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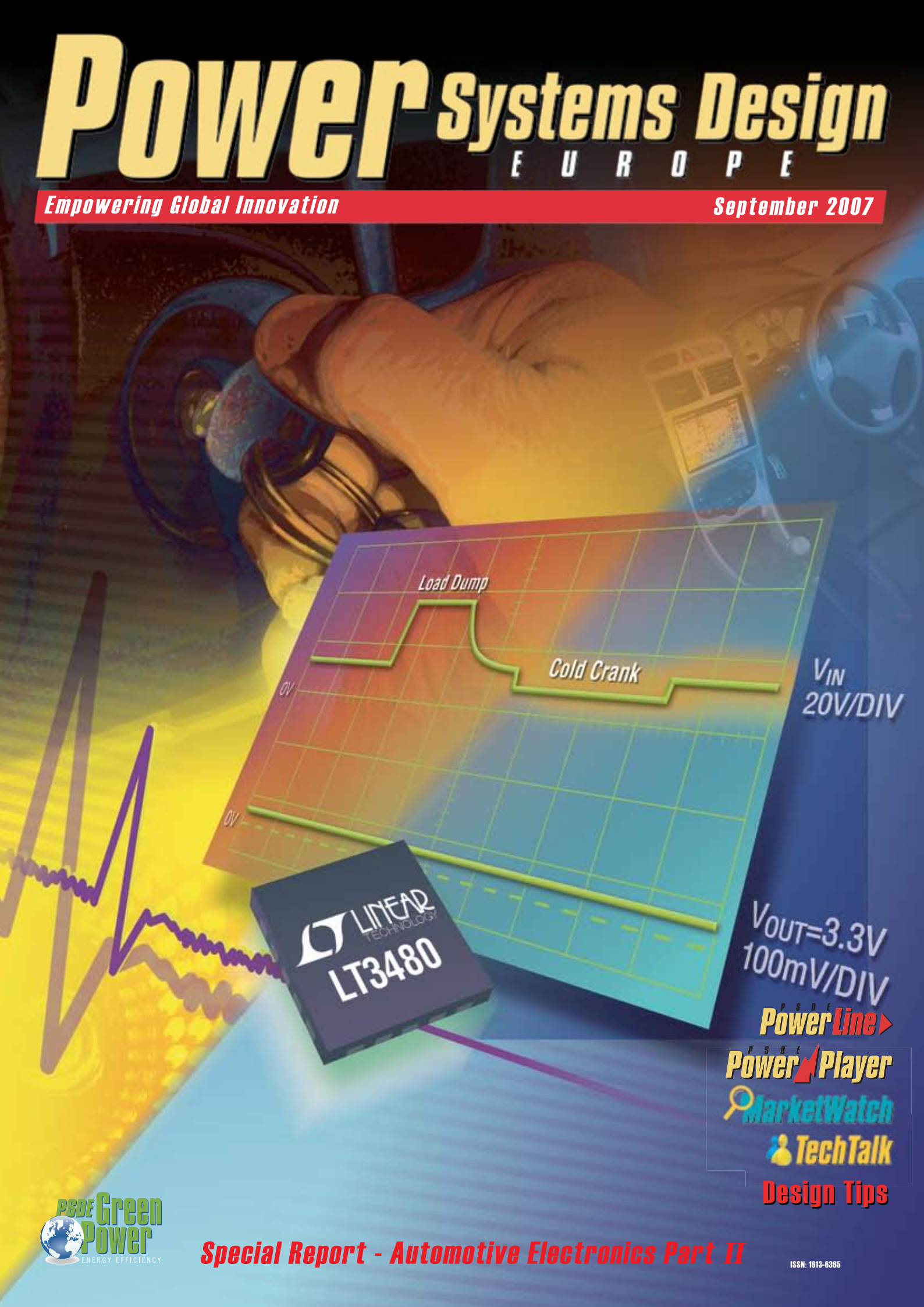
Empowering Global Innovation

September 2007



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PSDE Green Power
ENERGY EFFICIENCY

Special Report - Automotive Electronics Part II

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Power Systems Design Europe

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Volume 4, Issue 7

The Wind Blows Power

Welcome to the second part of our automotive feature. The response has been tremendous and not enough space in this issue for them all. I'll get the articles to you in a subsequent issue.

According to iSuppli, the explosion of digital multimedia infotainment systems in cars is now prompting auto makers to adopt Hard Disk Drives (HDDs) for storage and playback of music, video and other digital content.

Shipments of HDDs for automotive infotainment systems are expected to reach 16.6 million units by 2013, nearly five times the 3.5 million in 2006. Automotive HDD shipments will rise at a Compound Annual Growth Rate of 25.1% from 2006 to 2013, making hard drives the fastest-growing storage solutions for cars in the coming years.

It's been quite a month. Apart from the normally frustrating holiday season, where everyone you need -be it doctor, lawyer or tax consultant- is away on a 3-4 week vacation…one would have thought such 'vital' services should be covered better in this 'seamless' customer-caring age!

Hopefully you are refreshed after the summer break and have recovered from the inevitable re-entry problems when going back to work.

I have been out and about on both business and a little pleasure over the past month and have seen the difference in terrain across Germany. I visited Danfoss Silicon Power, to see their splendid facility in Schleswig, north of Kiel.

It's located on the northern extremity of Germany where the wind blows like crazy over these beautiful flat lands. Even driving a car at 'within the official speed limit' can be a precarious adventure. It's obviously no coincidence that there are so many windmills generating power in the cleanest way possible there. It's also very good for us in the power industry! Denmark, just across the border, produces around 20% of its electricity this way.

They have a great operation there. Apart from a very welcome opportunity for me to get dressed up to get a tour of their clean room, it was good to see well qualified people working as a team in a high technology environment.

The alliances Danfoss has with the universities within Europe makes me feel that there is much more life to be lived here in the power industry and will, for sure, keep a well run company like Danfoss in the capable hands of a well educated workforce.

So, returning to this month's issue. In our 'On the Road' feature I report on EPCOS and Infineon. These were two good press conferences from two major players. The press conference and seminar season always follows the vacation season. As I am getting out more these days, I hope to bring you Ad-hoc reports on my visits and dialogs with the top guys in the power business.

One last point before I sign off. Check out our enhanced website www.powersystemsdesign.com which now includes a Google powered search engine, so you can now keyword search our current and all past issues for articles of interest to you.

I hope you enjoy the magazine and as ever, please let me know what's happening with your design project.

All the best!

Cliff Keys

Editor-in-Chief, PSDE
Cliff.Keys@powersystemsdesign.com

Ansoft Announces "First-Pass System Success"

Application workshops for high-performance design scheduled for Asia, North America and Europe

Ansoft Corporation announces "First-Pass System Success," application workshops for high-performance design, to take place from September through November throughout Asia, North America and Europe.

During these events, leading technology companies and Ansoft's technical staff will collaborate to discuss the latest simulation techniques and design methodologies to help engineers achieve first-pass system success when designing high-performance electronic systems.

- Topics include:
- IC design and verification
- Signal- and power-integrity simulation
- RF, microwave and antenna design
- Advanced packaging and PCB design
- Electromechanical and power systems design
- Medical electronics
- EMI/EMC

For the latest information on "First-Pass System Success," including specific dates and locations visit:

www.ansoft.com/firstpass

Microsemi Enters Silicon Carbide Supply Agreement with SemiSouth Laboratories

Microsemi Corporation and SemiSouth Laboratories Inc. of Starkville, Mississippi, have announced that they have entered into an agreement which provides for cooperation between the two companies in the area of silicon carbide (SiC) epitaxy wafer supply as well as certain technical exchanges. SemiSouth is a privately held company specializing in SiC material and device fabrication (www.semisouth.com).

Russell Crecraft, Microsemi Power Products Group Vice President and General Manager, stated "We are pleased to enter into a closer working relationship with SemiSouth. Microsemi's requirements for SiC wafers will grow in the future and we expect that this agreement will help SemiSouth's talented team of engineers to continue their progress toward highly manufacturable silicon carbide epitaxy."

SemiSouth's President, Jeff Casady commented "At SemiSouth, our long-term goals have always been to enable the SiC power device market through high-quality SiC epitaxy wafers and devices. We are excited to be able to work with Microsemi by supplying them epitaxy wafer products needed for their product goals. Microsemi has a great track record of supplying high performance power device products, and this agreement represents a great step forward for the SiC power electronics market."

www.microsemi.com

Groundbreaking Ceremony for the World's Most Advanced LED Chip Fabrication Plant in Penang

Model of the new LED chip factory in Penang, Malaysia.

The groundbreaking for the new LED chip factory – Werner Gelner, Managing Director OSRAM Opto Semiconductors Penang, Dr. Rüdiger Müller, CEO OSRAM Opto Semiconductors, Tan Sri Dr Koh Tsu Koon, Chief Minister of Penang/Malaysia, Herbert Jess, Ambassador of Germany to Malaysia (from left to right).

In a joint groundbreaking ceremony Tan Sri Dr Koh Tsu Koon, Chief Minister of Penang/Malaysia, and Dr. Rüdiger Müller, Chief Executive Officer of OSRAM Opto Semiconductors GmbH, signaled the start of construction of an LED chip factory in Penang. By the spring of 2009 Penang will have the world's most advanced chip factory, with a floor area of more than 30,000 square meters, to serve the booming LED market. With the expansion of its production capacity in its factory in Penang and the simultaneous expansion of the LED chip fabrication plant in Regensburg, OSRAM Opto Semiconductors is building on its position as the number two on the world LED market so it will be in an even better position to meet growing demand for LEDs far into the future. As a leading innovator, OSRAM has one of the broadest portfolios of patents on the market. Expansion of its production capacity is a clear signal that it is on course for sustained growth in the exciting LED market.

The factory in Penang will operate in addition to the main plant in Regensburg to manufacture LED chips in state-of-the-art nitride technology. OSRAM is investing millions of euros in the new factory. The total investment here is in high double figures. In addition, the capacity of the existing LED assembly line in Penang, which started operation back in 1972, will be increased by more than 50 percent. This will lead to the creation of over 800 new jobs in the long term and bring the total number of jobs to more than 3000, making OSRAM one of the largest employers in the northern region.

Dr. Rüdiger Müller said: "Today marks the beginning of a new era in more than 30 years of cooperation between OSRAM and Penang. We are delighted to be further strengthening our partnership today at this groundbreaking ceremony and to be embarking on a new chapter in our shared success story. In constructing this LED chip factory here in Penang, OSRAM is for the first time exporting central strategic technology know-how to another market outside its home country of Germany. This is only possible because our many years of cooperation have meant that we have the utmost trust in the quality, motivation and skills of the local workforce and authorities. Regensburg will continue to be our main site where we will concentrate our know-how and benefit from having our research and development facilities so close to our production line."

www.osram-os.com

The Challenge of Feeding and Handling Thermally Conductive Adhesives is Solved

Scheugenpflug develops new A280 – TCA (Thermally Conductive Adhesive)

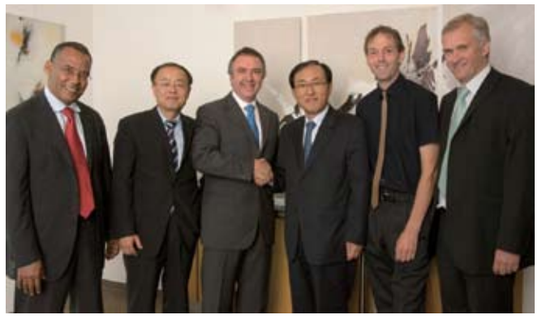
Sealing bead made of abrasive casting material

To protect electronic components against overheating, they are connected using cast materials to cooling bodies which cover as large a surface area as possible. This connection must produce a gap-free, thermal contact with reliable electrical insulation. To achieve excellent heat conductivity, casting materials are used which are made up of at least 70% ceramic filler materials (aluminium oxide, silicate etc.). The disadvantages of these filler materials can be found in their hardness and the sharp-edged profile which, when the material is transferred, can lead to abrasion and thus to shorter system availability times.

This results in shorter maintenance intervals and subsequently to very high maintenance and spare parts costs. Scheugenpflug has collaborated with manufacturers of heat conducing resins to develop the first material feeding and casting procedure which passed the endurance test for abrasive resins. Thanks to the optimised design principle and the specific choice of material, the new A280 can offer a level of availability which is many times longer than conventional systems.

www.scheugenpflug.de

Seoul Semiconductor Signs-up Avnet to Extend Global Reach of LED Technology



From left: Tesfay Embaye, Silica, Vice Persident; John S. Bae, Seoul Semiconductor, Managing Director for American and European Export Group; Miguel Fernandez, Silica, President; Yang-Hee Han, Seoul Semiconductor, New Vice President and General Managing Director for Sales and Marketing; Gary Winten, Silica, Business Development Manager Lighting (Europe); Richard Gill, Seoul Semiconductor, UK/Nordic Area Manager

Seoul Semiconductor, one of the world largest LED producers, has announced that it has signed European and Asian distribution agreements with Avnet Electronics Marketing, a division of Avnet, Inc. to expand and reinforce its sales network. The agreements followed an announcement the companies made in January for Avnet to distribute Seoul Semiconductor's products in the North American market.

The North American agreement ensured Seoul Semiconductor clients enjoy a higher level of service such as solution-centered support, and quicker delivery by maintaining inventory of its offerings. The recent agreements in Asia and Europe are expected to provide these benefits and more. Avnet's professionals will not only be supplying LED products but will also be providing crucial technical support services necessary to apply Seoul Semiconductor's technology to customers' actual applications. Ultimately this will save customers time and money, and enhance Seoul Semiconductor's competitiveness.

Seoul Semiconductor is a leading innovator of high-brightness and energy-efficient LEDs. It recently introduced a number of highly innovative LED technologies, among them "Acriche", the world's only semiconductor light source capable of running directly from household AC power without the need for additional converters. Furthermore, the company's brightest single-die white LED emitting 100 lumens per watt is predestined to replace conventional lighting sources such as fluorescent or incandescent lamps. These technical advances have enabled Seoul Semiconductor's LED technology to penetrate key illumination markets.

"These agreements provide us with a significant opportunity to accelerate the sales of our LEDs in the European and Asian markets," said Yang-hee Han, a new managing director for sales and marketing at Seoul Semiconductor. "As the world's largest distributor of electronic components, Avnet has an enormous sales network and professional sales know-how through its long experience. The recent series of agreements with Avnet is a competitive advantage," added Han.

Miguel Fernandez, president of Silica, a division of Avnet Electronics Marketing EMEA, said: "Seoul Semiconductor's broad range of advanced LED technology will revolutionize many segments of the lighting industry and is therefore a valuable addition to our existing portfolio."

"We are pleased to collaborate with Seoul Semiconductor and penetrate the Asia market with innovative LED technology," said Stephen Wong, president, Avnet Electronics Marketing Asia. "Seoul Semiconductor's customers in Asia will experience a high standard of sales and support services, including access to Avnet premier team of engineers and technology specialists who are experienced in solid-state lighting, thermal management, power driver stage and secondary optics."

www.avnet.com

www.seoulsemicon.com

TI Launches New Customer Support Center in Prague

Texas Instruments has announced that it has opened a new Customer Support Center and representative office in Prague (Czech Republic), adding to existing recently established offices in Warsaw, Moscow and Istanbul and providing new levels of support to Eastern European markets by extending its local customer service. TI also now offers a toll-free number for its European Customer Support Center (00800 ASK TEXAS), available in 26 countries across the region and allowing customers to speak directly to a TI technical expert in ten languages.

The Prague Customer Support Center is the second such Center that TI has created in the region, building on the success of its existing Center in Freising, Germany. Both Centers, accessible through a single, toll-free number, offer design engineers the possibility of easily reaching TI product information and technical support, providing rapid access to an expert TI engineer in one of ten languages spoken in the region. Specifically targeting Eastern European countries with support in Polish, Czech, Hungarian and Russian, the new Customer Support Center in Prague is the latest addition to TI's extended support for customers in these countries, adding to a recently-launched Russian language website, Russian-language training sessions and the latest TI Developer Conference held in Moscow in April this year.

"TI's strategy is to be as close to its customers as possible," said Jean-Francois Fau, TI President Europe, Middle East & Africa (EMEA). "Making it easier for engineers to reach TI technical experts that speak their language is an essential element of our strategy, and as the new Eastern European markets continue to grow, we will continue to enhance our support levels to accelerate our customers' success."

www.ti.com

Cree Announces Agreement with NIEC for SiC Diodes in Japan

Cree, Inc. a market leader in silicon carbide (SiC) power semiconductors, has announced an agreement under which Nihon Inter Electronics Corporation (NIEC) will introduce a line of silicon carbide (SiC)-based Schottky power rectifier diodes in Japan with die manufactured by Cree, Inc. NIEC is a world leader in silicon-based Schottky diodes, and Cree is the leader in silicon carbide-based Schottky diodes.

"Silicon carbide offers numerous concrete benefits over silicon-based rectifiers. Our market is showing growing demand for the far greater efficiency and performance offered by silicon carbide-based diodes, which enables reduced energy consumption in applications for home appliances including air conditioner and automotive invertors," said Masao Ishii, NIEC president. "Cree is the world's leader in silicon carbide components and materials, and it only makes sense that we chose the leading products."

"We are excited to see the growing interest in power components based on silicon carbide. Our agreement with NIEC will allow us access to their extensive marketing and sales channels in Japan, and is consistent with our current strategy to create a more global sales and marketing presence. We are excited about the potential impact our two companies can make on the Japanese market by combining our strengths," said John Palmour, Cree executive vice president for advanced devices.

Compared with traditional silicon-based diodes, Cree's SiC-based rectifiers can:

- Simplify power factor correction (PFC) boost design by eliminating the need for snubbers and reducing component count
- Reduce power losses, leading to cooler operating temperatures
- Produce significantly less electromagnetic interference (EMI)

www.cree.com

www.niec.co.jp/english/

Vacuumschmelze Invests Twelve Million Euros in New Production Plant

Vacuumschmelze GmbH & Co. KG is currently investing twelve million euros in its cold rolled strip production facility. At the centre is the construction of a new 20-high rolling mill scheduled for production startup in the late summer of 2007. In addition to ancillary facilities such as a strip trimming line and roll grinding centre, the Hanau company's future-proof production plant includes a state-of-the-art continuous production line.

This major investment is the last in a series of modernization measures aimed at assuring and retaining leadership status for Vacuumschmelze among the international competition on the materials market, while securing jobs in Germany. In 2002 the company built a vacuum induction furnace with melting capacity of six tonnes, and subsequently upgraded its blooming mill to roll the new larger two-tonne blocks into slabs. Finally, two years ago VAC installed a new slab grinding system for slab finishing. These three investment phases alone totaled around ten million euros.

Since Vacuumschmelze was founded in 1923, the company's materials operations have concentrated on semi-manufactured products and parts, covering production of over 150 different metal alloys and the strips and wires produced from them. The advanced magnetic and physical properties of these materials are precisely tailored to each customer's specifications and are unique throughout the industry.

www.vacuumschmelze.com

Digi-Key and Riedon Sign Global Distribution Agreement

Thief River Falls, Minnesota and Alhambra, California - August 7, 2007 - Electronic components distributor Digi-Key Corporation and resistor manufacturer Riedon, Inc. announced today that the companies have entered into a global distribution agreement.

With manufacturing, technical support and sales facilities in the United States, Europe, Mexico and China, Riedon is a global manufacturer/service provider of resistive solutions utilizing wire wound, thick and thin film, and Nichrome™ and Manganin™ foil resistive products used in such industries as communication, power management, medical devices and instrumentation.

The 15 and 30-watt Manganin foil resistors stocked by Digi-Key have a one percent tolerance, are available in TO-220, SMD TO-220 and TO-218 packages and range in value from 0.005 to 50 ohms, These resistors are ideal for applications such as measurement and test equipment, motor drives, power supplies and electricity meters. These products are featured in Digi-Key's print and online catalogs and are available for purchase directly from Digi-Key. This new distribution agreement will enable Digi-Key to fulfill both the prototype and production quantity needs of its diverse customer base.

"We are very happy to expand our resistive product offering with innovative products from Riedon," said Mark Larson, Digi-Key president and COO. "We are certain that the new technology of foil resistors will be of consequential interest and appeal to our customers."

"Riedon is delighted to have signed a global distribution agreement with Digi-Key" said Gary Cavagnaro, Riedon's vice president of sales. "Our Manganin foil offering is a unique and great first product for our companies to work together on, as it offers the best combination of low ohmic values, tight tolerances and lowest TCR of any TO package offered in the market today. With Digi-Key's global sales channel and our extensive resistive product offering, we see significant opportunities for growth coming from this agreement."

www.digikey.com

www.riedon.com

New Power Conversion Specialist PIV Technology Launches with RECOM as First Franchise

A new specialist power conversion distribution company, PIV Technology, has been launched promising to deliver the best quality products at the right price with full technical and logistical support, from design through to production. Founded by Marc Hogg, who brings more than 15 years' experience of working in the power supply market, PIV Technology's first franchise is RECOM, the Austria/German based manufacturer of DC/DC products.

Explains Hogg: "We are trying to offer something different. We will build very tight relationships with our partner suppliers; for example, if design is done in the UK, but production moves to the Far East, we will manage the whole process transparently for both manufacturer and customer."

He continues: "RECOM is our first partner and they are the embodiment of our approach of offering the whole package: exceptional quality, great support and competitive pricing." One example of RECOM's leadership position in the DC/DC market is the company's R78 series, which at just 11.5x7.5x10.2mm high is claimed to be the smallest 7.5W switching regulator in the world.

RECOM's European Distribution Manager Christine Schwegler states:" As a global supplier we are happy to have PIV Technology's Marc Hogg join our sales efforts in the UK. PIV's design-in skills will greatly assist our UK customers; the company's expertise will also give us a valuable insight into the needs of the UK market".

www.pivtechnology.com

UR Group Appoints Director of Power Solutions

UR Holding S.p.A. has appointed Joe Matano to the newly created position of Group Director of Power Solutions, a move that reaffirms the company's commitment to the European power supply market. Matano has been managing director since establishing UR in the UK in 1999 and retains that role whilst taking responsibility for UR's power supply business across Europe, including the UK, Germany, Italy, France and Spain.

Matano's brief is to build on UR's position as one of Europe's leading resellers of power supply technology which also encompasses fans and filters. The company has strong partnerships with major manufacturers including Artesyn, Astec, Delta, Ericsson Power Modules, TDI and Vicor, as well as relative newcomers such as Enpirion, which produces the world's smallest Power System on Silicon (PSoS).

Giovanbattista Laghezza, CEO of UR Holding, commented: "Joe has 23 years' experience in power supply technology, gained with manufacturers and distributors, which means that he is exceptionally well qualified to expand our business in this important sector. Whilst we also supply a wide range of semiconductor and communications technology, including leading-edge wireless solutions, power remains our core area of expertise."

Matano added: "I am looking forward to strengthening UR's position in the power supply market. All areas of our business are growing, including semis and comms, and we are totally committed to each of them, but it makes sense for us and our customers to place a special focus on power."

www.ur-group.co.uk

Power Events

- ***The China International Power Supply (CPS EXPO),*** *November 6-8,Shanghai, China, www.cpsexpo.cn/en/index.html*
- ***APEC 2008,*** *February 28-28, Austin, Texas, USA, www.apec-conf.com*
- ***PCIM China 2008,*** *March 18 – 20, Shanghai, China, www.mesago.de/en/PCChinamain.htm*
- ***Productronica,*** *November 13-16, Munich, Germany, www.productronica.com*
- ***PCIM Europe 2008,*** *May 27-29, Nuremberg, Germany, www.pcim.de*

SynQor Completes its Product Offering for Railway and Transportation Applications

This new 36V Input Quarter Brick family complements SynQor's 24V, 72V & 110V devices already in place for this key industry

SynQor, a privately owned company headquartered in Massachusetts, US, has recently announced the release of its IQ36xxxQTA family of Isolated Quarter Brick DC/DC Converters. This new range is targeted predominantly at the Railway & Transportation industry, but products in this family will also suit a variety of other applications due to the ultra wide 4:1 input voltage range of 18-75V.

By adding this 36V nominal input device to the InQor™ family of Industrial DC/DC converters, SynQor now offers a complete suite of quarter brick products for Railway applications required to operate from a nominal 24V, 36V, 72V or 110V input. Each individual voltage range is designed to meet the respective input requirement of EN50155 including associated transients.

The industry standard footprint and pin-out of this product offers up to 120W of power in the following single output configurations - 1.8V/40A; 3.3V/30A; 5V/24A; 7V/17A; 12V/10A; 15V/8A; 24V/5A; 30V/4A and 48V/2.5A. With a wide trim range of +10%/-20%, several other voltages can easily be achieved ranging from 1.45V to 53V. Basic grade isolation from input to output of 2250Vdc offers the flexibility of choosing either a positive or negative output, as well as being able to connect the outputs in series to achieve higher voltages.

The devices are available in one of three mechanical configurations - open frame for convection-cooled applications; with an attached baseplate for conduction-cooled applications; and fully encapsulated for harsh environment applications. The encapsulated option brings the additional benefit of having reinforced-grade isolation from input to output.

Calculated MTBF figures of the IQ36-QTA series are in excess of 2MHrs, and all units are fully 6/6 RoHS compliant. Further control and protection features include remote sense, input under-voltage lockout, output OVP, current limit, short circuit protection, and thermal shutdown. Operating temperature range is -40 to +100°C.

Sample and production quantities are available immediately with a stock to 8-week lead-time.

Equally significant is SynQor's very successful entry into the military, medical and industrial market segments with the company's MilQor, InQor and AcuQor (AC/DC) product lines. These new technology leading DC/DC and AC/DC product lines have enabled customers to realize vast savings in space, weight and overall system costs while dramatically increasing power densities and end system performance. Just as important is the service and support advantage SynQor has put in place for their customers in these market segments.

SynQor has a power design center in Dallas Texas, with sales and marketing offices in Europe, Singapore, Korea, China and Japan. More information is available on the company's website.

www.synqor.com

We live in Interesting Times

By Peter Sontheimer, Director Marketing & Development for industrial products, Tyco Electronics Power Systems

Granted, advancing climate change, as well politicians' response and consumers' growing awareness of the problem, will bring major changes to society; changes that will affect us all. But this is precisely what makes the times we live in so exciting. The greatest challenge we face today is how to reconcile opposite interests. How we can satisfy our fundamental needs for unlimited mobility and boundless communication, yet preserve and protect rather than exploit the planet's resources, leaving the legacy of a hospitable world to coming generations? The market for power electronics plays a decisive role in rising to this challenge.

At Tyco, our environmental, health & safety policies and procedures are laid out extremely clearly. We, and our subsidiaries, affiliates, and operating units are committed to protecting our staff as well as protecting the environment. We are committed to providing a safe working environment for all our people, independent contractors, vendors, and customers and we operate our facilities in a way that prevents harm to the wider public health and the environment. We strive ceaselessly to conserve energy, water and raw materials in our production facilities and use recycling to reduce waste wherever appropriate. As any responsible company should, we do our utmost to be respected in our communities by insuring that our facilities do not pose environmental risks. The whole company designs its products in a manner that does its very best to eliminate unreasonable risks from the manufacture, usage and even the eventual disposal of the products.

In the automotive sector, there are many proposals on the table for moving a car from point A to point B. The proposal's real-world feasibility and the vehicle's price will decide the future of passenger transport. Today's passenger vehicles yield considerable tax income based on fuel consumption.

Future alternatives would seem to grow more attractive as their costs dip below today's price of gas and automobile diesel. However, much of this appeal is owed to tax breaks. If public demand for an alternative fuel grows strongly, the state will be compelled to levy higher taxes on this fuel to protect government income.

Hydrogen is not deployable today and will hardly be so for some time to come. This is due to the nature of hydrogen as an energy carrier and the problem of how to generate this energy. Infrastructural problems pose further obstacles. And finally, the issue of saving and storing this energy will have to be resolved before high-volume production of hydrogen-powered vehicles can begin.

When discussing the use of biofuel, one would be entirely justified in asking if large-scale cultivation of biofuel plants is the smartest approach to tackling the problem of global warming. The risks are certainly considered to be great. Efforts must be redoubled to utilize plants fully and tap all their energy potential.

Vehicle drives that support a combustion engine (hybrid engines) or fully electric drives, in turn, pose other questions. Their superior driving dynamics and savings potential with respect to fossil fuel consumption and CO_2 emissions are out of the question, but concerns over supply chains are well-founded. To what extent and how soon purely battery-powered vehicles will gain currency is a question mainly of how quickly engineers are able to develop new battery technologies with greater charging capacities. Li ions and Li polymer technologies look very promising today. One issue meriting discussion is energy storage in an HEV (hybrid electric vehicle) or BEV (battery electric vehicle). Another one is the investment required to enable silicon production and particularly to supply special engineered materials such as magnets for electric motors and metals for sophisticated cooling systems. These issues are relevant to other markets and have been discussed in that context, but not in any scope comparable to this. If various experts' forecasts prove even remotely reliable, new factories will have to be built. It almost appears as if the solution to the individual problems hinges on obtaining the necessary financial resources, and demonstrating the necessary entrepreneurial courage. But that's just they way it is in an exciting and interesting era and world. I am confident that this courage can be found.

www.tycoelectronics.com

China Driving Toward Automotive Opportunities

The rise in China's automotive semiconductor supply will change the competitive landscape

By Marijana Vukicevic, iSuppli Corporation

China's vehicle market is small but with huge potential for growth has companies flocking to get a piece of the market. China's vehicle production is forecast to surpass Japan's by 2010 to become the world's second largest automobile manufacturer, however, China's automotive semiconductor market remains relatively small at the moment. But the potential for growth during the next several years is tremendous as the country becomes one of the leading automotive centers in the world.

In 2006, China's total automotive semiconductor consumption for domestic electronic systems is estimated to reach $1.5 billion. Only 45 percent of this is sourced within China. Furthermore, only about 40 percent of this figure is generated from domestic designs—the rest using foreign designs.

However, China's share of design activities will improve quickly sometime in 2008. This turnaround is being encouraged by favorable Chinese government policies on capital investment as well as tax incentives.

Domestic designs will spread from automotive entertainment to navigation, body and security systems, and finally to other control systems. iSuppli Corp. forecasts that China's domestic automotive electronic equipment design activities will reach 6.1 billion in 2011 or 33 percent of China's total production value in 2006. This is up from $2.45 billion or only 24 percent of total production value in 2006. In 2006, China's domestic entertainment designs will account for more than 60 percent of total production value. Power train, chassis and safety systems will experience the largest growth rates. The opportunities for the domestic design work are in automotive audio and video. Navigation, body electronics, airbags, Anti-lock Braking Systems (ABS) and Engine Control Units (ECUs) will also be a source of much of this automotive design activity.

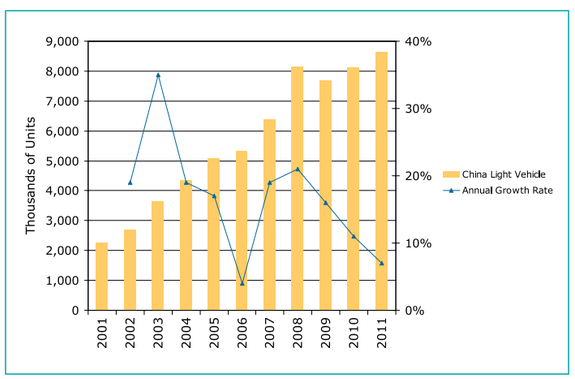


Figure 1. China's light vehicle production forecast from 2006 to 2011.

iSuppli predicts that China's light vehicle electronic content will rise from $1,059 on average per vehicle in 2006 to $1,359 in 2011. Electronic content for cars will increase from $1,243 to $1,488 over the same period. The Top 5 automotive electronic systems by value are: airbags, Transmission Control Units (TCUs), engine control units, electric HVAC and ABS systems.

Domestic demand fluctuations greatly impact automotive electronic systems manufacturing and design in China—especially in the face of the future market potential. The five electronic systems listed previously generate the largest demand and will likely attract more manufacturer and designer involvement. This is good news for foreign design companies who are looking to penetrate the Chinese market with power semiconductors. The most likely effect on the market will be price erosion for some of these semiconductor products driving down the costs of the overall systems Figure 1 shows iSuppli's light vehicle production forecast for China from 2001 to 2011.

Marijana Vukicevic is the senior analyst for power management at iSuppli Corp., based in El Segundo, California

www.isuppli.com

Is Your Input Filter Causing Trouble?

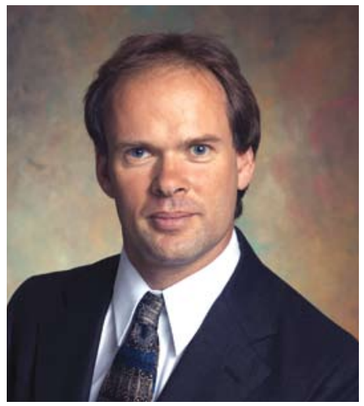
This month's article comes with a free giveaway to help you with your power supply design process. Whether you are designing complete PWM converters from scratch, working with modular power supplies, or something in between, you will be faced with input filter design issues. Once you have read this article, you can download the free program InputFilter.xls to analyze your input filter design quickly and easily.

By Dr. Ray Ridley, Ridley Engineering

A perpetual problem in designing switching power supplies lies with the input filter. Modern power electronics started with this issue when the very first switching power supplies were built. It was discovered that adding an input filter can make a previously stable system unstable. Much has been written about this in the past, and the reader is encouraged to look at the literature available, starting with reference [1].

With modern dc-dc converters available in either fully packaged form, or as integrated controllers, many new engineers are placing power supplies on a board. The input filter interaction issue continues to plague many designs, especially for engineers who are not familiar with proper design guidelines.

Power supply input filters are used to attenuate switching power supply noise, and to prevent corruption of the input line. If you are designing to meet



stringent emissions standards, at least a two-stage filter is needed to attenuate the noise to an acceptable level. If you are designing for board-mount power, and switching substantial currents, at least an LC filter is advised to prevent noise problems on the board.

Figure 1 shows a typical two-stage filter configuration. Two different capacitors are shown on the output of the filter. One provides bulk energy storage, and one provides low impedance at high frequencies.

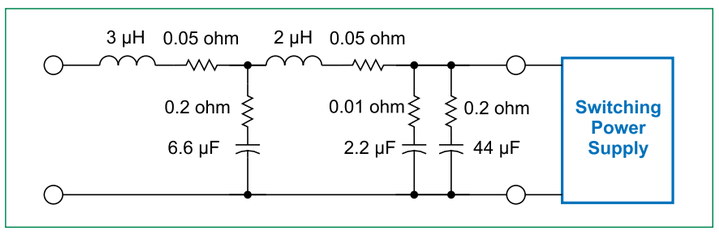


Figure 1: Input filter with five reactive elements.

Input Filter Attenuation

An input filter works in two ways. First, it attenuates noise from the input source to the output of the filter. In this direction, it can be viewed as a voltage filter, and the transfer function is expressed as the voltage ratio from V_{in} to V_{out}.

Then, to attenuate the power supply noise, the filter acts as a current filter. The input of the power supply is a switching current, which drives the filter. The transfer function is from the current at the right of the filter to the current at the left of the filter, assuming the input is short circuited (a voltage source.)

In either case, the attenuation is the same. Figure 2 shows the attenuation for the example filter values of Figure 1.

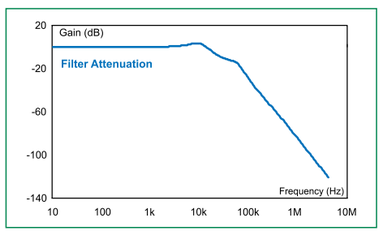


Figure 2: Input filter attenuation.

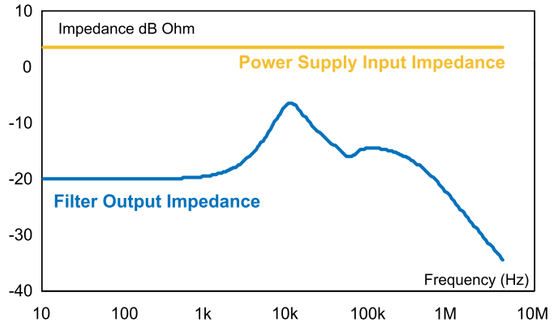


Figure 3: Input filter output impedance.

You will need to measure the noise spectrum before the filter is added to determine how much attenuation is needed to meet your system requirements.

Input Filter Output Impedance

The first requirement of the design is filter attenuation to meet noise specifications. The second requirement is to produce a filter that has low output impedance. This output impedance must be lower than the input impedance of the power supply. If the filter output impedance exceeds the negative input impedance of the power supply, the system typically becomes unstable.

Figure 3 shows the output impedance of the input filter plotted versus the input impedance of a sample switching power supply. It is essential to plot this curve for any design that you do, to be certain that your system will be stable.

How do you achieve low impedance? The general rule is to use large capacitors and smaller inductors. Damping must also be included in the filter. This is provided by the series resistances of the inductors, and the ESR of the filter capacitors. Unfortunately, the series resistor in the inductor causes loss, and a high ESR in the capacitor degrades the filter attenuation.

Modern multilayer ceramic capacitors have extremely low ESRs. The filters will be very undamped if these are the only components uses. Experienced power designers will use a combination of different capacitor types to provide the needed filter functions of attenuation, low impedance, and low-loss damping. They will combine high value electrolytics with damping ESRs, and MLCs for bypassing.

Input Filter Design Program

The free downloadable program can assist experienced designers as well as those who are not mainstream designers or power specialists. It is easy to use, and is available on the Switching Power Magazine website (www.switchingpowermagazine.com). Once you have registered, go to the download section of the website to retrieve the program InputFilter.xls.

Figure 4 shows the design screen of the program. Simply enter your power supply specifications of input and output voltage and power, and then the filter elements. The program allows for a 5th order filter. You build a simpler filter by setting any of the components you don't want to use to zero.

As you enter the elements, the curves of attenuation and impedance will immediately show the performance of your design. The analytical solutions of attenuation and impedance of the 5th order system are used within the program to provide these curves.

You can certainly use any version of Spice to do the same task, and this can be useful if your filter becomes more complicated. However, you will find that the speed of the Excel approach, and its ease-of-use allows you to design much more rapidly, and without the simulation errors that can occur when working with Spice.

Additional Reading

[1] "The Evolution of Power Electronics", http://www.switchingpowermagazine.com/downloads/Evolution of Power Electronics.pdf

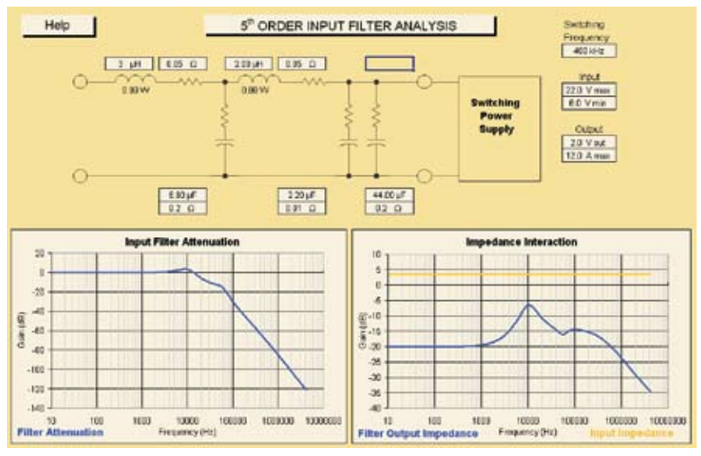


Figure 4: Input filter design program.

Current Monitoring is Key to Improved Efficiency and Safety in Automotive Applications

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

I had the opportunity recently of interviewing Charles Cordonnier, LEM's Business Development Manager for Automotive. I knew LEM mainly from their reputation and success in the industrial market and more recently, the white goods area. I was curious to find out what they offered for automotive, their vision of the future and indeed, the level of success they had already achieved.

With the growing emphasis on power control in automotive applications, where do you see the industry, from LEM's perspective, heading?

There is a demand for ever-greater energy efficiency in road vehicles of all types. In conventional systems, it is important only to provide charge to the battery only when it is needed. Even more importantly, in emerging hybrid systems, it is necessary to know the state of charge of the large battery pack that is receiving charge from the combustion engine or from the braking mode and then driving the electric motor. There is also a growing need for additional safety features, such as battery auto-disconnect. For LEM this presents a great opportunity with their ASICs such as developed for LEM's Minisens current sensors. Automotive often benefits from products originally developed for industrial applications. Fuel cells are a good example.

The 'old' auto industry requirements were quite modest. What do you see as emerging needs? Automotive specification requirements have always been very demanding for the power industry. How do you see LEM meeting these needs?

These demands have led in turn to a much greater requirement for reliable, accurate measurement of currents at a number of places within vehicle electrical systems. LEM's many decades of experience in the development of Hall-effect current sensors for industrial applications has enabled it to build on its technologies to produce transducers for use in emerging automotive systems. For example, current measurement techniques used in passenger and goods lifts can be applied to applications in hybrid vehicles. Hall-effect sensors can offer a rugged and high accuracy performance coupled with failure rates in accordance with the automotive requirements (less than 1 ppm). LEM is well known for its commitment to industry and has earned for itself the image of a world leader in transducers with a sales network close to its customers to constantly monitor their needs.

Is this a new area for LEM? Where do you see your other main strengths in this industry?

Today, LEM already offers current sensors based on Hall-effect open-loop, closed-loop and also with fluxgate technologies where very low level current monitoring (from 2mA to 1A) are required. Closed-loop devices are principally used in industrial applications, but both open-loop and fluxgate devices can offer accuracy at low cost in a range of automotive applications. We are best in class from very low to very high current monitoring.

In general, "Battery Management" automotive applications require current measurements in three different ranges: low for battery leakage, normal for operating and high for cranking (starting). LEM's sensors can offer a choice of measurement ranges between 2mA and 2000A, and can operate reliably in harsh automotive environments. They offer voltage or pulse-width modulation (PWM) outputs. Another option is an output compatible with the well-known LIN bus. All LEM sensors use non-intrusive technology with large apertures, so that they may be attached to a cable without the need to remove terminations, which is not the case with conventional shunt techniques. This provides the customer with much more versatility in both the application and manufacturing of their product. LEM is now developing sensors that integrate a number of additional

measurement functions, including voltage and temperature. This approach can offer many advantages in the monitoring of the overall state of battery health.

LEM provides a versatile approach offering different housings which enables the sensor to be connected on a simple battery cable (type HAB and DHAB), on a rectangular bus bar (HAH1BV) and also with connections onto printed circuit boards with rectangular or circular bus bars (HC2, HC6). In today's hybrid vehicles, there are basically two types of applications in which current measurement is important. The first of these is battery monitoring, which is defined by a slowly changing signal at relatively low currents. The second is current measurement to enable accurate control of the motor-control inverter. In this application, what is needed is a very fast response time sensor capable of measuring currents of up to 2000A in a few microseconds, so that an IGBT module can be switched in 10 microseconds or less. This measurement must also be accurate to within 1 or 2 percent. Recent developments have made this level of performance possible, but even more responsive sensors are already on the horizon.

Are you already engaged with automotive customers?

Yes, certainly. We are working with very significant auto customers in Korea and Japan. The arrival of hybrid vehicles means that many systems now have to be electrically powered and controlled. Brake-by-wire and Steer-by-Wire systems require measurements of currents somewhat lower than motor control (between 100 and 400A), but still require precision of 1 or 2 percent and a response time of 10 microseconds or less.

Why did they choose you?

LEM is extremely well qualified for delivering this level of performance and extreme safety. Additionally, similar measurements are needed for auxiliary systems, such as electric air-conditioning compressors.

Also, as vehicle energy efficiency becomes more and more important for performance and environmental reasons, it will become essential to monitor currents in many more parts of the system. Hall-effect technology, with its benefits of rapid response times, reliability and versatility, is the best solution for almost all these applications and LEM excels here.

www.lem.com

Power ICs Designed to Thrive in Caustic Automotive Environment

Extreme conditions require supreme products

Power devices for automotive can be subjected to load-dump, cold-crank and high ambient temperatures. Some of these systems operate in an always-on standby mode requiring minimal supply current. Add to this, the space constraints and you have a unique design scenario.

By Jeff Gruetter, Product Marketing Engineer, Linear Technology Corporation

Each year automobiles continue to incorporate increasingly complex electronic systems to maximize comfort, safety and performance while minimizing harmful emissions. Strategy Analytics, a market research firm, offers an interesting perspective: Today, electronic systems account for more than 22% of a typical car's cost, but that figure will jump to more than 33% by 2009. Examples of these electronic systems are infotainment systems (telematics), safety systems, engine management, satellite Radio and TV, LED lighting, Bluetooth and other wireless systems and rear view cameras. Five years ago, these systems were only found in "high-end" European luxury cars but now they are now being integrated into midrange automobiles from every manufacturer, accelerating automotive IC gat even a faster rate.

A key driver for electronics applications is engine control management. Each year, worldwide emissions standards get stricter while gas mileage requirements increase, yet customers demand even higher performance. Once mutually exclusive requirements, the adoption of "smart" engine control systems, a myriad of sensors and several DSPs enable car manufactures to attain higher levels of engine efficiency with cleaner running engines. Electronic systems are making similar revolutions in safety, climate control, lighting, navigation, wireless connectivity as well as chassis control

Table 1: High Voltage, Low Quiescent Current Switching Regulators from Linear Technology.

Part No	Device Architecture	V_{IN} Range	I_{OUT} (A)	Frequency	I_Q	Package
LT3437	Step-Down Regulator	3.3V to 80V	0.40	200kHz	100µA	DFN-10
LT3433	Buck-Boost Regulator	4V to 60V	0.40	200kHZ	100µA	TSSOP-16E
LT1976/7	Step-Down Regulator	3.3V to 60V	1.25	200/500kHZ	100µA	TSSOP-16E
LT3480	Step-Down Regulator	3.6 to 38V, $60V_{MAX}$	2.00	200kHz to 2.4MHz	70µA	3x3 DFN-10, MSOP-10E
LT3481	Step-Down Regulator	3.6 to 34V, $36V_{MAX}$	2.00	300kHz to 2.8MHz	50µA	3x3 DFN-10, MSOP-10E
LT3681	Step-Down Regulator	3.6 to 34V, $36V_{MAX}$	2.00	300kHz to 2.8MHz	50µA	3x4 DFN-14
LT3434/5	Step-Down Regulator	3.3V to 60V	2.50	200/500kHZ	100µA	TSSOP-16E
LT3680	Step-Down Regulator	3.6V to 36V	3.50	200kHz to 2.4MHz	75µA	3x3 DFN-10, MSOP-10E

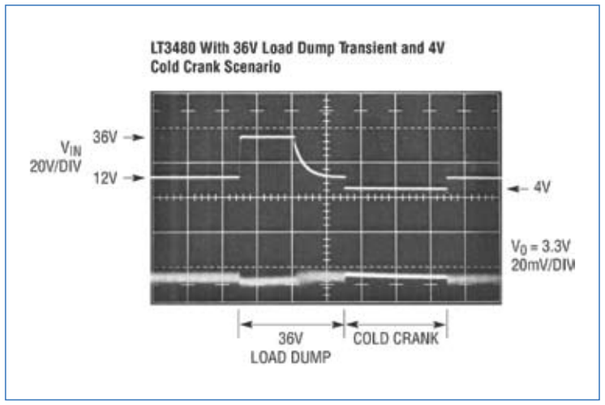


Figure 1: 36V Load Dump & Cold Crank Conditions.

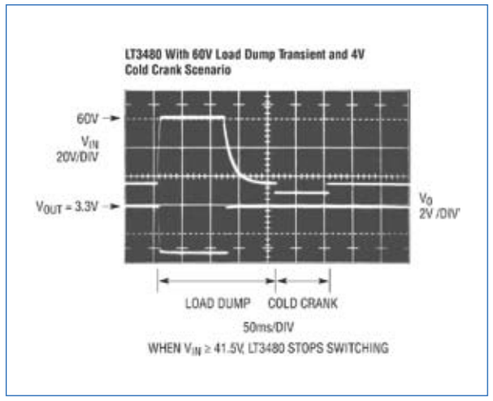


Figure 2: 60V Load Dump & Cold Crank Conditions.

systems. Collectively, these new systems improve safety, performance and comfort for the driver and help to provide a cleaner environment for all of us.

As the electronic component count in these automotive systems increases, the available space requirements continue to shrink, greatly increasing the electronic density of each system. All of these systems require power conversion ICs, usually with multiple voltage rails for each subsystem. Traditionally, linear regulators provided the majority of these power conversion needs as efficiency and small size were not of primary importance. But as the power density has increased by an order of magnitude, and many applications require relatively high ambient temperature operation, any practical heat sinking is too large to be accommodated. Thus power conversion efficiency has become critical due these space and operating-temperature-range constraints. At low output voltages and even with moderate current levels above a few hundred milliamps, it is no longer practical to simply use a linear regulator to generate these voltages because they generate too much heat. As a result of these thermal constraints, switching regulators are starting to replace linear regulators. The benefits of a switching regulator, including the increased efficiency and smaller footprint, outweigh the additional design complexity and EMI considerations.

"Always-On" Systems Need Ultralow (I_Q<100uA) Supply Current

Many electronic subsystems are required to operate in "standby" or "keep alive" mode drawing minimal quiescent current while in this state. These circuits can be found in most navigation, safety, security, and engine management electronic power systems. Each of these subsystems can use several microprocessors and microcontrollers. Most luxury cars have between 60 and 100 of these DSPs onboard and 10% and 20% of these will operate in two different modes. First, when the car is running the power supplies that power these DSPs will generally operate at full current fed by the battery and charging system. However, when the car ignition is turned off, these microprocessors must remain "alive", requiring their power ICs to provide a constant voltage while drawing minimal current from the battery (<100uA). Since there can be upwards of 20 of these "always-on" processors required for the navigation, security, climate control and engine management systems, there is an significant power demand on the battery even when the ignition is turned off. Collectively, several hundreds of milliamps (mA) of supply current can be required to power these always-on processors, which could completely drain a battery in a matter of days. For example, if a car's high voltage step-down converters require 2-10mAs of supply current each, combining 20 of these from security systems, GPS systems and remote keyless entry systems with other mandatory always-on systems such as ABS brakes and leakage current from electronically actuated windows could drain a battery after an extended 2 to 3 week business trip, rendering it unable to crank over the engine. Quiescent current of these power supplies needs to be drastically reduced in order to preserve battery life without increasing the size or complexity of the electronic systems. Until recently, the requirement of high input voltage capability and low quiescent currents were mutually exclusive parameters for a DC/DC converter IC.

In order to better manage these requirements, several automotive manufacturers created a low quiescent current target of 100uA for each always-on DC/DC converter. Until recently, systems manufacturers were required to connect a low quiescent current, LDO in parallel with a step-down converter, and switch from this converter to a much lower current LDO each time the car was turned off. This created expensive, bulky and relatively inefficient solutions. Linear Technology's 36V to 60V input voltage capable, <100uA step-down DC/DC converter family can be seen in Table 1. For example, the LT3680 can deliver up to 3.5A of output current from input voltages as high as 36V with only 75uA of no load quiescent current. All this functionality comes packaged in either a leaded, thermally enhanced MSOP-10E package or a 3mm x 3mm DFN providing a much more compact and efficient solution to the always-on problem.

Electronic Challenges: Load Dump Condition & Cold Crank Conditions

"Load-Dump" is a condition where the battery cables are disconnected while

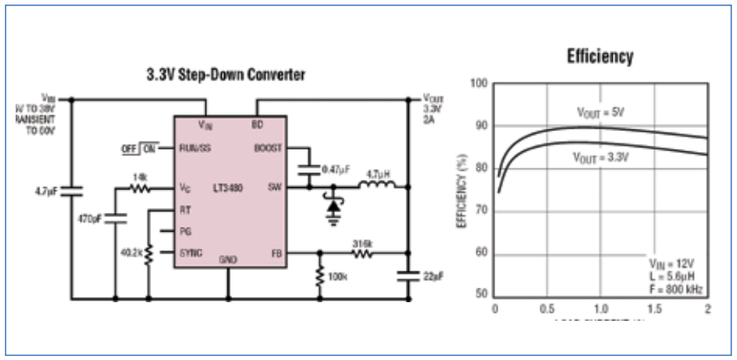


Figure 3: LT3480 Schematic & Efficiency Graph.

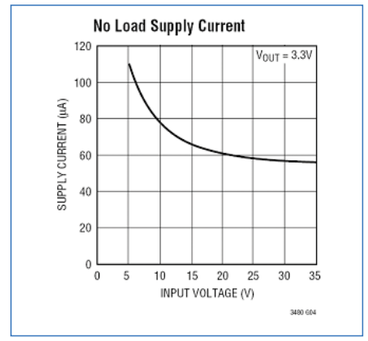


Figure 4: LT3480 No Load Quiescent Current vs. Input Voltage.

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 60V as the alternator is attempting a full-charge of an absent battery; see Figure 1 and Figure 2 for graphical representations of these 36V and 60V transients. Transorbs on the alternator usually clamp the bus voltage somewhere between 36V and 60V and absorb the majority of the surge; however DC/DC converters down stream of the alternator are subjected to these 36V to 60V transient voltage spikes. These converters are expected to survive, and in some instances regulate an output voltage through this transient event; it is critical that they are capable of dealing with these high voltage transients. There are various alternative protection circuits, usually transorbs, which could be implemented externally; however, they add cost and 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 (see Figure1). It is imperative for some applications such as engine control, safety and navigation systems to require a well-regulated output voltage (usually 3.3V) through a cold crank scenario, so as to continually operate.

Solutions are Available

Depending on output current and the level of transient protection required, Linear Technology has several switching regulators that can operate through both cold crank and load dump scenarios and require less than 100uA of quiescent current (see table 1). One example is the LT3480, a 2A, 38V step-down switching regulator with input transient protection up to 60V. Its Burst Mode® operation keeps quiescent current under 70uA in no load standby conditions.

The LT3480's 3.6V to 38V input voltage range and 60V transient protection make it ideal for load dump and cold-crank conditions found in automotive applications. In figure 1, the LT3480 will regulate a 3.3V output thru the 36V transient. In figure 2, the LT3480 actually shuts itself down above 41.5V, to protect itself and circuitry down stream. When the transient drops below 38V, the LT3480 will go back into regulation.

Its 3A internal switch can deliver up to 2A of continuous output current to voltages as low as 0.79V. It requires minimal externals and can deliver efficiencies as high as 90% (see Figure 3). The LT3480's Burst Mode operation offers no load quiescent current of only 70µA (see Figure 4), which is well suited for applications such as automotive or telecom systems, which demand always-on operation and optimum battery life. Switching frequency is user programmable from 200kHz to 2.4MHz enabling the designer to optimize efficiency while avoiding critical noise-sensitive frequency bands. The combination of its 3mm x 3mm DFN-10 package (or thermally enhanced MSOP-10E) and high switching frequency keeps external inductors and capacitors small, providing a very compact, thermally efficient footprint.

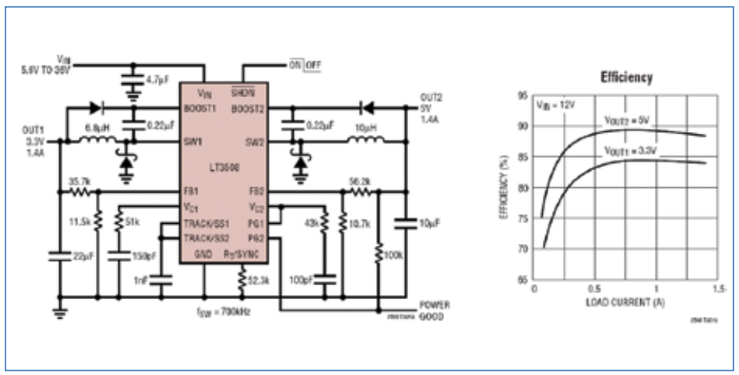


Figure 5: LT3508 $12V_{IN}$ (Nominal) & $5V_{OUT}$ & $3.3V_{OUT}$ & Resultant Efficiency.

Table 2: H Grade Power Regulators.

Part Number	V_{IN} Range	Output Current	Topology	$T_{J(MAX)}$ C	Package
LT3010H/-5	3V to 80V	50mA	LDO	140	MSOP-8E
LT3012/3H	4V to 80V	250mA	LDO	150	DFN-12
LT3470H	**4V to 40V**	**300mA**	**Buck Converter**	**150**	**2x3 DFN-8**
LT3437H	**3.3V to 60V, 80V Transients**	**500mA**	**Buck Converter**	**140**	**3x3 DFN-10, TSSOP-16E**
LT1933H	**3.6V to 36V**	**600mA**	**Buck Converter**	**150**	**2x3 DFN-6**
LT1766H	**5.5V to 60V**	**1.25A**	**Buck Converter**	**140**	**TSSOP-16E**
LT1976H	**3.3V to 60V**	**1.25A**	**Buck Converter**	**140**	**TSSOP-16E**
LT1936H	**3.6V to 36V**	**1.4A**	**Buck Converter**	**150**	**MSOP-8E**
LT3508	**3.7V to 36V**	**2x 1.4A**	**Dual Buck Converter**	**140**	**4x4 QFN-24, TSSOP-16E**
LTC3803H-5	6V to 72V	3A	FlyBack Controller	150	ThinSOT
LTC1772H	2.5V to 9.8V	5A	Buck Controller	140	ThinSOT
LTC1871H	2.5V to 36V	10A	FlyBack Controller	150	MSOP-10
LTC3731H	4.5V to 36V	60A	Sync Buck Controller	140	SSOP-36

The LT3480 utilizes a high efficiency 3.A, 0.25 Ohm switch, with the necessary boost diode, oscillator, control and logic circuitry integrated into a single die. Low ripple Burst Mode operation maintains high efficiency at low output currents while keeping output ripple below $15mV_{PK-PK}$. Special design techniques and a new high voltage process enable high efficiency over a wide input voltage range while its current mode topology enables fast transient response and excellent loop stability. Other features include external synchronization (from 250kHz to 2MHz), a power good flag and soft-start capability.

Thermal Challenges in an Automotive Environment

In addition to the caustic electrical environment in automotive applications, the thermal environment can be equally challenging. As more electronics share the same prime real estate in cars, thermal management becomes critical. Under-the-hood applications typically require ambient operating temperatures of 125°C, or higher, while prime electronics real estate such as the navigation/infotainment systems experience thermal challenges as they are both close to the cars firewall with high ambient temperatures and have a very high density of electronics. All electronics dissipate some amount of electrical power as heat. The key in managing heat generation in power converters starts with maximizing each converter's efficiency thereby minimizing the power lost as heat. This has been one of the driving forces in replacing LDOs with switching regulators in the past few years.

In addition to any given devices efficiency, it is also important that each power conversion device have a very thermally efficient package to effectively conduct heat away from the IC. Linear Technology achieves this by packaging automotive parts in the most thermally efficient packages available. Leadless packages, such as DFNs as well as MSOP and TSSOP packages all use thermally enhanced designs which incorporate a thermal pad on the bottom of the package to reduce thermal resistance by more than a factor of 2 over conventional packages.

In order to meet the most demanding high temperature applications, such as under-the-hood applications, Linear Technology offers a family of "H" Grade converters which can operate with junction temperatures of either 140°C or 150°C depending on the part (see Table 2). A comprehensive table of these can be found in Table 3 below. Conversion topologies include LDOs, high voltage monolithic switching regulators and controllers.

Consider an application running from a nominal 12V and regulating a 5V, 1.5A output. An LDO would offer only 41% efficiency, dissipating 10.5W of wasted power which requires a substantial heat sink to prevent thermal failure at even 80°C. Conversely, a switching regulator such as the LT3508 found in figure 5 would operate at 89% efficiency dissipating only 0.8W externally. With a $Theta_{JA}$ of 40°C/W of its TSSOP-16E package; this would represent a 32°C temperature rise. This enables a 93°C ambient temperature for an industrial grade device (125°C) and a 108°C ambient temperature for an "H" Grade rated device.

Conclusion

The rapid growth of very specialized electronic subsystems in automobiles has created stringent performance requirements for power ICs in automotive applications. Depending on where the power supplies operate on the automotive power bus, they may be subjected to load-dump and cold-crank conditions as well as high ambient temperatures. Additionally, some of these systems will operate in an always-on standby mode requiring minimal supply current. As more electronic systems are added to each vehicle, minimizing the solution footprint while maximizing thermal efficiency is also critical. Fortunately some power IC designers have created solutions to meet these requirements, paving the way for even higher electronic content in future cars.

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Full Metal TIMs Take Out the Heat

Metal thermal interface materials offer highest thermal conductivity

Metal thermal interface materials (TIMs) serve as ideal thermal solutions in critical heat flow situations. The high thermal conductivity of metals and alloys, and their ease of fabrication, dominate thermal management applications in heat sinks, spreaders and heat pipes.

By R.N. Jarrett/J.P. Ross Indium Corporation

The characteristically high electrical and thermal conductivity of metal is due to the free electrons. These free electrons readily conduct heat, as well as electricity, between the joints. It is interesting to note that the metals with the highest electrical conductivity (Cu, Ag, Au, Al) also have the highest thermal conductivity (see Table 1).

The thermal conductivities of metals and alloys are isotropic providing both good spreading- and through-conduction paths for dissipating heat from local hot spots. In contrast, ceramics, plastics, semi-conductors, salts, etc., metals and alloys transfer a substantial portion of thermal energy by electronic vibration (electron-phonon interaction). The interfaces between polymers and metals or polymers and ceramics have conducting capability limited to matrix vibration only. This phenomenon is referred to phonon mismatch.

Table 1: Thermal Conductivity of Selected Materials.

Material		Thermal Conductivity @85°C (W/m· K)	Electrical Conductivity (% AICS @1.72 µohm·cm)
Silver	Ag	429	108.6
Copper	Cu	396	100
Gold	Au	318	73.4
Aluminum	Al	240	65.9
Indium	In	86	24.0
Tin	Sn	73	15.6
Gallium	Ga	41	12.3
Lead	Pb	35	7.9
Bismuth	Bi	8.0	1.3
Phase Change Materials		3 - 8	
Thermal Grease		0.75 - 6	
Ag - Filled Die Attach		1.3 - 5	
Molding Compounds		0.6 - 0.7	
BT Epoxy		0.19	
FR - 4		0.11	

Despite filling polymeric greases, adhesives and fluids with highly conductive materials such as silver flake, diamond particles, and carbon nanotubes (with conductivities of ~400, 2400 and up to 10,000 W/m•K), the resulting composites have bulk thermal conductivities of less than 10 W/m•K. This means the heat transfer from the wetting agent (polymer) to the conducting solid is limited.

The downside of free electrons in metals is their affinity to elements like oxygen and sulfur. In noble metals (Au, Pt, Pd) oxygen will adhere to the surface of the metal but does not form a stable oxide. Less noble metals (Al, Ag, Ni, In, Sn) form passivating thin layers of tightly adhering oxide that limit further penetration of oxygen.

The key to achieving the benefits of the metal TIM is making intimate contact with the working surfaces. To achieve this bond, metals are used in four different forms — solder, liquid metals, phase change metals, and compressible metals. The interfacial barriers can be broken down by either fusing the metal to make liquid contact or applying pressure to make a solid contact. Solders, phase change metals, and liquid alloys rely on making contact in the liquid phase. The compressible metal TIM relies on pressure to plastically deform into intimate contact.

Solder TIM

Soldering is the common means for joining pieces of the thermal solution. In a typical laptop computer, the cooling fins and the contact plate are connected to the heat pipe by solder joints. The solder joint offers low thermal resistance and mechanical continuity for the heat path.

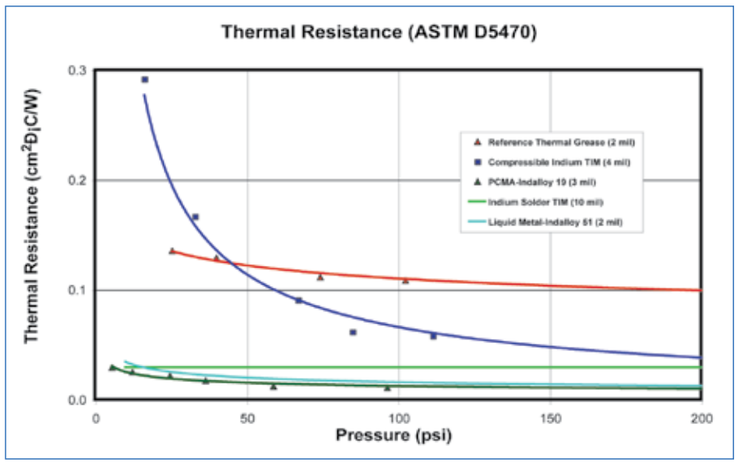

Figure 1: Thermal resistance of the various Metal Thermal Interface Materials as a function of clamping pressure and the corresponding plot of high-performance thermal grease.

Joining the heat sink to a silicon die requires metallization on the die to promote solder wetting of that surface. Typically, several layers of metal, such as titanium, vanadium and chromium, are applied to the backside of the die. An intermediate layer (for example, nickel, cobalt, or platinum) then bonds to both the solder and the base metal on the silicon. Finally, a protective flash-coating of gold or platinum is used to prevent the formation of an oxide layer on the intermediate layer.

In the soldering operation, the gold flash-coating is dissolved in the solder which enables the solder to bond to the nickel layer. The solder forms a thin layer of alloy with the nickel and remains metallurgically bonded after solidifying.

A die-attach solder joint is formed by melting a controlled volume of metal in the form of preform wire or paste. Fluxes are used to ensure that the metallurgical bond between the solder and the metal interface is made without the interference of an oxide layer.

The solder joint mechanically links the die to the heat sink. Due to the differential expansion of the copper (16.7 ppm/C) versus the die (3.2 ppm/C), large shear stresses can develop. A solder thermal joint must accommodate this CTE (coefficient of thermal expansion) mismatch by either internal yielding (like the soft solders) or transferring the stresses to other components that can flex. In practical applications, a thicker bond line is used for the solder joint to increase the compliance of the CTE mismatch.

Liquid Alloys

Several alloys of gallium are liquid at room temperature — the most common are gallium-indium eutectic and gallium-indium-tin. These gallium alloys are also non-toxic.

Liquid metals can be applied directly between the die and the heat spreader or heat sink, forming a very thin interface. The thermal contact formed with these alloys provides a fully wetted surface with minimum thermal resistance. As a liquid, the TIM conforms to any CTE mismatch.

To use these alloys in practical devices, a containment system should be used to prevent the metal from dislodging and shorting other electrical devices. This containment system also serves to minimize the exposure of the liquid alloy to oxidation. This is because the passivating oxide layers in the liquid alloys are constantly disrupted allowing oxidation of the newly exposed surfaces. This oxidation can degrade the thermal contact and limit the life the TIM.

Gallium is corrosive to most metals, especially aluminum. For that reason, elastomers, plastics and silicone components are the preferred materials for containing liquid alloys. Where metals are in contact with the liquid alloys, surfaces can be coated with chromium, tungsten or other refractory metals to counter the gallium reaction.

Figure 2: Liquid metal used as a TIM.

Table 2: Metal TIM Materials.

Indalloy Number	Melting Range (°C)	Elemental Composition (Percent by Mass)	Density (gm/cm³)	Thermal Conductivity @ 85°C (W/m·K)	Expansion Coefficient @ 20°C (ppm/°C)
		Solder TIM alloys			
281	138	58 Bi 42 Sn	8.56	19	15
290	143	97 In 3 Ag	7.38	73	22
4	157	100 In	7.31	86	29
227	175 -187	77.2 Sn 20 In 2.8 Ag	7.25	54	28
106	183	63 Sn 37 Pb	8.40	50	25
209	233	65 Sn 25 Ag 10 Sb	7.80	57	36
182	280	80 Au 20 Sn	14.51	57	16
164	300 -310	92.5 Pb 5 In 2.5 Ag	11.02	25	25
171	308 -312	95 Pb 5 Sn	11.06	23	30
183	356	88 Au 12 Ge	14.67	44	13
184	363	96.8 Au 3.24 Si	15.40	27	12
		Compressible TIM alloys			
1E	118	52 In 48 Sn	7.30	34	20
290	143	97 In 3 Ag	7.38	73	22
4	157	100 In	7.31	86	29
128	232	100 Sn	7.28	73	24
3	143 -237	90 In 10 Ag	7.54	67	15
		Liquid alloys			
46L	6.5 -7.6	61 Ga 25 In 13 Sn 1 Zn	6.50		
51	10.7	62.5 Ga 21.5 In 16 Sn	6.50		
60	15.7	75.5 Ga 24.5 In	6.35		
		Phase change metal alloys			
19	60	51 In 32.5 Bi 16.5 Sn	7.88		
18	61.5	61.7 In 30.8 Bi 7.5 Cd	8.02		
162	72	66.3 In 33.7 Bi	7.99		
25	77.5	48.5 Bi 41.5 In 10 Cd	8.49		
27	81	54 Bi 29.7 In 16.3 Sn	8.47		

Table 3: Summary of Metal TIMs Attributes.

	Solder	Compressible Metal	Phase Change Metal	Liquid Metal
High Thermal Conductivity	■	■	■	■
Clean Installation	■	■	■	
Dispensable				■
Mechanically Bonds	■			
Does not need reflow		■	■	■
Flux less		■	■	■
Re-workable		■	■	■
No Residue		■		
Resists Bake Out	■	■	■	■
Resists Pump Out	■	■	■	■
Available on Tape and Reel	■	■		
Available as a pre-attach	■	■	■	
Available in High Volumes	■	■	■	■
Available with an Adhesive		■	■	
Custom Packaging	■	■	■	■
Custom Shapes	■	■	■	

Phase Change Metal Alloys (PCMA)

Phase change metals are installed in the interface as a solid foil, similar to a gap-filler. The alloy melts, either during the first duty cycle or in a pre-heat as part of the assembly operations, permitting the alloy to flow over the IC (integrated circuit) surface and wet to it like a solder. Unlike the solders, the PCMA remelts during the normal operation of the IC, conducting heat like a liquid metal TIM. These alloys are also subject to oxidation degradation like liquid metal TIMs, requiring the surface of the foil to be isolated from the atmosphere to prevent oxidation.

Compressible Metal TIM

Soft metals can be compressed between the two surfaces of a thermal interface to create a TIM with very low resistance. Generally, this type of interface requires pressures of several hundred pounds per square inch or more to conform to the contact surfaces. With a room temperature tensile strength of only 270 psi (6 times softer than lead), indium metal and indium alloys are well suited to lower pressure applications.

It is important to note that when pressed against a rough surface, a metal TIM conforms to the highest (microscopic) peaks. The harder material mechanically embeds into the softer material resulting in intimate contact over that area. When the materials in contact are metals, the electrical and thermal contact is enhanced by the shared electrons. The plastic deformation exposes a fresh metal surface, resulting in a “metallurgical” bond over that region.

Summary

Metal Thermal Interface Materials offer substantially higher thermal conductivity than other commercially available TIMs. With this high conductivity, these metal TIMs offer the lowest thermal interface resistance, enabling design of higher power and smaller electronic devices. Additionally, the high conductivity translates to less sensitivity to bond line thicknesses and coplanarity issues than polymeric TIMs.

Metal TIMs are designed to form intimate contact with the interface surfaces by wetting (solders, liquid metals, and phase change metals) or by plastic deformation (compressible metal). The metal TIM can join the interfaces mechanically, provide conformance for gap filling, or remain as a fluid. With these options, metal TIM solutions are available in application configurations ranging from paste to preforms to dispensable liquid.

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Driving RGB Power LEDs

LCD backlight or architecture lighting

This article describers a four channel LED driver and 8 bit microcontroller to encode full color modulation of RGB power LED module.

By Ulrich Kirchenberger, STMicroelectronics Design & Application GmbH, Grasbrunn and Pavel Koutensky, STMicroelectronics, Prague

New high power and high brightness Red, Green, and Blue (RGB) LEDs are becoming used in many different lighting applications as Backlighting, Architectural Lighting and "Wall Washing", General lighting systems, Traffic signals, Automotive Mood lighting, Advertising, etc. They are becoming popular mainly because it is possible to generate easily multicolor light with special lighting effects and their brightness can be easily changed. Finally their mercury free composition, long lifetime "if temperature controlled and driven correctly", and their small size make them one of the most promising light sources of the future.

For simplification of understanding in this article High Power LEDs are considered to have a current of 350mA or higher and power levels equal above 1W. Due to human eye sensitivity on colors very often 2 green LEDs with 1 red LED and 1 blue LED are used to create a RGB color light source.

This leads to the requirement of a four channel LED driver. In the following a LED driver solution using the STP04CM596, a 4 channel linear current source with SPI interface, a microcontroller and a voltage pre-regulator is described.

Driving concept for RGB LEDs

LEDs render their nominal wavelength and color at a defined current value. Therefore an optimal drive of LEDs is provided by a current source. A continuous color spectrum within the color gamut can be achieved by mixing of colors. If RGB LEDs are used, all colors within the triangle built by the natural colors red, green, and blue can be created. The mixed colors are achieved by tuning the brightness of each color, which means each LED. Brightness modulation however is not achieved by linear variation of the current, which would also vary the color of each LED, but by PWM modulation of the current. In Figure 1 an application circuit using a 4 channel Power LED driver STP04CM596 with current sink and shift register and a ST7Lite09 microcontroller is shown. In the output stage of the Power LED driver, four regulated linear current sources provide 80-500mA constant current, adjusted by just one resistor for all channels. The LED supply voltage is connected to the anodes of the LEDs or LED strings (series connection of LEDs) and the cathodes of the LEDs or LED strings are connected to the open collector drivers that serve as current

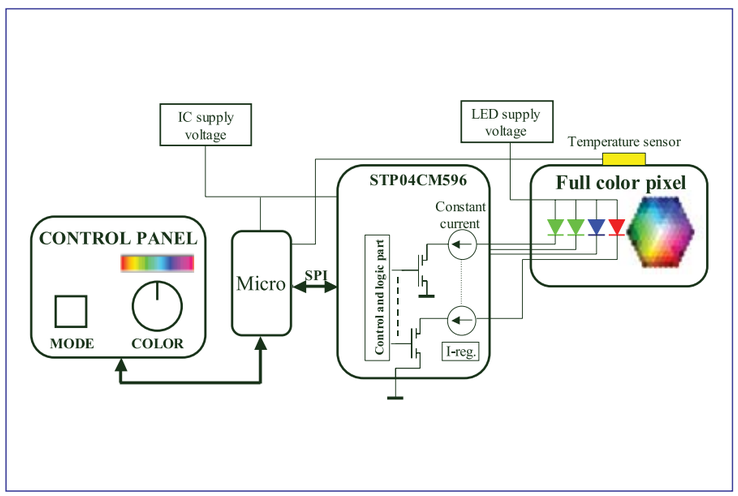

Figure 1: Driving concept for RGGB LEDs.

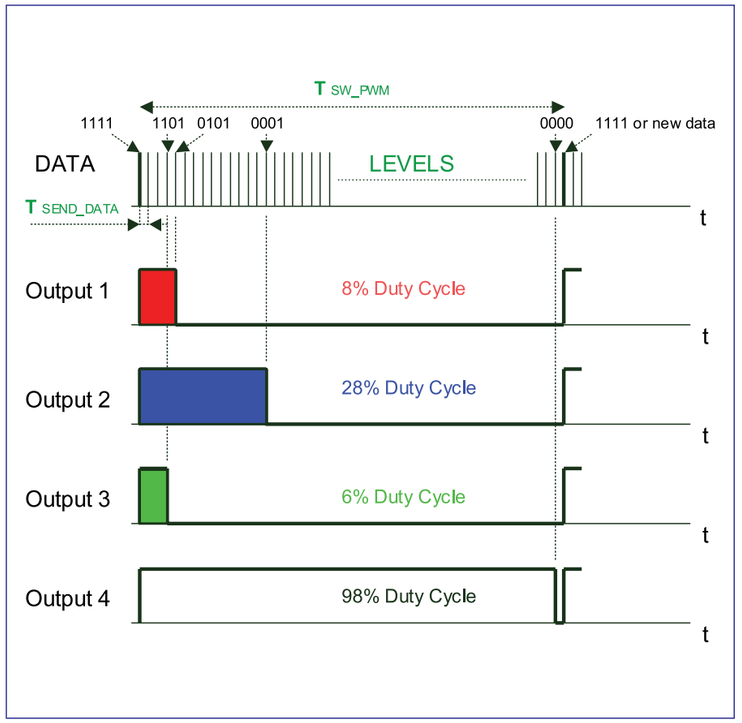

Figure 2: Color control by pulse width modulation.

source. The supply voltage value is very important in order to keep the dissipation in the linear current sources at a minimum. The LED supply is adjusted by an integrated switch mode DC/DC converter L4973D3.3 that delivers up to 3A and the voltage is selected to be the forward voltage of the LEDs plus the drop-out voltage, "typically 0.7V", of the constant current source.

Due to different technologies the forward voltage of Power LEDs is different depending on the color. If all LEDs are supplied by same supply voltage higher power dissipation will occur on the channel driving the lowest voltage drop (red or amber) LEDs. In order to keep the losses in the linear current source driver STP04CM596 minimal either different supply voltages are provided, not just one as shown in Fig.1, or a resistance is added in series to the LEDs which have the lowest voltage drop. The maximum number of LEDs in series in one string on one driver output of STP04CM596 is defined by the maximum voltage of the driver of 16V. In general this means up to 4 LEDs in series can be driven.

The control unit in this application is a microcontroller, which sends data through serial peripheral interface (SPI) or serial data interface (SDI) to the shift registers inside the STP04CM596. If more than 4 channels are required the drivers can be cascaded. The data are shifted bit by bit to the next driver in a cascade with falling edge of the clock frequency (the maximum communication frequency for this SPI interface is 25MHz). When all data are transmitted to the drivers through SPI, the micro sets the latch input terminal (LE) pin "log 1" to rewrite the data to the storage registers and to turn on or off the LEDs.

How to increase the driving current

Especially some new developments of Power LEDs require an operating current above 500mA, the current source capability of each channel of the STP04CM596. Due to the current source nature it is possible to parallel several channels of the driver in common drain configuration in order to achieve the required drive current. E.g. for the load of an OSTAR projection LED with 4 LEDs, each 700mA, 2 drivers STP04CM596 with total 8 channels can be used to drive the LEDs. Each 2 of the output channels are connected in parallel (2x350mA).

Power Dissipation

The maximum power dissipation acceptable for the LED driver can be calculated with ambient temperature and thermal resistance of the LED driver. The thermal resistance depends on the type of package and can be found together with the maximum junction temperature in the datasheet, e.g. the TSSOP16 with exposed pad has a low R_{thja} = 37.5°C/W. The maximum allowable power dissipation P_{dmax} without extra heatsink is calculated as follows:

$$P_{d\max} = \frac{T_{j\max} - T_a}{R_{thja}}$$

With

T_{jmax} the maximum Junction temperature and T_a the ambient temperature.

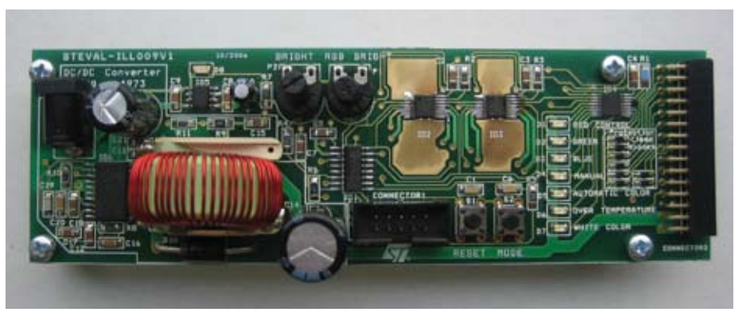

Figure 3: Demonstrator board STEVAL-ILL009V1.

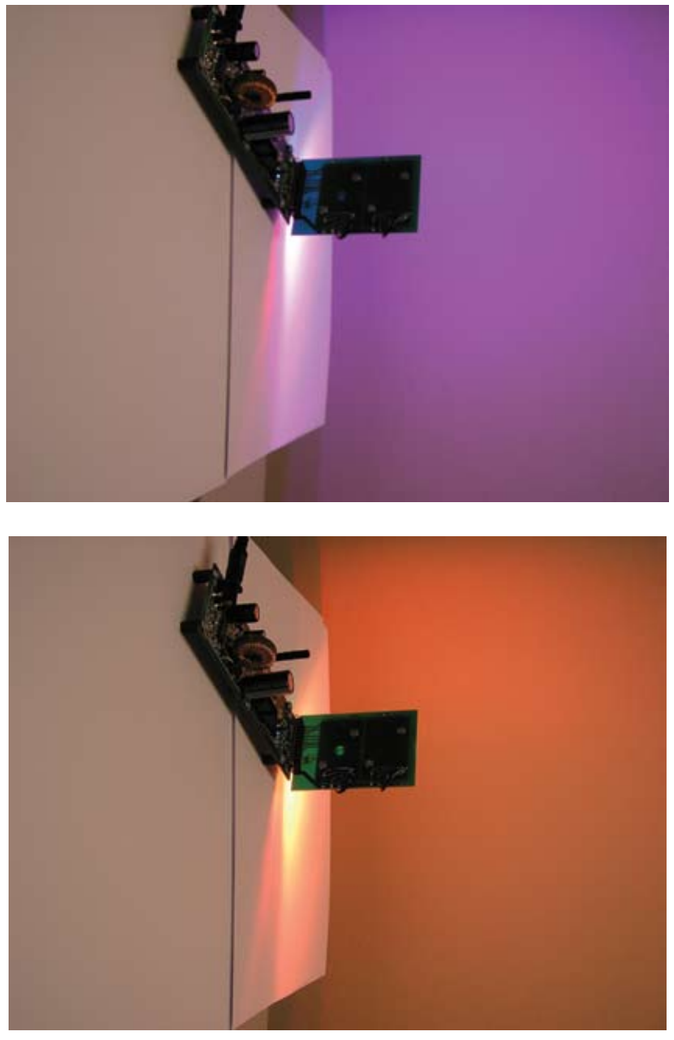

Figure 4: Generating different colors with RGB LEDs.

The voltage across the driver, which is the difference between the supply voltage V_C and the voltage drop on the LEDs V_{f_xxx} is important for the total losses P_{tot}. V_C is adjusted by the DC/DC converter. For example with RGGB LEDs:

$$P_{tot} = I * \left(V_C - V_{f\_RED}\right) + I * \left(V_C - V_{f\_BLUE}\right) + 2 * I \left(V_C - V_{f\_GREEN}\right)$$

Where:
I is the constant LED current.
To maintain the maximum junction temperature
$P_{tot} < P_{dmax}$
has to be ensured by design.

Color Control

The most important feature for the user is the flexible color setting. Already in the introduction it has been highlighted that an almost infinite number of color variants can be set by mixing the basic colors RGB. In Fig. 2 it is shown how the brightness of each basic colors is set by a string of data sent on the SPI interface.

Depending on the number of LEDs to be driven, the PWM frequency required and the SPI frequency, the PWM resolution and thereby the color resolution can be determined.

With the ST7Lite09, a small 8-bit micro, a SPI frequency of only 2MHz and 8 channels, a resolution of 256 levels per channel can be reached. In this assumption, more than the 90% of CPU power is used for supervision and calculation of lighting modes.

In Fig. 3 a demonstrator board (15cm x 4.8cm) is shown, that incorporates all functions described above: DC/DC converter for an input voltage of 8 to 30V, 2 Drivers STP04CM596 for 8 LED channels, ST7Flite09 and some status LEDs to show the selected operation mode. Different LED boards can be attached to this driver board. Figure 4 demonstrates the generation of different colors by mixing of RGB.

Summary

With ever higher efficient High Power LEDs flexible drivers are required to use the advantage of such LEDs. In this paper a flexible and efficient way to drive RGB LEDs by user programmable current sources based on the current source driver STP04CM596 has been shown. Additional features like over-temperature protection and over-voltage protection have not been detailed, but are also implemented in the shown demonstration board in order to maximize the live time of the driven LEDs.

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Frequency Compensation in Switching Regulator Design

Part 1: Forward path compensation

Of all the aspects related to designing switching regulator circuits, probably the most daunting for inexperienced engineers is the issue of frequency compensation. However, even without a great deal of mathematics, stable operation and good performance can be achieved. In this, the first of a two-part series, the forward path is considered.

By Nigel Smith, Business Development Manager, Portable Power, Texas Instruments

Regardless of topology, for the purposes of frequency compensation, all switching regulators employing negative feedback can be described in terms of the control loop block diagram shown in Figure 1. In the forward path from V_{IN} to V_{OUT}, the input voltage is converted to the output voltage in response to a control signal, V_C. This output voltage is then compared to a reference voltage, V_{REF}, and V_C adjusted as needed to correct the error. This is the feedback path.

In practice, the gain and phase of the forward path varies with frequency, and therefore it is possible that at some frequency (or frequencies) the output voltage may respond too slowly, resulting in inadequate performance or too fast, causing oscillation or ringing.

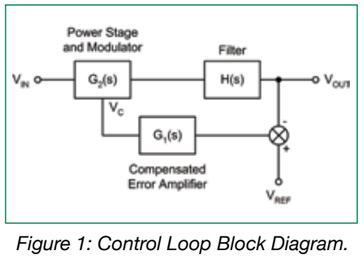

Figure 1: Control Loop Block Diagram.

The term frequency compensation describes the design of a feedback path that takes into account the frequency response of the forward path, and ensures that the fed-back signal compensates it in such a way that the system provides adequate performance and is stable.

The basic requirement for stability in a negative feedback system is that the loop gain must be less than 0dB when the phase change around the loop is 360°. Getting too close to these theoretical limits may result in excessive ringing, even though the system may be stable, so in practice feedback systems are deliberately designed with built-in margin. Phase Margin refers to the loop phase at the frequency where the loop gain equals 0dB, and Gain Margin refers to the loop gain at the frequency where the loop phase equals 360° (see Figure 2). Both are figures of merit describing the performance of a negative feedback system, and in general higher gain and phase margins indicate a more stable system. In practice, minimum gain and phase margins of 10dB and 45° are considered an adequate compromise between performance and stability.

The first step towards compensating a switching converter is to draw the gain and phase response of the forward path, which generally comprises a power stage and an output filter.

The power stage converts the input voltage to the desired output voltage according to its topology by controlling the switching duty cycle, D. The ideal transfer function of three of the most common topologies, the buck, the boost and the buck-boost (inverter) are:

$$V_{OUT} = V_{IN} \times D$$

$$V_{OUT} = V_{IN} \times \frac{1}{1-D}$$

$$V_{OUT} = -V_{IN} \times \frac{D}{1-D}$$

There are various ways in which the duty cycle itself is controlled in order to achieve the desired output voltage.

In direct duty cycle control the duty cycle of the switches is determined by

comparing the control voltage V_C to a fixed amplitude sawtooth waveform V_{RAMP} (see Figure 3). The result is a PWM signal whose duty cycle is given by:

$$D = \frac{V_C}{V_{RAMP}}$$

Knowing this, it is now possible to calculate the input to output gain. For a simple buck converter, this is:

$$G_2(s) = \frac{V_{IN}(s)}{V_{RAMP}(s)}$$

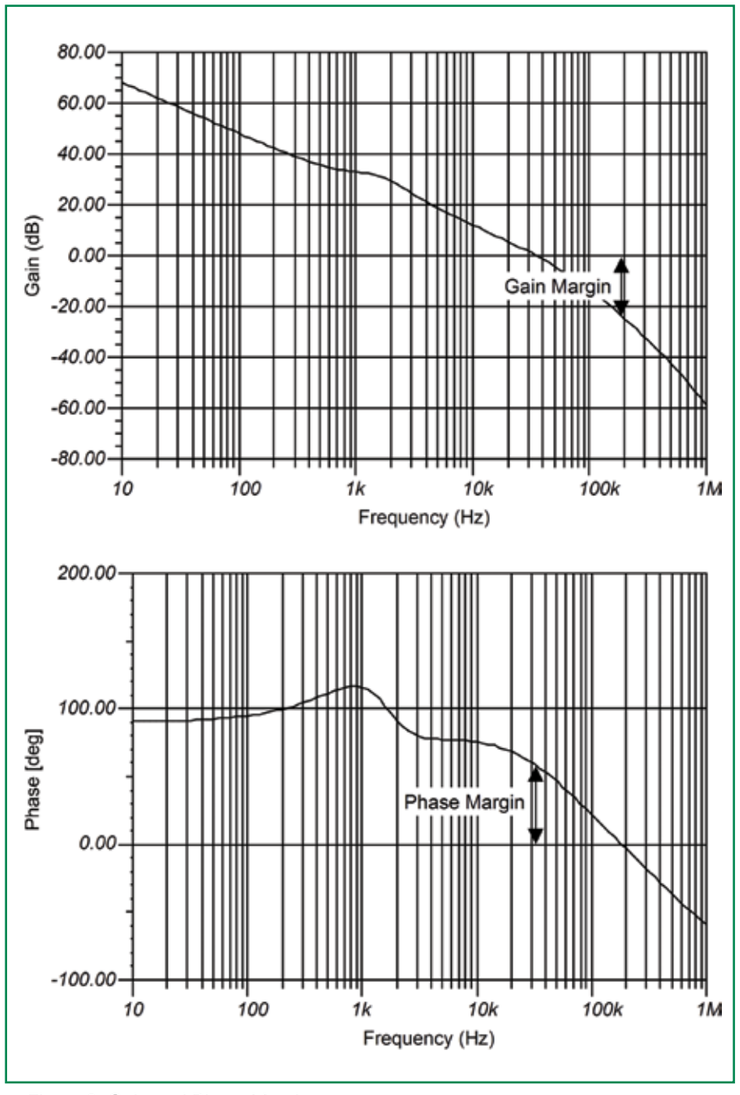

Figure 2: Gain and Phase Margin.

In this case, gain varies with input voltage, a fact that must be taken into account when compensating the loop. Switching converters using direct duty cycle control, respond relatively slowly to line changes because an error must first appear at V_{OUT} before the feedback loop can correct it.

A superior control method known as voltage feed-forward overcomes this problem by generating a ramp waveform whose amplitude is proportional to the input voltage such that $V_{RAMP}=K \times V_{IN}$. The resulting expression for $G_2(s)$ is

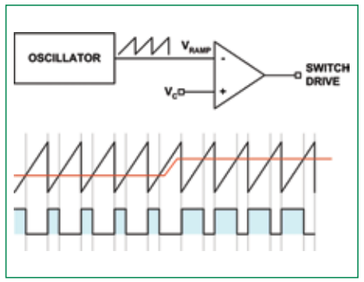

Figure 3: Pulse Width Modulation Scheme.

independent of V_{IN} and is given by:

$$G_2(s) = \frac{1}{k}$$

The power stage gain is now constant, which simplifies loop compensation. Switching converters using voltage feed-forward are able to respond much quicker to changes in input voltage because the duty cycle is automatically adjusted to accommodate changes in VIN without having to wait for an error to appear on the output (which takes time because of the low-pass output filter in the forward path).

Another control method that automatically corrects for line changes is current mode control. Using this approach, the current at some part of the forward path is controlled by an inner control loop and an outer control loop regulates the output voltage. Once again, changes in VIN are automatically compensated for without having to wait for an error to appear at the output.

Each of the above control schemes could be used in the same converter topology and yet result in a different power stage gain, so each converter must be considered on a case-by-case basis. Furthermore, in current-mode control schemes, the presence of an inner current loop means that the output inductor is excluded from the output filter characteristic (because it is effectively driven by a current source). Thus, while the output filter in a voltage-mode buck converter comprises an inductor and capacitor, the output filter in a current-mode version of the same converter (from a frequency compensation point of view) comprises just a capacitor.

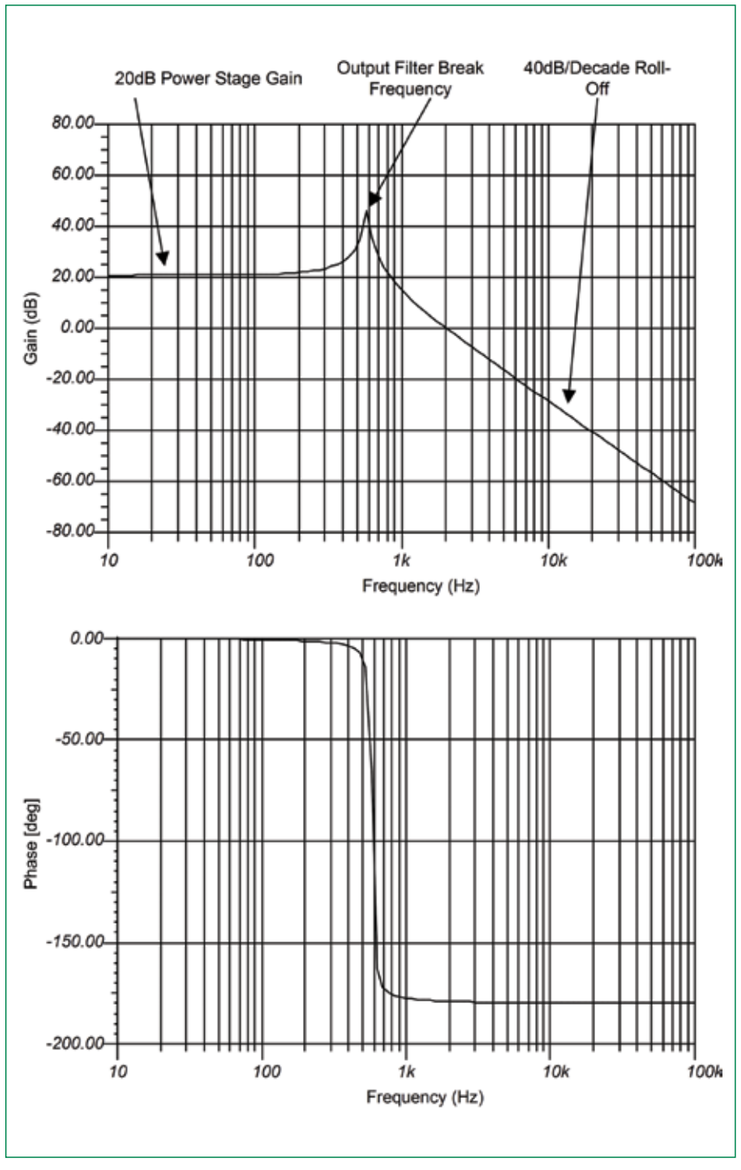

Figure 4: Typical TPS40200 Forward Path Bode Plot.

The transfer functions stated above are based on an important assumption; namely, that the converter is operating in continuous conduction mode (CCM). This means that current is continuously flowing in the inductor. Conversely, the term discontinuous conduction mode (DCM) means the inductor current is zero for some part of the switching cycle. Whether a converter operates in CCM or DCM is important because the transfer functions are different in each case, and the frequency compensation scheme must take this into account. Generally speaking, most converters are designed to operate in either DCM or CCM under normal operating conditions, but this is not always the case. Non-synchronous converters transition between CCM and DCM according to their operating conditions; however, synchronous converters always operate in CCM, which tends to simplify compensation.

Output filter components are usually chosen during the design of the forward path according to the application's output voltage ripple requirements, but the resulting gain and phase response is also very important for the design of the frequency compensation.

In most switching converters the output filter is either a double-pole type (the combination of the output capacitor and inductor), which rolls off at 40dB/decade, or a single-pole type (the output capacitor on its own), which rolls off at 20dB/decade. In both cases, any ESR (equivalent series resistance) in the output capacitor will add a zero at high frequencies that must be considered, since it changes the slope of the filter response by increasing gain and phase.

As soon as mathematical expressions or equivalent circuits are available for the power stage and output filter the gain and phase response of the forward path can be drawn. Figure 4 shows the Bode plots for Texas Instruments' TPS40200 step-down converter (taken from the circuit shown in Figure 47 of the device's data sheet). This plot provides all the information needed to start designing the compensation.

In the second and final part of this article, to appear in Power Systems Design Europe next month, the feedback path is considered as the loop is closed and the overall circuit is compensated.

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On the Road

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

EPCOS

I participated in the EPCOS press conference recently where I had the great opportunity to gain an insight from senior management into the diverse areas the company is currently penetrating. There was a wealth of well prepared, highly relevant and interesting information, a précis of which I have put together for you in the following report.

Pressure Measurement in Harsh Environments

Presented by, Dr. Bernhard Ostrick, Vice President Product Marketing Sensor Systems

In 2007, EPCOS acquired Aktiv Sensor GmbH, extending its technology and product range in sensorics to include pressure sensors in addition to temperature sensors. The critical development and production steps are carried out at the company's own 300-m^2 cleanroom.

Pressure sensors are vital for applications operating under demanding conditions. Aktiv Sensor has been particularly successful with an element for absolute pressure measurement that permits direct contact of moist and liquid media with the silicon bending plate. Millions of these sensor elements are used in automotive exhaust feedback systems.

Future products will be based on low-temperature co-fired ceramic (LTCC) and molded interconnect device (MID) technologies. This allows the measuring options for aggressive media to be extended and miniaturized sensor types to be developed for low-pressure domains.

The main applications for these Aktiv Sensor products are in the automotive and medical sectors as well as in measurement, control, environmental and air-conditioning technologies.

SineFormer™ Output Filters for Frequency Converters

Presented by, René Osthold, Director Development EMC Filters

Power line filters and sine wave EMC output filters are an integral part of an overall EMC concept for variable-speed drives.

Besides obvious huge benefits for modern drive technology, frequency converters also create their own set of problems. At the converter output there is a pulsed output voltage with very steep edges, which endanger both the motor and its insulation. In addition, the pulse frequency of the converter produces interference in the kilohertz range. Longer motor cables also require higher converter outputs to compensate their associated losses. Moreover, there are limitations caused by the conducted and radiated EMC.

EPCOS has developed an innovative series of output filters: in addition to a symmetric choke the SineFormer™ filters integrate a second filter unit to transform the phase-to-phase voltages into a sinusoidal signal, effectively attenuate common mode currents and convert the phase-to-ground voltage into a sinusoidal voltage. Measurements at the SineFormer™ output show a significant reduction of the harmonics in the lower frequency range.

The SineFormer™ considerably reduces the edge steepness of the phase-to-ground voltage and automatically minimizes the leakage current resulting from the parasitic cable capacitances and the high dv/dt of the pulsed output voltage. The result is a significant reduction of the bearing currents and possible reduced demands on the power filter.

SineFormer™ reduces the common mode effects so much that shielded motor cables may not even be necessary.

Power Capacitor Chips for Low-C IGBT DC Links

Presented bv, Harald Vetter, Product Marketing Manager Power Capacitors

EPCOS series of Power Capacitor Chips (PCCs) for frequency converters are based on standard IGBT modules such as PrimeStack from Infineon Technologies or modules from other leading manufacturers.

PCCs are used in modern power electronics, particularly in industrial and automotive electronics as well as traction applications, but also in low-capacitance IGBT-DC links for solar and wind power installations.

The DC link of frequency converters contains several high-capacitance aluminum electrolytic capacitors combined into capacitor batteries that act as energy storage units.

The demand for a long operating life, strong current handling capability and emergency operation capability of the frequency converters tends to lead to over-dimensioning of these capacitors. This can be avoided in new low-capacitance converter designs by the use of PCCs: they offer the advantage of very low equivalent series resistance (ESR) and equivalent series inductance (ESL) values, so that high current handling capabilities can be achieved with relatively low capacitance values. They also avoid voltage surges caused by parasitic inductances at the steep switching edges of the IGBTs.

PCCs are ideal for integration in mechatronic systems, where they save volume, weight and costs. Customized geometries can also be implemented very easily.

The newly developed capacitor technology operates with dry self-healing flat or stacked windings in power capacitor format. Unlike the MKP circular winding technology, this allows a maximum volume filling factor of almost unity.

The new PCCs are particularly well suited for the DC link of frequency converters used in solar and wind power installations.

Compared with solutions based on high-capacitance aluminum electrolytic capacitors with rated capacitance bandwidths from 5 to 10mF, PCC solutions can also be operated with capacitances in the range from 0.8 to 1.50mF while avoiding performance losses.

Flat Power-Piezo Transformers

Presented by, Johannes Lehrhofer, Product Marketing Manager Piezo Commodities

In contrast to conventional electromagnetic transformers whose secondary and primary sides are coupled via a magnetic field, the coupling in the piezo transformer takes place mechanically on the basis of both the standard and inverse piezoelectric effects.

This technology currently allows power densities of up to 50 W/cm^3 to be achieved. The currently feasible transmission ratio is greater than 1:1000. This allows for extremely compact designs to be implemented with a low insertion height of less than 1 mm.

The piezo-transformer thus satisfies the demand for an ever flatter design made particularly by the mobile phone manufacturers. Thanks to an extremely flexible form factor, piezo-transformers are also suitable for lamp ballasts as well as applications in automotive, consumer, data and telecommunications electronics.

Another advantage of piezo transformers is their high efficiency of about 95 percent. This is significantly greater than that of electromagnetic transformers, thus extending operating times of electronic devices, especially those powered by standard or rechargeable batteries. As the coupling of the primary and secondary sides takes place purely mechanically in the piezo transformer, EMC problems of the kind occurring with electromagnetic coupling are eliminated. This is critical when the piezo transformer is operated in the immediate vicinity of sensitive MOS-ICs that operate with low supply and signal voltages as well as high impedances.

Piezo transformers are well suited for all types of DC/DC converters, including Low-power versions for supplying OLED displays for mobile phones, Converters for LED lighting systems and high-voltage converters for the ignition of small combustion engines as well as for setting the hardness of automotive shock absorbers.

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Infineon

At their press conference held in Munich, Germany, Infineon recently announced that it has outperformed the automotive electronics market by 44% and now holds the No.2 global market position reinforced by faster-than-market average growth in all regions.

Infineon is the no.1 provider of automotive power products, with a market share of 23.7 percent in 2006. With its chipsets comprising microcontroller, system chip, driver and MOSFET, Infineon's automotive power semiconductors are active in applications, such as airbags, ABS and VSC (Vehicle Stability Control). The company's automotive Power ICs puts Infineon at no.3 in ABS applications and a market share of approximately 15% worldwide. Another strong area for its power semiconductors is the emerging application for electronic safety belt tensioner. This is now beginning to see wider adoption in automobile designs.

In Europe, Infineon remained the undisputed leader in the market with a market share of 15%.

Peter Bauer, Infineon management board member and head of the company's Automotive, Industrial and Multimarket business group, attributed the organization's sustained success to a consistent focus on automotive applications and their requirements, a deep understanding of automotive systems based on almost 40 years of experience, and a broad, high quality product portfolio. Infineon supplies the automotive industry with sensors, microcontrollers and power semiconductors.

According to Bauer, one of the factors that have helped Infineon's automotive above-average growth in the US is the new legislation to improve vehicle safety and environmental protection. Infineon has a strong position in both of these areas. In the US, every new vehicle will be required to have a tyre pressure sensor system beginning in September 2007 and Infineon is the world market leader in this field. Infineon is also one of the leading semiconductor suppliers in the automotive safety applications sector.

The company is a leader internationally in pressure sensors for side airbags and for ABS sensor systems to measure the wheel speed. Intelligent chips for engine management that regulate the optimum air-fuel mixture and ideal injection and ignition timing for each individual cylinder have helped sustain Infineon's success in this segment. For example, the company's 32-bit AUDO-NG (Next Generation) series microcontrollers reduce fuel consumption by approximately15 percent over previous models.

"We are the most successful non-Japanese chip supplier for automotive applications in Japan, which is convincing proof of our outstanding quality, reliability and customer orientation," explains Bauer. "We firmly believe that our 'Automotive Excellence' program is the most comprehensive quality assurance program in the semiconductor industry." This program was introduced in the spring of 2003.

Powerful New MCU Family Launched

At the press conference, Infineon unveiled its powerful and scalable XC2300 microcontroller family for future safety standards; automotive airbag and power-steering safety currently being discussed by the automotive industry and scheduled for adoption in Europe in 2008.

"The safety segment is the strongest-growing automotive application area with about a 10% growth-rate for the next five years. Infineon's combined in-house offering of MCU, sensor and power semiconductors together with our broad system know-how for safety applications make us unique among automotive chip suppliers," said Bauer. "System suppliers and car manufacturers benefit from our complete solutions, which are cost-effective and fulfill the stringent quality requirements and safety standards of the automotive industry."

The XC2300 family is designed to enable scalability, hardware and software reuse and compatibility across automotive electronics safety systems. The product family features a high-performance central processing unit (CPU) that can process up to 80 million instructions per second (MIPS) at 80 MHz.

The two parallel A/D converters lead to high performance with up to 24-channels, optional data pre-processing and a conversion time down to 1.2 μs. The A/D converters have specific safety features such as the ability to detect broken connections and to synchronize the two A/D converters to redundantly sample incoming signals.

The Memory Protection Unit (MPU) offers an additional benefit to the developers of safety systems by allowing the integration of software from third party suppliers (e.g. AUTOSAR) into a protected execution environment.

The low power consumption of the XC2300 products (less than 60 mA at maximum performance of 80MHz) reduces system costs since only tiny voltage regulators are needed.

The members of the XC2300 family will feature between 128 kBytes and 1.6 Mbytes of flash memory to fit both e.g. airbag systems and highly complex safety-systems such as power steering, low-end chassis control and sensor clusters.

Further characteristics include AUTOSAR compliance with Infineon supporting software standardization for interfaces and software modules for automotive systems by providing AUTOSAR software drivers for all XC2300 products.

The broad XC2300 product portfolio is planned to comprise more than 50 products, offering safety application design engineers the scalability to select an MCU with the optimal combination of memory, peripheral set, frequency, temperature and packaging to match the application's feature and performance requirements, during and after the design cycle, without any changes to the printed circuit board design. Once the software is compiled, it can easily be used for various safety applications within different model platforms of a car manufacturer.

Overall cost savings in development, qualification, validation and testing of hardware and software can be up to 30%.

Samples of the XC2365 and XC2387 of the XC2300 family are available for dedicated automotive customers.

www.infineon.com

60 Great Years of International Rectifier

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

In this hi-tech world, we take it for granted that state of the art technology will take care of our automotive comfort and safety. But were it not for dedicated work, not to mention the considerable investment that companies like IR need to make to even get it started, it just would not happen.

IR celebrates and with very good reason, 60 years of innovation in our industry and I have compiled just a fraction of their vast portfolio for our automotive issue.

The fact that the electric car is here, is undisputable. Whether the automotive industry or government authorities will let it live - probably when they can no longer make profit from petroleum fuelled offerings - is another matter. Anyone who has seen the film, 'Who Killed the Electric Car' will know what I mean.

1947 Building, Eric Lidow and his father, Leon Lidow, found International Rectifier in August 1947 with just six employees at the facility in Inglewood, CA.

1951 IR introduces selenium stack rectifiers for battery charging.

Power electronics continue to dominate automotive designs. As reliable electric motors replace belts and hydraulic systems and automotive electrical systems are moving to 42V, IR offers leading edge automotive power management solutions for everything from creature comforts to the power train. With its proven expertise in power management, International Rectifier is a logical and safe choice to move over to electronic automotive systems with confidence.

By focusing on technological innovation and the highest standards of quality and reliability, IR remains a worldwide leader in the manufacture of power semiconductors. The company's goal is to provide its customers with a competitive advantage and maximize shareholder equity through investment in the R&D of the best products and services.

1960 IR introduces world's first solar powered car in Los Angeles, Chicago and New York City.

The Chevy Volt, a concept car, is an aggressive-looking four-door sedan running on what Chevrolet calls its E-Flex platform. The Volt has both a fuel-burning engine -- which can be configured to run on gasoline, E85 or biodiesel -- and an electric drive. But unlike the current hybrids, the internal combustion engine isn't connected to the drivetrain: it charges the batteries. It's a full-on electric vehicle with range-extending capabilities.

1968 IR develops experimental electric car to demonstrate the flexibility of the control system and to prove that the day is not far off when battery-operated electric vehicles will be available for the consumer.

Quality and Reliability

IR has established a complete quality and reliability system as is required from an automotive system supplier. The company's 'Quality System' establishes policies and sets standards across all manufacturing locations, building on the foundation of world-class standards with bedrock IR processes and programs. All primary IR manufacturing facilities are certified to ISO9001 and QS9000. The company's semiconductor products for automotive applications are qualified to the 'Production Part Approval Process' (PPAP) as required by ISO/QS standards. As part of the PPAP qualification process, IR employs a comprehensive array of test methods and procedures to ensure the highest quality products for this most discerning industry.

Manufacturing Capability

International Rectifier's manufacturing facilities include wafer fabs, semiconductor assembly, advanced power electronics, hybrid module and SMT system assembly. International Rectifier has ISO/QS certified wafer fabrication facilities in Temecula and El Segundo, California, Newport, Wales as well as Turin, Italy, providing state-of-the-art die, test and tape and reel capabilities. The company's 'Known Good Die' (KGD) process guarantees die quality through 100% testing. Using true Kelvin connections to enable measurements at high current, the die are examined in a proprietary test nest. This results in measurably higher yields in module assembly. In addition, QS9000 certified facilities also contain a 'Class 10,000' clean room environment. IR's highly skilled team of technicians and operators use fully-automated, high-volume manufacturing processes focused on zero defects for demand fulfillment. Their facilities all have the necessary equipment, including printing, drying, dynamic trimming and pick-and-place for production of high-volume thick-film hybrid circuits. IR Automotive produces power generation electronics sold to major first tier automotive suppliers for chassis and power-train applications. With the company's huge resource and continued investment in the automotive industry we will for sure hear more from IR. Congratulations!

www.irf.com/product-info/auto/

Power Systems Design EUROPE

Special Report Automotive Electronics Part II

Image Courtesy of DaimlerChrysler

No Chance of Heat Death in Automotive Applications

PTC thermistors as current limiters for LEDs

Like all semiconductors, LEDs have a maximum permissible junction temperature that must not be exceeded in order to avoid premature aging or total failure. The maximum permissible forward current must drop as the ambient temperature rises if the junction temperature is to remain below the critical value

By Dr. Stefan Benkhof, Product Marketing Manager PTC, EPCOS

Light-emitting diodes (LEDs) have developed greatly in recent years: from leading a niche existence as pure indicator lamps to high-power LEDs with a light output currently exceeding 100 lumens. Lighting costs with LEDs will soon drop to levels similar to those of classic cold cathode fluorescent (CCFL) lamps. This makes these devices increasingly interesting for automotive lighting, as LED sources in and on buildings as well as for LCD panel backlighting in notebook PCs or TVs.

Advances in high-power LED technology have increased the importance of thermal considerations in the design phase. Like all other semiconductors, LEDs must not get too hot in order to avoid an accelerated degradation in output or, worst case, total failure. Although high-power LEDs have a higher efficiency than incandescent lamps, a high proportion of their power input nevertheless generates heat as well as light. Reliable operation thus demands good heat sinking and the consideration of any high ambient temperature in the design phase already.

Thermal aspects must also be considered when dimensioning the drive circuit of the LEDs: their forward current must be selected to ensure that the LED chip does not over-heat, even at maximum ambient temperatures. This is achieved

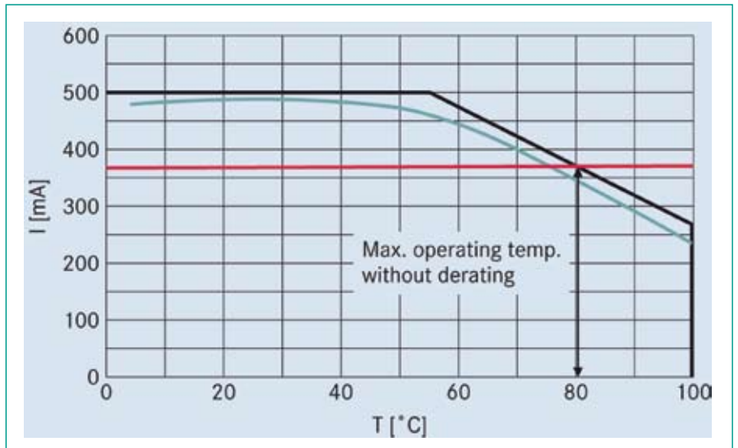

Figure 1: LED Derating Curve.
Red: At a maximum operating temperature of 80°C a constant current must be limited to 370mA. The maximum light efficiency is not reached at lower temperatures.
Green: When the operating voltage is applied as a function of temperature, the light efficiency can be increased over a large temperature range.
Black: LED derating curve.

by reducing the maximum acceptable current as the temperature increases, a procedure known as derating. LED manufacturers include the derating curve in their specifications. An example of this curve is shown in Figure 1.

Operating an LED with a temperature-independent current source has the disadvantage that at excessive temperatures the LED is operated outside its specifications. Moreover, at low temperatures the light source is then provided with a current significantly below the maximum permissible current (Red curve in Fig. 1). Controlling the LED current by using PTC thermistors in the LED driver circuit as illustrated in the green curve of Fig. 1 is a major improvement. Among other things, this offers

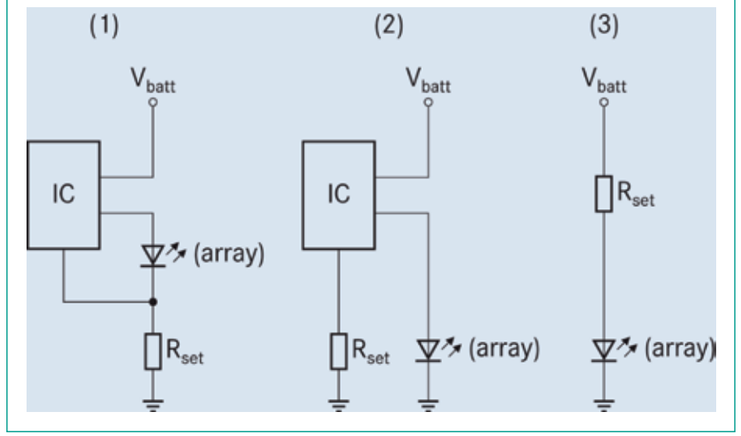

Figure 2: Conventional Driving of LEDs.

the following benefits:

- Increasing the forward current and thus the light output at room temperature.
- Cost savings, as the number of LEDs can be reduced, using less expensive driver ICs or even a driver circuit without integrated thermal management.
- The possibility of designing a driver circuit without IC control that is still able to vary the LED current dependent on temperature.
- The ability to use less expensive LEDs with more pronounced derating and a smaller safety reserve.
- Reliability is increased by the overheating-protection function.
- Thermo-mechanical design including heat sinks is simpler.

With most LED driver topologies, the forward current through the LED is set via a fixed resistor (Fig. 2). As a rule, the current flowing through the LED I_{LED} depends on this resistance Rout in accordance with $I_{LED} \sim 1/R_{out}$. As R_{out} does not change with temperature, the LED current is also temperature-independent.

In these drive circuits the current flowing through the LED is independent of the temperature. Thus, the derating required at high temperatures does not take place.

Thermal management of the LED current can be achieved by replacing the fixed resistor with a circuit that is temperature-dependent itself. The following diagrams illustrate how standard circuits can be improved with a PTC thermistor.

Example 1: constant-current source with a feedback loop

Circuit 1 in Figure 2 shows a frequently used driver topology. The constant-current source contains a feedback loop. The LED current is changed until the IC-specific feedback voltage V_{FB} across the setting resistor at the feedback pin of the IC is reached. The LED current consequently sets itself at $I_{LED} = V_{FB} / R_{out}$.

Figure 3 shows a modification of this circuit: it generates a temperature-dependent LED current through a PTC thermistor. This circuit is matched to a special combination of driver IC and LED by the correct selection of PTC thermistor, R_{series} and $R_{parallel}$. The LED current is calculated from the following equation:

$$I_{LED}(T) = \frac{V_{FB}}{R_{parallel}} \left(1 + \frac{R_{parallel} + R_{series}}{R_{PTC}(T)} \right)$$

The circuit shown in Figure 3 illustrates the resulting temperature dependence

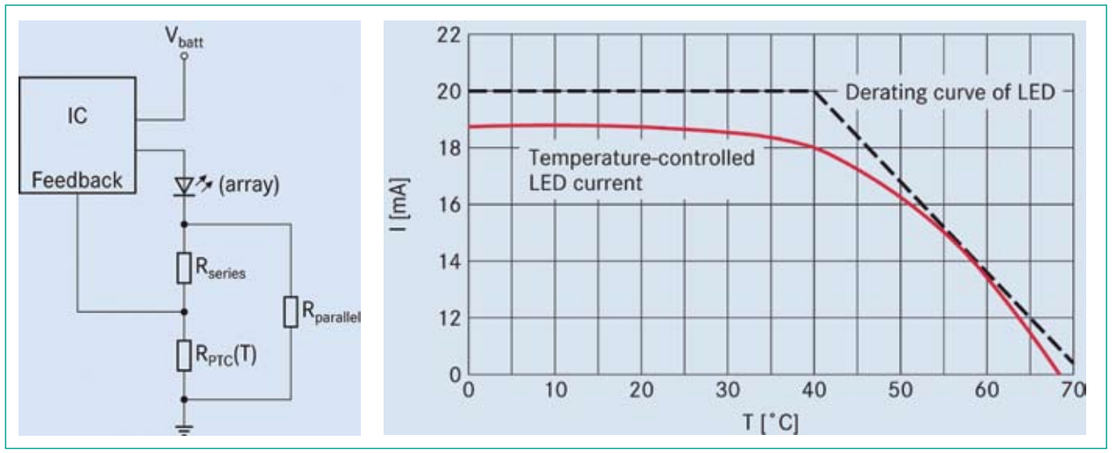

Figure 3: Temperature Monitoring and Derating with PTC Thermistors.
Caption Fig3a: In this case, the PTC is in the current path of the LED.
Caption Fig3b: The actual current curve as a function of the temperature corresponds to the LED specifications (R_{series} = 910Ω, $R_{parallel}$ = 18Ω).

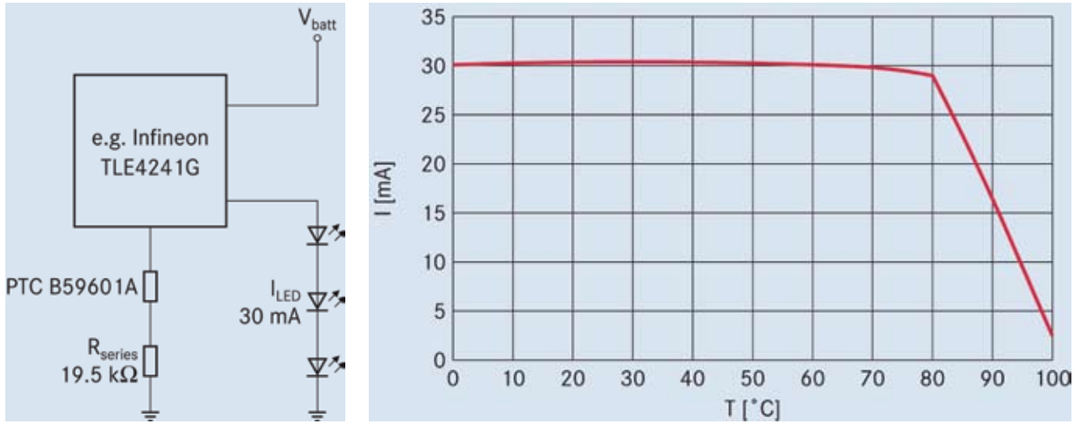

Figure 4: Temperature Recording Without Shunt Measurement.
Caption fig4a: In this circuit, the measurement is not performed in the current path. The circuit layout is simpler than in the example shown in Figure 3.
Caption fig4b: Resulting LED current as a function of the ambient temperature.

of the LED current. In comparison to a constant-current source dimensioned for a maximum operating temperature of 60°C, the LED current can be increased by up to 40 percent between 0°C and 40°C with a PTC thermistor and the brightness of the LED can be boosted by about the same percentage.

Example 2: Constant-current source with setting resistor not connected in series with the LED

Circuit 2 in Figure 2 shows another popular version of the constant-current source: the current is determined by a resistor connected to the driver IC. In this case, however, the setting resistor is not connected in series with the LED. The ratio between R_{set} and ILED is given in the IC specification. Thus, using a series resistance of 20 kΩ and a driver IC type TLE4241G from Infineon Technologies, results in an LED current of 30mA. Figure4 shows a modification of the standard circuit also containing a PTC thermistor. Although the PTC thermistors of the B59601A* series used here (size 0603) have a resistance of R_{25} = 470Ω, at the sensing temperature, which can be set in ten-degree increments, resistance of the component reaches 4.7kΩ with a tolerance of ±5°C (standard series) or ±3°C (tight-tolerance series).

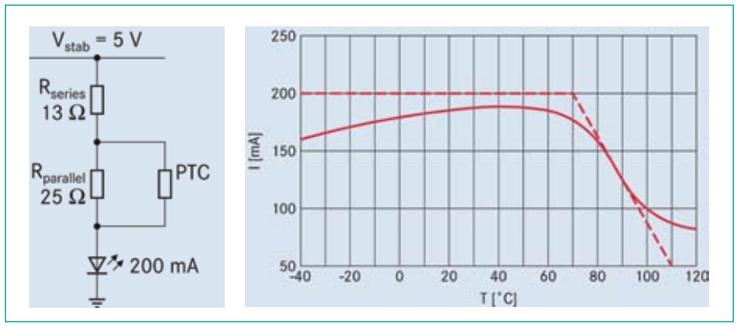

Figure 5: Temperature-Compensated Driving Without IC.
Caption fig5a: In this case, the greatest amount of the LED current flows via the PTC.
Caption fig5b: Current as a function of temperature.

Figure 4 shows the resulting LED current as a function of temperature. The narrowly toleranced fixed resistor R_{series} dominates the total resistance at low temperatures. Only from about 15K below the sensing temperature of the PTC thermistor does the current begin to drop due to the increasing resistance of the PTC thermistor. A current of about 23mA is reached at the sensing temperature (total resistance $R_{total} = R_{series} + R_{PTC}$ = 19.5kΩ + 4.7kΩ = 24.2kΩ). The steep rise of the PTC resistance at even higher temperatures leads quickly to shutdown and thus avoids 'heat death'.

Example 3: Simple driver circuit without IC

As circuit 3 in Figure 2 shows, LEDs can also be operated without a driving IC. This is illustrated by a circuit that drives a single 200mA LED from an automotive battery. To avoid the fluctuations of the supply voltage, a voltage stabilizer generates a stable supply voltage V_{stab} of 5V. The LED is operated at V_{stab} and the current set via a resistance element R_{out} connected in series to the LED. In this type of circuit, the temperature-independent forward current is obtained from the following equation, where V_{Diode} is the forward voltage of a single LED:

$$I_{LED}(T) = \frac{V_{stab} - V_{Diode}(T)}{R_{out}(T)}$$

Table: Overview of current PTC thermistors for excess temperature protection

Ordering Code	R_{25} [Ω]	R_{25} tolerance [±%]	Sensing temperature T_{NTT} [°C]	Tolerance of sensing temperature [±°C]	Reference temperature T_{ref} [°C]	Tolerance of reference temperature [±°C]	Package
B59602A0055A062	110	15	—	—	56°C	3°C	0603
B59602A0070A062	30	15	—	—	72°C	3°C	0603
Family: B59601A0****A062	470	15	55°C,85°C,105°C	5°C	45°C, 75°C, 95°C	5°C	0603
Family: B59601A0***A062	470	50	75°C to 135°C in steps of 10 degrees	5°C	—	—	0603
Family: B59601A0***B062	470	50	75°C to 135°C in steps of 10 degrees	3°C	—	—	0603
Family: B59***P1***A062	3.1 - 55	25	—	—	80°C, 120°C	Typical value	4032, 3225
B59606A0110A062	27	25	—	—	110°C	Typical value	1210
B59607A0120A062	55	25	—	—	120°C	Typical value	1210
B59707A0120A062	125	25	—	—	120°C	Typical value	1210
B59807A0120A062	400	25	—	—	90°C	Typical value	1210
Family: B599*5C0120A070	0.3 - 13	25	—	—	120°C	Typical value	Radial leaded
Family@ B599*0C0080A070	1.65 - 55	25	—	—	80°C	Typical value	Radial leaded

R_{25}: Resistance at 25°C
T_{NTT}: Temperature where the device resistance reaches 4.7kΩ
T_{ref}: Temperature where the device resistance reaches twice its minimum resistance

Alternatively, the fixed resistor can be replaced by a combination of a radial leaded PTC thermistor of the type B59940C0080A070 (R_{25} = 2.3Ω) and two fixed resistors as shown in Figure 5. The resulting forward current is calculated using the equation:

$$I_{LED}(T) = \frac{V_{stab} - V_{Diode}(T)}{R_s + \frac{R_{PTC}(T)R_P}{R_{PTC}(T)+R_P}}$$

As a significant amount of the LED current flows through the PTC thermistor itself, a larger radial-leaded component was selected. A significantly smaller chip PTC thermistor would itself heat up, because of the current flowing through it, and would always reduce the current independent of the ambient temperature (Figure 5). While connecting two or more chip PTC thermistors in parallel would divide the current, there are limits to this concept.

The current is essentially set to the desired value by suitable selection of the two fixed resistors. These resistors also play an essential role in improving the circuit by keeping the tolerance of the resulting LED forward current low. This is particularly important in the normal operating temperature range in which the PTC thermistor itself still has a high resistance tolerance. The second parallel fixed resistor also ensures that the PTC does not switch the LED off completely even at extreme excess temperatures. So the current never drops below the value calculated from:

$$I_{LED\ min}(T) = \frac{V_{stab} - V_{Diode}(T)}{R_P + R_S}$$

This property is extremely important, especially in automotive electronics, where safety requirements do not allow the lights to be switched off completely.

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High Temperature Limitations in Automotive

More work needed to achieve peak performance

Many innovations relating to safety, comfort and reduced emissions to comply with new legislation, are made possible by electronic control. To deliver these benefits effectively, operation under harsh environmental conditions is becoming increasingly important. Isotron outlines the reasons for high temperature electronics being used in such applications and describes the limiting factors for using devices at high temperatures

By Richard Sharp, Business Manager, Semiconductors and Sterilisation, Isotron Ltd., Harwell, Oxfordshire, UK

Legislation relating to emissions from cars and other motor vehicles is driving the development of better combustion monitoring and control systems. Furthermore, improved safety levels are being achieved by using new types of electronic device for sensing and detecting the status of various actuators, components and fluids. Benefits in terms of complexity, weight and reliability can be achieved only if the electronics are located close to the process being monitored.

Definitions of high temperature electronics (HTE) vary but the term is generally taken to mean devices or systems that are capable of sustained operation in high temperature environments. High temperature is usually defined as greater than the upper limit for MIL-SPEC 334, i.e. above 125°C, representing the ceiling for the majority of commercially available electronics. In automotive applications, the temperature can rise above 125°C and so necessitates the use of HTE. It is worth noting that when high temperature environments are encountered, additional hostile parameters, such as vibration, shock or corrosion are often also present.

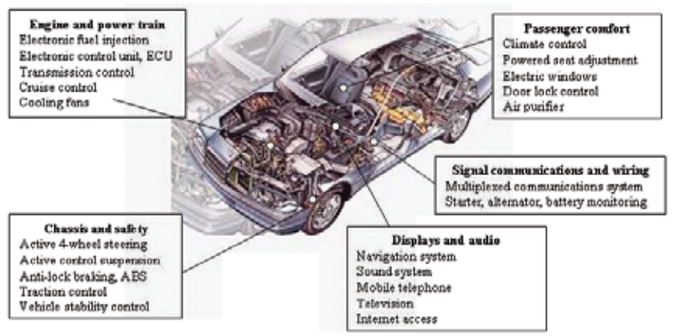

Figure 1: Systems where HTE components are used at present or in the future.

The HTE environment

Electronics are exposed to high temperatures in a variety of applications and environments. The greatest use at present is in the downhole oil and gas industry for well logging. The temperature requirement varies according to the depth of the well, ranging up to 600°C for the deepest geothermal wells but more typically 175 - 250°C for existing oil or gas wells. Aerospace needs relate to monitoring and control around engines and braking systems. Temperatures here are typically between 200 and 300°C.

Automotive Applications

HTE components for automotive applications comprise two main categories:

1.Sensors and discrete components (which can be developed into integrated smart sensors)

2.Electronic control units (hybrid circuits based on discrete components but moving towards ICs)

The key drivers in automotive developments have been the reduction of exhaust emissions and improved fuel efficiency. As a result, more and more sensors have been placed on automobiles and, in particular, in the drive areas. There has also been a pronounced move towards distributed control systems to reduce the overall wiring and cabling demands. However, the available space for such electronics has reduced as consumer demand pushes the overall automotive envelope down while passenger space is maximised. Hence, the electronics must be placed in very close proximity to the engine itself, with limited airflow and cooling available to manage the thermal loads.

At present, HTE components in automobiles experience a fairly severe mix of operating conditions but the maximum temperature excursions are relatively modest. However, in-cylinder monitoring will be different. Recently, SiC on silicon-on-insulator (SOI) pressure sensors have been fabricated for direct, dynamic measurement of the pressure within an operating engine.

Although the conventional, cost competitive nature of the automotive market means that new technologies penetrate it only slowly, HTE is appearing in high-end vehicles. It is estimated that back in 2005 the total available market for high temperature electronics in automotive applications was $1,000 million. Of this, approximately 25% was for engine control functions.

The automotive sector is potentially a user of very large volumes of HTE. Advanced cars now contain around 100 sensors and this is likely to double within ten years. These include sensors for engine speed and angular position, ABS, exhaust gas, power steering and engine condition monitoring. Smart sensors and associated electronics with operation up to 200°C will form an important part of the new developments required. Braking system sensors (<300°C) and combustion sensors (with surface temperatures up to 1,000°C) will need fundamental advances in reliability. Mechatronic systems, where electronics become an integral part of the component, will enable new functions to be delivered in terms of safety and passenger comfort, as well as offering cost savings. Figure 1 shows some of the systems currently using HTE or which would benefit from the availability of suitable components.

Semiconductors for HTE

More than 98% of current electronic devices use silicon as the semiconductor material. Although the highest temperature rating available on a commercial basis is 125°C, many devices function within their electronic specifications above that range. Some survive at temperatures of up 200°C and the intrinsic limit for silicon is around 400°C. The limiting factor, in practice, is the capability of the materials used for die attach and packaging the active device.

Other semiconductor materials are available and offer benefits to the high temperature market. SOI devices can operate reliably at rather higher temperatures than straightforward silicon. Gallium arsenide is a mature technology, although most devices are manufactured for RF applications and virtually no research is being carried out into its high temperature capabilities. In theory, GaAs devices are able to operate to 400°C or higher.

For temperatures greater than 300°C, wide band-gap semiconductors (WBS) are required. Silicon carbide is the main contender, being the most technologically advanced. Despite significant recent developments, however, challenges remain with wafer size and material quality. Gallium nitride is just at the research stage, apart from optical devices. Diamond is theoretically the best WBS but unlikely to be commercially available as an active device for many years.

Packaging issues

Whilst the operation of semiconductors may be possible at temperatures of several hundred degrees, the devices must be packaged using materials that are compatible with this. This remains the greatest challenge to the successful operation of electronics at high temperatures.

A very serious issue is electromigration, whereby voids and bulges form in conductors, especially when operated at high current densities. Increasing the size of conducting paths and reducing the current density are key to dealing with this aspect. The chemical reactivity of materials used for ohmic contacts tends to increase with temperature, leading to a need for barrier materials or alternative metals for wire bonding and contact pads. The diffusion rate of dopants is increased at elevated temperatures, dielectric breakdown strengths are reduced and mechanical stresses can be enhanced due to mismatched thermal properties of the various materials used in the construction of a working component. Die attach problems are often a feature of thermal expansion differentials, especially where temperature cycling is a feature of the environment, as in automotive applications.

Other materials issues relate to substrates, circuit boards, solders and adhesives. In each case, the basic high temperature functionality must be considered, along with thermal properties, chemical reactivity and ease of manufacture.

One example of the successful commercial development of high temperature components is the HTMOS range from Honeywell. These products are designed to last for at least 5 years at 225°C and include an operational amplifier, a microcontroller and a FPGA, amongst others. SOI is the chosen technology for these products, allied with a proprietary metallisation system to give the required reliability characteristics.

Conclusions

High temperature electronics will increasingly penetrate the automotive market, particularly where distributed systems and improved performance are required. HTE will enable sensors with increased functionality to be placed nearer to the point of measurement, which in turn will allow improved efficiency. However, reliability issues remain and further work is required to deliver lifetimes attractive to car users.

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Circuit Protection Considerations for In-Vehicle Infotainment Systems, I/O Ports and Electronic Modules

Volatile automotive power bus requires equipment to be protected

New in-vehicle infotainment and navigation systems provide more content, a higher quality audio and video experience, and improved connectivity for personal communication devices. To accommodate high data rates and conform to current communications requirements this equipment must be protected from circuit damage caused by customer misuse, environmental hazards and power variations.

By Guillemette Paour, Worldwide Market Manager – Automotive.
Tyco Electronics/Raychem Circuit Protection Products

Resettable PPTC (polymeric positive temperature coefficient) devices are widely used in infotainment applications to help protect sophisticated electronic components and peripherals. In applications where resettable functionality is not desirable or practical, chip-type surface-mount fuses are generally specified.

Infotainment equipment is also susceptible to damage caused by overvoltage transients, including ESD (electrostatic discharge) pulses from the operating environment and peripherals. ESD protection devices, MOVs (metal oxide varistors) and Zener diodes are frequently used to help protect onboard automotive electronics such as antennas, backlight heaters, batteries, buttons, circuit board traces, CD/DVD players, data line ports, hard disk drives, I/O ports and touchscreens.

Design Considerations for Automotive Circuit Protection Devices

• PPTC Overcurrent/Overtemperature Protection

The resettable functionality of the popular PPTC device allows for placement in inaccessible locations in a vehicle, and a wide range of electrical and physical sizes facilitate precise protection design solutions. When selecting a PPTC device, the primary consideration is to match the hold current rating of the device to the primary current drawn by the equipment under normal operating conditions.

• ESD Protection Devices

High-speed I/O ports require low capacitance ESD solutions to minimize signal degradation. The device chosen should be suitable for high-speed data transmission lines and radio frequency data lines, and capable of withstanding numerous ESD transients. RoHS & IEC61000-4-2 compliance, low capacitance, low trigger voltage and fast response time are also critical device characteristics.

• Surface Mount Fuses

High-current, small size devices, generally available in both fast and slow-blow configurations, should provide clean blow characteristics that physically contain the fusing event within the package. They should also provide excellent arc suppression characteristics as well as resistance to shock and vibration.

• MOV Devices

Available in a variety of diameters and in broad varistor-voltage ranges, MOV devices provide high current handling and energy absorption overvoltage protection. MOVs are selected on the basis of their clamping level (suppressed voltage rating) and their response time.

Special Report – Automotive Electronics Part II

DC Power Port Protection

Automotive power buses are notoriously dirty. Although they are nominally 12V, they can range in normal operation from 8V to 16V. Still, battery currents can exceed 100 Amps, and be stopped via a relay or fuse, generating large inductive spikes on the bus and increasing voltage by 5X or more.

In operation, automotive supplies are subject to damage from misconnected batteries and double battery jump-starts (24V). A condition known as "load dump" can also generate large potential voltages on the bus. Typical third-party power converters may filter some of these events, but Tyco Electronics' testing shows that the transient suppression capabilities of these power converters vary widely. Devices being charged via the USB interface are typically not designed to handle this type of voltage fluctuation and require overvoltage protection.

The new PolyZen™ device from Tyco Electronics addresses a growing need for overcurrent and overvoltage protection on portable equipment that can be charged in the car. The device helps provide coordinated protection with a component that protects like a Zener diode, but is capable of withstanding very high power fault conditions.

As shown in Figure 1, the PolyZen microassembly incorporates a stable Zener diode for precise voltage clamping and a resistively non-linear PPTC layer that responds to either diode heating or overcurrent events by transitioning from a low to high resistance state.

The PolyZen device is especially effective at clamping and smoothing inductive voltage spikes. In response to an inductive spike the Zener diode element shunts current to ground until the voltage is reduced to the normal operating range. In the case of a wrong voltage power supply, the device clamps the voltage, shunts excess power to ground, and eventually locks out the wrong supply. The relatively flat voltage vs. current response of the PolyZen device helps clamp the output voltage, even when input voltage and source currents vary.

Because of the potential for such high currents in automotive applications, care should be taken to assure appropriate protection. IFLT max, and Vout peak should both be reviewed for the devices being selected to ensure that the device provides the desired level of protection.

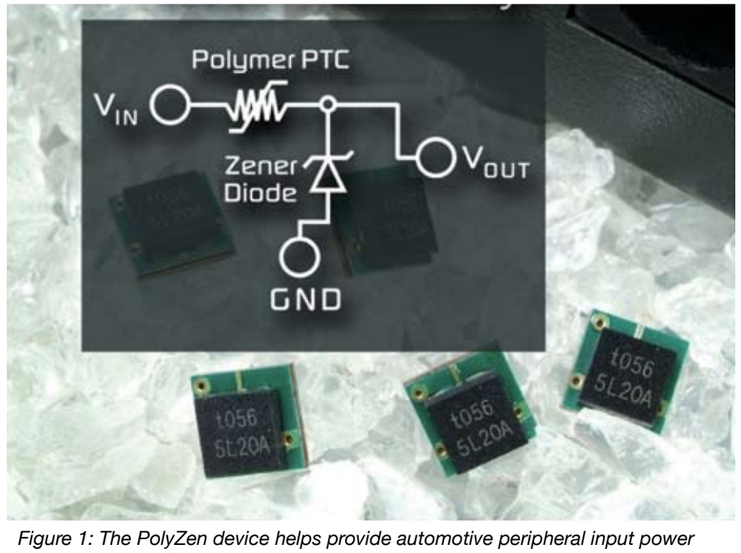


Figure 1: The PolyZen device helps provide automotive peripheral input power protection and DC power supply and output power conditioning.

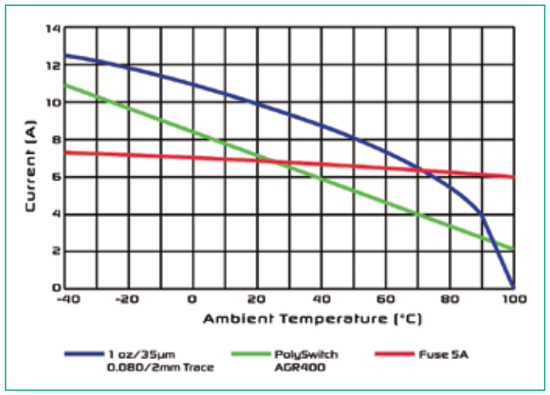


Figure 2: Performance comparison of fuse and PolySwitch AGR500 device performance comparison.

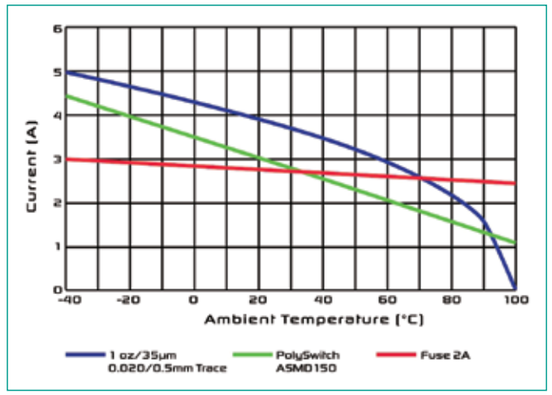


Figure 3: PolySwitch ASMD150 device performance comparison.

Protecting Electronic Module PCBs

Faced with market demands for more electronic devices and more interior space, automakers are squeezing more circuitry into smaller packages. In order to provide an increasing number of functions and interconnections on the surface area of a smaller and more densely printed circuit board, the width of the copper traces must be reduced.

Many of these "black box" control modules are now controlling a greater number of high-powered accessories, such as power windows, power seat adjusters, remotely controlled door locks, and radio and GPS antennas. Because these accessories are powered from high amperage circuits, there is increased potential for the narrow printed circuit board traces to sustain damage as a result of carrying excessive currents. This may happen, for example, if a power ground becomes detached from a load and the current reroutes through a narrow circuit board trace.

Printed circuit board traces function as wires carrying current from one point to another. Depending on its cross-sectional area, each trace can carry only so much current before the heat generated by I^2R losses causes it to fuse open. Even before it melts, a trace may become hot enough to damage the printed circuit board or some of the components mounted on it.

Resettable PPTC devices are frequently used to help protect these delicate traces because they are able to rapidly and effectively limit current to safe levels, yet are small enough to be mounted directly onto the circuit board. Using this technique, each individual power circuit within the module can be protected with a device that limits the current to a level that can be carried safely by the corresponding trace.

In the device comparisons shown in Figures 2 and 3, it has been assumed that the circuit board designer has chosen to limit the maximum trace temperature to 100°C. Therefore, as the trace approaches this temperature it is able to carry less and less current.

For the example shown in Figure 2 of a 1oz (35µm), 100mils (2.5mm) trace, a through-hole PolySwitch™ AGR500 device has been selected. In Figure 3 the trace width has been reduced to 20mils (0.5mm) and is protected by a PolySwitch surface-mount ASMD150 device.

It is important to note how the trip current of the PPTC device tracks the trace current over the temperature range. Even if a fuse could be used in either of these cases, the closest-sized fuse would fail to protect above a useful and standard automotive temperature.

PPTC circuit protection devices are widely accepted as a practical, cost-effective solution to overcurrent and/or overtemperature protection of electronic modules. They are frequently used for current limiting on GPS, DVDs, radios, and telematics boards.

Summary

A variety of innovative circuit protection solutions are available in a wide range of form factors and termination methods to help car makers and portable equipment manufacturers conform to stringent automotive requirements, improve equipment reliability and enhance end-user convenience and satisfaction. Coordinating overcurrent, overvoltage and ESD protection can help reduce component count and improve the efficiency and reliability of electronic components and networks.

www.circuitprotection.com

Analysing Vehicle Power Network Dynamics

Automotive power management requires specialised treatment

With the advantages of faster system response times, consolidation of functions and the promise of higher reliability with reduced cost, electronic content in vehicles continues to increase at an accelerated rate, posing significant design issues.

By Michael Jensen, Senior Corporate Applications Engineer, Synopsys, Inc

Not only is the number of purely electrical systems on the rise, but many systems that were once based on standalone technologies such as hydraulic, mechanical and pneumatic now have elements of electronic control. This places increased demand on the vehicle's power network (powernet), which generates and distributes energy to the electrical system. Powernet systems are traditionally comprised of three components: energy suppliers, energy consumers and cabling. A fourth and recent addition is energy management, which designers use to balance energy production and consumption.

Robust design techniques help developers ensure powernet reliability despite variations in system and environmental conditions. Including drive cycle testing as part of the development process helps account for system variability. Modern drive cycle testing incorporates drive cycle and load switching profiles with energy management measures. Combining these profiles, however, leads to very complicated test scenarios. Accurate electrical system analysis, therefore, is well beyond the typical design-prototype-test development process. The solution is to use simulation to design and build a virtual prototype of the system.

Virtual Prototyping

In traditional drive cycle testing, a prototype vehicle is driven real-time through several test scenarios. This process has two drawbacks: it is time consuming as test sequences can take several hours to complete; and a prototype vehicle is usually not available until late in the design cycle, which means any system problems can delay vehicle delivery. Virtual prototyping, where a model of the powernet is developed and analysed using software tools, becomes critical to the effective and efficient design of complex powernet systems. As shown in Figure 1, system developers use a virtual prototype to integrate and analyse components much earlier in the design process. System testing begins, including drive cycle and energy management scenarios, earlier in the development cycle. The result is a more reliable system

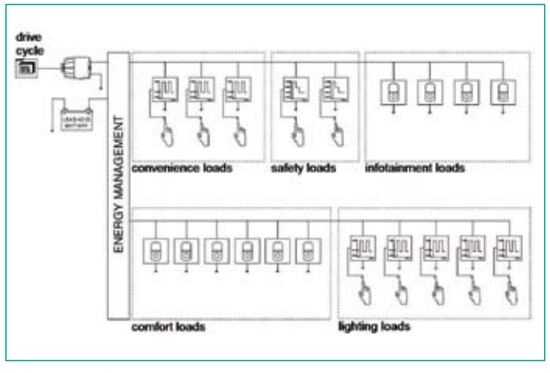


Figure 1: Typical vehicle powernet system integrating drive cycle and load switching profiles with energy management.

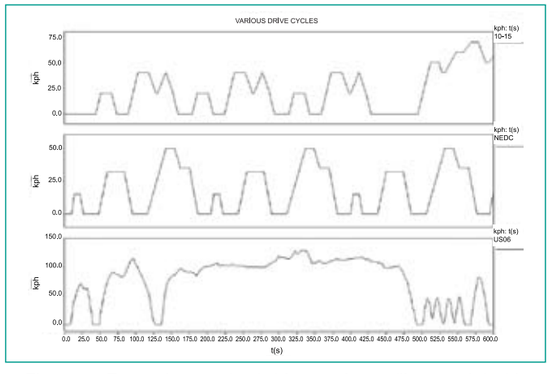


Figure 2: Example standard drive cycle profiles modeled in the Saber environment.

at lower cost and reduced schedule risk. Multi-technology simulators, such as the Saber® simulator from Synopsys®, Inc., give designers the tools, models, and analyses needed to create and analyse virtual powernet prototypes.

Drive Cycles

A drive cycle is a series of data points that represent a vehicle's speed versus time. Drive cycle patterns directly affect the performance of powernet systems, as engine speed determines how much energy the alternator can supply to drive electrical loads and charge the battery. Drive cycle profiles can be divided into two categories: transient and modal. A transient profile simulates stop-and-go driving where engine speed is constantly changing. During a transient drive cycle, the alternator is less apt to supply all of the electrical system's needs, as time constants in the system limit the ability of the alternator and its controller to respond to changes in energy demand. The system often depends, therefore, on the battery to handle peak energy requirements. A modal drive cycle, on the other hand, simulates extended driving at constant engine speed. If the engine speed is high enough, the alternator is better able to handle all electrical system energy demands. But if engine speed is low and energy requirements are high, the alternator will not be able to generate enough current and the powernet will again depend on the battery to supplement its energy needs. The ability of the alternator to meet powernet demands depends on engine speed, load requirements, alternator type, and temperature range. A properly sized alternator will meet the majority of system energy requirements, rely only briefly on the battery to meet peak demands and have enough excess energy to charge the battery. Figure 2 illustrates three of the many standard drive cycle profiles modeled in the Saber environment. Most drive cycle profiles are tailored for a specific geography.

Drive cycle testing begins by creating a baseline design, which includes the alternator, battery and all anticipated loads for the electrical system. System developers use this baseline design to determine appropriate sizes for the alternator and battery. A load balance analysis follows to analyse powernet loading effects and make certain the electrical system performs correctly under nominal conditions. With the baseline design established, drive cycle testing begins by adding profiles to the powernet so system dynamics can be analysed under transient and modal driving conditions.

Load Switching

Few loads in the vehicle electrical system are constant. Most are randomly switched on and off the network to adjust for driving conditions, driver comfort and seasonality. To get an accurate picture of powernet performance, design teams must analyse system loading within various drive cycles. Once the baseline design is complete and a drive cycle profile has been added to the virtual system, the remaining challenge is to coordinate load switching with the drive cycle analysis. Consider, for example, the effect driving season has on load switching and the electrical system's energy requirements.

Although drive cycle profiles are typically unaffected by changes in season, the seasonal effect on load switching profiles can be significant. Seasonality will determine which loads must be accommodated when the powernet is active. For example, a load switching profile for cold weather driving will typically turn on several heat related loads, whereas a profile for warm weather may simply activate an electric window or vent fan, or in hot weather, turn on the air conditioner.

Switching profiles must also account for the length of the drive cycle. The electrical load is generally greater at the beginning and tapers off as the cycle progresses. Under extreme conditions, it is possible for the electrical load to exceed 2kW early in a drive cycle, but eventually drop to well below 1kW. Vehicle start-up also puts an enormous strain on the powernet as the starter motor draws several hundred amps of current directly from the battery. Several minutes are required for the powernet system to compensate for this current draw and completely recharge the battery. To fully analyse powernet dynamics, design teams must integrate load switching with drive cycle timing. Some loads may have variable profiles with as many as three states: on, off, and sleep. Each state would draw a different level of energy from the powernet. Still other loads can be constant, speed dependent, or time dependent. With so many variables across a range of vehicle components, system developers must choose design tools that allow them to set load state and switch profiles for coordinating system loading with drive cycle timing. Design teams can then monitor and correct for the interaction between components across the system.

Energy Management

To ensure efficient powernet operation, design teams must focus on energy management to balance production with consumption. Finding the proper balance, however, is often a moving target as energy production and consumption vary with drive patterns and load switching. Recall that a powernet's ability to produce energy is markedly different between stop and go city and constant speed highway driving. Recall further that the amount of energy consumed not only changes with seasonality, but is typically higher at the beginning of a drive sequence. These factors combine to challenge design teams in managing powernet dynamics to ensure there is sufficient energy available for the electrical system.

When the nominal design is finished, energy management algorithms must be added to the system to match the generating capacity of the powernet to the load requirements. This includes the ability to regulate the voltage generated by the alternator, control the amount of energy remaining in and power taken from the battery, and switch system loads on and off as needed to ensure drive critical systems always have sufficient power to operate. The energy management system must also ensure the battery retains enough reserve energy to start the vehicle.

System Analysis

Using simulation to combine drive cycle with load switching profiles, designers can analyse powernet performance under different driving conditions long before a prototype vehicle is available for testing. Once the virtual prototype is assembled, design teams can integrate energy management algorithms

Special Report – Automotive Electronics Part II

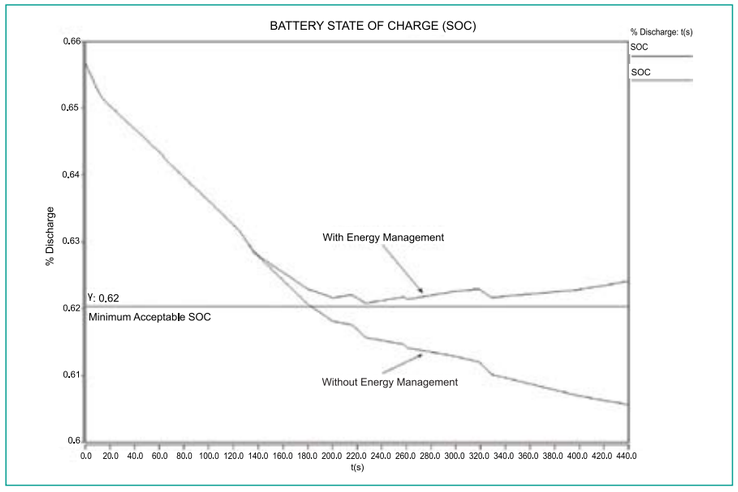


Figure 3: Battery state of charge with and without energy management.

to improve the system's ability to balance energy consumption with production. A typical task for an energy management protocol is to prevent the battery's state of charge from dropping below a set percent discharge, ensuring there is enough energy left in the battery to start the vehicle and maintain performance. Figure 3 compares the battery state of charge for an electrical system with and without integrated energy management.

Conclusion

Robust design methodologies help developers account for system and environmental variability during powernet development. Vehicle power network complexity requires that design teams use software tools and virtual prototyping techniques to develop and test the electrical system. Applying drive cycle and load switching profiles during system testing gives design teams a more thorough understanding of vehicle electrical system dynamics under a range of operational and environmental conditions. With the right tools, such as Synopsys' Saber simulator, designers can completely analyse power network dynamics long before a prototype vehicle is available for testing. The result is better system reliability, faster design turnaround and reduced development costs.

www.synopsys.com

PowerPack Power Systems Design

National Semiconductor

National Semiconductor embarks on a new tour of Power Design Technical Courses in 14 cities.

National Semiconductor is launching a new series of "Knowledge is Power" one-day technical courses on power management design in 14 cities throughout Europe and Israel between September 17th and October 11th, 2007. This course complements National's recently completed Power Seminars by focusing on tips and tricks for power supply designers working with switch-mode controllers, isolated power supplies, Power over Ethernet and LED lighting.

The training sessions will cover techniques, topologies and tools, accompanied by practical application examples, to address power supply design challenges.

For detailed information and registration, see **www.national.com/see/powercourses**

Texas Instruments

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

Linear Technology

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

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

To learn more: www.linear.com

Fairchild Semiconductor

Achieve 95% Efficiency with the Industry's Smallest, Fully Integrated 6A, 4V-Input Synchronous Buck Regulator

The FAN2106, a TinyBuck™ DC/DC buck regulator, integrates an advanced analog IC, MOSFETs and a boot diode into an ultra-compact molded leadless package (MLP). With a form factor of only 5mm X 6mm, the FAN2106 is the industry's smallest 6A, 24V-input synchronous buck regulator making it ideal for applications that need to conserve space such as set-top boxes, cable modems, in-cabin GPSs, notebooks, PCs and other portable applications.

To learn more: www.fairchildsemi.com/ds/FA/FAN2106.pdf

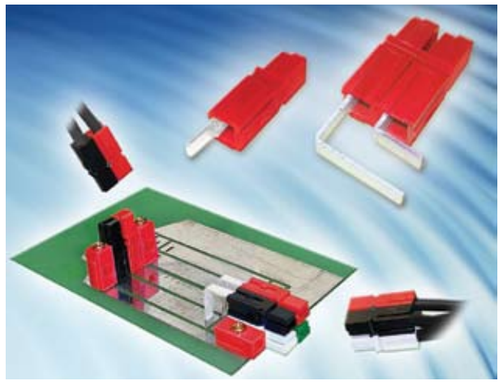
Microsemi

Designated the Thunderbolt HS IGBT Series, the new IGBTs are Microsemi's next generation of NPT technology targeting high switching frequency applications. These devices exhibit higher saturation voltage and significantly lower turn-off energy losses than previous generations. Low switching losses enable operation at switching frequencies over 100kHz, approaching power MOSFET performance but at lower cost. Thunderbolt HS IGBTs are available as single devices or packaged with a DQ Series fast, soft recovery diode.

An extremely tight parameter distribution combined with a positive temperature coefficient make it easy to parallel Thunderbolt HS IGBTs. Controlled slew rates result in high noise and oscillation immunity and low EMI. The short circuit duration rating of 10 microseconds makes these IGBTs suitable for inverter and motor drive applications. Reliability is further enhanced by avalanche energy ruggedness.

To learn more: www.microsemi.com

New 45 Amp PCB Connector and Contact Series for Automotive



Anderson Power Products® (APP) has announced a high power connector, ideal for applications such as automotive or computing that require high power connections to a PCB.

The new series may be pre-assembled in one or two row configurations, reducing assembly costs and eliminating accidental connector separation. Connectors and contacts are also available separately, allowing for customization of connector configurations.

When utilized with the APP Powerpole 15/45 Fingerproof connector housings, these products provide a reliable and safe wire to PCB connection. The connectors are RoHS compliant, have a UL rating of 45 amps per circuit and utilize contacts that are composed of copper alloy with tin plating. The connectors are available in a variety of colors and with multiple accessories that include mounting wings, spacers and board mounting staples.

www.andersonpower.com

Space-Efficient, 2mm x 2mm Green MLP Package Provides 45 Percent Improved Thermal Dissipation in Portables

Fairchild Semiconductor's FPF214X and FPF216X series of IntelliMAX™ advanced load switches feature superior thermal performance and full system protection for portable applications operating between 1.8V and 5.5V. Available in a 2mm x 2mm green-compliant MicroFETTM MLP package, this new series offers 45 percent enhanced thermal performance compared to traditional SOT-23 packages. These highly integrated advanced load switches simplify design, reduce component count and minimize board space by integrating a 0.11Ohm current-limited P-channel MOSFET with protection and control features, including thermal shutdown, controlled turn-on, reverse-current blocking and under-voltage lockout (UVLO).

"Fairchild's IntelliMAX integrated load switch solutions with higher current limits up to 1500mA and 2mm x 2mm MLP packaging offer critical protection features and thermal efficiency for small-form-factor power management designs," said Chris Winkler, marketing director, Low-Voltage Power Segment. "The latest portable applications, such as smart phones and integrated MP3/video media players, are packed with features that require additional battery-charging and auxiliary power supplied through a USB connector or other accessory interface. By integrating important functionality into an ultra-compact MLP package, these advanced load switches are ideal for today's new slimmer and lighter portable electronics."

These products utilize lead-free (Pb-free) terminals and have been characterized for moisture sensitivity in accordance with the Pb-free reflow requirements of the joint IPC/JEDEC standard J-STD-020. All Fairchild products are designed to meet the requirements of the European Union Directive on the restriction of the use of certain hazardous substances (RoHS).

Fairchild offers the industry's broadest portfolio of IntelliMAX advanced load switch solutions. These products provide a unique combination of protection and control features that reduce board space, component count and design complexity in power management designs. For more information about the FPF214X and FPF216X series and the entire IntelliMAX family of products, please go to:

www.fairchildsemi.com/intellimax

Energy-Efficient Torque Sensor For Electric Power Steering

Providing automotive design engineers with a non-contacting torque sensor designed for electric power steering systems, TT electronics has developed a steering sensor based on its proven Magnetorque® technology. The non-contacting steering sensor features dual phased outputs for reliable diagnostic characteristics.

According to Dan Sparks, vice president of the Automotive Business unit for BI Technologies Electronic Components Division, the Magnetorque technology is designed to track the relative positions of two steering shaft segments that are connected by a torsion bar. "Our design is unique in that it does not require the use of clock springs or slip rings to convey power and signal between rotating and non-rotating portions of the sensor. Magnetorque is a true non-contacting sensor technology," said Sparks. "Because of this feature, mechanical durability is extremely high."

Magnetorque sensors are programmable for gain and offset. At the time of assembly, customers can program the gain and offset values, allowing for adjustments to the mechanical tolerances in their system. This allows customers to use looser system mechanical tolerance resulting in cost savings and a more accurate system.

The Magnetorque® sensor has an accuracy of ±3% (±1.5% available) and hysteresis of 1%, with a rotational life of 25 million revolutions. Operating voltage is 5.0V (±10%), with a maximum current consumption of 10mA per output. Operating temperature range is -40°C to +125°C.

The Magnetorque sensor can be integrated into a single package with BI Technologies' digital angular position sensor (DAPS) technology. This provides a torque and position signal in one convenient space saving package. Integrated connector and lead wire options are also available.

www.bitechnologies.com/products/sensors.htm

Two New Configurable Dual Phase PWM Control ICs for High Performance Synchronous Buck DC-DC Converters

International Rectifier has introduced two dual channel synchronous buck control ICs with integrated high performance drivers for medium- to high-current point-of-load (POL) buck converters used in networking, computing, and communications systems.

The IR3622MPbF and IR3622AMPbF can be configured to support a single output in current share mode, capable of delivering up to 80 amperes, or to support two independent outputs. The independent channels run 180 degrees out of phase, and reduce the required input capacitance requirement.

A significant reduction in output ripple voltage is achieved in single output mode.

The IR3622MPbF targets 12V single input applications while the IR3622AMPbF can support 5V and 12V applications. Key protection features include selectable hiccup or latched current limit, pre-bias start-up, thermal shutdown protection, and under- and over-voltage protection.

The devices feature a programmable switching frequency up to 600 kHz to reduce input and output filtering requirements, and minimizing the size and number of external filter capacitors and inductors needed. Available in a 32-lead MLPQ package, the new ICs also feature two independently programmable soft-start functions to allow system level sequencing of output voltages in various configurations critical for system level start-up.

The IR3622 family is well suited to multi-rail applications that require sophisticated power-up and power-down tracking and sequencing of multiple rails by offering a combination of track, sequencing, enable, and "power good" output features that can be used to trigger a sequential rise of output voltages across multiple POL converters.

Data sheets for the devices are available on the website at www.irf.com. Also, two reference designs are available: the IRDC3622S for single output (dual phase) and the IRDC3622D for dual output. More information on these reference designs and the associated online simulation tools is available at:

mypower.irf.com

Low-Cost WLED Drivers Help Handset Manufactures Address Entry-Level Markets

A huge potential market of untapped cell phone users in regions like India, China, Russia, South America and Africa want cell phone service, but can only afford very basic, entry-level, reduced-feature-set phones. With AnalogicTech's AAT3193, designers building cell phones for these new markets can provide basic illumination for low-cost TFT-LCD panels in an extremely small footprint while requiring just two external components; a 1µF capacitor for the charge pump and a single external resistor to set the full-scale LED current.

The AAT3193 is the first in a family of two and three channel charge pump-based WLED drivers. Targeted at a new generation of highly affordable handsets, these new devices offer excellent performance in an extremely space-efficient 2x2mm package.

The AAT3193 does not sacrifice performance and drives up to three LEDs at up to 30mA each to support the illumination of lower cost, monochrome and highly opaque TFT-LCD panels. The next member in the product family, the AAT3192, will drive two LEDs. Both devices offer part-to-part current accuracy better than 10 percent and channel-to-channel current matching better than 3 percent. These charge pump-based devices automatically switch between 1x and 2x mode to maximise efficiency and to minimise the number of external components required.

Using the AAT3193, each LED can be programmed either using traditional linear PWM techniques or via AnalogicTech's proprietary, patented single-wire S^2Cwire interface. Designers using the S^2Cwire interface can program each WLED up to 30mA each in 16, 8 or 4 steps. The device also features integrated thermal protection and automatic soft start.

The AAT3193 is qualified across the -40 to +85 degrees C temperature range and comes in a Pb-free, 10-lead, 2x2-mm SC70JW package.

www.analogictech.com

New Eighth Bricks Feature Up to 93% Efficiency

Emerson Network Power has launched four Artesyn eighth-brick dc-dc converters featuring second-generation power conversion topology that provides up to 93% full load efficiency. The latest additions to the Artesyn LES series of converters offer designers a choice of 22A @ 2.5V, 20A @ 3.3V, 13A @ 5V and 6.7A @ 12V.

All four converters feature a wide input voltage range of 36 to 75Vdc, making them ideal for use with telecom-standard 48V supplies, and are fully protected against input voltage transients of up to 100V for 100ms. The converters' outputs can be adjusted from 90% to 110% of nominal, using an external trim resistor. Design-in flexibility is further enhanced by the fact that the converters have no minimum load requirement, and provide a true monotonic start-up characteristic under both normal and pre-biased load conditions. The converters have a typical start-up time of 20ms when driving a resistive load, and feature differential remote sense and remote on/off facilities as standard.

In common with all Artesyn LES series eighth-brick dc-dc converters, the latest models have an industry-standard 58.4 x 22.9mm footprint, which is 38% less than conventional quarter bricks, and are based on an open-frame, single-board package. The new models are available in both through-hole and surface-mounting configurations, and use surface-mount components and planar, in-the-board transformer structures to help minimise profile, allowing the installed height to be kept to just 8.1mm. This exceptionally low profile means that the converters are suitable for applications involving very tight inter-board spacing, such as latest-generation telecom switches and high-end servers. The converters' pin-out is identical to standard quarter-brick converters, facilitating drop-in replacement.

The converters are specified for operation over an ambient temperature range of -40 to +85 degrees Celsius. Standard features include under-voltage lockout and non-latching over-voltage protection, as well as protection against short-circuit and over-temperature conditions, with automatic recovery. The converters carry a full set of international safety approvals, including EN60950 TUV and UL/cUL60950.

www.emersonnetworkpower.com

Companies in this Issue

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

EU Keeps Duty on Light Bulbs

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

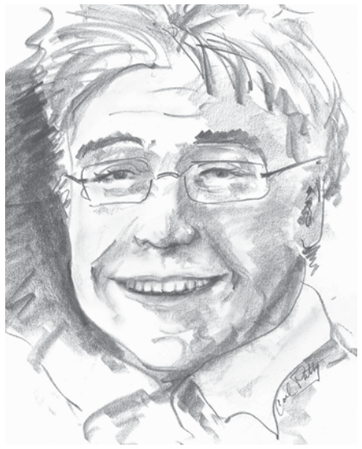
One wonders how much politics plays a part in Europe's 'green' activities. Always a sceptic, I have reported in past issues on the reasons for corporations to readily jump onto the 'green bandwagon'. Here follows an interesting recent report.

According to Jennifer Rankin of 'The Scotsman' online newspaper reporting from Brussels, the European Commission is under fire from green campaigners and retailers for plans to extend duties on energy-efficient light bulbs from China. These Chinese light bulbs have been subject to import duties since 2001, because the commission says the products are sold in EU markets for less than their true value.

EU commissioners have met in Brussels and agreed to keep tariffs of 66% in place, despite calls from green campaigners to bring down the price of energy-efficient light bulbs to encourage consumers to make 'greener' choices.

Johannes Laitenberger, a spokesman for the commission, said it was in the "overall community interest" to keep the tariffs in place to help European manufacturers to adjust to "a changing market reality".

The proposal must be approved by member states in September, but commission officials think it will be passed.



Environmental groups have slammed the decision as being inconsistent with the European Union's targets to improve energy efficiency and lead the world in tackling climate change.

Experts at the European office of the Worldwide Fund for Nature (WWF) estimate a faster take-up of energy-efficient light bulbs could save 23 million tonnes of carbon per year, the equivalent of 0.5 per cent of the EU's greenhouse gas emissions. Earlier this year, European leaders agreed to phase out ordinary bulbs as part of ambitious plans to cut greenhouse gas emissions by 20 per cent by 2020, compared with 1990 levels. The switch to energy-efficient bulbs will be a major shake-up for industry.

Around 270 million energy-efficient bulbs are sold each year, compared with two billion ordinary (incandescent) light bulbs. Energy-efficient bulbs are three to six times more expensive than ordinary ones, although they last five times longer. Both Philips and General Electric, two electronics giants, wanted restrictions lifted. They argue that Europe needs cheap energy-efficient bulbs from China to meet growing demand. However, Osram, a German company, opposes ending the duties.

While a majority of member states were amenable to scrapping anti-dumping measures, Germany has lobbied hard to keep the restrictions in place for longer. Speaking on behalf of the British Retail Consortium, Alisdair Gray said the proposal to extend anti-dumping measures was unjustified.

"We are really disappointed in it, because it has no basis in law; it's just caving in to one company, Osram," he said.

I shall be following up here to see what lies behind many of the decisions made for Europe, as well as the business rationales behind them. It is no longer, I feel, just a question of what is 'green and right', but of what threat is posed by such moves to existing businesses.

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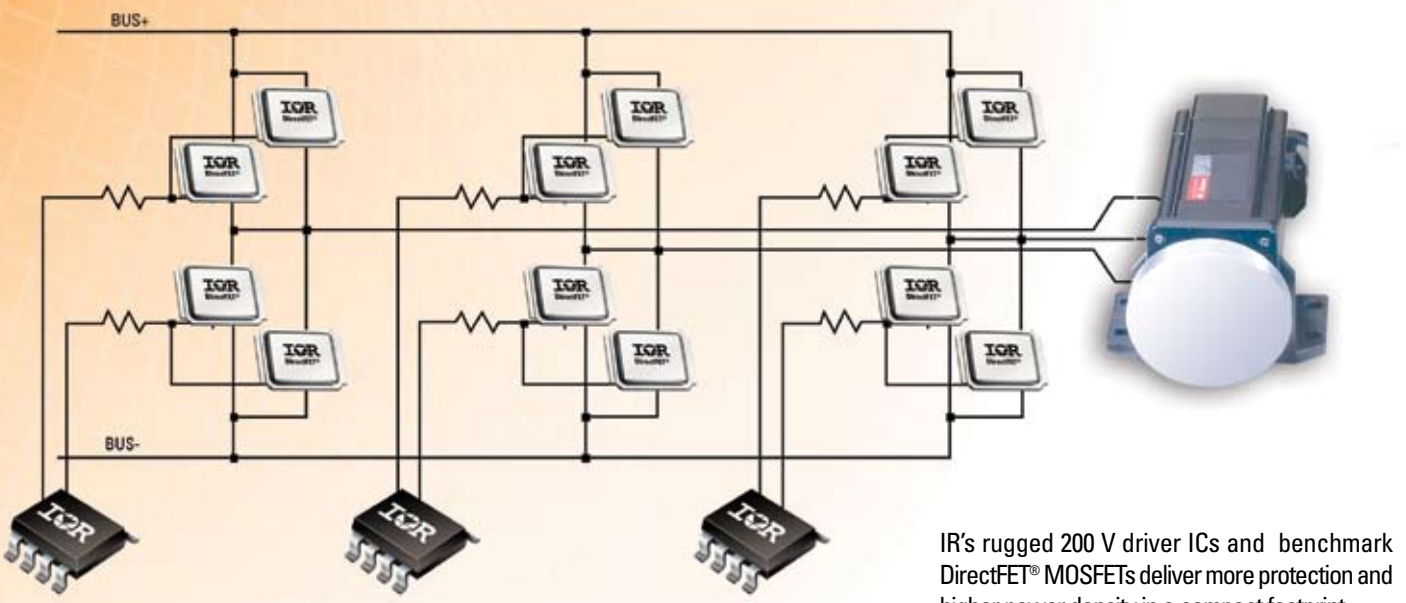

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- High-side circuitry powered by bootstrap power supply
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200 V Driver ICs

Part	Package	UVLO	Compliance	Typical Current	Input Logic	Additional Features
IRS2001PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	HIN, LIN	Independent high & low side drive
IRS2001SPBF	SOIC8 Bulk					
IRS2001STRPBF	SOIC8 Tape & Reel					
IRS2003PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	HIN, LIN/N	Deadtime
IRS2003SPBF	SOIC8 Bulk					
IRS2003STRPBF	SOIC8 Tape & Reel					
IRS2004PBF	DIP8	UVLO, VCC	RoHS & PBF	290 mA / 600 mA	IN, SD/N	SD Input & deadtime
IRS2004SPBF	SOIC8 Bulk					
IRS2004STRPBF	SOIC8 Tape & Reel					

DirectFET MOSFETs

Part	Package	Polarity	VBRDSS (V)	$R_{DS(on)}$ 4.5 V Max. (mΩ)	$R_{DS(on)}$ 10 V Max. (mΩ)	I_D @ TC = 25° C (A)	Qg Typ	Qgd Typ	$R_{th(JC)}$	Power Dissipation @ T_C = 25° C (W)
IRF6635	DirectFET	N	30	2.4	1.8	180	47.0	17.0	1.4	89
IRF6613	DirectFET	N	40	4.1	3.4	150	42.0	12.6	1.4	89
IRF6648	DirectFET	N	60		7.0	86	36.0	14.0	1.4	89
IRF6646	DirectFET	N	80		9.5	68	36.0	12.0	1.4	89

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