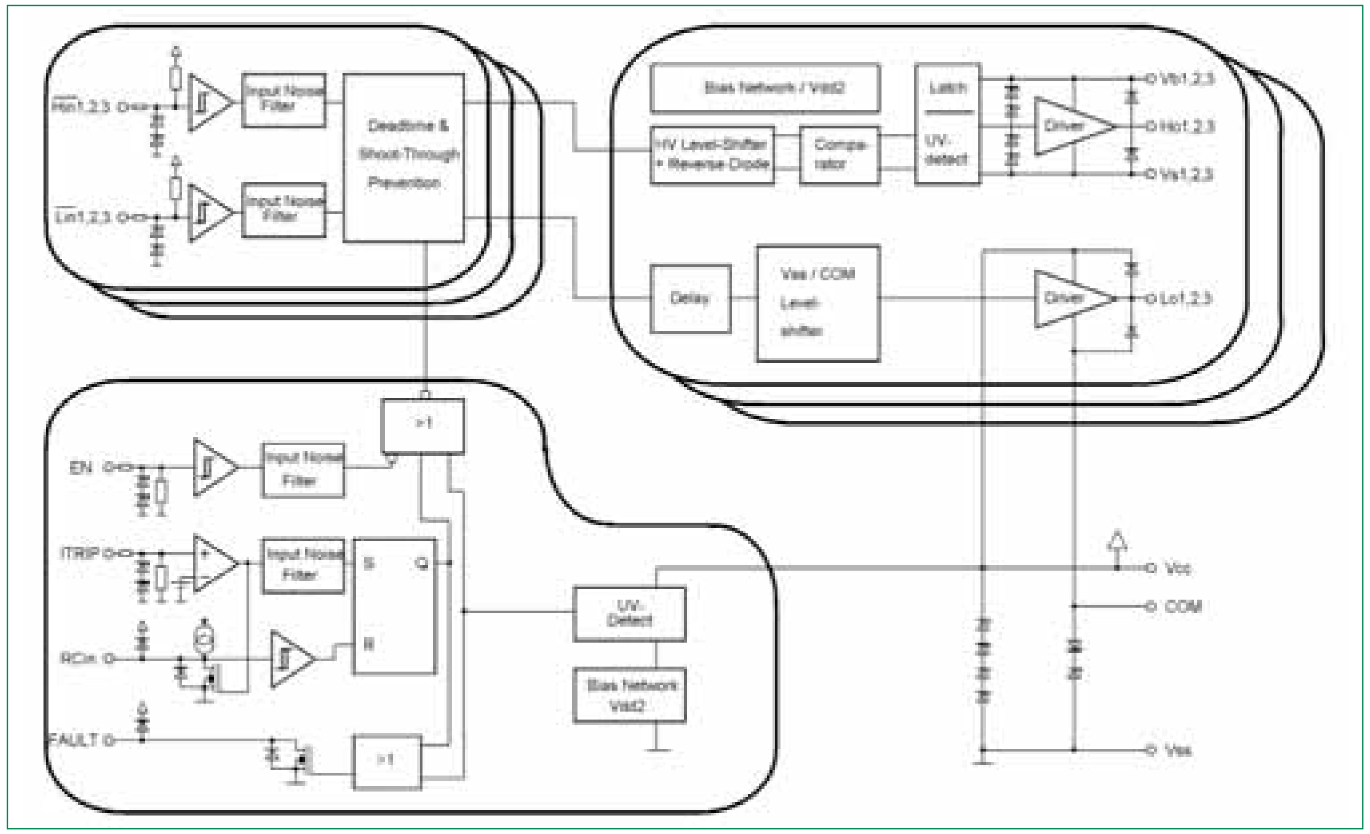

Figure 3. Functional block diagram

connected to the gates of the low-side IGBTs via gate resistors. Pin COM is connected to the emitters of the low-side IGBTs. In the high side, outputs $H_O1,2,3$ are connected to the gates of the high-side IGBTs via gate resistors. High-side Ground VS1,2,3 are connected to the emitters of the high-side IGBTs. The low-side power supply is connected to V_{CC} and V_{SS}, where V_{SS} is the signal Ground and is also the DC-link Ground. The high-side power supplies to be connected to $V_B1,2,3$ and $V_S1,2,3$ are created by the low-side power supply and boot-strap circuits.

The current-sensing resistor, which is normally placed between the common emitters of the low-side IGBTs and DC-link Ground, is connected to the I_{TRIP} input via a voltage-divider circuit. The FAULT output, which is an open-drain output sends active-low fault signal to the control unit. The RC_{IN} input is connected with a capacitor, which sets the duration of the output shut-down and fault signal. The EN input, which can accept analog signal, is connected with an NTC thermal sensor to detect the over-temperature (OT) condition. Therefore, this circuit realizes 3-phase IGBT gate drives and protection functions including SC/OC, OT and UV protections in a simple manner.

The advantages of 6ED003L06-F driver can be summarized as follows:

- High robustness to negative voltage spikes.
- No latch-up effect.
- High temperature stability, i.e. safe operation up to 125 °C.
- High immunity to radioactive radiation.
- High immunity to electromagnetic field.
- Small chip size, low chip cost.

Vision of the Applications

SOI driver 6ED003L06-F can be used to drive 600 V IGBT up to 30 A in 3-phase full-bridge configuration. From cost and size points of view, it is especially suitable to be used together with eupec Easy-750 modules to form cost-effective miniature inverters for low-power industrial or consumer drive applications. Combining with Easy-750 modules covering 6 A to 30 A ratings in unique housing, 6ED003L06-F can be used to construct a series of low-power inverters for drive application from 0.5 kW to 3 kW with unique board layout.

Conclusions

With the superiority of SOI technology, SOI driver 6ED003L06-F will be offered as a cost-effective, high-performance and highly reliable driver IC for low-power 3-phase applications. With this driver plus the excellent 600 V IGBT3, low-cost package and innovative mounting concept, the “Smart” series of modules will be a perfect solution for Low Power drive applications.

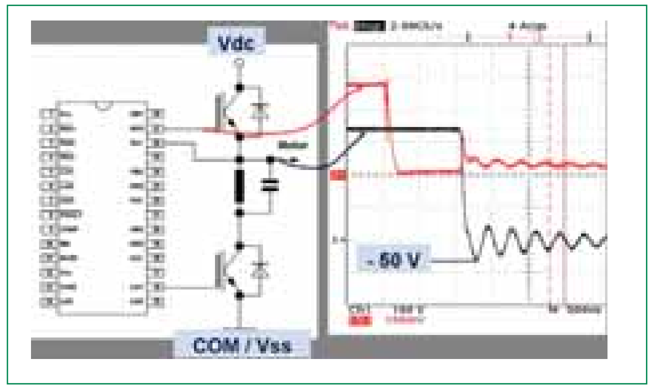

Figure 4. Immunity of 6ED003L06-F-driver to negative spikes.

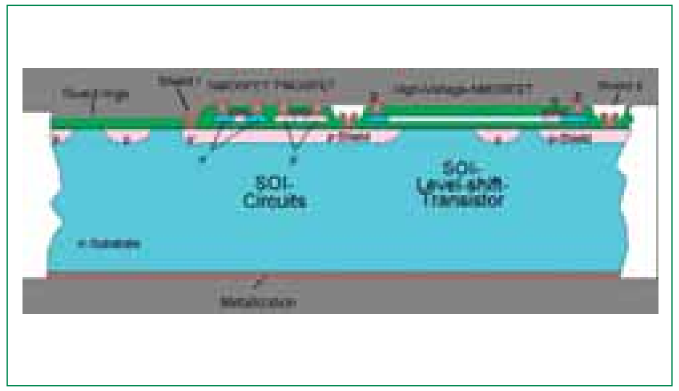

Figure 5. Cross-section of the driver chip.

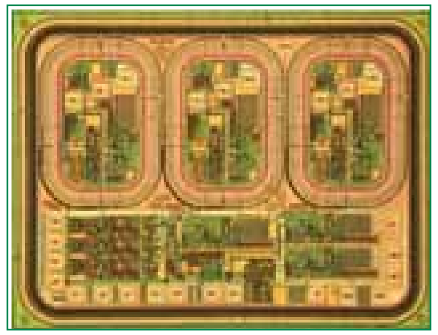

Figure 6. Photo of the chip.

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[1]Infineon Technologies AG, Max-Planck-Strasse 5, D-59581 Warstein, Germany
[2] Infineon Technologies Asia Pacific, 8 Kallang Sector, Singapore 349282
[3] Infineon Technologies AG, Finkenstraße 61, 47057 Duisburg, Germany

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[2] R. Rudolf, Infineon Technologies: "Introduction to the SOI Technology", November 2004

[3] A. Arens, Infineon Technologies AG: "6ED003L06-F (SOI Driver)", November 2004

[4] P. Kanschat, T. Stolze, T. Passe, H. Rüthing, F. Umbach, O. Hellmund: "600V IGBT3-Technology in New Low Cost Modules for Consumer Drive Applications", Conference Proceedings, PCIM Shanghai, March 2003

[5] T. Passe, T. Stolze, Z. Liang: "Low cost solution of IGBT modules for consumer drive applications", Conference Proceedings, PCIM Shanghai, March 2002

	Description	Value
Vs	High-side offset voltage	-6 V to 600 V
	High-side offset voltage (t < 10 µs)	-30 V to 600 V
TJ	Max. Junction Temperature	125 °C
Io	Max. Output Current of the Driver (Source / Sink)	210 mA / 360 mA
tr / tf	Rise Time / Fall Time (C_L=1 nF, R_L=82 Ω)	100 ns / 45 ns
ton / toff	Turn-On / Turn-Off Delay Time	700 ns / 700 ns
IQCC	Current Consumption of the "Low-Side"	0.9 mA

Table 2. Preliminary data of 6ED003L06-F.

[6] R. Keggenhoff, Infineon Technologies AG: "SOI Concept", November 2004

[7] Infineon Technologies AG: "EiceDRIVER™, 6ED003E06-F, Evaluation Board for EasyPACK750, Datasheet and Application Note", July 2003

www.infineon.com

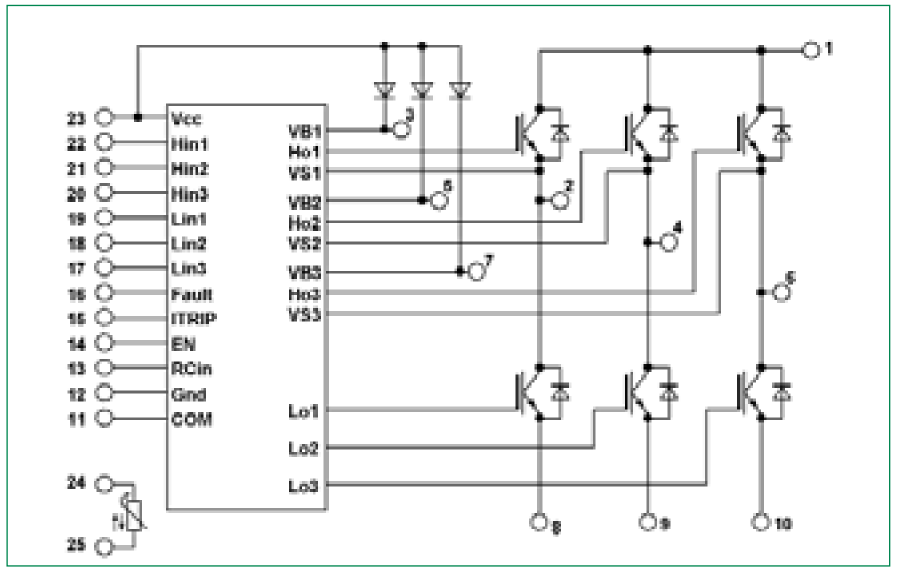


Figure 7. Typical application circuit for 6ED003L06-F.

Applying One Cycle Control

Simplify PFC design at 75W and higher

One Cycle Control (OCC) eliminates the requirement for a sinusoidal current reference. Instead, by assuming the modulation voltage produced by the voltage error amplifier is constant during a given switching cycle.

By Stephen Oliver, International Rectifier Marketing Manager, AC-DC Sector Business Unit

Legislation restricting the effects of appliances on mains power quality, as well as growing use of tariffs and levies to force improvements in energy efficiency, make power factor correction (PFC) an important part of converter designs for mains-connected appliances.

Figure 1 shows a schematic of a PFC implementation. Perfect power factor correction, equivalent to a power factor of unity, makes the load appear purely resistive. This reduces harmonic distortion and eliminates reactive power, thereby improving energy efficiency. There are broadly two ways of implementing PFC: discontinuous conduction mode PFC (DCM); or continuous conduction mode (CCM) PFC.

Historically, DCM has been the easiest to implement. However, discontinuous conduction operation leads to relatively high peak currents. When used with high power converters, the requirements for large heatsinks and large inductors for EMI filtering make DCM unattractive.

The point at which DCM becomes unfeasible is generally accepted to be between 100W and 200W. This is within the range of many computing, consumer, home appliance and industrial equipment applications, including high-end laptops, servers, home theatre, washing machines, UPS, small industrial motors and similar products. Indeed, some argue that DCM is not suitable above around 75W.

Continuous Conduction PFC

With CCM, peak currents are generally lower, making this approach suitable for systems up to several kW. However, the control requirements are more complex for CCM. This is because CCM operation is based on the action of an analog multiplier / divider, which samples the rectified AC line voltage and creates a sinusoidal current reference signal in order to force the input current to follow the input voltage. This signal then controls the duty cycle of the main PWM controller, forcing the input current of the converter to follow the sinusoidal shape of the input voltage, thereby providing near unity power factor and reduced current harmonics.

Given the sensitivity of the control loop and the multiplier block, any distortion or noise injected into the inputs can have a negative impact on the power factor and harmonic distortion of the input current.

PCB layout issues also play an important role, as does the selection of the components and their optimum values. In fact, the design steps necessary to

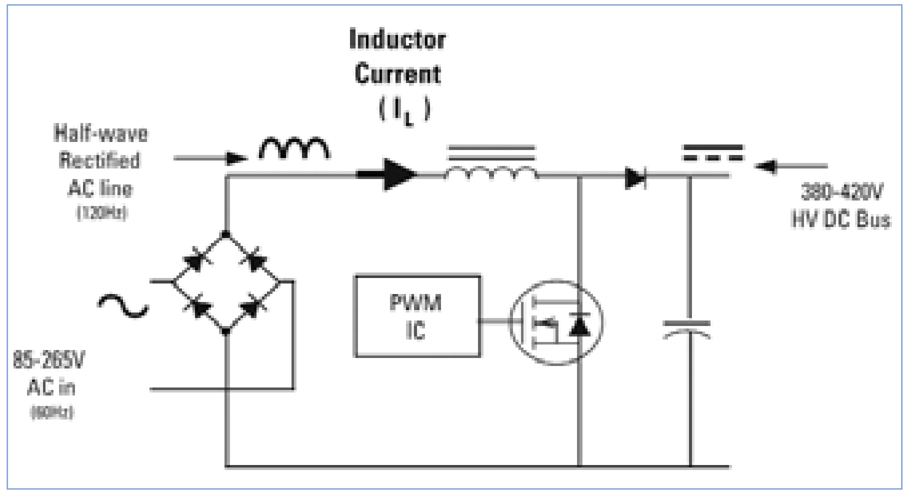


Figure 1. Power factor correction in a mains-connected converter.

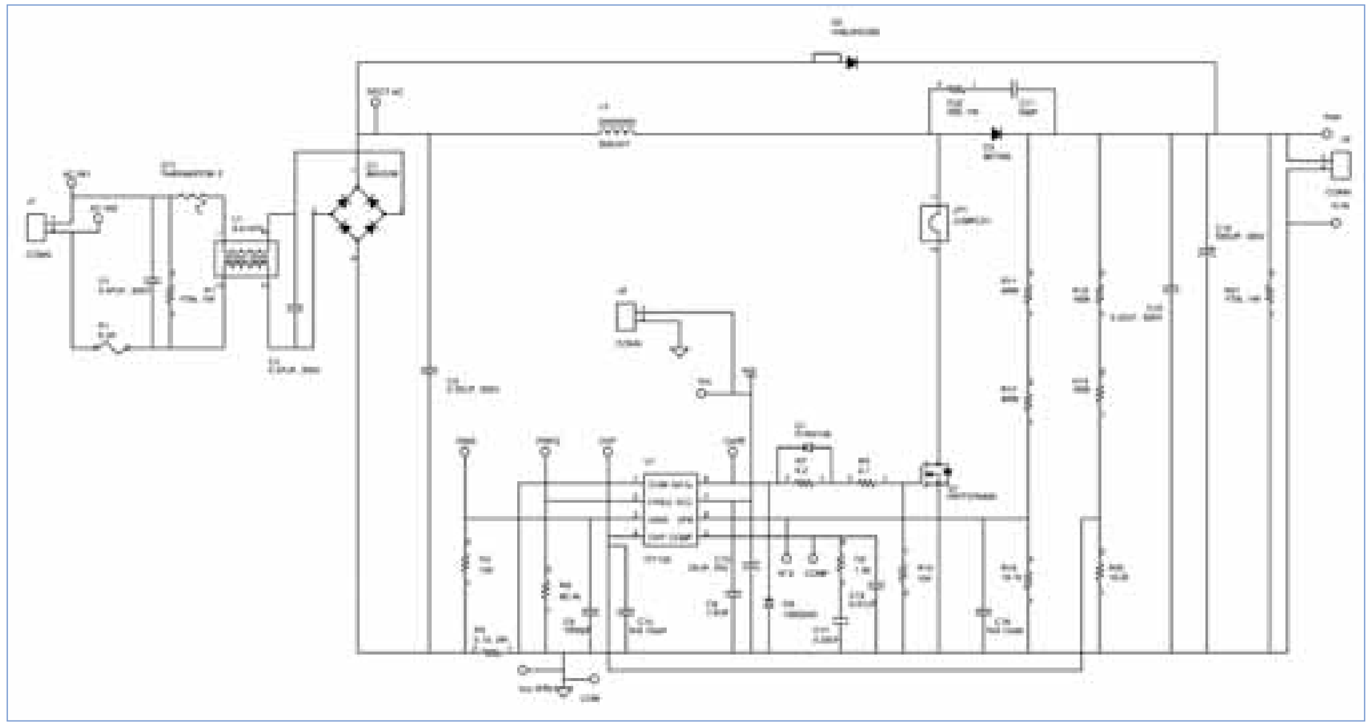


Figure 2. IR1150 demo board schematic diagram.

implement a conventional CCM are as follows:

- Design/select power circuit components
- Design/select current sense resistor
- Design resistive divider for peak current limit
- Design Enable circuit resistor divider
- Select IAC resistor, (multiplier setup)
- Design Vff divider, (multiplier setup)
- Select Rbias resistor, (multiplier setup)
- Select Rset resistor, (multiplier setup)
- Select Rmo resistor, (multiplier setup)
- Design current error amplifier compensation
- Design voltage error amplifier compensation
- Design output voltage feedback divider
- Design 2 cascaded pole feed forward filter

In practice, several design iterations are frequently necessary in order to optimize control circuit performance throughout the full line and load range. A well-designed (CCM) PFC circuit requires strong power engineering skills.

One Cycle Control

But there is another way to implement CCM PFC, which avoids this high level of design complexity. One Cycle Control (OCC) eliminates the requirement for a sinusoidal current reference. Instead, by assuming the modulation voltage produced by the voltage error amplifier is constant during a given switching cycle, OCC integrates this signal over a single cycle to produce a ramp signal whose slope is directly proportional to the output voltage of the error amplifier. A PWM controller compares the ramp signal to an analog reference voltage generated from the sum of the current and the error voltage, and terminates the PWM signal when the ramp reaches the reference level. In this way the controller manages the converter duty cycle to achieve output voltage regulation and power factor correction. It is reasonable to assume the modulation voltage is constant over a single cycle, because the voltage loop bandwidth is very small.

The integrator is reset at the end of every switching cycle. The name "One Cycle Control" simply refers to the cycle-by-cycle operation of the integrator and the generation of the reference signal during each switching cycle.

A One Cycle Control CCM PFC controller, such as the International Rectifier IR1150 combines the integrator, PWM controller and associated circuitry in a single component. The designer simply has to select the values of a small number of external components in order to ensure satisfactory operation at the desired power. Because this approach significantly simplifies the design processes as well as eliminating bulky wound components, CCM can now be applied in low-power, low-cost systems from around 75W upwards.

Using the IR1150, engineers with only a basic understanding of PFC control design can implement a CCM PFC controller. Controller design software is also available to further streamline the design procedure. A 300W demo board is also available (figure 2), allowing designers to quickly implement OCC CCM PFC using the IR1150 controller and optimize the system implementation by following a significantly streamlined design procedure:

- Design/select power circuit components
- Design/select current sense resistor
- Design voltage error amplifier compensation

Selecting the Current Sense Resistor

The current sense resistor determines the point of soft over-current, that is the point at which input current will be limited and the output voltage will drop. The worst case is at low line when the current is the highest and also the boost factor of the converter is higher. The current sense resistor RS must be designed so that at the lowest input line and largest load, the converter will be able to maintain the output voltage.

This can be determined by calculating the voltage required across the current sense resistor to set the "soft" current limit at minimum input voltage. The value of the sense resistor can then be calculated from the maximum peak inductor current:

$$R_S = \frac{V_{SNS(max)}}{I_{IN(PK)OVL}}$$

Power dissipation in the resistor can then be calculated based on worst case rms input current at minimum input voltage. Proper derating guidelines should also be applied.

Voltage Loop Compensation

Typical of PFC converters is the requirement to keep the voltage loop bandwidth less than half the line frequency in order to avoid distortion of the line current resulting from the voltage loop attempting to regulate out the 120Hz ripple on the output.

There is of course, the associated tradeoff between system transient response and input current distortion, where stability of the voltage loop is generally easily achieved. The goals of voltage loop compensation are to limit the amount of second harmonic ripple injected in the COMP pin from the error amplifier, and restrict open loop gain bandwidth to less than half the AC line frequency.

Selectable Switching Frequency

The switching frequency of the IC is programmable from 50-200kHz by an external resistor. This also allows designers to choose the optimum power switch technology for a given application. This is a trade-off between switching speed, switch gate-charge and switch current. For high current, low (~50kHz) frequency applications, IGBTs offer the best $/amp performance. At higher frequencies (to 200kHz), HEXFET power MOSFETs can be used with a choice of appropriate ultrafast boost diode.

Conclusion: Ease of Design, and More

In addition to this much simplified design procedure, OCC has demonstrated massive reductions in component count and PCB space compared to a typical conventional CCM PFC controller implementation. For a 1kW example, One Cycle Control using the IR1150 requires 40% fewer components and less than 50% of the original PCB space. Compared to a low cost DCM PFC design, say for a 120W laptop adaptor, OCC keeps the same number of components and ease of design but with a 10% improvement in power density.

www.irf.com

INDUSTRIAL ELECTRONICS II

Voltage Detector for Dangerous Voltage

Specification target railway applications

The average duration of operation aimed is 1 million hours for the VD1500 voltage detector. In order to optimize the correct operation of this apparatus, it is essential to carry out a preventive maintenance, in spite of the improvement made thanks to the redundancy of the two independent electronic boards.

By Thomas Peyrouzet, ABB Entrelec - Control Division, Sensors Marketing Department

Many applications in the field of traction market like the embarked equipment (main converters, auxiliary converters) and the systems of power electronics (battery chargers, choppers, sub-stations, etc) need a regular maintenance. In these applications, the capacitors banks, which store electrical power, can put a few tens of seconds to be discharged, even a few minutes. The high voltage at the terminals of these components presents an important risk for the operators of maintenance, and during a significant time. The voltage detector makes it possible to the operators to make sure that they can carry out the action of maintenance without risk. The equipment is declared "out of voltage" if the voltage compared with the earth (mass) is lower than the threshold of safety, fixed at 50V d.c. (specification of safety such as CF60-100).

ABB markets the first voltage detector, which is a safety product, which is adapted perfectly to the main specifications of the railway market. This new voltage detector was designed by integrating a new ABB innovation, a solution 100% electronics. This technology offers a reduced volume and weight. The first ABB voltage detector is available on the market, under the name of "VD1500", corresponding to a nominal voltage of 1500V d.c. The voltage amplitude of the VD1500 range that can be detected extends from 50V up to 1800V d.c. permanently.

This first version of VD1500 detector from ABB allows the operator maintenance to check the presence of a dangerous voltage up to 1500V d.c. nominal or 1000V a.c. under certain conditions. The dangerous voltage is indicated via 2 independent Electroluminescent Diodes (LED), which flash when the detected voltage is higher than the specified limit (maximum 50V according to specification CF60-100).

U_{OFF}: Lower limit to which the LED switches off, after the equipment is powered off.
U_{ON}: Upper limit to which the LED switches on (frequency of the flash is approximately 1.7Hz), after the equipment is powered on.
Below 40V d.c., the LED are switched off. Between these two limits, the LED can be either switched on or switched off.

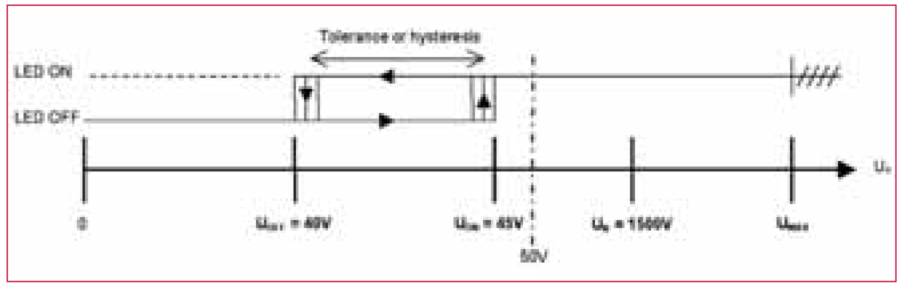


Figure 1. dangerous voltage is indicated via 2 independent LEDs.

The mechanical and electronic concept ensures an excellent reliability of the product by two independent electronic boards, which permanently ensure the correct operation of the detector. Below (Fig2) the explanatory diagram of the redundancy is presented (2 identical electronic boards having the same function in only one case).

The frequency of flash of the LED, being slightly different one from the other, these flashes are thus not synchronized and testify of the total independence of the 2 functions in the same case.

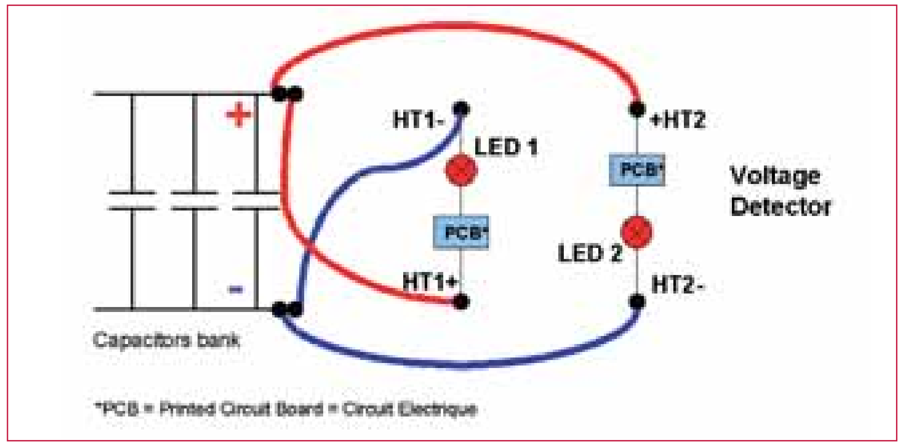


Figure 2. two independent electronic boards for correct operation.

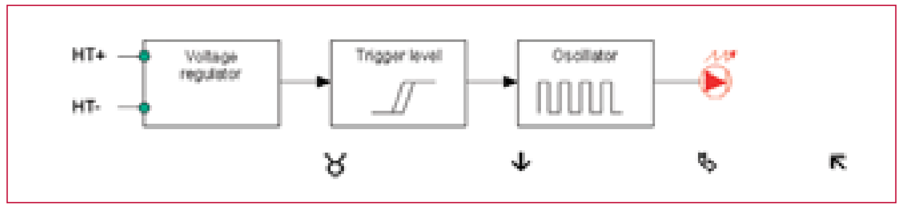


Figure 3. Block diagram of operation.

Principle of operation of the detector:
The constructions of the detector being based on a 100% electronics technology, 3 main blocks were implemented.

The block reduces the high voltage to be detected into an exploitable voltage by the trigger level. This block integrates all necessary protections against over voltages related to the on-board railway application.

The block defines the threshold level of detection of the dangerous voltage. It integrates a comparator with hysteresis, which avoids an unstable functioning around the 45V during the increase or of the reduction in voltage.

The block generates current pulses to the electroluminescent diode to obtain an intense and short luminous flash. This allows a reduced consumption of the detector (< 5W under a voltage of 1800V d.c.) and a perfect visualization for the operator.

Characteristics		Unit	VD1500
Nominal voltage (U_N)		V d.c.	1500
Permanent maximum voltage U_{MAX1}		V d.c.	1800
Maximum length-time voltage U_{MAX2}	5min	V d.c.	1950
Maximum overload voltage U_{MAX3}	20msec	V d.c.	2538
Rated insulated voltage1 (U_{ISR})	50Hz, 10sec	kV	9.5
Average no-load consumption current (LEDs flashing)		mA	≤1
Average LEDs flashing frequency		Hz	1.7
Trigger voltage level U_{ON}		V d.c.	≤45
Trigger voltage level U_{OFF}		V d.c.	≥40
Mass		Kg	≤0.5
Operating temperature		°C	- 40 ... +70
Storage and start-up temperature		°C	- 40 ... +85
LEDs color			red
LEDs vision angle			±15°

[1] Overvoltage category: III (OV3), pollution degree: 2 (PD2)

Table 1. Main electrical characteristics of the VD1500.

For correct applications of the VD1500 voltage detector, the high voltage must be connected to the 4 primary terminals of the detector.

A LED functions when terminals HT1+ and HT1- are connected. The other LED functions when terminals HT2+ and HT2- are connected. In order to ensure redundancy of the 2 functions, 4 high voltage wires must be connected starting from 4 different places from the capacitors bank as indicated on the preceding diagram.

Electrical characteristics:
The main electrical characteristics of the VD1500 voltage detector are described by table1.

From a safety point of view, it is very important to have in mind that the detector must be correctly mechanically fixed but can be assembled in any position. The maintenance staff must have an easy and fast access to the device and the 2 LEDs must be easily visible by the relevant personal.

The average duration of operation aimed is 1 million hours for the VD1500 voltage detector. In order to optimize the correct operation of this apparatus, it is essential to carry out a preventive maintenance, in spite of the improvement made thanks to the redundancy of the two independent electronic boards and to the use of LEDs.

The temperature range of the voltage detector extends from – 40°C up to +70°C. The VD range was studied in conformity with the railway standards: EN50155 for the electronic design and tests, EN50124-1 for the electric insulation and EN50163 for the network nominal voltage. It was also conceived according to the safety requirements EN50129 for the communication, the indication and the treatment of the signal.

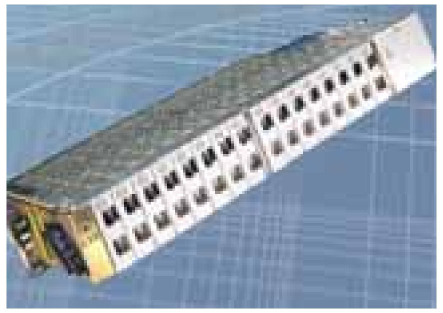
The ABB voltage detector offers a profitable solution, which is easy to install and to use. To help you to understand the ABB VD1500 voltage detector, we have created technical argumentations, mounting instructions as well as user guides and maintenance.

For a long time ABB is concerned by the environmental protection and is certified ISO14001 since 1998. This environmental approach is particularly present in the production of the VD range with the reduction of the components used, the applications of an economic manufacture procedure and of packing, which are recyclable.

Respect of the standards, improvement of the reliability and reduction of the preventive maintenance, the VD1500 presents undeniable technical and economical advantages for a safety product, which will meet the majority of the needs in applications requiring the implementation of capacitor banks until 1500V d.c. nominal line voltage. While waiting for the announced success of this new range of devices, other ratings, versions and accessories will come to supplement this first product.

www.abb.com/lowvoltage

FTTN and FTTC Power Solutions



Tyco Electronics Power Systems announced the launch of its new remote-powered offerings for fiber-to-the-node (FTTN) and fiber-to-the-curb (FTTC)—CPS2500D (for the downstream or customer end) and CPS3200U (for the upstream end).

These products use existing twisted pairs to provide remote powering for IP-DSLAMs and other equipment. They deliver power from the upstream site to electronics at the downstream or customer end of a fiber. When compared with commercial AC powered solutions, remote power requires far fewer battery/generator sites, thus improving availability while lowering the cost of battery maintenance. It can also speed time-to-market in two ways—by eliminating the need to run additional AC feeds to each downstream node and by streamlining the right-of-way approval process with municipal governments.

The CPS2500D is located with the video switching equipment at a site not served by batteries. The equipment is typically placed in a cross-connect cabinet or an optical network unit (ONU). The CPS2500D accepts up to 20 power circuits and provides up to 1300W. It is designed to operate best from a CPS3200U source, but works with a variety of other upstream equipment as well.

The CPS2500D and CPS3200U solutions deliver remote power using +/-190V or -190V at distances to 15,000 feet. As the line power makes better use of existing right-of-ways and avoids a trip to city hall, these solutions allow for quicker deployment to customers.

www.power.tycoelectronics.com/FTTX1

Functional Surfaces

In many technical sectors in the optical and chemical industries, in medical and measuring technology and engineering, in HI-FI systems and general technical consumer goods, cases for accommodating electronic equipment are required.

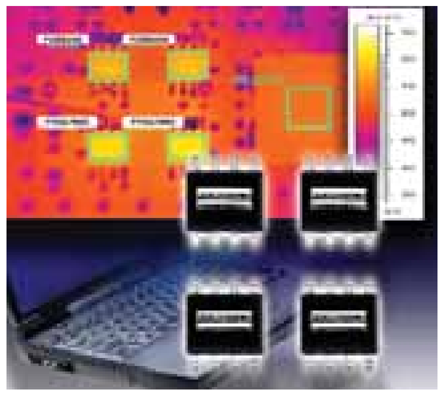
For a great number of applications, simple surface finishes such as lacquering, anodising etc. are not adequate or appropriate.

Fischer Elektronik, as a manufacturer of electronic cases, offers a decorative and functional surface finish using Nextel*. This matt, elastic, scratch- and abrasion-resistant surface has a uniform appearance with diffused reflection and is absolutely antiglare. Good resistance to chemicals, salt and extreme climatic conditions make this surface finish particularly suitable for use even in very harsh conditions.

The possibilities of design offered by the range of colours on functional electronic cases made by Fischer Elektronik give real added value to the user. We would be pleased to advise you.

www.fischerelektronik.com

30V Synchronous Buck Chip Set



Fairchild Semiconductor introduces a synchronous buck converter chip set designed specifically to optimize efficiency and space in notebooks using the latest IMVP (Intel Mobile Voltage Positioning) specifications. Utilizing Fairchild's PowerTrench MOSFET technology, the high-side "control" MOSFET (FDS6298) and the low-side "synchronous" MOSFET (FDS6299S) form a chip set providing increased current density and improved efficiency in synchronous buck converter applications. In addition, the FDS6299S device's monolithic SyncFET technology eliminates the need for an external Schottky diode, resulting in board space savings and reduced assembly costs.

This integrated chip set features a very low Qgd or "Miller" charge for fast switching speeds as well as a Qgd/Qgs ratio of less than 1 to limit the potential for cross-conduction losses. In addition to Vcore designs, the fast-switching FDS6298 and the low RDS(on) FDS6299S offer benefits as a matched pair that are well suited for high current point-of-load (POL) converters in such applications as high-end communications equipment.

These products are available in a lead (Pb)-free SO-8 package that meets or exceeds the requirements of the joint IPC/JEDEC standard J-STD-020B and are compliant with the European Union requirements now in effect.

www.fairchildsemi.com

High Accuracy, 4-20mA Transmitter

Texas Instruments announced a high accuracy, 4-20mA transmitter in a miniature MSOP-8 package. Featuring low offset and span errors, the XTR117 offers simple over-scale and noise resistant signaling with low power consumption (250uA max). The new transmitter, from the company's Burr-Brown product line, has a wide operating voltage range of 7.5V to 40V and is tolerant of power surges up to 50V. Its small size and accurate 4-20mA output scaling are ideal for pressure, temperature and humidity transducers as well as industrial process monitors. (See http://www.ti.com/sc05222.)

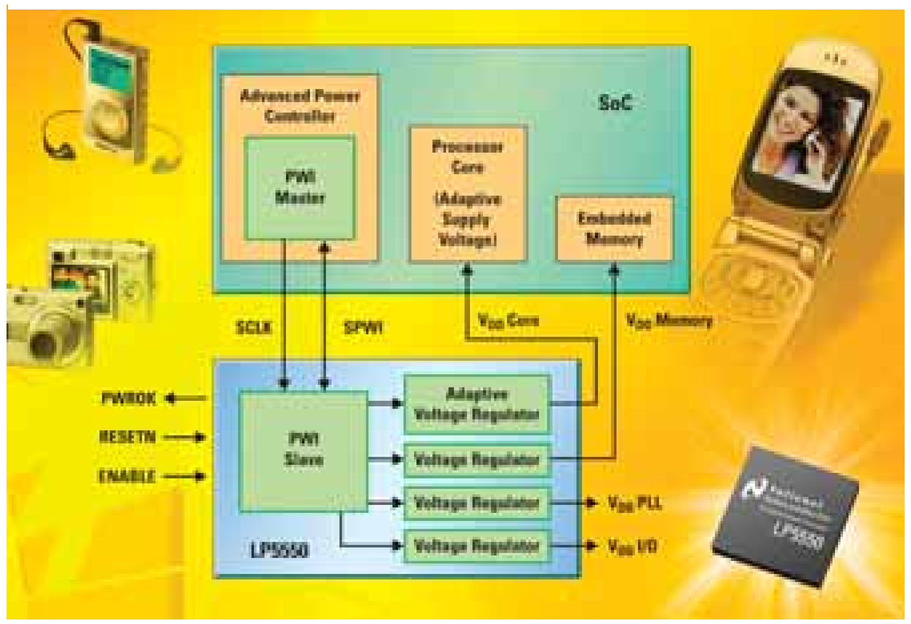
The XTR117 is robust in harsh electrical environments and has a generous 3.75mA at 5V (sub-regulated) available for external sensor conditioning circuitry power. The Iout/Iin transfer function of x100 can easily be created for voltage output sensor conditioning circuits with one external scaling resistor.

The low quiescent current, accurate 4-20mA scaling (without calibration), small size and low cost of the XTR117 make it a clear choice over discrete implementations of this function. The device operates over the extended industrial temperature range of -40C to 125C.

The XTR117 provides an excellent central building block for two-wire 4-20mA designs which can pre-condition sensor signals through digitally calibrated sensor signal conditioning chips (such as PGA309), low power microcontrollers (such as MSP430), or discrete combinations of instrumentation amplifiers and voltage references (such as INA122, INA118 and REF31xx), or low power op amps and voltage references (such as OPA335, OPA344 and REF32xx).

www.ti.com

Energy Management Reduces up to 70 Percent



National Semiconductor announced the industry's first digitally-controlled PowerWise energy management unit (EMU), a highly integrated circuit that reduces the power consumption of digital processors used in battery-powered handheld consumer products. The LP5550 EMU, used in conjunction with National's advanced power controller (APC) and intelligent energy manager (IEM) technology from ARM Ltd., reduces the power consumption of digital processor cores by up to 70 percent. The LP5550 and APC also support the PowerWise Interface (PWI) open-industry standard introduced by National Semiconductor and ARM.

National's LP5550 enables a digital processor to adaptively adjust its supply voltage to the minimum level needed, greatly reducing its power consumption. The LP5550 includes an adaptive-supply-voltage buck regulator for the processor core and three additional fixed-voltage regulators. The fixed-voltage regulators power the input/output ring, oscillator/phase-locked loops (PLL) and memory on a low-power system-on-chip (SoC). The PWI interface controls the LP5550's functions for simple interfacing to the digital processor.

For more information about the PowerWise adaptive voltage scaling technology visit http://powerwise.national.com

www.powerwise.national.com

1% Accurate PWM Controllers

International Rectifier has introduced two one-percent accurate, single output, synchronous buck PWM controllers with 4.5V to 16V input voltage capability. The new IR3637SPbF and IR3637ASPbF are compact and simple solutions for up to 15A DC-DC point-of-load applications such as dual data rate (DDR) memory, field programmable gate arrays (FPGAs), and video graphics processors. Combined with International Rectifier's broad selection of power MOSFETs, these two controllers offer greater design flexibility and improved performance versus integrated solutions.

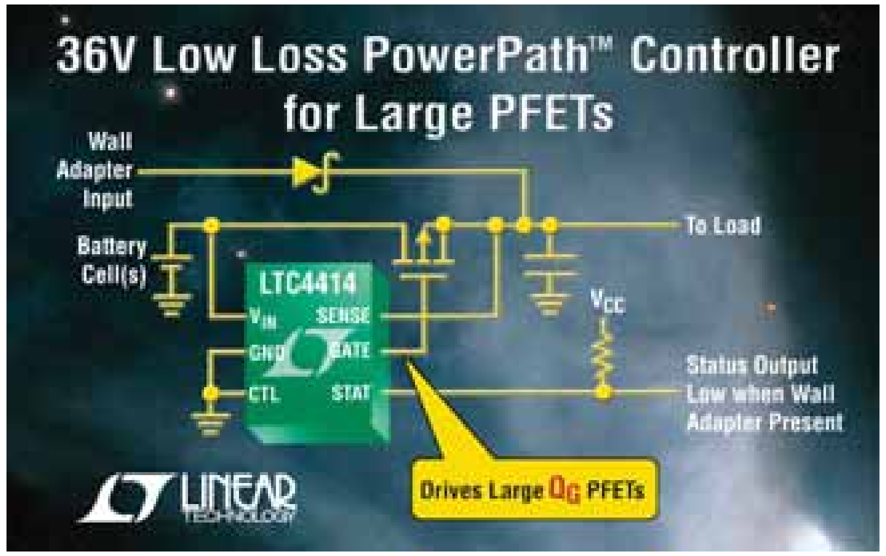
Lead-free and compliant with the Restriction of Hazardous Substances Directive (RoHS), these two PWM controllers feature a 0.8V, one percent accurate voltage reference. In next generation systems, peripheral rails can require as little as 3% total voltage error tolerance to ensure data signal integrity. The two PWM ICs with one percent accuracy allow designers to meet this stringent requirement. Both ICs include short-circuit protection, input under-voltage lockout, and an externally programmable soft-start function. The devices are available in the standard SO-8 package.

Operating at 400kHz, the IR3637SPbF is suitable for output currents up to 15A for applications including desktop motherboard peripheral rails such as DDR memory and chip set power.

The IR3637ASPbF runs at 600kHz and provides optimum efficiency in applications requiring less than 7A such as FPGAs. The 600kHz operating frequency reduces required inductor size when compared to lower frequency solutions and increases control loop bandwidth for improved transient response. Both PWM controllers are suitable for general purpose DC-DC conversion in a variety of other switching power supply applications.

www.irf.com

36V Low Loss PowerPath Controller Drives Large PFETs



Linear Technology Corporation introduces the LTC4414, a robust “ideal diode” PowerPath controller for driving large PFETs with substantial gate capacitance. The LTC4414 permits low-loss OR-ing of multiple input DC power sources. Its 20mV forward voltage is at least 10x lower than that of a Schottky diode. As a result, the device increases efficiency by an order of magnitude, due to much lower power loss and less self-heating, in systems requiring automatic switching or load sharing between power sources. The LTC4414 is guaranteed to meet performance specifications over a wide range of user conditions including an ambient temperature range of -40∞C to 125∞C and operating voltage range of 3V to 36V. The LTC4414 also provides reverse battery, overcurrent and MOSFET protection circuitry in a small MSOP package. In addition, the device offers a digital control input and an open-drain status output pin to simplify interfacing to a microcontroller. Applications include systems that typically take power from multiple input sources, including high current power path switches, uninterruptible power supplies, backup battery systems, logic-controlled power switches and automotive and industrial systems.

Multiple LTC4414 devices can be used to enable switchover between multiple batteries or charging of multiple batteries from a single charger. The LTC4414 status pin (STAT) can be used to control a second P-channel MOSFET power switch so that both Schottky diodes are eliminated from the diode-OR circuit. The IC’s ultra low 30uA quiescent current is independent of the load current. In addition, the LTC4414 utilizes a strong gate drive for gate turn-on and turn-off times of 600us and 20us, respectively. The LTC4414 is offered in an 8-lead MSOP package.

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Companies in this issue

Please note: **Bold**—companies advertising in this issue

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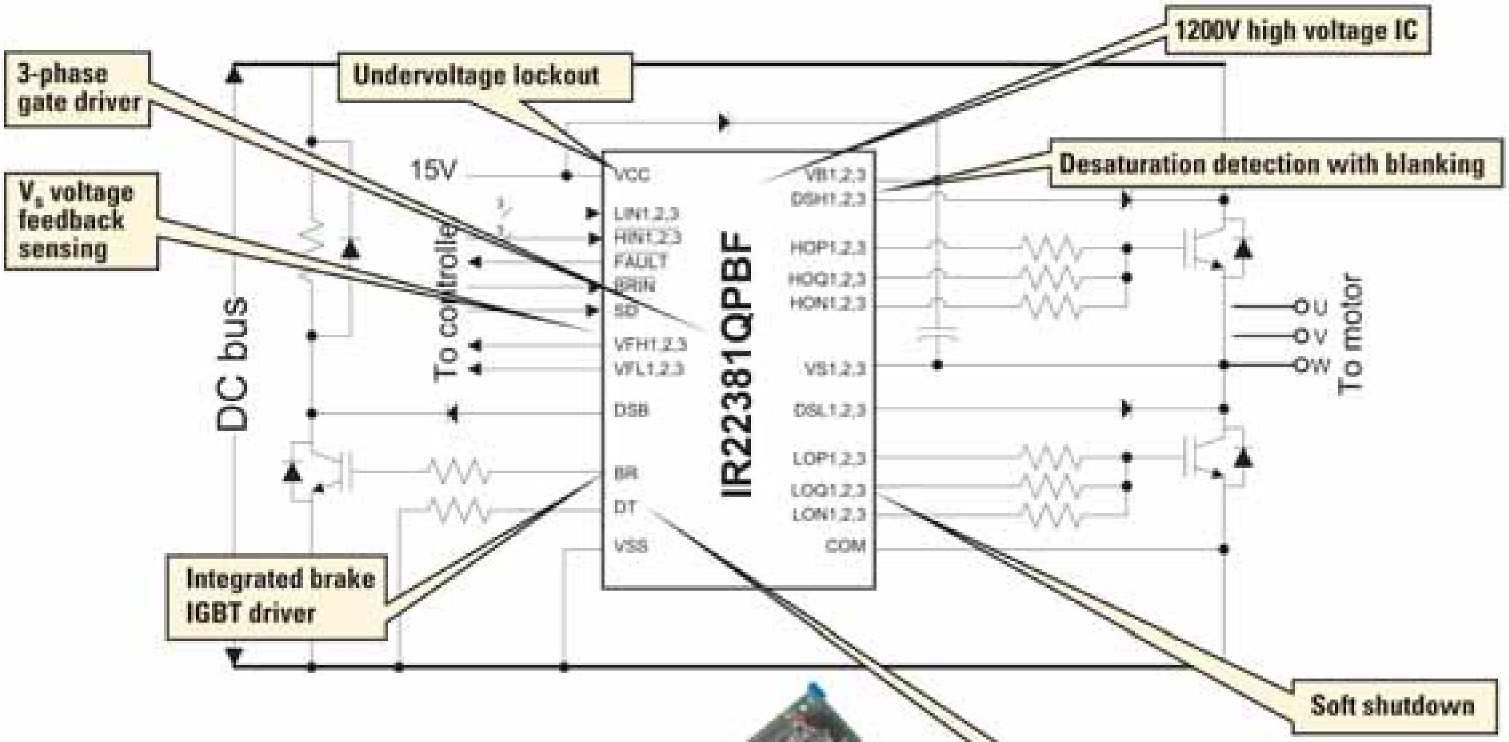

INTEGRATED DESIGN PLATFORM

Inverter Power Specifications	<3kW IR2233xPbF	IR22381QPbF	>3kW IR2213SPbF	IR22141S
Configuration	3-phase driver	3-phase driver	half-bridge driver	half-bridge driver
Voltage	1200V	1200V	1200V	1200V
Dead time (DT)	250ns	1μs	N/A	330ns
Soft shutdown duration time	No	6.0μs	No	9.25μs
t_{on}/t_{off}	750/700ns	550/550ns	280/225ns	440/440ns
Matching delay	No	100ns	30ns	75ns
Drive Current I_{o+}/I_{o-}	190mA/380mA	220mA/460mA	2.0A/2.5A	2.0A/3.0A
Desaturation blanking time	No	4.5μs	No	3μs
Independent half-bridge driver	Yes	No	Yes	No
Undervoltage lockout	Yes	Yes	Yes	Yes
Integrated brake driver	No	Yes	No	No

FEATURES

- High and low side gate driver IC
- Integrates low voltage driver with high voltage level shifter
- IR industry leading, high voltage technology
- Single, rugged, compact IC

IR brings digital controllers, analog stage and power modules together in one easy to implement, integrated design platform.

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