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July/August 2008

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Special Report Automotive Electronics – Part I

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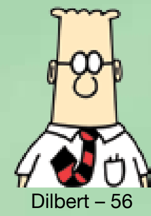

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Volume 5, Issue 6

Eco-Express Engineering

Welcome to the automotive issue of PSDE. In this and the next issue, we shall give our primary focus to the contribution engineers and companies are making to the automotive industry. It seems strange that whenever a crisis hits, whether in industry or environment or even in the running of companies, it is the engineer who normally is 'saddled' with the problem, normally thinly disguised, or dressed up as an opportunity or challenge.

How often have we heard that we are in challenging times, have a great opportunity to improve…it normally turns out to mean a whole range of dependents on committees, task forces, advisory boards etc, discovering a problem for the engineer to address in record time and ultimately to take responsibility for any shortfall. Fortunately, the engineering community is a resourceful group and engineers generally use their very special minds to engulf the problem and to propose a viable solution. Engineering companies also, know how to take a brilliant idea and turn into a viable business proposition.

It is always surprising to me that the pleas to our power community come in so late that it becomes difficult in many cases to give a considered view before being pressed for a well-engineered solution. Green energy, alternative sources, gasoline crisis, pollution, carbon footprints..the list is well known. Just a few minutes listening to any international news channel will hammer home the prime news value in this arena. So much so, that I am now getting news feeds on people making houses out of straw, due to its energy efficient/green properties in an 'eco-village'. Almost seems a shame they need concrete frames to be able to support the solar panels on the roof, not to mention the machinery to turn bio waste into some normally smelly form of energy. Trouble is, it's just the tip of the iceberg.

The auto industry is now well into a period of major change. If we sweep aside the politics of oil-based power, the major thing the oil crisis is fuelling now is change. The need has never been greater and as usual, has set the next tidal wave of 'challenges' to the power industry and to engineering in particular.

Already, there are innovative solutions hitting the streets. The hybrid electric vehicle (HEV) is no more confined to the prototype corner of the motor shows, with the gas-crazed executives of the old school now relegated to the corporate archive only to be replaced by well-rehearsed messages of sincerity on how we can make our highways a greener and cleaner place to queue in the inevitable 'surprising' traffic jam.

The power industry with its creative management, must again come to the rescue and I'm certain will put us back on the right track. Great products from brilliant engineers are now being capitalized as financial investors see this is the way to go. National Semiconductor has taken a grip on this by demonstrating its commitment to energy protection with its PowerWise crusade and recent launch into the photovoltaic industry. Infineon, the No 1 power company in the world, is also making great strides and investment into almost every energy related area one could imagine. Not surprisingly, the company is a major contributor to our automotive feature.

I hope you enjoy the issue. Check out the stories inside and please keep your comments coming.

All the best!

Cliff Keys

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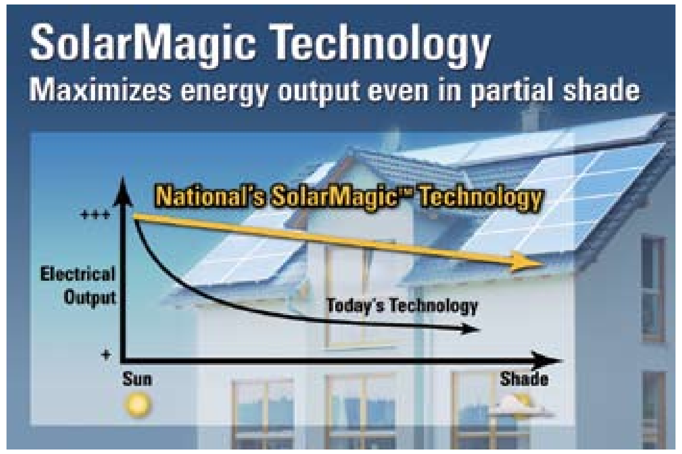
National Enters Photovoltaic Market

New technology maximizes solar energy extraction



Building on its leadership in power management and energy-efficient products, National Semiconductor has announced that it has entered the photovoltaic market with new technology designed to increase the overall energy output of solar electric power generating systems. National's SolarMagic™ technology extracts the maximum power efficiency of each photovoltaic panel, even when some panels in the array are compromised by shading, debris or inherent panel-to-panel mismatch.

Today's solar installations are heavily impacted by non-uniformities, caused by shading, panel mismatches or dirt accumulation. For example, a small amount of shading in the array can cut the energy harvest of a system in half. This significantly limits the energy output, design and location of typical residential solar installations. Shading conditions can even invalidate local utility and governmental incentives, making certain installations cost-prohibitive. National's SolarMagic technology recoups up to 50 percent of this lost energy, minimizing the economic impact these real-world conditions.

"National's entry into the photovoltaic market is a natural extension of our focus on energy efficient systems," said Brian L. Halla, National's chairman and CEO. "Our technologists solved this real-world problem and are enabling consumers to produce more energy under adverse conditions and reduce the payback time of their investment with an environmentally friendly source of power."

SolarMagic technology is a per-panel electronics solution that maximizes power output of multi-panel installations. It is compatible with today's solar architectures regardless of the underlying solar cell technology.

National has entered field trials with its SolarMagic technology. REgrid Power, Inc., one of the largest solar installers in California, has begun system testing of National's new technology.

"We are impressed with National's SolarMagic technology in our field trials and have seen a significant performance improvement in our solar installation," said Tom McCalmont, president and chief executive officer of REgrid Power, Inc. and founder and executive chairman of SolarTech, a Silicon Valley consortium. "We have observed energy output improvements of up to 44 percent during shaded conditions and 12 percent overall versus the same system running without SolarMagic technology."

Several additional solar companies are expected to join the field trials over the next several months, and National will expand these to include installers in other countries with high adoption rates of solar. Later this year, the company plans to introduce SolarMagic products for solar installers and system providers to include in their installations. For more information, please visit

www.national.com/solarmagic

Fairchild Receives Best Supplier Performance Award from Continental Corporation

Fairchild Semiconductor has been awarded 'Best Supplier Performance in Material Cluster Electronics' by Continental Corporation, a top supplier of systems and components to the automotive market.

"Delivering high performance products and services to our customers is our passion," said Mr. Guenter Fella, Senior Vice President of Purchasing, Continental Automotive. "We selected the Fairchild team as the recipient of this award because they share our vision and have provided leadership in power management technologies and products. They have demonstrated their commitment to the automotive segment through their focused management and strong top-management involvement to support Continental's strategy. We recognize key suppliers that support our high standards in product development, delivery and quality."

"We are honored to receive Continental's award as a Best Supplier Performance and will continue to work relentlessly to exceed our customers' expectation," said Ole-Petter Brusdal, Fairchild's Regional Vice President for Europe Sales and Marketing. "This award validates our focus to develop and deliver the right high quality products, on time to our customers."

Fairchild provides advanced process and packaging technologies, integrated power analog, power discrete and optoelectronic functionality with innovative packaging to develop energy efficient solutions for the automotive electronics market. The company offers the industry's most comprehensive portfolio of products to maximize energy efficiency in automotive electronic applications.

www.fairchildsemi.com

APEC Calls for Participation for February 2009 Conference

APEC 2009 February 15-19, 2009 Washington, DC

The IEEE Applied Power Electronics Conference (APEC), the leading worldwide conference and exhibit for practicing power electronics professionals, is soliciting papers and presentations for its 24th annual event to be held at the Marriott Wardman Park Hotel in Washington, DC, February 15-19, 2009.

As the world places a growing importance on energy efficiency, power electronics remains an enabling and important topic. With this in mind, the APEC conference committee issues its combined call for papers and participation.

Deadline for submission of paper digests is July 19, 2008. In addition, APEC invites participation in technical seminars, special presentations or serving as a reviewer of submitted papers. Additionally, industry practitioners are sought to teach a session as part of the conference's popular Professional Educational Seminars.

According to Kevin Parmenter, APEC 2009 General Chairman, "The hallmark of the APEC conference continues to be presentations of new and unique peer-reviewed technical papers covering all aspects of power electronics, combined with plenary sessions with viewpoints of critical issues in our industry."

Abstracts will be peer reviewed by an expert committee, and presenters will be informed of paper acceptance on October 3. All accepted abstracts, papers and presentations will be published in the conference CD and Web Proceedings following the conference.

Industry practitioners are invited to share their ideas, experience, strategies or technologies in power electronics by presenting a paper or by teaching a course in the Professional Education Seminars. Companies exhibiting at APEC can present an exhibitor seminar. They are also encouraged to submit a paper for the technical program and Special Presentation Sessions and sign up to review submitted papers.

www.apec-conf.org

New Sales Director for Cissoid

Cissoid, a leader in high temperature semiconductor solutions and pioneer of Silicon-on-Insulator (SOI) products, confirmed today the appointment of Thomas Krebs as Sales Director. With 20 years experience in the semiconductor arena, Krebs brings to Cissoid, the leadership the company needs to build up its sales organization and to extend its sales channels. Thomas has a wealth of experience in direct sales as well as distribution.

"The recruitment of a seasoned Sales leader is crucial to the execution of our aggressive growth plans," said Tony Denayer, CEO at Cissoid. "We are very excited to have Thomas on board. With his track record in standard products and custom solutions with leading companies such as Texas Instruments, Maxim and AMI Semiconductor and his experience in diverse markets, Thomas is an asset for our plans to penetrate new market segments."

Krebs holds a Diploma Degree in Electrical Engineering with Specials on Technical Information Technology from University of Luebeck, Germany.

www.cissoid.com

Chomerics Appoints Technical Sales Manager in Eastern Europe

Chomerics Europe has appointed Julien Millerioux to the position of Technical Sales Manager for Eastern Europe.

Julien brings significant expertise of the market to his new role having spent over seven years working for a well-known French company specialising in shielding materials. He is a graduate in mechanical engineering and also has considerable sales engineering experience.

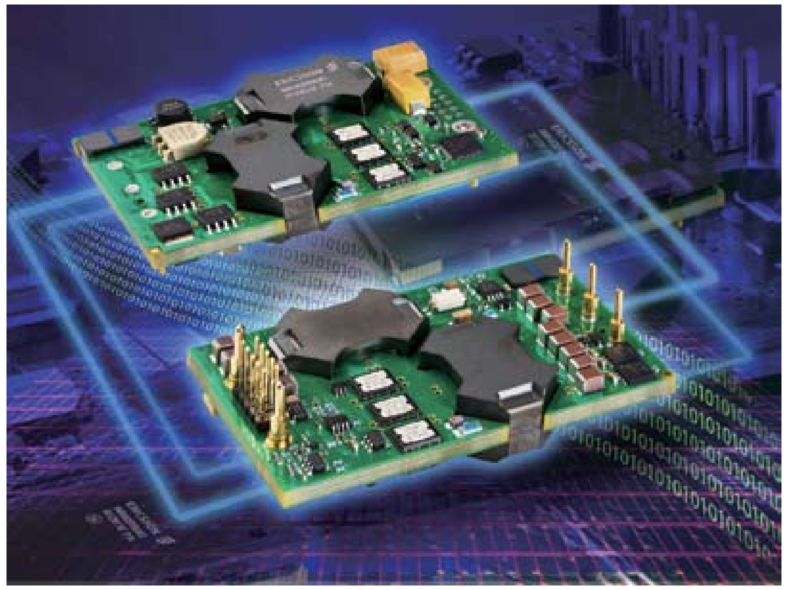
From his base in the Czech Republic, 31 year-old Julien will be responsible for managing and developing Chomerics' shielding and thermal management business with CEMs and OEMs in the key Eastern European markets such as Poland, Hungary, Romania and the Czech Republic.

www.parker.com/chomerics

Power Events

- ***European Fuel Cell Forum 2008,***
  June 30-July 4, Lucerne, Switzerland,
  www.efcf.com/exhibition/
- ***EPE-PEMC 2008,***
  September 1-3, Poznań, Poland,
  www.epe-pemc2008.put.poznan.pl
- ***23rd European Photovoltaic Solar Energy Conference,***
  September 1-5, Valencia,Spain,
  www.photovoltaic-conference.com
- ***electronicIndia 2008,***
  September 2-5, Bangalore, India,
  www.electronicindia.net
- ***Husum WindEnergy,***
  September 9-13, Husum, Germany,
  www.husumwind.com
- ***electronicAsia 2008,***
  October 13-16, Hong Kong, China,
  www.electronicasia.net
- ***electronica 2008,***
  November 11-14, Munich, Germany,
  www.electronica.de
- ***SPS/IPC/Drives 2008,***
  November 25-27, Nürnberg, Germany,
  www.mesago.de/en/SPS/main.htm

Digital DC/DC Converter Provides Highest Control and Power Density



Ericsson's BMR453 series of DC/DC converters uses a digital control platform contained within the modules themselves. By integrating more into the control circuitry, the concept frees up real estate for greatly improving the power density, simultaneously offered unprecedented levels of control.

With 96% efficiency, the BMR453 offers up to 400W output power or up to 33A with ±2% accuracy and has an input voltage range of 36V to 75V with output voltage variable from 8.5V to 13.5V.

Application areas are systems using a telecom input voltage with battery backup or both -48V and -60V nominal input voltages. Inherent load regulation allows the device to be used as an Intermediate Bus Controller (IBC) in systems where the intermediate bus voltage directly powers devices such as hard drives that cannot tolerate the wide variation in bus voltage provided by a normal IBC.

The converters meet the insulation requirements of EN60950 and come complete with vital industry standard features. The product also offers an extensive set of capabilities and features such as, remote sense, configurable protections (over-temperature, over current and over-voltage), switching frequency synchronization, PMBus interface, power good, extensive power management programmability.

BMR453 modules also feature a PMBus interface for system connection, opening up a whole new world of control features. The digital control system provides users with access to control, configure and monitor the device itself. This is a huge step forward for customers as this level of control has never been available before, and these new capabilities allow for much more intelligent energy management that helps to reduce energy consumption.

A synchronization facility enables multiple modules to operate at exactly the same frequency to facilitate optimum filter design for quiet running – RF or conducted. A 'power good' pin operates between active low and active high and is a useful feature for event-based programming, for example sequenced start-ups.

For current sharing duties, modules can be operated in parallel without the need for external balancing circuitry. Dedicated pins are simply tied together and current sharing is automatic. A voltage track pin can follow an external device and is used for event-based programming.

BMR453's micro-controller sweeps up a large quantity of discrete control and overhead components resulting in better integration, lower component count, less PCB area, and improved reliability. This is reflected in the higher power density achieved by this converter. The designer gains in virtually all areas; increased power density, greater accuracy, a much higher level of control and integration within a system, and reduced through life cost of ownership as a result of its high efficiency and intelligent use of energy management.

An evaluation kit is available to help designers evaluate and program the modules. It comprises evaluation board, operating manual, CD containing Graphic User Interface (GUI) and cables.

This is the first quarter brick DC/DC converter that can handle digital management and it is now possible to 'see' inside the module when using a GUI and to track what is happening in the converter.

www.ericsson.com/powermodules

Powering Small AMOLED Displays

By Matthew Borne, Marketing manager, Texas Instruments

To meet consumer demands for lighter, thinner, better performing portable media players and smart phones that cost less and last longer on a single charge, portable consumer product manufacturers continue to innovate and differentiate their goods. Being one of these consumers, I'm encouraged to see advancements in display technologies using organic light emitting diodes (OLED). The need for LED lighting is also a strong consideration for front headlights in automotive markets for similar reasons as the consumer segment. There is already a strong LED content in vehicle interior lighting and external rear lighting resulting in thinner module profiles and long term reliability

There are two types of OLED screens: passive matrix (PMOLED) and active matrix (AMOLED). PMOLED displays are less expensive and easier to manufacture. However, resolution and refresh rate are limited. Most of today's OLED displays are passive-matrix, but active matrix displays are growing at a much faster rate. Attributes such as high color saturation, thin form factor, high-contrast ratio, fast response time and low power consumption are driving the switch.

A PMOLED requires only a positive voltage to provide the overhead of the row and column drivers, VOH_r and VOH_c. Many boost converters can provide the boosted voltage for a PMOLED display, but an AMOLED display has a fast-switching TFT matrix to control the OLED. Thus, both positive and negative voltages are required to drive OLEDs in an AMOLED display.

The AMOLED requires less current and lower voltage. In fact, nearly an order of magnitude less power is needed

for a comparably sized PMOLED display. (Think microwatts versus milliwatts per column.) Previously, a designer searched IC manufacturer's websites to find a device to power their OLED display, but only a few devices were appropriate. These were primarily listed as "suitable for powering OLED". To power AMOLED, an appropriate ICs is needed so that power level is correct and external circuitry to provide negative and positive voltages is minimized

Advancing AMOLED displays requires a new generation of power ICs. Some ICs solve the need for positive and negative voltage by controlling two separate power loops using two inductors. A single inductor multiple output converter can be used to achieve a smaller solution size as well as lower component count and design cost. With load currents relatively closely matched between the positive and negative voltages, both sides of the inductor can be used to deliver two regulated rails.

A single inductor multiple output converter as used in the TPS65136 from Texas Instruments helps provide high picture quality for AMOLED displays. With just one 2.2uH inductor, it operates in a buck-boost topology to generate a positive and negative output voltage. This technology also enables excellent line and load regulation to avoid display disturbances occurring during transmit periods in mobile phones.

To maintain high efficiency over the entire load current range, a converter lowers the switching frequency as the load current decreases. When the frequency drops too low, a converter can cause audible noise from the vibration of the ceramic output capacitors. The TPS65136 avoids this by maintaining the switching frequency above the audible range with a voltage-controlled oscillator (VCO). This is especially important when using devices with small AMOLED displays such as mobile phones and portable media players.

Today, AMOLED panel and systems integrators are moving to second and third generation products. Mobile phones and portable media players will drive volume production for economies of scale, benefiting other equipment as well. With these advancements, the power IC evolution and selection plays a key role in the display's operation and innovation.

www.ti.com

Hybrids Growing but Still Have a Long Way to Go

Gas-electric vehicle shipments to surpass 4 million units by 2013

By Marijana Vukicevic, iSuppli Corp.

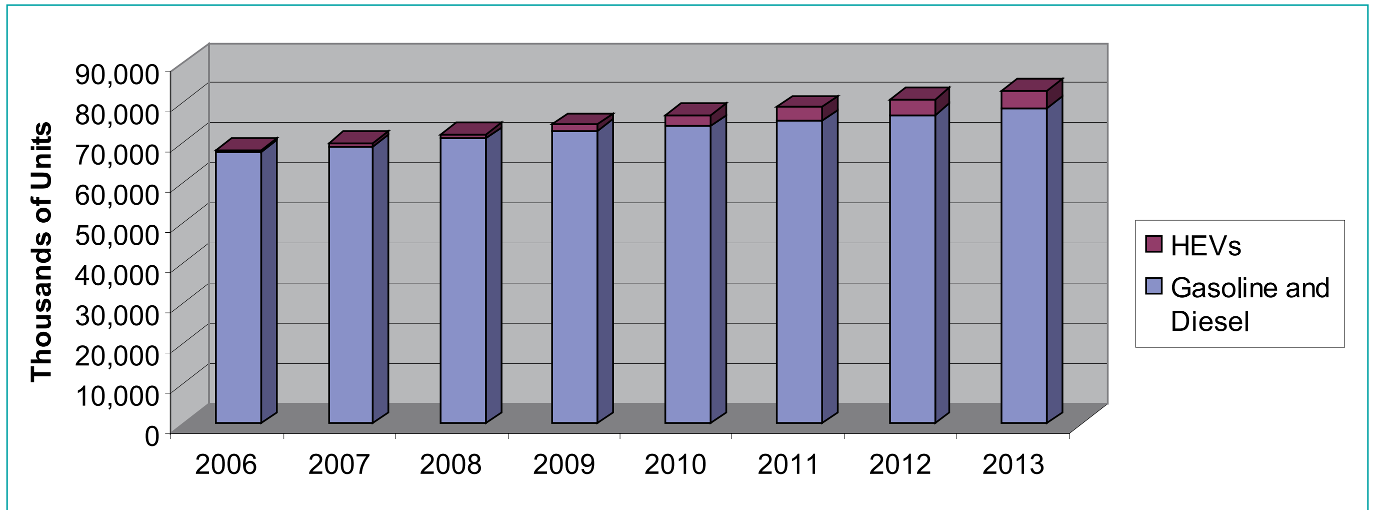
It is no secret that gasoline prices likely will not be coming down any time soon—if ever. Add to this the concerns over global warming, oil independence issues and the desire for vehicles to achieve better mileage per gallon of gasoline.

For the automotive industry, its long-term expansion and sustainability may hinge upon the development and proliferation of Hybrid Electric Vehicles (HEVs) and other environmentally oriented cars, iSuppli Corp. believes.

Because of this, it also is not a secret that the unit shipments for HEVs have been increasing steadily year-on-year as they offer excellent environmental protection as well as improved gas mileage to consumers looking for an alternative in a world filled with $4.00 per gallon gas. However, these unit volumes are far less than the average person might expect, or are forecast to grow, given the current climate.

Annual HEV shipments will grow to 4.4 million units by 2013, rising at a Compound Annual Growth Rate (CAGR) of 36.7 percent from just 494,000 units in 2006, according to Akira Minamikawa, vice president of iSuppli Japan Research and author of the new report, Hybrid Electric Vehicles: Here Today, Better Tomorrow.

While this growth may seem impressive, when compared with the combination of gasoline and diesel vehicles, it is just a blip on the radar. Gasoline and diesel car shipments are set to grow to 78.8 million units by 2013, rising at a CAGR of 2.2 percent from 67.8 million units in 2006.



iSuppli's forecast for HEV and gasoline/diesel vehicles; 2006 through 2013.

Prius rising

Since 2004, the HEV market has expanded rapidly, led by Toyota's popular Prius. In 2004, Honda and Ford rolled out their own hybrid vehicles to compete, but they were marketed only during the latter half of that year, giving Toyota a near six-month lead in the HEV market.

There are two reasons that Prius sales volumes have grown substantially. First, there is the soaring cost of crude oil, especially in the United States where prices for gasoline have nearly doubled in four years. Second is the impact of new vehicles, which encouraged buyers to adopt the next big thing.

Prius' stellar rise was also aided by Toyota's model makeover wherein it developed an automotive electric system called THS-II that succeeded in boosting power to the vehicle without sacrificing any of the mileage for which the car had become famous.

Perhaps the biggest question among consumers these days is how to reduce oil dependency. Automobile manufacturers have positioned fuel-cell cars as the ultimate environment and oil saver and have invested considerable developmental resources over the years. However, at least for the foreseeable future, automakers do not intend to turn fuel-cell cars into full-scale, mass-market vehicles.

The reasons for this are:
- No prospects of cost reduction
- HEVs offer environmental and oil reduction
- The hydrogen infrastructure is still in its infancy.

Given the steep rise in crude oil prices, this attitude might change, but HEV now seems to be the winner mostly because manufacturers see fuel cells as another developmental investment cost that in the current climate they are not able to afford. In addition, while electric vehicles have been discussed many times in the media and otherwise, such vehicles will also not be mass-marketed by any car company in the foreseeable future.

www.isuppli.com

Power Supply Control Design Tools – Part 4

Boost converter with current-mode control

In this article, Dr. Ridley presents a summary of current-mode control for the boost converter. A free piece of analysis software, the fourth in a series of six, is provided to readers of this column to aid with the analysis of their current-mode boost converters.

By Dr. Ray Ridley, Ridley Engineering

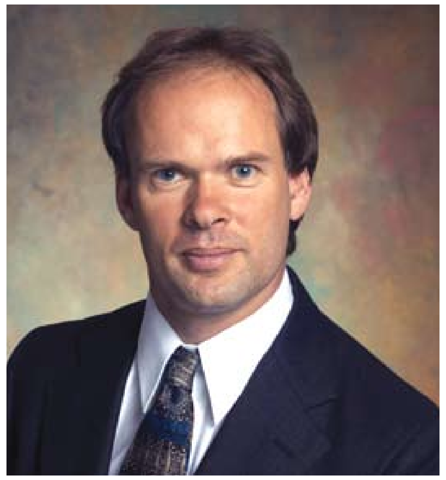
Modeling Power Supplies with Current-Mode Control

In the last article, the complications of modeling power circuits were discussed in some detail for a boost converter with voltage-mode control. The boost converter was shown to have the complication of a right-half-plane zero which makes control with voltage-mode very difficult in some cases.

The problem is made much easier with current-mode control. This is always the preferred approach for the boost converter, implemented as shown in Figure 1.

As with the buck converter, a whole new world of mathematical complexity arises when current-mode control is used for a power supply. The full analysis of current-mode control is completed, and you can download the complete book on the topic from www.ridleyengineering.com.

The dynamic analysis of current mode involves advanced techniques, including discrete-time and sampled-data modeling. This is essential to arrive at a model which explains all of the phenomena seen with your converter, and which accurately predicts the measured control-



to-output response and loop gain of the current-mode converter.

There are several important points to learn from the full analysis of the current-mode boost converter:

1. The power stage has a dominant-pole response at low frequencies, determined mainly by the time constant of the output capacitor and load resistor values.

2. The power stage has an additional pair of complex poles at half the switching frequency which, under certain conditions, will create instability in the current feedback loop. The damping of these complex poles is controlled by the addition of a compensating ramp.

3. The resulting transfer function of the power stage is third-order, even though there are only two state variables in the converter. (This apparent anomaly, for control theorists, is caused by the fact that the switching power converter is a nonlinear, time-varying system.)

4. The second-order double poles at half the switching frequency cannot be ignored, even though they may be well beyond the predicted loop crossover frequency.

5. The capacitor ESR zero is unchanged by the presence of the current loop feedback.

6. Finally, and most importantly, the current-mode boost converter retains the exact same RHP zero as the voltage-mode converter. However, since the current feedback has eliminated the double poles of the filter resonance, it is not difficult to control this RHP zero effectively.

As explained in reference[1], current-mode control has many advantages. These include elimination of the reso-

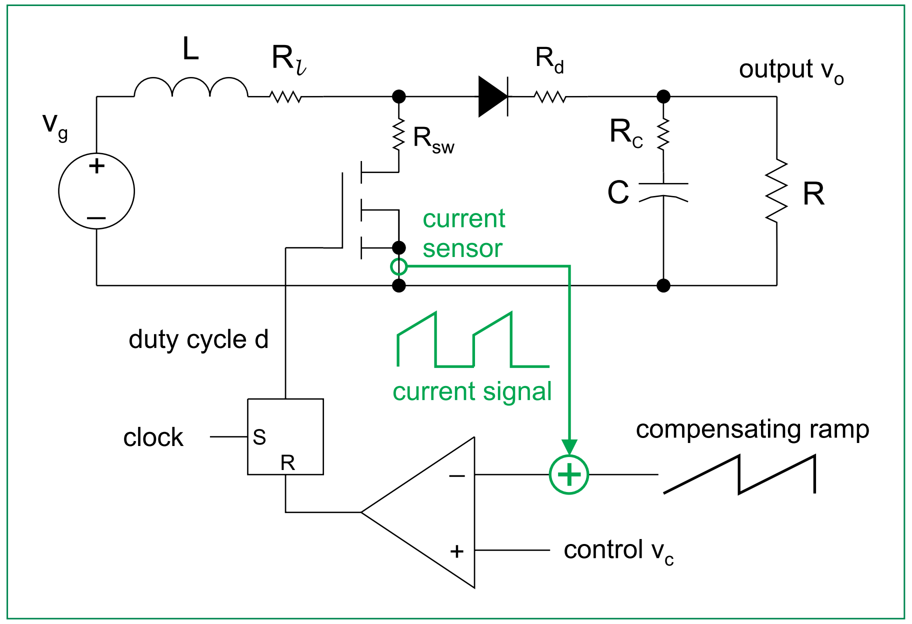


Figure 1: Boost converter with current-mode control. The green components show the current feedback; without these, the control is voltage-mode.

nant filter frequency, the ability to current share with multiple power stages, simplified compensation design, and inherent peak current limiting. The control is also optimum when operating in either continuous- or discontinuous-conduction mode, and there is no problem in operating the converter in both of these regions.

Designing with Current-Mode Control

While the analysis of current-mode control is quite complex to understand, the design process is quite simple. Much simpler, in fact, than voltage-mode control, and this is one of the reasons that current-mode control is so popular today.

Figure 1 shows the current-mode feedback system. The inductor current, or switch current, is sensed and compared to a voltage reference to set the duty cycle of the converter. A sawtooth ramp is added to the signal to stabilize the current loop if duty cycles approaching 50% are used.

Closing the current loop is straightforward. A current transformer, or sense resistor, is used to generate a voltage signal proportional to the actual current in the switch. The only requirement on the design of this network is that the resulting signal should not exceed the voltage headroom available in the PWM comparator. You do not have to think about the gain of the current loop, or resulting transfer functions at all during this phase of the design.

It is an interesting feature of the current loop that, regardless of how large you make the gain of the current sensing network, the current loop gain remains constant. This is because the PWM modulator gain, which is part of the current loop, is determined by the reciprocal of the slope of the sensed current. The higher the current gain, the lower the gain of the modulator. The two effects exactly cancel each other.

Once the current sense network is selected, you must decide whether you need to add a compensating ramp to the system. This is usually done for converters which will operate at duty cycles above 40%. Further details are given in [1]. Addition of the compensating ramp provides independent control of the PWM modulator gain. This stabilizes the tendency of the current feedback to oscillate at duty cycles approaching 50%.

Boost Converter Current-Mode Software

Software is available for download that allows you to predict the small-signal response of your boost converter with current-mode control. After entering your power stage values and switching frequency, you can design the current loop parameters of current gain, and compensating ramp value. The software will help you choose the proper values. Once this is done, the transfer function gain and phase of the power stage is plotted for you, and the resulting poles and zeros given.

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

Summary

If you work with a boost converter, it is advisable to use current-mode control. While the analysis is complex, the software tool made available with this article will help you design the current loop properly and show the transfer functions of the converter. Remember, however, the results of any power supply transfer functions should always be verified by measurement. Power systems are frequently dependent on circuit component parasitics that can be unpredictable, and can also be impacted by noise and improper board layout. Experimental verification[2] is an essential step for a rugged design, and should never be omitted.

References

1. *“A New Small-signal Model for Current-Mode Control”, Raymond B. Ridley, 1990 PhD dissertation, free download is available at www.ridleyengineering.com/cmode.htm*

2. *“Measuring Frequency Response, Tips and Methods” http://www.ridleyengineering.com/downloads/Spring 2002 feature.pdf*

www.ridleyengineering.com

On the Road

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

Analog Devices New Automotive iCoupler®

At its press conference recently in Munich, Germany ADI launched its breakthrough Automotive iCoupler products, a major breakthrough for the Automotive industry. Analog Devices is committed to help automotive design engineers maximize safety, comfort, and convenience for drivers. ADI’s Michael Mueller-Aulmann, Applications Engineer took us through Analog’s new offerings.

Digital isolators qualified to meet stringent requirements for electric-hybrid vehicles

ADI’s iCoupler® digital isolation technology is designed to meet the reliability and quality needs of emerging electric-hybrid vehicles and the company introduced a family of digital isolators qualified to operate in the electrically challenging automotive environment. Unlike the relatively low-voltage signals powering most in-car entertainment, safety, and power train systems, hybrid-vehicle batteries can operate at voltages in excess of 600V, which creates the need to galvanically isolate system-critical electronics. Analog Devices’ new ADuM120xW, ADuM130xW and ADuM140xW digital isolators were developed for electric-hybrid vehicle systems, such as motor drives and battery management systems. These new products are the first digital isolators to carry an AEC-Q100 qualified –40°C to +125°C automotive temperature rating.

Michael explained, “Until today, the only isolation available for hybrid car and truck batteries was in the form of optocouplers, which are notorious for

being difficult to manage and operate at temperatures over 105°C. In an application where fuel economy and battery capacity are everything, ADI’s digital isolators not only remove the limitations of optocouplers, they do so at 90 percent less power consumption.”

About the ADuM1xxxW Digital Isolators

The two-channel ADuM120xW, three-channel ADuM130xW and four-channel ADuM140xW digital isolators are based on Analog Devices’ proprietary iCoupler chip-scale micro-transformer technology that has been used in more than 150 million channels of isolation shipped into a wide array of applications including industrial, medical, power supply, and consumer systems. These new automotive products provide multiple isolation channels in a variety of channel configurations and data rates up to 25Mbps. The CMOS-based parts operate with the supply voltage on either side ranging from 3.0V to 5.5V, providing compatibility with lower voltage systems as well as enabling voltage translation across the isolation barrier.

Unlike alternative isolation technologies such as optocouplers, which suffer from performance degradation and wear-out at high temperatures, iCoupler digital isolators are relatively insensitive to temperature and demonstrate excellent

Four-Day

Power Supply Design Workshop

Bordeaux, France at the Burdigala Hotel • September 29 - October 2

Learn first-hand from Dr. Ray Ridley, a leading power electronics industry consultant and researcher. During his 28 years in the industry, he has taught advanced design to thousands of engineers worldwide. The world's leading engineering companies in aerospace, semiconductors and commercial applications send their engineers to the Workshop to take their designs to the next level.

The Workshop focuses on theoretical and practical concepts with hands-on experience. Learn to design, build and measure switching power supplies in our state-of-the-art travelling laboratory.

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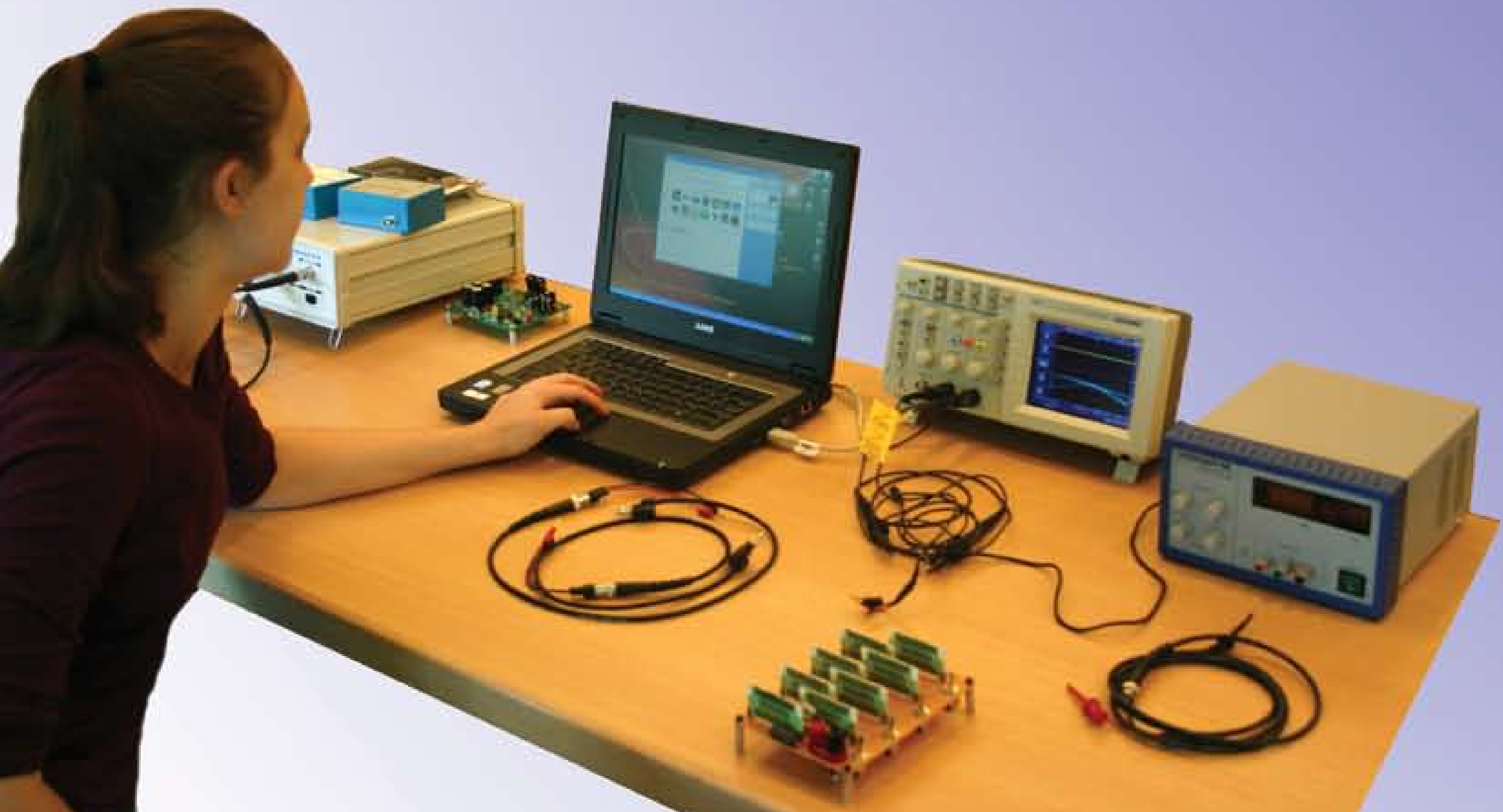
Download a registration form at www.ridleyengineering.com



Agenda

Monday

Morning Lecture 8:30 - 12:00
- Power Stage Topologies
- Inductor Design
- Saturation
- Core Loss
- Proximity Loss
- Practical Design Procedures

Afternoon Laboratory 13:00 - 17:00
- Design of Flyback Inductor/Transformer
- Construction, Winding, Gapping Transformer
- Impedance and Leakage Measurement
- In-Circuit Testing
- Snubber Design
- Full Power Testing
- Efficiency Measurements

Tuesday

Morning Lecture 8:30 - 12:00
- Transformer Design
- Saturation
- Leakage Inductance
- Planar Magnetics
- Proximity Loss
- Multiple Output Cross-Regulation
- Winding Capacitance
- Practical Design Procedures
- Gate Drive and Current-Sense Transformers

Afternoon Laboratory 13:00 - 17:00
- Design of Forward Inductor
- Design of Forward Transformer
- Construction, Winding, Gapping Forward Mag.
- Impedance and Leakage Measurement
- In-Circuit Testing
- Snubber Design
- Full Power Testing and Efficiency Measurements

Wednesday

Morning Lecture 8:30 - 12:00
- Simulation of Power Supplies
- Small-Signal Analysis for Voltage-Mode Control
- PWM Switch Model
- CCM and DCM Operation
- Right-Half-Plane Zeros
- Loop Gain Criteria
- Compensation Design

Afternoon Laboratory 13:00 - 17:00
- Measurement of Forward Control Characteristics
- Output Impedance Measurement
- Control Loop Compensation
- Loop Gain Measurement
- Stability Optimization
- Step-Load Response Measurement

Thursday

Morning Lecture 8:00 - 11:00
- Current-Mode Control
- Current-Mode Circuit Implementation
- Current-Mode Problems
- Current-Mode Advantages
- Small-signal Analysis of Current-Mode Control
- Subharmonic Oscillation
- Current-Mode Feedback Design

Afternoon Laboratory 12:00 - 15:30
- Measurement of Flyback with Current-Mode
- Compensating Ramp Addition
- Control Loop Compensation
- Loop Gain Measurement
- Stability Optimization
- Second-Stage Filter Design

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long-term reliability. Because iCoupler products have a digital interface, there is no need for external signal conditioning components, and they consume one-tenth to one-sixth the power of optocouplers at comparable signal data rates.

New 4-channel iCoupler® deliver 500 mW isolated power

ADI is expanding its extensive family of digital isolation products with a series of four-channel devices that isolate both data and power. Each device integrates the company's iCoupler digital isolation technology and its proprietary isoPower™ dc-to-dc converter, providing both isolated power and isolated signal channels within a single package. The ADuM540x iCoupler digital isolators with isoPower are a better choice over discrete solutions, such as optocouplers with external dc-to-dc converters, because their small 10mm x 10mm surface mount packages can reduce board space by up to 70 percent and cut costs by as much as 50 percent. In addition, the ADuM540x devices come with safety pre-approvals, allowing designers to realize faster design times as compared to discrete-based solutions, which require time-consuming safety approvals that can delay time-to-market.

Michael continued, "Delivering 500 mW of isolated power in a small, surface mount package, the ADuM540x products enable customers to put more channels of isolation into space-constrained designs at reduced cost. For example, industrial control designers can now increase the number of isolated data ports in a single control module without increasing its size, even though each port requires its own isolated power supply. With alternate solutions, such as optocouplers and separate, isolated dc-to-dc converters, the control module would need to increase in size and would not be backward compatible with installed industrial control systems."

The on-board isoPower isolated dc-to-dc converter provides up to 500 mW of regulated, isolated power and can operate at either 5.0-V or 3.3-V. A version with two channels (ADuM520x) and a version that features only the isoPower isolated power supply (ADuM5000) will be released later this year.

iCoupler® Technology

With more than 150 million channels deployed throughout the industry, ADI's proven iCoupler technology is based on chipscale transformers, rather than on the LEDs and photodiodes found in optocouplers. Transformers can support higher data rates and lower power consumption, and are more stable over life as compared to LEDs and photodiodes. By fabricating the transformers directly on-chip using wafer-level processing, iCoupler channels can be integrated with each other and other semiconductor functions at low cost. iCoupler transformers are planar structures formed from CMOS and gold metal layers. A high breakdown polyimide layer underneath the gold layer insulates the top transformer coil from the bottom. CMOS circuits connected to the top coil and bottom coil provide the interface between each transformer and its external signals. For more on ADI's iCoupler digital isolation technology, please visit: www.analog.com/isopower.

isoPower™ DC-to-DC Converter

iCoupler digital isolators condition and drive data across transformers. ADI's isoPower dc-to-dc converter uses the same chipscale transformer technology, but instead of transmitting data, isoPower employs switches, rectifiers, and regulators to generate power that is isolated to the same degree as the data channels. For more on ADI's technique for isolating power, please visit: www.analog.com/isopower.

The on-board isoPower isolated dc-to-dc converter provides up to 500mW of regulated, isolated power and can operate at either 5.0-V or 3.3-V. A version with two channels (ADuM520x) and a version that features only the isoPower isolated power supply (ADuM5000) will be released later this year.

www.analog.com

Solar Inverter Market Starts to Shine

Set for continued strong growth

As part of PSDE's commitment to the pursuit and reporting of new developments and trends in the power industry relating to green energy and renewables, I cover the breadth of the power electronics industry. Over the past year or so, Ash Sharma, Research Director, Power & Energy Research Group, IMS Research has periodically shared his own valuable insight with us. Here follow some of Ash's observations and predictions.

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

With the price of crude oil continuing to soar and increasing attention being paid to energy efficiency and 'green power', it's hardly surprising that more and more press coverage is being given to solar power every day. Most of this coverage however, is dominated by articles about solar cell and solar module manufacturers or another new start-up looking to take a slice of the growing thin-film PV market. One of the key components within every solar installation that is often overlooked and rarely talked about is the inverter.

Although solar modules account for the lion's share of the cost of a solar installation, the PV inverter can account for around 10% of the overall installation cost and as the main connection between the PV source and the grid (or the load) its importance cannot be ignored.

IMS Research estimates that annual photovoltaic installations totalled around 2.2GW last year, having grown by more than 40% over the previous year. By 2012, IMS Research forecasts that this figure will be close to 7GW, meaning nearly 25GW of photovoltaic installations over the next five years. This may sound impressive; however, it still represents just a tiny fraction of global electricity consumption and is likely to remain this way for decades to come.

The photovoltaic market is quite unique in the sense that it is not driven by either the products or by the end-user wanting a solution. The high market growth has been driven by (and will continue to be driven by) government policy and by introducing high feed-in tariffs that have made PV attractive enough to both householders and investors.

The way that each country has introduced these incentives and hence the subsequent dynamics of each market varies considerably. Japan was at one time the largest and most developed market for PV, driven by the introduction of generous incentives in the 1990s. This led to tremendous growth of PV within Japan, and helped to drive down installation costs considerably. However, now that incentives have ceased, the Japanese market has stalled and

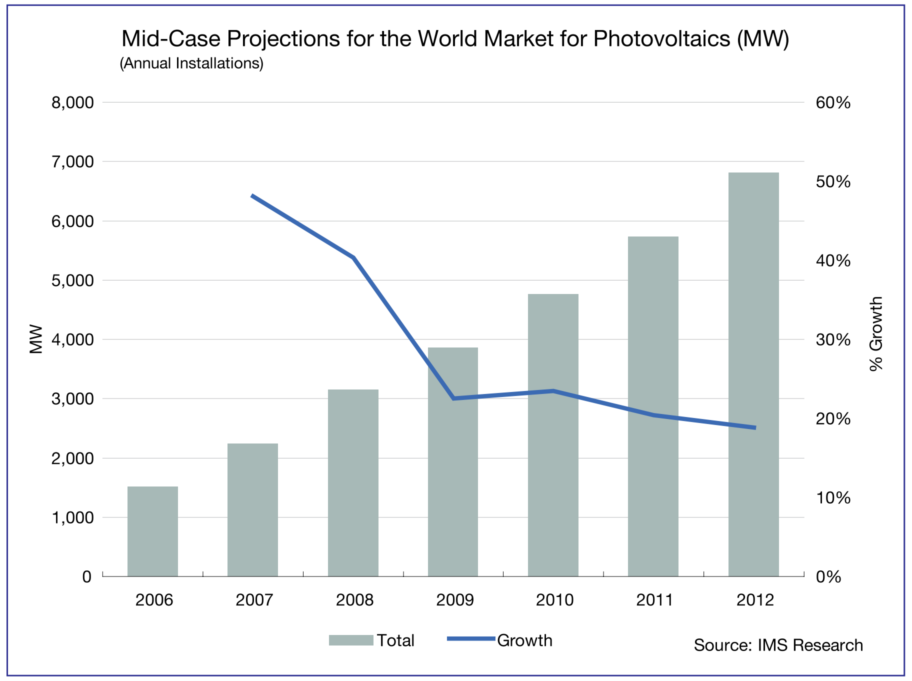


Figure 1: Annual installation growth for photovoltaic systems is projected to remain strong over the next 5 years.

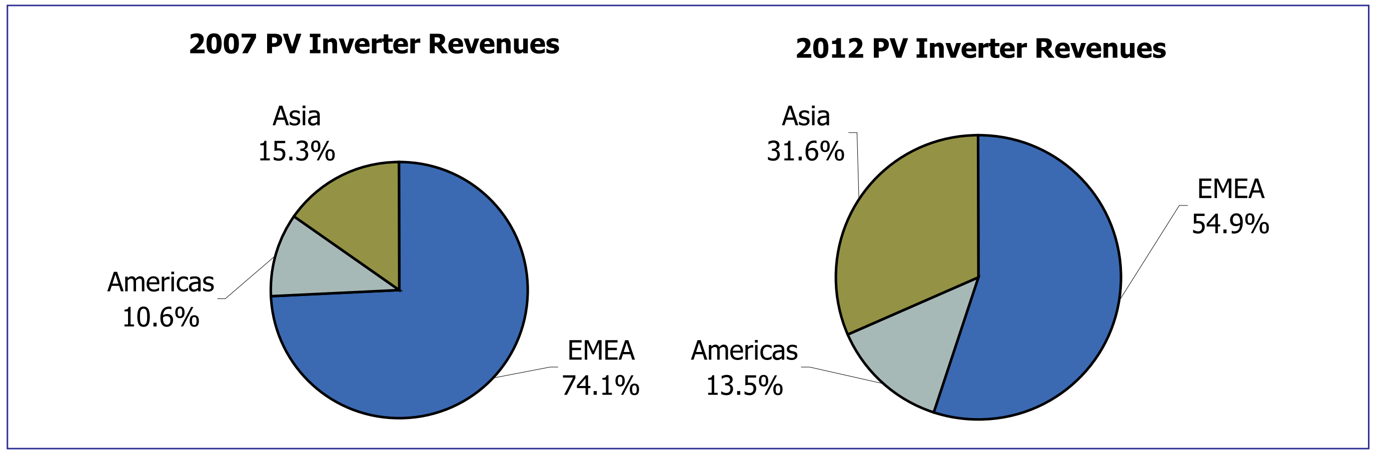


Figure 2: EMEA currently holds the largest portion of the PV inverter market, however new markets in Asia will capture significant share.

in fact contracted last year. In contrast, Germany is now by far the largest market for PV due to very generous feed-in tariffs which are shortly to be cut. However, this will be done at a rate that will still encourage market growth, albeit at a lower rate.

Other countries, such as Spain have had a much more aggressive approach to PV in terms of government policy and coupled with its high insolation rates, this has led to an explosion in the market. However, it is questionable who this rapid expansion has benefited in Spain as the biggest winners have been foreign investors. Tariff revisions are due in September which are reported likely to benefit smaller systems and could help drive the residential market.

The PV policy implemented by each country's government (or each State in the US) largely determines how the market for PV inverters will develop. For example, Spain's policy has favoured large solar parks and hence has driven the central inverter market. In contrast, Germany's policy has so far favoured residential systems and hence has driven the <5kW string inverter market.

The feed-in tariff also ultimately decides the PV installation cost. For example, the tariff in Germany has reduced by 5% each year and hence system installers expect to receive a 5% drop in the inverter (and other components) price. Some inverter manufacturers have tried to escape this by offering larger inverters whilst maintaining prices. These attempts, coupled with the fact that on average installation sizes are getting larger, will actually lead to increases in the average selling price of the inverter.

According to IMS Research's latest report on the global PV inverter market, last year the PV inverter market was worth in excess of $1.2 billion and is expected to generate almost $12 billion in revenues over the next five years. EMEA still accounts for the largest part of the market, largely due to the success in Germany and now in Spain. In future, IMS Research predicts strong growth in the US; however, this is largely dependent upon a federal program for PV being introduced, although individual states such as California have shown that PV can be financially viable without a nationwide program.

There are many different types of PV inverter and whilst, to some extent, these compete with each other, there is not likely to be a clear 'winner' in the near future. Again demand for each type is largely dependent upon the feed-in policy implemented and thus varies considerably between countries. Other factors also need to be considered when assessing demand for string inverters or central inverters. For example, central inverters typically provide a much lower initial installation cost, and thus tend to be favoured for large private investments.

In most countries, there is a clear trend towards transformerless inverters – even for large central inverters. Whilst some countries do not permit this, and installers can face strong resistance from utilities, transformerless inverters offer clear benefits such as higher peak efficiencies, lower weight and also a lower cost. One factor likely to reduce or even reverse this trend is the growing shipments of thin-film PV modules. Thin-film modules are an alternative to standard crystalline modules and usually require galvanic isolation to prevent damage to the modules. As thin-film is expect to hold a 20% share of the solar market within five years, this will have significant implications on the type of inverter used.

IMS Research projects that the PV inverter market will continue to grow strongly over the next five to ten years and also expects the supplier base to consolidate significantly, particularly as existing markets saturate and new markets emerge.

To obtain details of the latest and most detailed study on the global photovoltaic market, please contract IMS Research.

www.imsresearch.com

Silicon Labs Launches Highest Integration Isolated Gate Driver

I had the pleasure of a discussion with Phil Callahan, High Voltage Solutions Marketing Manager for Silicon Labs, based in Austin, Texas and leaders in high-performance, analog-intensive, mixed-signal ICs. He explained to me the leadership position the company enjoys in this steadily growing market and the great new products coming out of this silicon powerhouse. The new product just launched is called ISOdriver, which integrates an isolator and 4 Amp Driver into a Single Chip.

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

Ideal for power supplies, motor control and lighting systems, the ISOdriver family integrates a two-channel isolator and dual driver into a single chip while improving power efficiency, enabling designers to increase power supply density and performance.

Figure 1: Si823x ISOdriver family is industry's fastest and most integrated isolated gate drivers.

Based on Silicon Laboratories' proprietary RF isolator technology and advanced CMOS gate driver design, the ISOdriver family offers higher reliability, increased noise immunity and requiring less than half the PCB area compared to competing approaches. Traditionally, power system designers rely on expensive, complex multi-die optocouplers that use exotic process technologies and require a discrete bill-of-materials - including an external FET driver. By integrating the isolator and driver into a single chip, the ISOdriver external BOM is reduced to only three capacitors and a diode, allowing an isolated high-side/ low-side or dual low-side driver solution that occupies only 200mm^2.

The Si823x ISOdriver family also offers a number of performance improvements over optocoupler-based solutions. As the only isolated, high-side, low-side, 4Amp driver available, the ISOdriver family delivers significant improvements in MOSFET turn-on and turn-off times. Less power is wasted during a FET switching cycle, enabling higher efficiency supplies.

Integrated overlap protection also improves efficiency by preventing high-side and low-side MOSFETs from being on at the same time. Compared to typical opto-isolator based solutions with propagation delays of hundreds of nanoseconds or longer, the ISOdriver' s shorter propagation delay of 50ns (max) increases timing margins and improves control response for better overall system performance and reliability. Because the ISOdriver devices are designed in CMOS, they do not suffer from the perennial problem of performance drift over time and temperature of optocoupler-based solutions. The ISOdriver family's unique CMOS-based design has the added benefit of providing tighter tolerances on unit-to-unit variations, eliminating the need for factory screening or calibration after system assembly.

In addition to performance, integration

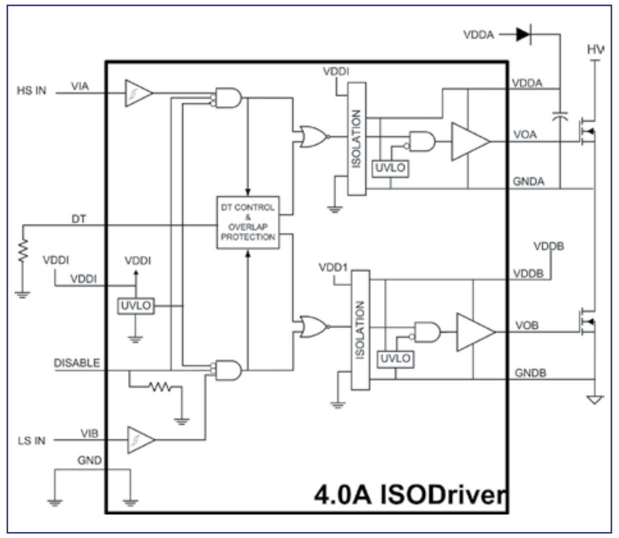


Figure 2: Si-Labs 4A Si823x ISOdriver.

and reliability advantages, the Si823x family features programmable dead-time, allowing users to optimize efficiency. Integrated under-voltage lock-out (UVLO) circuitry on both the input and output sides of the isolated driver prevents erroneous FET driver switching when input voltages are low during system start up or shut down, thus preventing damage to the supply.

Phil was obviously totally aware and sensitive to the fact that power designers face tough challenges when designing sophisticated, high-efficiency power delivery systems. He asserted that by offering higher functional integration, coupled with significant performance enhancements over traditional solutions, Si-Labs solve customers' key problems. He added, "Customers give us a great deal of feedback on what they want to have for their future power designs. This is a rich source of information from the 'real world' that enables us to develop engineering-acceptable products far ahead of the 'sea of vanilla' products on the market."

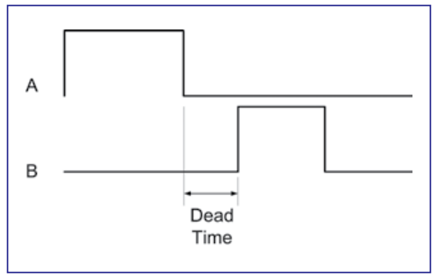


Figure 3: Programmable dead-time allows optimized efficiency.

These new additions were developed by Si-Labs' industry renowned engineering team whose expertise in mixed-signal design of highly-integrated, easy-to-use products continues to offer their customers real competitive advantages in terms of performance, size and power consumption.

www.silabs.com

Bright Future in Automotive Body Lighting

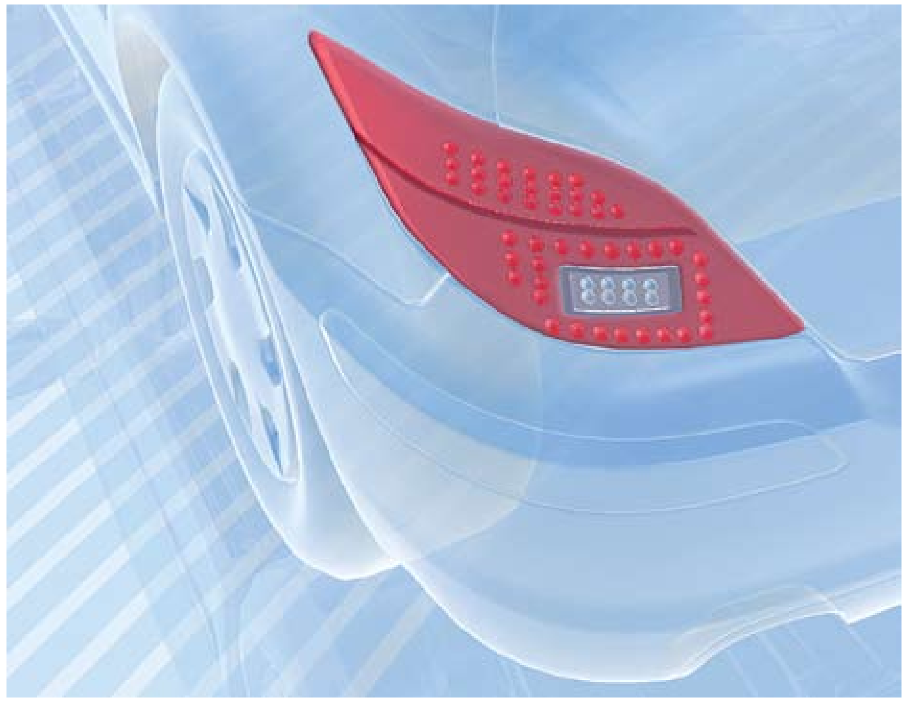
Integrated multichannel switch family for driving LEDs and traditional bulbs

Intelligent chip design and clever integration of digital and power functions enable smarter, more sophisticated automotive lighting control while reducing the part count and total system cost of advanced Body Controllers versus existing solutions.

By Jerome Py, Product Marketing Manager, Power Switches, Infineon Technologies

The transition from bulb to LEDs and increased complexity and density of the Body Control Module (BCM) transform the body lighting and control industry and its entire eco-system.

The automotive industry, in the Body segment arena, has seen multiple transitions and evolutions over the last decade, such as the replacement of fuses and relays by Smart Power switches, the introduction of Pulse Width Modulation operation for an improved lifetime of the bulbs, or the constantly increasing requirements for better protection and diagnostics of the loads. Today, two major evolutions are transforming the Body Lighting and Control industry and its entire eco-system: the transition from bulb to LEDs (Light Emitting Diodes) and the increased complexity and density of the BCM (Body Control Module). This article deals with the benefits of this transition to LED, its impact on the car maker strategy and the implications of those two major trends for the body architecture and consequently for the smart power switches. Additionally, it focuses on innovative driver IC concepts such as the SPI Power Controller (so-called SPOC) from Infineon that enable and embrace those trends.



Picture 1: New branding and styling opportunities for exterior lighting with LEDs.

Acceleration of the transition towards LED

One of the most important factors accelerating the replacement of standard bulbs by LEDs is greater styling and branding opportunities for the car makers, with creative and unique LED chains or matrix, to "personalize" certain high-end car models and attract customers

Parameter	Symbol	Value
Operating Voltage Power Switch	V_{bb}	5.5 ... 28 V
Logic Supply Voltage	V_{dd}	3.8 ... 5.5 V
Over Voltage Protection	$V_{bb(AZ,\ min)}$	40 V
Nominal Loads (bulbs) ▪ Channel 0, 1, 2 ▪ Channel 3, 4 ▪ Channel 5 (only in BTS56x2E)		 21 W (27 W) 10 W (5 W)
SPI Access Frequency	$f_{SCLK(max)}$	2 MHz

Picture 2: Overview of SPI Power Controllers. Compared to existing discrete solutions, SPOC reduces the need for external components and delivers board space and power dissipation savings by integrating multiple channels and featuring an SPI bus for diagnostics and control.

who are constantly looking for more and more differentiation.

Another catalyst of the transition is the decreased fuel consumption and reduced CO_2 emission requirement as constantly increased fuel price and new EU regulations for CO_2 emissions are forcing car makers to find ways to reduce the electrical power loss of the car. LEDs, with a higher light emitting efficiency (>50lm/W vs. <25lm/W for incandescent lamps) and lower optical losses can improve the total electrical power loss of the car by roughly 50W. This results in a reduced fuel consumption of about 0.05l/100km and a CO_2 reduction of about 1.2g/km.

Other factors such as a small packaging, increased lifetime or safety considerations have also a positive impact for the replacement of bulbs by LEDs.

However, some challenges still need to be overcome for a complete and rapid transition to LED technology. LED solutions are and will remain more expensive than standard bulbs, even with the latest efficiency projections (130lm/W in 2012). This is why LED is only offered as an option today, primarily for high-end cars. There are also still many technical challenges such as the consistency of LED light emission, the complex heat dissipation assembly (especially for the headlight) or the high repair replacement cost.

In the future, due to the global awareness and sensitivity of CO_2 emission topics, the many benefits of LED technology will become more predominant over the cost of its implementation.

Impact on car maker strategy and body architecture

Car makers are pursuing a platform approach for the Body Control Module (BCM), which controls among other loads the internal and external lighting of the car. The same BCM platform is used for multiple car models and variants, which requires a high flexibility for such unified BCM. For instance for a given car maker, the low-end car models will have no LED content (due to cost), the mid-range car model could have LEDs as an option for certain loads (such as tail lights or indicators) and the high-end cars could use LEDs possibly for all loads.

Consequently, even in the next decade the largest part of the BCM market will continue with a dual BCM architecture capable of driving either LEDs or bulbs.

At the same time, the complexity and density of BCMs is constantly increasing with more loads to drive and more features inside the module such as intelligent failure management, diagnostics of loads in various conditions or PWM of loads (i. e. for optimum power output).

Implications for Automotive power devices

There are multiple LED concepts for interior and exterior lighting and each of them requires a specific driving concept:

• DC/DC constant current source: This concept is optimized for high load current (>350mA) and is typically used for DRL (Daytime Running Light), High/Low beam or LED chains in Interior lighting.

• Linear constant current source: Typically used for low load current, it requires few external components and increases the LED lifetime. However, this solution is challenging in terms of energy efficiency and power dissipation.

• PWM smart power switch: Also for load current <350 mA, such drivers are capable of driving both LEDs and bulbs and are therefore able to address the dual LED/Bulb BCM architecture of today's platforms, especially for rear lighting loads such as tail, reverse or brake lights and indicators.

The trend towards more functionality and complexity inside the BCM has also an important impact on the driver ICs. Semiconductor suppliers have to consider new challenges that system suppliers are facing such as increased board density or digital capability requirements. As a result, the market is demanding advanced integrated driver ICs with multiple channels, more intelligence and enhanced functionality in order to offload the microcontroller and save board space. The diagnostic, control and programming of the driver IC is typically performed via SPI (Serial Peripheral Interface).

5 Channels 6 Channels	BTS5562E BTS5662E	BTS5572E BTS5672E	BTS5682E
Basic	✓	✓	✓
LED Mode		✓	✓
Cranking			✓

Picture 3: Family approach of SPOC. The unique value proposition of SPOC versus other integrated solutions is the modularity of the family which is scalable by number of channels and features (LED mode for example).

Channel 0, 1, 2	BULB Mode	LED Mode
Nominal load	21W (27W)	typ. 420mA max. 700mA
k_{ILIS} (current sense ratio)	3000	1000
Current limitation	24A .. 48A	7A .. 16A
Slew rate	0.1 V/µs .. 0.5V/µs	0.3 V/µs .. 1.5V/µs
Turn on times	< 250µs	< 100µs
I_{IS} settling time	< 300µs	< 115µs

Picture 4: SPOC load type configuration via SPI. This feature enables the customer, via a simple SPI command, to optimize the channel to the load type (bulb or LED), by adjusting key parameters.

Infineon SPOC devices - one generation ahead for advanced lighting control

The SPOC family is especially designed for standard exterior lighting and LED equivalent loads. It is available in a "green" (lead-free) and robust standard PG-DSO-36 package and consists of 5- or 6-channel integrated high-side switches suitable for driving rear and central lighting loads into a BCM.

SPOC features unique functions and brings multiple benefits for car equipment manufacturers:

• Modularity and scalability of the family: The PIN, function and package compatibility within one SPOC family and the ability to drive bulb or LED with the same device enable customers to develop a modular and scalable platform with only one PCB.

• High level of integration: The integration of five or six channels and the current sense multiplexer in a single package relaxes the board density and reduces the amount of external components generally required in high complexity platforms. Compared to a standard discrete implementation, SPOC architecture can bring more than 30% board space savings, allowing the customer to reduce the overall cost of the module due to less routing, less PCB material and less parts to handle.

• SPI (Serial Peripheral Interface) bus interface: SPOC features an 8-bit SPI for control and diagnostics of the loads. PWM operation can also be performed via the SPI bus in order to reduce the number of I/O's (Inputs/Outputs) of the microcontroller. This approach is especially valid in coming platforms, which are integrating more and more loads to be driven in PWM mode. In such cases, the microcontroller can quickly become saturated in terms of I/O count. For example, performing PWM via SPI for a 6-channel SPOC device saves seven I/O's and 14 external components versus an equivalent discrete implementation, resulting in a BOM (Bill Of Material) saving of about 8 Euro-cents at the system level. The SPI also provides daisy-chain capability to further save I/O's and therefore cost for the module.

• LED/Bulb mode configuration: As mentioned earlier, during the transition to LED, the vast majority of BCMs will have a dual Bulb/LED architecture where only certain car models or variants will offer LED for certain loads. The SPOC devices that feature LED/Bulb mode configurability via SPI, enable customers to keep the same PCB and footprint for all car variants of the platform. In such devices, each of the 27W channels can be programmed independently to drive either an LED chain or a standard bulb.

When set to LED mode via SPI, the following parameters are adjusted and optimized for LED:

• Lower nominal load current capability: To improve the current sense accuracy at low load currents

• High slew rate: For very fast diagnostic and faster PWM operation (up to 400Hz)

• Low current limitation: To reduce peak currents at overload conditions

• Fail safe operation: SPOC features a Limp-home pin (LHI) which will wake-up the device and is working without VDD supply. As a result, all channels can be activated via the dedicated input pins.

The unique scalability of the SPOC family, its high level of integration and its capability to support the dual LED/Bulb architecture, help customers to cope with the challenges of unified BCMs. There are today major car platforms in production or successfully ramping-up with SPOC. Moving forward, Infineon intends to complement the existing SPOC portfolio by introducing new and innovative integrated Power Switches targeting headlight as well as heating and body convenience applications.

In addition to SPOC, Infineon offers all key building blocks required in a body module such as microcontrollers, discrete PROFETs, CAN/LIN transceivers, system basis chip or multi-channel high- and low-side drivers.

www.infineon.com/SPOC

Flat Out – Low Profile Gate Drivers

Utilize PCB itself for high voltage insulation

The way galvanic isolation is implemented in gate drive systems very strongly influences the total performance and cost. IGBT and MOSFET gate driver specialist CT-CONCEPT exploits the known benefits of planar transformer topologies by extending the insulation voltage into the high reliability 1700V class.

By Sascha Pawel and Jan Thalheim, CT-Concept Technologie AG, Switzerland

Every way you look at the ubiquitous topic of serving tomorrow's energy demand, there is one natural solution - more efficient use. Power electronics plays a key role in making the most of our precious energy resources because power conversion allows to extract only the amount of energy just needed from the source and to supply it in the most appropriate form. Variable speed motor drives and renewable energy harvesting are very prominent application fields of power electronics.

Hidden amidst the sophisticated microcontrollers, IGBTs, MOSFETs, sensors and all other components of a power conversion system, the gate driver seems to be a straightforward and unimpressive building block, yet it is crucial for rugged and reliable operation. The main purpose of a gate drive module is to link the digital "intelligence" to the analog world of the power switches. In order to do so, every gate driver transmits signals across an electrical potential barrier. The way this insulation barrier is implemented has defined the shape, ruggedness and cost of the gate driver to a very large extend.

Conventional high voltage insulation

Wire-wound ring cores are most commonly employed in gate drive systems now on the market, because they allow step-by-step manufacturing, reasonable voltage scaling and because they are known to be capable of high reliability. Of course, all that comes at a cost. Wire wrapping and handling of the cores is an error-prone process, the volumetric power density of such transformers is easily outperformed by planar counterparts and most importantly, many non-automated production steps call for repeated testing if high quality is desired. Because

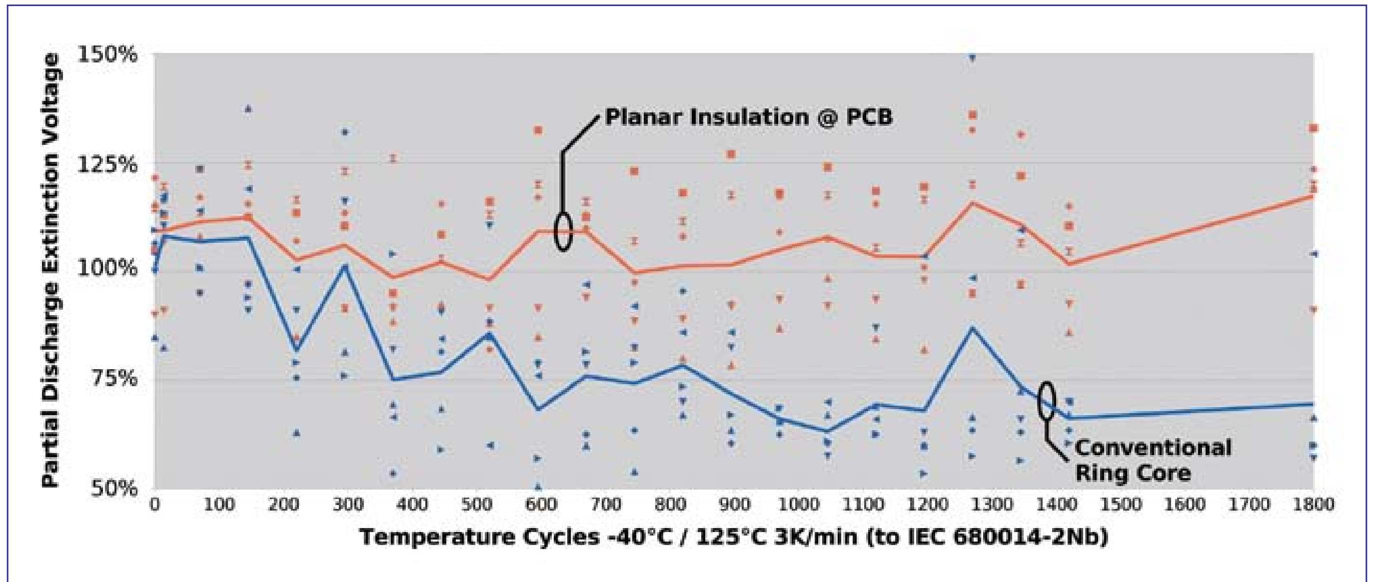


Figure 1: Accelerated ageing behavior of planar transformers versus conventional transformers.

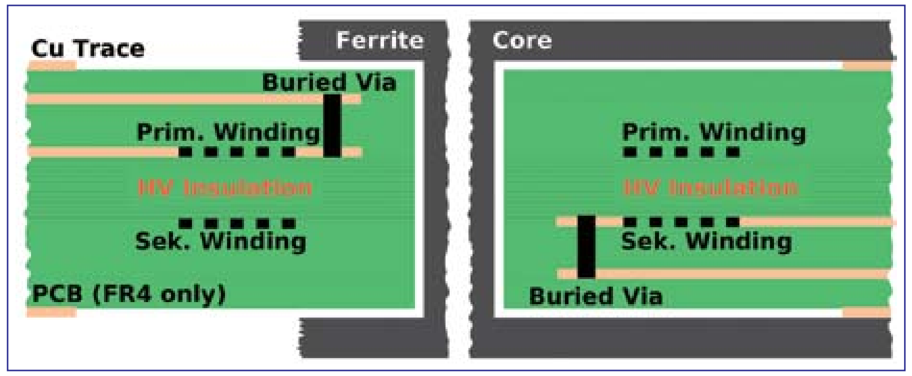


Figure 2: Schematic PCB layer buildup using no HV crossings.

of these shortcomings, ring cores have mostly been replaced by planar transformer topologies in applications requiring high power density and low cost, such as point of load (POL) regulation and low voltage DC-to-DC conversion. The insulation capabilities of planar transformers on the printed circuit board (PCB), however, have typically been limited to less than 300V operation voltage. Mains-connected planar circuits often rely on dedicated insulation materials that are not included in standard PCB processes.

Planar high voltage insulation

Our goal was to build planar transformers directly on standard PCBs and to achieve insulation suitable for the 1700V class of IGBT systems.

The most common PCB material is FR4 (glass reinforced epoxy resin). Freshly cured FR4 can sustain as much as 40kV/mm dielectric stress. However, the material is subject to chemical and mechanical aging and will not perform nearly as well after some 20 years in operation. Our accelerated aging tests showed that the insulation performance of FR4 planar transformers is remarkably stable once the dielectric stress is sufficiently derated. The maximum peak voltage gradient in our design was kept well below 4kV/mm, less than 10% of the initial FR4 value. Figure 1 shows measurements of the partial discharge extinction voltage versus thermal cycles between -40°C and 125°C. It can be seen that the PCB insulated planar group remains virtually unaffected by thermal cycling stress, whereas the reference group consisting of wire-wrapped and potted ring core transformers undergoes reduction in insulation strength down to 70% of the original value. The stability of the PCB insulated samples is underlined by the fact that the reference group consisted of series production types with a proven application lifetime of more than 15 years.

PCB buildup

Figure 2 shows the schematic buildup of our high voltage PCB. There is a dedicated HV insulation layer between primary and secondary copper wires. No via holes penetrate through the HV insulation layer. In order to facilitate low cost production of the PCB, no materials other than FR4 are used in the multilayer board. The HV insulation layer consists of a number of thin FR4 prepregs to spread out inhomogeneities, ensure good resin flow during pressing and in addition, to scale up insulation strength.

Conductive Anodic Filaments

In the past, attempts to make high voltage insulation on PCB reliable were foiled by the growth of conductive anodic filaments (CAF) also called filament formation. CAF has been studied extensively because it poses a serious threat to highly integrated multilayer boards in IT applications and telecommunication. Regular power electronics PCBs tend to have sufficiently large spacing between copper traces to avoid CAF influence. Yet at voltages greater 300V, the story is very different.

Conductive filaments can grow in fiber-reinforced board material under applied high voltage and high humidity. In a very complex electrochemical process starting from the anode side, copper salts are formed and dissolve in microscopic water layers that have adsorbed at the surface of glass fibers.

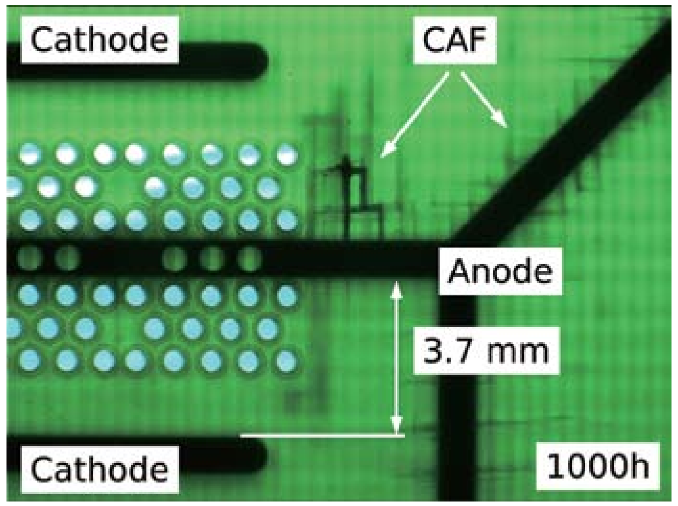


Figure 3: Lateral CAF in standard FR4 after 1000h at 85°C, 85% RH and 1500V DC.

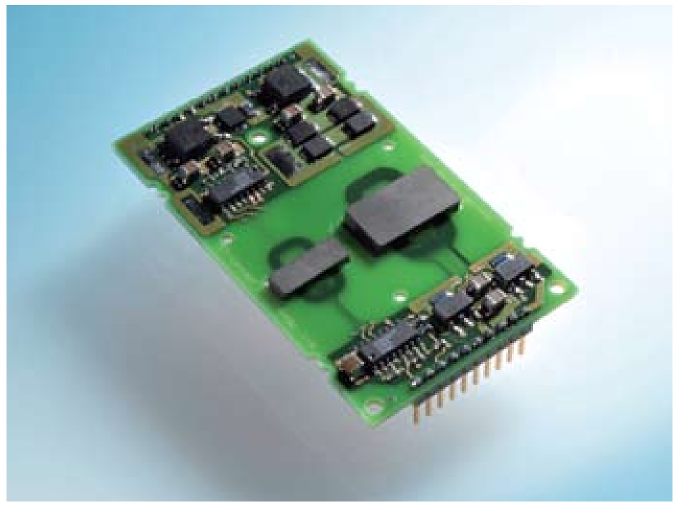


Figure 4: 20W, 20A gate driver core 1SD2020AI featuring planar transformers.

Gate Drivers

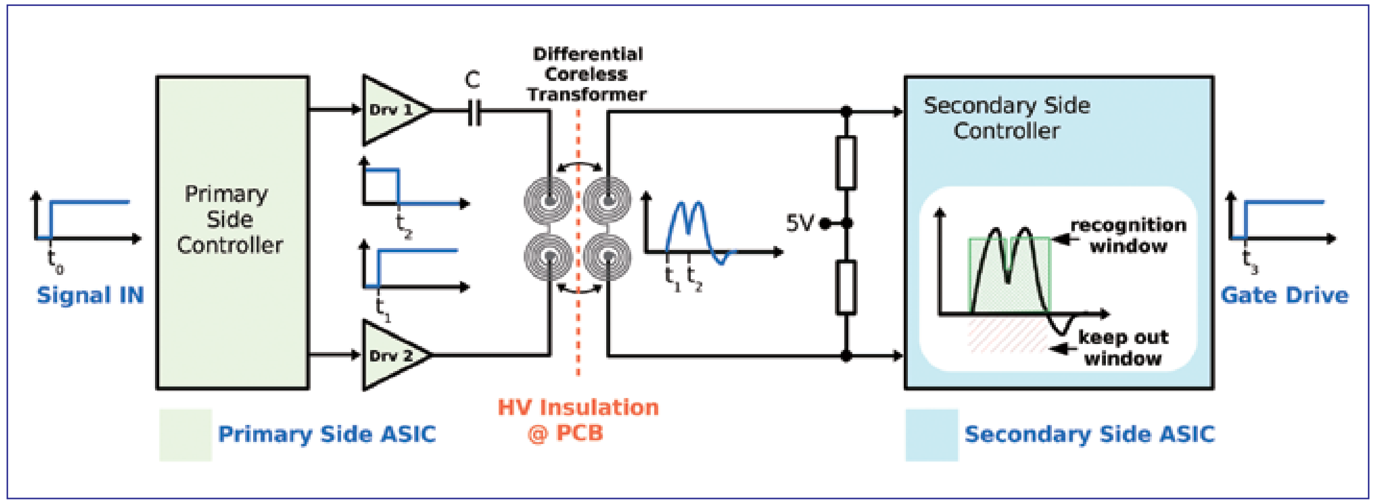


Figure 5: Block diagram of "double pulse" signal transmission system.

The electric field then transports the ions along the glass fiber surface where they can effectively form a short circuit to the cathode of the process. Several other mechanisms are involved such that CAF can propagate both laterally along the glass fibers as well as vertically between PCB layers.

Figure 3 shows a photograph of a standard FR4 PCB exhibiting severe lateral CAF after temperature humidity bias testing. Two things can be seen from this picture. First, lateral filaments bridge across as much as 3.7mm spacing between traces and second, these filaments can be stopped by overlapping rows of non plated through holes. Vertical CAF between different layers of the PCB does also occur, but is not visible in Figure 3.

High Reliability PCB Design

We carried out a large number of tests to identify the main contributors to CAF vulnerability under applied HV bias of 1500V and 2200V DC. The whole process chain from FR4 base material to thermal processing budget, surface finish, soldering, cleaning, and mounting the final board has to be considered and every step carefully optimized. If this approach is followed, the difference in reliability is dramatic. Going from standard FR4 to widely available low CTE (coefficient of thermal expansion), halogen free FR4, for instance, easily gives a factor of ten in CAF resistance. Visible filaments are no longer present in this FR4 material. Employing a dedicated HV insulation layer yields another factor of nine improvement. By lowering the thermal processing budget, the CAF resistance could be more than doubled. No-clean fluxes have to be rigorously tested for CAF influence. These and other combined factors lead to highly reliable HV insulation on the PCB. Detailed Weibull analysis of the CAF test shows that our design exceeds the criteria laid out by IPC-TM-650 2.6.25 and IPC 9691A for 20+ operational life.

Planar Transformer Gate Driver

A first gate drive product is in development around the newly established planar HV insulation on the PCB. The 1SD2020AI driver core, shown in Figure 4, is a high performance, 20W, single channel driver. It uses Concepts' own SCALE-2 chipset, the successor to the existing SCALE platform that is successfully established on the marked for more than 15 years now.

1SD2020AI shares the SCALE-2 performance figures of fast signal transmission with only 100ns delay time, extremely low jitter of less than +/-1ns (5 sigma), and as much as 60% less discrete components on the board. It has been designed for fast-switching resonant topologies up to 300 kHz, but it can also be used flexibly in any single or parallel gate drive circuit requiring high output power and current. With its very compact outline of 44mm x 73mm and a total height of just 6.5mm, it delivers high power density in an attractive form factor without compromising quality and reliability.

Coreless PCB Transformer

Once a dependable HV board insulation is in place, it is natural to leave out the ferrite core for low power gate drive systems. Doing so eliminates the most cost-intensive manufacturing step and leads to very appealing prices in multi channel designs. The main challenge, however, is to design a coreless signal interface that is both fast and robust. Existing solutions either use highly complicated, proprietary IC technology or are based on resonant signal transmission. In a resonant scheme, power dissipation is rather high, thus limiting the number of channels in parallel. In addition, there is a systematic jitter in delay time. This jitter corresponds to the resonance frequency and is typically as high as 25-50ns in PCB insulated systems. Such jitter values are not suited for high-performance gate drivers.

We therefore designed a custom ASIC implementing a fully differential coreless interface that is fast and insensitive to noise and spurious signals such as dv/dt or di/dt coupling into the coreless PCB transformers from the nearby power plane. Concepts' patented "double pulse" signal transmission scheme (Figure 5) generates two consecutive positive peaks followed by the inevitable back swing across the differential coreless transformer. The signal reconstruction on the secondary side applies a well-defined recognition window to filter out valid pulses only. Any oscillations coupling in from the surrounding power rails are effectively blocked by a second "keep out" window. The resulting noise insensitivity is at eye level with conventional ring core based drivers.

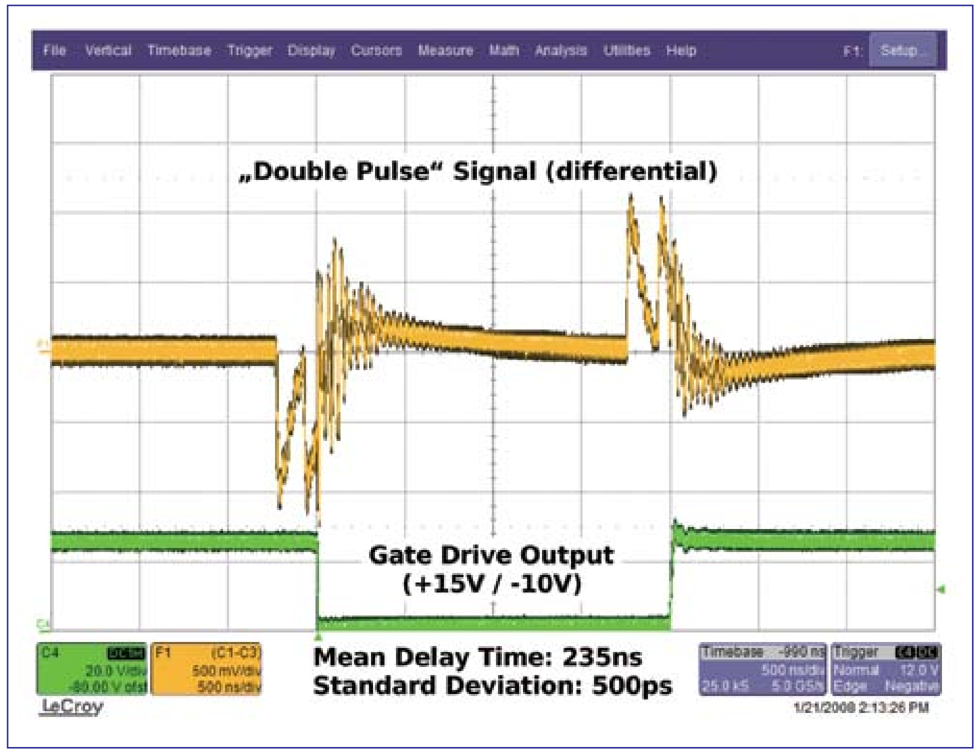


Figure 6: Measurement of undisturbed signal transmission.

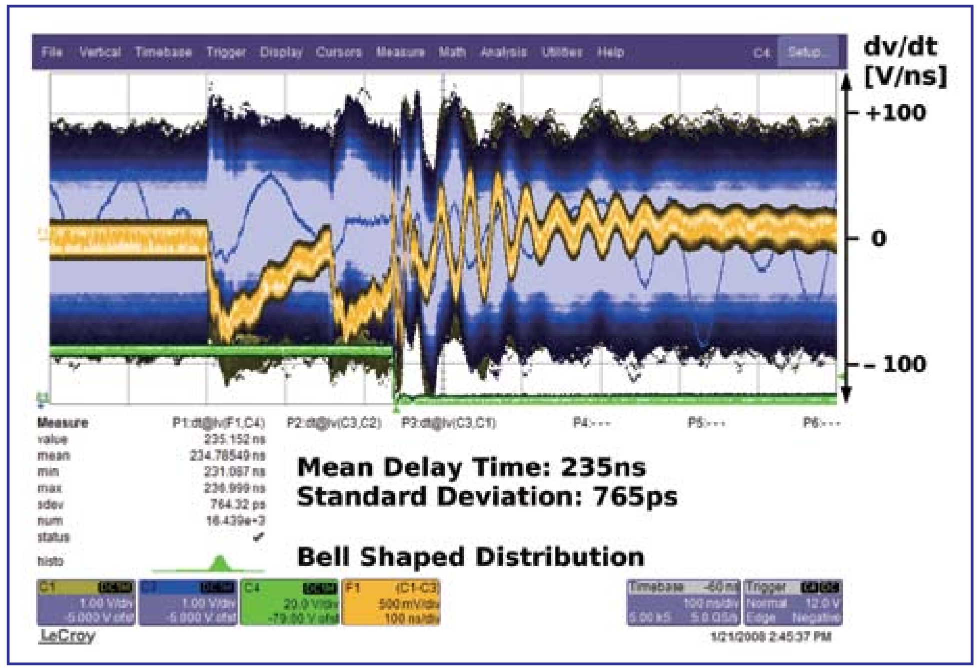


Figure 7: Measurement of signal transmission under dv/dt stress.

Exemplary measurements shown in Figures 6 and 7 illustrate the rejection of any dv/dt noise. As the voltage of the secondary side changes during each IGBT or MOS switching transition, current will be forced into the secondary side signal interface. This current is proportional to the coupling capacitance of the coreless differential transformer and the voltage change rate dv/dt. The comparison of delay time and jitter between the undisturbed measurement in Figure 6 and the data acquired under the equivalent of +/-100V/ns dv/dt stress in Figure 7 yields excellent rejection of dv/dt noise. Both delay time and jitter remain essentially constant at very low values. The delay time histogram in Figure 7 exhibits a bell shaped characteristic under the applied pseudo-random dv/dt stress, indicating that no systematic delay time jitter is present at all.

Any magnetic fields arising from di/dt in the power switches are strongly attenuated by the fully differential layout of the PCB transformers. In addition to that, a copper layer covering the whole coreless transformer area acts as an eddy current shield. It reduces all magnetic spectral components above 1MHz by more than 93%. The lowest relevant frequency component of the double pulse signal is even higher at roughly 1.6 MHz.

Summary

High voltage insulation is the single most important building block for today's gate drive systems. It is highly desirable to employ automated and well-controlled production steps only during fabrication. In order to do so, we developed an insulation platform on the printed circuit board that is applicable to the 1700V class of IGBT systems. Reliability under high voltage stress and harsh environmental conditions has been achieved by carefully optimizing the whole design and manufacturing chain. The PCB insulation platform serves an entirely new generation of gate drivers featuring both high-power planar core transformers as well as completely coreless low-cost solutions.

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SiC Impacts 'Greening' of Power

Understanding the differences between Silicon Carbide (SiC) and Silicon (Si) for power electronics

Silicon Carbide (SiC) is man made; it is the combination of silica sand and carbon combined at temperatures between 1600° and 2500°C. Though SiC has been around since 1824, it has not been used commercially in microelectronics and power electronics until the past decade or so when blue LEDs and Schottky Barrier Diodes (SBDs) became available from CREE as well as the latter from Infineon in 2001.

By Philip C. Zuk, SiC Strategic Marketing Manager and Bruce Odekirk, Director, SiC Program Microsemi Power Products Group

SiC is now being seen as a more ideal material than Si for power electronics. For an optimum power semiconductor switch, SiC offers a higher thermal conductivity (λ), higher breakdown electric field (E_M), larger bandgap (E_G), and higher saturation velocity (V_D) then Si. In addition, SiC is an extremely rugged and stable material. Having the same native oxide as Si, it can be used to develop a number of devices as follows:

- Schottky Barrier Diode (SBD)
- PIN Diode
- Junction Field Effect Transistor (JFET)
- Metal Semiconductor Field Effect Transistor (MESFET)
- Bipolar Junction Transistor (BJT)
- Metal Oxide Semiconductor Field Effect Transistor (MOSFET)
- Insulated Gate Bipolar Transistor (IGBT)

Silicon Carbide is available in a family of different crystal formations (known as polytypes) with wide bandgaps similar to Gallium Nitride (GaN). Though there are more than 200 different SiC polytypes, Table 1 lists the three most commonly occurring ones, along with their bandgaps (E_G), thermal conductivity (λ), breakdown electric field (E_M), and saturated electron drift velocity (V_D).

Wide Bandgap Material

SiC is termed as a "Wide bandgap" material. This refers to the energy gap between the conduction band minimum and the valence band maximum (Figure 1).

Increased Temperature of Operation

Because of the higher bandgap energy, the semiconductor properties of SiC are less sensitive to increased temperatures than Si. This benefit results from SiC's lower intrinsic carrier concentration (ηi). The intrinsic carrier concentration (ηi) defines when the device starts to behave as a bulk resistor (around 1 x $10^{15}cm^{-3}$) and fails to operate in a normal semiconductor fashion. Figure 2 shows a graph of ηi versus temperature for Si and SiC. SiC does not approach this critical intrinsic carrier concentration until temperatures exceed 1000°C.

Higher thermal conductivities of SiC (Table 1) ease heat sinking requirements contributing to the feasibility of high-temperature, high-power electronics in the future.

These attributes allow SiC devices to function as good semiconductors at temperatures in excess of 500°C.

Electric Field Characteristics (E_M)

SiC is able to handle a higher electric field (10 times greater than Si, see Table 1) before breakdown occurs. This allows the use of a thinner (0.1 times that of silicon devices), more highly doped (ten times the doping concentration) drift layer, resulting in a lower on-resistance ($R_{DS(ON)}$) – typically a minimum of 10 times lower than for Si devices of the same blocking voltage.

Figure 3 shows the relationship of drift velocity (V_D) versus field strength (E). While Si has higher low field mobility than SiC, SiC has higher high field saturation velocity. For Si this velocity limit occurs near the mean drift velocity of 1x10^7cm/s and represents the point at which added energy imparted by the field is transferred to the lattice rather than increasing the carrier velocity. At higher fields, SiC drift velocity is twice that of Si. This is advantageous for some high power applications.

Material	Bandgap (E_G) (eV)	Thermal Conductivity[1] (λ) (W/cm°C)	Breakdown Electric Field (E_M) (V/cm)	Saturated Electron Drift Velocity (cm/s) (V_D)	Additional Information
Silicon (Si)	1.1	1.3	3.1 x 10^5	1.0 x 10^7	
Silicon Carbide (3C-SiC)	2.7	3.6	>1.5 x 10^6	2.5 x 10^7	Superior transport properties, but used less due to smaller bandgap and lack of substrate technology
Silicon Carbide (4H-SiC)	3.26	3.7	3.5 x $10^{6(2)}$	2.0 x 10^7	Ideal for power device. Material well up the learning curve. Can use to develop simple commercial devices. Broad future markets and application. More isotropic than 6H-SiC
Silicon Carbide (6H-SiC)	3.0	3.7	2.5 x 10^6	2.0 x 10^7	The 6H means a hexagonal type lattice with an arrangement of 6 different Si+C layers before the pattern repeats itself. This is the polytype of SiC initially used as substrates for growth of GaN blue LEDs
Gallium Nitride (GaN)	3.2	1.3	3.0 x 10^6	2.5 x 10^7	Primarily used in optical devices (blue LEDs); power device type focused on High Electron Mobility Transistors (HEMT). Ideal for RF switching devices (S-Band and up). Cannot be used for IGBTs and MOSFETs. High material cost, high defect density.
Diamond	5	20	7 x 10^5		The perfect power device material. Many decades away from solving basic material problems.

Table 1: Semiconductor material overview @ 300°K
[1]Measure of the ability of a solid or liquid to transfer heat
[2]IEEE Transactions on Electron Devices, 1993
[3]An indirect bandgap semiconductor is a semiconductor in which the bottom of the conduction band does not occur at the same location in k space as the top of the valence band. Conservation of momentum requires phonon participation in electron-hole recombination in an indirect gap material, which significantly reduces the efficiency of optical transitions. Examples are: Si, Ge, GaP. Most III-V semiconductors (GaAs, InP, GaN) are direct gap materials, and therefore make very efficient optical devices.

Silicon Carbide Challenges

Even though there are advantages to the use of SiC over Si, there are still many challenges.

1. The material quality is lower and the cost is higher than is needed for broad commercialization. While both of these are improving year by year, SiC substrates and epi layers are still far from the level of maturity that silicon has obtained.

2. Primary material defects are:

a. Micro pipes, which are tornado like micron-sized holes through the wafer, also called an open core screw dislocation with a large Burghers vector, (Figure 4). These are killer defects for all devices.

b. Basal plane dislocations, which can cause V_F drift in conductivity modulated devices (PIN diodes, BJT's, etc), but are not harmful to majority carrier devices (MES FETs, MOSFETs, JFETs, Schottky diodes).

c. Screw dislocations, which are caused by rotational lattice mismatches that can be closed-core or open-core (Figure 5).

d. Edge dislocations, which are extended defect lines or planes not aligned with neighbors (Figure 6).

3. MOSFETs, though under development, have not been brought to the point where they are used in military or commercial applications. Primary challenges are:

a. MOS interface quality, where inter face state and fixed oxide charge densities need further re-

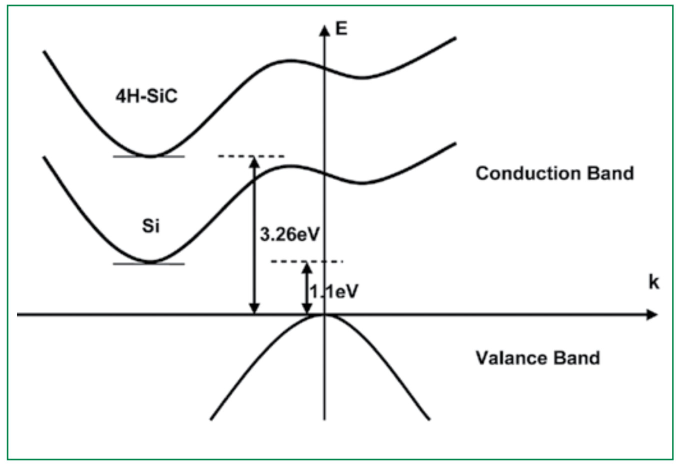

Figure 1: Indirect[3] conduction band bandgap comparison between Si and SiC.

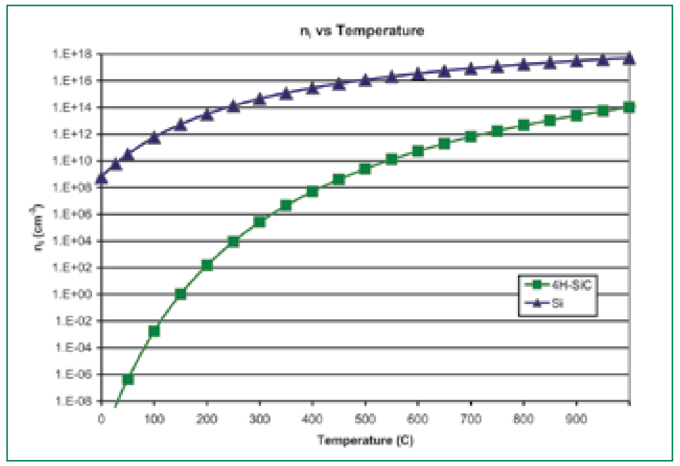

Figure 2: Intrinsic carrier concentration (ηi) comparison between Si and SiC.

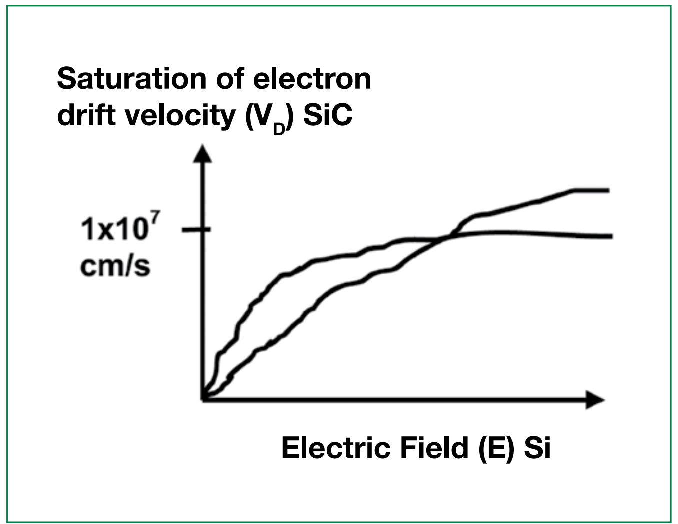

Figure 3: Drift velocity versus electric field comparison between Si and SiC.

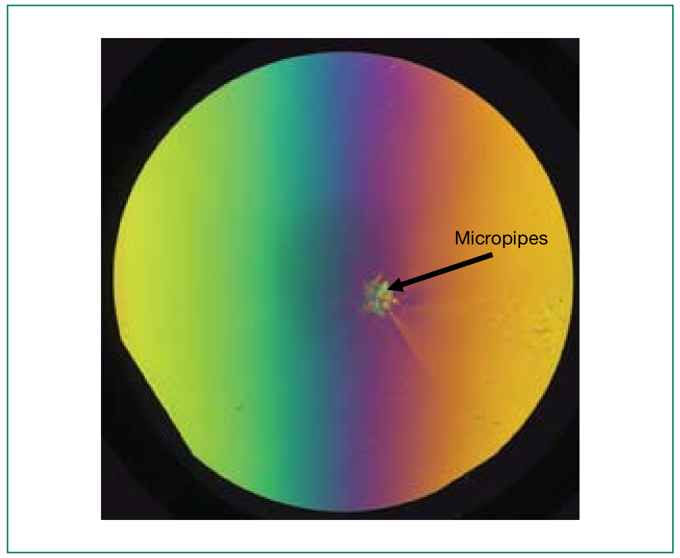

Figure 4: Micropipes within a wafer.

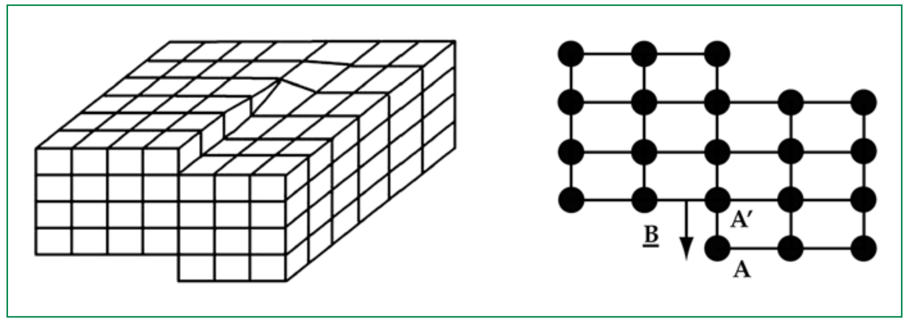

Figure 5: Screw Dislocation, A' would be at A if the dislocation had not happened.

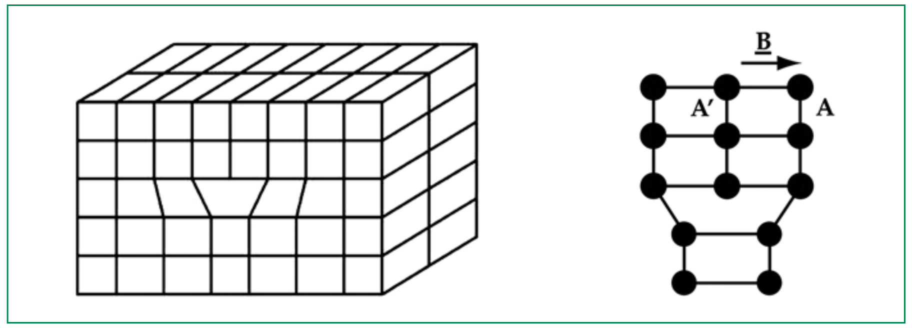

Figure 6: Edge Dislocation, A' would be at A if the dislocation had not happened.

duction for adequate control of Threshold Voltage (V_{th}) and For ward Voltage (V_F).

b. Reliability issues associated with a smaller barrier height at the oxide/SiC interface due to the large bandgap of SiC. This can result in increased Fowler-Nordheim current injection into the gate oxide at moder ate field strengths, which in turn can re-ducethe lifetime of the gate oxide.

4. In order to take full advantage of the much higher operating temperatures and power densities obtainable with SiC devices, significant packaging devel-opment is required. While SiC power devices can provide significant system performance advantages using conven-tional packaging, even greater improve-ments (and hence broader commercial utilization) will occur with enabling improvements in packaging.

Final Thoughts

In summary, SiC has advantages over Si in the high voltage (500V to >10KV), high power density, and high tempera-ture operation end of the RF Power and Power Switching markets. The char-acteristics of SiC allows higher dop-ing levels along with the use of thinner drift layers as compared with Si in high electric field (>500V) applications. With the higher doping and thinner drift layers in SiC, the on-resistance of the device can be reduced by more than an order of magnitude compared to Si. Addi-tional benefits, including higher thermal conductivity (the ability to transfer heat), higher electric field strength, and higher drift velocity, will have major impacts on the size, efficiency, and applications of power electronics in the years ahead.

Even though SiC has been around for sometime, the development of high quality material has only recently al-lowed it to be used in power electronic applications. With this in mind, there are still many hurdles to overcome in order for this technology to become main stream. As time moves forward these challenges will be met; power systems will become more efficient and smaller. SiC devices will have a profound impact on the “Greening” of our world.

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Power Systems Design EUROPE

Automotive Electronics Part I

Image Courtsey of Tesla Motors

Special Report – Automotive Electronics Part I

Stay Ahead of the Field in Hybrid Vehicle Design

Greater accuracy requirements in battery monitoring drive innovation

Across the developed world, demand for hybrid vehicles is growing and with it comes an increased need for accurate battery condition monitoring. Batteries in conventional vehicles require careful monitoring to ensure that the battery is maintained at an adequate state of charge, but experience relatively low charge and discharge currents. In a hybrid vehicle, the battery works much more rigorously making monitoring more complex and vital for correct operation.

By Luc Colombel, VP and Ramon Portas, European Automotive Sales Manager, LEM Automotive Division

When a vehicle is powered using its electric motor(s), the combustion engine is static, so in order to maximise efficiency the full capacity of the battery in hybrid vehicles must be used during every discharge cycle. If the combustion engine starts before the battery cycle is complete fuel consumption is needlessly increased. However if operation using the combustion engine is delayed too long, there is a risk of the battery fully discharging and the vehicle coming to a halt.

For hybrid vehicles, therefore, both low and high currents must be monitored and for the battery condition to be evaluated fully, the measurement system must measure drain and charging currents with a high degree of accuracy at both low and high currents.

Coulomb counting is a way of determining the state of charge of a battery by measuring the current entering and leaving the cells as a basis for calculating the remaining capacity. The charge transferred in or out of the cell is obtained by integrating the current drain over time. As with many electrical measurements, corrections are necessary for a number of sources of error across a typical cycle representing normal use of the battery. A new technique allows the integration error of the current sensor to be characterised with a small number of measurements, rather than evaluating the error over a full cycle. Such a cycle can typically take an hour.

LEM's DHAB family of Hall-effect sensors is automotive qualified and fixed onto the battery cable of a car. It is optimised to measure the difference between currents in and out. To ensure that it can offer the required accuracy across the very wide range of currents experienced in a hybrid vehicle, each sensor can measure two separate current ranges - one between ±20 and ±80A and the other between ±50 and ±600A. This enables full-range current measurements to be made in combination with highly-accurate measurements at lower currents, with good resolution on both ranges.

The 25 models in the DHAB range are the first in the industry to offer non-intrusive, galvanically-isolated solutions in this application. The sealed housing of the sensors means that no potting is required. Panel screw and cable-mount versions are available to offer maximum mounting versatility. The sensors meet all relevant standards, including ISO-TS and RoHS.

It is important that the sensors are optimised, not purely in terms of gain and offset, but in terms of coulometry (rate of charge/discharge). It is not easy to determine these parameters from the product data sheet. LEM has developed a technique to simulate results in coulometry terms to meet the needs of the customer's application.

In order to measure exactly the charge that has flowed in and out of the battery, it is necessary to evaluate what creates an error in each measurement. The four causes of error are electric offset, magnetic offset, gain error and linearity error. Some modern sensors, such as the DHAB family, incorporate an ASIC that corrects any linearity errors, so this factor does not need to be considered in the evaluation.

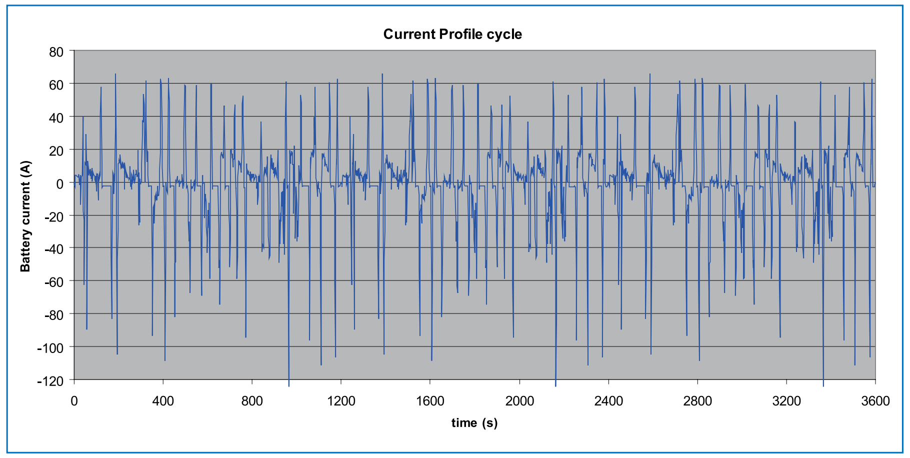

Figure 1: Standardised current profile.

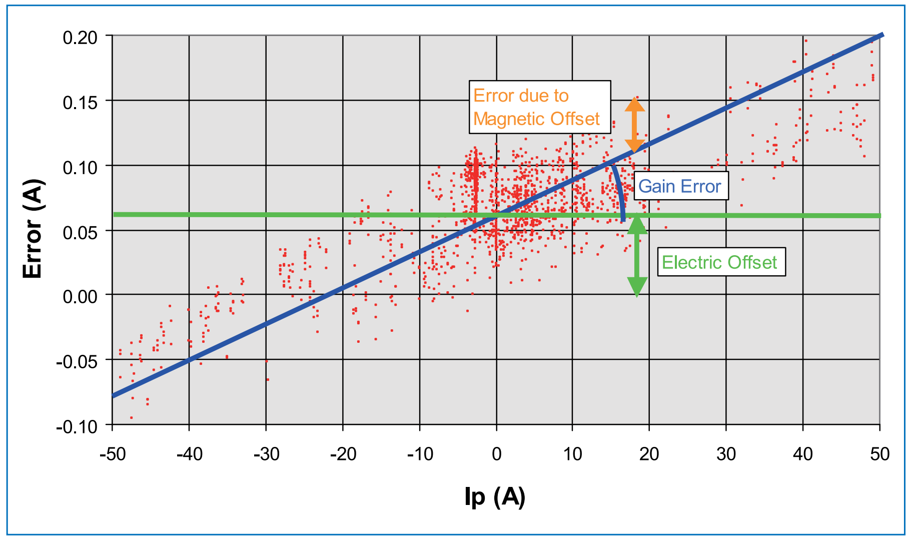

Figure 2: Transducer output error for given current cycle.

The error (expressed in Ah) of any measurement can therefore be expressed as:

$$\varepsilon = \left(\varepsilon_{elec\_offset} + \varepsilon_{mag\_offset} + \varepsilon_{gain\_error}\right) \times \frac{t}{3600}$$

The electric offset error remains constant across the measuring range. The gain error is directly proportional to the primary current.

The magnetic offset depends on the magnetisation of the core, which in turn is determined by the current that has been previously flowing through the sensor. The material therefore exhibits a memory effect, with the error linked to the history of the cycle as well as the sensor. The hypothesis is that the error due to the magnetic offset is directly proportional to that offset. Although this has been confirmed by practical evaluation, it has not yet been proven by a theory.

Evaluation of a sensor's characteristics requires four current measurements: one at maximum positive current (I_{PA}), then at zero current (I_{PB}), then at maximum negative current (I_{PC}) and finally a second measurement at zero current (I_{PD}) (Fig 1). The sensor measurements for each of these currents are also recorded as I_{MA}, I_{MB}, I_{MC} and I_{MD}.

As mentioned earlier, there are separate magnetic circuits for the two measuring ranges, so it is necessary to evaluate the errors for each range separately. This therefore requires eight measurements to be made - four for each of the two sensors.

The error during the calibration cycle would follow those shown in Figure 2. The measurements taken can be used to calculate the three sources of error:

The electrical offset (OFFSET) can be calculated as half the sum of the sensor measurements for the two zero current situations. This calculation cancels out the magnetic offsets, and there is no gain error as this is proportional to the current.

The magnetic offset (MAG) is half the difference of the sensor measurements with zero current. This calculation cancels out the electrical offsets, and there is no gain error as this is proportional to the current.

The calculation of gain error is slightly more complex. The actual gain is represented by the difference between the two peak measurements, divided by the difference between the peak currents. The gain error is therefore this value, less the theoretical gain. These calculations are expressed mathematically below:

$$OFFSET = \frac{I_{mB} + I_{mD}}{2}$$

$$MAG = \frac{I_{mB} - I_{mD}}{2}$$

$$\xi_{Gain} = \frac{I_{mA} - I_{mC}}{I_{PA} - I_{PC}} - Gain_{theoretical}$$

This technique is used to evaluate the current integration error for a high number of cycles. Indeed, it is necessary to make an entire cycle measurement with a representative set of samples to determine the electric offset, the magnetic offset and the gain error. However, once these coefficients have been calculated, the current integration error for another sensor can be evaluated very quickly, because it is only necessary to apply the calibration cycle (which is short) to determine the sensor's characteristics, and then make a short calculation (which is almost instantaneous).

By using this technique, the accuracy of measuring the charge in a hybrid vehicle's battery is dramatically increased, allowing the control electronics to count the charge (coulombs) actually in the battery. This improved accuracy and enables automotive engineers to maximise the efficiency without compromising vehicle reliability.

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Special Report – Automotive Electronics Part I

Can China's Automotive Electronics Be the Next Big Thing?

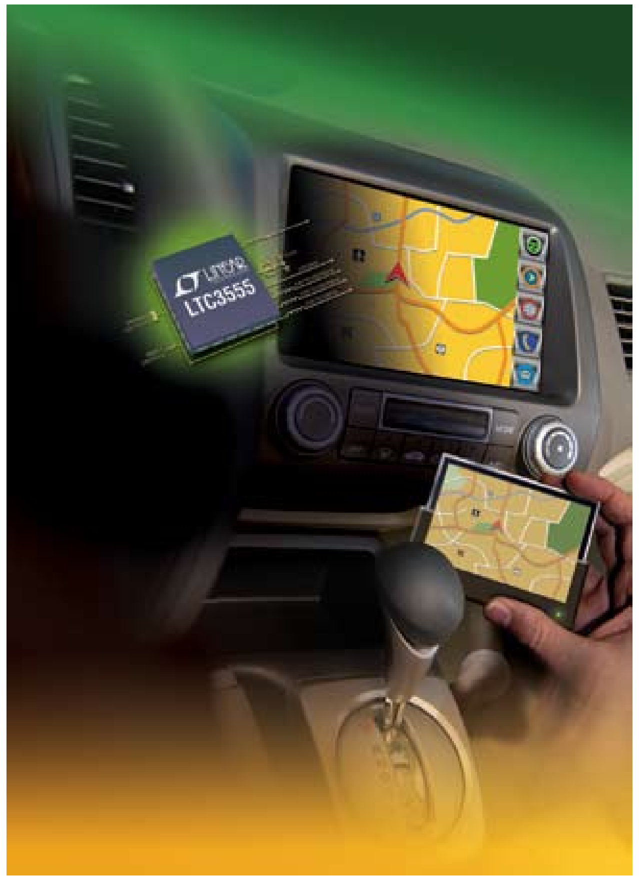
Seasoned automotive players will be in pole position

Many Analog IC manufacturers have been supplying power management and conversion ICs to automobile makers for many decades. Their products have been used in a variety of automotive electronics systems. The 'China-challenge' could open up great further growth opportunities.

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

Automotive products now widely used in powertrain, body & convenience, safety, in-vehicle networks, infotainment systems, LED vanity lights and engine control units have all showed growth in terms of usage in vehicles during 2007 and promise to have increased growth rates in 2008. LED headlamps, in particular, will have significant growth rates from 2008 onwards. As demonstrated in recent press announcements, Audi will use them in their R8 and A8 models – with the Cadillac Escalade and the VW Golf to have them as options in their 2009 model years due for release to the public later this year.

Unfortunately, collision avoidance systems with their large IC content, which have been underway for the past couple of years, are only now starting to appear in high-end luxury cars within the 2008 model year. However, for wide-spread adoption to occur, the costs of implementation will have to come down drastically. Therefore, it will be at least another five to eight years before these types of systems will become mainstream.



Low quiescent current and low EMI are vital for automotive infotainment systems.

The Chinese automotive electronics annual growth rate has been greater than 40% since 2005, and will most likely continue at this rate through the end of this decade. There are three main reasons for this continued growth: China is one of the fastest developing markets for automotive electronics content, it produces quick and innovative automotive products and has high demand from its domestic consumers.

It should also be noted that China has increased its automobile output by over 25% annually from 2001 to 2005, with sales in 2006 over 7.2 million units. Early indications in 2007 indicated that this sales pace would mean close to 9 million vehicles being produced – with 2008 having similar growth rate expectations. Clearly, the upside potential for manufacturers of power management and conversion ICs used in automotive electronics systems is going to be large in the China market.

One of the fastest growing applications segments in the China market will be automotive infotainment systems with about a 9% compounded annual growth rate (CAGR). This category can be broken down into five sub-categories, as follows; audio-only systems, front seat infotainment, rear seat infotainment, embedded navigation systems and emergency telematics. As a result, China is projected to have a worldwide market share of automotive infotainment systems a little over 10% by 2015. This is in sharp contrast to only a 3% share in 2006.

It is a well-accepted fact that modern automobiles continue to include increasingly complex electronic systems. At the same time, the automotive environment continues to be very harsh for any type of electronics. Wide operating voltage requirements coupled with large transient voltages and large temperature excursions combine to make life tough on electronic systems. What's more, the performance requirements continue to become even tougher. In addition, multiple supply voltages are usually required for different portions of any system. A typical in-dash infotainment system can have six or more different supplies including 8.5V, 5V, 3.3V, 2.5V, 1.5V and 1.2V. Moreover, as the number of components increases, space requirements continue to shrink. Therefore, efficiency becomes more critical in space-constrained systems because of the space limitations and temperature requirements. At low output voltages and even with moderate current levels, above a few hundreds of milli-amperes it is no longer practical to simply use a linear regulator to generate these system voltages. As a result, over the last several years, primarily due to thermal constraints, switching regulators have been replacing linear regulators. The benefits of a switcher, including the increased efficiency and smaller footprint, outweigh the additional complexity and EMI considerations.

For a switching regulator to be considered for use in an automotive environment, it needs the following features and characteristics at a minimum:

- A wide input operating range
- Good efficiency across a wide load range
- Low quiescent current during normal operation, standby and shutdown
- Low thermal resistance
- Minimal noise and EMI emissions

However, it is low quiescent current in a standby mode that is in high demand due to the large number of "always-on" systems that are still in operation even when the vehicle is parked. Examples include remote keyless entry, GPS location/tracking and alarm systems. A key requirement for these applications is a low quiescent current. A regulator would need to run in normal continuous switching mode until the output current drops below about 100mA. Below this level, the switching regulator must skip pulses in order to maintain load regulation. However, it can go into a sleep mode between pulses where only a portion of the internal circuitry is powered. At light load currents, a switching regulator needs to switch automatically to Burst Mode® operation. In this mode, the quiescent current should drop below 100uA for a 12V to 3.3V converter, as an example. The internal reference and power good circuit can remain active in sleep mode to monitor the output voltage.

Although switching regulators generate more noise than linear regulators, their efficiency is far superior. Noise and EMI levels have proven to be manageable in many sensitive applications as long as the switcher behaves predictably. If a switching regulator switches at a constant frequency in normal mode, and the switching edges are clean and predictable with no overshoot or high frequency ringing, then EMI is minimized. A small package size and high operating frequency can provide a small tight layout, which minimizes EMI radiation. Furthermore, if the regulator can be used with low ESR ceramic capacitors, both input and output voltage ripple can be minimized, which are additional sources of noise in the system.

Linear Technology continues to provide a wide array of products that meet all of the demands in automotive systems, these include:

- Wide input voltage ranges: 3.6V to 60V (and some up to 100V)
- Low quiescent current in standby mode: Typically less than 100μA and as low as 13μA.
- Minimal output noise and low EMI: less than 25mVpp for switching regulators and less than 100μV for linear regulators
- Extended temperature ranges: guaranteed 150°C ambient and junction temperature operation (H grade)
- High efficiency: up to 95% at full load and as high as 70% under light load conditions
- Low thermal resistance packages: as low as 10°C/W (θjc)
- High switching frequency operation: up to 2.8MHz
- High current densities: up to 2A of continuous output current from 3mm x 3mm DFN packages
- Industry leading FIT rates: typically less than 1

Conclusion

It is clear that Chinese automotive electronics will be a significant opportunity for semiconductor vendors going forward – particularly analog IC suppliers in the power management and conversion segment. As a result, those vendors who have worked on these types of products with the automobile manufactures in the USA, Europe and Japan will have the pole position in the Chinese market.

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Automotive Cold Cranking Design Considerations

Two-switch, buck-boost topology provides optimal solution

The wide input voltage range under cold crank conditions experienced in automotive applications, often require a buck-boost topology. This article explains cold crank requirements in detail and offers two different solutions; the conventional solution uses a SEPIC topology while the newer solution is a multiple switch buck-boost topology. Here, National discusses the advantages and disadvantages of each solution and demonstrates the benefits of a two-switch buck-boost topology versus the more traditional SEPIC.

By Michele Sclocchi and Frederik Dostal, Application Engineers, National Semiconductor

The cranking in an automobile, when the combustion engine is started with the electric starter motor, consumes a lot of power from the car battery. This heavy load causes the battery terminal voltage to reduce momentarily. The worst-case condition is aptly called 'cold crank', which applies to very cold temperatures. The friction of the combustion engine is at its highest at these temperatures, thus requiring more mechanical force to turn over, or crank, the engine. The peak currents in the electric starter motor are significantly higher under these conditions than during an engine start in 'normal' temperatures. The second influence under cold crank conditions is that the terminal voltage of the car battery is reduced, especially if the battery is old.

These two effects together, result in the supply voltage at the automobile's battery to be at its lowest. The ISO7637 norm defines a basic cold crank voltage waveform. Figure 1 shows such a voltage behavior during cranking condition. There are usually two levels defined, the lowest voltage level right when the electric starter motor gets going and the initial mechanical friction has to be overcome and then, the higher voltage level during which the mechanical system is running. Finally the system voltage goes back to nominal after the electric starter motor is turned off.

The values for Vlow and Vrecovery differ greatly from manufacturer to manufacturer and are defined in individual manufacturer's group norms, which are mostly based on ISO7637. Even within a single automotive manufacturer, there can be multiple 'cold crank' severities defined. Some electronic systems in the car may not need to operate down to the lowest voltage levels. Other systems, especially engine management control electronics, will be required to operate to the lowest voltage cold crank could possibly cause.

Automotive subsystems such as car radios, navigation systems and hands-free car kits often have the requirement to stay alive during cold crank conditions.

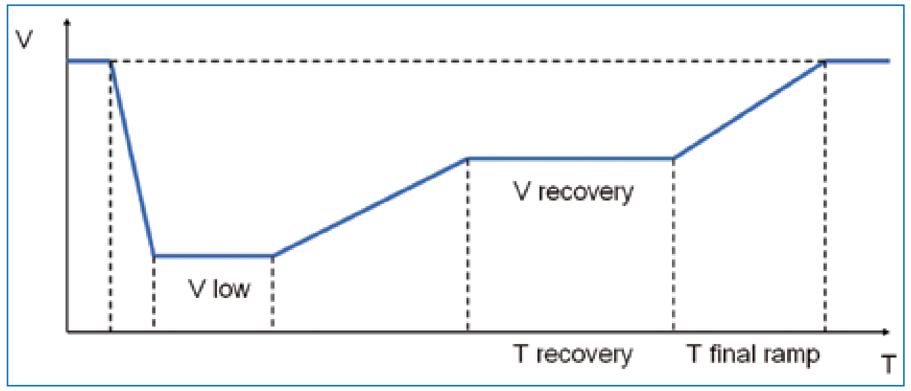

Figure 1: Typical cold crank voltage waveform.

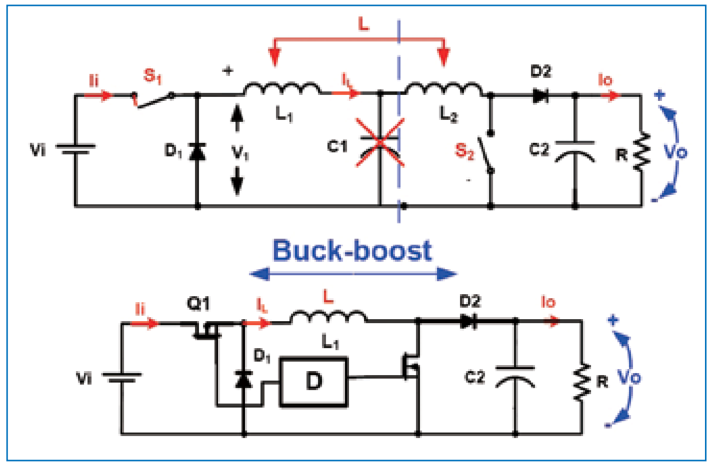

Figure 2: Buck-boost topology obtained with a buck converter in cascade with a boost.

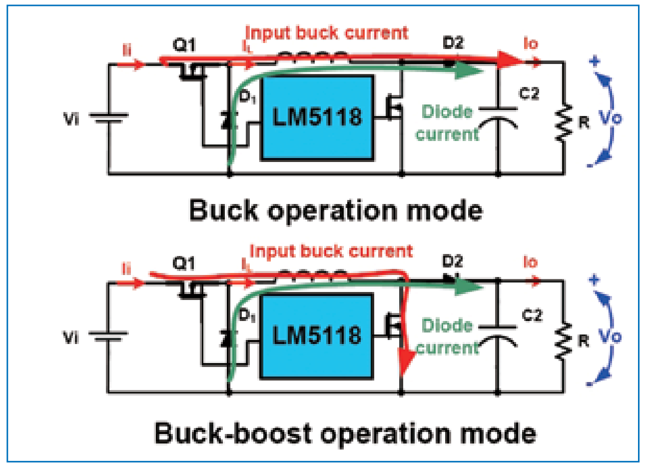

Figure 3: a) Buck operation mode, b) Buck-boost operation mode.

Under these wide-input voltage conditions, the output voltages of the power supply should remain in regulation whenever the input voltage is either greater then or less than the output voltage. This typical step-down and step-up functionality can be achieved by a buck-boost topology.

Single inductor dual switch buck-boost mode

Buck-boost configuration can be obtained from a cascaded combination of a buck converter and a boost converter. As shown on top of figure 2, the output capacitor of the buck stage can be omitted and the output inductor of the buck stage can be combined together with the input inductor of the boost stage, obtaining a single inductor dual switch buck-boost solution as shown on the bottom of figure 2.

In order to provide a precise output voltage regulation over the wide input voltage range, the two switching MOSFETs should be driven with an appropriate control scheme, providing a smooth transition from buck to buck-boost mode.

The controller operates in three different modes upon the input-output conditions:

- Buck Operation $V_{in} > V_{out}$: the regulator operates as a conventional buck regulator if Vin is greater than Vout by a sufficient margin. The buck transfer function is $V_{out}/V_{in} = D$, where D is the duty-cycle of Q1.True buck operation mode guarantees best efficiency and regulation. When Vin decreases relative to Vout to a point where the duty-cycle approaches 70%, then the boost switch is activated with a minimal duty-cycle and the regulator enters a soft buck-boost mode. (Figure 3a)

- Buck-Boost Operation $V_{in} \approx V_{out}$: as Vin further decreases towards Vout, the duty-cycle ratio of the buck switch decreases, while the duty-cycle ratio of the boost switch increases at the same time, providing a smooth transition from buck operation mode to boost operation mode.

- Buck-Boost operation $V_{in} < V_{out}$: As Vin further decreases below Vout, the duty-cycle of both the Buck and Boost switches are the same. The converter is in full Buck-Boost mode. The buck-boost transfer function is $V_{out}/V_{in} = D/(1-D)$, where D is the duty cycle of both switching MOSFETs Q1 and Q2. (Figure 3b)

With this operation mode, the output voltage remains stable as V_{in} approaches Vout because there is no 'bouncing', but a gradual shift between buck and buck–boost modes.

Emulated peak current mode control scheme

In order to ensure output voltage regulation with a wide input voltage range, a PWM current mode scheme must be used, since current mode control provides inherent line feed-forward, cycle by cycle current limit and easy closed loop compensation.

The only practical limitation associated with a traditional current mode scheme is the sensitivity to noise on the current sense path and difficulties to operate with small duty-cycles necessary in high input voltage applications.

An improved current mode control scheme, developed by National Semiconductor to mitigate these limitations, is the emulated current mode.

Emulated current mode reconstructs the inductor ramp current by measuring the current at the end of the switching cycle in the free-wheeling diode and adding on top of it a ramp that is proportional to the current ramp in the inductor.

To emulate the ramping portion of the inductor's current an external capacitor is charged with a constant current proportional to the difference between the input and the output voltage. The resulting ramp voltage at the capacitor is proportional to the ramping current in the inductor itself. For duty-cycles greater than 50%, current mode control circuits are subject to sub-harmonic oscillation. Adding a fixed slope voltage ramp signal (slope compensation) to the current sense signal prevents this oscillation.

Another advantage associated with emulated current mode, is that during short circuit and overload conditions, the inductor current cannot run-away since it is sampled before the buck switch is turned on. If the inductor current is excessive, cycles will be skipped until the current decays below the overcurrent threshold.

SEPIC topology versus single inductor buck-boost mode

Another topology often used to achieve output regulation over wide input voltage requirements is the SEPIC topology, which is a combination of a boost/buck-boost stage followed by a buck stage. SEPIC stands for Single Ended Primary Inductance Converter. “Single-ended” means that only one switch it used to gate energy into the converter.

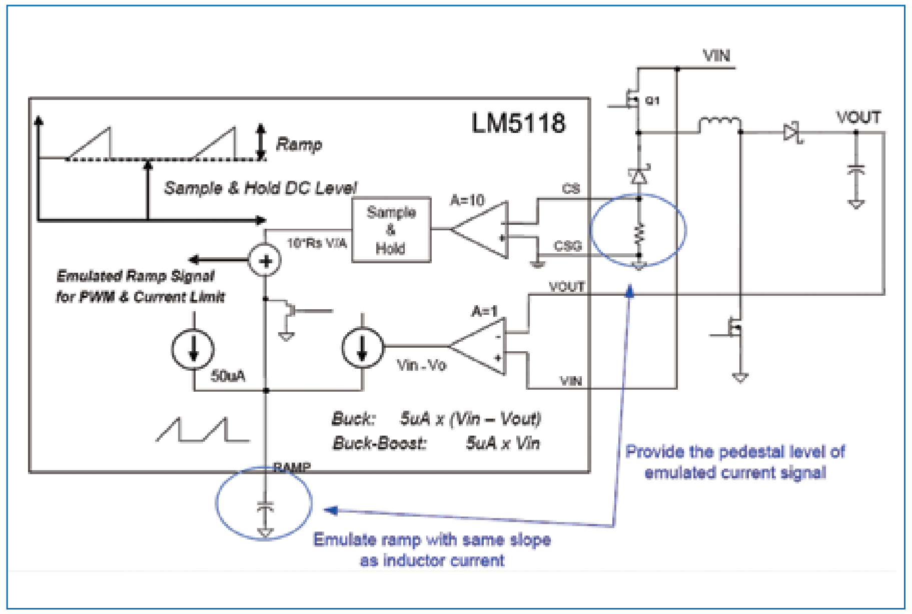

Figure 4: Emulated current mode scheme of the LM5118 buck-boost controller.

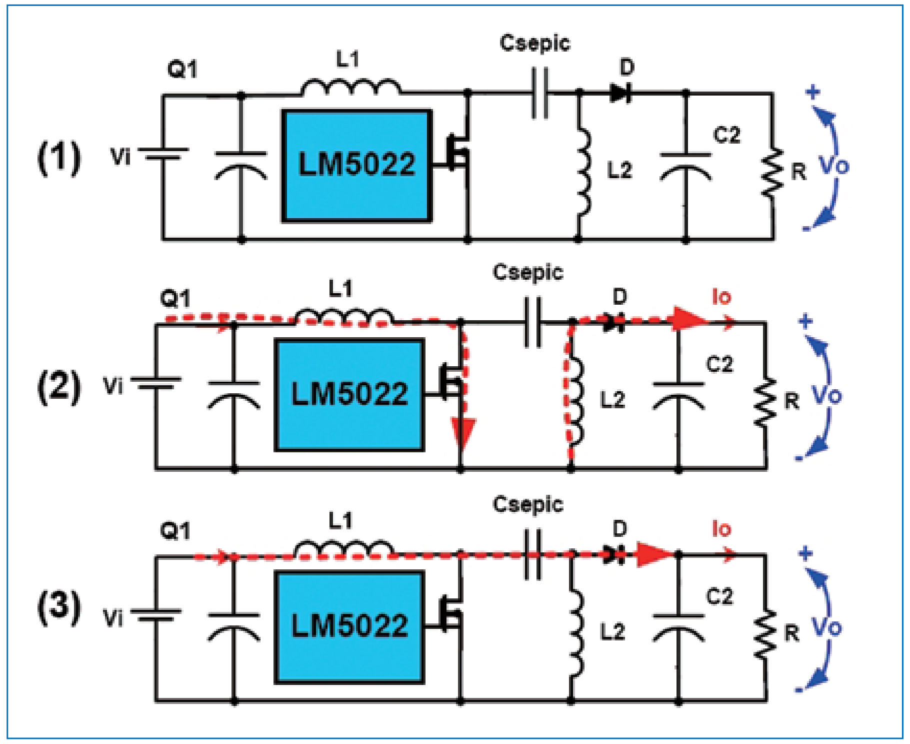

Figure 5: Three stages of the SEPIC topology.

The functionality of a SEPIC converter can be explained by reviewing the three main stages of commutations in figure 5:

1) The initial state of a SEPIC before the switch closes is shown at the top of figure 5. The SEPIC capacitor has charged to V_{IN}. The output is 0V, and no current is flowing in any of the components.

2) When the switch turns on, VIN is applied across the inductor L1. Current ramps up through L1, which stores energy (just like in a boost topology).

VIN is also applied across L2. This voltage comes from the SEPIC capacitor. The SEPIC capacitor starts dumping its energy into L2 by ramping current through L2. The diode is reverse biased during this time.

Now current is flowing in both inductors which can not change instantaneously when the switch opens again.

3) The switch opens. Current through L1 has no place to go but through the SEPIC capacitor to the output capacitor and the output. The current through L2 must also go to the output.

In order for the current to continue to flow through L1, the voltage on the switch “boosts” up to $V_{IN}+V_{OUT}+V_{DIODE}$. The current flowing through the SEPIC capacitor charges it up again to enable it to transfer this energy to L2 when the switch closes.

There is an energy balance between the SEPIC capacitor and L2, which helps determine the value of the SEPIC capacitor. Keeping the value of the SEPIC capacitor low helps ensure stable operation.

The efficiency of a SEPIC converter is somewhat lower then a pure boost or buck topology. This is mostly due to the increased number of external components involved. The second power inductor, as well as the SEPIC capacitor in the power path, add their losses to the overall efficiency consideration.

The SEPIC capacitor is the most critical element in a SEPIC converter because the total output power passes through it, which practically limits this topology to lower power applications.

In comparing the buck-boost topology with the SEPIC topology, buck-boost requires only one inductor and one less capacitor. When the input voltage is greater than the output voltage, which is in most cases for a typical automotive application, the converter operates as a buck converter, providing lower output ripple, higher efficiency and better load-line transient regulation.

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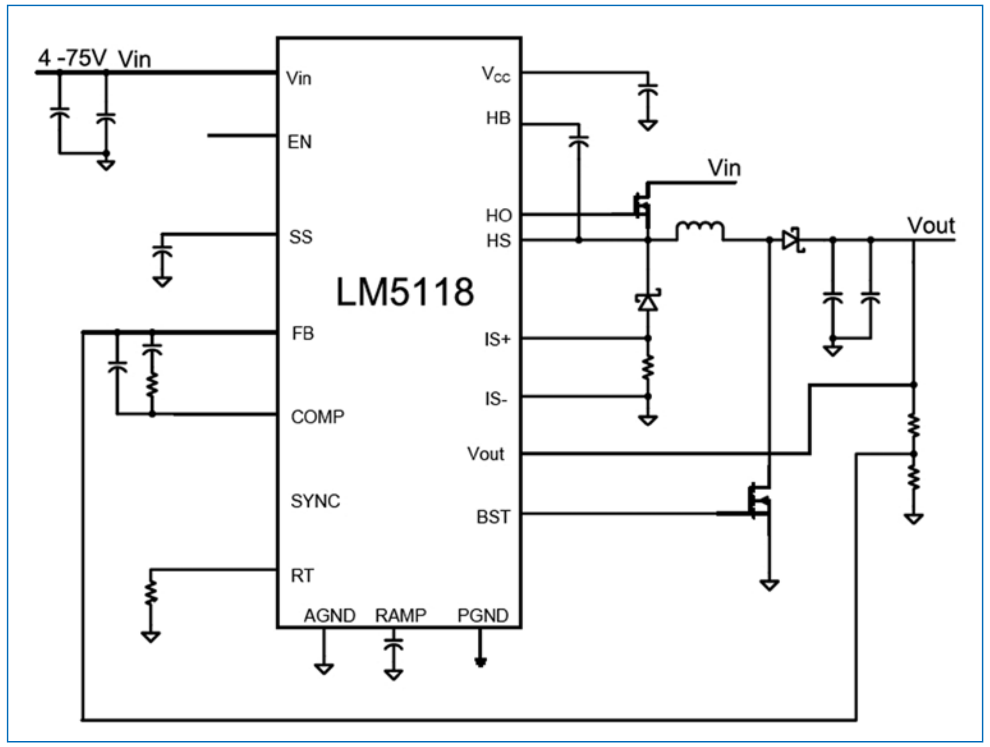

Figure 6: Wide input voltage range buck-boost power supply with National’s LM5118 controller.

In addition, a SEPIC topology could cause higher EMI noise due to the SEPIC capacitor parasitic effect.

Figure 6 shows a practical realization of a buck-boost topology using the LM5118 emulated current mode buck-boost controller.

Conclusions

The single inductor buck-boost controller offers several advantages to the designer in automotive cold crank applications, providing higher efficiency, higher dynamic performance and lower EMI noise versus conventional SEPIC converters.

www.national.com

Acoustic Inspection of Heat Sink Attach

Automotive thermals need specialized treatment

One of the key requirements for a power device used in an automotive environment is the removal of heat to prevent the device from overheating and failing. Heat transfer techniques such as fluid coolants and fans, often used in less demanding applications, are generally not suitable for automobiles.

By Steve Martell, Manager, Technical Support Services, Sonoscan, Inc.

The typical mechanism for heat transfer is the intimate bonding of a metal heat sink to the power device. A hybrid electronic module, for example, may be attached by solder or by a thermal interface material (TIM) to a base metal plate that serves as the heat sink. A small device such as a TO package may be bonded directly onto a heat sink. The heat sink is designed to achieve the level of thermal transfer required to avoid failure, but whether the desired level of thermal transfer is actually achieved depends largely on the quality of the bond and the integrity of the interface material.

A common reliability problem in heat sinks is the excellent insulating ability of air. During the assembly process, it is not unusual for air bubbles to become trapped in the solder or other bonding material. After the bonding material has hardened or cured, the bubbles are permanent voids within the material. The overall effect of the voids is to shrink the contact area because voids are an efficient mechanism for limiting thermal transfer. If the total area of voids is great enough, the power device will fail. Cracks within the bonding material and delamination of the bonding material from one or both adjoining surfaces also occur, and also interfere with thermal transfer, but both of these defects are much less frequent than voids.

Voids in the bonding material cannot be seen visually, and may be difficult to distinguish with X-ray. They can be made visible by physically cutting the assembly apart, but this method is destructive and so time-consuming that any data acquired may be gathered too late to make effective changes in production processes.

Acoustic micro imaging provides a non-destructive method that images various types of internal features, including voids, and leaves the assembly intact and still suitable for production. The method is widely used for non-destructive evaluation of electronics assemblies generally. One of its most frequent uses in automotive applications is the evaluation of the attachment of heat sinks.

An acoustic microscope uses a scanning transducer that serves two purposes: it pulses ultrasound into the target and receives the return echoes from the interior of the target. For example, an assembly may be positioned with the external surface of the heat sink upward (Figure 1). The transducer scans back and forth across this surface, pulsing and receiving return echoes several thousand times a second.

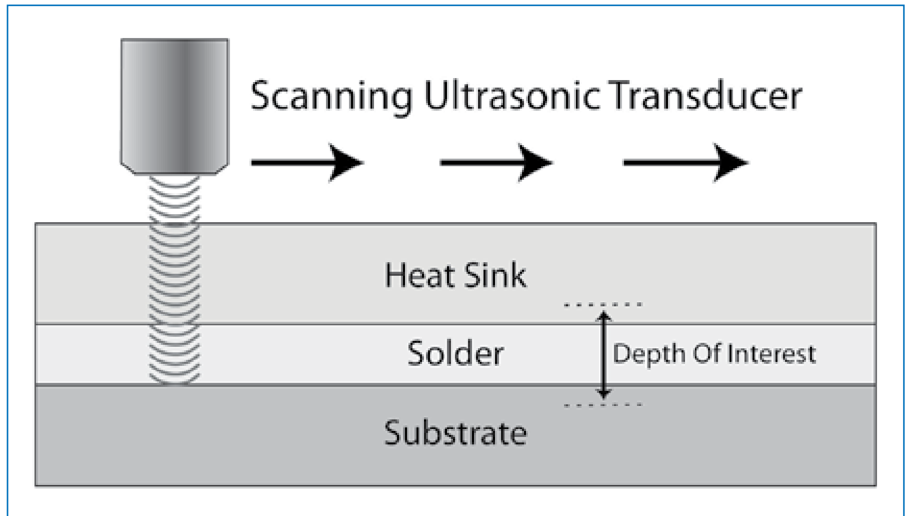

Figure 1: The scanning transducer of an acoustic micro imaging system pulses ultrasound into the target and receives echoes from the depth of interest.

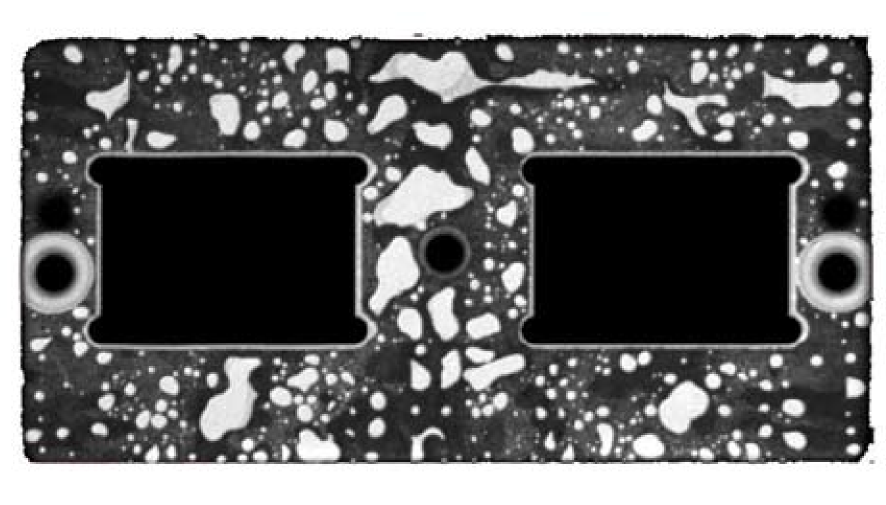

Figure 2: Irregular white areas are voids in the acoustic image of the solder attach of a heat sink coin.

The only ultrasonic reflections that come back to the transducer are from the interfaces between materials. As the ultrasound travels through the bulk metal of the heat sink, it sends back no reflections. However, at the interface between the heat sink and the solder, some portion of the ultrasound will be reflected while the rest of the ultrasound will travel deeper and be reflected from the next interface. This pattern is continued throughout the layers being inspected.

The reflections from multiple interfaces are generally not all used in a single acoustic image. Instead, the reflections used for a particular acoustic image are limited to a specific arrival time that defines the depth of interest within the assembly. If the depth of interest is the TIM/solder layer bonding the heat sink to a substrate, as shown in Figure 1, the time window (gate) would extend from just above the solder-heat sink interface to just below the die interface with the TIM/solder material.

After each pulse of ultrasound, one return echo is captured and is converted into one pixel in the acoustic image. At a location where the heat sink is firmly bonded to the solder, the amplitude of the reflection will be moderate and the

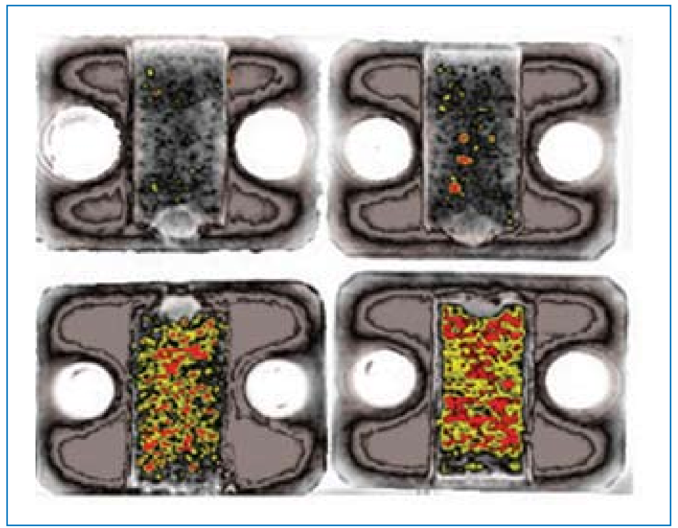

Figure 3: Four power devices out of many imaged automatically in a tray. Red and yellow areas are defects in the bond of a heat sink to a silicon die.

Figure 4: Red area is a delamination of mold compound from the substrate around this power device die. Loss of heat transfer will be small, but the delamination invites moisture and corrosion.

pixel will be gray. But if the reflection comes from an interface between the heat sink and air – in other words, from a location where there is a void in the solder – the amplitude of the reflection will be much higher, and the pixel will be bright white. Voids, delaminations and cracks that contain air or another gas, reflect virtually 100% of the ultrasound that strikes them and are imaged far more brightly than other features in the acoustic image.

Figure 2 is the acoustic image of a heat sink coin that has been soldered to the surface of a board. The two cutouts will hold power devices mounted on the other side. The echoes used to make this image were reflected from the interface between the heat sink and the solder. The heat sink is continuous across the entire image, including the cutouts, but the coin itself is not visible because it is a continuous bulk material and does not send back a reflection.

The white areas in the coin-to-solder interface are voids. They are numerous and cover such a large area of the bond that they will compromise the intended thermal transfer across the interface between the solder and the heat sink. Automated analysis of the total area of the voids showed that they occupy 26.3% of the intended bond area.

Although power devices having heat sink can be imaged individually on a laboratory-style acoustic microscope, it is more efficient to use automated acoustic microscope systems, especially where the volume of parts is high. The parts move on conveyors in trays designed to handle multiple parts. Trays can be stacked and fed through the acoustic system, and restacked after inspection. Alternately, external handling equipment can feed the trays into and out of the automated acoustic microscope. The collected data is automatically analyzed to identify each part as accept/reject. The exact criterion for accept/reject are determined by the user of the system and are stored in a library of programs that control tray handling, imaging and analysis for a range of part types.

Figure 3 is the acoustic image of four parts in a tray of power devices. In this image, a color map was used to highlight the defects. The depth of interest is the solder bond between a metal heat sink on top and a silicon die. The vertical rectangle in each part is the bond area. Red and yellow areas indicate high-amplitude reflections, and therefore represent poor contact and voids in the solder. The two parts in the top half of Figure 3 have few defects and would pass inspection. The two parts at the bottom of Figure 3 however, have extensive areas of voiding and would be rejects.

Figure 4 is the acoustic image of a power device from the top side, looking through the epoxy mold compound. The heat sink lies underneath the die, which is the gray rectangle at the center. Red and yellow areas indicate the delamination of the mold compound from the heat sink. Note, however, that the die itself is not disbonded from the heat sink. The gap between the mold compound and the heat sink will result in a minor reduction in thermal transfer, but most heat is transferred directly from the die down to the heat sink. The delamination is a reliability concern, but for a different reason: it may become a collection point for moisture that will promote corrosion within the device.

A newly developed technique permits acoustic microscopes to measure the thickness of an internal layer such as a bond layer very accurately. The technique was developed for measuring very thin (around 75 microns) thermal interface material between heat sinks and advanced flip chips, but can also be used on thicker internal layers.

The coverage, integrity and thickness of any thermal interface material between a heat sink and the device being cooled are critical for its optimum performance over its expected operating lifetime. The reliability of the device and the automobile that relies on the function of the assembly incorporating it will be compromised by these small, yet significant details.

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Special Report – Automotive Electronics Part I

Automotive Resettable Circuit Protection Devices

Designing for harness protection applications

Vehicle manufacturers need to find increasingly more efficient solutions to help protect power window, power seat, power outlet and other human interface functions against damage from high-current and high-voltage fault conditions in order to reduce warranty repair costs and improve user satisfaction. At the same time, the wiring harness architecture of automobiles has undergone considerable change as vehicle electrical and electronic content continues to increase.

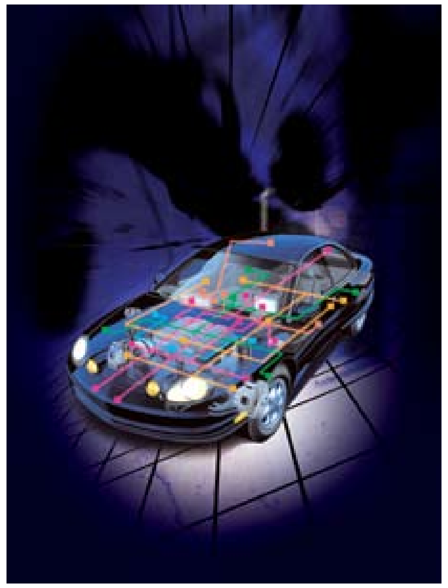
By Guillemete Paour, Global Market Manager, Raychem Circuit Protection Products, Tyco Electronics

A vehicle's ideal harness scheme has a hierarchal, tree-like structure with main power trunks dividing into smaller and smaller "branches," and with overcurrent protection at each node. This system allows the use of smaller, space-saving wires that can reduce weight and cost. It also optimizes system protection while providing fault isolation, which ultimately improves reliability.

Figure 1 shows a greatly simplified version of a partially distributed architecture, with each junction box either feeding a module directly or feeding another nodal module which supplies peripheral loads. Although this harness scheme offers many advantages, the sheer number of circuits being employed in today's automotive applications makes this type of approach difficult to realize in actual practice. With many tens of circuits emanating from an electrical center, it has become almost impossible to route all the wires in and out of a single box, and at the same time place it in a driver-accessible location.

As a result, system designers have resorted to harness design solutions that end up canceling out some of the desired end-benefits, such as:

(i) combining loads that sacrifice wire-size optimization and fault isolation;



(ii) burying electrical centers where they are only accessible by trained service personnel, at increased cost;

(iii) routing back and forth between various functional systems, increasing wiring length, size and cost. For example, an HVAC system may pass power output protection and switching functions such as vent motors, blower fan and A/C clutch, to the junction box and power distribution center where its relays and fuses will be located, as shown in Figure 2a.

Using resettable circuit protection devices that do not need to be driver accessible, such as polymeric positive temperature coefficient (PPTC) devices, offers designers a number of solutions that may be used separately or in combination. As shown in Figure 2b, a single junction box located in the instrument panel may still be employed. Instead of being positioned close to the conventional fuses however, PPTC devices can be located inside the box, saving frontal area and placing them close to the connectors. This also reduces the volume consumed by whatever system is used to bus current around the box.

Alternatively, the electrical centers can be divided into smaller units and relocated around the vehicle with no need to consider accessibility. Furthermore, with the availability of self-resetting circuit protection and the very high reliability that can now be expected from relays, modules can switch and protect their own output loads and still be positioned without consideration for any user access.

In these ways, the use of PPTC devices allows the electrical architecture to more closely reflect the ideal tree structure with its intended benefits.

Through-hole devices lend themselves to use in fuse boxes using circuit boards or IDC wired busses, while strap devices

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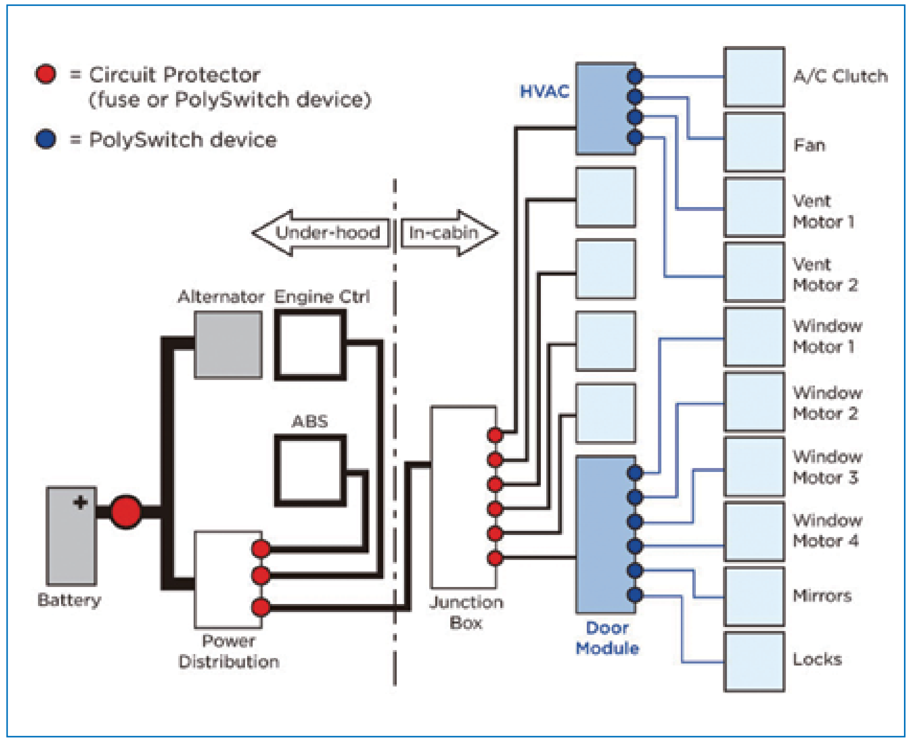

Figure 1: A partially distributed automotive harness architecture.

can be used in those that use metal fret routing. PPTC devices are available in a wide variety of current ratings, including lower current ratings than conventional fuses and are therefore more appropriate for use in protecting command functions.

If the electrical center or module incorporates a printed circuit board then surface mount PPTC devices can provide further packaging benefits.

Additionally, a new generation of PPTC bladed devices, as shown in Figure 3, can be inserted like a fuse or bi-metal breaker in the junction box. Designed to help provide resettable overcurrent protection for passenger vehicle wire harnesses using 12V battery systems, the PPTC bladed contact device features a 2.8 mm form factor to facilitate easy, one-to-one replacement of both mini-sized fuses and bi-metal circuit protection devices.

Even though these devices are resettable and need not be user-accessible, the bladed form factor allows the designer to replace a fuse or a bi-metal device without modifying an existing junction box design.

Conventional Technologies Vs. PPTC Devices

Fuses are single use devices that must be replaced when they blow. This characteristic requires that fuses be mounted in accessible fuse boxes—a requirement that dictates system architecture and forces packaging and system layout compromises. In contrast, PPTC devices latch into a high-resistance state when a fault occurs. Once the fault is removed and the power is cycled, the device automatically resets and the protected system is restored to normal operation.

Fuses have nominal current ratings from 2A to 30A in the same form-factor and are often substituted for ones that are larger than the design value or are jumped out of circuit when used in delocalized modules. In comparison, PPTC devices offer the added benefit of not being readily accessible, and so cannot be easily changed or substituted by the user.

When compared to bi-metal circuit protection devices, which typically cycle several times before latching, PPTC bladed devices use a resistance switching action to interrupt current. In addition to their resettable functionality, the PPTC bladed devices offer high resistance to shock, vibration and rough handling, lower surface temperature and power dissipation, and flatter thermal derating.

Protection Requirements

Automotive wiring harnesses must be protected from damage and fire hazards in the event of a short circuit in the vehicle wiring. Circuits typically require 0.10 to 30A of current at system voltages of 14V for 12V battery systems (28V for 24V battery systems found in trucks and busses).

Industry standards also play an important role in the design of a vehicle's electrical/electronic system. AEC-Q200, a stress test qualification for passive components, includes test requirements for PPTC devices used in the automotive environment. The test plan includes a series of electrical and environmental stress tests that require electrical verification prior to and after each stress. The electrical verification tests are designed to test that parts meet performance specifications for resistance, time-to-trip (TtT) and hold current at three different temperatures (-40°C, 25°C and max T).

Tyco Electronics has developed test procedures that define performance limits prior to and after the qualification stress tests and has included them in an internal specification. The PS400 specification encompasses the AEC-Q200 standard for PPTC devices. It incorporates relevant physical, functional, environmental, electrical, and mechanical requirements specified in a variety of ANSI, ISO, JEDEC, UL and military standards.

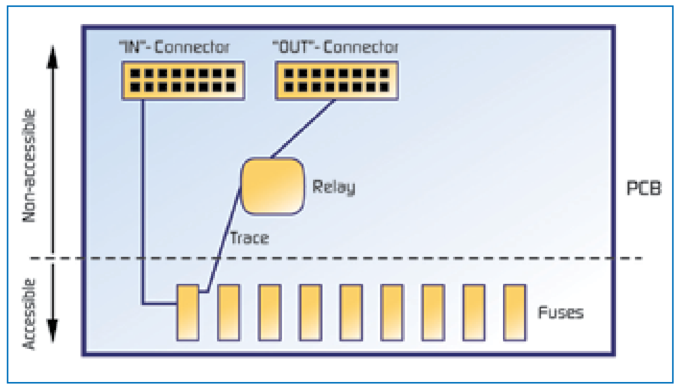

Figure 2a: Conventional current routing.

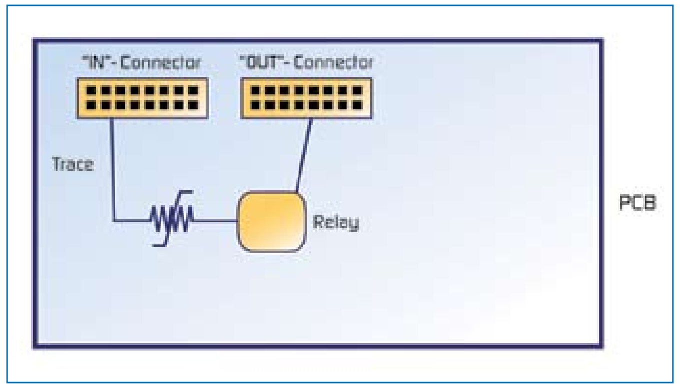

Figure 2b: Current routing using PPTC device.

Figure 3: PPTC bladed devices.

Conclusion

When it comes to harness protection in automotive applications, resettable PPTC devices offer benefits over conventional solutions to help protect automotive wiring harnesses from damage and fire hazards. They also facilitate designs that more closely reflect the ideal tree structure. A new generation of bladed PPTC devices also permits direct replacement of mini-sized automotive fuses and Type I or Type II bi-metal breakers.

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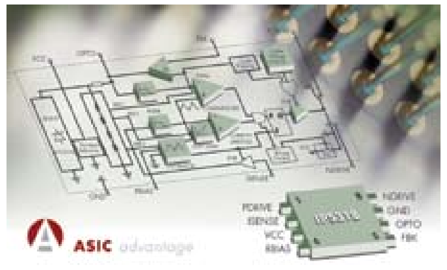
New Automotive Family of Enhanced LV SMPS Controllers



ASIC Advantage (AAI) has announced a new group of SMPS controllers in the Power Management family targeted for lower voltage applications. Consisting of the IPS315, IPS315H, and IPS318, this group is a low input voltage version of AAI's IPS15, IPS15H, and IPS18 controllers, respectively. Operating from input voltages as low as 7.2V, these controllers are ideal for lower voltage battery driven applications such as automotive.

The IPS315, IPS315H, and IPS318 share the same basic core features as their original counterparts, the IPS15, IPS15H, and IPS18. All devices incorporate an internal error amplifier and voltage reference for direct feedback into the controller allowing for soft start and active PWM. A shunt regulator, operating much like a zener diode, steadies the supply voltage around a typical value of 7.2V allowing maximum flexibility for powering the chip. Other principle core features include a precision oscillator, power shutdown for standby modes, undervoltage lockout, and thermal shutdown protection.

The IPS315 provides cycle-to-cycle over-current protection by using the ISENSE pin to monitor a current sense resistor connected to the source of the power MOSFET. If the voltage detected at ISENSE is over approximately 700mV, the chip will turn off the driven MOSFET. This ensures cycle-to-cycle protection of the MOSFET allowing for operation of the power supply in constant power mode.

The IPS315, IPS315H and IPS318 are offered in RoHS compliant 8-Pin PDIP or 8-Pin SOIC package options. Pricing in quantities of 1k begin at $0.22 for the SOIC package and $0.27 for the DIP version, with lower pricing available for higher volumes.

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New Automotive 4-Channel High-Side Control/Driver

The A3942 from Allegro is a 4-channel high-side MOSFET control/driver IC designed to provide an efficient interface between a system controller and the various high current inductive loads typically found in automotive engine control systems.

The device, which complements Allegro's existing automotive MOSFET pre-driver family, is designed to drive four N-channel MOSFETs in a high-side configuration with gate drive outputs that use a current-source topology, thereby eliminating the need for bootstrap capacitors.

Offering a high degree of flexibility for automotive engine control systems, it is designed to operate over a very wide voltage range (4.5 V to 60 V) and over the full automotive temperature range, making it an ideal choice for both 12 V and 24 V engine control systems.

The four outputs can be controlled with either four parallel input lines, or through an integrated serial peripheral interface (SPI) which greatly increases the flexibility of the IC by allowing software control of channel-specific blanking times for short-to-ground detection.

Extensive fault protection and diagnostic capabilities include use of the serial port to output a wide range of diagnostic signals to the controller via a serial data output pin. The A3942 provides full protection against open-load, short-to-ground and short-to-battery events, and reports all diagnostics back to the controller. Short-circuit fault thresholds can be adjusted on a 'per channel' basis with inexpensive external resistors.

Multiple A3942 devices can share an SPI interface by either connecting them in parallel or in a 'daisy chained' series using the chip select pin to address the appropriate IC. A 'sleep' mode is provided to reduce the quiescent current draw to less than 10A. The A3942 is supplied in the automotive 38L TSSOP package.

www.allegromicro.com

AUTOSAR for Engine Management Systems

Magneti Marelli Holding S.p.A. has introduced AUTOSAR-compliant development for its engine management systems. The Italian automotive supplier is using SystemDesk, dSPACE's system architecture software, for this purpose. SystemDesk is specially designed for planning, implementing and integrating complex system architectures and distributed software systems as described in the AUTOSAR standard.

This activity is part of a specific Magneti Marelli S.p.A. project: "Magneti Marelli Autosar Cross-Project X-PRO" that involves all Magneti Marelli divisions (Automotive Lighting, Powertrain, Electronic System, SDC Synaptic Damping Control).

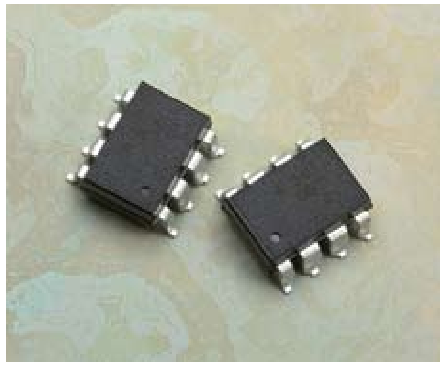
The starting-point for this project is an existing Magneti Marelli engine control unit (ECU) whose software is being completely migrated to AUTOSAR and re-implemented on the same ECU.

SystemDesk was used to design the entire software architecture and to implement the scheduling of all tasks. The volume of data to be handled for this was impressive: several thousand variables including their exact data types, scaling factors and min/max values. More than a hundred AUTOSAR software components were specified and the runnables they contain were configured according to the task schedule defined by Magneti Marelli.

When the architecture specification was complete, the supplier generated the run-time environment (RTE), the software layer that is essential for AUTOSAR systems. This was done directly from within SystemDesk.

www.magnetimarelli.com

New Automotive Grade 2.5A Gate Drive Optocoupler



Avago Technologies has announced a new gate drive optocoupler targeting automotive hybrid electric vehicle applications. Designed to met stringent automotive AEC-Q100 guidelines, the new ACPL-312T provides 2.5A maximum peak output current to drive high powered IGBTs/MOSFETs and operates up to a high temperature rating of 125°C. Additionally, a propagation delay of 0.5 µs allows the circuit designer to reduce switching dead time and improve inverter efficiency.

Avago manufactures automotive optocouplers that support TS16949 requirements and are qualified for automotives electronics council (AEC) guidelines under extreme environmental test conditions. The test is performed under AEC-Q100 stress test guidelines that is suitable for operating in automotive applications. In addition to automotive requirements, the ACPL-312T optocouplers meet worldwide safety standards (UL1577, EN/IEC 60747-5-2 and CSA).

Avago' s ACPL-312T optocoupler leverages an automotive-grade LED that was developed and produced in-house. The gate drive optocoupler has an enhanced construction with superior thermal conductivity, making it suitable for isolation needs in automotive, industrial inverters and power management applications over operating temperature from -40°C to 125°C. It offers high CMR (min 25 kV/µs @ VCM = 1500V) which makes it excellent for noise elimination and provides under voltage lockout (UVLO) for additional product protection.

www.avagotech.com

Power Supply Sets New Power Density Benchmark

Enpirion has announced a 9A DC-DC converter that sets a new standard for power density by delivering over 76 Watts per square inch (over 11 Watts per square centimeter). The EN5395QI features Enpirion's proprietary integrated-inductor technology and ultra-high switching frequency, enabling the PwrSoC (power supply on a chip) to achieve high noise immunity with a very small footprint. The part also offers two options for setting the output voltage, providing the utmost flexibility for the user.

Enpirion's 9A synchronous buck PWM DC-DC converter integrates the inductor, MOSFETS, and controller into a 10 x 12 x 1.85 mm package. The part requires as few as five external MLCC capacitors for a complete power management solution, with a total footprint of 250 sq mm. The EN5395QI delivers up to 30 watts of continuous output power, and achieves up to 93 percent efficiency.

In addition to small footprint, low part count, and low noise, the EN5395QI simplifies design due to output voltage scaling. Output voltage is programmed using a 3-pin voltage-ID (VID) input, allowing designers to choose one of seven pre-programmed output voltages. This allows developers to conserve power by optimizing the part's output voltage to each specific load requirement. It also provides the flexibility to use the same device for multiple solutions that require different output voltages. Increasing load current capacity is also simple – from 2 to 4 devices can be placed in parallel to provide a single load with up to 36A of output current.

The EN5395QI is a point-of-load power regulator designed to meet the precise voltage and fast transient requirements of low-power processors and SoCs used in a variety of markets, including storage, networking, computing, telecom, audio/video, and other distributed power architectures. With its low-noise PWM topology, the 9A part is ideally suited for noise-sensitive applications.

The EN5395QI is available now, and pricing is set at $8.10 for quantities of 1000 parts.

www.enpirion.com

PowerPack Power Systems Design

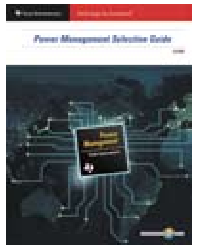
Fairchild Semiconductor

Enable Highly Efficient Two-Phase Switched Reluctance Motors with Fairchild's SRM-SPM® Modules

The FCAS20DN60BB and FCAS30DN60BB integrate two HVICs, one LVIC, four NPT IGBTs, four fast recovery diodes (FRDs), two bootstrap diodes, a thermistor and various protection functions in a single package. By integrating 14 fully tested power components in a compact 45mm x 28mm SIP package, these products offer 40 percent space savings for two-phase SRM motors in vacuum cleaners and other small motor applications. This space conservation allows vacuum cleaner designers to incorporate the controller into the SRM assembly, and also improves design productivity and manufacturability.

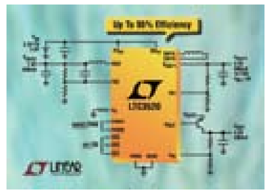
www.fairchildsemi.com/pf/FC/FCAS20DN60BB.html
www.fairchildsemi.com/pf/FC/FCAS30DN60BB.html

Texas Instruments



Texas Instruments offers a full line of high-performance products ranging from standard linear ICs to plug-in and integrated power solutions. And, TI makes designing easier with leading-edge support tools such as training, a broad selection of evaluation modules, application notes, data sheets and more. Visit **www.ti.com/analogelab** for complete information on all TI's analog training opportunities. Free samples and small orders (shipped within 24 hours via TI authorized distributors) are available to help accelerate your time-to-market. Download your copy of TI's Power Management Selection Guide for a comprehensive review of TI's complete line of high-performance power products...

Linear Technology



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

The LT3080 achieves high performance without any compromises. Featuring wide input voltage capability from 1.2V to 40V, it has a low dropout voltage of only 300mV at full load. The output voltage is adjustable, spanning a wide range from 0V to 40V, and the on-chip trimmed reference achieves high accuracy of +-1%. The wide V_{IN} & V_{OUT} capability, tight line and load regulation, high ripple rejection, low external parts count and parallel capability make it ideal for modern multi-rail systems.

www.linear.com

Magnetics

Magnetics is pleased to announce the addition of **XF**LUX™, a distributed air gap 6.5% SiFe material, to our existing powder core line. A true high temperature material, with no thermal aging, **XF**LUX offers lower losses than powder iron cores and superior DC Bias performance.

XFLUX cores are ideal for low and medium frequency chokes where inductance at peak is critical. One of the many challenges facing designers of high power circuits is maintaining inductance in the power choke at maximum load. **XF**LUX is the cost-effective solution to getting enough inductance in a reasonable size package.

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

www.mag-inc.com

Microchip Technology

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

Microchip announces 10 new 28- and 44-pin 16-bit Digital Signal Controllers (DSCs) for motor control designs requiring increased memory, performance, or enhanced peripherals, while obtaining cost and size savings by using lower pin-count devices. Additionally, Microchip announced five motor control software solutions for: Power Factor Correction (PFC), sensorless Field Oriented Control (FOC) of a PMSM motor, sensorless FOC of an ACIM motor, sensorless control of a BLDC motor using Back EMF filtering and sensorless BLDC control with Back-EMF Filtering Using a Majority Function.

www.microchip.com/DSCMOTOR

Companies in this Issue

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

Green – Colouring All Industries

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

There is much news on LEDs making huge advances in the automobile industry as efficient and anti-dazzle background illumination for dashboards and, as brake lights, replacing conventional light bulbs, as well as halogen and xenon lamps. Market researchers such as IMS Research estimated worldwide sales of LEDs in the automobile industry at $650 million in 2006; this is expected to double to $1,3 billion by 2016. The demand, due partly to mandatory daytime driving lights in an increasing number of regions, will lead to a growth in this sector from $5 million in 2007 to over $100 million in 2013.

As the profit potential of solar energy continues to draw big-name players, Intel and IBM did not waste time in jumping in. Intel has formed a new company called Spectra Watt to make photovoltaic cells for solar modules that will produce 60 megawatts-worth of solar cells a year, according to Chief Executive Officer Andrew Wilson.

The company received 50 million dollars from Intel Capital, the company's investment arm; Cogentrix Energy, a subsidiary of Goldman Sachs; PCG Clean Energy and Technology Fund; and Solon, a German solar company, according to Wilson. The company expects manufacturing to begin by mid-2009. Experts say the solar industry

will continue to see a 30 to 40% annual growth rate for the next several years.

IBM has announced new software designed to help customers around maximizing energy efficiency and reducing power and cooling costs.

The software is part of IBM's 'Project Big Green' initiative where it has committed $1 billion per year to deliver technologies that help customers increase energy efficiency in their data centers and physical plants.

From the latest version of IBM Tivoli Monitoring (ITM) software to 'green' data centers, and to energy savings of over 40% for an average data center, the company looks serious about its quest for greening.

The wind energy industry is growing rapidly on the back of technological advancements and political desire. Utility companies, independent power providers, institutional investors and oil companies are all seeking to capitalize on lucrative support mechanisms to unlock greater commercial and competitive advantages, meet their renewables targets and boost their green credentials. Strong growth therefore continues on the back of record sustainable energy investments, yet wind farm costs are now driving 'dot-com' comparisons as the economics of wind farming projects come under increasing pressure.

I am certain we'll see a continuous influx of news, but am always skeptical when major companies and especially government authorities announce 'green policies' for our future. Apart from the environmental concerns, it just makes good engineering sense to design this way. The difference is, in engineering there is a tangible objective with a tangible funding, commitment and output. All too often with these issues, corporations and governments are prone to green, but all too often, empty words. Only time will tell.

www.powersystemsdesign.com/greenpage.htm

Lower $R_{DS(on)}$ Higher Performance

Part Number	V_{DS} (V)	I_D (A)	$R_{DS(on)}$ Max V_{GS}=10V (mΩ)	Qg (nC)	Package
IRF2804PBF	40	270	2.3	160	TO-220
IRF2804SPBF	40	270	2.0	160	D^2-PAK
IRF2804S-7PPBF	40	320	1.6	170	D^2-PAK -7
IRFB3306PBF	60	160	4.2	85	TO-220
IRFP3306PBF	60	160	4.2	85	TO-247
IRFB3206PBF	60	210	3.0	120	TO-220
IRFS3206PBF	60	210	3.0	120	D^2-PAK
IRFP3206PBF	60	200	3.0	120	TO-247
IRFS3207ZPBF	75	170	4.1	120	D^2-PAK
IRF2907ZS-7PPBF	75	180	3.8	170	D^2-PAK -7
IRFB3077PBF	75	210	3.3	160	TO-220
IRFP3077PBF	75	200	3.3	160	TO-247
IRFS4310ZPBF	100	127	6.0	120	D^2-PAK
IRFP4310ZPBF	100	134	6.0	120	TO-247
IRFB4110PBF	100	180	4.5	150	TO-220
IRFP4110PBF	100	180	4.5	150	TO-247

- Tailored for Synchronous Rectification
- Optimized for fast switching
- Up to 20% lower $R_{DS(on)}$*
- Up to 20% increase in power density*
- RoHS Compliant
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