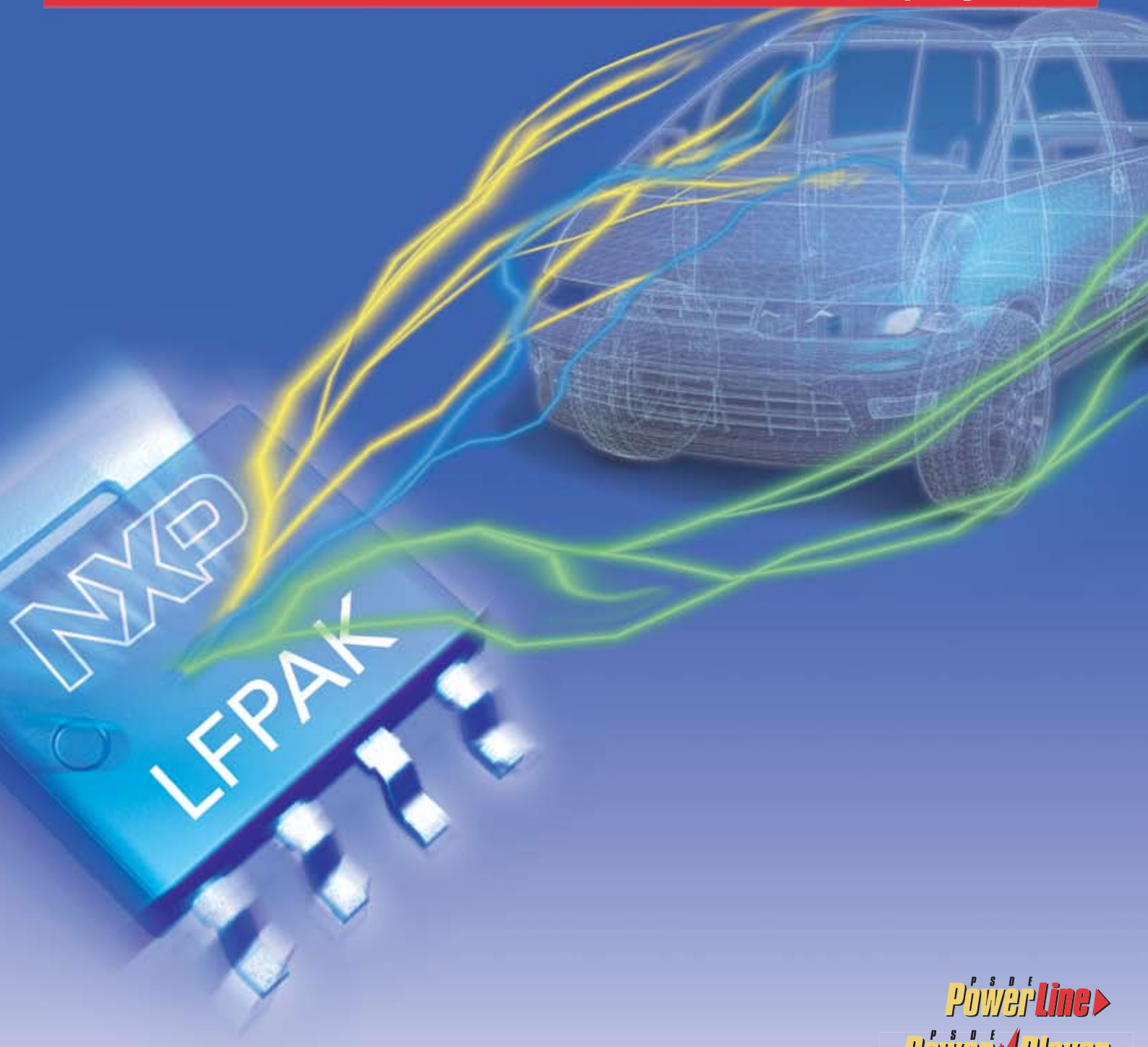
Power Systems Design EUROPE

Empowering Global Innovation

July/August 2007



PSDE PowerLine

PSDE PowerPlayer

MarketWatch

TechTalk

Design Tips

PSDE GreenPower
ENERGY EFFICIENCY

Special Report - Automotive Electronics Part I

ISSN: 1613-6365

Power Systems Design EUROPE


Dilbert – 60

Power Systems Design Europe

AGS Media Group
146 Charles Street
Annapolis, Maryland 21401 USA
Tel: +410-295-0177
Fax: +510-217-3608
www.powersystemsdesign.com

Editor-in-Chief
Cliff Keys
cliff.keys@powersystemsdesign.com

Contributing Editors
Liu Hong
Editor-in-Chief, Power Systems Design China
powersdc@126.com

Marijana Vukicevic, isuppli Corporation
mvukicevic@isuppli.com

Dr. Ray Ridley, Ridley Engineering
RRidley@ridleyengineering.com

Publishing Director
Jim Graham
jim.graham@powersystemsdesign.com

Publisher
Julia Stocks
julia.stocks@powersystemsdesign.com

Advertising Director, PowerPack Products
Cathy Schmidt
cathy.schmidt@powersystemsdesign.com

Circulation Management
Kathryn Ferris
kathryn.ferris@powersystemsdesign.com

Research Director
Meghan Corneal
meghan.corneal@powersystemsdesign.com

Magazine Design
Beata Rasmus, Eyemotive
beata@eyemotive.com

Production Manager
Abby Wang
abbyw@action-new.net

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Send address changes to:
circulation@powersystemsdesign.com

Volume 4, Issue 6

Summer is here…

The European family-holiday period is now still in full swing and many of us zooming out to exotic climes to get our well-deserved two weeks or so of 'rest and relaxation', normally consisting of either searing heat or wet and windy conditions with irritable kids making life anything but restful and relaxing for their beleaguered parents.

The nagging worry about that urgent project back at work which, miraculously, reached a critical phase just as your time-slot in the firm's holiday calendar came up. And exhausted from the pre vacation drive to leave things in good shape, it is a tough time for engineers. It doesn't get much better when you think of the mess you may come back to sort out after the said 'rest'.

Every year, we take it in our stride, I know, but there must be a better way. Tell me about yours.

This summer issue sees a fruitful set of press conferences covered. I had the pleasure of attending a new power electronics facility opened by PULS Power in Chomutov which is north of Prague. It was very gratifying to see manufacturing and production moving within Europe.

Inside this issue I also report great new products from Micrel and Mitsubishi and a whole armful from National. The next few weeks look to be much the same, so much so that we are launching a new 'On the Road' section to cope with the enthusiastic press conference and meeting content from power companies in Europe.

Unusually, here is a great deal of news coming in this summer with many industry and product related announcements, a lot of promotional activity too. Sometimes, there is just too much for us to cover in depth. To make sure this news gets the chance it deserves, my publisher is launching a new channel of communication titled, ePowerPack, to help manufacturers to get their new product information out for the benefit of our readers. More detail on this new service is available on our website.

The automotive theme we have taken for this and the September issue has certainly produced a rich crop of features leaving me in no doubt as to the state of health of our industry in this sector. With the transition from mechanical to electro-mechanical to purely electronic control in almost all automotive components, this looks to be big business. But combine this with the tidal wave of energy conservation and legislation awareness fuelled by the popular and technology media, the role played by the power industry increases to truly monumental proportions.

The green issue continues to gain momentum and I'd like to point you to the back of the magazine (but please read the rest!) to check out our observations here together with a new 'team member'. On these issues I'd really like your own observations and views on the escalating green campaigns launched almost daily by companies. I'd particularly like to get a better 'inside view' of what's happening in the professional IT industry where the green issue has recently been widely reported.

I wish you all that well-deserved break if you haven't yet taken it and would be very interested to hear your views on the industry, legislation, the magazine or more of your particular innovative project solutions.

All the best!

Cliff Keys.

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

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Publisher
Julia Stocks
julia.stocks@powersystemsdesign.com

Advertising Director, PowerPack Products
Cathy Schmidt
cathy.schmidt@powersystemsdesign.com

Circulation Management
Kathryn Ferris
kathryn.ferris@powersystemsdesign.com

Research Director
Meghan Corneal
meghan.corneal@powersystemsdesign.com

Magazine Design
Beata Rasmus, Eyemotive
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Abby Wang
abbyw@action-new.net

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All the best!

Cliff Keys.

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

Ansoft Ranked Among Fortune Small Business Magazine's 100 Fastest-Growing Small Public Companies

Fortune Small Business magazine has ranked Ansoft Corporation 29th on its annual FSB 100 list of fastest-growing small public companies.

"It's an honour to be included among the FSB 100," said Nicholas Csendes, Ansoft's president and CEO. "Ansoft's ongoing innovation in the high-performance electronic design software market and its unwavering commitment to customers and shareholders are the driving forces behind our continued growth."

Fortune Small Business ranks the top 100 public companies with annual revenues of less than $200 million and a stock price of more than $1, basing selections on percentage growth in earnings, revenue and stock performance over the past three years.

www.ansoft.com

Avago Acquires Infineon's Fiber Business

Avago Technologies adds solid expertise on automotive, industrial, home networking and mobile device technology to its polymer optical fiber group by its acquisition of Infineon Technologies AG's Polymer Optical Fiber (POF) business unit based in Regensburg, Germany.

With the integration of Infineon's POF group, Avago Technologies essentially doubles its investment of resources in R&D for automotive, industrial and home networking product lines, as well as in emerging markets like optical links for mobile devices. Additionally, Avago has resources in place to continue to support and grow market share in all areas targeted by Infineon's POF group.

"This strategic acquisition is in line with Avago's goal of increasing the value of our overall business in the four key end markets we serve," said Fariba Danesh, General Manager and Vice President of Avago's fiber optic products division. "It opens up opportunities for Avago's other product divisions and enables us to continue a leadership role in standards development in the optics space. We are pleased to welcome the team from Regensburg to Avago."

www.avagotech.com

Zetex appoints Özdisan for Turkey

Pictured left to right: Mustafa Yurttas, Director, Özdisan, Renate Maehner, Distribution Manager, Zetex, Okan Abdi, Sales and Marketing Manager, Özdisan, Gurkan Akcay, Deputy Sales Manager, Özdisan and Frank Marx, Chief Sales Officer, Zetex.

Zetex Semiconductors has added Özdisan, Turkey's leading distributor of active and passive components, to its global distribution network. Özdisan will provide local stocking and design-in support for the Zetex range of power management and LED driving products.

Frank Marx, Chief Sales Officer at Zetex Semiconductors said, "With more than 26 years experience of the Turkish electronics sector, Özdisan's knowledge of its local market is second to none. They clearly strengthen our presence in the country and we're delighted to have them on-board."

Mustafa Yurttas, Director of Özdisan commented, "The Zetex product range is highly complementary to our existing product portfolio and we're confident we can provide Zetex customers with just the right combination of product availability and technical know-how."

www.zetex.com

Digi-Key Announces Expansion of Infineon Technologies Product Line

Digi-Key Corporation has announced the broad expansion of its Infineon Technologies product offering to include Infineon's power semiconductors as well as discretes, sensors, wireless control products, communication ICs and microcontrollers.

As top supplier of power semiconductors, Infineon provides Digi-Key with power products ranging from MOSFETs, protected switches to Power ICs and diodes.

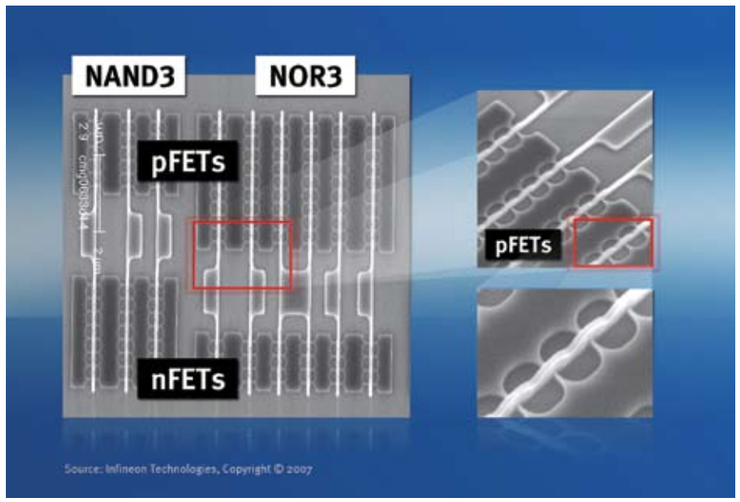
Within the Infineon microcontroller (MCU) family, Digi-Key now offers the XC166 and C166 16-bit, XC800 and C500 8-bit, and TriCore 32-bit families of MCUs. The XC166 family with pipelined 16-bit core architecture, optimized with real-time embedded control peripherals, offers a wide range of performance variations. The new and advanced XC800 family of 8-bit microcontrollers offers a wide selection of products, combining a high performance 8051 core with on-chip flash and ROM memory as well as a powerful mix of peripherals such as an enhanced CAPCOM (CC6), CAN, LIN and 10-bit ADC. The TriCore is the first unified, single-core, 32-bit microcontroller-DSP architecture optimized for real-time embedded systems. The TriCore Instruction Set Architecture (ISA) combines the real-time capability of a microcontroller, the computational power of a DSP and the high performance/price features of a RISC load/store architecture in a compact reprogrammable core. A wide range of products scalable in performance, memory and peripherals will make it easy for design engineers to best fit their application.

Featured in Digi-Key's print and online catalogs, these and hundreds of other products stocked by Digi-Key are available for immediate shipment and comprise one of the industry's largest inventories of Infineon products.

www.digikey.com

www.infineon.com

Infineon Scores A Major Technological Breakthrough - Innovative Semiconductor Structures Greatly Improve Energy Efficiency



Here is a critical path circuit as reference to µ-controller. It contains some 10.000 devices and integrates flip-flops and stacks (NAND/NOR) with high fan-out.

Infineon researchers have unveiled a new transistor architecture that removes many of the barriers to the production of smaller, more powerful electronic devices and circuits. Known as multi-gate field-effect transistor technology, these transistors are part of Infineon's energy-efficiency performance goals. Integrated multi-gate transistors can offer compared to today's 65nm transistors a more than 10 times reduction in off current and a 50% reduction in transistor switching power. Infineon's researcher have demonstrated as the first to integrate multi-gate transistors with enhanced high-k gate dielectrics and metal gate in highly complex digital circuits with record switching speed, leakage power and switching power efficiency.

Unlike today's commonly used two-dimensional, planar standard technology, multi-gate field-effect transistors are three-dimensional.

Active multimedia like games and videos need high processing speeds, but they also cause power consumption to increase rapidly. In some cases, this can drain device batteries in less than an hour, to the disappointment of users. At the same time, stand-by power consumption in today's mobile phones can increase threefold if the ambient temperature rises. Infineon's new architecture prevents this and radically improves the energy efficiency. Batteries would last twice as long during active operation, and in stand-by mode the digital baseband processor would consume 10 times less power. Infineon will continue to explore the new manufacturing process, which could be ready for use as a basic technology in mass production sometimes beyond the 32nm technology node, partially in connection with its participation in the core partner program at IMEC (Interuniversity Micro Electronics Center, Leuven, Belgium), the European Research Center.

www.infineon.com

National Runs Power Design Technical Courses 'KNOWLEDGE IS POWER'

National Semiconductor is running a new series of its highly acclaimed and industry respected one-day Power Design Technical Courses covering 14 European cities from September 17 to October 11, 2007.

The courses, developed for engineers involved in power projects, will cover all major aspects of power design and support tools with sessions run by top level engineers from National, Coilcraft and the Power faculty of the University of Salerno, Italy.

A nominal registration fee secures a place.

www.national.com/see/powercourses

Date	Location
9 Oct.	Te l Aviv, Israel
17 Sept.	Munich, Germany
18 Sept.	Stuttgart, Germany
19 Sept.	Zurich, Switzerland
20 Sept.	Copenhagen, Denmark
24 Sept.	Bracknell U.K.
25 Sept.	Manchester U.K.
26 Sept.	Paris, France
27 Sept.	Vienna, Austria
1 Oct.	Eindhoven, The Netherlands
3 Oct.	Verona, Italy
4 Oct.	Milan, Italy
2 Oct.	Barcelona, Spain
11 Oct.	Stockholm, Sweden

Ridley Engineering Brings Power Supply Design Laboratory Workshops to Europe

Ridley Engineering brought its highly successful four-day Power Supply Design Workshops to Europe in June 2007. The venues for these sold-out events were Bordeaux, France and Munich, Germany. Over 300 kilograms of laboratory equipment, shipped from the US, gave attendees the opportunity to build their own custom magnetics and power supplies.

"This course is going to shave months from my development time, and I highly recommend it to anyone." – Dr. Ali Shirsavar, University of Reading, England

"Excellent course. Incorporates all subjects from basic theory to more complicated topics in an easy, uncomplicated manner. – John Constantopolous, Texas Instruments, Germany

"The best and most useful workshop I have ever participated." – Michel Guenego, Areva T&D, France

"Despite a very high level, Dr. Ridley explains very clearly." – Alain Lafuente, Wurth Elektronik, Germany

A wide variety of industries and countries were represented at the workshops including:

AMI Semiconductor, Belgium; AMI Semiconductor, Czech Republic; Arcelik A.S., Turkey; AREVA T&D, France; Baker Hughes INTEQ, Germany; Barco N.V. Div View, Belgium; Cambridge Semiconductor, UK; Crane Aerospace, UK; Dionex Softron GMBH, Germany; ECI-Telecom, Israel; Eltam EH, Israel

Endress + Hauser, Germany; GE Energy, Sweden; Honeywell, Germany; Infineon Technologies, Italy

International Rectifier; National Semiconductor, Germany; Nokia, Denmark; Otis, Germany; OZAS - ESAB, Poland; Sedecal SA, Spain; Serco FM BV, The Netherlands; Siemens VDO, Germany; Smiths Aerospace, UK; Somfy SAS, France; Texas Instruments, Germany; University of Reading, UK; Vacuumschmelze, Germany; Whirlpool Europe, Italy; Wolfson Microelectronics, UK; Wurth Elektronik, Germany; and Xcel Power Systems, UK.

An additional European workshop is scheduled for early Fall 2007, and in the US in November. For details regarding content and upcoming venues, or call +1 770 640 9024 or visit:

www.ridleyengineering.com/workshop

ST Licenses Leading-Edge Smart Power Process Technologies to Bosch

STMicroelectronics has signed an agreement with Bosch in which the world's leading automotive electronic systems company will license ST's state-of-the-art BCD8 process technology, enabling Bosch to design and manufacture highly integrated automotive products using this leading-edge technology in its own wafer fabrication plant.

BCD8 (Bipolar-CMOS-DMOS) is the most recent implementation of ST's proprietary smart-power technology, which allows analog, digital and power circuits to be integrated on a single chip. This exceptional level of integration will deliver important benefits to Bosch's automotive systems in lower costs, increased reliability and more compact packaging.

Bosch is expected to make use of the new technology across the wh ole range of engine management, transmission control, occupant protection, chassis system and other applications. The HVCMOS8 high-voltage CMOS technology that ST is also licensing to Bosch, is typically used in applications such as sensor interfaces and analog processing.

"This extension of our 20-year partnership with Bosch is a demonstration of confidence in our leading-edge technologies, and we look forward to continuing to work with them on the world's most advanced automotive systems," said Ugo Carena, Corporate Vice President and General Manager of ST's Automotive Product Group. "As the worldwide automotive leader, Bosch has an outstanding reputation for quality in the industry."

According to iSuppli*, ST is the largest supplier of automotive application specific chips (ASICs/ASSPs), which include devices based on its BCD technology, and the third largest microchip supplier overall to the automotive industry. ST is also the leading provider of the power-management chips that handle the complex electrical power demands of today's increasingly sophisticated vehicles, and it counts all of the top-ten automotive OEMs in the world among its major customers.

The automotive market challenges the semiconductor industry through the severity of its price/performance demands. High volumes and intense competition make it extremely price-conscious, while its operating environment is especially hostile: ambient temperatures from -40 to +150°C, high energy transients, accidental battery reversals, and high levels of vibration.

www.st.com

Texas Instruments to Integrate a "High-K" Value Material in Transistors

Texas Instruments has announced plans to integrate a "high-k" value material within the transistors in its most advanced, high performance 45-nanometer (nm) chip products. For years, high-k dielectrics have been under consideration to address leakage, or power drain, which has become increasingly problematic as transistor dimensions continue to shrink.

Through its approach, TI will reduce leakage by more than 30 times per unit area as compared with commonly used silicon oxide (SiO_2) gate dielectrics. In addition, TI's high-k choice offers the compatibility, reliability and scalability to continue delivery of high volume, high performance and low power semiconductor solutions through the 45-nm and 32-nm process nodes.

"TI has been at the forefront of Hafnium-based research and development for nearly a decade, and we're confident that our high-k choice overcomes the technological hurdles faced through continued digital CMOS scaling and the transition to smaller process geometries," said Dr. Hans Stork, chief technology officer, Texas Instruments. "By moving forward with high-k at 45-nm, TI continues its commitment to deliver high performance, low power and cost-effective products to our customers."

www.ti.com

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*

Wide Input Voltage Range DC-DC Converters Designed for Extreme Environments

When a design is headed for implementation in automotive applications, the rules of the game are known to be tough. But when the design is for an environment where conditions are known to be the worst one can find and where human life is dependent on the survival of the power systems under these conditions, the components selected by the designer need to be best-in-class.

XP Power, a leading provider of power solutions, including AC-DC power supplies, DC-DC converters. XP offers in-house design through to manufacturing facilities around the world. The company has just announced availability of a brand new series of rugged isolated dc-dc converters for the harshest of environments. The MQP120 range has been specifically designed for systems that need to be powered from both 12VDC, 24/28VDC electrical supplies. The unit is ideally suited to ruggedized or military equipment that could be deployed in both army and commercial vehicles, such as those used for emergency aid or security initiatives. The converter accommodates a wide range of input voltage, from 9 to 40VDC, and is rated to 120W. Five standard output options are available, giving voltages of 3.3, 5, 12, 15 and 24VDC.

The MQP120 is fully encapsulated, making the unit highly resistant to the effects of dust as well as severe and continuous vibration and shock. The unit is compact, being just 95 x 11.5 x 65mm (3.74 x 0.45 x 2.56 inches), and has a high power density of 26.7 watts per cubic inch. The unit has an operating temperature range of -40°C up to a baseplate temperature of +100°C. An optional heatsink is available to simplify thermal design should cooling via the baseplate prove insufficient.

Typical systems that might use the MQP120 series include communications, sensors and guidance systems on military platforms. An example system is that of an imaging sensor, which needs to be powered from a 28VDC supply when used in a military vehicle but from 12VDC when used in a commercial SUV.

The MQP120 series can meet military standard, MIL-STD 461 for electro-magnetic immunity and MIL-STD 1275A-D for electrical immunity. An application note is available from XP Power that describes how a design engineer can achieve compliance with these very tough specifications.

www.xppower.com

Models and Ratings — **MQP Series**

Output Voltage	Output Current	Typical Input Current (Full Load/Min Input)	Efficiency	Max Output Power	Model Number[1]
3.3 VDC	17.6 A	6.6 A	77%	60 W	MQP120248V3
5.0 VDC	15.6 A	10.5 A	80%	80 W	MQP120248S5
12.0 VDC	7.9 A	13.5 A	80%	95 W	MQP120248S12
15.0 VDC	7.0 A	14.0 A	81%	105 W	MQP120248S15
24.0 VDC	4.8 A	15.0 A	82%	115 W	MQP120248S24

Notes
1. For integrated heatsink models add suffix 'H' to model number.

PSDE Power Player

PSDE Green Power ENERGY EFFICIENCY

Current Sensing - Saving Energy with Accuracy

By Hans Dieter Huber, Vice President, Industry, LEM Components

The sensor market today has two main technology drivers. Firstly, the desire for a greater degree of comfort and finer regulation. For example, in air conditioning units, inverter control significantly improves the performance for temperature regulation and reduces the noise of the system.

Secondly, the overwhelming need to save energy. This means that more and more applications that used to be mechanical are changing to full electronic control which provides increased reliability, improved regulation and more energy efficiency. Today only 15% of all motors have an inverter control. This control can save 50% of the total energy consumed, which is a huge potential for savings.

The inverter control used in these newer systems requires reliable, accurate current measurement to enable engineers to develop a system with isolated current measurement directly on the motor phases. This significantly reduces the complexity of programming in comparison to a measurement without isolation on the DC link. The measurement directly on the motor phase enables better performance to be achieved in terms of torque (fewer ripples) or speed Some emerging applications also require a very compact sensor which, in many cases, needs to be mounted automatically on a printed circuit board production line.

At LEM we are finding that our customers not only require an optimal solution to accurately measure the current in their applications, but that they are also looking for a current measurement solution which brings added value to the final application and give an edge to their competitive environment. This requires the smallest current transducer possible providing the best performance in accuracy and the ability to be easily integrated and linked with remaining electronic components, such as microcontrollers.

In addition, they are constantly looking for new ways of achieving even more cost reductions and further improving functionality. This drives the trend is towards smaller, higher performance transducers that are at the same time low cost. The challenge to manufacturers of sensors, such as LEM, is to be able to deliver this globally at a very high quality and service level.

We have developed a fully fledged current transducer incorporating magnetic concentrators into an SO-8 package. This very small component, called Minisens, provides an accurate solution to these industry requirements for direct and isolated current measurement in applications where this was not previously feasible and was, historically, the domain of the shunt.

Minisens is based on an ASIC that is designed in-house. These ASICs are designed specifically for current measurement, to optimize electrical performance.

There were 3 main challenges that we faced during the development of this solution.

The development of the ASIC itself (electronics + Hall element) in order to achieve the best performance in terms of offset, dv/dt and gain drift. A calibration in the product allows us to minimize this drift to achieve the highest accuracy in the temperature range that customers now demand from sensor manufacturers.

The development of a magnetic concentrator to achieve the high sensitivity required to measure several differing current ranges and the sourcing of suitable materials and finally, the ability to control the process integrating all necessary elements into the tiny SO8 package.

We are also able to provide some new enhancements that are not part of the usual current measurement methods – such as a faster output for short circuit detection or a standby mode and have also made a major move forward in the degree of integration and reduction in size.

As these devices are housed in a standard chip package (3.9 x 4.89 x 1.62mm), they can easily be mounted on PCBs in automated manufacturing processes.

For the future needs of the industry, we see major developments coming from two main areas.

Miniaturization: LEM started developing the first ASIC to be integrated into our products about eight years ago. This IP has allowed us to develop the Minisens and we will continue working on products with ASICs that will become even more precise and at the same time remain very small.

Performance improvement: Customers demand the best solution for all the many applications in the industry worldwide. The sensor business needs to keep up or even anticipate this. LEM remains in close collaboration with its customers and their applications to be able to react quickly to the market requirements and to maintain market leadership position in the sensor industry.

www.lem.com

HEVs Power Forward in Automotive Industry

Powerful impact anticipated on power management semiconductor market

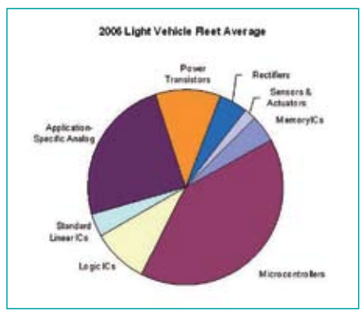
By Marijana Vukicevic, iSuppli Corporation

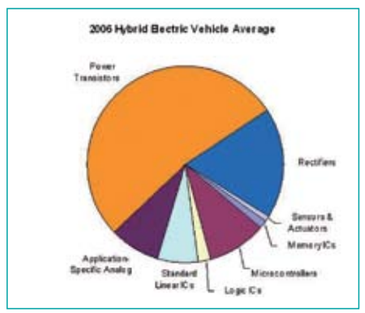
Hybrid Electric Vehicles (HEVs) are one of the most exciting applications for power management semiconductors. There are few other new applications on the horizon with as much hope or hype attached to them. Given the size and the diversity of the power management market, the rate of growth in power management systems and semiconductor markets is making it an exciting time for OEMs and chip vendors.

Worldwide shipments of hybrid light vehicles are increasing every year with projections of more than 100 percent growth year-over-year for the past several years. This has been a nice ride for the semiconductor companies involved in a food chain and in the United States — the largest market for automobiles in the world — more than 83,000 new registrations of HEVs were reported in 2004, an 81 percent increase over 2003. Clearly, hybrid vehicles have moved from curiosity to the mainstream.

In light of the last few years' tremendous growth, a large market in the future is assumed, and manufacturers are scrambling for a position in the HEV market. In fact, hybrids are in the very early adoption phase — despite their high growth, they are still in low single digits of vehicle production — and tremendous barriers to a robust, widespread adoption of HEV technologies remain. The various growth projections offered to the market thus far vary wildly, and the corresponding potential impact on the power semiconductor market could be anywhere from mildly significant to nearly overwhelming.

Approximately 6.4 percent of total semiconductor market is contained in automobiles. This percentage has in recent years been fairly constant, with steady increases in electronic content in cars being somewhat offset by equally steady reductions in component costs. In 2006, the automotive semiconductor market ended with more than $16 billion in sales. The charts here present iSuppli's semiconductor content estimates in power train for standard and hybrid vehicles in 2006 Of this automotive semiconductor content, about 26 percent on average in 2006 was contained in the power train of the vehicle, in functions directly related to providing vehicle propulsion. In conventional engines, this means engine control and related electronics. In HEVs, this also includes the electronics required to process all of the information to determine ICE/electric operation balances, as well as those required to manage the electric power flow and conversion throughout the vehicle and specifically to and from the electric motor(s) that propel it.





As the overall electrical content in hybrid vehicles increased, power management content in HEV vehicles increased too. A significant measure of increase is that power transistor content increased from 11 percent in standard vehicles to 53 percent of the total semiconductor content in hybrid vehicles in 2006. At the same time content of rectifiers grew from 4.7 percent in standard vehicles to 18 percent in HEV vehicles. Semiconductor content not related to power management mainly stayed flat. For example, microcontrollers for which the absolute content number didn't change, the relative percentage dropped from 40 percent in standard vehicles to 10 percent in HEVs.

Marijana Vukicevic is the senior analyst for power management at iSuppli Corporation

www.isuppli.com

Why Do Power Supplies Fail?

Modern switching power supplies have been with us for three decades now. From full-bridge circuits operating at power levels up to 10 kW to flyback circuits operating at less than 1 W, a enormous amount of research and development has transpired over the years. Any yet, despite 30 years of design maturity, switching power supplies remain a weak link of most electronic systems. Most of them are noisy, hot, and fail more often than they should.

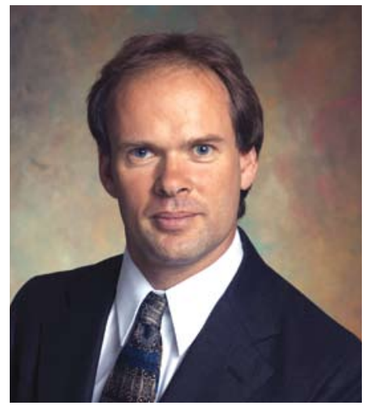
By Dr. Ray Ridley, Ridley Engineering

The Heart of the Problem

Let's get right to the problem — it is the power FET. Don't misunderstand this statement. Modern FETs from reputable manufacturers are rugged and reliable when operated properly. The problem is that it is easy for them to be improperly operated.

There is a huge disparity in the power capability of a FET, and the thermal rating of the package. For example, the common IRF640 device has an on-resistance of 0.15 ohms, and a voltage rating of 200 V. Electrically, the power rating is 26.67 kW! Thermally, however, the power rating is about 10 W for a TO220 package with appropriate heatsink. If the components around the FET that make up the power supply do not behave properly, a huge amount of stress can be placed on the device, leading to failure.

It is almost always the FET that eventually fails, but it is not always the direct cause of the problem. The reason for failure can often be very difficult to observe or prove. There are hundreds of parts in some power supplies, and numerous mechanisms that can cause destructive waveforms. Improper operation of the FET can lead to failures in less that 1µs, and unless you just happen to be probing the exact waveform at the right time, you cannot see the failure occurring.



As I started planning this article, I envisioned giving detailed waveforms showing the failure mechanisms. However, there are so many potential causes, all there is time for is a list of types of failure that can be encountered. Each one of these could merit a full length conference paper in itself.

MOSFETs

As mentioned above, the FET is usually the ultimate victim of erroneous operation in a power supply. In my experience, it is not often the major cause of a failure, but just the ultimate symptom that lets you know something is not working properly. Since so much destructive energy can be unleashed in the FET, it is the most dramatic sign of failure.

The FET itself can sometimes be the root cause of the failure. The most common events I have seen include the following:

- **Overheating.** This is mainly due to improper heatsinking, packaging, and airflow. Low estimation of the conduction losses (which increase with temperature) and switching losses also lead to excessive temperature. With small packages, be aware that junction temperatures can be substantially higher than package surfaces.

- **Drain overvoltage.** Early FETs in the 1980s had problems with overvoltages. Later on, they became very rugged, and today, manufacturers even provide avalanche ratings which allow you to operate beyond the normal voltage specifications. My advice is not to use avalanche capability unless you have very good data for your application, such as data you may have to collect yourself. Even then, I will not personally design a circuit to operate in this region under any conditions. Be aware that the ICs that incorporate control logic and a FET in the same package have seriously compromised drain-source ratings, and they reduce further with temperature.

- **Drain overcurrent.** It is hard to destroy a FET with overcurrent since they are very rugged devices. The overcurrent leads either to overvoltage when it's

turned off, or overheating of the package.

• **Gate overvoltage.** A weak electrical feature of FETs is the gate-source voltage rating. If you apply just a few volts over the rating, the gate oxide will fail very quickly.

• **Antiparallel diode.** The other Achilles heel of a FET is the internal diode. If the internal diode of a FET conducts, its reverse blocking capability is severely compromised with fast application of voltage. This frequently causes problems with full-bridge circuits, and can occur even at very light loads.

• **DC blocking.** If you apply a dc voltage for a long time, a FET can begin to fail. I've only heard about this one time, and it's an unusual application for a FET.

Power Diodes

Like the FET, power diodes can have high voltage and current ratings. However, due to the diode action, it is impossible for both of the ratings to be applied concurrently for any extended period of time. High current and voltage are only applied simultaneously during switching transitions with inductive loads. Diode failures can be caused by:

• **Overheating.** As with the FET, this is mainly due to improper heatsinking, packaging, and airflow.

• **Schottky overvoltage.** Do not for a minute think that schottky diodes can be pushed as hard as FETs. One cycle of overvoltage, and they are likely to fail. Derate the component, and make sure this never happens. Special care must be paid to full- and half-bridge circuits with dc blocking capacitors in the primary.

• **Switching losses.** This can be higher than anticipated due to reverse recovery of fast diodes. This is particularly a problem in boost power factor correction circuits where there are no magnetic elements to slow down rise and fall times.

Capacitors

Modern capacitors provide tremendous energy storage by volume, and are truly amazing components. However, they are often poorly specified by the vendor (as discussed in an earlier article in this magazine [1]) and are prone to failure if overstressed.

• **Overheating.** This is an issue due to excessive current, or placement on the PC board near hot components. Overheating will lead to early failure.

• **MLC capacitors breakage.** These capacitors can easily crack in the large format packages. Proper stress relief must be provided for soldering operations, and for operation with high currents.

• **Overvoltage.** MLC capacitors will not tolerate overvoltage.

• **Temperature Sensitivity.** Electrolytic capacitors dry out with prolonged ambient temperatures and current. They freeze with low temperatures, and this can lead to instability.

• **Safety Hazards.** Tantalums can fail in a short-circuit condition, leading to potential fire safety hazards. Like MLCs, they do not tolerate overvoltage well.

There are no ideal capacitors, and all power capacitors must be designed into the circuit carefully with a full understanding of all its characteristics and tradeoffs.

Magnetics

Actual catastrophic failure of the magnetics is an extreme condition. The insulation on the wire has to melt or fail, and usually you will see the semiconductors fail before this happens. However, the magnetics can enter regions of nonlinearity that overstress the rest of the circuit. Magnetic failures can be caused by:

• **Overtemperature.** Hot spots are often created in magnetics, and insulation can melt inside the parts even before an appreciable temperature rise is felt at the surface.

• **Saturation of the core.** Whether due to poor design margins, or overtemperature, inductances can reduce by more than an order of magnitude when too much voltage or current is applied.

• **Insulation failure.** This can occur due to overtemperature, overvoltage, damage due to initial construction, long term abrasion of adjacent parts, or corona breakdown with high voltages.

• **Core breakage.** Breakage can occur if a core is dropped during construction or with excessive mechanical stress during use. Cores are brittle like glass, and can have a complete crack that is undetectable on initial testing.

• **Thermal aging of cores.** This happens when cores contain binders that may degrade with time and temperature. [2]

• **Excessive ac current.** If proximity loss calculations are not performed on the magnetics, ac currents can lead to very high dissipations. [3]

Control Circuits

Control chips are low cost parts placed at the nerve center of the power supply. Every control chip I have ever worked with has had some unusual region of behavior which, if misunderstood, can lead to failure.

The control chip determines when and how the FET is turned on and off. It must be done perfectly every time to avoid failure.

• **Overtemperature.** Power dissipation in the control chip can be surprisingly high, especially when driving large FETs at high frequency. At the same time, package sizes and thermal capability keep dropping.

• **Erratic clock operation.** Improper layout can make chips very susceptible to noise, either generated internally, or from other sources in the power stage.

• **Instability.** A majority of converters shipped don't have their loops properly compensated. Oscillations can lead to overstress and failure. All conditions must be checked – start up, overcurrent, step loads, and all combinations of line and load.

• **Improper current limiting.** This is a major cause of failures. Regardless of how careful you are, power supplies will always be susceptible to spurious events beyond your control, and fast precise current limiting is the backup protection mechanism. Don't build a power supply without cycle-by-cycle current limiting if you want rugged operation.

• **Familiarity.** Stay with suppliers you know, trust, and have experience with. Don't just shoot for the lowest cost part. Be especially wary of parts that don't have complete data sheets, or conflicting data. If you've used a part on several projects already, stay with it on the next project, or be prepared for the time needed to learn new quirks of operation.

• **Gate drive circuits.** Whether using gate drive transformers (preferred for off-line supplies) or high side drivers, all transient events must be considered to ensure the gate drives are well designed. Gate drive speed must be carefully controlled.

Printed Circuit Boards

I never put a power supply design on a single-sided board. It is simply impossible to achieve the level of noise reduction and reliability that a good power supply needs. Going beyond double sided, however, also has its drawbacks. Buried planes for noise reduction can be useful, but can also conceal weak points of the design.

Board related failures include the following:

• **External spacing.** Proper spacing between high voltage traces must be maintained according to safety standards for your industry. If there are no safety standard requirements, high voltage traces must still be well separated or they will fail. This is especially an issue with TO220 packages which have woefully small clearances when inserted in the board with standard layout software.

• **Internal spacing.** Spacing on internal layers must be carefully checked. Even within a board, arcing can occur. Don't assume there is sufficient insulation in the board construction.

• **Degradation.** PCB materials degrade with excessive temperature for long periods of time. Be careful in choosing cheaper PCB materials.

• **Closing loops.** High current loops formed by board traces must be closed to prevent generation of magnetic fields.

• **Shielding.** High voltage parts should be shielded to prevent generation of electrostatic fields

Inadequate Specifications

Power supply specifications are often inadequate for the application. Depending on the conservative nature of the design, reliability can vary greatly. Most designs I see have not been adequately tested for the extremes that will be seen in the field.

• **Thermal Ratings.** Worst case airflow, ambient temperature, and electrical conditions must be combined to show true temperature rise of all parts.

• **Input voltage ratings.** Power supplies should be tested in excess of the ratings to have a good margin, both at the low and high end. For example, most power supplies are designed for high-line operation of 264 VAC. However, IBM's power line studies in the 1970s showed that 300 VAC for short periods of time would be regularly experienced, and designs should allow for this.

• **Load ratings.** Outputs must be loaded to full load, and then increased indefinitely until protection steps in to limit current. Short-circuit conditions are not usually the worst case situation for a power supply. Output load resistances should be gradually increased to identify the worst-case operating points.

• **Input surge ratings.** High frequency ringwaves, and other test waveforms are used to verify ruggedness in real-world environment. Surge suppression devices, and filter components are needed to survive these events, but they are often omitted to save money.

Mechanical Packaging

Mechanical packaging is often the cause of many failures. Unfortunately, the mechanical parts are often the first part of the system designed, and cannot be changed to accommodate thermal conditions inside the power supply. The following are common mistakes:

• Input connectors inadequately rated for mechanical stress and electrical current.

• Violation of spacing issues.

• Inadequate mounting of hot parts to heatsinks.

• Inadequate ventilation

• Improper orientation of parts for proper cooling.

• Improper shock and vibration design.

Summary

The list presented here is by no means complete. Almost every power supply I see has some new and unique combination of events that lead to failure, and good analog problem solving skills and experience are essential to redesign power supplies.

Additional Reading

[1] "Capacitors for Switching Power Supplies", Power Systems Design Europe, May 2007

[2] "Safe Reliable Designs Using Iron Powder Cores", Christopher Oliver, www.switchingpowermagazine.com/downloads/Iron%20Powder%20Cores.pdf

[3] "Proximity Loss in Magnetics Windings", www.switchingpowermagazine.com/downloads/13%20Proximity%20Loss.pdf

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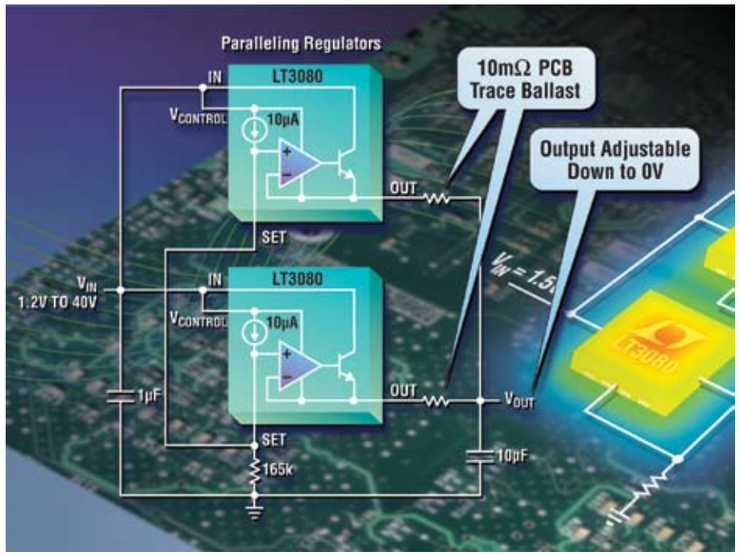
New Surface Mount 1.1A LDO from Linear

Easily paralleled for high IOUT without hot spots

I had the great opportunity to talk with Bob Dobkin, VP/CTO and co-founder of Linear Technology Corporation, about the announcement of his latest brainchild, the LT3080. A truly remarkable piece of analog engineering magic, much easier to design-in 'right-first-time' into demanding applications without suffering the penalties of high complexity and cost experienced with switching regulators.

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

This part is a 1.1A 3-terminal LDO that is ideal for SMT designs, often necessary where board height is at a premium -which excludes the use of heat sinks. This unique device can go down to an output of 0V, easily coping with the increasing demand for lower and lower processor rail voltages. But you might say that DSPs, FPGAs and other devices need more current than just 1.1A. "No problem", countered Bob. "The new LT3080 can be easily paralleled for heat spreading across the PCB and is adjustable with a single resistor. Not only that, but the output noise of less than 40μVRMS Wideband (100kHz) is more than good enough to drive these sensitive applications, even in high



current, noise-sensitive applications such as high-frequency serial data links which can run at well over 3GHz. These applications are often tightly specified by the manufacturer to be run on linear supplies only".

This new architecture regulator uses a 10μA current reference which allows sharing between multiple regulators. Just simply strap the SET pins together, calculate the value of the resistor to ground (Ohms law does it!) and with typically 4mm of PC trace on the outputs to act as the required 10mΩ ballasts, you have multi-amp linear regulation in all surface-mount systems without heat sinks.

The LT3080 out-performs other industry offerings with no compromises, tricks or tweaks. It is accurate, has a great transient response and is tolerant of many types of output capacitors purely as the result of a clean and creative design. Bob then added, "At Linear we design to a 'no phone call' specification". If only everyone did!

With a wide input voltage capability from 1.2V to 40V, this device has a low drop-out 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 a high accuracy of ±1%. The wide VIN & VOUT capability, tight line and load regulation, high ripple rejection, low external parts count and parallel capability make it ideal for modern multi-rail systems.

The LT3080 power dissipation can be split simply by inserting a suitable resistor in line with the output transistor collector i.e. at VIN. Alternatively, by strapping the VIN and CONTROL pins, the device will perform as a simple 3-Terminal regulator. These are just a couple of examples of what can be done with this 'first' from Linear. A delve into Linear's treasure-chest of application notes will demonstrate that 30 years after the first 3-terminal adjustable regulator was introduced, the magic of inspirational analog design lives on.

The LT3080 is offered in a variety of thermally-enhanced surface-mount compatible packages including the low profile (0.75mm) 8-lead DFN (3mm x 3mm), an 8-lead thermally-enhanced MSOP, and simple-to-use 3-lead SOT-223 package. These packages are able to dissipate 1W to 2W in surface mount applications without a heat sink. In addition, the device is available in a TO-220 power package for mounting on heat sinks for those who really want all the benefits of this unique device but need higher power dissipation.

www.linear.com

Trench MOSFET Robustness in Linear Mode Applications

Key to success is in understanding behaviour of the MOSFET

This is yet another classic case of Trench vs Planar. Is Trench MOSFET technology less robust in linear mode application compared to a Planar MOSFET? Is it possible for Trench MOSFET to operate safely in linear mode application?

By Adrian Koh, Adam Brown , NXP Semiconductor, Hazel Grove, UK
and Klaus Zametzky, Sitronic GmbH & Co KG, Gunzenhausen, Germany

Power Metal-Oxide-Field Effect Transistors (MOSFET) are most commonly used as a switching device turning the load from the Off state to the On state by applying sufficient voltage to the gate of the MOSFET. For such On/Off switching application the MOSFET on-state Drain-Source resistance ($R_{DS(ON)}$) is critical. The power dissipation during the On-state is defined by the $I^2R_{DS(ON)}$ losses in the MOSFET. For such application, Trench MOSFET technology has an advantage over planar DMOS. This is because the Trench topology allows dense MOSFET cell density thus reducing the specific $R_{DS(ON)}$. Power MOSFETs are also capable to be used in linear mode application by operating in their non-resistive region known as saturation region. In a linear mode application the $R_{DS(ON)}$ of the MOSFET is no longer critical as the power dissipation is defined by $V_{DS}I_{DS}$. The forward-bias safe operating area (FB-SOA) of the MOSFET now defines the safe operation. In both cases the MOSFET safe operation is also governed by its rated maximum junction temperature ($T_{j\,max}$).

Figure 1. An output characteristic curve of a MOSFET with its defined linear and saturation region.

An experienced electronic designer would have no reservation to conclude a Trench MOSFET is less robust in linear mode application when compared to a planar DMOS. This has been documented in various articles. Hence, the focus of this discussion is to identify the root cause of the problem that made the Trench MOSFET seems less robust in linear mode application. To unlock the mystery it is necessary to understand the behaviour of a MOSFET. Using the knowledge gained from this investigation, we present a novel Trench MOSFET solution optimised for linear mode application.

Clarification of "Linear" terminology

Before going further, it is crucial to clarify the term "Linear" as used in this discussion. There are two regions of MOSFET operation, identified as the Linear Region and Saturation Region in the output characteristic curve as illustrated in Figure 1.

When a design engineer refers to linear mode operation or application, the engineer is actually referring to the Bipolar Junction Transistor (BJT) linear region of its output characteristic. This is where the confusion starts as the BJT linear region equivalent in the MOSFET output characteristic is known as the saturation region. Therefore the linear mode discussed here is referring to the MOSFET saturation region of operation and not the same as operating in the MOSFET linear region.

Operating in Linear Mode = Operating in MOSFET Saturation Region.

Where does Linear Mode occur during operation

Having clarified the linear terminology, here are three examples of where and when linear mode occur during MOSFET operation.

Example 1

A PWM fan control where a MOSFET is essentially used as an On/Off switch. Figure 2(a) illustrates the transition where the MOSFET has to go through during the On/Off sequence in the output characteristic curve. The MOSFET starts in its Off-state at point A moving towards point B to its On-state. At which the MOSFET is operating in its resistive (V_{DS}/I_{DS}) regime. Here the power dissipated is define by $I^2R_{DS(ON)}$. In the process of switching, the MOSFET experiences a short transitional period in the saturation region before reaching its On-state. The same goes to the reverse sequence from the On-state to the Off-state. This transitional period in linear mode is known as the MOSFET switching time. The switching time for automotive applications are usually less then 100µs. This is known to be safe for Trench MOSFET.

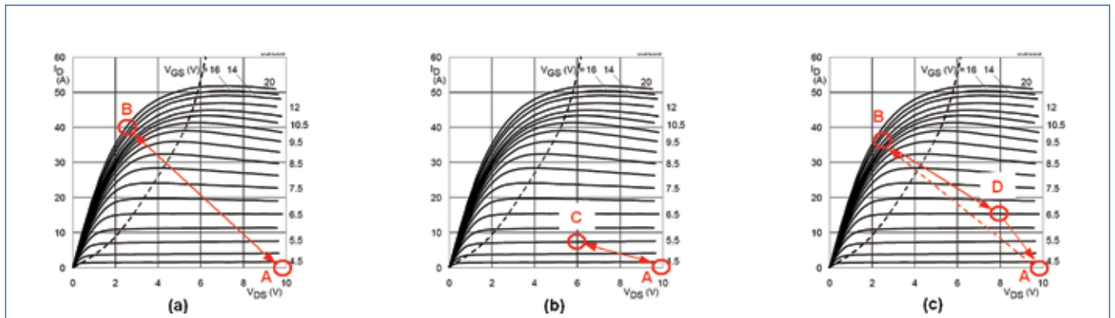


Figure 2. Output characteristic of a MOSFET illustrating transition of a MOSFET operating:
(a) as a switch. [A ↔ B]
(b) in linear mode application. [A ↔ C]
(c) in active clamped switching mode. [A → B → D → A]

Example 2

A linear mode fan control where a MOSFET is used to regulate the power flow into the fan motor by operating in the saturation mode. Figure 2(b) illustrates the operating points of the MOSFET in its output characteristic. From its Off-state at point A to its regulating On-state at point C within its saturation region. Note that the MOSFET is not operating in its resistive (V_{DS}/I_{DS}) regime. Here the power dissipated is define by $V_{DS}I_{DS}$. Safe operation is defined by the FB-SOA curve and $T_{j\,max}$ limit. The $R_{DS(ON)}$ of the MOSFET is not al criteria.

Example 3

An Anti-lock braking system (ABS)

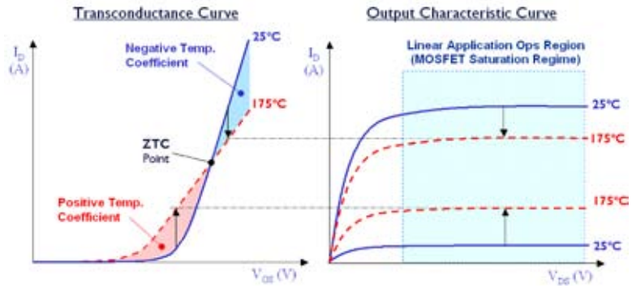


Figure 3. Transconductance and output characteristic of a MOSFET.

or Fuel/Diesel injection management system. In these applications, MOSFET are exposed to repetitive inductive load switching. On some design, a MOSFET with active clamp is preferred to prevent the MOSFET from repetitive avalanching. Depending on the inductive load energy and frequency, repetitive unclamped inducti ve switching may be detrimental or even catastrophic to the MOSFET. Clamping occurs in the MOSFET turn-off sequence. During the clamping period, the gate voltage is pulled up just enough to allow the inductive load to dissipate all its store energy through the MOSFET. Figure 2(c) illustrates the clamping transition during the turn-off cycle. From point B in the On-state to Point D in clamped mode eventually to Point A (off-state) once the inductive load energy is depleted. It is for such applications that both the $R_{DS(ON)}$ and the linear mode robustness are essential criteria for the selection of the MOSFET. Trench MOSFET becomes a very attractive candidate. The safe operation in clamped mode is defined by the FB-SOA curve and again limited to $T_{j\,max}$.

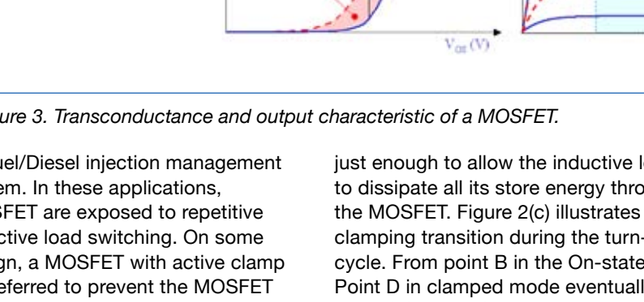


Figure 4. Typical linear mode application failure signature.

MOSFET Behaviour in Linear Mode Applications

To understand how a MOSFET behaves in a linear mode application regardless of whether it is a Trench or Planar, we need to look at the transconductance curve of the MOSFET as shown in Figure 3.

In this curve, there are two pseudo-regions in which a MOSFET operates in a linear mode application. They are a result of the MOSFET's transfer characteristic during hot and cold. The point at which the hot and cold transconductance curves crossover is known as the zero temperature coefficient (ZTC). Below the ZTC the red region is known as the positive temperature coefficient (PTC). Above the ZTC the blue region is known as the negative temperature coefficient (NTC). We shall discuss how the MOSFET behaves in these regions.

Zero Temperature Coefficient (ZTC) Region

When MOSFET operate at the ZTC point, its thermal behaviour is neutral.

Positive Temperature Coefficient (PTC) Region

In the PTC region, when a MOSFET operates at a position on the 25°C curve, the resulting power generated begins to warm up the MOSFET. This rise in T_j will cause the threshold voltage (V_{TH}) to drop thus allowing more current to flow as shown in Figure 2. This in turn increases the T_j further and the cycle repeats. If the power generated exceeds the power dissipated, the MOSFET will achieve thermal instability. Continued operation will result in thermal runaway and eventual failure.

Negative Temperature Coefficient (NTC) Region

Operating in the NTC region has a slightly different behaviour. When a MOSFET operates at a position on the 25°C curve, the resulting power generated begins to warm up the MOSFET. This causes the $R_{DS(ON)}$ of the MOSFET to rise thus limiting the amount of current flow. This prevents further escalation in T_j resulting in thermal stability, continued operation in this case is safe. This is widely known as a self-compensating mode.

Thermal Instability

Thermal instability can be realised in equation [1]. Thermal instability is achieved for a rise in temperature at a rate where power generated exceeds the rate of dissipation.

$$\frac{dP_G}{dT} > \frac{dP_{diss}}{dT} \quad [1]$$

For a Power MOSFET eqn. [1] can be rewritten as:

$$V_{DS}\frac{dI_D}{dT} > \frac{1}{Z_{th}} \quad [2]$$

where Z_{th} is the transient thermal impedance of the MOSFET.

Failure Signature

Figure 4 shows a typical catastrophic failure signature of a MOSFET operating in a linear mode application. The failure is usually found near to the bond wire but seldom directly underneath it. This is because the area underneath and surrounding the bond wires has the highest current density during conduction making it the hottest region. However, the bond wire serves as a heat sink to the cells directly underneath it making the cells surrounding the bond wires the hotter area.

From these images it was evident that intense localised heat was present at the failed spot. Molten aluminium top metal suggests localised heat may have exceeded 500°C. However, unlike the avalanche ruggedness failure signature, you will see the underlying cell structure remain intact. This is a

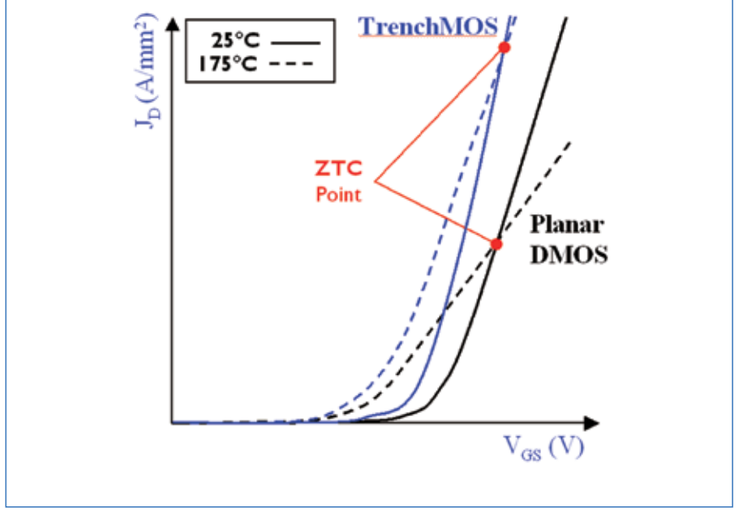


Figure 5. Normalised transconductance curve of a Trench and Planar MOSFET.

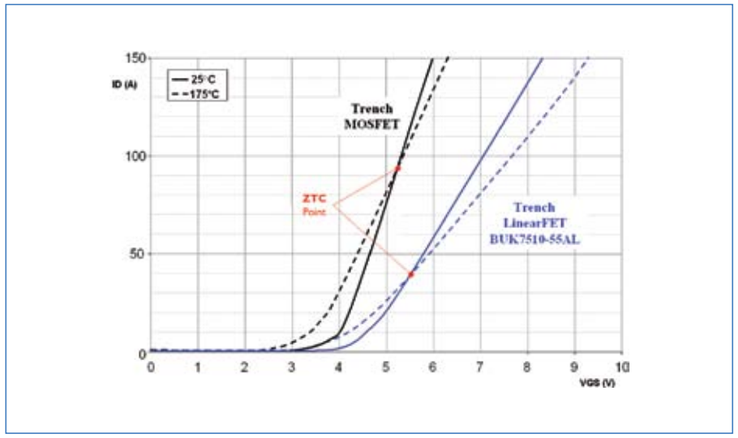


Figure 6. Transconductance of a standard Trench MOSFET and LinearFET.

Table 1. Independent MOSFET linear application robustness benchmark [Sitronic GmbH]

Linear Mode Operation Test Condition (Vds=30V, tp=30ms, Id = increasing)		
Product Under Test	MOSFET Technology	Energy (J) 1 5 10 15 20
BUK7510-55AL	Trench	
Sample 1 *	DMOS	
Sample 2	DMOS	
Sample 3	DMOS	
Sample 4	DMOS	
Sample 5	DMOS	
Sample 6	Trench	

* Benchmark

classic thermal runaway signature.

From this evidence, we can conclude the failure mechanism of a MOSFET in linear mode application is thermally activated.

So is Trench worst than Planar?

To solve this mystery we have to look at the normalised transconductance curve of a Trench and Planar MOSFET as shown in Figure 5.

Notice that the gradient of the Trench transconductance curve is steeper in contrast to Planar. This is because Trench technology is optimised for low specific On-state resistance with its higher cell density. The consequence of this is a higher ZTC point. This means there is a much higher chance of operating in the PTC region in a linear mode application, which may induce hotspots and result in catastrophic failures if not cooled properly.

For a MOSFET to be robust in linear mode, it is essential to make the ZTC point as low as possible. This minimises the risks of operating in the PTC region. This can be achieved regardless of the MOSFET cell structure. The cell structure does not dictate the linear mode robustness of a MOSFET but the physics that govern the MOSFET' s behaviour does. As a general rule for the electronic design engineer, the lower the specific On-state resistance of the MOSFET the higher the ZTC point will be and less robust it will be for linear mode applications, regardless of its cell structure technology.

Optimised Trench MOSFET for linear mode application.

As proof of concept, we have reinvented an existing Automotive Trench MOSFET platform optimised for linear mode application. The product of this concept is the BUK7510-55AL, LinearFET. Figure 6 shows the transconductance curves of a standard Trench MOSFET and a Trench LinearFET of the same silicon die size in a TO220 package. Both products have exact identical trench pitch, Trench technology and process. However, the ZTC point of the LinearFET is now half of the standard Trench MOSFET, from 90A down to 40A. This improves the linear mode performance of the MOSFET tremendously.

Benchmark

As our LinearFET went into production, an independent assessment on the LinearFET performance was conducted externally. The assessment were split into two main categories:

(i) Linear Mode Robustness Test Group and

(ii) Active Power Cycling Test Group.

In both test groups the LinearFET was put along side with leading DMOS and one other Trench MOSFET from a different manufacturer. The conditions for first test group were as follows:

(i) Devices under test (DUT) must be of automotive grade (AEC Q101)

(ii) Maximum die size (typically around 25mm^2) in TO220 package

(iii) Devices have to be of the same voltage grade. For this instance it was 55V or 60V if not available.

In the first test, five sample of each type were used. The Drain-Source Voltage (V_{DS}) was held at 30V for a pulse duration (t_p) of 30ms and the drain current (I_D) increasing in step until the MOSFET failed catastrophically. The last recorded I_D prior to failure was used. The energy was calculated using eqn. [3] and the results summarised in Table 1.

$$W_{\max} = P_{\max} \cdot t_p \quad [3]$$

where $P_{\max} = V_{ds} \cdot I_{d(\max)}$

Sample 1, a Planar DMOS was used as a benchmark device for this exercise as it was known to be extremely robust in linear mode applications. We observed that Sample 6, a Trench MOSFET performs badly in this test. However, the Trench LinearFET, BUK7510-55AL outperformed all other candidates topping the linear mode operation robustness test group by surviving up to 20J of energy. In the second test group, The test condition was set up to allow the DUTs to conduct in linear mode during On-state for a period of 20s and fan cooled during Off-state such that the T_j cycled between 70°C to $T_{j\,\max}$ of 170°C. This gives a delta T_j of 100°C thermal stress. The LinearFET passed the 100 000 active power cycling test.

Conclusion

Trench MOSFETs do have a level of linear mode robustness suitable for most switching application as shown in Figure 2(a) and active clamped inductive switching application shown in Figure 2(c). However, for pure linear mode application as illustrated in Figure 2(b), devices with low ZTC are needed. Here we have presented and demonstrated a Trench LinearFET solution that provides an alternative to the latter two applications. In conclusion, it has been demonstrated that Trench is not less robust than Planar for linear mode applications. The key is to understand the behaviour of the MOSFET.

www.nxp.com

Power Viruses Cause Expensive Problems

How to protect any industrial system

Electrical disturbances are surprisingly similar to computer viruses. They could reasonably be called power viruses since they too are unseen and can cause serious and expensive system failure.

By Kevin Beavan, Managing Director, POWERVAR, UK

Software viruses would be common occurrences in the computing-based world of commercial, retail and industrial installations, if everyone was not familiar with their potential for damage, and the news media routinely reporting the details of system disruption related to their appearances. It's a reasonable term to apply to these rogue programs. They enter systems unseen, often incubate in silence, and eventually come to life with results that range from merely annoying to catastrophic. Electrical disturbances are surprisingly similar. In fact they could reasonably be called power viruses since they too are unseen and can cause serious and expensive system failure. Power viruses are contracted the same way as other viruses. They're passed on by the system's electrical neighbours and although some of them may take time to cause noticeable damage others are immediately catastrophic resulting in cost and more importantly down-time and lost productivity.

The world's established and booming internet-dependent economy demands higher reliability from its power sources and providers – a level of reliability, which was once very acceptable to light and run the average business, is no longer adequate. International organisations continually review methods to improve the overall reliability of our electricity supplies and much has already been done within the OECD nations where for 99.9% of the time reasonably clean mains power is readily available to any business. At a local level UPS installations can ease simple supply issues but the reliability of any installation can be considerably improved by understanding six main power viruses which can invade any system and power-systems designers can track reliability improvements in days while the world-powers review the bigger picture.

Spikes from inside

The first is voltage spikes and impulses which result from electrical equipment inside the facility or building. Electrical loads like lifts, air conditioning compressors, relays, induction furnaces, printers and copying machines can cause sudden large increases in voltage inside the local electrical system. Conditions outside your facility can be to blame, too. Switching activities by the electricity supplier and lightning strikes can cause transient impulses so intense they literally "fried" sensitive circuitry. This virus is deadly to electronic systems — but not always immediately. Sometimes voltage spikes and impulses are relatively small in amplitude. In these cases, the virus weakens the system components over time leading to deteriorating health and eventual unexplained failure. Other times the impulses may be so large that they cause immediate system failure.

The second virus is also generally created inside the facility by the system's electrical neighbours. Almost every electricity consuming device contributes its share of electrical noise. Photocopiers, laser printers,

and electronic lighting ballasts are all noise sources that can cause computer based terminals to lock-up, lose data, or behave unreliably. Even computers themselves generate electrical noise. It's truly a paradox that our computers often infect other computers with power viruses. Although European directives help reduce electrical noise to an acceptable level in most cases there is still enough to be a problem in many installations.

What's between neutral and ground?

Then third comes common-mode voltages. Traditionally, the common-mode power virus hasn't received much attention but as detection of common mode voltage problems is now relatively easy more system problems are being traced to its existence. The condition is characterised by unwanted voltage measured between neutral and ground. In fact, the common mode voltage virus is probably the most serious power virus infecting digital systems today. It occurs as a result of high impedance safety grounds, neutral conductors shared with other circuits, and branch circuit lengths that are excessive – all very common in a modern retail installation. When the electrical noise virus appears between the neutral and ground conductors it becomes a common mode virus with the ability to cause lost files, system lock-ups or re-boots, communication errors, and inevitable "no problem found" service calls.

As long ago as 1986, the semiconductor industry at their fifth annual conference published their criteria for the type of environment where their products can operate as they were designed. In addition to setting standards for such factors as static discharge, the industry also published standards for the protection of their devices from spikes, normal mode noise and common-mode voltage. These three disturbances are the ones that are most prevalent in almost any electrical system. The industry established that power disturbances must be limited to less than 10 volts in the normal mode (phase to neutral) and less than 0.5 volts in the common mode (typically neutral to ground). In addition, the industry established that these criteria must be met even though power disturbance might be as large as 6000 volts as defined by the IEEE (Institute of Electrical and Electronic Engineers) in their guideline labeled IEEE C62.41.

Large load approaching

The fourth virus, voltage regulation, is characterised by abnormal variations in the electrical circuit's nominal operating voltage (230 volts, for example). These variations are generally greater than +10% of nominal voltage and may last for several line cycles or more. Traditionally this virus is referred to as the "sag" or "surge". The virus is typically caused by large loads turning on and off and overloaded branch circuits or distribution transformers. In some cases, voltage regulation viruses can be the responsibility of the power supplier. If an electronic system requires tightly regulated voltage (fortunately most of today's computer or microcontroller-based systems don't) the voltage regulation virus is likely to cause system lock-ups and unreliable operation in addition to damaged or destroyed components.

The power-cut or "outage"

Power cuts are the most visible and easily identifiable of all the power viruses. And they have the most obvious cause and effect. This is especially true if the system is a network or some other "fault intolerant" architecture. Fortunately, in spite of what most UPS manufacturers advertise, blackouts account for comparatively few occurrences of all the power viruses, less than 10% of all power related failures infact!

Last but not least the sixth, backdoor, virus infects your system via a secondary path unrelated to the power supply itself. Network cables, serial ports, telephone lines, and other I/O connections can all permit power viruses invisibly access. This virus causes driver chip failure and typically communication errors. The back door disturbance virus is often unrecognised. Without treatment, serious regular damage can occur.

Electrical bio-hazard protection

So accepting we're familiar with the damage that results from software viruses and where our digital systems are concerned, we've learned to practice "safe computing." We back up our data regularly, avoid logging onto questionable networks and all have firewalls. We also run anti-virus programs on a routine basis. Why don't we practice safe computing where power viruses are concerned? They have the same potential effect where our systems are concerned. They enter unseen. They can cause damage ranging from annoying to catastrophic. And like most other viruses, prevention is possible if you understand the basics.

There are five simple devices you can use. All five are required for complete immunity and if there's a magic pill to prevent power viruses, it's understanding that prevention must be practiced as a system – using combinations of devices as appropriate. Voltage spikes are addressed with a surge diverter and electrical noise with a noise filter. Isolation transformers eliminate common mode voltage problems. When surge diverters and noise filters are added to the isolation transformer, the resulting "system" kills all three viruses. Uninterruptible power supplies eliminate power-cuts, but in spite of many manufacturer's claims, most aren't capable of preventing other viruses at all. Once again, the UPS must be used with the other parts of the system to achieve total virus immunity. The backdoor disturbance can be addressed several ways. Fiber optic connections are one means of electrically closing the back door, but if ordinary copper wiring is used for communication lines, it may be necessary to employ special surge diversion techniques for these connections.

Luckily, the voltage regulation virus is no longer a serious hazard. Once upon a time, this virus was responsible for many system failures. However, today's systems use switch mode power supplies. This technology was designed as a way of reducing both power supply size and cost while simultaneously increasing electrical efficiency. To achieve these goals, switch mode supplies are designed to consume electrical power differently and these operational differences have created a beneficial by-product where voltage regulation is concerned. Additional preventative measures (voltage regulators, etc.) are unnecessary.

Power viruses are an appropriate description of the power quality problems that can plague electronic systems. Our economy's growing dependence on technology has created a natural awareness regarding the need to safeguard system integrity. Software viruses have led to the introduction of "anti-virus" programs and system data is routinely backed up to prevent loss. Part of this "safe computing" lifestyle should be the prevention of power viruses, too. This can only be possible when prevention is systematic. Voltage spikes, electrical noise, and common mode voltage is eliminated by a package that contains an isolation transformer, surge diverter, and noise filter. UPS and data line protection can be added to the system as applications demand.

www.powervar.com

On the Road

On the Road is appearing as a new section that is designed to bring you first hand coverage of major European power electronics technology press conferences as attended and reported by Cliff Keys, Editor-in-Chief, PSDE.

Reported by Cliff Keys, Editor-in-Chief PSDE

Super New Regulators Launched by Micrel

At their press conference in Munich, Germany, Micrel, renowned as a leading global manufacturer of advanced mixed-signal, analog and power semiconductors, unveiled two new, competition-beating Regulator groups.

500mA Synchronous Buck Regulators Featuring Hyper Light Load™

Micrel launched the MIC23050/1, two ultra-fast transient performance and high efficiency 4 MHz, 500mA synchronous buck (step-down) regulators assembled in a tiny 2mm x 2mm MLF® package. These super devices utilize a patented switching scheme that offer best-in-class light load efficiency, industry-leading transient performance, use the smallest inductors in their class and provide very low output ripple at all loads. This combination makes these devices the natural choice for today's portable designs where high efficiency, fast dynamic response, low output noise and a small solution size are critical such as in the design of cellular phones, portable media players, GPS systems, WiMax modules, digital still/video cameras and USB peripherals.

"Designing a step down regulator for portable applications to achieve over 85 percent efficiency at 1mA while providing the smallest inductor size in its class is a tough task." said Ralf Muenster, Micrel's director of marketing for power products. "Micrel's latest generation family of DC-to-DC converters, featuring Hyper Light LoadTM, achieves this goal while offering best-in-class transient performance and low ripple across all loads allowing for the smallest output capacitors."

The MIC23050/51 offers an input voltage range of 2.7V to 5.5V, preset output voltage options from 0.6V to 2.5V, and a low quiescent current of only 20uA. The device also features voltage scaling where an active signal can dynamically lower the output voltage reducing the sleep mode power draw by the circuit being powered, saving even more power and increasing stand-by time of portable applications. The MIC23050/51 are available in a tiny 8-pin 2mm x 2mm MLF® with a junction operating range from –40°C to +125°C.

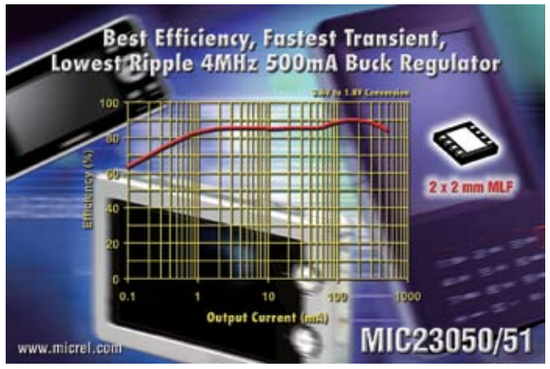
SuperLNR™ Family Of Low Noise Regulators

This new family of 'SuperLNRs' featuring the advantages and ease of use of LDOs with low noise, high PSRR, ultra-fast transient performance, while providing the efficiency of a switching regulator. Micrel's new SuperLNR family combines the 'best of both worlds' characteristics of linear regulators and DC-to-DC converters to produce a new generation of easy-to-use Low Noise Regulators. The MIC38300, the first device in this family, is a 3A voltage regulator housed in a tiny 4mm x 6mm MLF® package that produces less than 5mV of output noise and 70dB of PSRR. Industry leading, ultra-fast dynamic performance also allows the MIC28300 to maintain less than 30mV output voltage deviation, even during fast load transients. The IC is targeted at applications that need an easy upgrade from LDOs as power dissipation becomes an issue or where low-noise performance, small size and fast transient performance are paramount. Target markets include point-of-load and digital IC power regulators for networking, servers, wireless base stations, industrial and RF applications.

"As supply voltages continue to move lower, the output noise and transient response associated with a switching regulator poses a significant challenge for engineers," added Ralf Muenster, Micrel's marketing director for power products. "The MIC38300 creates the perfect low noise power supply for voltage sensitive point-of-load applications while combining the efficiency of a switcher with ease-of-use, transient performance and the low noise of an LDO — all resulting in an extremely small solution size that fits into the footprint of an LDO."

The MIC38300 features an input voltage range of 3.0V to 5.5V and adjustable output voltages as low as 1V. The solution requires no external inductor and fits into a total solution footprint of less than 40mm^2. The MIC38300 has a junction operating range from –40°C to +125°C.

www.micrel.com



Mitsubishi Shows its Power at Laser 2007 Show

At its press conference at Laser 2007, recently held in Munich, Germany, Mitsubishi Electric announced its significant line up of lasers developed for a wide range of applications.

High Power Lasers: Up to 60W

Mitsubishi showed its ML5 xxx series of high power lasers for the first time at the show. The ML5CPxx devices offer output power rates of up to 60W. The smaller ML561E10-01 is specified at 1W. All these devices operate in the popular 808nm wavelength-range.

HPLDs from Mitsubishi Electric

High Power Laser Diodes can be used in a wide range of applications in order to process and condition materials. Typical applications for these products are in welding, cutting, drilling, surface treatment and marking.

ML5xxx series

The ML5xxx series from Mitsubishi Electric is a family of high performance laser diodes (HPLDs). These devices are typically used in stacks for DPSS lasers (Diode-Pumped-Solid-State) in order to achieve output power rates of several thousand Watts at high beam quality.

In addition to the typical industrial applications, the scope of applications for HPLDs now extends into the medical sector for dental, cutting and surgical usage.

Applications are also to be found in the test and measurement sector (LIDAR, Light Detection and Ranging) as well as the use in scientific, printing and film-exposure.

ML5CPxx

These highly-efficient semiconductor laser bars ML5CP8, ML5CP9 and ML5CPxx provide a stable oscillation with an emission wavelength of 807nm and standard CW light output power rates of 40W or, 60W respectively.

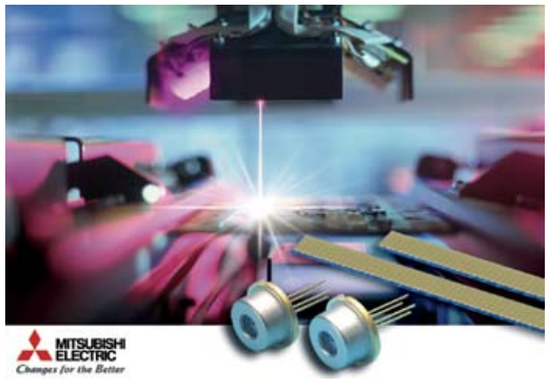
The multi-emitter chip of these new laser diodes measures just 10mm x 1.0mm or 10mm x 1.2mm. It is equipped with electrode structures to enable high bonding capabilities for AuSn (ML5CP8) and In solders (ML5CP9). For example, ML5CP8 operates with small internal losses, thereby improving the slope efficiency (reduction of the operating current).

Also, ML5CP8 has an Al-free single quantum well active layer, which prevents Catastrophic Optical Degradation (COD) even at extremely high output powers and leads to highly reliable operation.

ML561E10-01

Based on sophisticated technology and production of 808nm bars, Mitsubishi released the single emitter ML561E10-01 with a CW light output of over 1.0W at an emitting wavelength of typically 805nm.

ML561E10 is integrated in a TO-CAN package with a diameter of 10.5mm. Due to the Al-free MOCVD structure this laser diode's active layer is highly reliable and can



generate an optical output power that is several times as high as the nominal output.

Red Lasers

660nm wavelength

These laser diodes emit visible light with a wavelength of 660nm, and are often utilized in the fields of show effects, displays or industry, in which case the long-term output (CW, Continuous Wave) of 120mW or more is very attractive to users. According to Mitsubishi Electric these products offer the world's highest output power at 660nm in a TO-CAN.

These lasers from the production series ML1xx21 to ML1xx27 are also distinguished by a particularly fast modulation capability with high optical power density. The main application for these red diode lasers, accommodated in a compact 5.6mm TO package, are DVD burners.

642nm wavelength

These new laser diodes, available as single emitters and later as bars, are a worldwide first in the combination of excellent beam data, high outputs and outstanding dependability.

Due to the high spectral sensitivity of the human eye (642nm), the light emitted by the laser diodes appears especially bright to the eye. The single emitter LD for 640nm — which is integrated in a hermetically sealed 5.6mm TO package is designated ML520G51 01 and features an anticipated service life of more than 20,000 hours.

Next year, Mitsubishi Electric will launch the bar variant with a new TOCAN design that features an edge length of 25mm x 25mm. Both versions will also be available in an open variation (without cap) in order to enable the placement of micro-optics directly in front of the chip.

Mass products

The laser diodes from the Mitsubishi production series MLxxxx are conceived as mass products and are therefore available at very competitive cost. For instance, the easily visible laser can be utilized together with frequency converted laser beams for the colors green and blue in RGB laser systems, which are required for shows or displays (consumer or automotive).

Further applications lie in the realm of medical technology, biotechnology and reprography.

Other wavelengths

Mitsubishi Electric also manufactures laser diodes with wavelengths of 808nm or 940nm which are particularly suitable for pumping solid-state lasers. In addition, the product range includes analog and digital lasers and photo-diodes for the bands 1310nm and 1550nm.

www.mitsubishichips.com

Grand Opening of Super New PULS Power Factory in Chomutov (CZ)

On June 30th PULS had two reasons to celebrate; the grand opening of a futuristic new production plant in the Czech Republic as well as more than 25 years of successful business. Together with his employees, Bernhard Erdl, founder and owner of PULS welcomed worldwide political, business and media representatives, so it was with very great pleasure I accepted his invitation.

After a long and creatively professional development phase, PULS has been able to set a new standard in design for industrial building construction.

Work started back in September 2005 when construction commenced and the results are clearly outstanding, not only for its unusual future-world design, but also for the outstanding working conditions for the 300 employees in an ecological and environmentally-friendly design.

PULS has been producing high quality products in the Czech Republic since 1999 and due to its highly successful growth, it became clear that a vastly increased production capacity was required.

Now, the company has

taken a major positive step towards increasing unit quantities with its new 6,000 sq.m. production facility with a total site area of 60,000 sq.m.

The building and environmental detail is very impressive. A consci-ousness for energy conservation and the environment was obviously a major part throughout the design brief.

Apart from having an efficient and cost effective production facility as one would expect from a Power company such as PULS, the whole building was just very good to be in, a fact which I'm sure will reflect on employees.

On the financial side, the whole facility investment was some 17 million Euros of which nearly half was the investment in state-of-the-art production equipment to ensure an efficient and very cost-effective production of future products. This will, undoubtedly, have a great effect on the competitiveness of the company in the market.

On a brief technical note, I was very interested to hear that even on something as basic and necessary (but usually very wasteful of energy) as the burn-in process, PULS have adopted a method of cutting down the energy usage to just 16% of the traditional method by re-using the energy normally dissipated in the load, a bit different to the 'hot and heavy' cabinets I was used to in my early engineering days. This is yet another example of the impressive attention to energy conservation from the PULS operation.

So, why set up a major facility like this in Czech Republic? It is, of course, far less costly to set up an operation in CZ than in most other parts of Europe and yet the transport and travel links are all there. With many companies setting off to China — where incidentally PULS will also serve customers and establish a new building in 2008 — it is always still so refreshing to see that innovation with significant growth potential can live right on our own doorstep. PULS has managed to grow from a Euro 10 Mio. company in 1996 to Euro 60 Mio. in 2006. An outstanding achievement.

With the approach I saw on my visit, together with the views I heard from management and staff together with the new products emerging from the new facility, I am sure we shall hear much more from PULS in the world of Power. I also enjoyed a great party after the official launch with enthusiastic PULS staff.

www.pulspower.com

National's Analog Technologies Drive Energy-Efficient Handheld Multimedia Devices

National has launched a plethora of energy-efficient products at their press conferences across Europe. New power management, display and audio products enable power-frugal performance in handheld devices such as mobile phones, portable media players and converged devices that feature phone and media playback functions.

Enhancing the display

National's low-power Mobile Pixel Link (MPL) family of products stream large quantities of data to the display while maximising battery life.

The LM2512, is a high-speed serial host device that supports a video mode interface bridge between the processor and the display. Offered in a 49-bump UFBGA package, the LM2512 is highly programmable, with a unique built-in look-up table that allows for colour correction, enabling the designer to optimise the displays offered from multiple manufacturers.

National's new FPD95120, a high-performance Low Temperature Polycrystalline Silicon (LTPS) display driver, is the narrowest glass-mounted device available for half-VGA format. Just 0.9 millimeters wide, the FPD95120 maximises the available active area of the display glass. The highly integrated driver provides an MPL deserialiser, a high-efficiency inductive DC-DC switcher and random access memory (RAM) to enable standby, low-power display capabilities and is available in a 40-bump LLP and 49-bump FBGA.

Display backlighting and colour

New RGB LED drivers provide better colours on the display and lower power consumption than white LEDs. Available in a 25-bump micro SMD package, the LP5520 offers a small and simple solution without the need for optical feedback, producing a true white light over a wide temperature range while improving the colour

gamut from 70 percent up to 100 percent of the National Television System Committee (NTSC) standard. The LP5521, LP5522 and LP55281 colour management products feature low-power colour LED drivers for a variety of handheld lighting applications.

High-quality audio

National's new LM49100 audio subsystem allows routing of mono voice or stereo music signals to a mono speaker driver or stereo ground-referenced headphone amplifiers (or both) through simple selection of pre-set modes. In addition, it provides layout flexibility through its headphone ground-sensing function. The noise rejection improvement provided by this feature allows designers room to move in space-constrained systems. To maximise battery life, the LM49100 consumes the industry's lowest quiescent current of devices in its class — less than 5mA, with all channels active.

The device is offered in a 25-ball micro array package.

Powering digital processors

Video processing consumes substantial energy, limiting battery life on mobile terminals. National's innovative PowerWise® technology enables intelligent energy management of the processor using adaptive voltage scaling (AVS). Using National's PowerWise intellectual property integrated onto the processor along with compatible power management ICs such as the LP5552 reduces energy consumption up to 70 percent, greatly extending battery life.

The LP5552 is an advanced power management IC that supports AVS to enable the processor to adaptively adjust its supply voltage to the minimum level needed, greatly reducing its energy consumption. Offered in a 36-bump micro SMD package, the LP5552 includes two 800 mA buck regulators and five low-dropout regulators (LDOs).

For powering baseband functions, is the highly integrated LP3919 power management IC. In a 49-bump

micro SMD package, the LP3919 is the smallest integrated power management IC on the market featuring high-efficiency switching regulators, LDOs and a battery charger. The device powers the baseband processor as well as other support circuitry in the system.

Powering increased storage

The digital core processes data received from non-volatile storage, such as a secure digital card, FLASH or a micro hard drive. Each of these sources presents a unique energy saving challenge in handheld devices.

To power a micro-hard drive, the LM3668 buck-boost regulator provides a 3.3V output voltage to power the driver motor offering over 90 percent efficiency in buck and boost modes, essential for driving high-power applications. Li-Ion batteries discharge from levels above 3.3V to below 3.3V; however, the LM3668 creates seamless transition between buck and boost operation to provide a stable output for error-free operation. In addition, the stable output and high efficiency allows this device to be used as a pre-regulator for high-voltage applications in handheld devices. The 12-pin LLP® package combined with tiny external components provides a very small solution size.

National's secure digital (miniSD/SD) card interface IC, LP3929, is the industry's first to provide a robust interface to the outside world by combining level-shifter, power supply, EMI filtering and 15 kV ESD protection in a single device. The 2mm x 2mm, 24-bump micro SMD package and feature set free designers from mechanical constraints as they move toward smaller, more innovative designs.

Powering the wireless

The demand to share video wirelessly is increasing, but sending data wirelessly consumes significant battery power. National's new LM3207 DC-DC power supply, optimised for 3G RF power amplifiers, dynamically reduces energy consumption of the power amplifier by tightly regulating the RF power amplifier supply voltage to the lowest possible level while maintaining linearity in the power amplifier.

www.national.com

Power Systems Design EUROPE

Special Report Automotive Electronics Part I

Image Courtesy of DaimlerChrysler

Thermal Shock Poses No Problem in Automotive

Film capacitors for high temperature environments

More and more electronics content in automobiles is being placed up front in what are known as under-the-hood (UTH) applications and engine-mount (EM) modules. This is where the greatest stresses are found: vibration, heat and large temperature surges. Demands now made on the electronic components are consequently rising.

By Freddy Esteban, Product Development Film Capacitors, EPCOS, Malaga, Spain

Specific standards for automotive applications such as CDF-AEC-Q200, JASO D 001-87 or VW-801-01 define the requirements that the electronic components must satisfy in order to ensure reliable operation – under extreme and rapidly changing temperatures as well as with the necessary resistance to mechanical stresses.

One of today's extended requirements is that the components in motor vehicles retain their functional efficiency at a constant ambient temperature of 125°C. Increasingly, however, these applications must be able to withstand even higher temperatures of up to 175°C, at least temporarily. And the ability to withstand a constant ambient temperature of 150°C is now standard in certain sub-assemblies such as HID lamps for headlights as well as in other applications (Table 1).

Not to be shocked

In addition to being exposed to rapid changes in temperature, electronic components must also withstand hard thermal shocks. To simulate the behavior of a product under these conditions, thermal shock tests are carried out as a rule with 500 to 1000 cycles between -40°C and +150°C. Differences in thermal expansion or adhesion between the package and sealing compound are critical for the reliability and electrical properties of the component.

As maximum temperatures in most automobile applications lie in the region between 125°C and 175°C, these tests are highly relevant in practice. Most of these applications operate at temperatures up to 150°C.

A question of film

The dielectric film is crucial in enabling film capacitors to withstand high temperatures. However, other aspects such as the availability of materials and prices must also be included in the considerations as early as during the initial design phase. The most common materials are shown in Table 2.

Table 1: Environmental conditions for applications in automobiles.

Position	Temperature [°C]	Vibration [g]
Engine (EM)	-40 to +140	Sinusoidal <40
Engine compartment (UTH)	-40 to +125	Mixture <20
Chassis	-40 to +70	Noise <10
Front headlights	-40 to +170	Noise <10
Wheel mounting	-40 to +300	Noise <40
Combustion chamber/cylinder	-40 to +500	Mixture <40
Exhaust system	-40 to +800	Mixture <20

Special Report – Automotive Electronics Part I

Table 2: Characteristics of usual film materials.

	PET[1]	PEN[2]	PPS[3]	PP[4]
ε_r	3.3	3.0	3.0	2.2
tanδ at 1 kHZ in %	0.5	0.4	0.05	0.01
$R_{iso,25}$[GΩ × µF]	>30	>30	>60	>70
Δ C/C [10^{-6}/K]	+600	+200	-100	-250
$T_{op,max}$[°C]	125	150	140	110
T_{melt}[°C]	254	266	285	165
Costs	Low	High	Very high	Medium

(1) Polyester; (2) Polyethylene naphtalate; (3) Polyphenylene sulfide; (4) Polypropylene.

Due to harsh operating conditions and the need to minimize both dimensions and costs, EPCOS uses the materials PET and PEN to develop film capacitors for automotive electronics that can withstand the highest ambient temperatures.

PPS would normally be the most appropriate solution for applications requiring a lower loss factor than that of PET or PEN in combination with high operating temperatures. However, practical experience shows that PP can also be used at moderate constant temperatures, a fact that brings cost benefits.

EPCOS is currently developing capacitors mounted directly on the power train of the more recent hybrid automobiles. PP is used as the dielectric material in these cases, as the actual operating temperature lies below 110°C and PP capacitors also exhibit good properties at high frequencies.

PP exhibits the highest insulation resistance over a broad temperature range.

Apart from the operating conditions, processing by the system suppliers is another important factor. Thus SMT capacitors must also be tested at reflow solder temperatures that can reach peak values of up to 260°C.

PP also shows good values for the loss factor.

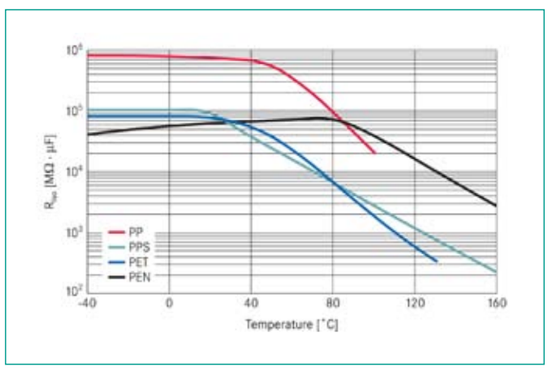


Figure 1: Insulation resistance of dielectrics.

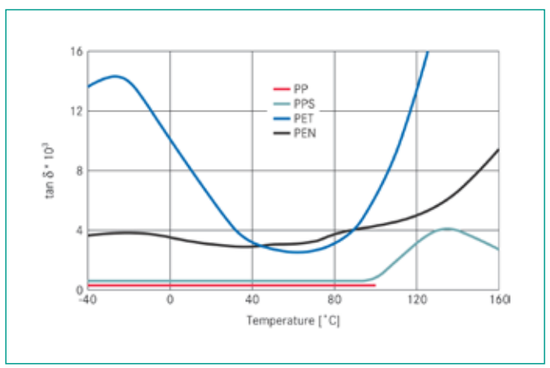


Figure 2: Loss factor as a function of temperature.

Special resin for longer operating life

EPCOS has developed various unpackaged capacitors for lighting systems and DC/DC converters in motor vehicles. Special packaged variants are offered for applications mounted more closely to the engine, which thus require higher vibration strength. In these capacitor series, epoxy resin is used to seal the package and protect the capacitor element.

Epoxy and polyurethane resins can cause electrochemical corrosion of the metallization by the hardener. This phenomenon can cause the capacitor's capacitance to drop, a process that depends on the proportion of hardener accelerator in the resin, the thickness of the metallization layer on the plastic film as well as the operating voltage and temperature.

However, the aging of the epoxy resin as a function of time and temperature must also be considered. It can lead to strong changes in flexibility as well as in the coefficient of thermal expansion of the resin when the ambient temperature is close to its vitrification point. Crevices and cracks may then occur in the resin and the contacts may even become detached in some circumstances. So EPCOS has developed a special epoxy resin to significantly reduce these negative effects on the operating life and electrical functionality of the capacitors.

Rigidity, brittleness, thermal expansion and flame retardance to the UL94-V0 approval play a key role in selecting the packaging material. Good

Table 3: Mechanical data of various package plastics.

	PBT(1)	PPS(2)	PP(3)
Expansion stress [MPa]	3000	11700	1500
Breaking stress [MPa]	55	150	34
Breaking stress [%]	2,5	1,9	>200
Melting point [ºC]	225	280	170
Vitrification point [ºC]	60	90	-10
Coefficient of thermal expansion [10^{-5}/K]	11	2,5	4

(1) Polybutylene terephthalate; (2) Polyphenylene sulfide; (3) Polypropylene.

*Table 4: Key data of the b3252*a and b3282*a series.*

	B3252*A	B3282*A
Dielectric material	PET	PEN
Package material	PBT/PPS	
Resin	Optimized epoxy resin	
Maximum capacitance	2.2 µF	
Rated voltage	250 V_{DC}	
Operating temperature	-40 °C to +135 ºC	-50 °C to +150 ºC

adhesion is also required between the package and the sealing resin in order to assure protection of the capacitor. Manufacturers of film capacitors use PBT and PP as the package materials, though PPS is also a suitable material for the plastic package. PP is highly elastic, but its low operating temperature of below 120°C, its low vitrification point as well as insufficient adhesion to the resin make it unsuitable for most automotive applications.

EPCOS has consequently focused its research and development activities in the sector of plastic packages on PBT and PPS. PBT has proved to be a reliable material in most products. An overview of the mechanical properties of typical package plastics is shown in Table 3.

PPS packages are the preferred solution, as this material shows good properties in the case of reflow soldering, hard thermal shocks at extremely low and high temperatures as well as very rapid changes between these temperatures.

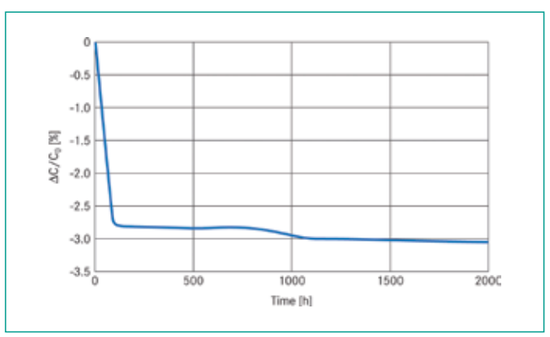


Figure 3: Capacitance drift of pen capacitors.

PEN and PET assure good performance

The results obtained within the scope of the test series with various dielectrics, resins and plastic packages provided the basis for the development of a series of capacitors designed specifically for automotive applications. The B3252*A series uses PET as the basic dielectric material for capacitors with a maximum operating temperature of 135°C. The B3282*A series is specified for temperatures up to 150°C and uses PEN as the dielectric material.

Two options are available when selecting the material for the plastic housing: PBT for usual boundary conditions with respect to thermal shocks and moisture (-40°C to +135°C or 40°C/93% relative humidity), and PPS in applications with tougher requirements (-50°C to +150°C or 85°C/85% relative humidity). The key data of this series is summarized in Table 4.

The process used to test the product life was defined in order to investigate the performance of the capacitors during their operation at the maximum permissible temperature. The category voltage applied within the scope of these tests is defined on the basis of the corresponding IEC standard.

The capacitance of the PEN capacitors remained fairly stable during the entire testing time at temperatures of both 150°C and 170°C (Fig. 3). The tested capacitors showed no relevant changes in loss factor and insulation resistance. The PET capacitors were tested at 125°C, the resulting curve being similar to that shown in Fig. 3.

Capacitance drift of a PEN capacitor in the lifetime test at 170°C and 62.5 percent of the rated voltage during a period of 2000 hours.

In the demanding automotive environment with its elevated temperatures and harsh physical environments together with the vicious thermal surges, EPCOS provides a proven, cost effective solution for the industry.

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Special Report – Automotive Electronics Part I

LEDs for Automotive Backlighting

Out with the old and in with the new

LEDs are now the predominant source for automotive display backlighting, displacing all other light sources in this application. This article describes the detail of the advantages and the technology characteristics.

By Bjoy Santos, Field Applications Engineer, Intersil Corporation

In the past, light emitting diodes (LEDs) were used merely as indicator lights. Now, LEDs have made their way to the automotive interior and exterior illumination. Automotive displays such as the dashboard instrument panels were primarily backlit by a filament-based incandescent bulb. Then, LCD display panels such as GPS navigation systems and DVD entertainment systems that are traditionally backlit by CCFLs (cold cathode fluorescent lamps) populated the automotive industry.
As car design continues to evolve, so does the display lighting requirements. The recent and rapid advances in LED solid state lighting have made them the superior choice not just for backlighting automotive displays but also for other interior and exterior automotive lighting as well. Although there are several areas that can be mentioned in interior and exterior automotive lighting, the scope of this article is limited to display backlighting.

Why LEDs?

LEDs offer numerous advantages over the traditional incandescent and CCFL light sources. Most of these advantages enable automotive designers to imagine new ways to enhance the way drivers respond to the dashboard and instrument panels. Consequently, new designs improve usability, driving visibility, and therefore safety. In addition, LEDs make instrument panels and LCD displays easy and inexpensive to mass produce.

LEDs are available in various small form factors. In addition to the standard-mount LED for a direct backlight method, they are available in side mounts for edge lit backlighting. They are customizable. This means that they can be mounted and inserted virtually anywhere within the proximity of the instrument panel. Clearly, LEDs allow automotive manufacturers a much more flexible implementation of aesthetic designs due to the small footprint of the LEDs.

LEDs are brighter and are more efficient. They have exceeded the brightness and the luminous efficacy compared to CCFLs. For instance, a GPS 7-inch LED backlit display can deliver up to 600 nits. To put into perspective, an LCD display requires 350 to 400 nits in order to be viewable under daylight.

LEDs have achieved more than 130 lumens per watt which is about twice of that of the CCFL, and 14 times that of the filament bulb. As power-consuming electronic hardware continues to proliferate in new car designs, efficiency becomes increasingly important.

LEDs have long life. They do not burn out unlike incandescent bulbs and fluorescent lamps. Instead, they gradually decrease in brightness. CCFL and incandescent bulb life expectancy are 10,000 hours and 2,000 hours respectively. LEDs will outlive the life of the vehicle. Hence, LEDs need not be replaced; they can be designed in and forgotten. Figure 1 shows that a High-power LED depreciates to 85% after 20,000 hours (roughly 2 years).

LEDs are available in different col-

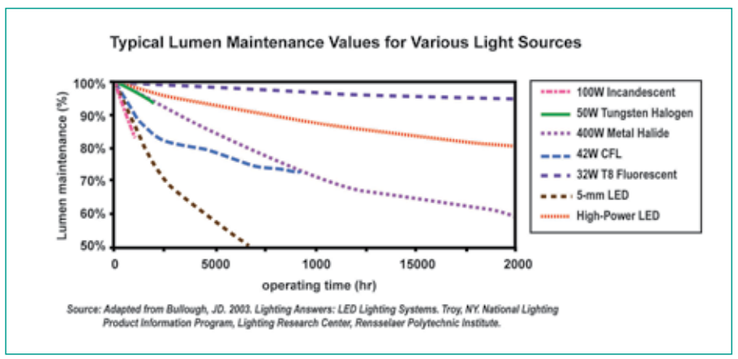


Figure 1: Compact fluorescent lamps (CFLs) are at 70% of its initial lumens after their 10,000-hour life.

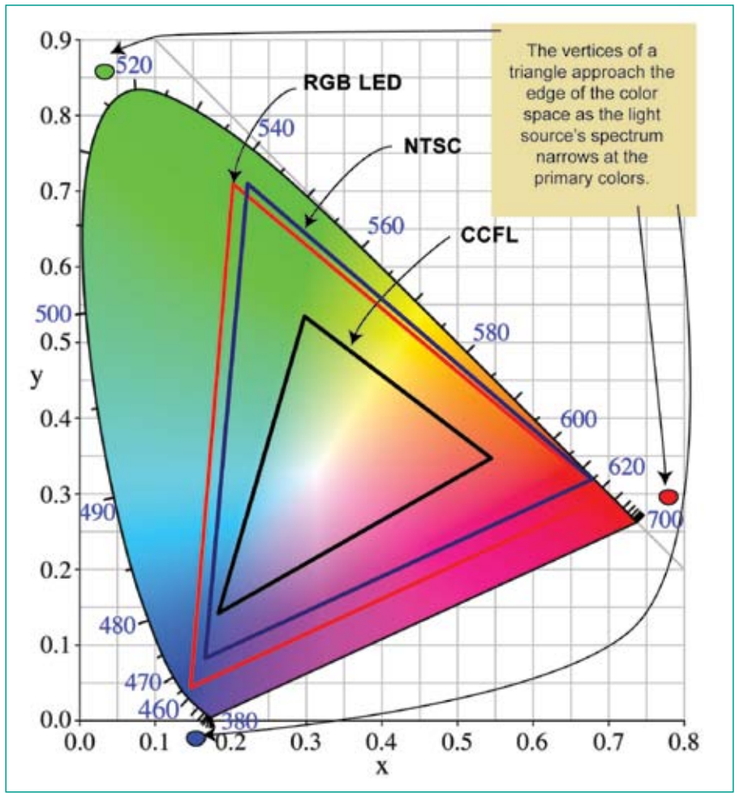


Figure 2: CIE Color space. RGB reveals 110% of the NTSC color gamut.

ors. The best LCD color gamut is achieved by firing separate narrow band red, green, and blue light sources for backlighting. RGB LEDs cover a bigger color space compared to CCFLs. See Figure 2. Clearly, RGB LEDs can reveal up to 110% of the NTSC color gamut space, enabling more vivid and realistic images on screen. Circuit 2 employs an LED driver to drive RGB LEDs and an EL7900 for color temperature control and compensation.

Finally, LEDs require a low-voltage driver. Unlike CCFL drivers, LEDs are simpler to drive. Circuit 1 has a single inductor-based white LED driver delivering 30mA each to eight LED strings.

Need for automatic brightness control.

For LCD displays, brighter doesn't necessarily mean better. Although high brightness backlighting allows more visibility during daylight driving conditions, it can be distractingly bright when driving at night in the dark. Conversely, a dimmed backlight is well-suited for night driving, but the dimmed LCD display is hardly visible during the daytime. Preferably, car drivers need daytime and nighttime readable displays.

Lighting requirements for buttons, keypads, dials and indicators is the opposite of that for the LCD display backlighting. That is, during daytime when it is bright, there is no need for lighting a push-button switch. For dim ambient conditions, backlighting the dials and other switch controls is essential.

While an easy accessible brightness control is extremely useful to a car driver, an automatic brightness control is paramount. A light sensor can detect the equivalent ambient light incident to the LCD display and adjust the backlight intensity accordingly. The added intelligence offered by the light sensor improves driving visibility, and enhances driving experience. The circuit below employs an ISL29002 light sensor.

Dimming techniques

Brightness or dimming control can be accomplished in two ways: analog dimming or PWM dimming. Analog dimming is implemented simply by varying the DC current through the LED. An increased current through the LED results in a brighter light output. However, the analog method limits the dimming range. The light output does not dim linearly at lower currents. See Figure 3. Light output can unpredictably turn off when an LED is driven at very low currents. Therefore, it is not a desirable dimming method for nighttime and daylight readable displays. Analog dimming is appropriate for compensating light depreciation due to aging and for correcting light deviations due to temperature.

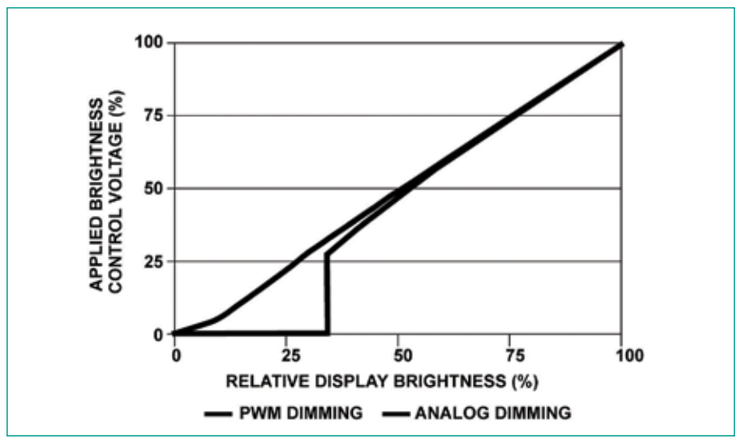
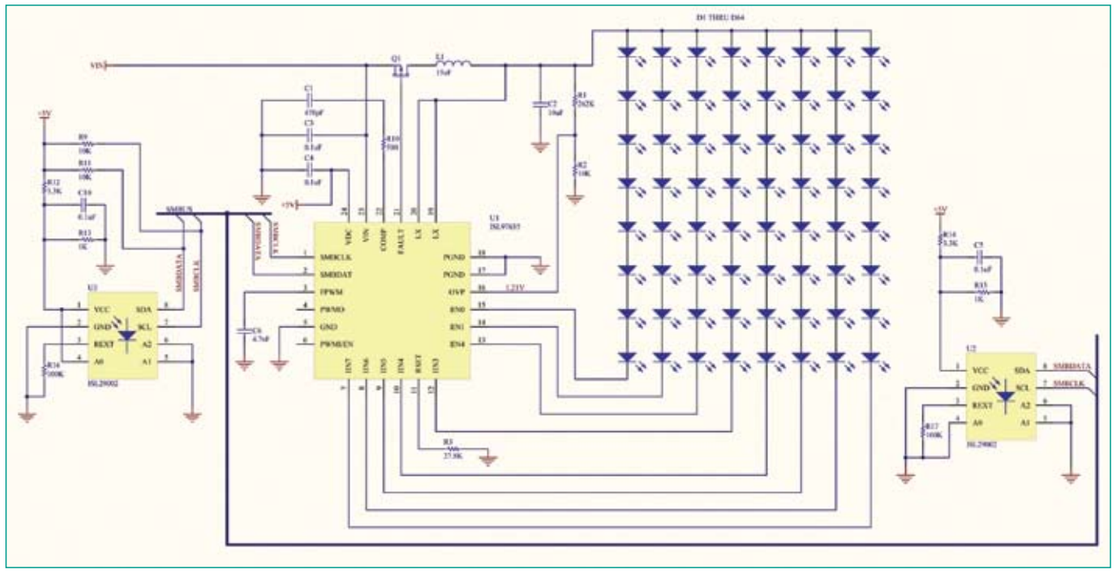


Figure 3: Analog vs. PWM dimming.

Special Report – Automotive Electronics Part I



Circuit 1: Backlight driver ISL97635 with two ISL29002 light sensors for backlight sensing and ambient light sensing.

Pulse width modulation (PWM) extends the dimming range. The LED is still forward-biased with the nominal current to ensure that it is turned on. The time that it is on per cycle (duty cycle), however, is varied. Although the on-time is periodic, the human perception is a continuous light source as long as the frequency is fast enough. The human eye naturally integrates the fast pulsing light source and interprets it as a constant luminance light source. Dimming can be achieved down to 1%. Circuit 1 uses an LED driver to drive strings of LEDs that can be dimmed using PWM and analog dimming.

Compensating for varying environmental conditions

Available white LED drivers ensure that the current through the LEDs are constant via feedback voltage regardless of ambient temperature. However, constant current is not enough to ensure that the luminance of the LEDs remain constant. Figure 4 shows that at constant current, the brightness of an LED is a strong function of temperature. White LEDs typically depreciate by roughly 1% of its luminance for every degree C. To compensate for temperature dependency, the current through the LED has to be adjusted accordingly. In addition to temperature fluctuations, LED light output also decreases over time. To correct for light output depreciation, more current is required to maintain constant light output. There is a limit as to how much to keep compensating for temperature dependency. As soon as temperatures above 80°C are reached, increasing LED current should be clamped for reliability purposes.

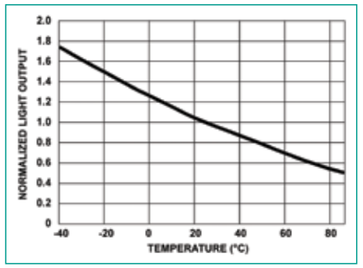
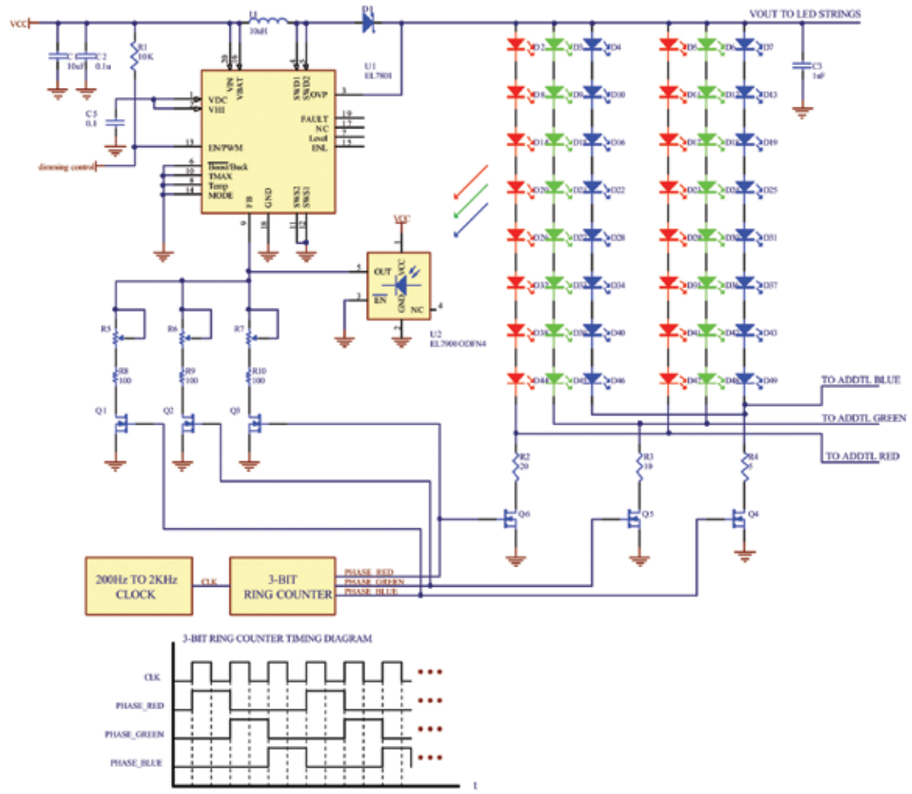


Figure 4: Typical LED luminance vs. temperature at constant current.

Design Idea 1: Circuit using two ISL29002s, and ISL97635

The LED driver is just as important as the LED light source. A good start is to find an LED driver that offers flexibility in dimming and brightness control. In circuit 1, the inductor-based ISL97635 LED, U1, driver uniformly lights up 64 LEDs in series and parallel combination for LCD backlighting. Each series connected LED is driven by a programmable current sink, ensuring a well-matched LED current. Brightness and dimming is achieved by a 255-step PWM and also 255-step analog scaling. The first ISL29002 light sensor, U2, is used to sense light output of the LEDs. The Intersil light sensor's built-in integrating type ADC allows averaged light measurements to remove the flicker. Placed within close proximity of the LEDs, the light sensor measures and converts the LED light output to digital signal that can be retrieved by the SMBus master. The microcontroller reads fluctuations of the light output caused by aging and temperature variations and then tells the LED driver to adjust the LED current or the duty cycle until the desired light output is desired. Hence, the LED light output temperature dependency and aging effect is compensated. The second light sensor, mounted close to the LCD panel, senses ambient light incident to the panel. The microcontroller retrieves ambient light information and then adjusts the backlight brightness appropriately. Consequently, automatic brightness control is achieved. For example, during daylight (around 5000lux), the backlighting can be commanded to output 500-600nits, and during nighttime (around 50lux) backlighting can be dimmed by programming the ISL97635 to output 100nits.



Circuit 2: ISL97801 driving RGB LEDs and EL7900 for color compensation.

Design Idea 2: Circuit using ISL29002, and ISL97801

A method of driving strings of RGB LEDs with an optical feedback loop is shown in Circuit 2. An inductor-based boost converter, the ISL97801, drives a combination of series and parallel RGB LEDs. The EL7900 is an optical photosensor that senses and converts optical signal into an electrical signal. The electrical signal is fed back to the ISL97801 controller to adjust the current through the LEDs. A unique modulation technique with the use of a 3-bit ring counter is employed such that a costly RGB optical sensor is avoided. The circuit ensures that the luminance (brightness) and the white point (color temperature) are kept constant over time and regardless of temperature fluctuations.

Each color is turned on sequentially one at a time at a rate determined by the clock CLK. See 3-bit ring counter timing diagram in Circuit 2. During the first clock cycle, PHASE_RED is exclusively high; PHASE_GREEN and PHASE_BLUE are low. Consequently, transistor Q6 is on to conduct current through red LEDs, and transistor Q3 is on to allow current path from the EL7900 light sensor, whose current output IOUT is proportional to the optical output of the red LED. Note that only red light is present during PHASE_RED. Red intensity is adjusted via variable resistor R7 whose resistance is inversely proportional to red light intensity. The lower the resistance, the higher the red luminance because the EL7801 controller will boost the current through the red LED increasing red intensity until the voltage at the FB is at its nominal value of 100mV.

On the second clock cycle, PHASE_GREEN is exclusively high, turning off Q3 and Q6 and shuts off the red LED. During this phase, Q2 and Q5 are on. The light sensor sees green light alone and starts another closed loop operation with the green LED.

The third cycle exclusively closes the loop on the blue LED. Note that the light sensor exclusively converts one color light at a time while the other colors are off. This method of modulation avoids the use of an RGB sensor.

At extremely slow clock rates, one can see individual colors turn on one at a time. At higher clock rates we perceive a constant white light because the human eyes are natural integrators. The complete cycle is analogous to a color wheel composed of primary colors. When spun slowly, humans see red, green and blue separately. When spun fast, the human eyes integrate and the human perception is a white wheel.

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Special Report – Automotive Electronics Part I

Eliminating Mechanical Damage in MLCCs for Automotive Applications

Zero failure rate is the utopia

Zero PPM failure rate for components supplied to the automotive industry has long been the target. At AVX, ongoing refinements to the materials and manufacturing processes, together with a comprehensive quality assurance regime results in an extremely reliable AEC-Q200 qualified multi-layer ceramic capacitor (MLCC).

By Jonathan Lennox, Technical Marketing, AVX

The 'utopia' approaching zero PPM failure rate could never be achieved unless a solution were found for the single issue that accounts for over 95% of returns: mechanical damage. It is common knowledge within the industry that whilst the MLCC is excellent in terms of reliability, ESR and cost, the ceramic body is susceptible to mechanical stress resulting in customer manufacturing and field failures.

Of course, the traditional short circuit failure mechanism gives the most concern to MLCC customers. Short circuits usually occur following some form of mechanical damage – perhaps during PCB assembly as a result of board flexure, or whilst in a vehicle, from mechanical stress. Examples of such vehicle mechanical stress include plugging / unplugging of the ECU and temperature cycling – the latter being particularly relevant to on-engine applications where the vehicle can go from a cold winter parked temperature to a hot engine running temperature very quickly. (Fig 1)

Repetitive expansion of the PCB by temperature cycling can result in a mechanical type crack forming in the capacitor.

To protect against MLCC field failure issues, AVX offers several solutions. For surface mount capacitors the FLEXITERM® range of AEC-Q200 approved components is manufactured with an additional layer of epoxy silver between the copper and nickel layers of the termination. This epoxy layer is added to each termination and has the effect of acting like a shock absorber, preventing mechanical stress from being transmitted to the ceramic body of the capacitor. (Fig 2)

First introduced to the automotive market in 2002, the FLEXITERM® range has already solved many issues for customers and is being increasingly designed into new builds were capacitors are positioned on high risk areas of the board, on small PCBs, and in applications where temperature co-efficiency mismatches between PCB and MLCC result in expansion / contraction at different rates, cracking and field failures. In the last year AVX has observed a quarterly 20% increase in FLEXITERM® product sales and it is expected that this growth will continue.

Building on the success of FLEXITERM®, AVX has developed a range of Automotive grade MLCCs called FLEXISAFE™, specifically designed and manufactured to be used in direct battery applications. By combining the cascade internal electrode structure (two capacitors in series), with the shock absorbing FLEXITERM® layer, AVX is able to offer a range of MLCCs with the highest level of designed in safety features. (Fig 3.)

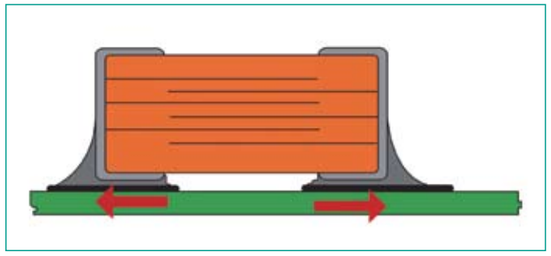

Figure 1

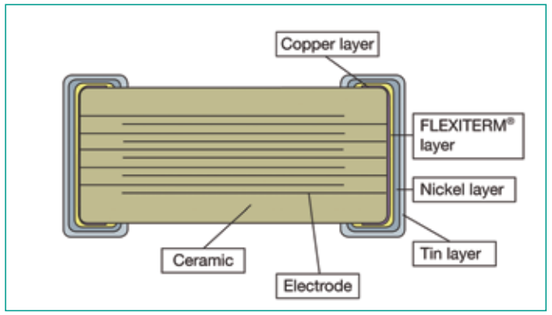

Figure 2

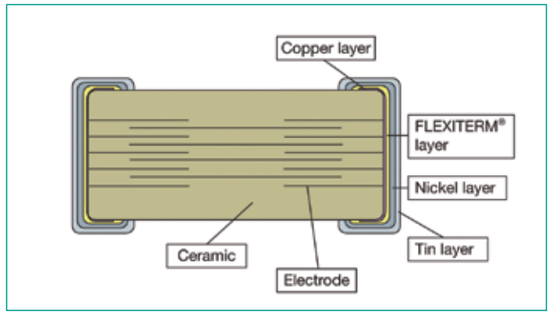

Figure 3

Finally, it is worth noting that for a mechanically robust MLCC, AVX still has available a range of leaded ceramic capacitors (AR series), qualified to AEC-Q200 standards. Leaded ceramic capacitors are still used for automotive applications and the lead-frame has several advantages. When soldering, the leads protect the capacitor against thermal stress, and subsequent board flexure and PCB expansion forces are absorbed by the leads, also protecting the capacitor. More, leaded ceramic capacitors are the preferred choice where mechanical crimp or weld type connections are required, or where the application demands molding.

As the electronics content of automobiles continues to increase, the opportunities for 0km (before the vehicle is driven at all) and field failures caused by temperature variation and handling will also increase. With its range of MLCC protection and mounting technologies – designed specifically to prevent automotive failures – AVX believes that it is in an excellent position to support the electronics suppliers, with the most reliable MLCCs ever, moving ever nearer that Zero PPM failure rate utopia.

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Reliable Automotive Power Management Design

Load dump and cold cranking problems overcome

Power management demands in automotive vehicles have become more stringent requiring the power supply to operate under wider input voltages, higher currents and higher temperature extremes driving switch mode power supply designs into the mainstream due to flexibility, configurability and thermal efficiency.

By John Constantopoulos, Sanmukh Patel and Brad Little, Texas Instruments Inc.

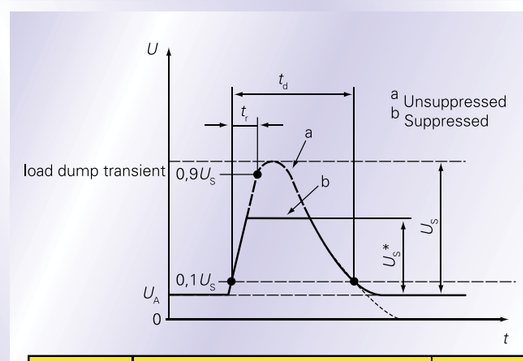
The core component of a switch mode power supply is the DC-DC converter. Today's automotive converters must support conditions such as low voltage operation (cold cranking) and positive transient survivability (Suppressed or unsuppressed load dump conditions). The higher load demands by emerging automotive subsystems further complicate the design of these converters. The sections below will provide the designer a brief introduction to automotive power supply needs and also introduce a new DC-DC converter recently released by Texas Instruments – TPIC74100.

Transient Protection

a) Load dump

Almost all electronic components and circuits that are connected directly to the car battery require protection against suppressed, transient voltages (up to 60V) and reverse voltage conditions. It is also a common requirement for electronic circuits to have to withstand some degree of over-voltage on the power-supply lines. This is especially true with automotive systems where the main power-supply input to any particular vehicle electronic system is required to tolerate transient voltage conditions, including alternator load dump.

Because the alternator's control loop is not fast enough to close, it generates a high output-voltage pulse when the battery voltage is removed. This high-energy pulse is normally clamped (suppressed) to a lower voltage at some central location in the car, but car manufacturers also specify to their suppliers the remaining overvoltage to be expected at the inputs of their power supplies. This spec differs among car manufacturers, but the typical peak value is around 40V in cars and 60V in commercial vehicles. The duration of a typical load-dump pulse is several tenths of a second. The diagram below (Figure 1) shows



Parameter	12 V system	24 V system
U_S	65 V to 87 V	123 V to 174 V
U_S^*	*Specified by customer, based on clamping diode circuitry (e.g., 40 V)*	
t_d	40 ms to 400 ms	100 ms to 350 ms
t_r	$(10\ ^{0}_{5})$ ms	

Figure 1: Load dump Transient.

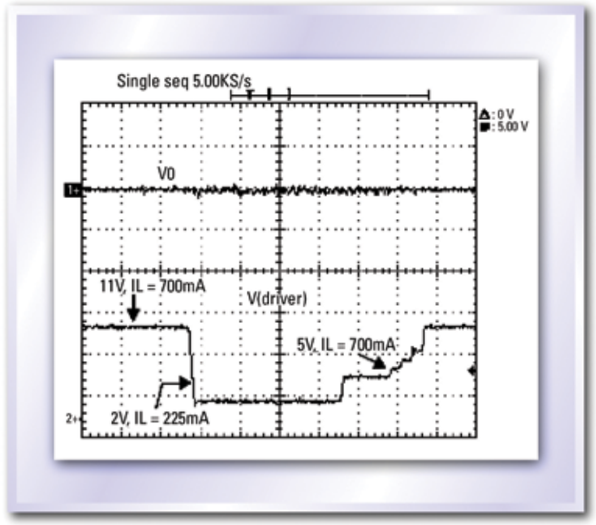


Figure 2: Input Voltage Variation - Cold Crank.

the typical pulse during a load dump condition.

b) Cold Cranking in dashboard applications

The automotive environment demands on power management ICs are increasing. One such requirement is the need for the power management IC to operate under a wide range of voltage excursions which are common to electronic systems connected directly to battery. An example of such a transient can be illustrated by looking at the cold crank pulse. This condition can occur when a vehicle is first started in a cold environment. If the temperature is low enough (freezing) the engine's oil can become viscous and place heavy load demands on the motor by asking it deliver more power (torque). This results in the need for the battery to provide more current. The heavy load demand can pull the battery voltage down to 3V momentarily during this ignition cycle.

The challenge is that some applications must remain operational during this process. These applications are not limited to powertrain ECU or safety critical application but are also being seen in Clusters and Infotainment subsystems. When this condition occurs the power management IC must boost the input voltage to maintain the proper regulated output voltage to keep the electronics systems functioning properly.

There are a few different topologies that can be used for a step-up/step-down conversion: SEPIC (single-ended primary inductance converter) or a pure Buck/Boost converter.

SEPIC converter

The SEPIC converter provides a step-down conversion until the input voltage equals or falls below the output voltage. It then provides step-up conversion until the battery voltage falls down to the minimum allowed input voltage. The main disadvantage of using SEPIC is that it requires a single coupled inductor (transformer) or two separate inductors as well as a coupling capacitor, as shown in Figure 3.

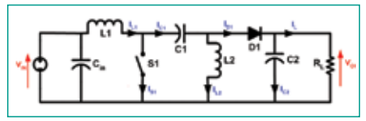


Figure 3: SEPIC Topology using two separate inductors.

Inductors and coils are large and require much space on the PCB. This is unfavorable in applications where conservation of size and board space are a major requirement.

Buck-Boost converters for Cranking

The need for buck-boost converters in automotive applications has been increasing dramatically over the past few years. This is especially beneficial for applications which need to be continuously "alive" during voltage transients such as cold cranking.

The **buck-boost converter** is a type of DC-DC converter that can have an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is a switch mode power supply with a similar circuit topology to the boost converter and the buck converter. The output voltage is adjustable based on the duty cycle of the switching transistor.

This topology consists of a buck power stage with its two power switches connected through the power inductor to a boost power stage with its two power switches. These switches can be controlled in three distinct modes of operation: buck-boost, buck and boost modes. A specific IC's mode of operation is a function of the input-to-output voltage ratio, and the IC's control topology.

The TPIC74100-Q1 is a buck-boost switch-mode regulator that operates in a power-supply concept to ensure a stable output voltage with input voltage excursions and specified load range.

The TPIC74100-Q1 has integrated switches for voltage-mode control and is also designed in a synchronous configuration for improved overall efficiency. With the aid of external components (LC combination), the device regulates the output to 5V ±3% for a wide input-voltage range which allows it to be used in a number of high input voltage applications. The device also offers a reset function to detect and indicate when the 5V output rail is outside of the specified tolerance. This reset delay is programmable using an external timing capacitor on the REST terminal.

The TPIC74100 has a frequency-modulation scheme to allow the system

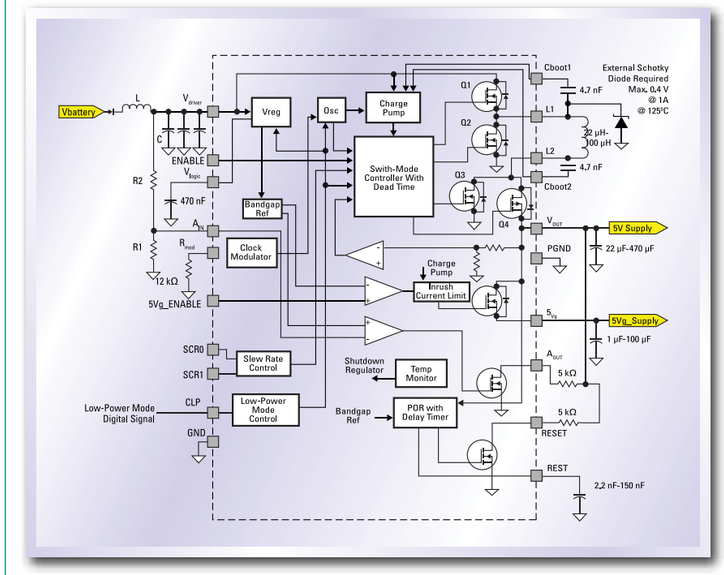


Figure 4: Overview of TPIC74100.

design to meet EMC requirements by spreading the spectrum noise over the frequency band instead of having peaks at specific frequencies...

The 5Vg output is a switched 5V regulated output with internal current limiting to prevent RESET from being asserted when powering a capacitive load on the supply line. This function is controlled by the 5Vg_ENABLE terminal. If there is a short to ground on this output (5Vg output), the output self-protects by operating in a chopping mode. This does, however, increase the output ripple voltage on VOUT during this fault condition.

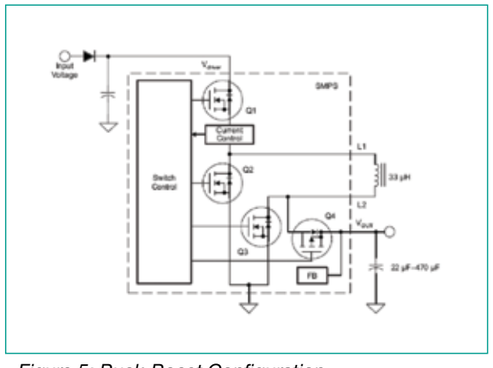


Figure 5: Buck-Boost Configuration.

Buck-Boost Transitioning

The operation mode switches automatically between buck and boost modes depending on the input voltage (Vdriver) and output load conditions.

In normal operating mode the system will be configured as a buck converter. However, during a low input voltage pulse the device automatically reverts to boost mode operation to maintain 5V regulation. This crossover window to switch to boost mode is when the input voltage (Vdriver) is between 5.8V and 5V and depends on the loading conditions.

When the device is operating in boost mode and V(driver) is in the crossover window of 5.8V to 5V, the output regulation may contain a higher than normal ripple and only maintain a 3% tolerance. This ripple and tolerance depends on the loading and improves with a higher loading condition.

Low Power operation

In applications such as powertrain and dashboard cluster, low power mode operation is required to minimize consumption during vehicle ignition OFF. The TPIC74100-Q1 has an input LPM which when enabled will operate in PFM (Pulse Frequency Modulation) during light loads (typically < 30mA). In most systems there are memory devices which require some power during ignition OFF to retain data; this is typically less than 100uA. To support this mode of operation total module consumption is less than 300uA. The TPIC74100-Q1 has low power mode quiescent current of 150uA (typical). Regulation is done by variation of the switching frequency.

There is no reduced load current capability for the output load in PFM mode. In this mode the converter efficiency is lower and output voltage ripple will be slightly larger than in PWM mode for higher load currents. Low power mode functionality is implemented for buck mode operation. In boost mode conditions the device will automatically work in PWM mode. With low power mode enabled, the transition between buck and boost is at the same time a transition between PWM mode and PFM mode.

Conclusion

Vehicle transient voltages are an issue that will continuously create challenges in many automotive applications. Buck-Boost converters will serve a vital role in many automotive power management systems where an application needs to be continuously functional during these conditions or when the battery voltage unexpectedly falls below the required output voltage. The TPIC74100-Q1 automotive buck/boost converter will simplify designs in the automotive environment and allow the design engineer to save external components and PCB space (integration of power switches and synchronous operation). The TPIC74100-Q1 is available in a 20 pin PWP package with thermal pad and is specified for the -40°C to +125°C temperature range.

www.ti.com

Switching Regulators for Automotive Applications

New switching step down converter increases efficiency in on-board applications

The technology in automotive on-board applications is growing dramatically to meet the tough requests in terms of performance, environmental issues (low consumption and pollution) safety and comfort.

By Alessandro Maggioni and Fulvio Lissoni, STMicroelectronics

This continuous demand for new equipment implies the increasing number of electronic components and the growing complexity in automotive applications.

These applications are mainly split into four categories:

- Body applications, which are used to enhance the comfort of passengers. Systems including air conditioning, wiper controls, power windows, doors and seats control, keyless entry systems and car alarm.

- Power train applications, directly related to the engine, such as engine cooling and management, throttle driving etc.

- Safety and chassis application, which increases occupant safety, such as airbag systems, anti lock brakes, traction control, electric power steering and suspension.

- Car entertainment and information, which includes all the communication applications such as car radio, navigation system and telematics box.

In automotive applications, due to the range of battery voltage given by the state of charge, temperature and operating phase and so on, the nominal operating input voltage can vary between approximately 8V and 16V. The extreme and wide operating conditions make this window even larger: for example a cold crank phase, where the car must start at low temperatures that cause the drop of the battery voltage down to 6V. Moreover, in the opposite direction, due to load dump or spikes, the circuit must be able to support an input voltage up to 40V, in order to prevent overvoltage damage. This often means that in automotive applications, the input voltage range must be at least from 6V up to 40V.

An important key feature in these applications is the efficiency of the system. Up to now, all the power conversions were made by LDOs, but the performance, especially in terms of power dissipation, becomes very low, due to the increasing current demand in the equipment of the new car. This implies that a switching approach is required more and more often.

The increase in the number of switching converters in automotive, introduces a new requirement: a low quiescent current. Infact, due to the higher complexity than an LDO, switching converters normally have a higher consumption. When the engine of the car is on and the battery is charging, there are no problems. Once the engine is turned off and the car is parked, some systems are always supplied, (e.g. memories, alarms, clock and much more…) and the battery starts to discharge. Due to this a low quiescent current in switching converters suited for automotive applications becomes mandatory.

A car must work properly during the winter season near the Poles, as well as during the summer close to the Equator. This means that the device must guarantee its parameters in a wide range of ambient temperatures. Usually, in car body and infotainment applications, an operating temperature range from -40°C up to 85°C must be guaranteed. In safety critical applications and

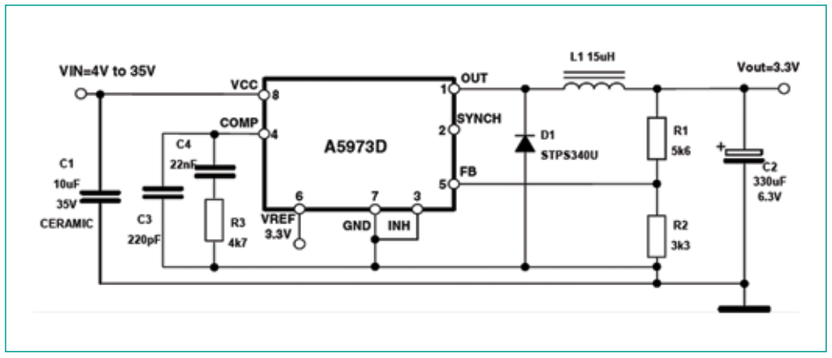


Figure 1. A5973D application circuit.

extreme environmental conditions, the temperature range request is usually from -40°C to 125°C. Moreover, more and more often, common part-qualification and quality-system standards are required, these standard requirements are explained in the AEC-Q100 regulation, and the compliancy to this specification implies longer reliability tests and additional parameter tests, in order to assure higher quality and reliability levels.

To satisfy the specific requirements of the automotive market STMicroelectronics has developed a new monolithic step-down asynchronous DC-DC converter family, qualified following to the AEC-Q100 specifications' guidelines. The highest current capability device is the A5973D. It is a monolithic step down DC-DC converter, able to deliver up to 2A of continuous output current, with embedded overcurrent, overvoltage and over temperature protection. The main benefit is to increase the MTBF of the final application, a key requirement of applications tailored to the automotive segment. The designer can disregard optimizations related to the selection of external components and avoid possible issues related to layout of power switches on the board. These advantages speed up the design and development, ensuring shorter time-to-market and offering a real cost reduction by cutting the fixed costs of external components. Figure 1 shows the typical application circuit.

The A5973D is based on voltage mode architecture and can manage short conduction times, around 200ns, of the power element with a fixed switching frequency of 250 kHz and it can be synchronized to a higher frequency. The operative input voltage ranges from 4V to 36V and the output voltage can be adjustable from 1.23V up to 35V. The output voltage has a ±3% precision all included: line, load and temperature.

On the other side, the minimum input voltage value assures a proper start-up also in the case of cold crank, when the battery voltage has fallen to 6 volts. Extreme conversion ratios are supported thanks to the short minimum conduction time of the embedded power element allowing a low output voltage to be regulated even during an overshoot of the bus. A series diode can be added at the input to support the reverse battery protection. The integrated P-channel MOS requires no external bootstrap capacitor and allows a 100% duty cycle. The low RDSON (typical value of 250mΩ) and the fast conduction times of the power element assure a very high efficiency in most of the application conditions and make the A5973D a very attractive solution compared to the widely diffused LDO regulators in the automotive segment, also in terms of size and cost of the overall application. Some efficiency results are reported in figure 2.

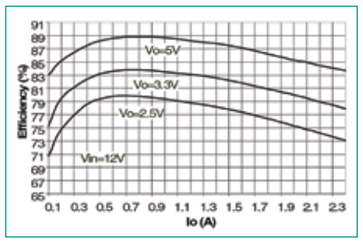


Figure 2. Efficiency vs. output current with Vin=12V.

The low quiescent current is useful to minimize the power consumption to increase the battery life when the car is parked or the engine is stopped.

The pulse by pulse current limit with internal frequency modulation offers an effective constant current short circuit protection.

The over-temperature circuitry monitors the junction temperature protecting the device. It disables the regulator in case the junction temperature reaches 150°C and provides a hysteresis of 20°C. Figure 3 shows how the junction temperature increases, increasing the output current.

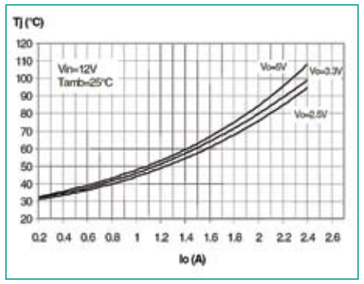


Figure 3. Junction temperature vs. output current.

Thanks to the high thermal performance HTSOP8 package with a typical Rthj-a of 40°C/W (mounted on the evaluation board) the device is able to manage high power dissipation. This feature helps increase the deliverable output power at the very high ambient temperatures typical in automotive applications.

www.st.com

Robust Energy Conversion in Automotive Applications

Tough environments need tough solutions

The increasing use of electronic systems in automotive applications places huge demands on the power systems which supply them. With PCB board space at a premium, higher levels of load power necessitate system level solutions with very high conversion efficiency and high power density.

By Dr. Iain Mosely – Consulting Senior Field Applications Engineer, National Semiconductor

The LM5010A is one of a family of advanced new hysteretic parts developed by National Semiconductor to cost-effectively address automotive industry needs for conversion efficiency and power density whilst meeting the extremely tough operating requirements found in automotive systems. The design example system used in this article achieves 90% full power efficiency whilst maintaining an IC temperature rise of less than 30°C above ambient.

Although trucks and buses may operate from 24V, most automotive applications still use a 12V battery system as the main power source. When the engine is started in a 12V system, the high current drawn by the starter motor (>100A) can transiently reduce the battery voltage down to 6V. At the other extreme, voltage surges due to load dump can transiently increase the system voltage to around 70V. Whilst the design should be optimised to operate at highest efficiency at the nominal 12V level, the power supply system should still be able to provide full power to the electrical systems over the full operating input voltage range.

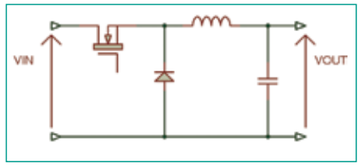


Figure 1: Buck converter topology.

Converter control

Most requirements for non-isolated step down conversion can be met with the buck converter topology, Figure 1. The output voltage from this converter is approximately the input voltage multiplied by the duty cycle of the buck converter switch. The output voltage of the converter can therefore be regulated by controlling the duty cycle of the switching device. Traditionally, this is achieved with running at a constant switching frequency and then varying the on-time of the device (Pulse Width Modulation). However, for a buck converter to step 70V down to less than 5V, a duty cycle significantly below 10% is required. In practice, this duty cycle combined with the trend to ever higher switching frequencies requires that the buck converter switch is held on for a very short time, typically only a few hundred nanoseconds. This creates a significant problem for traditional high frequency PWM controllers which can find it difficult to accurately control the very short device on-time.

Another way to control the duty cycle is to run the switch with a constant fixed on-time and then to vary the switching frequency to maintain regulation (Pulse Frequency Modulation). This mode of operation is used with hysteretic converters. As Equation 1 shows, a traditional hysteretic buck converter running in continuous conduction mode with a constant on-time, the switching frequency Fs will vary significantly as input voltage changes in order to maintain the output voltage at a constant level. In this equation, VD represents the forward conduction drop of the buck converter diode. For an automotive application running with an input voltage range of 6V to 70V, the variation in switching frequency will vary over a range of around 10:1

$$F_S = \frac{V_{OUT} + V_D}{T_{ON} \times (V_{IN} + V_D)}$$

The hysteretic operation therefore simultaneously allows for a high step down ratio and high switching frequency, both of which are essential for automotive solutions with restrictions on PSU area. The only problem here is that the wide range in switching frequency can sometimes lead to unpredictable EMI and interference.

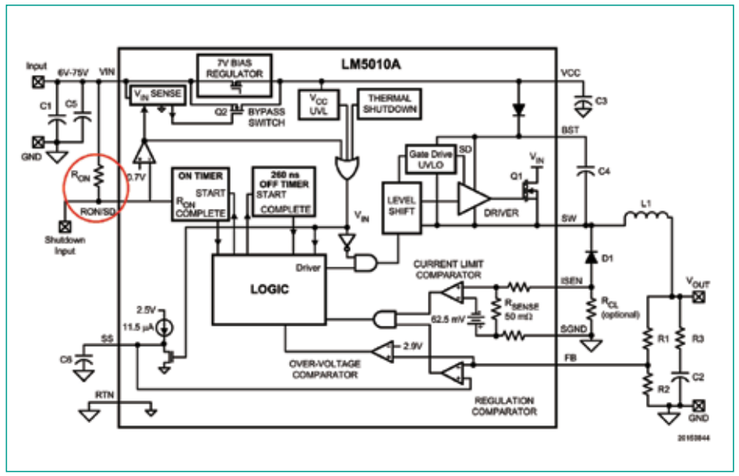


Figure 2: LM5010A block diagram.

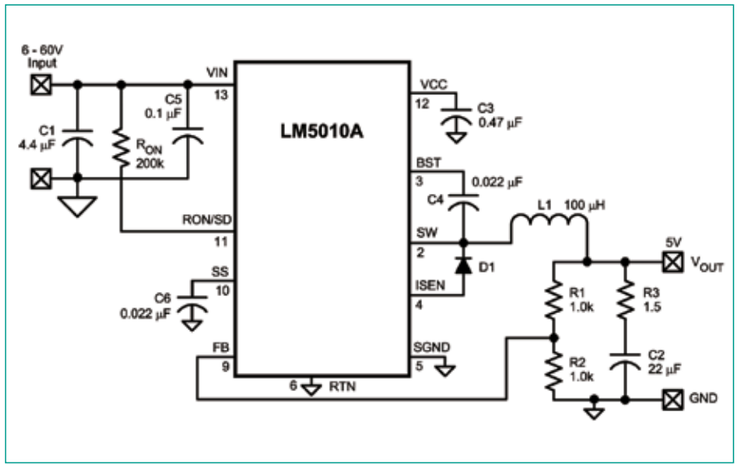


Figure 3: LM5010A full schematic.

Constant on-time control

The LM5010A operates as a hysteretic controller and therefore yields all the benefits discussed above. The difference compared to traditional hysteretic operation is that the on-time of the LM5010A switch is actually 'programmed' by the input voltage. The LM5010A block diagram, Figure 2, shows that the RON resistor sets the length of the on-timer by directly measuring the input voltage. As input voltage rises, the device on-time is reduced proportionately such that the switching frequency remains relatively constant over the full range of input voltages. The switching frequency will now only drop once the PSU enters discontinuous conduction mode under light load conditions and this transition point can be predicted through calculation.

The LM5010A operates as a digital on-off controller and as such does not need loop compensation components. This eliminates the delay normally associated with compensation and allows the controller to respond to output load or input voltage changes in the next switching cycle – i.e. within micro seconds. Also, since changes in input voltage change the device on-time almost instantly, rapid changes in input voltage have very little effect on output voltage and this practically eliminates voltage fluctuation on the output during load dump conditions.

Designing with the LM5010A is straightforward and involves the designer deciding on what nominal switching frequency to run at. Operation at higher switching frequencies will minimise the size of the power stage components and allow the use of small ceramic capacitors. The evaluation platform used here runs at a nominal design frequency of 200kHz and can deliver +5Vdc at 1A from an input voltage of 6V to 75V. Figure 3 shows the full schematic for this converter.

Figure 4 shows the actual measured switching frequency of the device as a function of load current at input voltages of 6V to 60V. Over most operating conditions of output load and input voltage, the device switching frequency is very close to the nominal 200kHz design value. A traditional hysteretic converter would demonstrate a much wider range of switching frequency variation with input voltage compared to the results given here.

At light loads (typically less than 10% of full load), the converter enters discontinuous conduction mode (DCM) and the switching frequency drops linearly with load. The point at which DCM mode begins can be predicted from Equation 2.

$$I_O = \frac{1}{2 \times L \times F_S \times V_{OUT}} \times \left(\frac{(V_{IN} - V_{OUT})(V_{OUT} + V_D)}{V_{IN} + V_D} \right)^2$$

Choosing a higher nominal switching frequency or larger buck inductance will allow the converter to run down to a lower output current before the frequency reduction due to DCM occurs. The lower operating frequency at light loads also helps to keep conversion efficiency high even down to very small loads as shown below. In the +5V evaluation board example used here, the efficiency is around 90% with 12V input and great-

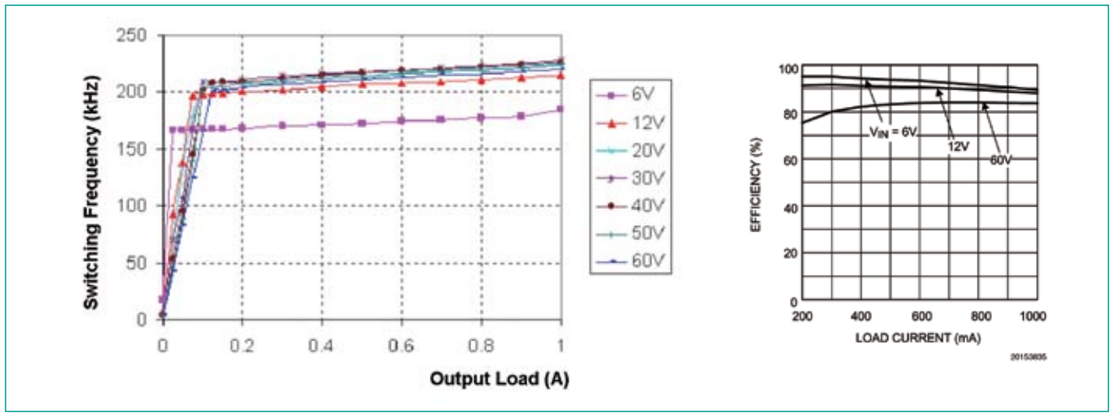


Figure 4: Actual measured switching frequency as a function of load current (This caption applies to Figures 4a & 4b).

er than 82% even with 60V input.

Good thermal management is a necessity for a robust and reliable converter design. The LM5010A is available in two different package styles which deliver a junction to case thermal impedance of just 40°C/W. At full output power of 1A, LM5010A used in the design example here demonstrated a temperature rise of just 30°C above ambient.

The new developments in constant on-time regulators detailed in this article have paved the way for integrated regulators to take the best features of hysteretic converters such as ultra-fast transient response and simple implementation and combine them with the predictable switching frequency behaviour normally only found with PWM control schemes. This combination of features has resulted in a new range of devices ideally suited to the difficult technical challenges posed by automotive applications.

www.national.com

Low-Cost Digital POL Modules Provide 60A at Over 92% Efficiency

Power-One introduces the 60A ZY8160; the highest current digital Point-of-Load (POL) module currently available. This fully-programmable DC-DC converter provides industry-leading power management capabilities with no additional cost or space requirements when compared to analog "conversion only" solutions. ZY8160-based systems can reduce development time, components, and PCB traces by up to 90%.

Bill Yeates, Power-One's CEO, commented, "The ZY8160 is an exciting addition to our maXyz® Z-Series and provides the advantages of open-architecture digital power management to high-current data server, data storage, and communications applications. The ZY8160 extends the digital-power leadership position of Power-One, and the Z-Alliance, in terms of the number of solutions currently available, demonstrated advantages offered to our customers, and markets served."

When used with Z-Alliance™ compatible ZM7000 Series Digital Power Managers (DPMs), the ZY8160 facilitates the complete elimination of external components for sequencing, tracking, protections, monitoring, and reporting. All parameters of the ZY8160 are programmable via the industry-standard I²C communication bus and an optional Graphical User Interface (GUI). Configuration capabilities also include the ability for "on the fly" operating-parameter changes, without hardware changes, at any time during system development or service.

Programmable parameters include: output voltages, sequencing, tracking, and protection limits. These user-defined settings are stored in a DPM and are used to initialize the ZY8160 during system start up. Unlike many other power management solutions, a ZY8160-based solution can operate autonomously in any system and does not require users to provide an I²C interface, host processor, or non-volatile memory.

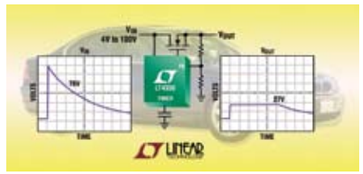
Other elements in the ZY8160 feature set:

- Wide input (8V–14V) and output (0.5V–2.75) ranges power a variety of applications with only one part number to inventory.
- ZY8160-based systems can be configured to manage up to 32 digital POLs and analog components such as converters, fans and LDO regulators.
- Compact packaging: 61 x 10.4mm SIP footprint and 28mm height.
- Active digital current sharing.
- Real time monitoring and reporting of output voltage, output current, operating temperature, and the status of all protections.
- Ramp rates and delays are easily set up using the Z-One GUI. The turn-on and turn-off of all outputs are controlled by the same clock, providing unsurpassed digital-timing precision.

RoHS lead free and lead-solder-exempt products are available. Certifications to UL60950, CSA C22.2 No. 60950-00, and TUV EN60950-1:2001 are pending.

www.power-one.com

Overvoltage Protection Regulator & Inrush Current Limiter Ensures Reliable Operation During Power Surges



Simplified Overvoltage and Overcurrent Protection.

Linear Technology introduces the LT4356, an overvoltage protection regulator, with overcurrent protection and inrush current limiting for high availability systems. In applications where electronic systems must cope with high voltage surges of short duration, such as load dump in automobiles, the LT4356 provides solid front-end protection for valuable, safety critical downstream components. The wide input operating range of 4V to 80V enables continuous operation during cold crank conditions where the battery voltage can be as low as 4V. With its high input voltage rating, the LT4356 can handle transient voltages of 100V and higher, and provides reverse input protection to -30V without damage to itself or the load. The LT4356 lends itself well to automotive, industrial and avionics applications, as well as positive high voltage distributed power Hot Swap™ systems.

The LT4356 replaces complicated and bulky protection circuitry with a simple IC and FET solution. It provides a well-regulated output during an overvoltage transient, allowing continued operation through the event. Front-end protection permits the use of lower cost DC/DC regulators downstream. During an overvoltage event, the LT4356 regulates the output to a user-defined voltage by controlling the gate of an external N-Channel MOSFET. Inrush current limiting is achieved by controlling the voltage slew rate of the gate. The LT4356 monitors voltage drop across a current sense resistor at the input of the circuit to protect against overcurrent faults. For either an overvoltage or overcurrent fault condition, an integrated fault timer ensures safe shutdown of the MOSFET if the fault persists.

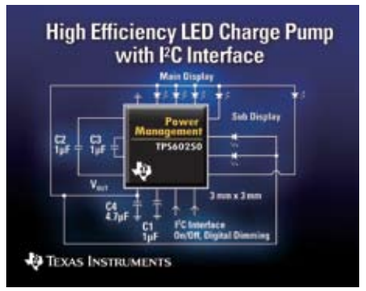
An auxiliary amplifier is provided for additional design flexibility. It may be used as a voltage detection comparator or a low drop out (LDO) linear regulator controller. The LT4356 is available in two options defined

by the function of the shutdown pin. For the LT4356-1, shutdown of the IC reduces the quiescent current to 5uA. For the LT4356-2, the auxiliary amplifier and internal reference remain active to ensure a keep-alive supply voltage for vital functions while the main system is shutdown. Quiescent current is reduced to 50uA during shutdown.

Specified over the full commercial, industrial and automotive temperature ranges, the LT4356 is offered in (4mm x 3mm) 12-pin DFN and 10-pin MSOP packages. Evaluation kits are available from the factory. The device is available now in production quantities.

www.linear.com

High-Efficiency Charge Pump with I²C Interface Drives Seven White LEDs



Texas Instruments has introduced a high-efficiency, constant-frequency charge pump DC/DC converter that uses dual-mode conversion to maximize efficiency over the input voltage range. The tiny 3mm x 3mm device provides a fully programmable current with I²C interface for applications, such as cellular phones, PDAs and multi-display handheld devices.

TI's TPS60250 drives up to five white LEDs for a main display and two white LEDs for a sub-display with regulated constant current for uniform intensity. By utilizing adaptive charge pump modes and very low-dropout current regulators, the TPS60250 achieves high efficiency over the full one-cell lithium-battery input voltage range. Four enable inputs, available through I²C, are used for simple on/off controls for the independent displays. To lower operating current when using one sub-display LED, the device provides completely separate operation in sub-display LEDs.

The TPS60250 is shipping in volume production today from TI and its worldwide network of distributors and packaged in a 3mm x 3mm, 16-pin QFN packaging.

www.ti.com

New High Performance 2-channel 120W Class D Power Audio amp Reference Design

International Rectifier has introduced the IRAUDAMP4 Class D audio power amplifier reference design. Compared to typical circuit designs, the new reference design illustrates how designers can reduce PCB board space by 50 percent for Class D audio amplifiers for the entire mid-voltage range of mid- and high-power amplifiers for home theatre applications, professional amplifiers, musical instruments and car entertainment.

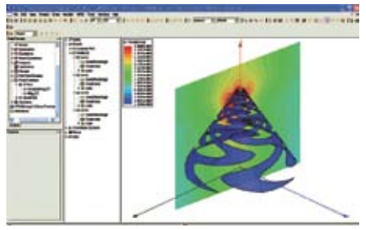
Showcasing IR's IRS20955 200V digital audio driver IC and the IRF6645 DirectFET® digital audio MOSFETs, the IRAUDAMP4 reference design is a two-channel, 120W half-bridge design offering 96% efficiency at 120W, four ohms. The design incorporates critical protection features such as over-current protection, over-voltage protection, under-voltage protection, DC-protection, and over-temperature protection, in addition to housekeeping functions such as a +/- 5V supply for analog signal processing for the preamplifier and a +12V supply (Vcc) referenced to -B for the Class D gate driver stage. The two-channel design is scalable for power and a number of channels, and requires no heatsink under normal operating conditions.

Specifications

Part Number	Supply Voltage	Load Impedance	Frequency	Gain Setting
IRAUDAMP4	+/-35V	4-Ohms	400kHz	26.8dB

www.irf.com

Industry-Standard Software for 3D Full-Wave Electromagnetic Field Simulation



Ansoft Corporation, developer of high-performance electronic design automation (EDA) software, has announced the release of HFSS™ v11. This release of Ansoft's flagship product features new technology that delivers even greater accuracy, capacity and performance than before. It includes new higher-order hierarchical basis functions combined with an iterative solver that provides accurate fields using smaller meshes and thus more efficient solutions for large multi-wavelength structures. A new fault tolerant, high-quality finite element meshing algorithm allows HFSS to simulate very complex models two to five times faster using half of the memory compared to

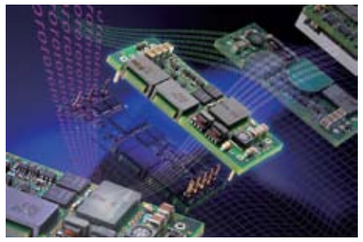
previous versions.

HFSS is the standard for 3D full-wave electromagnetic field simulation, a critical aspect in designing high-performance electronic devices that are more portable, smaller in size and operate at higher frequencies. These devices include RF/microwave components, on-chip passives, PCB interconnects, antennas and IC packages.

The dynamic link between HFSS and the company's advanced, combined frequency- and time-domain circuit simulator Nexxim®, and Ansoft Designer®, the company's integrated schematic and design management front-end, creates a powerful electromagnetic-based design flow. This design flow enables users to merge complex, highly nonlinear transistor-level circuits with 3D full-wave accurate component models to solve challenging high-performance electronic designs.

www.ansoft.com

1/8 Brick DC/DC Module Raises Benchmark for Power and Control Performance



Ericsson Power Modules' PKB-C DC/DC converter has considerably more output power than competitive products, vital where customers are looking for higher power in a smaller package than the traditional quarter-brick, or to obtain higher power in a standard eighth-brick format.

The use of a secondary digital monitoring circuit makes it possible to provide control of an infinite number of customers' output circuit characteristics, such as latching, Over Voltage Protection (OVP), Over Current Protection (OCP) and Over Temperature Protection (OTP) without adding extra components. Because this circuit can be programmed during manufacturing, it reduces the time-to-customer when a tailor-made protection configuration is required.

The module is available in through-hole and surface-mount. There is also a further mechanical option that features a broader baseplate to cater for higher operating temperatures in situations where airflow is reduced.

The surface mount PKB-C is less than 9mm high, making the module particularly suitable for applications designed for low building height, guaranteeing enough isolation distance from the module to an adjacent board.

Designed for use with 48V input applications, the PKB-C is primarily made for telecom and datacom applications such as routers, servers, data-storage, wireless-network, but also for many other applications requiring high power density modules with a high thermal performance such as process control, robotics, embedded computer applications, and many others.

The inclusion of the secondary digital monitoring control circuit makes it possible to characterize the module during manufacturing without adding any extra components, and on a unique PCB, to customize the output protection requirements to meet customers' specific requirements.

The use of secondary-side control enables tighter control of Vout and ensures that the most stringent requirements for monotonic and prebiased start-up can be met. A digital microcontroller handles all the protection features in an extremely flexible way, simultaneously taking up a minimal amount of the space needed for the current doubler and the power train. Thus, a single, basic product can be defined in an infinite number of combinations to provide a customized product at the same cost as a standard module.

www.ericsson.com/powermodules

Highly Integrated 'System-In-A-Package' Ballast IC for Compact Fluorescent Lamps

Fairchild Semiconductor introduces FAN7710, the most highly integrated ballast IC on the market developed for compact fluorescent lamp (CFL) designs. The system-in-a-package approach optimizes performance while simplifying design and overcoming space limitations of CFL lighting applications.

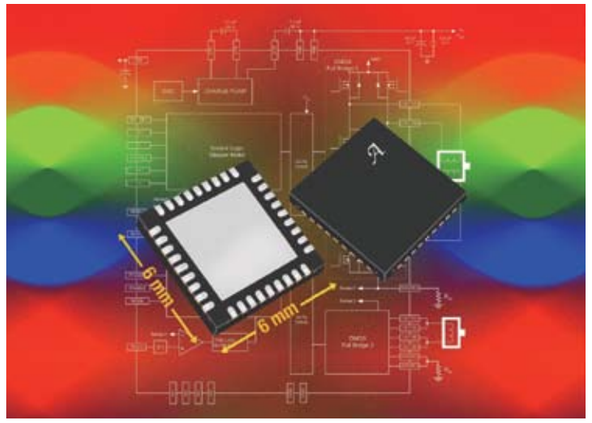
The device combines one high-side 625V gate driver circuit, two 550V MOSFETs, a frequency control circuit and a shunt regulator into one ultra-compact 8-DIP package. As the most integrated device solution, the FAN7710 helps designers simplify designs by reducing component count. The high functionality and built-in protection features save board space, reduce power dissipation and result in excellent temperature characteristics and enhanced system reliability.

In addition to the FAN7710, Fairchild offers the FAN7711 for linear fluorescent lamp (LFL) designs as well as CFL applications. This ballast IC integrates all but the two high-power MOSFETs offered by the FAN7710 to make it suited to LFL designs. The FAN7711 is available in both 8-DIP and 8-SOP packages.

These products are available in lead (Pb)-free packages that meet or exceed the requirements of the joint IPC/JEDEC standard J-STD-020C and are compliant with the European Union requirements now in effect.

www.fairchildsemi.com

Motor Driver IC Offers High Current from Very Small Package



The new A3989 from Allegro MicroSystems Europe is a high-efficiency motor driver IC designed to drive one bipolar stepper motor at up to 1.2A and one DC motor at up to 2.4A.

The A3989 is designed for applications in office automation, automated handling equipment and gaming machines, that incorporate one DC motor and one stepper motor. The integration of two motor drivers in one compact package makes the A3989 more cost effective than discrete IC motor drivers, while the small footprint is important in applications where PC board space is limited.

The new DMOS device can generate drive voltages of up to 36V, and includes three full-bridge circuits, each with an independent fixed off-time pulse width modulation (PWM) current regulator.

The two stepper-motor full-bridge circuits feature Allegro's patented mixed decay mode: a current decay control scheme which results in reduced audible motor noise, increased step accuracy, and reduced power dissipation. The DC motor full-bridge current regulator operates in either fast or slow decay mode, determined by the signal on the mode input pin.

High and low side internal synchronous rectification control circuitry is provided to improve power dissipation during PWM operation, eliminating the need for external Schottky diodes. Low-resistance DMOS outputs further reduce the power dissipation, and allow higher average output currents because of the lower die temperature rise.

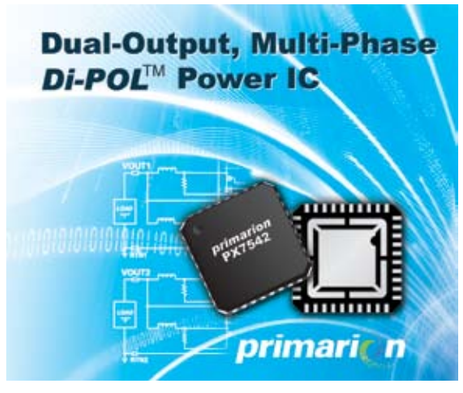
Phase, enable and mode inputs are provided for use in controlling the speed, torque, direction and brake or coast functions of a DC motor. The stepper motor driver features dual 2-bit nonlinear DACs (digital-to-analogue convertors) that enable control in full, half, and quarter steps.

Protection features include thermal shutdown with hysteresis, undervoltage lockout and crossover current protection. Special power-up sequencing is not required.

The A3989 is supplied in a 6 x 6 x 0.9mm, 36-pin QFN package with an exposed power tab for enhanced thermal performance. The package is lead (Pb) free, with 100% matte tin leadframe plating.

www.allegromicro.com

Primarion Unveils Dual-Output, Multi-Phase Digital DC/DC Controller



Primarion has announced the addition of the dual-output, four-phase PX7542, with 100 picoseconds pulse width modulation (PWM) resolution, to the Primarion Di-POL™ product family of fully programmable digital power conversion and power management ICs.

The highly configurable PX7542 is a power conversion and power management IC for synchronous DC/DC converters in the telecom, datacom, computing and storage markets, compliant with PMBus™ 1.1 specifications. The IC simplifies design and increases density of system level power management architecture with its minimum footprint, by controlling two independent outputs with two phases per output, or one to four phases in a single output mode. The control function handles both DCR and RDSon current sense topologies and a programmable output range of 0.5V to 8V.

"Datacom, telecom, computing and storage market OEMs look for increased

flexibility, efficiency, cost savings and density in managing their power systems," said Deepak Savadatti, vice president of marketing for Primarion. "The numerous features of the PX7542, combined with the easy to use GUI, address these key attributes while improving overall system reliability. With the introduction of the PX7542, Primarion has become a one-stop-shop for OEMs, offering cost-effective digital solutions with controllers featuring single output from one to four phases and dual outputs from one to two phases per output."

Configurations for the PX7542 are easily loaded, edited and saved to von-volatile memory (NVM) over the device's I^2C serial interface using Primarion's graphical user interface (GUI). With configurations stored on the IC, the controller can perform real-time adjustments to the designer's previously configured settings and thereby optimize performance accuracy, without the delay of accessing outside memory storage.

Other technologies would typically require an external microcontroller for this type of enhanced performance. By integrating the digital control functions with the PMBus interface and easy to use GUI, the PX7542's power management capabilities provide one complete solution, eliminating the need for additional components.

"Primarion has obviously studied the market carefully to determine customer requirements before introducing the PX7542," said Morry Marshall, partner, Advanced Technologies, Semiconductor Partners LLC. "Their GUI helps designers configure, optimize and monitor the power system with no programming required. It combines flexibility with ease of design."

The PX7542 is driven by a single +5V supply and operates over a frequency range of 150KHz to 1MHz. Precise current sharing between phases allows the flexibility to regulate multi-phase operation for higher output loads. The PX7542 maintains accuracy through internal calibrations, which assess and improve system-level current sense error sources upon startup. The programmable current sense temperature compensation allows designers to tailor responses for accuracy over temperature.

Primarion's innovative power system solutions are optimized for flexibility, efficiency and ease-of-use. The PX7542 expands Primarion's digital power management and conversion solutions portfolio and brings overall system cost saving and improved performance to customers.

Now with customers, Primarion's PX7542 power system controllers are available for general sampling this quarter. The PX7542 is available in a RoHS-compliant, 6mm-x-6mm 40-lead QFN package.

www.primarion.com

Automotive Certified Headlamp LED from OSRAM

OSTAR Headlamp LED achieves 620 lumen

OSRAM Opto Semiconductors has further developed its OSTAR Headlamp LED, which has been certified according to the automotive standard, making this LED light source much brighter than ever before. At an operating current of 700mA this high-power light source now achieves peak values of up to 620 lm and consumes 12W. Its typical brightness is 500lm. Initial samples are already available. Volume production will start at the end of 2008.

The new OSTAR Headlamp LED is now more than twice as bright as its predecessor, which at 250lm was already one of the top performers in its class. The high-power LED does not have a lens. Its five chips are connected in series and produce light with a color temperature of 6000K. In future, three or four OSTARs will be enough to produce the 1000 lumen required for headlights.

The exceptional brightness values have been achieved thanks to an impressive combination of measures. In the OSTAR Headlamp OSRAM makes use of all the features that provided the OSTAR Lighting with a significant boost in brightness (1000lm). The package has been designed for example to minimize reflections. An improved converter and advances in thin-film technology have improved luminous efficacy still further. The brightness of the OSTAR Headlamp has been increased by almost 100% to as much as 620lm.

Like all LEDs with thin-film chips, the OSTAR Headlamp offers a high luminance which is further enhanced by the closely packed chips. It can be combined with small optics, takes up very little space and offers designers maximum freedom.

www.osram-os.com

Companies in this Issue

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

Power Systems Design Europe **Green Page**

PSDE Green Power ENERGY EFFICIENCY

The Corporate Green Bonanza!

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

It seems every corporation wants to be greener these days. Not a day goes by without another company joining the folds. Not a bad thing I guess, but time will tell how much hype is involved in these declarations. I have a selection of the most significant here.

In the IT business, the clamour to make computers 'greener' has now been joined by technology icons Google and Intel, anxious to prove their green credentials. I have heard analysts, perhaps cynically, suggest that the move is driven only by regulation and cost-reduction programs and that the total carbon footprint of components during manufacture and disposal processes needs to be addressed. A point very effectively made by Alex Lidow of International Rectifier when I met him at the PCIM show.

Reports on carbon emissions generally focus on areas such as airlines and auto manufacturers. However, research firm Gartner demonstrates that the professional IT industry accounts for roughly 2% of global CO_2 emissions - about the same as the airline industry.

No surprise that Google and Intel are now going green.

There's a new Competitive Analysis on Energy Harvesting Released by Darnell that describes how most companies getting a jump on 'the next big thing' in power management are not well-known in the electronics industry. Many are start-ups, and many are based in Europe. With potential unit sales in the billions, these companies have targeted the low-power sensor and device market. They're highlighted in Darnell Group's latest report in the Energy Harvesting, Micro Batteries and Power Management ICs series: "Competitive Environment."

GE and BP have formed a global alliance to develop and deploy hydrogen power technologies for at least five power plants that could dramatically reduce emissions of CO_2 from electricity generation.

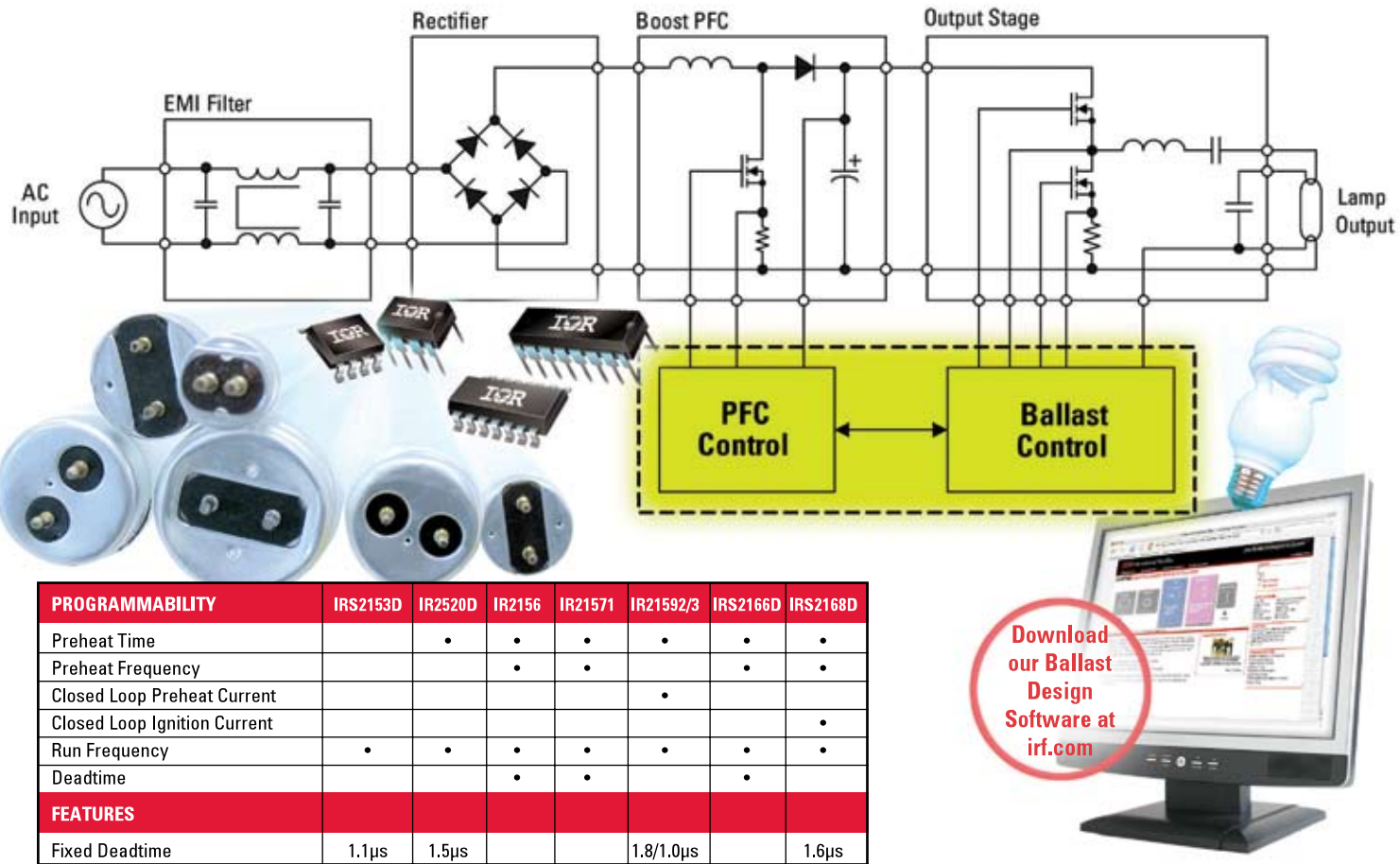
Additionally, GE and Hitachi, Ltd. have signed a formation agreement to proceed with plans to create a global alliance of their nuclear businesses. Based on this agreement, they will form cross-shareholding companies in U.S., Canada and Japan, subject to government approvals. Busy time for GE.

I think that all new, green announcements are viewed with some skepticism by the engineering fraternity. There are certainly sincere efforts going on, but only time and credible scientific results will tell.

www.powersystemsdesign.com/greenpage.htm

FLUORESCENT LIGHT CONTROL MADE SIMPLE

Integrated, Programmable, and Protected



PROGRAMMABILITY	IRS2153D	IR2520D	IR2156	IR21571	IR21592/3	IRS2166D	IRS2168D
Preheat Time		•	•	•	•	•	•
Preheat Frequency			•	•		•	•
Closed Loop Preheat Current					•		
Closed Loop Ignition Current							•
Run Frequency	•	•	•	•	•	•	•
Deadtime			•	•		•	
FEATURES							
Fixed Deadtime	1.1µs	1.5µs			1.8/1.0µs		1.6µs
Over-current Protection		•	•	•	•	•	•
Under-current Protection				•			
Failure to Strike		•	•	•	•	•	•
Open Filament		•	•	•	•	•	•
Brownout Protection		•	•	•	•	•	•
Thermal Overload Protection				•	•		
Shutdown Pin	•		•	•	•	•	•
Dimming					•		
Ignition Detection					•		
Fault Counter							•
End-of-Life Protection						•	•
PFC Over-Current Protection							•
INTEGRATION							
Bootstrap Diode	•	•				•	•
PFC						•	•
Inductor Saturation Detection		•					
Adaptive Non-ZVS Protection		•					
PACKAGE							
DIP & SOIC	8 pin	8 pin	14 pin	16 pin	16 pin	16 pin	16 pin

IR's family of 600V fluorescent lighting control ICs can shed light on simplifying your design while delivering exactly what you need for performance, programmability and protection. One small, easy-to-implement package. Less time to design. Less space on your board.

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