ZXZ 04717
3-06

Power Systems Design EUROPE

Power Control Intelligent Motion

March 2006

Brightness Control Technology

Light Sensors for Automatic Brightness Control

ISSN : 1613-6365

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Power Systems Design EUROPE

Power Systems Design

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www.powersystemsdesign.com/psd/subslogn.htm

Registration of copyright: January 2004
ISSN number: 1613-6365
Issue print run: 20,000
Printing by: Central - Druck Trost GmbH & Co. Heusenstamm, Germany

Send address changes to:
circulation@powersystemsdesign.com

Volume 3, Issue 2

APEC, PCIM, Three Big Events Coming Soon

I am ready to go to Dallas and meet old friends in the power family and enjoy the beginning of spring in Texas at APEC followed quickly in May by PCIM China in Shanghai and in May by PCIM Europe in Nuremberg. Just now while I am sitting typing the Viewpoint, it is still snowing and a nice white cover is down like a blanket here at my place at the Baltic Sea.

Healthy industrial environment in Europe and elsewhere is the platform for stable growth in power electronics. The European market is focused on industrial, automotive and telecom products.

As a tradition at PCIM Exhibition in Nuremberg I will moderate a Podiums Discussion each day. Experts from the industry will present their position and have open discussions in the auditorium. The topics for discussions are as follow:
"Gate Drivers optimized for MOS Devices" will be topic on Tuesday.
"Digital Power and the application focus" will highlight Wednesday's discussions.
"Passive Components are the Spices in Design" will be on Thursday.

I decided on this set of topics to complement the PCIM conference subjects.

So Nuremberg will be a focal point to meet and chat about power and its elements. Please stay tuned for updates on the final time and schedule for the daily podium discussions.

In the current issue we focus on portable power. Portability is what the customer is looking for. Modern technology for batteries and capacitors create solutions that match the requests for performance. Power Management by chip and system level is a mandatory subject for any electronics.

The cover story supplied by Microsemi tells us about brightness control on displays in automotive applications. We can understand automobiles as being a big portable product that needs to be efficient in power.

Texas Instruments explains a step-down converter to be optimized for small space. Small space is the important factor for portable applications.

Getting power supply off a USB port is detailed expressed by Code Mercenaries.

IMEC does research to use human body heat for power generation—a look into future solutions.

As we see, most of the efficiency enhancements have been stimulated by device improvement. The electronic switches have become better in respect to conduction and switching losses.

Silicon Carbide SiC is the material of choice in real applications. We have seen SiC diodes used in power supplies to enhance efficiency. APT and Northrop Grumman will work together to manufacture next-generation silicon carbide ("SiC") microelectronic devices—a step to commercial success for SiC.

The most important switch is still the MOSFET and we are looking forward to seeing what SiC can do for active switches. The ECPE user forum in Nuremberg in mid-March will generate us some more insight as to what SiC has achieved and what will be practical for the next generation of applications.

All details for the power events are listed on page 6 in this issue. If you are around during these events please stop by at our booth to have a chat.

Bodo Arlt
Editorial Director
The Power Systems Design Franchise

Formation of 5S Components

ON Semiconductor announced the appointmABB Switzerland Semiconductors and ABB Semiconductors announce the formation of 5S Components, headquartered in Pittsburgh, PA. In a management buy-out geared to giving semiconductor sales stronger focus, John Siefken (right) and Kenny Stephenson (center) purchased the business of ABB Semiconductors Inc from ABB Switzerland/Semiconductors, effective December 1, 2005 making 5S Components the successor to ABB Semiconductors Inc. Additionally, ABB Switzerland/Semiconductors has entered into an agreement with 5S Components to be the exclusive distributor of ABB Switzerland/Semiconductor products in North America. 5S Components will continue the business of ABB Semiconductors at the same location, with the same address and telephone numbers as before. Most of the ABB Semiconductor employees transferred to 5S.

Kurt Hörhager, Managing Director of ABB Switzerland/Semiconductors comments that "Creating 5S guarantees focus on semiconductor sales in North America, a vital part of our growth strategy. John, Kenny and the 5S team have my full backing and ABB will be able to support the North American market and its customers even better than in the past". Roland Villiger (left), VP of Sales & Marketing adds, "We are working with 5S to insure a smooth transition and an uninterrupted flow of products. This change will in no way impact the quality and dependability of the support that customers have always received: they can expect the same service from 5S and the ABB factories now as they previously received because the team remains the same".

www.abb.com/semiconductors

Emerson to Acquire Artesyn

Emerson and Artesyn Technologies announced that Artesyn will become part of Emerson Network Power. Emerson will acquire Artesyn for $11 a share in cash (approximately $500 million net of acquired cash) pending customary regulatory approvals and approval by Artesyn shareholders.

The agreement brings additional embedded power conversion technologies to Emerson Network Power's existing portfolio of solutions for customers in the enterprise computing, data, and telecommunications industries. Artesyn provides leading original equipment manufacturers (OEMs) with advanced power conversion equipment as well as hardware and software subsystems for a range of communication applications.

www.artesyn.com

www.emersonnetworkpower.com

Corporate Vice President Back-End Manufacturing

STMicroelectronics announced the appointment of Jeffrey See as Corporate Vice President and General Manager of ST's worldwide back-end operations.

Jeffrey See, currently General Manager of the ST 's manufacturing complex in Ang Mo Kio (Singapore) is promoted to the position of Corporate Vice President, Central Back-End General Manager, effective April 3, 2006. See's appointment follows the departure of Giordano Seragnoli, the current Corporate VP for back-end activities who, at 69, is leaving for a well deserved retirement at the end of Q2, 2006.

A respected veteran of semiconductor industry, See (born in Singapore in 1945) has played a vital role in establishing and growing the Company's state-of-the-art manufacturing operations in the Asia Pacific region, where the largest part of ST's assembly and test production is also located.

Jeffrey See has been with the Company since it started its operations in Singapore in 1969 when he joined it as a Quality Assurance Supervisor for ST's first Assembly and Test operation in Toa Payoh, becoming Deputy Plant Manager in 1980. In 1983, he was appointed to set up the region's first wafer fabrication plant in Ang Mo Kio, which has grown under his leadership to become the single largest volume-manufacturing facility within ST. Today, ST's Ang Mo Kio manufacturing complex with three plants and a staff of 5400 represents a global benchmark for achievements in quality, cost, and cycle time.

www.st.com

SiC License Between APT & Northrop Grumman

Advanced Power Technology announced that the company has entered into a license agreement with the Electronic Systems' sector of Northrop Grumman to manufacture next-generation silicon carbide ("SiC") microelectronic devices.

This agreement forms an exclusive foundry supplier relationship whereby Northrop Grumman will license certain SiC technology to Advanced Power Technology including relevant SiC patents and manufacturing methods to enable Advanced Power Technology to manufacture proprietary high performance SiC microelectronic devices exclusively for Northrop Grumman. In addition, the agreement allows Advanced Power Technology to use the licensed technology to manufacture and sell other high performance SiC devices for commercial purposes. Both companies possess substantial expertise in SiC technology and view SiC based power semiconductors as strategically important to a wide array of next generation applications.

The driving force for the adoption of silicon carbide for military as well as civilian applications is the need to reduce weight and size of power control and management systems and their associated support equipment, in particular cooling systems and heat dispersing packaging. SiC semiconductors have demonstrated large performance advantages in numerous test beds over the most advanced silicon components.

Military applications include radar, hybrid power systems, electric power control and distribution, electronic jamming, and wide-band communications systems.

Potential non-military applications that can benefit from silicon carbide's military-level performance include hybrid vehicles, electric power transmission, computer/servers, medical systems, and alternative energy.

www.northropgrumman.com

www.advancedpower.com

Maxwell Appoints Michael Liedtke

Maxwell Technologies announced that it has appointed Michael J. Liedtke vice president, business development, with primary responsibility for establishing and maintaining strategic relationships with major original equipment manufacturers (OEMs) to promote ultracapacitor-based solutions for industrial and transportation applications.

Liedtke, 45, has spent the past eight years as director of marketing and transportation design management for BMW's California-based DesignworksUSA. Previously he held a series of auto, truck and bus design and project management positions with DaimlerChrysler's Mercedes Benz division in Stuttgart, Germany, and its Freightliner truck division in Portland, Ore. He also spent more than four years in the aerospace industry with McDonnell Douglas and Boeing, where he held various engineering and research and development positions. He holds joint U.S. and German citizenship and is fluent in English, German and French.

Liedtke was born to German parents in the U.S., but was raised and educated in Germany before returning to the U.S. for most of his professional career. He holds a Master of Science degree in mechanical engineering from the University of Karlsruhe in Germany.

www.maxwell.com

Fairchild Experts at APEC 2006

Fairchild Semiconductor's power experts will offer techniques for developing power efficient designs and profile the leading edge products that make them possible at the 2006 Applied Power Electronics Conference and Exposition (APEC), held March 19 – 23 in Dallas, Texas. Fairchild's booth #63 will be staffed by motor, lighting, DC/DC and AC/DC power experts from the Global Power Resource who will offer solutions to design and power application challenges.

Fairchild technologists will present papers at the conference. The Global Power Resource is an integral element of Fairchild's delivery of highly integrated products for the consumer, communication, industrial, computing and automotive market. The Global Power Resource encompasses a worldwide network of design centers, staffed with system design experts, who partner closely with customers to optimize and develop innovative designs.

Additionally, Fairchild has implemented design, selection and educational tools into its web site (http://www.fairchildsemi.com/designcenter) to assist customers in the power optimization of their design at their convenience.

APEC, the Applied Power Electronics Conference and Exposition, is the leading event worldwide for practicing power electronics professionals, focused on the practical and applied aspects of the power electronics business.

www.fairchildsemi.com

Power Events

- ***APEC 2006**, March, 19 - 23, Dallas TX, www.apec-conf.org*
- ***PCIM China 2006,** Mar. 21 - 23, Shanghai www.pcimchina.com*
- ***PCIM Europe 2006,** May 30 - June 1, Nuremberg, www.pcim.de*
- ***SMT/HYBRID 2006**, May 30 - June1, Nuremberg, www.mesago.de*
- ***SENSOR/TEST 2006,** May 30 - June1, Nuremberg, www.sensor-test.de*
- ***EPE-PEMC 2006,** Aug 30 - Sep 1, Portoroz, Slovenia, www.ro.feri.uni-mb.si/epe-pemc2006*
- ***MICROSYSTEM,** October 5 - 6 , Munich, www.mesago.de*
- ***ELECTRONICA 2006,** Nov. 14 - 17, Munich, www.electronica.de*
- ***SPS/IPC/DRIVES 2006,** Nov. 28 - 30, Nuremberg, www.mesago.de*

World's Smallest Charger IC

Provides 750mA from a 500mA USB port, slashing charge time by 66% and cutting power dissipation by 90%, versus linear chargers

Summit Microelectronics announces the first product in a family of Programmable Li-Ion Charger IC's aimed at the latest portable consumer applications. Specially designed to operate with the popular Universal Serial Bus (USB™) and other current-limited power sources, the SMB135 revolutionizes single cell Li-Ion battery charging.

Combining switch-mode operation with Summit's proprietary *Turbo Charge*™ mode, the SMB135 dramatically cuts charge time, shrinking or eliminating costly and bulky AC/DC "wall-wart" power supplies. Additionally the SMB135 eliminates power cables and connectors by allowing standardization to a single mechanical connector (USB) for power and data. By addressing the major drawbacks of conventional solutions, namely charge time, power dissipation and solution size, the SMB135 enables new standards for performance, mobility and convenience in portable consumer electronics.

Features

The SMB135 comprises a 1A current-mode step-down (buck) switching bat-

tery charger including a fully programmable algorithm for single-cell Li-Ion and Li-Polymer cells. All charging parameters—pre-charge/fast-charge/charge termination current, cell float/pre-charge voltage, battery temperature/timer safety limits—are configurable via the I²C/SMBus interface enabling a wide variety of algorithms without hardware changes. The programmable algorithm combined with the inherent current multiplication effect of the switching regulator enables Summit's *Turbo Charge*™ mode that delivers up to 750mA charging current from a standard 500mA USB port (up to 1A from an AC/DC adapter). This represents more than double the charge current typically available from competing solutions, cutting the battery charge time by as much as 66%.

The SMB135 can be programmed either dynamically (real-time using volatile registers), by a microcontroller and software via the I²C/SMBus port, or statically (pre-programmed using non-volatile registers). If the static programming mode is used there is no need for software to access the I²C/SMBus interface and the SMB135 functions independently as a customized but parametrically fixed solution.

Additionally the SMB135's switch-mode operation provides another major advantage, reducing power dissipation by as much as 90% compared to competing linear-mode charger IC's. This characteristic has a dual benefit—dramatically reduced power dissipation eliminates the need for "thermal current foldback" circuitry of competing linear solutions, which unnecessarily extends charge time. Also reduced power dissipation allows the SMB135 to be packaged in a tiny 1.3mm x 2.1mm chip-scale package (CSP)—the world's smallest for a battery charger IC. Linear charger solutions are typically offered in large packages that have high power dissipation capacity and require extra PCB copper "flood" areas for heatsinking.

The SMB135 operates from a +4.35V to +6.0V input making it ideally suited for either USB or AC adapter power sources. However for applications where the AC adapter may be poorly regulated and/or an aftermarket product the SMB135 will tolerate +10V inputs without damage. Switching frequency is programmable between 750kHz and 1.25MHz providing for small external passive component size and cost. Ensuring long battery life when not connected to a DC power source, the reverse leakage current is less than 2μA. Also when not using the I2C/SMBus port for charge control/monitoring the SMB135 provides a 500mA/100mA control pin for USB compliance and a STATUS output to drive an LED.

Enhancing reliability the SMB135 integrates over-voltage, short-circuit and thermal protection circuits. Also the SMB135 protects the battery pack with a programmable battery temperature sensor and charge timers to prevent dangerous charging conditions. Furthermore, to protect deeply discharged cells, the SMB135 has a 3mA "trickle charge" mode below 2.0V. This mode allows safe, controlled recovery of the deeply discharged cell until it can accept normal charging currents. Finally the SMB135's programmability enables future battery upgrades while preserving safety.

Applications

The SMB135 is well suited to handheld consumer electronics devices such as 2.5G/3G phones, PDAs/smartphones, Bluetooth headsets, portable media players (PMP), portable game consoles, digital still cameras (DSC)/camcorders (DCC) and GPS terminals. In particular it is the ideal battery charging solution for applications that use a single USB connector to provide both data and power.

Design Software and Programmer for Prototype Development

To speed user product development, Summit offers customers the SMB135EV companion evaluation board and a graphical user interface (GUI) software so designers can quickly see the features and benefits and design a prototype power supply with the SMB135. This is a complete development tool that lets designers easily manipulate the characteristics of their systems. The SMB135EV design kit includes menu-driven Microsoft Windows® graphic user interface (GUI) software to automate programming tasks and also includes all necessary hardware to interface to the parallel or USB port of a laptop or PC.

Once a user completes design and prototyping, the SMB135EV automatically generates a HEX data file that can be transmitted to Summit for review and approval. Summit then assigns a unique customer identification code to the HEX file and programs the customer's production devices prior to final electrical test operations. This ensures that the device will operate properly in the end application. The design kit software can be downloaded today from Summit's website.

www.summitmicro.com

Power Player

Filling the "Experience Gap" with Modules

By Dave B. Bell, President, Linear Technology Corporation

There are a number of market dynamics within the power electronics industry that are converging to create a perplexing problem. To better understand what is happening, one simply has to look to the increasing complexity and performance requirements of power systems, as well as the intensity of time-to-market pressures. At the same time, the number of competent and seasoned power systems designers within the industry is diminishing.

During the last couple of decades universities have churned out graduates skilled in digital design techniques, while simultaneously producing fewer graduates capable of complex analog design. These factors have contributed to the growing "experience gap" within the power electronics industry. As a result of this gap, many systems are introduced late into the marketplace, and also have poorly designed power systems.

Some markets, like high volume consumer products such as cellular phones and video games, can justify the engineering effort to create a low, cost effective total solution. Companies can assign a team of analog designers to optimize their design for good system performance while also shaving pennies from the overall cost, because the extremely high volume manufacturing volumes associated with such products easily justifies the effort. However, most electronic products cannot justify this level of attention. In fact, it is becoming increasingly common that companies cannot locate a qualified engineer within their organizations to design the power system for their new products.

An Alternate Route

One straightforward and immediate solution that companies can readily adopt to address this decline in the

availability of power systems design expertise is to use an off-the-shelf DC/DC converter module. In so doing, they can minimize risk, reduce the number of component types purchased, and even reduce product development time.

Telecom power systems have used DC/DC modules for many years. Usually, these systems distribute their power via an intermediate 24V or 12V bus. However, most telecom subsystems do not use the 24V or 12V bus directly, but require DC/DC conversion from this bus voltage to the subsystem operating voltage. Therefore, a DC/DC converter module is used to convert from 24V or 12V to 2.5V, or an even lower one, from which the subsystem can then draw its power. These DC/DC modules are supplied by numerous vendors and have standard footprints and mechanical packages, making them a quick-to-apply solution. This not only saves on engineering time but enables a faster time to market.

This same method of DC/DC conversion can be readily utilized in any power system, therefore enabling a simple, quick and practical solution with minimal engineering resource. This helps companies with limited power system design expertise to bridge the "experience gap."

Some of the key advantages of DC/DC converter modules can be summarized as follows:

- Modules with internal input and output capacitors are relatively insensitive to PCB layout, being just as easy to use as linear regulators. This means that performance can be ensured without an ideal PCB layout.
- Because of the very tight component placement inside DC/DC converter modules, EMI is also minimized. All the high dv/dt nodes and high di/dt traces are located within the module, so coupling to external sensitive circuitry is minimized.
- Because all of the components needed to make a complete function are included within the module, the manufacturer can verify conformance to specifications despite variations in the individual components.

Not only do modules make perfect sense for a growing segment of the power management market, but they also make sense for other analog functions because the same "experience gap" exists throughout the analog world. Linear Technology and other manufacturers are releasing new DC/DC modules to address this need. An example of such a product is Linear's recently introduced LTM4600 uModule. This is a complete 10A switch-mode power supply in a 15mm x 15mm x 2.8mm LGA package that only needs a single external resistor to set the required output voltage. Developments such as this are helping to bridge the "experience gap."

www.linear.com

Getting Sexier Every Year?

By Chris Ambarian, Senior Analyst, iSuppli Corporation

As we head into this year's Applied Power Electronics Conference in Dallas, Texas, I am finding it quite interesting how power semiconductors have evolved in the last year vis-à-vis the semiconductor industry at large.

You may recall that I suggested about this time last year ("A Necessary Evil?", PSDE April 2005) that we have an opportunity before us—an opportunity to transform power semis into something as value-adding and sexy as the other semiconductors are. The alternative is to continue along a path of commoditization, allowing ourselves and our efforts to be considered a necessary evil.

Funny enough, what I've seen in the last year is that power semiconductors and the "rest" of the semiconductor market have to some extent converged on a point in-between where they have traditionally been respectively. From my perspective anyway, power semiconductors are gaining more and more importance and value and respect, though maybe not quite the point of being "sexy"—while semiconductors in general have begun to get commoditized and a little less valuable and sexy.

Why are power semis getting sexier?

Perhaps it's because of the tremendous amount of innovation being churned out by our industry's designers. A wealth of new technologies to address the more pressing needs for energy efficiency has been pouring out of the companies in this space—hardly displaying the kind of behavior a staid old commodity business usually displays. The power management semiconductor space these days is like a three-ring circus—whether it's new materials, or new process technologies, or new digital design approaches, or a new merger or acquisition, there's plenty of action just about everywhere you look. And it's not just commodity price and delivery—if a company doesn't choose well and constantly innovate, their business will quickly suffer—just like in the rest of the semiconductor market. On the other hand, if a company innovates well and provides a needed product, there are billions of dollars and some of the highest profit margins in the industry to be gained (just take a look at the leading analog chip suppliers). It doesn't get a whole lot sexier than that.

Or perhaps power semiconductors are becoming sexier because the world public is finally becoming aware of the limits to the amount of energy we can use, and of the pressing need for greater energy efficiency in our equipment. This greater public awareness is making it clearer that power management semiconductors will be a significant part of the solution to our world's power challenges. And heroes are always sexy.

But why is the rest of the industry looking a little more dowdy?

For one thing, the semiconductor industry just isn't growing as fast as it has in the past. It can't. Nothing ever grows indefinitely—the tree never grows to the sky—and certainly the semiconductor has become so much a part of the mainstream of human life that its growth rates are now constrained by things like population and GDP. (See figure 1.) This is a blessing—the fulfillment of the potential of semiconductors—as well as a curse. Along with the ambition of getting into every living room and every car and every shirt pocket, you also run the risk of eventually becoming as exciting as, say, bread or tires or bed sheets or any other pervasive commodity.

For another thing, you can blame the "Moore's Law mentality" that has driven much of the non-power semiconductor industry for decades. The relentless pursuit of higher and higher performance and new functionality at lower and lower prices has made the average consumer come to expect some pretty amazing things, and to not think twice about the latest amazing brainchild of the some of the brightest engineers on the planet. Whether we like it or not, our customers are spoiled, and it takes a lot more to impress them now.

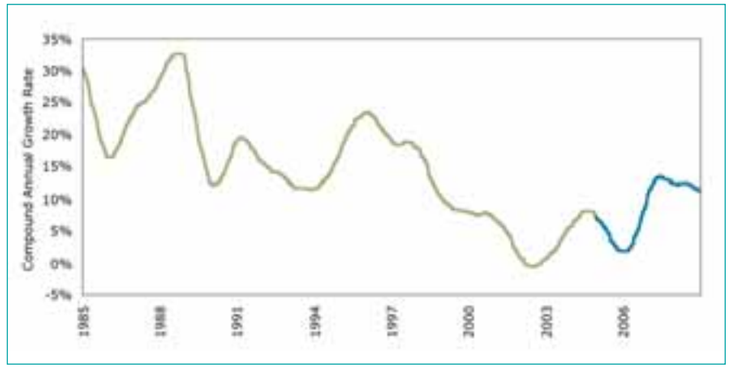


Figure 1. Rolling 5-year semiconductor industry growth. Like all markets eventually, the semiconductor industry's growth rate has slowed, even though the market continues a healthy increase in absolute terms. (Sources: WSTS and iSuppli.)

So to the rest of the semiconductor industry I say, "Welcome to our world." If you want to learn some coping skills because your customers are taking you for granted a bit more, and if they don't care how you get it done (just get it done), then you've come to the right place. We've been treated like that for a couple of generations now.

On the other hand, I'm planning to really take some enjoyment out of watching the increasing importance of power management in the world as it evolves into a more energy-constrained (and with the help of some brilliant colleagues, a more energy efficient) place. It's about time.

See you at APEC.

Christopher Ambarian is a senior analyst with the market research firm iSuppli Corp., El Segundo, Calif.

Contact him at cambarian@isuppli.com

www.iSuppli.com

Energy Savings and Low Cost Are Our Goal

Interview with Doug Bailey, Vice President of Marketing, Power Integrations

During the 11th China International Power Supply Show held in Shenzhen, China, Mr. Doug Bailey, Vice President of Marketing for Power Integrations, talked to *PSD China* about Power Integrations' two newly introduced IC families, the LinkSwitch®-LP family for designing the world's simplest handset chargers, and the LinkSwitch®-XT family, targeted for power supply applications where tight output is required. These ICs are the simplest and energy efficient solutions that designers can choose for designing their power supplies.

Doug Bailey, Vice President of Marketing, Power Integrations.

This article is based on an interview with Mr. Doug Bailey.

Fewer components means cost savings

"Energy efficient, low power chargers using an IC from the LinkSwitch-LP family require just 14 components—the lowest component count available for energy efficient switched-mode chargers," Mr. Bailey told *PSD China*.

He said that this new IC family is mainly for ultra low cost battery charger applications. It is the simplest and most energy efficient solution, being capable of entire replacement of the unregulated line frequency transformers. These chargers are commonly sold with products such as cell phones, cordless phones, portable audio players, shavers and other personal electronics, and therefore are extremely price sensitive.

This family of products with its cost advantage is enabled by the simplicity of circuit design offered by a number of Power Integrations innovations, including Clampless™ design methodology utilizing proprietary IC trimming technology and innovative transformer construction techniques to eliminate RCD clam circuitry and control of charger output voltage and current by primary circuitry to eliminate optical coupler and relevant components. Other innovations include an integrated frequency jitter and unique Filterfuse™ input stage to achieve EMI filtering with a single capacitor and E-Shield™ transformer design to eliminate the need for a Y capacitor.

Hysteretic thermal shutdown feature removes the need for thermal fuses commonly used in transformer based design or additional components associated with RCC designs. In addition, EcoSmart® energy efficiency technology enables compliance with all current and proposed energy standards worldwide and a universal input range enables designs that can be used worldwide. Plus, an auto restart feature reduces output power by more than 85% when short circuit and open loop failures occur and a simple ON/OFF control scheme eliminates the need for loop compensation. On top of that, a high bandwidth provides fast no-overshoot and outstanding transitive load response. All these features make it possible to reduce system cost and increase efficiency.

"Chargers employing LinkSwitch-LP are vastly simpler than discrete designs, which typically contain dozens of components," said Bailey. "LinkSwitch-LP also offers integrated energy efficiency and safety features that are either unavailable in discrete designs or require additional components and design effort." He said that LinkSwitch-LP family features a 700-V power MOSFET integrated with control and fault protection circuitry on a single silicon chip. The chip operates across the universal input range of 85 to 265 VAC, and achieves an extremely low no-load power consumption of less than 150 mW at 265 VAC. The simple ON/OFF control scheme of LinkSwitch-LP provides constant efficiency even at light loads, enabling easy compliance with recent efficiency standards, and offer excellent efficiency as compared with designs using linear transformers. Figure 1 shows a typical application of LinkSwitch-LP.

The lowest system cost and advanced safety features of LinkSwitch-LP family make it a switch device with impressive performance and the lowest count of external components, superior to linear transformer and RCC designs, and the simplest energy efficient replacement for linear transformer based chargers. Its typical applications include battery chargers for handsets or cordless phones, PDAs, power tools, MP3 players or portable audio equipment and shavers, and standby and auxiliary power sources.

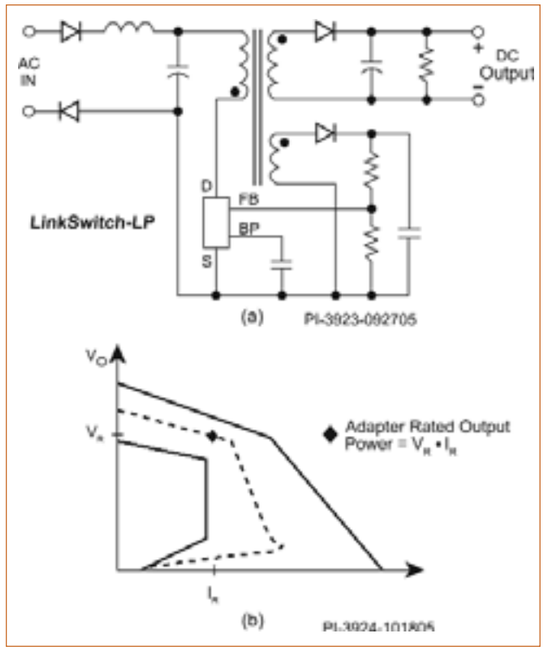


Figure 1. The typical application circuitry of LinkSwitch-LP.

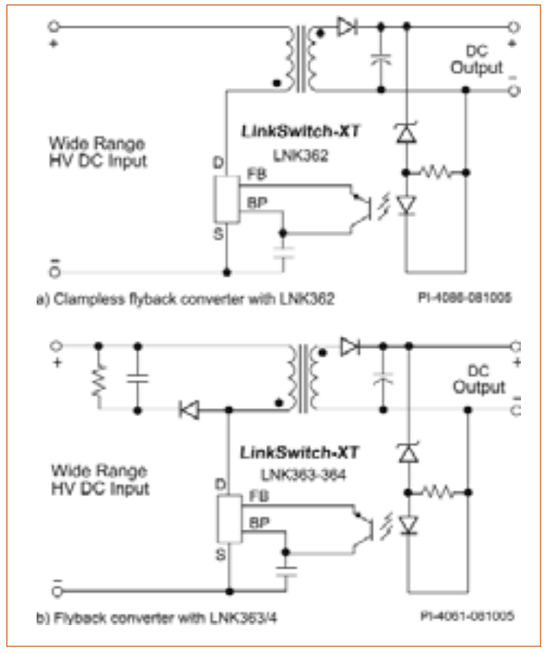


Figure 2. The typical application circuitry of LinkSwitch-XT.

Compliance and Accuracy

Mr. Bailey said that the IC products for low power supply applications are growing rapidly. Power Integrations, therefore, continues to expand its high efficient and low power IC families for charger and adapter applications. The newly introduced LinkSwitch-XT is targeted for applications in which tight regulation of output voltage and current are key design priorities. The new ICs support universal input (85 VAC to 265 VAC) range chargers and adapters with output levels of up to 4 watts and may be used in open frame applications up to 9 watts (230 VAC).

He said that the simple ON/OFF control scheme of LinkSwitch-XT enables a high level of efficiency even at light loads, and reduces no-load consumption to less than 300 mW. The use of a transformer with a bias winding further reduces no-load power consumption to less than 50 mW.

LinkSwitch-XT features a 700-V power MOSFET together with control circuitry on a single silicon die. Its integrated safety and reliability features include hysteretic thermal shutdown for over temperature protection, as well as auto restart for output short circuit and open loop protection. It offers replacement of low efficient power supplies using linear line frequency transformers. The LinkSwitch family offers a variety of parts to meet a range of power levels and design parameters at universal input voltage: LinkSwitch-LP family (LNK562-564) for ultra low cost, loosely regulated power supplies up to 3 W; LinkSwitch (LNK500-501, LNK520) for loosely regulated power supplies up to 3.5 W; LinkSwitch-XT (LNK362-364) for tightly regulated power supplies up to 6 W; and the LinkSwitch-TN (LNK302-306) for no-isolated buck converters with output current up to 360 mA. Typical applications include chargers for handsets or cordless phones, PDAs, digital still cameras, MP3 players or portable audio players and shavers, and power supplies for home appliances, industrial equipment as well as measurement instruments. Figure 2 is a typical application circuitry of LinkSwitch-XT.

"With the introduction of LinkSwitch-XT, we now have a complete portfolio of linear replacement," Mr. Bailey said. "The designers can choose his desired output characteristics and be guaranteed an energy efficient design with the lowest possible cost. We have a LinkSwitch that fits every common charger and adapter application."

"Power Integrations' breakthrough technology enables compact, energy efficient power supplies in a wide range of electronics products, including both AC-DC and DC-DC converters. This company's EcoSmart energy efficiency technology dramatically reduces energy waste, and has saved consumers and businesses around the world an estimated more than $1 billion on their electricity bills since its introduction in 1998."

—Liu Hong, editor, Power Systems Design China.

www.powerint.com

Advances in Brightness Control Technology

Drive critical automotive display improvements

Liquid crystal display technology has proliferated rapidly throughout the electronics world, from notebook computers and large screen television sets to the automobile.

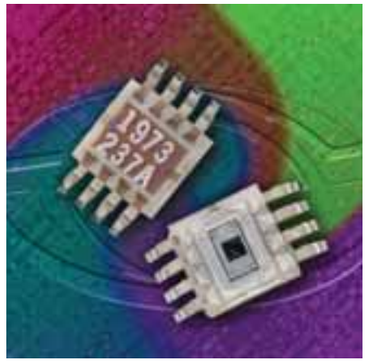
By Roger Holliday, Vice President Strategic Business Development, Integrated Products Group
Microsemi Corporation

Each application imposes unique demands for its system designers. Especially demanding are the requirements found in today's competitive automotive industry. As with many new features, the use of LCD technology in automotive displays began in luxury models, where manufacturers have been using bright full-color displays to differentiate their model offerings.

Dashboard navigation displays now have become standard features in these high-end vehicles, either for Global Positioning System functionality or, when this capability is not customer-selected, then for other traditional vehicle and diagnostic data.

In addition to providing the means to display useful GPS maps, LCD displays increasingly are being used to communicate more "driver critical" information. Typical of these premium vehicle features are traffic avoidance, rear end and blind spot monitoring via charge-coupled device (CCD) cameras on their GPS displays. These provide full-motion rear-view video for added safety when the vehicle is moving in reverse.

Rapidly gaining popularity in high-end vans and sport-utility vehicles are rear seat full-motion video entertainment



systems using LCD screens. Coming soon are video and wireless communication systems, as well as LCD cluster displays that will allow drivers to customize their speedometers, tachometers and engine monitoring gauges in formats tailored precisely to their preferences.

Regardless of the specific display, in the automotive world brightness control is an essential design challenge that must be met. Unlike notebook computer or television applications, automotive displays have an inherent impact on owner safety and manufacturer liability concerns.

The fundamental issue is the wide range of display brightness required to function both in broad daylight and the dark of night. This creates a serious safety challenge, since brightness levels required for daytime viewing can effectively blind drivers at night.

Night driving, with its potential for "snow-blindness" (the brief vision loss when looking from a bright light into the darkness) is a significant danger. Even display intensities as little as 20 percent above optimal levels can threaten driver safety due to the eye's need to readjust to the different brightness levels.

In addition, screen contrast and brightness levels in vehicular displays are extremely critical compared to other consumer applications due to the different manner in which they are used. When viewing a computer or television display, we generally remain focused on the screen for extended periods. Drivers, on the other hand, must repeatedly focus and refocus between the highway ahead and their close-up dashboard displays. This rapid and frequent glancing to retrieve data and then to remain in control of the vehicle regardless of traffic conditions necessitates well-engineered display brightness control.

As with all flat panel displays, the essential prerequisite for assuring the most readable presentation of data on

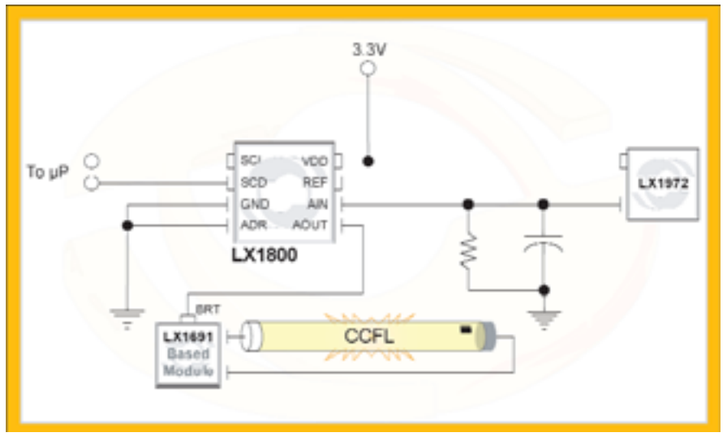


Figure1. Integrated circuit-based backlighting control technology enables brightness levels to automatically adapt to changing automotive ambient environments. In this example, an LX1800 integrated circuit has been added for additional digital microprocessor control.

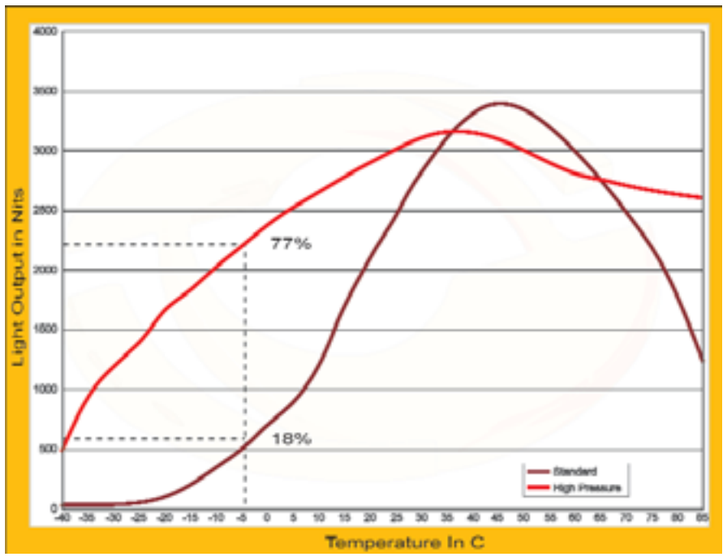


Figure 2. Automotive display systems require high performance at low temperature.

screen is having a well designed side or backlighting. In respect to automotive applications today, there are two basic approaches for achieving safe driver-viewable displays under varying light conditions.

The first approach is simply to reverse the display contrast under software control, as ambient light changes to preset levels. Software-controlled systems essentially toggle the backgrounds from light to dark, and the on-screen information from dark to light. This results in a much lower overall luminance level to the driver. Unfortunately, this approach has only limited effectiveness, questionable ergonomic characteristics, and will not work with the increasing number of video-based applications.

The second approach, based on integrated circuit control, uses a wide-range cold cathode fluorescent lamp (CCFL) dimming control technique. This approach allows display brightness to fluctuate fully as needed in response to ambient light, providing bright daylight displays and a comfortable low-level nighttime mode. Night mode brightness levels are typically less than one percent of the maximum daytime levels (see Figure 1).

This second approach yields a much higher viewer satisfaction solution that rapidly is establishing itself as the leading technology for automotive displays. It provides true, flicker-free uniform lamp-dimming across the extreme range of ambient light and harsh temperature conditions experienced in every vehicle. Importantly, it also is perfectly suited for every current and planned automotive display application including still data, GPS graphics, full-motion "blind spot" and traffic avoidance monitoring, and rear passenger entertainment video displays.

In addition, integrated circuit control requires much lower power levels when operating in low brightness, than with the "screen reversal" technique. This provides additional advantages in terms of lamp life, cluster heat and reliability. Since all of this can be achieved with no cost penalty, it has become the preferred system-level design choice for today's sophisticated automotive information and entertainment displays.

Automotive Performance Requirements

CCFLs are the preferred choice for automotive display applications because of their superior brightness capability as compared to the alternative of light emitting diodes (LEDs), which can be used in less demanding handheld display applications such as mobile phones and PDAs.

To operate in bright sunlit ambient environments, automotive display backlighting systems may be required to provide outputs in excess of 600 candelas/m2 (nits). This is approximately four times the brightness provided in a typical laptop computer (see Figure 2). Current LED offerings used in PDAs and other display products of similar size provide light output an order of magnitude below what is needed to meet dashboard readability requirements in full daylight conditions. Continuing LED development is underway with the goal of meeting these higher light output goals.

Nighttime driving conditions require performance at the opposite end of the brightness scale as well. In these conditions, flicker-free backlight operation must be capable even down to the 1 to 2 nit range. Traditional analog lamp current control cannot achieve these levels. To provide a consistent, safe visual environment for both driver and passengers, CCFL automotive displays must be able to handle dynamic dimming ranges of greater than 250:1. This is more than 10 times those typically provided in the very best computer displays.

Dimming at these low light levels creates additional challenges, even for the advanced duty cycle drive techniques employed in today's pulse-width-modulated (PWM)-driven inverters. For example, at the low duty cycles encountered when providing light levels below one percent of rated maximum, only a few lamp current bursts per cycle, are firing the CCFLs each cycle. Here, any variation in the number of PWM pulses per burst would appear as unacceptable display characteristics. All of these challenges, however, can be met when using the proper system engineering approach.

Thermal Issues

Unlike most consumer goods, automobiles must operate in temperature extremes from -40 to +85 °C, further complicating display ballast design. CCFLs must provide the same high outputs for optimum readability on winter mornings in cold climates as they do on afternoons in the tropics. Failure to do so can lead a driver to believe that the display is not functioning. As a result, various forms of high pressure (also referred to as self-heating) lamps have become the standard for cold weather operation of automotive displays.

Self-heating lamps can require strike voltages as high as 3,000 volts, or about four times the strike voltage of CCFLs used in comparably-sized standard displays. In addition to these high voltage requirements, boost (current overdrive) techniques are employed to achieve driver-suitable brightness levels quickly when displays are turned on in cold weather. Lamp current overdrive of as much as 50 percent may be used to achieve this rapid "warm up."

This combination of voltage and boost power requirements needs to be managed carefully at the system level from a software and hardware standpoint. A good portion of that effort is applied to the transformers. Consequently, high voltage transformers used in conventional inverter designs require significant re-engineering to operate in automotive applications. As the final challenges, all of these advanced performance capabilities must be done while meeting the necessary target costs and form factors.

Fault Protection

Bulb fault protection is particularly critical in automotive backlighting systems, since any arcing or unwanted striking due to a missing, or accidentally-damaged, CCFL lamp is simply not allowable in the possible presence of vaporized or liquid gasoline.

In automotive inverter topologies, the sensing of bulb current provides fault detection—a lack of current denotes an open circuit and a failed or damaged CCFL lamp. At low brightness levels and low duty cycles, differentiating lamp current from parasitic leakage and system noise can be difficult. But clever circuit design has been demonstrated to meet this challenge in a number of automotive display products.

Human "Eye-Like" Sensor Performance

Of course, any discussion of automatic brightness control implementation must include an analysis of whether the desired automatic control can be met at the necessary cost targets. Fortunately, this cost/performance design challenge is now being met by a new generation of optical sensors capable of providing high-performance automatic brightness control at low cost.

When it comes to controlling display brightness in response to fluctuating ambient light conditions, the best template is the human eye, a high performance standard, especially for automotive displays. The human eye constantly adapts to different light conditions, automatically and easily. Thus emulating the spectral response of the human eye becomes critical for any effective display brightness control technology.

The second requirement is to eliminate human involvement. Brightness adjustments must be automatic. Studies have shown, for instance, that most consumers of handheld cell phones and PDAs can't recall how to change the brightness level manually. And, even when they do know, consumers say that changing display brightness takes more time or trouble than is warranted for such simple viewing needs as retrieving an appointment or phone number, or dialing a phone number. Even laptop computer users rarely bother to lower brightness levels, even though they know it would extend their battery operation. It is obvious that the only way to gain the many benefits achieved with variable display brightness is to automate the adjustment process. Simply remove that responsibility from the user.

There is even less chance that drivers will adjust display brightness manually. An automobile moving in traffic does not lend itself for any added distractions. Additionally, the impact of failing to change display brightness is often moderated by the excellent design of the human eye itself—as it continually adjusts its aperture to block or receive light.

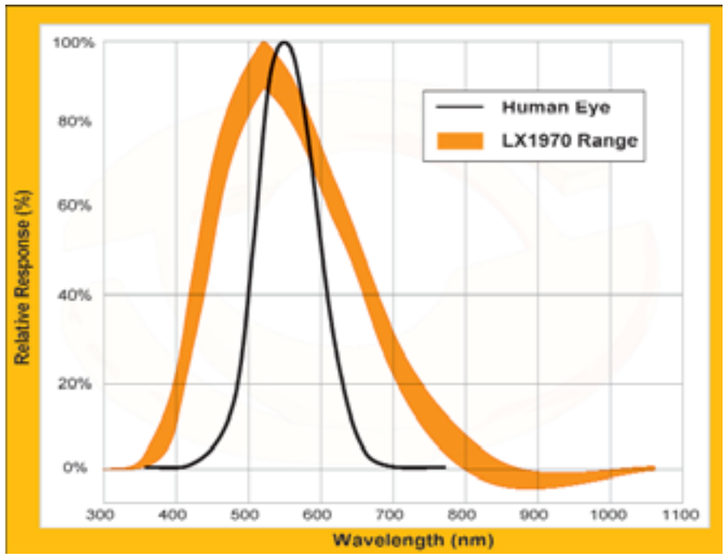


Figure 3. Sensor response is approaching human-eye capabilities, a critical factor for controlling display brightness characteristics.

So how do we emulate eye-like performance in automatic display control? The answer is superior sensor technology. Because earlier sensors were extremely susceptible to infrared and ultraviolet light, they often provided false readings based upon these non-visible light sources. Often the results were unpredictable, resulting in brightness adjustments contrary to the desired levels. Display brightness adjustments might be triggered by unseen infrared or ultraviolet light originating from such sources as the sun, incandescent light bulbs, fluorescent lamps and even heat. Poorly designed systems would set up an erroneous display brightness based on high UV and IR content.

In contrast, today's latest sensors have the ability to detect and respond to light wavelengths that correlate very closely to the response characteristics of the human eye itself. These sensors eliminate several problems encountered with prior technology. Figure 3 shows an example of the latest sensor technology's response profiles as compared to those of the human eye.

In addition to delivering improved spectral response, these new silicon sensors such as the Microsemi LX1972 (Fig. 1) also offer extremely good temperature stability. This is essential as most CCFLs or LED backlit displays experience substantial temperature swings as they operate, especially in an automotive environment. Poor temperature stability can result in erroneous changes to display brightness based on temperature and not light. A light sensor should not be a "thermostat."

Automotive Displays of the Future

Technology is on its way that will extend flicker-free operation well beyond today's 225:1 display brightness levels to as much as 300:1 levels and beyond, and at lower costs. This will be achieved over the full automotive temperature range with solid fault detection.

We also will be able to achieve acceptable levels of electromagnetic interference (EMI) and interference for "head unit" environments, and we will see the broad adoption of "human eye" light sensor technology that will enable automatic adjustments to display brightness.

Despite the many stringent technical requirements and a demanding cost model associated with advanced flat-panel automotive display systems, luxury car manufacturers continue to lead the way in implementing them. Meanwhile, consumer enthusiasm grows for vehicle video applications that also require the brightness of LCD screens.

As these differentiating features progress globally downward into mid-level vehicles and below, an increasing number of consumers will benefit from the many advancements in lamp construction, system engineering, and backlight power-management designs being pioneered for displays found in these luxury brands.

System-level performance expectations continue to grow. With ever more demanding applications for safety and entertainment, automotive displays will favor the bright CCFL backlighting found in LCD designs—even as organic light-emitting diode (OLED) and LED technologies seek to find ways to compete with these current solutions.

Meanwhile, wide-range backlighting dimming technology under integrated circuit control continues to solidify its position as the ideal solution for meeting the rigorous automotive display requirements found in both current and future designs. Its performance is only enhanced by the incorporation of the latest "human eye" light sensors for automatic brightness control.

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Advances in Power Management

Technologists pushing the performance of exciting new technology

All electrical and electronic equipment uses some form of power management, from a simple on-off switch to the sophisticated power management unit (PMU) in a third-generation cellular handset.

By Paul Greenland, Strategic Marketing Director, Power Management Group, and Werner Berns, Power Application Design Center Manager Europe, National Semiconductor

Technologists pushing the performance envelope for tomorrow's microprocessors reluctantly admit that getting the power into the chip and the heat out are major challenges, concurrent processing techniques notwithstanding. Power management has reached the status of a true enabling technology. This article examines emerging applications, impending legislation and standards, as well as exciting new technology that will enhance the performance and functionality of tomorrow's equipment.

Figure 1. LEDs makes the traffic light almost maintenance-free.

LED lighting

High-brightness white LEDs or mixed red, green and blue light from LEDs, is rapidly spreading out in environments where high luminous efficiency, shock resistance and small size are an advantage. In automotive applications for signaling and illumination, LED lighting has an impact on safety and the ergonomics of the vehicle. A short trip through the streets of European cities will reveal LEDs in the majority of traffic signals where their extended life makes the traffic light almost maintenance-free. LED backlighting in flat-panel displays enhances the color, depth perception and intensity of the image while simultaneously reducing power consumption. High-brightness LEDs are driven with a constant current, and high-power LEDs can draw up to an Ampere. Where multiple strings of LEDs are used, care must be taken to ensure that the current in each string is matched to that flowing in all the other strings in an array.

The junction temperature of the LED affects the color temperature or spectral frequency of the light emitted and it's luminosity. Where red, green and blue light is mixed to form white for a display, compensation for these effects is essential. LEDs are also attractive where cooler, concentrated light sources are used, such as in endoscopes for laparoscopic surgery and for the spot curing of dental composites. In cellular handsets, LEDs are used since many years and it's usage is not limited to the LCD backlight, but also used as "fun-light".

Digital management & control

As the number of complex loads in distributed power architectures and high-end consumer applications increases, so does the requirement for sophisticated power management. Complex loads such as DSPs, FPGAs and microcontrollers frequently have more than one supply rail. The central core or data-processing brain of the device runs from an ever-decreasing voltage driven by Moore's law. The input-output circuit or communication interface runs from a standard higher-voltage rail. As the core supply potential drops below a volt, leakage currents flowing in the devices therein increase. Substrate biasing schemes that apply a negative voltage offset to reduce this leakage current are common in state-of-the-art graphics and digital signal processors. Some attention must be paid to the sequencing and control of

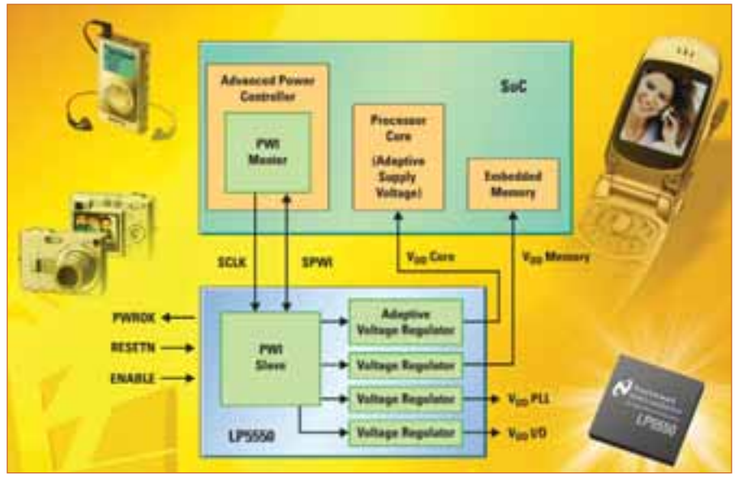


Figure 2. Advanced Power Management.

different rails for reliable operation. This type of control is referred to as "digital power management" or "digitally assisted power management."

Digital power control, sometimes called "processor inside the loop" is an entirely different matter. Digital power control entails comparing two digital words to produce a pulse width driving the power switch, rather than using the traditional analog PWM comparator approach. This adaptive technique is compelling in applications where the time constants of the load allow power stage operation below 100 kHz, for instance power factor correction, uninterruptible power supplies, multi-chemistry battery charging and motor control. The other application is in PMUs for cellular handsets and PDAs where several fully synthesizable PWM cores are deployed, together with control, diagnostic and interface circuitry. Run-time control schemes, where the sub-circuit or peripheral is supplied with the optimum operating voltage for its current state of operation to save energy, benefit from digital power control which makes the regulator more agile and responsive.

Legislation & Standards
RoHS

Legislation and standards have always driven power management technology. In recent years, European legislation for power factor correction, electromagnetic compatibility and worldwide energy-saving initiatives have spawned innovative power management techniques. The latest Restriction of Hazardous Substances (RoHS) measures are causing customers to switch to lead-free semiconductor packages and investigate alternatives to cold cathode fluorescent lighting which contains minute amounts of mercury.

EMC

As the electromagnetic spectrum becomes more crowded, it becomes unavoidable that compatibility standards will be made more stringent. This will stimulate new power management topologies and control developments. Spread-spectrum or dithered clock techniques, which integrate the peaks in the electromagnetic spectrum generated by switching power supplies, are well-known. Soft switching and resonant converter technology, where the switching transition is a portion of the sine wave with low high-frequency harmonic content, will experience a renaissance in noise-sensitive applications.

Energy Efficiency

Limited natural resources and fast-growing energy-hungry economies push up fuel costs and motivate investigation of alternative energy sources. Advisory standards on energy efficiency will soon become mandates, eliminating inefficient appliances and office equipment. The power supply designer is the steward of energy in electrical and electronic equipment. Measures to increase energy efficiency include multimode operation (standby and sleep mode), run-time and sweet-spot control, where devices are supplied with the optimum voltage for peak efficiency and precise matching of switch to load and driver to switch. White goods that communicate through the Internet with the utilities, drawing power which smoothes out fluctuating demand have been proposed. Studies have shown that replacing all motor drives in industrial applications with efficient vector-controlled drives would result in North America not having to build power stations for the foreseeable future.

Technology: Copper

Escalating power density and efficiency requirements motivates investigation of techniques to increase the current density of integrated regulators. One weapon in the arsenal available to the power management IC designer is the use of a copper current redistribution layer. Copper has a higher thermal and electrical conductivity than the aluminum used for integrated circuit interconnections and power switch electrodes. This technology, coupled with multi-chip techniques that allow the designer to combine sophisticated digital control, precision analog and high-current density power devices in the same package, holds great promise.

Integrated Passives

Any study of increased power density would be incomplete without the investigation of components that store energy. Considerable research has been conducted on the integration of passive components into semiconductor packaging and combination devices such as the integrated L-C-T (Inductor-Capacitor-Transformer). Integrating the filter inductor into semiconductor packaging makes a lot of sense, particularly for non-isolated point-of-load regulators. Co-packaging the inductor with the regulator chip reduces parasitic resistances and radiated emissions. Also, it is one

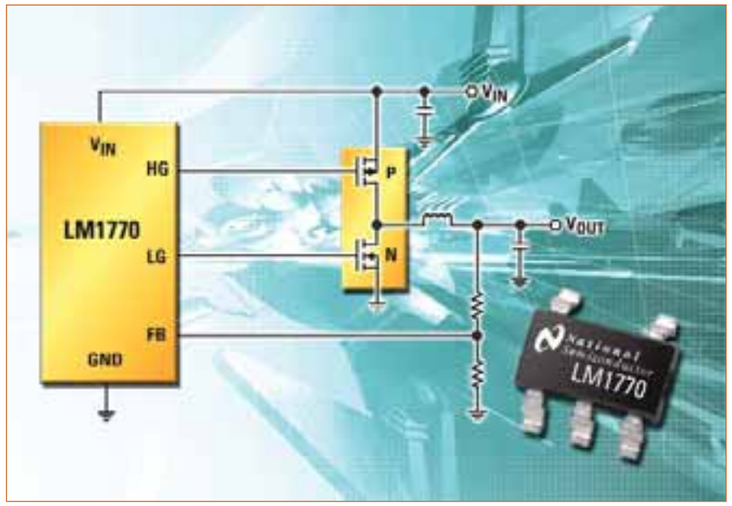


Figure 3. LM1770 easy-to-use three-terminal regulator.

step toward making the switching regulator as easy-to-use as a three-terminal regulator. Wound component design has always been a black art to the system designer, rivaled only by the mysteries of loop compensation.

Silicon Carbide

Semiconductor technology experts are continually pushing the boundaries of power device capability. Silicon Carbide has some of the most attractive properties of any semiconductor yet developed. It withstands voltages eight times higher than silicon; it conducts current up to 100 times more freely; and it conducts heat better than gold. Random thermal fluctuations create electron-hole pairs causing leakage current and electrical noise in all semiconductors; this effect is 16 orders of magnitude lower in SiC. The SiC power switches now coming onto the market can operate 10 times more efficiently than their silicon counterparts. This translates to a 10-fold increase in switching speed, or a to-fold reduction in die area for the same power rating. Silicon Carbide also has been used for jewelry, super-abrasive coatings for machine tools, and to line the brakes of the Porsche 911 turbo, reducing rotor weight by 16kg, increasing friction by 25% and lifetime to more than 300,000 km.

Power management is a far more dynamic and compelling discipline now that it is acknowledged that effective power management enables new technology and differentiates the performance of end-equipment. Legislation and standards continue to stimulate and drive research and innovation. The environmentally conscious power supply designer is a key contributor to the energy efficiency and electromagnetic compatibility of equipment. Traditionally, power supply design was "afterthought engineering," considered only after a system design was complete. Nowadays, power considerations are increasingly part of the concept stage of development, and justifiably so. National Semiconductor is providing state-of-the-art power management solutions to their customers. With the recently opened Power Application design center in National's European Headquarters in Fürstenfeldbruck, Germany, it goes beyond the point of "just" providing power management IC's. The new design center can provide customized reference designs and proposals for tomorrow's power design needs.

www.power.national.com

Optimizing Step-Down Converter Applications

Fine tuning by capacitor value

A step-down converter can be optimized for small space and fast transient response. An example is given, based on the TPS6420X step-down controller.

By Thomas Schaeffner, Texas Instruments

Step-down converters for battery operated equipment need to fulfill certain requirements:

- Small board area for the total application
- Easy to use
- High efficiency meaning
- Optimized for low input voltage
- Low quiescent current

The area used for an application can be minimized by using external components in packages with small footprints as well as by minimizing total part count.

As compared to a converter with integrated switches, a controller has external switches in addition to supporting passive components. Therefore, the controller's control topology, as well as its input voltage range and quiescent current, must be considered early during development of the controller IC in order to ensure minimal external part count for the final application. There are different control methods that could be used for such a design:

- Pulsewidth modulation (PWM)
- A combination of pulsewidth modulation and pulse frequency modulation (PWM/PFM)
- Hysteretic
- Fixed-On-time or fixed-OFF-time

	PWM	PWM /PFM	Hysteretic	fixed-ON, fixed-OFF
Control/Stabilization	"voltage mode" or "current mode" LC & compensation determine stability	PFM – same as hysteretic	Comparator with either time or voltage hysteresis requires output capacitor with ESR	Comparator with time hysteresis requires output capacitor with ESR
Load transient response	loop gain determines transient response	loop gain determines transient response	fastest possible response to load current changes	Fixed minimum energy per switching cycle (minimum-ON-time) delay up to „minimum off-time" at load transient
Switching frequency efficiency	fixed frequency low for low output current	PWM: fixed frequency PFM: depending on load current high efficiency at low output current in PFM mode	Switching frequency depends on Vin, Vout, L, Cout and ESR	Switching frequency comparable to PWM/PFM

Table 1. Pros and cons for converter methods.

Operating Principle:

The TPS6420X is a controller for non synchronous step-down converters operating with a minimum on-time/minimum off-time control scheme. An external PMOS transistor is switched on until the output voltage has reached the nominal value or the current limit has been exceeded. Once turned off, the PMOS stays off for the minimum off-time and is only turned on again when the output voltage has fallen below its nominal value.

In figure 1, a typical application is shown. The ripple current is set by the inductor value, by the switching frequency as well as by input and output voltage. The value of the output capacitor sets the ripple voltage in steady state operation as well as voltage drop during load transients.

Typically, a small capacitor in parallel to R1 is recommended to reduce the effect of parasitic capacitance from the feedback pin to ground. In order to get a good overdrive for the internal comparator, the parasitic series resistance in the output capacitor (ESR) should be in the range from 30mR to 150mR.

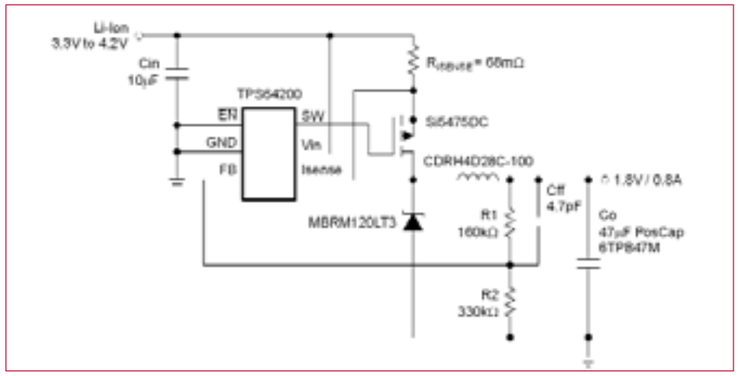


Figure 1. 1.8V-Step-down converter with 47uF Tantalum output capacitor.

The application according to figure 1 can be further optimized with regard to small solution size by:

- Increasing the switching frequency and use of a small inductor value
- Replacing the tantalum with a ceramic capacitor

The switching frequency for a given input voltage range and output voltage is set by the minimum on-time or minimum off-time of the controller. It is therefore important to select the optimum device for the application. There are four different versions—TPS64200 to TPS64203 available. The only difference is the minimum on-time and minimum off-time. The table „selecting the right device for the application“, given in the data sheet helps to select the right device without the need for complicated calculations.

More details are given in an application report (SLVA160) about TPS64200. Another helpful tool is a Microsoft-EXCEL based spreadsheet (SLVC038.ZIP), which can be downloaded from the TI website. It can be used to determine the value of all external components as well as basic operating parameters like inductor current ripple and switching frequency. By replacing TPS64200 with TPS64203, the switching frequency in our application will be increased and the inductor value can be reduced to 4.7uH.

Ceramic capacitors with a capacity of 47uF or lower are not only smaller in size compared to tantalums, they are also a more ideal capacitor with almost no series resistance (ESR).

ESR of Tantalum is 30mR to 150m while Ceramic X5R or X7R is typically 5mR. Therefore, the output voltage ripple caused by ESR is smaller by a factor of 6 to 30 for a ceramic capacitor compared to a tantalum. While a small voltage ripple is ideal from an application point of view, the comparator inside TPS6420X needs a certain voltage overdrive at its input for proper operation. ESR of a tantalum capacitor produces an almost linear voltage rise in the output capacitor as inductor current rises. However, the voltage rise caused by the much smaller ESR of the ceramic capacitor lags behind the rising inductor current, causing a lower switching frequency and a sinusoidal voltage at the output. To replace the tantalum capacitor with a ceramic capacitor, one additional passive component, R1b as shown in figure 2, is required.

The upper resistor of the output voltage divider is split into two segments. R1a monitors the output voltage directly at the output capacitor while R1b connects to the switch node, the node between the power transistor and the inductor. Since the average voltage across an inductor equals zero, the voltage sensed by R1b at the switch node is equal to the output voltage excluding the voltage drop caused by the resistance of the inductor. If R1b was the only feedback resistor in the system, the average output current times the resistance of the inductor would cause the output voltage to drop with the output current. Therefore, R1a is used to reduce this effect.

Using both R1a and R1b in parallel will:
- Slightly decrease the output voltage with load current
- Couple an AC voltage to the FB-pin

The ratio of R1a and R1b determines by how much the output voltage changes with current for a given inductor. A ratio of R1b = 2 …4 x R1a is sufficient. If the resistance R1b is too low compared to R1a, the output shows high output voltage change with current, but is usually easier to stabilize by Cff.

Additional advantages:
- Low output voltage ripple
- Small output capacitor (size and capacity)
- Fast transient response
- Load dependent dc output voltage gives additional margin during load transient

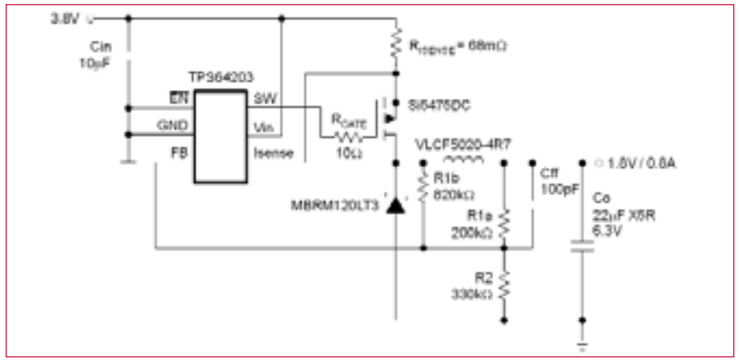


Figure 2. 1.8V-Step-down converter with 22uF ceramic output capacitor.

$$Cff = \frac{\left[\frac{-1}{R1a^2} + \frac{1}{0.005^2} \times \left[\frac{1}{R1b} \times Vin_{avg} - Vref \times \left(\frac{1}{R2} + \frac{1}{R1b}\right)\right]^2\right]^{1/2}}{2 \times \pi \times fsw}$$

Equation 1. Starting point for the value of Cff.

Equation 1 provides a good starting point for the value of Cff, given the feedback resistors, average input voltage and predicted switching frequency per the software tool slvc038.zip for the TPS6420x which is available at www.ti.com.

Where fsw is the switching frequency predicted by the design tool, assuming a higher ESR capacitor is being used, and VREF is the reference voltage of the controller IC (1.213 V for the TPS6420x. During bench testing, Cff may need to be increased or decreased slightly to find the value that gives optimal load transient performance and acceptable output ripple at light load.

The following scope plots show transient response. As already mentioned, the output voltage drops slightly with the load current. This however is an advantage for transient response. The energy stored in an inductor is proportional to the square of the load current ($E=1/2LxI^2$). The higher the load current, the higher the energy stored in the inductor. When the load is abruptly removed , this energy will be delivered to the output and charges the output capacitor. Even if the control loop could react with no time delay, the output voltage would rise for a short period of time. The transient voltage rise can only be reduced by:
- Larger output capacitance
- Smaller inductor value

Since the output voltage at high output current is slightly less than the nominal value, it is easier to design the application in such a way to keep the voltage within tolerance during a load transient. The dependency of the output voltage of the load is also an advantage when the load current increases quickly. Even with a small inductor value, the inductor current needs time to rise to the higher value. During this time, the energy has to be delivered by the output capacitor, causing the output voltage to drop even if there is no delay in the control loop. The circuit can be designed in such a way that the output voltage at no load is slightly above the nominal value, making it easier to stay within the limits for the output voltage also for a positive load step.

High voltage over- / undershoot during load transient caused by a too small feedforward capacitor. The PMOS does not turn on/off continuously during the load step.

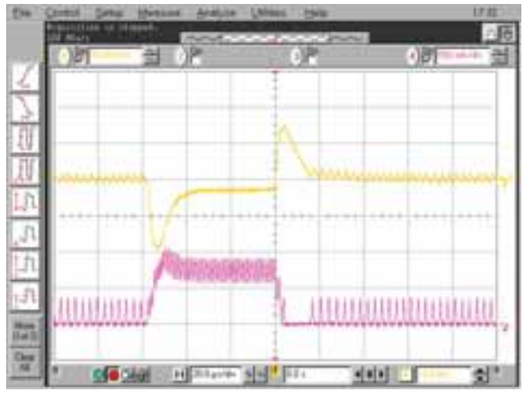


Figure 3. Feedforward capacitor too small. Vin=3.8V, Vout=1.8V, Iout=80mA .. 720mA .. 80mA, Cff=33pF, Cout=22uF. Channel 1: output voltage, Channel 4: inductor current.

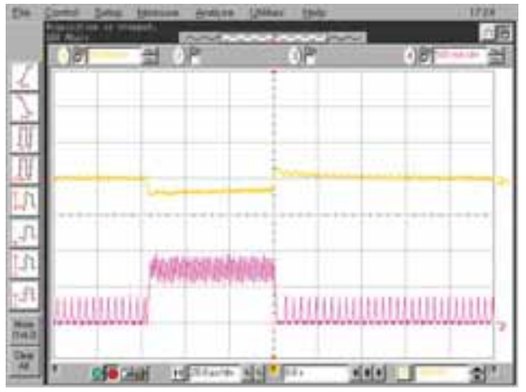


Figure 4. Larger output capacitor and larger feedforward capacitor. Vin=3.8V, Vout=1.8V, Iout=80mA .. 720mA .. 80mA, Cff=220pF, Cout=2 x 22uF. Channel1: output voltage, Channel 4: inductor current.

The output capacitor has been increased and the feed forward capacitor Cff has been increased to accommodate the larger output capacitor. The output voltage almost shows no transient voltage overshoot and undershoot.

The optimal value of the feedforward capacitor Cff can easily be determined by measuring the transient response. With a too small value, the control loop delay is too high and the voltage will show large over- / undershoot. With a too large value, there will be a voltage overshoot when the load is removed. Figures 3 to 4 show the behavior at different conditions.

Getting You Power

Negotiation with the system for optimum power supply

The general availability of USB ports on todays computers make them an attractive option for powering or charging devices, though this has its pitfalls.

Guido Körber, Code Mercenaries

Drawing power off the USB is not as simple as it might seem at first glance. A USB port does supply 5V to a connected device as long as the computer is powered. But the available current can vary over several orders of magnitude. Before grabbing a USB plug and connecting the power supply lines to some device it is a good idea to understand how power is managed on the USB.

USB does have a power management scheme that can be followed only by a real USB device that understands the bus protocol. Just connecting to the power supply lines of the USB can result in drawing more current than allowed which can cause other devices connected to the bus to fail because the supply voltage drops, or it can drain the battery of a portable computer.

There are two options for the power supply of USB devices. A device can be “self powered” in which case it does not draw power off the bus and has to have its own power supply, or it can be “bus powered”.

When a USB device is plugged into a port it may draw up to 100mA until it gets configured by the host or until it detects the bus to be suspended (i.e. computer went to sleep mode). In case of a suspended bus the device has to reduce its current to just 500 μA or in some configurations to 2.5mA.

Depending on the port it is connected to a device may draw up to 100mA or up to 500mA once it is configured by the host computer. Ports on a computer or on a “self powered hub” allow 500mA per device. Ports on a “bus powered hub” like the ones in a keyboard allow only 100mA for each device. But since the device can not tell which kind of port it gets connected to it has to constrain its current to 100mA until it gets configured to use more, or it even has to drop to 500μA if it detects that the host computer is sleeping.

USB hubs and ports have overcurrent protection that prevents damage resulting from a misbehaving device. But the protection usually has a relatively wide margin to prevent tripping on inrush currents when a device gets plugged in. Typically a bus powered hub which can supply 100mA on each of its maximum 4 ports will not have its protection kick in before almost 1A is drawn combined on all its ports. Long before that the overcurrent will result in a voltage drop that can affect other devices and destabilize the whole USB setup.

Devices like portable media players do not have a problem following the power management of the USB since they have a USB controller in any case. But for simple devices the development of the necessary controller can be quite costly.

Depends on the OS

By using so called descriptors a USB device advertises its capabilities and requirements to the system. USB devices have the option to offer a number of alternate configurations for different operating modes. One of the properties defined for each configuration is the current required by the device when used in that specific configuration. If a device does actually get configured for the maximum current available depends to a good part on the operating system.

The current implementation of USB on Linux does the worst job. It just grabs the first configuration and enables it without checking if there is sufficient current available. So using bus powered devices with Linux depends on the user to keep track.

Windows in its various versions does a slightly better job. It looks at the first configuration and enables it if there is sufficient current. If there is not sufficient current the device will not get enabled, no checking for alternate configurations is done.

Only MacOS X checks the available configurations until it finds one for which it has sufficient current and enables this one.

A power controller should know about all these details and make the best effort to get the maximum current allocated. Since it is not possible for the device to detect which operating system is running on the host computer it has to use a trial and error approach in case of Windows. For Linux it is currently not possible to do automatic power optimization until the USB function gets fixed.

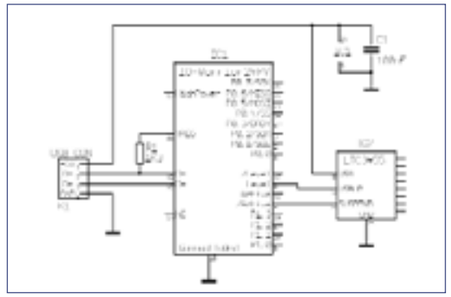


Figure 1. The IOW24PV needs only minimal external components and allows glueless integration with power management chips like the LTC3455.

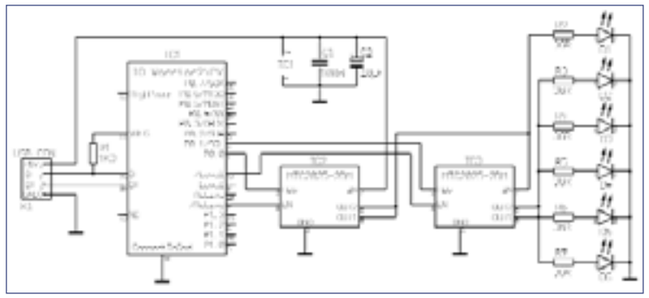


Figure 2. Adding two high side switches like MIC2025 allows a device to adapt to the available current. Like this simple LED light which uses Superflux LEDs with a typ. forward current of 70mA each.

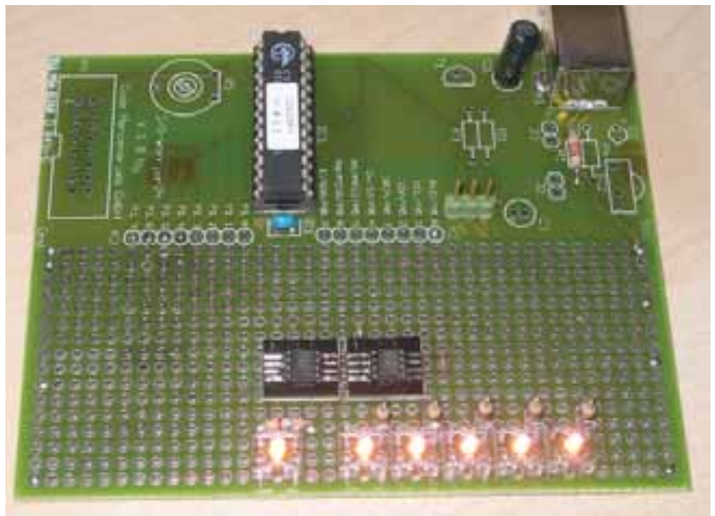


Figure 3. The LED lamp built on a IO-Warrior starterkit. This one is plugged into a high power port, all LEDs are on.

What the Vampire does for you

The IOW24PowerVampire does the negotiation with the system for optimum power supply. Building a device that needs USB basically as a power source is getting very simple with IOW24PV. Besides signaling the available power IOW24PV also offers 12 generic I/O lines that can be accessed from applications running on the host computer. Some of the I/O pins can be used for a IIC and/or SPI Master port to connect additional circuitry.

IOW24PV provides a status line each for the availability of power and the power level. To simplify external circuits it has both signal lines in inverted and not inverted form. It also has an input that restricts it to negotiate only for 500mA in case a circuit can not operate at all with 100mA.

When combined with the LTC3455 chip by Linear Technology (see Power Systems Design Europe Nov. 2005) you get a complete power management system including a LiIon charger. The National Semiconductor LP3947 offers similar features as the LTC3455 but it also has an IIC interface to set charging paramters which can be done via the IIC function of IOW24PV.

Lighting up

A simple design example is a LED light that selects its brightness depending on the available current. Cascading two high side power switches like the Micrel MIC2025 and controlling them by IOW24PV allows to build a USB standard compliant LED light. Depending on how much current is available either only one or all six of the LEDs light up. With a forward current of 70mA per LED, a worst case current of 20mA for IOW24PV, and a few μA for the switches this circuit always stays within the 100mA or 500mA current budget.

Taking control

The I/O functions of IOW24PV can be controlled by an application running on the host computer. No driver installation is required, IOW24PV uses standard system drivers. Since it is part of the IO-Warrior chip family of Code Mercenaries there are libraries and sample code for Linux, MacOS, and Windows available. The programming support includes Java and AppleScript.

www.codemercs.com

Complete 10A DC/DC Converter

A power supply at the size of an IC

Defining and designing a DC/DC power supply is often the final design step for digital system designers. Designers must spend precious time on the design, layout and debugging of a DC/DC regulator circuit. Identifying an appropriate DC/DC controller IC, MOSFETs, inductor, capacitors, resistors and diodes are just part of the challenge.

By Afshin Odabaee, Product Marketing Engineer, Power Management Products, Linear Technology Corp.

Layout, component selection and debugging of the power supply consume more time and require extensive power supply design expertise. A digital designer's time is better spent interfacing sophisticated digital ICs and writing code than analyzing the load transient response of a DC/DC circuit and defining the inductor, MOSFETs and capacitors. Let's not forget the output current ripple and loop stability calculations.

Pre-manufactured DC/DC power supplies, also referred to as point-of-load modules, have been promising simpler, smaller and quicker solutions but they fall short in meeting the demands for system assembly of densely populated embedded boards. Some power supply solutions require an external inductor, many additional input and output capacitors, and compensation circuitry. Most are assembled on a small printed circuit board (PCB) and require hand inspection for reliability, since the circuit components are exposed and not encapsulated.

For heat dissipation and safe component spacing, many embedded systems specify a maximum thickness for both the top and bottom of the board. Unfortunately, high power density DC/DC modules must implement tall inductors and rely on thick PCBs to alleviate heat dissipation. The large size and tall profile inhibits their use. Therefore, a designer must either design a discrete power supply where it can be optimized to meet the profile requirement or rely on lower power DC/DC modules where thinner inductors are used.

System designers are compelled to make compromises in the selection, performance and definition of the optimum power supply. The best solution is a complete power supply with no external power components, no mathematical analysis, easy layout and a product that fully meets the surface mount assembly requirements, just as the other digital ICs on the board. The result is a solution that is easy to select, design and assemble.

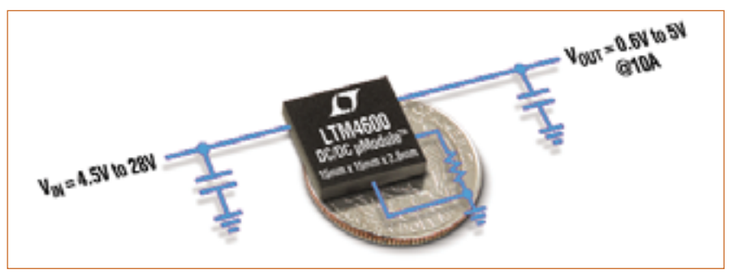


Figure 1. The LTM4600 is a complete 10A switchmode DC/DC power supply with layout and assembly as simple as an IC.

Complete Power Supply in an IC Form-Factor

Figure 1 shows a complete DC/DC power supply solution. This IC-like solution is a 10A synchronous switchmode regulator with built-in inductor, supporting power components and compensation circuitry (see Figure 2). The LTM4600 is the DC/DC module that meets the spacing and assembly requirements of the densely populated and advanced embedded systems. This encapsulated μModule DC/DC power supply is housed in a 15mm x 15mm x 2.8mm LGA package. Its size is smaller than most FPGAs and processors. With only a 2.8mm profile, the LTM4600 can

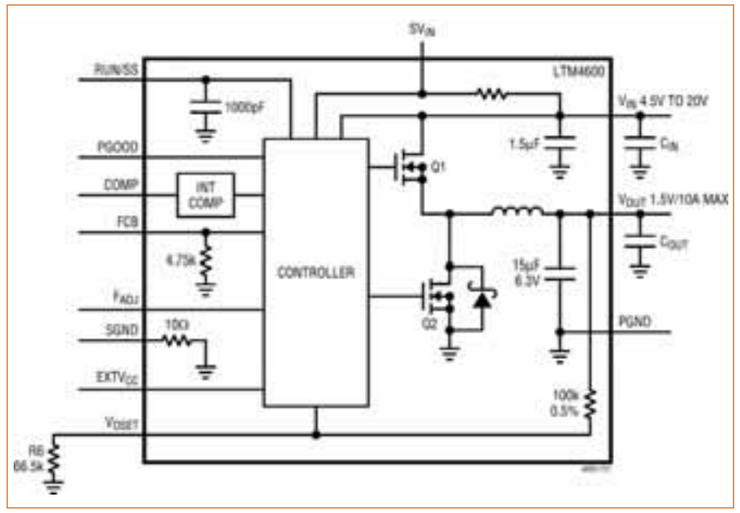


Figure 2. The LTM4600 requires minimum external components. The difficult compensation circuitry, inductor, MOSFET, DC/DC controller and input/output capacitors are on-board. 1.5V, 10A application is shown here.

be readily placed on the backside of a board.

This µModule is rated for 20V and 28V input operation (two versions). The output voltage is adjustable with a single resistor from 0.6V to 5V. The LTM4600 can deliver up to 10A of output current and offers excellent transient response to fast changing load current transients.

Easy Design Replication by Copying and Pasting the Layout

A common complaint among system designers is the assembly-house's alteration of a specified layout. The result is many rounds of debugging layouts. This problem is alleviated with the LTM4600. The simplicity of the LTM4600 minimizes layout errors. The µModule's assembly requires no special tooling. This simple assembly and layout allows two LTM4600 µModules to share the load, therefore doubling the output current capability for higher power applications.

Excellent Thermal Performance

The LTM4600 µModule has only 15ºC/W thermal resistance. It avoids overheating by dissipating heat efficiently from both the top and bottom of the package. The device's packaging technology permits delivery of 10A load current at 3.3V from a 12V input with excellent thermal performance. For applications with high ambient temperature, the LTM4600 with a heatsink and some air flow still exhibits exceptionally good thermal performance even at high power. A detailed application analysis with thermal imaging photos under variety of conditions is provided at www.linear.com/micromodule

High Input Voltage, Ultra-Fast Transient Response

The LTM4600, unlike other DC/DC point-of-load modules that have limited input range, can convert input supply voltages as high as 28V, without any input supply protection or additional external components. The output voltage is adjustable from 0.6V to 5V with ±1.5% accuracy.

A unique capability of the LTM4600 is its no-clock latency current mode architecture, allowing it to respond quickly to rapid load current changes. Where other modules must wait one full clock cycle to pass before responding to a load

Figure 3. Gold-finish pads allow the RoHS compliant LTM4600 to be mounted with Pb-based and lead-free solder pastes.

change, the LTM4600's response is instant, eliminating up to five external load capacitors required with other solutions.

20A Load Current by Paralleling Two µModules

Two LTM4600 µModules can be easily paralleled to provide more than 10A (up to 20A) output current. The µModule features a current mode control scheme which ensures excellent current sharing among the devices. Sharing the load current among two µModules and balancing the power dissipation minimizes the thermal stress and reduces requirements for heatsinking and airflow.

By interconnecting only three pins between two LTM4600s, a power supply can be easily scaled for higher output current. All the necessary circuitry for balanced and accurate current sharing is integrated. There are no requirements for external op amps and supporting components. Refer to the LTM4600 data sheet for details and schematics of a 20A solution at 2.5V from a 4.5V to 20V input supply.

RoHS Compliant; Mounts with both Pb-based and Lead-free Solder Pastes

The LTM4600 is RoHS compliant. However, unlike many lead-free packages with matte-tin lead finish, the LTM4600 is offered with gold-finish pads. Gold-finish pads allow the µModule it to be used with either PbSn- or SnAgCu-based solder pastes for surface-mount processing (Figure 3). This unique feature is especially attractive to companies that have not decided to convert to lead-free manufacturing and where the LTM4600 can be qualified immediately for surface mounting with Pb-based pastes. In addition, lead-free exempt manufacturers such as military and some industrial companies can take advantage of the LTM4600's benefits, although the µModule is RoHS compliant. A copy of the LTM4600 RoHS material declaration is available at www.linear.com/micromodule

Only 1.73 Grams

Beside its tiny and low profile size, the LTM4600 weighs only 1.73g. This high voltage and high power supply requires no special surface mount tooling procedures or machines. The µModules light weight and small size is easily handled by the same pick-and-place machines as the ones used with FPGAs and microcontrollers. This compatibility speeds manufacturing of high density system boards such as AdvancedTCA or CompactPCI.

The LTM4600 DC/DC µModule represents a new architecture for point-of-load power supplies, significantly simplifying the power design task. Innovative DC/DC design and improved packaging technology allows a digital system designer with minimal analog knowledge to quickly construct a high performance DC/DC power supply.

In addition to ease of design, the layout and assembly are simple and straightforward. The LTM4600 uses the same pick-and-place machines as the digital ICs on the board. Although this µModule is capable of delivering high output power, its excellent thermal characteristics allow it to be placed near the other ICs. The LTM4600's small size and low profile design mean that digital system designers no longer must sacrifice expensive board space or compromise on the performance of point-of-load power supplies.

www.linear.com

Thermoelectric Generator

Power a human body area network

Miniaturized and cost-effective thermoelectric generators (TEGs) scavenging energy from wasted human body heat are good candidates to power the human body area networks of tomorrow.

By Mieke Van Bavel, IMEC, Leuven

Such a network could be composed of electronic modules with wireless sensors and actuators that typically consume 100μW of power per sensor node. This power is obtainable on several square centimeters of the skin, i.e., the typical size of a miniature electronic module.

In order to model and design efficient small-sized TEGs, IMEC has measured the thermal properties of the human body that is used as a heat source. Based on the results of this investigation, prototypes of the TEG have been designed and tested. Watch-sized prototypes made of miniaturized commercial BiTe thermopiles have demonstrated to generate sufficient output voltage and power to supply the wireless sensor modules. Research on next-generation TEGs using the less expensive micromachined SiGe thermopiles is currently ongoing. They could possibly replace the batteries in a consumer product, operating on a human body, with small-size scavengers possessing virtually infinite lifetime.

Introduction: thermoelectric generators

Thermoelectric generators (TEGs), also called "thermoelectric converters", are most ideally suited to generate electrical energy from industrial sources of wasted heat. The history of thermoelectric generation brings us back to 1823, when the German physicist Seebeck discovered that a voltage was developed in a loop containing two dissimilar metals, provided that the two junctions were exposed to different temperatures. Thermoelectric generators of today are made up of semiconductors. They contain a large number of p-type and n-type miniature bars of thermoelectric material (see figure 1).

The reason for this design is that the Seebeck voltage, i.e. the thermoelectric voltage generated by one thermocouple at one-degree temperature difference between the "hot" and "cold" junctions, does usually not exceed 0.2mV. The thermoelectric legs are arranged electrically in series, to generate the voltage required for electronics, and thermally in parallel, to obtain the large temperature difference between the junctions. Featured with no moving parts, being small in size and producing no pollutants, thermoelectric generators are attractive alternatives for the batteries or wiring of many applications. These cover industry, medical, consumer or telecommunications areas, security systems and fire alarms whenever natural thermal gradients or industrial heat flows are available for utilization.

Miniaturized and cost-effective TEGs are of particular interest for applications of wearable electronics, where wasted body heat can be used to provide power autonomy to ICs, sensing elements and

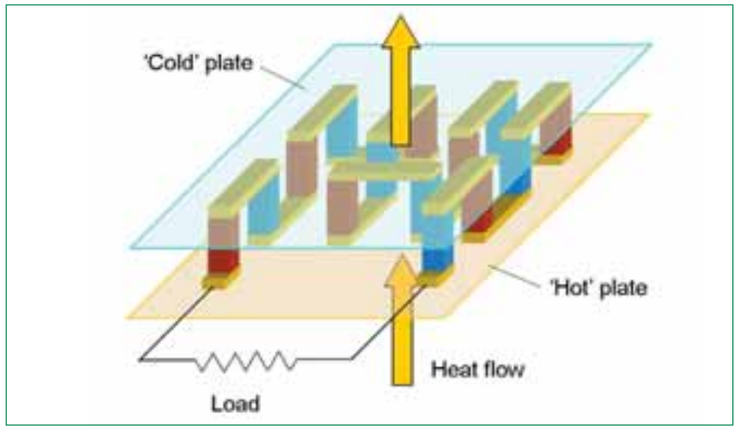


Figure 1. Design of a typical thermopile.

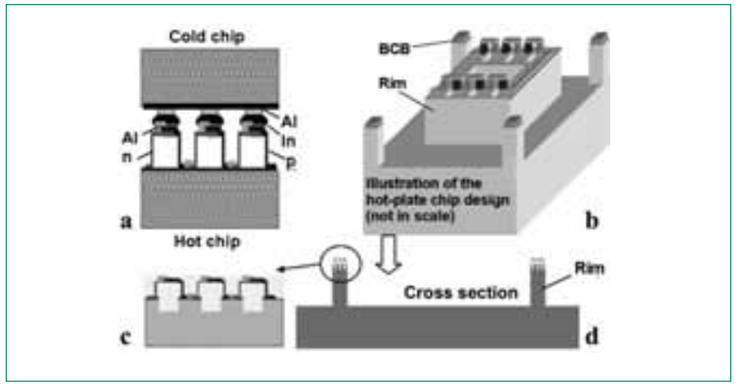


Figure 2. Design of the poly-SiGe thermopile sandwich.

transceivers that operate at low power, not exceeding a few milliwatt. For example, TEGs that generate electricity from human heat have been mounted in a wristwatch to drive a digital watch. The use of TEGs for such applications is preferable in indoor conditions, where other more powerful renewable energy sources such as sunlight or wind are not available. It should however be noticed that thermoelectric generators usually work much better outdoor.

It is the aim of IMEC's research to develop cost-effective, reliable, miniature energy scavengers, built on MEMS technology, as a power supply for a body area network. This body area network, in development as part of IMEC's Human++ program, consists of a set of wireless sensors and actuators able to provide health, sports, comfort and safety monitoring functions to the user. These sensor nodes typically require 50 to 100μW of power. The cheap and small-sized TEGs will enable a truly power autonomous solution and avoid the use of cumbersome batteries.

The human body as a heat generator

Modeling a TEG on a human body requires knowledge of the thermal properties of the latter. The heat flow from the body is determined by many factors, such as the body thermal regulation mechanisms, the physical activity of the person, his/her age and acclimatization, clothes and weather conditions. The body of a human being or a warm-blooded animal has a non-uniform temperature distribution caused by its cardiovascular system and by the air convection around the body. As a result, the place of attachment of the device to the body plays an important role for the density of body heat on the skin available for conversion into electricity.

Therefore, prior to the modeling and development of the TEG for this particular application, the heat flow through the human skin and the thermal features of the body have been investigated. The regulation increasing the local heat flows through the skin using a TEG is accompanied by a possible feeling of discomfort, which has been also investigated to make the devices acceptable to be worn. The research has been performed on 158 volunteers. To this purpose, 'first-generation' thermopile converters were used, consisting of a 3-layer stack of classical BiTe thermopiles supplied with a conventional multi-fin radiator of about 2x4x4cm^3 size. The main results of this study are summarized below.

First, it is clear that in case of forced air convection (walking, presence of wind …), the heat flow through the skin increases significantly. To obtain such a rise of heat flow in still air, IMEC's TEG attached to the skin is finished with a radiator. This increases its contact area with air, so that this surface exceeds the surface of the skin covered by the device. In this way, the interface resistance between the device and the air is significantly decreased, allowing more efficient heat transfer through the skin. In the experiment, the generators supplied with a radiator demonstrated up to 7 times larger heat flow than the natural one. Moreover, it has been observed that the heat flows "painlessly" extractable with a small-featured TEG significantly exceed the flows occurring on a human body without the generator.

Secondly, the place of attachment of the device to the body plays an important role for the magnitude of the heat flow. Besides the positive effect of clothes, which thermally isolate most of the body surface, increase the skin temperature and cause larger heat flows from the open surfaces (the hands and a head), the presence of arteries is responsible for a significant variation of the body properties from place to place. The cardiovascular system affects both the heat flow density on the skin and the thermal resistance of the body between its inner (deep) part and the skin surface. As an example, changing the location of the TEG from the watch's place to the one on the radial artery, i.e. the place on a wrist which is used to measure the pulse, almost halved the body thermal resistance. For these reasons, the radial artery on the wrist has been used as the most appropriate place for the TEG, as it results in a larger heat flow density and consequently more electrical power generated. Finally, it was observed that the heat flows up to 20mW/cm^2 on the outer side of the wrist and up to 30mW/cm^2 on the radial artery in general do not cause a local thermal discomfort for a sitting person.

Modeling and design of the thermoelectric generator

The above results have been used to model and design the MEMS-based TEG for application on the human body. The body features have been modeled as a serial variable equivalent thermal resistor. The final goal of IMEC's research on thermoelectric generators is to use micromachined thermopiles, with a minimal feature size of 1μm. The idea of using micromachined thermopiles is not new: the self-supported thermocouples, standing on the bottom hot-plate silicon chip, must touch the indium bumps formed on the top cold-plate chip. Two chips form a sandwich with the thermopile in between. However, traditional designs such as these suffer from a parasitic heat exchange between the hot and cold plates, decreasing the thermal gradient on the thermopile down to tens of millikelvin and resulting in a negligibly low generated power. Therefore, IMEC proposes an innovative design that consists of making a rim in both silicon chips. The thermopile of a few micrometer in size is to be fabricated on top of this rim. Additional spacers above the thermopile sandwich will be used to further decrease the influence of the parasitic heat flow inside the device on its performance.

Figure 3a. Demonstrator of IMEC's second-generation TEG.

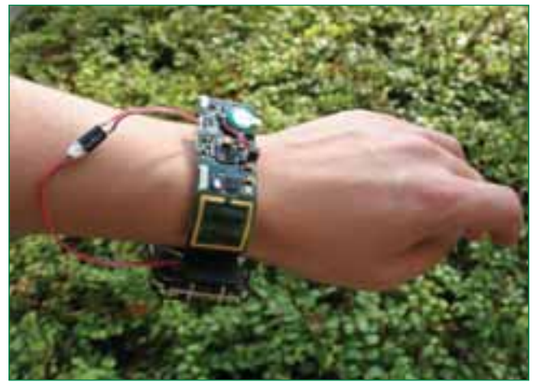


Figure 3b. Electronic modules, mounted on a watchstrap.

Calculations based on this design show an output voltage of 1—1.5V and a generated power of 1—2μW on average for a watch-sized TEG built with 2.5μm-tall polycrystalline SiGe thermocouples. It is important to notice that, without the use of the rim, the generated power would have been more than 100 times less at the same output voltage. The output parameters highly depend on the material used for the thermocouples and technological possibilities. Therefore, further improvement of the micromachined thermopile chips is expected with an electrical production up to 30μW per square centimeter of the skin.

Proof of concept: prototype with BiTe thermopiles

The main advantages afforded by micromachining for manufacturing the thermopiles are the small size of the thermopiles and their potentially low cost. However, the demonstration of the wireless body area sensor nodes self-powered from the body can as well be done with thermopiles available on the market. Therefore, in parallel to the development of micromachined TEGs, the concept of thermal matching the TEG to the human body and to the air has first been demonstrated with a non-MEMS prototype. This is however at the expense of a slightly increased size and of significantly more cost of fabrication. Nevertheless, simultaneously, it can demonstrate the improvement of the energy generation by placing the TEG on the artery.

In a first demonstrator of these 'second-generation' thermoelectric bracelets, 48 thermopiles are used in total. Each thermopile has a size of 8x9x2.4mm^3 and is composed of 128 thermocouples. The BiTe thermopiles are composed into a miniature 3-dimensional matrix to match its thermal resistance to the ones of the air and human body. That is why IMEC's first demonstrator was called 'T-Matrix'. The power conditioning electronics suitable for a TEG operating on a human body has been developed. It includes up-conversion and voltage stabilization. The TEG generates an average of 100μW of useful electrical power stored in two nickel-metal hydride (NiMH) batteries. The electronic modules are mounted on a watchstrap and completed with a sensor layer, a microcontroller and a wireless transceiver thereby creating a wireless sensor node module. This first prototype of a self-powered sensor node has been used to transmit several measured quantities to a nearby pc with a transceiver operating at 2.4GHz in a pulse regime. Transmission of the data once per 15s gives enough time for complete energy recovery to keep the batteries permanently charged.

A second demonstrator has been built in 2005 with smaller dimensions, such that its volume does not exceed the one of a typical man's watch. In this design, the custom-made four-stage BiTe thermopile block consists of about 3500 thermocouples with only 0.2mm cross-section of the thermoelectric legs. Each contact of two adjacent thermocouple legs provides approximately 0.2mV of generated voltage per one degree of temperature difference between the hot and cold junctions. The generator produces 100—200μW average power if located on the radial artery. The output voltage, nominally, is 1.2V. The wireless sensor module on a flexible carrier covers part of a watchstrap. It includes a low-power micro-controller that is used to control duty-cycled sensing applications and application-specific sensors, which process e.g. biopotential signals such as in electrocardiography (ECG),

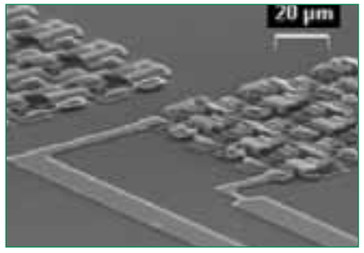


Figure 4. A corner of the chip containing about 2500 poly-SiGe thermocouples forming a thermopile before etching the rim.

electromyography (EMG) and electroencephalography (EEG). The transmission rate is increased to 0.5s^{-1}, however, the decreased power consumption in the electronic module provides non-stop operation on a human body.

Outlook: next-generation TEGs

BiTe versus SiGe

BiTe thermopiles are expected to generate more power than SiGe thermopiles. IMEC's calculations on micromachined BiTe thermopiles, inside the building and at 22°C, show up to 30μW of generated power per 1cm^2 of skin, while poly-SiGe may offer up to 5μW per 1cm^2. However, the main target of IMEC's investigation is not the best performance, but the lowest cost, as these TEGs are to replace the cheap batteries used nowadays. In addition, polycrystalline SiGe is the material that is more extensively studied in microelectronics. Therefore, next-generation TEGs will be fabricated using micromachined SiGe thermopiles. The additional advantage is that the technology for poly-SiGe layers developed at IMEC provides a very low thermal conductivity of only 0.03W/cm K. The advantage of using micromachined thermopiles is the large surface density of thermocouples that can be achieved. Thanks to this feature and the use of IMEC's novel design, it will be possible to deliver the power at a reasonably high voltage.

Technology for polycrystalline SiGe thermopiles

IMEC has developed a process flow for fabricating and assembling the micromachined TEG. The process flow starts with etching microcavities under the thermocouples and filling them with SiO_2. This is followed by deposition and patterning the SiO_2 pads on top of the SiO_2-filled microcavities. Then, p- and n-poly-SiGe legs are formed and aluminum interconnects are made for hot and cold junctions. Deep ion reactive etch of silicon is subsequently performed to fabricate the rim structure. At this point, the chip surface that isn't covered with the thermocouples or metal lines, is the subject of a deep 0.25mm etch. After opening the side of the thermocouples, the sacrificial SiO_2 layers are etched away. The top, a heat-spreading chip, represents patterned Al squares covered with indium. The aluminum layer is electrically isolated from silicon with a thin Si_3N_4 layer. Upon fabrication of this structure, the top chip is also etched to form a rim of the same height, i.e., 0.25mm.

In order not to destroy the thermopile mechanically during assembling the device and further exploitation, a number of thermocouples are left with sacrificial oxide. These thermocouples serve as mechanical stoppers when mounting the top chip on the bottom one. The assembling of two chips is performed using a benzocyclobutene layer on top of four pillars made on the chip corners. The assembled thermopile sandwich will be mounted on a metal plate touching the skin and supplied with a watch-strap. The radiator as well as the rest of the device will be protected with a touch- and shock-protecting grid similar to the one shown in figure 3. Fabrication of the poly-SiGe thermopiles based on this process flow is currently ongoing.

IMEC has developed first prototypes of a thermoelectric generator scavenging energy from wasted human body heat. The design is built on the basis of a thermal model of the device, which includes the human body as one of its important elements. Novel element of the thermal design is the presence of a pillar/rim structure, on which the thermopile and the heat spreading structure are placed. This significantly decreases the parasitic heat exchange between the hot and cold plates, resulting in useful output parameters. Prototypes of a TEG have been made using commercial BiTe thermopiles and have the size of a typical man's watch. Output voltage nominally is 1.2 or 2.4V; the average power is about 100 – 200μW.

The final goal of this research is to develop cost-effective miniaturized TEGs built on MEMS technology. They are to power the variety of sensor nodes that can be attached to a human skin, as well as the incorporated wireless sensor modules transmitting measured parameters to a nearby base station and receiving the information for actuators from the station. Further research focuses on the development of micromachined poly-SiGe TEGs, as they offer a cheap solution. A process flow has already been developed and a first demonstrator run is being fabricated.

Contact: mieke.vanbavel@imec.be

www.imec.de

Intelligent Lighting Saves Power

Economical lighting source is now available

New buildings are benefiting from economical LED lighting automated by low-power wireless networks.

By Ofer Aluf, Technical Sales Manager, Future Electronics Europe

"Smart buildings" is the phrase used by engineers to describe office complexes, residential blocks or factories that are built with automation in mind. One driving force for automation is to reduce energy consumption. Intelligent control of lighting sources - for example, turning them off when there is no motion detected in a room – promises to slash power costs and make a welcome contribution to reducing greenhouse gas emissions.

Coincidentally, a new, economical lighting source is now commercially available to building engineers which runs at a fraction of the power of incandescent light sources. Called High-power LEDs, these devices also benefit from rapid start-up and switch-off. These devices finally provide lighting engineers with an opportunity to move lighting out of the 19th Century.

The basis of building automation is a smart sensor network, allowing devices to communicate intelligently. These sensors can then be used to detect and control any number of devices. Typical applications range from smoke detectors, air conditioning, intruder alarms and lighting.

To make them cost effective the sensors have to be cheap to make and install, and run at low power for long periods with very low duty cycles. It also helps if the devices communicate wirelessly, because that removes the need for the kilometres of expensive wiring a large office or residential block would demand. ZigBee, the low-power, low data rate, IEEE-based communications protocol has been designed with exactly this kind of application in mind.

High-power LEDs allied to a network of ZigBee-enabled sensors endows smart buildings with efficient, unobtrusive and responsive lighting controlled by a reliable, robust, low-power mesh network able to service hundreds of nodes. The "intelligence" added by ZigBee allows the lighting system to be extended beyond a simple passive system. For example, high power LEDs controlled by a network that includes motion detectors could be used as a security measure to flood rooms with light when an intruder is detected. This would make it much easier to see the intruder on security cameras.

There are some challenges in implementing a ZigBee network controlling building lights. These range from ensuring the efficient transfer of data, to reducing the power at each node of the control network, and designing a power supply for the high power LEDs. However, with guidance from a knowledgeable supplier and the use of proven hardware and software from companies such as Freescale and Lumileds, the task can be simplified.

A network for smart buildings

While there are other smart building network technologies, ZigBee is the one gaining most traction. This is partly because it is backed by an Alliance of powerful silicon vendors and partly because it has been designed specifically to be inexpensive to install and operate.

While ZigBee is a proprietary protocol belonging to the Alliance, it is founded on the IEEE 802.15.4 RF communications standard. ZigBee operates in the licence-free global 2.4GHz, European 868MHz, or US 915MHz ISM (Industrial Scientific Medical) band. The data rate at 2.4 GHz is 250 kbit/s (10 channels), 20 kbit/s (single channel) and 40 kbit/s (6 channels) for the European and US bands respectively.

Each ZigBee network must have at least one network coordinator; this unit maintains overall network knowledge and requires the most computing power and memory. The network also needs a full function device (FFD) to provide initialisation, node-management and node-information storage. (It's also possible for a FFD to function as a network coordinator.) The remaining nodes can then

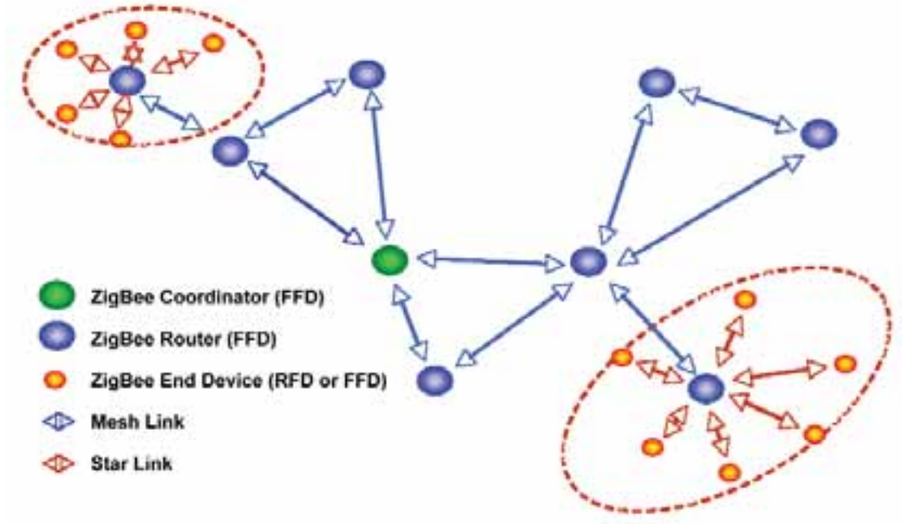


Figure 1. ZigBee network.

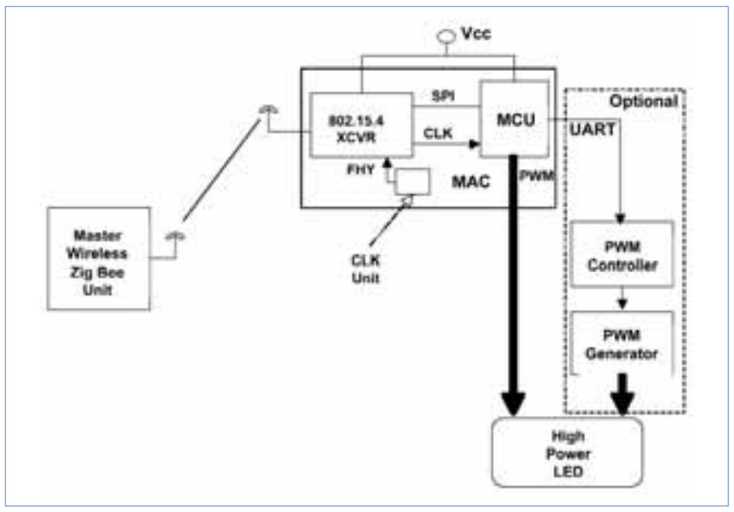


Figure 2. Pulse width modulation (PWM) control.

be simple, battery-operated reduced function devices (RFDs) with limited resources. This keeps the cost down and reduces power consumption. Each ZigBee network can have up to 254 client nodes, plus the network coordinator or FFD acting as a master. In addition, there can be up to 100 co-located networks. (See Figure 1.)

ZigBee networks can use “beacon” or “non-beacon” configurations. Beacon mode is used when the network coordinator is battery-operated, because it allows the system to minimise its power consumption in extended mesh networks. The fact that the clients know when to communicate with each other prevents clashes (and hence corrupted packets) and the need for retransmission. The network coordinator manages the channel and arranges the times of the calls. A client registers with the coordinator and looks for any messages; if nothing is pending, the client returns to sleep. Once the client communications are completed, the coordinator goes to sleep, saving power.

In addition, ZigBee’s network (NWK) layer incorporates an algorithm that attempts to maximise quality of the end-to-end communication link, thus avoiding the need to frequency hop and retransmit lost packets. This also helps to lower overall power consumption.

In contrast, the non-beacon mode is designed for peer-to-peer access. The network coordinator is usually powered from the main source so its receiver is on constantly. Each client is autonomous and can initiate a communication at will, but could interfere with others. For example, the system might be used for security systems where client units, such as intrusion sensors, sleep for 99.999% of the time. The remote sensors wake up on a regular (although random) basis to announce their presence to the coordinator. When an event occurs, the sensor wakes up instantly and transmits an alert.

In a lighting application, one end of the ZigBee wireless link in the switch-to-light link will have access to mains power (the end controlling the high-power LED). However, the switch can be battery powered. Such an arrangement suits a non-beacon mode whereby the network coordinator allows clients to sleep for unlimited periods, enabling them to save power.

Let there be light

Manufacturer Lumileds has invested considerable research effort and expense to develop power LED technology. These devices offer many advantages over their incandescent rivals. For a start, they are much more efficient: This is because an incandescent bulb has to use much of the energy input simply to heat up the filament. That heat is wasted, and only a small proportion of the energy is emitted as light.

Apart from superior energy efficiency, high power LEDs have many other advantages over traditional lighting. These advantages include: Instant-start; no IR radiation or UV components to the beam; no mercury in the light source; very long operating life (up to 100,000 hours); and a compact source offering unobtrusive lighting with minimal maintenance costs.

However, there are some downsides. For example, compared to filament bulbs or fluorescent tubes the power supply challenges for high power LEDs are more complicated. In particular, the fast start-up of high power LEDs - varying from 15 ns for AlInGaP-based LEDs to 20 ns for InGaN – dictates that the designer must consider issues such as maintaining and monitoring the power supply circuit input and output voltage within strict tolerances.

While powering traditional light sources is straightforward, high power LEDs require some special considerations. A LED is current-driven instead of voltage-driven. This means its driver can be as simple as a series resistor, although this is inefficient. Superior methods include pulse width modulation (PWM) control, which also imparts fine dimmer control. (See Figure 2.)

ZigBee is ideally suited to take advantage of PWM control. An instruction to dim a light requires several packets to be transmitted and received in the correct sequence. An acknowledgement frame format provides active feedback from the lighting wireless receiver unit to the transmitter that the dimming data packet was received without errors.

For specific advice on LED driver circuit design, it is best to consult with the manufacturer or distributor. Future, for instance, employs engineers that are conversant with hi-power LED power supply requirements.

Don’t get overheated

Apart from the power requirements of this new generation of lighting, the design engineer must also understand the challenge presented by the heat generated inside the device.

The emitter produces around 1W, which is dissipated partially as light, but primarily as heat. While electrical overload can rapidly degrade the LED, heat is a biggest enemy. White LEDs (the most likely to be used for building lighting) are particularly vulnerable, because the heat degrades both the chip and the phosphor coating of the LED dome that “converts” the chip output to white light.

A good starting point when considering the thermal challenge is to consult Reference 1. This application brief describes how to estimate and calculate thermal resistances and operating temperatures.

The designer must take care when interpreting the data sheet; the lifetime of the device is determined by the die temperature during operation, and some manufacturers make it somewhat difficult to find this information. However, Lumileds, a major supplier of hi-power LEDs, clearly specifies the lifetime of its devices based on die temperature (rather than ambient temperature).

Calculating LED life related to die temperature allows the designer to select the appropriate heatsink for the application. For example, if the product is destined to operate in an elevated ambient temperature environment, the designer can select a larger heatsink to keep the die temperature the same as that in a product used in circumstances that are more normal.

Design expertise available

Freescale, a member of the ZigBee Alliance, manufactures proven chipsets adhering to the IEEE standard and ZigBee protocol. The company’s product comprises an RF data modem IC operating in the 2.4GHz, a low power 8-bit HCS08 Flash microcontroller, and software meeting current ZigBee protocol. The current product comprises two chips, but continuing development will see an integrated solution on a single chip.

Maxstream is another ZigBee supplier. The company uses Freescale’s silicon for assembled units using ZigBee wireless communication. Both companies provide solutions suitable for controlling high power LEDs. These products, and many others, are available from Future Electronics. The company is also able to provide advice and expertise on how to implement ZigBee-controlled LED-based building lighting.

ZigBee is increasingly gaining momentum in smart building applications because it adds “intelligence” while minimising complexity, cost and power consumption. ZigBee allied to a new generation of lighting in the form of high-power LEDs provides lighting design engineers with the ideal opportunity to bring building lighting into the 21st century.

www.FutureElectronics.com

Dynamic Power Control for Power Amplifiers

Giving CDMA cellular phones longer talk time

As more functions are added to 2.5G and 3G cellular phones, the trend has been for the power amplifier (PA) to carry the transmission of large amount of high speed data. Higher data rates inevitably increase the power required by a PA.

By Lei Feng, Senior Strategic Applications Engineer, Micrel Inc.

Deliberately controlling the power delivered to a PA is essential to maintain battery life and obtain the longest possible talk time. Figure 1 illustrates a simplified diagram showing the structure of a typical PA for a CDMA/WCDMA cellular phone. The bias voltage provides a reference potential to the amplifier. The V_{CC1} and V_{CC2}, normally tied together to one power supply with much higher output capability, drive the output stage to attain adequate transmitting power.

In a typical power controlling scheme, and depending upon the signal quality in a certain area, the PA is powered either directly by the battery or through a DC/DC converter. When the maximum transmitting power is required, then the PA power is connected to the battery directly with a MOSFET switch, which bypasses the DC/DC converter and its external inductor. This option offers two advantages. First, for the high-power mode, a MOSFET switch with very low on-resistance can be used to power the PA with nearly the same voltage of the battery, in order to avoid signal distortion caused by unexpected voltage drop out. Second, the DC/DC converter is only required to deal with the power in low power mode, which then allows for a much smaller form factor for both the internal switching elements and the external inductors.

This structure requires a number of features from the device: The DC/DC converter must have a very high efficiency, the output voltage of DC/DC converter must be able to be dynamically adjusted to make the system easy to be designed with different PAs, as well as adaptive to different infrastructures and the oscillating frequency of the DC/DC converter should be set to be far away from the base band modulation frequency of the cellular phone. In addition, the transient speed from a low to high power mode, or the opposite direction, must be high enough and to get as high transmitting power as possible; the bypass MOSFET switch must have low enough on-resistance to ensure a very low drop out from the battery voltage when working at high power mode and the entire circuit area should be as small as possible.

Figure 2 depicts the power solution offered by the Micrel MIC2224. It includes a synchronous DC/DC converter for the low-power mode, with a very high efficiency of more than 90 percent, and a low resistance bypass MOSFET, 40mohm typically. The output voltage of

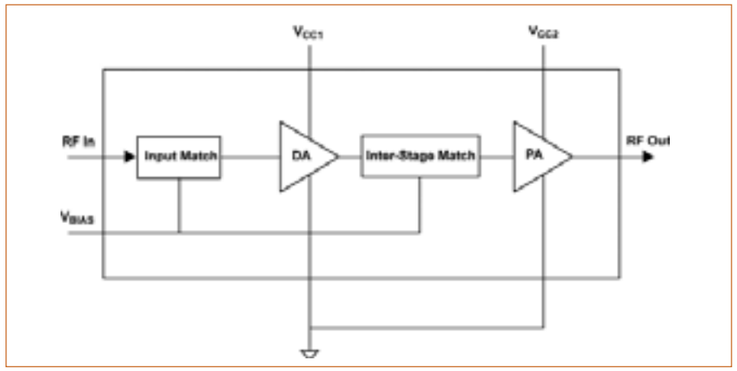


Figure 1. A Simplified Diagram of Power Amplifier.

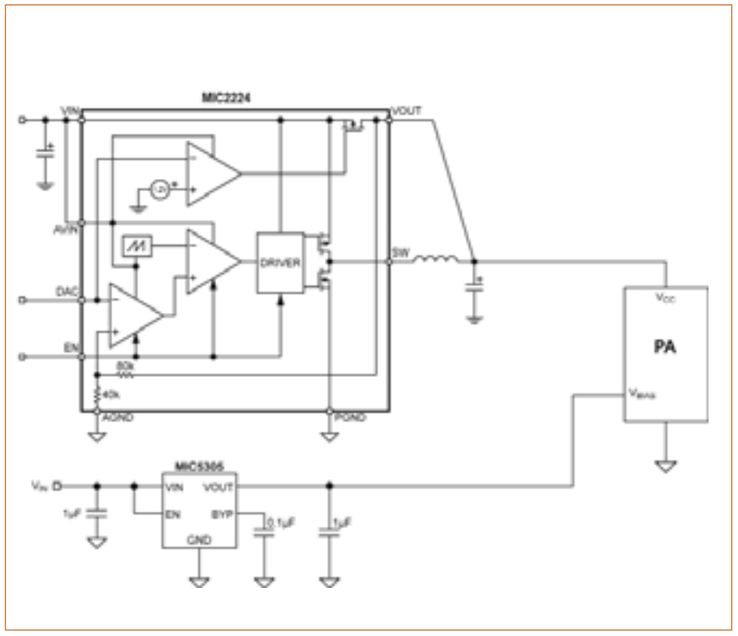
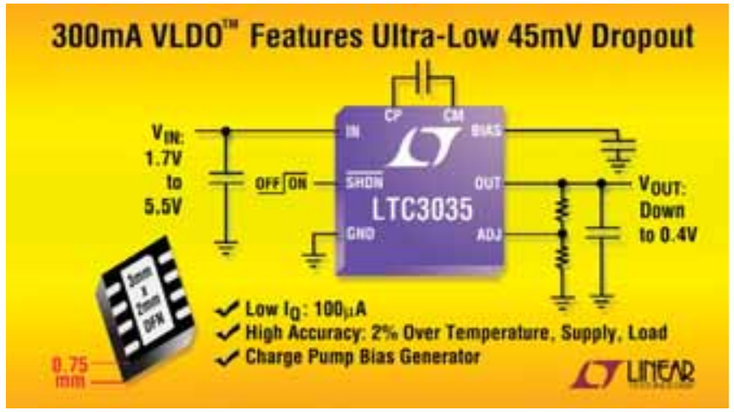


Figure 2. Micrel Power Solution for PA.

the DC/DC converter can be digitally adjusted by the DAC output of the microcontroller, from 0 to 3.6V. When the DAC voltage is higher than 1.2V, then the device will automatically switch into the high-power mode, turning on the bypass MOSFET and shutting down the DC/DC converter. The oscillating frequency of the DC/DC converter is fixed at 2MHz and hence, will not cause interference. This high frequency, together with Micrel's patented compensation scheme, provides stable operation with world smallest external components, requiring only tiny 2.2uH inductor and 1uF output capacitor. Experiments in this area have shown that the above power supply system can increase valuable talk time by up to 40 percent, thereby significantly increasing talk time and making Micrel's MIC2224 an fitting solution for today's demanding cellular phone applications.

www.micrel.com

300mA VLDO Features 45mV



Linear Technology Corporation announces the LTC3035, a 300mA very low dropout (VLDO) linear regulator with input voltage capability down to 1.7V. Featuring a low internal reference voltage with corresponding adjustable output voltage operation from 0.4V to 3.6V, the LTC3035 also maintains an extremely low dropout voltage of only 45mV at full load current. To allow operation at low input voltages, the LTC3035 includes an integrated charge pump converter that provides the necessary headroom for the internal LDO circuitry. This low input voltage capability enables performance in applications ranging from Li-Ion or 2xAA alkaline cell to low input to low output voltage conversion systems. The LTC3035's tight output voltage ±2% accuracy, low quiescent and shutdown currents of 100uA and 1uA, respectively, combined with fast transient response and small solution footprint with few external components, make it ideal for battery-powered handheld devices such as Bluetooth-enabled devices, cellular phones, media players, handheld medical and industrial instruments.

The LTC3035 regulator optimizes stability and transient response with low ESR, ceramic output capacitors as small as 1uF. Internal safety circuitry includes short-circuit and reverse output current protection, plus output current and thermal limiting.

www.linear.com

I²C Power Supply Controller

Linear Technology introduces the LTC2970, a dual I²C power supply monitor and margining controller designed for digital management of power supplies in high-availability systems. The LTC2970 offers the best melding of digital and analog for digital power management. The I2C digital interface, 14-bit ADC, highly accurate reference and current output DACs give digital power supply designers what they want: digital control of an analog power supply. The LTC2970 works with most any power supply, allowing designers to choose the optimal DC-DC converter with an analog control loop that provides smooth control of the output voltage and fast transient response. An on-chip reference and 14-bit ΔΣ A/D converter ensure accurate measurements of supply voltages, load currents or temperature. Two voltage-buffered 8-bit DACs drive the supplies' feedback nodes for improved accuracy or can be programmed by a slow, linear voltage servo to trim and margin the output voltages. This makes the LTC2970 useful in determining the sensitivity of the power supply during the prototype phase or in production to test for manufacturing variations.

The superior accuracy of the IC allows it to precisely servo each supply's output voltage over a wide range of operating conditions, while integrating all the vital functions in a compact 4mm x 5mm QFN package. Extensive, user-configurable fault monitoring provides increased reliability by alerting a system's host to incipient failures before they occur. The LTC2970's ΔΣ architecture was specifically chosen to average out power supply noise and allow to ignore fast transients.

www.linear.com

High-Performance Precision Amplifiers

National Semiconductor expanded its high-performance precision amplifier portfolio with the addition of three high common-mode difference amplifiers.

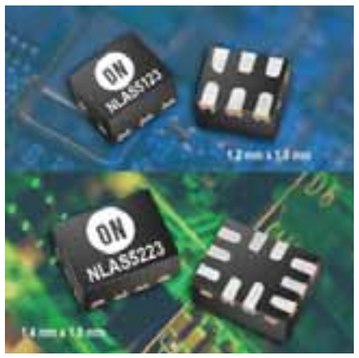
Designed for broad-based industrial, medical and telecommunication applications, these new amplifiers meet the requirements for accurate current sensing measurements in products such as base stations, notebook PCs and sensor controls in industrial applications.

The LMP8275 and LMP8277 high common-mode amplifiers and LMP8276 high common-mode bidirectional amplifier join National's LMP (linear monolithic precision) product family, which detects, amplifies and filters small differential signals in the presence of high common-mode voltages.

The very low offset voltage (less than 2 millivolts) and offset drift (less than 30 microvolts/degrees Celsius) of these products allow for accurate differential signal conditioning of small signals, with minimal voltage offset error through the entire temperature range. Additionally, the extended operating temperature range of -40 degrees Celsius to +125 degrees Celsius ensures these amplifiers can be used in extreme conditions, such as those found in industrial applications.

www.national.com

Smallest Packaged Analog Switches



ON Semiconductor has introduced three new low resistance analog switches for portable and wireless audio applications. Offered in lead-free (Pb-free) Thin QFN / Thin DFN packages that utilize between 1.2 mm2 and 4.7 mm2 of board space, these 6-pin, 10-pin and 16-pin devices are the industry's smallest and highest performance audio analog switches.

The three new high performance audio analog switches are designed for high-current switching of an audio signal in portable and wireless applications with low operating voltages. The devices are ideal for higher power audio applications that require low on-resistance (Ron) for improved power efficiency.

The NLAS3799MNR2G is a low voltage, ultra low Ron, Dual Double Pole-Double Throw (Dual DPDT) switch. It achieves total harmonic distortion of 0.11% and low Ron of 0.35 Ohm allowing for superior audio performance and low power consumption.

The NLAS5223MNR2G is a low voltage, ultra low Ron, Dual Single Pole-Double Throw (Dual SPDT) switch. This analog switch has enhanced lower Ron performance and has a 70 percent smaller footprint than the very popular NLAS4684MNR2G. It achieves total harmonic distortion of 0.12% and low Ron of 0.35 Ohm allowing for superior audio performance and low power consumption.

The NLAS5123MNR2G is a 1 ohm, Ron, Single SPDT analog switch with 0.012 % total harmonic distortion and break before make capability. It is available in a Pb-free, 6-lead, Thin DFN that measures 1.2 mm x 1.0 mm x 0.75mm and utilizes 53 percent less board space than competitor products.

www.onsemi.com

USB Power Switch IC

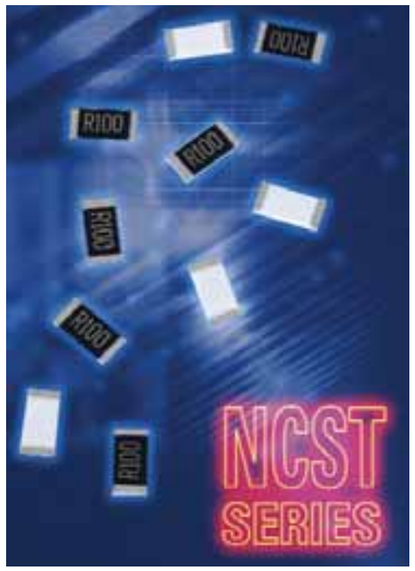
Analog Integration Corporation is launching a series of USB Power Switch ICs, called AIC1525/AIC1526/AIC1528/AIC1529, for self-powered and bus-powered applications. The high-side switch MOSFET with 70 mΩ and 110mΩ $R_{DS(ON)}$, meets USB voltage drop requirements for maximum transmission wire length. They provide applications with benefits of circuit reliability and low cost by eliminating the need for external components.

AIC1525 and AIC1526 are 500mA USB power switch IC that are one channel and two channels respectively. AIC1528 and AIC1529 are 1A USB power switch that are two channels and four channels respectively. A multi-purpose open-drain fault flag output indicates over-current limiting, thermal shutdown, or under voltage lockout for each channel. These devices provide all protection functions: over-current limiting, short-circuit protection, thermal protection, and under voltage lockout.

Enable active-high and active low make shutdown control by firmware much easier for users. Low on-state supply current, typical 75μA for AIC1525 and 110μA for AIC1526/AIC1528 and 220μA for AIC1529, makes these devices ideal for low standby power application.

www.analog.com.tw

Ultra-Stable Current Sensing Resistors



NIC Components Europe has introduced four new ranges of current sensing surface mount resistors. The NCSR, NCST, NCSP and NCSW series address the rapidly growing need for current sensing in power management and control applications in low voltage, high current circuits. The trend towards smaller handheld and portable electronics equipment has also increased the need for ultra-small current sensing resistors.

The NCSR and NCST series are precision thick film devices that are available in case sizes from 2512 down to 0402 (NCST series). The NCSP series meanwhile uses a stable precision conductor construction within a surface mountable moulded flat pack. The NCSP series is available in case sizes from 5724 down to 2512. Devices from the NCSW series utilize a thin film construction that enables them to achieve precision resistancetolerances, low noise, and long-term stability. The reverse termination format of the NCSW series gives increased heat dissipation to three Watts. Case sizes availabl are either 0815 or 0830.

All devices from the new ranges of current sensing resistors comply with EU lead-free directives that come into force from July 2006 and are fully compatible with Pb-free reflow processes. Samples and sample kits are available from NIC.

www.niccomp.com

Compact Inverter for LCDs Backlit

The LDS Series inverters from Endicott Research Group provide a high efficiency DC-AC inverter in a compact form factor for use with a range of LCD panel sizes from 6.4″ to 12.1″ diagonal.

Measuring only 5.24″ (133.1 mm) long x 1.22″ (31.0 mm) wide and less than 9 mm high, LDS Series inverters provide up to 12 watts of output power, with direct display connection and wide range PWM dimming.

LDS Series inverters are designed to power up to four CCFLs (cold cathode fluorescent lamps) with a combined power of 12 watts. An external analog control interfaces with an on-board pulse width modulator (PWM) to provide dimming control. LDS inverters can reliably dim to less than 5% of duty cycle. Operating temperature is –20°C to +70°C.

These inverters also offer expanded output connector options to meet the needs of both the OEM as well as system integrators and value-added resellers of LCDs.

www.ergpower.com

High-Power Eighth Brick DC-DC Converter

Tyco Electronics Power Systems announced the release of its EQW010-040 series DC-DC converters, an extensive line of new generation, eighth brick, DC-DC power modules designed for regulated single output voltages ranging from 1.0Vdc to 12Vdc. The EQW series delivers up to 10A at 12Vout, 20A at 5V, 30A at 3.3V, 35A at 2.5V and 40A of output current for 1.8V and lower output voltages. These converters are suited for use in distributed power architectures, wireless networks, access and optical network equipment, enterprise networks for powering the latest generation ICs (DSP, FPGA, ASIC), and microprocessor powered applications.

EQW010-040 Series converters operate over a wide input voltage range of 36 to 75 Vdc, providing a single, precisely regulated output with full load efficiency of 92% at 3.3V output. This high efficiency converter series employs half-bridge conversion topology with highly optimized synchronous rectification and incorporates innovative edge-plating and packaging techniques to deliver superior thermal performance. Built-in filtering for both input and output minimizes the need for external filtering.

The EQW010-040 series is rated for wide operating temperature range of -40°C to - 85°C in an industry standard eighth-brick package of 57.9 mm x 22.9 mm x 8.5 mm. Standard features include: remote on/off, remote sense, monotonic start-up under pre-bias conditions, zero reverse current during start-up and shutdown, over-temperature protection, input under/overvoltage protection, and output overcurrent/voltage protection. Surface mount interconnect and a base plate for superior thermal performance are available as options. The converters are designed to be fully compliant to RoHS EU Directive 2002/95/EC.

www.power.tycoelectronics.com

Touch-Safe Connector

Anderson Power Products announces its new PowerMod HP (high power) “B” series connector family, featuring touch-safe female housings, integral positive latches and cable strain relief. These safety features, combined with the ease of connector assembly, establish a new standard for cost effective high power connectors.

APP’s PowerMod HP “B” Series connector is rated over 350 amps for appropriate applications and to 250 amps at a 30 ºC temperature rise. The product accommodates American wire sizes from 1/0 to 4/0 AWG and metric wires from 50 to 95mm^2. These connectors use APP’s patented Sterling contact technology that offers low electrical resistance, provides a minimum of 500 mating cycles and is rated for circuit interruption (true hot-plug).

The unique latching system, with distinct blue buttons for clear identification, offers superior security and ergonomics. These connectors are IP 20 rated (touch safe) for user safety, and the integral coding key provides further protection by allowing the user to configure unique mating of up to 6 individual connectors.

www.andersonpower.com

Power Supplies for VoIP

Phihong USA has developed a redundant power source with up to 180 Power-over-Ethernet ports to meet the needs of telecom applications, such as VoIP systems. The RPS accepts three 500-watt power supplies for powering VoIP phones, DC UPS, and lighting systems with single UPS. A typical VoIP phone draws less than 8 watts. With 1500 watts available, 180 PoE phones can be supported from this redundant source.

Each output in the redundant power source is individually protected against overloads causing overheating of wiring from excessive current, thus fully protecting the system against overload, over-temperature and over-voltage. It features diagnostic capabilities and LEDs next to each connector. The RPS was designed to allow easy connection of a battery plant for full DC UPS capability for VoIP phone systems or network switches. A single battery plant can provide a UPS function for over 180 IP phones or a complete rack of network switches.

The redundant power source is 17.25 inches x 13.77 inches x 1.75 inches, and it weighs 2.5 pounds.

www.phihong.com

Synchronous Rectification MOSFETs

International Rectifier has introduced very high efficiency 75V and 100V HEXFET power MOSFETs in the TO-220 package that enable a part count reduction of 30% or more in secondary synchronous rectification, full-bridge topology power supplies compared to competing devices in the same package.

The 75V MOSFETs are designed to shrink circuit size and increase power density in high power server AC-DC switch-mode power supplies (SMPS) with 12V output or in 48V rail ORing circuits. The new 100V devices suit high power flyback secondary rectification or offer enhanced primary-side efficiency in high power telecom isolated 48V DC-DC converters. In addition, the new MOSFETs can be used in stepper motor and brushless DC motor drive applications.

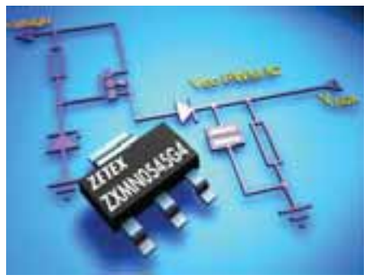
The IRFB3077PbF is a 75V MOSFET with 3.3mOhm maximum device on-resistance, and enables a 30% parts count reduction (from ten TO-220 devices to seven TO-220 devices), with a reduced PCB area and heatsinking for higher power density in 3kW server SMPS with 12V output.

The IRFB4110PbF is a 100V MOSFET with 4.0mOhm maximum device on-resistance, and can slash component count in half, reducing PCB area and reducing heat sink size.

The new synchronous HEXFET MOSFETs are available now and are lead-free (PbF) and are RoHS-compliant.

www.irf.com

Power Supply Start-Up MOSFET



A high voltage MOSFET from Zetex Semiconductors has been introduced to handle the requirements of pre-bias supply circuitry. A 450V enhancement mode N-channel device, the ZXMN0545G4 is used in a simple linear regulator to supply PWM ICs at start-up, and is disabled once the converter is fully on. Compared to alternative resistor dependent solutions, the MOSFET based approach improves system efficiency and reduces start-up time.

To maximise resistance to high voltage creepage, the MOSFET is provided in a unique 4-pinned SOT223-package. By simply disconnecting one of the two conventional drain pin positions, the device’s new leadframe design significantly extends inter-pin spacing, which helps designers comply with UL and CE creepage distance specifications.

Characterised by low on resistance—a maximum of 50Ω—and supporting continuous drain currents up to 140mA, and pulsed currents of 600mA, the transistor offers a highly efficient power handling capability. Switching speed is also fast, with turn-on and rise times specified at 7ns.

www.zetex.com

Configurable Multi-Output Power Supply

Powerstax announces introduction of the new A3600 series of ultra low profile, 1U high 19” rack mount, configurable AC-DC power supply. Capable of providing up to 3,600W output power the A3600 offers users multi-output “custom” power solutions without extended lead times and high NRE costs.

The A3600 employs a modular construction that has been developed to deliver advanced market-leading versatility using ultra-high efficiency (>90%) standard products from the Powerstax range. In a very compact, ultra low profile 1U high 19“ rack mount package 351mm deep, the A3600 offers combinations of single or multi-output, regulated DC power from a universal input mains supply of 85-264Vac. Input and output connection may be specified at front or rear and may be cable entry, connector or safety stud as required.

With up to 18 isolated and adjustable outputs, it is possible to individually margin, enable, parallel or stack the outputs to provide literally millions of power variants. Features include zero load operation and fully floating outputs that have standard output voltage ranges from 1.5V to 58V, few electrolytic capacitors (all long life), local and remote adjustment, and user adjustable current limit and inhibit/enable functions.

www.powerstaxplc.com

Precision Power Analyser

An advanced calculation function has been introduced as an option for the Yokogawa WT3000 precision power analyser to support customer requirements for more advanced and complex power analysis capabilities.

The new /G6 Option adds the capability for IEC61000-3-2 compliant harmonic measurements, wide bandwidth harmonic measurements, FFT calculations and waveform mathematical function, plus the ability to store transient waveform data.

In the IEC harmonic measurement mode, the instrument can be used with Yokogawa's new 761922 harmonic measurement software to perform tests conforming to IEC 61000-3-2 rev. 2.2. It complies with the latest IEC61000-3-2 and IEC61000-4-7 requirements, including 10/12 cycle waves at 50/60Hz, interharmonic measurements and grouping.

The wide-bandwidth harmonic measurement function allows harmonic analysis on waveforms with a fundamental frequency range from 0.1 Hz to 1 kHz (or 0.1-10 Hz using an external sampling clock). Measurements can be made up to the 50th-order harmonic at a 1 kHz fundamental frequency, or up to the 20th-order harmonic in the range from 1.1 kHz to 2.6 kHz.

Two FFT calculations can be performed simultaneously on waveform data of measured voltage and current, with a user-selectable minimum resolution of 1 Hz or 10 Hz. FFT analysis can be performed at up to 100 kHz.

www.yokogawa.com

Smallest Telecom 30W DC/DC Converter

Aimed at telecoms, mobile communications and networking applications with 48VDC input for onboard power, XP Power's SWX series of low power DC/DC converters includes the world's smallest footprint 30W version. The low cost converters save valuable board space.

The 10 to 30W SWX series is aimed at optical fibre access equipment, ADSL applications, routers, switches, and cellular base stations where small size, high efficiency, high operating temperatures, low profile, and surface mount capability are requirements.

Obviating the need for fans, the convection-cooled converters have an operating temperature range of -40 to +85 degrees C. Their 91% efficiency ensures that minimal heat is generated, providing increased reliability and simplifying cooling arrangements.

Useful in applications where PCBs are stacked closely, the converters have a low profile. The 10, 15 and 20W models have a footprint of 38.7 x 27.2 x 5mm, and the 30W version has a footprint of 38.7 x 31.2 x 8mm. SWX DC/DC converters employ synchronous rectification to enhance efficiency. The input voltage range for 48V models is 36—76VDC, and the 24V input versions accept a voltage input range of 18 to 36VDC. Output voltages are from 1.2V to 15.0V.

www.xppower.com

Companies in this issue

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

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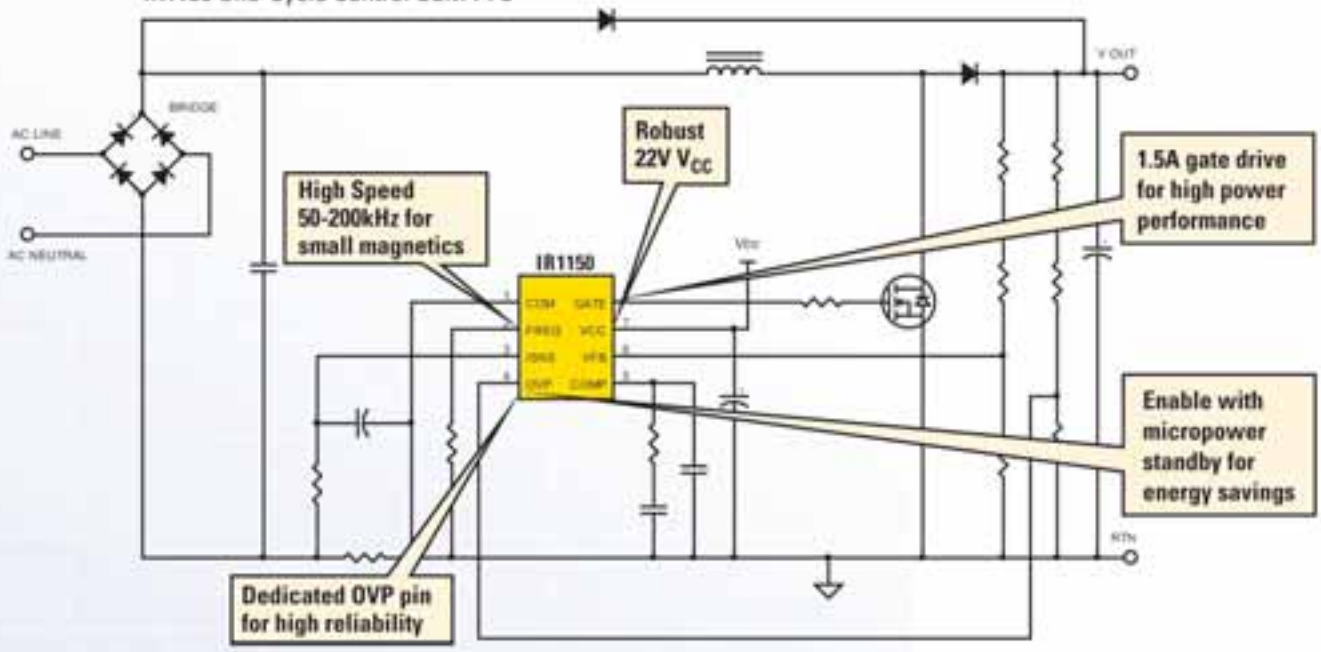

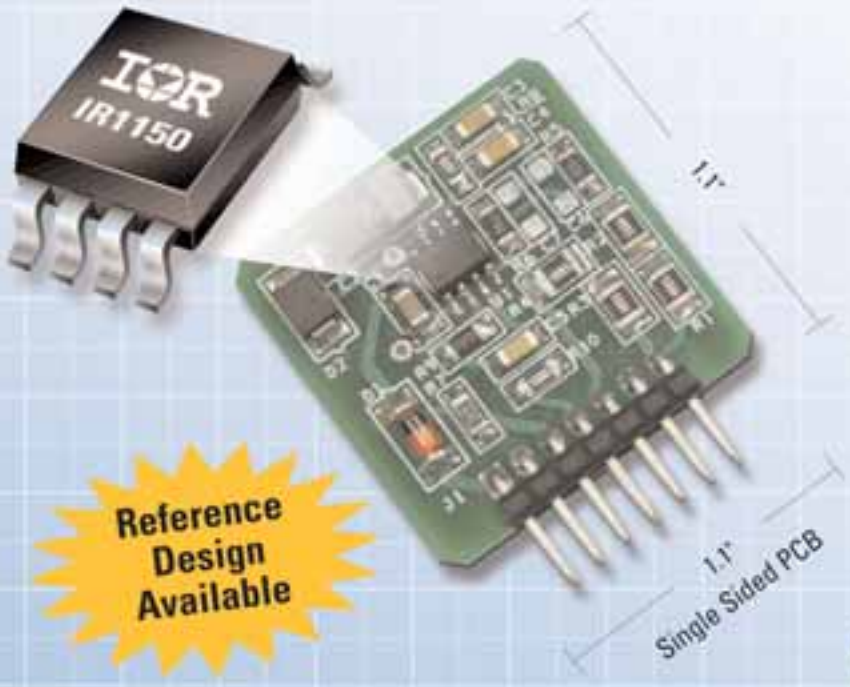

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* in typical 1kW power supply

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