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Volume 6, Issue 6

Auto-Anticipation…

Welcome to this very full Automotive-themed issue of Power Systems Design, 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 in the US where controversy continues on the bail outs and the future of this once-proud industry.

The Western European auto industry has also been hit hard by the worldwide recession; government stimulus packages in Germany and France are mitigating the downturn in those nations, according to iSuppli. For 2009 sales are expected to fall by 16.7 percent, but as the economy recovers, regional auto sales are projected to increase slowly starting in 2010 and will return to nearly the 2008 sales level by 2014.

Governments are desperately trying to help stabilize their valuable auto markets during the recession with incentives that give buyers of new cars a discount if they trade in old cars that generate more air pollution than new, cleaner vehicles. The results are encouraging, particularly in Germany where an incentive of 2,500 euros for a new car commenced in mid January and immediately impacted sales. France's incentive, which started in December, 2008, was much smaller at 1,000 euros, so its impact was somewhat lessened compared to Germany. Time will tell.

Despite the uncertainty and anticipation, we have a huge crop of contributions from our 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 are '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 the 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, PSDE
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Abengoa Solar Inaugurates 2nd-Generation Solar Tower

Abengoa Solar's first high-temperature power tower, Eureka, was unveiled by Martín Soler Márquez, Director of Innovation, Science and Enterprise for the Andalusian Regional Government.

This power tower is intended to test, on an experimental basis, a new type of receiver that will achieve the higher temperatures needed for higher-efficiency thermodynamic power cycles. It is the only plant featuring these characteristics in operation in Andalusia and Europe. The aim of this new technology is to increase plant performance, thereby reducing both generating costs and the area of the solar field.

This experimental plant occupies a 16,000-square foot (~1500m^2) portion of the Solúcar Platform and uses 35 heliostats and a 164-foot (~50m) tower which houses the experimental superheating receiver. The power output capacity of the experimental plant is approximately 2MW. The plant includes a thermal energy storage system supplying power supply to the grid for short periods when there is no sunlight.

According to Rafael Osuna, General Manger Abengoa Solar New Technologies, "this marks the beginning of the next experimental phase for this high-potential solar power tower technology which could lead to an important step forward in our goals of generating clean electricity at competitive prices. Our significant investment in research and development has made this groundbreaking concentrating solar power technology a reality."

Abengoa Solar now has three solar power towers in operation, two for commercial use and this experimental tower.

The new plant is part of the Solúcar Platform, a solar thermal and photovoltaic solar installation complex scheduled for completion in 2013. Thanks to its 300MW power output, the plant will supply clean electricity to 153,000 households and eliminate the emission of 185,000 tons (~188,000 tonnes) of CO_2 per year, reaching a total of four million tons over the course of its useful life.

The Solúcar Platform also features a research and development area that is building several demonstration plants for new technologies. This makes the platform the only place in the world with installations employing practically every type of solar technology available, whether in commercial use or under demonstration.

Abengoa Solar focuses its activity on the development and application of technology for generating electrical power with the sun.

www.abengoasolar.com

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

Solyndra Signs $115 Million Contract with Ebitschenergietechnik

SOLYNDRA The new shape of solar™

Solyndra, Inc., a manufacturer of innovative proprietary photovoltaic (PV) systems for commercial rooftops, announced it has signed a new long-term sales contract with solar integrator Ebitschenergietechnik, based in Zapfendorf, Germany. The Euro-based contract, worth up to $115 million, extends through 2013 and brings Solyndra's contractual backlog to approximately $1.8 billion. The solar panels for these contracts will be manufactured at Solyndra's facilities in Fremont and Milpitas, California.

"We are very pleased to announce this relationship with Ebitschenergietechnik, a true pioneer in the field of renewable energy with more than 20 years installation experience. Together with Solyndra's innovative PV systems, Ebitschenergietechnik's strong presence in Germany and elsewhere in Europe should lead to world-class photovoltaic installations in the fastest growing markets for commercial scale solar," said Dr. Kelly Truman, Solyndra's VP of Marketing, Sales and Business Development.

Solyndra's cylindrical, thin film PV systems are designed to generate more electricity on an annual basis from typical low-slope commercial rooftops, while uniquely providing much lower installation costs than conventional PV flat panel technologies.

"The photovoltaics market is fast moving, so it is important to keep your eyes open for new products. Solyndra's solution dramatically changes the model for installation of PV systems, expanding the market by addressing large numbers of industrial rooftops which are not economically viable with other PV technologies. We're confident that we have taken a smart step into a sunny future with Solyndra," said Horst Ebitsch, founder and managing director of Ebitschenergietechnik.

www.ebitschenergietechnik.de

www.solyndra.com

Osram Showcases Siemens' Hamburg Office

Siemens has long been based at Lindenplatz in Hamburg's St. Georg district. To redesign the square the company has joined other local businesses in a public-private partnership project in collaboration with the city of Hamburg. Contemporary LED solutions from Munich lighting manufacturer Osram, part of Siemens' Industry business unit, showcase the square and the Siemens building in the evening hours and at night.

Alongside the façade Osram LED modules also illuminate two water features with cascades on the edge of the square.

At night, a 70-metre long Osram LED band immerses the façade of Siemens' office building and the hedges on the square in alternating colours from yellow to green, blue, red and lilac. The installed RGB-LED modules are capable of showing around 16 million different colours. Apart from the façade, LEDs also illuminate two water features with cascades on the side of the square. Nautilus Midi Ostar LED built-in floor lights were also used to mark the driveway up to the Siemens building and to highlight the five linden trees on the eponymous square.

Hamburg's Göpotec Company supplied a total of 80 Linearlight-Dragon Colormix individual circuit boards (LD18A-RGB) with 14x22° lens attachments for the façade lighting alone set in specially produced lamps and combined to make a light band. The Linearlight-Dragon Colormix modules by OSRAM are ideal for dynamic colour applications and lighting effects in architecture. Their lens attachments, which are also used on Lindenplatz, enable impressive wall-wash effects and coved lighting. The 18 Golden Dragon high-performance LEDs (six each in red, green and blue) per module provide intensive colour effects.

LED modules by Osram immerse the Siemens office on Hamburg's Lindenplatz in alternating colours.

The LED lamps come with OT 75 E 24V-Optronic ballasts and OTi Dali DIM Dali Easy II control units. They make the harmonious change in colours possible. OSRAM's Easy Color control software allows the light to be designed and controlled in the process.

The Lindenplatz makeover adds even more value to the St. Georg district. Apart from the new lighting system, the square was also surfaced in granite and had new benches and more hedges added. What was once a dark street corner has not only become a bright and ingeniously lit square but an inviting place for local residents to spend time in and enjoy.

www.osram.com

PCIM Europe 2010 Call for Papers

Best Paper and Young Engineer Awards for outstanding presentations

The call for papers for PCIM Europe 2010 is now open. The event is Europe's number one meeting place for all fields of Power Electronics, Intelligent Motion and Power Quality/Energy Management, held in Nuremberg, 4-6 May 2010.

Reflecting all aspects of industry and science

The topics of lectures cover, amongst others, recent developments in power semiconductors, passive components, products for thermal management, new materials, sensors as well as servo-technology and the wider field of power quality and energy management. The focus of the 2010 event is Energy Savings and Sustainability.

The deadline for abstract submissions (previously unpublished presentations only) is 15th October 2009.

Proposals will be considered for conference papers, posters or tutorials (the conference language is English). The successful papers will be selected by the Advisory Board which comprises international experts from industry and academia supported by the overall Conference Director Prof. Alfred Rufer of EPFL, Switzerland. All accepted papers will be included in the official PCIM proceedings CD and the IET Inspec database.

3,000 Euro prize - and a trip to Shanghai

For outstanding contributions from young authors (under the age of 35), three "Young Engineer Awards" of 1,000 Euros each will be granted. In addition the author of the best paper in the field of "Energy Efficiency in Automotive, Industrial and Renewable Applications" will receive a Best Paper Award comprising participation at PCIM China Conference in Shanghai including flights and accommodation. The prizes will be awarded at the PCIM Europe 2010 Conference.

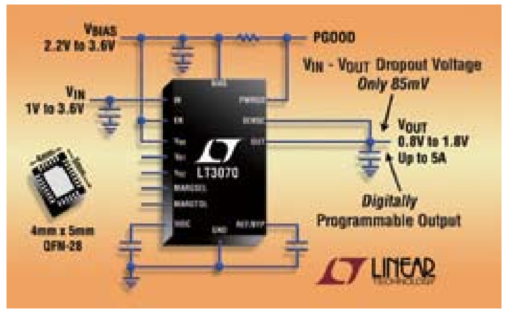
For further details on the call for papers and abstract submission go to:

www.pcim.de

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.

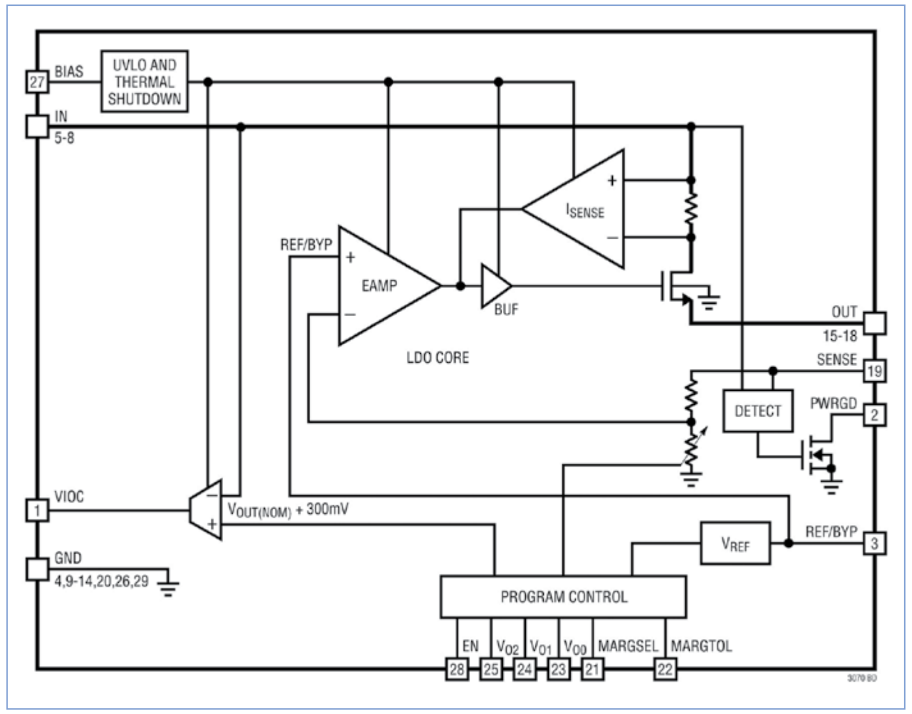


Linear's UltraFast™, digitally programmable ultralow dropout, low noise 5A LDO.

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.

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.



Block diagram of the LT3070.

www.linear.com

Time for Automotive Innovation

By Dr. Henning Hauenstein, Vice President of Automotive Products, International Rectifier Corp

Clearly the automotive sector is having a torrid time - barely a day goes by without reports of the latest woes of vehicle makers in both the commercial and the consumer markets. Furthermore, from Tier 1 suppliers to component manufacturers, the current climate affects all those companies who sell to the sector. However - and this may be hard to believe right now - there is every possibility that we will look back on this downturn as a positive turning point for the industry and its associated supply chain. And, if this is the case, it is those companies with expertise in power management and control that may benefit the most.

Let me explain. To date the automotive industry has been fairly conservative, with product development typically involving the evolution of well-known or established systems and corresponding quality improvements and cost reductions over time. When times are good and sales are high such an approach is fine. Now, though, the current crisis forces automotive OEMs and system suppliers to think again and to look for less conventional solutions that will allow them to deliver competitive advantage and so regain their former strength and success.

But this is not the only issue encouraging innovation. For the current downturn also coincides with the growing commercial, legislative and consumer pressure to deliver step changes in vehicle efficiency without compromising – and, in reality, further improving - the 'automotive experience' for driver and passenger.

This combination of the need to establish competitive advantage and (or, potentially, through) efficiency improvements is behind fundamental changes to the nature and the requirements of automotive development. Changes that will, increasingly, be addressed through

ongoing innovation made possible by semiconductor technologies.

The silicon content of vehicles has grown significantly in recent years and semiconductor technology is set to be the enabler for many of the new innovations that we will see in the future. Efficient hybrid power trains and management systems that reduce exhaust gases will rely on semiconductors, as will driver assistance and safety systems and sophisticated infotainment implementations. Indeed, no other technology will play such an important a role in allowing vehicle manufacturers to address the requirements of the myriad of electronics systems deployed in an automobile while simultaneously driving down the energy and fuel that these vehicles consume.

So what are the semiconductor technologies that will (a) help automotive designers improve the functionality and user experience that a vehicle may offer and (b) meet the efficiency and emission requirements that are mandated in law or demanded by an ever-more environmentally conscious buying public?

Certainly we can expect to see more application-specific devices and chipsets in areas such as direct fuel injection, electric power steering, and high intensity discharge (HID) lighting. Semiconductor manufacturers are also developing and enhancing ASSPs for motion control designs ranging from hybrid electric vehicle (HEV) power trains to key peripherals such as air conditioning compressors, electric pumps and fans.

The need to minimise energy losses during power switching is behind ongoing improvements in power MOSFET technology targeted at conventional 12V car and 24V commercial vehicle power nets. However, the power levels encountered in many new and emerging HEV designs demands products that go beyond the '12-24V' world. Switching devices like IGBTs capable of handling the higher voltages encountered in HEV applications (which require voltages as high as 1200V) will become much more prevalent, while Intelligent Power Switches (IPS) with integrated protection and intelligence, as well as high-current and high-voltage mixed-signal ICs will become much more important.

There is one further change worth mentioning because it will, over time, have an impact on semiconductor suppliers and other companies in the automotive supply chain. Driven by the significant consolidations taking place in the automotive arena, OEMs who, to date, have been fierce rivals are now looking to reduce cost and improve purchasing power by combining their R&D efforts. One impact of this improved cooperation is likely to be the increased adoption and development of key vehicle systems that can be standardised between vehicle brands and models. For the semiconductor manufacturer such standardisation provides a significant incentive for ongoing investment in processes and product developments as the final volume of products targeted at standardised applications is likely to be higher and, thus, lead to greater ROI.

www.irf.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.

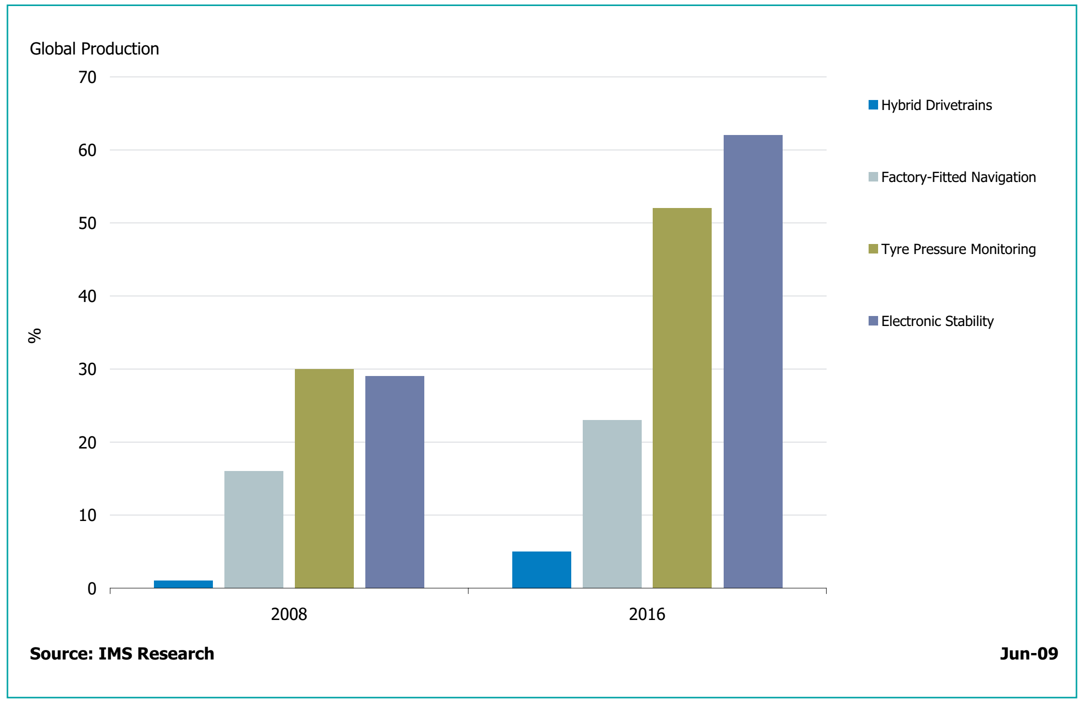


Figure 1: Percentage of New Light Vehicles Featuring Different Systems.

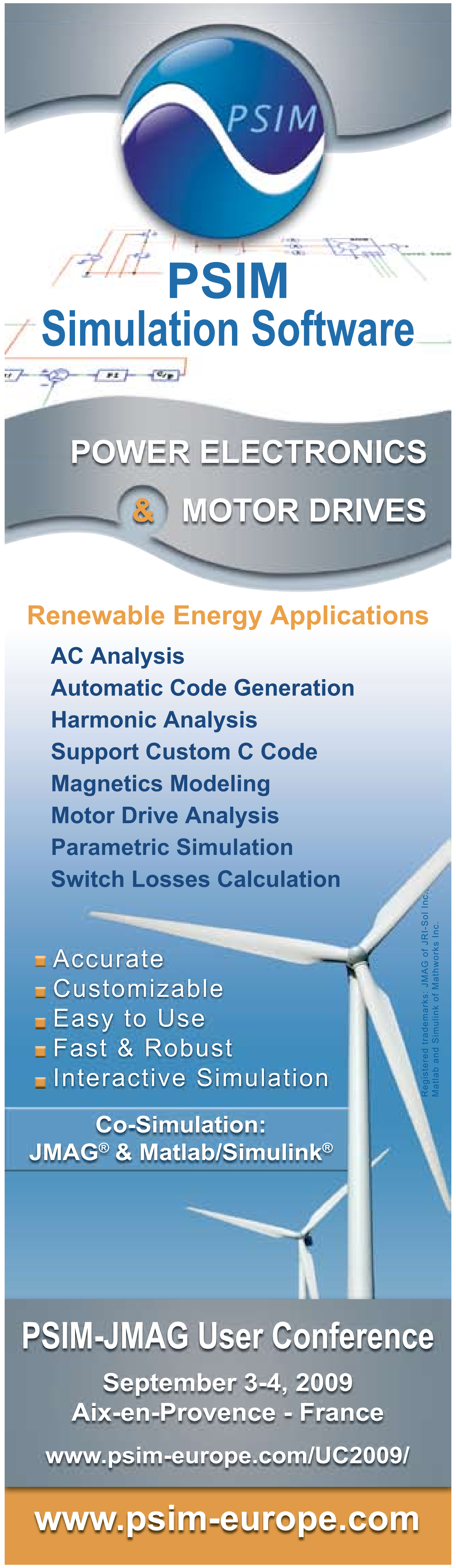
The first of these trends is to make vehicles that use less fuel and are less harmful to the environment. According to our recent report on "Advanced Automotive Fuel Technologies", legislation is a major factor here. Stricter rules on fuel economy and stricter engine emission standards are being introduced 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



Frequency Response of Switching Power Supplies – Part 6

Loop gain assessment

In this article, Dr. Ridley continues the topic of frequency response measurements for switching power supplies. This fifth article shows how the injected signal size can impact the quality of the measured results, and demonstrates how to optimize the level of injection.

By Dr. Ray Ridley, Ridley Engineering

Introduction

In this article, Dr. Ridley continues the topic of frequency response measurements for switching power supplies. This sixth article discusses the measures of relative stability that can be obtained from a loop gain of a power supply.

Phase Margin of a Control Loop

The previous articles in this series have shown how to make successful frequency response measurements on power supplies, including loop gain. Figure 1 shows the standard loop gain measurement test setup described in the previous articles of this series [1].

Figure 2 shows a typical measured loop gain with the gain monotonically decreasing with frequency. For this case, definitions of stability are quite clear. At the crossover frequency, where the gain crosses 0 dB, we measure how many degrees the phase is above -180 degrees. This measurement is defined as the phase margin.

(Notice that when you measure the loop with the circuit of Figure 1, the measurement will give the phase margin directly, without having to measure it

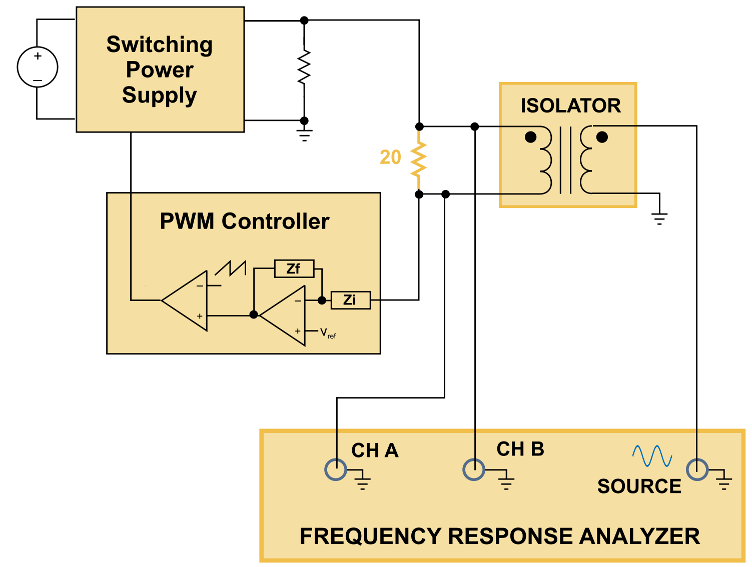


Figure 1: Open Loop Gain Measurement with the Loop Electronically Broken.

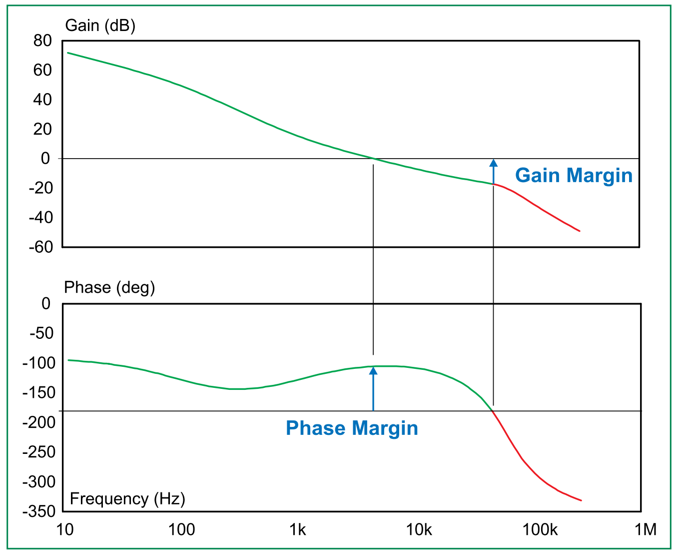


Figure 2: Well-behaved loop gain with monotonic decrease of gain with frequency.

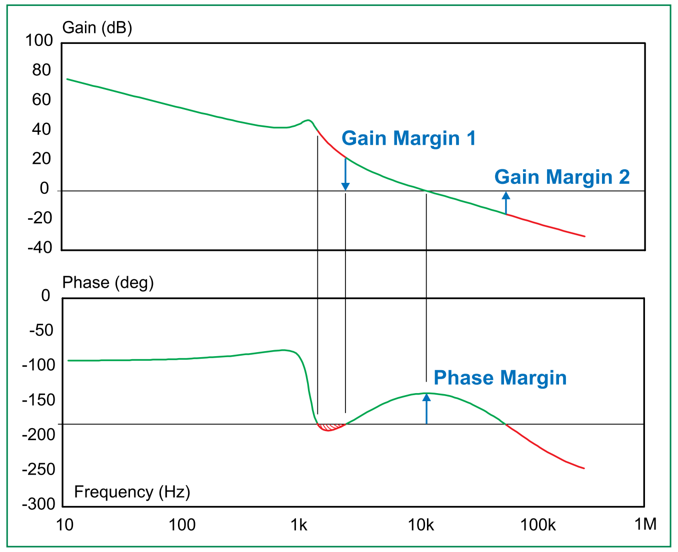


Figure 3: Loop gain with more than 180 degrees phase delay at low frequencies. The system is still stable.

from -180 degrees. That is because the measurement test setup includes an extra inversion that was not part of Bode's original theory for loop gains.)

The phase margin for the loop gain of Figure 2 is approximately 70 degrees. This amount of phase margin is relatively easy to achieve for a current-mode controlled converter with a conservative crossover frequency.

Designers in different industries have different standards for phase margin requirements. For rugged military or aerospace supplies, they look for a worst-case phase margin of 60 to 90 degrees. For many practical supplies, a worst-case phase margin of 50 degrees is the standard that I use in commercial design. The power supply will exhibit a small amount of damped ringing with this phase margin, but with very wide line and load ranges, it is often impossible to do much better than 50 degrees under all conditions of line, load, and temperature, without seriously compromising transient performance. Less than 45 degrees gives serious cause for concern.

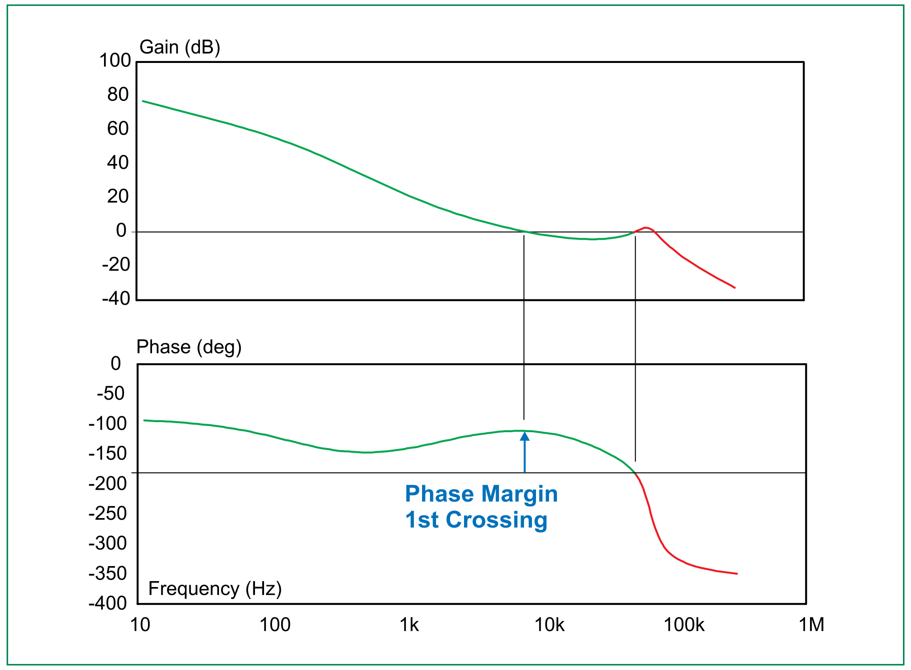


Figure 4: Loop gain measurement with multiple crossing frequencies.

Many companies today have forgotten the point of measuring loops and having a good phase margin. It is not unheard of to see designs with less than 30 degrees phase margin. While a single unit designed like this may be nominally stable, the whole point of a good phase margin is to ensure that power supplies produced in large quantities will all be stable, and remain that way throughout their lifetime.

Optimizing the loop for good phase margin takes time, and incurs some engineering costs. Perhaps 5 man-days of work are required for a conscientious design. This is a very small price to pay when compared to the cost of a product recall caused by oscillation.

Gain Margin of a Control Loop

There is more to stability assessment than just the phase margin. The phase margin only addresses one frequency, the crossover point. It does not give information about other frequencies that may cause trouble with variations of parameters in the feedback system. Beyond the crossover of loop, it is important to look at the gain margin. This is defined as the amount the gain is below 0 dB when the phase hits -180 degrees. A gain margin of 10 dB is reasonable. This allows parameter changes which could cause the loop gain to change by a factor of approximately 3 before the system becomes unstable.

The gain margin for the loop gain of Figure 2 is approximately 17 dB, a good value for a rugged and conservatively-designed control system.

Point-of-load converters often push the crossover frequency of a power supply very high in order to minimize the amount of capacitance on the output. In doing so, they often end up with a loop with very small gain margin, and the system may be on the verge of instability even though the phase margin under nominal conditions is reasonable. This is not good design practice.

Conditionally Stable Systems

It is quite common in power supply design to encounter loops which are conditionally stable. An example of such a loop is shown in Figure 3. A conditionally stable system is one in which the phase delay of the loop exceeds -180 degrees while there is still gain in the loop. This is a common occurrence with voltage-mode control where the phase dips abruptly around the resonant frequency, then recovers with the effect of real zeros added in the compensation. It also is common in the feedback loop of power factor correction circuits, and is often impossible to avoid.

In the loop of Figure 3, there is between 20 and 40 dB of gain, shown in red, when the phase drops below -180 degrees. There is no problem with such a system. As long as there is plenty of gain margin and phase margin, the control will be rugged.

In Figure 3, the phase margin is about 50 degrees, and the gain margin above the crossover frequency is about 15 dB.

We must also be concerned with the phase margin to the left of the crossover. This is a measure of how much the gain would need to be reduced due to parameter variations before the system would become unstable. It can be seen that this example has no problem since it has more than 20 dB gain margin at several kHz.

Loop Gains with Multiple Crossover Frequencies

It is common in power design to encounter loops with more than one crossover frequency, as shown in Figure 4. If the loop crosses over multiple times, it is the final crossover (the one at highest frequency) that determines stability.

In Figure 4, the phase margin at the first crossover frequency (about 9 kHz) is very good, approximately 65 degrees. However, the loop crosses over two more times, each time with more than 180 degrees phase delay, so this system will be unstable.

There are numerous systems that might have multiple crossings. Three common examples are:

1. Current-mode control systems where the subharmonic oscillation is not properly damped with sufficient compensating ramp.
2. Converters which have RHP zeros in their control transfer function, causing the gain to flatten out.
3. Converters with improperly damped input filters in front of them.

For the loop gain of Figure 4, either the shape of the compensation must be changed to prevent the increase in gain at high frequencies, or the crossover frequency must be significantly reduced to avoid instability.

Summary

Every power supply has a unique control loop which can change significantly with line, load, temperature, and component variations. It is important to measure the loop and ensure that the gain and phase margins are properly designed for a rugged power supply. The entire loop gain must be studied, not just the crossover region, to ensure that the system will always be stable.

Unusual loop gains are relatively common in power supply design, resulting in conditionally stable systems, and loops with multiple crossings.

References

1. "Frequency Response of Switching Power Supplies, Parts 1-5", Power Systems Design Magazine, Design Tips Archive. http://www.powersystemsdesign.com

2. "AP Instruments AP300 User Manual", http://www.apinstruments.com/files/Model300.pdf

www.ridleyengineering.com

On the Road

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

Texas Instruments

TI recently launched its single-chip SWIFT™ point-of-load device for telecom and computing systems, which supports up to 17V; 60% smaller package than multi-chip converters.

Texas Instruments unveils smallest 6A, 17V step-down DC/DC converter

Extending its family of easy-to-use SWIFT™ power management integrated circuits, Texas Instruments has introduced the industry's smallest single-chip, 6-A, 17-V step-down synchronous switcher with integrated FETs. The high-performance TPS54620 is 60 percent smaller than today's multi-chip converters, resulting in a complete 6-A power solution less than $195mm^2$ -- one-quarter the size of a postage stamp.

Growing trend to reduce DC/DC solution sizes

Many architectural standards (PCI, ATCA), telecom, and server rack equipment have fixed shelf/cabinet sizes and power supply budgets:

• Increasing PCB density allows designers to differentiate their product

• High power efficiency allows increased card density and higher product performance

The conventional 12V bus is still a popular choice:

• Higher current distribution requires smaller connectors:

TI's Uwe Mengelkamp.

• 20W distributed at 12V is ~1.6A

• 20W distributed at 3.3V is ~6A

• Higher efficiency than 3.3V MOSFET gate drive voltage

With this new product offering, TI has satisfied the industry's greatest need to increase POL density, without sacrificing efficiency and performance.

The 1.6-MHz monolithic DC/DC converter supports input voltages from 4.5 to 17V, allowing it to manage space-constrained 5-V and 12-V point-of-load designs, such as a wireless base station or high-density server. See: www.ti.com/tps54620-pr.

"As telecommunications designs become more dense and complex, they need more integrated, highly efficient power management devices that support a 12-V power rail," said Uwe Mengelkamp, who is responsible for definition, development, engineering and sales of DC/DC Converter products worldwide. "We continue to develop smaller, more robust SWIFT converters, so designers can more quickly develop differentiated products for the market."

In addition to size improvements, the TPS54620 offers a high degree of performance and reliability, such as a highly accurate voltage reference with +/- one percent accuracy over temperature. Achieving a 95-percent power conversion efficiency and a 25 percent lower $R_{ds(on)}$ than previous 6-A SWIFT devices, the converter easily powers deep sub-micron TI digital signal processors (DSPs) and other embedded processors, such as FPGAs and ASICs.

TI provides the broadest range of step-down converters in the industry, including its SWIFT and discrete DC/DC converters. In addition to the TPS54620, TI recently introduced its new TPS54418 4-A switcher with integrated FETs, which supports input voltages from 2.95V to 6V. The device switches up to 2 MHz, can be synchronized and achieve greater than 95-percent power efficiency in a small 3mm x 3mm QFN package. See: www.ti.com/tps54418-pr.

www.ti.com

Vincotech

I recently had the distinct pleasure of visiting Joachim Fietz, CEO and Peter Sontheimer, Vice President R&D and Marketing, Vincotech at their company HQ near Munich, Germany.

Vincotech Navigates to Success

Since joining in January 2009, Joachim Fietz heads up the Vincotech Group with 600 employees. The company is headquartered in Germany, has manufacturing plants in Hungary and China and sales offices worldwide. Vincotech develops and manufactures subsystems and electronic components for the industrial, solar and navigation segments.

With the current financial climate it's a challenging time for all companies in our industry. Vincotech is a new independent business with new leadership. Joachim and Peter told me about the way they see the company's future.

One of Joachim's first actions as CEO was to continue and reinforce the company's program to measure the level of customer satisfaction achieved. In classic marketing style he and his team determined the key components of customers' expectations and the degree to which the new company, Vincotech, achieved this in comparison to the former Tyco operating organization.

He explained, "Our customers, who are made up mainly of mid-sized companies, are happier now than with the former regime. We are now able to react to their needs in a much more flexible and faster way, which in turn helps them to get to market faster. We have a very tightly knit management team here at Vincotech, which helps us to communicate faster and to make decisions in a matter of hours, which would take larger and more traditionally structured firms weeks to carry out. We do not suffer under multi layers of administration and do not need to seek the 'top-level' approvals found in many larger organizations."

Vincotech's customer base is made up mainly from medium sized firms which have an absolute need to be flexible and be able to customize their end products

to differentiate themselves from the 'one size fits all' offerings from the well known industry giants.

As a consequence, Vincotech needs to retain its flexibility and ability to respond to these needs. At Vincotech, management staff and employees alike are encouraged to question and challenge established procedures and processes, even those that have been in place and working satisfactorily for many years. There is no place at the new company for a 'comfort zone' mode of operation in these highly challenging and competitive times.

Joachim reflected, "Sometimes it takes an industry or financial crisis to forge a new and better mode of operation. We all get too comfortable in the good times, and when the pressure to survive and flourish in these hard times suddenly descends upon us, we find that we have latent reserves of ingenuity and creativity to help propel the company into a higher level of thinking and achievement.

As a sailor, I am determined to navi-

gate the storm with the sound knowledge that our ship is in good shape and fully capable of making it through these unfriendly seas.

We are operating also with a 'back to basics' approach. We are a young company with solid and well-founded roots. We strive to maintain and continuously improve our value proposition to our customers.

In the area of power modules, our ability to serve markets such as solar and renewable energy applications with top quality modules which are also easy and cost-effective to manufacture utilizing our press-fit technology, is establishing for us and our customers, an enviable position in the market."

When I asked about the huge media coverage regarding emerging automotive and other energy efficient applications of power technology, Peter Sontheimer explained, "There is a lot of hype and mis-information around in this area at the moment. We have a long term responsibility to our customers to deliver the best products on the market. We have our own highly competitive goals in delivering world class solutions to them and will not divert valuable R&D resource into programs that will not help enhance this. We prefer not to enter into the energy efficient hype that is to be seen all around us – to the extent that the term itself becomes diluted- and we concentrate on the task of sustainable loss reduction, which I believe is a much clearer and tangible definition of what we do.

We are already extremely well positioned to contribute significantly to the success of our automotive, industrial drives and solar partners."

Joachim added, "We have the unique ability to select the best chips and components to build modules that are truly industry beating products. When our customers are, for instance, building a solar plant, each percentage point of extra efficiency helps minimize the loss or wastage of energy (and therefore revenue). Vincotech is not a manufacturer of chips and MOSFETs so can select the very best parts for the job. There are therefore no compromises as found in other module manufacturers who must, by corporate edict, only use their own chips and components. History shows that no one manufacturer can be the best in every field."

In the industrial drives and solar applications the company faces the added requirement for extreme reliability. These industries need to work around the clock, unattended and in extremely hostile environments. A service call to fix a failure in a remote and difficult terrain can be very expensive indeed. Vincotech's experience, heritage and deep rooted commitment to quality in these fields can assure their customers a very bright future.

I came away from my visit to Vincotech with the reassuring feeling that the company was indeed run as a very tight ship and well set on its course with a captain and crew working tirelessly toward the common goal of success.

www.vincotech.com

Vicor

At the National Electronics Week, London 16-18 June, Vicor introduced the VI Brick BCM ArrayTM. This is a high-efficiency (typically 95%), high power (up to 650W), vertically mounted BCM array, that provides isolation and conversion from 380V to 12 or 48V for low voltage distribution near the Point-of-Load (POL). It incorporates the superior technical attributes of V·I ChipTM technology in a robust package that facilitates thermal management. Vicor offers tens of thousands of standard and custom high-performance power conversion components to customers worldwide.

Vicor Launches VI Brick BCMTM Array with Vertical Mount Heatsink

The combination of a high voltage bus converter with an integrated heatsink that simplifies thermal management and minimises board space is unique and has already been adopted by major customers. The VI Brick BCM Array is ideal for PFC front-end applications, providing the capability of a high voltage bus with minimal distribution losses. This is a highly efficient solution for applications using POL and is available with 384V and 352V nominal input voltages, and output voltages of 11, 12, 44 and 48VDC. The efficiency and compact size of these modules yields power density up to 290W/in3 and fast transient response. Models with output power up to 650W in a board space of less than 2in2 will also be available, in a 1U high package. The vertical package orientation also provides better exposure

of the heatsink to system airflow.

The new VI Brick BCM Arrays are ideally suited for server applications using a PFC front-end requiring relatively high power levels with challenging thermal issues. The offline power can be bussed to the motherboard and converted to either 48V or 12V, which minimises distribution losses, reduces conversion steps, improves efficiency and reduces overall cost. In addition, less capacitance required for energy storage near the load returns further space and cost savings.

These products can be used in a wide variety of applications that require high efficiency, high power density, improved thermal management, low noise, fast transient response and overall design flexibility. The 384V input modules are immediately available from stock in sample size quantities. Standard lead time for higher quantities is four to six weeks. For data sheets and additional information on Vicor DC-DC and AC-DC power products, visit the Vicor website.

www.vicorpower.com

New ISOpro Family from Silicon Labs

Over 70 Low Power, High Performance Digital Isolators

I talked recently with Phil Callahan, Senior Marketing Manager for Silicon Labs, global leaders in high-performance, analog-intensive, mixed-signal ICs. He told me about the company's new digital isolator family, called ISOpro, which offers the industry's first 6-channel Isolator, highest data rates and bidirectional solutions for I^2C, SMBus and PMBus Applications. These patented solutions serve a broad set of markets and applications including consumer, communications, computing, industrial and automotive.

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

Silicon Laboratories has recently introduced the Si84xx ISOpro digital isolator family, the industry's first to support as many as six unidirectional isolation channels capable of data rates up to 150Mbps. Offering space-efficient packaging options, a choice of isolation ratings up to 2.5kVRMS and the industry's most highly integrated I^2C isolators, the ISOpro family delivers unsurpassed system design flexibility for use in applications such as power supplies, motor control systems, hybrid electric vehicles, industrial networking, medical and consumer products.

Building on Silicon Labs' patented CMOS-based isolation technology, the ISOpro family offers flexible solutions to simplify isolation design challenges, with unprecedented performance and best-in-class reliability:

- Support for the highest data rate in the industry at 150Mbps across the widest temperature range: -40 to +125°C, making the devices suitable in a wide variety of industrial applications.
- Jitter performance of less than 250ps (peak) is more than two times lower than competitive offerings. Low jitter is critical to enabling robust and reliable performance essential for minimizing data transmission errors and bit-error-rates (BERs).
- Industry-leading electro-static discharge (ESD) performance of 4kV human body model (HBM), 2kV charged device model (CDM) and 400V machine model (MM) to enable the highest reliability in harsh application environments.
- Over 25kV/us of common mode

transient immunity (CMTI) and up to 50V/m of electric field immunity to provide robust performance and safe operation in applications such as switch mode power supplies, motor control and industrial networking.

For systems where galvanic isolation is required such as Power over Ethernet (PoE) power sourcing equipment (PSE), switch mode power supplies (SMPS) and isolated SMBus or PMBus interfaces, the ISOpro family includes single-chip, I^2C-compatible isolators. The Si8400 provides bidirectional isolated channels on both the serial data (SDA) and serial clock (SCL) lines, combining the I^2C transmit and receive lines to reduce BOM cost and complexity. The Si8405 offers two additional independent unidirectional channels for system signals such as a reset or interrupt, eliminating ten or more discrete components and the need for additional isolators on the PCB. In addition, the Si8400 and Si8405 support bus speeds of up to 1.7 Mbps, nearly twice as fast the competition, and I^2C clock stretching to simplify the design task of matching bus speeds.

Efficiency continues to be a critical consideration for designers when estimating their power budgets. With typical power consumption of less than 1.7mA at 10Mbps and less than 4mA at 100 Mbps, the ISOpro family offers up to four times lower power consumption than competitive solutions. In addition, the devices feature an optional 200µA energy-efficient "sleep mode" to reduce quiescent power by more than 3 times over the closest competitor. The Si84xx also features typical propagation delays of less than 10ns that are 65% lower than optocoupler-based solutions. Low propagation delays enable higher bandwidths in closed loop systems and higher data rates in communication links.

Phil explained, "Isolators are a critical safety component in many switch mode power supplies, hybrid electric vehicles, lighting, motor control, communications and other power subsystems. Silicon Labs is proud to offer best-in-class isolator technology to meet all the isolation design challenges of these systems. With 70 new ISOpro digital isolator products, Silicon Labs gives system designers maximum flexibility in their design without sacrificing performance."

Samples of the ISOpro Si84xx one- and two-channel devices are available in narrow body (NB) SOIC-8 packages; the 3, 4, 5 and 6-channel devices are available in NB SOIC-16 and wide body (WB) SOIC-16 packages.

www.silabs.com/power

Powervation's Uniquely Digital Power

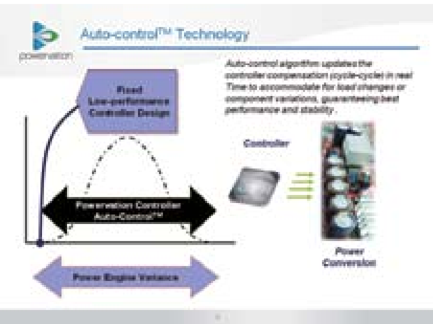
I talked with Benoit Herve, Vice President, Marketing, Powervation, a leading provider of IC solutions for energy control and management in information processing systems. Powervation provides a new class of Auto-control™ digital power IC solutions that optimize power-supply performance and efficiencies for manufacturers of electronic systems used in computing, communications and consumer applications. In a simple yet revolutionary Plug-and-Power™ package, the company's unique technology delivers a reliable, scalable solution that reduces design complexity and cost, and accelerates time-to-market of eco power-smart systems.

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

New Auto-control™ Digital Power-Conversion Chip

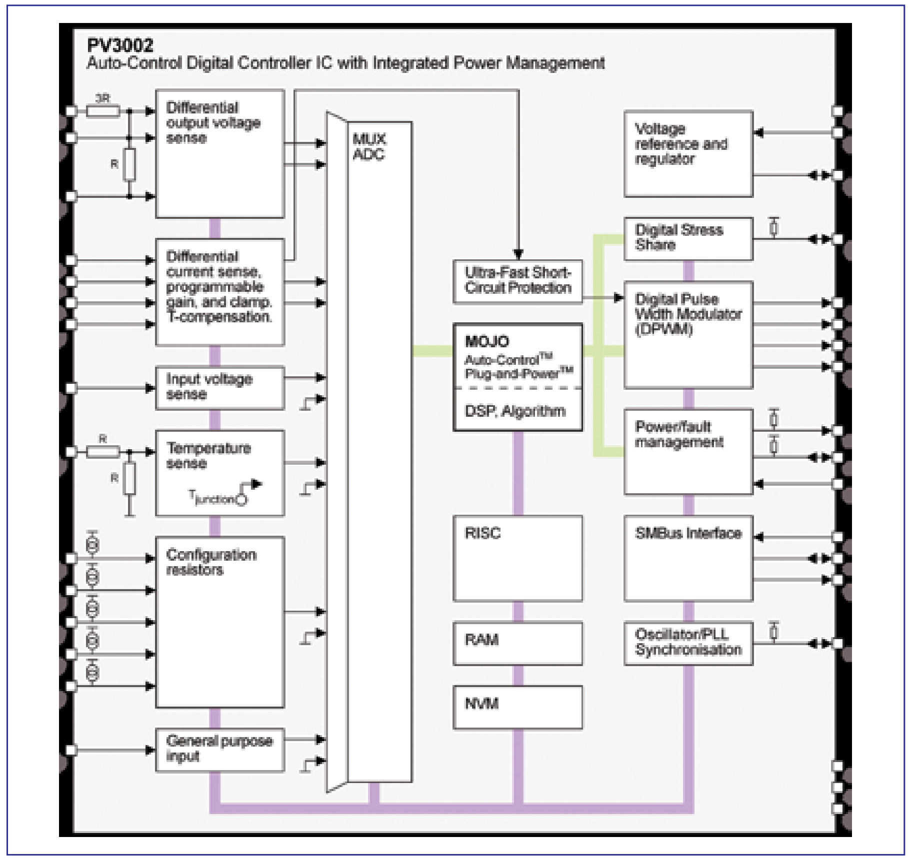
The company has recently announced the PV3002, Powervation's inaugural product and the industry's first Auto-control™ digital power-conversion IC. The new chip is aimed at electronic systems used in Computing, NetComms and Storage applications where it brings fully automatic adaptive control to DC-DC conversion for the first time. Now, designers of power supplies have an intelligent "no compromises" solution that is impervious to variations in component values and applications context, making it easier to build complex designs that conform to today's stringent energy-efficient standards.

At half the size of comparative analog solutions, the PV3002 can reduce total system component counts by as much as 50%. This advantage cuts system costs and improves Mean Time Before Failure (MTBF). In beta tests at multiple customer sites, the chip demonstrated efficiency gains of more than 10% for light-load configurations while improving stability and transient performance. Moreover, at the system level, the PV3002 enables digital power management at no extra cost delivering energy savings of up to 30%, and reducing overall cost of ownership by 30%.



True Adaptive Control

Powervation achieves these breakthroughs via its unique Auto-control technology that empowers engineers with new ease-of-design capabilities and eliminates the time-consuming challenge of accounting for the production tolerances of all components in the control loop.



Unlike conventional analog regulators that use external components and require complex calculations to compensate the controller, Powervation's Auto-control regulates and monitors the output voltage on a cycle-by-cycle basis and automatically compensates for variations in line, load, capacitance and inductance. The key driver of this capability is "MOJO", a single parameter that is used to adjust the loop compensation (poles, zeros and gain) to guarantee stability and best performance. The result is "true" adaptive control, with Plug-and-Power™ advantages that eliminates the need for the designer to compensate the control loop. For designers of power supplies, this breakthrough can cut design time from weeks to days.

Boosting System Efficiency and Performance

With Auto-control at its core, the PV3002 is custom-built for Computing, NetComms, Storage and other applications where a more efficient power supply has become a key competitive differentiator. Here, the PV3002 exerts a considerable advantage. For instance, in advanced networking equipment, such as mid-range Ethernet switches where there may be as many as 150 different voltage rails in a single switch fabric, optimizing power management across the entire system is extraordinarily complex. With true adaptive control, the PV3002 intelligently distributes the power, enabling the system to consistently operate at peak efficiency.

Benoit explained that the PV3002 represents a fundamental shift in power-supply design and solves the most pressing performance, reliability and cost challenges facing designers. "It is the first product in the industry to reliably adapt power conversion to changing system behavior and unpredictable variations, and guarantees unprecedented stability over a wide range of conditions throughout the lifetime of the system. Customers report that with Auto-control, they can breach the performance barriers that have limited traditional digital power technologies—a breakthrough that offers unprecedented ease-of-use and new efficiency advantages."

PV3002 Features and Benefits

- Auto-control technology
  - Automatic adjustment of the com pensation
  - Guaranteed stability
  - Improved transient response
  - Improved efficiency
- Multi-phase operation
  - One or two-phase operation
  - Digital current sharing
  - Phase add-and-drop with auto-compensation
- Monitoring
  - Precise current monitoring
  - Internal and external temperature sensing
- Power conversion
  - Wide output and input voltage range
  - Differential voltage sense
  - Precise voltage set point accuracy (+/- 10mV)
- Power management
  - Fault detection (OVP, OTP, UVLO)
  - High-reliability non-volatile memory (fuse-based OTP)
- Single 3.3V supply operation
- RoHS compliant 32-leads plastic QFN package

Packaging

The PV3002 is available in a space-saving 5mm x 5mm QFN package and is fully specified over the -40°C to +85°C extended temperature range.

www.powervation.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, PSDE

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 road-map 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.

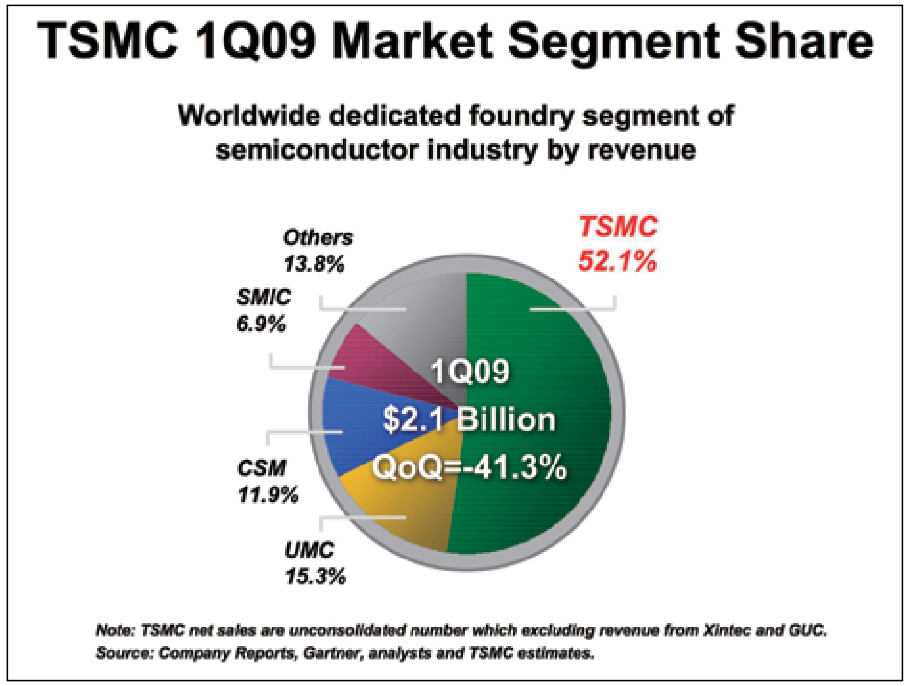
The advantage for foundry technology to support this trend is its efficiency in technology platforms and manufacturing capability. However, there are challenges to support the integration of the designs on device and IP blocks among digital, analog and power management functions.

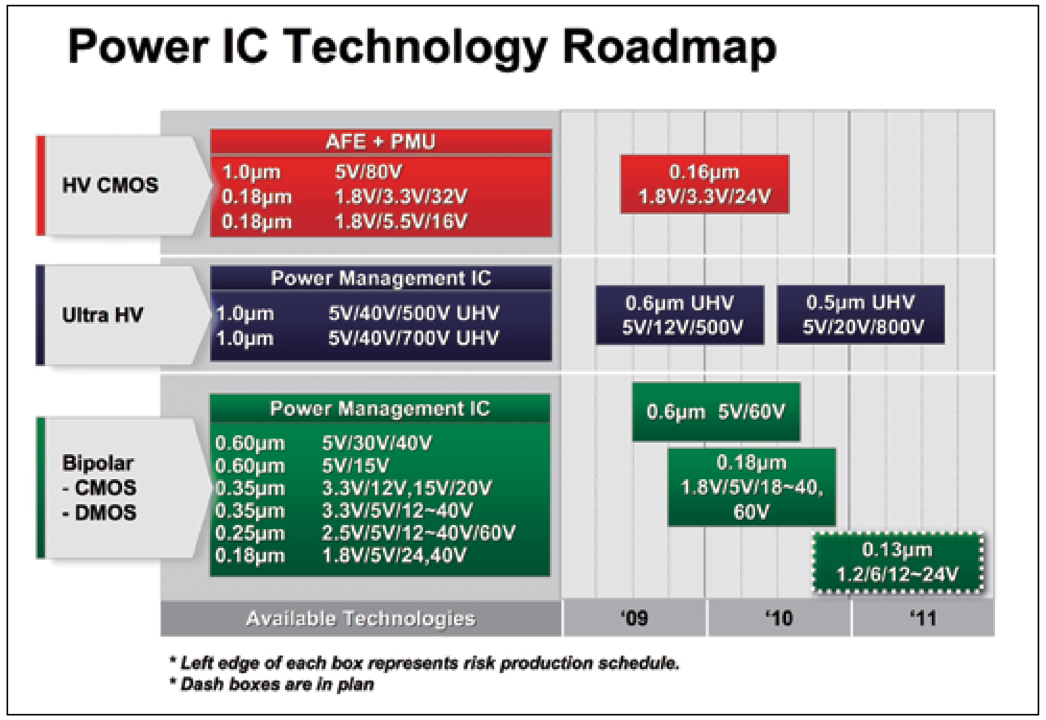
Challenges of Design Integration

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

2009 GreenPower Leadership Awards

Winners and Finalists Announced at PCIM Europe

For the past year the readers of Power Systems Design Europe have been voting for the best editorial contribution in the area of "energy efficiency". The 2009 GreenPower Leadership Awards program has been made possible by the financial contributions of our two Gold Sponsors: Intersil and Linear Technology.

The Winner is: Company: Fairchild Semiconductor, Article: "Solar Power Shines", Author: Alfred Hesener.

The four finalists (in alphabetical order by company) are: Company: Coilcraft, Article: "Designing for Efficiency at the Component Level", Author: Len Crane • Company: Linear Technology, Article: "Solving Current Source Design Challenges", Author: Robert Dobkin • Company: Microsemi, Article: "SiC Impacts 'Greening' of Power", Authors: Philip C. Zuk & Bruce Odekirk • Company: Philips Lumileds, Article: "Avoiding Current Spikes with LEDs", Author: Pat Goodman.

Educational Donation. A significant component of the *2009 GreenPower Leadership Awards* program is an educational donation, given to the European Engineering University of choice by the article author. This year's donation is awarded to: The Institute of Robotics at the University of Maribor, Maribor, Slovenia. The University conducts research on motion control solutions.

2010 GreenPower Leadership Awards. Voting has already begun for our expanded *2010 GreenPower Leadership Awards Program* and will continue through the April 2010 issue of Power Systems Design Europe. If you want to summit editorial content on "energy efficiency" to be judged for next years program, contact Cliff Keys, Editor-in-Chief, **cliff.keys@ powersystemsdesign.com** • For sponsorship opportunities, contact Julia Stocks, Publisher, **julia@powersystemsdesign.com.**

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TechTalk

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, PSDE

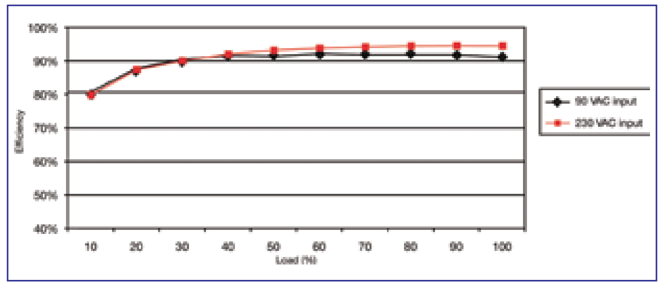
First 250W AC/DC Power Supply to hit 95% Efficiency

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.

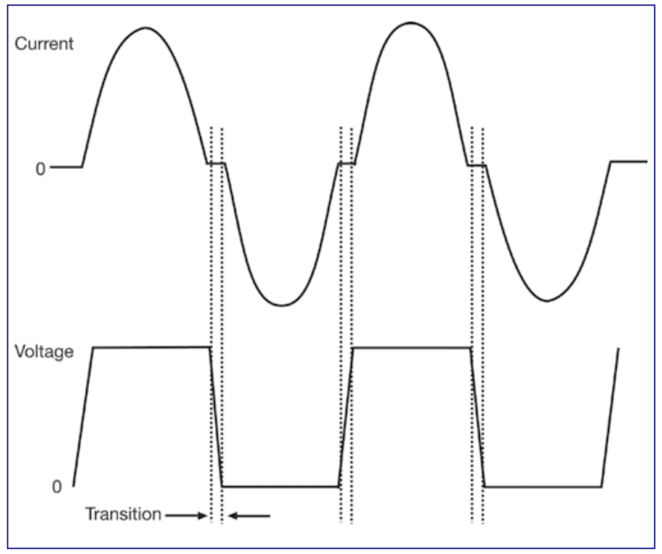
Removing the need for fans greatly increases reliability while reducing cost, audible noise, system complexity and size. Avoiding audible noise is particularly important in medical applications, where it disturbs patients. Both conducted and radiated emissions are below Class B limits as defined by EN55011,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



50% reduction in wasted energy.



XP's Novel power conversion features lossless switching.

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, 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

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).

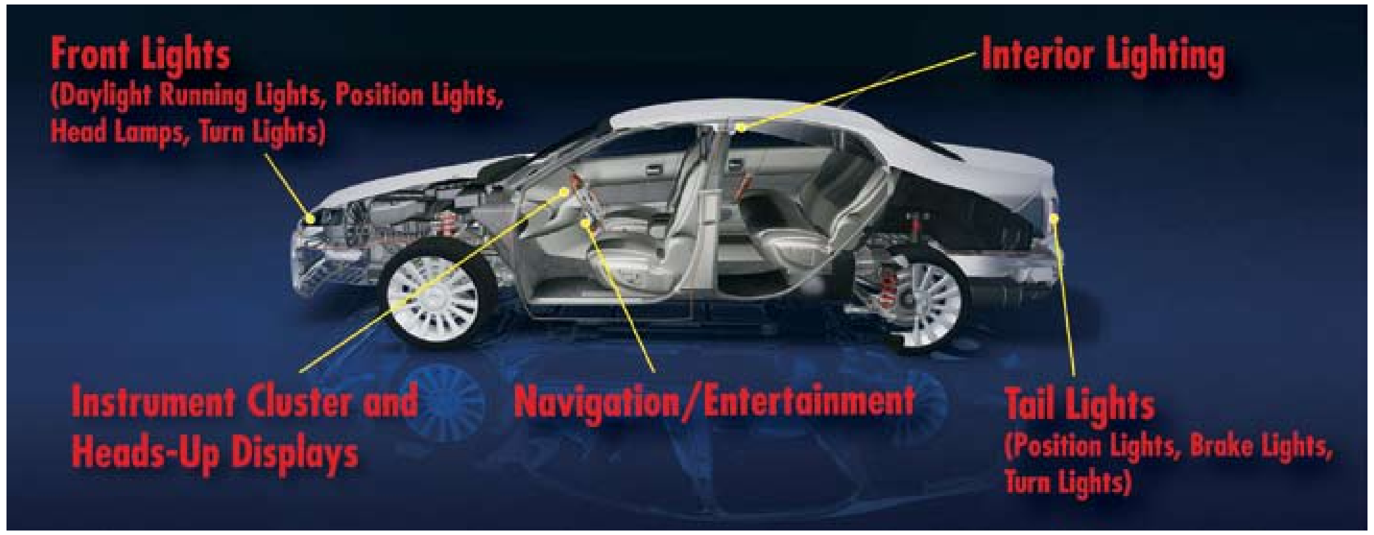


Figure 1: HBLEDs are making inroads into every lighting application in a car - from headlamps to brakelights and everything in between.

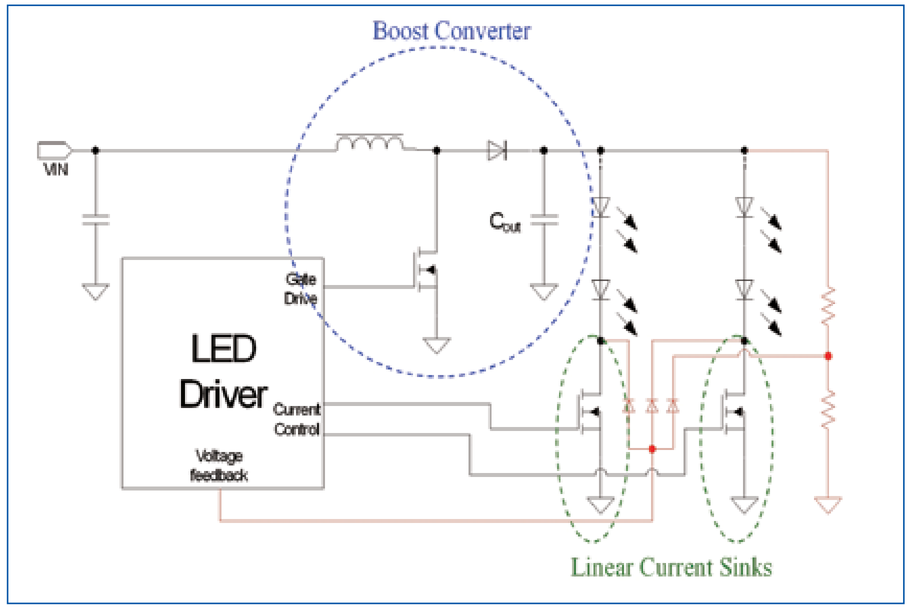


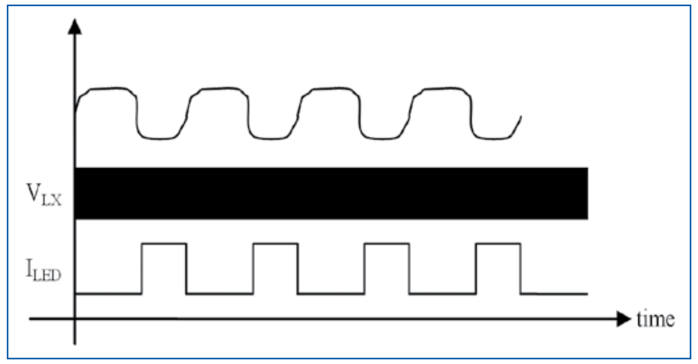
Figure 2: A basic multi-string driver configuration uses a single chip to control the current to multiple LED strings. Components shown in red can be added to do adaptive voltage optimization while the boost converter and linear current sinks work independently.

LED technology is also important for completely new applications. 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



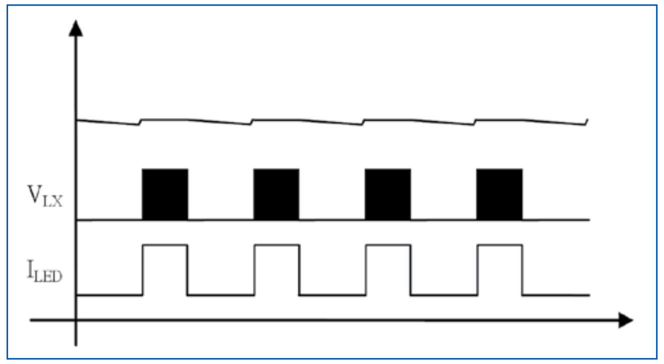


Figure 3a: With a traditional driver doing PWM dimming and using the external circuitry of Figure 2, the boost output voltage changes between on and off time of the LED current, voltage rail is noisy.

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.

COVER STORY

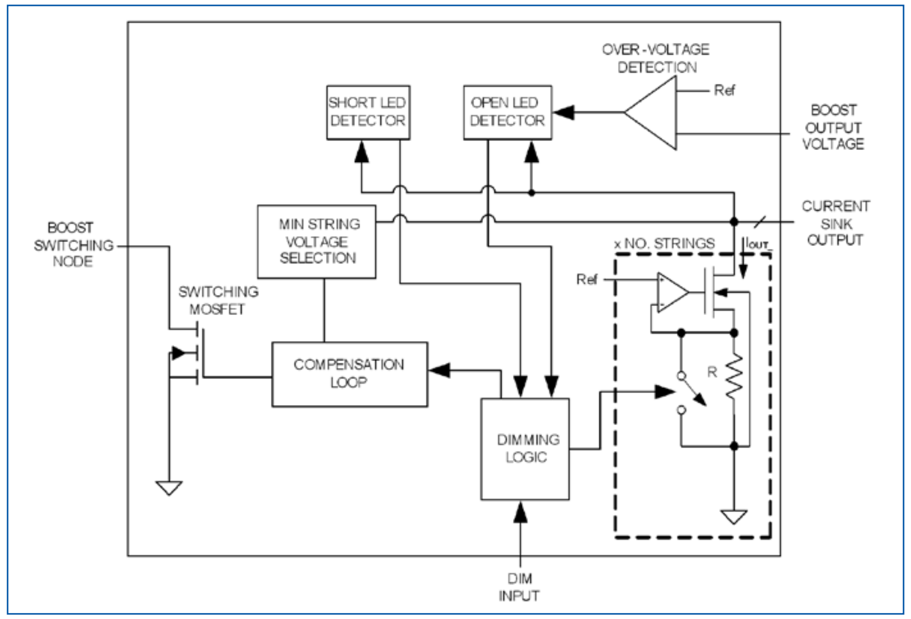


Figure 4: In a new generation driver IC, internal communication between the LED sink drivers and the boost converter allows more effective control and eliminates many of the issues encountered by older drivers.

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).

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.

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 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

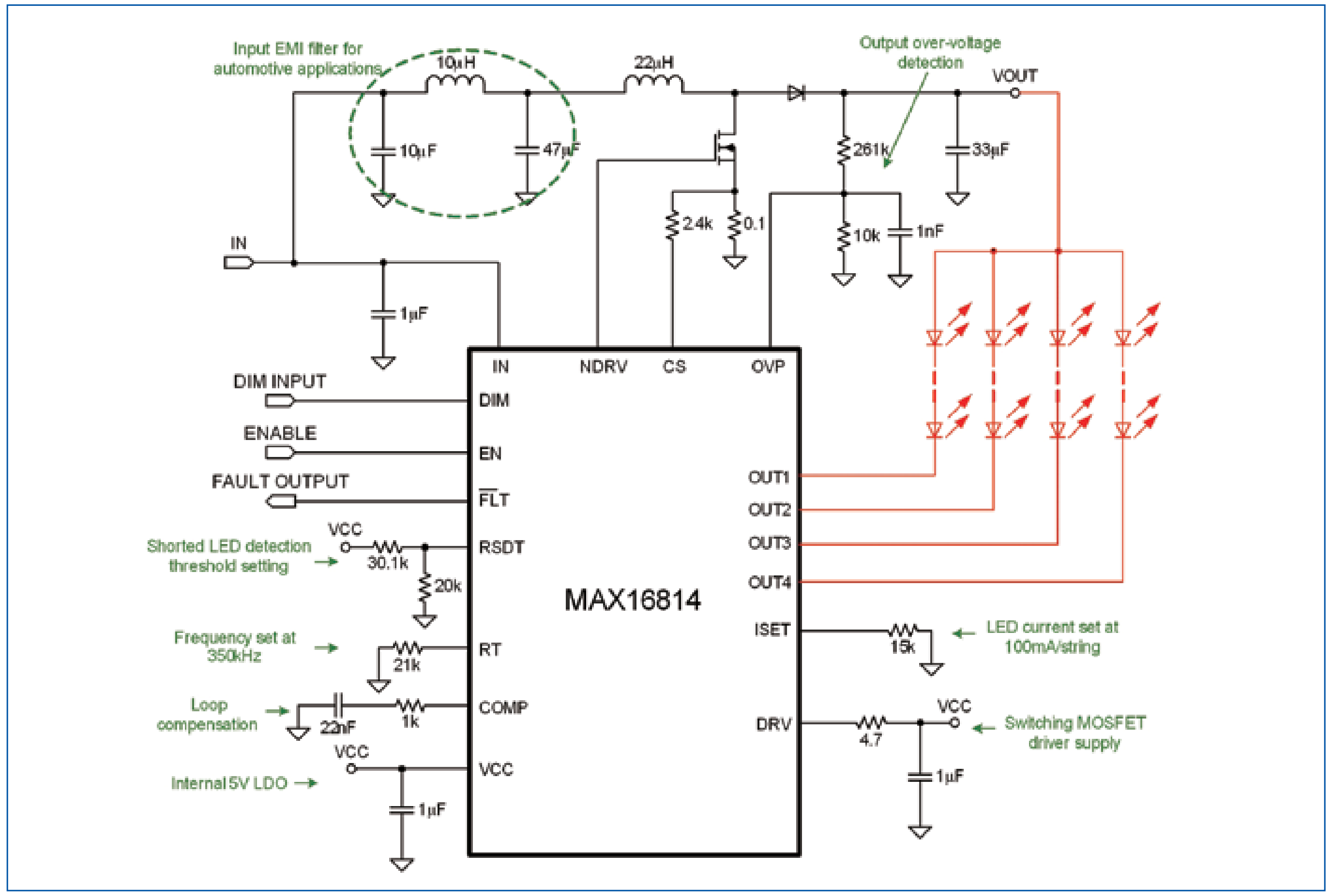


Figure 5: In this heads-up or running-light driver subsystem, the MAX16814 drives four LED strings with up to 100mA per string driver. This is an example of a complete automotive design, including all the external components and an input EMI filter. Thanks to the low noise of MAX16814, the EMI filter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

Solution	External components	Efficiency	Current balancing	What happens to other strings if one opens?	EMI and noise with PWM dimming	PWM dimming range
Multiple switching converters	Many	High	Good	They continue to work	Low	Wide
LED strings paralleled, single string driver	Very few	Medium	Bad	Their current increases, they can break	Low	Wide
Independent boost and linear sinks, without AVO	Few	Low	Good	They continue working	Low	Wide
Independent boost and linear sinks, with AVO	Some	Medium	Good	They can turn off	Noise atdimming frequency	Wide
Boost + multiple linears, communicating	Few	Medium	Good	They can continue working	Low	Limited
Maxim MAX16814	Few	Medium	Good	They continue working	Low	Wide

Table 1: Comparison and summary of HB LED driving approaches.

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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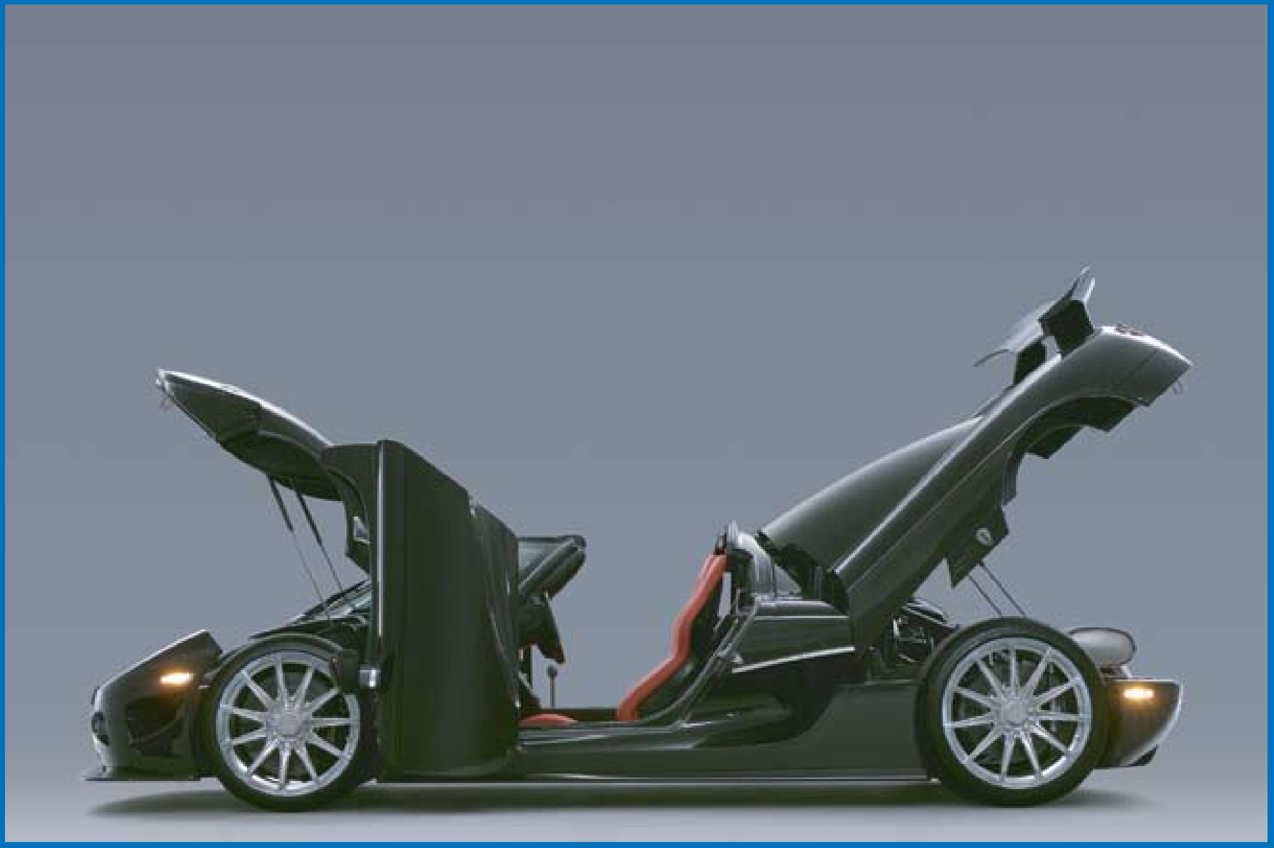

Koenigsegg Automotive AG – Photo by Stuart Collins

Powering Automotive

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 underdeveloped. 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 / 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.

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

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.)

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 manu-

VAC magnets used in Servo and Hybrid motors.

facturers. 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.

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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".

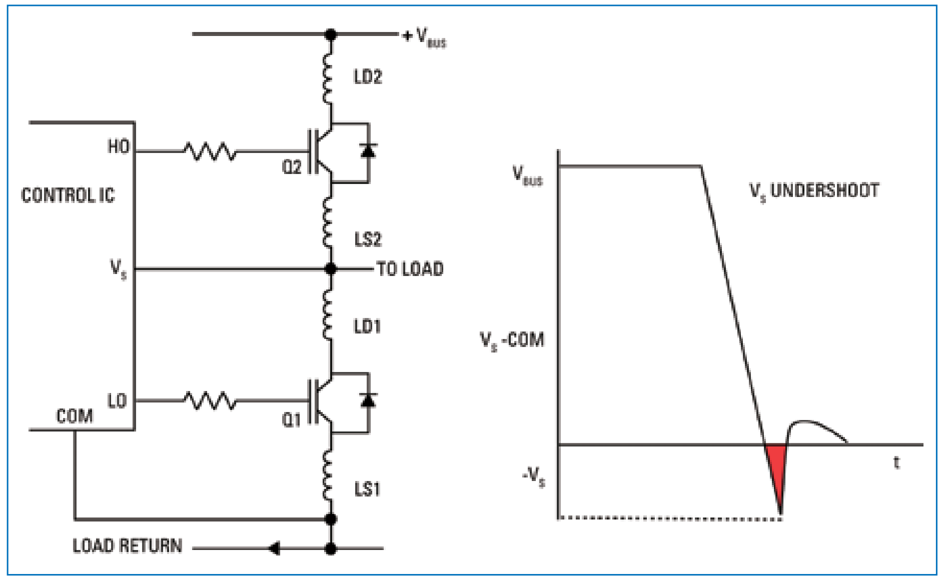

Figure 1: Negative transient at VS output node during standard operation.

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

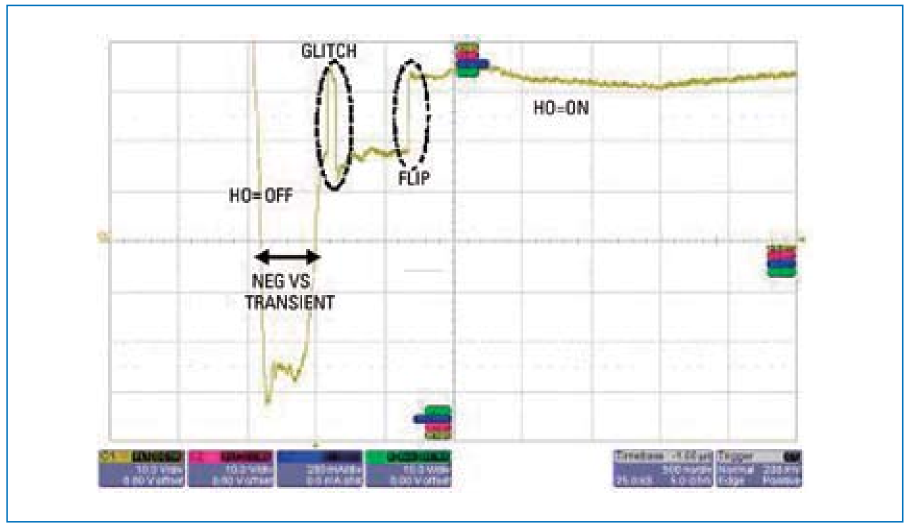

Figure 2: FLIP and GLITCH classification.

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

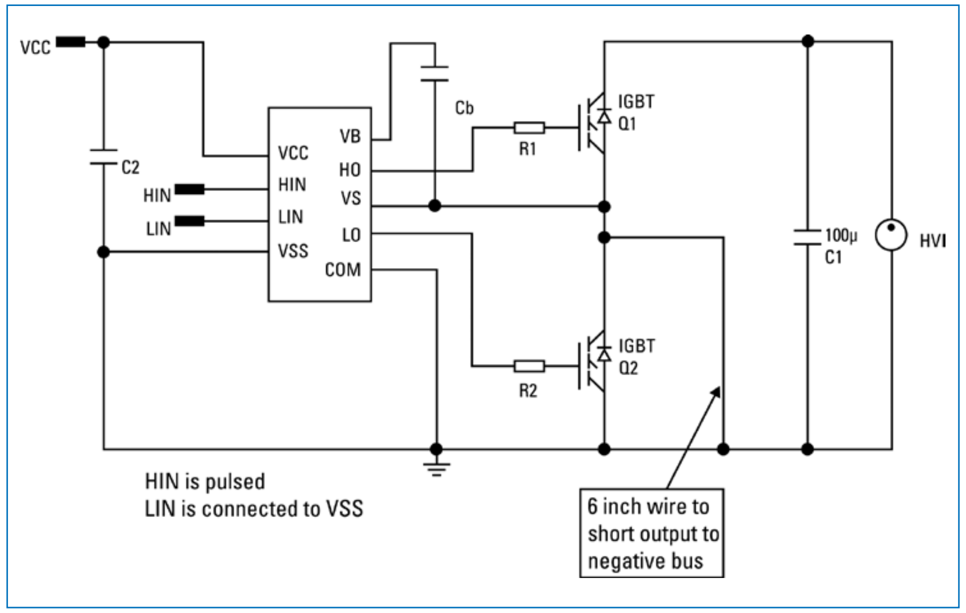

Figure 3: Short Circuit test setup for negative transient event observation.

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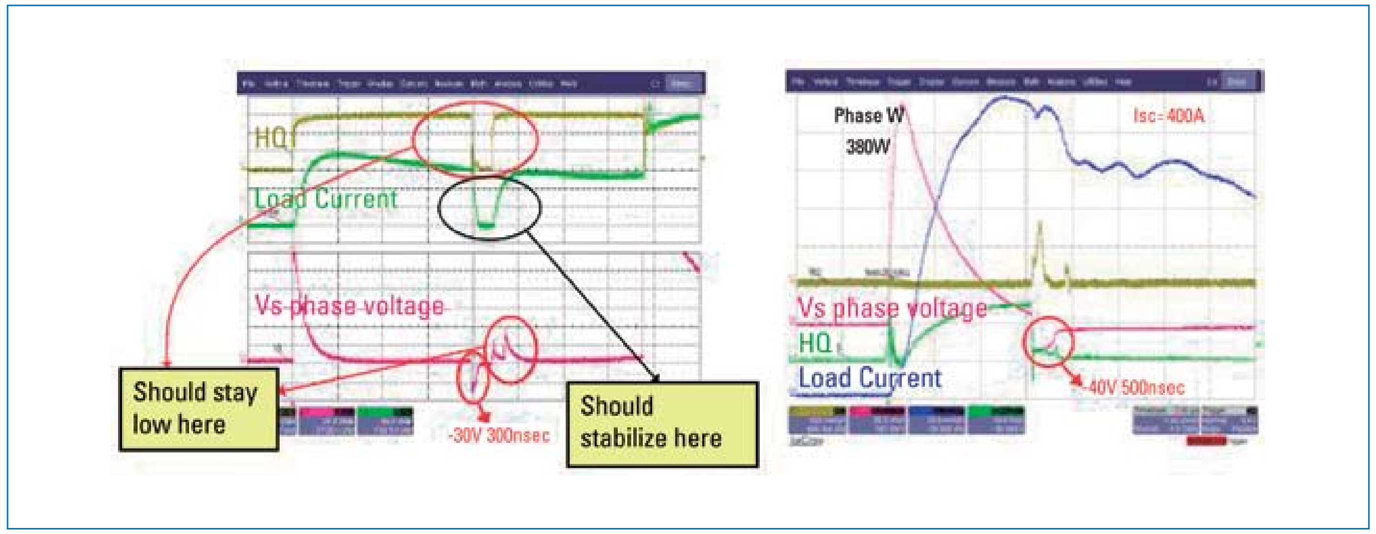

Figure 4a&b: Bad (standard HVJI GD) and Good (IRS2607D) HO gate driver behavior at SC test.

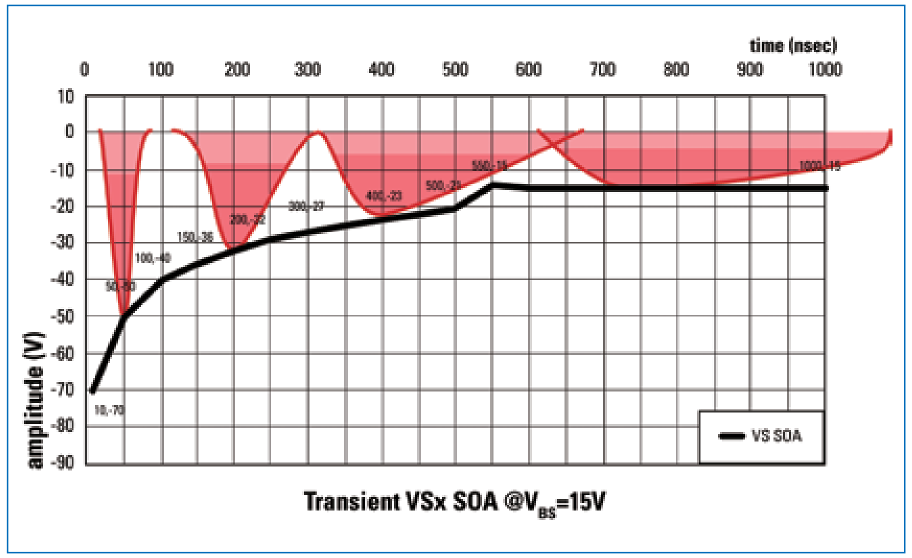

Figure 5: NTSOA: Negative Transient Safe Operating Area.

count and reduce PCB. The output drivers feature a high 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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LED Biasing in Automotive Applications

Utilising two terminal constant current regulators (CCR)

Often a two terminal constant current source is required to set a regulated current for LED regulation or sensor regulation in automotive applications such as Centre High Mount Stop Lamps (CHMSLs), interior map lights, instrument cluster indicators and switch cluster backlights. Circuit designers may often find themselves reaching for discrete semiconductor components such as zener diodes, NPN and PNP transistors or various diodes and MOSFETs to address this design challenge.

By Brian Blackburn, Senior Field Applications Engineer, ON Semiconductor

In the case of LED biasing however, a two terminal constant current source is an ideal choice for achieving current regulation, especially in the automotive market where battery voltage can continually vary from as low as 7 Volts (V) up to 19V. A designer may use two or three transistors that are matched to provide a current source, or an old standby such as an LM317 voltage regulator connected as a floating current source.

The problem with resistor bias

In their simplest form current sources are no more than a properly chosen resistor value in which a current is set from a variable battery source such as those seen in automotive applications. For instance, in a CHMSL application, three red LEDs are connected in series, and a properly chosen resistor is added in series to limit the current in the LED string. Figure 1a shows this type of arrangement. This circuit is repeated for as many LEDs as are required to make up the entire CHMSL. Usually the input voltage used for the resistor calculation is 13.5V; the set-up also includes a reverse polarity diode in series to provide added protection. Three LEDs in a string are a typical electrical arrangement since they can be easily biased from a vehicle's battery /charging and cranking system.

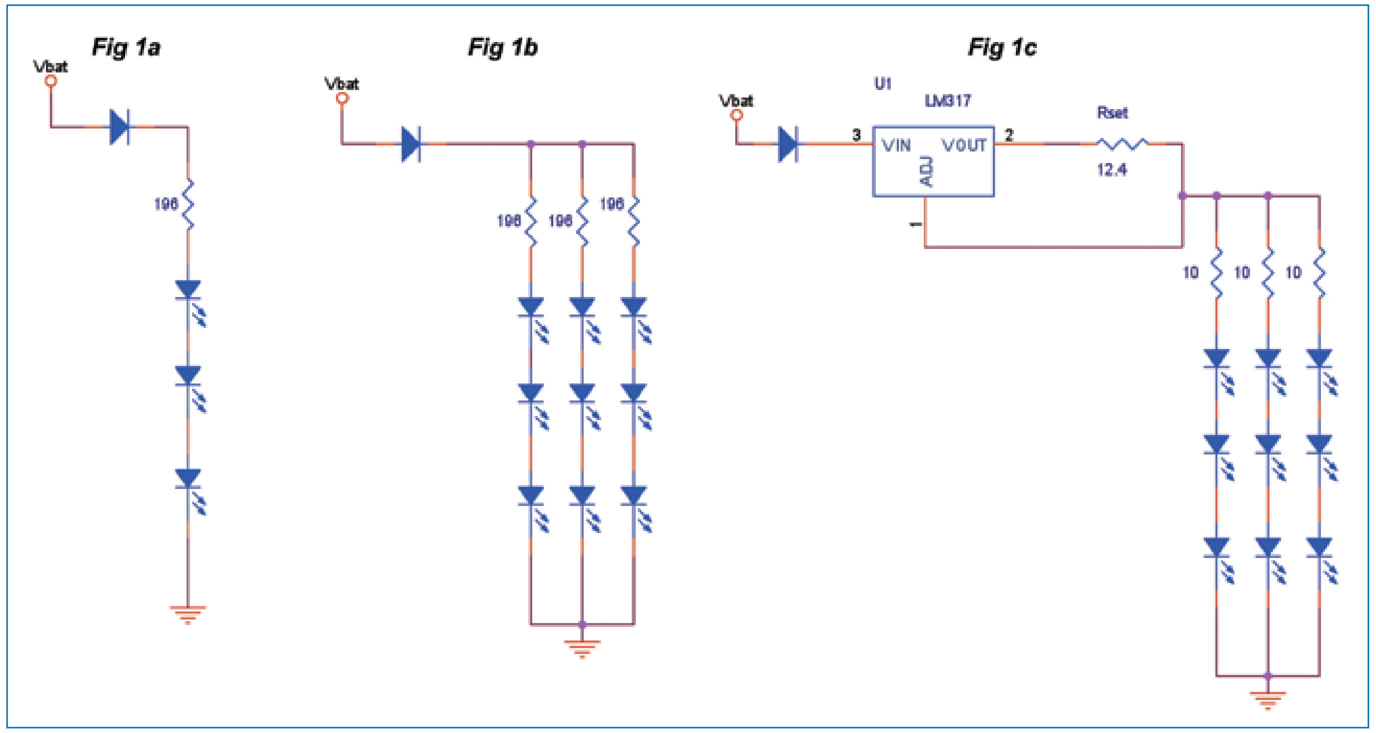

Figure 1a: A basic resistive biased string.
Figure 1b: Multiple LED strings in parallel.
Figure 1c: LM317 arranged as a constant current source.

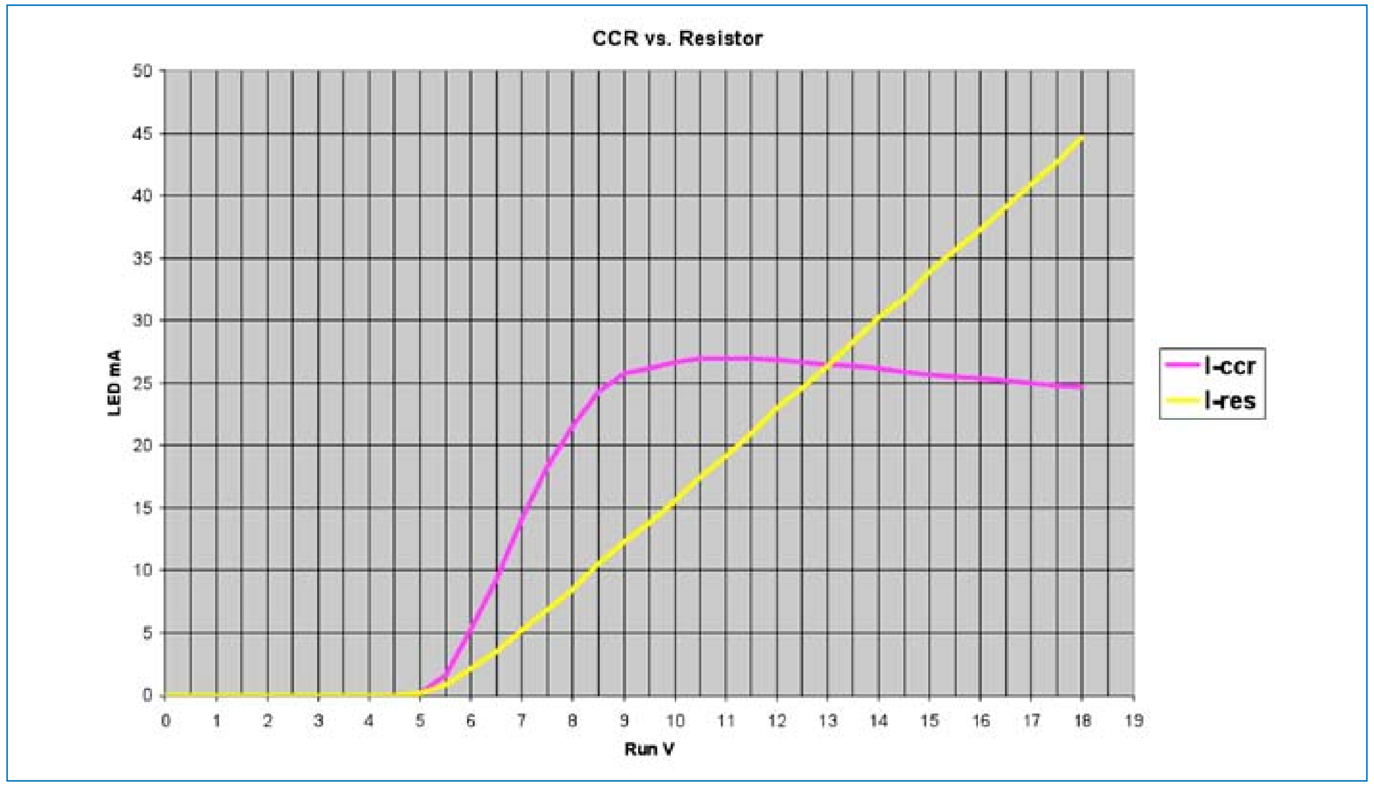

Figure 2: The attributes of utilizing a CCR rather than a resister are highlighted in the IV curve.

If the vehicle's battery voltage increases to 16 V, the LED string current will increase by around 30%. Conversely, when the battery voltage decreases to 9V it only allows 7 milliamps (mA) to flow in the Led string, representing a decrease of 77% in comparison to the 13.5 V case. From these simple calculations, it is easy to see that a resistor is not a very good current source to use for the regulation of LEDs. However, one good aspect of resistor based current regulation is that each string in the CHMSL array can have an individual device to set the current for that string (Figure 1b). Individual string biasing means that if one LED string happens to go open circuit, it does not affect the other adjacent strings.

An alternative current source is based on the old standby LM317 arranged as a floating current source. Examining Figure 1c, the LM317 has an internal bandgap reference of 1.25V. When the adjust pin is fed to the output through a resistor it forces the reference to be applied across the resistor. No ground connection is required for this device and it can float above the LED string voltage providing a highly accurate current source that has outstanding line regulation over the full automotive voltage range.

The problem is that in an application, the designer would only use one LM317 to current-regulate all of the LEDs in the array. Special care should be taken when connecting LEDs in a parallel as in Figure 1c due to the mismatched forward voltage of the LEDs. By feeding the array with a single current source, it forces the current to divide amongst the parallel connected LED strings. Sometimes a resistor is added to each string to take up the slight differences in forward voltage, and force more even current sharing of the LED strings.

If a string goes open circuit, the LM317 cannot distinguish this from a normal operation, and forces the same current to flow among the remaining LEDs. This added power stress will lead to reduction in LED lifetime due to an increase in the LED's junction temperature.

Another often overlooked issue when using the LM317 as a current source is the large drop out voltage that is required. The dropout voltage of Figure 1c consists of the bandgap reference of 1.25 V across the resistor plus the saturation voltage drop across the series pass transistor inside the LM317. This may be as high as 2V or greater depending on the value of the current. Therefore, a low line voltage will cause the LM317 to work in the drop out region, where the regulated current falls rapidly to zero; this may result in little or no light output from the Led array. Ideally, a low cost, two terminal constant current source that can be placed

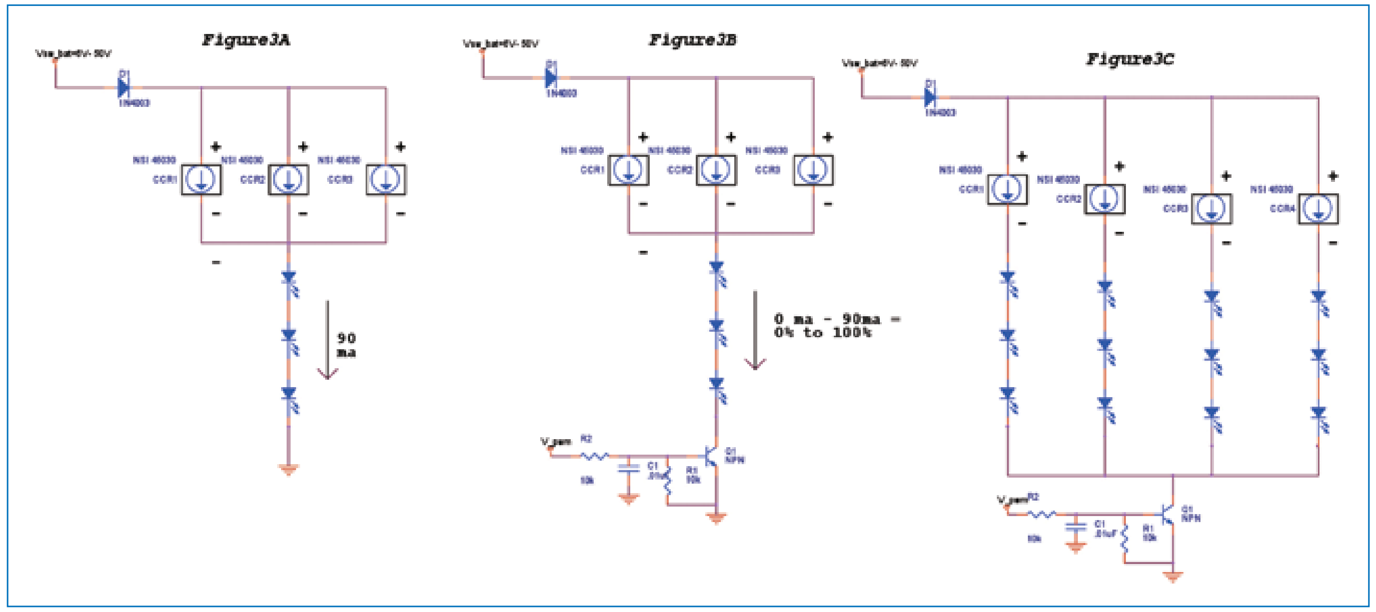

Figure 3a: Due to the constant current nature of the device, CCRs add perfectly in parallel.
Figure 3b: Using a simple NPN Bias Resistor Transistor or BRT allows for the CCR to be PWM controlled for applications that require dimming.
Figure 3c: Several CCR and LED strings could be controlled through a single low side transistor.

in each string like the resistive current source in Figure 1b, combined with solid state current regulation of figure 1c would offer the best circuit approach when LED current regulation is required over the full automotive voltage range.

Constant Current Regulation (CCR) as a design option

A new breed regulation – such as the Constant Current Regulators (CCR) offered by ON Semiconductor – can deliver an easy to implement, economical and robust option for designs requiring a regulated current over a broad voltage range. The added benefit is they are as easy-to-use as a resistor.

In Figure 2, the current / voltage (I/V) characteristic is plotted for both a CCR device and a Resistor in the circuit shown Figure 1a which represents a linear load line with a slope of 1/R or 5.1x10-3 mhos of conduction. If the 196 ohm resistor is replaced with a 30mA CCR, we can see that the slope of the IV line changes as a function of the voltage applied across the device. The initial turn-on shows a conduction of approximately 10 mhos. This higher slope in comparison to the resistor slope shows that at low line voltage, the CCR will allow for greater light output. As the line voltage increases the CCR conduction slope abruptly changes, and the current begins to regulate as the line voltage increases. At a specific line voltage the CCR current will equal the resistor as the two curves cross each other. As the line voltage increases further, the current in the resistor grows at the same linear rate, the CCR however remains constant. It is this high voltage region in which the CCR outshines the resistor bias approach because the regulated current protects the LEDs from the extreme voltage conditions experienced.

Since the Circuit designer needs to provide current regulation for LEDs that have several light intensities across the same LED part number, ON Semiconductor offers CCRs in three current ranges and two packages. 20mA, 25mA and 30mA devices are available in the cost effective SOD 123 package, with 25mA and 30mA parts also offered in a SOT 223 package. If needed, these devices can easily be placed in parallel for higher current requirements.

Due to the constant current nature of the device, CCRs can be added in parallel as shown in figure 3a; this allows the excess power to be amongst several devices thereby limiting the individual junction temperatures. ON Semiconductor will soon be releasing higher current devices suited for applications such as automotive interior map lighting, centre stack lighting, exterior side repeaters, and accent lighting.

Using a simple NPN Bias Resistor Transistor (BRT) as shown in Figure 3 b, allows the CCR to be pulse width modulation (PWM) controlled for applications that require dimming. Several CCR and LED strings could be controlled through a single low side transistor as in figure 3c.

Conclusion

LED current biasing using resistors or expensive current sources like the LM317 can be easily accomplished. However, resistors offer poor regulation and LM317 biasing forces parallel LED configurations that are not desirable from an LED array and current sharing perspective. New solutions such as the CCRs have been shown to provide an optimum way to apply low cost current regulation for individual and series string LEDs for most low current automotive applications. The fact that the CCR devices are available in several current ranges and allow for parallel connections to give increased current ranges, not only facilitates greater design flexibility, but also allows the circuit designer to maintain individual string bias without having to sacrifice outstanding current regulation.

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Special Report – Automotive Electronics

Addressing Automotive Safety

When power meets digital

As digital electronics and software creep into power electronics platforms, how can the resulting systems continue to meet the standards required for safety-critical or high-reliability design?

By Wayne Lyons, Global Director of Embedded Solutions, ARM Ltd., Cambridge, England

Safety First

Safety features in the car today are not just desired, but in most cases expected. Car safety research suggests that at least 88% of car buyers believe safety features should be provided as standard fit. For some time, safety in vehicle electronics was primarily focused around key features such as the anti-lock braking system, but now safety is reaching into more and more of the electronic components. The rise in popularity of intelligent sensors and actuators means that more of the vehicle components are involved in driver assistance and safety applications. Additionally, the migration towards hybrid and electric vehicles has resulted in the use of more electric motors in mission-critical applications.

Electric motor control is a typical example of where power meets digital electronics; mixed signal digital controllers already provide precision analog for current sense and diagnostics, whilst some are also starting to integrate drivers for power FETs and high voltage inputs.

Digital electronics can suffer from different types of random faults, eg permanent faults where a logical bit may be 'stuck-at' a certain value as well as transient and intermittent faults. Safety standards have evolved to categorize the capability of the platform to detect such faults. Working with silicon Partners such as Texas Instruments, ARM® technology now powers around two-thirds of today's electronic braking systems, which enables the company to provide important insight into the requirements of future safety systems.

In addition to regulatory requirements, continued evolution of process geometry has resulted in a new generation of faults and failure modes, making the integrity of electronic functions even more critical.

IEC 61508 is a generic standard to define the "Functional safety of electrical, electronic, programmable electronic safety related systems". As a safety norm IEC61508 has given rise to the emergence of specific standards in various application domains, such as process machinery, train control, medical equipment control. It has also led to the ongoing development of a standard intended to cover safety in the automobile: ISO WD 26262.

Within the IEC 61508, different levels of safety integrity are prescribed to outline what is expected for a particular platform. The relevant Safety Integrity Levels (SIL) and Safe Failure Fraction (SFF) are prescribed as follows:

- SIL1: SFF > 60%, fault model mostly oriented to static (permanent) faults
- SIL2: SFF > 90%, fault model includes transients
- SIL3: SFF > 99%, fault model includes transients

These margins effectively prescribe the reliability safety levels expected for a particular platform. While standards such as ISO 26262 for automobile will prescribe

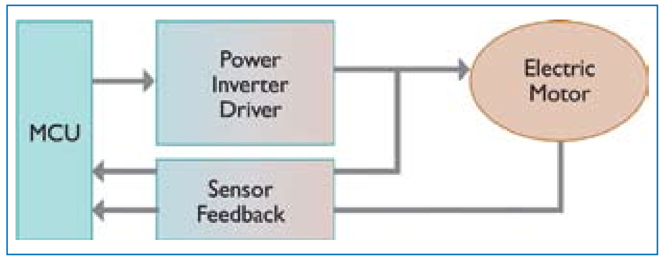

Figure 1: Electric motor control: Typical configuration.

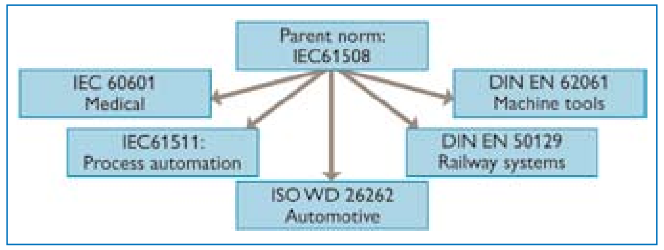

Figure 2: Safety standards.

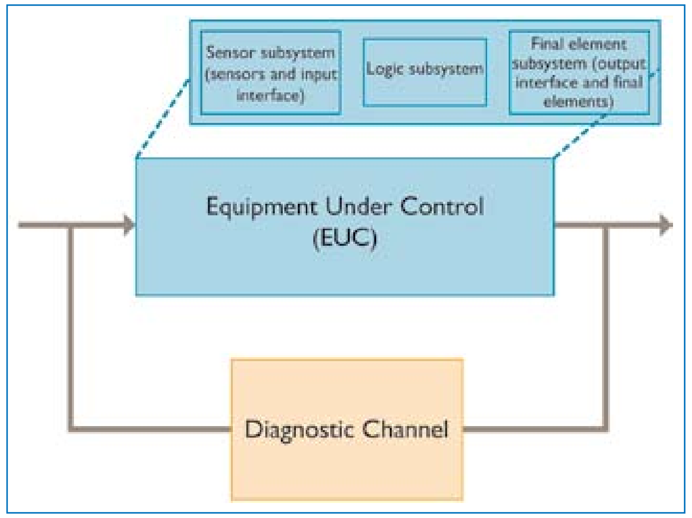

Figure 3: Basic diagnostic architecture: Single channel with diagnostics.

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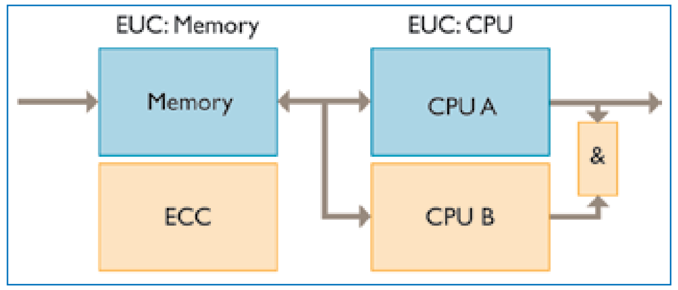

Figure 4: Black box technique: Dual core lock step.

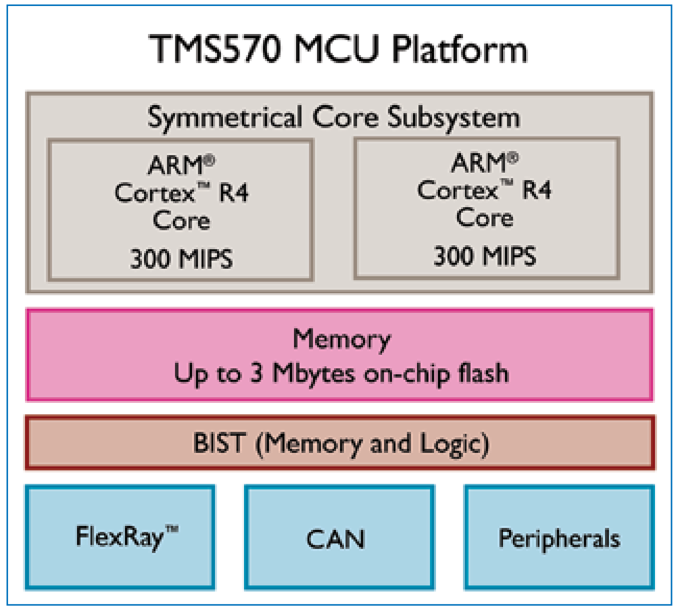

Figure 5: TMS570 MCU platform.

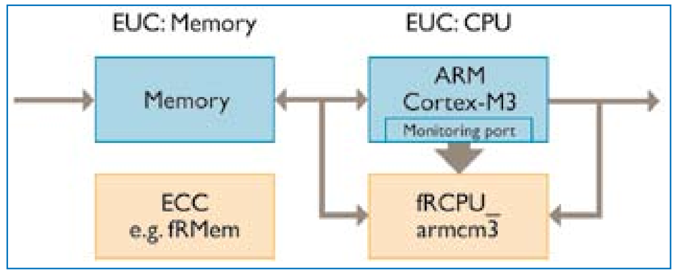

Figure 6: White box architecture.

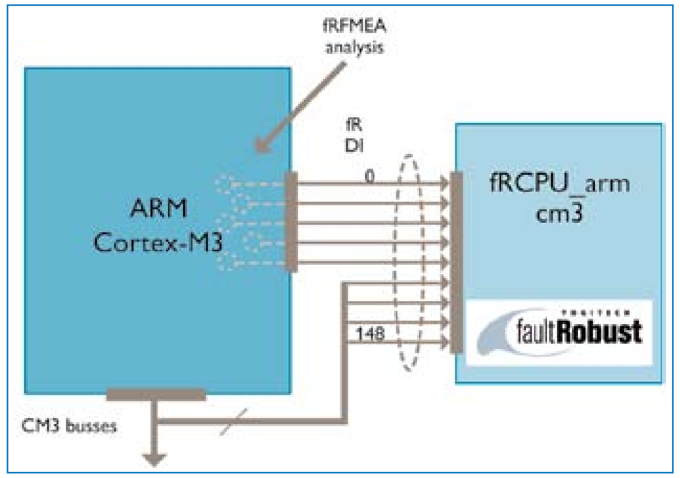

Figure 7: ARM Cortex-M3 faultRobust diagnostic interface (fRDI), block diagram.

market specific levels in more detail, it is likely that a growing number of safety critical vehicle features in addition to stability control and braking will be expected to reach the highest level in these guidelines, namely SIL 3 (comparable to ASILD of ISO 26262). The challenge is that many 8-bit CPU architectures used today in mixed signal solutions, such as the 8051, pre-date safety standards such as the IEC61508 norm by many years. In contrast, ARM's range of embedded processors, such as the ARM Cortex™-M Series and ARM Cortex-R Series were developed in full knowledge of this specification.

Methodologies to Address Safety

The recommended techniques to address this within a microcontroller platform are prescribed in the following diagram where the diagnostic channel consists of many elements to check consistency of the logic subsystem: A common approach to tackle this challenge is a 'black box' approach, whereby an external perspective is taken. Individual components such as the CPU are either replicated or continuously tested via their external interfaces.

This concept can be found in several safety systems today and has proven very popular since the approach is relatively straightforward; the CPU is duplicated so that one CPU can be used to check the results generated by the CPU used in the logic sub-system. Some form of architectural diversity is usually necessary to avoid the potential of a common-cause fault affecting both CPUs, which cannot be detected by the compare unit. As a result, the dual-CPU lock-step architecture requires additional measures to reach SIL3. Such measures are outlined in IEC 61508 and include the use of an external watchdog, diverse synthesis for the CPU checker and specific layout requirements. In addition, IEC 61508 also requires a minimum diagnostic coverage for each CPU of at least 60%, so software routines for CPU initialization and periodic diagnostic tests are also needed.

The first IEC 61508 compliant processor solution to be released is the Texas Instruments TMS570, which features the ARM Cortex-R4 processor in the dual core configuration described earlier.

As mixed signed and power electronics evolve, digital electronics systems become increasingly integrated. In these systems gate count can become extremely important to help reduce the overall die size. A 'white box' approach seeks to understand the operation of the logic subsystem through a detailed failure modes and effects analysis (FMEA), providing an asymmetric monitoring approach that inherently prevents many common cause failures. Since the CPU is not being completely duplicated, the overall die size is also reduced. One company that has pioneered significant developments in this white box approach is Yogitech with its faultRobust portfolio. This portfolio extends from memory check and on-chip bus components such as fRMEM and fRBUS through to the fRCPU component, optimized for a specific CPU.

Fault robust technology and the ARM Cortex-M3 fault observation interface

The development of Yogitech's fRCPU IP starts with a detailed FMEA analysis of the target CPU using the fRFMEA process included in fRMethodology. fRMethodology is approved by TÜV SÜD, a well-known leading international service organization that conducts safety testing and IEC certification. According to the fRMethodology, the CPU is partitioned into "sensitive zones" that cover the logic cones related to all CPU registers. For these sensitive zones, the main effect of a fault is then evaluated at an observation point. Failure modes are defined for permanent, intermittent/transient and IEC defined faults. Each failure mode is then weighed with statistics, such as the gate count and connectivity of the input logic cone. Diagnostic coverage and a safe/dangerous failure fraction associated with each failure mode are then calculated. The target diagnostic coverage for each sensitive zone is selected to provide a Safe Failure Fraction (SFF) = 99% in an optimized silicon footprint.

In tests, one ARM silicon partner, Toshiba, collaborated with Yogitech to develop a demonstration platform and the resulting fRCPU takes up less than half the original CPU size. From an architectural point of view, fRCPU is composed of sub-units that monitor the CPU and model its behavior on an abstract level. It uses a set of independent blocks tailored to check and detect deviations of the CPU behavior from this model [2].

As such, fRCPU is not provided as a replication of the CPU, hence it is architecturally and functionally diverse, which helps to address the IEC 61508 requirement.

For the fRCPU to deliver the required coverage level with minimum gate count, it is essential to provide it with the correct visibility of the activities going on inside the CPU. To achieve this, ARM worked in close collaboration with Yogitech to identify the requirements and develop the necessary interface. The result of this collaboration was the definition of a Fault Observation interface known as the faultRobust Diagnostic interface (fRDI), which totals almost 150 signals and was made public with the release 2 of the ARM Cortex-M3 processor in 2008. The observation interface includes information on the register bank ports, the instruction in the execute stage of the pipeline and certain debug information.

Summary

Precise digital control of power electronics can provide active solutions for drive train, vehicle safety and driver assistance in the car whilst reducing vehicle weight and energy consumption. While safety and reliability standards continue to evolve, the economic reality is that any resulting platform must meet the appropriate level at the right price. This also holds true for applications outside of the automotive industry, such as process control or medical electronics. It is clear that dual-core lock step architectures such as the TMS570, as a proven solution, will gain momentum in safety systems. In the future, as an increasing number of highly integrated applications require fault tolerance, the Fault Robust technology defined by Yogitech can provide additional benefits in terms of gate count and power consumption.

www.arm.com

Automotive Education

European students go green with CarEcology

New ecological requirements demand new technologies, and new technologies demand new skills. Over the last three years, several European institutions of higher education have jointly developed a new master programme in automotive engineering with the focus on new technological trends and ecologic design of vehicles. The programme has been thoroughly tested and will gain full momentum from the next academic year (2009-2010) onwards.

By Paul De Meulenaere, Senior Researcher Automotive ICT; Sofie Krol, International Co-ordinator, Karel de Grote-University College, Antwerp, Belgium and David Perry, Lecturer in English and Communications, Technical University of Valencia, Spain

The new Master in Automotive Engineering (aka 'CarEcology') has been designed to enable students to update their knowledge in a number of related fields, such as new materials, hybrid drives, production automation, materials recycling and sustainability, embedded software and hardware. Moreover, it brings innovative ideas to car concepts and production processes.

Thus, the course will provide a platform for career advancement in an increasingly competitive job market. The international aspect of the programme – students must follow modules in at least two locations in Europe – increases the students' skills to perform in a multicultural environment.

Figure 1: Overview of the institutions participating in CarEcology.

8 partners, 7 countries

The 'CarEcology' master programme is the result of a Socrates-project funded by the European Commission, and was developed by eight partners from seven different EU-countries, see figure 1. In addition, an external non-profit organisation representing the automotive industry, called AGORIA and which is based in Belgium, acted as an external evaluator.

The differences between the partners were sometimes striking. Besides the cultural and language barriers, both small and large institutions were obliged to find ways of working together. Some partners had a broad tradition in many different aspects of vehicle design, while others had dedicated skills related to one specific subtopic. Some institutions focus on student skills at bachelor degree only, while others deliver master degrees.

It was therefore both challenging and satisfying to reach the main goal of this curriculum development project; namely, the creation, together with the partners, of a master programme of 60 ECTS-credits with the focus on:

- Automotive engineering
- New ecological trends
- Communication and management skills
- Student and teacher mobility
- Alternative teaching methods

The resulting CarEcology programme comprises 6 compulsory taught modules covering the core areas of the discipline plus an individual research thesis. Teaching includes lectures, seminars, case studies, group work, group and individual projects, visits and guest lectures.

The education programme is shown in figure 2. Besides the "traditional" subjects such as engine technology, vehicle dynamics, control theory, etc., special attention is given to new technologies. For example, alternative drive systems (hybrid and electric vehicles, battery technology, ultracapacitors, …) and green fuels each represent a module of 6 ECTS. The module on vehicle electronics covers current trends such as FlexRay, environmental sensing, lightning, vehicle communications, etc.

The nature of the programme is inherently cross-disciplinary. Students with a background in electronics will suddenly find themselves immersed in principles of chemistry, and students from electromechanical engineering learn the ins and outs of project management.

'NAL'

During the General Meetings of the CarEcology project, it was agreed that a substantial part of the teaching materials which were being developed should be based on methodologies which would encourage and foment more active and participatory learning processes by the students, rather than rely on established and traditional ex-cathedra forms of teaching.

While discussions continued and ways to avoid a too-classical approach were explored, our Finnish colleague, Markku Ikonen, suggested that anything would do, "as long as it is Not A Lecture". In this way the idea and the word 'NAL' were born.

From that moment onwards, all partners were required to come up with more active teaching methods that engage the students. Previously lengthy lectures now include small-group exercises or discussion sessions. Group work, distance learning and problem-based learning are used extensively. One consequence of this is an emphasis on continuous evaluation and the need for students to carry out assignments. On the other hand, the number of traditional examinations is reduced. At this moment, more than 50% of the courses in the CarEcology programme are a kind of NAL.

Project test phase

Using these teaching methods, the CarEcology programme has been tested with students in two locations in Europe during the academic year 2008-2009. During the fall semester, three modules were taught at the Technical University of Valencia, Spain. The remaining three modules were taught during the spring semester at the Karel de Grote-University College in Antwerp, Belgium. The nationalities of the students during this test phase were Belgian, Finnish, Spanish, Greek and Polish.

car ECOLOGY

Module 1	Developing engine technologies	(6 ECTS)
Module 2	Energy efficient design of powertrain and body	(6 ECTS)
Module 3	Alternative drive systems	(6 ECTS)
Module 4	Green fuels	(6 ECTS)
Module 5	Trends in vehicle electronics	(6 ECTS)
Module 6	Communication and management for engineers	(10 ECTS)

Figure 2: CarEcology programme overview.

International Conference CarEcology
Wednesday 16th September 2009
Karel de Grote-University College Antwerp

Conference Programme

9:00 am Registration and welcome

10:00 am Keynote Speech (dr. ir. Egbert-Jan Sol)

11:00 am Coffee Break

11:30 am Workshops

Workshop 1: New trends in vehicle technology

Workshop 2: New method(ologie)s as opportunities for sustainable automotive education - NAL

Workshop 3: In and inter-vehicle communication networks - NAL

Workshop 4: Green mobility

Workshop 5: Green mobility - NAL

12:30 pm Buffet lunch

14:00 pm Panel discussion

16:00 pm Closure followed by reception

Figure 3: CarEcology conference programme.

At the end of this testing period, the reactions of the students showed that they learned a lot from the international setup. It's not just the visit to a local brewery, but also working in team with different nationalities, speaking only English, and taking cultural differences into account. "Next time I work in team, I need to take into account that the quality level of our work is appreciated differently in different countries," said one of the students.

The NAL-methods also stimulate out-of-the-box thinking. "Write a project plan for the development of a boat powered by solar energy", was one of the assignments. The students didn't know where to start, but in the end were surprised, and satisfied, to find that they could accomplish the job by developing the ideas generated in their cross-disciplinary teams.

What's next?

The above mentioned experiences in curriculum development and NALs will be presented in an international conference that will take place on September 16 at the Karel de Grote-University College Antwerp, Belgium, see figure 3.

In the future the CarEcology programme will take place each year in two different locations. For the next academic year, students will study in two locations: Karel de Grote-University College Antwerp, Belgium in the fall semester of 2009 and Wrocław University of Technology, Poland in the spring semester of 2010. Students can enroll via the website of either of these institutions, or via the CarEcology website mentioned below.

Conclusions

The above discussion shows that the curriculum development programme "CarEcology" has effectively brought together a number of European institutions of higher education in the area of automotive engineering. Not only was a new master programme on ecological concepts of automotive engineering conceived, alternative teaching methods were explored and encouraged as well.

Acknowledgement

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www.carecology.eu

Special Report – Automotive Electronics

Automotive Industry Woes

The need for semiconductor EOL planning

The recent dramatic downturn in the automotive industry may force automakers and their suppliers to take a new approach to semiconductor end-of-life (EOL) issues by structuring proactive plans to ensure a continuing supply of critical components for the future.

By George Karalias, Director of Product Marketing, Rochester Electronics, LLC

In general, car owners expect automakers to support a new car purchase for up to 12 to 15 years, and the automakers expect the same commitment from their parts suppliers. Considering that engineers usually begin the design of a new model seven years before it reaches the showroom floor, it's easy to see that long-term availability of key semiconductors will remain an ongoing critical issue.

Authorized suppliers like Rochester Electronics purchase finished chip inventories for storage and sale, as well as manufacture, store, and distribute EOL semiconductors to OEMs, saving them the time and money required of a total system redesign.

Up until now, automakers have purchased such a high volume of parts directly from the manufacturer; purchasing contracts were created, offering supply commitment and volume discounts in exchange for years of high-volume orders. For example, if the manufacturer of the microcontroller for a brake system made the part obsolete, the chip manufacturer could make an end-of-life run of the component and store it for the brake system manufacturer. They in turn could support any of the automakers using their brake systems and the return on the investment would be justified.

Authorized EOL suppliers often purchase wafer and die inventories from the original manufacturer for use in recreation services when finished semiconductor inventories are unavailable.

The question now is: Will this continue? With car companies filing for bankruptcy, dealerships shutting their doors, and car sales flat-lining, the auto industry is losing its bargaining position. If manufacturers are unable to trade the promise of high-volume sales for quantity discounts and long-term commitments, are parts suppliers going to be willing to enter into agreements that will commit them to providing a continuous parts supply for 15 or 20 years? And if they are not, how will auto makers, service providers, and car owners deal with part obsolescence for cars that still have plenty of miles yet to go?

Only time will tell. But auto industry manufacturers need to begin thinking now of alternative solutions. They can't afford to wait until the first time they discover that the semiconductor that powers a critical system in a popular car model has reached end-of-life.

The alternatives to planning ahead to ensure a continuous supply of a necessary semiconductor are faced every day by manufacturers in other industries.

For the auto industry, as for other industries, there are a lot of questions to answer:

• Is an end-of-life buyout the right solution? Are there enough parts available? Do we still have enough leverage with the semiconductor manufacturer to make it happen? And, are the right storage options available if the buyout can be made?

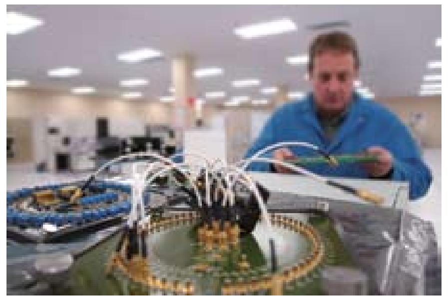
• Can another part be substituted? If it can, how long will it remain available?

• Can we depend on distributors to sell us reliable components?

• Is redesign an option? Can we justify the huge expense in support of a car that isn't even being made anymore?

• What will happen to our reputation if repairs simply cannot be made because parts are not available?

Given the number of parts in question, the solution to the EOL problem at first seems insurmountable. However, there is an answer: Partner with a reliable supplier with a proven track record of successful Extension-of-Life™* services, like Rochester Electronics, a semiconductor manufacturer and distributor that specializes in making obsolete semiconductors available on a long-term basis. Because Rochester has been authorized by more than fifty original semiconductor manufacturers, customers can be assured that they are purchasing authentic, high-quality product that will be available on a long-term basis, and has been handled and stored according to standards set by the original manufacturer.



Engineering schemes, test programs, and test fixtures from the original semiconductor manufacturers can be turned into exact replicas of finished devices than can then be tested to the original manufacturer's specifications.

Rochester can provide a range of options, including product storage, continuing manufacture, and replication/re-creation. Plus, multiple proven programs can be implemented to help manufacturers build a strategy that best fits their business goals and bottom lines.

The earlier an EOL strategy is put in place, the more options there are for a cost-effective plan. A partnership with Rochester, for example, can include the following services:

• Purchasing finished device inventories for storage and later use;

• Storing and releasing a manufacturer's part inventory through a scheduled, fully managed program;

• Controlling the storage, logistics, and distribution of die products purchased in a last-time buy;

• Purchasing wafer and die inventories and tooling from the original manufacturer and using them to manufacture finished devices—and purchasing test programs, and test fixtures, so that the devices can be tested to the original manufacturer's specifications;

• Offering long-term supply programs that bundle together a number of individual services to provide extended product life for decades;

• Requesting a bill-of-materials from the OEM and then alerting the manufacturer when a product on the list has been discontinued and action is required.

So much about the future of the automotive industry is a question mark, but component end-of-life doesn't have to be. As industries change in our volatile economy, the auto industry might take the cue from other industries that have profited by planning ahead in the face of component obsolescence. There are many options out there for smart, prepared manufacturers to turn "end-of-life" into "Extension-of-Life."

**Extension-of-Life is a trademark of Rochester Electronics, LLC.*

www.rocelec.com

From Russia with Automotive

AC electric drive-train of a hybrid city bus

High environmental and fuel-saving requirements in public transport may be implemented by applying diesel-electric hybrid drive-train. The author, Stanislav N. Florentsev, Doctor of Electrical Engineering, full member of the Russian academy of electrotechnical sciences, IEEE and SAE member tells us about this project.

By Stanislav N. Florentsev, General Director, Ruselprom-ElectricDrive Ltd. Moscow, Russia

A shuttle city bus with a hybrid drive-train offers the following advantages:

- Up to ten-fold decrease of the emission level, especially in urban conditions
- Fuel savings of 25-50%
- The possibility to start a diesel engine by means of hybrid drive-train, to generate and recuperate the power
- Decrease of diesel engine power by 25-30% with keeping the same torque on wheels
- Operating the diesel engine in optimal modes in terms of fuel efficiency and emissions
- Increase of bus comfort (noise, vibration, steering response)
- Increase of bus reliability and operational life

A Traction Electric Equipment Set (TEES) of series configuration has been designed and successfully tested for the most widespread 12-m city bus (19 tons). TEES functional block diagram is given in Fig. 1.

The complete set of Traction Electric Equipment (TEES) includes:

- Asynchronous motor - generator (AMG)
- Traction asynchronous motor (AM)
- Power converters with a microprocessor control system (mCont) for AMG and AM
- Storage unit based on Ultracapacitors (U-cap)
- High level controller (HLC) for controlling power flows and the steering link with controls and information displays in a driver cabin
- Auxiliary power supply system for TEES and a battery charger (DC/DC)

Both DC/DC converters and controllers are included in power electronic module (PEM). All converters and electric motors have liquid cooling system. HLC is connected to all the controllers by CAN-bus. HLC regulates also the diesel engine controller and ensures functioning of the diesel engine in a maximum fuel efficiency mode in all modes of bus operation. HLC has an interface to external computer for programming and operation analysis and may be connected to GPS/GLONASS positioning systems. The U-cap storage unit has also the microcontroller which supervises voltage and temperature of each element of the U-cap unit.

The storage unit is located on the bus roof under the special cover. Also there are located some elements of cooling system. Ultracapacitors were chosen for the storage unit for their good power density characteristics, reliability, safe operation and high operation life which is about two times the same of the best modern batteries. Application of electric drive-train causes the excellent bus drivability and very smooth starts, stops and speed changes. The electric drive-train also provides deep control and visualization of all bus parameters in real time and collecting the information of all the processes in electronic "black box".

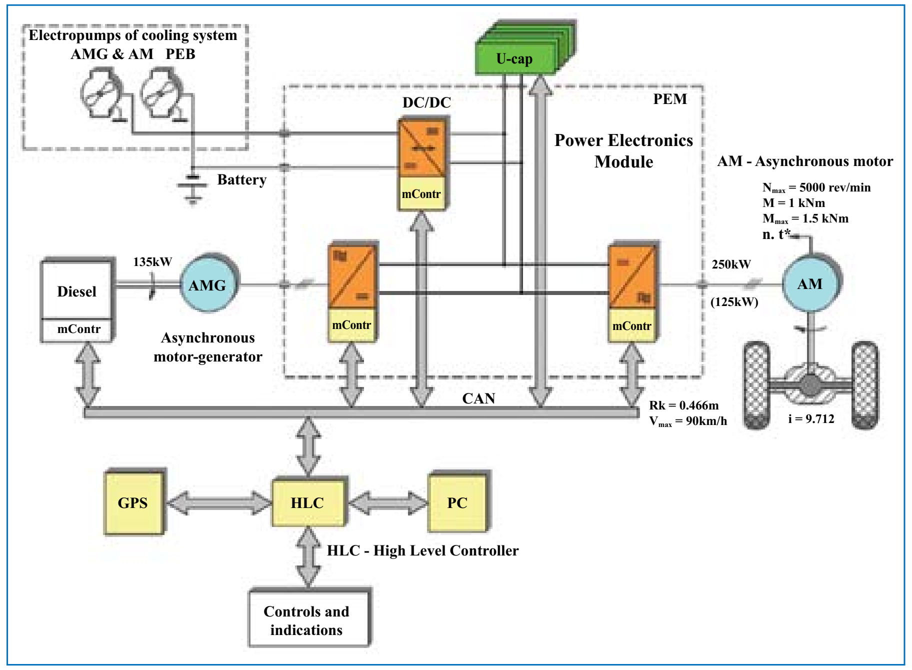


Figure 1: TEES function block diagram of a hybrid city bus. (picture by Ruselprom-ElectricDrive)

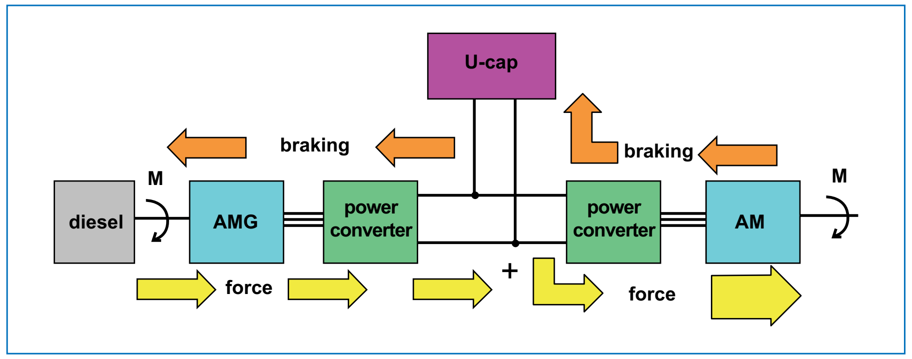


Figure 2: Power flow diagram for scries hybrid drivetrain configuration. (picture by Ruselprom-ElectricDrive)

Figure 3: LIAZ-5292 hybrid city bus at the Moscow International Automobile Forum. (picture by Ruselprom-ElectricDrive)

Choice of the series drive-train configuration has been based on the world experience, minimal cost and time limits specified for design, rollout and cost considerations of the project. This is characterized by the absence of mechanical power channel from diesel engine to wheels which is essential for the best weight balancing of the bus and arranging of drivetrain components. A MAN Lion's City Hybrid city bus may serve as an example of such development. It was designed by MAN Nutzfahrzeuge AG and Siemens A&D and, as experts suppose, is one of the first economically viable projects of a hybrid city bus with the mass production planned for 2010. Power flow diagram for the series hybrid configuration is shown in Fig. 2.

During a uniform movement mode mechanical power from a diesel engine is transferred to the driving wheels in amount of up to 125 kW through the following line: AMG –power converter – DC link – power converter - traction motor (AM). This power can be used simultaneously for charging the U-cap. During accelerations U-cap power in amount of up to other 125kW is added to the power of AMG, providing fast acceleration of the bus at a start from a bus stop or crossroad. These provides total torque of 1 kNm (peak 1.5 kNm) on the ground, which ensures fully loaded bus operation with maximum cruising speed of up to 90km/h.

During bus braking mechanical power is transformed in electric power by the traction motor functioning as a generator and is used for U-cap charging. At a fully charged U-cap the power is used for braking by a diesel engine. The generator then functions as a motor. Thus the part of braking energy is saved in the U-cap and can be used then during accelerations. Also, the U-cap power may be used for diesel engine starting (the starter and the battery charging generator may be excluded from the diesel engine). The so-called electric baking saves mechanical brakes operating life very much. Actually mechanical brakes are used mainly for parking. One should also note the derated diesel engine power which is only 135kW and is produced in very narrow speed interval of the motor thus providing the higher diesel operation life and lower maintenance cost.

TEES has been mounted on modern low-floor LIAZ-5292 serial bus produced by Russian leading bus manufacturer (65% of Russian bus market in the 12-18-m segment) LIAZ plant, owned by GAZ-Group, Division "Passenger buses" (see Fig. 3). Proving and final operational testing has been carried out for the bus structures. Test results have confirmed all required technical and economic characteristics.

The bus was presented for the first time at the Moscow International Automobile Forum held in September 2008 and was heralded the "Best Bus of Russia 2008".

All components of the traction electric equipment are developed and produced at the enterprises of Russian electric engineering corporate group RUSELPROM which is one of the leaders in the Russian industry (123.8 million RUR, or about $4 million net operating profit after tax in FY2008).

The development of the project was completed in an extremely short timescale. The whole set of a traction electric equipment may be adapted and mounted on any bus of the 12-m class. The estimated cost of serial hybrid bus drive-train with TEES by RUSELPROM is significantly lower than the same of any other hybrid drive-train manufacturer. The TEES is adaptable to any type of diesel engine.

www.ruselprom.ru

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.

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

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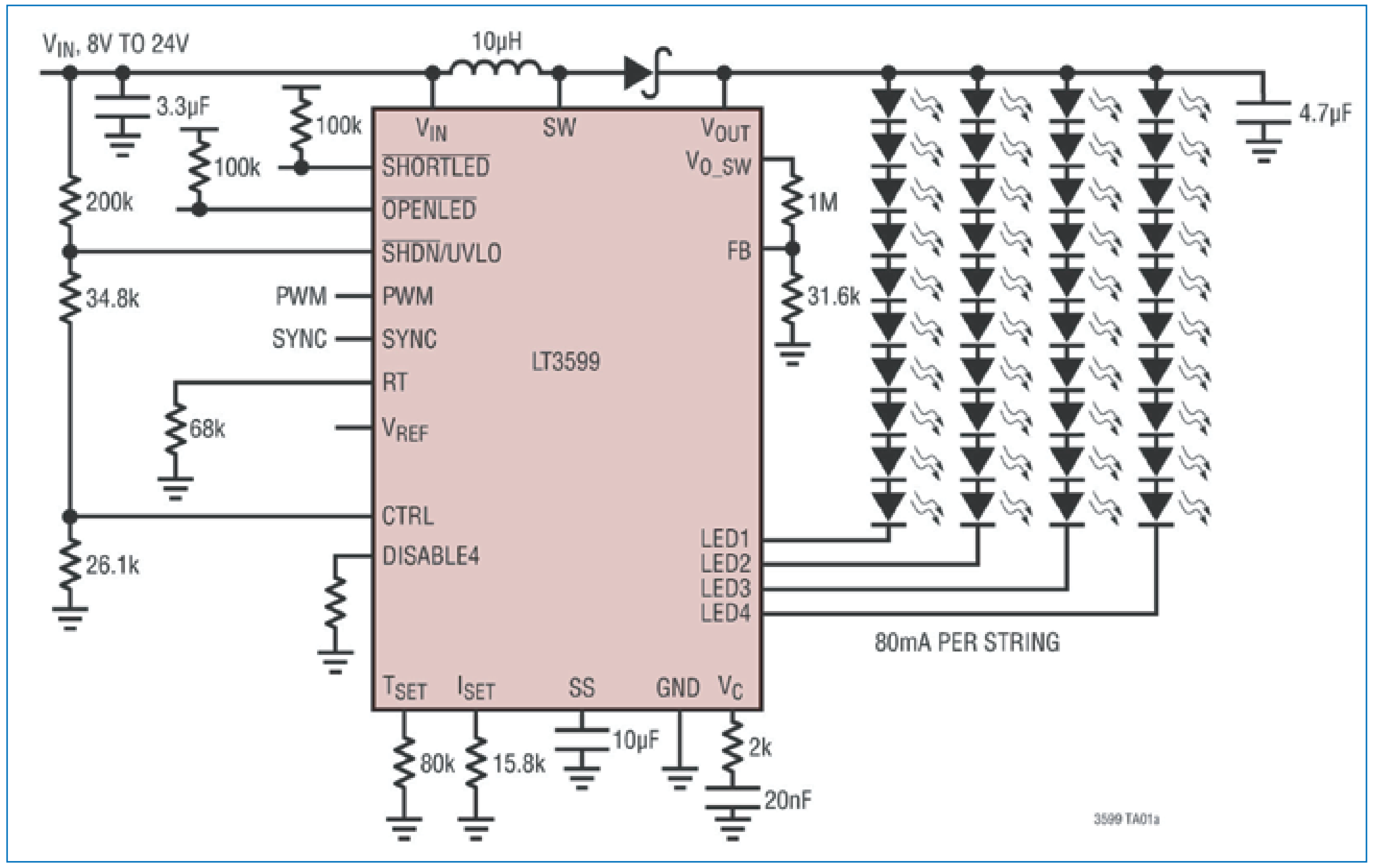


Figure 2: 90% Efficient 12 Watt LED backlighting circuit using the LT3599.

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 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.

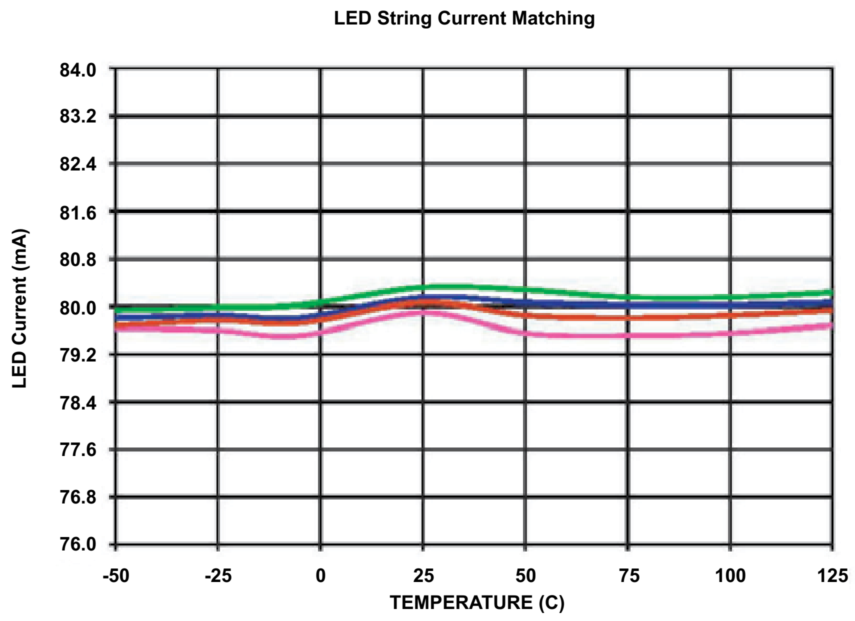
Another important benefit of LED backlighting is the wide dimming ratio capability provided by a high performance LED driver IC. As the interior of a car is subjected to a very wide variation of ambient lighting conditions, ranging from direct sunlight to complete darkness with every variation in between, 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.

Design parameters for automotive LED lighting

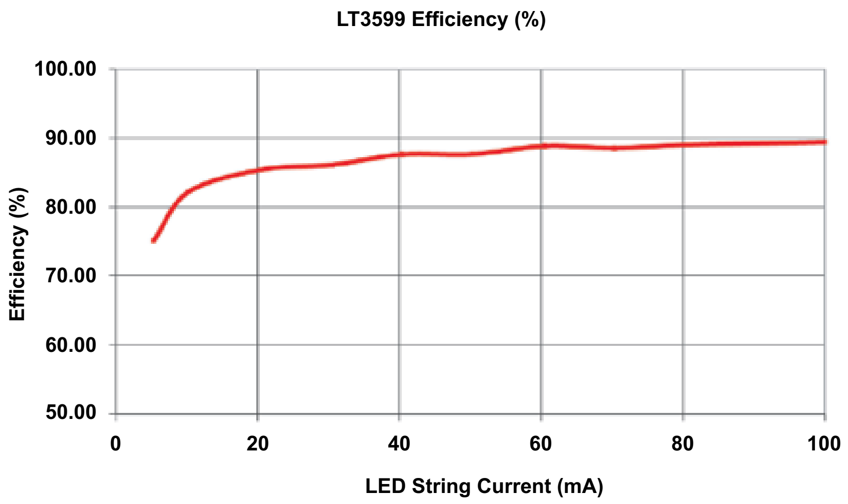
In order to ensure optimal performance and long operating life, LEDs require an effective drive circuit. These driver ICs must be capable of operating from the caustic automotive power bus and also be both cost and space effective. In order to maintain their long operating life, it is imperative that 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.



Current Matching Over Temperature



Efficiency vs. LED Current Temperature

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

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 backlighting 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.

www.linear.com

Are We Really Serious?

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

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.

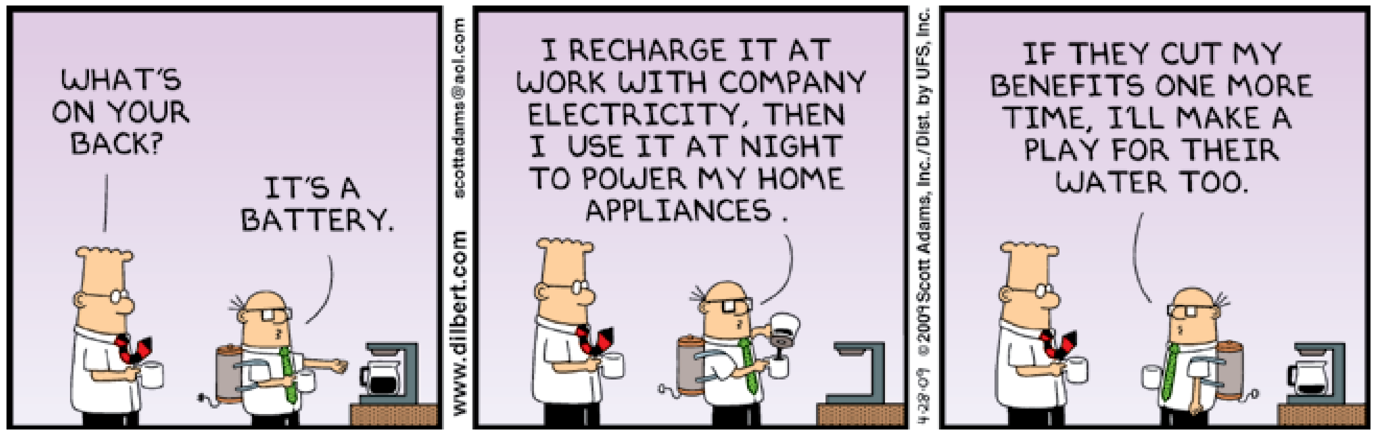
It is estimated that oil, coal and natural gas will provide 80% of the world's power demand in 2030, with gas and coal providing 50% of this. EU member states have done little more than pick the 'lowest hanging fruit' by implementing policy incentives that back wide-scale deployment of wind power generation, 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. An artificial demand surge was created in Spain when the country's feed-in-tariff rate was set to drop and a new cap of 500 Megawatts loomed for projects qualifying for the above-market tariff. This set a well-defined deadline for growth in the Spanish market in 2009. 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.

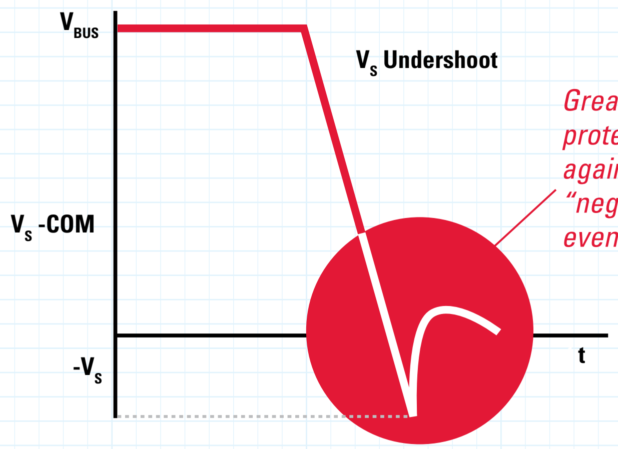
I would suggest that in Europe we are not progressing as fast as we need. It seems the only forces that really work are fuelled by potential profit and image-popularity; the former, necessary for industry and the latter for posturing company leaders and governments. In the meantime we suffer the lip-service until it becomes 'power-threatening'.

www.powersystemsdesign.com/greenpage.htm



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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