ZKZ 04717
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Power Systems Design EUROPE

Power Control Intelligent Motion

September 2005

Driving Future Auto Ignition Systems

PowerLine

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Marketwatch

Automotive Electronics - Part II

ISSN : 1613-6365

Power Systems Design EUROPE

Viewpoint

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Cover Story

Features

Automotive Electronics: Part II

New Products

Power Systems Design Europe

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Advertising Rates, Sizes and Digital File Requirements available at:
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www.powersystemsdesign.com/psd/subslogn.htm

Registration of copyright: January 2004
ISSN number: 1613-6365
Issue print run: 20,000
Printing by: Central - Druck Trost GmbH & Co.
Heusenstamm, Germany

Send address changes to:
circulation@powersystemsdesign.com

Volume 2, Issue 7

Fall Showtime

Fall is always an exciting showtime. The last big show before fall had been PCIM Nuremberg. We are now looking forward to specialized events like H2Expo in Hamburg. The science driven conference in Europe is EPE in Dresden. SPS/IPC/DRIVES is the industrial highlight in Nuremberg and Productronica in Munich which both happen in November.

We want to express our heartfelt sympathy to the many lives that were affected in the US by the devastating hurricane Katrina. APEC 2006 will go on, but the location (and possibly dates) are being reconsidered. Updates will be posted on the website www.apec-conf.org Call for papers for PCIM 2006 Europe and China is on for October. Details for the shows are published in our Power Events list at the end of the industry news on page 6.

Optimized switches particularly IGBTs is the key to efficient applications. The cover story by Fairchild shows us how to use the intelligent ignition IGBTs for combustion motors. To reach this point development has run through innovation cycles up to the optimized smart design of today.

In our last issue we had the practical side for power devices and their use in automotive. The topic of our special Automotive Part II continues in this issue.

Hybrid vehicles get more attention to regenerative braking. In the past we had discussed 42volt in automotive. The discussion had cooled down and semiconductor manufactures are happy if they sell the special designed 75 volt MOSFETs for the 42 volt automotive applications to industrial users.

It's amazing to think about all the electronics built into today's automobile. One of the most popular vehicles today is the "family mini- van". These moving "living rooms" come equipped with all types of electrical devices to keep riders entertained, the article from Texas Instruments looks at a way to reduce costs in automotive power supplies.

Safety systems continue to become more sophisticated like seat position sensing by Hall sensors from Allegro is used to determine the position of an occupant in relation to the steering wheel, preventing the air bags from deploying with excessive force.

Our magazine brings the latest technical subjects in power electronics, we encourage your comments and feedback.

I am looking forward to meeting you at one of the future shows and have a chat about technology and trends.

Best regards,

Bodo Arlt

Bodo Arlt
Editorial Director
The Power Systems Design Franchise

eupec to be integrated into Infineon

eupec GmbH is to be dissolved as a separate legal entity by October 1, 2005 and fully integrated into Infineon Technologies AG. eupec is a wholly-owned subsidiary of Infineon Technologies AG, and is based in Warstein. From October on, the Warstein location will become an operating site of Infineon, which is headquartered in Munich. The eupec name will continue as a trade name for at least the next two years.

eupec managing director Erich Wallner emphasizes that their continuing presence in the region is not open to question: "We will continue our development and production activities in Warstein."

The employment contracts for employees will remain unchanged, and will be taken over by Infineon Technologies AG.

According to Wallner, the reason for the revised legal status is that, on the one hand, "With the restructuring of the Infineon group and its consolidation from four to three business units the focus is now increasingly on industrial business."

On the other hand, the product portfolios offered by eupec and Infineon have converged more and more. "In recent years eupec, which has so far mostly been known for high power semiconductors, has positioned itself increasingly in the low-power sector. The situation at Infineon is the other way round. So amalgamation into one business unit is a logical step," eupec managing director Wallner explains.

According to Wallner, basically nothing will change for eupec customers. They can continue to rely on good service, as the existing eupec sales force will form the core of the new Infineon Industrial Sales team. The wider product portfolio will be an advantage in future: "Our customers will have the benefit of a totally integrated solution, into which the combined application and product know-how will be incorporated."

The spread of the product portfolio will reach from bare chips on silicon wafers via packaged chips all the way to complete power modules.

www.eupec.com

www.infineon.com

Hall of Fame Supplier

Littelfuse announced it has been named a "Hall of Fame" supplier by the Lear Corporation. The Southfield, Michigan-based auto-interior supplier annually awards manufacturers for their dedication to helping make Lear Corporation a continuing success. Lear Corporation's Hall of Fame Supplier Awards, which have been presented since 1998, single out nine companies each year from a pool of more than 3,200 potential suppliers. The winners are selected using the Lear Supplier Rating System, which measures performance in key areas of quality, service, technology and competitiveness.

"We are obviously pleased and honored to receive this award," said Dave Heinzmann, Vice President and General Manager of Littelfuse's Automotive Business Unit. "This was a group effort in every sense, and one that all Littelfuse employees can be very proud of. It is our intention to continue to serve Lear Corporation above and beyond expectations in the future."

As the world's leading supplier of circuit protection solutions, Littelfuse is committed to providing customers with unparalleled access to product, technical expertise, technical support and applications assistance.

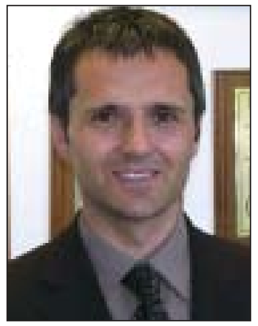
www.littelfuse.com

New Management Team at Micrel

Micrel announced that it has named David Brown as the Company's new managing director of Micrel Europe. The Company also appointed David Foster deputy managing director for Micrel Europe. Brown, who has been with Micrel for nine years, was most recently the Company's Technical Sales Manager. Brown will now be responsible for Micrel's legal entity in the U.K., as well as all sales in Europe, the Middle East, Africa (EMEA) and India. Foster has been with Micrel for eight years, most recently as Micrel's European Distribution Manager, and will now add Contract Manufacturing for EMEA and India to his list of responsibilities.

Messrs. Brown and Foster bring to their new positions a strategic blend of sales experience and technical skills that will enable them to establish a cohesive partnership for Micrel's European organization. David Brown's technical knowledge, combined with his key account management experience, will enable him to focus on the continuing development of Micrel's extensive major account base in the region. Managing both channels, David Foster will be able to enhance the symmetry between Micrel's distribution network and contract manufacturing partners in EMEA and India, thereby ensuring total satisfaction for Micrel customers.

"I have confidence that with David Brown's extensive major account experience, excellent product knowledge and his ability to get things done, he will continue to drive our sales and grow Micrel's presence in the territory," noted Mark Lunsford, vice president of worldwide sales for Micrel. Lunsford added, "By putting David Foster in charge of the contract manufacturing channel, as well as our distribution network, Micrel can optimize the supply solutions for our CM partners assuring them the best possible service while at the same time, bringing more strategic value to the distributor network."



David Brown

David Foster

www.micrel.com

TDK buys Lambda

Lambda, the global power supply specialist based in Ilfracombe, UK, has been acquired from Invensys by TDK Corporation of Japan in a deal worth $235 million (£134 million). The agreement, which was signed on 19 July 2005 and is subject to regulatory approval, includes Lambda's entire North American and European operations, as well as Invensys' current 58.2% shareholding in Densei Lambda KK.

The combination of TDK's existing power supply business with that of Lambda will create the second-largest power supply manufacturer in the world, with the largest market share in the industrial power sector by some considerable distance. The new business will remain focused on providing its customers a market-leading power offering by taking advantage of Lambda and TDK's respective strengths.

Adam Rawicz, Managing Director of Lambda Europe, comments: "This offer from TDK demonstrates the Corporation's faith in the future of Lambda's power supply business. Invensys has for some time been open about its intention to sell Lambda. We welcome the end of this uncertainty, and look forward to receiving a strong parent with significant investment resources focused on the high technology electronics business."

The acquisition is expected to be complete by 30 September 2005.

www.lambda-europe.com

International Engine of the Year

Eight of the 12 winners of the International Engine of the Year Awards contain powertrain control solutions from Freescale. Freescale-powered winners include BMW's new five-liter V10 (named International Engine of the Year, Best New Engine, Best Performance Engine and Best Above 4-liter), as well as Fiat-GM's 1.3 liter diesel (named Best 1-liter to 1.4-liter).

Freescale's 32-bit microcontrollers containing PowerPC cores help improve vehicle performance, increase fuel economy, decrease emissions and create a smoother driving experience for a wide range of engine sizes. The technology provides sophisticated injection and engine management, and enables a number of features such as cruise control, cold engine start-up, fuel shut-off for safety and security lock-out.The company's microcontrollers act as the brains behind automotive electronic systems from remote keyless entry and infotainment to antilock braking and powertrain control.

www.freescale.com/files/pr/eoy.html.

www.freescale.com/files/pr/eoy.html

New Distributor for Central Europe

Photo: Jim O'Sullivan (left), VP Distributor Sales for Artesyn and Michael J. Knappmann (right), VP of Marketing for Sasco Holz

Artesyn Technologies has appointed Sasco Holz GmbH as a distributor for power conversion products in central Europe. The appointment is the direct result of Sasco Holz's successful penetration of key established and emerging markets in countries such as Germany, Hungary and the Czech Republic. Sasco Holz is part of Arrow Electronics, Inc., one of the world's largest distributors of electronic components and computer products. The company has offices throughout central Europe - this agreement covers eight countries in the region - in order to site support personnel as close as possible to key customers.

"Sasco Holz's strategy of placing highly skilled applications specialists at the disposal of key customers fits well with our aim of establishing relationships with OEMs as early as possible in the design cycle," says Jim O'Sullivan, VP of Worldwide Distributor Sales for Artesyn Technologies. "The company is very much design-driven, and we are confident that this approach, which helps customers reduce their costs and shorten time-to-market, will further strengthen our sales position in central Europe."

Michael J. Knappmann, Vice President of Marketing for Sasco Holz, points out that the new distribution agreement will work to the advantage of all parties. "We are seeing significant sales growth in the power conversion sector, especially for advanced dc-dc products such as intermediate bus converters and point-of-load converters, which are being used by more and more designers for powering low-voltage silicon. As the leader in distributed power technology, Artesyn has a very wide product portfolio, which will enable us to provide our customers with leading-edge solutions."

www.artesyn.com

www.sascosemi.com

Power Events

- ***EPE 2005,*** *Sep. 11-14, Dresden, www.epe2005.com*
- ***SPS/IPC/DRIVES,*** *Nov. 22 - 24, Nuremberg, www.mesago.de/sps*
- ***PRODUCTRONICA,*** *Nov.15 - 18, Munich www.productronica.com*
- ***PCIM China 2006,*** *Mar. 21 - 23, Shanghai www.pcimchina.com*
- ***PCIM Europe 2006,*** *May 30 - June 1, Nuremberg, www.pcim.de*

austriamicrosystems Launches World's First High Precision 4x400mA LED Driver

AS3691 Is Ideal for White and RGB High Brightness LED applications

austriamicrosystems, a leading designer and manufacturer of high performance analog ICs, has extended its LED driver family with the addition of the AS3691 4x400mA LED driver, specially designed for the fast-growing high and ultra high brightness LED application market.

The strong growth in high-brightness LED applications – for example, in general lighting or for LCD monitor backlighting – is currently served by universal LED driver ICs leading to suboptimal solutions. The AS3691 is ideally suited for white and color high brightness LED applications since it supports very high currents, and delivers outstanding accuracy with great flexibility and efficiency, while being very simple to use.

The AS3691 includes four independent high precision current sources each capable of sinking 400mA. The operating current per LED channel can be set easily via an external resistor while the LED brightness is controlled by four independent pulse width modulated inputs. The AS3691 integrates four independent current sinks per chip, enabling it to drive either four white LEDs each sinking 400mA or a single white LED with up to 1.6A.

The ICs absolute current accuracy of 0.5% allows for highly accurate brightness settings and is thus ideal for support sophisticated color management applications like LCD monitors with RGB backlighting. With four independent current sinks available, the AS3691 offers great flexibility in combining various color LED settings such as RGGB or RGBA strings. The current sources have a wide voltage compliance range of 15V and special internal circuitry allows for very high LED supply voltages that are limited only by the maximum power dissipation allowed for the entire application.

The AS3691's linear driver avoids issues that are typical of inductive boosters, like EMI, or flickering images that are particularly critical in LCD monitor applications.

To optimize the application's power efficiency, each channel includes a feedback output that enables simple adjustment of one or more external power supplies allowing overall power dissipation to be kept at a minimum.

The AS3691 is available in a small QFN4x4 package or as a die-only solution.

www.austriamicrosystems.com

Entering the Age of High-Current Power Modules for Automotive

By Claus A. Petersen, Danfoss Silicon Power

Ten years ago, the automotive industry displayed very little enthusiasm toward high current rated power electronics. Battery electric vehicles suffered the penalties of both high weight and limited range. Early hybrid-electric projects like Audi's Duo were terminated before they had enough time establish to their market. The 42 Volt hype is over and fuel cells seem to be postponed for many years. Out of the blue, hybrid-electric vehicles from Japan changed the picture. The once-mocked curious vehicles have now found a growing market niche of avant-garde customers. Hybrid customers enjoy a 30% increase in fuel efficiency and an attractive alternative to Diesel engines. This technology could help the automotive industry meet future CO2 emission targets and save fossil fuels.

As the public in Europe and the U.S. is drawn toward the current generation of hybrid vehicles so is the interest of many automotive executives drawn toward advanced power electronics and traction drives. The perception of hybrids has changed dramatically. Every car manufacturer is now investigating electric traction applications. Even the most passionate sports driving auto industry board members and engineers find fascination in the driving pleasure and acceleration potential of modern hybrid-electric powertrains.

The industry is talking about electric power ratings in the 10 to over 100 kW range. This power level is a new experience aboard an automobile. The semiconductors to control these forces are no longer trivial. Neither discrete transistors that drive the information technology world nor off-the shelf transistor modules created for industrial motor drives are capable of surviving in the harsh mobile environment. High temperature water cooling and extreme packaging density are clearly a must for every under-the-hood device. In addition, the modules must survive demanding passive and active temperature cycles. It is also clear that automotive power electronics must survive for the entire lifetime of a car (15 to 25 years) and cannot be a serviceable component.

On-board energy networks likely consist of electrochemical cells and optional super capacitors. Voltages found on full-hybrid traction drive vehicles range from 100 volts to greater than 1,000 volts. This gives both high voltage MOSFETs and various IGBTs a new market. Moreover, these energy grid architectures always include a conventional 12 volt battery and DC to DC converters to couple high and low voltage levels.

Water cooling is time-proven approach for cooling internal combustion engines and is available under every hood and bonnet. However, asking a semiconductor to share a liquid cooling cycle of up to 120°C with an engine casting presents a new challenge. As with every innovation, specifications are not firm. Demands from the mechanical engineering world must be carefully balanced with restrictions from the semiconductor and packaging worlds. Often, every additional degree of operating temperature is paid for with silicon area, but the real bottleneck is neither silicon nor silicon carbide. Bonding and joining technology are the clear limitations.

Independent from automotive traction applications is a growing demand for dedicated auxiliary drive modules. The most eminent is Electronic Power Steering (EPS). EPS systems have emerged with great advantages over traditional hydraulic power steering. EPS improves fuel efficiency by up to 5% and can be more easily integrated into a dense engine compartment. Module currents are increasing as EPS finds its way into heavier sedans and minivans up to 1,600 kg. This creates a demand for advanced module solutions with improved thermal and lifetime characteristics than discrete transistor packages can offer.

Danfoss Silicon Power is convinced that reliable and economic solutions are created holistically. Only a custom module can exactly meet the requirements of automotive system suppliers and OEM customers. The ability to create custom modules is the result of many years experience in the design and production of high reliability components and a reliable and experienced supply base. A module supplier who can both talk automotive and communicate with the semiconductor world has a clear advantage. Danfoss has considerable experience in working on collaborative development projects for automotive power modules and will actively take part in the development of future cars.

www.danfoss.com/siliconpower

Hybrid Vehicles Drive Auto Power Chip Market

Part two of two-part series

Part one of this article, which appeared in July/August issue, covered the forecast for automotive power semiconductors and discussed the challenges in implementing inverter switching for hybrid vehicle drive trains. This article examines issues related to hybrid vehicles' control scheme and their isolation and drive challenges.

By Chris Ambarian, Senior Analyst, iSuppli Corporation

Isolation and Drive Issues

One of the significant challenges reported by systems suppliers is the need for a more economical way to implement the isolation and gate driving in the power bridge. Designers wanting to drive a motor with a high-voltage bus have a choice of the same high-side gate drive options that they have had for a decade: optoelectronics, or junction-isolated high-side driver ICs.

This isolation function long been considered expensive by industrial motor-drive designers, but to date a better, less-expensive solution has not been created. As high-voltage motor drives now move into the automotive realm, some Japanese system suppliers are focusing more attention on this function, in the hopes that some way to cost reduce it can be found before it enters high-volume production. However, to this analyst's knowledge, no such solution is yet on the radar screen.

Getting Control of the Control Scheme

Clearly, a vehicle chock full of electronic functions requires some sort of architecture and control network. Presently, this network looks like a Component Area Network (CAN) bus, plus a Local Interconnect Network (LIN) bus and soon another bus or two or

three, each specialized for a specific application or set of applications. Examples of this approach include BMW's proprietary Byteflight high-speed protocol, and FlexRay, a new high-speed scheme developed by BMW, DaimlerChrysler, Motorola and Philips Semiconductors.

It is possible, even likely, that the market will continue to proceed in this application-specific fashion, roughly along lines drawn by the load's speed or bandwidth requirements. But with the impending explosion in the amount of data flowing around the vehicle, another opportunity will emerge.

iSuppli expects that its concept of a Power Operating System (POS) will prove critical to the economical and reliable management of hybrid power trains. Such a system would employ a central microprocessor or microcontroller to manage all of the various components in the hybrid power train. This would be a multi-level, multi-bandwidth network with demanding requirements for data quality.

With the implementation of such an in-vehicle network, it may be useful for the industry to consider handling all of the vehicle's power sources and loads within that control scheme. The power-management unit could handle at least the most important tasks of overall system management, while sending simpler instructions to local smart actuators or hubs.

However, given the challenges seen to date in simply aligning OEMs and suppliers in setting standards in a small subset of automotive functions, it is difficult to imagine that such an overarching system will be achievable. Still, the huge increase in power converters and drive and regeneration functions in hybrid vehicles, and the potential cost and energy savings of power operating systems, makes such a system more worthwhile to seriously consider.

MARKETWATCH

At a recent iSuppli conference in Japan, there was some indication that the Japanese suppliers have been working on just such a solution. Overall, it appears that the Japanese suppliers are still better-coordinated among each other in defining such systems. The American and European OEMs and suppliers will need to coordinate closely and aggressively in order to participate in the hybrid market with any kind of a competitive offering.

It is likely that the explosion in the amount of information flowing around the vehicle also will bring a revolution in software and software quality. Combined with the hardware and architectural advances that will come with more extensively-digitalized motor controls and DC/DC converters in hybrid vehicles, a significantly more robust and efficient automobile power system will result. The devices contained in these new automotive power systems will drive a significant amount of the growth in automotive semiconductors— and they will require significant development to bring them to market.

While automotive electronics are evolving quickly, it will be some time before the fate of this market has been decided, and there remains plenty of room for innovation and aggressive cooperation among semiconductor suppliers and automotive systems manufacturers to help shape that evolution.

Christopher Ambarian is a senior analyst with the market research firm iSuppli Corp. Contact him at cambarian@isuppli.com

www.iSuppli.com

Advances in Automotive Ignition Devices

Ignition IGBTs get smarter and offering increased functionality.

The coil charging switch has evolved from a simple mechanical switch to charge the ignition coil and create a spark to a sophisticated power control function, highly integrated into the ignition coil on each spark plug.

By Jim Gillberg and Jack Wojslawowicz, Fairchild Semiconductor

While you weren't looking, some major changes were happening under the hood of your car. It doesn't matter if you're driving a small economy car, a luxury sedan or a sports car; without a spark jumping across the gap in the spark plug, you aren't going anywhere. Beyond calculating the liters/100km our vehicles consume, we all take the burning of fuel in the combustion chamber for granted.

Let's start with some basics on how the engine control system generates the spark and then we can move on to some of the latest systems and advances in ignition circuits.

To generate a spark, all you need is a power source, a battery, a transformer (the ignition coil), and a switch for controlling the current in the primary of the transformer. From Electronics 101, we know that V=L di/dt. So, if we try to force an immediate change in the current through the primary winding of the coil (large value of di/dt), the reaction will be a high voltage level on the primary winding. Now if the ignition coil has a turns ratio of N we can amplify that voltage by that turns ratio. The result is a voltage of 10 to 20KV on the secondary, which is impressed across the spark plug gap. Once the voltage level exceeds the dielectric constant of the air in the vicinity of the gap, the gap breaks down producing a spark. This spark then ignites the gasoline-air mixture producing the power phase of the engine operation.

This basic circuit is in every "internal combustion" non-diesel engine. The coil charging switch element has evolved from a mechanical switch, the breaker points in the distributor, to a high voltage Darlington bipolar transistor either in the distributor or in a separate electronic control module, to an Insulated Gate Bipolar Transistor or IGBT and now to an Intelligent IGBT mounted in the ignition coil that is located on the spark plug.

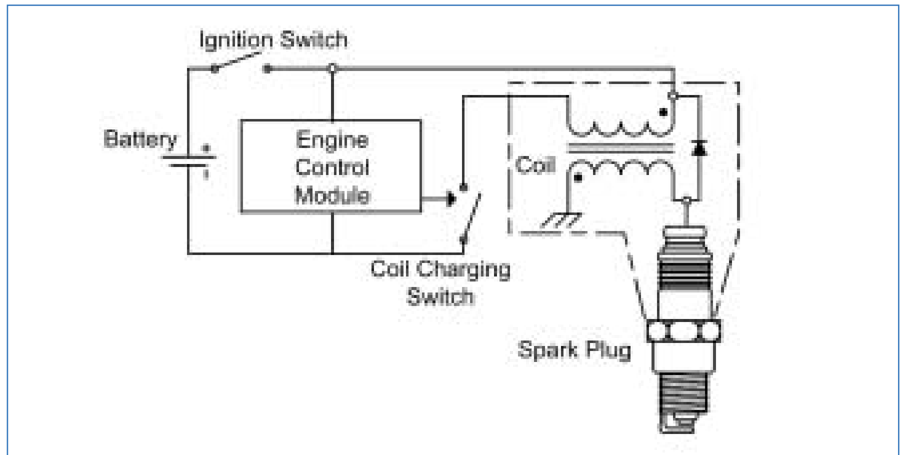


Figure 1a. Basic automotive ignition system.

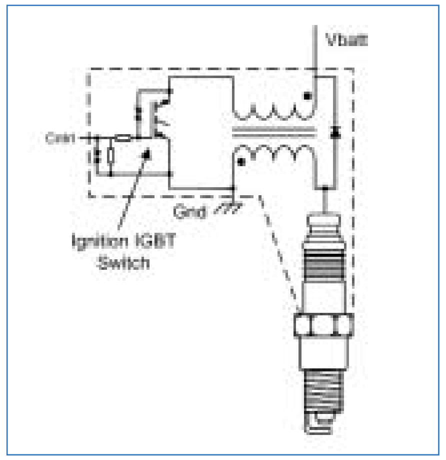


Figure 1b. IGBT based coil charging switch.

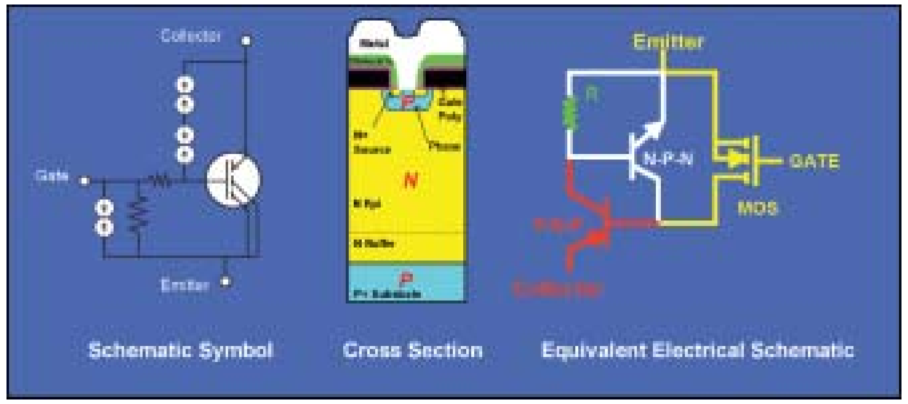


Figure 2. Ignition Circuit and Cross Section.

For a number of years, the Insulated Gate Bipolar Transistor or IGBT has become the primary switch used in ignition applications. A cross section of the IGBT is shown in Figure 2.

The IGBT has several key benefits over other technologies:

- Low forward conduction drop at high currents
- Easily built-to-handle the high voltage coils (400V to 600V)
- Simplified MOS drive capability
- Ability to handle high energy dissipation during abnormal coil operation (SCIS rating).

The Ignition IGBT schematic shown in Figure 2 includes several additional key elements. The zener diode stack from collector to gate establishes a "turn on" voltage, which when the collector jumps up to this voltage (as forced by the flyback or inductive spike from the coil), the IGBT is turned on to dissipate any remaining energy in the coil, not delivered to the spark, in the active region of the IGBT. Using this integrated zener clamp allows the IGBT to set the "clamp" voltage significantly lower than the bulk silicon breakdown voltage of the N epi/P base to assure safe operation. This permits the Ignition IGBT to have a significant SCIS (Self Clamped Inductive Switching) Energy handling capability. This handling capability is a rating for the energy absorbed by the IGBT each time the energy in the ignition coil is discharged to generate the spark. By limiting the voltage on the primary, the coil itself is also protected from excessive voltage levels.

The latest generation of Ignition IGBTs has allowed significant die area reductions in the IGBT while still having superior SCIS capability. This is now leading to the development of multi-die "smart"/ intelligent IGBT products. These products combine high performance Bipolar CMOS Digital (BCD) IC technologies with high performance power discrete IGBTs. The driving force that is generating the need for the intelligent IGBT coil drivers is the migration of the power switch function from the engine control module to being molded within the ignition coil positioned directly over the spark plug on the engine. When the coil is located on the spark plug, the topology is known as "coil on plug" and when the coil driver is included within the coil the topology is called "switch on coil (SOC)"

There are significant system performance, reliability and cost advantages to the switch on coil topology, several are listed below:

- Elimination of the high voltage spark plug wires
- Elimination of heat generation within the engine control module
- Freeing up physical space in the engine control module
- Allows monitoring of the actual spark permitting improved engine control

It is this final performance benefit that is generating the need for Smart IGBTs. So, the ignition switch function is evolving into an intelligent device that can monitor the spark, protect the coil by limiting the current and communicate to the engine control system the status of the engine's ignition.

Desired Smart IGBT functions for Switch on Coil Applications.

a) Signal Interface to the engine control module.

Driving the SOC Smart IGBT from the engine control module has many issues. The electrical environment under the hood of an automobile is extremely noisy. The signal interface from the engine control module has to deal not only with this noise but also the potential several meters of wire between the engine control module and the coil location. The electrical noise can be in the form EMI radiated signal noise or possibly a magnetically induced noise from high currents flowing in adjacent wires.

In addition to the above noise issues, the actual ground reference of the engine control module could be several volts different from the ground at the coil or engine block. Therefore, the defined interface between the engine control module and the Smart Ignition Coil Driver has to be capable of handling these issues.

b) Protection of the ignition coil (Figure 3a and 3b).

This input signal commands the IGBT to begin to charge the ignition coil. Under normal conditions the coil will reach a current between 7 to 10 amps when the current is terminated and the spark initiated. However under low engine RPMs, particularly in rapid deceleration or if an error were to occur in the engine control timing, if the input is not terminated, the IGBT can charge the coil to currents above its ratings leading to potential failure of the coil windings.

There are several circuit designs being incorporated into Smart IGBTs to help protect the ignition coils from this condition.

The first is a current limiting function, using either a direct measurement of the IGBT collector current with a sense resistor or a measurement using a current sense IGBT. These two circuits are shown in Figure 4.

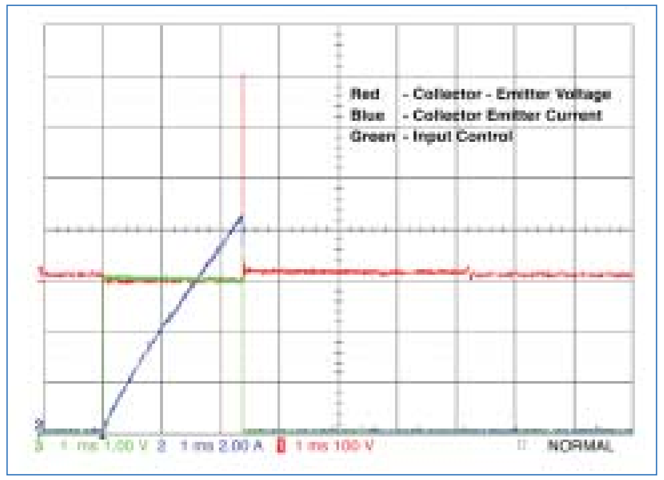


Figure 3a. Ignition IGBT waveforms during coil charging.

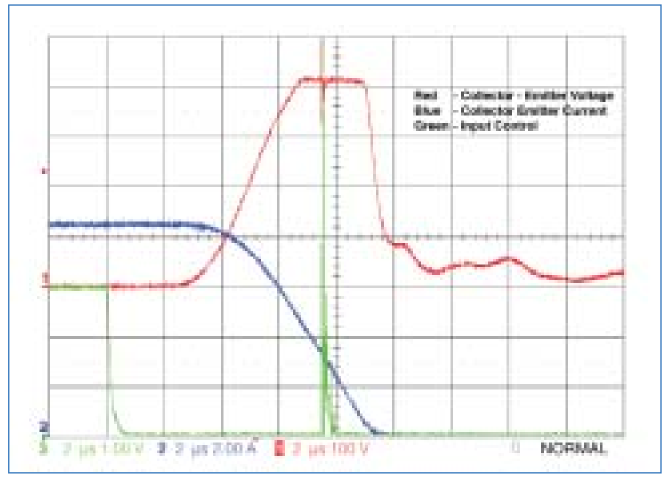


Figure 3b. Ignition IGBT waveforms during spark generation.

The direct measurement has the advantage that it can make an extremely accurate measurement of the coil current; however it comes at a price. Any sense resistor placed in the emitter line adds significantly to the total voltage drop of the power switch function at the 7 to 10 amps coil charging current and generates additional power dissipation and heat that must be dealt with in the design. Another negative effect is the added resistance in series with the IGBT will slow the charge time of the coil affecting the systems timing.

A current sensing IGBT is an IGBT where a small ratio of the total current is diverted into a current monitoring circuit which is used to predict the total collector current flowing through the IGBT. The current sensing IGBT eliminates the two issues with the direct measurement technique as no additional resistor is placed in series with the high current path of the IGBT. However, since this technique is no longer a direct measurement of the emitter current, additional system inaccuracies such as variation in the current sense ratio over temperature or current need to be considered in the design. The current sense IGBT has a portion of its cells placed in parallel with the main IGBT section but connected to a separate emitter bond pad. Thus, a portion of the total collector current will flow through this sense (or pilot) portion of the IGBT. The percentage of the total IGBT current channeled through the pilot is primarily dependent on the drawn cell ratio of this pilot region to the remaining active region of the IGBT. However, any dissimilar conditions between the pilot and the main active region will affect the current ratio and thus the accuracy of the current sensing. Of particular concern is to maintain the emitters of main and sense potion of the IGBT at the same voltage potential. Any difference will directly vary the gate to emitter voltage of that section.

Once the IGBT has limited the coil charging current, the over current failure of the coil has been eliminated. However, the IGBT itself is now in a very high power dissipation mode and can not be kept in that condition for long without damage to the IGBT. When in current limit, the power in the IGBT will climb into a range of 60 to 100 watts. When mounted within the ignition coil, the IGBT thermal impedance to ambient can be as high as 60° to 70° C/W as there is no low thermal path heat sink available. So, since the junction temperature is equal to Tj=Ta+Pd x Rth(ja)., one can see that the junction temperature would quickly exceed the acceptable junction temperature for any semiconductor device.

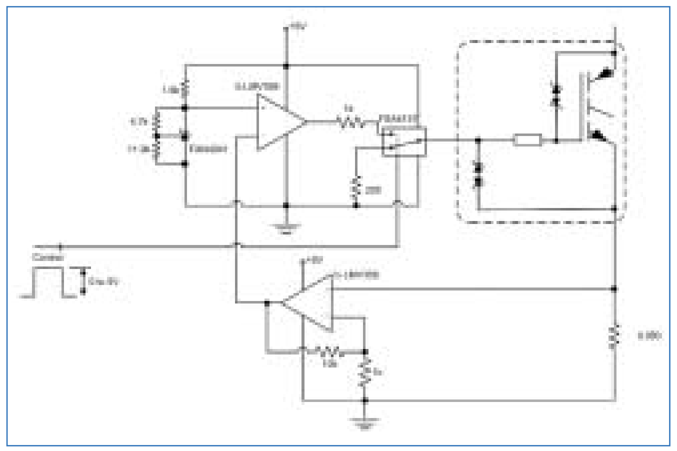


Figure 4a. Current Limiting Circuit with conventional Ignition IGBT.

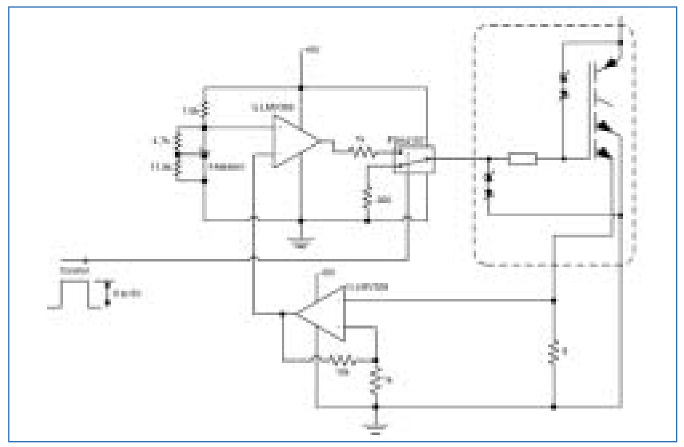


Figure 4b. Current Limiting Circuit with current sense Ignition IGBT.

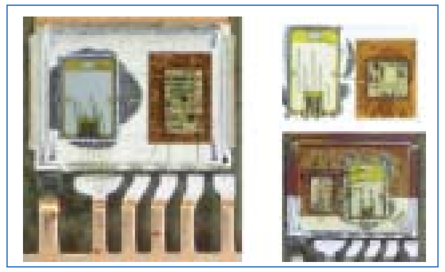


Figure 5. Multiple Die Smart Ignition Devices.

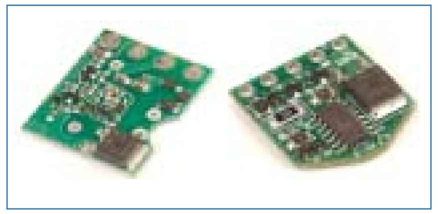


Figure 6. PC Board developed Smart Ignition Systems.

One solution to the above problem is the addition of a “Maximum Dwell” circuit into the Smart IGBT. This circuit is a timeout function which turns the IGBT off after a predetermined coil charging time to protect the IGBT from over dissipation.

Analogous to the current limiting circuit, the maximum dwell circuit can protect the IGBT. However, it does have a negative side effect. It is possible to indiscriminately fire the spark plug whenever the maximum dwell circuit time exceeds a preset limit. Typically, the maximum dwell circuit is not under the control of the engine management system, but is only dependent upon the time the IGBT starts charging the ignition coil. It could fire the spark during an improper piston position, resulting in damage to the engine.

Again the “Smart” IGBT can remedy this issue also by adding a feature known as “Soft Shutdown”. The soft shutdown circuit would be enabled when reaching the maximum dwell timing. Instead of immediately terminating the current in the IGBT, the IGBT is controlled to slowly allow the current to decay. By maintaining a slow decay of the collector current, the voltage generated within the coil can be maintained low enough to prohibit the spark from occurring at a time not determined by the engine management system.

A smart IGBT can also monitor the secondary voltage of the ignition coil to gain information on the quality of the generated spark. The secondary coil voltage is reflected to the primary winding by the turns ratio of the coil. This information can be captured and communicated back to the engine management system for use in optimizing engine performance leading to improved power or reduced emissions from the engine.

These suggestions are only a short list of the possible functions that can be included when the ignition switch is placed in the ignition coil. Specific ignition functions and features varies widely between different engine control manufacturers, but the general trend in many of the emerging system developments is the inclusion of the switch on coil topology due to the system cost and performance benefits.

These additional ignition features are optimally combined with the IGBT through the use of multi-die packaging technologies. The automotive environment and particularly the ignition environment is subject to both high temperature and extreme noise. By keeping the IGBT and control circuit physically separated, the designer can improve each device’s resistance to noise and temperature related issues. The design and process of the IGBT can be focused on the key parameters for the IGBT such as SCIS and $V_{ce(on)}$, while the control IC can be optimized for the high performance analog functions.

Figure 5 shows several different smart IGBTs in development using this multi-die assembly capability. These products use the latest EcoSpark IGBT technologies providing the highest SCIS/mm2 performance in the industry coupled with extremely low $V_{ce(on)}$ specifications. When combined with a high performance analog BICMOS control die, a single package smart ignition coil driver can be created.

The control die and IGBT are combined in a multi-leaded TO-220 or TO-263 package. The IGBT is soldered to the header to provide the lowest electrical and thermal impedance to the package.

The control die is attached to the same header by a non conductive polyimide material to isolate the die from the high voltage collector of the IGBT.

Another construction option would be to mount the IGBT and control die along with any required external components into a small module which can be placed within the Ignition coil. Several examples of this construction are shown in Figure 6.

Whatever the construction, it is clear the ignition power switch and the control/monitoring intelligence are migrating into the ignition coil. The development of these new smart ignition devices has many challenges:

High voltage and high current power switch placed side by side with low power analog control circuitry:

- High temperature operation
- Potentially damaging battery transients
- High performance analog functions
- Small size
- High power dissipation in a poor thermal system.

Ignition systems have come a long way from the mechanical points that used to be contained within the distributor of the car. The points and distributor have been eliminated. The IGBT switch now controlling the current in the coil has become more than just a switch, but a control element integrated with the rest of the engine management system. More and more features are being planned for inclusion into the coil switch function such as developing multiple sparks for improved fuel combustion or monitoring the secondary (spark plug) current to monitor the quality of the combustion.

The latest generation ignition IGBT, mixed signal IC, and packaging technologies are enabling the system advantages that the switch on coil topology will allow. So, the next time you rev up your engine, while you might not be thinking about the spark that enables the combustion in the engine, there just might be an intelligent Ignition IGBT working hard to take you wherever you’re going.

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POWER SEMICONDUCTORS

New Series of CoolMOS MOSFETs

Benchmark in high power SMPS efficiency at lowest system cost

A dramatic reduction of MOSFET on-resistance per package type, high switching speed and lowered gate charge, makes this device the ideal MOSFET in hard-switching CCM type applications.

By Dr. Gerald Deboy, Dr. Fanny Dahlquist; Automotive, Industrial & Multimarket business group at Infineon Technologies AG

Abstract

A new series of CoolMOS superjunction MOSFETs in 600V blocking voltage class has recently been introduced by Infineon Technologies. A dramatic reduction of MOSFET on-resistance per package type, high switching speed and lowered gate charge, makes this device the ideal MOSFET in hard-switching CCM type applications such as PFC stages and hard-switching full-bridges for output powers ranging from 200W up to 2000W. This article shows technical component details and demonstrates examples of the system benefits of increased efficiency and better form factor which can be obtained in notebook and LCD adapters, telecom and server power supply designs.

Introduction

Power supply manufacturers in computing, communications and industrial area are under continuous pressure to increase power density by delivering more power in similar or smaller form factors than today's products. Typical request is to upgrade output power by 20-30% while keeping the same housing and form factor. As a result thermal management must be controlled through increased system efficiency. Since system cost per watt is not allowed to rise, increasing efficiency puts tough demands on semiconductor and passive component performance as well as topology innovation.

Due to legal requirements, power factor correction (PFC) is standard in high power SMPS applications. Continuous conduction mode (CCM) boost converter is today state-of-the-art for PFC above roughly 200W output power due to lower peak currents, better system stability at light load and less complex EMI filtering compared to discontinuous conduction mode. Key features of the active components for reaching high efficiency are extremely low on-resistance of the boost MOSFET and an ultrafast boost diode with very low reverse recovery. A wide AC voltage input range makes these features even more critical since under low line conditions power losses are at its peak due to maximum current requirement and high turn off losses.

The main stream topology for high power density and high efficiency SMPS converters above around 500W is resonant topologies like the zero-voltage-switching (ZVS) full-bridge. The virtual elimination of turn-on power losses and losses associated with the output capacitance of the MOSFET makes the ZVS benchmark in efficiency. However, the price to pay for the high efficiency is a higher system complexity with advanced control scheme, bulky and costly resonance inductor and high reliability requirements on the MOSFET body diode during abnormal operation conditions. Furthermore, the well known drop in efficiency during light-load condition in the ZVS system has to be taken into account.

Hard switching alternatives like the two-transistor forward (TTF) or interleaved two-transistor forward converter (ITTF), pose demanding requirements not only on current handling capability but most important, on switching speed of the power MOSFET. The TTF topology is well known in the lower power arena, up to around 400W. But until today the performance of high voltage power MOSFETs has not been sufficient to meet efficiency for extending the use of this topology to higher power levels. MOSFET on-resistance and switching losses have not been low enough to reach the efficiency of resonant topologies. The main advantages with the ITTF are simplicity, efficiency and identical voltage ripple to that of the ZVS bridge. Furthermore, no resonance inductor is needed, control scheme is easy and high efficiency is maintained also for light load operation.

This article shows how recent advancements in CoolMOS superjunction MOSFETs enable the use of hard-switching topologies in high power supplies thanks to a dramatic reduction of on-resistance and switching power losses in a given package. New ideas for increasing PFC stage efficiency are shown, which make use of the new CoolMOS series and thinQ! silicon carbide Schottky diodes.

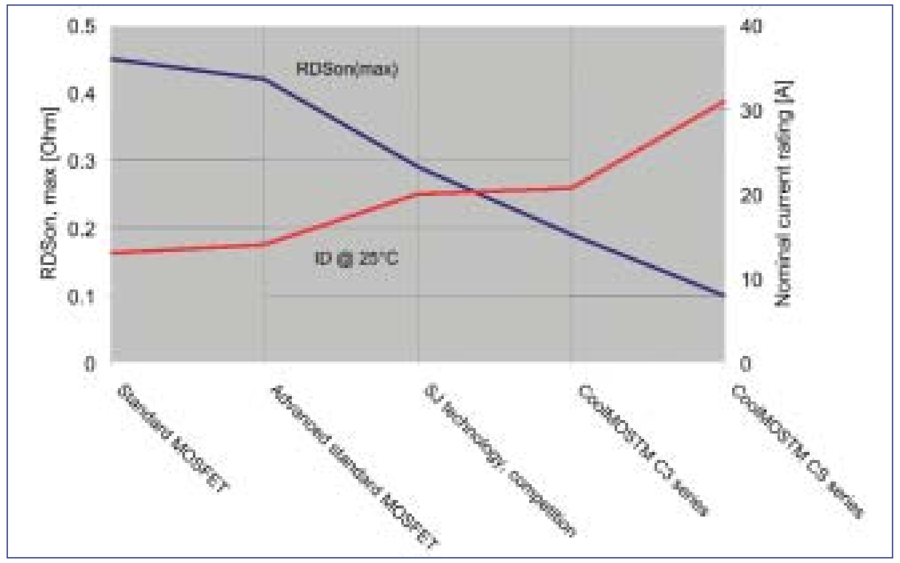


Figure 1. Technology advances in RDSon and continuous drain current handling capability for 600 V rated MOSFETs.

New series of CoolMOS superjunction MOSFETs

This year a new 600V CoolMOS series have been introduced targeting high power applications such as server or telecom power supplies [1]. Main features with the new series are a dramatic reduction of drain-source on-resistance (RDS,on) in a given package compared to existing technology, in combination with a 40% reduction of total gate charge that reduces the required driving power significantly, and a very low energy stored in the output capacitance. Switching losses are kept on extremely low level, which is the signature of superjunction (SJ) devices [2]. An RDS,on of 99mOhm in TO220/TO247 package and 45mOhm in TO247 package are the first products, compared to existing CoolMOS technology with 190mOhm and 70mOhm in TO220 and TO247 package, respectively. The reduction of RDS,on is possible due to an increase in MOS cell density and a reduction of the pitch of the SJ structure [3]. Together with the RDS,on reduction the current handling capability increases correspondingly. The dependency between continuous drain current rating and RDS,on as well as a comparison between standard MOSFET and SJ technology in TO220 packages are shown in Figure 1. Lowest RDS,on available in 600V and TO220 package for each techonology are compared. Similar impressive steps for switching speed have been reached with SJ technology. Coming from rise time/fall times in the 20-50 ns range for standard MOSFETs, today's performance of below 5 ns allows a cut in turn-on and turn-off power losses of nearly one order of magnitude.

Next RDS,on classes of the new CoolMOS series to come are set between 99 mOhm and 400 mOhm. These parts are specifically designed to give highest efficiency and best thermal management in hard-switching CCM type applications, such as PFC stages and ITTF main stages.

Application benefits and device selection

PFC stage:

A wide voltage input range, 85-265Vac, is the trend in computing and communication power supplies up to roughly 2kW. A low RDS,on of the power MOSFET becomes then a vital parameter for high efficiency at low line operation. As an example, in the PFC stage in a server, telecom or notebook adapter power supply, the new CoolMOS series can be used to lower system cost in two ways:

Replacement of several paralleled MOSFETs by fewer components of new CooMOS series. The reduction of part count will save space on the PCB and largely facilitate gate driving. Especially versatile replacements are 2x 190mOhm or 2x 170mOhm by 1x 99mOhm, or 3x 190/170mOhm by 2x 125mOhm. The design will benefit from a lower energy stored in the output capacitance, the lower gate drive power and the higher switching speed. With the highest thermal resistance being heat sink to ambient the effective increase of thermal resistance junction to ambient is relatively small. The reduction of number of parts is therefore very applicable.

Or

Changing from less advanced SJ technologies or conventional MOSFETs to new CoolMOS series with identical RDS,on. The much faster switching speed, lower energy stored in the output capacitance and lower required gate drive power will enable a higher operation frequency, for example up to 130 kHz or 250 kHz. This will result in smaller passive components and hence a reduction in form factor.

PWM stage:

The approach for obtaining system benefits and lower system cost in the PWM stage, such as in an ITTF, is similar to that just described for the PFC stage. The difference is that RDS,on classes change to higher ratings. 165mOhm up to 385mOhm are here the optimal RDS,on in ITTF designs from around 1500W to 650W. Component benefits are here again the extremely low switching losses and low energy stored in the output capacitance.

Experimental results from reference designs

An example of replacement of several paralleled MOSFETs into one 99mOhm CoolMOS is shown in Figure 2. A 600W reference design was used to measure efficiency at 90V input voltage at 130

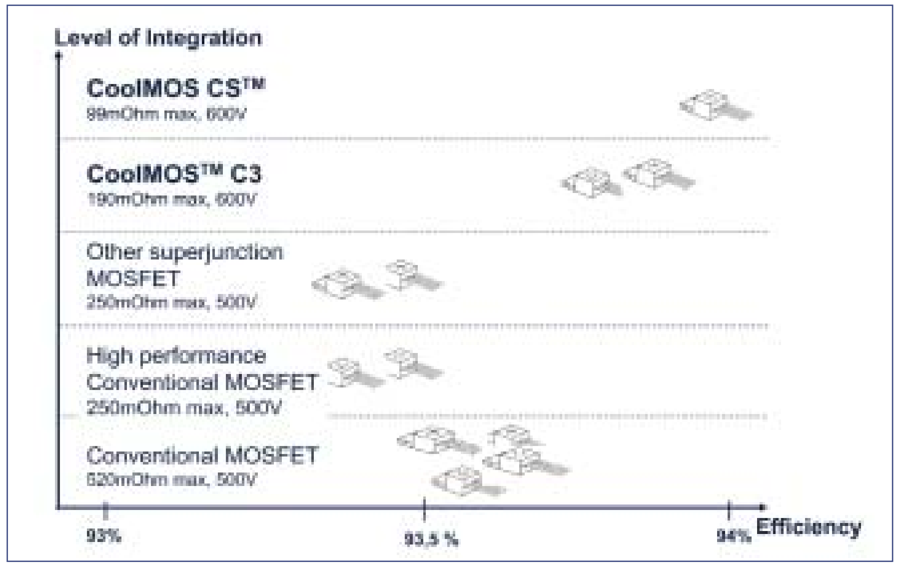


Figure 2. Level of integration and measured system efficiency for a 600W CCM PFC stage, 130kHz, at 90V input voltage. TO220 packages are compared.

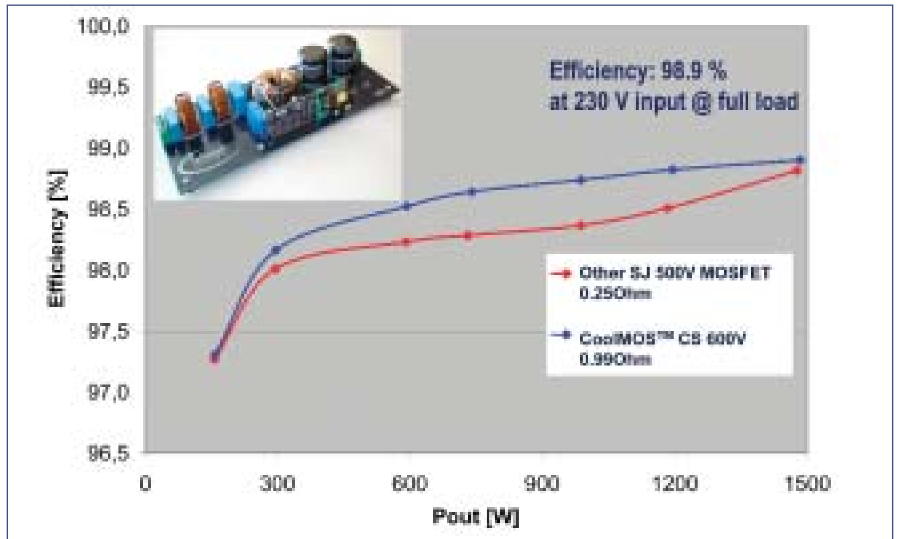


Figure 3. Circuit diagram of a 1500W dual PFC stage switching at 130kHz.

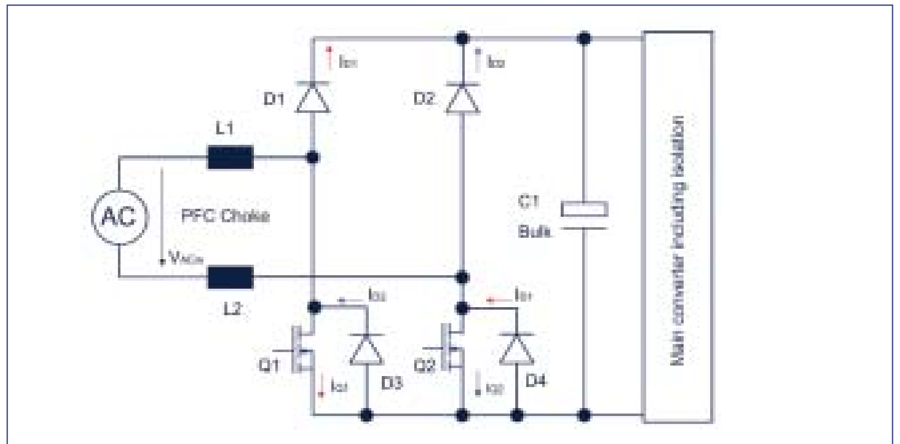


Figure 4. Efficiency versus output power for a dual PFC stage board.

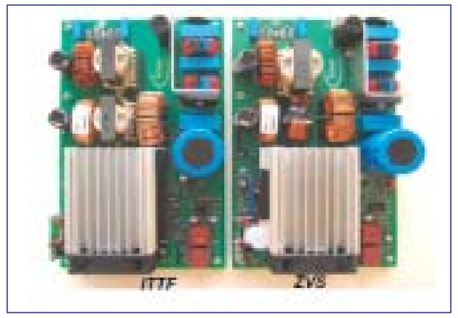
kHz. Best-in-class RDS,on products in TO220 package were measured. Therefore 500V MOSFETs were used in some cases, although 600V MOSFETs are state-of-the-art in high power PFC stages today.

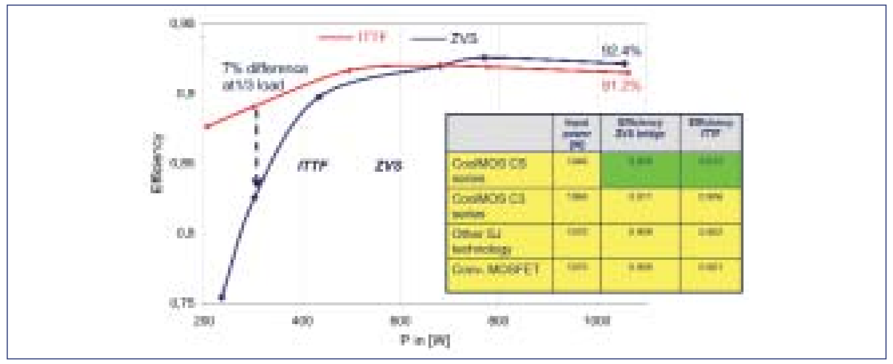
As well-known to power supply designers, the higher power loss sources in a PFC stage are the bridge rectifier together with the fuse and PFC switch and PFC diode. In order to maximize PFC efficiency to the extreme, we built up a dual stage PFC solution, which eliminates the need for a bridge rectifier. Circuit diagram for this 1500W design is shown in Figure 3. Two paralleled 99mOhm CoolMOS in TO220 were measured in comparison with four paralleled other superjunction 250mOhm 500V MOSFETs. In both cases, an 8A thinQ! SiC Schottky diode was used as boost diode. A record efficiency of 99% was reached at 230V input and full load, see Figure 4.

For comparing resonant with hard-switching topology, we built two 1000W reference designs: one using phase-shift resonant ZVS bridge and the other using an interleaved two-transistor forward topology (ITTF). Details of the two designs are described elsewhere [4]. Figure 5 shows the efficiency curves versus input power for the two topologies, both measured with 99mOhm CoolMOS CS. It is clear that for high load operation, the efficiency (PFC + main stage + secondary side) of the ZVS bridge is almost reached in the ITTF design, which is a much less complex design. The inset table shows benchmarking results from measurements with CoolMOS C3 series (190mOhm/600V), other SJ part (250mOhm/500V) and a conventional MOSFET (250mOhm/500V), all in TO220 package.

Conclusion

Infineon Technologies has introduced a new series of CoolMOS superjunction MOSFETs in 600V blocking voltage class. The extremely low RDS,on per package type together with high switching speed and low gate charge, offer system benefits of increased efficiency and





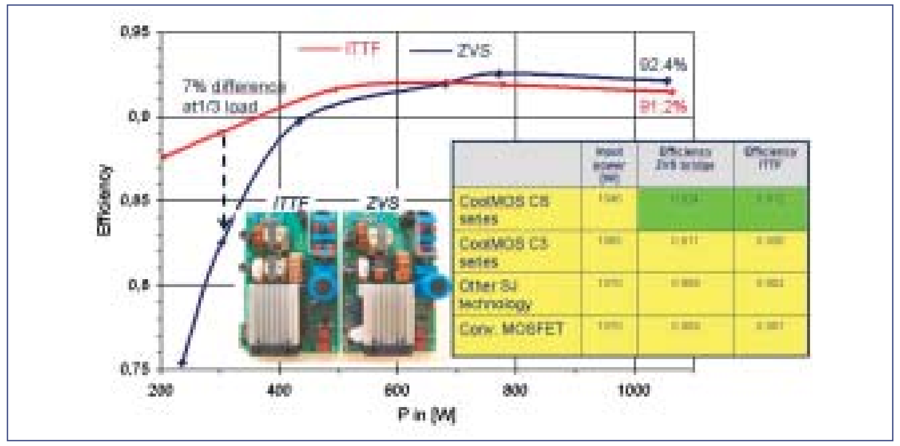


Figure 5. Measured system efficiency (mains to output connectors) of a 1000W phase-shift ZVS board and an 1000W ITTF board. High line condition efficiency as function of input power.

better form factor in hard-switching CCM type applications, such as PFC stages and ITTF main stages. Several RDS,on classes ranging from 45mOhm (best-in-class in TO247 package) up to 385mOhm (best-in-class in DPAK), are specifically designed to serve the need of the active switch in PFC and PWM main stages. This is with respect to static losses, switching losses and thermal management in notebook adapter, LCD adapter, telecom and server power supply designs.

Acknowledgements
The authors wish to thank Dr. Tobias Reimann and Ing. Marko Scherf from ISLE GmbH Germany for valuable discussions and the demoboard designs.

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3W Charger Design Consumes Less Than 30mW at No-Load

EcoSmart technology intelligently manages the flow of power into a device's power supply, resulting in dramatic energy savings compared to older power supply technologies.

By Rich Fassler, Director of Product Marketing Power Integrations

A 3-watt charger reference design that consumes less than 30 mW of no-load power has been proposed by Power Integrations, the leading supplier of high-voltage integrated circuits used in power conversion. Based on the company's EcoSmart energy-efficiency technology, typical applications for this design include cell phones, cordless phones, PDAs, MP3 players and other battery-powered portable equipment. The sheer proliferation and ubiquity of products that use external chargers and adapters makes their overall contribution to energy waste highly significant. This new low-power charger design allows manufacturers to rapidly bring products to market that exceed all worldwide mandatory and advisory efficiency and standby power consumption regulations.

EcoSmart technology intelligently manages the flow of power into a device's power supply, resulting in dramatic energy savings compared to older power supply technologies. The 5 V, 600 mA charger design (ref DI-84, available on www.powerint.com) is built using Power Integrations' TinySwitch-II power conversion IC family and operates over the universal input voltage range from 85 to 265 VAC. Besides providing a high level of energy efficiency, TinySwitch-II ICs also include safety and fault protection features not always found in lower-cost discrete MOSFET/PWM controller or ringing choke converter (RCC) circuit designs, such as over-voltage protection, under-voltage lockout, and hysteretic thermal shutdown, which protects the entire circuit from over-temperature faults.

More, the new low-cost charger design offers a low component count, and meets CISPR-22 Class B without requiring a Y capacitor.

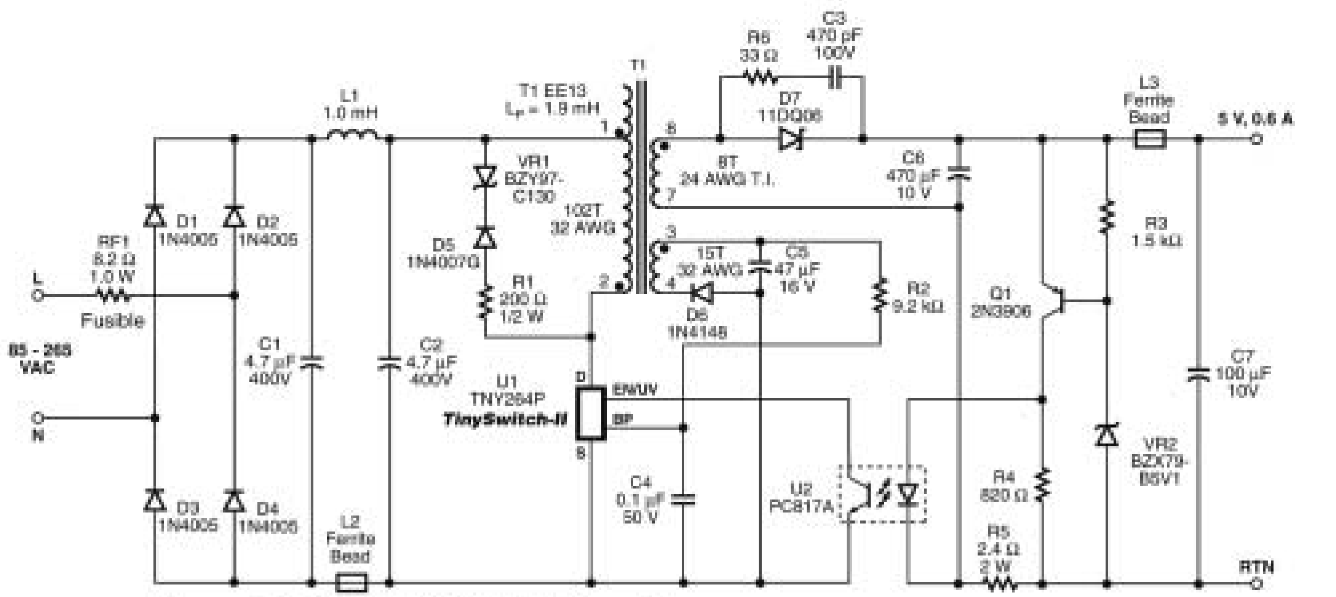

Figure 1. TinySwitch-II 3.0 W Cell Phone Charger.

Figure 1. TinySwitch-II 3,0W Cell Phone Charger.

Design Schematic

The TinySwitch-II flyback converter in Figure 1 generates a constant voltage, constant current (CV/CC) 5 V, 600 mA output. The key performance characteristic of the circuit shown is the extremely low no-load consumption of less than 30 mW. (No-load power, the energy consumed by a charger or adapter when it is not powering a device but is still plugged into a wall socket, is considered a major source of energy waste, costing consumers billions of dollars annually.) In comparison, a linear transformer charger of similar rating will typically consume 1 to 4 W at no-load. At $0.12/kWh, TinySwitch-II therefore reduces energy costs by $1 to $4 per year. TinySwitch-II achieves this no-load performance by using a transformer bias winding as a low-voltage source for its operating current. Even without this winding, a TinySwitch-II circuit consumes under 300 mW at no-load. The bias winding disables the internal high-voltage current source, which normally powers the IC from the DRAIN pin, thereby further reducing power consumption.

The bias winding should provide enough current to fully disable the internal current source at no-load. Other load conditions are not important, as the device will be powered from the DRAIN pin if bias is lost. This allows a simple flyback winding to be used. Figure 2 shows that the bias winding and choice of R2 should provide approximately 600 µA at no-load to minimize consumption.

Because the charger circuit meets CISPR-22 Class B conducted EMI limits without using a Y capacitor, it therefore has very low AC leakage current. Superior EMI performance is achieved via the TinySwitch-II frequency jitter, an output RC snubber, use of the bias winding as a shield, and careful selection of clamp Zener voltage.

Other key design considerations include:

- The design of the bias winding circuit must provide approximately 600 µA at no-load.

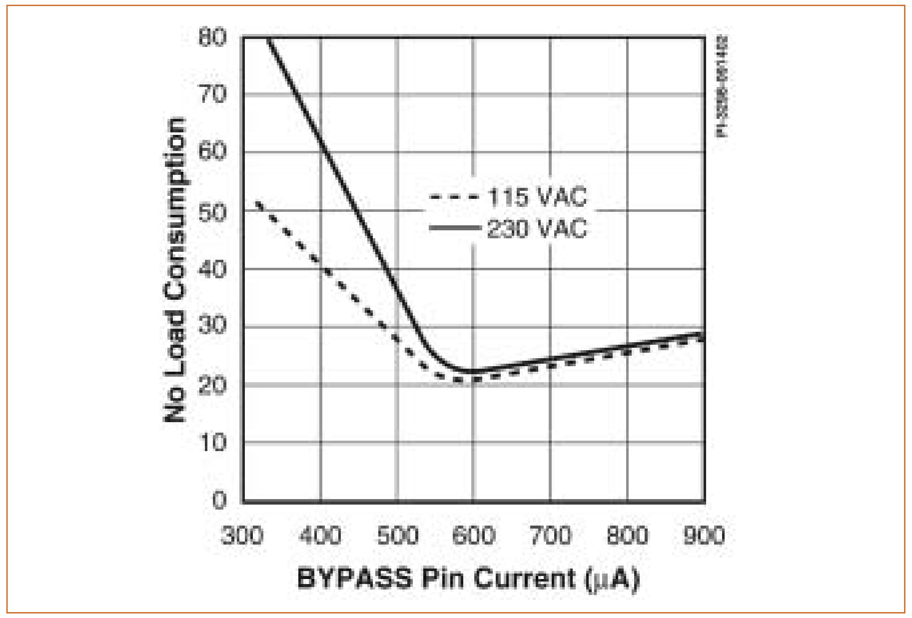

Figure 2. No-load Input Power vs. BYPASS Pin Current.

- Secondary circuit bias currents should be minimized. Low current feedback Zener diodes offer the best tolerance. The very low Zener bias current in this design provides better than ±10% output voltage tolerance.
- Transformer design should feature low reflected voltage, thus minimizing clamp losses. A larger TinySwitch-II device may enable further reduction in VOR.
- The transformer should be wound for lowest leakage inductance. Wire gauges should be selected to completely fill winding layers.

This design results in a charger that consumes 97 percent less no-load energy than traditional linear transformer-based power supplies and comfortably beats the recently announced mandatory regulations from the California Energy Commission (CEC), which permit up to 500 mW of no-load energy consumption. The remarkable performance of the DI-84 is achieved through a combination of a reduction in the IC's internal power consumption, the low bias current design of the secondary feedback circuits, and efficient transformer design.

Power Integrations offers a complete suite of design tools for designers of energy-efficient power supplies rated from under one watt to over 200 watts. Energy-efficient circuits that conform to current efficiency standards are highlighted on the Power Integrations Web site at www.powerint.com/appcircuits.htm. The Green Room section of company's Web site (http://www.powerint.com/greenroom) provides an easy-to-use, comprehensive guide to energy efficiency standards around the world as well as other topics relating to the design of energy-efficient power supplies.

www.powerint.com

Military Specification of Power Supplies

How to achieve flexibility and economy in the design

When developing a military power supply it is wise to make the design flexible enough to accommodate a range of possible markets and international defense standards.

By Martin Brabham, Military Power specialist, XP Power

The relevant military specifications of various countries cover four main areas:

1. Input voltage characteristics
2. Electromagnetic compatibility (EMC)
3. Environmental testing
4. Component qualification and screening

Typically, the standards tell you the correct limits for the type of platform on which the end product is to be used e.g. army vehicles, naval craft and aircraft. The specifications are often updated as new platforms are developed and the situation is complicated because the older specifications, although superseded and generally no longer maintained, are still in common usage. Power supply designs should meet the most stringent version of the specification to gain the widest acceptance.

Some common example specifications with respect to various characteristics are shown in Tables 1 to 3.

Few of the above requirements can be met using commercial off-the-shelf (COTS) DC/DC converters, but full custom design can be risky and expensive. The alternative is to use either military DC/DC converters or rugged industrial versions to which external filtering and control are added to achieve compliance.

NATO ACTP 500	NATO	New standard being proposed. Based on 461E and has the potential to be one of the first to encompass both US and European standards.
MIL-STD-461C	USA	An older version of the US EMC specification that is still in common use; conducted emissions are measured using a current probe in dBμA but in the D and E versions of the specification - the newer ones – conducted emissions measured using a line impedance stabilisation network (LISN) specific to this specification in dBμV. There is no conversion factor between dBμA and dBμV that can be consistently applied.
MIL-STD 461D	USA	US EMC specification. Introduction of the LISN to standardised measurements
MIL-STD 461E	USA	Latest version of EMC specification that covers both radiated and conduction emissions and susceptibility and test methods. Industry sources say the specification is close to being revised to MIL-STD 461F.
MIL-STD 462	USA	The test method for MIL STD 461D that was later incorporated into the MIL STD 461E document.
DEF-STAN 59-41	UK	Many similarities with MIL STD 461D and E specifications but uses a different LISN and current probe to make dBμA measurements for conducted emissions.
GAM EG 13B	France	French National EMC standard.
VG95370	Germany	German National EMC standard.
EN55022	European	Not a military specification but defines commercial and industrial EMC emissions. May apply to a military product if it is also to be connected to a municipal mains network or used in a non-military environment.
DO160 C&D	USA	This is an specification for civil aircraft that covers EMC, electrical test, input voltage and environment.

Table 1. Common defense specifications relating to EMC.

MIL-STD 704 A to F	US	Includes AC and DC inputs on military aircraft. Earlier versions are typically more stringent than later versions. Version B onwards contains the 270VDC Input Bus.
MIL-STD 1275 A & B	US	Characteristics of 28VDC electrical systems in military vehicles.
DEF-STAN 61-5 part 6	UK	Characteristics of 28VDC electrical systems in UK military vehicles.

Table 2. Common defense specifications relating to input voltage.

MIL-STD 810 D, E, & F	US	Used for environmental testing for numerous military platforms including military aircraft, vehicles, cargo etc.
DEF-STAN 00-353	UK	As above, but UK specification.
MIL-STD 202	US	Method for testing electronics and electrical equipment.
MIL-STD 883	US	For testing hybrids and micro-circuits, including some types of DC/DC converter.

Table 3. Common defense specifications relating to environmental performance and component screening.

POWER SUPPLY

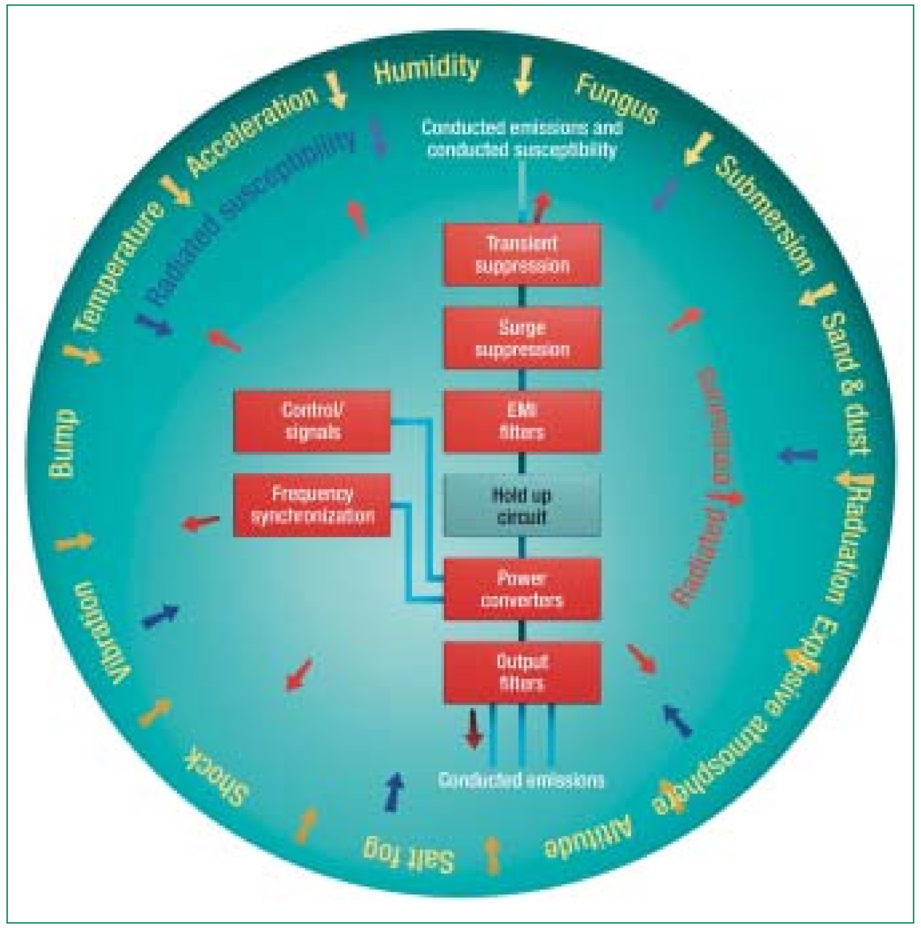

Figure 1. Various characteristics of the system interact, as shown.

However, the power system design must take account of the way in which various characteristics of the system interact, as shown in Figure 1.

We now consider the power system characteristics affected by military specifications and possible design approaches.

Normal Operating voltages

Input voltages are primarily dependent on the power converter. Industrial converters are normally rated for 18-36VDC input and are suitable for military some power system applications, subject to acceptable voltage drops across filtering and suppression components and stresses on surge suppression circuits. Military specification converters often have a wider input voltage range, perhaps 15-50VDC. This makes it easier or even unnecessary to provide surge suppression, and makes the design suitable for a wider range of operating environments.

Abnormal operating voltages

If there is an input voltage drop of short duration, the system designer needs to define an acceptable way of dealing with it - whether automatic re-start without user intervention is required, or if a manual re-start is acceptable. For example, cranking a vehicle can cause a sudden drop in input voltage for a protracted period of time. Designing a power system to work through this event is technically possible but will have a big impact on parameters such as efficiency and mechanical size.

For short drops (mSecs) using bulk capacitance may be appropriate. Alternatively, a boost converter hold-up circuit can be used. It saves space over bulk capacitance but brings added complexity and cost, lowering the system MTBF and adding switching noise.

Surge and transient suppression

The design must keep the input voltage clamped to the maximum permissible. This may be the maximum operating voltage of the converter or the maximum surge voltage. Clamping to the surge voltage creates less stress on the suppression circuit and reduces its size but can cause line steps on the output voltage(s). Determining the optimum surge protection method demands an understanding of both the source impedance and the maximum tolerable Volt x Second product (how many volts and for how long). For a high source impedance and a small Volt x Second product this is simple. If the reverse is true then specialist circuitry may be required. For short transients, solutions include transorbs, MOVs and series inductors. For long-term surges with low source impedance, a MOSFET may be needed to meet the 80V surge requirement in MIL-STD 704A or the 100V surge limit in MIL-STD 1275A.

Conducted emissions

Noise conducted onto the input power bus must be filtered with respect to common mode and differential signals. The layout of the system should keep inputs well away from noise sources and it may be helpful to use devices with over 400kHz switching frequency to move noise into an area where limits are not so tight. An alternative is to use resonant mode topology, with sinusoidal input currents with low harmonic content, to minimize conducted emissions and make the EMC problem easier to solve.

Input ripple

Input ripple filters need careful design. Standards such as MIL-STD 1275A/B and DEF-STAN 61-5 pt 6 have stringent ripple tests across a wide frequency range that can cause a poorly designed input filter to fail. Furthermore, in a system without sufficient ripple rejection or adequate output filtering the input ripple can produce excess output ripple and lead to system failure.

Figure 2. MCC 28VDC input, configurable, 1 – 4 output power supply rated at 400W.

Environmental considerations

All aspects of a power system design will affect its environmental performance so care must be taken to understand the conditions from which data sheet specifications are derived. Where operation at over 100 °C is needed, a metal-cased hybrid converter with a conductive baseplate for effective heat dissipation is normally the most reliable solution. Military specifications will also specify other requirements with respect to the effects of altitude, atmosphere (humidity, salt fog etc.) and vibration.

Radiated emissions and susceptibility

Both of these characteristics are system level issues but the conducted emissions from a PSU input and output will have a big influence. The cabling and interconnect between the power supply and the system, and screening, are key factors in ensuring compliance with specifications. Practical design example using the techniques described.

Figure 2 shows the MCC 28VDC input, configurable, 1 – 4 output power supply rated at 400W. The MCC product uses COTS DC/DC converters and meets MIL-STD 461E and MIL-STD 1275B. The design is adaptable to meet national standards such as DEF-STAN 61-5 pt 6 and DEF STAN 59-41. The DC/DC converters are stress screened over the military temperature range and there is flexibility for providing different output voltages. An optional filtered, unregulated output can be used to power other system components that are sensitive to input voltage, saving the cost of additional filtering.

The product is easily adapted for applications that require custom signals.

For further information:
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Power Systems Design EUROPE

Automotive Electronics
Part II

Innovative Power Control in High Demand

Technology with a Perspective

More sophisticated technologies such as silicon substrate thinning, implantation of special junction layers and Power Balling optimises discrete electronic power components. Besides IT and consumer electronics the automotive industry is the major requestor for the most advanced power components.

By Detlef Friedrich, Helmut Bernt, Henning Hanssen, Klaus Kohlmann, Jürgen Schliwinski
Fraunhofer-Institut für Siliziumtechnologie ISIT, Itzehoe

Nowadays state-of-the-art power semiconductors can still be further improved by a series of measures: Optimisation of silicon technology e.g. by extreme substrate thinning and by further geometrical shrinks. The application of new assembly methods is required to reduce losses caused by mounting and packaging and to increase integration density. Meanwhile power transistors have come down in structure sizes around 0.25µm. Therefore advanced process technologies coming from modern CMOS production such as chemical/mechanical polishing or high resolution lithography are utilized and so production of power components is performed with the most advanced microelectronics technologies - conventional technologies are no longer in demand for advanced applications.

Power electronics is dominated by two types of active components, the PowerMOSFET (Metal Oxide Semiconductor Field Effect Transistor) and IGBT (Insulated Gate Bipolar Transistor). The PowerMOSFET is used as a fast switch with maximum off-state voltages up to approximately 200 V as the on-state-resistance RDS on shows a disproportional increase due to the low drift zone doping level for higher voltages. For higher voltage levels SuperJunction PowerMOSFETs, so called compensation devices, are recommending themselves, for which new architectures are in development. Because of it's low on-state losses the IGBT is more suitable for higher voltages in the range of 600V and above. Therefore it is mainly used for mains driven industrial applications, home appliances and electric drive circuits. Besides it's low on-state losses, good switching parameters and short circuit capability are the major features of IGBTs.

With the transition from planar to vertically structured trench power semiconductors, substrate thinning (Figure 1) plays a major roll besides the shrinkage of cell geometries.

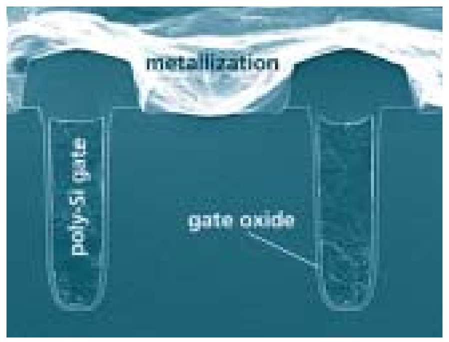

Figure 1. Cross Section of a Trench IGTB.

There are limits to substrate thinning, because in the blocking mode a voltage dependent depletion layer depths is needed to keep the maximum electric field below the onset of avalanche breakdown. However, if it is possible, to shorten the field strength decay by means of a higher doped layer within the drift zone - a so called Field Stop Layer - substrates can even be thinned further. In case of a 600 Volt value the substrate can be thinned down to the physical limit of approximately 50µm.

How can a Field Stop Layer be processed within an ultra thin wafer, or better say foil? One solution is to start from a homogeneous n- substrate with a doping concentration of approximately 1014 cm-3 and to insert the Field Stop Layer along with the Emitter on the back side of the wafer at the end of the process by ion implantation. The implanted atoms come to stay anywhere in the Si-crystal and need to be moved into their regular position by a subsequent activation process, which is done by tempering in the range of 1000°C. Since this would affect the Al-metallization, that just withstands temperatures up to 500°C the front side of the wafer can only be processed without metal layers. After the substrate thinning the

AUTOMOTIVE ELECTRONICS: PART II

Field Stop Layer and the Emitter must be implanted on the backside before metallization and passivation can be deposited on the front side. This however requires a demanding production process on ultra thin wafers.

ISIT scientists chose a different approach for the above outlined reasons: They took a substrate as base material with a dopant concentration appropriate for a Field Stop Layer and a drift zone epitaxial layer. All transistor layers are processed on top within the drift zone. Only the Emitter needs to be ion implanted and activated for adjustment of the switching characteristics but that can be done at only approximately 450°C with no harm to the already deposited metallization layers. The remaining challenge is a high precision back grinding and a Chemical/Mechanical Polishing process (CMP) in 5 µm proximity to the drift zone layer (Figure 2).

Another promising approach which is now in the test phase is the activation of the Field-Stop and Emitter dopants on the wafer back side by laser annealing. It allows implantation of the Field-Stop-Layer and Emitter and subsequent activation by laser without heating up the wafer front side. The activation of dopant atoms is nearly 100 per cent depending on the energy of the utilized XeCl-laser (308nm). The main benefit of the laser process is, that the front side can be entirely processed and the back side processing can be finished afterwards.

For stabilization of the ultra thin wafer handling in standard process equipment an appropriate carrier is required, that is thermally robust, chemically neutral and vacuum tolerant. For multiple use of the carrier it needs to be detachable after processing. The ISIT specialists chose silicon wafers as carriers. Carrier and device wafer are joined temporarily by bonding on a double sided adhesive foil on which the substrate is attached upside-down on the carrier. Now the device wafer can be thinned and handled afterwards like a standard thickness wafer within the normal processing environment. By heating up to 170°C

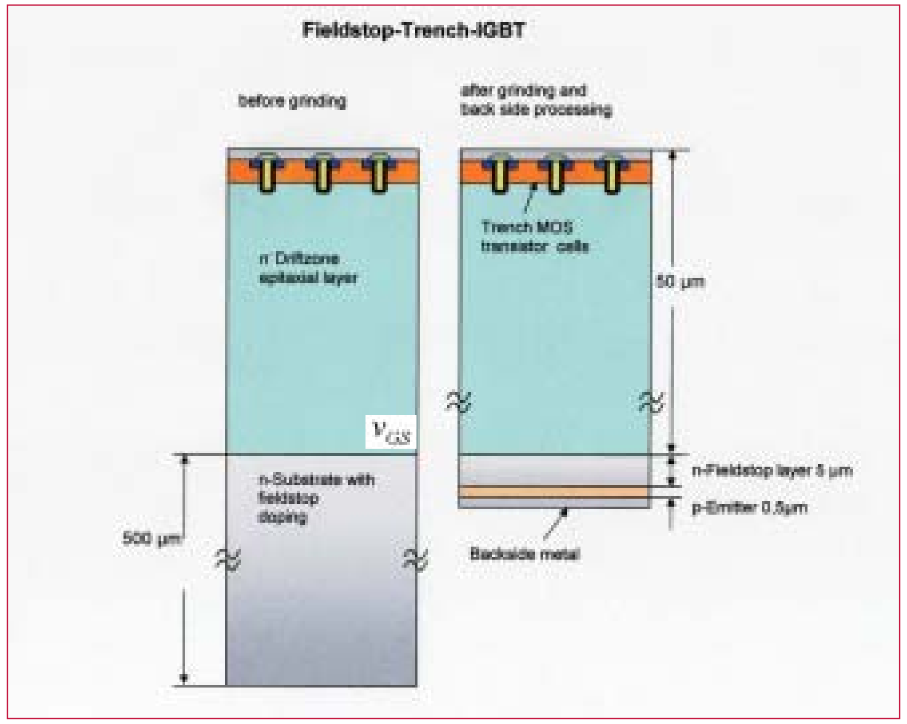

Figure 2. Schematic of a Field-Stop-Trench IGTB.

one of the three layers of the Thermal Release Foil is foaming up and releases the thinned wafer. All process steps like grinding and polishing, implantation and metallization can be performed with this method except for the activation, which requires higher temperatures.

New process technologies lead to a continuing higher integration and thinner silicon substrates with improved properties of power components. Classic assembly technologies such as wire bonding can not cope with this trend if the power transistor performance is supposed to be maintained through the packaging process. It comes to a limit with ultra thin PowerMOS transistors because the resistance of the wire bonds is in the same order of magnitude compared to the transistor's on-state-resistance $R_{DS\text{-}on}$. Power Balling across the entire chip front surface (Figure 3 and 4) is the obvious solution.

This new module technology is transferred from Wafer Level/Chip Size-Packaging (WL-CSP) to power components. It is based on an Al-NiV-Cu under-bump metallization, a BCB passivation (Benzo Cyclo Butene) and solder ball attach with subsequent solder ball reflow. The solder bump technology is qualified for lead-free soldering.

By means of solder bumping process parasitic resistance and inductance values can be reduced and heat dissipate directly via the bumps. This good heat transfer is especially important for automotive applications, where ambient temperatures of 150°C and higher may occur. Another benefit is, that due to the missing wire bonds there is no extra module or package real estate required for bond pads and so the integration density of power components can be further improved in assembly. However, new methods are required to assemble high performance power devices with solder bumps in power modules

With an increased sophistication of technologies discrete power semiconductors can be further optimised but a major quantum leap is not taking place. More functionality and higher integration density can be achieved only by monolithic integration of power devices. One of today attempts is SmartPower, a combination of Bipolar, DMOS and CMOS technologies, but this solution is limited in terms of the maximum switching power.

ISIT scientists are already working on new concepts for monolithic integration of diodes, IGBTs and control logic on one substrate. Aim of this project is the development of short circuit proof half-bridge circuits completely monolithically integrated together with the entire control logic. This concept can only be implemented by using a vertical insulation - deep trench grooves - between the diodes and the IGBT pairs. The next step would be a bi-directional MOS-controlled switch for matrix converter applications.

The scientists team of the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe, Germany manage to continuously further optimise discrete electronic power components. The increasing demand for adaptive control and efficiency improvement of power systems in practically all areas of everyday-life is the driving force.

Fraunhofer Institute for Silicon Technology ISIT in Itzehoe and Vishay Itzehoe GmbH are in a good working relation. Vishay Itzehoe GmbH is producing most advanced PowerMOS components in high volume. With the already started conversion from 150mm to 200mm wafer size this location will be the first European 8 inch production and development center for power components.

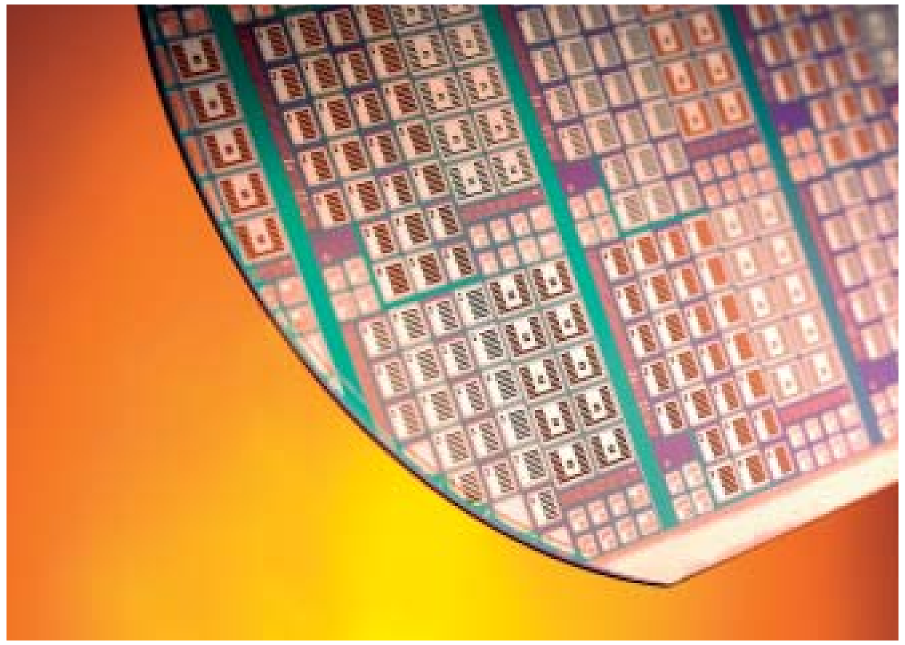

Figure 3. IGBTs with Power Balling.

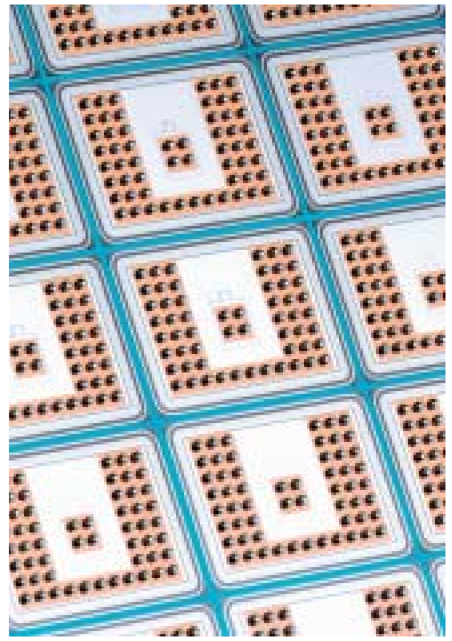

Figure 4. Power Balling on IGBT Wafer.

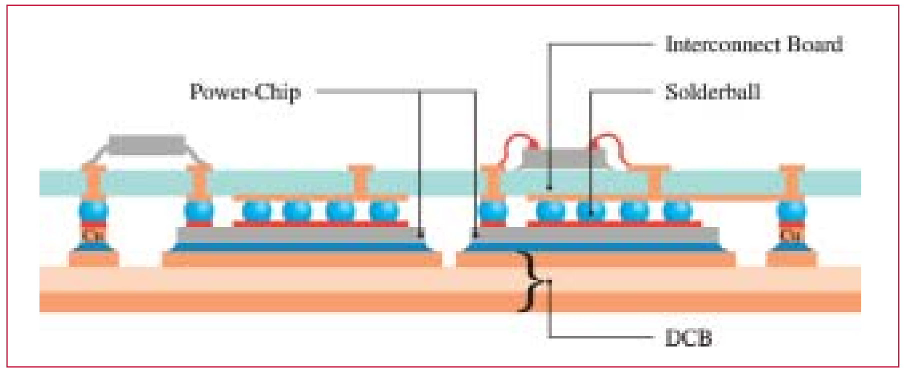

Figure 5. Sandwich Structure of a Power Module suitable for Solder Bumped Power Devices.

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Three-Terminal Shunt Regulator

A way to reduce Costs in automotive power supplies

It's amazing to think about all the electronics built into today's automobile. One of the most popular vehicles today is the "family mini-van". These moving "living rooms" come equipped with all types of electrical devices to keep riders entertained

By Michael O'Loughlin, Texas Instruments

It's amazing to think about all the electronics built into today's automobile. One of the most popular vehicles today is the "family mini-van". These moving "living rooms" come equipped with all types of electrical devices to keep riders entertained such as: CD players, TVs, and DVD players. In addition, features such as automatic door openers make it easier to load family members. With their different electrical needs, these components demand flexible, well-designed power supplies. In addition, the automotive market is very cost competitive. To keep a cost competitive edge, a designer needs to reduce costs wherever possible. To this end, many semiconductor companies produce inexpensive three-terminal shunt regulators. These devices have an internal precision reference, operational amplifier and an internal shunt transistor to control a precision voltage source. However, these devices have hidden applications that can help the automotive designers reduce costs in the power supply. The semiconductor devices can be used as inexpensive operational amplifiers for control loop feedback. The device can be used in conjunction with transistor and passive components for fast boot-strap circuits. These devices can also be configured to work as a low-power auxiliary supply to power the pulse-width modulator (PWM) controller under light load operations. These circuits will not be found in the shunt regulator's data sheet, but will help the power supply designer reduce the cost of their designs.

Operational Amplifier:

In power supply designs that contain PWMs without a voltage amplifier, a system designer can use a shunt regulator as a cost-affordable operational amplifier. Figure 2 contains a functional block diagram of this application. The small signal transfer function for this compensation network can be explained with Equation 1.

(1)

$$G_V(s) = \frac{V_{bar}}{V_{out}} = \frac{s \cdot R_Z \cdot C_Z + 1}{s \cdot R_i (C_Z + C_P)\left(\frac{s \cdot R_Z \cdot C_P \cdot C_Z}{C_P + C_Z} + 1\right)} \cdot \frac{R2}{R1} \cdot \left(\frac{1}{\frac{s}{2 \cdot \pi \cdot f_P} + 1}\right)$$

Resistor Ri and R set the DC output voltage. Components Cp, Cz and Rz are used to compensate the control loop. The Optocoupler (Opto) provides galvanic isolation. Resistor R1 is used to bias the optocoupler and the TL431.

Resistor R3 and diode D1 provide a fixed bias point to ensure that bias resistor R1 does not form a feedback path. Resistors R1 and R2 are used to control the gain across the optocoupler. In most designs, the ratio of R2 to R1 is set roughly ten-to-one. The optocoupler has a high frequency pole (fp). The optocoupler's data sheet typically does not provide information on fp. Using a network analyzer, one can find the high frequency pole. If a network analyzer is not available, the designer can estimate that the pole (fp) is roughly 10 kHz. Note in some applications a capacitor might be needed across D1 to filter out noise.

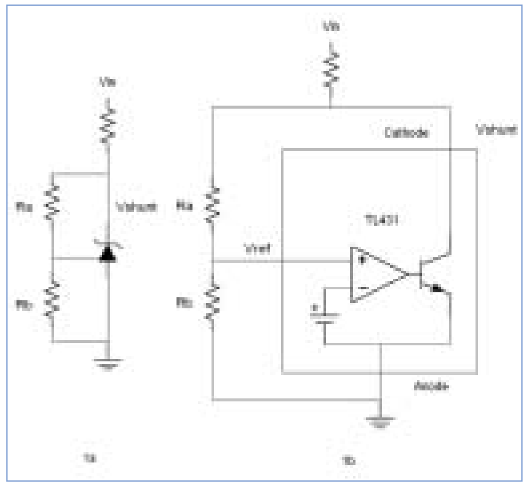

Figure 1. Shunt Regulator.

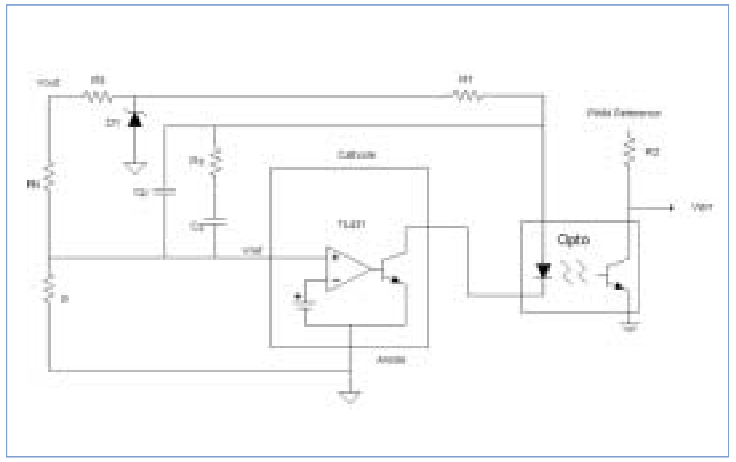

Figure 2. Operational Amplifier for PWM Feedback with Galvanic Isolation.

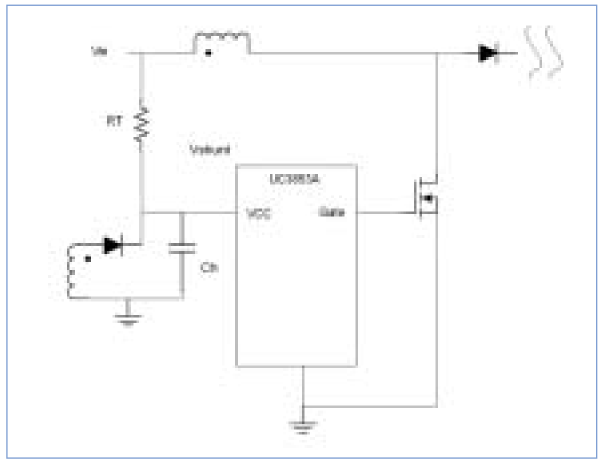

Figure 3. Switching Power Supply Boot-Strap Circuit.

Boot-Strap Circuit:

In a switching power supply design, the pulse width modulator IC is typically powered by an auxiliary winding as shown in Figure 3. To start this circuit requires a trickle charge resistor (Rt) as well as a hold-up capacitor (Ch). To keep power consumption to a minimum, the trickle charge resistor is chosen to be as large as possible. The hold-up capacitor also needs to be large as well, because it supplies energy to the PWM until the power supply starts switching.

The shunt regulator can be configured using a bipolar transistor and a few resistors to speed-up the boot- strap time. Please refer to Figure 4 for details. Electrical components C, D1, Q1 and Ra through Rd form the boot-strap circuit. At power-up, capacitor C will be completely discharged and the voltage at the PWM's power input (Vaux) will be determined by the series pass regulator that is controlled through Q1 and D1. At turn "on", the Vaux voltage will be at its peak voltage (Vaux_peak) and is determined by the resistor ratio of Ra and Rb. Capacitor C and resistor Rc are used to determine the timing and turn "off" voltage of the boost-strap circuit to conserve energy. Resistor Rd supplies bias current to the TL431, while resistor Re limits the current to keep transistor Q1 in its safe operating area (SOA).

Setting up the circuit is not that difficult. Resistors Ra and Rb are selected to set the peak-charging voltage (Vaux_peak).

(2)

$$\frac{Vref}{Rb} = \frac{Vaux\_peak + Vd3 + Vbe - Vref}{Ra + Rb}$$

Resistor Rc is selected to lower the shunt voltage below the nominal Vaux voltage (Vaux_nominal) that is supplied by the auxiliary winding.

(3)

$$RC = \frac{Vref \times Ra + (Vref - Vaux\_nominal)Rb}{Vaux\_nominal - Vref - 1V}$$

Capacitor C sets the boost strap time (Tboot).

(4)

$$C = \frac{2 * Tboot}{Rc}$$

Low Power PWM Bias Supply:

In some power supplies, the PWM is powered by an auxiliary winding similar to the circuit presented in Figure 3. The problem with this circuit is under light load operation when there is not enough energy stored in the auxiliary winding to power the IC. The behavior of the power supply may even become erratic because the PWM will be turning " on-and-off". The circuit presented in Figure 5 shows how to overcome this problem with a serie- pass regulator that turns "on" under light load conditions and turns "off" when the bias winding can supply the energy to the PWM controller.

Resistors Ra through Rd, Diodes D1, D2 and transistor Q1 form the low-power bias supply. This low- power bias supply is set-up to regulate a voltage above the PWM's turn-off voltage and below the nominal auxiliary winding voltage (Vaux_nominal). This allows for transistor Q1 to act as a diode OR circuit. When the PWM is powered by the auxiliary winding, the voltage at Vaux will be back-biased turning "off" transistor Q1 and conserving energy. When the voltage at Vaux drops due to lack of energy, Q1 will become forward-bias to deliver needed energy to the PWM controller.

Setting-up the low-pass series pass regulator is also not difficult. Resistor Rc is sized to supply bias-current to D1, resistor Rd is sized to keep transistor Q1 within its SOA, and resistors Ra and Rb are sized to regulate the voltage of the low-power series pass regulator. The voltage provided by this low-power series pass regulator needs to be set at voltage above the control ICs turn "on" voltage and below the nominal voltage supplied by the auxiliary winding (Vaux_nominal).

The following equation is used to adjust the resistor divider formed by resistors Ra and Rb. The voltage set at the emitter of Q1 needs to be below the nominal auxiliary voltage (Vaux_nominal) supply by the secondary winding from transformer T1. Vref is the internal reference of shunt regulator D1. Vd2 and Vbeq1 are the voltage drops of diode d2 and the base emitter voltage of Q1, respectively.

(5)

$$\frac{Vref}{Rb} = \frac{Vaux\_nominal - Vd2 - Vbeq1 - Vref - 1V}{Ra}$$

Summary:

The three-terminal shunt regulator, such as the TL431, is useful in many applications to reduce the cost of an automobile's power supply. These three-terminal devices are inexpensive and versatile. The regulators can be configured to perform many functions in switching power supplies. The devices can be used as a precision reference and can function as an affordable operational amplifier to provide feedback control. The regulator can be used for quick boot-strapping of the power supply compared to conventional methods. The shunt regulator in conjunction with a NPN transistor can provide a low-power bias supply, which turns "on" under light load conditions and turns "off" when the power from an auxiliary winding is sufficient enough to supply energy to the PWM.

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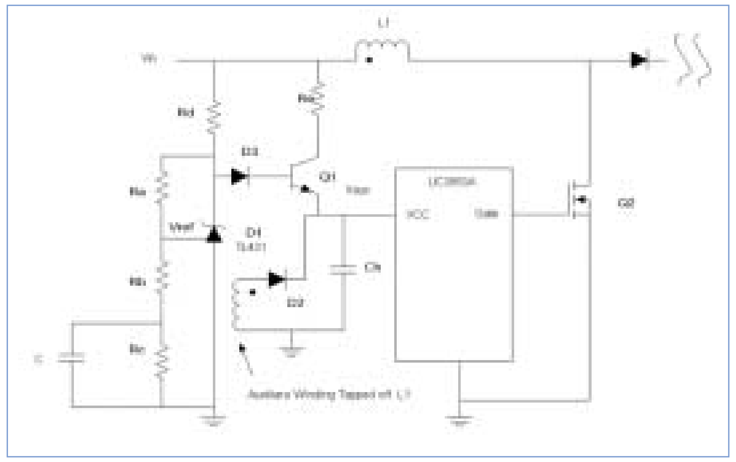

Figure 4. Improved Boot-Strap Circuit.

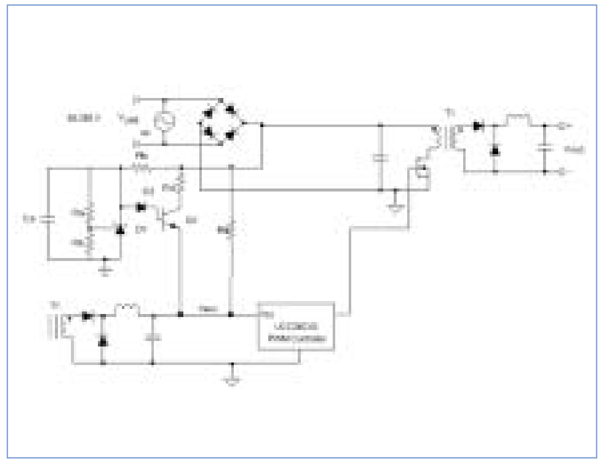

Figure 5. Low-Power Auxiliary Supply.

Protecting High Brightness LEDs from Thermal Stress

LEDs can be protected by low cost electronics

When using high brightness, high power LEDs however, heat dissipation is a serious concern and the fact that 20% of power input to an LED is converted into light while 80% generates heat means that automotive lighting designers can be faced with a serious problem to overcome.

By Alan Buxton, Marketing Manager, Lighting Products and Ho Wong, Product Marketing Manager, Zetex Semiconductors

There's no doubt that the ruggedness and long life of LEDs present clear advantages for automotive applications. When using high brightness, high power LEDs however, heat dissipation is a serious concern and the fact that 20% of power input to an LED is converted into light while 80% generates heat means that automotive lighting designers can be faced with a serious problem to overcome.

Since even the best possible thermal design practice can be thwarted by an inappropriate lighting installation, the responsibility of maintaining safe LED operating conditions and minimising the impact of thermal effects on LED life must surely fall to the drive electronics.

A look at the specs

A quick review of the product specifications provided by manufacturers of high brightness LEDs serves to identify some key design parameters, which need to be taken into account and to illustrate the negative effects of running such components at high temperatures:

The effective life of the LED is inversely related to the power dissipation and temperature of the LED junction. Manufacturers show MTBF figures of about 100M hours at Tj 80ºC. In practical automotive systems LED failure is not likely to be a problem. However, in systems where heat is not adequately removed and Tj rises to 120ºC or beyond, then LED life will be significantly shortened. In extreme conditions the LED could suffer immediate failure.

Thermal design can certainly apply some overcompensation to take into account worst-case installation scenarios, but in certain instances this may not be possible. Consider an instrument light installed in a well-insulated plastic cavity. The cavity not only acts to prevent adequate heat dissipation it also doesn't offer sufficient housing space to fit a suitable heatsink.

Relative light intensity is inversely related to junction temperature. While data sheets vary, manufacturers quote a reduction of light output of up to 30% at maximum junction temperature.

Lumen maintenance over time is inversely related to junction temperature. An LED can typically lose 30% of its light output over 50k hours when run at 70°C junction temperature -presumably the reduction is greater at higher temperatures, but figures are not published.

In reality, the reduction in light output over time – whatever the cause – is actually not a great issue. In fact it may not be all that noticeable and in any case LED performance will be comparable with that experienced with alternative light sources.

Control the junction temperature

In considering the factors discussed, the single most important goal for a prudent designer is to remove heat from the LED, in order to keep the junction temperature below the maximum rating, thereby avoiding premature failure.

The electronics used to generate the required LED current can easily incorporate methods of detecting over temperature conditions which serve to reduce the LED drive current in order to maintain a stable operating temperature.

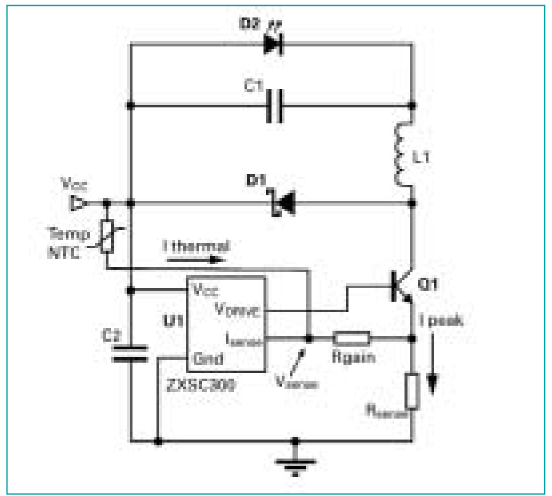

Figure 1. Incorporating temperature control in a buck converter configuration.

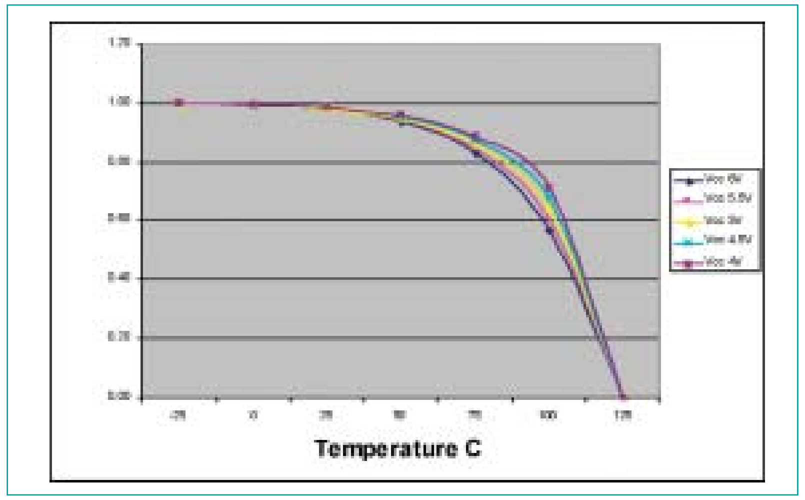

Figure 2. The effect of thermistor characteristics on peak current for voltages in the 4 volt to 6 volt range.

Clearly the light output would reduce, but the LED would survive to enjoy a long and bright future.

By way of an example, the circuit shown in Figure 1 incorporates temperature control in a buck converter configuration. The circuit is designed to drive an LED with a drive current up to 1 amp. The supply voltage is from 4 volts to 6 volts.

Buck converter operation.

When the switch Q1 is on, current flows through the LED and L1. This current builds up to a point where the voltage across R_{sense} reaches the threshold of U1. The ZXSC300 controller then removes the drive to Q1 which turns off. The energy stored in L1 is then discharged, flowing through D1 and the LED. The ZXSC300 has a fixed turn off period of 1.7µs, after which time Q1 turns on and the cycle is repeated. In this application the switch frequency is about 150kHz.

Adding thermal control

Temperature detection is achieved using a 150kΩ NTC thermistor, which is located in close thermal contact to the LED. The current flowing through the thermistor is multiplied and summed with the peak switch current in order to regulate the LED current.

As the temperature increases the thermistor resistance reduces and a larger current flows through the thermistor, producing an increase in the I_{sense} voltage which causes the controller to turn off at a lower LED current. Suitable values of thermistor, R_{gain} and R_{sense} are chosen to maintain the LED operating temperature within the safe operating limits. Supply voltage variation has only a small effect on the temperature control as shown in the control graph.

Formula

The circuit shown in Figure 1 uses components calculated using the following simple formula.

V_{cc}-V_{sense} = $I_{thermal}$ x R_{NTC}.

(V_{sense} of ZXSC300 is 20mV and thus is negligible relative to V_{cc})

So $I_{thermal} = V_{cc} / R_{NTC}$

(Assuming $I_{peak} >> I_{thermal}$ and $R_{gain} >> R_{sense}$)

$V_{sense} = (I_{thermal} \times R_{gain}) + (I_{peak} \times R_{sense})$

$I_{peak} = (V_{sense} - I_{thermal} \times R_{gain})/R_{sense} = (V_{sense} - V_{cc}/ R_{NTC} \times R_{gain}) / R_{sense}$

In this circuit example a Yuden 150kΩ thermistor is used as the temperature sensor. The target control temperature is 75°C and the output current is 833mA. Rgain is 10Ω, Rsense is 20mΩ and Vsense is 20mV.

Table 1 shows the thermistor temperature characteristics and the effect on peak current with a 6 V supply. These results are shown graphically in Figure 2 for several voltages in the 4 volt to 6 volt range.

Temp °C	R_{NTC} kOhm	Ipeak A	Change %
-25	28000	1.00	20
0	600	1.00	19
25	160	0.98	18
50	50	0.94	13
75	18	0.83	0
100	7	0.57	-31
125	1.6	0.00	-100

Table 1. Thermistor temperature characteristics and effect on peak current.

This example shows the components required for driving an LED current of 833mA. The circuit can be easily adapted to drive lower currents by changing the values of Rsense. A different temperature break point can be chosen by changing the value of Rgain.

In summary

It is shown then that costly high brightness LEDs can be protected by the addition of some relatively simple and low cost electronics. This technique can be applied to many different control systems in both buck and boost operating modes using any of the ZXSC series LED driver ICs. Using this method of thermal protection allows the lighting designer to achieve automotive solutions which are smaller and less expensive to produce. In some cases a form factor can be used which would not be achievable without thermal protection.

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Hall Sensors Aid Vehicle Seat Safety

Safety systems continue to become more sophisticated

Seat position sensing is used in safety systems to determine the position of an occupant in relation to the steering wheel, preventing the air bags from deploying with excessive force. There can be any number of zones, depending on how many Hall-effect sensors are used; a typical installation would have two sensors per seat track, so that four zones would be possible.

by Christine Graham, Allegro MicroSystems

Occupant safety is one of the most critical elements of the automobile design. As a result, safety systems continue to become more sophisticated in order to limit, and ultimately prevent, personal injury in the case of an accident.

Seat position sensing is used in safety systems to determine the position of an occupant in relation to the steering wheel, preventing the air bags from deploying with excessive force.

The most common solution today incorporates two-wire unipolar Hall-effect switches to sense discrete seat position zones. The sensor must relay this information in the form of a digital output to the controller unit indicating a particular zone. This information must be correct at start-up of the vehicle, and so the sensor output must be decoded without any requirement for user action.

The seat track is typically a ferrous metal material capable of interrupting the magnetic field between the Hall-effect sensor and a magnet. The ferrous metal of the seat track passes between the switch and the magnet causing the switch to turn on or off, relaying seat position information to the controller unit. A change in the output state of the sensor indicates to the controller unit that the seat has passed into a particular zone.

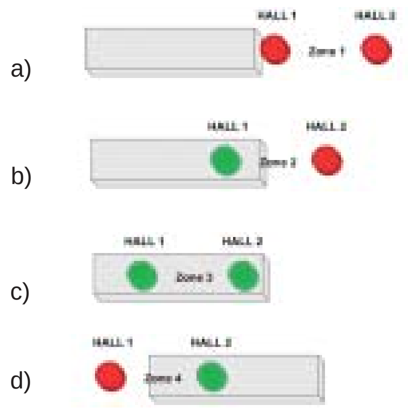

Figure 1a,b,c,d. Position sensors relay proper seat location to the controller unit the entire time the vehicle is on. Occupants are unaware of the fact that the vehicle is making life or death decisions automatically with no user interface required

There can be any number of zones, depending on how many Hall-effect sensors are used; a typical installation would have two sensors per seat track, so that four zones would be possible.

The information provided by the Hall sensor is processed by the controller to determine the seat position relative to the steering wheel. A seat that is in one of the closer zones to the steering wheel would indicate to the controller unit that a lower force deployment of the air bag is necessary. Seat positions that are in one of the rear zones, furthest from the steering wheel, require a higher force deployment. The controller unit decodes the output states of the Hall-effect sensors to determine in which zone the seat is positioned. Two sensors will provide a convenient Grey Code output as shown in Fig.1 and Table 1.

The vast selection of Hall-effect sensors now available allows different solutions for the same application. For example, a higher resolution may be required to determine exactly where the seat is at all times. The highest-resolution solution is to use a linear analogue Hall sensor, which produces a voltage output proportional to the strength of the magnetic field. A dual-pole magnet in a slide-by configuration with the linear device will produce an output ranging from 0 to 5 V with the appropriate design.

AUTOMOTIVE ELECTRONICS: PART II

Zone	Sensor 2 Output	Sensor 1 Output
1	0	0
2	0	1
3	1	1
4	1	0

Figure 3. Board-bend test specified for AEC-Q200 qualification.

Hall-effect technology is highly reliable: an absolute essential for automatic sensing. It is also relatively inexpensive. If higher precision is required, programmable switches and linear devices are available, and can minimise stack-up tolerances by allowing end-of-line programming.

Ferrous targets can be detected using a back-biased Hall-effect sensor. These sensors incorporate a Hall IC and magnet in one overmoulded assembly. Back-biased solutions are offered for switch and linear designs. These assemblies simplify manufacturing and offer an optimised electrical and magnetic design in a single overmoulded package.

Seat-belt buckle sensor

The seat-belt buckle is another area where Hall-effect technology has been used as a part of the safety system. The two-wire unipolar switch is again a simple, yet reliable, solution common to many automobiles on the road today. The purpose of the Hall-effect device is to guarantee proper latching of the buckle to ensure that the occupant is properly restrained in the event of an accident or sudden stop.

As with the seat position-sensing application, seat-belt buckle switches operate using a vane interrupt concept. In this case the buckle, made of a ferrous material, is responsible for interrupting the magnetic field between a magnet and the Hall-effect device. Typically, when the field is interrupted, the device output switches on, and when the buckle is removed the device switches off. This information is sent to the controller, which then processes the data in conjunction with data from the seat position sensor and other outputs in order to reliably deploy air bags in the event of an accident.

Application hurdles

The seat-belt buckle sensor has tight spatial constraints, making the use of a printed wafer board difficult. As a result, welding of the wires to the leads is the more common approach as part of the packaging process to minimise size. However, welding to the leads takes expertise in the area of welding, and is typically contracted out to a welding facility. One of the most common errors seen in welding Hall-effect devices is the amount of heat or power allowed to reach the IC, causing wire bonds to be catastrophically damaged. Another common error seen in new welding processes is insufficient clamping of the leads, allowing them to twist or pull during the contact with the weld tip. This will also cause catastrophic damage to the wire bonds.

In addition to the spatial constraints, the sensor is subjected to high levels of electrostatic discharge (up to 15 kV) from customer-accessible points within the vehicle such as the tongue of the buckle assembly. In addition, shunting effects on the magnetic field experienced by the sensor result from the ferrous properties of the buckle assembly, and wide tolerances of the mechanical buckle assembly can cause large variations in the magnetic field seen by the Hall sensor. Choosing the right sensor is critical to meeting all these requirements.

Application solutions

Protection against transients and electrostatic discharges protection has been accomplished with the use of a 0.1 µF bypass capacitor welded between sensor supply and sensor ground. For installations where a circuit board is used, a metal oxide varistor may be needed in addition to the bypass capacitor to protect the sensor against harsh EMC/ESD conditions arising from the chassis ground, although some sensors are sufficiently robust not to need this.

A large magnet is required to overcome the shunting effect caused by the buckle assembly itself. Samarium-cobalt or neodymium are the magnetic materials most commonly used in seat-belt buckle applications. They provide large field

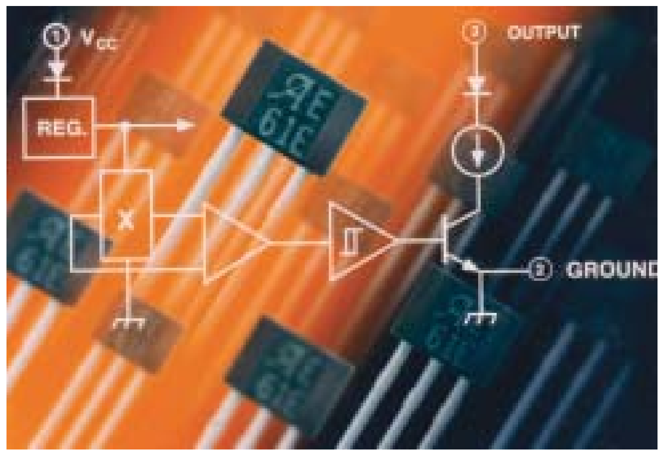

Figure 2.The Allegro 3161 Hall-effect switch IC.

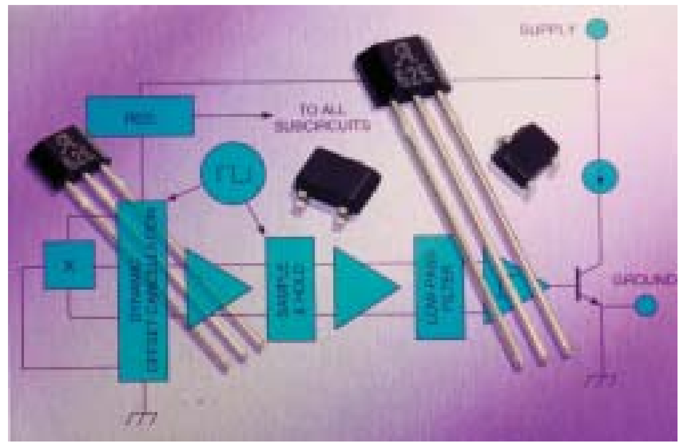

Figure 3.The Allegro A3361/62 chopper-stabilised precision Hall-effect switches.

levels to compensate for the mechanical tolerances and possibly large air gaps (more than 3 mm) encountered in seat-belt buckle applications.

Tolerances of the mechanical assembly can cause a large variation (typically hundreds of gauss) in the magnetic field level seen by the sensor; as a result, all conditions must be characterised to ensure that the sensor never switches into the incorrect state. The conditions that must not cause false switching of the Hall sensor are as follows: Normal buckled position with the tongue in place, normal unbuckled position with the tongue removed, over-travel of the tongue when pushed in and held by a person sitting on it or a child seat resting on the buckle assembly, false latch condition when something other than the actual tongue is pushed in, holding the buckle in a falsely latched condition (lollipop stick, toy etc.).

Practical switches

Examples of currently available Hall-effect sensor/switches for this type of two-wire application are shown in Figs. 2 and 3. Each device is a monolithic integrated-circuit chip that contains the Hall sensor plus all the necessary voltage-regulation, signal-conditioning and protection circuitry. All the devices are rugged enough in terms of both mechanical and temperature specifications for use in automotive applications.

The devices shown in Fig.3 offer additional benefits in terms of tight switch points and chopper stabilisation to achieve dynamic offset cancellation. This reduces the residual offset voltage normally caused by device overmoulding, temperature dependencies and thermal stress.

www.allegromicro.com

IPM for Photovoltaic Application

Adopting latest 5th generation trench chip (CSTBT) technology and adjusting the chip performance on the trade-off curve towards lower switching losses, Mitsubishi Electric launches an Intelligent Power Module which reaches the high efficiency required in photovoltaic inverter systems.

In spite of the switching speed improvement, the typical saturation voltage $V_{CE(sat)}$ is 1.55V at rated collector current and a junction temperature of 125°C. The optimised switching performance allows switching frequencies up to 30kHz without special cooling solutions. Low noise interference is realised by controlled di/dt. Mitsubishi Solar IPMs include protection functions against arm and load short circuit, supply under voltage and junction over temperature (by using an on-chip temperature sensor). Both arms have own fault output.

The new Solar IPMs with a rated voltage of 600V are available at rated currents of 50A and 75A in the compact “L-Series” package with screw and pin terminals. Single phase output inverter circuit and chopper circuit (optional with one, two or without chopper) are built in for multi-string operation.

Just like the 5th generation Mitsubishi “L-Series” IPM, the new photovoltaic modules have UL certification (Yellow Card No. E80276(N), File No. E80271).

www.mitsubishichips.com

High-Current Leaded Inductor Family

Vishay Intertechnology has extended its range of high-current filter inductors with the launch of new devices aimed at cost-sensitive applications in the lighting, audio, and domestic appliance sectors.

The Vishay Dale IHD-2 and IHD-4 inductors are axial-leaded for through-hole PCB mounting, and are available in standard inductance values ranging from 1 µH to 100 mH, with tolerance of ±15 % across the range. The use of a high-saturation bobbin in the construction of these devices enables DCR to be kept low, ranging from 7 milliohms to 76 ohms, depending on inductance. Saturation current is up to 8.2 A.

These new inductors are designed for use in applications as diverse as RFI suppression, SCR and triac controls, filters, and audio speaker crossover networks. The IHD-2 and IHD-4 inductors have UL-type VW-1 polyolefin tubing, providing flame-retardant insulation and protection of the copper coil.

Operating temperature range for the IHD-2 and IHD-4 devices is -55 °C to 85 °C. All of the inductors are lead (Pb)-free and compatible with tin/lead (Sn/Pb) and lead (Pb)-free soldering processes, allowing use by all assemblers transitioning to lead (Pb)-free processes. In addition, all devices comply with EU directives on vehicle end of life, including 2000/53/EC End of Vehicle Life Directive (ELV) and 2000/53/EC Annex II to End of Vehicle Life Directive (ELV II). All devices also meet 2002/95/EC Restriction of the use of Hazardous Substances Directive (RoHS) and 2002/96/EC Waste Electrical and Electronic Equipment Directive (WEEE).

Samples and production quantities are available now. Lead time for production quantities is eight to ten weeks.

www.vishay.com

High Speed, Robust BiCMOS/DMOS MOSFET Drivers

Micrel announced three new families of high performance BiCMOS/DMOS MOSFET drivers; the MIC4123/24/25 dual 3A drivers, the MIC4126/27/28 dual 1.5A drivers and the MIC4120/29 single 6A drivers. These ICs augment Micrel's family of MIC4100/01/02 drivers which were launched in 2004. These latest devices are aimed at power MOSFET applications in the industrial, telecom, networking and datacom markets for applications in off-line power conversion, UPS and motor control. The chips are offered in heat sink pad packages which are pin-compatible with Micrel's MIC44xx series, as well as new, space saving MLF packaging. All are Pb-free (RoHS compliant) and currently sampling, with production quantities available in 10 weeks.

The MIC412x family is designed to cover the full gamut of power MOSFETs commonly used today. With an operating voltage range of 4.5V to 20V, MIC412x's rail-to-rail output voltage swing assures full enhancement for any FET, from today's newest 'logic level' devices to industry workhorse IRF500, 600 and 700 families that have been in use for more than two decades.

Micrel's ICs feature high speed operation and advanced, low thermal resistance packaging technology to keep the parts running cool while driving higher capacitance loads. The MIC412x family is offered in very low thermal resistance, "exposed" pad SOIC and MSOP packaging, which are pin-compatible with the original MIC442x family of drivers.

MIC412x's robust architecture increases maximum operating voltage to 29V and makes these devices suitable for any environment, no matter how rough. The inputs can withstand negative voltage swings down to 5V below ground. The output drivers are also latch-up protected with a unique device structure that allows the output to withstand high reverse current and voltage typically associated with driving MOSFETs in inductive environments.

www.micrel.com

Miniature Cooling Aggregates

For the dissipation of important quantities of heat produced in a small space, cooling aggregates are very useful as due to the strong air flows significantly more heat per volume unit can be dissipated than in the case of free convection.

Fischer Elektronik have developed small sized cooling aggregates with a cross section of 30x30 or 40x40 mm, in order to meet the demand for small-volume cooling aggregates.

These cooling aggregates of the LAM product line are suitable for installation in cases, in PCBs etc.

The compact design with internal heat exchange structure enables homogeneous heat dissipation. The strong axial fan motor with 12 or 24V DC features a high air throughput at high pressure, so that even longer cooling distances can be bridged.

Threaded drill holes for fitting components or for fastening can be provided on all surfaces.

In addition to the existing standard range of products, modified products and special versions according to customer's specifications are available. Please contact us, we are always available to give you any advice you may require.

www.fischerelektronik.de

Companies in this issue

Company	Page	Company	Page	Company	Page
ABB Lyon	**13**	**Fairchild Semiconductor**	**C2**	**National Semiconductor**	**33**
ABB Switzerland	**C3**	Fairchild Semiconductor	1,14	National Semiconductor	1
ABB Switzerland	1	Freescale	6	Ohmite	1
Advanced Power Technology	**23**	Fisher Elektronik	48	**On Semi - EBV Elektronik**	**30**
Allegro Microsystems	44	Fraunhofer-Institut fur Siliziumtechnologie ISIT	32	On Semiconductor	1
Anagenesis	1	**Hitachi**	**29**	**Power Integrations**	**7**
Analog Devices	1	Infineon Technologies	1,4,20	Power Integrations	1,24
Ansoft	**11**	**International Rectifier**	**C4**	**Productronica**	**47**
Ansoft	1	International Rectifier	1	Sasco	6
APEC	**43**	iSuppli	12	Semikron	1
Artesyn Technologies	1,6	Lambda	6	SPS/IPC Drivers	41
austriamicrosystems	8	**LEM Components**	**3**	SynQor	1
Bergquist	**9**	LEM Components	1	**Texas Instruments**	**15**
CT-Concept Technology	**19**	**Linear Technology**	**5**	Texas Instruments	1,36
CT-Concept Technology	1	Linear Technology	1	Tyco Electronics	1
Danfoss	**39**	Littelfuse	4	Vishay	46
Danfoss	10	Micrel	4,48	XP Power	26
Eupec	**27**	**Macrosemi**	**37**	Zetex	40
Eupec	4				

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