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July/August 2009

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Special Report - Automotive Electronics

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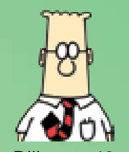

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Volume 1, Issue 4

Too Good to Fail…

Welcome to this very full Automotive-themed issue of Power Systems Design North America, featuring a full print issue and even more to be found online on our website.

Certainly, we have already seen many changes in this industry, particularly here in the US where controversy surrounds the future of this once-proud industry, which I believe will spring back to its former glory. It's just too important to be allowed to fail.

When a US federal judge in the GM bankruptcy case approved the sale of the troubled automaker's assets to a "new GM" he said that it was the only available means to preserve the continuation of the company's business.

US taxpayers now own 60% of the new GM, with other stakes held by Canadian governments, bondholders and the United Auto Workers union. Customers will be the top priority with the focus on value and the deployment of environmental technology.

A successful and swift move through bankruptcy was crucial to GM's restructuring and a key test of the Obama administration's efforts to rescue GM and Chrysler. Chrysler's bankruptcy was approved on June 1, just hours before GM entered Chapter 11.

Despite the current uncertainty in the auto industry, we have a huge crop of contributions from our power industry in this issue. The need for automobiles, like all products, falls in recession, but the need for differentiation goes on. The huge and increasing volume of power electronics in vehicles, even conventionally powered cars, is still rising. With the regulatory and environmental requirements for 'cleaner and leaner' designs and the advent of HEVs and electric vehicles, this requirement will not die.

Of course, we are all painfully aware that at the moment, business is suffering on many fronts; times are hard, shareholders need to be pleased, spreadsheets satisfied and as a result, many talented people have been 'let go'. Short term fixes such as these are widespread.

But this often spurs those same innovative and creative engineers to deploy their valuable skills in a more productive way; to utilize their outstanding engineering talents to develop designs for the good of the environment and its people in smaller, more responsible companies, design consultancies and start-ups, rather than just to satisfy corporate investors. There are more and more examples of this to be found within our industry and, naturally, within our magazine.

I hope you enjoy this issue, please keep your feedback coming, check out the expanded online content and don't forget to chuckle at our fun-strip, Dilbert, at the back of the magazine.

All the best!

Cliff Keys

Editor-in-Chief, PSDNA
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American Superconductor Receives Cable Order

American Superconductor Corporation (AMSC) announced that LS Cable Ltd. (LS Cable) has ordered approximately 80,000 meters (50 miles) of type 344 superconductors, AMSC's proprietary brand of second generation (2G) high temperature superconductor (HTS) wire. LS Cable will utilize the wire to manufacture a 22.9 kilovolt cable system that it will install in Korea Electric Power Corporation's (KEPCO) commercial power delivery network near the city of Seoul in 2010. Founded in 1962 and based in Anyang, South Korea, LS Cable is Korea's largest power cable manufacturer with nearly 8,200 employees worldwide and annual sales in excess of US$6 billion. This is the single largest commercial order for 2G HTS wire in the world.

Under the terms of the contract, AMSC will deliver the wire to LS Cable by the end of 2009. LS Cable will then strand the wire into a superconductor cable system capable of carrying 50 megawatts of power. The cable system will be nearly a half mile in length, making it the world's longest distribution-voltage superconductor cable system. It is scheduled to be installed by the middle of 2010 and energized in one of Seoul's largest satellite cities by the end of 2010.

A power cable made with HTS wire inside can conduct up to 10 times the amount of power of the same diameter cable made with copper wire inside. By replacing copper cables with high-capacity superconductor cables in cities using existing underground tunnels and ductwork, utilities can avoid digging up city streets while also relieving grid congestion and increasing the reliability and security of power networks.

New white paper on superconductor electricity pipelines

AMSC has published a white paper entitled "Superconductor Electricity Pipelines Carrying Renewable Electricity Across the U.S.A. Out of Sight and Out of Harm's Way." This paper details the benefits of direct current (DC) superconductor cables for long-haul transmission of renewable energy.

A significant challenge facing the U.S. in the near term will be carrying 100's of gigawatts of green power from the country's rural heartlands to urban load centers. Plans for interstate 765kV overhead power lines requiring 400- to 600-foot-wide rights of way are being considered. Placed underground in existing rights-of-way, Superconductor Electricity Pipelines could carry this same amount of power in a three-foot pipe. Superconductor Electricity Pipelines are much more efficient, cost competitive and, with the ability to leverage existing rights of way, are easier to site.

To request a free copy of the white paper, visit www.amsc.com/powerpipes. To view an animation of the benefits of Superconductor Electricity Pipelines, visit http://www.amsc.com/products/applications/utilities/superconductorpipeline.html.

www.amsc.com

APEC Calls for Participation in February 2010 Conference

This is the most important Power Conference in our industry's calendar and celebrates 25 years of power electronics innovation. Now is the time to plan your participation whether as a visitor or as an active contributor to this top-level Power Electronics Conference. Time is short, so make contact as soon as possible.

APEC 2010
February 21 - 25, 2010 Palm Springs, California

The IEEE Applied Power Electronics and Exposition Conference (APEC), the leading worldwide conference and exhibit for practicing power electronics professionals, announces a combined call for technical papers and special presentations for APEC 2010. This 25th annual event will be held in Palm Springs, California, February 21- 25, 2010.

"As the world places growing importance on energy efficiency, innovations in all aspects of power electronics has increased APEC's role in the industry to one of critical relevance," said Babak Fahimi, APEC 2010 General Chairman. "With this in mind, APEC 2010 has made optimal energy management the central conference theme. We encourage industry professionals to showcase the most recent technologies and share their different viewpoints."

The APEC 2010 conference committee is now soliciting two types of industry participation. The first is a call for technical papers. At the conference, these unique, peer-reviewed papers will be combined with rap sessions, dialogue sessions, and plenary sessions covering all aspects of power electronics. The conference committee is also issuing a call for special presentations, or sessions that do not require a formal paper. To celebrate APEC's 25th anniversary, these popular special presentation sessions have been expanded to reflect the applied and practical nature of the conference by covering Automotive, Communications, Computing, Consumer, and Industrial applications.

Important Submission Deadlines

APEC offers six ways for industry professionals to participate in the conference and exhibition (visit www.apec-conf.org for complete details):

1. Submit a technical digest for publishing a technical paper. Accepted papers will be available in the conference proceedings and on IEEE Explore for others to reference.
   Deadline for submission of paper digests is July 17, 2009
2. Sign up to review technical papers. The peer review and selection process is one of the key factors for high quality papers. **Deadline to sign up as a technical paper reviewer is July 17, 2009.**

3. Propose a short 20 minute special presentation.
   Deadline for submission of special presentation proposals is August 31, 2009.
4. Propose a 3.5 hour professional education seminar.
   Deadline for submission of professional education seminar proposals is August 31, 2009.
5. Sign up for one of the 200+ spots to exhibit at APEC 2010.
   Exhibit space is limited and nearly sold-out.
6. Exhibitors can sign up for an exhibitor seminar.
   Exhibitor seminars are booked on a first-come basis. See website for details.

www.apec-conf.org

Digi-Key Announces Expansion of Distribution Agreement with GE Sensing & Inspection Technologies

Digi-Key Corporation has announced the expansion of its distribution contract with GE Sensing & Inspection Technologies from a North American agreement to a global agreement.

GE Sensing & Inspection Technologies is a leading innovator in advanced measurement, sensor-based, and inspection solutions that delivery accuracy, productivity, and safety. The company designs and manufactures sensing instruments that measure temperature, pressure, moisture, gas, and flow rate for demanding applications in a wide range of industries, including oil and gas, power generation, aerospace, transportation, and healthcare.

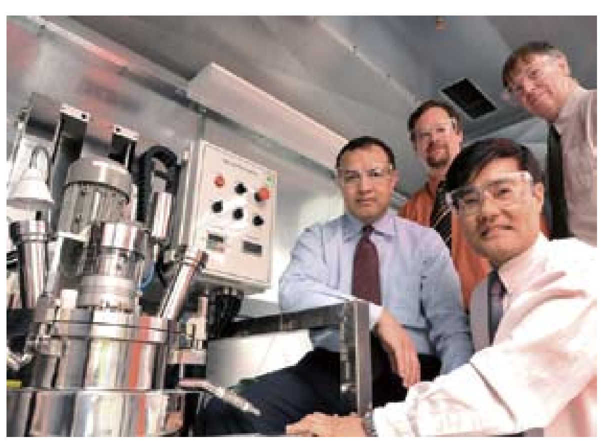
GE Sensing products stocked by Digi-Key include circuit protection products, sensors, and transducers. Featured in Digi-Key's print and online catalogs, these products are available for immediate shipment on Digi-Key's global websites.

Jeff Shafer, Digi-Key vice president of interconnect, passive, and electromechanical products, said, "We are very pleased about the expansion of our agreement with GE Sensing. Its quality products add significant value to our product lineup for our customers in Europe and Asia."

www.digikey.com

Argonne's Lithium-Ion Battery Technology to be Commercialized by BASF

The U.S. Department of Energy's (DOE) Argonne National Laboratory and BASF, the world's largest chemical company, have signed a world-wide licensing agreement to mass produce and market Argonne's patented composite cathode materials to manufacturers of advanced lithium-ion batteries. BASF will conduct further lithium-ion battery material application development in its current Beachwood, Ohio facility. Contingent upon winning a DOE grant under Recovery Act – Electric Drive Vehicle Battery and Component Manufacturing Initiative (DE-FOA-0000026), BASF plans to build one of North America's largest cathode material production facilities in Elyria, Ohio.



Argonne National Laboratory battery researchers (from left) Khalil Amine, Chris Johnson, Sun-Ho Kang and Mike Thackeray flank a continuously stirred tank reactor used to produce scaled-up quantities of cathode materials for lithium-ion batteries. Argonne's lithium-ion battery technology will be commercialized by chemical company BASF under a licensing agreement announced recently.

The patented cathode materials licensed to BASF are part of a large and diverse suite of lithium-ion battery inventions and patents developed at Argonne with funding from DOE's Vehicle Technologies Program. The further development and commercialization of the cathode materials will result in advanced batteries that are higher-performing, longer-lasting and safer when compared to the existing technology that has dominated the market for nearly two decades.

When completed, the proposed BASF facility in Elyria, Ohio is expected to be the largest cathode material production facility in North America. The cathode material licensed from the DOE has been shown to be a material of choice among the largest North American and Asian cell manufacturers that are actively engaged in providing lithium-ion battery solutions to the automotive and other commercial marketplaces. The impact of such a facility is anticipated to be significant as the facility construction and staffing will have a positive economic impact for Ohio and will attract further businesses to North America.

Argonne's composite cathode material employs a unique combination of lithium and manganese rich mixed metal oxides in a revolutionary materials-design approach to extend the operating time between charges, increase the calendar life and improve the inherent safety of lithium-ion cells. Moreover, the enhanced stability of the composite material permits battery systems to charge at higher voltages, which leads to a substantially higher energy storage capacity than currently available materials through both the higher voltage and higher capacity per unit weight of active material. BASF intends to commercialize these cathode materials for transportation and other applications.

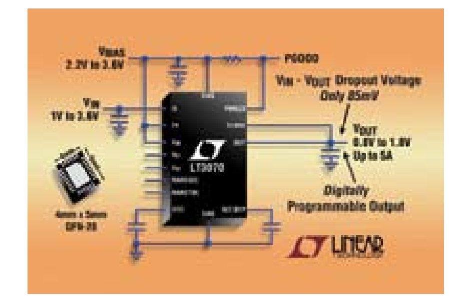
www.basf.com

www.anl.gov

Linear's New UltraFast™ Digitally Programmable 5A LDO

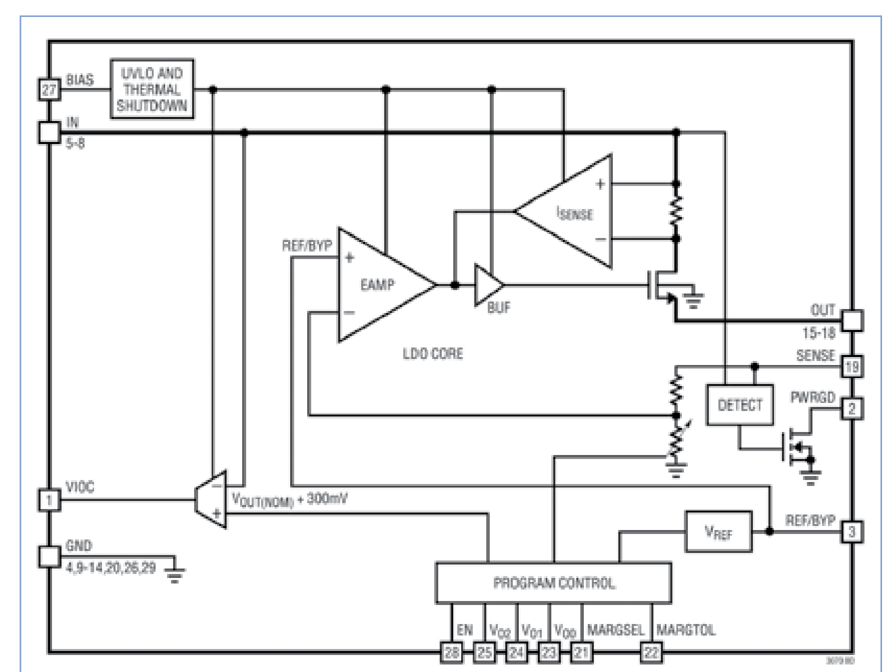
Linear Technology has recently launched the LT3070, a digitally programmable linear regulator with the lowest dropout voltage, lowest noise and fastest transient response of any monolithic 5A LDO currently available.

The LTC3070 dropout voltage at 5A is an ultralow 85mV. Output voltage noise at 5A is only 25µVRMS over a 10Hz to 100kHz bandwidth. The LT3070's 1MHz unity gain bandwidth, coupled with its minimum 15uF ceramic output capacitance, provides a mere 30mV of overshoot/undershoot in response to a fast 4.5A output load step, saving significant bulk capacitance, space and cost. The LT3070 is ideal for efficiently powering low voltage, high current devices such as FPGAs, DSPs, ASICs, microprocessors, sensitive communication supplies, server/storage devices, and post-buck regulation applications.



Linear's UltraFast™, digitally programmable ultralow dropout, low noise 5A LDO.

Output voltage is digitally programmable from 0.8V to 1.8V in 50mV increments. Accuracy is tightly specified at ±1% over line, load and temperature. A digital margining feature can adjust system output voltage in increments of ±1%, ±3% or ±5%, advantageous during system development debug. A PowerGood flag indicates if output voltage is in regulation or the device is in UVLO and the flag also provides an early warning indication of a thermal fault. The LT3070's input supply voltage range is 0.95V to 3.0V and its bias supply voltage ranges from 2.2V to 3.6V. The bias supply provides gate drive to the internal NMOS pass device.



Block diagram of the LT3070.

Multiple LT3070 devices can be easily paralleled for higher output current and to spread heat across a PCB. A tracking feature can control a buck regulator powering the LT3070's input. This tracking function drives the upstream buck regulator to maintain the LT3070's input voltage at VOUT + 300mV, minimizing power dissipation. If output voltage is dynamically changed, the tracking function automatically adjusts the output voltage of the buck regulator to maintain efficiency. Internal protection circuitry includes UVLO, reverse-current protection, precision current limiting with power foldback and thermal shutdown with hysteresis.

The LT3070 is offered in a thermally enhanced, low profile (0.75mm) 28-lead 4mm x 5mm QFN package, and both E and I grades operate from -40°C to +125°C junction temperature range. Pricing for these parts ranges from $4.20 (E-Grade) to $4.80 (I-Grade) in 1k quantities.

www.linear.com

Power Electronics in Automotive Design

By Paul Greenland, VP of Marketing, Power Management Group, Semtech Corporation

Automotive development has a significant part to play in the creation of merged technology processes and discrete power devices. Arguably the first power circuit in the automobile was an electromechanical one, the Kettering ignition, introduced in the 1911 Cadillac which consisted of a coil (auto-transformer), points (power switch) a capacitor (condenser) and a distributor which directs the high voltage pulse from the coil to each spark plug in sequence.

Today, capacitive and inductive discharge electronic ignition together with the ability to accurately measure cam and crank position using Hall effect transducers has largely solved these problems. In fact modern engines can dynamically reduce the number of cylinders firing to cut fuel consumption and fire cylinders out of sequence to reduce the mass of the starter motor or eliminate it altogether.

Discrete power devices for ignition, especially those used with coil-on-plug systems, have migrated from high-voltage Darlington transistors to Insulated Gate Bipolar Transistors (IGBT) where low power gate circuit protection circuitry improves robustness without degrading switching efficiency. Solenoid actuated valves that permit variable valve timing without bounce at high RPM are in development, especially in vehicles where a higher voltage power bus is available. A myriad of hybrid vehicle and turbo-diesel developments are underway to maximize fuel efficiency without sacrificing performance.

Automotive Electronics with its concentration on safety and reliability has been key to the development of merged technology integrated circuit processes especially Bipolar-CMOS-DMOS (BCD), which combines three processes; bipolar for precise analog control, CMOS for digital/timing control and DMOS for high current switching. The Engine Control Unit (ECU) was the first application where BCD technology was widely deployed, usually to integrate power switches, drivers, timing regulation and interface to the embedded microprocessor control. New cars carry two hundred pounds of electronics subassemblies and over a mile of wiring.

In 1929, Paul Galvin, the head of Galvin Manufacturing Corporation, invented the first integrated car radio. Galvin coined the name "Motorola" for the company's new products combining the idea of motion and radio. Today's infotainment systems coupled with GPS, mobile office and highway networks will soon enable the driver to respond to regional targeted advertisements, purchase media and get discount from fast food restaurants en route.

Automotive lighting has gone through a number of changes in recent years, today many vehicles have High Intensity Discharge headlamps and LED brake lights as standard. LEDs, once used for dashboard signals are now used in interior lighting and backlights. Many LCDs in driver information systems are backlit by white LEDs as their luminous efficacy approaches that of compact fluorescent lamps without fragility or increase in display thickness.

A semiconductor vendors' reputation in this fast growing business depends on the ability to extend the evaluation of the product in the end application to embrace extremes of temperature, Electro-Magnetic Compatibility (EMC), Failure Modes Effects and Criticality Analysis (FMECA). The SC441A, an efficient boost LED driver from Semtech Corporation is a case in point; the LCD display manufacturer expects full backlight functionality under extremes of temperature with margin and support from concept to mass production to ensure the assembly does not create or is susceptible to conducted or radiated interference. A definite challenge in a vehicle that contains several tuners (AM to microwave) uses spark fuel ignition and a controlled electric discharge for headlights.

Despite the flagging fortunes of large car manufacturers, new opportunities abound for semiconductor vendors wishing to apply advanced power management technology.

www.semtech.com

Key Trends Offer Hope to Depressed Automotive Suppliers

By Jon Cropley, Research Director, Automotive Group, IMS Research

The automotive industry is suffering particularly badly in the current economic downturn. Vehicles are one of the most substantial purchases that consumers make. As they tighten their belts, many defer this purchase. Even those consumers who are willing to purchase are finding it tough to access credit. Sales of new vehicles have therefore fallen heavily and this is having a knock-on effect on suppliers of automotive electronics.

The numbers tell their own story. In 2007 around 68 million new light vehicles were sold worldwide. In 2009 it is expected that less than 54 million will be sold. Vehicle manufacturers are finding it difficult to cope with such a sharp reduction in demand. Chrysler and General Motors have already entered bankruptcy protection and even the mighty Toyota is losing money for the first time in its history.

Despite the short-term gloom, we firmly believe that growth will be re-established in the automotive electronics market, most probably in 2010, and that great new opportunities will emerge over the next few years. There are three major ongoing trends in the automotive industry that will continue to drive demand for electronics in the medium and longer term. These trends are likely to fundamentally change the nature of the vehicles we purchase in future.

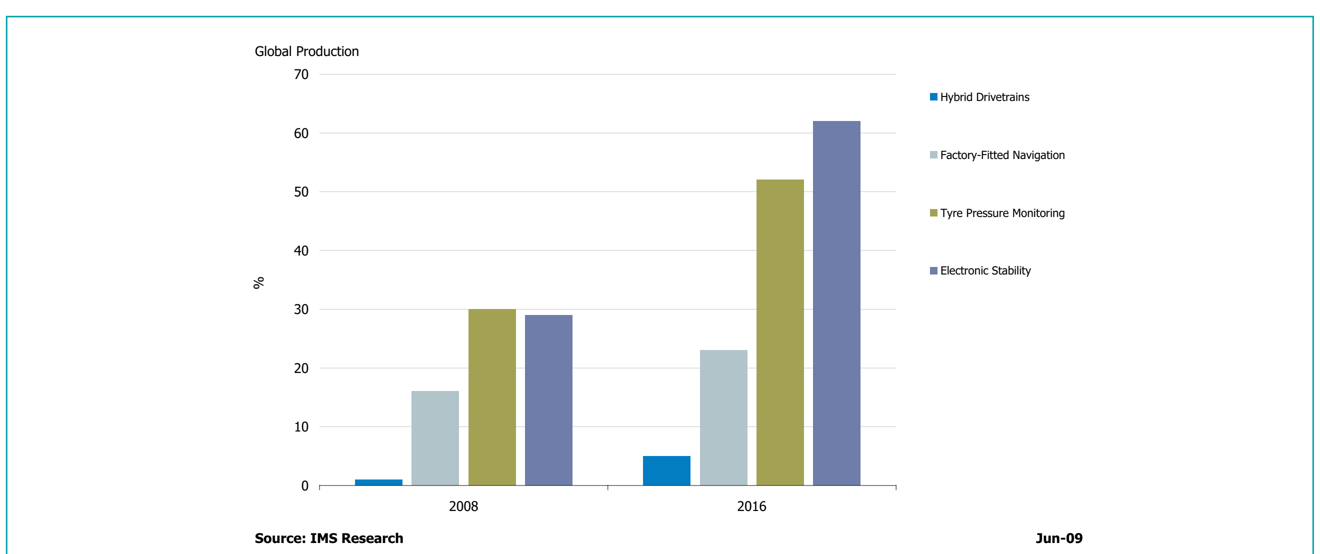


Figure 1: Percentage of New Light Vehicles Featuring Different Systems.

The first of these trends is to make vehicles that use less fuel and are less harmful to the environment. According to our recent report on "Advanced Automotive Fuel Technologies", legislation is a major factor here. Stricter rules on fuel economy and stricter engine emission standards are being introduced in most regions. To comply with these in the short term, vehicle manufacturers will increasingly adopt existing technologies like direct injection, stop-start systems and turbochargers. In the longer term, hybrid, plug-in hybrid and battery electric vehicles are likely to become increasingly common on our roads.

The second trend is the use of advanced technology to make vehicles safer. Our recent research on "Advanced Driver Assistance Systems", found that legislation is playing a role here too. Fitment of both tyre-pressure monitoring systems and electronic stability control systems is already mandated in the U.S. Fitment of both systems is soon likely to be compulsory in the European Union. As the figure shows this will contribute to a dramatic rise in the fitment rate of these systems. A range of other safety systems like adaptive cruise control, blind spot detection and collision mitigation are also being fitted to an increasing proportion of vehicles. For example, we are forecasting that almost four times as many adaptive cruise control systems will feature in vehicles produced in 2012 than in 2008.

The third trend is the increasing fitment of "infotainment" systems – delivering not only audio and video entertainment, but also navigation and other driver information, and two-way data services or "telematics". Against the backdrop of declining vehicle sales, the penetration of such systems as telematics, digital TV, and satellite radio is expected to continue to increase. It is forecast that 2016 in Western Europe alone almost two million vehicles will be sold that feature in-vehicle internet.

The current economic climate means that suppliers to the automotive industry are undoubtedly facing difficult trading conditions. However, the three ongoing trends identified above mean that the average electronic content of light vehicles will continue to increase. At the same time, vehicle production volumes are expected to start growing again next year. Suppliers of automotive electronics that can ride out the current storm can therefore look forward to a much brighter long-term future.

www.imsresearch.com

DESIGN TIPS

Frequency Response of Switching Power Supplies – Part 4

Loop gain measurement injection technique

In this article, Dr. Ridley continues the topic of frequency response of switching power supplies. This fourth article shows in detail how an analyzer is connected to measure the open loop gain of a power supply or any other feedback system, while keeping the loop closed and regulated.

By Dr. Ray Ridley, Ridley Engineering

Power Supply Loop Gain

The loop measurement of a power supply is something that should always be made. As pointed out in previous articles, specialized equipment is needed to isolate injected frequencies and measure them one at a time in the presence of large amounts of noise. Loop measurement requires some skill to implement but it provides powerful design guidance during the development phase of a power supply, and a very sensitive measure of a final production assembly.

Fig. 2 shows a switching power supply with feedback loop. The output voltage is compared to a reference, and the difference is amplified through the feedback error amplifier. The output signal of the error amplifier is used by the PWM modulator to set the duty cycle of the power switch. The loop gain measurement consists of the gain (in dB) of the power stage, plus the gain (in dB) of the feedback compensator.

Fig. 2 shows how this could conceptually be measured with the loop physically opened and a signal with dc offset injected into the compensator.

There are two problems with trying to measure the loop gain in this way. First, with a high gain feedback amplifier, it is impossible systems to apply exactly the right dc offset to the injected signal to prevent the error amplifier from saturating.

Second, the gain of the loop changes by many orders of magnitude over the full frequency range, and the size of the injected signal with this measurement technique would also need to change by the same amount to keep perturbation signals relatively constant.

Breaking the Loop with the Injection Signal

Fig. 3 shows how we overcome the measurement problems for a high loop gain. In this circuit, a 20 ohm resistor is inserted into the feedback loop from the output of the power supply into the error amplifier. The value of this resistor is not critical, but it should be low compared to the feedback resistors of the compensation network.

The test voltage is injected differentially across the resistor via a transformer isolator as shown. The transformer should have a reasonably flat response over the range that the loop will be measured. This is typically from 10Hz up to beyond the switching frequency. For power factor correction circuits, it may be necessary to go as low as 0.1Hz. An upper band of 10MHz may be needed for high-frequency converters.

With this technique, the loop is kept closed in order to regulate the output voltage, but the voltage impressed across the resistor allows the measurement of the open loop gain. In effect, we are electronically breaking the loop, forcing a difference between the loop input and output signals on either side of the resistor. The loop is only electronically opened at the injection frequency, and kept closed and in regulation at all other frequencies.

The injected signal is set by the frequency response analyzer. However, it is the power supply loop gain that determines the size of the input and output signals. At all times, the injected signal will be the difference between the input and output signals. The signal will be distributed on either

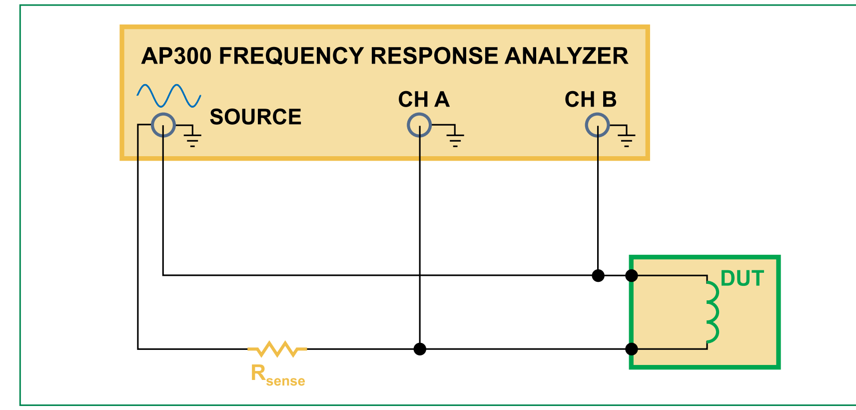


Figure 1: Power Supply with Feedback Loop.

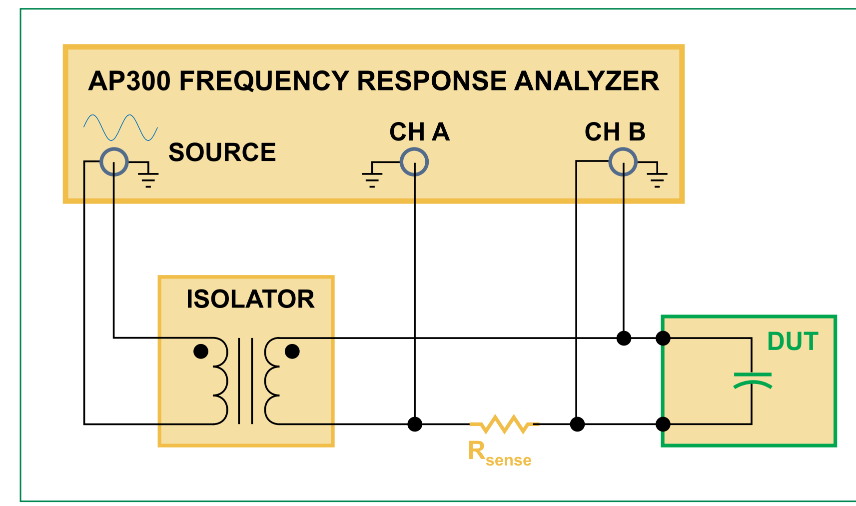


Figure 2: Open Loop Gain Measurement with the Loop Physically Broken.

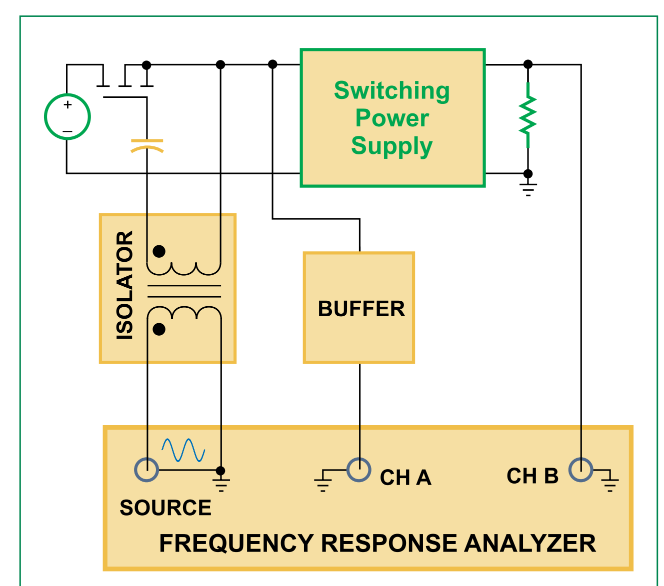


Figure 3: Open Loop Gain Measurement with the Loop Electronically Broken.

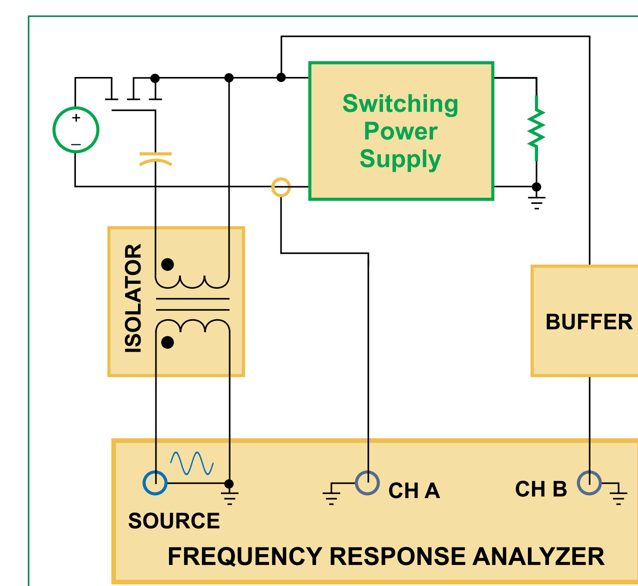


Figure 4: Loop Injection at Low Frequency, Gain Greater than 0 dB.

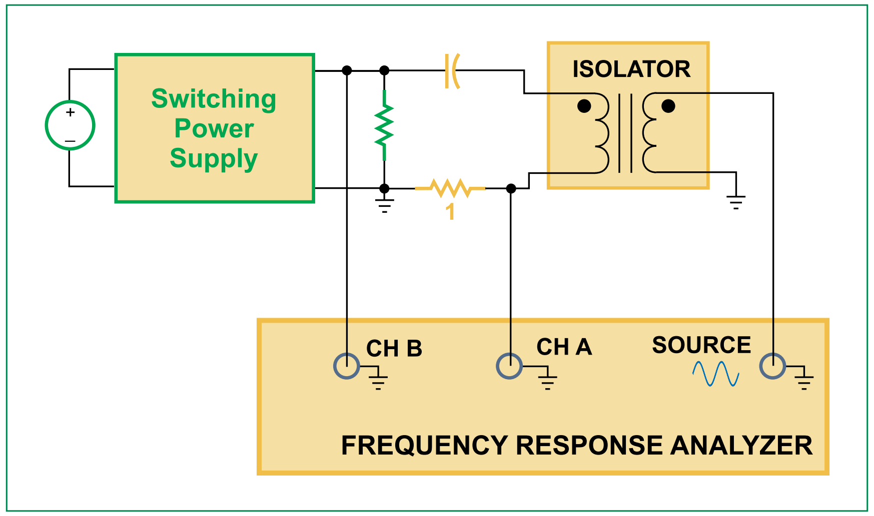


Figure 5: Loop Injection at Medium Frequency with Gain about 0 dB.

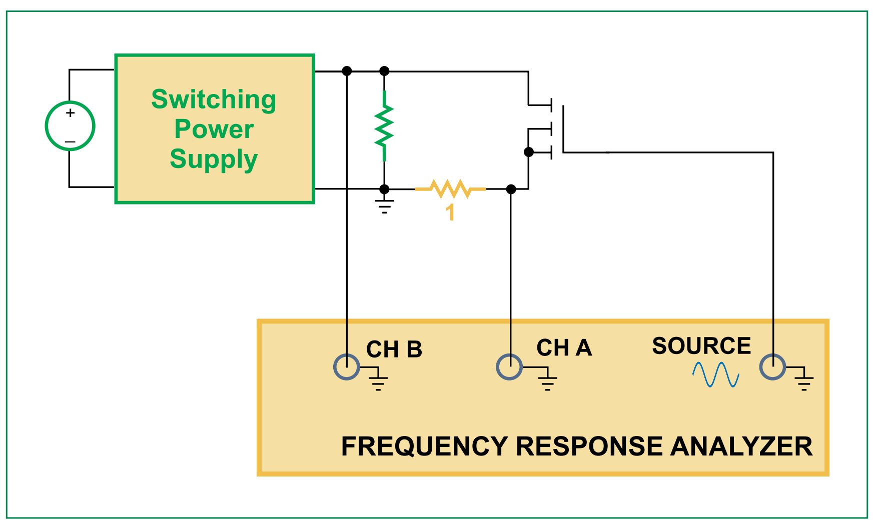


Figure 6: Loop Injection at High Frequency with Gain Less than 0 dB.

side of the injection resistor relative to ground depending on the loop gain of the power supply. This is illustrated below.

Loop Injection at Different Frequencies.

Fig. 4 shows a signal (gold) injected across the 20 ohm resistor. Since the loop gain is high at this injection frequency, most of the injected signal appears at the output of the power supply loop, as shown by the red waveform. The input of the loop, shown in green, is attenuated by the value of the loop at that frequency, and very little of the injected signal is seen here.

At all times, the vector sum of the input and output signal will equal the injected signal. The relative phase of the two signals is given by the phase of the loop gain at that frequency.

Note that all of the signals in Figs. 4-6 are shown to be free of noise in order to illustrate the concept of loop injection better. In reality, all of these signals would be immersed in noise as discussed in [1].

Fig. 5 shows the signals at a frequency near the crossover frequency of the loop gain. The input and output signals on either side of the injection resistor are now approximately equal, and the phase shift between them gives the phase of the loop gain at crossover.

Fig. 6 shows the signals at high frequencies beyond the crossover frequency of the loop gain. At this frequency, the input signal is large, and the output signal is small, but the vector sum is still equal to the injected frequency.

Throughout the frequency range of injection, the output signal can never be bigger than the injected signal. This solves the second problem encountered when trying to inject into the open loop system of Fig. 2: the injected signal does not need to be changed over many orders of magnitude to keep the perturbation signal sizes constant. It still requires adjustment with frequency in most cases for optimal measurements. In the next article of this series, the size of the injected signal and its effect on loop measurement will be considered.

Summary

Loop gain is an essential measurement on all switching power supplies since it will provide information of stability, closed-loop performance, long-term ruggedness of the control, and a sensitive measure of many parts involved in the power supply construction. This article describes the industry-standard technique for injecting into a power supply loop for proper measurements.

References

1. "Frequency Response of Switching Power Supplies, Parts 1-3", Power Systems Design Magazine, Design Tips Archive. http://www.powersystemsdesign.com

www.ridleyengineering.com

XP Power Moves Ahead in Medical

I spoke with Steve Elliott, European Sales Director for XP Power. He is based at the company HQ in Pangbourne, UK. The company offers the widest range of power products available from a single source with unrivalled technical and customer support. With design centres in Pangbourne and Fyfield (UK), Sunnyvale and Anaheim (California), and Singapore, the design teams develop industry-leading power products. The XP applications team provides expert technical support to help customers integrate and use XP power products worldwide.

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

First 250W AC/DC Power Supply to hit 95% Efficiency

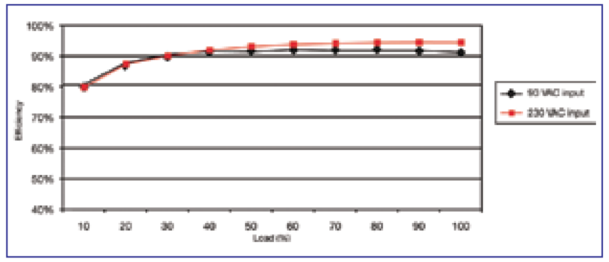
XP Power's new 250W AC/DC power supply, the CCM250, achieves up to 95% efficiency, dramatically cutting the heat generated in medical, IT and industrial systems. Rival products typically operate at 90% maximum efficiency, with 10% of the input energy being converted to waste heat that needs to be removed. The 5% improvement in efficiency offered by the CCM250 means that it dissipates only half the heat, reducing or eliminating the requirement for heatsinks, or fans for forced-air cooling, vital in medical applications.

Removing the need for fans greatly increases reliability while reducing cost, audible noise, system complexity and size. Avoiding audible noise is particularly important in medical applications, where it disturbs patients. Both conducted and radiated emissions are below Class B limits as defined by EN55011, another important consideration in achieving type approval for medical equipment.

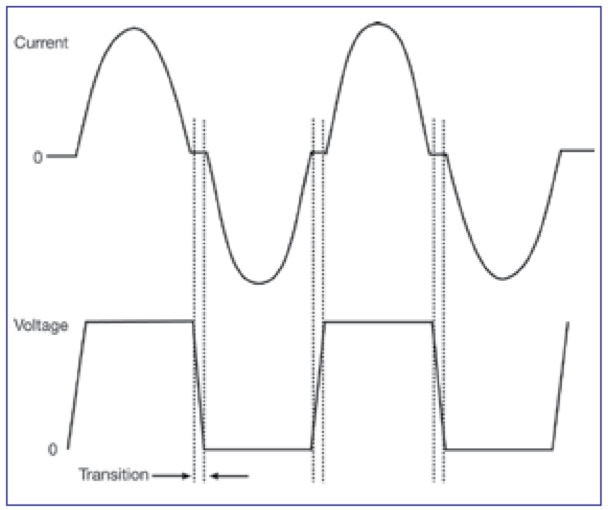
The power supply delivers full output with convection cooling over input voltages from 90 to 275VAC, and 200 Watts from 80VAC, in ambient temperatures of -10 to +50 degrees centigrade. It measures only 152.4 x 101.6 x 39.1 mm (6 x 4 x 1.54 inches), making it the smallest product in its class and ideal for fitting in 1U enclosures. Where short-term peak power is needed, for example for motor start-up, the power supply will deliver up to 300W for 500ms.

The units have a full feature set for controlling the supply and external monitoring and control equipment. This includes a 5V standby rail, remote on/off switching and power fail signals.

The design of the CCM250 combines conventional and novel design techniques to achieve a step-function in power density and efficiency. A 3-stage converter using an interleaved, resonant, half-bridge, means that two relatively small transformers can replace one large one,



50% reduction in wasted energy.



XP's Novel power conversion features lossless switching.

saving board space.

A zero current, virtually lossless switching topology for the main converter ensures high efficiency over a wide load range and contributes to exceptional EMI performance. A crystal-controlled clock and digitally generated drive signals are used to ensure accurate, fixed-frequency timing for switching transistors. The power supply's footprint is minimised through innovative mechanical construction. Heat-generating parts are bonded directly to the U-channel chassis, and magnetic components are conduction-cooled, enabling the use of smaller parts.

The CCM250 is now available in sample quantities from Farnell or direct from XP Power.

Ultra Compact Isolated DC/DC Converter

XP Power has also launched the JHM series of ultra compact low power isolated DC/DC converters. Offering 3 and 6 Watt board mounted variants and packaged in an industry standard 24-pin DIP package, the converters conform to the international medical equipment safety standards UL / IEC 60601-1 and CSA-C22.2 No 601.1. The units provide 3,000 VAC input to output isolation for up to 1 minute, meeting the secondary isolation requirements for BF and CF applications and 5,000VAC isolation up to 10 milliseconds for defibrillation proof compliance. Any medical appliance that may involve patient contact needs to provide isolation from hazardous voltages and have an extremely low leakage current. With such a small leakage current of 2µA, and low 20pF input to output capacitance, the JHM series meets these requirements and provides a reliable and cost effective solution for designers of medical equipment.

The JHM series comprises a total of 20 models. The 3 Watt and 6 Watt units are available in +12VDC or +24VDC nominal input versions covering the ranges of +10 to +17VDC or +20 to +30VDC. Single output models are available with +5, +12 or +15VDC outputs. Dual output models offer +/-12 or +/-15VDC options. Output voltages are fully regulated to within +/- 0.3% over all input conditions and less than +/- 2.0% over all load conditions.

The converters are capable of operating in most environments without any additional heat sinking or forced airflow. Full load output is available from -20°C to +60°C and up to the maximum case temperature of +100°C with derating.

The units conform to EN55011 and EN55022 level A standards for conducted and radiated EMI without the need for any additional external components.

Units are available for immediate delivery from Farnell or direct from XP Power.

www.xppower.com

TSMC Powers Forward with R&D

I talked with Ken Chen, TSMC's Director of Mainstream Marketing. He gave me his perspective on future power management developments including the company's commitment to continuing investments in R&D.

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

TSMC is the world's leading semiconductor foundry and has signed a new, expanded research agreement with IMEC, Europe's independent nanoelectronics research center on leading-edge process technology, for the next generations of IC manufacturing.

Ken told me that the foundry business model was initiated around the time when TSMC was established 22 years ago. This foundry model has now proven to have enabled many of today's digital-centric designs, such as processors and programmable gate arrays.

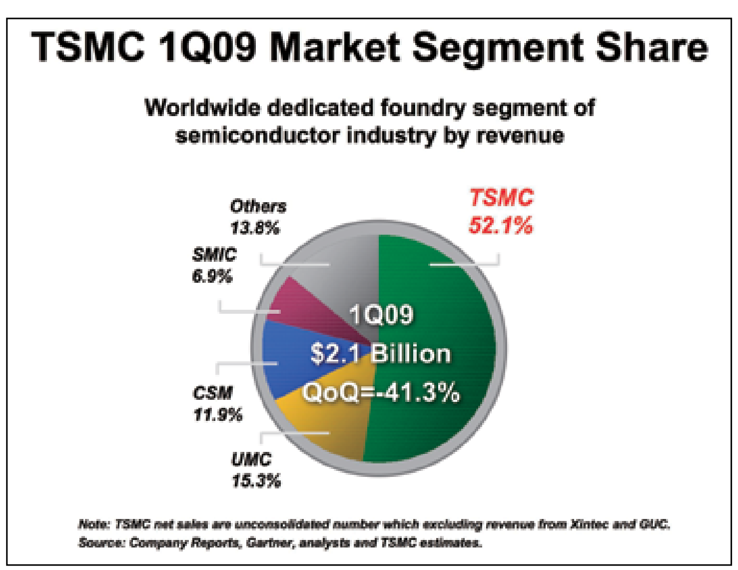
With today's trend of "faster, lighter & greener", Moore's law guides the roadmap well in speed, geometry and operating power. On the other hand, analog signal and power management, which always used to be in separate chips (or packages) are now entering into chip level integration for more efficient form factor, power saving and time to market considerations, examples of which are now seen in many portable devices, such as cellular phones, portable TVs & MP3 players.

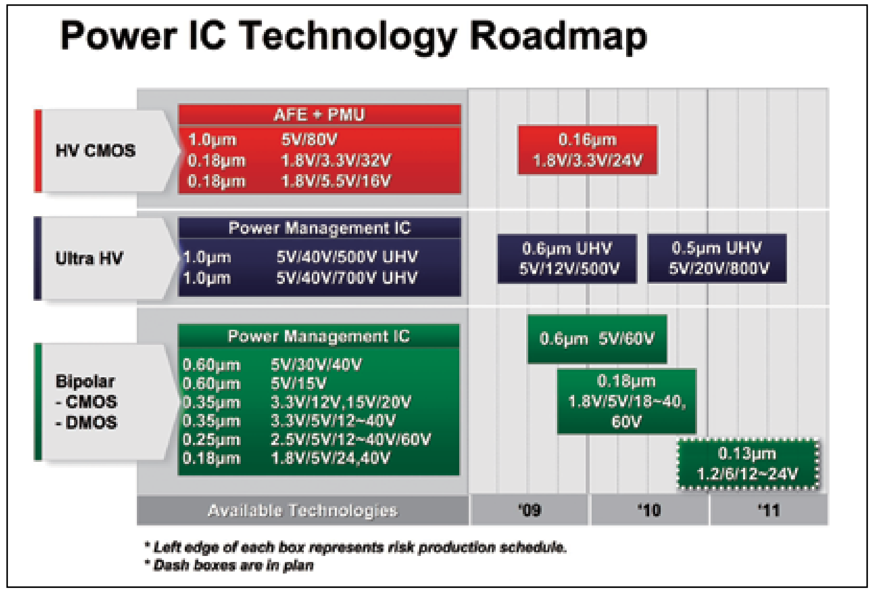
The advantage for foundry technology to support this trend is its efficiency in technology platforms and manufacturing capability. However, there are challenges to support the integration of the designs on device and IP blocks among digital, analog and power management functions.

Challenges of Design Integration

There are 2 major considerations to the support of analog and power management design; design friendly environment and integration with digital design.

One trade-off between design budget and Moore's law migration is to develop a transistor with high quality linear range at decreasing size and voltage swing when it moves with Moore's law. Based on the mainstream analog design adoptions, TSMC selects 5V and 1.8V devices as the primary transistors, and optimizes them. This allows the devices to be shrunk and integrated, with all digital function blocks, all the way to 0.152um, a digital shrunk "quarter node" of 0.18um. Besides active device consideration, there is also a need of existing foundry technologies to further optimize passive components, such as stable and high Q inductors, capacitors and resistors.





There are many refinements for the design community that TSMC's team put in place after the leading edge R&D team has migrated forward along Moore's Path.

One such effort is to assemble these fine tuned devices into the model and design kit, the PDK, so that analog designers in industry can find it user friendly when designing with it.

As part of TSMC's global effort to strongly expand its R&D, including an expansion of research in Europe, TSMC decided to base its European R&D at the IMEC facilities. In this way, TSMC can benefit from IMEC's state-of-the-art clean room infrastructure which is currently being expanded to house the most advanced, often pre-production semiconductor manufacturing tools, enabling the research of technologies ahead of industrial needs. IMEC and its members can benefit from TSMC's broad-based technology roadmap and platform expertise, customers, suppliers, and ecosystem partners.

Ken concluded that TSMC is striving for innovation through collaboration to provide the most competitive technology and greatest value to its customers. The expansion of the partnership between IMEC and TSMC further underscores TSMC's commitment to increasing R&D for designs of the future.

www.tsmc.com

Integrating HB LEDs in Automobile Systems

Overcoming the challenges

Today's automobile manufacturers are converting more of their lighting systems from incandescent and cold-cathode fluorescents to high brightness LEDs. These HB LEDs are taking on applications such as backlighting for navigation and entertainment displays, as well as being employed in both internal cabin lights and external lighting such as daylight running lights and tail lights. New applications such as heads-up displays are also expected to leverage HB LEDs. However, integrating the HB LEDs into the various systems presents many challenges to achieve high operating efficiencies, lower costs, wide dimming ranges and other benefits such as minimizing EMI. To meet these challenges designers can leverage multi-string LED drivers. Such drivers have the advantage of being able to power multiple LED strings with a single IC, thus lowering cost and improving system integration.

By Piero Bianco, Business Manager, SPM Business Unit, Maxim Integrated Products Inc, Sunnyvale, California

First-generation drivers had some limitations and did not allow designers to optimize efficiency, minimize external component count, minimize EMI and achieve a very wide PWM dimming range. The latest generation multi-string LED drivers, such as the MAX16814, solve the above mentioned challenges in very neat ways, by allowing intercommunication between their switching and linear control sections. An example design for daylight running lights or heads up displays will be presented.

Why HB LEDs

HB LEDs are gaining popularity in the automotive world – they offer automobile designers many advantages: HB LEDs are a more environmentally friendly technology than other lighting technologies – they have superior energy efficiency and do not contain mercury, thus releasing fewer harmful chemicals when recycled. HB LEDs can also improve car safety, thanks to the fact that they turn on and off faster than incandescent lamps, and for this reason they are largely adopted for brake lights.

Additionally, they allow car makers greater freedom in the design of the style of their cars: LEDs are small, directional sources of light that require almost no depth behind the panel. That lets designers create light arrays of any shape; and being a small emitter of light makes them ideal for applications with light guides. Finally, LEDs have much longer life than any other lighting technology, with lifetimes of 50,000 hours or more, and for this reason they are ideal for any application where the light remains on for an extensive amount of time, like daytime running lights.

The applications of LEDs in automotive today range from brake lights and rear lights, to front lights (daytime running lights and position lights in today's mid-to-high end cars, and high and low beam lights showing up in very high end vehicles), to interior lights, where RGB LEDs allow to control the light color, giving a unique style to the vehicle. The application of LEDs in navigation, entertainment and cluster display backlights is also becoming mainstream (Figure 1).

LED technology is also important for completely new applications.

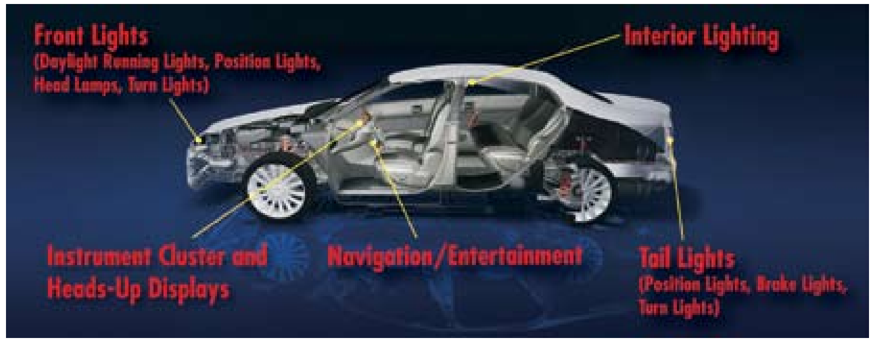


Figure 1: HBLEDs are making inroads into every lighting application in a car - from headlamps to brakelights and everything in between.

One example is heads-up displays. The possibility of dimming LEDs over a very wide range, using PWM dimming, is particularly useful for this application, where the intensity of the light must be adjusted from very low to very high, depending on the intensity of the ambient light.

Challenges of designing with HB LEDs

Of course, the integration of LEDs into automotive applications also presents a number of challenges. One such challenge is keeping cost as low as possible. LED lamps are, in general, a more costly lighting solution than other technologies (incandescent, halogen, CCFL) at the component level. For this reason, the cost of LED solutions at the system level has to be minimized to improve the market penetration of this technology. One approach to reduce the solution cost is to keep the number of components required by the driver solution as low as possible; this also improves reliability, because each component on the PCB is a potential failure point in the system.

Another challenge is efficiency. High energy efficiency is an increasingly important feature in cars, especially for hybrid vehicles. And efficiency must also be optimized to reduce power dissipation (heat). Automotive components work in a hot environment, with ambient temperatures of 105°C for parts in the engine compartment, or 85°C for many other applications. And LEDs generate a lot of conducted heat (they don't irradiate energy in IR or UV bands like other kinds of lights), and so their power dissipation also adds its share to raising the ambient temperature. Thus, it is essential to minimize power dissipation from the driver, to avoid overheating the driver IC, or other components in the driver module.

And of course automotive environments have challenging requirements for EMI – any lighting subsystem must not interfere with other subsystems in the car, the AM radio being usually the most sensitive one.

A number of automotive applications require LEDs to be placed on multiple strings (a string is defined as a group of LEDs connected in series, therefore having the same current). The form factor of displays makes it easier to place LEDs on multiple strings for their backlights. Having multiple strings improves fault tolerance (if one LED breaks as an open circuit only the LEDs in that string don't light, instead of all of them). Another reason to use multiple strings is to limit the LED string voltage for safety reasons. For example, a single LED string with 80V total voltage can be split in two strings with 40V, to avoid the risk of injury to someone who accidentally touches the LED contacts or wires.

Multi-string drivers then have the obvious advantage of requiring just one IC for many strings. For example, a multi-string configuration could include the LED strings, a single boost converter, which converts the input battery voltage into a higher voltage required by the LED strings, and multiple linear current sinks that set the current of each string (Figure 2).

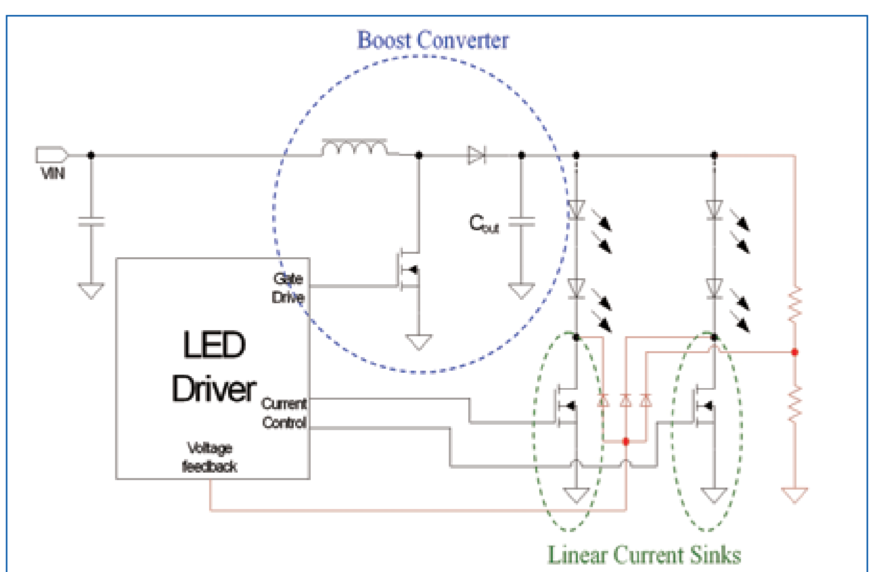


Figure 2: A basic multi-string driver configuration uses a single chip to control the current to multiple LED strings. Components shown in red can be added to do adaptive voltage optimization while the boost converter and linear current sinks work independently.

COVER STORY

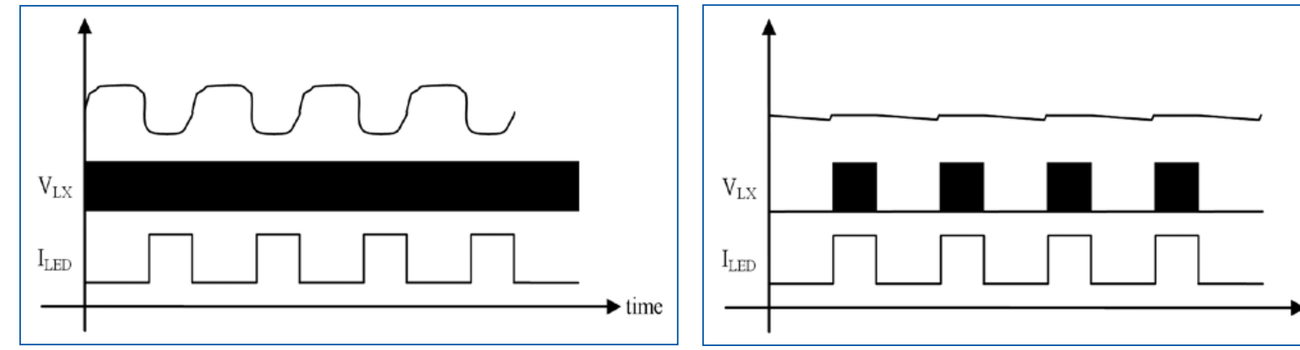


Figure 3a: With a traditional driver doing PWM dimming and using the external circuity of Figure 2, the boost output voltage changes between on and off time of the LED current, voltage rail is noisy.

Figure 3b: With a new generation driver, the boost converter stops switching during the off time of the LED current; as such, the converter's output voltage is maintained by its output capacitor, and the voltage only slightly decreases due to leakage currents.

Compared to the solution of having multiple switching converters, this solution has fewer components and lower cost (a single inductor and fewer shunt capacitors are needed). Compared to having a single string driver and directly connecting the LED strings in parallel, there is an advantage in the current balancing between the strings. If multiple strings are directly connected in parallel, the current splits unevenly between them, because some LEDs have higher forward voltage than others. In addition, since the LED forward voltage decreases with increasing temperature, this current imbalance can cause thermal runaway: the string with more current is hotter, its forward voltage decreases, so it draws even more current, becomes even hotter, and so on. The current imbalance grows and one or more strings with more current can fail. Finally, if the LED strings are simply paralleled, when one string fails and opens, its current is transferred to the other ones, since the driver only controls the total current, and this can cause the other strings to fail because they are over-driven. This does not happen with the solution in Figure 2.

A limitation of the topology of Figure 2 is in the use of linear MOSFETs to set the string currents. In order to keep the temperature of those MOSFETs low, the voltage drop across them must be as low as possible, but high enough to keep them in their saturation region. The boost output voltage must then ideally be:

$$V_{boost} = \max(V_{string,i}) + V_{sat}$$

Where $V_{string,i}$ is the total forward voltage of string i, and V_{sat} is the VDS needed by the linear MOSFETs to be in saturation. A driver that sets this voltage to its ideal value is said to perform adaptive voltage optimization (AVO).

AVO is further complicated by the fact that LEDs must be PWM-dimmed in most applications, i.e. they must be turned on and off with a certain duty cycle, by turning their linear current sinks on and off. What the boost converter should do when all the LED strings are turned off is a problem which has multiple possible answers and some limitations, as we will discuss later on.

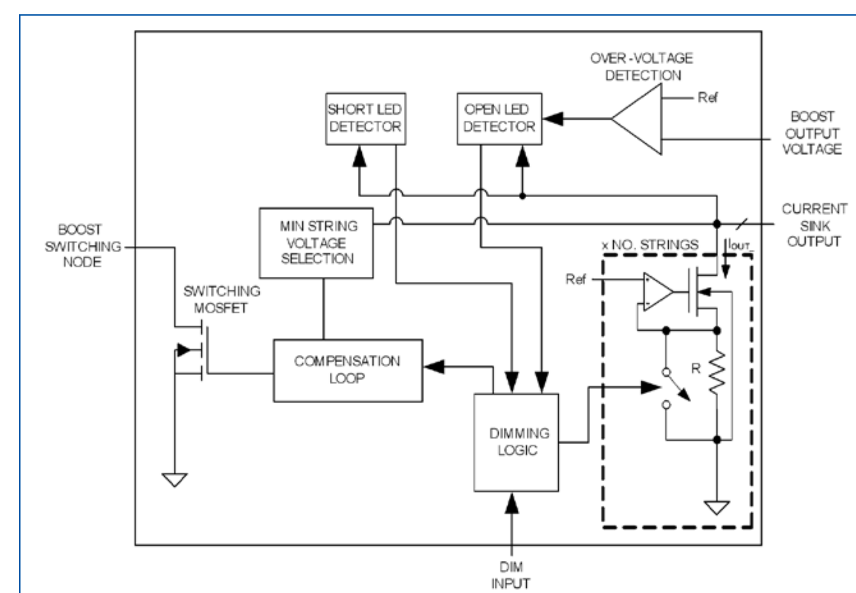


Figure 4: In a new generation driver IC, internal communication between the LED sink drivers and the boost converter allows more effective control and eliminates many of the issues encountered by older drivers.

Traditional multi-string drivers

Traditional LED driver solutions using the topology of Figure 2 include a boost switching converter and multiple currents sinks that work as separate entities. With those converters, implementing AVO requires a certain number of external components, and can cause some issues.

An external circuit must detect which LED string has the highest forward voltage (or the lowest cathode voltage); this can be done with a structure made of a number of diodes, such as the structure marked in red in Figure 2. This solution causes the board area and solution cost to increase.

Another problem with this solution is what happens in case of a LED fault. If one LED fails as an open circuit, the voltage at the cathode of that string falls to zero, so the diode circuit detects that string as the one with the highest forward voltage, and starts increasing the boost output voltage, trying to provide enough voltage for that string. The effect of this event is an increase in the voltage applied to the current-sink MOSFETs of the other strings, which can cause them to fail, or can trigger the output overvoltage protection of the boost converter (if present) which shuts it off, turning off all the strings.

A third issue is what this circuit should do when the LEDs are PWM-dimmed. When the LEDs are off, the diode circuit has no string voltage to take as reference to set the boost output voltage. A possible solution is to add another diode, connected to the boost output through a divider, as the circuitry marked in red in Figure 2; this diode turns on when the LEDs are off, and sets the boost output voltage to a predetermined voltage. The obvious problem with this solution is that the output voltage of the boost converter has a high ripple at the PWM dimming frequency, as in Figure 3a; this can cause EMI noise, which, as mentioned, is a serious problem for automotive applications, and it can also cause unpleasant audible noise from the output capacitor C_{out}.

New generation multi-string drivers

New generation multi-string drivers have greatly improved performance, and solve (or partially solve) the three issues mentioned above, by allowing

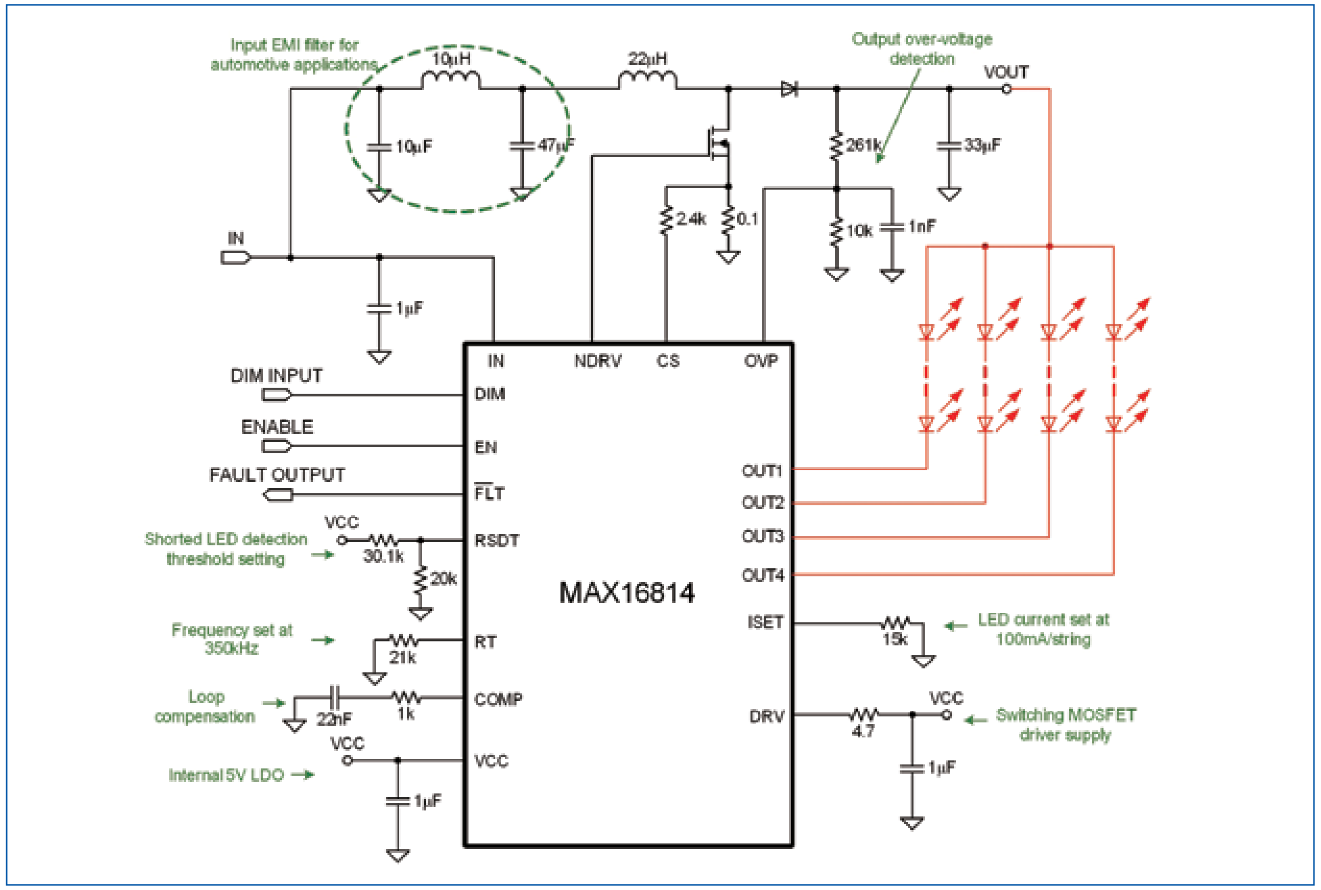


Figure 5: In this heads-up or running-light driver subsystem, the MAX16814 drives four LED strings with up to 100mA per string driver. This is an example of a complete automotive design, including all the external components and an input EMI filter. Thanks to the low noise of MAX16814, the EMI filter component value can be kept low.

intercommunication between the boost switching converter section and the linear current sink section, instead of having them work independently. In these new generation drivers, the IC internally senses the LED string voltages, i.e. the voltages at the drains of each current sink MOSFET, and selects the lowest of them with an internal diode- or analog switch-based circuit (Figure 4). In this way, the number of external components can substantially decrease, together with the solution cost.

In addition, having this kind of intercommunication can solve the issue of what happens when one LED in a string fails and opens. The IC can be designed so that, if this happens, and the boost converter output voltage starts increasing, once this voltage reaches an overvoltage protection threshold, the faulty string is identified, disabled and removed from the AVO control loop. The other strings can then continue working normally, so that the effect of the failure for the user is just a reduction in the brightness of the light instead of its complete turn off.

When LEDs are dimmed using the new-generation drivers, the integration of the switching and linear sections allows a different and quieter solution from the one described in Figure 2. It is possible to freeze the boost converter when the LEDs are off, as in Figure 3b. In other words, during that time the converter stops switching, the switching power MOSFET is kept open, and the compensation circuitry is opened as well. At this point the compensation capacitor retains its charge (which is the state of the compensation loop). The boost output voltage is then retained by the output capacitor C_{out}, which is not discharged because the LEDs are off, and so its only discharge current is leakage current. When the LEDs come back on the converter restarts switching with minimal ripple. With this solution, the boost output voltage remains almost constant throughout the PWM dimming cycle, reducing EMI noise, and audible noise from the output capacitor, considerably.

The only limitation of this solution is that the PWM dimming on time must be longer than few (e.g. three or four) switching cycles, because during this time the boost converter must be able to recharge its output capacitor with the charge that leaked off during the off time. This limits the minimum duty cycle that can be achieved.

Applying the new-generation drivers

In a car both the daytime running lights and heads-up display have similar performance demands—they are on whenever the car is running and need high reliability/redundancy to ensure they always available. By using a new generation multi-string driver such as the MAX16814, high reliability can be achieved for the running lights and the heads-up display, while at the same time, component count can be minimized, thus reducing system cost and improving reliability. These applications also have similar requirements in terms of operating over a wide input voltage range, sustaining voltage peaks (load dump) of typically up to 40V from the car battery, and low EMI generation.

Fault tolerance is essential for both applications: those are life-critical applications, and it is essential that the LED light never shuts off completely in case of a fault. Using a multi-string approach in combination with the MAX16814 assures that if one LED opens or shorts, only that string is shut down; other strings will continue to work normally. Additionally, thanks to its fault output, the MAX16814 can signal back to the driver that one LED failed (Figure 5).

Heads-up display applications also need very wide (1000:1 or more) PWM dimming range. The MAX16814 integrates a unique, patent-pending PWM dimming solution that eliminates ripple at the boost output voltage (at the dimming frequency), thus minimizing EMI and audible noise. This solution is similar to the approach used in Figure 3b, but at the same time allows a very wide PWM dimming range of 5000:1 at 200Hz (wider than any other similar product), overcoming the minimum on-time limitation mentioned above.

The chip can drive four LED strings and was designed to provide the intercommunication between switching and linear sections mentioned above, allowing a dramatic reduction in external component count. Additionally, the MAX16814 includes a complete set of fault protection and detection features, so that if any string has LED open or short failures that string is disabled and the fault condition is signaled to the system. It is a full featured automotive product, with 40V maximum input voltage capability and -40°C to 125°C operating temperature range.

When designing a HB LED-based system there are many tradeoffs that can be made—component count, efficiency, reliability, etc. Table 1 sums up and compares various multi-LED driver solutions to better help designers select the best approach for their application.

Newer generation LED drivers are able to provide lower component count, better cost effective solutions, higher efficiency and improved features, including better fault protection and detection, by leveraging the intercommunication between switching and linear section. The MAX16814 in particular is a multi-string driver which provides all those advantages, especially a very low external component count. Additionally, thanks to a patent pending solution, it provides wider PWM dimming range than any similar product available in the market.

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Synchronous Rectification in Flyback Converters

Achieving energy saving goals

External power adaptors today support a myriad of different products. Notebook computers, printers and conference phones all rely on the simple electrical device, but they remain bulky, heavy and deliver poor energy efficiency. Several regulatory bodies from around the globe are now beginning to address the efficiency issue.

By Yong Ang, Applications Engineer, Mike Townson, Bipolar Transistor Marketing Manager and Adrian Wong, Systems Engineer, Diodes Incorporated

Last year, the Energy Star® V2.0 initiative came into force, followed this year by the European Code of Conduct V3. These specifications will require compliant adapters to meet the active mode and standby power requirements, detailed in Tables 1 and 2, and have been driven by a desire to reduce energy consumption.

AC/DC adapters

The preferred topology for this range of external power supplies is flyback. In general these converters work in one of two ways: direct universal AC/DC conversion or DC/DC conversion following a front end PFC stage. These adapters are both economical and practical in a wide range of typical offline applications with output power below 150W; the power component count is minimal and the PWM control scheme is the simplest amongst all other topologies. Moreover, their critical parts including the power transformer, the primary switch, the input bulk capacitor, the output rectifier, the output capacitor and the heatsinks have been acceptable in terms of both size and cost.

At output power levels up to about 100W for high voltage and low to medium current output operations, discontinuous conduction mode (DCM) is typically preferred to continuous conduction mode (CCM). DCM allows the use of a slow and low-cost output rectifier in the absence of any reverse recovery related switching loss. What's more, there is naturally no turn-on loss for the primary switch. In addition, the DCM transformer size can be reduced owing to the lower average energy storage while its smaller magnetizing inductance yields a better transient line/load response. Finally, a generic DCM Flyback converter is a first-order single-pole control system without the existence of an unstable right half plane zero, which facilitates the feedback loop compensation.

However, the DCM operation inherently incurs high RMS current in the primary switch, which significantly increases the conduction loss, and the ripple voltage and current stresses on the output capacitors as well. In a conventional diode-rectified DCM flyback converter, the output rectifier usually contributes a substantial power loss during conduction. Although the average current in the output rectifier is equivalent to the DC output current, the peak current is several times higher, depending on the duty cycle at various input voltage and output current conditions. Alternatively, the CCM operation offers a higher efficiency due to the lower primary and secondary peak/RMS currents at the expense of a bigger transformer. In this way, the critical conduction mode (CrCM) operation is found to be a good compromise.

Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode
0 to ≤ 1 watt	≥ 0.495 * P_{no} + 0.143
> 1 to ≤ 49 watts	≥ [0.06 * Ln (P_{no})] + 0.638
> 49 watts	≥ 0.870

Table 1: Active mode efficiency requirement for Energy Star V2.0

Nameplate Output Power (P_{no})	Maximum Power in No-Load	
	AC-AC EPS	AC-DC EPS
0 to < 50 watts	≤ 0.5 watts	≤ 0.3 watts
≥ 50 to ≤ 250 watts	≤ 0.5 watts	≤ 0.5 watts

Table 2: No-load energy consumption criteria

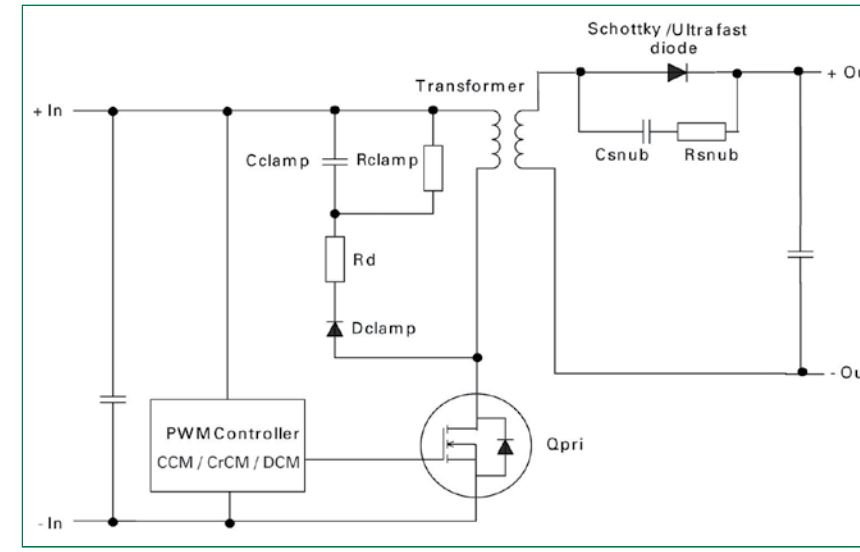

Figure 1: Conventional diode rectified flyback converter.

Improving adapter efficiency

Critically, much of an adapter's heat generation and inefficiency is caused by the Schottky or ultra-fast recovery diode used on the secondary side of many existing synchronous rectifier schemes. Replacing the diode with a more efficient MOSFET is recognized as a clear means of drastically improving adapter efficiency, thereby removing the need for bulky heat sinks and reducing the size and weight of power adapters.

Unfortunately, driving the MOSFET in such a way that it can achieve the exact same function of the ideal diode it replaces, has to date required the use of synchronous controllers that are complex, costly and require the support of a large number of external circuit components.

The Zetex ZXGD3101 synchronous MOSFET controller from Diodes Incorporated was introduced to optimize MOSFET driving, without adding circuit complexity while remaining affordable at the same time. A member of the Zero Point Detector Driver family (ZPDD) the device accurately senses the point at which secondary current descends to zero and turns off the MOSFET ensuring no cross conduction.

The synchronous MOSFET driver

The ZXGD3101 integrates a high voltage differential amplifier stage and a high current driver into the compact SM8 surface mount package. The device monitors the reverse Drain-Source voltage of the MOSFET and when conduction occurs in the body-diode, it applies a positive voltage to its gate control pin, turning the MOSFET on. The gate drive voltage is then proportional to the Drain-Source reverse voltage, ensuring rapid turn-off as MOSFET current decays.

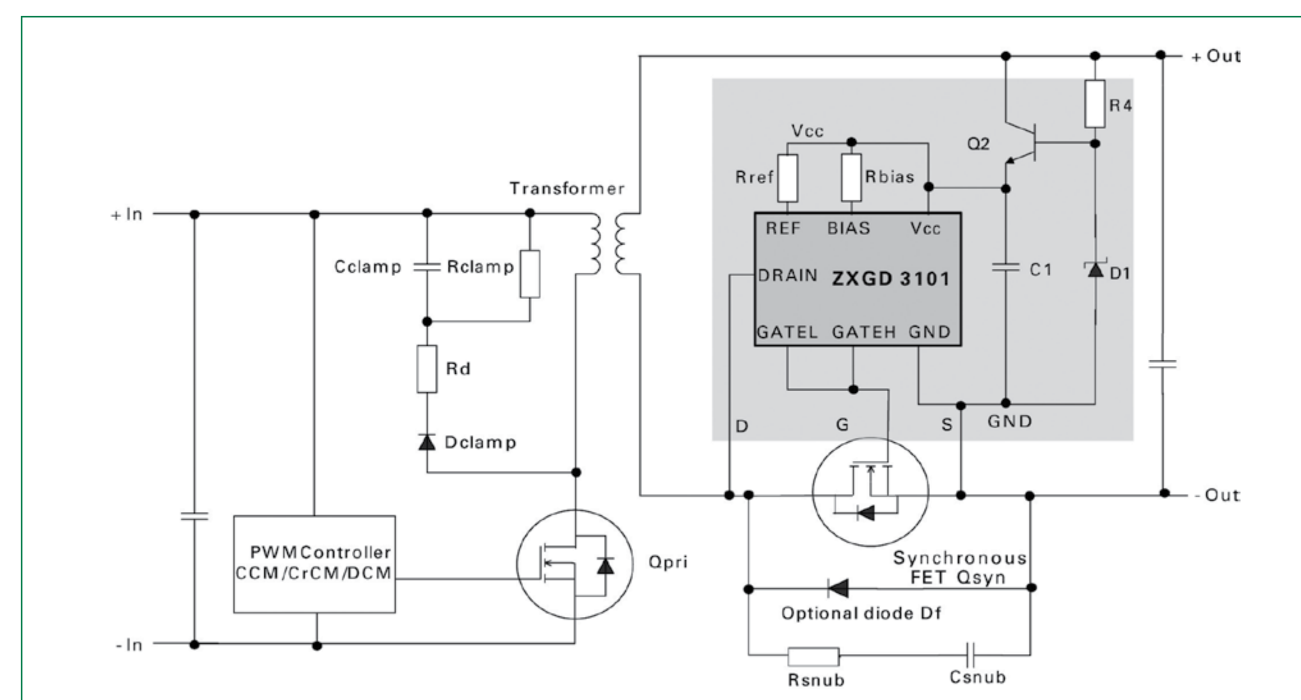

Figure 2: Typical configuration for the ZXGD3101 synchronous MOSFET controller.

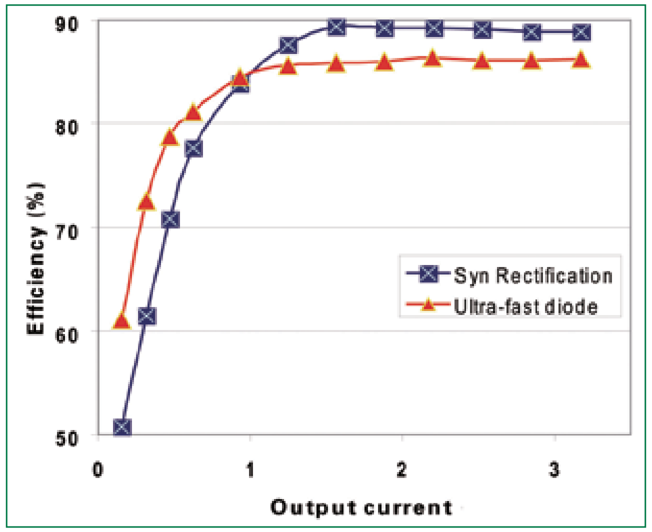

Figure 3: Comparing diode and MOSFET solutions at 115Vac.

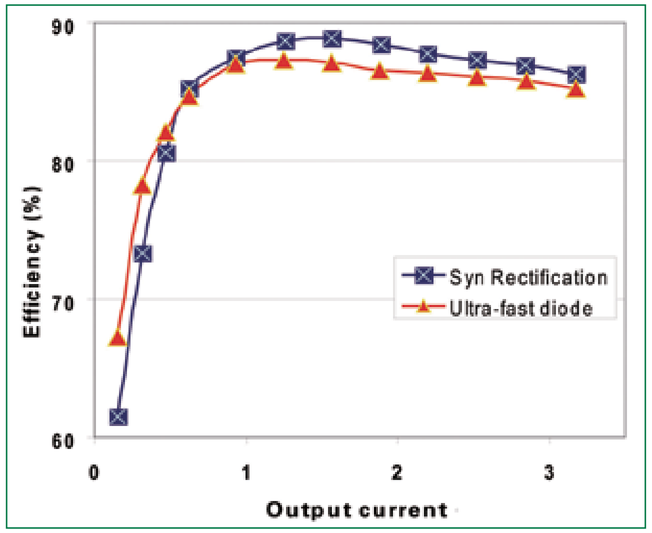

Figure 4: Comparing diode and MOSFET solutions at 230Vac.

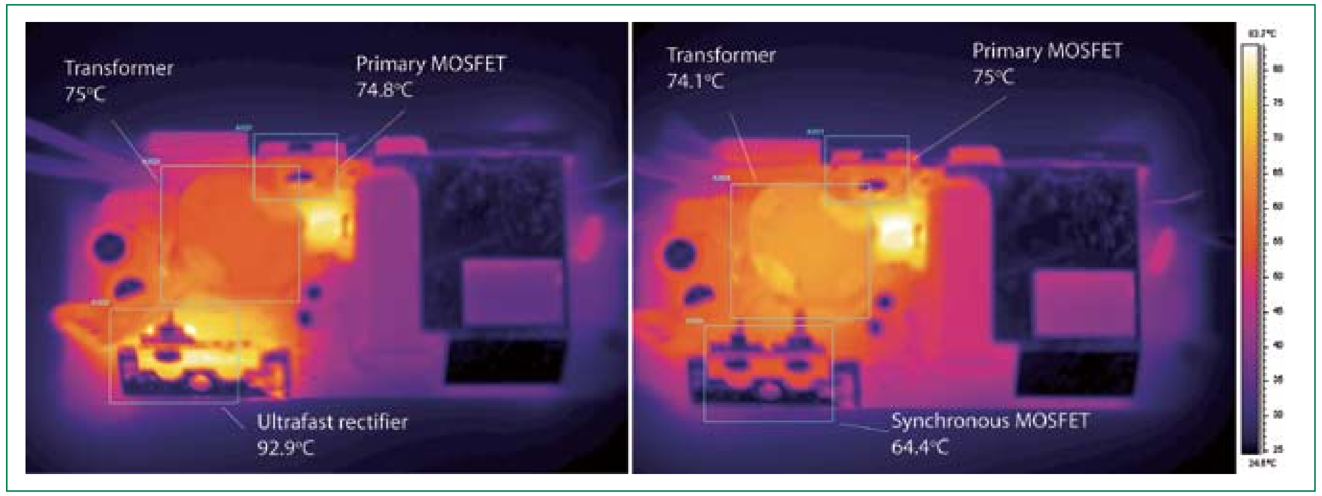

Figure 5: Thermal comparison between adapters using ultra-fast recovery diode and synchronous MOSFET solutions. The latter's operating temperature is 28.5ºC lower.

Since no timing information needs to be transferred from the primary side and no timing components are needed on the secondary side, the ZXGD3101 is very simple to implement. Rival solutions are being manufactured, but on more costly processes or ones that have a tendency to inhibit the drive capability or voltage rating; as a result these solutions have to use extra external components which simply adds cost to the bill of materials

Practical results

Measurements have been taken to quantify the efficiency improvements that are achievable when the Schottky or ultra-fast recovery diode is replaced with a synchronous MOSFET. For evaluation purposes a 60W (19V/3.2A) CrCM flyback converter was used and the results can be seen in Figures 3 and 4. As will be seen, at output current above 1A, efficiency is dramatically improved by the order of 3%.

Another major benefit of switching to a synchronous MOSFET is the reduction in device temperature which has a big impact on the power supply reliability. This can be clearly seen from the thermal images taken during the power supply evaluation shown in Figure 5 where a 28.5°C reduction in device temperature is recorded.

Summary

When a Schottky or ultra-fast recovery diode is replaced by a synchronous MOSFET it is possible to achieve the standards set out by Energy Star V2.0 and European Code of Conduct V3. Using the ZXGD3101 to control and drive the synchronous MOSFET provides efficient switching that minimizes circuit losses while the power supply is in active mode and ensures the no-load conditions are satisfied.

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Magnets in hybrid vehicles

Hybrid vehicles are a growing trend. Faces with dwindling oil supplies and soaring energy prices, our often-cited "mobile society" has begun to reflect on its actions. The automotive industry has undertaken the task to reduce future exhaust emissions to a maximum of 100g CO_2 / km, particularly in response to CO_2 emission levels and in the wake of the Kyoto Protocol; however, this target will surely be utopian unless alternative propulsion systems such as those in hybrid vehicles are brought into the equation.

By Dipl.-Ing. Jan Michael Weickhmann, Permanent Magnets Div., Product Marketing Manager, Vacuumschmelze GmbH & CO.KG

Alternatives to the internal combustion engine are slowly but surely gaining in acceptability, although not yet capable of serving as a vehicle's sole method of propulsion since the network of alternative fuel stations is as yet extremely under-developed. Hybrid vehicles are a reasonably priced compromise between reliable energy supply and compliance with future environmental issues, in the form of a low-cost drive technology; in other words, they combine conventional internal combustion engines as the main power source with electric machines which use a variety of energy storage systems.

The term "hybrid" comes from the Greek and means "mixed, of two different origins". This is the precise definition of a hybrid vehicle – namely, a vehicle operating with two distinct types of energy or propulsion systems. The most common type of hybrid is the combination of an internal combustion engine as the main energy source plus an electric machine with electric energy storage in the form of a battery (generally NiMH or Li Ion battery) or SuperCaps.

Internal combustion engines are petrol or diesel fuelled; however, diesel is expected to present some difficulties in a hybrid system, although Citroen

External Rotor, as used in SUVs by BMW, made by ZF Sachs AG (Formerly knows as Fichtel & Sachs and later Mannesmann Sachs).

/ Peugeot recently issued an unexpected announcement of the development of a diesel hybrid.

In general, there are three different levels of hybridization. Micro-hybrid vehicles offer only start-stop functions with an energy recuperation system to deliver on-board power. (In micro-hybrid vehicles this recuperation system is extremely small, although in comparison to other types of hybrid the cost is extremely low.) Mild hybrid systems use an electric system to support and boost the main fuel source. In full hybrids, each of the vehicle's forms of propulsion operates independently. This is the only type of vehicle capable of reaching maximum speeds of approximately 45 kilometers per hour with the electric system alone; it thus promises to deliver the greatest driving enjoyment, particularly in view of the SUVs slated to be launched in the near future such as the VW Touareg Hybrid, Porsche Cayenne Hybrid and Audi Q7 Hybrid. In addition to these three types of hybrid vehicle, a number of intermediate designs also exist.

Although the economy and usefulness of hybrid vehicles only seems to have emerged into public attention in recent years, hybrid technology has a long history. As early as 1896, Ferdinand Porsche patented an electric wheel hub motor and worked with Viennese vehicle manufacturer Jacob Lohner to build the "Mixte" hybrid drive, in which a dynamo was powered by a petrol engine to supply current for the battery. The wheel hub motors of the time did not require gears or power transmission systems.

Prototypes of electro-hybrid vehicles as we know them today can be traced back to 1972, when American inventor Victor Wouk converted a General Motors Buick Skylark into a hybrid vehicle, inspired by the Federal Clean Car Incentive Program, launched in 1970 but halted in 1976 by the US Environmental Protection Agency. (Hybrid vehicles were also built at Aachen Technical University (RWTH) as early as the 1970s, although offering minimal customer benefit.)

VAC magnets used in Servo and Hybrid motors.

By today, almost all major automotive manufacturers have dabbled in hybrid vehicles, some of which have even made it to the production line – for example, the Toyota Prius,

Lexus RX 400 H or Lexus GS 450 H. The Toyota Prius has a petrol engine and two electric motors connected to the power train by a planetary gear set.

Permanently excited synchronous motors in hybrid systems

German automotive manufacturers tend to favour a different solution from the Prius concept, namely a modular system with conventional gears connecting the electric motor to the power train via a second clutch. In this design, a compact permanently excited synchronous motor is located between the combustion motor and the gears.

A three-phase synchronous motor is merely an electric motor operating on three-phase current or a generator producing three-phase power. The motor has a stator winding (generally external) which creates a rotating magnetic field or in which an electric current is induced. The rotor, which is generally inset (permanent magnet rotor), contains either permanent magnets or an exciter winding contributing to magnetization, although the latter is less common.

Permanent magnets from Hanau-based Company Vacuumschmelze GmbH & Co.KG (VAC) are ideally suited for use in permanently excited synchronous motors for hybrid systems and are used by all leading automotive manufacturers. The neodymium-iron-boron (NdFeB) magnetic materials VACODYM® 688 AP and 890 AP offer extremely high coercivity of over 2865 kA/m and typical remanence (residual magnetism) of up to 1.08 T.

VAC magnets are blocks approximately 26 millimeters long, approximately 12 millimeters wide and only four to five millimeters high. These magnetic blocks are mounted inside the rotor in "pockets" cut out of a laminated stack of silicon iron sheets, and are thus known as "embedded magnets" or IPMs, standing for "internal permanent magnet". (The magnets may also be mounted in the rotor tangentially, or in a V-shaped arrangement. Rotor assembly is generally carried out by the electric motor manufacturers, but Vacuumschmelze is also conducting

R&D activities into mounting magnets in rotary systems.)

Salt, harmful gases and aggressive oils

The magnets inserted in the "pockets" may cause bridging to occur between the laminations, causing eddy currents to be conducted through the magnets and increasing eddy current losses. To eliminate this, VAC magnets feature a unique insulating coating which effectively suppresses these eddy currents and significantly reduces eddy current losses. The special coating process – for example, using aluminium spray coating VACCOAT 10047, which is annealed after application – offers an array of additional benefits rendering it ideal for use in synchronous motors for hybrid vehicles. While the other magnetic materials specified, VACODYM® 688 AP and 890 AP, are intrinsically corrosion-resistant, coating with VACCOAT 10047 provides enhanced corrosion protection.

In sophisticated tests with a duration of over 1000 hours, the coated magnets also showed high resistance to salt spray atmosphere. VACCOAT 10047-coated magnets are also resistant to sulphurous gases like those occurring in high concentrations in vehicle exhaust gases - a further reason in favour of selecting VAC magnets for use in hybrid drives.

When magnets are in close proximity to a clutch system, a further hazard emerges, since manufacturers frequently use highly aggressive hydraulic oil such as Dexron VI. However, here too tests have shown that the special coating of VAC permanent magnets offers impressive resistance to aggressive oils. In fact, VAC coated alloys generally deliver outstanding protection.

Conclusion

The trend is unmistakable: Hybrid vehicles are no longer exotic rarities, but an increasingly familiar sight on our roads. The trend is certainly boosted by the demands of the EU parliament to reduce CO_2 emission levels to below 100g/km by 2010. Even though the ACEA (Association des Constructeurs Européens d'Automobiles) has set a considerably more modest target of 120g of CO_2 per km by 2012 and Europe-wide legislation has yet to be passed, in future even the lobbying association formed by Europe's 13 largest automotive manufacturers will be unable to avoid further consistent development of hybrid drives. Advancements in technology and materials – such as VAC permanent magnets in synchronous motors for hybrid drives – have already contributed to a definite improvement of the hybrid concept, helping to create vehicles that are of practical everyday use and need not fear comparison with conventional internal combustion engine vehicles.

www.vacuumschmelze.de

Rugged and Reliable Motor Drive Solutions

New gate driver ICs for electric and hybrid electric vehicles

The automotive market is currently in turmoil. Despite the low sales volumes of conventional cars, government and environmental regulations together with changing purchasing behavior of end customers is forcing OEMs and system suppliers to rethink their strategies and seek new, unconventional solutions in order to regain their former strength and success. The car of tomorrow requires advanced electronic systems which make vehicles more environmentally friendly, safer to drive and, at the same time, more pleasurable to travel in. These advanced capabilities are enabled by the rising adoption of faster and more powerful semiconductors, leading to increasing silicon content in cars.

By Dr. Henning Hauenstein, Vice President of Automotive Products and Marco Giandalia, Director IC Development, Energy Saving Products, International Rectifier

Power electronics, in particular, is an enabling factor for hybrid and electrical cars which currently hold great promise for fuel-efficient and low/zero emission transportation. These cars are equipped with very advanced and powerful electric motors which typically range from 10-15kW for mild-hybrids to over 100kW for full-hybrids, plug-in hybrids and electric vehicles using high-voltage gate driver and IGBTs from typically 600V to 1200V. These high-voltage motors are often driven sinusoidally by a DC/AC-inverter which requires a reliable control circuit that can switch very high currents of several 100 Amperes typically with a frequency in the 6-10 kHz range. A major challenge is the design of fail proof and rugged electronics in a power and voltage range far beyond the conventional "12V-automotive world".

This article discusses the latest generation of products for rugged automotive high-voltage gate drivers with enhanced reliability and protection

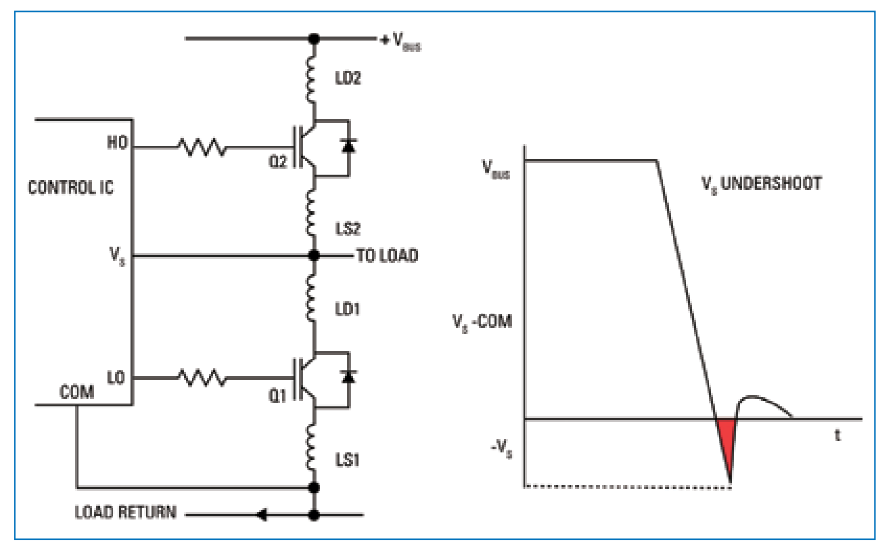

Figure 1: Negative transient at VS output node during standard operation.

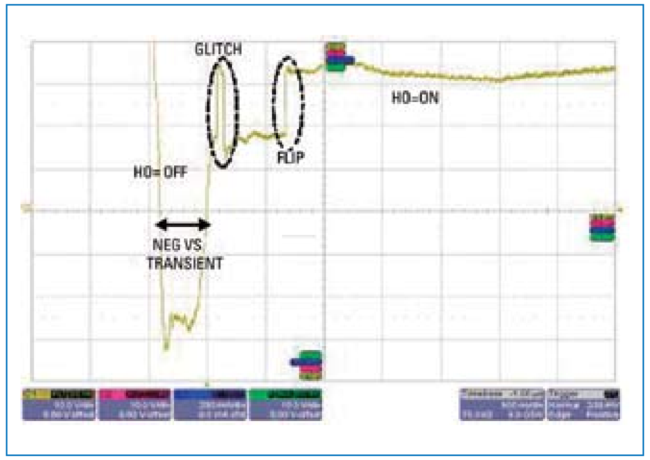

Figure 2: FLIP and GLITCH classification.

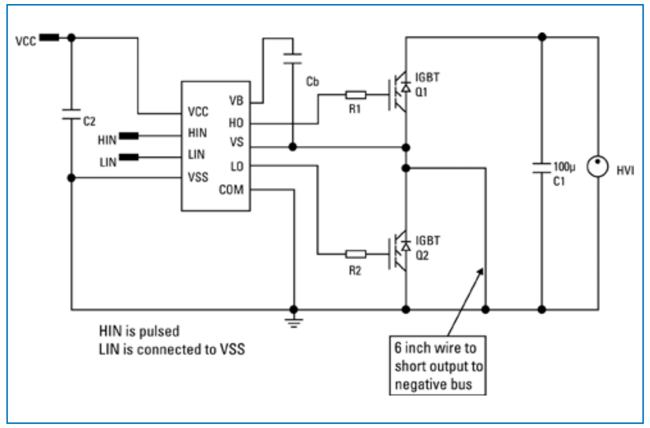

Figure 3: Short Circuit test setup for negative transient event observation.

features and will demonstrate how by addressing the well known negative voltage spike problem and catastrophic short circuit event, these ICs can switch large IGBTs with very high current capabilities reliably. The Negative Transient Safe Operation Area (NTSOA) which quantifies the negative voltage spike immunity of these driver ICs will help designers to lay out very rugged and optimized motor drive solutions without the need for a costly bandwidth to accommodate an unknown voltage spike immunity of the driver circuit. Further, the ICs ability to handle motor short circuit events protecting against catastrophic failures of the entire system will be demonstrated.

The main problems of driving powerful motors are associated with the very high currents that need to be controlled and switched reliably. The switching current in motor winding flows through PCB tracks and produces noise coupling but the most severe effect is related to the parasitic inductance that the PCB introduces. By increasing the IGBT size and the switching speed the amplitude and the duration of VS undershoot increases dramatically.

The VS undershoot is recognized as one of the most severe failure root causes forcing system designers to protect the gate driver using an unreliable clamping structure that impacts the layout. In automotive, in particular, there is a desire for a reliable solution using fewer and more rugged components in the control circuit.

The negative transient voltage spike problem becomes even more severe at short circuit intervention since the size of the spike can increase significantly. Typical inverter drive failures at high switching current are often attributed to gate driver misbehavior that appears as spurious turn-on of the high-side channel (HO). Two different behaviors can be observed and classified as transient negative VS event effects:

- GLITCH: is defined as a turn on followed by a turn off of HO

- FLIP: permanent HO turns on

These two phenomena can show up individually as well as together as a consequence of the same negative VS event (Fig.2).

These phenomena lead the system into an un-safe region (HO=ON even if the related command is still Hin=OFF) and can potentially lead to catastrophic system failure under uncontrollable load current and output power stage destruction.

Extensive investigation of this behavior has been undertaken which has resulted in a unique patented solution that assures the proper HO behavior even under the most sever negative VS event. A new family of gate drivers (available in industrial or automotive (AU) versions (AU)IRS260xD, (AU)IRS233xD) has been designed and extensively tested in order to provide robustness and reliable working operating condition.

The IRS260xD family offers optional dependent or independent high- and low-side referenced output channels with a gate drive supply range from 10V to 20V. The output drivers feature a high-pulse current buffer stage designed for minimum driver cross-conduction while the floating channel can be used to drive N-channel power MOSFETs or IGBTs in the high-side configuration operating up to 600V. The devices provide matched propagation delay for both channels and an advanced input filter to improve noise immunity.

The IRS233x(D) is a three-phase bridge- driver with referenced output channels to provide 200 mA/420 mA drive current at up to 20 V MOS gate drive capability operating up to 600 V. The devices feature an integrated ground-referenced operational amplifier to provide analog feedback of the bridge current via an external current sense resistor and optional integrated bootstrap diode to reduce external part count and reduce PCB. The output drivers feature a high

PowerPack Power Systems Design

Fairchild Semiconductor

Extend Talk Time in 3G Handsets

Fairchild Semiconductor's RF power DC-DC converter, the FAN5902, helps to extend talk-time by up to 40 minutes in 3G handsets by adapting the voltage supply level of the 3G RF power amplifier according to the RF power sent through the antennae, enabling higher power efficiency for a wide range of antenna power levels.

www.fairchildsemi.com/pf/FA/FAN5902.html

Ohmite

New Wirewound Tubular Lug Resistors Range

Available with three durable coating options; lead-free vitreous enamel, silicone-ceramic and our patented, flameproof Centohm cement designed to withstand temperatures to 2000°C, the E Series will range from 72 to 700 Watts. Available in both adjustable and fixed styles, with both live and isolated integrated mounting terminals, the E Series enhances Ohmite's hugely successful lug offering by adding sizes commonly used by the European electronics market. Rugged construction allied to a choice of coatings makes these resistors ideal for applications requiring high wattage ratings.

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Texas Instruments

TI's New Eight-Channel Sequencer and Monitor with Non-Volatile Error Logging, UCD9081, Supports the Latest Generation Microprocessors, ASICs and DSPs, to Improve System Reliability and Ease Eequencing on Boards with Multiple Points of Load.

The sequencer operates from a 3.3-V supply and does not require external memory or a clock, to help reduce board space in a variety of equipment, including telecommunication switches, servers, industrial, networking and test equipment. The UCD9081 is available from Texas Instruments and its authorized distributors in a 32-pin QFN package. Application notes, evaluation modules and the GUI software tool for the UCD9081 are also available online at

www.ti.com/ucd9081-pr

International Rectifier

Improved 25V and 30V MOSFETs for Point of Load Synchronous Buck Converter Applications

This new family of 25V and 30V N-channel trench HEXFET® power MOSFETs feature enhanced switching performance for synchronous buck converter and battery protection. Delivering benchmark on-state resistance ($R_{DS(on)}$), the devices' low conduction losses improve full-load efficiency and thermal performance while low switching losses help to achieve high efficiency even at light loads.

The new MOSFETs are also offered in a Power QFN package to provide improved power density when compared with an SO-8 package while keeping the same pin-out configuration. Depending upon application, the dual SO-8 MOSFETs allow a 'two for one' exchange to reduce component count.

www.irf.com/whats-new/nr090507.html

Infineon

HybridPACK™ 2 - Compact Power for Your Electric Drive Train

Based on the long time experience in the development of IGBT power modules and intense research efforts of new material combinations and assembly technologies, Infineon has developed – dedicated for automotive applications – this HybridPACK™ 2 power module belonging to the HybridPACK™ family. With its pin fin base plate for direct water cooling Infineon HybridPACK™ 2 is designed to fulfill the requirements of your electric drive train application with power ratings of up to 80kW.

www.infineon.com/hybridpack_psdeonline

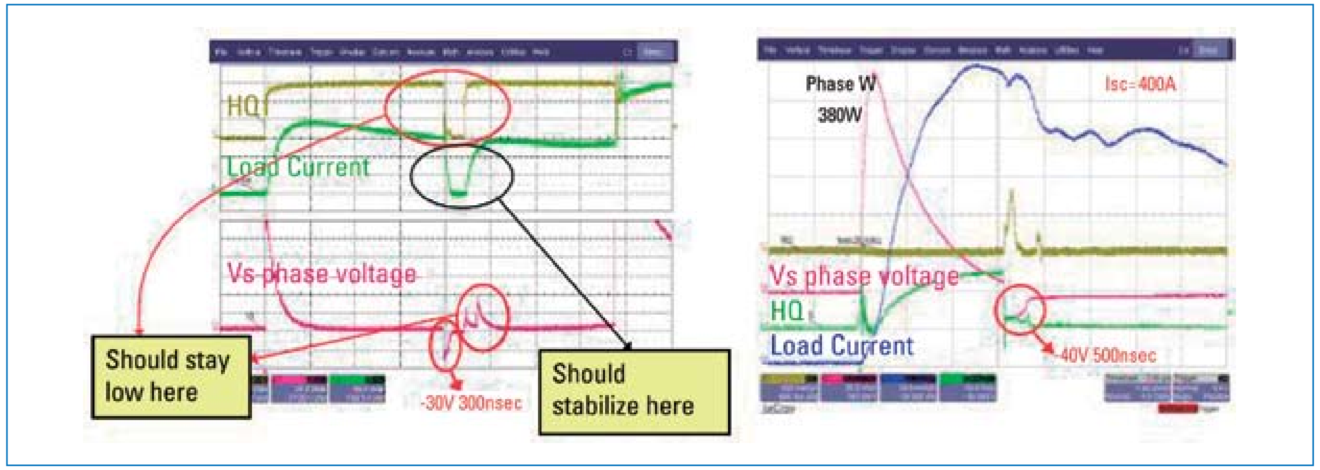

Figure 4a&b: Bad (standard HVJI GD) and Good (IRS2607D) HO gate driver behavior at SC test.

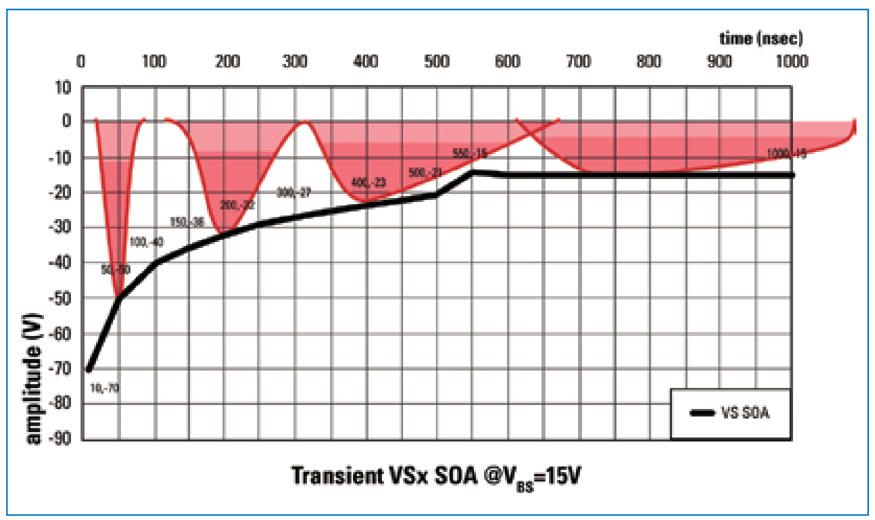

Figure 5: NTSOA: Negative Transient Safe Operating Area.

pulse current buffer stage designed for minimum driver cross-conduction. Propagation delays are matched to simplify use at high frequencies. The floating channel can be used to drive N-channel power MOSFET or IGBT in the high-side configuration.

The following tests are related to bench characterization using dedicated development test equipment to verify the proper behavior of the driver IC for all the negative VS amplitude-duration points shown in the NTSOA. Application short circuit tests are performed using modern state of the art Trench IGBTs with very high current densities to account for high end motor drive solutions.

Figures 3 and 4 show the short circuit" (SC) test setup and the experimental results comparing a standard HVJI Gate driver and the optimized IRS2607D respectively. The results show a clear advantage and fail proof behavior of the latest generation of motor drive ICs.

In Fig.4a a bad SC test management operated by a standard HVJI Gate Driver is shown. The graph clearly shows that the first HO turn-off causes a negative voltage spike; this negative VS event consequently produces a spurious HO turn-on.

The same experiment conducted using the IRS2607D shows that a rugged and reliable gate driver provides a safe HO turn-off even under higher switching currents (Fig.4b). An extensive characterization and SC test experiment on the new gate drivers was performed. Several IGBT types and sizes were used and tested at hot system temperatures, where failures are typically even more severe. The dataset resulted in the state of the art NTSOA for rugged inverter gate drivers which is shown in Fig. 5

Summary

It is possible to design very rugged and reliable high power motor drives if the gate driver is immune to negative transient voltage spikes. This is a significant step forward and tremendous benefit for the designer of powerful motor drives. While in the past this was a problem area for industrial or larger appliance motor drive engineers, it is becoming an issue in the automotive world as electro motors in the range of 10 to >100kW enter the automotive space in electric or hybrid electric vehicles, requiring safe and fail proof design for the life of the vehicle. This new generation of gate drivers offers designers a solution for the automotive power train and peripheral side applications that require a rugged, reliable and well controlled motor drive solution without compromise.

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Automotive Rollover Stability

Control system using model-based design

The ongoing trend in automotive electronics to incorporate active safety mechanisms has led automobile manufacturers to incorporate antirollover capabilities into traditional vehicle chassis control systems, such as those for antilock brakes and traction control systems that are now being enhanced to incorporate antirollover capabilities.

By Vinod Cherian, Technical Marketing Specialist, The MathWorks, Natick, Massachusetts

This trend is driven by the National Highway Traffic Safety Administration (NHTSA), which mandates that all 2011 model year vehicles and beyond have antirollover controllers. The requirement is based on NHTSA analysis of accident data from rollover crashes. For example, in 2001, according to NHTSA's National Center for Statistics and Analysis, 10,138 people died in rollover crashes, representing 32 percent of occupant fatalities for the year. Implementing active safety mechanisms to lower the risk of vehicle rollover could potentially reduce fatalities. One method of lowering the risk of rollover is to implement an Electronic Stability Control (ESC) that applies differential braking based on measured and estimated vehicle states. This article highlights the use of Model-Based Design to develop and automatically optimize an ESC for a sport-utility vehicle (SUV).

Vehicle and controller model

A central concept in Model-Based Design is the executable specification, or model, that describes the dynamic behavior of the system. A validated model of the automobile, in this case a high-fidelity model of an SUV, can be leveraged to achieve a significant savings in the development cost and time associated with controller design. Numerical simulation of the model can be used to study the vehicle response to various steering maneuvers and these tests can be repeated easily while varying parameters like road surfaces, tire models, and vehicle properties. Additionally, the models can be used in the development and verification of the embedded control system.

The vehicle used in this article is representative of a midsize SUV. The vehicle model is available in CarSim®, a commercial off-the-shelf vehicle dynamics simulation tool. The vehicle model's performance has been verified against test data and is suitable for simulating vehicle response under significant roll motions. The vehicle model has dual independent front suspensions and a solid rear axle that supports the sprung mass. The nonlinear mathematical model has degrees of freedom for the sprung mass, each axle, each wheel, steering system, and braking system. The vehicle model can be customized using different vehicle parameters as well as road and environmental conditions.

Figure 1 shows the CarSim user interface and some of the physical vehicle parameters used to build up the vehicle model. These parameters can be modified separately from the controller parameters to test the behavior of the controller under different vehicle conditions, such as single occupant, multi-occupant, and high center of gravity. The vehicle model used for this paper applies steering inputs concordant with the NHTSA fishhook maneuver, a standard maneuver used to assess dynamic vehicle stability. This test is designed to mimic the actions a driver might perform to avoid a sudden obstacle in their path. For the numerical simulation, we set up this steering input for the SUV model and verified that in the absence of an ESC, the vehicle exhibits rollover.

Controller development and optimization

The implemented ESC discussed in this paper prevents unsafe levels of body roll and yaw motion in response to driver inputs. It regulates the vehicle's body roll and yaw rate by applying differential braking to the wheels, while minimizing the loss of vehicle speed from electronic braking, which is automatically applied by the controller. The implemented ESC switches between three control modes. The control modes are activated based on three potential causes of the vehicle entering a state of wheel slip: loss of traction, excessive roll, or excessive yaw. The mode-switching logic controls a set of proportional-integral-derivative

(PID) compensators that regulates the commanded brake pressures at the wheel in response to measured and estimated parameters. The controller design implemented in Simulink® has six PID gains that can be varied to optimize ESC performance.

In this model, we have access to wheel speeds, brake pressures, body roll, yaw rates, and slip rates. Some vehicle states are estimated from available sensor data just as they would be in an actual vehicle controller, while other states are estimated from mathematical relationships between measured and estimated parameters. The vehicle speed is estimated from the averaged wheel speeds of the unbraked wheels. A low-pass filter is used to simulate the effect of vehicle inertia on the measured wheel speeds and prevent the occurrence of undefined values of the vehicle speed in the estimator when brake pressures are applied to the four wheels.

Body-slip rate is a difficult parameter to measure directly without the use of expensive sensors.

The implemented ESC estimates body-slip rate from measured yaw rates. The body-roll angle is estimated from a transfer function that relates the lateral acceleration to the body-roll angle. This transfer function is valid for cases when the body-roll angle is within specified design limits. By ensuring that the optimization algorithm heavily penalizes the controller for estimated body-roll angles that exceed the design limits, we can show that estimation algorithms for accurately predicting the body-roll angle outside of the design range are not needed. As a result, we can substantially simplify the algorithm for body-roll angle estimation in normal vehicle operating conditions.

Once the controller structure has been specified, the next task is tuning the controller gains to meet design requirements. Without models that can be experimented with systematically, engineers will typically need to rely on knowledge from past vehicle programs or spend many hours trying to tune the parameter values for the PID compensators via on-track testing. Model-Based Design shifts the process away from tweaking hardware and toward using models to explore the design space. By combining these models with automated optimization-based methods, engineers can significantly reduce the need for exhaustive testing with prototypes or simulation to arrive at the optimal controller gains.

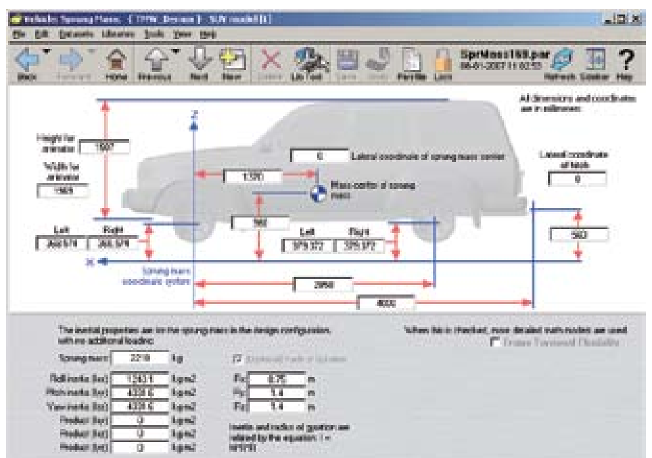

Figure 1: Setting up the vehicle parameters using the CarSim user interface.

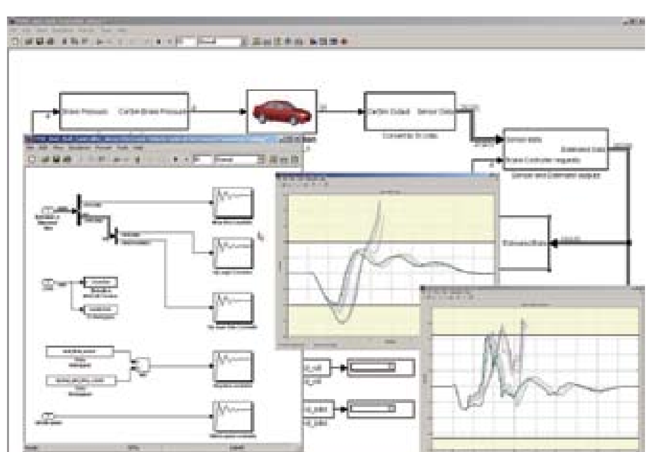

Figure 2: Details of the signals (left) fed to the signal constraint blocks and variation (right) of the roll and slip-rate signals as the optimization progresses. The yellow area represents the inadmissible range of signal values.

For this application, the optimization algorithm starts out with controller gains set to zero and requires about a hundred iterations over four minutes of computation time to find the optimal controller gain values that keep the system within design limits. Iterative trial-and-error methods requiring intensive manual testing for the same number of test cases would take over four hours, assuming the tests were perfectly repeatable and no damage to the vehicle, due to rollover, occurred during the tuning process. Numerically simulating a ten-second NHTSA fishhook maneuver takes less than three seconds on a modern PC and can be repeated infinitely without the overheads associated with on-track testing.

In this model, we are looking for the optimal controller gains for the PID compensators in the ESC that will keep the vehicle within certain design limits for body-roll angle, slip rate, and slip angle, while minimizing speed loss as a result of differential braking. The six tunable gains provide a nearly infinite set of controller gain combinations that would be impossible to test exhaustively. Simulink® Response Optimization™ lets us graphically set up the system requirements to limit body roll and vehicle slip while simultaneously minimizing energy lost to ESC braking. After the performance criteria are specified, optimization-based routines automatically adjust the parameters so that the vehicle can execute the fishhook maneuver without rolling over.

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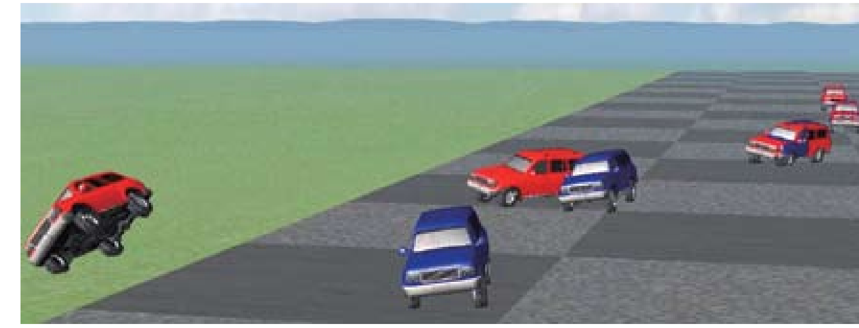

Figure 3: Visual representation of SUV behavior with and without the ESC when performing a fishhook maneuver at 50 miles/hour. The blue SUV has the optimized ESC; the red SUV does not have an ESC.

The signals that need to be constrained are fed to Signal Constraint blocks and their design limits are set graphically, as shown by the solid horizontal lines in figure 2. The following requirements (constraints) are selected to meet design goals:

- Body roll is limited to +/-11.5 degrees.

- Vehicle slip is limited to +/-11.5 degrees.

- Maximum slip rate is set to +/-37.25 degrees/second.

- Minimum vehicle speed at the end of the fishhook maneuver is set to 10 miles/hour.

- Time at the end of the simulation is set at 10 seconds.

The simulation time constraint is needed to penalize any early termination of the simulation at vehicle rollover that results from a set of unsuitable controller gain values.

Each signal constraint defines piecewise linear upper and lower bounds on the signal. During optimization the controller gains are adjusted and the simulation is rerun in an iterative loop until the simulated signals satisfy the specified bounds or the optimization routine fails to solve the problem. Figure 2 shows the variation of the roll signal and the slip-rate signal as the optimization algorithm iterates to a solution. In solving this feasibility problem, the optimization algorithm computes the maximum signed distance of the signal being constrained to each edge of the piecewise linear bound. Typically, a negative value indicates that the constraint is satisfied.

The optimization algorithm uses the signed distance to each edge to update the controller parameters. The optimization algorithm constructs the optimization problem independently of the numerical solver used to compute the states of the system. Gradient- or nongradient-based methods, such as genetic algorithms, can be used. In this case, given the switching nature of the controller and consequent nonsmooth behavior, gradient-based solvers are less likely to find a global solution. As a result, a pattern search algorithm is used. In practice, we recommend switching among a few different types of optimization methods to ensure that the optimization algorithm finds a global extremum and to rule out convergence to local minima of the cost function.

Controller verification and performance validation

Figure 3 shows a visual representation of the performance of the optimized ESC eliminating the rollover in the vehicle. The red vehicle rolling over has no controller; the blue vehicle has an optimized controller. Through this simulation, we have demonstrated controller design that eliminates SUV rollover, thereby greatly reducing the amount of on-track tuning and complete reliance on testing with a physical vehicle.

Figure 3: Visual representation of SUV behavior with and without the ESC when performing a fishhook maneuver at 50 miles/hour. The blue SUV has the optimized ESC; the red SUV does not have an ESC.

Next steps and conclusion

The next steps in the design would typically involve converting the control algorithm from the Simulink model into code that is implemented on a chassis controller. To perform design verification before vehicle production, track testing of the code on an instrumented prototype vehicle is possible with integrated rapid prototyping and hardware-in-the-loop (HIL) tools. Production code generation tools can be used to obtain the realization of the algorithm to code implemented on the prototype vehicle; this approach minimizes errors in the conversion process and further accelerates the vehicle development process. Additionally, using the model, engineers can also test the controller against different vehicle configurations, enabling rapid modifications maximizing the reuse of the controller design over a range of vehicle programs.

This article highlights the use of Model-Based Design for developing an ESC algorithm that addresses the rollover problem. A method of automatically tuning the ESC based on design requirements is also presented.

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Virtual Prototyping with Simulation for Complex HEV Applications

Boosts quality and cuts costs

Today's advanced hybrid electric vehicles (HEVs) bring together an almost unimaginable collection of mechanical components, electronic control systems, wiring harnesses and interfaces. For this complex machine to function properly, all components, coupled with other elements for safety, comfort and efficiency, must work together seamlessly as a reliable, cost-effective drivetrain. The challenge lies in building, analyzing and debugging these separate components so that when they are assembled and finally shipped, a reliable vehicle is ready for the road.

By David Smith, Synopsys Scientist, Saber Product Line, Hillsboro, Oregon

Traditionally, the components and subsystems in a drivetrain were developed and tested almost in a vacuum; each team of mechanical, electrical and software engineers worked separately designing, building and testing subsystem components against a set of allowable defect tolerances. The problem with this method was that any given component in the drivetrain might work within tolerable limits in isolation, but could fail when integrated with other drivetrain components. Even if each subsystem met its assigned tolerance requirements, the combination of individual allowable defects could lead to failure when coupled with other components operating within their tolerance ranges. This combined failure resulted in warranty repairs, rounds of finger pointing by suppliers and OEMs and bad publicity for the manufacturer.

Virtually, the right approach

For a complex design, like an HEV, a Robust Design methodology consisting of virtual prototyping and simulation is essential. With this methodology, a system's design, analysis and debugging can be controlled by engineers at workstations, as opposed to traditional methods where physical prototypes are used. Prototypes are limited by cost because a manufacturer must develop a relatively small number to stay within tight budget guidelines. Additionally, prototyping in extreme environmental conditions can be impractical or dangerous.

In a Robust Design environment,

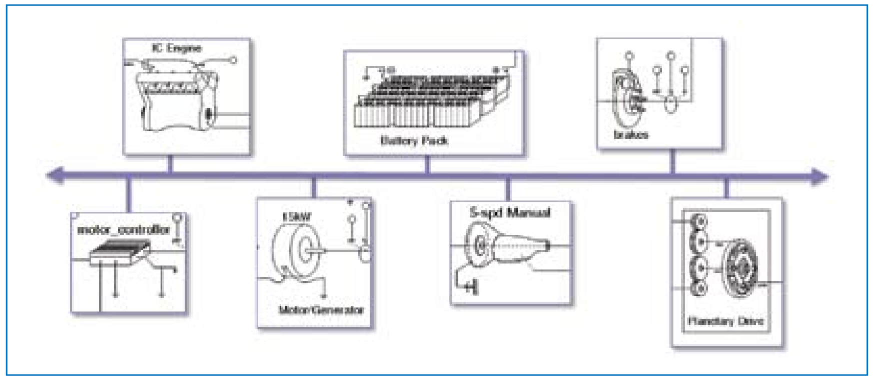

Figure 1: In a virtual prototyping and simulation environment, each component in the drivetrain can be created, exercised and analyzed before being integrated and simulated as part of the whole design.

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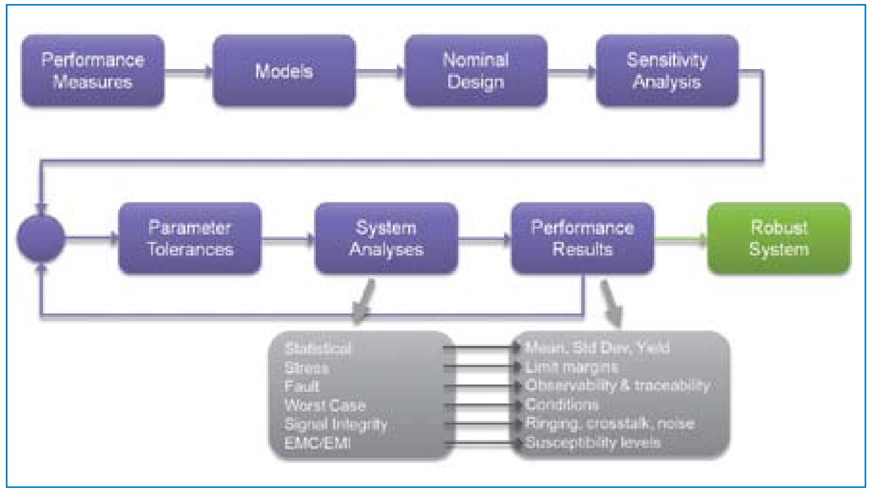

Figure 2: In this VHDL-AMS model of a lithium-ion battery, statistical tolerances can be analyzed and represented in a waveform, allowing engineers to test the design under a range of operating conditions.

however, tens of thousands of permutations of values can be applied to drivetrain components at minimal incremental cost (and no danger!); this permits engineers to analyze a wide range of variations (due to environment or part tolerance) for a given component and their overall effect when combined with other elements in a design. This process greatly reduces the chance of failures in the field, where all of the elements must work together in harsh real-world conditions.

There are numerous simulation and statistical analysis tools on the market that employ proven models, design languages, component libraries and standards. The problem lies in educating mechanical, electrical and software engineers on proper Robust Design methodologies and best practices for debugging virtual prototypes. Currently, teams in each discipline are familiar with the prototyping and testing methodologies in their separate domains, and are well-versed in using tools that are meant for each particular subsystem. Most mechanical simulation, for example, uses finite element analysis tools, not dynamic simulators. Similarly, software engineers have their own tools and methodologies to check their code for inefficiencies and bugs that can cause system failures. For their part, electro-mechanical engineers rely mainly on Spice simulators for the analog components in their designs.

While these tools and methodologies have worked well in the past, they are inadequate for spanning the disparate realms of electric, mechanical and hydraulic systems that converge in an HEV drivetrain (Figure 1). An overarching multi-domain simulation, analysis and debug methodology is therefore essential for a successful HEV design.

Complex challenges demand proven solutions

Software tools, such as Synopsys' Saber circuit simulator for mixed-signal, mixed-domain Mechatronic systems, have been used successfully for system verification for some time now; they are perfectly suited to the growing market requirement for Zero Defect design of complex new target applications like the HEV drivetrain. Saber's analysis and modeling capabilities, comprehensive model libraries and multi-language model creation tools help engineers achieve an optimized, robust design. Saber also includes failure mode effects analysis (FMEA), which can analyze virtual prototypes of any system under various conditions from ideal to worst case. These advanced simulation environments give engineers the ability to simulate, analyze and verify interactions between multiple physical domains, allowing them to factor

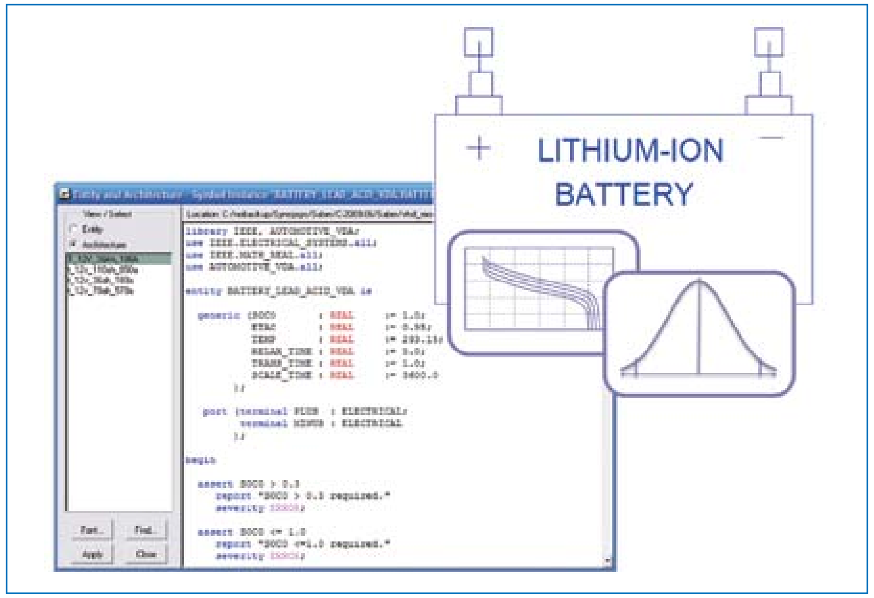

Figure 3: A virtual prototyping environment lets engineers achieve test coverage that would be unattainable with actual physical models. Superior results can be achieved when stress analysis, worst case scenarios, signal integrity and other conditions are addressed and analyzed.

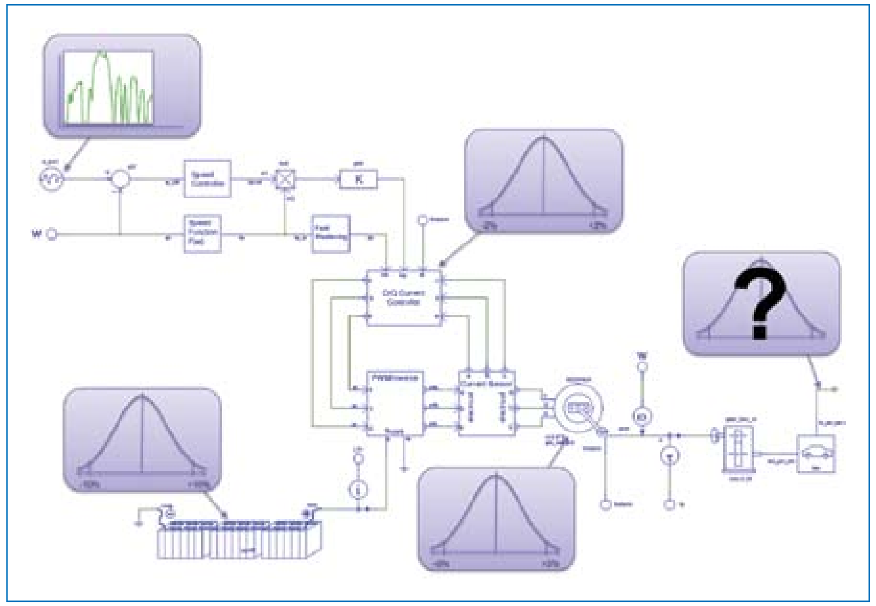

Figure 4: As each component is integrated into the drive train, statistical simulation lets engineers analyze and understand the impact of a range of tolerances within each component and their combined effect on the whole system.

electrical, magnetic, mechanical, thermal and hydraulic effects into their design verification processes.

Simulating a virtual prototype of a system begins with the construction of a dynamic model that will accurately represent the behavior of a system across the operating conditions it will face. Hardware description languages (HDLs), like VHDL-AMS and MAST, allow engineers to create complex models that span engineering disciplines. These models go well beyond capturing nominal system behavior and include parameter tolerances to account for the variance and uncertainty that occur in the physical world (Figure 2).

Properly developed virtual models can also be employed in any combination of statistical, parametric, sensitivity, stress and failure mode analyses to promote complete system verification. Statistical analysis can predict how component tolerance variations affect system performance, allowing designs to achieve Six Sigma quality. Parametric analysis lets engineers fine-tune key parameters in a design, while sensitivity analysis can determine which parameters most affect system performance. Stress analysis helps engineers evaluate the degree of component stress in a system during operation. The aforementioned failure mode analysis plays a key role as well, by providing a vehicle for analysis and assessment of systems under various user-defined fault conditions. Post-simulation, automatically generated reports help designers quickly assess the reliability of the complete system design (Figure 3).

As these individual component models are integrated together, statistical simulation techniques (e.g. Monte Carlo analysis) can be used to predict the impact of part variations in the system and further identify the components and parameters that have the greatest effect on system robustness. Early in the product design, possibly even prior to prototyping, issues due to multi-domain tolerance stackup can be addressed and verified (Figure 4). Similarly, product reliability may be quantified, through either injecting faults into the system, or by identifying worst-case performance of the virtual prototype that might be impractical (or impossible) to measure on a physical prototype.

Standards bodies offer open solutions

When selecting the right simulation environment, engineers must also take standards efforts into account. Using tools and methodologies based upon open standards can minimize risk for engineers without limiting their choice of vendors or library models. Standards bodies, such as the Society for Automotive Engineers (SAE) International and the German Automobile Industry Association (VDA), are resources that designers may tap for useful information on standardization efforts for design languages, model library interoperability and other related concerns. Additionally, focused working groups within these bodies, such as the VDA's FAT-AK30, can also be useful for engineers who want to track and possibly participate in standardization efforts. (For more information, visit: http://www.sae.org/servlets/index; http://www.vda.de/en/verband/index.html; and http://fat-ak30.eas.iis.fraunhofer.de/index_en.html).

The time is now

Traditional design, debug and analysis tools are quickly running out of steam, as the stringent requirements for product quality (e.g. Zero Defect Design) are applied to ever more complex applications. Subsystems and components that are built and tested as separate entities are more likely to fail when employed as a single working unit in a complex HEV. Companies that evaluate and use tools and methodologies geared towards Robust Design processes will lower costs, reduce risk and ultimately gain market share with vehicles that move passengers efficiently and safely to their destinations.

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Automotive Optocouplers

Beyond electrical performance at high temperature

The trend in electric or hybrid electric vehicles has accelerated the introduction of electronic components into cars. Components residing under the hood will experience high ambient temperatures in excess of +105°C. While some products are able to meet electrical specifications up to +125°C, they cannot be conveniently assumed to be suitable for automotive applications.

By Andy Poh, Product Manager; Leong Yik Loong, Quality Engineer; Roy Tan, R&D Engineer; Avago Technologies

Here, we take a look at what goes into an automotive grade optocoupler beyond meeting high temperature electrical specifications. As part of the R^2Coupler™ family, Avago Technologies' automotive grade optocouplers were designed and qualified to meet these stringent standards.

Automotive components, like any other devices, need to comply with certain specifications or standards. The most well-known technical specification for automotive suppliers is the ISO/TS 16949 quality management system, prepared by the International Automotive Task Force (IATF), in conjunction with the International Organization for Standardization (ISO). The Automotive Electronics Council' s AEC-Q100 standard provides a guideline for failure mechanism based stress tests for qualification of automotive integrated circuits.

AEC-Q100

In the AEC-Q100 document, a comprehensive set of qualification tests is recommended for different grades (segregated according to different operating temperature) and/or different packaging (plastic or hermetic). It stipulates the quantity, coupled with variability, of samples required per stress test. The qualification groups, as summarized in Figure 1, involve accessing the assembly and packaging parameters before performing electrical testing. Parts are then subsequently subjected to various electrical, environmental as well as mechanical stresses to ascertain the reliability of the parts for automotive applications.

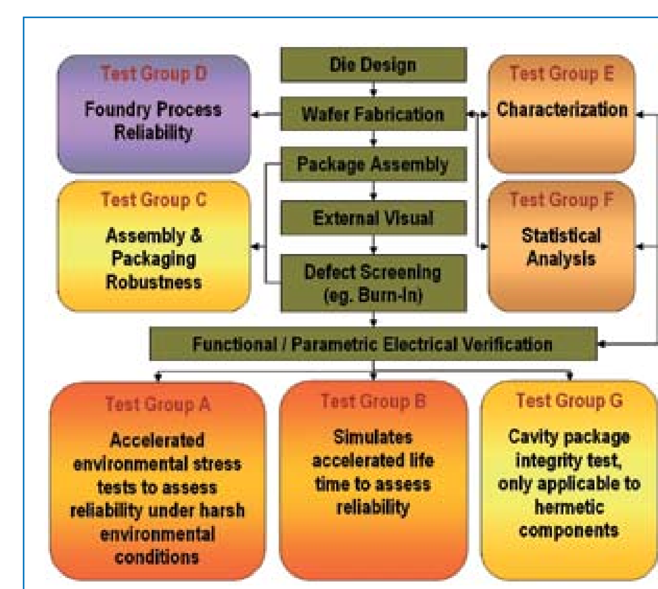

Figure 1: AEC-Q100 Qualification Groups.

Starting at the foundry level, Test Group D evaluates the reliability of the foundry process and their design rules. These tests are typically performed by the foundry and reliability is checked through the monitoring of critical data, such as electro-migration and hot carrier injection. For assembly packaging, in-process tests under Test Group C include wire pull tests, physical dimensions validation and solderability verification to ensure package assembly robustness.

Test Groups E and F assess the performance of the parts in terms of statistical distributions and electrical

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characteristics. Test Group G is classified as cavity package integrity tests, which recommends specialized tests applicable only to hermetic components, and is not applicable to plastic encapsulated R^2Couplers.

Test Group B simulates accelerated lifetime to assess reliability. A common test in Test Group B is the High Temperature Operating Life, where parts are biased under high temperature over time, to screen for potential failure modes during actual operation. For R^2Couplers, careful considerations on biasing conditions are taken to ensure both LED and silicon IC's are well-assessed. The LED used in R^2Couplers is designed to cope with the high junction temperature to ensure long life operation with minimal drop in light output power when subjected to temperature and current stress. Packaging design to cope with heat dissipation from the chip set was taken into consideration as well.

Test Group A utilizes various accelerated environmental stress tests, such as Temperature Cycling and Autoclave to evaluate reliability under harsh environments with temperature and/or humidity extremes. Optocouplers, having more components and involving more complex assembly processes than monolithic ICs, tend to face many technical challenges in order to survive the tests in this group. R^2Couplers implement the concept of redundancy by reinforcing critical functional pads with double wire bonds (see Figure 2), improving package robustness and reliability under such harsh conditions.

R^2Couplers are focused on reinforced insulation and reliability to deliver safe signal isolation which is critical in automotive and high temperature industrial applications. Assessment on reliability of the insulation barrier is not specifically defined under the AEC-Q100 guidelines. Optocouplers have been

Table 1. Key Differences between Industrial and Automotive Grade Optocouplers

	Industrial Grade Optocouplers	R^2Coupler Extended Temp ACPL-xxxU	R^2Coupler Automotive Grade ACPL-xxxV/xxxT
Maximum Temperature Range	$-40°C \le T_A \le +105°C$	$-40°C \le T_A \le +125°C$	$-40°C \le T_A \le +125°C$
Piece Part	Industrial Grade	Industrial Grade	Automotive Grade
Critical Wire Bonds	Single Wire	Double Wire	Double Wire
Qualification Plan	JEDEC47	JEDEC47	AEC-Q100
Qualification Sample	3 x 25 units typically (Per JEDEC)	3 x 25 units typically (Per JEDEC)	3 x 77 units typically (Per AEC-Q100)
Qualification Groups	Per JEDEC47	Per JEDEC47	Per AEC-Q100
Quality Management	ISO 9001	ISO 9001	ISO/TS 16949
Assembly Line	ISO certified	ISO certified	TS certified
PPAP	Not provided	Not provided	Per customer requirement
Record Retention	≤10 years typically	≤10 years typically	≥10 years typically
Lot Tracking	Normal datecode marking	Normal datecode marking	Extended datecode marking

in use for high voltage insulation for many years and experienced manufacturers have developed appropriate tests to check on the integrity and reliability of insulation layers and construction. R^2Couplers are certified to safety standards specifically for optocouplers, such as UL1577, CSA Component Acceptance Notice #5 and IEC60747-5-2 or IEC60747-5-5, with well-defined high voltage safety criteria in terms of: withstand voltage, transient overvoltage, working voltage, creepage and clearance.

At the end of the qualification, a Certificate of Design, Construction and Qualification will be prepared by the supplier for submission to the customer.

In addition to having qualification flow for new parts, AEC-Q100 also has guidelines for any changes to released automotive parts. This ensures that potential quality and reliability

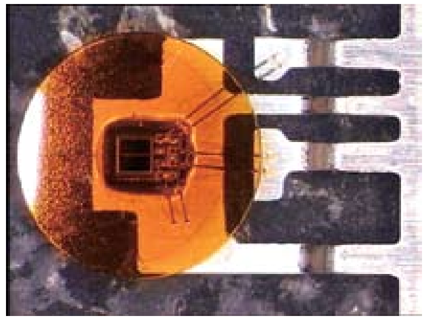

Figure 2: Reinforcing critical functional pads with double wire bonds.

concerns shall be addressed during qualification of the change prior to actual implementation and notification to customers.

ISO/TS 16949

AEC-Q100 provides the necessary confidence on the robustness of the product, but not the quality management system of ensuring consistent production of quality parts for automotive applications. ISO/TS 16949 quality specification helps to address this gap specifically for the automotive industry.

While ISO 9000 quality management principles are widely accepted in the industry, ISO/TS 16949 technical specification includes additional clauses pertaining to the automotive industry and incorporates any applicable automotive customer specific requirements into the quality management system.

Certification of the automotive optocoupler line to ISO/TS 16949 specification ensures a quality management system is in place that provides for continual improvement, emphasizing defect prevention and reduction of variation and waste in the supply chain, as well as being customer-centric, taking into account additional customer requirements.

There are 5 technical reference handbooks from ISO/TS 16949. These include 3 core tools; Potential Failure Mode Effects Analysis (FMEA), Fundamental Statistical Process Control (SPC) and Measurement System Analysis (MSA), and 2 technical handbooks; Advanced Product Quality and Control Plan (APQP) and Production Part Approval Process (PPAP).

Depending on the level of submission requested by the automotive customers, PPAP documentation may be required for any new parts, product modification or correction of discrepancy on previous submitted parts. Once completed, the PPAP documentation may be submitted to the customer for review to validate if their requirements are met.

In addition to the extensive and detailed documentary support highlighted above, automotive customers often have more stringent requirements than other industries. A few examples are cited below on how Avago's automotive grade optocouplers support such administrative demands.

Longer record retention period

Automotive customers are typically requesting a minimum 10 years of record retention. A comprehensive and organized database was set up for automotive optocouplers to cater for the longer retention period as well as fast retrieval of any related information as needed.

Enhanced lot traceability

In the event of any quality or reliability problems, the unique date code extensions marked on individual automotive optocouplers will facilitate quick traceability of detailed lot histories of affected parts for containment action. Critical information such as LED and IC wafers or a batch of raw materials used, can be retrieved based on the unit marking.

Conclusion

A comparison of key differences of Avago's industrial and automotive grade optocouplers is summarized in Table 1, reflecting the need for suppliers of automotive parts to comply with more comprehensive qualification guidelines (AEC-Q100) and quality management systems (ISO/TS 16949). Optocouplers, being insulation components, will need to be stressed beyond what is stipulated in the AEC-Q100, and having more piece parts and complex processes, will require emphasis on the quality system to ensure consistent quality parts.

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Automotive Infotainment LCD-TFT Panels

Require rugged LED drivers for backlighting

The market size for all LEDs is expected to reach $10.3 billion by 2012. High and ultrahigh brightness LEDs combined will represent approximately $4.45 billion of this total; almost 5.5 times the $783 million market size in 2007. One of the major drivers of this staggering growth is the adoption of LED lighting in modern automobiles. LED applications include Thin Film Transistor-Liquid Crystal Display (TFT-LCD) panel backlighting in infotainment systems and gauge clusters, interior lighting, brake lights, day time running lights, turn signal indicators and most recently head lights.

By Jeff Gruetter, Product Marketing Engineer, Linear Technology Corp.

How can such an impressive growth potential in automotive lighting be supported? First of all, LEDs are ten times more efficient at producing light than incandescent bulbs and almost twice as efficient as fluorescent lamps, including cold cathode fluorescent lamps (CCFL). This reduces the amount of electrical power required to deliver a given amount of light output (measured in lumens), as well as the dissipated heat. As LEDs are further developed, their efficiency at producing lumens from electrical power will only continue to increase. Secondly, in a very environmentally conscience world, LED lighting does not require the handling, exposure and disposal of the toxic mercury vapor commonly found in CCFL/fluorescent bulbs. Thirdly, incandescent bulbs need to be replaced about every 1,000 hours, while fluorescent bulbs last up to 10,000 hours compared to a 100,000+ hour lifetime for LEDs. In most applications, this allows the LEDs to be permanently embedded into the final application without the need for a fixture. This is especially important for backlighting automotive navigation/infotainment panels which are embedded into a car's interior as they will never require replacement during the life of the car. Additionally, LEDs are orders of magnitude smaller and flatter then their counterparts so the LCD panels can be very thin, thereby requiring minimal space in the interior of the car. Furthermore, by using a configuration of Red, Green and Blue (RGB) LEDs, an infinite number of colors can be delivered. LEDs also have the ability to dim and turn on/off much faster than the human eye can detect, enabling dramatic improvements in backlighting of LCD displays while simultaneously allowing dramatic contrast ratios and high resolution.

Figure 1: Navigation LCD display.

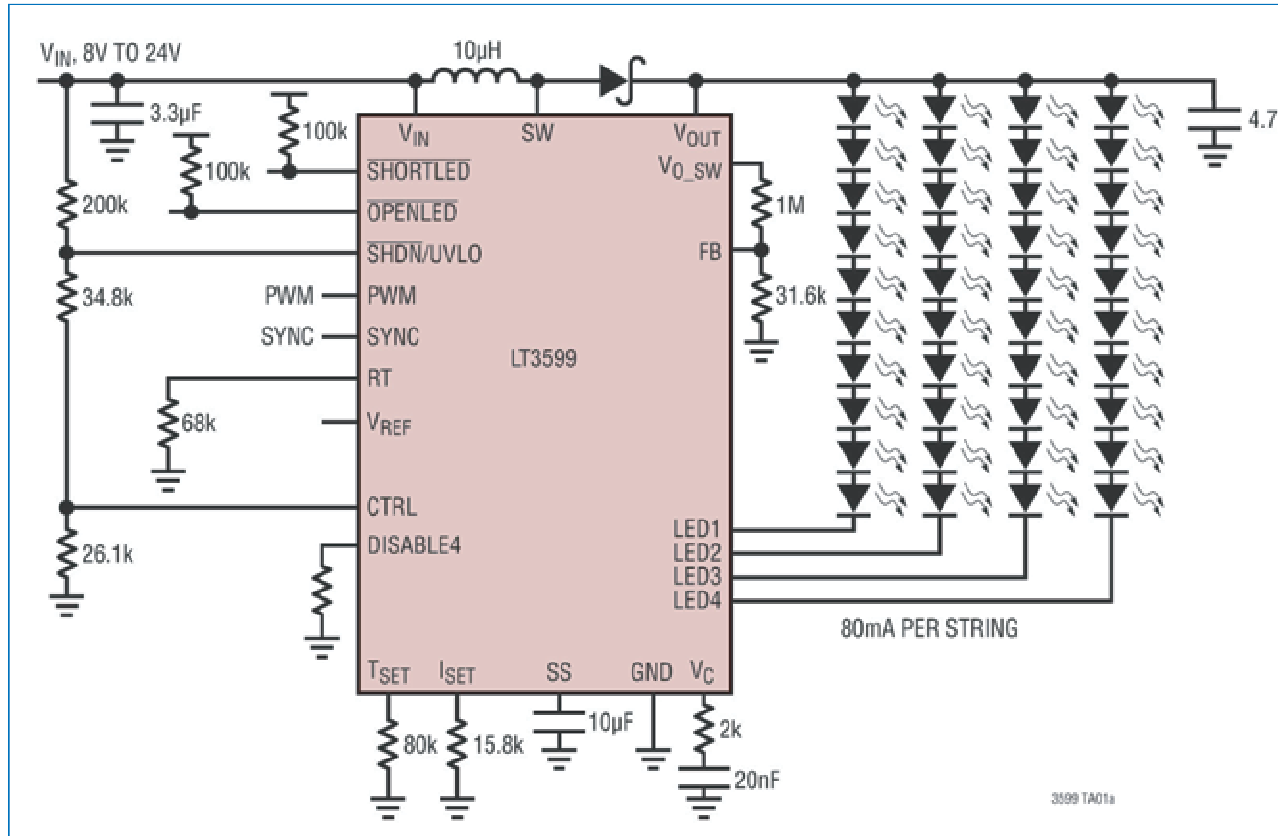

Figure 2: 90% Efficient 12 Watt LED backlighting circuit using the LT3599.

One of the biggest challenges for automotive lighting systems designers is how to optimize all the benefits of the latest generation of LEDs. As LEDs generally require an accurate and efficient DC current source and a means for dimming, the LED driver IC must be designed to address these requirements under a wide variety of conditions. Power solutions must be highly efficient, robust in features and be very compact as well as cost effective. Arguably, one of the most demanding applications for driving LEDs will be found in automotive infotainment TFT-LCD backlighting applications as they are subjected to the rigors of the automotive electrical environment, must compensate for a wide variation of ambient lighting conditions and must fit in a very space-constrained footprint, all while maintaining an attractive cost structure.

Automotive LED backlighting

Benefits, such as small size, extremely long life, low power consumption and enhanced dimming capability have triggered the wide spread adoption of LED TFT-LCD backlighting in today's automobiles. Infotainment systems usually have an LCD screen mounted somewhere in the center of the dashboard so both the driver and the passenger can easily view their location, perform audio tuning and a variety of other tasks. Additionally, many cars also have LCD displays that entertain passengers in the rear seat with movies, video games and so forth. Historically, these displays used CCFL backlighting, but it s becoming more common to replace these relatively large bulbs by very low-profile arrays of white LEDs, which provide more precise and adjustable backlighting as well as a service life that will easily out live the vehicle.

The benefits of using LEDs in this environment have several positive implications. First, they never need to be replaced since their solid state longevity of up to 100K+ hours (11.5 service years) surpasses the life of the vehicle. This allows automobile manufactures to permanently embed

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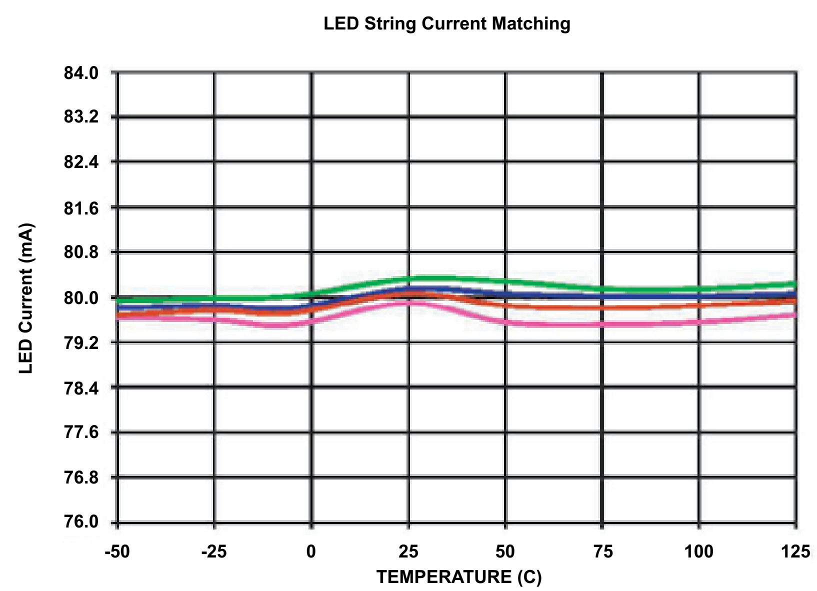
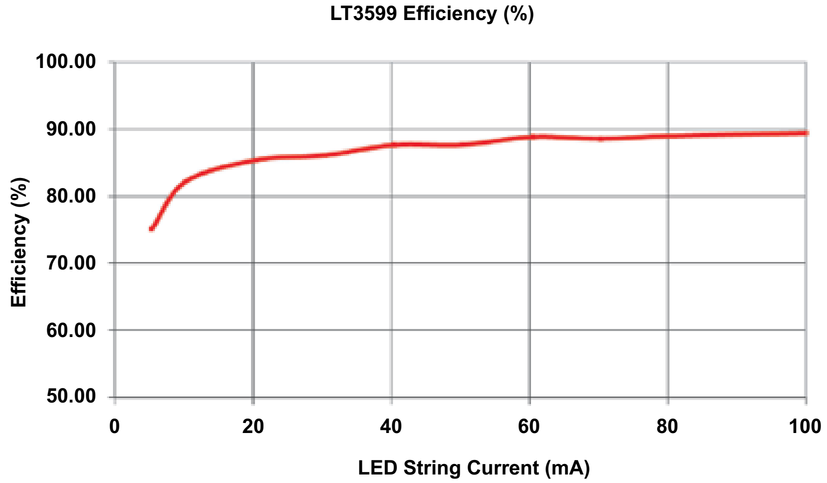
them into "in cabin" back lighting without requiring accessibility for replacement. Styling can also be dramatically changed as LED lighting systems do not require the depth or area as do CCFL bulbs. LEDs are also generally more efficient than fluorescent bulbs at delivering light output from the input electrical power. This has two positive effects. First, it drains less electrical power from the automotive bus, and equally important, it reduces the amount of heat that needs to be dissipated in the display, eliminating any requirement for bulky and expensive heat sinking.

Another important benefit of LED backlighting is the wide dimming ratio capability provided by a high performance LED driver IC. As the interior of a car is subjected to a very wide variation of ambient lighting conditions, ranging from direct sunlight to complete darkness with every variation in between, it is imperative that the LED backlighting system is capable of very wide dimming ratios, generally up to 3,000:1. With the proper LED driver IC, these wide dimming ratios are relatively easy to attain which are not possible with CCFL backlighting. Figure 1 shows a typical LCD based infotainment screen.



Current Matching Over Temperature



Efficiency vs. LED Current Temperature

Figure 3: LED current matching & efficiency of LT3599 in Figure 2.

Design parameters for automotive LED lighting

In order to ensure optimal performance and long operating life, LEDs require an effective drive circuit. These driver ICs must be capable of operating from the caustic automotive power bus and also be both cost and space effective. In order to maintain their long operating life, it is imperative that the LEDs current and temperature limits are not exceeded.

One of the automotive industry's major challenges is overcoming the electrically caustic environment found on the car's power bus. The major challenges are transient conditions known as "load dump" and "cold crank." Load dump is a condition where the battery cables are disconnected while the alternator is still charging the battery. This can occur when a battery cable is loose while the car is operating, or when a battery cable breaks while the car is running. Such an abrupt disconnection of the battery cable can produce transient voltage spikes up to 40V as the alternator is attempting a full-charge of an absent battery. Transorbs on the alternator usually clamp the bus voltage to approximately 36V and absorb the majority of the current surge, however DC/DC converters down stream of the alternator are subjected to these 36V to 40V transient voltage spikes. These converters are expected to survive and regulate an output voltage during this transient event. There are various alternative protection circuits, usually transorbs, which can be implemented externally. However, they add cost, weight and take up space.

Cold crank is a condition that occurs when a car's engine is subjected to cold or freezing temperatures for a period of time. The engine oil becomes extremely viscous and requires the starter motor to deliver more torque, which in turn, draws more current from the battery. This large current load can pull the battery/primary bus voltage below 4.0V upon ignition, after which it typically returns to a nominal 12V.

However, there is a new solution to the dilemmas, Linear Technology' s LT3599, which is capable of both surviving and regulating a fixed output voltage through out both of these conditions. Its input voltage range of 3V to 30V, with transient protection to 40V, makes it ideal for the automotive environment. Even when V_{IN} is greater than V_{OUT}, which could occur during a 36V transient, the LT3599 will regulate the required output voltage.

As most LCD backlighting applications require between 10 and 15watts of LED power, the LT3599 has been designed to service this application. It can boost the automotive bus voltage (nominal 12V) to as high as 44V to drive up to four parallel strings, each containing ten 100mA LEDs in series. Figure 2 shows a schematic of the LT3599 driving four parallel strings with each string comprised of ten 80mA LEDs, delivering a total of 12W.

The LT3599 utilizes an adaptive feedback loop design, which adjusts the output voltage slightly higher than the highest voltage LED string. This minimizes power lost through the ballasting circuitry to optimize the efficiency. Figure 3 illustrates the LT3599's efficiency that can be as high as high as 90%. This is important because it eliminates any requirement for heat sinking, enabling a very compact low profile footprint. Equally important for driving LED arrays is the provision of accurate current matching to insure that the backlighting brightness remains uniform across the entirety of the panel. The LT3599 is guaranteed to deliver less than 2% LED current variation across its -40˚C to 125˚C temperature range.

The LT3599 uses a fixed frequency, constant current boost converter topology. Its internal 44V, 2A switch is capable of driving four strings of up to ten 100mA LEDs connected in series. Its switching frequency is programmable and synchronizable between 200kHz and 2.5MHz enabling it to keep switching frequency out of the AM radio band while minimizing the size of the external components. Its design also enables it to run one to four strings of LEDs. If fewer strings are used, each string is capable of delivering additional LED current. Each string of LEDs can use the same number of LEDs or can be run asymmetrically with a different number of LEDs per string.

The LT3599 can dim the LEDs using either True Color PWM™ dimming or analog dimming via the control pin. True Color PWM offers dimming ratios as high as 3,000:1, which are often required in automotive applications. By PWMing the LEDs at full current, any color shifts of the LED light are eliminated and the frequency is so high, it is undetectable by the human eye. Analog dimming offers a very simple means to achieve dimming ratios up to 20:1 by varying the level of CNTRL pin voltage. This means of dimming will be dependent on the variations of ambient light that the LCD panel is subjected to.

Furthermore, the LT3599 has integrated protection features that include open and short circuit protection and alert pins. For example, if one or more LED strings are open circuit, the LT3599 will regulate the remaining strings. If all of the strings are left open, it will still regulate the output voltage and in both cases would signal the OPENLED pin.

Similarly, if a short circuit occurs between V_{OUT} and any LED pin, the LT3599 immediately turns off that channel and sets a SHORTLED flag. Disabling the channel protects the LT3599 from high power thermal dissipation and ensures reliable operation. Other features that optimize reliability include output disconnect in shutdown, programmable under voltage lockout and programmable LED temperature derating. The high voltage capability and high level of integration of the LT3599 offers an ideal LED driver solution for automotive back-lighting applications.

Conclusion

The unprecedented acceleration of LED backlighting applications in automobiles has created many specific performance requirements for LED driver ICs. These LED drivers must also provide constant current in order to maintain uniform brightness, regardless of input voltage or LED forward voltage variations, must operate with high efficiency, offer wide dimming ratios and have a variety of protection features to enhance system reliability. These applications also require very compact, thermally efficient solution footprints. Linear Technology has taken these design requirements head-on with LED driver ICs like the LT3599. Additionally, Linear Technology has developed an entire family of high current LED driver products aimed specifically at automotive applications ranging from LCD backlighting to turn signals and even headlight applications. Today's automotive lighting system designers now have an easy and effective LED driver source for their most challenging LED lighting designs.

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Green Page

PSDNA Green Power ENERGY EFFICIENCY

Are We Really Serious?

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

Green is big news right now. It has dominated the mass media to the point where no-one can avoid being sensitized to the effects and potential solutions to climate change and the 'urgent need' to find better ways to generate and use energy.

Certainly in Europe, leaders in industry and government bodies alike have been quick to jump wholeheartedly onto the bandwagon. It looks a compelling and attractive proposition, particularly for those of us connected to the power industry, but are we doing all we should?

Scientific evidence for climate change is abundant and irrefutable, as is the fact that carbon capture and storage technologies must play a role in mitigating this threat. Yet, the gaping disconnect between this important role and the current European policy approach means that emissions are unlikely to be diverted from their current path of rapid growth, according to a new report by independent market analyst Datamonitor.

Established technology

Carbon capture and storage (CCS) technologies present few technical barriers. The technologies are established and have already been successfully demonstrated in a number of cases. Europe's current weak and wavering policy responses as far as CCS is concerned are likely to cause the technology and its much-needed contributions to be pushed back further still. Today, the most significant limiting factor standing in the way of

the technology's wide-scale deployment is the lack of credible policy incentives across European member states.

It is estimated that oil, coal and natural gas will provide 80% of the world's power demand in 2030, with gas and coal providing 50% of this. EU member states have done little more than pick the 'lowest hanging fruit' by implementing policy incentives that back wide-scale deployment of wind power generation, while doing too little to give true credence to the notion of the widespread use of CCS in coal-fired power generation.

PV to recover

A sharp decline in expected PV installations in Spain has meant that on a global level, installations are expected to decline by 32.3% in 2009 according to iSuppli. Spain accounted for 50% of worldwide PV installations in 2008. However, megawatt installations are predicted to rebound in 2010 with growth of 42.5%, followed by a 73.6% rise in 2012 and a 68.6% increase in 2013.

President Obama is signed up to a new energy future, investing heavily in alternative and renewable energy, ending addiction to foreign oil, addressing the global climate crisis and creating millions of new jobs with a goal of generating 25% of US energy from renewable sources by 2025.

This sounds great for the US energy industry and for the environment. It is a brave and decisive step forward for a world leader and is commendable, albeit rare. No doubt there will be setbacks and challenges with the economy along the route, but it is heartening to see a leader making public future commitment and making real financial investment to back it up.

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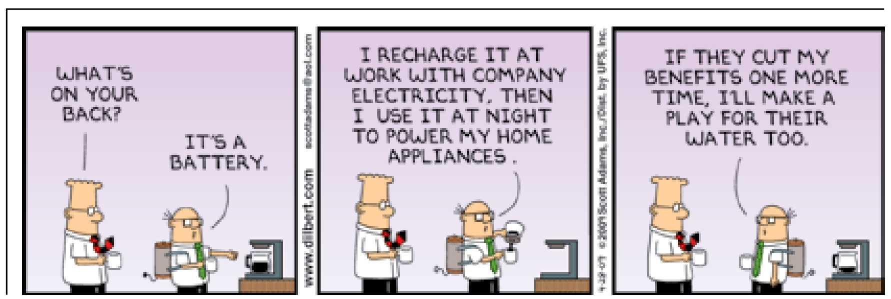
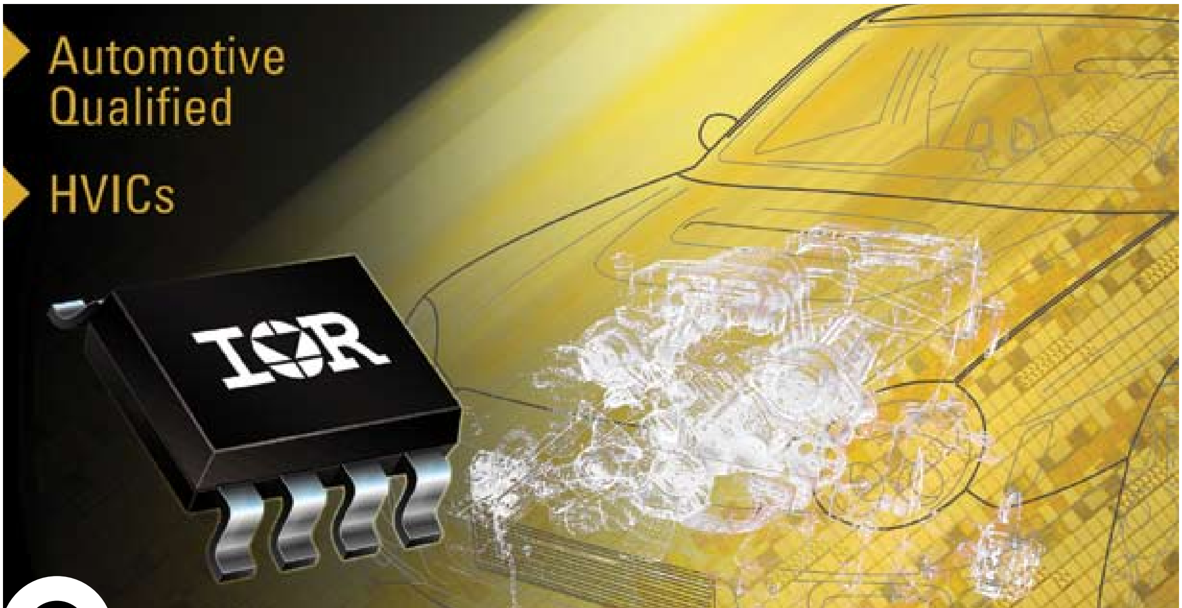




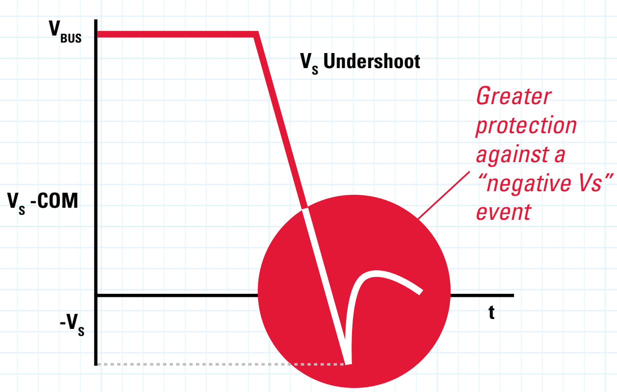
Rugged, Reliable Automotive-Qualified 600V ICs

Part Number	Package	V_{OFFSET}	V_{OUT}	IO+ & IO- (typical)	t_{ON} & t_{OFF} (typical)
AUIRS2123S	SOIC8	600V	10V - 20V	500mA	140 ns & 140 ns
AUIRS2124S	SOIC8	600V	10V - 20V	500mA	140 ns & 140 ns

The AUIRS212xS family of 600V, single channel high-side driver ICs for low-, mid-, and high-voltage automotive applications features exceptional negative Vs immunity to deliver the ruggedness and reliability essential for harsh environments and automotive under-the-hood applications.

Features

- Designed and characterized to be tolerant to repetitive Vs transient voltage
- Fully operational up to 600V
- Tolerant to large dV/ dt
- Under voltage lockout
- Lead-free, RoHS compliant
- Automotive qualified per AEC-Q100



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